



ESSENTIAL

FREUDENBERG SEALING TECHNOLOGIES
THE MAGAZINE – ISSUE NOVEMBER 2014

IN TIMES OF CHANGE

Prof. Dr. Claudia Kemfert on the status of the energy transition
Five countries in an energy comparison
Sealing products for renewable energies

THE END OF MASS PRODUCTION?

What lean manufacturing has
to do with photosynthesis

ENERGY STORAGE XXL

Kingsize energy accumulators

INTO THE FUTURE ON RAILS

New technologies for clean
and quiet rail traffic



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GERMAN BEER

Spotlight on the global beer market. Why do German breweries play such a minor role in the worldwide beer market, despite brewing technology from Germany being in worldwide demand?



#1

HUMANS ARE BECOMING
URBAN CREATURES

Today, 75 percent of all people in OECD countries (including Western Europe, the U.S, Canada, Mexico, Japan and Australia among others) live in an urban environment. By the year 2040, the figure will be more than 85 percent. Outside of the OECD, the trend is developing much more rapidly. While 45 percent of the population was living in cities in 2010, the percentage will rise to more than 60 percent in 25 years.

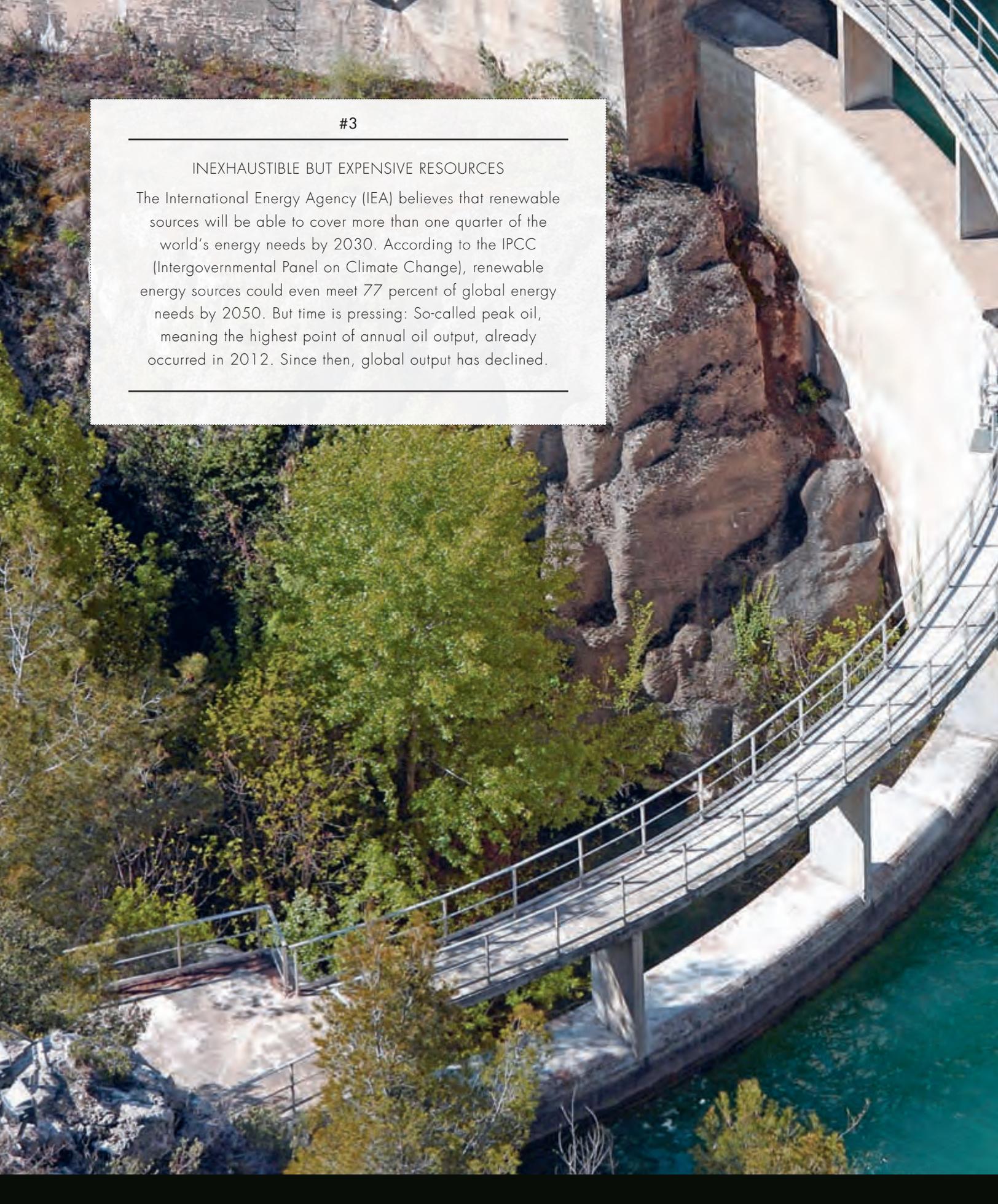


URBAN ENERGY EFFICIENCY

#2

But this is not a bad development from the standpoint of the environment and energy supplies. Thanks to smart multi-story architecture, effective public mass transit and the economical use of resources, inhabitants of modern cities consume less energy per capita than the average rural resident. If there is forward-looking planning, a more dense residential structure creates more open spaces – where environmentally friendly renewable energy can be produced and CO₂ can be simultaneously absorbed.

CO₂ emissions in New York are actually about two-thirds less than the nationwide U.S. average.

An aerial photograph of a dam structure. A concrete walkway with metal railings curves along the side of the dam. To the right, a large waterfall cascades down a rocky cliff face. The surrounding area is filled with dense green trees and vegetation. The sky is not visible, suggesting a high-angle shot.

#3

INEXHAUSTIBLE BUT EXPENSIVE RESOURCES

The International Energy Agency (IEA) believes that renewable sources will be able to cover more than one quarter of the world's energy needs by 2030. According to the IPCC (Intergovernmental Panel on Climate Change), renewable energy sources could even meet 77 percent of global energy needs by 2050. But time is pressing: So-called peak oil, meaning the highest point of annual oil output, already occurred in 2012. Since then, global output has declined.



RENEWABLE ENERGY

#4

The energy transition requires enormous financial exertions, however. Scientists at Stanford University and the University of California at Davis put the cost of making the world emissions free by 2030 at about \$100 trillion – for the systematic conversion to wind, water and solar energy. But the costs of staying with fossil-nuclear energy sources would ultimately be much higher. The Energy Watch Group puts these expenses – including all follow-up costs – at nearly \$10 trillion per year, which works out at \$150 trillion by 2030.

#5

MORE AND MORE –
BUT WITH INCREASING EFFICIENCY

Nearly 9 billion people will live on the planet by 2040. Economic output per capita will rise by up to 80 percent in the same timeframe. And the demand for energy will climb with it, but only by 38 percent. The reason: As prosperity grows, humanity is dealing with energy increasing efficiently.





ACCESS TO ENERGY

#6

This cybernetic system thrives on a balance – like nature itself – and gives the concept of sustainable energy a new facet. On this topic, Columbia University’s Center on Global Energy Policy has determined that “energy is a necessary input to improving quality of life and economic growth. Access to reliable and affordable energy sources can reduce poverty, improve public health and improve living standards in myriad ways.”



**CLAUS
MÖHLENKAMP**

CEO of
Freudenberg Sealing Technologies



A CONVERSATION ABOUT THE ENERGY TRANSITION, RENEWABLE ENERGIES AND WHY EFFICIENCY IS THE KEY TO SUSTAINABILITY.

1 MR. MÖHLENKAMP, THE ENERGY TRANSITION SEEMS INEXORABLE. WHAT DOES THIS MEAN FOR THE ENTREPRENEURIAL OPPORTUNITIES AND RISKS FACING A MARKET LEADER IN SEALING TECHNOLOGY? Without a doubt, we are seeing the need for a resource-sparing and sustainable energy supply. The growing scarcity of raw materials accompanied by an expanding global population will force industrial and developing countries to find new solutions for the production and use of energy. In early September, Global Atmosphere Watch (GAW) released a report saying that the increase in CO₂ between 2012 and 2013 was greater than at any time since 1984. So there is an enormous need for action. But from an entrepreneurial standpoint, the situation is leading to some positive approaches. Sustainable energy production in particular requires excellent sealing know-how, and we make a valuable contribution in this area.

3 WIND ENERGY IS CERTAINLY NOT THE ONLY SUSTAINABLE FORM OF ENERGY PRODUCTION WITH WHICH FREUDENBERG SEALING TECHNOLOGIES IS ENGAGED. No, but seals for wind power facilities are a key focus of our strategic orientation in the energy field. We have a head start in terms of experience here, which we are happy to exploit in view of the wind sector's global growth. We are of course developing technologies for other forms of alternative energy production. But the "energy transition" issue demands a broader approach than just a focus on the generation of electricity.

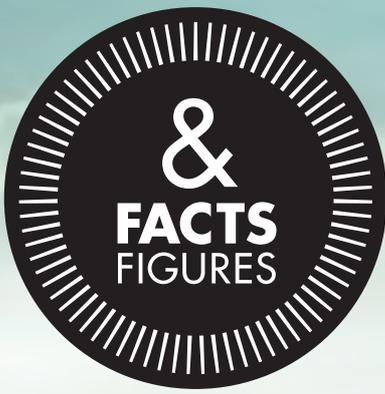
4 YOU MEAN THAT IT ALSO INVOLVES HOW THE AVAILABLE ENERGY IS USED? Exactly. The energy supplies of the future will incorporate the efficiency issue in particular. You can see the potential if you consider the differences in energy efficiency found across industrial countries. Whether due to conversion or pure waste, the energy losses that we permit as a society are huge. Efficiency is becoming the key competency of the coming decades. And efficiency is something that we are extremely familiar with as

"IN THE END, IT IS A MATTER OF ACHIEVING GREATER EFFICIENCY."

2 CAN YOU GIVE US AN EXAMPLE? Offshore wind parks are considered one of the key technologies of the energy transition. Apart from the complex anchoring of wind facilities into the sea floor, ensuring their trouble-free operation for years is also a very demanding challenge. An offshore facility can only produce clean electricity reliably and economically with a functioning seal system. We offer numerous sealing solutions for the turbines of offshore wind power plants that not only work with the lowest possible frictional losses, but even offset the eccentricities of their shafts. They also cope with the difficult conditions at sea: significant temperature fluctuations, with icing in the winter and high UV radiation in the summer, not to mention the salty air. Since tests and trial runs are not really possible for seals with a diameter of up to 3.5 meters, it all comes down to design expertise. Due to our years of experience, we have a very precise knowledge of these conditions and requirements and offer products consistent with our claim that we are the global market and technology leader.

a sealing specialist. Our products are always judged by whether they function the way they should, as well as whether they keep frictional resistance to a minimum.

5 SO A KNOWLEDGE OF FRICTION MINIMIZATION AND IMPROVEMENTS IN EFFICIENCY IS ALSO HELPING TO BRING ABOUT THE ENERGY TRANSITION? You see this at the interface between energy and mobility, one of our most important business fields. The range of an electric vehicle is the absolutely critical factor for its acceptance in the marketplace. Every electric vehicle, powered of course by electric current, generates substantially fewer emissions during operation than a conventional vehicle – if the electricity comes from a renewable source. But electric vehicles will take hold only if they can be driven with maximum efficiency and achieve an acceptable range. In this respect, the efficiency aspect is far more important for an electric car than it is for a conventional vehicle. In the long term, this applies to all areas of application where we deal with energy. In the end, it is a matter of achieving greater efficiency.

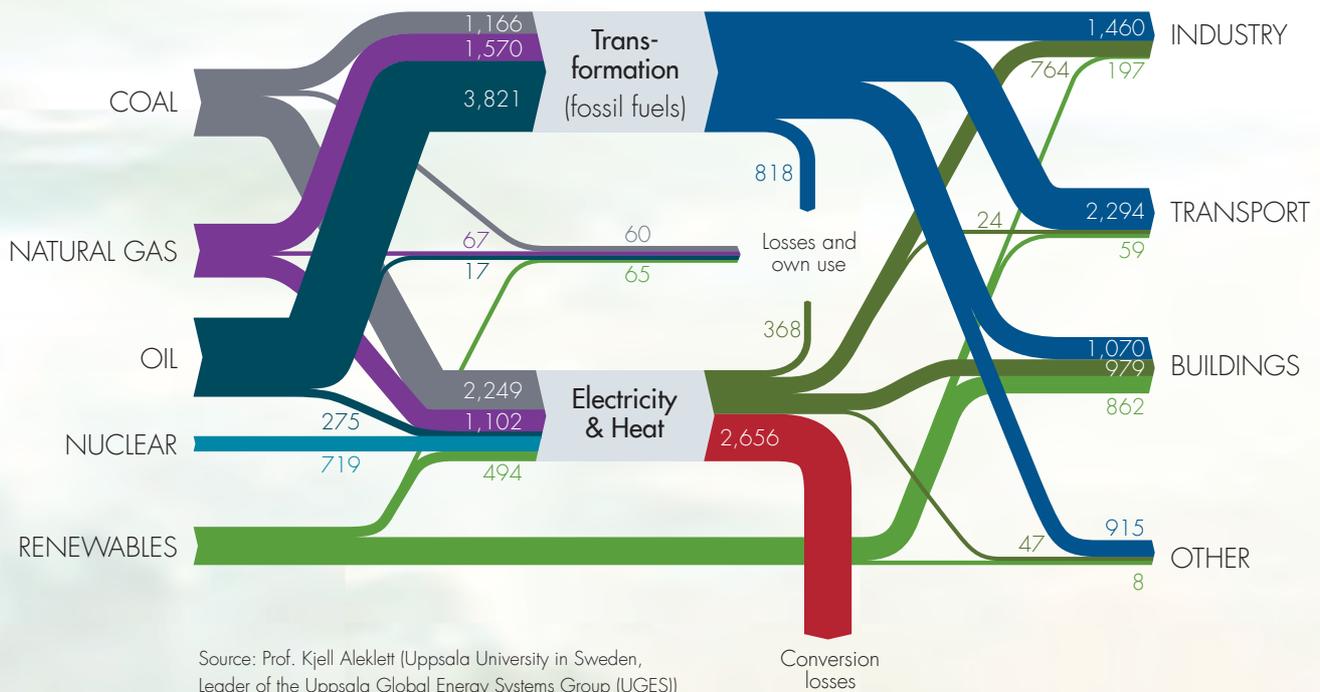


ENERGY IN FLUX

Energy has an impact on our lives. Its availability is a necessity for industry and commerce, mobility and prosperity. Without energy, there would be no production of goods, no heated homes, no cooled drinks and no trips by car or train. What are our primary sources of energy? Where do we consume the most energy and in what form? Energy is primarily transformed to make it useful for a wide variety of purposes since – whether in liquid, gaseous, electrical or chemical form – it has a hugely varying capacity to be stored or transported. During conversion, the volume of usable energy lost to humanity worldwide is greater than the amount ultimately needed to heat and power buildings – the largest area of application.

We continue to be hugely dependent on fossil energy. Today, it still covers nearly 90 percent of the energy volume worldwide. Mobility, a crucial element of our era, would be practically unimaginable without oil. Coal, which tends to be seen as the energy source of the last century, remains a provider of electricity and heat to a great many people.

THE GLOBAL ENERGY SYSTEM 2010 (MTOE¹)



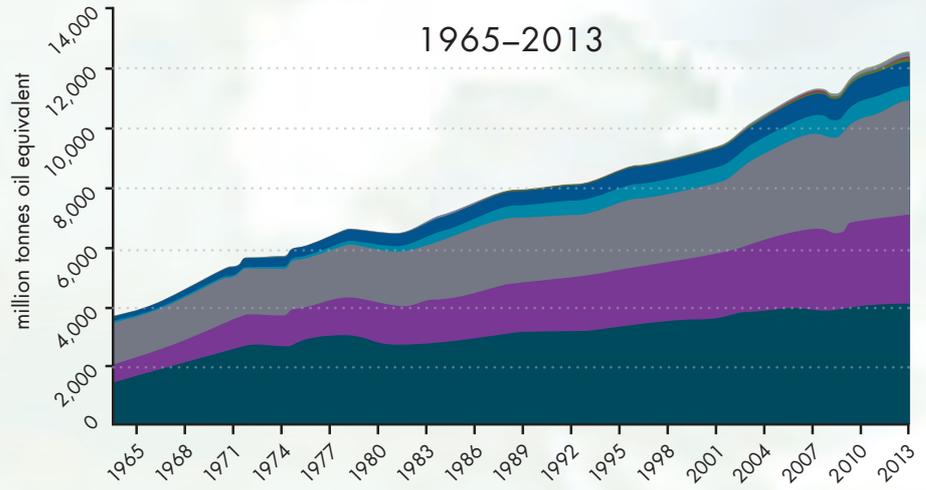
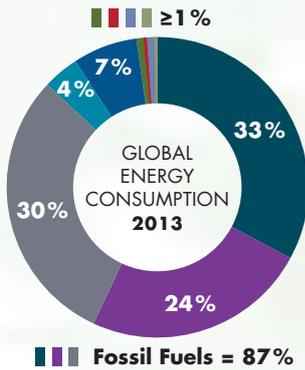
¹ MTOE = Megatons oil equivalent. ² In TWh = Terrawatt hours

THE GLOBAL HUNGER FOR ENERGY

Global energy consumption has more than tripled in the last 50 years – despite all the efforts to achieve greater efficiencies. The reasons relate to the continued growth of the world’s population and its progressive industrialization.

