

Well positioned.

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ANNUAL 2013





MOSCOW, RUSSIA



REGIONAL GROWTH MARKETS

Linde is particularly strong in markets expected to grow at the fastest pace in the medium term.



LINDE TRUCK,  
BASEL, SWITZERLAND



PROCESS OPTIMISATION

Linde is establishing best practices across all  
business lines worldwide.

PROFESSOR DR KRZYSZTOF SZYMANOWSKI,  
POZNAŃ MATERNITY HOSPITAL, POLAND



HEALTHCARE

The global healthcare megatrend is being accelerated  
by changing demographics.



HYDROGEN FILLING STATION,  
BERLIN, GERMANY



ENERGY AND THE ENVIRONMENT

Linde has the necessary expertise to ensure the world's  
resources are developed and used efficiently.

LINDE RESEARCH AND DEVELOPMENT CENTRE,  
SAN MARCOS, USA



INNOVATIVE DRIVE

Targeted research and development activities are  
crucial to Linde's long-term success.

## CONTENTS

### Expansion in regional growth markets

*Page 4*

### Sustainable process optimisation

*Page 18*

---

INTERVIEW :  
Dr Hans-Hermann Kremer,  
Head of Regional Business Unit  
Middle East & Eastern Europe

»A market leader has to be better than the competition.«

*Page 6*

REPORT :  
On-site business in Russia  
**Solid partnership**

*Page 10*

---

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INTERVIEW :  
Andrew Smith,  
Head of Bulk Distribution

**When the means is the end...**

*Page 20*

REPORT :  
Supply chain for liquefied gases  
**Efficiency in logistics**

*Page 24*

---



## Global megatrend healthcare

Page 34

---

INTERVIEW :

Dr Christian Wojczewski,  
Head of Global Business  
Unit Healthcare

### Holistic approach to healthcare

Page 36

REPORT :

Telehealth  
Keeping a finger on the pulse

Page 40

REPORT :

Analgesic gases

### Smooth delivery

Page 44

---

## Technologies for the energy and environment growth market

Page 48

---

REPORT :

Hydrogen

### Versatile all-rounder

Page 50

INTERVIEW :

Markus Bachmeier,  
Head of Hydrogen Solutions

### Fast, furious and future-proof

Page 58

---

## Developments for the future

Page 62

---

INTERVIEW :

Dr Kevin McKeigue,  
Innovation Manager and  
Head of Nanotechnology

### Growing a bright idea into a successful business model

Page 64

REPORT :

Carbon nanotubes

### Stuff of the future

Page 68

---

### Review of the year

Page 76

### Publishing details

Page 78

### Corporate profile

Page 1

### Linde financial highlights

Cover

# Expansion in regional growth markets

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INTERVIEW :

Dr Hans-Hermann Kremer,  
Head of Regional Business Unit  
Middle East & Eastern Europe

»A MARKET LEADER  
HAS TO BE BETTER  
THAN THE  
COMPETITION.«

*Page 6*

REPORT :

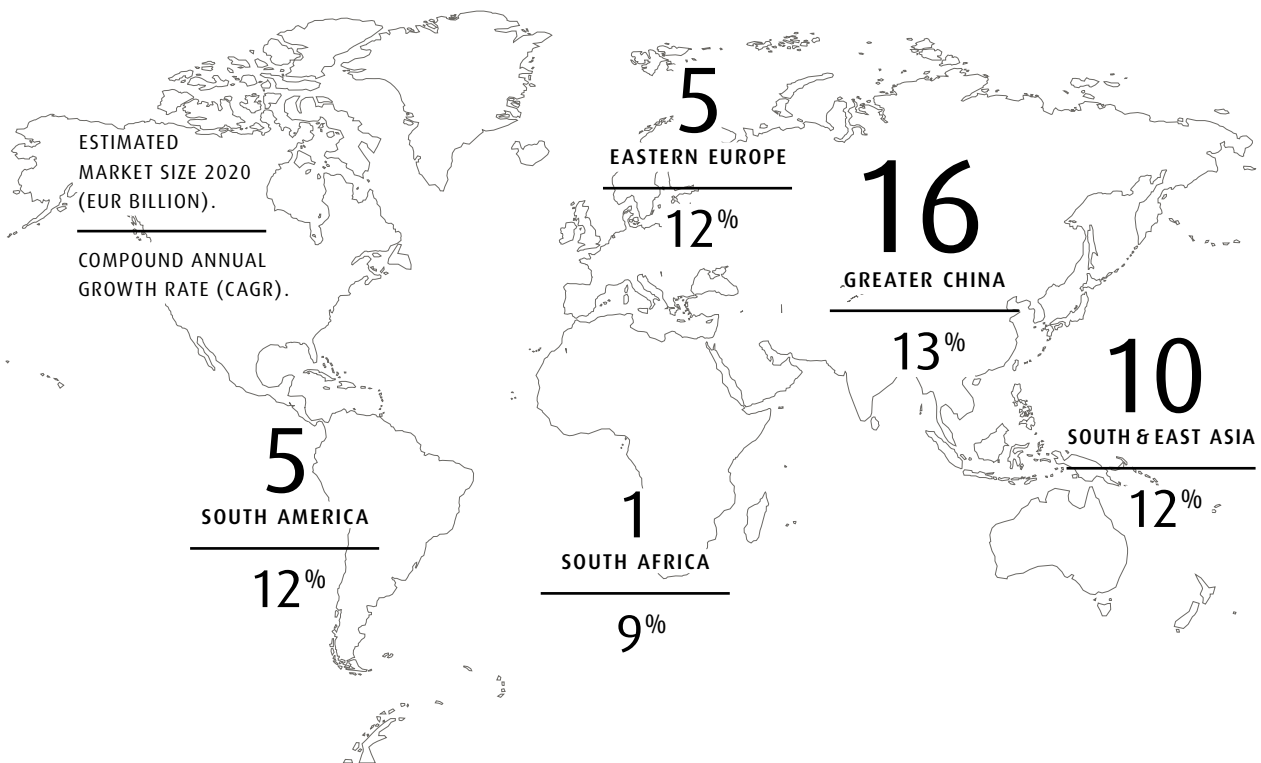
On-site business in Russia

SOLID  
PARTNERSHIP

*Page 10*

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Linde holds the number one position for industrial gases in four of the world's five growth regions: Eastern Europe, Greater China, South & East Asia, and South Africa. This means that the company has a particularly strong presence in the markets set to experience the biggest momentum in the medium term. Linde has invested heavily in reinforcing its outstanding position in emerging economies over the last few years and intends to continue on this course, channeling around seventy percent of its project investments in the gases business into growth markets during the next three years. This engagement is clearly paying off, as demonstrated by two examples from 2013: On the one hand, the start-up of India's largest air separation unit, engineered by Linde for Tata Steel, has had a particularly significant impact on revenue in the Asia/Pacific segment. And on the other, a similar facility went on stream in Kazakhstan – that country's first large air separation unit – to support Linde's on-site business in Eastern Europe.







Dr Hans-Hermann Kremer

—  
Head of  
Regional Business Unit  
Middle East  
& Eastern Europe

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»A MARKET LEADER  
HAS TO BE BETTER THAN  
THE COMPETITION.«

Over the coming years, Linde will continue to channel the lion's share of its project investments into emerging economies. Dr Hans-Hermann Kremer explains how the company intends to build on its strong position in the Middle East and Eastern Europe.

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*INTERVIEW*

»WE AIM TO CONTINUE ON AN  
ABOVE-AVERAGE GROWTH COURSE IN  
ALL OUR BUSINESS SEGMENTS.«



**Dr Hans-Hermann Kremer**

**How do you define a true growth market?**

As far as we're concerned, a market becomes a growth market if it offers above-average potential over the longer term. We are primarily guided here by industrial production and, in Eastern Europe, by modernisation requirements in industry. Once we have identified that potential, we then evaluate the opportunities for each of our business segments. In Russia, for instance, we see strong potential for our on-site business, in other words, installing gases supply facilities at the customer's own premises, and for our liquid and cylinder business.

**What are your growth targets for the Middle East and Eastern Europe?**

Against the 2011 baseline, we are aiming to double our sales and operating profit in this region by 2016. We are pursuing two lines of action here: continuing to build on business with existing customers on one hand, and driving above-average growth by winning new customers on the other. We are combining these measures with dedicated investments.

**Where are you focussing these investments?**

We are seeing a clear move towards greater industrialisation in key Eastern European countries, flanked by a large backlog of modernisation projects for industrial infrastructure. In Russia, for instance, they stopped building new air separation units and replacing existing ones at the start of the 1980s, so the plants there are at least thirty years old. At the same time, companies are increasingly ready for gases providers such as Linde to construct and then manage new on-site facilities at their production locations. That opens up solid growth potential for our gases business, as well as for our Engineering Division.

**Do you think we are seeing a change in mindset among Russian companies?**

I certainly think so. Convincing Russian companies of the benefits of the on-site model used to be an uphill struggle. They preferred to invest themselves and run the

facilities autonomously – despite the fact that this was not a particularly efficient solution in most cases. Since the financial crisis, though, companies in Russia too are giving a lot more thought to how they use their funds and now favour investing in their core business.

**You are number one in the Eastern European market – how crucial is this position for further growth?**

Essentially, a leading position is key to continue growing in expanding markets – at the very least it makes things easier. We need to have a certain weight just to uphold our high quality standards in areas such as occupational safety, finance, controlling and sales. Not to mention our Code of Ethics, which defines our globally binding, non-negotiable values. Equally, our on-site experience has shown that we have a much stronger position with our customers with a professional management team representing us on the ground. So critical mass, international focus, high standards of quality across all areas and local presence – these are our success factors.

**So the on-site business is a growth driver?**

Absolutely. Our air separation units are a great example of this, enabling growth not only through direct supplies to the on-site customer in question but also through parallel supplies of oxygen, nitrogen and argon to other customers in the area. We deliver these products as cryogenic liquids in vacuum-insulated tanks and as high-pressure gases in steel cylinders. This is all part of our integrated gases business model.

**How does the interplay between the Gases and Engineering Divisions work here?**

Especially in the Middle East and Eastern Europe, Linde Engineering has an excellent reputation. Our engineering skills and competence have enjoyed widespread acclaim in these markets for decades now and this gives our gases business a foot in the door. Engineering builds the facilities, while our Gases Division offers to invest in them and run



them. Naturally our customers can also ‘just’ buy the facility outright, but we are always keen to convince them that operations will be both more efficient and more reliable with us at the helm. This leaves them free to focus in full on their core business – in the steel or chemical industry, for instance – and rely on our expertise in the gases business.

**What – in your view – were the most important projects in 2013?**

We brought major air separation units on stream in Vorsino, southeast of Moscow, and in Temirtau, in the northeast of Kazakhstan. We were also able to agree new long-term supply contracts in Russia – with KuibyshevAzot in Togliatti and with Sibur in Dzerzhinsk. These projects involve high investments, and our task now is to ensure that they are implemented on time and on budget.

**In which sectors are you looking to expand further?**

Alongside the metal and steel industry, we also have our sights set on the chemical, petrochemical, oil and gas sectors. And thanks to our dedicated application know-how, we have also been able to gain new customers in the food industry. Meanwhile, the healthcare market is also gaining ground. In comparison with Western Europe, this business segment is still relatively small here, but we are making systematic efforts to expand.

**How do you go about that?**

Our aim is to impress potential customers with the high quality of our products and services, aligning ourselves with international standards. In the Middle East and Eastern Europe, in particular, we are committed to introducing and

ensuring compliance with Western European gas-related standards as part of our wider industry engagement. This especially applies to higher equipment and process safety standards and the appropriate product quality standards. Healthcare is a good example – inevitably, in some countries in this region, requirements governing medical oxygen supplies to hospitals are not yet on a par with Western Europe. So we actively support any efforts to make gas products and services safer here.

**What challenges do you foresee in the years ahead?**

We aim to continue on an above-average development path across all our business segments. That means we need to offer compelling products and services, competing against local providers on the cylinder gases market in Russia, the Ukraine, Turkey and Saudi Arabia, for instance. We are looking to gain ground there by establishing new local sales partners and will also consider smaller acquisitions if they make sense. In the on-site business, our focus for the next two and a half years will be on commercialisation, putting new facilities on stream – on time.

**So fairly ambitious goals...**

Yes, and it goes without saying that we can’t win every project. But as a market leader, our aim is clear: we want to be the ones deciding whether or not to bid. If we see that a particular project would not make financial sense for us, we will pass. But if we were not invited to bid in the first place – that’s when we would be doing something wrong. Quite simply, as the market leader, we have to be better than the competition. That is the benchmark for our performance.

SELECT INVESTMENTS 2013

PROJECT 1	PROJECT 2	PROJECT 3
<b>DZERZHINSK, RUSSIA</b>	<b>TEMIRTAU, KAZAKHSTAN</b>	<b>TOGLIATTI, RUSSIA</b>
<i>Engineering two ASUs for Sibur</i>	<i>Bringing Kazakhstan’s largest ASU on stream for ArcelorMittal</i>	<i>Agreeing a long-term contract to supply KuibyshevAzot with ammonia</i>
<b>Contract signed:</b> June 2013	<b>Start-up:</b> March 2013	<b>Contract signed:</b> May 2013
<b>Investment volume:</b> approx. 70 million euros	<b>Investment volume:</b> 95 million euros	<b>Investment volume:</b> approx. 275 million euros
<b>Production capacity:</b> approx. 30,000 normal cubic metres gaseous oxygen per hour	<b>Production capacity:</b> 2,000 tonnes industrial gases per day	<b>Production capacity:</b> 1,340 tonnes of ammonia per day



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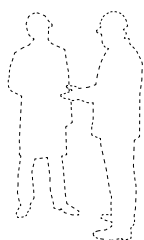
# SOLID PARTNERSHIP

When Alexander Zvonov, Managing Director of Linde Gas Russia, successfully executed the country's first on-site project for steel group NLMK, he marked the start of a new trend. Increasing numbers of Russian companies are now contracting external gas companies to operate air separation units on their behalf.

