

SEA CHANGE

A PIPELINE LINKS RUSSIA AND EUROPE

CASTORO SEI

A VISIT TO THE FACTORY SHIP

INTERVIEW

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IS RUSSIAN GAS FOR US?

BOMBS AND MINES

DANGEROUS INHERITANCE
FROM TWO WORLD WARS

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Richard Zinken
Publishing Director
Spektrum der Wissenschaft Verlagsgesellschaft mbH

The Dawning of a New Era—with Natural Gas?

With no apparent destination, the helicopter flies out to sea. But somewhere out there, moving a few kilometers further every day, there is the *Castoro Sei*—a floating factory in the middle of the Baltic Sea. From inside this ship the Baltic Sea pipeline is being created—gas pipes connecting Lubmin in northern Germany with Vyborg on Russia’s western coast, more than 1,200 kilometers away.

We visited the *Castoro Sei* and in this issue we will explain how every few minutes the men there weld one piece of pipe to the next and then sink it to the bottom of the sea—and why our author was so impressed by the “strangely relaxed routine on board.”

The construction of this pipeline across the Baltic Sea is truly a gigantic project, costing the operator, Nord Stream, a total of around 7.4 billion euros. Naturally, the plans have not been without controversy—political, economic and, of course, from the perspective of many environmental campaigners.

One thing is certain: we are not yet able to quench our ever-growing thirst for energy with renewable energy sources. It is no surprise that

more and more people see modern gas and steam combined power plants—especially after the reactor accident at Fukushima—as an acceptable bridging technology.

But where will the search for a sustainable energy strategy lead us? Could our desire for security of supply result in our being dangerously dependent?

No less important, of course, is the question of environmental protection: What impact will the installation work have on the fragile ecosystem of the Baltic Sea? What about the explosive or toxic munitions left over from the two world wars lying dormant on the seabed? And what of the concerns about long-term consequences—for the flora and fauna, as well as for the fishing industries of the neighboring countries?

These are all questions we want to answer in this magazine.

Enjoy this exciting read!

IMPRESSUM

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E&C



Production Line in the Sea

Since April 2010, the men aboard the Castoro Sei have been welding together 12-meter-long steel pipes and lowering them onto the bed of the Baltic Sea. The pipeline they are building—at a rate of about three kilometers a day—will transport gas from Russia to Europe when it is completed in 2011 and stretch 1,224 kilometers across the sea. Our author visited their floating pipe factory situated off the coast of Finland.

By Roland Knauer



Off to a new job: In early 2010, after her overhaul at a shipyard in Rotterdam, the Castoro Sei made her way to the Baltic Sea. Here she is passing by the Storebæltsbroen, the bridge over the Great Belt.

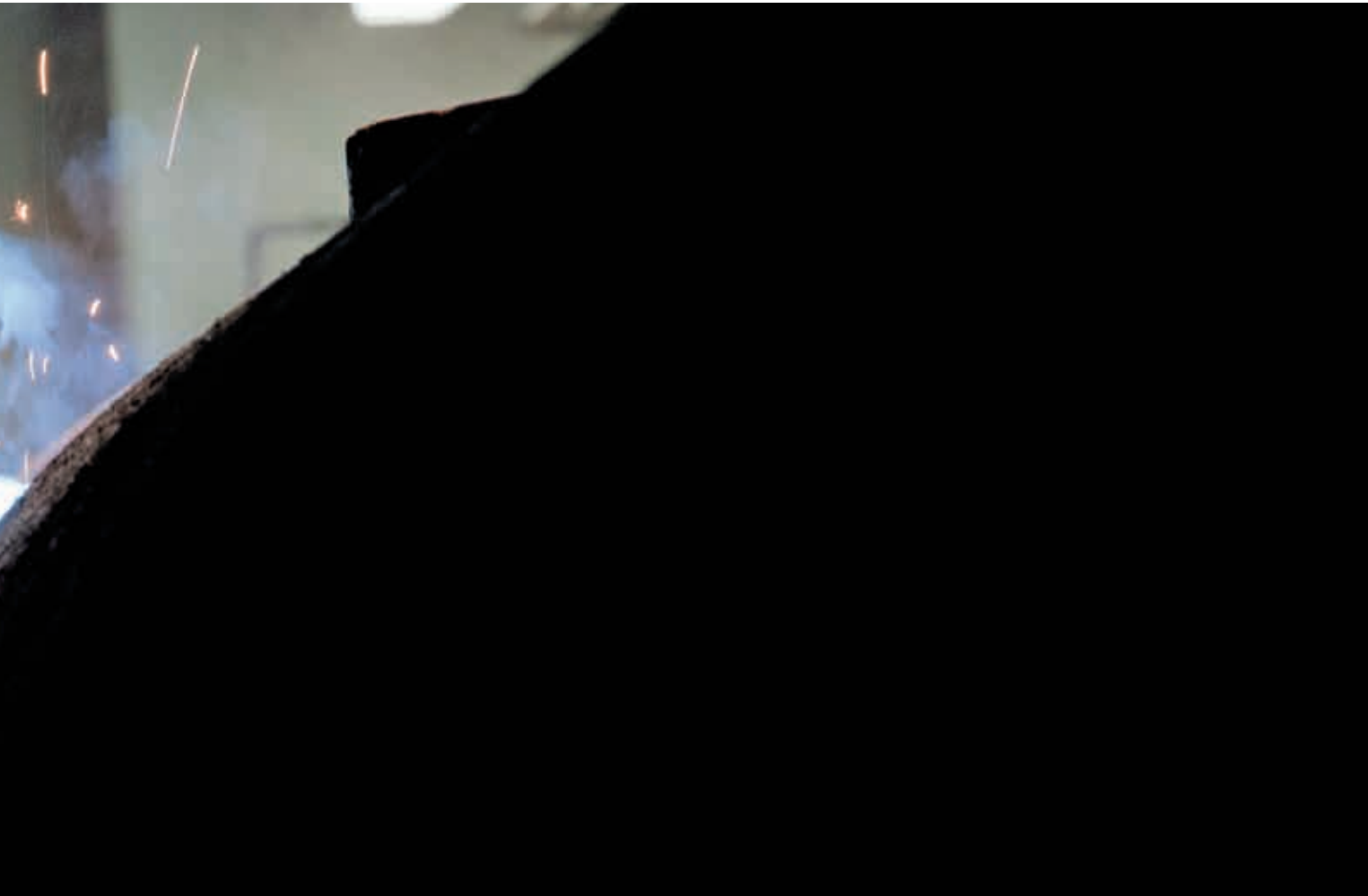


On good days, more than 300 of the 12-meter-long pipe sections disappear into the belly of the Castoro Sei. At the bow of the ship (bottom left), the finished pipeline dives down into the sea.

Before being moved to the ship's interior, the pipes, weighed down with their concrete casings, are cleaned and have any rust removed.







Each pipe joint is welded three times—to protect it from conditions at the bottom of the Baltic Sea and keep it impermeable for decades to come.



Every few minutes the pipeline grows the length of another double-pipe. After several painstaking maneuvers the gas pipeline leaves the ship on its way to the seabed.





Domenico Alferj has come to the Finnish town of Turku, where he is now squeezed into a tight wetsuit, in order to make the last part of his journey to work. Alferj, who has just spent time with his family in Italy, climbs into the waiting helicopter. The uncomfortable outfit is a safety requirement, designed to save the lives of the passengers in the event of an emergency landing in the chilly water of the Baltic Sea. His fellow passenger in the helicopter, Arcangelo De Luca, is wearing a similar wetsuit and laughing. The pair cannot talk to each other, as the two turbines above their heads are making an infernal noise. Luckily, the flight only takes half an hour, after which we can see the men's workplace, a boat called the *Castoro Sei*. Alferj is the captain of this ship and De Luca, its engineer.

The helicopter, carrying the two men and a dozen other crew members, touches down gently on the landing deck at the stern of the ship—33 meters above the water's surface. Anyone seeing the *Castoro Sei* for the first time may wonder why it does not resemble a freighter, ferry or cruise ship. In fact, it looks more like an oil rig. This is because the 152-meter-long and 70-meter-wide boat is essentially a giant platform resting on two rows each composed of five

huge pillars, against which the Baltic's waves are breaking 16 meters below. Experts call this kind of construction "semi-submersible." Underwater, the pillars connect with two pontoons that carry the 32,000-ton vessel. The ship is also equipped with ballast tanks that can be flooded to allow the vessel to descend into the sea until she has a draught of more than 15 meters. At this point, the semi-submersible is so deep that even in stormy weather she hardly rocks. One happy result of this is that seasickness among the approximately 330 men on board is rare.

But the well-being of the crew is not the reason for ship's elaborate construction. The steadiness of this workshop on the high seas guarantees that the technicians and engineers are able to carry out the high-precision work needed for the job. The *Castoro Sei* is a floating factory, or more precisely, one of three pipe-laying vessels that are welding together and laying the two 1,224-kilometer-long pipelines on the bed of the Baltic Sea. The plan, upon completion of the project in 2012, is for the pipes to carry about 55 billion cubic meters of gas from Russia to Europe every year—around ten percent of the current gas consumption in Europe and enough to supply 26 million households. "We are going to lay around 70 percent, the lion's share of the

Captain Domenico Alferj (left) is usually found on the bridge of the Castoro Sei, while engineer Arcangelo De Luca is always on hand whenever something on the floating factory needs fixing.



NORD STREAM / THOMAS EUGSTER

SAIPEM / FRANCOIS COSTE



Anyone getting aboard here is heading home—usually for three weeks. After that the helicopter brings them back to their workplace, with 12 hours on and 12 hours off.

two pipes,” explains Alferj, while the noise of the helicopter flying back to Turku fades into the distance.

The newly arrived crew members have swapped their uncomfortable wetsuits for orange overalls, since their shift will begin soon. They will remain on the ship for four weeks, followed by three weeks rest at home: 28 working days, 21 days off. This may sound like an attractive schedule, but every day is tough on board, always following the same rhythm—12 hours on, 12 hours off. Sundays are workdays, as are Christmas, New Year’s Day and Easter. “We only celebrate Ferragosto if we’re off duty and on land,” says Alferj. Ferragosto, or Assumption Day, on August 15th, is not only the longest celebrated public holiday in Bella Italia, but it is also the highlight of its holiday season. However, the Italians on the *Castoro Sei* are in the minority, as most of the workers on the ship, owned by Italian firm Saipem, are from Southeast Asia.

PREPARING THE PIPES

Now, just as they do every day, two giant cranes move on tracks along both sides of the work deck, steadily lifting pipes, one after the other, from the decks of the transport ships docked alongside the *Castoro Sei*. Seen from the bridge, the 12-meter-long pipes seem tiny—you very quickly lose your sense of scale here. Only the men on the deck using long ropes to pull the pipes into position provide a reference for comparison.

The pipes, which have an internal diameter of approximately 1.15 meters, are manufactured in Mülheim an der Ruhr, Germany, in Vyksa, about 350 kilometers east of Moscow, and in Japan. Measuring about 12 meters long when they leave the steelworks, they can just

about fit onto a truck. Since the steel is up to 41 millimeters thick, each tube weighs 11 to 12 tons. A brownish-red layer of epoxy resin, barely a tenth of a millimeter thick, is applied inside the pipe to reduce frictional resistance and allow the gas to flow easily through the pipeline. On the outside, a plastic layer approximately five millimeters thick prevents the steel from rusting in the depths of the sea.

The completed pipes made in Mülheim arrive by train at the port of Mukran auf Rügen, Germany, while those from Vyksa end their long rail journey at the Finnish port of Kotka. There, every day, in factories specially built for this purpose, about 200 of these hefty pipes are fitted with a concrete shell up to 11 inches thick. Without this shell, the pipeline would be too light and would have to be anchored to the seabed, at great expense. The concrete doubles each pipe’s weight to about 23 tons.

Transport ships from Germany, Finland and Russia carry finished tubes to the port of Hanko, Finland, as well as to the Swedish ports of Karlskrona and Slite on Gotland. Together with Mukran and Kotka, there are five storage depots from which relatively small transport ships constantly restock the *Castoro Sei* with new pipes. “Because we work all day and night, we constantly need new supplies,” says De Luca.

To ensure this non-stop operation keeps going, most positions on board have several occupants. Two men take turns on the boat in the 12-hour rhythm of work and leisure, while a third man is resting on land. When, during the course of a shift, someone needs to take a break, a stand-by takes over the job.

On this day, an area of strong high pressure is moving over the Baltic Sea, while one of the cranes is starting to haul another pipe to one

AT A GLANCE

1. The *Castoro Sei* is one of three pipe-laying vessels that are building the Baltic Sea pipeline.
2. While the men on board weld another piece onto the gas pipeline, the ship is pulled along towards giant anchors.
3. Finally, specialist divers weld the pipeline sections together on the seabed.



Perez Alvin is in command of the mighty winches (right). With the help of their arm-thick cables, he pulls the *Castoro Sei* towards the distant kedge anchors.



BOTH PHOTOS: SPECTRUM DER WISSENSCHAFT / JOACHIM SCHÖRING

of the first welding stations. Since the concrete casing ends a few hand spans away from the pipe's extremities, there are only the anti-corrosion coating and the steel walls at each end. They are mechanically cleaned and prepared for the welding process with a special milling machine. The first step involves two of the 12-meter-long pipeline sections being joined together using welding machines. Once the liquid metal solidifies, the seam is examined for the first time, millimeter by millimeter, using special ultrasound equipment. Even the smallest weaknesses can be reliably detected this way. If an error is discovered, the shift manager decides whether the damage is repairable or whether the two pipes should be recycled.

A MEDIEVAL METHOD

A kind of elevator then moves the 24-meter-long, 46-ton section of pipe to the actual production line, dubbed the Firing Line, which runs through the length of the *Castoro Sei*. At the front end, at the bow of the floating factory, the final pipeline sections leave the ship and then, via a 40-meter-long boom known as the Stinger, dive down into the Baltic Sea. "As this is taking place the whole ship moves backwards from under the pipeline," says Alferj. This is executed not with a motorized propeller, as one might expect, but in a manner first practiced in medieval times—on river barges, for example. At that time, workers would row a small boat some distance ahead and drop an anchor with a long rope attached. Crew members back on the barge would then use the rope to pull themselves and

their boat towards the anchor. Once they arrived, the anchor would be hauled aboard and the arduous routine would start all over again. This technique is called kedging, and it is how the *Castoro Sei* moves through the Baltic Sea.

Here, however, instead of men pulling on a rope, there are eight diesel engines with more than 30,000 horsepower drawing on a total of 12 kedge anchors. As tall as a house and weighing in at 25 tons, just one of these anchors is heavier than 16 medium-sized cars. At each of the four corners of the *Castoro Sei*, winches connect to three of these giants. The anchors are dropped a long way from the bow of the ship so as not to endanger the newly laid pipeline. At the rear, they are closer, positioned only a few degrees off the direction of travel. As soon as another double joint is connected to the pipeline, the machines reel in the arm-thick steel cables at the rear, so that the boat takes another 24-meter step backwards, allowing the ever-lengthening pipeline at the front of the ship to drop into the water. The lines on the bow are slackened accordingly. If anchors have to be repositioned, the monsters are picked up by auxiliary ships and transported to their new location. The vessel also has four propeller pods, or nacelles, with which the helmsman fine-tune its movements, in a similar way to that employed on large cruise ships.