Developing countries in particular are a source of enormous growth in the demand for energy. It is a trend that has gained momentum since the late 1990s and that will continue for the foreseeable future.

2013 in percent



■ OIL ■ GAS ■ COAL ■ NUCLEAR ■ HYDRO ■ WIND ■ SOLAR ■ GEOTHERMAL & BIOMASS ■ BIOFUELS

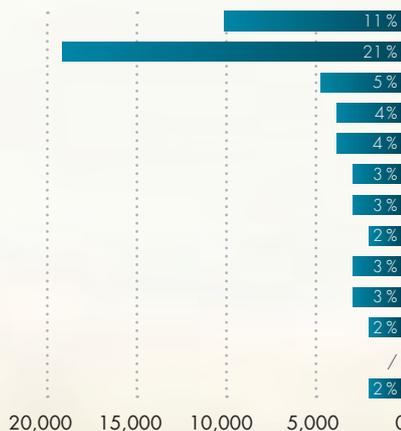
Source: euanmearns.com (BP 2014 data)

Source: euanmearns.com (BP 2014 data)

CONSUMPTION VS. PRODUCTION

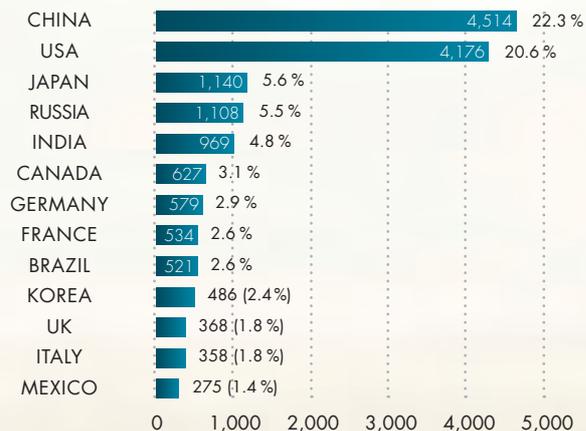
Oil consumption is an indicator of the degree of mobility. Electricity production is a marker for industrialization and the development of civilization. The U.S. consumes 21 percent of the global supply of oil. At 11 percent, the Chinese are certainly far behind the Americans, but China already produces more electricity than the U.S. And China’s rising level of mobility is having an enormous impact on its demand for oil.

OIL CONSUMPTION AS PERCENTAGE OF WORLD TOTAL BY COUNTRY IN 2012

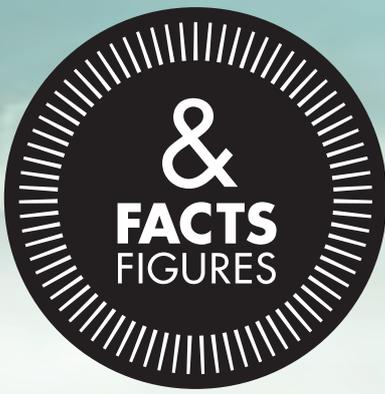


Total 2012 World Oil Consumption: 89.429 million barrels per day

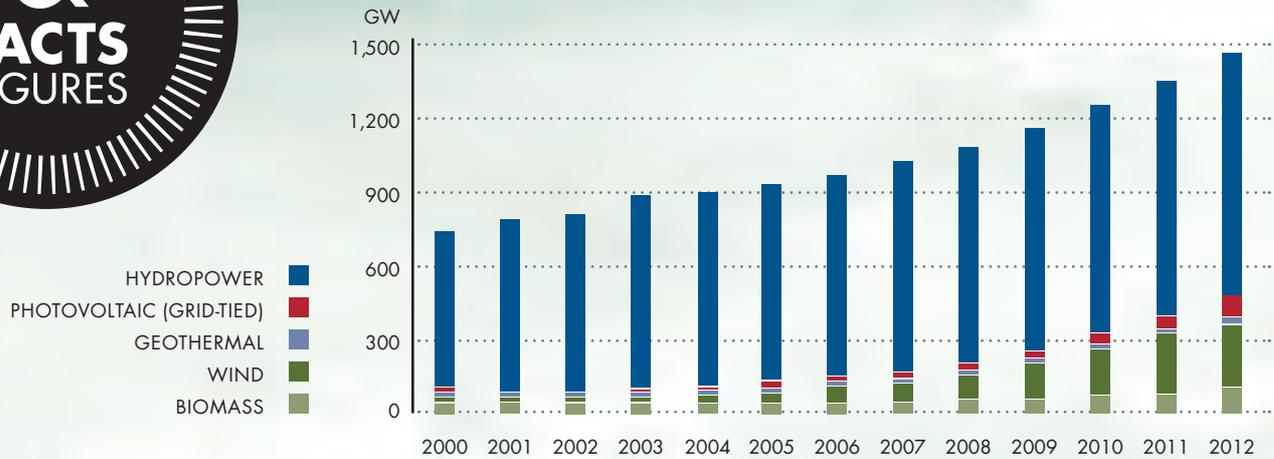
WORLD TOP 13 COUNTRIES WITH HIGHEST ELECTRICITY GENERATION² IN 2011



Source: theshiftproject.org



WORLDWIDE RENEWABLE ELECTRICITY CAPACITY



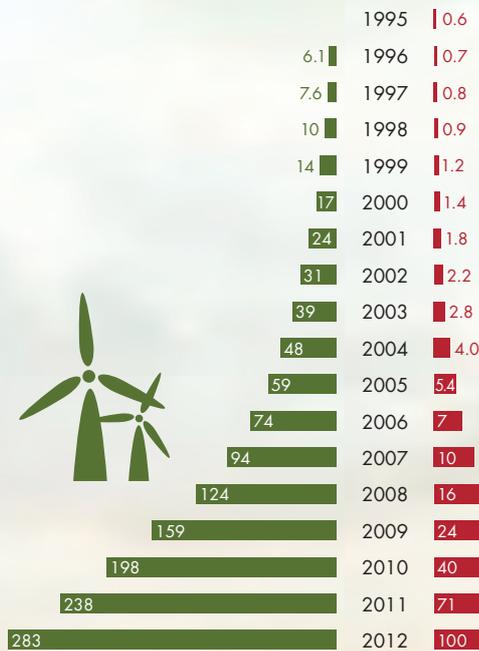
Source: Global Renewable Energy Development October 2013

A DELICATE LITTLE PLANT

Its share of global energy production is still small. About 10 percent of the global demand for energy is met by renewable sources. But the trend is gaining strength. For example, the amount of installed capacity for renewable energy has more than doubled in

the last 10 years. And the increase is not solely due to hydroelectric power, which still provides the lion's share. Wind, biomass and solar energy have become increasingly important sources that are being advanced around the world.

GLOBAL WIND ENERGY CAPACITY (1996–2012)



GLOBAL SOLAR PV CAPACITY (1995–2012)



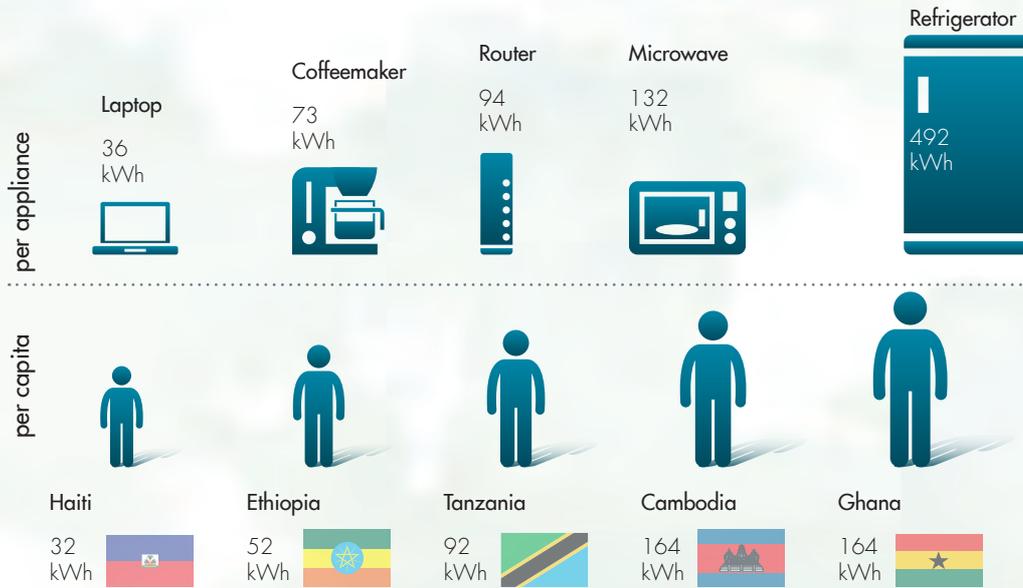
WIND AND SOLAR ARE GROWING

The knowledge of the dangers to the climate and the finite nature of fossil energy reserves have led to a rethinking that can be documented ever more clearly. Within just five years, the capacity of photovoltaic facilities has increased tenfold. The wind energy parks in place worldwide can now provide triple the volume of energy, and even many developing countries have recognized the importance of wind power in their own efforts.

Source: REN21 "Renewables 2013 Global Status Report"

³Metric Tons/year

ENERGY CONSUMPTION



Source: sierraclub.org

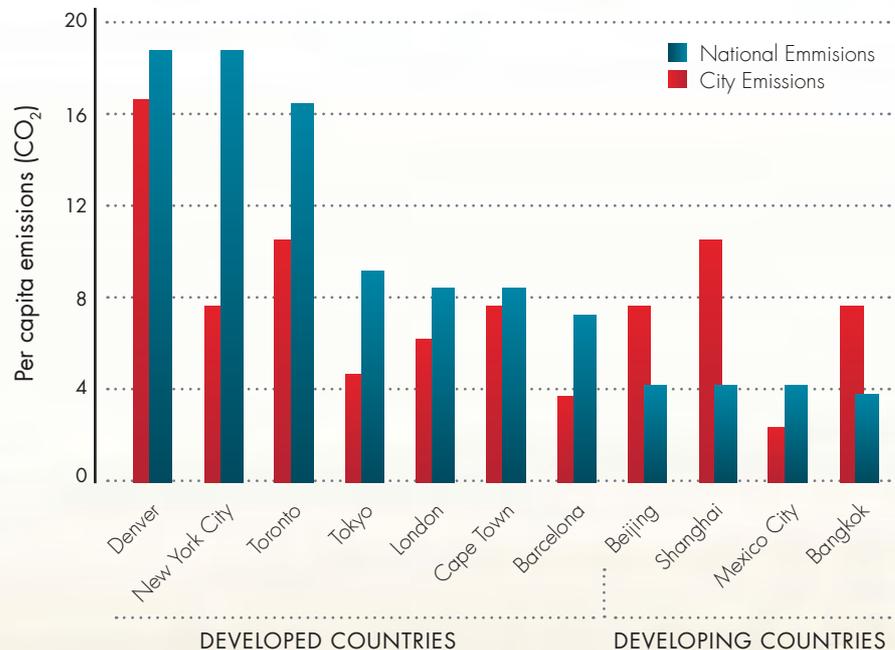
LIMITED ACCESS

Access to energy is an indicator of prosperity. Energy is only available to many people to a limited extent. In Germany, every citizen has access to 6,600 kWh. A Haitian has access to a mere 32 kWh, which is not even enough to power a laptop. About 15 Haitians would have to get together to run a refrigerator. By comparison, the amount of energy available per capita in Germany is enough for 13 refrigerators – or 183 laptops.

URBANIZATION – THE KEY TO GREATER EFFICIENCY

Megacities naturally need a great deal of energy. But from a per capita standpoint, they promote efficiency – especially due to better building insulation to deal with heat or cold and their inhabitants' reduced need for mobility. Residents of New York have on average less than half the energy needs of an American in the Midwest – here represented by CO₂ emissions per capita. The relationship is the reverse in developing countries since their rural residents continue to have very limited access to energy. The urbanization advancing around the globe will help increase energy efficiency in future. The parameters of urban centers are already coming closer to one another. For example, the inhabitants of Beijing, Bangkok, New York City and Cape Town account for nearly the same CO₂ emissions per capita.

CITY AND NATIONAL PER CAPITA EMISSIONS (CO₂)³



Source: Citywide and national per capita greenhouse gas emissions for selected locations. Source data from Kennedy et al. (2009) and Wang et al. (2012).



PROF. DR. CLAUDIA KEMFERT

has led the department of energy, transportation and environment at the German Institute for Economic Research (DIW) in Berlin, since 2004. During the same year, she began a professorship for environmental economics at the Humboldt University in Berlin. In April 2009, she moved to the private Hertie School of Governance in the German capital as a professor of energy economics and sustainability.

She is active as a consultant and political advisor on various sustainability panels and commissions.



THE ENERGY ECONOMIST

PROF. DR. CLAUDIA KEMFERT ON THE ENERGY TRANSITION, RESOURCE SCARCITY, COMPETITIVE ADVANTAGES AND THE HOPES FOR GLOBAL CLIMATE PROTECTION THAT HAVE AND HAVE NOT BEEN FULFILLED.

DR. KEMFERT – THE INCREASE IN THE WORLD'S POPULATION HAS SLOWED SOMEWHAT. NONETHELESS, ITS STEADY INCREASE CONTINUES TO CREATE MAJOR PROBLEMS WITH ENERGY SUPPLIES. IN YOUR VIEW, WHAT HAS TO HAPPEN TO ENSURE THE LONG-TERM GLOBAL SUPPLY OF ENERGY?

KEMFERT: We need an enduringly sustainable energy supply that consistently relies on the conservation of energy and the use of renewable energy and climate-friendly technologies. Fossil energy sources such as oil, coal and natural gas are increasingly expensive and in short supply. They also cause environmental problems and make a considerable contribution to climate change. A sustainable energy supply should rely on renewable energy and energy conservation in every sector. Renewable energy, especially for electric power generation, is playing an important role. The use of renewable energy should be facilitated for building energy systems, along with consistent energy conservation. In my view, sustainable mobility can combine all the aspects. For example, batteries can serve as electric power storage systems. Fuels such as hydrogen and methane can be manufactured with the help of excess renewable energy. Aside from the efficient use of energy, sustainable mobility should above all turn to climate-friendly fuels and technologies.

SUPPOSE YOU WERE TO GO BACK 10 YEARS TO THE YEAR 2004. WHAT DID YOU EXPECT THEN? WHAT WOULD HAVE HAD TO HAPPEN IN THE ENERGY AND CLIMATE FIELDS BY 2014? AND WHAT COMPARISONS WOULD YOU DRAW WITH THE REALITY TODAY? WHAT, IN YOUR VIEW, WENT BETTER – AND WHAT WENT WORSE?

KEMFERT: In the area of global climate change, people then assumed that it was possible to reduce greenhouse gases more quickly worldwide, especially since an international commitment for its reduction was made with the Kyoto protocol of 1997. Today we see that the world unfortunately failed to meet its targets. Greenhouse gas emissions are continuing to climb worldwide. To date, there has also been no success in agreeing on a follow-up agreement with international objectives on emissions reduction. In Japan, there has been an even greater reliance on fossil fuels after the Fukushima disaster. In Australia, people no longer want to hear about protecting the climate. In Asia, the hunger for energy and thus the volume of greenhouse gases are growing continually. To be sure, we can now see the first aspirations for greater climate protection in the U.S. But even in Europe, many countries have missed their own goals in this area. First and foremost in Germany, where emissions of greenhouse gases are rising and not declining – primarily because more

PROF. DR. CLAUDIA KEMFERT

»NUCLEAR ENERGY WILL RETAIN A REDUCED SHARE. THE EXPANSION OF RENEWABLE ENERGIES IS MORE IMPORTANT.«



coal-burning power plants are in operation in Germany. This country has at least surpassed its own goals for the expansion of renewable energy. That is a small ray of hope in the global battle against climate change.

