

## What comes after coal?

*In 2030, the coal era will come to an end in the Rhenish mining area just west of Cologne. Leaders in the region hope it can become a model for how an economy can shift from mining to renewable raw materials. But the promising possibilities still face significant challenges.*

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*Abandoned open-pit mines could be used to grow safflowers.*

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Each summer, the bright yellow of a few hundred safflowers provides the only splash of color for several kilometers in front of a vista of brown-gray earth dotted with steel machines that stretch nearly 100 meters high and weigh more than 10,000 tons. Here, at the Hambach open-pit mine, the flowers symbolize a possible future for the Rhenish mining area. They grow



*The Hambach lignite mine has shaped the region for decades.*

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on nutrient-poor soils exposed by the open-pit mine, where little else thrives, and they produce an oil that can be processed into lubricant. Renewable raw materials instead of fossil fuels – can that be the answer to the economic shift that is looming over the region?

Exactly 40 years ago, the RWE company, then known as Rheinbraun, started to mine lignite in Hambach. Its huge machines have extracted more than three billion tons of coal from the largest lignite mine in Europe. But the end is in sight. The last German coal-fired power plant is scheduled to go offline in 2038. The state government of North Rhine-Westphalia (NRW) has already negotiated 2030 as the phase-out year for the Rhenish mining area. The rural region in western Germany, surrounded by the major cities of Aachen, Bonn, Cologne and Düsseldorf, is facing a dramatic economic shift in record time. The federal and state governments are providing around 15 billion euros to help soften the blow.

## Characterized by coal

The coal and energy industries and their suppliers have shaped the region for decades. At its peak at the end of the 1950s, 26,000 people were employed in the brown coal industry in the Rhenish mining area, and a further 46,000 in hard coal mining in Aachen and Ibbenbüren. "I have many neighbors and acquaintances who work at RWE," says Gaby Schmitz-Esser. As the mayor of Niederzier-Krauthausen, a town less than five kilometers from the Hambach mine, she knows the concerns of the local people. She is in her early 50s, sells sustainable cleaning products out of her home, and has been active in local politics for more than 20 years. "Our main concern in politics is to replace and create jobs," she says, referring to the coal phase-out. The energy in her voice leaves no doubt about her drive to help her community.



*The Rhenish district is surrounded by Düsseldorf, Cologne, Bonn and Aachen.  
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RWE has a good image here. The company is not only the most important taxpayer, but also provides philanthropical support to many projects in the region. "We are already noticing in the Niederrhein budget that there is less money in the coffers because of falling tax income," says Schmitz-Esser, who also serves as the local parliamentary group leader for the Christian Democratic Union (CDU). The region's economic transformation has become a large part of Schmitz-Esser's political efforts. According to the NRW state government, only 7,700 people worked directly in the lignite industry in 2022, but suppliers and service providers connected to mining employ many more. The Zukunftsagentur Rhenisches Revier, a government-funded agency set up to help manage the transformation, expects around 50,000 employees to be affected by the economic shift.

The NRW state government is investing in several sectors to help shape the future of the Rhenish mining district. These include hydrogen production and digitalization, but the key focus is on the so-called bioeconomy. The term refers to all products and services that are based on biological raw materials, including agriculture, forestry, biotechnology, food production, pharmaceutical manufacturing, the construction industry, sewage treatment plants, paper manufacturing, packaging companies, and even the textile industry — anything that uses raw materials or products from plants, fungi, animals or microbes.

### **The bioeconomy is not really a new concept**

"Many regions already had an active bioeconomy before the fossil fuel industry arrived," explains Ulrich Schurr. "They did business with the regional resources that were here." Schurr, 60, is a plant researcher at the Jülich Research Center, three kilometers from the Hambach mine. To reach his office, one passes long rows of greenhouses. He is frequently there late into the evening, talking on the phone or chatting with invited guests. That the bioeconomy should become an important pillar of structural change in the Rhenish region is largely due to this man.



*Plant researcher Ulrich Schurr coordinates the bioeconomy district.*

The yellow safflowers growing on the open pit mining soil are part of one of Schurr's projects.