Meanwhile, inside the *Castoro Sei*, three clamps hold the end of the pipeline in position. They are reminiscent of tank crawler tracks, pressing against the pipe from above and below. As soon as another double joint is welded, it travels out of this tank track conveyer belt to the

**HUGE MACHINES
MOVE HUGE
MASSES—
AND YET THE
STRANGE GOINGS
ON ARE GOVERNED
BY A SEEMINGLY
RELAXED ROUTINE**

bow, and disappears over the Stinger and into the water. The pieces form two huge arches in the shape of the letter S, before finally coming to rest at the bottom of the Baltic Sea. “If the sea is 80 meters deep, the pipe only reaches the ground at a distance of 350 meters,” says De Luca.

Over this length the supposedly rigid steel and concrete pipe becomes as flexible as a long straw. Even a skyscraper can sway back and forth by up to a meter in a storm, so much so that its inhabitants sometimes get seasick. Theoretically, the pipeline could be laid out on the bottom of the Baltic in a circle four kilometers in diameter without it being damaged. In comparison, the stresses that occur along the narrow S-curve while the pipe is lowered to the seabed are much lower, although this does not mean the process is not continuously monitored and reviewed.

WITH CLOCKWORK PRECISION

Every few minutes the *Castoro Sei* pulls itself back another 24 meters. “The first weld takes five or six minutes,” explains De Luca. Then the pipeline, with its new end section, moves a further 24 meters. While a new double joint is attached, the most recent connection, still glowing, is welded a second time. Again, it takes a few minutes, and then the pipeline rolls along another 24 meters and gets a third weld. The process resembles a conveyor belt production line.

It’s noisy down here and fairly dark. Sparks fly and bathe the scene in a brilliant light. The men wear goggles with black lenses for protection. Huge machines move huge masses—and yet the strange goings on are governed by what seems to be an unusually relaxed routine. Everyone who works here has his place and knows exactly what he has to do. Only a few dozen men have welded all of these massive pipes to create a more than 1,000-kilometer-long pipeline with clockwork precision. Errors are rare, and accidents even rarer.

Just as health and safety are scrupulously monitored here—with an elaborate network of roads with traffic lights and signal horns—there is also no compromise when it comes to quality control. The intention is for gas to flow through the pipeline for 50 years. If a leak were to be discovered after the pipeline begins operation, the repairs could cost millions. That is why the three welds now undergo a further ultrasound examination designed to spot any microscopic irregularities—potential targets for dangerous rust. How often do the alarm bells sound at this stage? With his usual enthusiasm when explaining the project’s technical details, De Luca says, “If that happens, then the weld certainly gets repaired.” It is very rare, but sometimes double joints do have to be replaced.

But today everything is running smoothly. Another 24 meters of the pipeline moves one

FACTS

1.153
meters—diameter of the gas pipes.

202,000
The number of concrete-coated pipes being laid.

2,150,000
tons of steel resting on the Baltic seabed.

7,400,000,000
euros—the cost of the Baltic Sea pipeline.



Inside the pipe-laying ship, the tank's track-like conveyor belts keep a firm grip on the pipeline.

The *Castoro Sei* at Work

In April 2010 Nord Stream started building the first of the two tubes which will make up the pipeline. Taking on the lion's share of the construction work, the *Castoro Sei* began its mammoth task off the island of Gotland.

The route stretches for 1,224 kilometers across the Baltic seabed, from Vyborg in Russia to Lubmin, near Greifswald in Germany. Nord Stream commissioned the Italian company Saipem, a leader in the field of offshore projects, to take charge of the construction.

About 70 percent of the pipeline will be installed by the *Castoro Sei*, an anchored pipe-laying ship. In the Gulf of Finland, an area known for a high traffic volume and historical munitions dumps, the *Solitaire* is used by Allseas, which operates without using anchors. In shallower waters nearer the German coast the Saipem vessel *Castoro Dieci* is used, a ship with an extra flat hull. Each ship is a floating factory: the pipes are delivered by cargo ships, welded together on board and then laid onto the seabed.

Soon the pipeline will be carrying 55 billion cubic meters of natural gas every year—enough to meet the demands of 26 million European households. The receiving station in Lubmin will send the natural gas on into the European gas pipeline system, through which it will reach consumers in countries such as Germany, Denmark, France and Great Britain.

CRANE

Two revolving cranes travel on rails on the main deck. Each can lift up to 200 pipes a day onto the barge.

STINGER

The Stinger provides support to the pipeline as it is lowered to its designated place on the seabed.

POST-PIPELAYING SURVEY

As it touches down on the seabed, the pipeline is monitored to ensure that it is correctly positioned.

ROV

A remotely operated vehicle (ROV) fitted with sensors and instruments including cameras transmits information from the seabed directly to the survey vessel.

ROCK PLACEMENT

The strategic placement of coarse gravel is necessary in some locations along the route to create a stable base on which the pipeline can rest.

S-CURVE

As the pipeline is lowered to the seabed, it forms an "S" shape, which prevents it from being damaged during installation.

A FLOATING FACTORY

The *Castoro Sei* is the semi-submersible responsible for laying around 70 percent of the Nord Stream pipeline.

- Dimensions: 152 meters long, 70.5 meters wide
- Draft: 14 meters
- Laying rate: around 2.5 kilometers per day

PIPE CARRIER VESSEL

Pipes weighing about 22 tons each are shipped to the laybarge from five stockyards strategically located along the route.

HELIPAD

Personnel is transferred to and from the vessel via helicopter, which lands on the helipad at the stern of the *Castoro Sei*.

PRE-PIPELAYING SURVEY

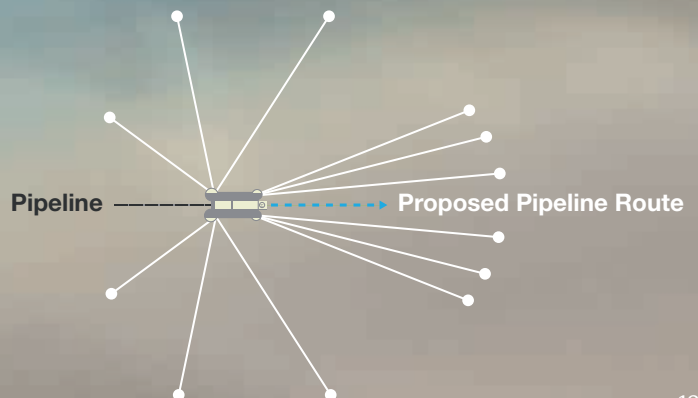
Though the seabed was surveyed during the route-planning phase, a pre-pipelaying survey performed before pipeline installation confirms past data and ensures pipelay safety.

PONTOONS

The *Castoro Sei* floats on twin pontoons located below the water surface. The pontoons can be submerged by adding ballast water, making the vessel more stable in turbulent seas.

ANCHOR PATTERN

During construction the *Castoro Sei* is positioned by means of a 12-point mooring system. This system enables it to maintain accurate positioning. Each of the 12 mooring lines, or anchor lines, are controlled by a tension winch weighing 124 tons. The vessel also features thrusters to further ensure precise positioning.





A Pig on Tour

Intelligent inspection devices, called PIGs (Pipeline Inspection Gauges) are regularly sent through the gas line to search for internal corrosion or leaks (pictured). External checks on the laid pipes are done with the aid of remote-controlled underwater vehicles, or ROVs (Remotely-Operated Vehicles).

stage closer to the end of its production line. Here, two workers wrap plastic sheeting around the welded ends of the two pipes and heat it with a gas burner. The canvas shrinks and seals the area between the concrete shells. Finally, they take a steel plate that fits between the concrete casings of one pipe and the next, fix it with steel straps and fill the cavity with plastic foam through a small hole. Now there are only a few meters to go until the still-warm section is forever immersed in the Baltic Sea.

Meanwhile, a few floors higher, Alferj observes the horizon carefully. The weather report has just announced that the sun may soon disappear behind clouds and that a storm could be brewing. “Storms usually only cause us real problems in autumn and winter,” he explains in English, with a strong Italian intonation. If the waves get higher than three or three and a half meters, pontoons deep under the water may no longer hold the *Castoro Sei* perfectly still. In such a case, laying the long pipeline becomes more difficult, although not impossible. “We just work a bit slower,” says Alferj.

Only at wind force eight, when gusts on the work deck reach speeds of over 60 kilometers per hour, will Alferj order a halt to proceedings. When this happens technicians weld a large steel cap on the open end of the pipeline to prevent water from getting in. Then the men secure a ten-centimeter-thick steel cable and lower the closed pipeline to the seabed. “The whole process takes about three or four hours,” says De Luca. That is why reliable weather forecasts are so important. The men on the *Castoro Sei* have to have this maneuver completed well before the storm hits. If everything goes smoothly, the

ship will be ready and waiting on the exact same spot at the end of the storm.

Work restarts even before the wind dies down again. An unmanned, remote-controlled underwater robot dives to collect the loose pipeline end, picks up the steel cable and brings it back to the *Castoro Sei*. The pipe is then hauled aboard with the help of winches. About five hours later the steel cap is removed, and when the wind has finally died down the men in the Firing Line once again get on with their work. “If everything goes well, we can manage more than four kilometers of pipeline in one day,” says Alferj. “Even on average, it is still three kilometers.”

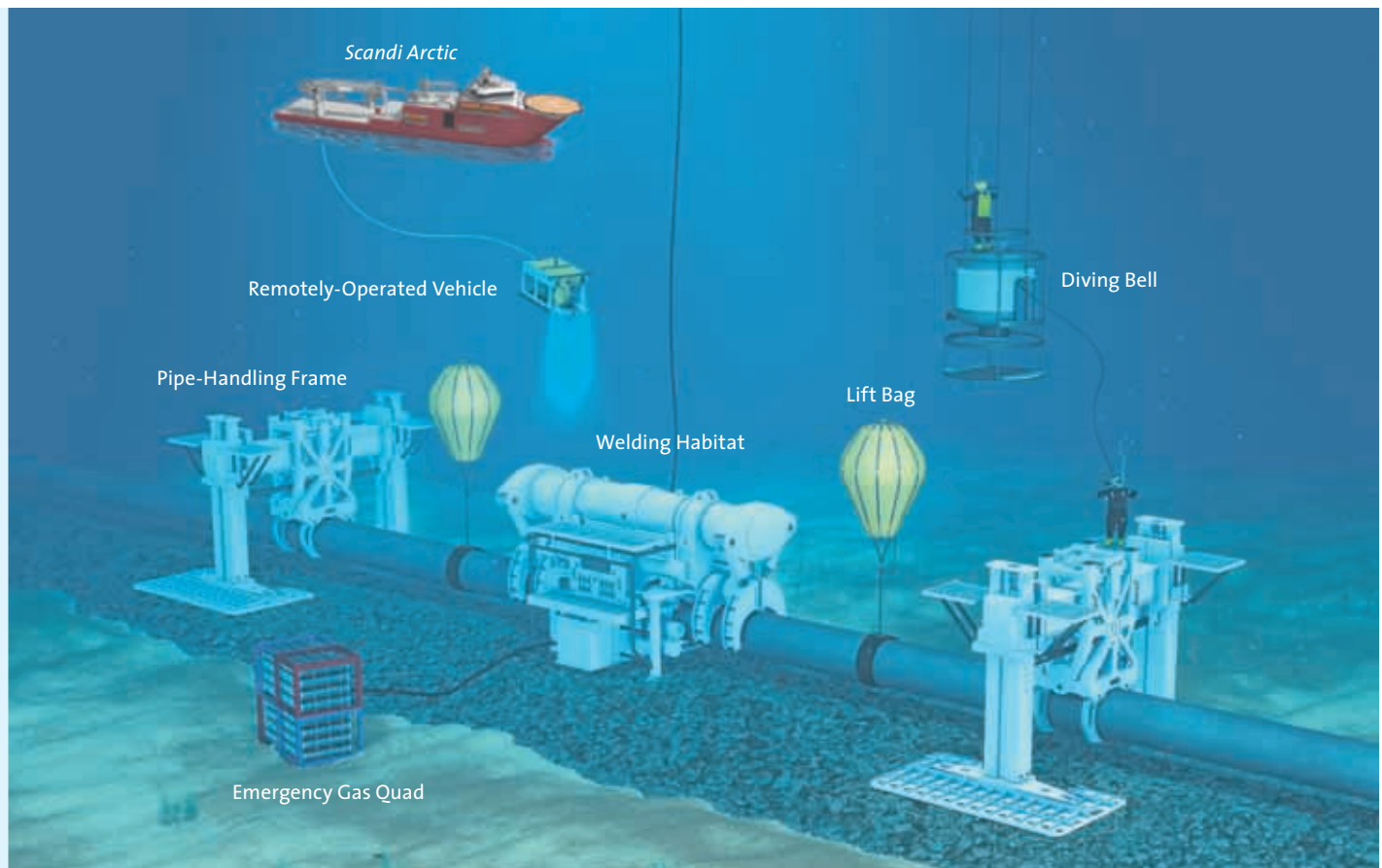
WITH HIGH PRESSURE THROUGH THE BALTIC SEA

Construction work on the first pipeline lasted from April 2010 until early May 2011. In June 2011, the crew of the *Castoro Sei* began laying the second pipe, which is scheduled for completion by May 2012. About 80 percent of the line lies directly on the Baltic seabed. In some places, the uneven ocean floor had to be levelled out with gravel in order to ensure stability. In shallow waters, such as the Bay of Greifswald, or in places where the pipeline crosses busy shipping routes, trenches are dug to prevent any possible damage from a nautical accident.

After completion, gas from a pumping station in Russia will be forced into the tube at high pressure. On account of the low temperatures and high pressure on the seabed, the gas will be able to flow at a much higher pressure than would be possible on most on-shore pipelines, and so Nord Stream’s developers were able to do without having to build intermediate pumping stations along the line. Nevertheless, the gas pressure falls continuously over the 1,224-kilometer route from Russia to Germany, which is why the pipes that make up the first 300 kilometers across the Gulf of Finland are made from 41-millimeter-thick steel and can withstand an operating pressure of up to 220 bar. For comparison, the maximum pressure of a car tire is 3.0 bar. When the gas finally reaches Germany, the pressure will have dropped to 110 bar. Here, the steel walls are only 27 millimeters thick. Both strands of the Baltic pipeline consist of three sections of varying wall thickness. They are laid independently and only connected after each section of work is completed, in the depths of the cold water at the bottom of the sea.

The fine Italian way: In the galley of the Castoro Sei the waiter places great emphasis on a stylish appearance.