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*REPORT*

LINDE ANNUAL 2013



Sergey Shalyaev:  
CEO of NLMK Kaluga

Alexander Zvonov:  
Managing Director  
of Linde Gas Russia



It is a sunny and – even by Russian standards – unusually cold morning when Alexander Zvonov and Sergey Shalyaev meet in Vorsino. Zvonov, Managing Director of Linde Gas Russia, has come to join Shalyaev on a tour of the air separation unit (ASU) that Linde has constructed eighty kilometres southwest of Moscow on behalf of Russian steel group NLMK. For Shalyaev, CEO of NLMK’s steel plant in Vorsino, this essentially takes him to his own backyard, since the facility is located on his company’s premises. A first for the steel giant and a rarity on the Russian industrial gas market, where domestic companies usually prefer to work at their own locations without involving contractors.

### WANTED: A GAS COMPANY WITH STEEL INDUSTRY EXPERTISE

When NLMK invited tenders for the air separation unit in 2008, the company was looking for a reliable partner, capable of delivering international standards at a fair market price. Today, the two men stand alongside the pipelines that deliver oxygen, nitrogen and argon straight into the steelworks. “Vorsino is a good example of the growing demand for on-site facilities. This type of supply concept for major customers based on their own premises was previously almost unheard of in Russia but is gaining ground now. Linde is at the forefront of a developing market here,” states Alexander Zvonov.

### OUTSOURCING PARTS OF THE PROCESS

“It didn’t take much to convince NLMK that our plants are engineered to the highest standards,” explains the 53-year-old chemist. “The real challenge lay in persuading NLMK that they should entrust both construction and operation of the unit to us.” Like many other Russian steel companies, NLMK already had positive experiences working with Linde’s Engineering Division. As Zvonov describes, the key difference here was that the customer would no longer be paying for a facility that it would then have to manage itself. “Here, Linde both engineers and operates the unit, thus investing in the customer’s infrastructure. The customer pays for the volume of gases it actually consumes – and since this only applies once the unit is on stream and producing, costs are covered by the steel plant’s current income.”

### “PLAYING TO OUR OWN STRENGTHS”

This supply concept marks a new departure for NLMK in Vorsino. At its other production locations, the company purchased air separation units outright and is thus responsible for operation. “Initially, we were contemplating the purchase model in Vorsino too, but decided against that approach in the end,” outlines Shalyaev. “We realised it would be more efficient for us to outsource operation.” Outside the huge hall containing the ASU, with the door



**Linde constructed a new air separation unit on the grounds of Russian steel manufacturer NLMK.**

## PROJECT DATA

LINDE	PROJECT	NLMK
<b>ALEXANDER ZVONOV</b>	<b>VORSINO, RUSSIA</b>	<b>SERGEY SHALYAEV</b>
With a doctorate in chemistry, the Managing Director of Linde Gas Russia knows exactly what it takes to successfully execute major international projects in his home country.	<i>Construction of an ASU for NLMK</i>	Now 42, the metallurgical engineer began overseeing construction of the NLMK Kaluga steelworks in January 2005. What started out as a green field has since progressed into a massive undertaking.
	<b>Start-up:</b> May 2013	
	<b>Investment volume:</b> 37 million euros	
	<b>Production capacity:</b> 9,000 normal cubic metres gaseous oxygen per hour	

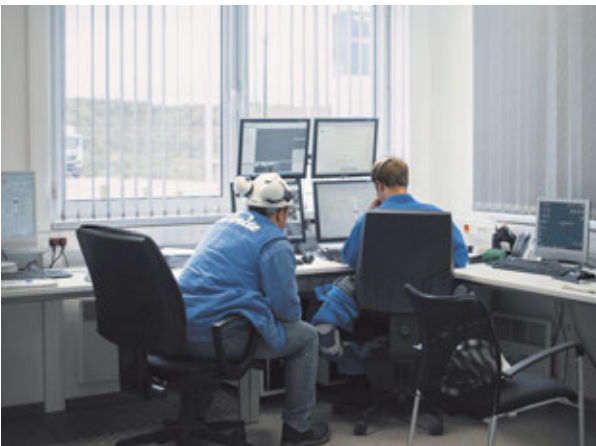
opening to reveal a complex network of coloured turbines, long pipelines and barometer controllers, he continues with a smile: "Basically, Linde showed us that it's a win-win if each of us plays to our own strengths." In NLMK's case, that means producing and selling steel rather than generating high-purity industrial gases. The company posted sales of 12.2 billion dollars for 2012. Building on its expertise in metallurgy, NLMK realised that investing in a 1,250-person plant in Vorsino would pay off for one key reason: scrap metal. Each year, the region around Moscow – Europe's largest metropolitan area, with 15 million inhabitants – discards three million tonnes of metal. To a group like NLMK, that is feedstock that can be recycled into pure steel.

#### A PROBLEM-SOLVING PARTNERSHIP

The air separation unit went on stream in May 2013 and is now running at almost full capacity, supplying the plant with the industrial gases required for steel production. "Alongside scrap metal, these gases are our most important feedstock," declares Shalyaev, who estimates the capacity of his steel plant at around 1.5 million tonnes per year – as soon as all engineering work has been completed. Not unusual for major projects of this type, it takes some time for

the new facility to attain maximum production capacity. In charge of plant engineering here since 2005, Shalyaev can hardly wait for every last challenge, large and small, to finally be resolved. Last year, for instance, the water supply to the construction site went down. Fortunately, though, Linde and NLMK were able to support each other without red tape and overcame the problem together.

"Linde's ASU has been the least of my worries throughout this whole project," Shalyaev confirms. "We had no doubt at all that it would be ready on time." The two men walk around the hall, Zvonov explaining where the air is drawn in, where the filters and compressors are located, where carbon dioxide is separated, and where exactly the pressure is increased in order to obtain high-quality industrial gases from the surrounding atmosphere. Mid-scale facilities such as the Vorsino ASU, whose investment volume totalled 37 million euros, are among the plants that Linde now most frequently engineers in Eastern Europe. "The bottom line is that the on-site model costs our customers less, since we not only produce industrial gases for NLMK, but also liquid gases for the commercial market," Zvonov reveals. "This cuts system operating costs, generating added value that we can pass on to our customers in the form of lower



Linde employees monitor on-site supplies to the steelworks.

gas prices.” As the first trucks loaded with liquid gas carefully manoeuvre over the (still rather bumpy) gravel track outside, Zvonov leads Shalyaev between the pipelines.

### A MODEL PROJECT

Similar to other emerging regions, the Russian market is characterised by above-average growth rates and particularly aggressive competition. Linde alone experiences 15 to 20 percent growth here each year – and is the region’s largest gas supplier, with a market share of around 15 percent.

Leading Russian corporations are increasingly keen to bring in know-how from Linde. In a joint venture with JSC KuibyshevAzot in Togliatti, by the Volga river, Linde is constructing a new, energy-efficient ammonia plant, for instance. Once this starts up in 2016, it will produce some 1,340 tonnes of ammonia per day. Linde and JSC KuibyshevAzot each hold a fifty percent stake in the joint venture and are investing around 275 million euros in the project altogether. Meanwhile, on behalf of gas and petrochemical company Sibur, Linde is channelling 70 million euros into air separation units for Dzerzhinsk, a city to the east of Moscow. Due to go on stream at the end of 2015, these are also typical on-site projects, with the units constructed on Sibur’s various premises to supply the company with the gases it requires for production.

“We’re noticing that Russian companies are taking a fresh perspective on gas supply,” reports Zvonov, as he and Shalyaev emerge from the warm hall into the cold local climate and remove their protective clothing. “You have to be open to collaboration,” agrees Shalyaev, “and our joint project here in Vorsino is an outstanding example.” Leaving the site with Zvonov, he concludes: “Fortunately, we had plenty of time to get to know each other. If you’re going to enter into a long-term contract over the next twenty years, you want to be really sure you’ve found the right partner.”



**NLMK plans to extend Linde’s successful on-site supply and operation model in Vorsino to other locations.**







# Sustainable process optimisation

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INTERVIEW :

Andrew Smith,  
Head of Bulk Distribution

WHEN THE MEANS  
IS THE END ...

*Page 20*

REPORT :

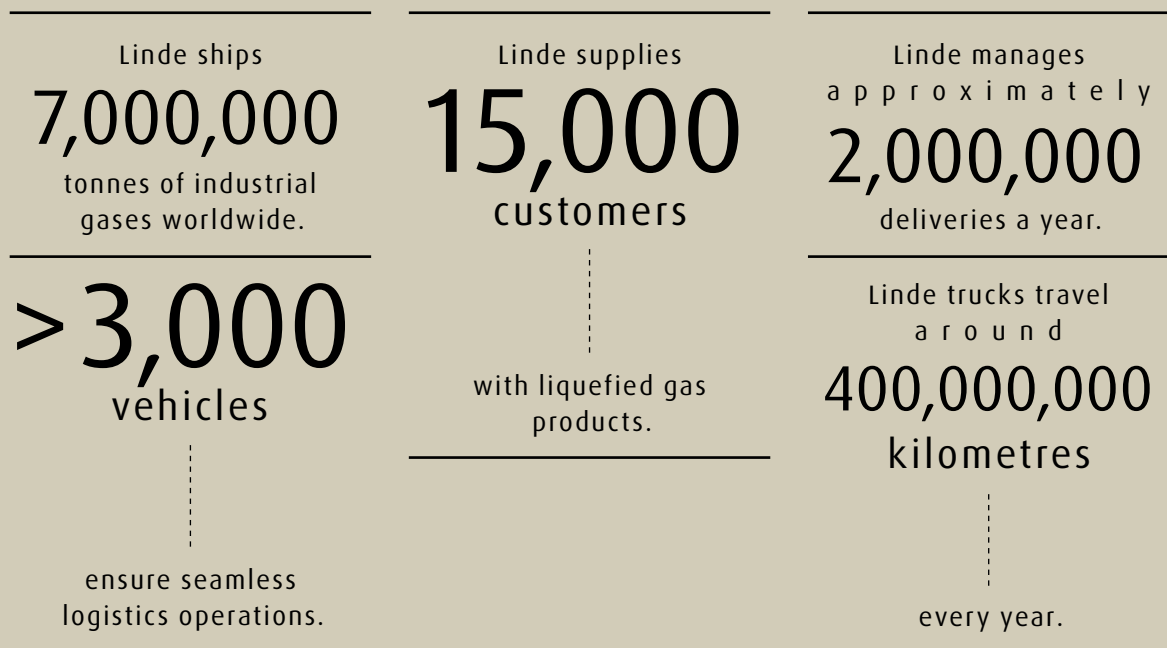
Supply chain for liquefied gases

EFFICIENCY  
IN LOGISTICS

*Page 24*

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To continually improve its internal processes and operations, Linde has introduced a holistic High Performance Organisation (HPO) concept for lasting efficiency gains. Over the four-year period from 2013 to 2016, the aim is to reduce gross costs by a total of 750 to 900 million euros through HPO initiatives. To achieve this, the company is building on best practices across all business lines worldwide. Linde has identified purchasing, IT and the supply chain for the cylinder and liquefied gases business as holding the greatest potential here. The intention is to realise at least half the target savings through the supply chain alone. Logistics and distribution have a key role to play in this effort – Linde runs a network of over three thousand trucks around the globe to ensure the right delivery reaches the right customer at the right time.







Andrew Smith  
—  
Head of  
Bulk Distribution

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# WHEN THE MEANS IS THE END ...

Linde delivers liquefied gases around two million times a year to customers all over the globe. This requires a maximum of flexibility and efficiency. Andrew Smith, Head of Bulk Distribution, explains how Linde is continually optimising its supply chain.

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*INTERVIEW*

»ULTIMATELY, THE AIM IS ALWAYS TO  
FIND THE BEST SOLUTION.«

**Andrew Smith**

**What logistical challenges does the liquefied gases business hold?**

The supply chains we have set up for our customers hinge on a number of variables. Let's take the most important factor: the product, our liquefied gases. We are constantly asking ourselves what quantities to generate – when and where. This is a key question because production costs fluctuate, often in line with energy prices. And production costs have a direct impact on our transport routes. Ultimately, the aim is always to find the best solution – but that changes day by day on a local, regional and global basis.

**So your job is to align production and distribution as closely as possible in an ever-changing playing field?**

That's right. Nitrogen, for instance, typically has very short delivery routes because it can be produced economically and at high volumes – unlike noble gases such as argon. In short, it is a "local" gas. The deciding factor with nitrogen is the density of the customer supply network around an air separation plant. By contrast, we consider argon a regional gas – it is quite common to transport it 600 kilometres to its destination.

how and when we can run each facility – during the day, overnight or at weekends – and to what capacity level. All of these factors affect our purchasing rates for electricity. The electricity market is in constant flux and that also has direct repercussions on our delivery channels.

**Plus the electricity market varies from region to region...**

Exactly. On the US West Coast, for instance, we receive financial reimbursement if we manage production so that our large air separation units are not running at, say, 5 p.m., when everyone there gets home and turns on the air-conditioning, and instead we pump our energy back into the grid.

**Flexibility is vital, then?**

Absolutely – speed and flexibility carry economic benefits when it comes to production and transport. It might make sense to supply a customer from a facility further away, for example, if production there is cheaper for you at a certain time. Applying the "power versus wheels" logic, we always balance energy against transport costs.

»IF YOU REDUCE  
CONSUMPTION, YOU CREATE MORE  
VALUE AND PROTECT  
THE ENVIRONMENT TOO.«

**And helium?**

Helium is an even rarer gas – it's a global gas. There are only a dozen sources of helium in the world, an important one being in Qatar. From there, we transport it to our customers around the globe. When we look at delivery channels, in the end it all comes down to one thing: efficiency.

**You mentioned energy as a factor – how much impact does it have on gas production?**

We need a lot of energy to operate our plants. The efficiency of our production depends a great deal on

**How does Linde organise deliveries to customers?**

We differentiate between planning and scheduling on the one hand, and transport execution on the other. The former focuses on variable production planning and dynamic demand forecasting, and the latter on concrete organisation and execution of deliveries. Both lines of activity are precisely aligned, in real time. So if an issue arises at one of our facilities, for example, we are able to adjust our transport and production to the change in circumstances immediately.