WE HAVE THE IMPRESSION THAT CLIMATE CHANGE AND ITS CONSEQUENCES HAVE INCREASINGLY COME INTO QUESTION. DO YOU SHARE THIS IMPRESSION?



CONSEQUENCES OF CLIMATE CHANGE
Melting glacier in Norway

KEMFERT: No, I do not share that impression. The global IPCC report (Editor's note: International Panel on Climate Change) has very emphatically pointed out the dangers of unabated climate change. The U.S. meanwhile is facing up to climate protection, even if its ambitions are rather tentative. In Europe, in particular, people are taking the issue seriously, even if other problems are currently dominating political decision-making. Even the Chinese have understood that protection of the environment is important and that it brings economic benefits. The reason is that conserving energy helps to lower costs. The development of new climate-protection markets is an engine for innovation and offers competitive economic advantages. One would naturally want a more consistent approach to counter climate change. In any case, with the use of sustainable technologies for energy supplies and mobility, the environment and the climate can be better protected.

IS THE DEBATE OVER THE EFFECT OF CLIMATE CHANGE REALLY CONSTRUCTIVE? SHOULDN'T THE REAL ISSUE BE THE FINITE NATURE OF RESOURCES – BECAUSE THERE REALLY IS NO ALTERNATIVE OPINION ON THIS?

KEMFERT: Both should be issues since you really can't separate them. Burning fossil fuels produces greenhouse gases that endanger the climate. And the fact is that the supply of oil and natural gas is becoming tighter at a faster pace. Their extraction is becoming more expensive. But coal will still be available



INCREASED COMPETITIVENESS
The energy transition in Germany

in coming decades on nearly every continent. That is why I consider it important to bring alternative technologies to the market to protect the climate and focus on the improvement of energy efficiency around the world. This will bring innovation and economic advantages.

WHERE HAVE YOU SEEN THE GREATEST DEVELOPMENT ADVANCES IN RENEWABLE ENERGIES IN THE PAST FEW YEARS AND WHERE YOU EXPECT THE GREATEST PROGRESS IN THE FUTURE?

KEMFERT: There have been substantial learning curve effects and cost reductions in solar energy, which, however, are more based on economies of scale than on significant leaps in technology. The economies of scale are based on the global expansion of the supply of solar energy. This has reduced costs tremendously. To some extent, solar power plants today are even less expensive than their fossil fuel counterparts, as we were able to observe recently in the U.S. There will be further cost reductions in wind energy as well, especially for offshore facilities. But the greatest progress is certainly expected to be in the storage of electric power, both in the battery area as well as in the production of innovative fuels that in turn will serve as storage.

MANY COUNTRIES ARE EXPERIMENTING WITH OFFSHORE WIND ENERGY. RENEWABLE ENERGY OFTEN INVOLVES THE PROBLEM THAT THE ELECTRICITY IS NOT PRODUCED WHERE IT IS NEEDED – OR IT IS PRODUCED AT THE WRONG TIME. IN YOUR VIEW, DOES IT MAKE SENSE TO TRANSPORT ELECTRICAL ENERGY OVER HUNDREDS OF KILOMETERS WHILE LOSING MUCH OF IT IN THE PROCESS. IS THERE A TECHNICAL ALTERNATIVE?

KEMFERT: Several elements are needed to significantly increase the share of renewable energy. In addition to new electricity highways, we need decentralized solutions and more storage options. It is definitely feasible to keep the losses low during the transport of electricity through the use of new transmission technologies. But the conversion of energy systems will demand greater flexibility on our part. The demand for electricity must be able to respond to real-time prices. Energy and load management can optimize the system with the help of smart controls and intelligent networks. In addition, we will have to store more energy to offset fluctuations.

CAN A COUNTRY SHOULDER AN ENERGY TRANSITION UNILATERALLY? OR DOES SOMETHING LIKE THIS ULTIMATELY IMPAIR THE COMPETITIVENESS OF “REASONABLE” PLAYERS WHILE THE OTHERS PURSUE THEIR SELF INTEREST?

KEMFERT: The truth is that the energy transition improves competitiveness. For one thing, fossil fuels are becoming increasingly expensive and acquiring them is becoming more and more difficult due to conflicts and environmental hazards. As a result, energy conservation is the best way to lower real costs. For another, the use of innovative energy technologies produces a market advantage. After all, every country sooner or later faces the same challenges. The longer we wait, the more costly it will become. The cost of fossil energy is rising, and the cost of renewable energy is declining. That makes the “reasonable” players the winners because they are fashioning a competitive advantage. The protection of the climate creates value and jobs while preventing damage to the economy.

IF YOU WERE TO THINK ABOUT THE ENERGY TRANSITION AND DRAW UP A LIST OF RANKINGS FOR GLOBAL COMPARISON, WHICH COUNTRIES WOULD TOP THE LIST IN YOUR OPINION – AND WHY?

KEMFERT: Countries like Sweden, Italy and Brazil are in the forefront of the global ranking based on the expansion of renewable energy production and energy efficiency. In a global comparison, Germany would range in the upper midfield. I would personally put at the forefront those countries that have undertaken a massive energy transition and can show major successes. You have to include Denmark, where the expansion of renewable energy has proceeded especially well. Norway also intends to achieve an energy transition in the post-fossil-fuel era.

Overall, the Scandinavian countries are a model of sustainability. They are pursuing a holistic approach, which you can see in their waste recovery programs. We are also pinning special hopes on large and important countries such as the U.S. and China. To some extent, both countries are moving toward the protection of the environment and climate, even if the pace is exceedingly slow. Since Germany is an important model for China, it is important that the energy transition succeed in this country.



BACKGROUND

THE ENERGY TRANSITION – WHO IS FURTHEST FORWARD?

The London-based World Energy Council (WEC) is a nongovernmental, nonprofit organization with about 90 national committees that represent more than 90 percent of the world's energy production. The goal of the WEC is to advance the sustainable use of all forms of energy for the benefit of all humanity. In May 2014, Germany's member of the WEC, Weltenergierat – Deutschland e.V., published a study that identified the most important trends in the energy transition in various countries based on a variety of indicators. A number of parameters lend themselves to interesting international comparisons. They include end-use energy consumption, end-use energy intensity, per capita energy consumption and renewable energy's share of electricity consumption. Here ESSENTIAL sums up the key findings of the comparison.





THE WORLD ENERGY CHAMPION

IT IS IMPOSSIBLE TO CIRCUMVENT RENEWABLE ENERGY IF YOU WANT TO REDUCE DEPENDENCE ON FOSSIL FUELS AND SIMULTANEOUSLY MITIGATE THE EFFECTS OF GREENHOUSE GASES. A STUDY UNDER THE AUSPICES OF THE WORLD ENERGY COUNCIL COMPETENCE NETWORK HAS EXPLORED THE SITUATION IN SELECTED COUNTRIES. THE COMPARISON INCLUDES CHINA, BRAZIL, UNITED STATES, SAUDI ARABIA AND GERMANY. THE QUESTION: WHO HAS COME THE FURTHEST WITH THE ENERGY TRANSITION? WHO IS IN THE LEAD IN THE USE OF RENEWABLE ENERGY? THE RESULTS ARE SURPRISING.

FIRST PLACE: BRAZIL

It may be a surprise to many people, but Brazil is far ahead when it comes to the energy transition. The concept of transition hardly applies to South America's largest country in terms of area. The tradition of renewable energy dates almost as far back into its history as the samba. Brazil is a clear first, with renewable electricity production accounting for 84 percent of its installed capacity. Hydropower in particular accounts for a massive share of its energy production. In 2011, 35 percent of Brazil's energy consumption came from this renewable energy source. At the start of the 1990s, the share of renewable electricity production even stood at 95 percent. But hydropower and wind energy capa-

city could not keep up with the growing demand for energy during the country's ongoing economic boom. Its economy has grown an average of 3.3 percent annually over the last two decades. The country wants to put a stop to this energy trend. Energy planning for coming years clearly focuses on hydropower – despite the recent discovery of massive oil deposits in the deep ocean off the Brazilian coast, likely accompanied by considerable quantities of natural gas. By 2022, hydropower capacity is due to be expanded from 79 to 114 gigawatts. The plans for the expansion of wind energy are even more dynamic. Although wind energy has been merely a fringe phenomenon, generating 2 gigawatts until now, an expansion to 17 gigawatts of wind power capacity has been announced for the coming years. Overall,

the share of renewable energy is expected to climb further: The goal of 86 percent has been set for electricity production in 2022. The decisive factor is that Brazil's energy production is in the government's hands. It proposes an updated 10-year plan every year, which serves as the basis for proposals to investors. The type of energy production is predetermined. If the proposal calls for the creation of wind energy, no other energy source can be used. The state is also involved in setting energy prices. The government caps both gasoline and electricity prices. However, at 18 US cents per kilowatt hour, Brazilians – like customers in China and Germany – pay more than twice as much for their electricity as consumers in the U.S., for example. Renewable sources of fuel also have a long history in Brazil. Since the early 1970s,



worries about dependence on oil imports and a surplus of sugarcane have led the government to promote ethanol production. The proportion of ethanol at Brazil's filling stations is currently between 20 and 25 percent. Brazil is the second largest consumer of ethanol, trailing only the United States, and it even has to import some of its supply.

Like other countries, Brazil struggles with the reality that some of its electricity is produced in remote areas but is consumed in and around megacities. It tries to counter the high transmission losses with 500 kV and 750 kV high-voltage transmission lines. Nonetheless, the reliability of the energy supply is subject to bottlenecks – especially in dry periods. The shortages must be offset with comparatively costly fossil fuels.

SECOND PLACE: GERMANY

At 24.8 percent, Germany occupies second place in the renewable comparison and is far behind front-runner Brazil. But the dramatic increase in the last 20 years is remarkable. Back in 1990, renewable energy was still a wallflower with 5 percent. But, in the interim, it has become a true energy mainstay, with an annual growth rate of nearly 8 percent.

In contrast to Brazil, wind power has the highest share of renewable energy in Germany. With some specific problems: The high volatility of electricity production – depending on wind strength – has the result that wind power represents 19 percent of the installed power plant capacity, but only 9 percent of actual energy production. Accordingly, power must be constantly held in reserve for slack periods.

Like Brazil, Germany's sustainable energy is not necessarily produced where it is needed. As a result, the transport and storage of electricity are important issues. The available infrastructure is not up to the task. As result, there are plans to expand the available 380 kV three-phase power network. Four low-loss high voltage direct current lines – up to 800 km long – should mark the first step in developing the capacity to bring offshore electricity to the industrial regions of southern Germany efficiently. But the timing for the construction of the lines is completely up in the air at this point.

One explanation for this is that the expansion goals cited in the "network energy plan" have had to be constantly modified, in some cases massively. The exit from nuclear energy approved in 2000 was canceled with an operating life extension in 2009. The catastrophe in Fukushima, Japan, led to another course correction

in 2011. Moreover, the effort to meet the construction goals for offshore wind power plants has not succeeded so far. While the assumption in 2012 was that between 10 and 13 percent of electricity production could be covered with offshore wind turbines, the share has now been reduced to 9 to 11 percent. In any case, this will only involve a delay in the construction plans. Renewable energy's share of electricity output is due to reach 80 percent by 2050, so the "electric autobahn" would have to be in place by then at the latest.

Energy consumption in Germany has been stable for nearly 20 years – among both industrial and private customers. On the other hand, energy prices have risen dramatically – especially since the end of the 1990s. Since then, the price of electricity has risen from 7 U.S. cents per kilowatt hour to 17 U.S. cents per kilowatt hour. The prices for industrial electricity in Germany top the list in the international comparison. While the price of electricity has declined in China and the U.S. since 2009, it has been heading in the other direction in Germany. At 14 U.S. cents per kilowatt hour, industrial customers in Germany have to pay three times what their counterparts in the U.S. pay. And fuel prices are only going in one direction: up. Since 1990, the average annual increase in Germany has been 2.7 percent.



THIRD PLACE: CHINA

The most populous country on the planet is simultaneously the greatest energy consumer and producer in the world. Renewable energy accounts for at least 16 percent of the electricity production in this country. The figure was even as much as 20 percent at the start of the 1990s. In view of the country's dynamic growth, ensuring supply security is an enormous challenge, and this has been the main goal of China's energy policy. Since 1990, consumption has grown at an average of 10.2 percent annually. And not just due to industrial uses: at 16.1 percent a year, the growth in household consumption per capita has been even more significant – even though, at 426 kWh per capita, it is less than one-tenth of the comparable

figure in the United States. China's rapid economic growth has long catapulted it into first place for the generation of electricity: Coal accounts for the lion's share of the production. It is no surprise that the concentration of pollutants in many Chinese cities is more than 50 percent above the maximum value recommended by the World Health Organization. At least the country has recognized the problem: By 2013, it had already exceeded the goals of its 2010 five-year plan for more renewable energy by installing solar facilities with a total output of 11 to 12 gigawatts. According to estimates, more than 35 gigawatts could be in operation by 2015. In the wind power area, facilities with an additional 16 gigawatts were installed in 2013 alone – as much as Brazil is planning on for all its installed capacity in 2017. Overall, the five-year plan calls

for the expansion of wind power capacity by 70 gigawatts by 2015. Hydropower plants are supposed to be able to deliver as much as 120 gigawatts of additional electricity by then. And the Chinese are not bidding farewell to nuclear energy: The plan calls for a 40-gigawatt expansion. While the energy transition represents a substitution of energy sources in other countries, this is only true to a certain extent in China. Nowhere else has the shutdown of climate-damaging power plants proved harder – due to the country's steadily rising demand for electricity.

China is now dealing with another lesson: it can't reach its goals simply by creating capacity. Integrating capacity into the existing grid is proving to be a stumbling block for a rapid expansion. As a result, the National Energy Bureau was founded





in 2013 to coordinate and manage all measures centrally – a sign that the problem is on the table and its solution has been given a high priority. Another reason may be that the Chinese see the potential of renewable technologies: If the world’s largest energy producer succeeds in developing significantly less costly technologies and products for this sector, it could end up with another winning line of exports, given the looming global energy transition.

FOURTH PLACE: THE UNITED STATES

The United States is the second largest energy consumer, trailing only China. The current share of renewable energy in electricity generation is 13 percent and it has grown only 0.3 percent between 1990 and 2011. But when it comes to key energy consumption indicators, the changes in the U.S. are the least dynamic. For example, the energy consumption per capita grew an average of only 1 percent per year between 1990 and 2011, and the consumption of end-use energy grew only 0.7 percent annually during the same timeframe. The price of electricity has even dropped in the U.S. – by 0.5 percent per year.

That may be the reason why Americans continue to consume enormous amounts of electricity. At 4569 kWh per capita, the figure is nearly four times that of the German consumer. It is, in fact, the highest in the world. In general, energy is just very cheap for Americans. To be sure, fuel prices have climbed 2.7 percent per year – just as they have in Germany – but they are about half what German or Chinese drivers pay for fuel. The key driver for the U.S. energy policy is the reduction of dependence on imports. For this reason, a major effort to extract shale gas – “fracking” – is underway in the U.S.

Another issue relates to cost reductions for industry – to improve their international competitiveness – which ranks above climate protection. In 2013, the government presented a





climate action plan with three pillars: the reduction of carbon dioxide emissions, preparation for the effects of climate change and efforts to lead the battle against global climate change. The U.S. Department of Energy has introduced the Investment Tax Credit (ITC) to promote renewable energy – with comparatively long life spans and thus relative stability for solar energy. The first effects of these measures are evident: The creation of 4.8 gigawatts of solar energy represents an increase of 41 percent compared with 2012. By contrast, merely short-term incentives like those for wind energy are barely taking hold: In 2013, only 1.1 gigawatts of wind power capacity were installed, while China installed 15 times the capacity in the same timeframe.

The ongoing battle between Democrats and Republicans over the U.S. budget is hindering the implementation of a long-term energy strategy. The coordination of regulations on the federal and state levels also poses challenges. Above all, there is hardly a country where controversy dominates the debate over the effects of greenhouse gases more than in the U.S. One look at the key energy indicators reveals why. To take climate change really seriously and draw conclusions about it, no other country in the world would have to change its lifestyle as radically as the U.S. would.