The process is now complete for the first of the twin pipelines. But beforehand, there was a moment of truth. A special ship tested whether the line on the seabed was watertight by pumping purified seawater into the respective sections and increasing the pressure to the maximum allowable limit—far higher than the planned operating pressure the pipes will have to endure later. Only when the gauges showed no drop in the pressure after 24 hours were the sections joined together. This, too, is a masterpiece of engineering. After a remote-controlled underwater robot removed the steel cap at the end of the section and sealed it off with a stopper, a huge underwater bell was lowered to a depth of between 80 and 110 meters, drained and placed in position on the two adjacent ends of the pipes. Once all the water was squeezed out and the steel pipe ends were dry, several divers made their way into the depths—where they carried out exactly the same process as their counterparts in the heart of the *Castoro Sei*. They joined the ends of the pipes using a welding robot that was controlled and monitored by the *Scandi Arctic*—a special ship that has all the tools necessary to move the pipe ends around, lift, cut and weld them together. The final step of the

process was for the divers to seal the underwater seam.

All of this takes a few weeks. It's a long time, during which the specialists live under high pressure, in the truest sense of the phrase, in cabins where the atmospheric pressure is as high as in the depths of the Baltic Sea. When their work is done, huge compressors pump the seawater out of the completed pipeline. A steady stream of air ensures that the tube is completely dry before the gas starts flowing.

That is scheduled to begin at the end of 2011, when the first of the two pipes in the line will become operational, and high-ranking politicians, business leaders and other VIPs from all of the participating countries will make their way to Lubmin, near Greifswald. For it is here, in this spa resort of 2,000 inhabitants, that the pipeline comes ashore, and where, amid a great deal of media attention, they will celebrate the completion of this remarkable project. But then Captain Domenico Alferj and his engineer Arcangelo De Luca head off on yet another long journey to lay another pipeline somewhere in the world.

Roland Knauer is a freelance journalist and photographer from Lehnin in Brandenburg.

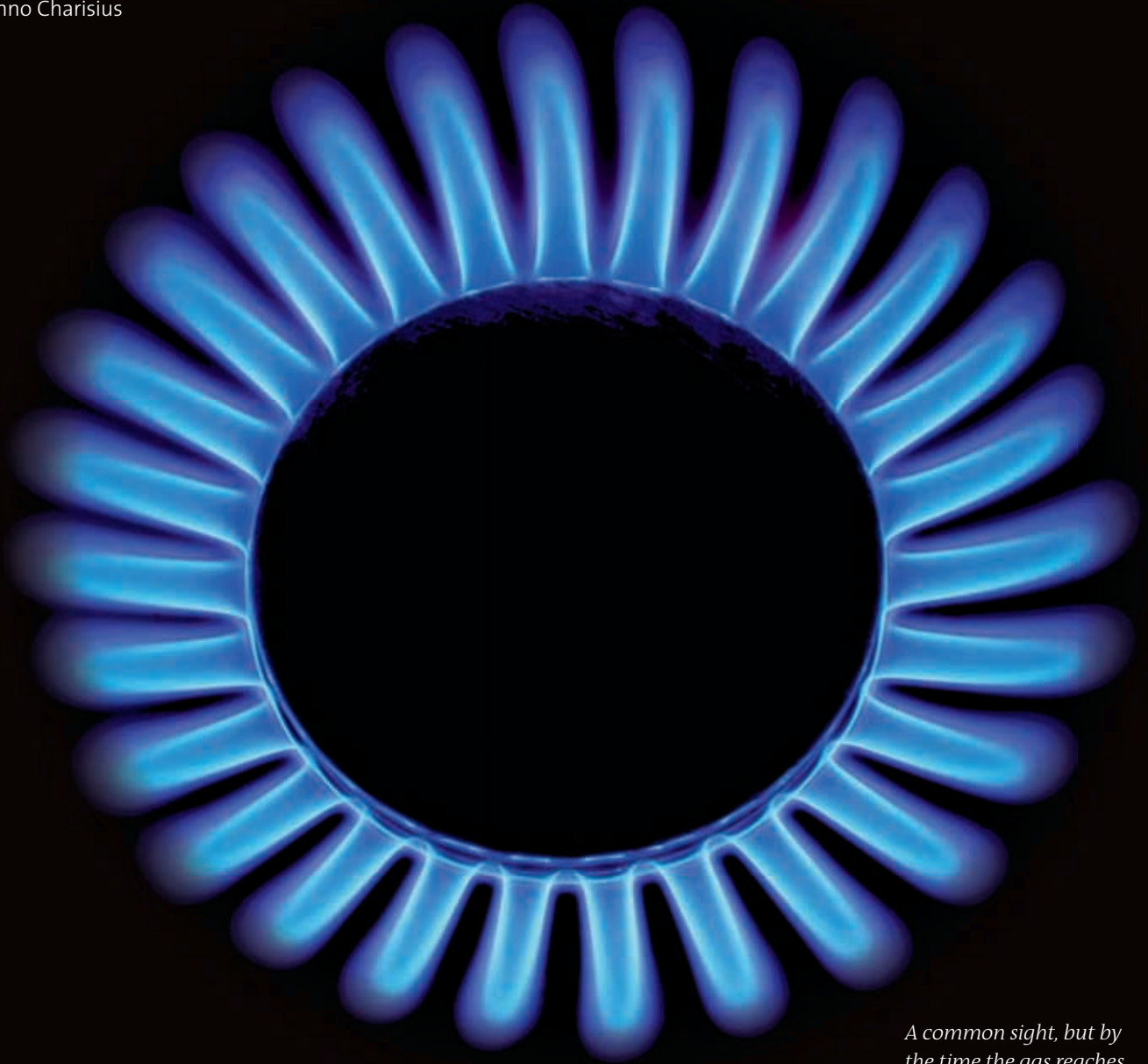
The Baltic Sea pipeline is laid in several sections. Underwater robots position the pipe ends near to each other. Then the Scandi Arctic lowers heavy equipment into the depths, including the welding station, which will permanently connect the pipes together.

A Burning Passion...

...for Gas

After oil and coal, natural gas is the world's most important fossil fuel. Within the space of a few decades it may move up to first place. But where does the fuel actually come from? And how does it get to our kitchen?

By Hanno Charisius



A common sight, but by the time the gas reaches the kitchen stove it has been on a journey of thousands of miles—and many millions of years.

In one way gas is like water: you simply turn the tap on and it flows. But its origin and how it gets there stays well hidden behind the kitchen wall. Whenever we use the fuel, for cooking, heating or to generate electricity, the gas has always been on a very long journey—through space and time. In the near future, once the Baltic Sea pipeline is completed, that journey could begin in Siberia, at the Yuzhno Russkoye gas field. Part of the gas extracted from this reserve will flow through a network of long-distance pipes to Vyborg on Russia's Baltic Sea coast, more than 2,500 kilometers away. From there the gas will pass through the Nord Stream pipeline to Greifswald on the German Baltic coast, where it will join the European gas network and, eventually, be delivered to someone's kitchen stove.

The gas originates from around 1,000 meters under the Siberian permafrost. There is so much natural gas stored in the porous sandstone there that Germany could meet its needs from it for decades. These deposits have occurred due to a variety of geological accidents—and the passing of a great deal of time. In the late Jurassic period, around 150 million years ago, Siberia was covered by a warm, shallow sea. Whereas nowadays temperatures in the summer get up to 40 degrees Celsius and as low as minus 60 in winter, at that time the Yuzhno Russkoye region knew only tropical conditions. Summers in Western Siberia were warm and wet, winters warm and dry—just like the Bahamas today, where the water laps gently onto the palm-lined beaches. The ocean currents were weak and the water hardly circulated. This led to oxygen concentrations decreasing rapidly at depth. Dead organisms sank to the ocean floor and were unable to decompose. Over millions of years they formed a steadily growing layer of sludge. The shallow sea silted up and the black deposits eventually disappeared under ever-thicker layers of sediment.

As a result of large-scale tectonic processes, during which entire mountain ranges grew, the sludge ended up at a depth of four to six kilometers, where temperatures were around 180 degrees Celsius. Eventually, due to complicated chemical processes, the dead organisms turned, at first, into oil and then later into gas. These hydrocarbons were then pushed out of their "parent rock" and, due to their low density, literally squeezed towards the Earth's surface—much like a big drop of wax in the colorful lava lamps

from the 1970s. But sooner or later, one impermeable layer of stone blocked the gas's upward journey. It is here, in these traps, that the huge amounts of oil and gas finally gathered and were ultimately discovered by geologists in the late 1960s.

Random as the geological circumstances that created them, oil and gas deposits are spread out arbitrarily across the world. The countries in the Middle East were particularly lucky—even more so than Russia. Northern Africa has reasonable reserves, while Western Europe's appear somewhat modest in comparison. They are far from sufficient for Europe to meet its own needs. And this is why Germany for example gets almost 90 percent of its supplies from abroad—about a third of which comes from the large Russian gas fields, especially those in Siberia. Other major suppliers include Norway, with 29 percent, and the Netherlands, with 20 percent. At the very most, 13 percent can be obtained from domestic sources, which are mainly located in Lower Saxony and off Germany's North Sea coast. However, in recent years the natural pressure in the gas fields has decreased, reducing the yield significantly.

SIMPLY BURNED OFF

When the systematic extraction of petroleum began, some 150 years ago, gas was a troublesome and dangerous byproduct that bubbled out of the drill holes like carbon dioxide from a lemonade bottle—or even like a shaken champagne bottle. Violent explosions, sometimes sending entire oil wells into the air, were not uncommon. As a result the risky gas was captured, transported some distance away and then simply burned off. Evidence of this can still be seen at night, with gas flares betraying the fact that, for technical or economic reasons, some natural gas deposits remain unused. Nonetheless, its value is undisputed and global demand is rising steadily: Its share of the fossil fuel market is already around 25 percent. Only oil and coal have larger sales volumes.

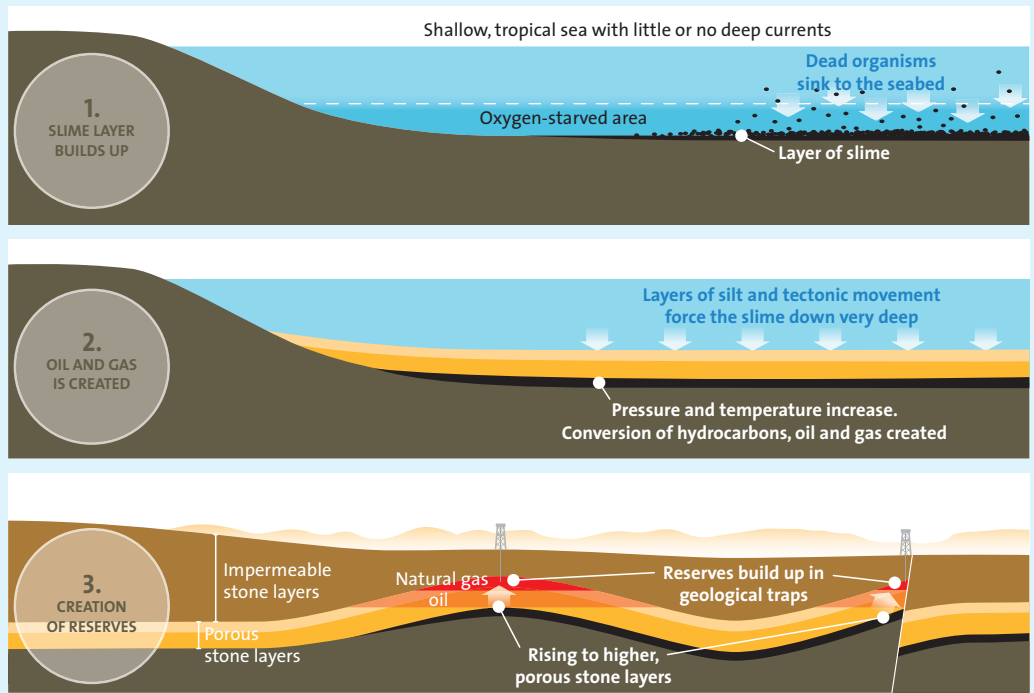
But it is still not enough just to pipe the gas being extracted from the reserves into a tube and wait until it reaches the homes of the end users thousands of kilometers away. Transporting gas is far more expensive and complicated than oil and coal. The pressure in above-ground pipelines sinks so much over long distances that compressor stations have to be built every 100 to 200 kilometers to ensure optimal transport

AT A GLANCE

1. The Baltic Sea gas pipeline will carry gas from the Siberian Yuzhno Russkoye gas field—one of the largest in the world—to Europe.
2. The creation of the fossil fuel took many millions of years and happened because of a series of geological coincidences.
3. The Baltic Sea gas pipeline comes onto land at Lubmin, northern Germany. From here the gas flows into the European gas network.

**AROUND
1.5 BILLION GAS
LIGHTERS ARE
SOLD IN EUROPE
EVERY YEAR.
TO FILL THEM
WITH NATURAL
GAS FROM
SIBERIA, YOU
WOULD NEED
TO OPEN THE
BALTIC SEA PIPE-
LINE FOR ABOUT
45 MINUTES**

The raw material which made Siberian oil and gas was myriad dead microorganisms. They sank to the bottom of a shallow, oxygen-starved sea some 150 million years ago, creating a huge layer of foul slime. After the sea became land, the black sediments emerged as a result of tectonic movements in the depths, where, under increasing pressure and temperature levels, the slime had been transformed into oil and gas. This was then squeezed out from the parent rock and moved upwards—before gathering in “traps” below impermeable layers.



conditions. And these gas compressors consume quite a lot of energy. For a pipeline length of 2,500 kilometers, this loss can be up to ten percent of the energy stored in the gas pumped through the pipes.

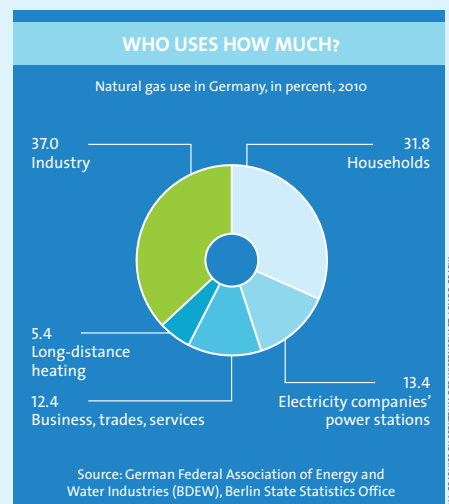
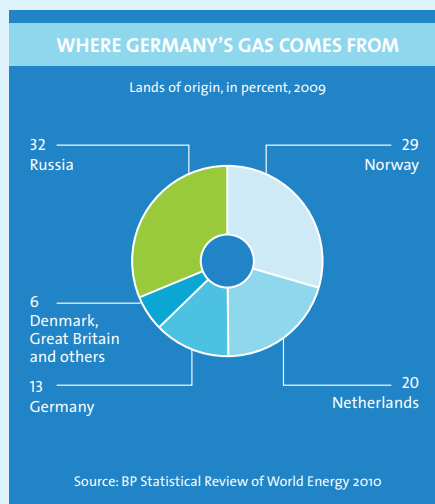
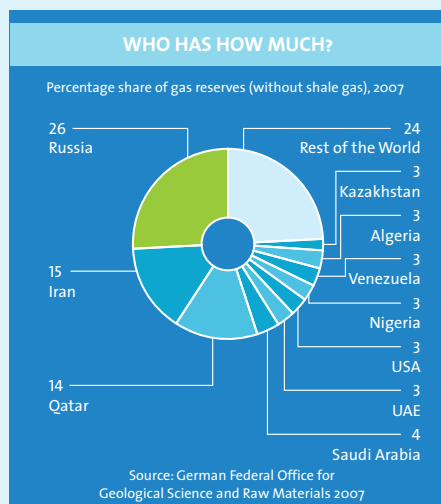
This drawback does not apply to pipelines laid under the sea. The high pressure load on a pipeline on the seabed from the sea water allows the gas in the pipe to be pumped at a much higher internal pressure, with the same thickness of steel wall. Whereas gas in above-ground pipes flows with 90 bar of pressure, gas will enter the Baltic Sea pipeline at up to 220 bar. This means that no intermediate compressor stations are needed until the gas reaches a station some 100 kilometers inland from the Baltic coast.

