GreenTech made in Germany

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Environmental Technologies in Germany

Environmental technology ranks as one of the most important markets of the 21st century. In all kinds of different ways, it helps society to remedy damage done in the past, reduce ongoing pollution and avoid further damage to the environment in future. At the same time, it helps the corporate sector to make more efficient use of materials that are scarce and, hence, ever more expensive.

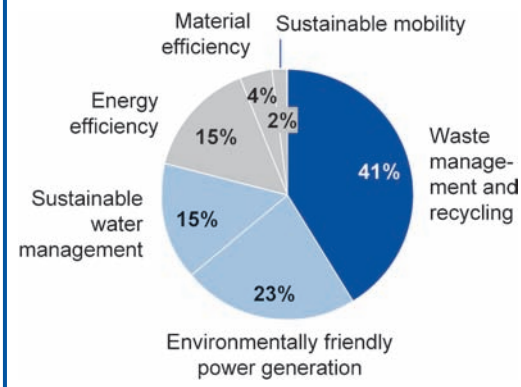
In Germany, environmental technology is established as an economic force to be reckoned with – a forward-looking sector that is increasingly driving both growth and employment. "GreenTech made in Germany" pans out across the whole broad spectrum of environmental technology. The six chapters that make up this book outline the answers that modern technology is finding to the key ecological questions of today and tomorrow.

Taking as its starting point the challenge of worldwide pollution of the environment, this book homes in on six core markets. Each one plays a key role in conserving the vital resources that keep the human race alive and meet our most fundamental needs: access to clean water, hygienic wastewater disposal, the use of materials, waste disposal, mobility and the supply of energy. These basic needs have in turn been condensed into the six "lead markets" for environmental technology that form the focus of "GreenTech made in Germany":

- Environmentally friendly power generation and storage
- Energy efficiency
- Material efficiency
- Waste management and recycling
- Sustainable mobility
- Sustainable water management

The purpose of this atlas is to map out the breadth and diversity of environmental technology. Each chapter reveals the tremendous innovative capabilities that exist in these markets and spells out the opportunities they present to German companies in future. As such, our treatment of technological solutions to today's global challenges also charts future market potential for environmental technology. Most of the data presented in this atlas derives from market studies and interviews with experts. To enrich this input, an extensive survey was con-

ducted of environmental technology companies and related research organizations in Germany. In February 2007, several thousand German enterprises in this sector were asked to take part in an online survey on behalf of the German Ministry for the Environment. Around 1,500 firms and some 250 research establishments responded. The results therefore paint a representative picture of the environmental technology and research landscape in Germany (see figure). The online survey yielded valuable insights into the various players' range of activities, into the trend in sales, earnings and employment, into research and development spending and into global market share. It also traced the networks and collaborative ventures to which German environmental technology companies are committed, as well as highlighting focal areas of research.



Spread of companies in the "GreenTech made in Germany" study

Source: Roland Berger

All these findings are complemented by brief examples of exceptionally innovative strategies that are already operational today. These examples appear separately in blue "technology boxes" throughout the book. In addition, a selection of maps charts the environmental technology landscape in Germany, thereby fulfilling the primary purpose of "GreenTech made in Germany": to serve – literally – as an environmental technology atlas of Germany.

All the maps shown in this atlas illustrate the findings of our survey of companies and research organizations. While they lay no claim to completeness, they do give a valid and representative impression of the sector as a whole. A brief look at the research landscape for environmental technologies and relevant political conditions and constraints rounds off each chapter.

This environmental technology atlas aspires to do more than merely document facts and analysis results, however. It is intended also to serve as a very practical guidebook. An extensive selection of company and research organization profiles is therefore included too. Profiles were chosen based on the organizations' own data on sales growth/research budgets, innovative achievements, research spending and inter-

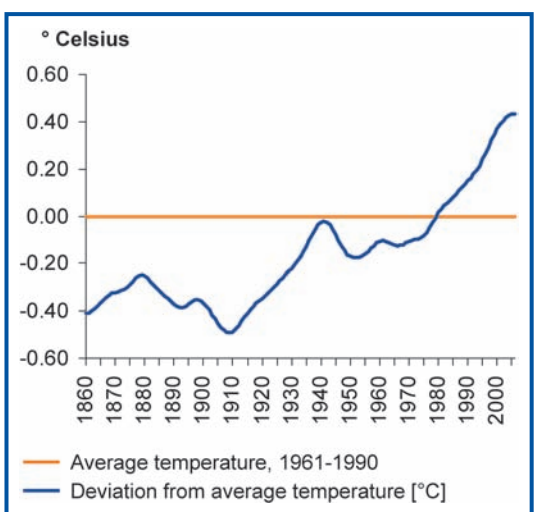
national focus. At the same time, the selected mix is consciously intended to reflect the sheer diversity of this fascinating industry. The profiles are supplemented by an even more extensive directory, sorted by lead market, which contains contact data for all the companies and research organizations that participated in the survey.

To begin with, however, let us cast a glance at the discipline of environmental technology *per se*, and at the challenges that have established GreenTech made in Germany as a fast-growing, lucrative market of the future.

Global megatrends and environmental challenges

Leading scientists agree: If we continue to live as we are doing now, the Earth will become a decidedly inhospitable place to live in. Three causal factors are driving the destruction of what mankind needs to survive: worldwide industrialization, global population growth and increasing urbanization.

Worldwide industrialization in particular is heating up the Earth's climate (see figure). The economic rise of emerging and developing countries is placing an added burden on the environment. In the first six years of this century alone, China's energy consumption surged by more than 700 million tons of oil equivalents per annum – twice as much as Germany uses in a year. Broad consensus also exists among scientists on another point: If we do not limit the increase in the global temperature to 2 °C relative to the pre-industrial era in the next 15 years, the consequences for our planet will be disastrous.



Global warming

Source: Climatic Research Unit, Roland Berger

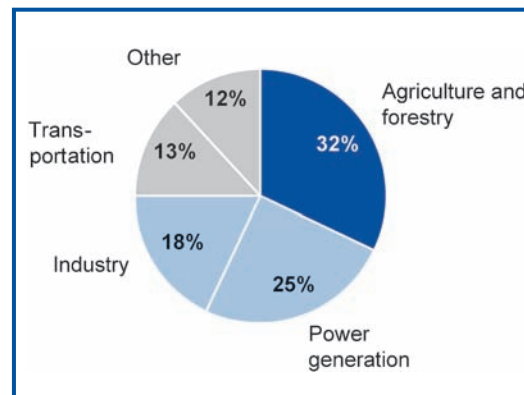
Global population growth too is manifestly leaving its mark on the environment. According to UN forecasts, more than nine billion people will inhabit this planet about 50 years from now, up from 6.1 billion today. Since more people will need

more resources, consumption is bound to increase. The Earth's resources are, however, both finite and unequally distributed. Conflicts over their distribution are therefore virtually inevitable in future. Take fresh water, for example. As early as 2025, about one third less fresh water will be available than we have today. Moreover, existing variations in the regions affected will be exacerbated. Although over 60% of the world's population lives in Asia, this continent has only about one third of the planet's fresh water reserves. Those regions in which population growth is fastest will experience worse water shortages than ever. In the worst-case scenario, seven billion people in 60 countries could have too little water in 2050.