**How important are the vehicles in this process?**

They naturally play a key role at the end of the logistics chain. That is why we are making targeted investments to optimise trucks and tankers – around 200 million euros this year alone. Our focus here is on innovations that contribute to lasting improvements to our margins.

**Could you give us examples?**

Well, aluminium is a case in point. We are using this more and more in our tankers because it is a very light material, which improves the overall energy balance and translates into cost reductions. At the same time, we are changing over to larger tankers in an effort to cut trans-

however, we have automated this process and installed telemetry at the tanks. This allows us to see how much gas a customer has left at any time, so the customer no longer needs to order new deliveries.

**Technical improvements are only part of the story though, aren't they?**

That's true – the core remains an effective team and good communication. Bundling information is important. Last year, for instance, we launched a programme that supports central, weekly optimisation of liquefied gas production and deliveries across entire markets – which means we can react faster and more flexibly than ever before.

»WE BALANCE PRODUCTION AND DELIVERY EXACTLY.«



port costs further. Particularly in conjunction with the new, improved aerodynamics of heavy goods vehicles, this is an important factor, and we work closely with vehicle manufacturers to optimise design. After all, if you reduce consumption, you create more value and protect the environment too.

**Do you use electronic innovations?**

Yes – digital technology is growing in importance at all levels. To take telemetry as an example: Each of our customers has a tank on their premises. Previously, they monitored the gas level themselves and called us when they needed a top-up, or we predicted their usage. Over the last few years,

**What exactly are the benefits of central optimisation?**

It gathers all the important information – and we process tens of thousands of details every day – in one place so that we can coordinate our production and deliveries more precisely. We have already rolled this out successfully across much of Europe, and China is set to follow this year.

**What are the most important insights from this project to date?**

The system is throwing up several minor areas with room for further improvement, as well as delivering potential approaches for new, integrated solutions to keep optimising our entire supply chain.





Herbert Schenke

—  
Head of Bulk  
Product & Supply Chain  
Management,  
Region Continental &  
Northern Europe

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# EFFICIENCY IN LOGISTICS

Linde is constantly working to ensure the most reliable, cost-efficient liquefied gases delivery service to its customers. Success hinges on attention to detail – from precise production analysis through smooth communication channels right up to flexible transport management.

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*REPORT*

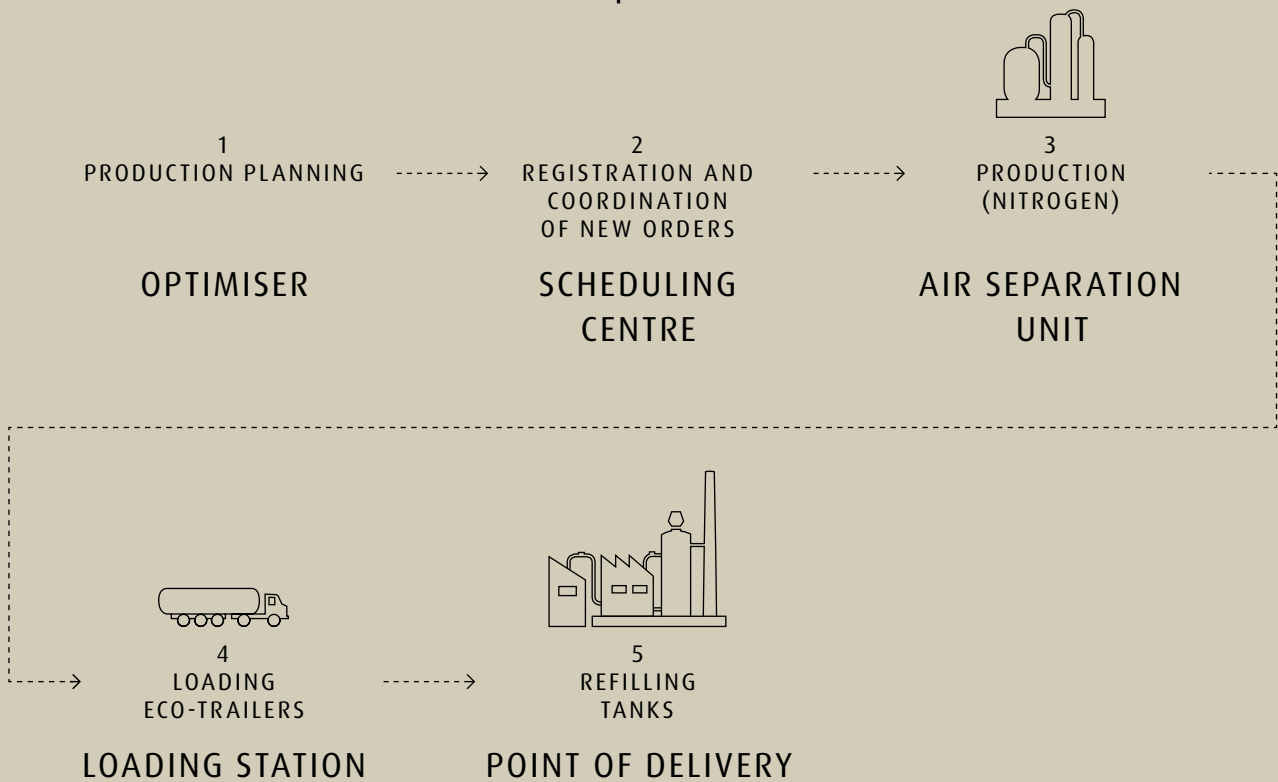
## FILLING UP

It's 7 o'clock in the morning. With extreme precision, Linde driver Manfred Wieland reverses his 40-tonne truck to sit under the 15-metre storage tank on the air separation unit (ASU) in Basel, Switzerland. On-board cameras help guide the truck inch by inch towards the giant vessel, which holds three million cubic metres of nitrogen. Wieland starts off by cleaning the special stainless steel mesh pipe used to fill his tanker. "Air – or should I say, the absence of air – matters," he explains. "When I fill my tanker, I need to be absolutely sure that there are no traces of other gases in the pipeline." Like

all other drivers at Linde, Wieland regularly attends dedicated training courses on the safe transport of industrial gases. And he has clocked up 14 years of experience on the job. To fill the vacuum-insulated tank on the lightweight trailer, Wieland keys his driver data into the registration panel of the automatic filling system. Soon afterwards, the liquid nitrogen, cooled to minus 196 degrees Celsius, flows into the trailer. The entire filling process is monitored by a second control line, which measures online pressure and analysis parameters.

### LOGISTICS CHAIN

Steps 1–5



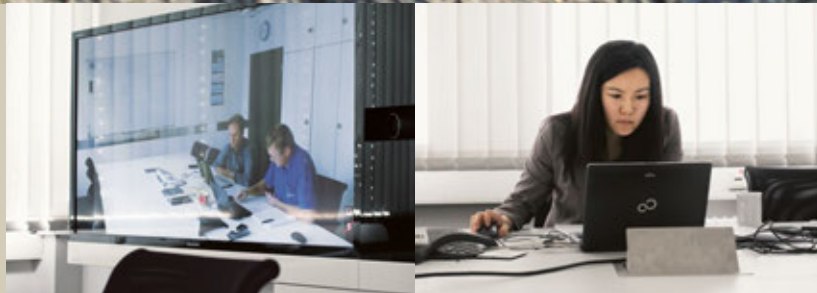
PROCESS OPTIMISATION



TEAMWORK AT ITS BEST

Linde driver Manfred Wieland fills his trailer with liquid nitrogen while logistics experts based in Munich balance supply versus demand over the next ten days.





LINDE ANNUAL 2013

**CENTRAL COORDINATION**  
Supply chain analyst Dr Dexin Luo is in constant contact with her colleagues at the air separation units in central Europe.



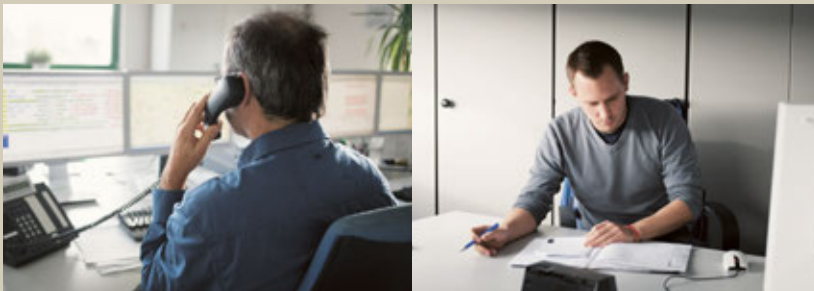
AUTOMATED EFFICIENCY

The logistics team at the Scheduling Centre knows exactly when gas has been delivered to a customer – thanks to real-time telemetry functionality. They also know when the next delivery is due.

## SUPERVISION

At the same time, it's business as usual back in Pullach near Munich. Dr Dexin Luo, supply chain analyst at Linde, is leading a video conference. One by one, the representatives from all of Linde's air separation units across central Europe join the call and appear on the four-metre conference wall. The Friday alignment calls always kick off with the same key questions. Who needs industrial gases – how much and where? How much will be produced where over the coming week? And – most importantly – how can supply and demand be better balanced given the current market dynamics? “Even a

small variation in temperature as a result of a change in weather can have an impact on our production and logistics network,” explains Luo. “If it's cold at a given location, we need less energy to generate gases there, making operations more cost-effective. So it might make sense to supply our customers from that location even though we had originally earmarked a different ASU. In today's market, details such as this are key to supply chain efficiency. And that is precisely what we are aiming for. We even develop special programmes to maximise efficiencies.”



## IMPROVED ROUTE PLANNING

Customer orders are sent daily to the Scheduling Centre in Augsburg. The scheduling experts coordinate the entire trailer fleet and constantly update and optimise the delivery routes.

## STRUCTURAL PROCESS CHANGE

One such programme is called Tonnage and Bulk Operational Optimiser. This central optimisation process helps Linde achieve operational excellence for both on-site supplies (where the gas is produced on the customer's premises and supplied by pipeline) and bulk deliveries (where the gas is delivered in liquid form by tanker). Taking the widest range of variables into consideration, this programme gives the Pullach supervision the insights it needs to manage and optimise production and distribution across 25 ASUs in central Europe.

It can be a complex task – as Basel clearly shows. At this single ASU, up to 50 loads are scheduled every day with nitrogen, oxygen and argon. These gases are then delivered to customers dotted around a border triangle – taking drivers to Lake Constance near the

Alps, Alsace in northern France, the Valais in southern Switzerland and the German midlands, to mention but a few. "Today, logistics also means being able to work efficiently and independently across national borders," says Herbert Schenke, responsible for coordinating and constantly refining the liquefied gases supply chain at Linde. "When we talk improvements, we always look at the entire chain rather than just at individual segments," he continues. "We have seen an overall structural shift in logistics in recent times. The new landscape is defined by innovative software and modern digital capabilities. And we are keen to make the most of these developments – from production analysis through to satellite navigation with special maps that we have supplied to our vehicles. All of which we support with regular training for our people."

## THE VEHICLES

Worldwide, Linde operates over 3,000 vehicles to secure liquefied gases deliveries to its customers. In total, these trucks travel over 400 million kilometres every year. Manfred Wieland, for instance, completes around 300 runs a year, serving around 1,000 customers. Which adds up to a travel distance of around 120,000 kilometres.

The tractors are used for around five years before being replaced with new, more environmentally friendly and cost-effective models. Wieland's latest unit, an eco-

trailer, is significantly lighter than its predecessor, has a higher payload, comes with more active and passive safety features and consumes on average two litres less fuel per hundred kilometres. "Of course each new truck is a big investment," says Schenke. "But it pays off quickly." For Schenke, a transport fleet equipped to the highest standards is one of the pillars underpinning the business. "Our lightweight trailers featuring state-of-the-art software translate into reliable, cost-effective deliveries to our customers," he concludes.

## SCOPING DEMAND

While the Pullach team is busy planning gas production operations, the Scheduling Centre in Gablingen (near Augsburg) is consolidating and evaluating customer data for Germany and neighbouring countries. "This is the heart of our logistics operations," reveals Schenke. Customer requirements are sent to the Scheduling Centre, where orders are processed and delivery routes mapped out. More than ten thousand customers are served from this centre alone. Each individual team member looks after several hundred customers, using dashboards that pull information from multiple sources. Where are Linde trailers currently located? How much

gas does a customer have left? Which customers urgently need a refill? The answers are all in Augsburg. Here the team speaks English, German, French, Italian and Dutch. Day after day, they work hard to determine the best delivery slot and route, relying on tank telemetry rather than phone calls. Previously, customers had to phone in their orders, but now the Linde team can use the latest software and telecommunications advances to verify tank levels remotely – in real time. So they know exactly which customers will need which liquefied gases, in what volumes and where over the next few hours.



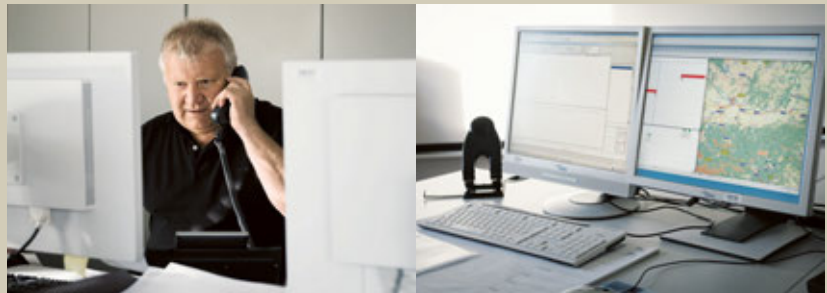
## DELIVERY

The Augsburg logistics centre is playing an increasingly important role at Linde. "At present, we are looking at the possibility of coordinating transport processes for other neighbouring countries from Gablingen," says Schenke, underlining that, as ever, close cooperation with production is key.

Truck driver Wieland provides daily proof of the successful interplay between production and logistics across national borders. He leaves Basel with a trailer full of nitrogen for a manufacturer of pumps, turbines and compressors based in Hésinque in northeastern France. "We deliver nitrogen in varying purities to the widest range of industries," he reports. "For instance,

we supply cryobanks, food manufacturers and even watchmakers, who need nitrogen to harden the metal." Once Wieland arrives at the sprawling manufacturing site in Hésinque, Linde's dedicated satellite system in the on-board computer navigates the trailer directly to the point of delivery, ensuring Wieland gets to the right tank as quickly and efficiently as possible.