If the distance is too great for pipelines or the sea too wide, gas can also reach consumers aboard special ships. Cooled down to minus 160

degrees Celsius it becomes liquid, thereby reducing its volume 640-fold. This allows gas tankers to carry up to 210,000 cubic meters of LNG (liquefied natural gas)—enough to supply at least 40,000 households with natural gas for a whole year. By comparison, today’s super tankers hold about 300 million liters of crude oil—enough to heat around 80,000 households for a year.

Currently, only about 200 of these LNG tankers exist—and every single one of them would have to visit a European port at least three times a year to compete with the pipeline from Siberia. After all, the two tubes of the Nord Stream pipeline will supply enough energy for 26 million households. In addition, there are only about a dozen European ports where LNG tankers can unload their cargo—none of which are in Germany. About 80 percent of the world’s

As with all natural reserves, natural gas deposits are randomly distributed all over the world (left). Germany, for example, buys most of its supply from Russia and Norway (middle). Factories and households are the largest consumers (right).



natural gas that is shipped this way goes to regions either difficult or impossible to reach by pipeline, such as Japan, South Korea and Taiwan.

ONE OF EUROPE'S MAIN ARTERIES

The place where the tubes of the Baltic pipeline emerge from the sea onto land is fairly un spectacular. There is not much more to see of the huge construction at the small seaside town of Lubmin than a few pipes and valves. Here the Siberian gas is fed into two lines, which run southward and westward through Europe. The few main lines that connect the individual states with each other feed a denser grid, operated by regional utility companies, which, in turn, branches off and finally reaches cities and towns. These companies control the last part of the network, the fine-mesh which connects to each household. In Germany this gas supply capillary system includes some 370,000 kilometers of low-pressure lines, as thin as a garden hose.

The Baltic Sea pipeline will be one of the main arteries in Europe's energy supply network—and it will become even more important in the future. According to calculations by the International Energy Agency (IEA), by the year 2080 natural gas will have a market share of over 50 percent and become the world's most significant fossil fuel.

Demand in Europe is increasing even more rapidly. According to various calculations, as early as 2030, the countries of the Union will need to import 150 to 200 billion cubic meters more gas than they do today—partly because of a decline in domestic production and also because consumption is rising steadily. In the first six months of 2011 alone, Russia, Europe's main gas supplier, increased its deliveries by 26 percent. If that rate continues the Baltic Sea pipeline will not be able to fill the gap and it would only deliver 11 percent of the projected demand in 2030. So, this means new challenges for pipeline builders, who will have to keep expanding Europe's main arteries.

This also applies to Germany, where, after the reactor accident in Fukushima, the issue of supply security has become enormously significant. Now that the policy of phasing out nuclear energy seems truly irreversible, the dependence on fossil fuels has increased—at least until renewable energy sources become sufficiently productive. Here, gas plays a vital role as it emits far less carbon dioxide than other fossil



THE YUZHNO RUSSKOYE RESERVES

Discovered: 1969

The gas field covers an **area** of around **83** by **16** kilometers. It is one of the largest reserves in the world.

Geologists estimate the **recoverable reserves** at around **1 TRILLION** (1,000 billion) cubic meters. By comparison, Germany annually consumes around **100**, Russia about **460** and the United States nearly **660** billion cubic meters.

The gas, gas condensate and oil are **extracted** from depths of between **760** and **3,300** meters.

fuels when combusted. Quick-start gas power stations are also best able to complement intermittent renewable energy sources such as wind and solar power. And so the Baltic Sea pipeline—as both industry specialists and environmentalists agree—has become a bridge to a new era. We are in a time in which the appetite for energy continues to rise while targets to reduce carbon dioxide emissions also have to be met. Energy from solar and wind power plants alone is not enough to manage this tricky balancing act—for now, anyway. Until that time comes, the gas from Siberia is the most sensible compromise. The pipeline was designed to last for 50 years. Will that be enough time?

Hanno Charisius is a freelance journalist based in Munich.

At Any Price?

Europe is looking to Russia's vast reserves of natural gas to quench its ever-growing thirst for energy, and plans for further pipelines connecting the two continents are in the works. But as the global gas markets undergo unprecedented changes, new competition from providers in the United States, Turkmenistan, Qatar and elsewhere is emerging. What will these changes mean for the future of Europe's energy supply?

By Daniel Heldmann

AT A GLANCE

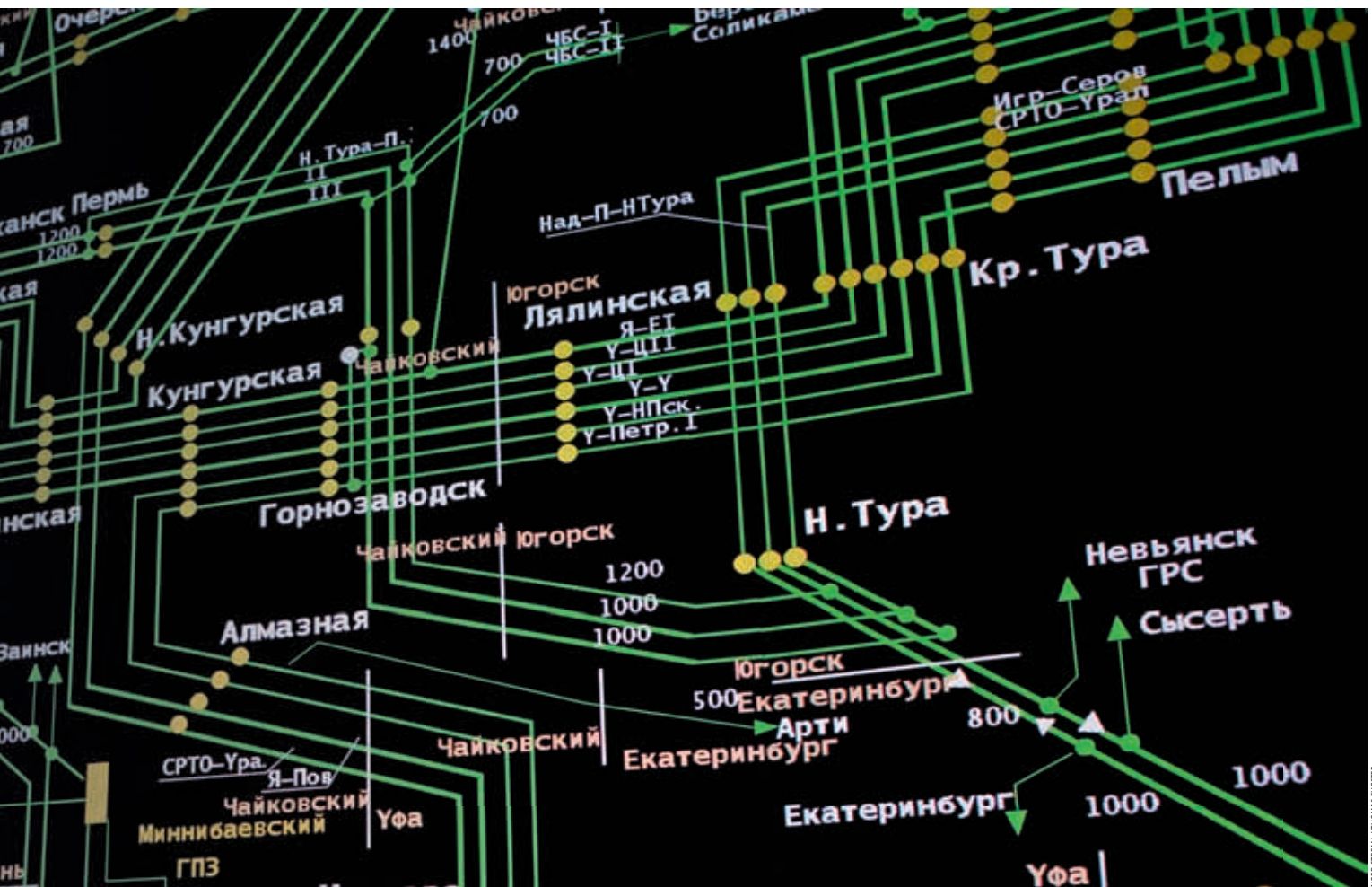
1. Europe's gas demand is rising, while the yield from its own sources is declining. The result: an ever-growing shortfall.
2. Because of its huge shale gas reserves the USA has almost no need for imports. This has led to natural gas being abundantly available on the world market.
3. Europe is trying to diversify its gas supply—and may build more pipelines to Russia and Central Asia.

Even before the gas begins to flow through the first of Nord Stream's twin pipelines, some are already seeking additional energy solutions to enhance Europe's power supply. "Of course Germany will need more gas in the coming years," said Chancellor Angela Merkel to the Russian President Dmitry Medvedev in July 2011 during governmental consultations between Berlin and Moscow, just a few months before the start of operations of the Nord Stream pipeline. The gas consumption trend in Germany, as well as in the whole European Union, supports the Chancellor's claim. Over the next 20 years, annual demand is predicted to increase from around 550 million cubic meters today to more than 620 million. Since EU gas production is expected to halve during the same period, Europe will be increasingly dependent on imports—and Russian reserves are among the largest in the world. So what could be better than to bring the supply in line with this demand?

By 2030, without supplies from Russia, Europe's energy deficit could increase to nearly 190 million cubic meters per year. In addition, the region will be facing the consequences of

Germany's phasing out of nuclear power. Fuel from Russia could not only help provide the necessary base load, but could also fill the gaps in the power supply caused by the phase-out. "Gas-fired power plants are particularly well suited for the energy revolution, because they are easy to combine with renewable energies," says Claudia Kemfert, the Head of the Energy, Transport and Environment department at the German Institute for Economic Research (DIW) in Berlin. "They are flexible, because they can increase and decrease energy production quickly and easily. In addition, they generate significantly fewer greenhouse gas emissions."

Europe is in the geographically fortunate position of having some of the planet's largest natural gas deposits located relatively close by. "Russia has the largest gas reserves in the world, followed by Iran and Qatar," says Kemfert. Many countries do not use their reserves at all, but simply burn them off, as is the case in the Middle East. "So far, the region has mainly concentrated on oil production and export," says Harald Andruleit, from the Department of Economic Geology of Energy Resources of the Federal Institute



for Geosciences and Natural Resources (BGR) in Hannover. “It is only recently that infrastructure for gas production has been created in some areas, such as in Qatar.”

However, gas is far more difficult to transport than petroleum. The options are pipelines or liquefied natural gas (LNG) carriers. “At a distance of 3,000 kilometers, the transport of liquefied gas is cheaper than through pipelines,” explains Andruleit. However, Germany has no ports where these ships can unload liquid gas. While the construction of a terminal in the Jade-Weser-Port Wilhelmshaven specifically for this purpose has been discussed for years, whether it will ever happen is unclear. Instead, the gas has to be fed into appropriate facilities in Belgium, France or Italy before being sent into the European pipeline network and finally pumped into the German Federal Republic. Each of these steps generates further costs that drive up the final price.

Germany produces only 13 percent of its own energy and currently draws its natural gas mainly from Russia, Norway and the Netherlands. Because of favorable long-term supply agreements,

from a market perspective, these countries were by far the best providers.

Until recently, all parties benefited from these kinds of contracts. There have been longstanding and strong trade relations, especially with Russian companies, some with contracts for up to 28 years. Kemfert emphasizes the special relationship with the commodity giants in the East, but also points out other aspects. “These close contacts provide the necessary stability, but do also have a downside,” she says. “Gas prices in Germany are contractually bound to the oil price.” And while the cost of oil soars, there is also an abundance of gas available—with the corresponding consequences. “The price on the international markets is much lower than what we currently pay,” Kemfert explains.

The reason for these changes in the gas market is attributed to newly developed energy sources. “The successful exploitation of so-called shale gas in the USA has changed the global situation,” says Andruleit. “There is currently an oversupply of natural gas.” This has come about because new technological developments are facilitating fuel extraction from deposits that were

While it looks just like the Moscow subway system, this is the circuit diagram of the Russian gas supplier Gazprom’s control center. From here the complex network of pipelines is monitored around the clock.

OIL DETERMINES THE PRICE OF GAS

Since 1965, gas prices in many countries have been closely linked to the price of oil. This is the result of international cross-industry agreements between producers, importers and suppliers, some of which were made decades ago. Their aim is to protect investments in production facilities and pipelines and prevent customers from permanently switching to cheaper energy sources. It's because of these agreements that, every three to six months, gas prices follow those of oil.

Natural gas is also traded on the so-called spot markets—stock exchanges where delivery and payment of the raw material take place immediately after sale. Owing to high supply levels, these prices are currently lower than those in most of the contracts, which were negotiated some time ago.

In the United States and Great Britain, the price maintenance agreement system is no longer in use. However, both countries are now discussing its re-introduction, since extreme fluctuations in gas prices may compromise planning security for some large consumers. Strictly speaking, this fixing of gas to oil prices is effectively a cartel-like action and has been deemed unlawful by the German Federal Court and Federal Constitutional Court. The practice has not been stopped entirely by these judgments, but passing on increases in purchase prices to customers is only lawful if the overall costs have also increased.

minimally profitable in the past, but which have become financially attractive due to rising prices worldwide. Shale gas is now being offered so cheaply in the US that it could even squeeze imported liquefied gas out of the market. It is believed that over the next 30 years the US will increase its production capacity considerably. According to a study by Amy Myers Jaffe and her colleagues at the Baker Institute at Rice University in Houston, by 2040, more than 280 million cubic meters of gas will flow daily from the deposits. "The geopolitical implications of this increase in production in the USA will be enormous," writes Myers Jaffe. "Alternative ways to improve energy security in Europe and a much larger supply generally may see the influence of the Russian or other providers diminish," she says, since suppliers who had previously sold to the US are likely to look for new customers. As a result, Russia's share of the European gas market could shrink from 27 percent in 2009 to half that in 2040—but with total demand increasing significantly.