FIFTH PLACE: SAUDI ARABIA

There is no known Saudi indicator showing renewable energy's share of total electricity generation – the production of electricity from sustainable sources is virtually non-existent. This desert nation, which has more than one-fifth of all proven oil deposits worldwide and is the world's largest oil exporter, relies mainly on oil and natural gas – which it has in abundance – for energy production. Although the climatic conditions seem virtually ideal for solar energy, Saudi Arabia has installed a capacity of just 12 megawatts (0.012 gigawatts).

In Saudi Arabia, the rising consumption of end-use energy – 6 percent per year since 1990 – has led to plans for the first nuclear power plant to connect to the grid in 2020. A total of 16 reactors are planned by 2030 to cover 20 percent of the country's energy needs.

But the country has at least recognized that it needs to work on the issue of its intensive use of electricity. It has founded the Saudi Energy Efficiency Center (SEEC), the main task of which is the development of energy-efficient technologies. The center's main short-term goal is the improved energy efficiency of windows and air conditioners. This is urgently needed.

Within a 20-year period, household consumption grew almost 14 percent per capita – the greatest annual growth of all the five countries in the comparison. As a result, Saudi Arabia could soon replace the U.S. as the top country for the private consumption of electricity. The difference between them is already negligible. The main reason is the extremely low price of energy. For example, the cost of electricity is only about one-tenth of that in Germany, Brazil or China, and is even significantly less than in the U.S. The price of electricity has fallen steadily over the last 20 years – by more than 2 percent annually. In the comparison, the difference in fuel prices is even more significant.

The sheikhs want to expand their renewable energy sector so the country won't damage its reputation and end up on the international sidelines. So they have formed an agency, the King Abdullah City for Atomic and Renewable Energies (K.A.CARE), designed to press ahead with both nuclear and renewable energy – which probably makes it something of a rarity worldwide. The government-financed organization has set the goal of producing a total of 41 gigawatts from solar energy, 9 gigawatts from wind energy, as well as 2 gigawatts each from biomass and geothermal sources by 2032. The country will most likely only be able to control its biggest problem – the lack of efficiency – with higher prices.

WINDENERGY HAMBURG: GLOBAL MEETING PLACE FOR THE WIND POWER SECTOR

Alternating with HUSUM WindEnergy, it is scheduled to take place every other year and is expected to establish itself as the meeting place for the global players in the energy economy. WindEnergy Hamburg was held for the first time September 23-26 2014 in the Hanseatic city. More than 1,000 exhibitors from over 30 countries used the trade fair as an important platform for dialog and introduced their new products to a professional audience. Freudenberg Sealing Technologies also presented innovative solutions at the event. First and foremost, the wind power industry requires the lowest possible friction, optimal wear characteristics and reliable functioning at low temperatures. The systems that Freudenberg presented are used to seal swivel bearings in rotating assemblies, as piston seals in hydraulic pitch cylinders and as oil seals for main transmissions



VENTOGARD

The profile rings that Freudenberg Sealing Technologies developed to seal swivel bearings in rotating assemblies are geared to functional reliability and longevity. The premium material Ventogard stands out for its excellent temperature flexibility. Another advantage is its resistance to ozone, salt water and fats – making it ideally suited to a variety of applications. For example, while the compound used in swivel bearings exhibits very good relaxation behavior, another compound used to seal the housing is optimized more for resistance to weathering.





NEW POLYURETHANE MATERIAL

The new polyurethane material shows the potential in the development of base materials for seals. In comparison with the standard PU seal, it has a significantly longer service life, is more resistant to water and is conceived for a broader usage spectrum. Its viscoelastic behavior was optimized to maintain the flexibility of its soft segments. As a result, the seals function reliably up to 120°C and are still flexible enough for use in wind power facilities at low temperatures. In comparison tests, the new material displays no appreciable evidence of wear, even when traditional seals fail prematurely. At 120 MPa, its tear resistance is about 30 percent greater than that of comparable polyurethanes.



SIMKO 300

Normal sealing systems in hydraulic piston accumulators mostly employ two seals, one for oil and another for gas. Since the two seals are used "back-to-back", there is supposed to be a pressure relief mechanism between the seals. If the pressure relief fails, any leakage leads to a complete breakdown of the hydraulic system. The SIMKO 300 seal ring is a single seal consisting of a polyurethane seal ring and an elastomer pressure ring. At a Shore hardness of 98, the polyurethane material roughly corresponds to the hardness of PTFE, but is less susceptible to damage - during installation, for example. The material's excellent form stability, good wear resistance, and effective sealing operation and longevity make the Simko 300 seal especially appealing for use in the piston accumulators of wind turbines.

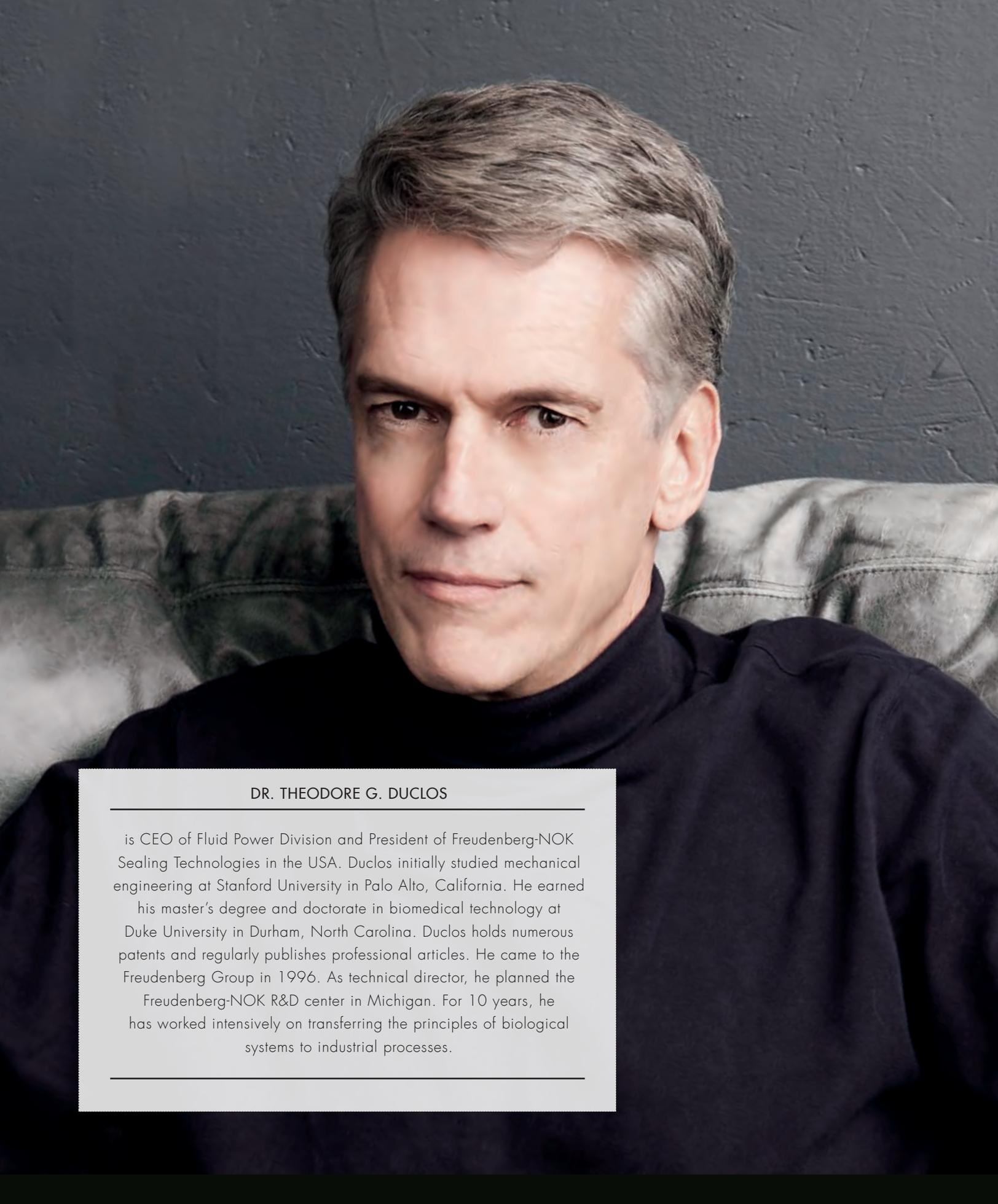


RADIAMATIC® RCD

The PTFE Radiamatic® RCD labyrinth seal is destined for use in the main transmissions of wind power facilities. Freudenberg Sealing Technologies is setting new standards for durability, design and the use of materials with this new liquid-collecting labyrinth seal. The letters RCD stand for its three main functional principles: Transmission oil spray is rejected (rejection); residual oil is collected in collection chambers (collection) and fed into the oil sump (drain). This contactless, wear-free approach enables a service life of several decades.

Shaft surfaces and housings for main transmissions can now be manufactured at a lower cost because they can be produced without additional processing. The Radiamatic RCD is self-locating and can compensate for shaft flexing. With its extra dust protection and assembly aids in one single solution, mounting the seal in open installation spaces leads to even more savings. The seal's production using machining and not molds allows fast modification to meet customer needs and short delivery times.





DR. THEODORE G. DUCLOS

is CEO of Fluid Power Division and President of Freudenberg-NOK Sealing Technologies in the USA. Duclos initially studied mechanical engineering at Stanford University in Palo Alto, California. He earned his master's degree and doctorate in biomedical technology at Duke University in Durham, North Carolina. Duclos holds numerous patents and regularly publishes professional articles. He came to the Freudenberg Group in 1996. As technical director, he planned the Freudenberg-NOK R&D center in Michigan. For 10 years, he has worked intensively on transferring the principles of biological systems to industrial processes.



THE END OF MASS PRODUCTION?

DR. TED DUCLOS IS RESPONSIBLE FOR SEVERAL GLOBALLY ACTIVE FLUID TECHNOLOGY PLANTS AS WELL AS REGIONAL FLUID TECHNOLOGY PLANTS. ESSENTIAL SPOKE WITH HIM ABOUT HIS EXTRAORDINARY BACKGROUND, ON NEW DIRECTIONS IN LEAN MANUFACTURING AND A PARADIGM SHIFT IN MASS PRODUCTION.

DR. DUCLOS, YOU STUDIED BIOMEDICAL ENGINEERING. HOW DOES THAT FIT IN WITH FREUDENBERG SEALING TECHNOLOGIES?

DUCLOS: In fact, I began my education as a mechanical engineering student, which was a good match for my inclinations. But my mother worked as a nurse, so there was always a certain interest in medical topics. Actually, I have always found both topics exciting: mechanical engineering and medicine. A scholarship offered to me by Duke University in North Carolina was the turning point. I was able to study biomedical engineering there and work on a project involving sensor feedback in prosthetics. This gave me the opportunity to combine both interests.

WHAT DID YOU TAKE FROM YOUR STUDIES INTO YOUR LATER CAREER?

DUCLOS: I especially developed a great respect for nature. I learned to appreciate how sophisticated and esthetic biological systems are. And I learned a great deal about their functionality and efficiency. What we encounter in natural systems is very complex on one hand, but composed of individual building blocks that are very simple and fulfill a single purpose. Conversely, you don't find anything that does not fulfill a function – unless evolution has not yet eliminated a particular building block. Toward the end of my studies, I was able to determine that my experience in biomechanics had applications in other areas as well. I approached Lord

Corporation, which was building a research and development center in North Carolina. During my first conversations, it became clear to me how many parallels there were between biological systems, on one hand, and systems and components made of metal, rubber and polymers on the other.

WHAT IS THE CONNECTION BETWEEN BIOLOGICAL SYSTEMS AND INDUSTRIAL PRODUCTION?

DUCLOS: In my view, the creation and growth of biological objects are the first results of lean manufacturing. Plants are the ultimate lean production factories. They need no intermediate stock to manufacture the end product. They use photosynthesis



to create energy, which drives their growth and produces new material for their survival. Plants reproduce themselves, molecule by molecule, in parallel processes. And they are very efficient at it because they produce little waste. You can apply these principles to industrial production. Are we really making only what is necessary? If you internalize the nature of biological systems, they inevitably lead you to lean manufacturing. And you learn to think on a smaller scale.

AS A GLOBAL PLAYER, WOULDN'T YOU NEED TO THINK ON A LARGER SCALE INSTEAD?

DUCLOS: My first job at Freudenberg was to establish a development center for North America. It was very good, for me and for Freudenberg, that I had plenty of freedom to implement my ideas. One central aspect of a biological system is bringing things together that ultimately create something complex from simple building blocks – and we apply these basic principles to industrial production. This requires a radical rejection of established patterns of thought. Thinking on a smaller scale is actually part of this. One example is the fact that we are striving to use fewer and fewer cavities per mold. The approach is truly revolutionary.

THAT DOES SOUND REVOLUTIONARY. BUT YOU SHOULD ASSUME THAT THE INCREASINGLY LONG PRODUCTION RUNS FOR THE GLOBAL MARKET ALSO LEAD TO EVER LARGER BATCHES IN THE PRODUCTION PROCESS.

DUCLOS: Just the opposite is true. Our motivation is to work more efficiently and, at the same time, achieve a higher level of quality. For example, we are reducing our material use. If you have a mold with 20 cavities, injection residue accumulates. In a number of materials, you can collect, grind up and reuse this waste product. But that takes more time. And the more frequently you subject the material to this process, the more quality suffers. If we do without a cavity, we get by without injection residue and reduce the effort for the final processing of the article and the potential processing of the waste material.

BUT CAN YOU ACTUALLY PRODUCE THE REQUIRED VOLUMES IN THE SAME TIMEFRAME IN THIS WAY?

DUCLOS: As the example of the injection residue shows, we are reducing the number of required production steps. If the cycle times are short enough, we can generally achieve higher volumes when we are producing parts individually, one after

another, instead of numerous parts in one step. In the process, we are certainly not replacing a 10-cavity mold with 10 molds with one cavity each, but are limiting ourselves to one simple mold per facility. This way, we are freeing ourselves from the disadvantages that a 10-cavity mold entails.

WHAT ARE THOSE ADVANTAGES?

DUCLOS: To start with, the capacity of a 10-cavity mold is often greater than what is actually needed. The disadvantage that you accept is the constant switching of the mold. Ultimately, you want to produce no more than you can sell. By contrast, with a “single mold,” you can produce as many parts as you want. With small batches, you gain a great deal of flexibility in production. You also achieve greater flexibility in logistics and production planning. If you are working with a 10-cavity mold, you want to produce all the parts at one facility. But if you use three or four one-cavity molds, you can use them in the precise production process where they are needed.

There is another aspect: When we used to work with a 10-cavity mold and one cavity broke, we continued to work with nine cavities. The productivity that we lost was never built into our cost models or business cases. We would actually have had to ask ourselves, “How many cavities have to break before we stop production for repairs?” But when we work with one cavity,



PLANTS SET A NATURAL EXAMPLE

Lean manufacturing in perfection

and it breaks, we have to make an immediate repair. We are under pressure to handle things immediately to keep the system running and avoid complacency about productivity losses.

WHAT IS THE QUALITY LIKE? DOES IT REMAIN CONSTANT?

DUCLOS: That is one of the most important arguments for our strategy. By removing production steps, we are also eliminating areas where quality problems can occur – for example, in the trimming of a part. The production tolerances for one mold with one cavity are considerably lower than for a mold with multiple cavities. Our data demonstrate that it is virtually impossible to produce the same quality with a four-cavity mold as with a one-cavity mold. The larger the mold, the more variation in the temperature and pressure distribution, as well as the distribution of the material inside it. It is ultimately possible to ensure consistent quality in this way. I consider this to be proof of the applicability of the principles of biological systems. By configuring things more simply and on a smaller scale, we can get by with fewer resources and work more stably and effectively.

WOULD YOU DESCRIBE THIS PROCESS AS THE CORE OF YOUR COMPANY?

DUCLOS: I am convinced that thinking in terms of lean systems is something approaching the core of Freudenberg Sealing Technologies. We are a supplier to an extremely wide variety of industries and a provider of very high-value and highly technical products. So we must be very good at the things that we make, and manufacture them efficiently. We invest a great deal of time in understanding the technical foundations. I think part of what makes the company so special is that we combine our broad technical experience in the product area with our commitment to precision and quality in production.