And just one hour later, the last drop of liquid gas evaporates as the pipe is removed from the tank. Wieland gets behind the wheel again to see that his on-board computer has already worked out his next assignment – a metallurgy customer at Lake Constance needs a refill.



## FLEXIBLE PLANNING

If a customer needs a delivery at short notice, the logistics experts can modify delivery routes on demand and transmit new schedules to the driver's on-board computer.



DELIVERY

On target – a customer gets the liquid nitrogen they need for their production and Manfred Wieland moves on to supply the next customer.

# Global megatrend healthcare

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INTERVIEW :

Dr Christian Wojczewski,  
Head of Global Business  
Unit Healthcare

## HOLISTIC APPROACH TO HEALTHCARE

*Page 36*

REPORT :

Telehealth

## KEEPING A FINGER ON THE PULSE

*Page 40*

REPORT :

Analgesic gases

## SMOOTH DELIVERY

*Page 44*

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The global healthcare megatrend is being accelerated by changing demographics as the world's population continues to age. Linde is already one of the world's leading gases companies in this growth market. The company supports patients, doctors and other healthcare professionals with products and services that extend far beyond medical gases. Linde provides caregivers and patients with the right therapy and offers training on the correct use of medical equipment, also advising on diet and exercise. Always expanding its medical expertise, the company is becoming a trusted partner for comprehensive, integrated respiratory healthcare offerings.

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Linde serves

**1.4**  
million  
patients  
worldwide.

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Linde is one of the  
leading global healthcare  
providers in  
the gases industry.

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Linde is active on  
the healthcare market in

**60**  
countries.

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The global market  
relevant to Linde in  
this sector will  
grow to around

**17**  
billion euros

by 2020.

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**Dr Christian Wojczewski**  
—  
**Head of  
Global Business Unit  
Healthcare**

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# HOLISTIC APPROACH TO HEALTHCARE

Linde Healthcare currently delivers medical gases, medical devices, clinical care, therapies and supporting services to over 1.4 million patients and thousands of doctors and therapists worldwide. The healthcare market is a key growth driver for the Group. Dr Christian Wojczewski, Head of Global Business Unit Healthcare, discusses global opportunities, innovative products and the benefits of a holistic approach to healthcare.

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*INTERVIEW*

»**DEMOGRAPHIC  
CHANGE IS A STRONG  
GROWTH DRIVER  
FOR LINDE.**«



**Dr Christian Wojczewski**

**What are Linde's aims in the healthcare business?**

We completed a number of major acquisitions in 2012, including Lincare, the largest respiratory homecare company in the US. Integration is progressing very well, so we are now looking to realise further potential in the course of this year. As the gases industry's largest healthcare provider, we also have clear plans when it comes to our long-term positioning. We intend to further expand our market leadership, develop innovative products and invest selectively in new markets.

**As the population continues to age, what impact is demographic change having on Linde's operations?**

Demographic change is a strong growth driver for us. Today, the world's population includes around 400 million people aged 65 or over. By 2050, this age group will swell by a further billion people. If you then consider that the likelihood of chronic illness like COPD (editor's note: Chronic Obstructive Pulmonary Disease) rises rapidly at that stage of life, you can quickly see how much potential changing demographics holds for Linde.

**Is this surge in over-65s restricted to certain countries?**

Not at all – we are looking at a global trend here. In Europe, for instance, more than a third of the population will be over 65 years old by 2050. And China is also seeing a rapid increase in numbers of older people, particularly as a result of its one-child policy. Additionally, medical care has not only improved significantly in the emerging

Asian economies, but also in South America, the Middle East and Eastern Europe. So life expectancy continues to rise in all these regions too.

**How high are the growth rates in these countries?**

Growth across all these regions is in the double-digit per cent range. The countries I mentioned are investing billions in healthcare, and we are certainly feeling the effects of this. It is an urgent necessity, since the Asian healthcare market is still far from European standards – and reaching them would require ten million extra hospital beds, for a start.

**Linde is now a global leader on the respiratory homecare market – could you describe your offering here?**

We offer a wide range of services and clinical care options in the homecare segment – from oxygen therapy through ventilation support to treatment for sleep apnoea. Our top priority here is to ensure outstanding quality when it comes to patient care. Ultimately, that is the platform from which we will continue to build on our market leadership.

**How important is size in this sector?**

Especially in the homecare segment, size plays a key role, since it determines the density of the supply network and thus essentially dictates how cost-effectively a business can be run. We currently serve around 1.4 million patients around the world – which represents growth of around 100,000 relative to the previous year.

**Where do you see the biggest opportunities for the healthcare business overall in the coming years?**

Within the hospital care segment, which supplies medical gases, medical devices and supporting services for hospitals, it is definitely the service side that is on course for rapid growth. The entire segment is also positioned for above-average development in the emerging economies, and pharmaceutical gases such as a nitrous oxide/oxygen mixture remain on a growth path too. In the homecare business, we see potential for further development worldwide, as countries increasingly come to realise that caring for people at home not only relieves cost pressures on healthcare systems, but also benefits the patient.

**Why does care at home relieve cost pressure?**

Well, the main reason is that it is more expensive to care for patients in hospital than at home, which has given the homecare market a huge boost over the past few years. In Germany, we actually celebrated a significant anniversary in this area last year: 25 years of oxygen therapy in the home environment. Our first ever homecare patient was able to attend, saying that he wouldn't be as well as he was if he hadn't been cared for by Linde for the past 25 years. That, to me, is success.

**How important are recent developments in telehealth for future patient care?**

Until recently, telehealth was a vision for the future. But it has now become reality, and in Spain for example we are actively exploring this area. It offers multiple benefits for all participants and, for patients with respiratory conditions such as COPD, enables more individual and proactive care. Various vital signs including respiratory rate, oxygen saturation, pulse and blood pressure are measured daily and automatically transmitted to a clinical call centre. If any of these values fall outside the predefined range, the responsible doctor is informed and can initiate appropriate treatment straight away. This can avoid admission to hospital, for instance. So telehealth helps patients on a day-to-day basis, supports doctors in optimising treatment plans and also eases the burden on the healthcare system, since it makes patient care significantly more efficient.

**How would you describe the ideal healthcare scenario?**

I think it will increasingly hinge on what many experts call 'integrated disease management' in future. Our aim is to offer real added value through our products, services and therapies at every step along the respiratory care path – from disease awareness through diagnosis to all aspects of treatment. It's about taking a holistic approach to both the condition and the patient – focussing on the whole person. In some cases, a COPD patient may require daily oxygen therapy, for instance, but if their condition suddenly deteriorates, hospital admission could become essential and ventilation therapy might be called for. They might

then spend some time at one of our REMEO® centres, which offer integrated care for mechanically ventilated patients, following which they may return to their own home.

**So you accompany your patients every step of the way?**

Yes, that is our aim. We want to look beyond the course of a disease to focus on the overall accompanying care path. Our vision is to make lasting, all-round improvements along the entire patient care continuum, raising the quality offered while also reducing the overall costs.

**Sounds like a good basis for consolidating your market leadership in the healthcare sector...**

It's the only way. We need to convince our patients, doctors and payors that we are offering outstanding quality and reliable service on a daily basis – and all at reasonable cost. To ensure we can sustain this, we are constantly striving to improve – across all processes and lines of business – in the interests of our patients.





Dr Cristina Gomez  
—  
Business Development  
Manager Homecare,  
Region Continental &  
Northern Europe

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# KEEPING A FINGER ON THE PULSE

Linde is constantly striving to improve quality of care for people who suffer from respiratory and other chronic conditions, offering an extensive range of patient-centred medical services.

Dr Cristina Gomez, Business Development Manager Homecare, Region Continental & Northern Europe, has conducted several trials investigating the use of information and communications technology as a way to communicate patient data. The results are highly promising.

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*REPORT*

»DIGITAL TRANSFER OF PATIENT  
DATA ALLOWED US TO REDUCE HOSPITAL  
STAYS BY 60 PERCENT.«



**Dr Cristina Gomez**

Thanks to better standards of living and advances in medical care, the world's population is steadily ageing. As a result of this, we are seeing a rise in chronic diseases and – with it – a greater burden on our healthcare systems. This pressure on healthcare resources is fuelling demand for professional healthcare services and consultations beyond the usual clinical setting – in other words, in patients' own homes.

Linde has extensive know-how and long-standing experience in the homecare space. Always keen to leverage new technologies, the company sees huge potential in e-health tools as a vehicle to remotely communicate and monitor vital patient data (known as telehealth).

Living at home or in familiar surroundings increases quality of life for patients with chronic conditions. However, to date this has usually involved frequent visits to doctors and hospitals, both for monitoring and, in particular, for urgent treatment. In the near future, telehealth could eliminate the need for at least some of these trips and avoid unplanned hospitalisation, saving resources.

In telehealth, measurements taken by the patient with easy-to-use remote monitoring equipment are sent over the Internet or telephone lines to doctors and specially trained staff. The goal is to detect patient deterioration at an early stage, enabling prompt action to prevent hospital admissions. Linde tested this service for the first time in Spain. The recent PROMETE trial involved providing the necessary infrastructure for thirty patients with chronic respiratory conditions to measure and electronically transmit their own blood pressure, peak flow, pulse rate and blood oxygen levels. "The trial clearly demonstrated that it is worth investing in this area," reports Business Development Manager Dr Cristina Gomez, who is based in Madrid. "A well-coordinated and integrated telehealth

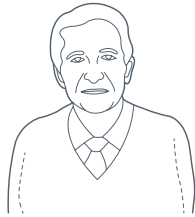
programme helps reduce healthcare costs without compromising the quality of medical treatment." Linde deliberately selected patients with chronic obstructive pulmonary disease (COPD) for the PROMETE project, as this is one of the areas where the company has gathered the most experience – particularly as a trusted supplier of long-term oxygen therapy to these patients.

"COPD patients can experience rapid exacerbation, so often have to be admitted to hospital at very short notice," explains Gomez. "Through real-time daily monitoring of patients' vital signs, we were able to reduce the number of hospital stays by 60 percent during our trial." The number of emergency admissions even dropped by 65 percent, since Linde's specialists were able to react in a prompt manner when values deteriorated. Initially, Linde's homecare nurses called the patients to assess possible sources of error in using the equipment or taking medication. Then the generated and confirmed clinical alerts were used to arrive at a diagnosis, based on which the medication dosage could be adjusted as a preventative measure or a priority appointment made with a lung specialist if required. This swift response helped prevent any serious decline in patient health.

In the next stage, Gomez and her team will conduct a new, larger trial, covering more patients and hospitals. The aim is to analyse the cost efficiencies and benefits of using integrated managed telehealth programmes, and hence the potential savings.

Cristina Gomez witnessed patient reactions to the new technology first hand during the PROMETE trial: "After a brief introduction, patients of seventy to eighty years of age were a bit reluctant to use the new technology, but were also reluctant to give it back at the end of the project!"

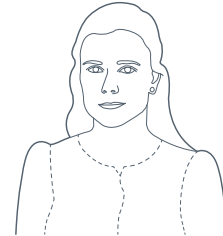
Positive findings – participants in the PROMETE trial in Spain share their experiences.



**ALFREDO ARÉVALO OÑORO  
MADRID**

*Patient*

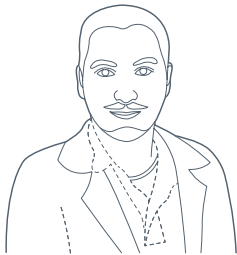
»I felt really well cared for – it was as if a doctor was always by my side. I always knew exactly what my health status was and that was very reassuring. I also knew that Linde would be in touch immediately if any of my values showed cause for concern.«



**ANA JORDÁN DE LA CAMPA  
MADRID**

*Homecare Product Manager  
at Linde*

»Telehealth offers greater peace of mind for everyone involved – patients as well as caregivers. It builds confidence in the care pathway – after all, a specialist team is monitoring vital signs, in real time. This gives the patient greater independence and enhanced quality of life.«



**PABLO PÉREZ  
SEVILLE**

*Nurse, Pulmonology department  
at Virgen del Rocío university hospital*

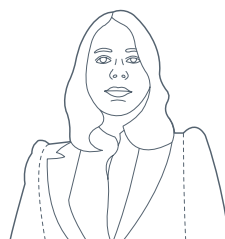
»Online access to medical data allowed us to keep a close eye on each patient's health condition at all times. It meant we were in a position to react promptly if need be – before a critical situation could even arise.«



**DR JULIO ANCOCHEA BERMÚDEZ  
MADRID**

*Head of the Pulmonology department  
at La Princesa university hospital*

»Given the pressures of rising healthcare costs, it is important that patients with chronic conditions can also be treated at home. Telehealth opens up brand new possibilities here. The key success factor is close collaboration between the external service provider and hospital staff. This worked extremely well with Linde and our team.«



**INMA MOLINA  
MADRID**

*Head of Linde's PROMETE  
Network service*

»I am convinced that telehealth will play an increasingly important role in healthcare delivery. The whole programme just works really well for patients – while also helping to relieve pressure on the healthcare system.«





Professor Dr Krzysztof Szymanowski

Maternity  
Hospital Director,  
GPSK UM, Poznań

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# SMOOTH DELIVERY

Pain cannot always be prevented completely – but it can certainly be eased for many patients. Medical gases can provide a useful helping hand here. They are simple to administer and work quickly, for instance during childbirth. Jaroslaw Fil, Product Manager at Linde's Global Business Unit Healthcare, supervised the market launch of Linde's nitrous oxide/oxygen mixture in Poland.