"The region has good soils, a good climate and therefore high biomass production," Schurr explains. Agriculture, the textile industry and the paper industry have always been strong in the Rhenish region. The aim now is to better network the players already in the region, take advantage of modern technologies, and make more efficient use of the region's biomass production. The consulting firm Prognos AG calculated in 2020 that almost 1.2 million tons of biological residues are created in the Rhenish mining area every year, most of which go unused. Finding ways to make use of these residues can both minimize waste and make companies more profitable.

Back in 2010, Schurr co-founded the Bioeconomy Science Center, an association of RWTH Aachen, the universities of Bonn and Düsseldorf and the Research Center Jülich. Since then, 68 institutes and departments have been working on the bioeconomy.

The project got a boost in 2017, when the NRW economics minister at the time, Andreas Pinkwart, said the Rhenish mining district should become a model for economic transformation. A short time later, the concept of a bioeconomy received special mention in legislation that provided funding to help the region transform away from coal mining. The [BioökonomieREVIER](#) project was born.

At the beginning, the project took inventory of the raw materials available, their quantity, and the value chains already in place. The researchers also created municipal bioeconomy profiles for 20 cities and communities that border on opencast mines, taking stock of what initiatives were already in place, how the land was being used, what bioresidues were available, and how well civil society was already involved.

The project also involved companies right from the start, since the goal was to help support the economic transition by boosting bioeconomic aspects already in place. Another key goal was to bring together different regional players, such as companies that generate biological residues with other companies that could use this waste as raw materials. Last but not least, the projects should be publicized, and projects should look for ways to involve the local population.

### **Initial funding quickly attracted investors**

One idea that made it from research to practice in a short time is the startup SenseUP Biotech. The company, which has won several innovation awards, has its office just a five-minute walk from Schurr's, at the other end of the Jülich Research Center. Georg Schaumann, co-founder and one of the managing directors, waits with his laptop in the rather sparse meeting room. "We are in discussions with major investors from Germany, the U.S. and Asia," says the biotechnologist. "That's millions of euros that we're bringing into the district here."



*Georg Schaumann, managing director of SenseUP, is developing environmentally friendly pesticides based on RNA interference.*

SenseUP produces highly specific biopesticides that can attack pests by targeting their genetic code — their RNA, to be more precise. Such biopesticides are extremely promising but have had two problems that have prevented them from being widely used: They degrade too quickly, and they are very expensive. “We have developed a method that reduces costs from 10,000 euros to around five euros per hectare,” reports Schaumann, visibly proud. The company has also found a way to improve the stability of the active ingredient.

### **How the SenseUP method works**

RNA interference has been known to science for around 20 years — its discoverers were awarded the Nobel Prize for Physiology or Medicine in 2006. In cells, DNA serves as a template for messenger RNA (mRNA). This, in turn, is the blueprint that the cell uses to produce proteins and other molecules. RNA interference uses a foreign piece of RNA that fits exactly onto a target mRNA. That blocks the cell from using the building instructions in the target mRNA, and the corresponding protein is no longer produced.

Researchers around the world quickly realized that this could be an ideal formula for especially safe biopesticides. The interfering RNA can be designed so that it only binds to very specific target mRNAs. That allows it to disrupt the metabolism of the Colorado potato beetle, for example, without affecting any other insects — even close beetle relatives. Another advantage is the fact that RNA is a natural molecule that breaks down in a few days, so it doesn't remain in the environment as many other pesticides do.

SenseUP has found a way to ensure that the interfering RNA remains stable on the leaves for long enough to be effective. They do this by introducing the molecules into the cells of dead bacteria. The bacterial cell walls protect the RNA from environmental influences such as UV radiation that would otherwise decompose the molecule. If a Colorado potato beetle larva eats a leaf sprayed with these cells, the cell walls of the killed bacterium are broken down in the insect's intestine, and the RNA is released and can take effect.

SenseUP is benefitting from funding designated to smooth the region's economic transition. A large building is currently under construction in Jülich and should be occupied by the end of the year. Without the funding, the company would not have been able to develop their technology, says Schaumann. "We are now growing and hiring more people."

### Plastics with natural fibers

The story of the company IP Verpackungen in Aldenhoven is quite different. The company, founded in 1978, claims to be the market leader in Europe for foamed packaging used in take-away meals. Its headquarters are only two kilometers away from the Inden open-pit mine, and Hambach is a few minutes' drive away. Many of the company's 190 employees live in the towns on the edge of the mines.