This commitment accompanies us through the entire process chain, starting with how we configure our facilities, define processes and manage our facilities. It involves where we get our ideas and how we promote the ideas of our employees so we can continually improve. One side is our material and production know-how and an understanding of the market's requirements. The other driver is the commitment to continual improvement on the production side. Our great task is to bring the possibilities of technology into harmony with the needs of the market. The nice part is that it's a lot of fun!



A GROWING FAMILY



WITH ITS HYDRAULIC ACCUMULATORS, FREUDENBERG SEALING TECHNOLOGIES IS MAKING A KEY CONTRIBUTION TO APPLICATIONS SUCH AS START-STOP SYSTEMS AND AUTOMATIC TRANSMISSIONS. LARGER HYDRAULIC ACCUMULATORS FOR INDUSTRIAL USES WERE NOT PREVIOUSLY PART OF THE FST PRODUCT LINE. THIS HAS NOW CHANGED. TOBUL ACCUMULATOR INC., A LEADING DEVELOPER AND MANUFACTURER OF HYDRAULIC ENERGY STORAGE SYSTEMS, HAS BEEN PART OF THE FREUDENBERG GROUP SINCE THE END OF JULY 2014.





Tobul products ideally round out the company's existing portfolio of miniaturized hydraulic accumulators from FST's global Lead Center Accumulators in Remagen, Germany. Part of the newly formed Accumulator & Vibration Control Division, which launches in January 2015 under the direction of Kurt Ziminski, Tobul is allowing FST to pursue new strategic objectives.

The products manufactured by Tobul Inc, founded by Jim Tobul in 1980, include piston and bladder accumulators for industrial applications. Its focus is on the energy/oil and gas, mining and fluid power market segments in North and South America. Hydraulic accumulators for blowout preventers are its most important product line.

They are used to prevent the uncontrolled flow of drilling fluids, oil or natural gas during the extraction of raw materials.

STRONGER IN ALL MARKETS

"With the Tobul acquisition, we are strengthening our established accumulator business by expanding our portfolio with innovative, technical solutions," said Dr. Mohsen Sohi, Freudenberg Group CEO. "This also gives us production capacity in the U.S." The acquisition makes it possible for Freudenberg Sealing Technologies to set new strategic goals. It reduces the

company's heavy dependence on accumulator production for the auto industry and ensures a better balance in various regions thanks to the American firm's presence in the North American Free Trade Agreement (NAFTA) zone. Tobul industrial accumulators are used in more than 50 countries.

"Becoming part of the Freudenberg Group is crucial for our development," said Jim Tobul, who will continue to work for the company. "In this kind of globally positioned technology alliance, we can use the Freudenberg Sealing Technologies market presence to further expand our business internationally and become No. 1 in the hydraulic accumulators market."



1 HYDRAULIC ACCUMULATOR APPLICATIONS

ACCUMULATORS EMPLOYED IN MULTIPLE WAYS:

► ENERGY STORAGE

Hydraulic accumulators contain a gas combined with a hydraulic fluid. The oil normally used in hydraulic applications is compressed to 1.7 percent of its natural volume under a pressure of 350 bar. The system pressure breaks down even with the slightest loss of pressure – so leak tightness is the highest possible priority for the accumulator's functionality. The gas corresponds to the hydraulic fluid and can be compressed under high pressures to low volumes within the accumulator. Potential energy is stored in the form of compressed gas, to be released when needed. In the piston accumulator, the compressed gas exerts pressure on the piston, which then presses the hydraulic fluid from the cylinder into the system where the energy is needed.

► PULSATION DAMPING

In most hydraulic systems, pumps deliver the necessary force. Many pumps produce this force in pulsations, that is, non-continuously. The use of pulsation dampers can offset this effect by providing a continuous delivery stream. Piston pumps, which are normally used for higher pressures, have a tendency to transfer undesirable vibrations to the high-pressure system. With hydraulic accumulators within the system, these pressure fluctuations can be decisively offset.

BIG AND NEW

The sizes of Tobul accumulators sharply distinguish them from the miniaturized hydraulic accumulators produced by the Lead Center Accumulators in Remagen, where about 2.6 million units come off the line each year. Some of the Tobul energy accumulators manufactured to customer specifications measure up to 28 inches (71.12 cm) in diameter and have a volume of more than 1,100 liters. They are also made from innovative materials: for example, the company supplies piston accumulators made from stainless steel, aluminum or high-strength carbon.

A key factor in the acquisition was the two companies' totally complementary product portfolios. In fact, there was no overlap at all – the bladder and piston accumulators for industrial applications represented completely new territory for FST. At the same time, Tobul has not previously had a presence in the automotive sector. The globally recognized materials and sealing competency of Freudenberg Sealing Technologies was a crucial criterion for the American firm to become a member of the Freudenberg Group. The reason is that the sealing of the hydraulic cylinder is an absolutely key technology for the safe and reliable operation of hydraulic accumulators. Customers of both companies will benefit in future from design and production expertise in this area.

BROAD APPLICATION SPECTRUM

Tobul accumulators are used in extremely wide-ranging fields – in the chemical industry as well as hydropower and wind energy facilities. But they are also found in amusement parks, where they serve as emergency braking aids. Other typical areas of application are agriculture, forestry and mining. But hydraulic accumulators are also used in ships, aircraft and even in the aerospace sector.

The American company also has expertise in other products in the high-pressure field. For example, Tobul makes safety valves and blowout disks for hydraulic systems. Cylindrical high-pressure vessels made from carbon, steel or aluminum are part of the product line. The company is especially proud of its vertical integration – nearly 100 percent of all its products are made entirely in its own production operations. In the U.S., the company has modern production facilities at its headquarters in Bamberg, South Carolina, and in Houston, Texas, and it operates a sales office in Shanghai, China.

PERFECT PARTNER

Freudenberg Sealing Technologies' global Lead Center for accumulators – primarily for the auto industry – is located in Remagen, Germany. "The two companies complement each other tremendously," said Claus Möhlenkamp, CEO of Freudenberg Sealing Technologies. "Synergies in know-how and in regional markets can be exploited, along with those in the after-sales business." Japan's EKK Group has a 25 percent stake in the accumulators business.

2 HYDRAULIC ACCUMULATOR APPLICATIONS

▶ SHOCK DAMPING

When a driven element stops suddenly, it can trigger a reverse shockwave in a hydraulic system. The percussion wave frequently exhibits pressures that are several times higher than the normal operating pressure. This can lead not only to higher noise levels, but even a system breakdown. Once integrated into the system, the gas cushion in a hydraulic accumulator can substantially minimize the extent of the shock. One example is the percussion absorption when a tractor's hydraulically driven loading shovel suddenly stops. Without accumulators, one result would be that the rear wheels lift up. Another would be a violent impulse from the tractor frame and axle.

▶ DELIVERING ADDITIONAL ENERGY

An accumulator that stores electricity can supplement a fluid pump by providing electrical energy. During the idling stages of the work cycle, the pump stores potential energy in a battery. The battery feeds this reserve power back into the system when the cycle requires it, whether in an emergency or when peak performance is called upon. This makes it possible to use smaller pumps with a lower basic output, reducing costs.

▶ PRESSURE BACKUP

Pressure changes can appear in a hydraulic system when the fluid is exposed to rising or falling temperatures or when leakage occurs. A hydraulic accumulator can compensate for such pressure changes by taking in or releasing small quantities of hydraulic fluid. If the main energy source malfunctions, the accumulator can also serve as an auxiliary energy source to ensure that system pressure is maintained.

▶ DISTRIBUTION

A hydraulic accumulator can also be used to distribute fluids such as lubricating grease or lubricating oil under pressure with precise dosing and targeting.



DRIVING IN CHINA

TEN-LANE ROADS WITH ENDLESS LINES OF CARS MOVING IN BOTH DIRECTIONS. TRAFFIC POLICE WITH THE GRACE OF DANCERS TRY TO BRING ORDER TO THE CHAOS IN THE MIDST OF THE OVERSIZED INTERSECTIONS – AND CONTROL THE VEHICLES STREAMING IN FROM SEVEN DIRECTIONS. MULTILEVEL BRIDGES OVER WHICH A NEVER-ENDING FLOW OF CARS, TRUCKS, BUSES AND TWO-WHEELED VEHICLES CONTINUES NEARLY EVERY HOUR OF THE DAY AND NIGHT. WE HAVE THOSE IMAGES IN MIND – BUT HOW DO THINGS LOOK FROM THE PERSPECTIVE OF THOSE WHO DRIVE IN CHINA’S MAJOR CITIES EVERY DAY? AND WHAT DOES ONE NEED TO DO TO BECOME A PARTICIPANT IN THE COUNTRY’S URBAN TRAFFIC ADVENTURE? ESSENTIAL TAKES A LOOK BEHIND THE SCENES.

Her name is Emma Yang. She is 32 years old, married and the mother of a four-year-old daughter. Emma is not her real first name – her Chinese friends call her Danhong. But many Chinese women adopt an international first name if they frequently come into contact with foreigners. That applies to Emma, who works for an international advertising agency in the middle of Beijing. Her position as a project manager at the agency is already her third job after completing her studies – and her third in Beijing. The extremely high density of domestic and foreign firms in the metropolis makes it easier to change jobs. She makes 15,000 renminbi yuan (1,800 euros) a month, quite a good income, and the family’s income is considerably beyond what it needs for an apartment, a child and general living expenses. This is the basic precondition for someone considering the

purchase of a car. The opportunity first came along for the Yang household two years ago. Emma comes from a traditional Chinese family and studied in both China and the U.S. She is simultaneously open to the world and deeply rooted in the Chinese culture. For Emma, it would be extremely discomfiting to drive a car with a license plate ending with the number “4”, but more on that later.

THE PATH TO A DRIVER’S LICENSE – THE LONG MARCH THROUGH THE AGENCIES

Like everywhere else in the world, drivers in China have to obtain a driver’s license. The

mandatory program includes theoretical lessons and a test with questions on rules and traffic signs. If drivers pass the written test, they move on to the first driving lesson. But they are not accompanied by a driving instructor on public roads – as is the case in most other countries – but in a blocked-off practice area. This may make learning to drive somewhat less stressful, but it is vastly different from driving in China’s tough everyday traffic. Numerous guides are painted onto the course, offering tips on proper alignments or turns. The aids are certainly helpful during the practice sessions, but they aren’t available during the drivers’ everyday routines. Incidentally, when the practice vehicles were assigned, Emma immediately had to choose either a car with manual or automatic transmission. The principle that applies is – once a manual transmission, always a manual transmission – and the reverse.



The next step is at least consistent: A test, actually a practical driving trial, is held in the protected area as well. But the training still isn't over – far from it. After passing the practical sessions, the driving student still has to sign up for “roadtraining” in real traffic, offered in small, medium and large packages. They may not exceed three hours of driving. Emma decided on the large package and afterwards felt reasonably well prepared for her driver's license test in Beijing traffic. Accompanied by two instructors, the driver covers a predefined course. Even if the individual's driving skills stand up to the two experts' critical assessments,

the student is still not given the green light for unsupervised driving. A fourth test is required – the Chinese do like to be thorough. The final test consists of yet another written examination, which no longer merely covers traffic signs and rules. It features multiple-choice questions on typical traffic scenarios, with just one correct answer in each case. Success only comes when the student has cleared this last hurdle. A driver's license is the reward for all the effort. Did Emma feel prepared for tough everyday traffic after just three hours of real-life driving? She says no. That's why she took additional private driving lessons to boost her comfort level, as many of her compatriots do.

ONE LICENSE PLATE – BUT MANY MEANINGS

If a German driver attracts attention with his unconventional or poor driving, more knowledgeable observers grumble that the person probably won his driver's license “in the lotto”. In Beijing, driver's licenses and lotteries actually do have something in common: Without a driver's license, you cannot participate in the lottery for a license plate. This doesn't mean a vanity plate. Because demand is high and traffic is becoming denser, Beijing's administration issues only a limited number of new license plates every other month. To obtain one of them, you have either to be from Beijing or – there is always a pragmatic solution in China – pay extra taxes for five years.

License plates can also be passed on within the family or even inherited. But the basic prerequisite is always to have a valid driver's license. The waiting period can easily be as much as two to three years – it was “only” six months for Emma. The assignment of a license plate is in any case a major event that is celebrated lavishly with friends and relatives. But all the excitement can fade if the combination



FREUDENBERG SEALING TECHNOLOGIES IN CHINA

Freudenberg Sealing Technologies has been involved in the manufacture of seals and components in China for more than two decades. In the process, the company has followed the guiding principles written down by Carl Johann Freudenberg in 1887 that formed a company culture based on innovation, closeness to the customer, responsibility, leadership, people and a long-term orientation. Torsten Maschke, President Automotive Marketing and Sales at Freudenberg Sealing Technologies, considers these values to be an important guide even today. "Companies that want to take advantage of opportunities in this country must be ready to manufacture in this country as well. Moreover, they have to be fully integrated locally to be successful," he said. A main component of the FST philosophy is not to develop new regions just because of their low labor costs. The investments are made where the company can become a local supplier. "We want to manufacture where our customers are," Maschke said. "That means adapting innovations, business processes and technologies to local needs and cultures."

The benefits of an industrial presence in China are not solely related to the sheer size of the market. This is how companies can better meet the fast-changing needs of the international customers that are manufacturing locally. At the same time, relationships with Chinese vehicle manufacturers can be expanded. As for the central issue of how to compete with established local players, FST has the answer: higher quality, better processes, more innovations and superior customer service. To sum it up: The goal is to offer greater added value than the competition as a local and international supplier. FST's activities in China are undertaken through a joint venture with the Japanese NOK Corporation. Meanwhile, there are more than 70 Freudenberg locations with 6,300 employees and 23 production facilities in China.



of letters and digits ends with a "4". The Chinese word "si" for four sounds like "si" for "death" – an omen of disaster to many superstitious Chinese. That's why there is no fourth or 14th floor in many high-rise buildings in China and Taiwan. In Taiwan, there are actually no license plate numbers that end in "4". Emma was lucky. Her license plate number ended with a "2". This number stands for a balance of yin and yang – and therefore harmony, one of the most important Confucian life goals. The only better number would have been an "8", a synonym for wealth and plenty, but you can't have everything.

The final digits of a license plate have another, much more practical meaning – namely, they indicate what days you can take your car onto Beijing streets – and what days you can't. Currently, with "2" as her final digit, Emma has to do without her car every Thursday. The date changes every quarter, but there is always one day a week when driving her car is prohibited. In this way, the city government wants to regulate traffic and at least keep it more or less under control.

A LONG WAIT – AND THEN A QUICK DECISION

It is crucial to act quickly after the lottery has assigned a license plate and the matter has been duly celebrated. If the driver does not buy his car within six months, he loses his chance to make the purchase and has to take his chances in the lottery all over again. He would be wise to use this period to save some money and not waste much time thinking about financing. In China, the option of installment payments has existed for only a few years. Previously, consumer loans were not permitted and the full sum had to be paid in cash. Emma decided on a used, dark-red VW Golf. She and her husband considered the purchase of a three-room apartment to be their most important life goal. Neither saw a car primarily as a status symbol. This totally contradicts the attitude of many of their compatriots, as China's sales figures for high-performance premium vehicles show.



CLEAR GUIDELINES

Learner drivers and those who have just passed their test are maneuvered safely through the obstacles.

Emma remembers her first trip very well. She was very nervous and worried about making a mistake, so she drove very slowly. During rush hour, she didn't even want to get behind the wheel at first. Meanwhile, she has become accustomed to the traffic and driving has become routine. If she often leaves her Golf in an underground garage, it's not because she is nervous. On particularly heavy traffic days, she can reach the office more quickly by subway.

What gets on her nerves? The egotistical and largely uncooperative attitude of other Chinese drivers in traffic. Emma finds that their behavior slows the flow of traffic considerably. And people still note that many Chinese drive very unsafely. "Perhaps because they haven't signed up for any extra, voluntary driver's training," Emma said with a wink. In any case, she no longer worries about making a mistake. Instead, she fears that others might be inattentive and involve her in an accident. Above all, her VW Golf gives her a great deal of freedom. She is proud to give friends or colleagues a lift and, most of all, go on weekend excursions with her husband and daughter. Under no circumstances would Emma Yang ever do without a car again.





HIGH TECH IN THE FIELDS

MANY A PASSENGER CAR CAN ONLY DREAM ABOUT THE HIGH-TECH FEATURES THAT EQUIP MODERN TRACTORS. ADVANCED TECHNOLOGY FROM FREUDENBERG SEALING TECHNOLOGIES MAKES SURE THAT WORK ON THE FARM CAN BE HANDLED AS COMFORTABLY AND SAFELY AS POSSIBLE WITH THE AXION 800, THE TOP MODEL FROM GERMAN MANUFACTURER CLAAS.