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*REPORT*

## »WE ALREADY OFFER THIS GAS MIXTURE IN 22 COUNTRIES.«

SYBILLE PETERSOHN,  
GLOBAL BUSINESS MANAGER ANALGESICS

### Prof. Dr Krzysztof Szymanowski

The university hospital (GPSK UM) in the Polish city of Poznań is an ideal location to demonstrate the merits of a particular gas mixture. With 7,000 births each year, its newborn nursery is one of the country's largest. Linde's analgesic gas mixture is ideal for birthing facilities such as these. "The gas mixture is fifty percent high-purity oxygen and fifty percent nitrous oxide," describes Jaroslaw Fil, Product Manager at Linde's Global Business Unit Healthcare. "It is well tolerated by patients, works fast and can even be combined with other methods of pain relief."

After more than 25 years as a midwife at the Poznań hospital, Bogumila Pawlak is well acquainted with the wishes of mothers-to-be. "Many women want to consciously experience the birth of their child while still reducing the accompanying pain as far as possible," she reports. "This gas mixture from Linde is a great help here – especially since it not only relieves pain, but also has a calming effect," adds Prof. Dr Krzysztof Szymanowski, Maternity Hospital Director at GPSK UM. Ease of use is another benefit. The gas is inhaled and the dose can be regulated by the mothers themselves after brief instructions from the midwife – no anaesthetist is required. This was also the deciding factor for Hospital Director Tomasz Opala, since it frees up his specialists to focus on more complex procedures.

During market launch, the main priority for Jaroslaw Fil and his team was targeted training. "We introduced our product to experts at the hospitals and discussed the benefits with them; the gas mixture was also explained by midwives to patients during antenatal classes," confirms the Linde manager. These activities spanned around 400 maternity hospitals all over Poland.

The upshot is that Linde is currently supplying the gas mixture to around 250 facilities nationwide – a success Sybille Petersohn, Global Business Manager Analgesics, is happy to recount: "We now offer this gas mixture in 22 countries. In Poland it is a new arrival, whereas in England it has played an established role in childbirth for some forty years now." This is not its only field of application in all countries, however. In France and Denmark, for instance, Linde is focusing on its potential as a source of pain relief for children.

One thing, though, is common to all regions: demand for Linde's oxygen and nitrous oxide mixture is growing. That is why the company has also decided to open a dedicated filling station for this product in Poland – the third in Europe, alongside France and Sweden. This will leave Linde well positioned to ensure security of supply and maximum efficiency.



**Maternity hospital  
director Prof. Dr  
Krzysztof Szymanowski  
and head midwife  
Bogumila Pawlak trust  
in Linde's reliability.**



**Linde's nitrous oxide/oxygen  
mixture is a valuable aid at the maternity ward.  
It is inhaled using a demand valve  
for personal pain control by the mother-to-be.**



# Technologies for the energy and environment growth market

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REPORT:  
Hydrogen

VERSATILE  
ALL-ROUNDER

*Page 50*

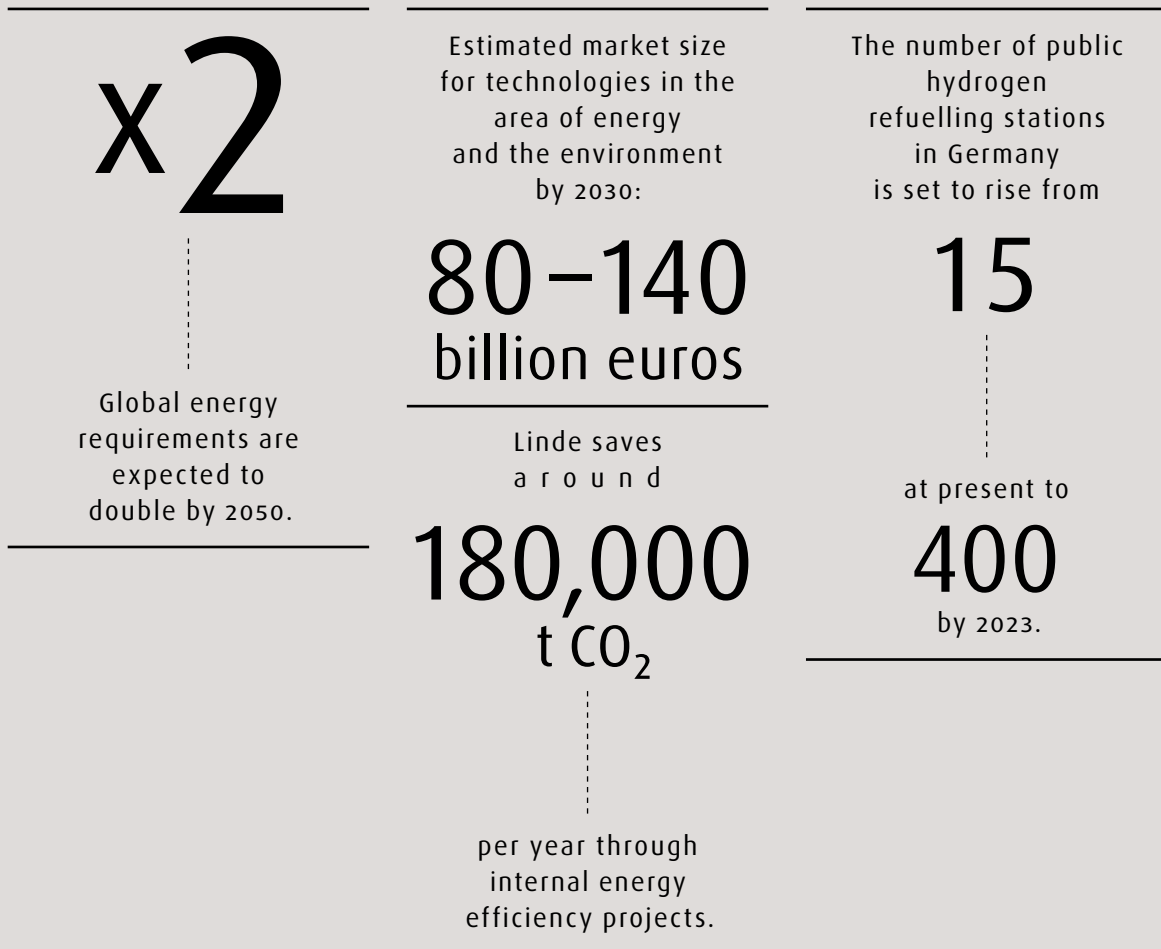
INTERVIEW:  
Markus Bachmeier,  
Head of Hydrogen Solutions

FAST, FURIOUS  
AND FUTURE-PROOF

*Page 58*

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Demand for affordable, secure and environmentally compatible energy supplies continues to grow worldwide. Meeting rising needs means steadily increasing the share of renewable energy sources and making effective use of innovative technologies. Linde has the necessary expertise to ensure the world's resources are developed and used efficiently. With its comprehensive portfolio of clean technologies, the company has achieved an excellent global position in the structural growth market of energy and the environment, making a valuable contribution to sustainable energy production and supply. Hydrogen plays a key role here, both as a source of energy and, increasingly, as a storage medium.





Dr Christoph Stiller  
—  
Head of  
Energy Production  
and Storage,  
Linde Innovation  
Management

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# VERSATILE ALL-ROUNDER

Hydrogen is an environmentally sound energy carrier.  
It is also an ideal medium for storing energy from  
renewable sources such as the wind and the sun. Pioneering  
the latest hydrogen technologies, Linde is working  
on a range of projects to turn our vision of  
sustainable energy and clean transport into reality.

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*REPORT*

DR CHRISTOPH STILLER

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»HOW CAN WE  
BEST STORE THE INCREASING  
AMOUNTS OF ENERGY  
WE ARE PRODUCING FROM  
RENEWABLE SOURCES?«

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## STORING ENERGY

Looking ahead, one of the biggest questions society is facing is how to secure a clean supply of electricity to meet future energy needs. Should we harness the power of the sun, wind or water? Dr Christoph Stiller, Head of Energy Production and Storage at Linde Innovation Management, is already ahead of the game. For him, the big question is: "How can we best store the increasing amounts of energy we are producing from renewable sources?"

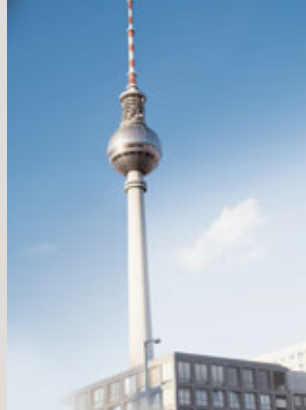
As Stiller stands in front of a wind farm to the south of Berlin, the blades of the hundred-metre turbines swoosh in the autumn wind and energy flows at top speed. Yet that is not always the case, since wind and solar power, by their very nature, are subject to fluctuations. The wind doesn't always blow and when it does, it is never at a consistent speed. Similarly, the sun only shines during the day – and not always at that – and in more temperate climates it is only strong enough in the summer months. Demand-driven distribution of energy from renewable sources such as these thus hinges on effective storage solutions. And that is where hydrogen (H<sub>2</sub>) comes into the picture. "Hydrogen is the key to our future energy landscape," declares the engineer. "It has a high energy density and is easy to transport." As an industrial-scale storage solution, it also tops the economy ratings. "If you

store energy in a battery, you're looking at an investment of around 400 euros per kilowatt hour. Storing the same amount of energy as hydrogen in underground caverns costs well under a euro."

Hydrogen-based options also compare favourably to pumped-storage hydroelectric plants, which only have limited capacity. In Germany, for instance, just 40 gigawatt hours can currently be stored in this way. Meanwhile, experts estimate that around forty terawatt hours would be required to meet the country's entire energy needs solely from renewable sources – so a thousand times the current capacity. Another benefit of hydrogen is that, unlike batteries, it does not run down over time, so is still available even if it has been stored for an extended period. The process of using electrolysis to convert energy to a gas such as hydrogen for easier storage is referred to as power-to-gas. The resulting green hydrogen can then be used in a number of ways. "At times of peak demand, the hydrogen can be turned back into electricity by gas-fired power plants, or used by combined heat and power stations," explains Stiller. Alternatively, it can be fed into the natural gas network – either directly, with the gas grid able to absorb up to five percent hydrogen – or indirectly following methanation. Here the volume of hydrogen



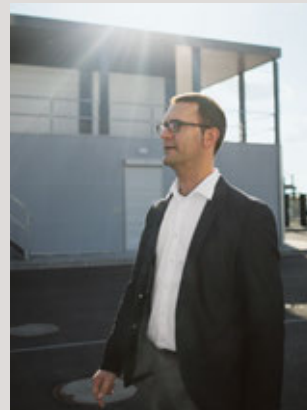
1-3



4-5



6-8



9



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1-3 Hydrogen-powered fuel-cell vehicles can easily cover 400 kilometres and more on a single tank.  
4-5 State of charge and power flow are displayed on the on-board computer.  
6-9 Clean energy expert Dr Christoph Stiller at the new hydrogen refuelling facility at Berlin airport. Linde and its partners are committed to expanding the filling station network.

9-11



12



13-15



16-17



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9-11 A special dispenser fills vehicles with the hydrogen, cooled to temperatures as low as minus 40 degrees Celsius.  
12-15 Once converted to hydrogen, renewable energy can be placed in temporary storage. An ionic compressor – no bigger than a container – increases the pressure prior to refuelling.  
16-17 Demanding requirements: hydrogen for electric vehicles must be 99.999 percent pure.

that can be fed into the natural gas network is unlimited. Methanation entails adding carbon dioxide to the hydrogen to produce synthetic natural gas. "Hydrogen is enabling completely new connections across the energy landscape," Stiller confirms. "It is both a storage medium and a highly versatile product in its own right."

This potential is set to drive demand for facilities that convert electrical energy into hydrogen. Linde's Innovation Management team plays an important role here, evaluating relevant products and technologies, designing implementation measures and ensuring smooth execution. One such project is currently under way at the "Energiepark Mainz" in the German city of Mainz. Supported by the German federal government's Energy Storage Funding Initiative, Linde, Siemens and municipal utility company Stadtwerke Mainz are investing a total of 17 million euros in the construction of a hydrogen facility. This will be able to absorb up to six megawatts of electrical power – roughly the output of three wind energy plants – and

produce up to 200 tonnes of hydrogen per year. Part of this will be fed into a local natural gas pipeline and converted back into electricity on demand at a modern gas and steam power station.

Power-to-gas is shaping up as a key technology not only in the transition to a greater share of renewable energies, but also in the move towards eco-friendly transport options. That is why Mainz will also be home to a filling station for hydrogen trailers, which in turn will supply hydrogen refuelling facilities. This system will have the capacity to power 1,500 fuel-cell vehicles running on hydrogen. Industrial customers will also be able to obtain green hydrogen for their production operations from Mainz. "Energiepark Mainz is the most ambitious lighthouse project for hydrogen energy storage to date. We are combining several new technologies here – and, for the first time, on a scale that could make a real difference to our energy landscape," reveals Stiller. The plant is scheduled to go on stream in early 2015.

## IDEAL FUEL

Outside the wind farm to the south of Berlin, Christoph Stiller gets into a car and accelerates to over fifty kilometres per hour in just a few seconds – without a sound. The Linde expert is sitting in a Mercedes F-Cell, a hydrogen-powered fuel-cell vehicle. "It just goes to show – hydrogen and electric mobility are by no means at odds," he remarks. "Like a battery-operated vehicle, this car is also electric and produces zero emissions." Combining hydrogen with a fuel cell gives the Mercedes model a range of 400 kilometres, and it takes just three minutes to refuel – almost the same as a conventional combustion-engine car.

The in-car hydrogen is stored in pressurised gas tanks integrated in the floor beneath the passenger compartment. From here it flows to a fuel cell, where it reacts with oxygen from the air to produce electricity and power the motor, which drives the car via the front axle. An additional high-voltage battery absorbs kinetic energy on braking, which in turn enables powerful acceleration. The journey to the capital's new main airport generates no emissions. If Stiller accelerates hard, the exhaust pipe emits a few drops of water, and otherwise just water vapour – whether in stop-and-go traffic around town or doing 100 mph on the German motorways. "This

car is a lot of fun to drive," exclaims Stiller, as he pulls onto the site of the newly opened Total filling station at Berlin airport. "It ticks every single box for the perfect modern vehicle."