Because more people also need more food, forests will be cleared and turned into farmland. From 2000 through 2005, the world's forests shrank by 7 million hectares a year. Woodland is disappearing fastest in Brazil, where 3 million hectares were razed to the ground each year. Every minute, forests the size of nine soccer fields are chopped down. The clearing of virgin forest leads to particularly alarming consequences, as its unique ecosystem cannot regenerate itself and is lost forever.

Industrialization and population growth are causing more and more people to live in cities. Between 1965 and 1990, the urban population in developing countries nearly tripled from 657 million to 1,800 million. UN forecasts predict that the pace of this rural exodus will quicken in the years ahead. By 2020, more than 60% of humanity will thus live in cities. Concentration of the population in what are now referred to as "megacities" will only increase the pressure on natural resources. City dwellers need to be supplied with food and water. Waste and wastewater must be removed from conurbations. Air pollution is already worst in large cities in the emerging industrial nations. Of the 20 cities in the world with the most serious air pollution problems, 16 are in China alone.

Industrialization, global population growth and urbanization are accelerating global warming. The world's average temperature has increased by 1 °C since the mid-19th century. Twelve of the highest average temperatures in the past 150 years have



Sources of greenhouse gas emissions

Source: World Resources Institute 2005, Roland Berger

been recorded since 1990. Scientists see the writing on the wall: It is we, the human race, who are responsible for global warming. Close to one third of all the greenhouse gases released into the atmosphere in 2004 was generated by agriculture and forestry. One quarter was caused by power generation and one fifth by industry (see figure, page 5). Since 1970, global emissions of greenhouse gases have risen by more than 50%. If countermeasures are not taken in short order, emissions will experience a further significant increase by 2030.

The poorest people in the world suffer most from deteriorating living conditions. The developing countries south of the Sahara (where desertification is advancing relentlessly) and the countries of Asia will be hardest hit by water shortages. It is reasonable to fear that droughts, flooding and shortages of drinking water will force millions of people to flee their homelands. The United Nations anticipates more than 50 million "environmental refugees" as early as 2010. We cannot sit idly by and watch this disaster unfold. Countermeasures must be taken resolutely if these horrific visions are not to become reality. Nor can we turn back the clock, as industrialization promises billions of people a better life than their forefathers.

Modern industrial society is polluting the environment. Yet it also holds in its hands the key to ease this burden. If we wish to inhabit a world that is still worth living in tomorrow, we must make better use of the technologies we have today and continue to develop and improve them. We must use sophisticated environmental technology to help us extract resources more efficiently, and to help us make ever more and better use of renewable materials instead of squandering finite resources. GreenTech made in Germany has a major contribution to make.

Toward a sustainable economy – Lead markets for environmental technology

True, not all environmental problems can be solved with the aid of technology. However, just as much of the damage done to the environment is caused directly or indirectly by technology, so modern technology can play a part in remedying, reducing or avoiding pollution of the world around us. Especially in the past few years, technological development has made huge progress. To quote just two of many examples: Electricity generated from renewable sources is not only clean but

also increasingly able to compete on cost. Similarly, clean water too is becoming affordable to more and more people.

On a macroeconomic level, there is little question that regulations to conserve the environment will increase prosperity by reducing the inefficient consumption of resources. From the point of view of the companies affected, however, stricter rules push up costs. The macroeconomic benefits must therefore be weighed against commercial considerations. In the past, the desire to cut costs clashed with the voluntary deployment of environmentally friendly technology. As such modes of thought lose their grip, however, yesterday's rivals are becoming tomorrow's allies. Today, environmental technology is an integral component of virtually all economic activity:

- Environmental technology makes companies more competitive. As the price of energy and many materials continues to spiral on the world's markets, it prevents unnecessary consumption and thereby cuts costs
- Market potential for environmental technology products is enormous. As the climate changes and industrialization advances – especially in emerging countries – global demand is growing for both products and production processes that are kinder to the environment

What is often referred to as "GreenTech" embraces much more than traditional environmental technology. The relationship between ecological activity and commercial necessity has changed in both quantitative and qualitative terms. A contemporary understanding of environmental technology therefore has to broaden the definition, if only because the challenges raised by pollution of the environment today affect virtually every industry. As we have seen, growing demand for energy and for scarce resources has assumed the dimensions of a megatrend. Consumers' "needs" too are expanding continually. Accordingly, efficiency and sustainability must be placed firmly at the center of all strategies to modernize both the corporate sector and the economy in general. Accepting this broader definition, environmental technology is no longer restricted to conventional disciplines such as filter technology, wastewater purification and waste disposal. It now encompasses all technologies that can play a part in cutting emissions and reducing or avoiding other forms of environmental pollution. In other words, it includes all technologies that will contribute to satisfying ever greater needs in a more environmentally friendly way.

In the interests of clarity, we have divided the broad spectrum of environmental technology innovations and products into six lead markets that are exceptionally important from an economic and ecological perspective. These six markets are: environmentally friendly power generation and storage, energy efficiency, material efficiency, waste management and recycling, sustainable water management and sustainable mobility. This split emerged in the course of studies conducted on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Lead markets are those markets that link pivotal future challenges to technological innovation to an exceptional degree. A country's ability to contribute innovative technology to such lead markets largely determines whether or not it will be able to compete in the international arena. This takes much more than research, however. Above all, it also requires a modern system of innovation in which close collaboration is fostered between all organizations that generate, accumulate and communicate knowledge, that train the work force, that develop technologies and that create and disseminate innovative products and processes. At the same time, a conducive regulatory framework must be put in place; and the government too must invest in a suitable infrastructure. Lead markets are the markets of tomorrow. They are shaped not only by economic considerations but also by social policy ideals.

These markets deliver powerful stimulus to the macroeconomy. The development and manufacture of products and services that protect the environment thus helps a country penetrate international sales markets. Moreover, by improving the efficiency with which we use energy and resources, these technologies also create competitive advantages for more traditional branches of industry. Whether or not certain ecological innovations become established is not only determined by the knowledge and R&D activities pursued in concert by the business and scientific communities. The demand for these technology solutions must exist, of course. And an appropriate political and institutional framework is equally imperative. This atlas of environmental technology thus provides a high-level map of the capabilities of this industry in selected lead markets in Germany. The picture that emerges makes one thing abundantly clear: Besides being a powerful engine of growth, environmental protection will also determine whether Germany as a nation is able to compete in many markets of the future.

GreenTech is high tech – New technology drives progress

The examples on the pages that follow are indicative of the extent to which economic and ecological imperatives have already converged. They also illustrate how technological innovation can substantially ease the burden on the environment. At the same time, they clearly show that GreenTech is almost always high tech. Environmental protection has nothing to do with a sentimental hankering for bygone days, nor does it presuppose a Luddite skepticism of all things technical. On the contrary: Technological progress is the very lifeblood of energy- and resource-efficient production methods. Cross-sectional technologies in particular, such as white (or industrial) biotechnology and nanotechnology, are playing an ever more important role in almost all lead markets. They are literally changing the face of environmental technology. Nanotechnology applications are improving the ecological efficiency of products and processes. Examples include lower consumption of materials and energy, the ability to recycle more materials and the extension of product lifecycles.

Nanoceramic membranes are one such forward-looking idea that will enable CO_2 to be filtered out of exhaust gases, thereby attenuating the greenhouse effect. In the energy industry, these membranes can make fuel cells more efficient. Alternatively, they can also be used as separators in high-performance batteries. Measurement and control systems too contribute to more efficient economic activity and are likewise increasingly benefiting from nanotechnology. Contaminated soil is yet another sphere of nanotechnology application. In this area, new measuring techniques and nanostructured pesticides are doing a lot to lessen the burden of pollution.