Autonomous driving is currently one of the most discussed issues in the auto industry. But what has so far only been realized in prototypes on the highway has already arrived in agriculture: Automatic, GPS-controlled steering systems are the state-of-the-art in high-end tractors. They benefit farmers by working the fields highly efficiently, thus promoting productivity. The powertrain technology of today's tractors is impressive as well: In the CLAAS Axion 800, for example, common-rail engines with four-valve technology and variable geometry deliver up to 264 horsepower and a maximum torque of more than 1,100 Newton meters. Power shift transmissions with automatic

gear shifting and up to 24 gear ratios ensure that the power always arrives at the four driven wheels in the optimum rev range. One true innovation in the Axion 800 series is the individually configured PROACTIV front-axle suspension system, which emerged from joint development work with Freudenberg Sealing Technologies. Adapting to the tractor's load status, the suspension automatically remains in the mid-position, while compensating for load shifts resulting from braking and turning. A patented system from the Lead Center Accumulators in Remagen keeps the pressure differences at the cylinder seals as low as possible. This reduces cylinder friction,

achieving greater spring travel under all load conditions. Its parallelogram suspension and 90-mm spring travel guarantee excellent driving characteristics under all operating conditions.

Just two months after its debut, the high-end tractor created a sensation in the technical world. Coinciding with the company's 100th birthday, trade journalists bestowed a double honor on the CLAAS Axion 800 at the 2013 Agritechnica trade fair in Hanover, naming it "Tractor of the Year 2014" and "Machine of the Year 2014" for special innovations in agricultural technology.



TWO-MILLION ENDURANCE RUN

A LONG-TERM DEVELOPMENT PROJECT UNDERTAKEN BY SWISS PUMP MANUFACTURER AUMETRA AG AND FREUDENBERG SEALING TECHNOLOGIES HAS BECOME A BESTSELLER. THE TWO COMPANIES RECENTLY MARKED PRODUCTION OF THE 2 MILLIONTH SCR PUMP CONTAINING FST SEALING TECHNOLOGY. A SUCCESS STORY WITH OBSTACLES. BUT DETERMINATION PAYS OFF IN THE END.

Guido Brüggemann, Managing Director of Freudenberg Simrit AG in Zürich, at some point stopped counting how many sampling inspections and design changes he had been through. Between 2000 and 2005, the engineer made countless trips to neighboring Sursee. The development of various rubber parts for an Aumetra AG project was shaping up to be a true challenge that repeatedly called for determination and endurance. A great deal was at stake. With the arrival of the new millennium, exhaust gas after-treatment was emerging as a development focus in the commercial vehicle industry. Without SCR (selective catalytic reduction) systems, it would be impossible to achieve future emissions limits for trucks. To decrease the level of harmful nitrogen oxides in exhaust gases, urea is injected into the exhaust. Aumetra supplies the pumps that are needed to do this. The task was to find the optimal design and the right production process for the seals that the Swiss company wanted the Freudenberg sealing specialists to champion. Given the aggressive characteristics

of the urea – which is sold under the trade name AdBlue – and the pump manufacturer's extremely stringent requirements for cleanliness, this was no easy undertaking. It all came together in 2006 when The Aumetra SCR pump with FST sealing know-how entered series production. All's well that ends well? Not entirely. After about a year, it turned out that many truckers had a problem with their still-unfamiliar equipment. They were pouring diesel instead of AdBlue into the feed pipe intended for the urea product. But the EPDM (ethylene propylene diene rubber) seals were not designed for contact with diesel. Quite a few new tests, development steps and sampling inspections followed, until 2009 when it was finally possible to switch to HNBR (hydrated acrylonitrilbutadiene rubber) – a material that is both resistant to AdBlue and unfazed by diesel. After that, nothing more stood in the way of the companies' hard-won success. In 2014, Aumetra and FST were able to mark the 2-millionth SCR pump with membrane discs, valve plates and working diaphragms. The endurance run had paid off.

NEWS

CHANNEL



DAIMLER TRUCK SEALS FOR THE ATEGO



The four- and six-cylinder OM 934 and OM 936 are designed as Euro 6 engines and are being deployed in the new Mercedes-Benz Atego. The spectrum of medium-heavy engines ranges from 5.1 liters and 156 horsepower to 7.7 liters and 304 horsepower.

Freudenberg Sealing Technologies is on-board the new Mercedes-Benz generation of commercial vehicle engines. The Atego engine is sealed by Simmerrings, flat gaskets, O-rings, special seals and valves stem seals. Simmerrings and O-rings are also incorporated into the axles and transmission. In addition, FST is providing additional oil transfer and baffle plates, so-called V-4 parts, along with double groove rings. FST liquid silicone seals are being used to seal the on-board electronics.

This partnership with FST sealing technology benefits from a global production network and proximity to the customer.

SUPERMILEAGE

FREUDENBERG SEALING TECHNOLOGIES SUPPORTS ENGINEERING STUDENTS

SAE Supermileage is an annual competition among colleges and universities that challenges students to develop a single-passenger vehicle that achieves the **highest possible fuel economy**. "To help the students out and test a new line of sealing products, we conceived, machined and manufactured tailor-made Energy Saving Seals (ESS) for the crankshaft in the vehicle's engine," said Rory Pawl, Director Future Technology, at Freudenberg Sealing Technologies in the United States. The seals, which were offered to all the work groups in the competition, reduce friction by 57 percent. **Concordia University of Montréal, Québec**, was one of the teams using the Freudenberg seal in its vehicle. The team achieved an average fuel economy equivalent to 0.62 liters per 100 km in five runs. That was enough to win the **35th Annual SAE Endurance Award**, which goes to the team that completes at least five runs with the best average fuel economy.

"Sponsors like Freudenberg provide the resources we need to turn ideas that fall outside normal thinking into reality," said mechanical engineering student Alexandre Laroche of the victorious Concordia team. Conversely, it is in the interests of Freudenberg Sealing Technologies to support programs that help develop new engineering talent and product innovations.



SIMPLE ASSEMBLY LONGER LIFECYCLE

GM LOW-LOAD SEALING

With flexible offset seals, Freudenberg-NOK is improving sealing performance for General Motors engines. Low-load sealing can be easily installed and removed by hand. **The mounting force has been reduced by more than 70 percent.** GM has been using the concept in its engines in multiple ways: to seal the glow plug tube, a vacuum pump and two cover gaskets at the camshaft adjustment.

The design of the offset seals allows the use of different materials and reduces stresses on the component, which helps improve durability. The basic principle is that an O-ring will no longer be compressed into a metal housing. Instead, the seal is mounted in a defined form – but can adjust flexibly.

After elaborate validation tests, GM used the innovative seal in the 2014 Cadillac CTS sedan, GMC Acadia and Chevrolet Malibu. This patented sealing principle is not only intended for engine applications, it can also be used in other, static radial offset applications. **"The offset seal reduces the contact pressure, which increases the service life of the seal and the components,"** said John Wagner, a Freudenberg Sealing Technologies designer.

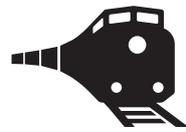


INTO THE FUTURE ON RAILS

TECHNOLOGY SHOW IN BERLIN

RAIL VEHICLES: THE PERFECT TRANSPORTATION FOR THE ENERGY TRANSITION

It is the platform for national and international providers and customers of passenger and freight transportation. InnoTrans has established itself as an international industry event and offers a comprehensive overview of the current state of the rail transportation industry. Moreover, future railway trends are presented and discussed in numerous expert forums. This means of transportation, now more than 150 years old, is still far from reaching the end of its development. ESSENTIAL took a look and discovered interesting prospects for greater efficiency and better environmental sustainability in the transportation of people and goods.



REACHING THE DESTINATION MORE QUICKLY – FREIGHT TRANSPORT AT 200 KM/H

A speed of 120 km/h has been established as the international speed standard for freight trains. That means freight trains travel much more slowly than most passenger trains. Apart from long transport times, another problem comes up: the difficult harmonization when two types of trains use the same route network – which continues to be the case.

As a result, all the major manufacturers of freight cars and bogies are working to increase speeds to 160 km/h. China, in particular, is pressing vigorously ahead with this development. At least 10 percent of the 100,000 km network run by the China Railway Corporation (CRC) is already laid out as high-speed track – a further 20 percent expansion is planned over the next five years. The figures for rolling stock are even more impressive: 2,660 of the 4,890 CRC trains are high-

speed trains. To meet demand from the booming e-commerce sector in China, there are six one-stop direct freight trains between Beijing, Shanghai, Guangzhou and Shenzhen.

CRC is even pursuing plans for freight trains to transport their goods at 200 km/h. A prototype has been developed with manufacturers JRVEC (Jinan Railway Vehicles Equipment Co.) and QRRS (Qiqihar Eisenbahnfahrzeuge Co., Ltd.) as well as Chengdu University. It is now being tested in dynamic trials. The JNZ 200, the bogie of the JRVEC prototype, is equipped with components from FSVC.

CLEAN – BUT NOISY!

Rail transportation is environmentally friendly – there is arguably no one who would contest that. When it comes to emissions, trains powered by renewable energy are in fact hard to beat. But a serious environmental problem with rail transportation is increasingly turning into

a stumbling block in the expansion of rail networks and endangers the political goal of moving more traffic off the roads and onto the rails: noise.

Rail transportation is a significant source of noise in Germany. About one third of the German population feels disturbed by or annoyed with the noise of rail transport. The figure comes from a representative survey of about 2,000 participants for a study, "Environmental Awareness in Germany 2012". The biggest problems are "hotspots" along European freight transport corridors with extremely high, geographically concentrated stresses. These subjective feelings have been confirmed by objective investigations. With the EU environmental noise guideline in 2007, the noise stress on the population in metropolitan areas with at least 250,000 inhabitants and at rail lines with traffic of at least 60,000 trains were determined. It indicated that 605,000 people in Germany are exposed to levels of more than 65 dB(A) throughout the day. During the night, 1.4 million people have to tolerate noise levels of more than 55 dB(A). A good night's sleep is hardly imaginable under these conditions.



There are many factors that affect noise levels: the number and type of rail vehicles, their speed, the type of track (e.g. sleeper track, slab track) or a building's distance from the track. In Germany, there is no general rule to provide protection against noise from trains. Emission limits must only be adhered to when there is new construction or a significant change in a rail line.

The most likely approach would be to deal with rolling stock: The Technical Specification for Interoperability in the subsection "Vehicles – Noise" (TSI Noise 2011) sets uniform noise limits for new rail vehicles Europe-wide. The catch is that there are no noise limits for rail vehicles commissioned before the TSI Noise 2006 first went into effect. The approvals for commissioning these vehicles remain valid – even if they are reminiscent of old, historic documents. For example, the Y-25 bogie that is common today made its test run in 1946 and many bogies have rolled on the rails for more than 50 years. Noise-based route charges could be an incentive offering financial rewards for quiet vehicles, but there are no concrete plans for this.

They would, however, be necessary to achieve Europe's ambitious objectives. The EU wants to increase railway's share of freight transportation from the current 17 to 25 percent by 2030. For that to happen, the level of acceptance of rail-based freight transportation must be greatly increased. But this would only work if its greatest disadvantage is systematically addressed: Freight trains would have to run more quietly.

THE BATTLE AGAINST SOOT – CLEAN DIESEL LOCOMOTIVES

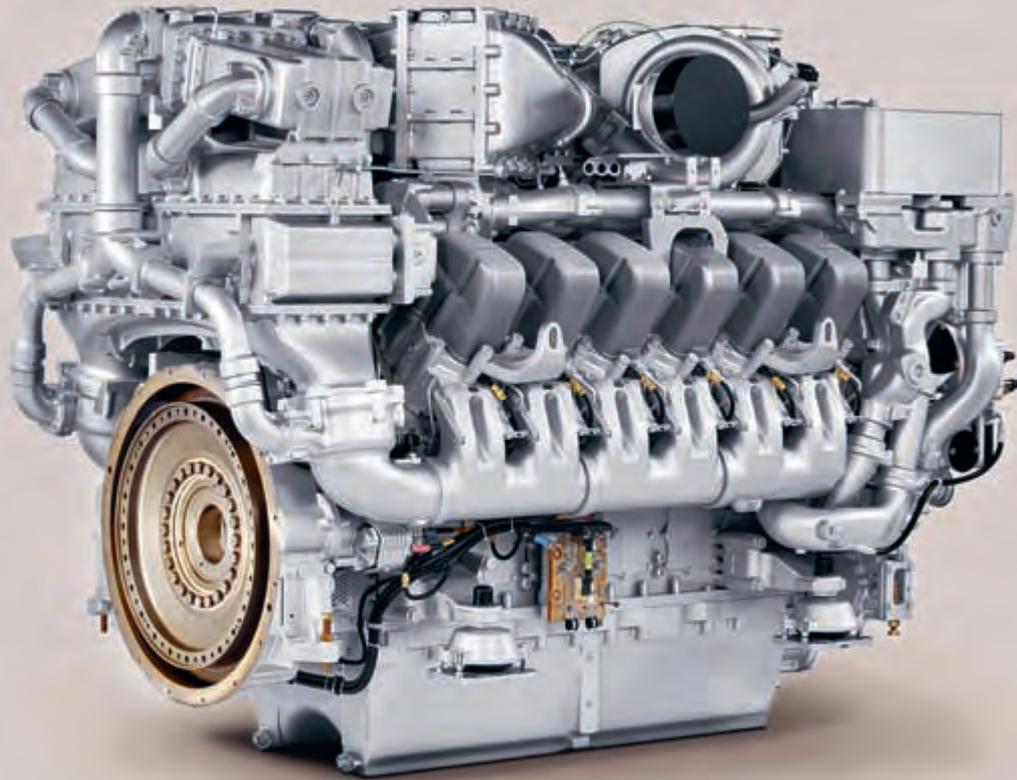
Nearly 80 percent of European rail traffic runs on electrified tracks – in many cases, even climate-neutrally on renewably produced electricity. But diesel locomotives still play a major role



IDEAL CONDITION: SMOOTH WHEELS – SMOOTH RAILS

From a technological standpoint, the way to achieve effective noise reduction for the 600,000 freight cars in Europe has long been known. At the usual speeds, rolling noise is the predominant source of sound. To reduce it – based on the philosophy "smooth wheels on smooth rails" – various aspects involving both rails and wheels must be considered:

- ▶ The rail must be smooth (this is achieved, for instance, through rail grinding, as is the case for a "specially monitored rail", or with high-speed grinding).
- ▶ The rail must generate only a small amount of sound (rail crosspiece damper, rail crosspiece shielding, low sound protection walls).
- ▶ The wheels must be smooth (disk brakes, K or LL shoes, regular wheel care).
- ▶ The wheels should generate little noise (proper wheel design, wheel absorbers, wheel shielding) – and so should the remainder of the vehicle structure



wherever few tracks are electrified: in the United Kingdom, the Baltic states, Ireland and Greece, for example. For diesel-based rail transport to operate as ecologically as possible, the EU Commission passed pollutant limits for locomotives for the first time in 2004 and has been tightening them continuously ever since. These limits have been accompanied by Project CleanER-D, which is designed to highlight the technological directions that could lead to cleaner diesel locomotives. As part of the project, engine manufacturer MTU has developed a power plant that makes it possible for freight locomotives to meet the Euro Stage IIIB pollutant standard that has reduced the permissible particulate emissions from 0.2g/kWh to 0.025 g/kWh, a reduction of nearly 90 percent, since 2012. The MTU 12V40009 power plant, with an output of 1,800 kW at 1,800 revolutions per minute, is equipped with a series of innovative technologies that help to reduce emissions. Some are internal and others involve exhaust-gas treatment:

- ▶ A cooled, MTU-patented dispenser-cylinder exhaust-gas recirculator to reduce nitrogen oxides
- ▶ A diesel particulate filter (DPF)
- ▶ An emissions-reducing design of the combustion chamber
- ▶ A two-stage turbocharger with charge-air cooler that ensures sufficient air is available for efficient, low-soot combustion under all operating conditions
- ▶ The “LEAD2” common-rail injection system with a maximum injection pressure of 2200 bar for low pre-catalytic converter particulate emissions – creating the opportunity to use a compact particulate filter

MTU has been gradually introducing new engines since 2012. At the end of the process, 8, 12, 16 and 20-cylinder engines, ranging from 1000 to 2700 kW, were available – each meeting the IIIB emissions standard. Especially gratifying is the fact that MTU’s sophisticated exhaust-gas aftertreatment does not come at the expense of increased fuel consumption. On the contrary, MTU was even able to reduce consumption compared to the previous-generation engine. The MTU 12V4000 power plant demonstrated its capabilities in a more than 40-year-old diesel locomotive operated by Deutsche Bahn AG. This provided proof that conversion of the company’s existing rolling stock could deliver significant progress.