After just a few minutes at the hydrogen dispenser, not far from the kerosene tank for aircraft fuel, the car is already full up. Stiller replaces the hose, the handle slightly cold as the hydrogen flows into the car's compressed gas tank at temperatures as low as minus 40 degrees Celsius. And without a hint of an odour. The hydrogen used for road transport has to be 99.999 percent pure, so for every million hydrogen molecules, a maximum of ten other molecules is permitted. Linde ensures this at every process step, directly at the airport. The hydrogen available here is currently delivered from Leuna, where it is manufactured from raw glycerine or biogas. However, from mid-2014, it will be produced by an electrolysis facility at the airport itself. As part of the H<sub>2</sub>-BER project, Linde is working with Total, Enertrag and McPhy to demonstrate how power-to-gas can already change the face of everyday mobility. The project is supported by the German national innovation programme for hydrogen and fuel-cell technology (NIP).

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ENERGY STORAGE  
 COSTS PER KWH  
 STORAGE CAPACITY:

BATTERY:  
 400 EUROS

HYDROGEN:  
 <1 EURO

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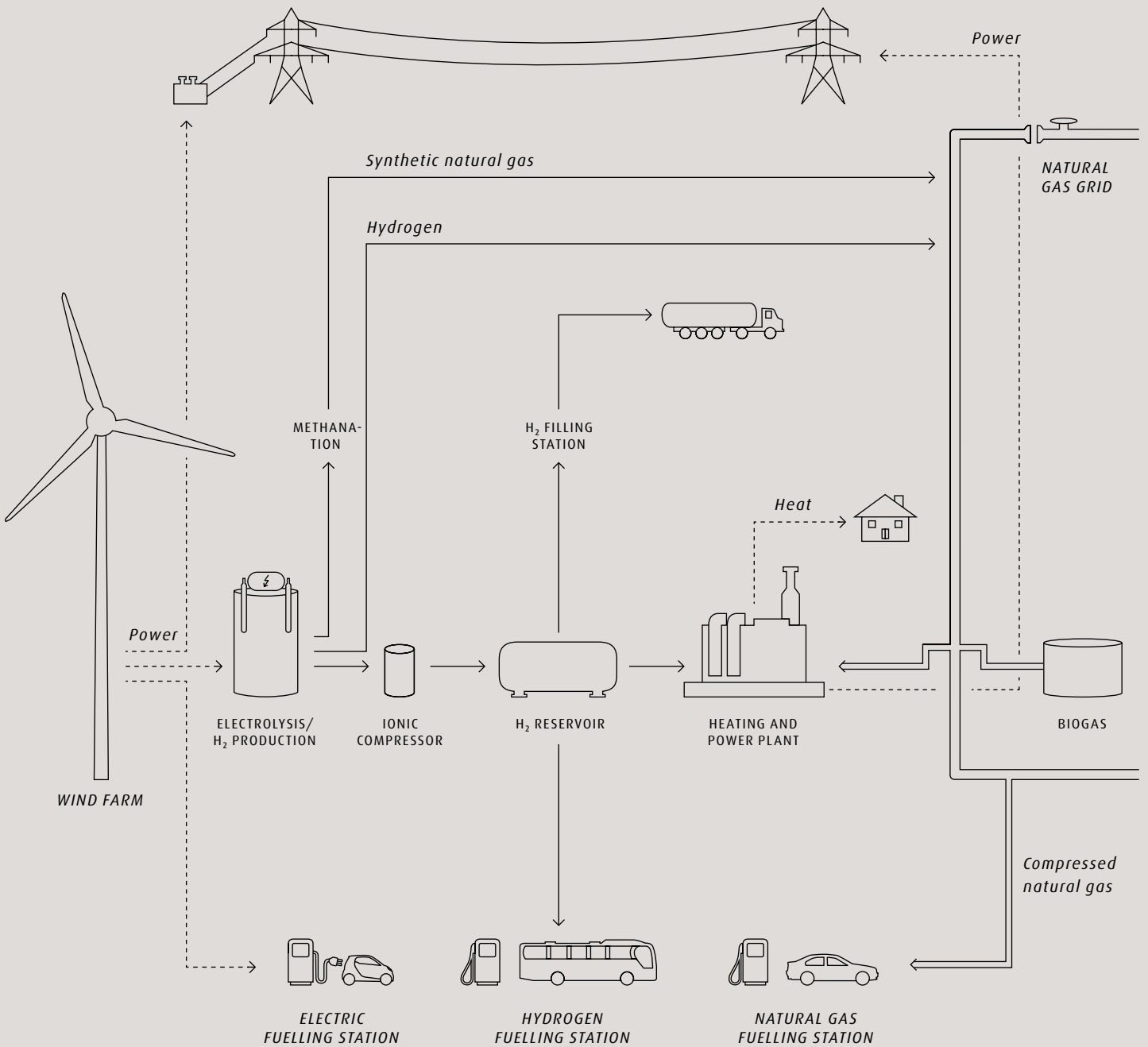


The digital display on the fuel dispenser shows the price: 9.50 euros per kilogram, so just under 40 euros for a full tank. Stiller pays by card, as do all members of the Clean Energy Partnership, which includes companies such as Total and Shell, Daimler, BMW, Volkswagen, Toyota and Hyundai, Siemens and Linde. Their mutual aim is to advance widespread adoption of clean hydrogen technology.

At the rear of the building, Stiller meets Alexander Zörner, Linde's project manager for hydrogen applications in northeast Germany. "This filling station is in a league of its own," confirms Zörner. "We have linked up the entire hydrogen chain here – from the initial energy source right through to the point of use." Indeed, the H<sub>2</sub>-BER project is like a one-stop mobility shop, extending from hydrogen production to fuel sales at the pump. The energy from the wind is converted into hydrogen by a 12-metre electrolysis

system. The gaseous hydrogen then flows into a state-of-the-art ionic compressor developed by Linde, initially at a pressure of around 50bar. This increases many times over inside the compressor, since the in-car hydrogen needs to be stored at 700bar. Leading vehicle manufacturers are now turning their attention to hydrogen power. And in several countries, the necessary infrastructure is gradually expanding towards nationwide coverage. By the end of 2015, there should be fifty hydrogen fuelling stations in Germany and a hundred in Japan, for instance. Linde is already supplying components for these pioneering hydrogen stations to the European, Asian and American markets. "Market maturity is now a given," concludes Stiller. "The important thing is to gain experience from pilot projects so that we can commercialise hydrogen technology cost-effectively, ensuring widespread coverage as soon as possible." Berlin airport seems a promising start.

HYDROGEN CYCLE



NETWORKED HYDROGEN ECONOMY

Wind farms produce large volumes of renewable energy. Depending on requirements, this might be fed directly into the grid, used to power electric cars or stored in the form of hydrogen. There are many different applications for hydrogen generated from wind power. It can be used to power fuel-cell vehicles, co-fed into natural gas pipelines or converted into synthetic natural gas by means of methanation. It can even be used as a fuel in heating and power plants.





Markus Bachmeier  
—  
Head of  
Hydrogen  
Solutions

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# FAST, FURIOUS AND FUTURE-PROOF

Hydrogen is considered the fuel of the future – this eco-friendly energy carrier holds the potential to revolutionise our mobility choices.

Markus Bachmeier is working with industry partners to turn hydrogen technology into a market success. Here, we discuss long ranges, short refuelling times and the need for an efficient infrastructure.

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*INTERVIEW*

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»THERE ARE AROUND A BILLION CARS IN THE WORLD TODAY, AND THAT NUMBER IS RISING. IF, IN FIVE OR TEN YEARS' TIME, EVEN JUST ONE OR ONE AND A HALF PERCENT OF THOSE VEHICLES ARE FUELLED BY HYDROGEN, THAT TRANSLATES INTO A MASSIVE MARKET. FORTUNATELY, WE IDENTIFIED THESE OPPORTUNITIES EARLY ON.«




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**Markus Bachmeier**

**What is so fascinating about hydrogen mobility?**

For the general public, the biggest appeal is undoubtedly the driving experience – these eco-friendly cars are extremely practical. Hydrogen fuel does not generate any emissions, and the vehicles are clean, quiet and powerful. As one of the biggest manufacturers of hydrogen, we are impressed by the potential it offers and by the wide choice of generation options. We will increasingly be relying on renewable sources of energy – especially wind and solar power – to produce hydrogen, for instance.

**What potential does hydrogen mobility hold in economic terms?**

There are around a billion cars in the world today, and that number is rising. If, in five or ten years' time, even just one or one and a half percent of those vehicles are fuelled by hydrogen, that translates into a massive market. Fortunately, we identified these opportunities early on – Linde has been making targeted investments to advance hydrogen refuelling technology and build up the necessary infrastructure for over 25 years now.

**Are you seeing heightened interest in hydrogen power overall?**

Absolutely – we need solutions to slash carbon emissions and more and more of our customers and partner companies are recognising the potential of hydrogen technology here. Within the auto industry, powerful new alliances have formed over the past twelve months. Premium and volume manufacturers in Asia, Europe and North America are working closer and closer together. Daimler, Ford and

Nissan have announced that they are joining forces to build hydrogen cars, for instance, while Volkswagen recently placed a development order with a fuel-cell manufacturer. Meanwhile, Hyundai, Toyota and Honda are planning to go into mass production in 2015. We definitely expect to see more series production from 2017 onwards.

**What technical hurdles must still be overcome?**

Well, the industry has done its homework, so the key technical requirements for hydrogen mobility are already in place: cold-start capabilities at temperatures down to minus 35 degrees Celsius are no longer an issue, a single tank of fuel lasts up to 700 kilometres, and refuelling takes an average of just three minutes, so no longer than with a conventional diesel or petrol engine. Global refuelling standards have also been established – we started pushing for that very early on. We already offer customised H<sub>2</sub> refuelling stations and are working to build a core nationwide supply network for private transport.

**So Linde is a pioneer for hydrogen-powered mobility?**

Yes, indeed. We are a founding member of the Clean Energy Partnership and the H<sub>2</sub>Mobility initiatives; we are active across the US, Europe and Asia; and we are working with numerous partners and even government agencies to plan a suitable hydrogen infrastructure and ensure that build plans are put into action. We started communicating the huge potential of hydrogen technology to the public around ten years ago and have established a valuable forum in the shape of our International Hydrogen Day.

**Are hydrogen cars in competition with battery-powered electric vehicles?**

In the end, of course, hydrogen cars are electric vehicles too – it's just that they use a hydrogen fuel cell rather than a battery to drive the electric motor. We anticipate that these carbon-free technologies will complement each other. Battery power certainly makes sense for smaller vehicles and shorter, inner-city routes. But if you're looking for larger vehicles, longer ranges and shorter refuelling windows, hydrogen is the fuel of choice – by far.

**Linde is also investing in hydrogen power for commercial vehicles. What kind of opportunities do you expect to see here?**

Hydrogen is already a cost-effective alternative for commercial vehicles today. We supply hydrogen for BMW's forklift fleet in Spartanburg in the US, for instance. We are also running similar projects with Coca-Cola and Walmart. Any "back-to-base" fleet – so forklifts, buses or taxis, say – is ideally placed to benefit from hydrogen. For these deployment scenarios, we can design the refuelling infrastructure for optimum capacity utilisation right from the start, cutting costs for the customer.

**Does your hydrogen know-how transfer to other projects too?**

Yes, we are building on our existing knowledge base for public transport projects, for example. Linde was responsible for constructing the largest hydrogen fuelling station for buses in the US just east of San Francisco Bay, refuelling twelve buses and several cars each day. In Germany, we have built a station in the Hafencity area of Hamburg that is also mainly used for public transport. And the next station is already planned for Bolzano, in the South Tyrol province of northern Italy. We are now able to build facilities capable of refuelling up to 120 buses daily – which corresponds to a large city bus depot. The trend will shift more and more towards larger infrastructural facilities in the commercial segment, simply because they are more cost-effective to operate.

**What challenges do you now face in the journey towards efficient hydrogen-powered mobility choices – especially in the private space?**

In the private automobile sector, we are working to achieve basic coverage in the relevant markets. This calls for around 150 filling stations in Germany, the first 50 of which we will be building with our partners as part of a programme that runs until 2016. Once this backbone infrastructure is in place, drivers will realise that a hydrogen-powered car will provide them with a similar range to a petrol-based equivalent. At the same time, we are aiming to shrink the footprint of each hydrogen refuelling system at the filling stations. The facility at Berlin airport is a good example. Here we have integrated an on-site system that converts wind energy into hydrogen – which can then be pumped straight into the vehicles.

**What prospects do you see for green hydrogen?**

The production of green hydrogen generates very little – if any – CO<sub>2</sub>. There are several ways to obtain green hydrogen, such as from biomass – as at our H<sub>2</sub> demo facility in Leuna – or through electrolysis, which involves using renewable electricity to split water into hydrogen and oxygen. The prospect of cars running on fuel obtained from renewable sources dramatically increases the appeal of hydrogen.

**And yet hydrogen is still mainly obtained from natural gas. Why is that?**

Because that method is still cheaper. We should also bear in mind that cars running on H<sub>2</sub> from conventional natural gas sources still release 30 percent less carbon than typical diesel or petrol engines. Again, though, our intention is to gradually increase the proportion of green hydrogen.

**What milestones are coming up for Linde in the hydrogen mobility journey?**

We will steadily continue to advance our refuelling technologies. The main aims here are to keep cutting filling station costs, improve user-friendliness and reliability even further, and reduce the space required. We will also go on working with our partners to ensure an economically sustainable basis for infrastructure development. Linde is already demonstrating the everyday viability of hydrogen transport in flagship projects such as the Berlin Sachsendamm refuelling facility, and is now ready to begin the next stage: building up a nationwide refuelling network.