Visitors arriving at the company's headquarters by bus first pass steel tanks, roaring machines and production halls. From the outside, the administration building has all the charm of a prefab container.



*The historic paper factory in Zerkall has been idle since flood damage. Now companies and research institutions there want to work on bio-based fiber technologies*



*The empty town of Morschenich is hoping to attract new residents by becoming a center for agri-photovoltaics.*

Inside, however, chief operating officer Stephan Förster welcomes guests into a spacious office with a sofa and armchairs. “We researched bioplastics from 2004 to 2018,” he says. The company wanted to move away from crude oil as a raw material. Then the EU’s single-use plastic ban regulation came into force in 2019. Suddenly the same recycling requirements applied to all plastics – whether they were organic and biodegradable or not. “After that, there was no reason to continue with bioplastics,” says Förster. “They are too expensive, and you have no market advantage.” The idea was dead.

### **Sugar beets not on the plate, but in the plate**

Nevertheless, the Aldenhover company is staying involved in the bioeconomy. Jan Phillip Féron, son of the company president and currently a project manager, wanted to explore the idea of packaging made from cast fiber, a combination of waste paper and renewable natural fibres such as hay, straw, hemp or other cellulose. He was so inspired by the idea that he abandoned his plan to enroll for an MBA program in London.



*Jan-Phillip Féron leads the development of fiber-based packaging for take-away products at IP Verpackungen..*

Féron arrives in jeans and a sweatshirt, but driving a Mercedes AMG sports car. He proudly leads us into a new factory hall. “We have invested 12 million euros here,” he says. The hall is still half empty, with room for further growth, and the machines in the other half are not running at the moment. Production is scheduled to start in a few days. Plates and bowls will be made here from a fiber mix. Most of the fibers still come from wood — mainly spruce and some recycled paper. “But there are better ways to use wood,” Féron acknowledges. He’d prefer to use agricultural residues.

The BioökonomieREVIER network helped Féron make contact with a sugar factory in nearby Jülich. The factory generates 300,000 tons of residues from sugar beet processing each year. The

residues usually end up as animal feed, but now some is delivered to the packaging factory. At IP Verpackungen, 20% of the fibers in the mix are now beet residues. This isn't optimal, because sugar beet fibers are strong but short. Further research is still needed to find ways increase the proportion of non-wood fibers in the fiber casting process. But the new production hall is already slated to process 1,000 tons of beet residue per year, and up to 3,000 tons could be possible.

However, there is still a key hurdle, says Féron. Containers made of cast fiber require twelve times as much energy to produce as those made of plastic. "I would ideally like to convert completely to renewable energy," he says. He is watching with interest a project on deep geothermal energy in neighboring Weisweiler. But he is also on the lookout for other solutions.

### **The Rhenish region supports a diverse range of bioeconomy projects**

— **Agro-photovoltaics:** Morschenich is a village that had been slated to be razed as the open-cast mine expanded underneath it. Most residents have already moved away, but now there is new hope that the town could be revitalized with the help of agro-photovoltaics. In such systems, photovoltaic panels provide protection for plants growing underneath them, whether from hail or heat. They also facilitate water management and reduce erosion. RWE is planning to build a 3.5 megawatt installation in one opencast mine. Just a short distance away, the Research Center Jülich is testing farming robots that are intended to help reduce the use of water, fertilizers and pesticides.

— **Networking of small food companies:** The Food Campus Elsdorf is being built in a former sugar factory to the east of the Hambach mine. It hopes to attract small and medium-sized companies that process and refine local agricultural products.

— **Joint fiber research:** At the Zerkall Fiber Innovation Center, companies and research institutions want to develop different applications of fibers from bioresidues. Several paper and packaging companies are involved, including IP Verpackungen.

— **Model paper factory:** South of the open-pit mines, in Düren, more than 20 companies and around 10 research institutions have joined together to establish a model paper factory, unique in Europe, which will attempt to produce paper without wetting the fibers. The industry wants to save 80% of its energy requirements by 2045.

### **The coal industry is focused on logistics**

The coal industry is also preparing its own transformation. As part of this effort, the MineReWIR association was created to help shape the transition of the mining companies and their suppliers. Stefan



Böschchen, professor of technology and society at RWTH Aachen University, is a member of the association's board. The members of MineReWIR haven't yet taken much notice of the bioeconomy, he says. "RWE's suppliers do other things, like metal construction and electrical engineering." Their future plans revolve more around energy, logistics and infrastructure.