Siemens is going a step further with the hybrid locomotive presented in 2012. The Desiro Classic is equipped with two diesel-electric 315 kW power packs. As in a hybrid car, this enables storage of braking energy for subsequent use in forward propulsion. This “green” prototype can run in both operating modes. Lithium-ion batteries serve as the energy storage medium for the electric drive. They are attached to the roof of the train and also supply its on-board network. This approach can achieve fuel savings of up to 25 percent. Moreover, under electric propulsion, the hybrid generates significantly less noise than the diesel mode – a major advantage on portions of the route that are sensitive to noise emissions. Hybridization has facilitated another innovation. Siemens engineers have replaced the air-conditioning system, which was previously mechanically driven, with a newly developed CO₂ climate control system with an electric drive. This not only means that the Desiro’s air-conditioning system is more environmentally friendly, it is more efficient as well. Fuel consumption has declined another 10 percent. The series production of this hybrid train is scheduled for this year.

EVERY KILOWATT COUNTS: THE RECOVERY OF BRAKING ENERGY

The recovery of braking energy is standard in electric locomotives and has been underway since their beginnings. For example, back in 1919, the famous SBB Ce 6/8 “Crocodile” had a braking recuperation system that could feed electric energy from the drive engines, acting as generators, back into the driveline. But the technology only enabled the recuperation of about 5 percent of the energy used, and its braking power was weak and erratic. Today, modern vehicles with traction converters can exploit braking energy with much greater efficiency. In the process, the locomotive engines store three-phase current in their converters. There, the energy is converted into alternating current, which must be stepped up and fed into the driveline. The circuit operates across the entire speed range, up to peak engine output. The result is

recuperation of about 25 to 30 percent of the energy needed for propulsion. What works in AC overhead contact lines is only possible to a limited degree in direct current networks. Streetcar networks are not capable of receiving energy since they are often incapable of feeding energy back. As it now stands, the situation could lead to excess voltage. Here, too, energy must be stored to make it possible to exploit braking energy.



POWER PACK

High-performance capacitors store braking energy.

The MITRAC Energy Saver from Bombardier is a pioneer in streetcar systems. Three storage units mounted on the vehicle’s roof draw energy from the streetcar’s braking system and use capacitors to store it. The energy is then dispensed as the vehicle pulls away or is in operation. The high-performance, double-layer capacitors store up to 3 kWh. As the vehicle pulls away and accelerates, it requires an especially large amount of electric current and places considerable demands on the electric network. With the MITRAC Energy Saver, the load is reduced by about 40 percent, so the network can be designed less expensively. Rhein-Neckar-Verkehr GmbH (RNV) uses the system on 18 routes in Heidelberg. The Variobahn trains consume up to 30 percent less energy and can operate for periods of time without overhead lines. The use of the MITRAC Energy Saver saves 93,000 kWh of electricity annually, which benefits the environment due to lower emissions during the production of electricity. The Southeastern Pennsylvania Transportation Authority (SEPTA) is taking a different direction. It has installed a smart grid technology in its subway system. The SEPTA Wayside Energy Storage Project consists of a high-performance lithium-ion battery located in a railway station and stores braking energy from the subway trains. The energy is transmitted back to the trains to help them accelerate as they pull away. Surplus energy can even be fed into the city’s electric grid, making an important contribution to network stability. The Letterly station in Kensington was the first to get this clever technology and has been using it since 2012. With the system’s installation in all of Philadelphia’s stations, SEPTA calculates savings of \$250,000 per year.

ELECTRIC ASSISTANCE

QUIETER AND MORE FUEL EFFICIENT THANKS TO HYBRID TECHNOLOGY

Hybrid locomotives not only reduce fuel consumption by up to 25 percent, they can also run on electricity alone, and therefore far more quietly, on particularly sensitive track sections.





DR. DETLEF CORDTS

develops the technology of the future at Schwab Vibration Control in Velten, near Berlin. Cordts, 58, studied vehicle technology and design in Brunswick and then earned his doctorate in plastic mechanics at Darmstadt.

Since 1987, Dr. Cordts has worked in various fields at Freudenberg. He currently manages future technology development. Dr. Cordts is a co-inventor of the hydraulic axle guide bearing (HALL), whose second generation has just been presented at InnoTrans. HALL not only makes trains quieter and more cost-effective, the rails are subjected to less stress as well.



AND SUDDENLY TRAINS CAN DRIVE ROUND CORNERS

SCHWAB VIBRATION CONTROL IS A LEADING MANUFACTURER OF VIBRATION CONTROL TECHNOLOGIES FOR RAIL VEHICLES, WHETHER THEY ARE IN SUBWAY TRAINS, TRAMS OR HIGH-SPEED TRAINS. ESSENTIAL SPOKE WITH DR. DETLEF CORDTS, AN ADVANCED DEVELOPMENT ENGINEER AT SVC, ABOUT A REVOLUTIONARY DEVELOPMENT THAT DRASTICALLY REDUCES NOISE AND WEAR, THUS DECREASING THE IMPACT OF TRAINS ON PEOPLE, MATERIALS AND THE ENVIRONMENT.

DR. CORDTS, DO YOU LIKE TO PLAY WITH MODEL TRAIN SETS IN YOUR PRIVATE LIFE?

CORDTS: No, I don't have a model train set at home and I don't play with trains. I only travel by train from time to time. I became involved with rail vehicles by chance. But I quickly noticed that it is an extremely interesting and very demanding sector. Trains and automobiles are very different: Train systems are significantly larger and heavier, and have to travel much longer distances over their lifetimes. Moreover, they are built in far smaller volumes. This has to be taken into consideration, even for individual components and prototypes.

AS A LAYPERSON ONE MIGHT THINK THAT TRAINS SIMPLY TRAVEL ON RAILS.

CORDTS: It's not that simple. A train or locomotive is a highly complicated piece of equipment with an engine and a chassis. And then there are the rails in the track bed. At Schwab Vibration Control, we primarily develop suspension and damping systems that influence track guiding for the chassis and other components to reduce vibration, wear and noise.

A train's characteristics and driving behavior can be significantly changed with these components – in a positive way.

IN WHAT FORM?

CORDTS: To overstate the matter – our hydraulic axle guide bearing (HALL) helps trains drive round bends. Conventional axle guide bearings have always been just a compromise. Low rigidity would be optimal for driving round bends, so the rigid wheel set can adjust to the rails' curvature. But high rigidity is an absolute necessity for the stability of the vehicle at high speeds. The greater the speed, the harder the axle must be guided. Otherwise, the train begins to roll and, in the worst case, it can jump off the tracks. This is where HALL steps in. At specified loads, the bearing adapts its hardness passively and automatically, which is a big advantage for regional railways in particular. We have achieved a spread of between 2,800 Newton millimeters and 27,000 Newton millimeters. In this way, low longitudinal rigidity for traveling around bends is combined with high longitudinal rigidity for fast, straight-ahead travel.



WHAT PRACTICAL ADVANTAGES RESULT FROM THIS?

CORDTS: For one thing, wheels abrade less and last longer as a result. The train needs to head into the service depot for a complete wheel overhaul less often. A 60 percent reduction in friction on bends lowers the train's overall frictional resistance. The locomotive requires less power and thus less energy. As a result, it travels more economically and efficiently, and with less impact on the environment. There is also a reduction in rail wear. In the end, dangerous rolling-contact fatigue is significantly reduced.

WHAT DOES THAT MEAN?

CORDTS: On October 17, 2000, a devastating train disaster took place in Hatfield, England. Four people died and about 70 were injured. The cause was a broken rail. As a consequence, all the rails along the entire West Coast Main Line were investigated for fractures and replaced. The cost came to more than 580 million British pounds. In the search for the causes of the wear, it was recognized that bends in the rails are very severely stressed by fast trains with high torsional rigidity in the axle guide bearings. The result is known as rolling-contact fatigue. It involves severe disruptions in the surface, caused by expanding

fractures beneath the surface. Even back then, we knew how to solve this problem – with our new bearing.

WHEN DID YOU COME UP WITH THE IDEA?

CORDTS: We came up with the idea for HALL back in 1994. We definitely wanted to resolve the conflict between soft and hard adjustments. But after a test with hydraulic bearings from the automotive area, it was clear to us that the bearing for heavy industry would have to be conceived differently. At this point, a request came in from Switzerland for flexible bearings to improve travel through bends. In 1995, the first functional prototype was completed and we tested it extensively. Surprised and impressed by the results, we continued our development work. Together with the University of Hamburg, we carried out long-term tests covering up to 12 million kilometers of operation. This was a valid basis for a regional train covering between 150,000 and 450,000 km a year.

In 2002, 32 components were used in regular operation on a Swiss operator's trains. After five years of operation, there was no evidence of wear at all. Since 2009, we have sold the component throughout the world, since it really offers only benefits.

HALL SYSTEM

NO MORE CONTRADICTIONS

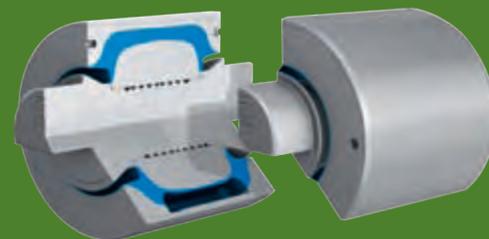
High-tech on rails. The flexible HALL system enables a quieter ride and protects the track material – yet offers sufficient stability for high speeds.

WHAT TRAINS ARE USING HALL?

CORDTS: HALL makes excellent sense primarily when it comes to dealing with bends in regional rail transportation. These situations play strongly to the strengths of our passive hydraulic bearings. Trains from Bombardier, Stadler Rail and Siemens already have them on board and are running regular passenger services in England and Switzerland. HALL makes less sense on express trains like the ICE 3 or the TGV, since they travel mostly on straight tracks. In these cases, there are fewer radii and bends that are subject to extreme wear. For this reason, conventional bearings can be designed to be very hard. Trains with conventional bearings have the highest stresses from rolling contact while traveling through bends with radii of 800 meters. HALL shifts this range strongly toward very small radii of 200 meters or even lower. That means extremely sharp bends that are rare even on regional routes. The passive bearing is ideal for these trains.

DOES HALL PAY OFF FOR THE OPERATOR?

CORDTS: Here it is interesting to look at the U.K. Since 2009, British railway operators have had to pay a so-called "track charge" for every trip. The fee is based on calculated rail wear as well as the length of the route. Our passive bearings put demonstrably less stress on the routes, so lower fees are incurred. A conversion repays the investment in less than

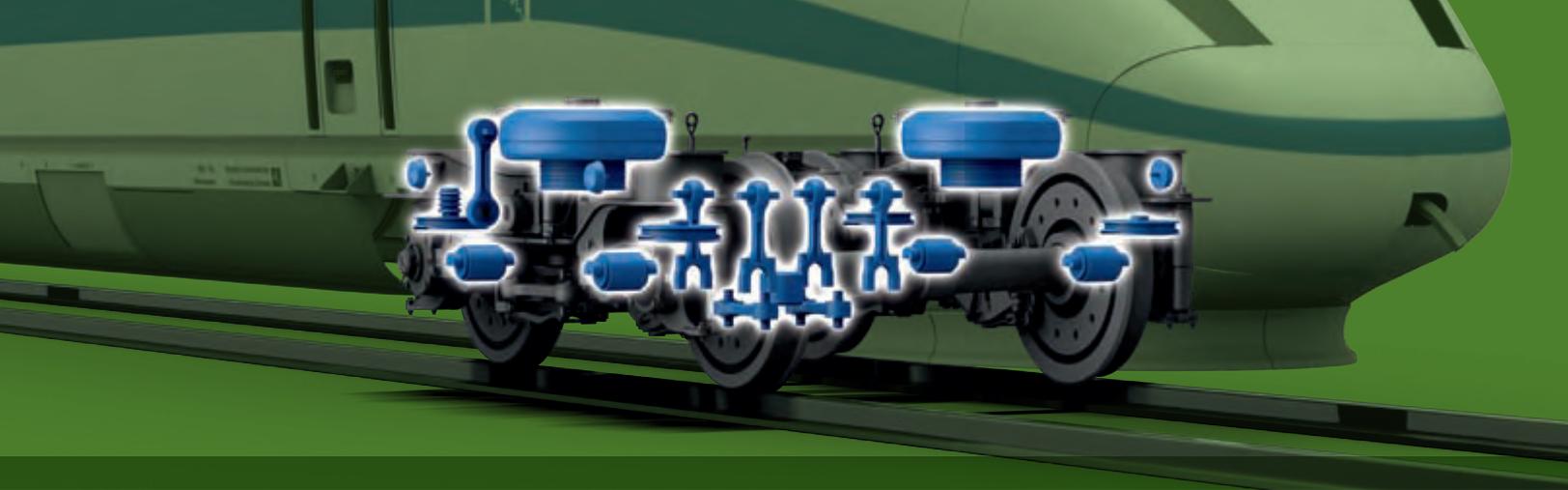


FUNCTION OF THE HYDRAULIC AXLE GUIDE BEARING (HALL)

The axle guide bearing is responsible for the wheel set's longitudinal and transverse connection to the bogie. In a single part, HALL combines low longitudinal rigidity for travel on bends with high longitudinal rigidity for fast, straight-ahead travel.

HALL consists of a solid metal housing and natural rubber, which is ideal for damping and durability. Long-term tests have certified a service life of eight years. This rubber-metallic part has an internal channel fed with a polyglycol fluid. This leads to frequency-dependent changes in the part's longitudinal rigidity. When the adjustment movements are slower, for entering and exiting bends, for example, a lower rigidity is automatically adopted. By contrast, dynamic excitation during rapid travel leads the rigidity of the bearing to climb substantially – by as much as factor of 10. The result is a significant expansion of stability reserves for higher speeds.

Since HALL fits into the installation space for conventional axle guide bearings, it can be installed at the bogie without design changes, in both new and existing vehicles. Modifications to the vehicle are not required. Besides its use in trains and rail cars, this bearing is also suited to many other industrial vehicles, such as farm machinery or excavators, i.e. anywhere bearings need to handle a large amount of energy during severe shocks over a short period of time.



“WE CONCEIVE, DEVELOPE AND BUILD EVERY PART INDIVIDUALLY
FOR THE CUSTOMER, THE VEHICLE AND THE ROUTE.”

two years. Other countries, such as Sweden, are planning a rail use fee. Route fees are also expected to start in Switzerland in 2017. So the market will grow rapidly in the next few years.

IS HALL FOR PASSENGER TRAINS ONLY ?

CORDTS: So far, HALL has only been used on passenger trains. But there is still enormous potential for freight trains, since the abrasion from their heavy, fully laden cars is very extensive. However, these trains are produced at an extremely low cost, and with our high-tech bearing, we cannot keep pace with those cost levels. But the industry will rethink the matter as soon as rail fees emerge for freight transport. Then these trains will also be quieter because the loud squealing on very sharp bends is reduced.

IS HALL A STANDARD COMPONENT?

CORDTS: No, we conceive, develop and build every part individually for the customer, the vehicles and the route. The reason is that it is not just the trains that are different. The routes, in particular, are different, too. Some are rather straight and others very winding. We adjust our bearings to the precise conditions while calculating their size and rigidity. To achieve this, we have developed special programs that take many factors into account. Through the use of a precise matrix, we can calculate the benefits that a conversion offers operators and customers. It takes

around a year and a half from order receipt to series application. For the production itself, we actually only need up to nine months – but the certification runs are very time consuming.

WHICH FUTURE PROJECTS ARE YOU WORKING ON AT THE MOMENT?

CORDTS: Among other things, we at Schwab Vibration Control are developing new, active axle guide bearings. Using GPS, program maps or cameras at the front of the train, the course of the route and its bends will be evaluated in advance. This is ideal for the fixed stretches that we have with rail vehicles. The information is passed to a control unit, which uses a hydraulic system to adjust the bearing for the next radius. This means the wheel is already set at the optimum angle for the next bend and thus grinds less on the rails. The system ensures improved wheel adjustments for the very sharp bends encountered by trams and subways.

WITH SO MUCH HIGH TECHNOLOGY, ISN'T SOME OF THE ROMANCE OF THE TRAIN LOST?