Furthermore, the EU is searching for other supply channels to keep its options as open as possible, such as the Nabucco pipeline, which would run from Central Asia, through Turkey and south Eastern Europe to Austria. "Europe is

not only relying on Nord Stream," says Kemfert. As yet, the Nabucco project only exists on paper, despite enjoying political support from the highest circles. Joschka Fischer, former German Foreign Minister, advises RWE and OMV (Austria), the companies involved in the consortium.

Nabucco's construction is expected to begin in 2013. By 2017, the line could be carrying natural gas from the rich gas fields around the Caspian Sea. Competition between providers would increase and prices should fall. However, it is still uncertain how much gas Nabucco is likely to deliver. Producers such as Azerbaijan and Turkmenistan are considered to be unreliable suppliers, and doing business with Iran is currently either difficult or politically undesirable. Also, Turkmenistan and Azerbaijan are believed to have sealed large-scale supply deals with China and Russia, thereby limiting the amounts available to sell to Europe for the time being.

In addition, the explosion of costs for the construction and operation of Nabucco are causing headaches for those responsible. "Nabucco will cost 12 to 15 billion euros," said EU Energy Commissioner Günther Oettinger at an energy industry conference held by the Forum Institute in May 2011 in Stuttgart. The operator had originally said it would cost seven billion euros. By comparison, the Nord Stream Baltic Sea pipeline is expected to have a total final cost of 7.4 billion euros. Nabucco also faces further possible competition in the form of South Stream—a pipeline stretching under the Black Sea to Southern Europe and Austria, with a second line to Italy. South Stream would bypass the transit countries of Belarus and Ukraine and their associated reliability issues, through which the gas supply to the south and southeast of the EU currently travels. However, this project is still only in the planning stages.

In contrast, the first of Nord Stream's two pipelines will be supplying gas from Vyborg in Russia to Greifswald in Mecklenburg-Vorpommern by the fall of 2011. Some 40 years after the first natural gas contract was made with the then Soviet Union in 1970, this pipeline marks the beginning of a new chapter in German-Russian trade relations. Back then the deal was for 500 million cubic meters annually, whereas today that much gas could flow through the Nord Stream pipeline in just over three days.

Daniel Heldmann is a freelance journalist in Nuremberg.

IN 1970 THE EU WAS ALMOST ENTIRELY ABLE TO MEET ITS GAS NEEDS OF 100 BILLION CUBIC METERS PER YEAR ON ITS OWN. ANNUAL CONSUMPTION IS NOW 500 BILLION CUBIC METERS—OF WHICH 60 PERCENT HAS TO BE IMPORTED

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“I see the pipeline as a stabilizing factor”

Will the Baltic Sea pipeline make Germany too dependent on Russian gas?
We asked political scientist Alexander Rahr of the German Foreign Policy Society

Mr. Rahr, are we making ourselves dependent on Russia with the Baltic Sea pipeline or are we simply binding the country closer to us?

That’s the key question! My ideal vision is a mutual dependency. It is fine for it to be a strong dependency, but it must be equal. Russia has the resources—and we have the technology to extract them, refine them on site and, together, to sell them. It’s not like we are a colonial power exerting control over resources. Also, Russia is no longer a colonial power that can decide which of its neighbors gets their gas and which doesn’t. It’s more about partnership. At the moment we are talking about partnerships in raw materials and energy, which will turn into alliances as trust builds.

How would you describe the German-Russian relationship of today?

There is a certain imbalance. From surveys we know that in Germany itself, far fewer people have a positive image of Russia than Russians

do of Germany. Russians consider Germany to be by far the most agreeable modernization partner and role model in terms of economic development. There are two clearly contrasting schools of thought in Germany: Many believe that building Europe without Russia is impossible. They are grateful for the German reunification and do everything they can to support Russia. They also believe that Russia is a natural partner of the West and the Germans, because the bottom line is that there has been a lot of good experience with gas trading between the countries for the last 40 years. The result of this collaboration is the Nord Stream pipeline. On the other hand, many Germans have a highly critical view of Russia, because the country—unlike Poland—has dared to resist Western liberalization.

Do you think that the pipeline will help to improve East-West relations in the long term?

The gas pipeline will soon become a part of everyday life and, before long, very little will be written about it. Sooner or later everything will calm down and then discussions about other pipelines will help to accelerate European integration.

The Baltic Sea pipeline started as a European project, but has ended up being, above all, a German-Russian project. How must the rest of Europe feel about Germany’s new role as the “gas station”?

We are not the big controller, but rather a freight station. For some, we will become for Europe’s gas what Rotterdam has long been for oil. The Netherlands couldn’t use that oil to exert pressure. I see the pipeline as a stabilizing factor. This gives us some leverage on Russia which the other countries don’t have.

We can provide more security. We can moderate. I think this task will suit us well. We should have done this from the start, anyway,

Russia and Germany are good partners, says the political scientist Alexander Rahr (left) in conversation with Hanno Charisius.



JAN PETER BÖHMING

rather than set our hopes solely on the European Union, which does work sometimes, but not always. I think it's important that countries with a tradition of exchange with Russia take a leading role in ensuring Europe's energy security.

Do you think the other countries' fears have been adequately dealt with by Germany?

I think so, but a few more political gestures certainly could have been made—such as inviting a Polish representative to the first strategic meeting. But we also have to see that at that time some countries, especially in Central Eastern Europe, weren't ready to start a dialogue yet or even to listen to our arguments. Many of these countries have now been incorporated into NATO and the EU and in doing so have become part of the West.

We now share more than a common destiny, we are an alliance and we will protect every partner. But no one can expect the Germans, with all the good experience and developments they made with Russia under Gorbachev, Yeltsin and Putin, to just throw that away to suit the mood in other countries.

How does Russia view the Nabucco pipeline, which various countries in the south are planning, to bring gas to Europe from Asia?

Russia sees the pipeline as a rival, but can't prevent it going ahead if the political will, the investors' money and the necessary gas are all available. Currently, these three conditions are only partially fulfilled. Also, Russia has developed a counter-model to Nabucco—the South Stream pipeline.

Which would also pump Russian gas to Europe.

The ideal solution would be to combine South Stream and Nabucco. Ultimately, we will need such large quantities of gas in the future, that we may soon need the security of having two pipelines in the south. In any case, this gas wouldn't flow directly to Germany, but to other countries, who would take on the role of distributing the Russian or Central Asian gas. In the south, Austria and Italy could take the position we hold in the north.

This is not a competition, but a sharing of responsibility for energy security and the diversification of supply in Europe. It is important that a single European gas market emerges, that we link our pipelines and in doing so help each other to be more recession-proof.

So this means that we can't simply sit back and relax for the next 50 years, but rather



JAN-PETER BOENING

we need to continue looking for new gas and renewable energy sources?

In the future we will have to be less reliant on imported energy and raw materials. Supporting renewable energies can also be a great stimulus to German industry. The industry could be facing great change and we could be providing new products that other countries can't develop as quickly. We are currently building up a very nice lead. Russia has noticed this, of course, and knows that hardly any countries will be interested in natural gas in 50 years' time. That is why they are trying to sell as much as possible now, to China, for example.

Do you think that the newly found reserves of so-called shale gas in Western Europe will contribute to European energy security?

Politically, it's very important for some countries, Poland, for example. But I hope that extracting this gas will never be necessary, because it's associated with considerable environmental pollution. The United States is currently experiencing lots of difficulties in their vast country. In densely populated Europe it would definitely be even more problematic. But the psychological factor is important: If someone wanted to put our gas supplies under pressure we now know that we could extract the shale gas if necessary. Of course, it's a difficult and expensive technology, but we no longer have to worry as much about one-sided dependencies as we did a few years ago.

Among his other roles at the German Foreign Policy Society (DGAP), **Alexander Rahr** is responsible for energy policy and Russia. His book *Russland gibt Gas* (which translates as *Russia Gives Gas*) was published in 2008, followed by *Der kalte Freund* (The Cold Friend) in 2011. In it he describes how, thanks to its natural resources, Russia has re-emerged as a major power and as a profiteer from the financial crisis. He studied history and political science in Munich, received the German Order of Merit in 2003 and is an honorary professor at Moscow State University for International Relations.

The questions were asked by Hanno Charisius.



Lubmin, near Greifswald in northern Germany, is where the Baltic Sea pipeline comes ashore—and the gas feeds into the European gas network. What impact will the construction and operation of the line have on the Baltic Sea ecosystem?

The Pipeline and the Sea

There is no doubt that the energy revolution is taking place. Still, even with the help of wind and solar power, Europe's thirst for energy has yet to be quenched. Energy companies and politicians are working to fill this supply gap with a new pipeline bringing gas from Russia. But will the success of this venture come at a cost to the environment?

By Stefanie Reinberger

AT A GLANCE

1. An underwater pipeline is considered to be an environmentally friendly way to transport gas. Its operation causes hardly any CO₂ emissions and saves energy.
2. However, environmentalists were concerned about the installation work going straight through the sensitive Baltic Sea ecosystem.
3. Because of extensive monitoring and protection programs the impact was significantly reduced.

When Greenpeace and the energy industry reach consensus you might be forgiven for being a little suspicious, especially when it's not about the construction of new wind or solar power plants, but rather the promotion of a fossil fuel. The construction of more than two thousand kilometers of pipeline through the Baltic Sea certainly does not sound like an "ecological project." But the supply of Russian gas to European households and factories has met with little resistance from environmentalists. The reason: the pipelines do not threaten the transition to renewable energies—in fact, they facilitate it. "The only energy source which really deserves to be called 'a bridge to renewable energy' is gas," says Andree Böhling, an energy expert at Greenpeace.

Böhling can support this claim with a study by the renowned Wuppertal Institute for Climate, Environment and Energy. Indeed, the combustion of natural gas for electricity generation is relatively climate-friendly, because when it is burned it produces much less carbon dioxide per unit of energy generated than burning coal (see box). The Wuppertal-based researchers calculate that if coal power stations were to be replaced by gas power plants, then the emission levels of greenhouse gases produced during electricity generation could be reduced by around 40 percent. Furthermore, modern gas and steam combination power plants can be controlled better and faster when dealing with load changes than their coal or nuclear siblings. If the number of wind and solar power plants increases, the gas and steam technology will play an important role in balancing demand caused by weather-related fluctuations.

Environmentalists and energy companies even agree that the decision to lay the pipeline along the seabed has a positive impact on the

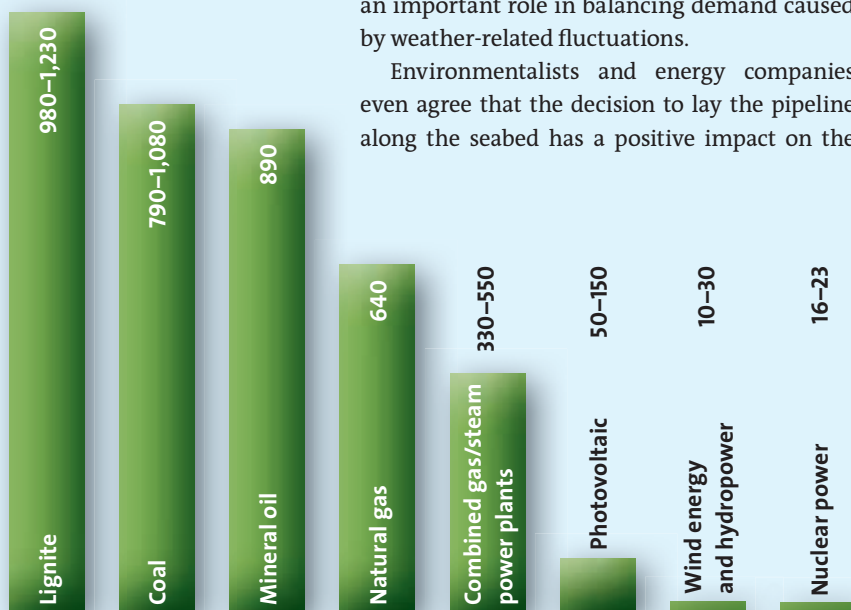
climate balance sheet. Not only does the route through the Baltic Sea follow the shortest possible path between Russia's Siberian gas fields and Western Europe, but its operation will also cause about 40 percent less carbon dioxide to be released than if an overland line had been built. This is because the high water pressure and low temperature on the seabed means the pipeline does not require additional, energy-consuming, pumping stations. "Because of the short lines and the effective pressure conditions, over the next 50 years we will save more than 200 million tons of CO₂," explains Werner Rott, Nord Stream Project Deputy Director of Engineering. By comparison, the total carbon dioxide emissions in Germany in 2009 were 760 million tons.

NEIGHBORS WITH EAGLE EYES

But the construction of the two 1,224-kilometer steel pipes through the Baltic Sea was not without controversy. From the very start of the planning phase there were calls from scientists, environmental organizations and authorities, from all of the countries involved, for comprehensive scientific monitoring of the project and the assessment of both short- and long-term consequences. So Nord Stream spent more than 100 million euros on the most comprehensive research ever conducted on the Baltic Sea in planning the pipeline and consulted widely with experts to ensure that the design, routing, construction and operation of the pipeline will be safe and environmentally sound. This included, for example, the analysis of over 1,000 water and soil samples at 96 stations as well as watching the behavior of fish, marine mammals and birds at 77 other sites. Geological studies were carried out along more than 40,000 kilometers of the seabed as part of four research campaigns.

The operator had to obtain permits from all five countries through whose waters the pipeline passes: Russia, Finland, Sweden, Denmark and Germany. "Of course, the national authorities also agreed internationally—especially on the subjects of the environment, shipping, fishing and safety," says Ludwig Krämer, Honorary Professor of German and European Environmental Law at the Law Faculty of the University of Bremen. "But the criteria of the respective national laws were always taken into account—for example, with regard to distances from protected areas or the protection of spawning grounds."

CO₂ emissions per kilowatt hour (in grams)



The Baltic Sea is considered to be a particularly fragile ecosystem, for the small bordering sea is only connected to the North Sea, and then the Atlantic Ocean, via the narrow Danish Straits. An additional factor is that, on average, it is only a little more than 50 meters deep. “The result is an extremely low exchange of water,” said Günther Nausch, marine biologist and head of the Working Group for General Marine Chemistry at the Leibniz Institute for the Baltic Sea Research in Warnemünde, in northern Germany. “While water in the North Sea is exchanged in full every two to three years, in the Baltic Sea this takes more than 30 years.” The implication is that any substances that get dissolved into the Baltic Sea or are swirled up from the seabed in the course of construction can affect the ecosystem there for decades.

Another vital consideration is that the Baltic Sea consists of brackish water and is characterized by the different saline water layers in its deeper areas. The upper 60 meters of water are oxygen-rich and brackish, so they have only a low salt content. The layer below usually has a higher salt content and very little oxygen, which is why it is often referred to as a death zone. No intelligent forms of life can exist there.