Membrane technologies: What you want is what gets through

Membranes work rather like coffee filters: They only let certain substances through. The difference is that membranes filter far smaller particles. A membrane is a thin layer or film that separates two different composite substances (liquids or gases) from each other. Nanotechnology membrane films are used in the water industry, for example, to purify wastewater or desalinate seawater. Membrane filters can keep bacteria or viruses out of drinking water. They can also separate or absorb gases. When filtering CO_2 in coal-, oil- and gas-fired power plants, they bind the CO_2 emissions that would otherwise harm the atmosphere. Exhaust gases accumulated in road tunnels can be filtered by hollow-fiber membranes. Now, new high-temperature membranes should pave the way to far more compact, efficient and inexpensive fuel cell systems for automobiles.

Low-CO_2 power plants go easy on the climate

German power utilities can now burn coal but still produce only small quantities of CO_2. Progress is currently being made with two environmentally friendly combustion processes. The first is used in what are called integrated gasification combined cycle plants (IGCCs). Gasification of the coal creates a mixture of hydrogen and carbon dioxide. Before combustion begins, the CO_2 is separated off so that the remaining hydrogen can burn cleanly. The intention is to store the isolated carbon dioxide in former gas towers and in sedimentary rock. By 2014, RWE plans to build a large-scale IGCC power plant complete with CO_2 storage depot. Right now, it is the only company in the world that is developing this entire process chain – from power generation through pipeline transportation to storage – on an industrial scale.

An alternative way to reduce emissions is being developed by Vattenfall Europe at its Schwarze Pumpe pilot power plant in Spremberg, Saxony. This plant uses an oxyfuel process, which burns a mixture of oxygen and exhaust gas that has been cleaned of nitrogen together with coal. The resultant flue gas consists of 98% CO_2 and can easily be liquefied and stored. The 30 MW pilot plant – due to go into service in 2008 – will be the first low-CO_2 coal-fired power plant in Europe.

Measurement systems: High tech with its finger on the Earth's pulse

Effective action to conserve the environment can be taken only on the basis of reliable data. This data is supplied by modern tools that measure pollutants in the air, water and soil and also record both noise pollution and adverse effects on the climate.

German companies lead the international field in the measurement of ultrafine particles (extremely small particulate matter). Intelligent measurement systems also activate automated control and process systems to optimize energy consumption. A software tool deployed at Essen-based Powitec GmbH, for example, measures flame patterns in power plant furnaces, cement kilns and waste incinerators. This information is then analyzed to improve the burning process. Nationwide application of this technology would slash 3 million tons off German carbon dioxide emissions every year.

As well as delivering information, measurements can even save lives. The German-Indonesian tsunami early warning system is intended to prevent a repeat of the disaster that shook the world in December 2005. Coastal regions can now be warned of impending floods within minutes of the formation of a tsunami on the open sea. This gives coastal populations more time to escape to safety.

Contemporary efforts to protect the environment – in wastewater purification, waste treatment, fuel production, exhaust air purification or whatever – would be equally unthinkable without white biotechnology. White biotechnology processes complement or, in some cases, substitute for traditional chemical and physical/mechanical processes. By reducing the volume of materials and energy consumed, they significantly improve ecological efficiency. This effect is indeed enhanced by the fact that biotechnology processes take place under far less extreme reactive conditions (in terms of pressure, temperature, acid content and energy, for instance). Instead, biotechnology unfolds its impact through the agency of enzymes, microorganisms and cellular systems.

Synthetic fuels – Whole plants in the tank

Biomass-to-liquid (BTL) fuels and bioethanol created by the enzymatic decomposition of cellulose are second-generation biofuels. Unlike their first-generation predecessors (such as biodiesel, vegetable oils and bioethanol produced by traditional means), these new fuels can be extracted not only from agricultural produce but also from biological waste. The energy yield per unit of space is thus twice as high in the second generation. Net CO_2 emissions are also far lower than in first-generation biofuels. In addition, synthetic biofuels reduce particulate emissions – even in older vehicles and without the need for technical modifications.

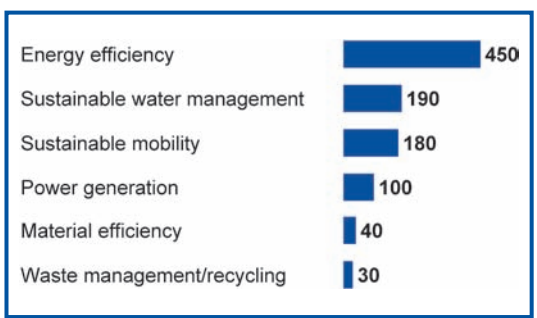
Biotechnology has a particularly strong influence on the development of fuels, helping to convert the solar energy stored in plants into usable fuels. In future, biotechnology could also be used to remedy damage to the environment. For instance, poplars have been made more resistant to heavy metals by giving them an extra gene from the E. coli bacterium. This shows a lot of promise as a potential means of cleaning up

Cool solar systems: The sun as a source of cooling energy

The sun reduces the temperature. At least, it does when you use solar energy as a cooling agent. Solar cooling energy is helping to meet extra demand for cooling capacity for foods and industrial products. It is also being used to maintain agreeable temperatures on work premises – eliminating the need to install power-hungry air-conditioning systems. Besides saving energy, solar cooling – unlike solar heating – never runs into storage problems, because of the direct correlation between solar energy and demand for cooling energy. The hotter it gets, the more cooling energy is needed; and the more intense the sun's rays, the more effectively solar cooling systems work. Different solar cooling methods are used depending on the precise application. Refrigerators can run using adsorption or compression methods. Buildings and rooms are cooled by extracting water from warm ambient air through a process of adsorption. The resultant evaporation cools rooms to an agreeable temperature.

Biorefineries: Microorganisms in the service of chemical engineering

Biorefineries break organic substances down into their constituent parts without having to use chemicals that would pollute the environment. This principle is enabling physical, chemical, enzymatic and microbial methods to convert renewable materials into fuels. White biotechnology is regarded as the key technology in biorefining, as the metabolism of numerous bacteria and fungi supplies many of the valuable substances used in this discipline. Like conventional refineries, biorefineries too set in motion a series of downstream processes that enable substances to be exploited. Polysaccharides (also known as glycans), for example, can be derived from cereals and used in the food industry as thickeners, gelling agents and stabilizers. The biggest advantage of biorefineries, however, is that they give off only as much carbon dioxide as the plants had previously absorbed. Biorefineries are strict vegetarians, meeting their own energy needs from the residue and combustible vapors left behind by the renewable substances that they process. As oil reserves dwindle, the chemical industry in particular – which alone consumes 10% of the world's crude oil – is developing a keen interest in using biorefineries to exploit renewable resources.



Global market volume for environmental technologies [EUR bn]

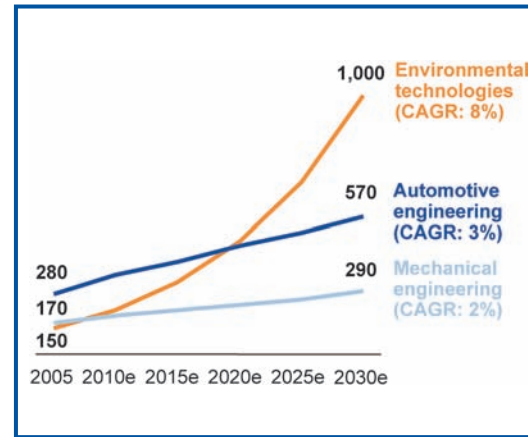
Source: Market studies, interviews with experts, Roland Berger

contaminated soil. However, a number of health and safety issues need to be clarified before the approach can be applied. The selective use of bacteria in waste treatment enables biogenous components to be degraded quickly and efficiently. The boxes on page 10 and 11 present on exceptionally innovative developments and cross-sectional technologies that are of considerable importance to the various lead markets for environmental technology. At the same time, these developments again underscore the high-tech nature of GreenTech made in Germany.