CORDTS: That does not have to be the case. My favorite stretch, for example, is the 206-km Immensee-Chiasso route along the Gotthard massif. Beautifully winding and with a great view!

DR. DETLEF CORDTS

HEAD OF DEVELOPMENT AT SVC



THE FUTURE: HALL 2.0 – AN ACTIVE BEARING FOR BOGIES

Schwab Vibration Control goes one step further. The company presented an active axle guide bearing at InnoTrans, the International Trade Fair for Transport Technology, in Berlin. HALL 2.0 obtains its route information from cameras, passive sensors, GPS data or a programmed map. Based on these external signals, the axles turn in automatically to a pre-determined degree. As with passively

acting axle guide bearings with hydraulic damping channels, active HALL also employs hydraulic axle guide bearings. With passive HALL, the weight forces of the carriage work with the rail's forces on the wheel set to produce the turn into the bend. But with HALL 2.0, the bearing is adjusted using targeted external pressure. The system's control and power electronics handle precise

route data while controlling a pressure reservoir for a particular axle guide bearing through the use of hydraulic lines – precisely at the moment when the train enters the bend. This adjusts the axle guide bearing to the optimal angle for entering the bend. The result is even lower frictional losses, increased energy efficiency, and, above all, a further reduction in noise levels.



GERMAN BEER

GERMAN BEER AND GERMAN CARS

Everywhere in the world, they both enjoy an outstanding reputation and are the epitome of quality and tradition. But while German automakers in fact rank among the global players, the internationalization of the beer market has passed German breweries by. ESSENTIAL wanted to know who the major players in international brewing are and what trends are driving the industry.



THE TYPICAL GERMAN CONSUMES 107 LITERS OF BEER PER YEAR

That is no small amount, but it's only enough for third place in an international comparison of drinking habits – and the trend has been on the decline for three years. The Czech Republic, the home of Pilsner, is out front with 154 liters, while Austria holds the second spot. But it is undisputed in industry circles that Germany still has the greatest know-how when it comes to brewing beer.

INTERNATIONAL GROUPS DOMINATE THE BEER MARKET

That is one reason why German master brewers are still in demand around the world. But others are making the big money. The four largest breweries in the world dominate the global market. They include the Netherlands' Heineken, SAB Miller from the UK, Belgian group Anheuser-Busch inBEV and Denmark's Carlsberg Group. The largest German brewery, the Radeberger Group, is in 23rd place – with a global market share of barely 0.7 percent. German breweries have not yet succeeded in their expansion into Eastern Europe, Asia and South America – due to the fact that the domestic beer market is very fragmented and hotly contested. More than 1,300 breweries sell an estimated 5,000 different beer brands in about 30 varieties. And nowhere do regional preferences affect market trends as much as they do in the land of national purity law. Varieties or brands can be top dog in one location – and be considered utterly unimportant in a neighboring

city. With clever marketing, the trend toward regionalization ensures the survival of the 900 smallest breweries in Germany – a trend also seen in fruits and vegetables. At the same time, a price war is raging in Germany to a degree matched by practically no other market. Low-priced beer frequently serves as a loss leader in German stores. German consumers often only consider the purity law as an indicator of quality. The regulations in the Bavarian Law of 1516 often stand in the way of new developments. Many breweries, however, recognize alcohol-free beer as a potential growth market. At 4.1 million hectoliters, Germany's breweries are the world's market leaders in these products – and not least because of their flavors.

ENTERING NEW MARKETS WITH NEW FLAVORS

The brewing sector has great expectations for novel forms of hop cultivation. "Special flavor hops" are expected to ramp up beer consumption significantly. Since 2006, the hops research institute Hüll (of the Bavarian Regional Agency for Agriculture) has been conducting research on special hybrids to develop varieties of hops designed to give beer multifaceted flowery, fruity, citrus-like and resinous notes. POLARIS, MANDARINA BAVARIA, HUELL MELON and HALLERTAU BLANC are the first four new Hüll varieties; they exhibit rather fruity-citrusy



nuances that are not typical of hops. As of 2014, they are available under specified licensing and cultivation terms. The most recent BrauBeviale in Nuremberg demonstrated that German beer from small and medium-sized breweries can help shape the market. The international industry gathering is held three out of every four years. The three top-ranking beers in the European Dear Star Award competition included two beers from German breweries, as judged by 100 experts. "Weiherer Rauch", a smoked beer from the Kundmüller brewery-inn in Viereth-Trunstadt, won the bronze medal, while "Schimpf Hefe Hell", from the Kronenbrauerei Alfred Schimpf in Neustetten, won silver. The overall winner out of all 1,366 candidates was an American product, "Double Jack", an imperial India pale ale from the Firestone Walker Brewery in Paso Robles, California.

MARKET LEADER: BREWERY TECHNOLOGY MADE IN GERMANY

The manufacturers of drinks machines have been considerably more successful in their international efforts than Germany's breweries. With a global market share of about 25 percent, German bottling and packaging machinery is in first place, far ahead of the competition. A full 85 percent of the equipment is exported, with the

largest share going to Asia. To help quench the world's thirst, more than 100 firms with 14,000 employees produce goods valued at more than 2 billion euros per year. To keep the equipment from German companies running smoothly worldwide, the choice of the right sealing technology is crucially important. It is a demanding task: Besides absolute hygiene and functional reliability of the bottling systems, there is a need for maximum resistance to aggressive cleaning substances – the seals have to reliably withstand bases, acids and sterilization with peracetic acid or steam. The Process Seals Division of Freudenberg Sealing Technologies has developed materials that stand up to more than just beerstone and carbon dioxide. The trend toward flavored, beer-like drinks, in particular, is posing new challenges to the industry: special varieties of hops with sophisticated hop oils and flavorings that have rarely found their way into breweries until now. If various kinds of beer go through the same bottling equipment, it is important to block the transfer of flavors. At the same time, a variety of food regulations must be observed.

Freudenberg Sealing Technologies can turn to a comprehensive sealing portfolio for breweries and bottling operations – ranging from O-rings to customer-specific formed parts – choosing from 19 different products for 12 defined areas of application. Its assortment of seals corresponds to what generally distinguishes the beer industry: innovation and diversity.



GLOBAL BEER PLAYER

Belgian-based InBev has gathered more than 200 beer brands under one roof – including its core brand Stella Artois and the German brand Beck's. More than 116,000 InBev employees produce nearly 400 million hectoliters of beer in 26 countries per year.



CONSOLIDATION PROCESS
Traditional German brands
in Belgian hands



NEW PRESENCE ON THE NET

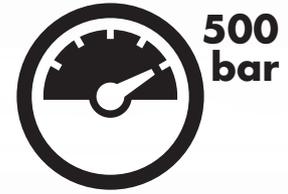
TOWARDS THE END OF 2014, THE OUTWARD-FACING PRESENTATION OF FREUDENBERG SEALING TECHNOLOGIES WILL REACH ANOTHER MILESTONE. AT FST.COM, THE COMPANY IS PRESENTING ITSELF WITH A COMPLETELY NEW LOOK. THE NEW FST PRESENCE SELF-CONFIDENTLY DEMONSTRATES ITS COMPETENCE AS A GLOBAL MARKET AND INNOVATION LEADER IN SEALING SOLUTIONS.

The new Internet presence reflects the company's altered brand architecture. Since early 2013, all tasks and activities have come under the "Freudenberg Sealing Technologies" umbrella brand. "Previously, the configuration of our external presentation was complicated and inconsistent," said CEO Claus Möhlenkamp. "Our goal has been greater clarity for the customer – with one brand and a promise. Wherever our brand appears, it should be perceived as a global supplier of sealing solutions for all mobile and industrial applications." To lend the new brand

architecture a sharpened profile and to communicate the associated benefits to the customer, the company is presenting itself openly and transparently in its Internet presence. The website is yet another step in the direction of continual and active communication with the customer. "We wanted to take a market-specific approach to the new market segments instead of using different sales channels," said Michael Scheuer, Senior Vice President Corporate Communications at Freudenberg Sealing Technologies. "In the process, we considered it especially important to

achieve an integrated brand presence as well as to improve our services for mobile devices. In an extremely wide variety of industries, our products and solutions stand for quality and technology, along with reliability and the capacity to innovate," he said. "That is content that we want to convey on the Internet as well." But the new website is only a first step. "First, we want to improve people's ability to find our web presence. In the next step, we will build up tools and services so we can stay even closer to our customers throughout the world."





HDR-2C

HIGH-PERFORMANCE HYDRAULICS SEALING FOR EXTREME CONDITIONS

The advantages of the new rod seal HDR-2C from Freudenberg Sealing Technologies (FST) include special extrusion stability in the high-pressure range and great flexibility down to a temperature of $-50\text{ }^{\circ}\text{C}$, thanks to an innovative material combination of two different polyurethanes. Seals in hydraulic cylinders have to withstand substantial loads. They are exposed to severe pressure and temperature fluctuations as well as the hydraulic media that are used. The individual sub-areas of the rod seals must also meet different requirements that to some degree require contradictory material properties. At the same time, they should guarantee reliable sealing over the entire lifetime and a broad spectrum of performance. HDR-2C's two-component technology takes the loads on the rod seal's various functional areas into account by combining the advantages

of two high-performance materials with different physical properties into just one element. The seal back of FST U-rings consists of polyurethane 98 AU 928, a material with a Shore hardness of 98 A, which stands out for its extreme stability even under high operating pressures. Its seal lips made of polyurethane 92 AU 21100 have very good dynamic sealing properties due to the material's high elasticity and low compression remainder. Compared to the standard seal, the HDR-2C's two-component technology offers a **significantly improved performance range.** Greater gap tolerances, reliable use under operating pressures up to 500 bar and excellent leak tightness in the temperature range of $-50\text{ }^{\circ}\text{C}$ to $+110\text{ }^{\circ}\text{C}$ make the new Freudenberg Sealing Technologies rod seals an extremely high-performance sealing solution with outstanding value for the price.



NEW LOGISTICS CENTER FOR THE AEROSPACE INDUSTRY

To respond even more effectively to the specific needs of the European aerospace industry, Freudenberg Sealing Technologies has now consolidated customer service, office operations, logistics and product support for its European aerospace customers and its service center in Lutterworth, Leicestershire, in the UK. The service center provides warehousing, product support and logistics services. Although it had focused on customers in the UK to this point, it now serves as an **aerospace hub supporting all the key European aerospace players**, including those in Germany, France, Italy and Spain. "Our strong growth in this sector required the creation of a central launch and coordination center," said Sean Morgan, Global Segment Director, Aerospace. "It is permitting a focused approach to all our customer interactions, ranging from communication and order fulfillment to product support and logistics."

The facility is certified under the AS9120/EN9120 quality management system. It has also won the coveted **"Pattonair Gold Supplier" award** three times for its outstanding performance in customer service, technical support and delivery reliability.

With dozens of locations worldwide, Freudenberg Sealing Technologies meets its aerospace customers' sealing requirements for engines, chassis, and wheel and braking systems. The service center, which is near Birmingham, is in an ideal location for coordinating European activities for Freudenberg production facilities serving the aerospace sector.



PTFE

ADVANTAGES OF IN-HOUSE COMPOUND PRODUCTION

Polytetrafluoroethylene (PTFE) is known colloquially as Teflon in reference to the DuPont trade name. PTFE has become a popular sealing material due to its high chemical resistance, its non-stick properties and its low frictional tendencies. Freudenberg Sealing Technologies previously had to purchase the compound's base material, granular PTFE. "At the start of the year, we acquired PTFE Compounds Germany GmbH in Biere, near Magdeburg," explained Dr. Jan Kuiken, Director Process Technology at FST. The advantages of in-house compound production are clear: In addition to **being independent of outside suppliers** when bottlenecks occur, the integration of this process step also promotes, in particular, an **understanding of the material** and makes it easier to develop materials tailored to customer needs.



FEEDBACK & CONTACT

UP-TO-DATE, COMPREHENSIVE INFORMATION

Would you like to know more about Freudenberg Sealing Technologies, our products, solutions and services? Then go to www.fst.com and take a look at our extensive portfolio. You can also go to our website to download back issues of our customer magazine in PDF format or to register for a free subscription to the magazine.

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PRODUZIERT AUF FSC-ZERTIFIZIERTEM
PAPIER AUS NACHHALTIGER FORSTWIRTSCHAFT



KLIMANEUTRAL PRODUZIERT



OFTEN INVISIBLE ALWAYS ESSENTIAL

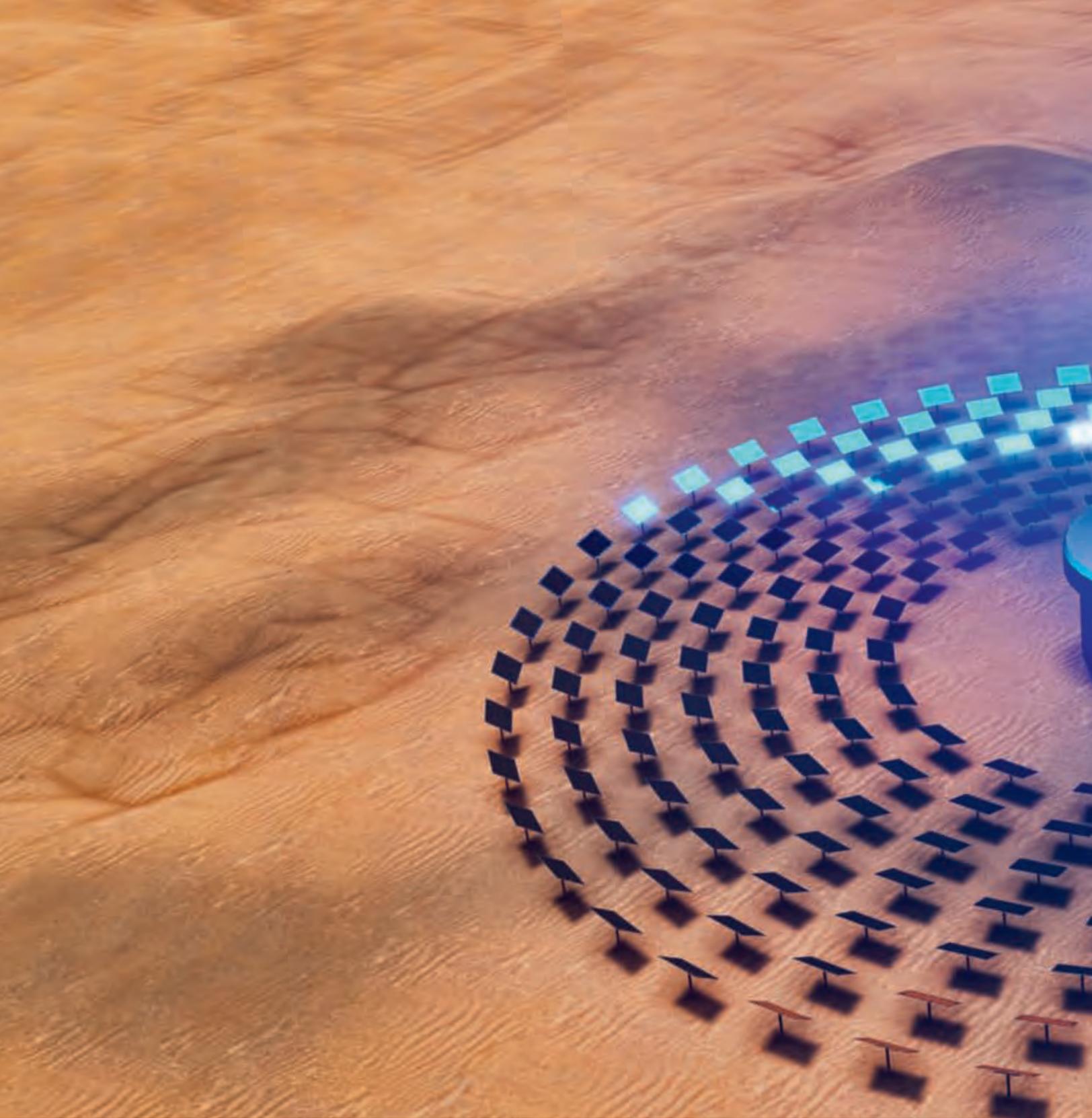
Resistance really motivates us

We cannot rest on our laurels. Right from the start of a new project, our engineers face a strong headwind. Because every industry sector and every application poses new challenges and requires new solutions. One size will not fit all. So, whether we like it or not, we have to reinvent the wheel every time – especially, if that wheel has to withstand unbelievable speeds.

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