In the death zone, nutrients such as organic substances, phosphate and ammonia collect on the seabed. Most come from intensively used agricultural land and have been washed through to the Baltic Sea via rivers for decades now. “These compounds don’t usually affect the nutrient balance in the surface water,” says Nausch. However, if they are displaced to the higher layers during the construction work they would act as fertilizer there. Algae could grow almost explosively—with the result that after it dies and falls to the ocean floor, the decomposition of the organic matter would cause an additional drain on the already scarce supply of oxygen—and the dead zones would spread out. The consequences for the environment, and for fishing in particular, would be dramatic.

Therefore, all of the countries around the Baltic agreed that it was necessary to minimize this very dangerous whirling up of sediment during the construction. In Swedish waters, the steel pipe runs near three Natura 2000 areas—transnational, European Union protected zones. Here, researchers from the Swedish Meteorological and Hydrological Institute (SMHI) and the Danish DHI Group take water samples and



measure the sea floor to see how sedimentation rates have changed and examine the growth patterns of mussels. In this way, they hope to ensure that the various limits are not exceeded as a result of the construction and that the sensitive ecosystems remain intact.

The Finns responded to the pipeline project with particular concern. And for good reason: lying dormant on the seabed in Finnish waters is the dangerous legacy of two world wars. This is where chemical warfare agents, mines and ammunition were “disposed of.” After World War II, it was the Allies who dumped the ammunition they seized from Germany into the Baltic Sea. Later on, some of the neighboring states got rid of chemical weapons in this manner. The former German Democratic Republic did so until the early 1960s. It was clear that these kinds of highly toxic substances in particular should not be disturbed under any circumstances.

“On several occasions, this led to the route having to be adjusted and the line taken around the danger zone in a large curving arc,” says Nord Stream spokesman Frank Dudley. The Estonians were also concerned, because although legally their territorial waters remained unaffected, they would certainly not be immune

Environmental experts repeatedly took soil samples from the area around Bornholm. The silt here is partially contaminated with chemical warfare agents that could be stirred up by the construction work (top). Whether the contaminants are actually being spread around should be shown by a study which is looking at mussels: Biologists took some of the creatures that grew in the endangered areas and then compared their contamination levels to specimens from unaffected areas (above).

The environment under observation

What influence does the pipeline have on the flora and fauna of the Baltic? Monitoring stations at more than 1,000 locations along the route are helping Nord Stream to answer this question.

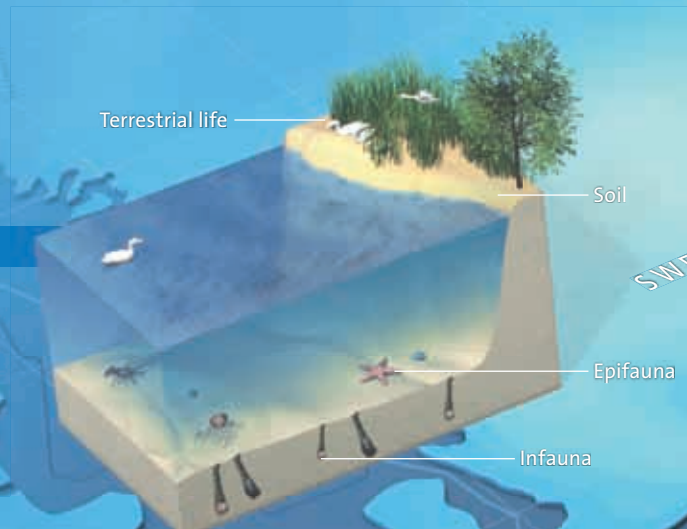
Researchers working on behalf of the pipeline operator made observations about 16 key characteristics of the Baltic Sea ecosystem. These included water quality and the structure of the seabed, as well as population levels of birds, fish and mammals. Nord Stream also documented the effects on fisheries and archaeological heritage sites. The results were not only made available to the relevant authorities, but also to the public. This monitoring will continue into the year 2016, with an expected cost to Nord Stream of around 40 million euros.

WATER QUALITY

Water quality is a top priority throughout the project. Therefore, turbidity, or murkiness caused by suspended seabed sediment, is monitored at several locations as a measure of water quality during construction work. Buoys equipped with sensors are installed at sensitive locations to measure turbidity and other water quality parameters. This is done to ensure that the threshold values for turbidity are not exceeded during construction work, such as dredging and trenching, and to take appropriate action in case turbidity approaches threshold values. Turbidity plumes are tracked by air and sea. The possible spreading of contaminants associated with turbidity is also tested by measuring the impact on common mussels in cages. The content of chemicals in these mussels is compared with mussels from reference cages.

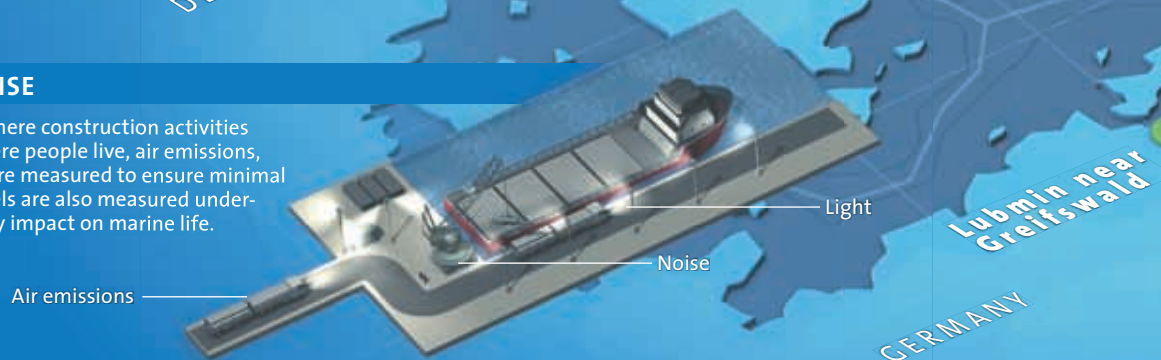
BENTHIC FLORA & FAUNA

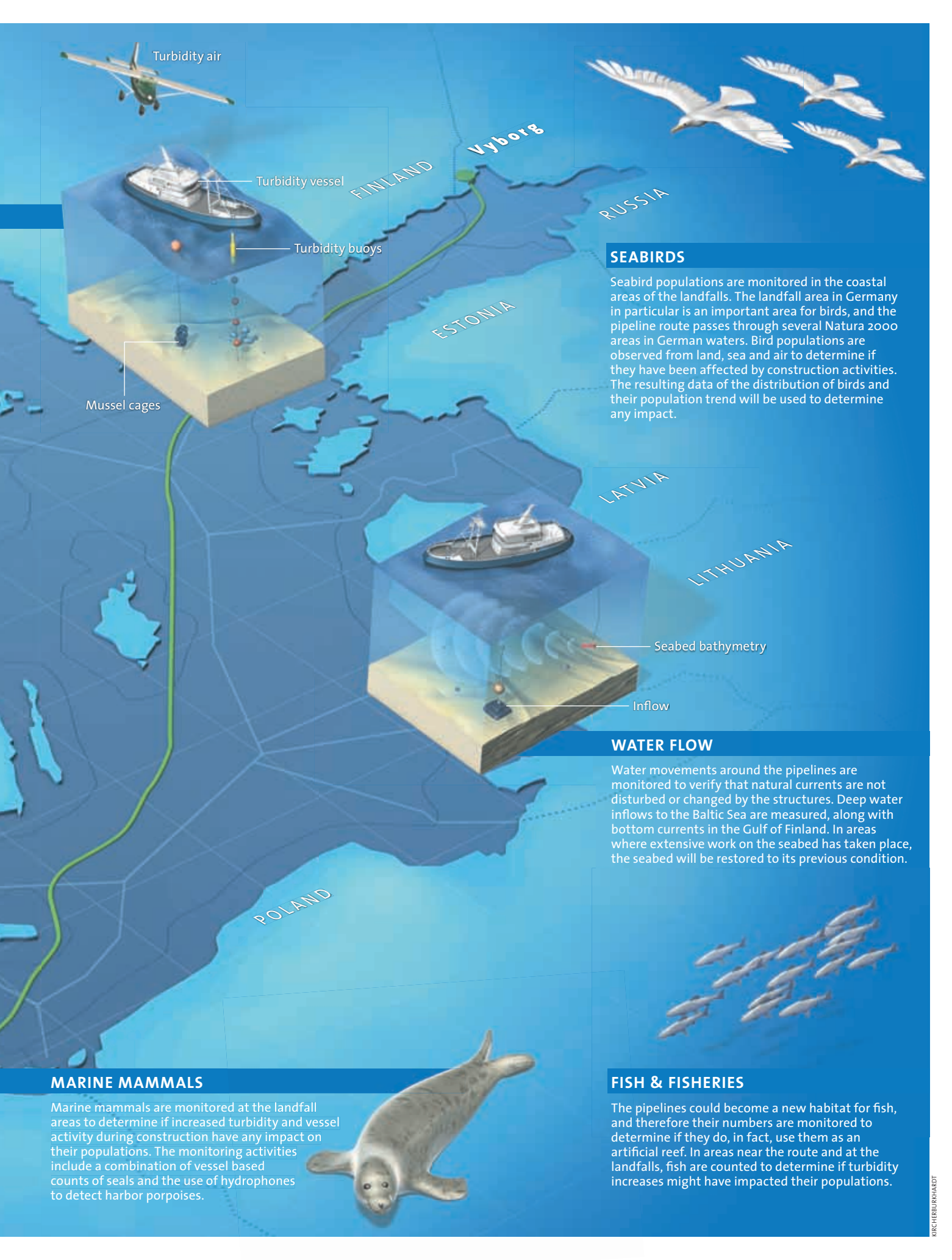
Benthic, or aquatic, fauna is monitored along the entirety of both pipelines. Infauna is monitored where dredging or trenching has disturbed the seabed in order to follow the rate of its regrowth. Epifauna growth on the pipelines themselves is also expected, and will be recorded. Recovery studies will take place for several years following project completion.



AIR, LIGHT & NOISE

At the landfall areas where construction activities take place close to where people live, air emissions, light and noise levels are measured to ensure minimal disturbance. Noise levels are also measured underwater to determine any impact on marine life.





Turbidity air

Turbidity vessel

Turbidity buoys

Mussel cages

Vyborg

FINLAND

RUSSIA

ESTONIA

LATVIA

LITHUANIA

POLAND

Seabed bathymetry

Inflow

SEABIRDS

Seabird populations are monitored in the coastal areas of the landfalls. The landfall area in Germany in particular is an important area for birds, and the pipeline route passes through several Natura 2000 areas in German waters. Bird populations are observed from land, sea and air to determine if they have been affected by construction activities. The resulting data of the distribution of birds and their population trend will be used to determine any impact.

WATER FLOW

Water movements around the pipelines are monitored to verify that natural currents are not disturbed or changed by the structures. Deep water inflows to the Baltic Sea are measured, along with bottom currents in the Gulf of Finland. In areas where extensive work on the seabed has taken place, the seabed will be restored to its previous condition.

MARINE MAMMALS

Marine mammals are monitored at the landfall areas to determine if increased turbidity and vessel activity during construction have any impact on their populations. The monitoring activities include a combination of vessel based counts of seals and the use of hydrophones to detect harbor porpoises.



FISH & FISHERIES

The pipelines could become a new habitat for fish, and therefore their numbers are monitored to determine if they do, in fact, use them as an artificial reef. In areas near the route and at the landfalls, fish are counted to determine if turbidity increases might have impacted their populations.





ARE FISHERMEN BEING LEFT OUT IN THE COLD?

Fishing has a long tradition in the Baltic Sea and is therefore not only an important source of income, but also of huge cultural significance. More than 100 salt, brackish and freshwater fish species live in this small sea, including cod, herring and sprat. These species are vital for fishing, but it has become increasingly rare for nets to be full to the brim. As a result of environmental changes and overfishing, yields have fallen by 40 percent since the 1980s!

Under no circumstances would the pipeline be allowed to cause this ailing industry any further complications. It could create particular difficulties for the plaice and shrimp fishermen who drag their nets along the seabed. Fortunately, the surfaces of the gas pipes are just smooth enough for the nets to glide safely over them. Because Nord Stream was able to prove that neither the pipes nor the nets would be damaged, Denmark dropped plans for a ban on trawling around the pipeline.

However, it was not possible to prevent fishing restrictions during the construction work. “No access” areas were applied around the pipe-laying vessels, for which the fishermen were compensated financially. The researchers viewed the effects of digging the trenches in the shallow waters with a much more critical eye. “What happens if the sediments which get disturbed and cloud the water threaten the highly-sensitive fish spawning?” asked Christian von Dorrien, fisheries biologist from the Thünen Institute for Baltic Sea Fisheries in Rostock, who demanded that the construction not begin before June 2010. In the end, the researchers and pipeline operator agreed to mid-May 2010 as the start date. This assured that both the operator’s ambitious timetable would be met and that the young herring population would not be unduly affected.

should any ocean currents become poisoned. As a result, Nord Stream undertook continued testing of the water quality near the Estonian coast as part of its environmental monitoring program for Finland. In addition, the Estonian Ministry of Environment conducted their own investigations. In April 2011, they were relieved to reach the conclusion that the construction work had caused no measurable increase in the turbidity of the water zones near the seabed. Further, the level of dioxins (toxins that come mainly from incinerators and pass through precipitation into the Baltic Sea) in herring remained below the legal limits. Based on these findings, says Heidi Käär, marine specialist of the Estonian Environmental Ministry, it can be concluded that the installation work poses no danger to Estonia’s marine environment.

Another area of concern was the shallow Bay of Greifswald, off the coast of Mecklenburg-Western Pomerania, near where the pipeline reaches land at Lubmin. The shallow water depth required a trench to be dug for the pipeline to be laid in so that it would be protected from any possible future shipping accidents. Environmentalists and fishermen were equally concerned, as this is a spawning area for herring. Should sediment be stirred up, particularly during the excavation of the trench, the light and oxygen conditions could become so bad that the young fish would be dangerously compromised. “The turbidity did increase in the area up to 500 meters from the excavation work, but it never went above natural levels,” explains Jan Kube, the marine biologist responsible for monitoring the German environment at Nord Stream. “We measured significant turbidity only in the immediate vicinity of the dredging.” Again, this is no cause for concern, as it is completely normal for the particle concentration to rise and then fall again, just as in strong winds. Therefore, it comes as no surprise that researchers at the Thünen Institute of Fisheries Biology at Rostock have seen no decline in levels of the fish larvae.

NOISE-SENSITIVE PORPOISES

Close to the Bay of Greifswald lies the Pomeranian Bay, a haven for rare harbor porpoises. If they were to be affected by the construction, the already low stocks could become permanently threatened. “Porpoises orientate themselves with the help of ultrasound localization,” says marine biologist Ansgar Diederichs, from the company BioConsult SH, in Husum. “If their hearing is impaired it can have dramatic consequences.” However, the pipe-laying work hardly poses a threat, because the noise from the dredgers and vessels arrives and then goes away again fairly slowly, so the animals have time to adjust to it and move to quieter areas to avoid the disruption. Diederichs considers the explosion-like noises generated by the pile driving during the construction of offshore wind farms as cause for greater concern.