The markets for environmental technologies – Germany excellently placed

According to data from the European Commission, the market for environmental technology expanded at an annual rate of 7% from 1999

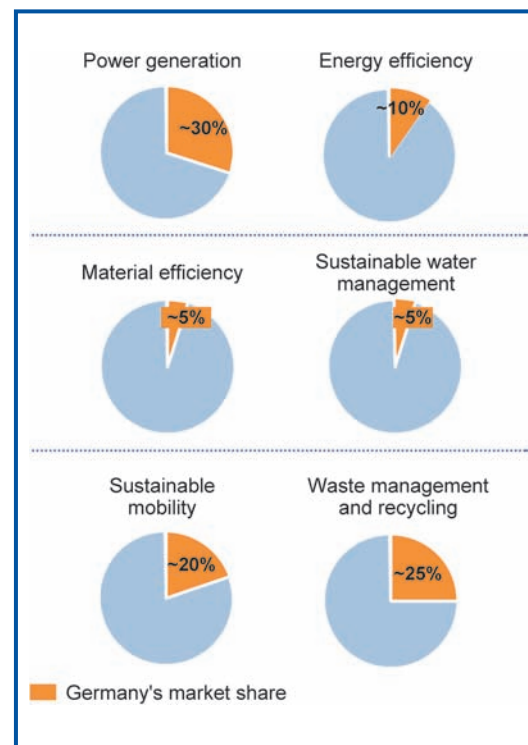
through 2004 in Europe – outstripping even the most optimistic forecasts of the past. A study by Roland Berger Strategy Consultants found that environmental technology accounted for around 4% of total revenues in German industry in 2005. The study predicts that, between now and 2030, this figure will quadruple to 16% of total revenues. Such numbers alone clearly show that environmental technology has long since shed its image as a niche market. Today, it is recognized as a fast-growing market that is tremendously important to the economy as a whole. In the medium term, the environmental technology sector will outgrow traditional branches of industry such as mechanical and automotive engineering.



Trend in the German environmental technology industry, 2005-2030 [EUR bn]

Source: Prognos 2006, Roland Berger

The lead markets described in this atlas already had a combined global market volume of about EUR 1,000 billion in 2005. Enabling technologies such as biotechnology and nanotechnology, both of which will be of great significance to environmental technology in future, themselves already command markets worth EUR 30 billion and EUR 100 billion respectively. By 2020, environmental technology industries will see total revenues more than double to EUR 2,200 billion. Prince Hassan of Jordan, President of the Club of Rome, put this development in a nutshell when he said that "The markets of the future are green." The fastest-growing segments are alternative energies and renewable materials.



Germany's share of global markets for environmental technologies

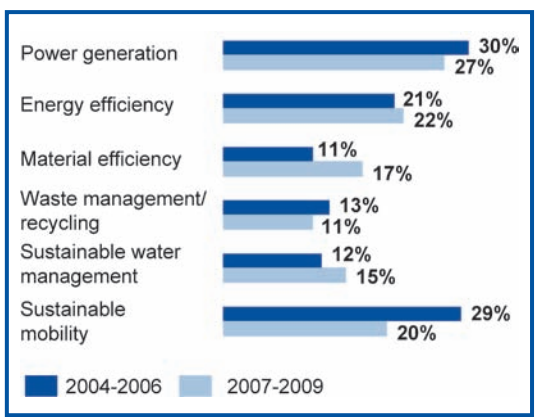
Source: Market studies, interviews with experts, Roland Berger

Germany is excellently placed to supply the markets of the world with its own green technology, or "Green-

Tech". As things stand, the country already occupies global market shares of between 5 and 30% in various segments. Germany is particularly strong on technologies for environmentally friendly power generation and on key processes in the separation and recycling of waste – a segment in which German companies have cornered more than a quarter of the world market (see figure, page 13). Environmental technology is boosting economic growth and hence also employment. In Europe, more than two million jobs could be created by 2020 in the renewable materials segment alone.

Sales and jobs – Power generation leads the field

The environmental industry is booming in Germany. This is the core finding of a survey of some 1,500 companies, including everything from energy consultants to wind energy firms, from sewer system vendors to service companies that convert diesel engines. 40% of the respondent companies increased their sales by more than 10% per annum from 2004 through 2006. Moreover, they expect this trend to continue through 2009. In boom industries such as solar technology, innovative young companies and incumbents alike are experiencing growth of over 50% per year. Average growth rates from 2004 to 2006 range from 11% in material efficiency to 30% in the market for environmentally friendly power generation (see figure).



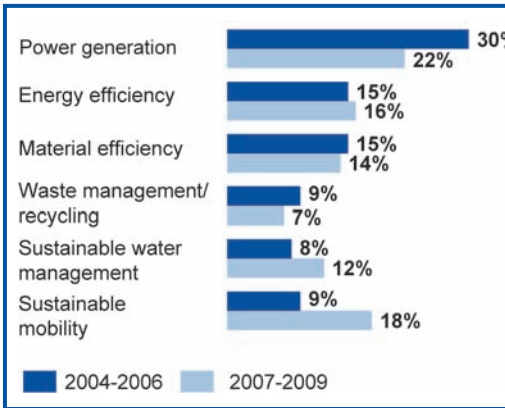
Past and future sales growth in the various lead markets

Source: Roland Berger

Environmentally friendly power generation is the number one engine of growth. Within this lead market, renewable energy and power storage are enjoying singular success. They are followed by the sustainable mobility market, in which small companies in the biofuels and fuel cell segments have posted strong growth to date.

In future too, enterprises that operate in the various lead markets outlined in this atlas can expect annual growth to average as much as 27%.

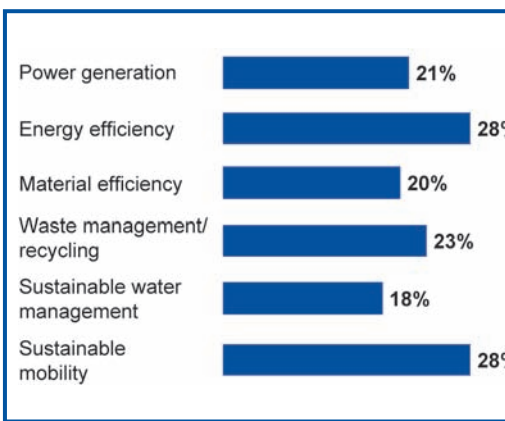
Sustainable mobility will see its rate of expansion ease slightly. On the other hand, the corporate sector will feel the impact of the increasing importance of material efficiency. This lead market is projected to grow by 17% per annum through 2009 – considerably faster than the 11% rate recorded hitherto (see figure, page 14). Companies in some lead markets do expect sales growth to slacken a little. Having said that, all firms surveyed still expect to expand very rapidly on the whole. Double-digit growth is projected on average, even in markets such as energy efficiency, which has already reached a very high volume in absolute terms.