# Developments for the future

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INTERVIEW :

Dr Kevin McKeigue,  
Innovation Manager and  
Head of Nanotechnology

GROWING  
A BRIGHT IDEA INTO  
A SUCCESSFUL  
BUSINESS MODEL

*Page 64*

REPORT :

Carbon nanotubes

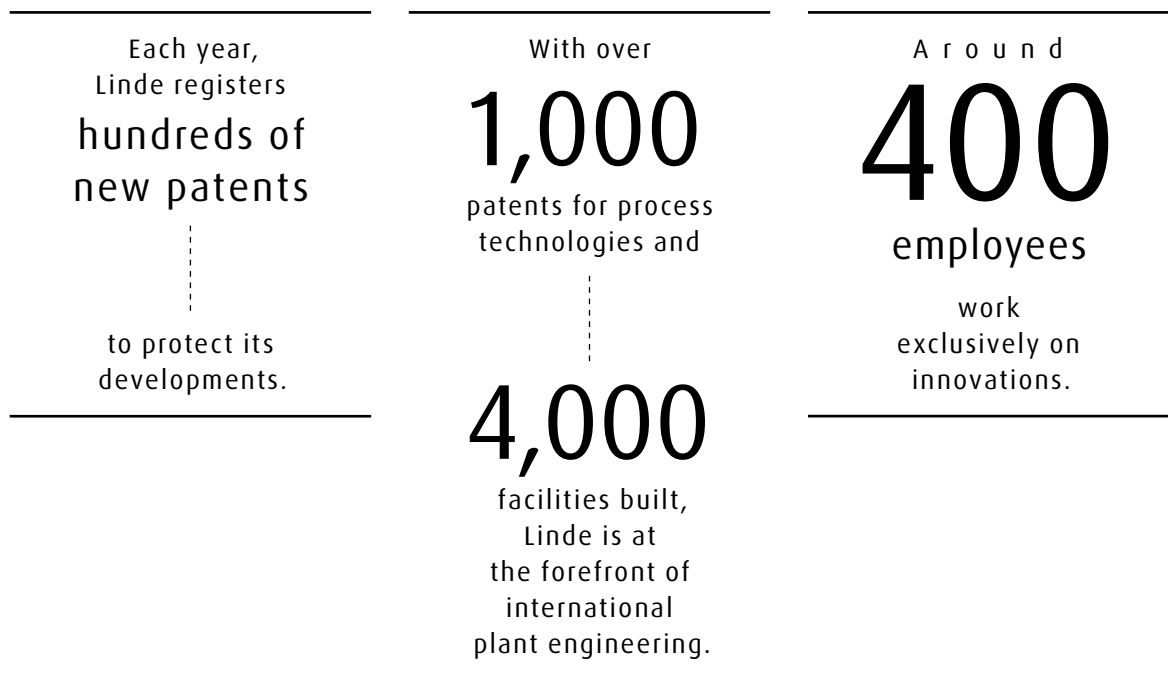
STUFF  
OF THE FUTURE

*Page 68*

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Targeted research and development activities play a defining role in Linde's long-term success. Drawing on the findings of its pure research, the company is continually moving into new areas of application for its gases and enhancing existing processes and technologies. This always involves close liaison with customers and a clear understanding of individual needs. All R&D work at Linde is inspired by a commitment to improving the environmental performance of manufacturing processes. The company is constantly looking for ways to make its plants more energy-efficient and reduce emissions. Efforts also focus on researching methods of generating liquefied natural gas with a minimal environmental footprint and on actively advancing the use of hydrogen as a fuel. Industrial-scale energy storage and biomass-to-fuel technologies also offer potential for Linde's future. And in the nanotechnology sector, the company is breaking new ground to radically simplify the production of high-tech displays for the electronics industry.





Dr Kevin McKeigue  
—  
Innovation Manager  
and Head of  
Nanotechnology

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## GROWING A BRIGHT IDEA INTO A SUCCESSFUL BUSINESS MODEL

Linde is firmly committed to supporting innovations that have the potential to reach new markets and target customers. In dedicated project groups, experts from the company team up with acclaimed institutes and scientists to bring these applications to market. Dr Kevin McKeigue explains how this works.

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*INTERVIEW*

**Dr Kevin McKeigue:****# 1: What does successful innovation management entail?**

The world is full of good ideas, but there simply aren't enough resources to pursue them all. That's why we have established a management process at Linde that targets selected innovations for further development. We focus in particular on the areas where we see the greatest potential for the company. At the same time, we want to build intellectual capital within the company – creating an internal “brain pool”, so to speak. It's true that you can license technologies, but our own patents and internal know-how are actually much more valuable to us.

**# 2: What factors determine whether or not you pursue a particular idea?**

To start off with, we look at whether an innovation aligns with our company's core business. And then it's a matter of answering key discovery questions: Could this innovation represent a fundamental advance in technology? Does it have a broad application spectrum? Is there a market for this technology? Does it meet the requirements of potential customers?

**# 3: But is that always easy to ascertain?**

Well, you need an excellent understanding of the area you are researching for new solutions. You have to have a lot of experience to answer these questions properly, and be able to draw a line from an innovation to its actual fields of application very quickly. That's the only way for us to determine whether it is really worth engaging with a project in the longer term.

**# 4: And Linde has this expertise?**

Most definitely. As a technology group with a strong tradition in innovation, we have the right people to assess the potential of new ideas and methods. We also have a strong track record in process efficiency. After all, Linde is one of the few companies worldwide with the ability to transition an initial idea to an industrial-scale facility. This is certainly an advantage, since the people who ultimately engineer a plant can be involved right from the initial research stages.

**# 5: Who has the final say when it comes to financing a project?**

If we are convinced that an idea has potential and is worthy of funding, we then reach out to the relevant innovation and R&D councils.

**# 6: Who sits on these bodies?**

They include various senior executives from the relevant business lines, as well as from Innovation Management and R&D. This is where the best suggestions across the company are pitted against each other. So, you see, there is also internal competition for the best ideas.

**# 7: How do you discover new technologies for Linde in the first place?**

You have to be very well networked and stay in close communication with the most prominent institutes. Personal contacts are vital – that’s how I get to hear about the really promising initiatives at the earliest possible stage.

**# 8: Could you give us a current example?**

In nanotechnology, close collaboration with external scientists has just enabled us to develop a process for a material made of carbon nanotubes. This could be used in flexible smartphone and tablet screens.

**# 9: How did you go about this?**

Nanotechnology is a highly specialised field that calls for dedicated expertise, so we formed a project group of chemists, physicists and materials scientists already familiar with this area. The group is also guided by a higher-level body – the advisory board.

**# 10: What role does this advisory board play?**

Staffed by Linde managers and a professor from the University of California, Berkeley (US), the board provides an objective view of the project as possible and secures the necessary resources. It also ensures that we keep current developments on our radar and adapt our projects as necessary.

**# 11: What are the success factors when forming a research team?**

You have to bear in mind that scientists are not necessarily motivated by the same aims as researchers and managers in industry. Of course, everyone is keen to develop a good technology, but the team members may evaluate the success of a project very differently. Both sides have to accommodate these differences in perspective for the partnership to run smoothly.

**# 12: What are the main differences here?**

In an industrial setting, the requirements, timelines and pressures governing project execution differ from those in a research setting. Equally, it is important for companies to understand that university researchers are not simply subcontractors, but approach their work in quite a different way. For knowledge transfer to be successful, scientists and colleagues in industry need to talk to each other and work together constructively. That is the only way to turn a bright idea into a successful business model.

**»When we look at a new technology, we ask ourselves whether there is a market for it and whether it fits with our wider strategy.«**







Dr Siân Fogden  
—  
Market and  
Technology  
Development  
Manager

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# STUFF OF THE FUTURE

From PhD to innovative process technology:  
Dr Siân Fogden's research into the dissolution of carbon  
nanotubes holds the potential for far-reaching  
enhancements to smartphone and tablet displays.  
For Linde, it also opens up new opportunities  
on the electronic materials market.

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*REPORT*

**Step # 1: A closer look:** At first glance, the material of tomorrow's displays looks quite bizarre: the carbon in the sealed jar that Dr Siân Fogden holds up has formed itself into abstract mini-sculptures made of small black crumbs. Standing in a laboratory at Linde's research and development centre in San Marcos, southern California, she explains: "They may not look it, but carbon nanotubes are strong and flexible – this is a very light material." When it comes to describing the special properties of carbon nanotubes, Fogden is bursting with enthusiasm. The 33-year-old chemist is Market and Technology Development Manager for Linde Nanomaterials.

**Dr Siân Fogden:**

**»In nanotechnology,  
everything is new,  
different and –  
in the beginning at least –  
a challenge.«**

**Step # 2: The ammonia solution:**

Once processed, carbon nanotubes offer significant advantages over established technologies for applications such as smartphone and tablet touchscreens, as they can be bent and folded without losing conductivity. Carbon nanotubes now put innovations such as an ultra-compact tablet with a screen that folds in half within our reach.

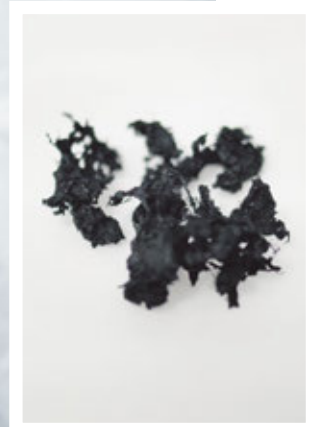
In its original state, however, the interwoven structure of carbon nanotubes more closely resembles a plate of spaghetti than a tablet flatscreen. To obtain a stable solution of this conductive material, researchers had to develop an entirely new process technology to alter the carbon at nano-level. Previously, every method of dissolving the nanotubes had the serious drawback of degrading their properties. They were often left damaged and a great deal shorter, losing some of their conductivity in the process.

Siân Fogden began tackling this dissolution challenge back in 2005. Having completed her chemistry degree at Oxford, she went on to investigate methods of organising carbon nanotubes without structural damage for her PhD at Imperial College London. For four years, her daily work focussed on ways of cleanly separating the nanotubes. Recalling her experiences during this period, Fogden declares: "In nanotechnology, everything is new, different and – in the beginning at least – a challenge. But in the end, it all came together." At a theoretical process level, ammonia provided the breakthrough. And the shift from theory to practice came in the shape of a recommendation by Dr Kevin McKeigue, Head of Nanotechnology at Linde. Years earlier, McKeigue was introduced to a team of scientists from the London Centre for Nanotechnology who were starting to investigate the dissolution of carbon nanotubes and he immediately recognised the potential of their method.



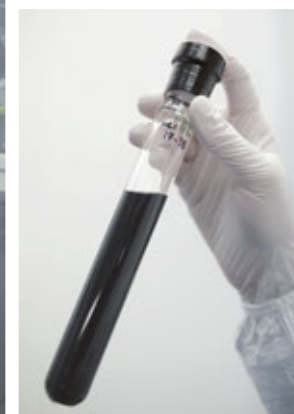
**Step #3:**  
The ammonia causes carbon nanotubes to become negatively charged, so they repel each other.

Dr Kee-Chan Kim



**Step #4:**  
The nanotubes  
dissolve  
in the liquid.

Kathleen Ligsay



**Step #5:**  
Touchscreen films  
can be manufactured  
from this  
high-tech ink.



Once Fogden's PhD had successfully established its viability, McKeigue recommended this innovative process to the Group's Advanced Technology Council for further development, licensed the patent for Linde and decided on San Marcos as the location for the new research centre. "This is the ideal location for us," explains McKeigue, "because it is also home to the research and development centre for our electronic gases, widely used in the semiconductor and electronics industry."

**Step # 3: The chemical reaction:** The newly developed method is called salt-enhanced electrostatic repulsion (SEER). It disentangles bundles of single-walled carbon nanotubes. Liquid ammonia plays a key role in this complex process – a chemical already well known to Linde engineers. Placed in this solution, the nanotubes dissolve when an alkali metal is added. This occurs because they become negatively charged. Since they all have the same charge, the tubes repel each other, which causes them to disentangle and separate into individual strings within the liquid. Removing the ammonia leaves a nanotube salt, which is then treated with an organic solvent. The result is an ink-like solution consisting of individual nanotubes – an ideal material for high-performance screens.

**Step # 4: The ink:** "In February 2013, Linde set up a new cleanroom, so now we have even better research capabilities," reveals associate chemist Kathleen Ligsay, as she pours white pellets into a test tube. She then takes a few drops from a previous ink sample. "This is when I start praying," admits Ligsay. "If the ink has been unintentionally exposed to air, we've lost several weeks' work." High-quality resource materials and a clean process are essential to produce ink of the high quality required for touchscreen development.

**Dr Siân Fogden:**

**»The core aim of every method is to generate a layer that is as thin and transparent as possible, but still able to conduct electricity.«**



**Step #6:**  
The films can conduct electricity but are also pliable, making foldable smart-phone screens a real possibility.

**Dr Amélie Catheline**



**Step # 5: The film:** Following discussions with major display manufacturers, Fogden and her manager Graham McFarlane – Head of Linde Nanomaterials – expanded the scope of their research work, turning their attention to transparent conductive films (TCFs). Deposited on a carrier substrate, these films require particularly thin and transparent layers of carbon nanotubes.

“Our colleagues in the Business Area Electronics are delighted that we have succeeded in developing such an innovative technology,” reports McFarlane.

**Step # 7: The future:** While improvements to the nanotube-based films are still ongoing in the cleanroom, Linde researchers are already experimenting with the next big material: graphene. In this case, though, the carbon molecules are not arranged into tubes but into flat sheets. Graphene is another substance with vast potential across a wide range of applications, such as aircraft manufacturing. However, as McKeigue also points out, graphene research is still in its infancy.

**Step # 6: The research:** The various ways of producing film from the ink share a common aim: generating a layer that is as thin and transparent as possible, but still able to conduct an electrical current. “The new iPhone, for example, would need extremely high-grade films,” explains McFarlane, while less sophisticated applications would not need such premium material. Amélie Catheline, a postdoc from UC Berkeley and member of the San Marcos research team, has already put the film’s performance to the test: “I folded and bent a film around sixty times without the material losing its conductivity,” she confirms. Further applications of carbon nanotubes might include sensing odours or transporting medication to the right part of the body – although that is still some way off.

**Dr Siân Fogden:**

**»Anything is possible –  
from sensing odours to  
transporting medication within  
the human body.«**

# REVIEW OF THE YEAR 2013

## JANUARY

1 / 1

Linde acquires 100 percent of the shares in Calea France SAS. Calea is a good complement to the European homecare operations purchased by Linde from Air Products in spring 2012. As a result, the Group significantly improves its position in the French homecare market.