Using underwater microphones called hydrophones, the researchers searched for the porpoises’ characteristic clicking sounds and found that the marine mammals were actually staying in the area around the laying vessels. “Surprisingly, the animals seemed to turn up there more than usual when the pile-drivers were at work,”

“The fear of environmental damage was huge”

Neel Strøbæk advises the pipeline operator Nord Stream on environmental protection matters, thereby helping to get planning permission granted. We asked her about the impact of the pipeline construction and the possible long-term consequences.

Mrs. Strøbæk, as a project manager at Rambøll, your role is to support Nord Stream in taking into account the diverse nature conservation interests of the coastal countries involved in the pipeline project. Have you been successful?

Well, even if it took a little longer in some cases, in the end, Nord Stream was granted all of the planning permits. It was an enormous organizational challenge for us. Each of the neighboring countries has its own rules and regulations. At peak times we had 60 coordinators working on the permitting process.

What role did environmental issues play in the construction of the Baltic pipeline?

A very large role. Most companies only consider technical and economic aspects when planning a project. Then, when the plans are complete, environmental consultants like us look to see what can be done to rescue the situation. In this case it was different. The interests of nature conservation and environmental protection were already being considered during the planning stage.

One reason for the high standards in environmental protection may be that the nature conservation and environmental groups spoke up loudly very early on.

Yes, that's right. There was a huge amount of fear. There were real concerns that the construction and operation of the pipeline could cause a massive ecological disaster. Here in the Baltic Sea, which, for example, is much flatter than the North Sea, where there are countless pipelines, nobody has any experience with these kinds of pipelines. So, accordingly, this caused a great deal of uncertainty in the regulatory authorities of the affected countries.

And were you and Nord Stream able to clarify everything?

Yes, more than 100 million euros was invested in a very intensive accompanying environmental assessment program. We hired experts to

document the condition of the affected areas a long time before the construction work was commissioned. We then continued making observations during and after the pipeline had been laid. There are also the remains of lots of dangerous munitions dumped in the Baltic Sea, which, of course, also were noted and disposed of where necessary. Other experts looked into the impact on fish, seabirds and marine mammals.

Did the feared negative consequences occur in the end?

One major concern was that stirring up the nutrient-rich sediments would result in algae blooms. Judging by our measurements, they have not occurred anywhere. We can give the all-clear for the animal world. Important spawning areas for herring were not affected and, as far as we can see, there is no danger to birds or marine mammals.

In some areas, trenches were dug for the pipeline to be buried in. Is that not a massive intervention?

Dredging the ocean floor does cause a disturbance, of course. But the excavated material was stored in accordance with regulations and after the pipe had been laid it was put back in the same place. So we are optimistic that after a while it will look the same down there as it did before. The monitoring program will continue until 2016. The data will be made available to the public so that scientists can use it for other research projects.

The pipeline will remain in operation at least 50 years. What long-term consequences are you expecting?

Actually we are not expecting there to be any long-term consequences. Of course, it will be quite different if someone wants to get the pipes back out again one day. But that is not currently up for debate.

The questions were asked by Kerstin Viering, a freelance journalist based in Lehnin, Brandenburg.



Neel Strøbæk is a specialist in environmental assessments and international approval processes. As a project manager at the Danish consultancy company Rambøll, she wrote the decisive environmental impact study that formed the basis of the evidence on which the planning permits were approved.



NORD STREAM

WHAT ACTUALLY HAPPENS... ...IF THE PIPELINE BREAKS?

With around 60,000 ship passages per year, the Baltic is one of the world's busiest seas, and the risk of accidents cannot be excluded. In a worst-case scenario, the gas pipeline could be damaged and start to leak.

In such an event, sensors would immediately register the drop in pressure within the pipeline and sound the alarm in the Nord Stream emergency response center in the Swiss town of Zug. All of the valves on the Russian side would be automatically shut off. At the same time, all valves on the German side would be opened. This way, only as much gas as was in the pipeline could escape.

Even then, we would not expect to see a negative impact on the environment. Unlike a broken oil pipeline, a leaking gas pipeline would not cause water pollution. The gas would simply rise to the surface and escape into the atmosphere.

says Diederichs. The researchers have no answer to why this may be, but perhaps the porpoises were simply curious about what was going on. He hopes results will come from the further observations planned for the construction of the second tube, which should be finished in spring 2012. "Regrettably, the number of these porpoises in the Baltic Sea is so low," says Diederichs, "that we are pleased if we see any at all." Will his observations allow him to arrive at statistically reliable conclusions? He does not know.

While the pipe-laying vessels and their noise and vibration move several kilometers every day, the pipeline itself will remain on the seabed forever. A greater impact than the short-term disruptions may come from the long-term effects of its presence on the complex and fragile ecosystems there. Regardless of whether the pipeline is being placed directly onto the seabed in shallow waters or whether a trench is being dug first, the fact is that biologists and environmentalists have considerable fears about the possible consequences of these interventions. How will nature react to these foreign bodies in the Baltic Sea in the coming decades? These and other similar questions must now be answered by the various monitoring programs.

THE THOUSAND-KILOMETER REEF

Scientists from the Institute for Applied Ecosystem Research in Neu Broderstorf, near Rostock, have been observing developments on the German side of the Baltic Sea. Their first task, completed before the construction work started, was to meticulously map the sandbanks, reefs and rocks, as well as to find out which animals and plants live there. Once the bulldozers had moved in, the team, along with marine biologist Anja Schanz, compared the before and after.

The initial results seemed disappointing, but were to be expected. The excavators had put the underwater landscape back the way they found it, as agreed: where there had been large rocks before, there were large rocks again, now. However, animals and plants did not re-colonize the scar across the seabed within the first few months. The habitat, with its diverse organisms (which scientists call the "benthos"), was largely destroyed along the gas route. However, Schanz is confident. "New life will settle here next year," says the biologist, referring to experiences of other pipeline projects, such as the one between Baltrum and Langeoog in the North Sea, in which the characteristic species rapidly resettled.

What is more, in places where the pipeline is not in a trench but lies directly on the seabed, new life will move in. "The pipeline acts as an artificial reef and is colonized by the corresponding organisms very quickly," says Schanz. Species then settle in these areas that do not otherwise inhabit such predominantly soft and sandy soil. This is exactly what scientists are observing, not only on the foundations of large wind turbines off the North Sea coast, but also at the artificial Reef Nienhagen near Warnemünde, northern Germany, where researchers explore the effects on the flora and fauna of man-made structures on the seabed. "It only takes one year before the meter-high stone and concrete elements are covered in several layers of life which has settled there," says Thomas Mohr of the National Research Institute for Agriculture and Fishery in Mecklenburg-Vorpommern. After four to five years, an artificial reef could be seen as a relatively stable, seasonally changing ecosystem. There is no reason why this should not also be the case for the pipeline.

But, of course, there is a catch: the concrete-coated steel pipe also attracts invasive animal and plant species that do not usually live in those parts of the Baltic Sea. We already know from the offshore wind farms in the North Sea to expect the arrival of sea squirts and invertebrate organisms, creatures that often dominate the ecosystems in their new surroundings and will actually displace native species.

So, despite all of the precautions taken, some things may change on the seabed in the long term. Whether this happens, and, if so, to what extent, will be revealed in the coming years.

Based on previous experience with similar projects around the world, however, environmentalists are optimistic. They hope that the Baltic Sea pipeline can literally be a bridge to a new era. For the effects of global climate change have long been apparent, even in Europe, and a broad and noticeable change in mood can be felt in society as a result. In addition, environmental disasters involving fuels, such as the Deepwater Horizon incident in the Gulf of Mexico or the meltdown of the nuclear power plant in Fukushima, have increased the public's desire for a climate-friendly, pollution-free and safe energy supply. The future for renewable energies is brighter than ever.

Stefanie Reinberger, Ph.D., is a biologist and freelance science journalist based in Cologne.

An aerial photograph of a cityscape. On the left, a prominent church spire with a green patina rises above the rooftops. In the middle ground, several white wind turbines are visible against a clear blue sky. On the right, two tall industrial smokestacks emit thick white plumes of smoke. The foreground shows a dense cluster of buildings with red-tiled roofs.

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Specialist divers were deployed before construction began.

Detective Work on the Seabed

The floor of the Baltic Sea is littered with the explosive legacy of two world wars. Nord Stream vessels spent four long years searching for bombs and shells—to the delight of underwater archaeologists.

By Kerstin Viering

This does not look good. A mysterious piece of metal is lying on the seabed of the Bay of Greifswald, about eight kilometers northeast of the north German state of Lubmin. A thick layer of rust and mussels encases the barrel-shaped object. The combined forces of water, salt and marine animals have been taking their toll for some time now. But what exactly is it? At first glance it's hard to tell. It is possible that the truth may not be too pleasant, because hidden deep beneath the surface of the Baltic Sea lies the legacy of several wars. Sea mines and grenades, bombs and poison gas munitions—there are many things resting quietly down there that, if stirred, just might blow up. So what happens if the strange metal cylinder is full of explosives?

There is little time for the matter to be resolved. It is May 2010, not long before excavators are set to create a 27-kilometer-long ditch through the bay to make way for the Baltic pipeline to be laid. Naturally, the company in charge of the operation, Nord Stream, does not want any explosive surprises. So just before the start of construction, it has asked SeaTerra, a Wandlitz, Germany-based firm specializing in geophysics and unexploded munitions clearance, to take one more really good look at the seafloor. A metal object of this shape and size is always suspicious. But the experts can finally give the all clear. It is not a bomb, but a cast-iron stove with decorative lion's feet. Not at all dangerous—but still exciting. Research divers from the State Office for Culture and Heritage in Schwerin investigate the site of the find, and lo and behold: the oven is just the beginning. Buried under the mud and sand they uncover a shipwreck more than 200 years old.

Discoveries such as these are not unexpected for workers on the pipeline project. "It was clear that we'd find something interesting in our preliminary investigations," said Nord Stream employee Steffen Ebert. After all, there are believed to be around 100,000 shipwrecks on the Baltic Sea floor, and the tens of thousands of mines from the First and Second World Wars have by no means all been removed. It would be most unusual if the pipeline's route just happened to be completely free of munitions and wrecks.

EXPLOSIVE FINDINGS

"We've tried to avoid problem areas while planning the route," Ebert emphasizes. For example, the region around Bornholm caused quite a few headaches. Originally, the pipes were intended to pass to the south of this Danish island—until the country's authorities pointed out there is a known dumping ground for chemical weapons in the area. "After the Second World War, the Allies ordered the German poison gas stocks be destroyed," explains Robert Mollitor, from the Mecklenburg-Vorpommern State Munitions Recovery Service in Schwerin. Simply throwing the ammunition into the sea was seen as a perfectly acceptable way of disposing of it at the time. Fishermen, sailing under the supervision of the Russian military, were paid to drop their toxic cargo in certain regions of the Baltic Sea. "We also know about dumping grounds near the Gotland Basin and Bornholm," says the munitions expert. Building a pipeline through these chemical weapon graveyards would have been too risky. The planners searched for a new pathway north of Bornholm, but it was found to

AT A GLANCE

1. All in all, the ships commissioned by Nord Stream explored more than 40,000 kilometers of the Baltic Sea.
2. Many mines had to be destroyed. Where this was not possible, the pipeline builders bypassed the explosive finds.
3. Again and again, wrecks were found that archaeologists were able to secure or salvage.

MINES ARE ONLY ONE OF AROUND 1,000 TYPES OF SUSPICIOUS FINDS—THE OTHERS ARE MAINLY PIECES OF SCRAP WHICH HAVE BEEN THROWN OVERBOARD, SUCH AS BICYCLES, SHOPPING CARTS AND REFRIGERATORS

The munitions can only be inspected safely by using diving robots. Even though they have been under water for decades, the mines could still explode.

be too close to a major shipping zone. So the final pipeline route runs south of Bornholm, skirting around the munitions area.

However, it is still most unfortunate that the location of many of the Baltic Sea's military contamination sites remain unknown. "The seabed has never been completely surveyed in this respect," says Mollitor. This meant Mollitor and his colleagues were unable to rule out the possibility of risky explosives being found in the Bay of Greifswald, or that the long-standing rumors about poison gas close to the German coast might be true. Did the fishermen hired after the war really take the ammunition all the way to Bornholm? Or did they just dump their cargo overboard shortly after setting sail? Nobody knows.

"We put a great deal of emphasis on thorough preliminary investigations because of this," says Ebert. Since 2005, research ships commissioned by the pipeline operator have covered more than 40,000 kilometers along the route and studied the sea bottom in several stages with ever-increasing detail. Experts used the data to decide on the best route, and the 15-meter-wide strip was then scoured yet again, even more thoroughly this time.

This research employed the most varied technical assistance available. Sonar devices provided a clear picture of the Baltic Sea bed and the objects lying on it. With the help of a sediment echo sounder, the seabed was scanned with ultrasound, allowing the various geological layers

to be uncovered. A magnetometer dragged across the seafloor helped detect telltale traces of magnetic ferrous material. More highly sensitive metal detectors called gradiometers enabled the detection of pieces of iron buried in sediment. Researchers used remotely operated underwater vehicles to traverse the pipeline's route in order to collect the gradiometer data, as well as detailed images of the seafloor.

SHELLS, SHIPWRECKS AND SHOPPING CARTS

"These recordings show all of the various things which lie on the seabed of the Bay of Greifswald," says Mollitor. "Lots of shopping carts, for example, old cars and some things which are hard to recognize." In these cases, Nord Stream hired specialist divers to clear the sediment and provide an accurate analysis of the suspect finds. "It's often only specialists who can distinguish whether a find is actually dangerous," explains Mollitor. Live ammunition and harmless practice munitions can be confusingly similar when you are unsure which tiny screw differentiates one from the other.

In order to remove the dangerous legacy of the wars, Nord Stream collaborated with the British mine clearing company BACTEC and the relevant authorities of the various countries involved. In total, the experts have exploded about one hundred mines along the route of the pipeline, primarily in the Gulf of Finland. By contrast, in the German coastal waters they found mostly blank ammunition. In the end, controlled explosions were not necessary and, fortunately, the rumors of large amounts of poison gas having been dumped were not confirmed.

Nonetheless, the laying of the pipeline in the area of the Bay of Greifswald would need to be handled with the utmost care. Although the pipeline simply lies on the Baltic seabed for great stretches of its route, for safety reasons it needed to be laid in a trench, which then had to be filled in. These kinds of disruptive activities always come with a large amount of risk. "Just before the start of construction the divers from SeaTerra had another close look at all of the metal objects on the route," says Ebert. It was only at this point, in May 2010, that the lion-footed oven and the shipwreck underneath were discovered off the coast of Lubmin.