Past and future work force growth in the various lead markets

Source: Roland Berger

Our study also showed that environmental technology is creating jobs in Germany. On average, the work force employed in all lead markets swelled by 15% a year from 2004 through 2006. The mean figure for employee growth between 2007 and 2009 stands at 13%. These remarkable gains come as telling evidence that environmental technology is one of Germany's strongest generators of new jobs. On this score too, environmentally friendly power generation is once again top of the league, although a measure of convergence with the levels in other lead markets is anticipated. From 30% per annum up to now, the increase in staffing levels is expected to decline on average to 22% in 2007 through 2009 (see figure).



Percentage of companies whose returns on sales exceed 10% in each lead market

Source: Roland Berger

The majority of environmental technology firms are profitable too, although the spread in returns on sales is broader for small companies with sales of under EUR 10 million. Small firms include both the highest proportion of loss-making enterprises and the largest share of operations that post returns on sales of more than 10%. Differences also exist between the individual lead markets. Some can be explained by

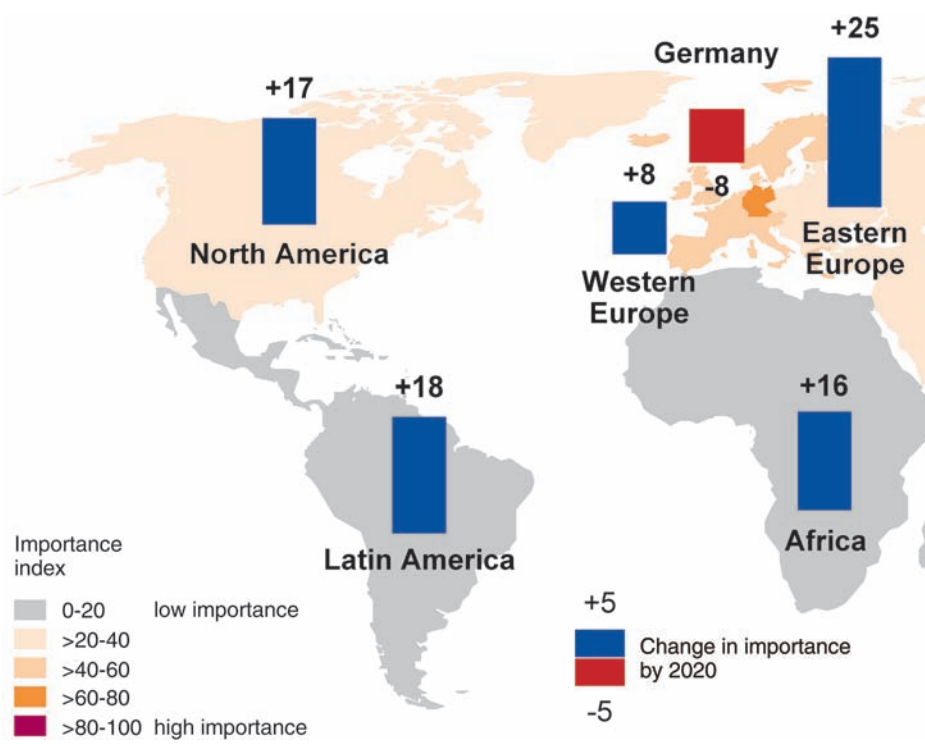
varying market structures. The lead markets for energy efficiency, sustainable mobility and waste management/recycling boast the largest share of highly profitable firms (see figure, page 5). Within these groups, it is conspicuous that the most profitable companies tend to be those that make a major in-house contribution to the technologies concerned. Examples include manufacturers of energy-efficient equipment, planning offices, vendors of biofuel plants and makers of technology that enables industry to reduce harmful emissions.

International outlook – Development potential greatest in Eastern Europe

Across all lead markets, Germany remains singularly important to native companies. It is indeed by far the largest target market. Even for companies with international operations, Germany still commands top slot. In five out of six cases, German companies give their home market 80 out of a possible 100 points in the importance index.

For manufacturing companies, Germany is likewise a key production location. Nor is that going to change between now and 2010. In some lead markets, such as that for energy efficiency, production in Germany will actually be ramped up in this period. This finding confirms the hypothesis that GreenTech is emerging as an ever more vital force in the German economy.

Closer examination of the regional focus of companies reveals that half of all mid-sized and large companies already have EU-wide or even worldwide operations (see figure, page 17). The signifi-



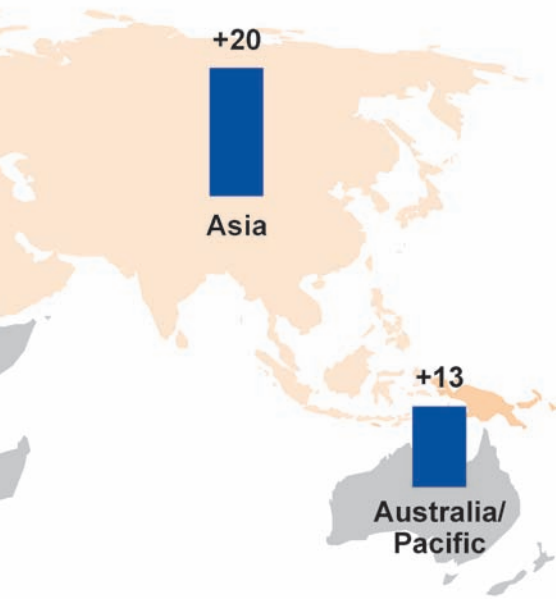
Importance of regional markets 2007 and 2020

cance of foreign markets – especially the emerging markets of Asia and Eastern Europe – will increase further in future. Alongside Eastern Europe, the fastest-growing GreenTech markets are India, China and Russia. The companies in this industry believe that the sales markets of Eastern Europe will draw almost level with those of Western Europe by 2020. Also by 2020, India, China and Russia will be ahead of North America – and way ahead of Japan.

The importance of different regions varies considerably in different lead markets, however. North America, for example, plays a much more important role in sustainable mobility than in the other lead markets. By 2020, Africa too will have gained markedly in significance for the environmentally friendly power generation market (see World Map).

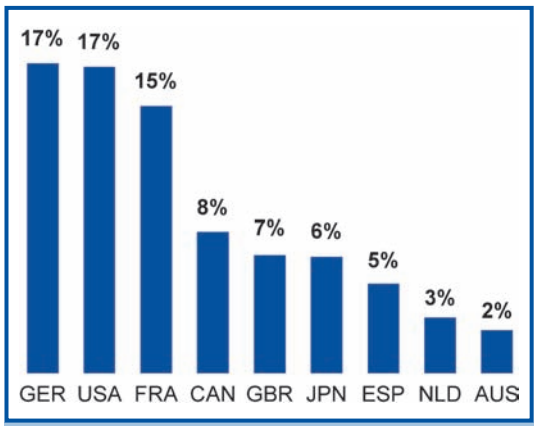
Percentage of companies with an international reach, by revenue bracket

Source: Roland Berger



Innovation in the environmental technology industry – Germany up among the global leaders

Germany is one of the world's leading research hubs for environmental technology. This statement applies both to the quality of research and to the absolute volume of research conducted. In terms of private and public research spending, Germany trails the USA and Japan, but still occupies a leading position and is definitely in the European vanguard. Notwithstanding, both the government and industry must redou-



Percentage of environmental research spending contributed by OECD member states

Source: NIW

ble their efforts if Germany is to meet the EU's goal of raising research expenditure to 3% of GDP by 2010. In environmental technology, Germany is already excellently placed in terms of government research and development spending. In 2004, Germany alone accounted for about 17% of the OECD's total environmental R&D spend – the largest contribution by any single country (see figure). Although the pace of research has slackened somewhat in recent years, the number of research projects receiving public subsidies has rebounded since 2005.