2 / 1

Linde announces that it is to build a new air separation plant and a new nitrogen liquefaction plant on the Kwinana site in Australia. This project is part of an investment programme worth around EUR 80 m being implemented by the Group to ensure long-term security of supply for its customers in Western Australia.

## FEBRUARY

1 / 2

Linde concludes a long-term on-site contract with ArcelorMittal for the supply of gaseous oxygen and nitrogen at the Kryviy Rih site in Ukraine. The agreement is for the construction of an air separation plant and investment in the project is around EUR 64 m.

2 / 2

Linde brings on stream its new plant for the production of nitrous oxide in Chungcheongnam, Korea. The plant has a production capacity of 3,000 tonnes per annum, enabling the Group to meet rising demand in that Asian country in both the rapidly growing electronics market and the health sector.

## MARCH

1 / 3

Linde is to build six large air separation plants for Shenhua in Yinchuan, China.

Each of the six plants will have a production capacity of around 100,000 normal cubic metres of gaseous oxygen per hour. Shenhua requires the oxygen for the production of liquid fuel from coal at its coal-to-liquid complex on the Ningdong Energy Chemical Base. This is currently one of the biggest coal-to-liquid projects in the world.

2 / 3

In Kazakhstan, Linde brings on stream the first large air separation plant in the country. This plant enables the Group to supply gaseous oxygen and nitrogen to its customer ArcelorMittal, the world's largest steel company. The new plant also supplies liquefied products to the regional market in Kazakhstan.

## APRIL

1 / 4

Linde wins a major contract from Reliance Industries Ltd. (RIL) to build several plants for the production and purification of gases in Jamnagar, India. RIL requires large quantities of oxygen for its proposed plants on the site for the gasification of petroleum coke and coal. Linde will also supply two RECTISOL® acid-gas removal units to treat the synthesis gas generated by the gasification process.

2 / 4

Linde AG issues a EUR 650 m bond and a USD 500 m bond. Both transactions meet with high demand from institutional investors and retail banks. The funds generated by the transactions are used to repay the remaining portion of the syndicated credit which had been agreed by Linde in order to finance the acquisition of US homecare company Lincare.

## MAY

1 / 5

Linde is to build and operate a large ammonia plant on the Togliatti site in the Samara region of Russia in a joint venture with chemical company JSC KuibyshevAzot. The total investment in this project will be around EUR 275 m. The ultra-modern on-site plant, which is designed to be particularly energy-efficient, will have a production capacity of 1,340 tonnes of ammonia per day.

2 / 5

Linde signs a long-term on-site contract with SSI Steel UK for the supply of gaseous oxygen, nitrogen and argon on the Teesside site in England. The agreement involves the expansion of three existing air separation plants and the modernisation of the existing pipeline network. Linde will be investing GBP 25 m in this project over the next two years.

## JUNE

1 / 6

Under an on-site agreement with SIBUR, Linde will supply gases to the petrochemical company in Dzherzhinsk, Russia, and will build and operate two new air separation plants for this purpose. Linde is also modernising the four existing air separation plants on the site. Investment in the project is around EUR 70 m. The new plants will have a total production capacity of around 30,000 normal cubic metres of gaseous oxygen per hour.

2 / 6

Linde will build a new large-scale air separation plant at its US site in La Porte, Texas, as well as installing a new gasification train for its synthesis gas complex on the site. The Group will also supply related equipment and infrastructure

elements. Linde will be investing a total of more than USD 200 m in this project, which will create the largest complex in the world for the production and subsequent processing of synthesis gas to be based on natural gas.

**JULY**

1 / 7

Sapphire Energy, Inc. (one of the world's leading producers of crude oil from algae) expands its partnership with Linde to commercialise a new industrial-scale conversion technology needed to upgrade algae biomass into crude oil. The two companies will refine the hydrothermal treatment process, which uses high temperatures to exploit the whole of the algae cell.

2 / 7

BASF, Linde and ThyssenKrupp cooperate on research to develop an environmentally friendly and competitive basis for utilising the climate gas carbon dioxide on an industrial scale. They aim to employ innovative process technology to use carbon dioxide as a raw material, with positive effects on climate protection. The German Federal Ministry of Education and Research (BMBF) is sponsoring the three-year project.

**AUGUST**

1 / 8

Linde is to build the world's largest plant for the purification and liquefaction of carbon dioxide (CO<sub>2</sub>) in the Jubail Industrial Park in Saudi Arabia. The contract was awarded by Jubail United Petrochemical Company. The plant will have a capacity of 1,500 tonnes of CO<sub>2</sub> per day and will source the CO<sub>2</sub> from two nearby ethylene-glycol plants. Via a pipeline network, the CO<sub>2</sub> will then be used in the production of methanol and urea. Methanol is a basic product in the chemical industry, while urea is used for example in the manufacture of fertilisers. Carbon dioxide recycling via this project will save around 500,000 tonnes of carbon emissions per annum.

**SEPTEMBER**

1 / 9

The Supervisory Board of Linde AG appoints Dr Wolfgang Büchele as a member of the Executive Board with effect from 1 May 2014 and nominates him as CEO designate. Dr Büchele will take up his appointment as CEO following the Annual General Meeting on 20 May 2014, replacing Professor Dr Wolfgang Reitzle, whose contract ends on that date as he will have reached the stipulated age limit.

2 / 9

The six partners in the H<sub>2</sub>Mobility initiative – Air Liquide, Daimler, Linde, OMV, Shell and Total – have agreed a specific action plan for the construction of a nationwide hydrogen (H<sub>2</sub>) refuelling network in Germany for fuel-cell vehicles. The number of H<sub>2</sub> filling stations in Germany's public hydrogen infrastructure is set to increase from its current figure of 15 to around 400 by 2023. This will ensure that future supplies of hydrogen will be sufficient to meet demand from electric fuel-cell vehicles.

**OCTOBER**

1 / 1 0

Linde brings on stream its new air separation plant on the Motherwell site in Scotland. In the course of a general overhaul of the existing plants, Linde invests GBP 13.6 m in expanding its on-site capacity. Linde supplies around 18,000 customers in Scotland from the plant, which is now more efficient and environmentally friendly.

**NOVEMBER**

1 / 1 1

In its Healthcare business unit Linde launches LIV<sup>®</sup> IQ, the new generation of Linde Integrated Valves for mobile oxygen therapy onto the market. This intelligent valve has a digital flow and time display that indicates the remaining time to the exact minute and alerts the user when a critical gas level is reached and thus when it is time to change to a new cylinder. These and other intelligent functions give healthcare professionals more time to focus on patient care whilst ensuring cost-effective use of the cylinder contents.

2 / 1 1

Plans to build and operate the first liquefied natural gas terminals in Germany are coming to fruition in Hamburg and Bremerhaven, future hubs for the supply of LNG to the German coast. Bomin Linde LNG (a joint venture between Linde and Bomin Deutschland GmbH & Co. KG) finalises its preparations for the manufacture of key parts and the construction of the terminals.

**DECEMBER**

1 / 1 2

The planned Energiepark Mainz (Germany) can go ahead, with construction set to start in the spring of 2014. This has been confirmed by Siemens, Linde, RheinMain University of Applied Sciences and Stadtwerke Mainz. After its commissioning in 2015, the Energiepark Mainz is set to make a significant contribution to the success of Germany's "Energie-wende", or energy turnaround: in the pilot project, a specially developed electrolysis plant will produce major quantities of hydrogen, using energy sources including "green" electricity from wind power. This hydrogen can be stored, loaded into tank trailers or fed directly into the natural gas grid, for use in generating heat or electricity. This makes it possible to store electricity from renewable energy sources.



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### ANNUAL FINANCIAL REPORT

The Annual and the  
Financial Report of The Linde Group  
are available in both German  
and English and can also be  
downloaded from our website at  
www.linde.com. In addition,  
an interactive online version of the  
Annual Report, comprising  
the Financial Report of The Linde Group  
and the Annual, is available  
at this address. Supplementary  
information about Linde can be obtained  
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LINDE

CORPORATE PROFILE

II

THE LINDE WORLD  
CUSTOMER SEGMENTATION  
WITHIN THE GASES DIVISION

III

OUR VISION  
OUR COMPANY VALUES

IV

## CORPORATE PROFILE

### THE LINDE GROUP

In the 2013 financial year, The Linde Group generated revenue of EUR 16.655 bn, making it the largest gases and engineering company in the world with approximately 63,500 employees working in more than 100 countries worldwide. The strategy of The Linde Group is geared towards long-term, profitable growth and focuses on the expansion of its international business with forward-looking products and services. Linde acts responsibly towards its shareholders, business partners, employees, society and the environment – in every one of its business areas, regions and locations across the globe. The company is committed to technologies and products that unite the goals of customer value and sustainable development.

### ORGANISATION

The Group comprises three divisions: Gases and Engineering (the two core divisions) and Other Activities (logistics services company Gist). The largest division, Gases, has three reportable segments – EMEA (Europe, Middle East and Africa), Asia/Pacific and the Americas. These are divided into seven Regional Business Units (RBUs). The Gases Division also includes the two Global Business Units (GBUs) Healthcare (medical gases, medical devices, clinical care and related services) and Tonnage (on-site supply of gases to major customers), as well as the Business Area (BA) Electronics (electronic gases).

### GASES DIVISION

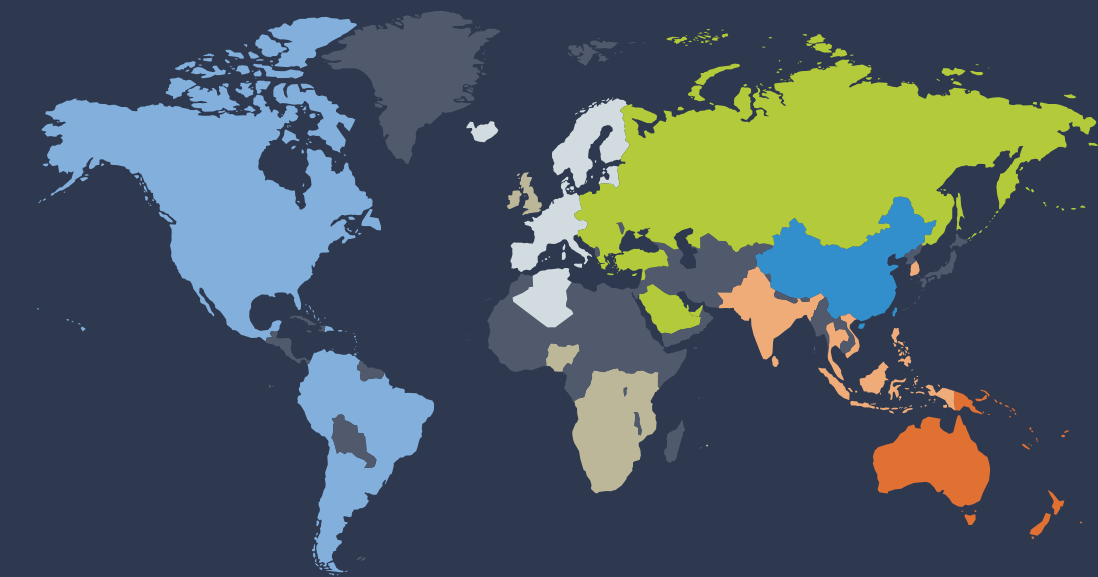
The Linde Group is a world leader in the international gases market. The company offers a wide range of compressed and liquefied gases as well as chemicals, and is the partner of choice across a huge variety of industries. Linde gases are used, for example, in the energy sector, steel production, chemical processing, environmental protection and welding, as well as in food processing, glass production and electronics. The company is also investing in the expansion of its Healthcare business (medical gases and services), and is a leading global player in the development of environmentally friendly hydrogen technologies.

### ENGINEERING DIVISION

Linde's Engineering Division is successful throughout the world, with its focus on promising market segments such as olefin, natural gas, air separation, hydrogen and synthesis gas plants. In contrast to virtually all competitors, the company can rely on its own extensive process engineering know-how in the planning, project development and construction of turnkey industrial plants. Linde plants are used in a wide variety of fields: in the petrochemical and chemical industries, in refineries and fertiliser plants, to recover air gases, to produce hydrogen and synthesis gases, to treat natural gas and in the pharmaceutical industry.

## THE LINDE WORLD

The Gases Division has three segments – EMEA (Europe, Middle East and Africa), Asia/Pacific and the Americas. These are divided into seven Regional Business Units (RBUs). The Gases Division also includes the two Global Business Units (GBUs) Healthcare (medical gases and services) and Tonnage (on-site), as well as the Business Area (BA) Electronics (electronic gases). Active the world over, the Engineering Division specialises in olefin, natural gas, air separation, hydrogen and synthesis gas plants.



■ AMERICAS  
 ■ AFRICA & UK  
 ■ CONTINENTAL & NORTHERN EUROPE  
■ MIDDLE EAST & EASTERN EUROPE  
 ■ SOUTH & EAST ASIA  
 ■ GREATER CHINA  
 ■ SOUTH PACIFIC

## CUSTOMER SEGMENTATION WITHIN THE GASES DIVISION

FOOD & BEVERAGES	CHEMISTRY & ENERGY	METALLURGY & GLASS	MANUFACTURING INDUSTRY	ELECTRONICS	HEALTHCARE	OTHERS
Aquaculture & Water Treatment	Energy	Glass & Fibre Optics	Aerospace	Solar	Hospital Care	Education & Research
Beverages	Fine & Petro-chemistry	Heat Treatment	Automotive	Semi-conductor	Homecare	Retail
Food	Pharma	Non-ferrous	Heavy Construction & Machinery	Chip Packaging	Gas Therapies	Distributors
	Other Chemistry	Steel	Light Metal Fab. & Prod.		Care Concepts	
		Other Metallurgy & Glass	Other manufacturing			

## OUR VISION

We will be the leading global gases and engineering company, admired for our people, who provide innovative solutions that make a difference to the world.

## OUR COMPANY VALUES

PASSION TO EXCEL.

INNOVATING FOR CUSTOMERS.

EMPOWERING PEOPLE.

THRIVING THROUGH DIVERSITY.





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