"The ship was completely hidden beneath the sediment, so no one had seen it during the



NORD STREAM / ROY



REUTERS / INTS KALININS

A huge water fountain shows that a mine deep under the sea has been detonated. Expert demolition squads had to destroy the dangerous finds on the spot.

preliminary studies,” explains Detlef Jantzen, head of the Department of Archaeology at the State Department for Culture and Heritage in Schwerin. Using an underwater vacuum cleaner, his colleagues gradually revealed a small freighter, most likely dating from around 1800, which had been crossing the Baltic Sea with a cargo of lime. The researchers have carefully examined the wreckage, made drawings and taken photographs—and also discovered why the nearly ten-meter-long vessel ended up on the Baltic seabed. It appears the stove was to blame. Burn marks around it reveal that a fire had broken out on the ship. A few tools and cooking utensils, glass bottles and shards of pottery still tell of life on board. One of the sailors had a pipe, for example, with a colorful porcelain bowl and a woman painted on it. But what became of him and the rest of the crew, whether they saved themselves or drowned, we will probably never know.

The wreck is of great interest to the Schwerin-based researcher. “There are not many ships from that time which are so well preserved,” explains Jantzen. So he and his colleagues developed a plan to rescue the freighter from the depths of the Baltic. “That was an exciting project,” says the archaeologist. “The ship was so stable that we were able to raise it and move it

in one piece.” Employees of the Dutch salvage company Periplus Archeomare took charge of the difficult task. Constrained by two strong belts that crisscrossed under the hull and were attached to a metal frame, the wreck was initially left floating just below the surface of the water. It was then transported to its new destination. Supported by sandbags and wrapped in special textiles to protect against erosion and ship worms and covered again with sediment, the ship now rests in a pit about 120 meters away from the site where it originally sank.

A VALUABLE CARGO OF COPPER

But there was still plenty more work ahead for the wreck rescuers from Schwerin. In early June 2010, while excavation was still underway on the ship with the oven, Nord Stream announced the next find, situated a short distance outside of the Bay of Greifswald. Once again, the divers leapt into action. This time, buried in the sediment, at a depth of about seven meters, they discovered the remains of a copper-laden shipwreck from the mid-15th century. “This is a particularly exciting discovery,” says a delighted Jantzen. The copper plates on board could reveal details of numerous medieval trade relationships. In those days the metal was sold in disc form, with many of the pieces bearing the

At first this potbellied stove was mistaken for a bomb. Divers eventually realized that it belonged to a sunken ship.



LANDESAMT FÜR KULTUR UND DENKMALPFLEGE, ABTEILUNG ARCHÄOLOGIE UND DENKMALPFLEGE SCHWERIN / SABINE SÜHR

An Explosive Job

The Baltic Sea contains the dangerous remnants of two world wars. More than 80 items were cleared from the path of the Nord Stream pipeline.

Nord Stream profited from the experience of the naval units of the countries involved. Within the framework of “Partnership for Peace,” an initiative from NATO and 22 other countries, over 1,000 mines have been cleared since 1996.

In Russian waters, in the Baltic pipeline’s security and anchor corridor, about 30 mines were found and removed by the Russian Navy. In the Finnish “exclusive economic zone” specialists from the British company BACTEC International disposed of around 35 mines, as well as seven in Swedish waters and two munitions dumps in the German area.

ROV SUPPORT VESSEL

A munitions disposal team of 15 is on the vessel along with the crew. VHF (very high frequency) radio ensures that nearby ship traffic is aware of clearance operations.



Survey Vessel

CLEARANCE PROCEDURES

- 1** The ROV carries out a site survey of the seabed with a 1,000-meter radius while the support vessel is waiting at a safe distance.
- 2** The survey confirms the state of the mine. The ROV is recovered. A mammal protection system is set up and the marine mammal observers begin monitoring.
- 3** The clearance plan is finalized and authorities are advised. The ROV maneuvers the frame with the explosives into position for demolition.
- 4** The RIB lays the Firing Line and then begins scanning for fish and marine mammals in the area. A warning to all ship traffic is issued.
- 5** The fish-scarer charge is fired and is immediately followed by the main charge.
- 6** The RIB visually checks the surface. The ROV confirms the demolition. Fragments of scrap and equipment are recovered.

SEAL SCRAMMER

The seal scrammer acoustic device emits very high intensity sounds that can be heard for many kilometers underwater. This noise makes the vicinity uncomfortable for marine mammals and causes them to vacate the area.



TMS

The TMS (tether management system) is the ROV’s “garage.” It eliminates the effect of drag of the long length of umbilical attached to the ROV. It also provides protection to the ROV during its launch and recovery.



ROV

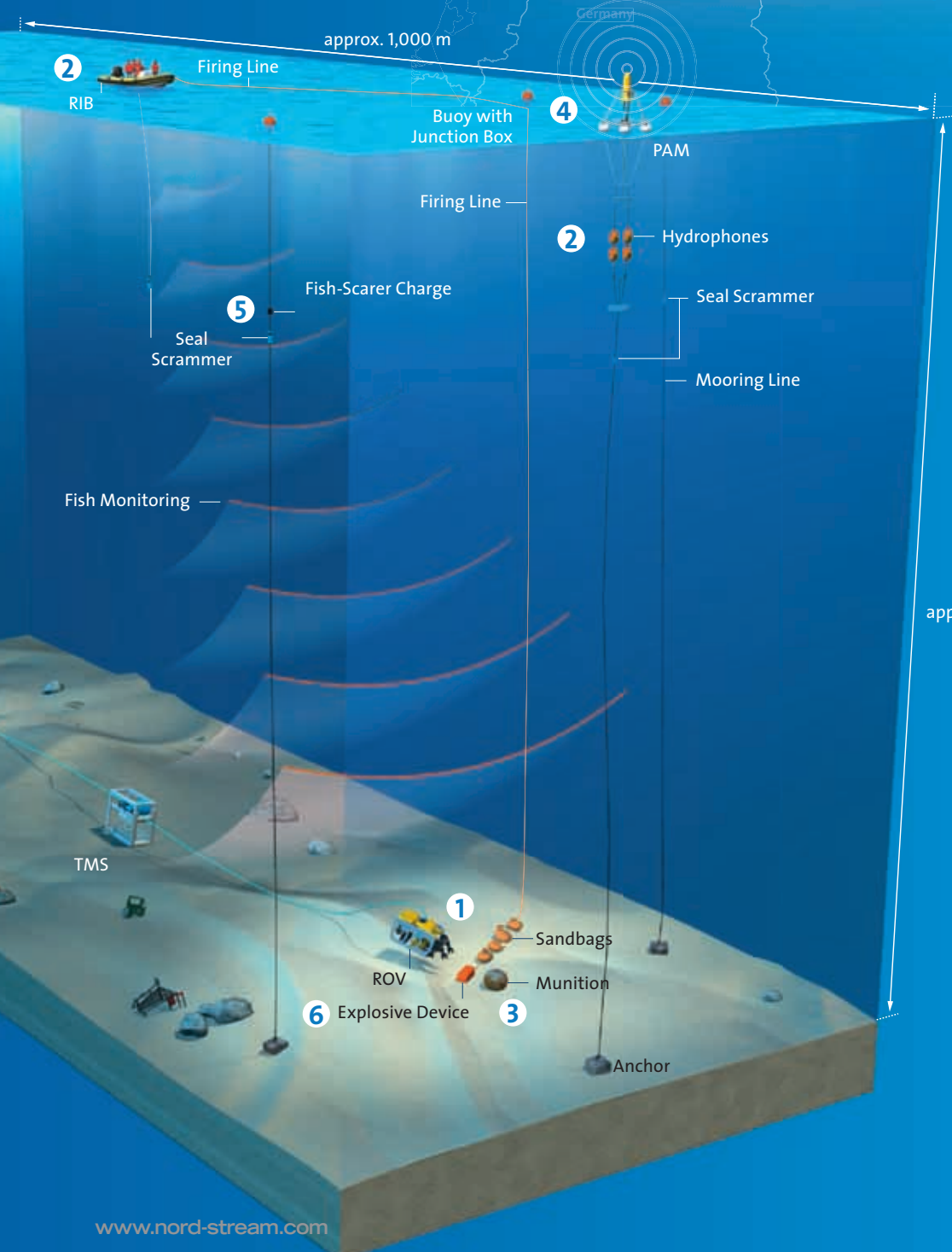
Via an umbilical, the ROV (remotely operated vehicle) transmits survey data to the support vessel. With its manipulator arms it deploys the explosive charge and collects scrap after the demolition.



RIB
The RIB (rigid inflatable boat) accommodates the marine mammal observers, and undertakes fish monitoring.



Identified Munition
Nord Stream Route



PAM
The Passive acoustic monitoring (PAM) detects marine mammals by monitoring their vocalizations. The array of hydrophones (orange) listens to establish the presence of mammals. The radar beacon (yellow) makes it visible to ship traffic.



MUNITION
Between 100,000 and 150,000 mines were deployed in the Baltic Sea, particularly in the Gulf of Finland, during the First and Second World Wars.



In the murky waters of the Bay of Greifswald, Nord Stream came across the remains of old freighters. The wreckage revealed a lot about how such ships were built.

hallmarks of the buyer or seller. The place where the copper was smelted can sometimes also be identified.

However, because of its advanced age, this ship did not prove to be as robust as was hoped. Moving it in one piece was simply out of the question. Instead, the archaeologists took the wreck apart, piece by piece, and then brought the individual parts to the surface. Since any wood or metal that has spent centuries on the seabed cannot be brought onto dry land without extensive conservation measures, the pieces are now stored in large water-filled containers in Schwerin, awaiting further investigation.

Another vessel from the Baltic seabed tells the story of a military plot gone awry. This wreck, from the 18th century, belongs to a line of twenty ships that form a chain along the floor of the Boddendorfschwelle, the sand bank at the entrance of the Bay of Greifswald. In 1715, during the Great Northern War, the Swedish military sank one small boat every forty to sixty meters in the shallow water to stop the enemy Danish fleet from entering the bay.

GENTLY THROUGH THE CORDON

In military terms, the plan turned out to be a complete failure, as a local fisherman showed the Danes the only navigable route through the wrecks. However, almost 300 years later, in the 1990s, the rediscovered ships proved to be a serious obstacle. This time it was not an advancing army being hindered, but rather the builders of the pipeline. And there would be no traitorous insider tips from fishermen to help them find their way. “We looked into which of the ships would be the best one to move,” says Jantzen. In the end, the smallest and most poorly preserved wreck was chosen. Of the original, possibly 20-meter-long boat, not much more than a pile of ballast stones and planks remained.

It is also fair to assume that the boat was not in very good shape before it met its end. “Of course, the Swedes wouldn’t have sunk particularly valuable ships,” says the archaeologist. The annual rings in its wood planks reveal that the small freighter had probably seen several decades’ service before its final voyage. Nevertheless, preserving the boat is still seen as a worthwhile exercise. “If you want to learn something about ships from that time you need originals,” says Jantzen. Only a few of these have survived. As with the medieval vessel, the State Office archaeologists lifted the boat up in separate parts. In this case, preservation on land would have been too expensive, so the freighter was placed in a new berth about twenty kilometers away. There, wrapped in special textiles, in a pit dug by the experts, the many broken pieces of the wreck were once again laid to rest in the sand of the Baltic Sea. Another witness to history saved, this small ship is sure to have its own tale to tell researchers in the future.

Kerstin Viering is a freelance science journalist living in Lehnin, Brandenburg.

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R U S S I A



THE UNDERSEA WORLD OF OMK

Pipes for subsea gas pipelines are the trademark of one of Russia's largest metallurgical corporations, United Metallurgical Company (OMK). The projects of the past decade are as follows: Nord Stream gas pipeline (one of the most sophisticated projects), submerged crossing of the Bovanenkovo–Ukhta gas pipeline across the Baydaratskaya Bay, Dzhubga–Lazarevskoye–Sochi main gas pipeline, and OML 58 O.U.R. (Obite–Ubeta–Rumuji) gas pipeline in Nigeria (project operator: Total).

The production of large-diameter pipes for subsea gas pipelines was launched at Vyksa Steel Works (VSW), part of United Metallurgical Company, in 2005–2007. In November 2007, OMK entered into the contract for the production of pipes for the first line of the Nord Stream gas pipeline. Under the contract, VSW produced more than 260 thousand tonnes of pipes of 1,220 mm in diameter with wall thicknesses of 30.9, 34.6, and 41.0 mm (steel grade: SAWL 485 IFD [Kh70]). The pipes are made of steel SAWL 485 IFD (Kh70) and have an external three-layer corrosion-resistant coating and an internal friction-reducing coating. The pipes of 41 mm in wall thickness are unique in terms of their characteristics and withstand a working pressure of 220 atmospheres. All pipes meet Norway-based Det Norske Veritas's (DNV) standards for subsea gas pipelines and additional requirements of the Nord Stream project.

For Phases 1 and 2 of the Nord Stream gas pipeline construction, VSW produced a total of more than 460 thousand tonnes of large-diameter pipes.

"United Metallurgical Company can be proud that it entered the league of global leading suppliers of pipes for the biggest megaprojects," emphasized Henning Kothe, Nord Stream Project Director. "We are satisfied with the way OMK fulfills its obligations. While selecting suppliers of pipes for the second link, we employed an integrated approach, taking into account their track records in the supply of their products as well as their proposals as to quality, prices, and other characteristics."

High mechanical properties of pipe base material and weld seams allow OMK pipes to be used for pipeline construction in different climatic regions, including Far Northern areas. Production of sophisticated high quality pipes is possible owing to the Company's investment policy. Over the past seven years, OMK has invested \$4 billion in the modernization of its production facilities. The large-scale investment program enabled the Company not only to profoundly upgrade its existing facilities, but also construct two unique greenfield projects: a complete cycle plant for the

production of hot-rolled steel coils and Mill 5000 for the production of wide thick sheets further used to make pipes for main pipelines.

"Owing to our investment in the replacement of pipe facilities, our Company can manufacture pipes of any level of complexity, including pipes for the most sophisticated and responsible projects for the construction of subsea gas pipelines," said OMK President Vladimir Markin.

Meanwhile, the Company is getting ready to submit bids for supplying large-diameter pipes to new main pipelines: South Stream, Shtokman, Nabucco, and others. OMK has a good "subsea track record," which raises its hopes of being awarded contracts under these and other large projects.

On the photo: A. Parunov, Export Sales Director, V. Markin, Member of the OMK Board of Directors, OMK President, A. Sedykh, Chairman of the OMK Board of Directors, O. Davydyuk, Advisor, Member of the OMK Board of Directors, A. Kastravets, PR Director





Line One Is on Stream

Line 1 of the Nord Stream Pipeline system is now capable of delivering natural gas from Russia's vast reserves to Europe's ever-growing energy market via the European gas network. This major feat of engineering across 1,224 kilometres of the Baltic Sea was made possible thanks to the hard work and dedication of Nord Stream's employees. It is also a result of constructive support from our shareholders, partners, contractors, and experts from around the Baltic region. Special thanks go to everyone who has contributed to strengthening Europe's security of supply.

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