Companies in the environmental industry in Germany invest in innovation to varying degrees. In our study, the respondent companies channeled an average of 3% of total sales into research and development. Large enterprises with the corresponding R&D budgets essentially determine this average. Small companies, however, tend to invest considerably more in research and development – between 5 and 12% of sales, depending on the lead market.

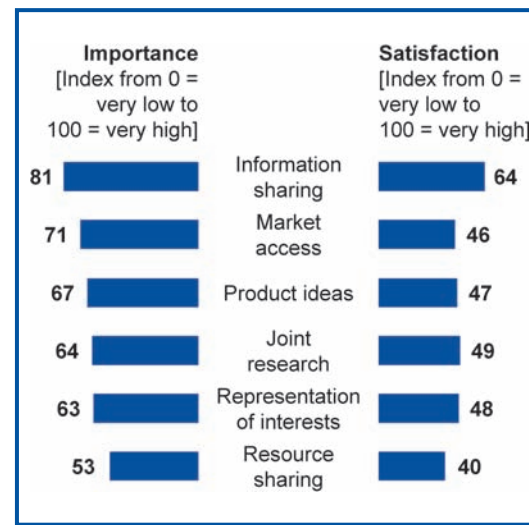
Owing to its large proportion of service companies, the waste management and recycling industry exhibits the lowest R&D spending rate. At the other end of the scale are the lead markets for sustainable mobility and material efficiency. Rapid-fire innovation in these segments is influenced to no small degree by the fact that they include large numbers of startup companies. Manufacturers of drive technologies and fuel cells are just two examples.

The companies surveyed plan to step up their innovative endeavors in the coming years. Firms in the lead markets for environmentally friendly power generation and sustainable mobility are leading the way. On average, the players in these segments will increase their research spending at annual rates of 14 and 12% respectively. Both markets also occupy pride of place in the broader context of publicly subsidized research projects. More than half of research expenditure on projects launched between 2003 and 2005 was devoted to "renewable energies and CO_2-free fossil energy sources" and to "mobility and logistics".

Collaboration and networks – The key to systems expertise and business success

Environmental technology places heavy demands on the companies committed to these markets. Innovation processes are frequently based on an interdisciplinary combination of technologies that must then be translated into products. The key challenge is therefore to dovetail research organizations and the corporate sector in a way that facilitates the necessary dialog and cross-pollination. Germany has evidently risen well to this challenge. Its wealth of systems expertise – i.e. its strong commitment to applied research and the close collaboration that takes place between research and industry – commands international respect.

The respondent companies confirmed this trend. 57% claimed to participate in networks of innovation. Of these, about half are engaged in dialog with research organizations. The other half work together with customers, suppliers and/or – albeit in rarer instances – competitors.



Importance/satisfaction of different motives why companies collaborate on environmental technology

Source: Roland Berger

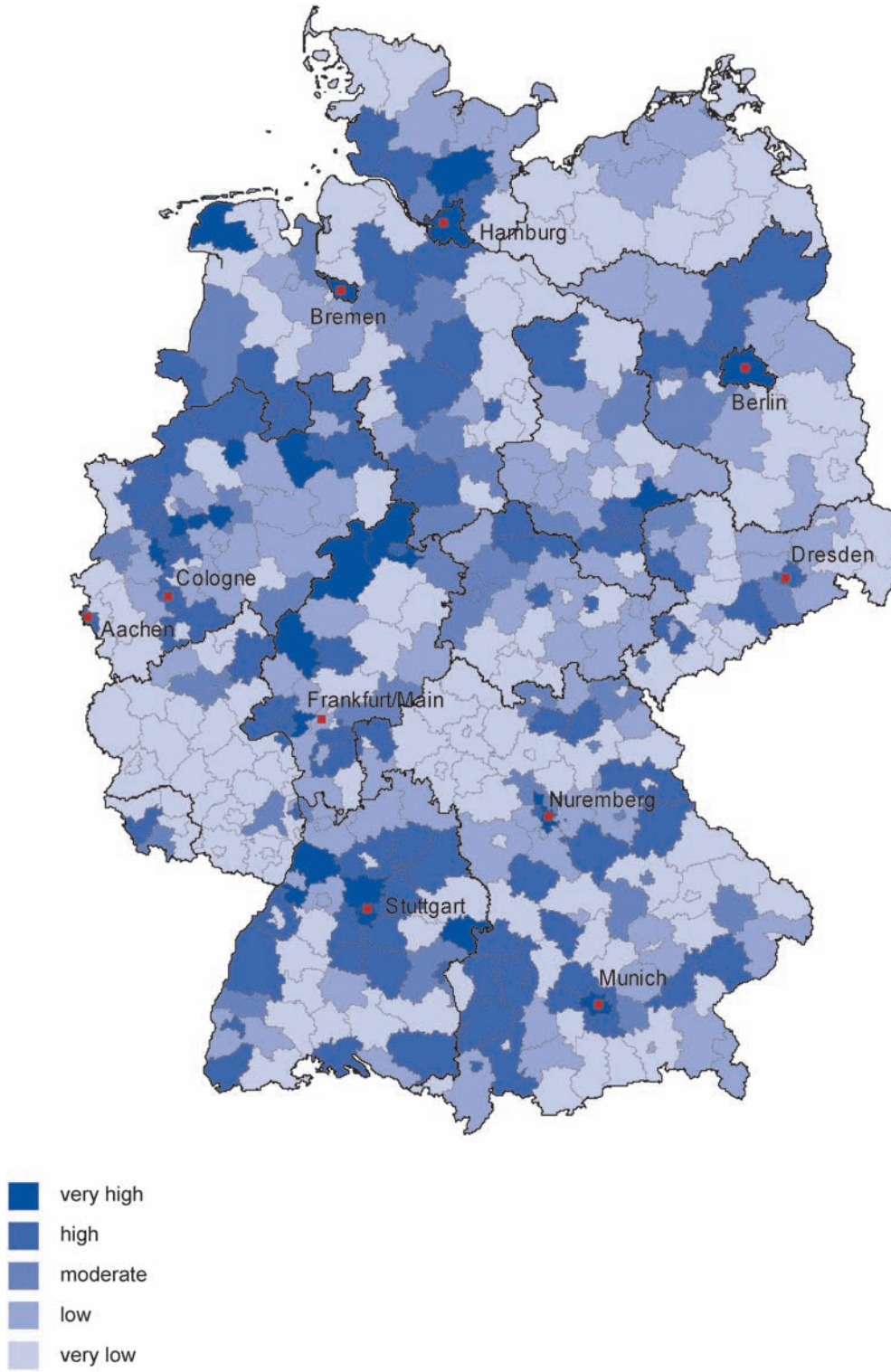
Commitment to networks clearly has a positive effect on corporate earnings. Every second company that participates in networks of innovation realizes a return on sales of over 5%. Of those companies that do not cooperate in this way, only 43% can say the same. Moreover, the study indicated that nationwide and international collaboration has a greater impact than regional networks: Those groups that take part in supraregional cooperation are both considerably more profitable and much more satisfied with the quality of networked collaboration.

Regional focus of environmental technology – Innovation hubs in eastern Germany

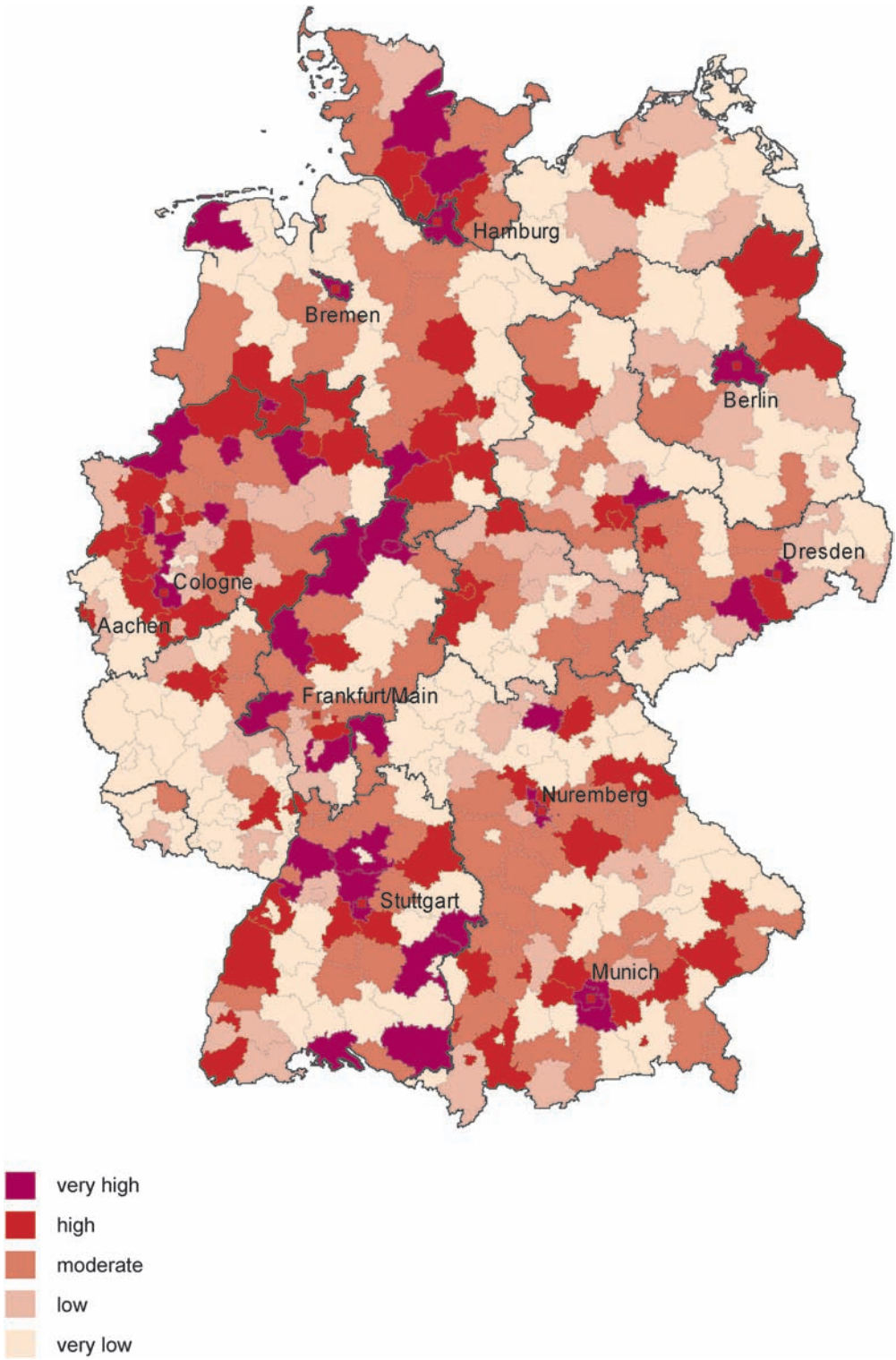
The environmental technology industry is not spread evenly throughout the country. Comparison of employment volumes in each administrative district (see the "Employment" map, page 21) puts Bavaria – and the cities of Munich and Erlangen in particular – out in front. They are followed by Berlin and Hamburg, two other major urban centers. Other districts with a heavy concentration of GreenTech workers are situated primarily in North Rhine-Westphalia and Hesse. In eastern Germany, many districts have very few jobs in the environmental technology industry. Exceptions include Dresden, Halle, Erfurt and Freiberg. One district truly stands out from the crowd: Bitterfeld. Despite this uneven distribution, eastern Germany has clearly become an important venue for the renewable energy segment in particular – especially in industrial production. The solar industry too is causing the environmental technology work force to expand sharply in Germany's eastern states.

If we turn our attention to the absolute figures for research spending by environmental technology companies, a similar picture emerges (see the "Research spending" map, page 22). The few discrepancies are extremely interesting, however. Those districts that rank considerably higher on research spending than on employment can be categorized as the exceptionally innovative regions. Bitterfeld, for example, ranks 20th in Germany in terms of the number of GreenTech jobs within its catchment area, but 5th in terms of research expenditure. The same goes for Aschaffenburg, which ranks 9th in the research spending table but only 24th in the volume of employment created.

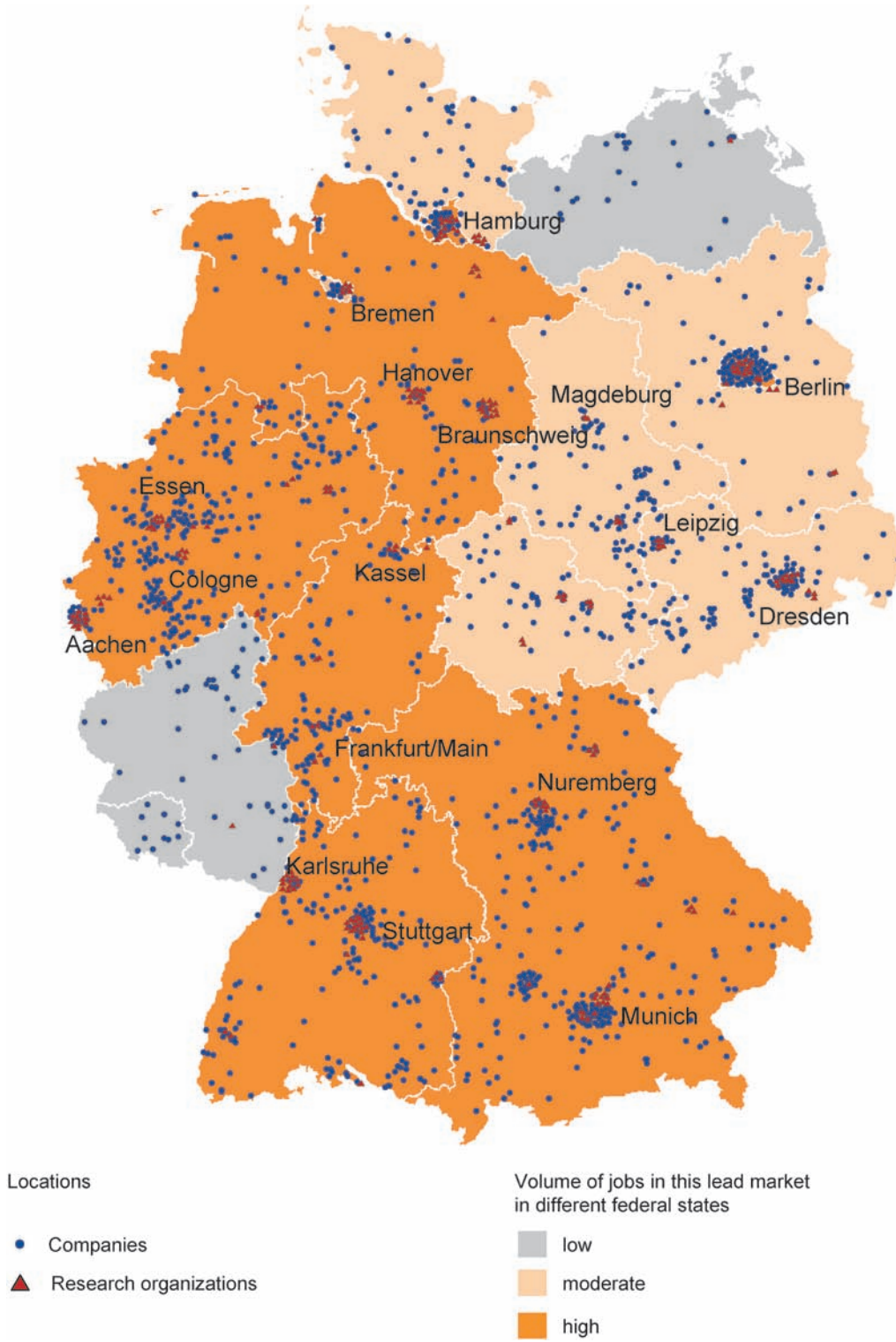
The map depicting the locations of all the companies surveyed combines national and local employment data. The predominance of western Germany as the home of environmental technology firms is clearly visible from this map. So too is the concentration of companies in and around Germany's large conurbations. This is true especially of Berlin, where many young companies are based, and Hamburg, the market-leading region for solar and wind energy. Stuttgart has emerged as a hub for efficiency technologies and sustainable mobility, while the renewable energy segment is focused largely on the Freiberg and Bitterfeld regions. A strikingly large number of technology firms have set up shop in and around Dresden, Aachen, Karlsruhe and Erlangen/Nuremberg, in close proximity to established research organizations.



Volume of environmental technology jobs in different administrative districts



Spending on environmental technology research in different administrative districts



Regional spread of companies and research organizations in the environmental technology industry in Germany

Other research institutions in Hanover, Braunschweig and Leipzig and the technical universities in many major German cities are likewise contributing new technologies to the cause of environmental protection. The individual chapters on the lead markets profile a number of regional and nationwide collaborative ventures between research organizations and the corporate sector. What they all have in common is a deep commitment not only to basic research but also to the development of new products. These range from the traffic telematics model in Nuremberg, through nationwide cooperation to develop new ways of cleaning ballast water, to collaborative projects to develop thin-film solar cells in Bitterfeld and Halle. One significant finding of our study is this: On whatever level collaboration takes place – on a local level, between research organizations and midsized companies on a regional level or between larger research bodies and corporations on a national level – it is a vital ingredient in the innovative processes that are driving GreenTech made in Germany.

20 years of German environmental policy – An engine of growth and employment

Worldwide, Germany plays a pioneering role in the realms of environmental policy. The importance of environmental protection in Germany is reflected today in the excellent economic health of the related industries. The environmental program launched by the German government in 1971 and key laws such as the Waste Disposal Act (1972) and the Emissions Control Act (1974) were way ahead of their time.

In 1986, responsibility for national environmental policy was placed in the hands of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Wasting no time, this new ministry very quickly tackled the most pressing environmental challenges of the day. To begin with, attention was focused on the need to clean up the inherited problem of serious pollution. In short order, the ministry therefore prohibited leaded gasoline and leaded emissions in industrial production, later also prohibiting the use of chlorofluorocarbons (CFCs). On a technological level, this “retroactive” approach to environmental protection was reflected in the predominance of what are known as end-of-pipe technologies. These early efforts paid dividends. German rivers are now once again inhabited by a plethora of species. Smog has become a rarer phenomenon in German cities. The sky over the Ruhr once again shines blue.

Since the 1990s, the environment ministry has increasingly adopted more forward-looking policies and an integrated approach to protecting the environment. Key examples include a waste treatment policy that has raised the recycling quota and moves to place greater responsibility on manufacturers. In addition, Germany is setting an example in proactively conserving the environment and ramping up its use of renewable energy.

German environmental policy has crafted a conducive legal and organizational framework and set ambitious targets in the various lead markets. In doing so, it has repeatedly and successfully created powerful incentives to innovation. This has given German companies a competitive edge over rivals in other countries who operate within far less rigorous legal frameworks. In other words, environmental policy has been instrumental in making Germany the world's biggest net exporter of products and services to protect the environment. Innovative technology made in Germany today accounts for a share of more than 16% world trade in this sector.

New challenges such as climate change are arising and ecological concerns are becoming ever more important aspects of economic decision making. This makes innovation in environmental policy all the more significant. Environmental policy will not be reduced to innovation in future. But coming up with environmental innovations and promoting the development and proliferation of environmental technologies will be key to our economic and ecological success. Specifically, political conditions must be put in place that enable the government

- To reinforce the strategic industries of tomorrow and help the German economy get in shape for the lead markets of the future
- To promote innovation, initiate advances in technology and help new technologies to find their way to market more quickly in the form of workable applications
- To adjust the industrial structure of the economy in line with ever scarcer resources
- To nudge key sectors of industry in the direction of renewable materials
- To trigger a "third industrial revolution"

The overriding challenge that confronts policymakers today and that innovation-oriented environmental policy will help them to master is this: to position German companies that produce innovative environmental technologies in the growing global market for the resultant products; and to create conditions that will allow GreenTech to spread rapidly.

The state must take an active role. This is one of the findings of our study. Companies attach great importance to a regulatory policy framework combined with clear environmental policy targets that support innovation in industry. Furthermore, there is a definite expectation among firms that innovation should actively be promoted and industries of the future given a strong backing. Research should be aligned with lead markets, should concentrate on strategic core areas and should be built around product marketability. Time and again environmental technology companies voice a number of clear-cut demands. They say industrial policies should help them in the market launch phase, favor innovation and sustainability in public sector tendering and promote their business overseas.

Ultimately, this environmental technology atlas does more than merely document the impressive capabilities of a forward-looking industry. It also documents the demands that this industry is placing on an environmentally friendly industrial policy. In all six lead markets, companies in Germany are very well placed right now. Having said that, neither the government nor the corporate sector can afford to rest on their laurels. Further action is imperative in all the lead markets we have examined. The chapters that follow spell out the potential that the individual lead markets present to German companies. They also describe the specific challenges facing the players in these markets. This publication – and the in-depth study of German companies and research organizations that underpins it – thus broadens our base of empirical knowledge of environmental technology as an economic force. It also sharpens our awareness of the importance of this forward-looking industry. Lastly, this book provides a valuable insight into the agenda for an environmentally friendly industrial policy – a policy that must protect the environment, make Germany more competitive, open up new ways to add value and encourage the creation of new jobs.

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- Bundesverband Erneuerbare Energie e.V. (BEE)
- Bundesverband Solarwirtschaft e.V. (BSW)
- Bundesverband WindEnergie e.V. (BWE)
- CO_2-Handel.de (emissions trading and climate protection portal)
- Conference of University Deans
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