*Past and future: The coal industry still exists in the Rhenish mining area, but it is being replaced by renewable energies and other industries.*

And what do local citizens think of all the activity? "It's likely only particularly attentive newspaper readers who are aware of the bioeconomy developments," says Krauthausen's mayor Schmitz-Esser. Many of the local residents had been hoping that more tourism might be part of the region's transformation. Some are also in favor of new forms of agriculture, including aquaculture — topics that "count" as part of the bioeconomy and which are already part of the BioökonomieREVIER project. Schmitz-Esser is critical of the fact that the bioeconomy efforts are very research-heavy and that so much money flows into the research center. "We are concerned about the many people who are currently employed by RWE in positions for which you don't need a university degree." It isn't clear that the bioeconomy will have enough jobs for them.

RWE will probably offer many early retirement options, particularly for employees over the age of 40. And because there is plenty of work to do to dismantle and close the mines, many jobs will not be lost immediately.

### **Getting young people excited about the bioeconomy**

"But young people have to orient themselves differently now," Schmitz-Esser says. The goal is to keep young people in the region with attractive opportunities. She would like to publicize the bioeconomy and its possibilities more widely, including in schools.

One example is a special bioeconomy prize, which the BioökonomieREVIER initiative has awarded the past four years in the regional school science fair competition. This year it went to elementary school students from Jülich who made a skin cream and tea out of nettles.



*Gaby Schmitz-Esser is the mayor of Krauthausen, five kilometers away from the Hambach mine. The economy's transformation already affects the politician's work.*

However, IP Verpackungen's Förster has other concerns. "We are desperately looking for people to fill open positions," he says, including electricians and machine operators. There is currently a lack of skilled workers in the Düren district, similar to many regions across Germany.

SenseUp's Schaumann has had better luck hiring people, especially for research positions. "When we advertise jobs, we find good people very quickly," he says. The Rhenish region benefits strongly from the Jülich Research Center, the technical college in Jülich as well as the universities in Aachen, Bonn, Cologne and Düsseldorf, he says. The region also has a bioreactor manufacturer, good sources of raw materials such as the Pfeifer & Langen sugar factory, and plenty of farmers available for cooperation projects.

It's still not clear whether the bioeconomy in the region will develop quickly enough to absorb the economic fallout of the coal phase-out by 2030. Most experts doubt it will be enough. But plant researcher Schurr emphasizes that the bioeconomy has a major advantage over other economic efforts such as digitalization or hydrogen: It is already deeply and broadly rooted in the region. "Most of the bioeconomy projects have a long time horizon, but we are always looking for chances to implement parts of them right away with industrial partners," he says.

## **Learning from the Rhenish district**

For the federal government, the BioökonomieREVIER is more than just a local effort to cushion the coal phase-out in the Rhenish district. It is a model project that other regions should learn from. As the country, and the world, move away from coal, gas and oil, a bio-based, circular economy will gain importance in many regions.

Schurr is well aware that there is no one-size-fits-all solution. The coordinator of the BioökonomieREVIER is in active contact with people who are trying to manage the economic transition in eastern German coal mining regions. "They are also interested in establishing a bioeconomy, but the soil is much worse, there are fewer other industries, and the social background is also different," he says. "Different regions have to develop their bioeconomy in different ways, because it has to grow out of the strengths of each region."



*The Hambach opencast brown coal mine will cease operations in a few years. A bio-based economy could grow in its place.*



*The oil and fibers of safflowers can be used for a range of products.*

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The other regions need to analyze and catalog those strengths and opportunities in the way the Rhenish district did, he says. That can allow producers of raw materials and residuals to link up with potential users and, together with research investments, find and develop concepts that are economically viable.

In the meantime, it is not only eastern German regions that are interested in the experiences from the Rhenish region. At the beginning of this year, the EU-funded project Bio2Reg started in eight European countries. Coordinated by BioökonomieREVIER, the project is designed to help regions with carbon-intensive economic sectors transform themselves. The research project aims to provide regional actors with practical knowledge in order to find ideas that are suited to the respective region. Iceland, where the focus is on fishing and aquaculture, is one participant. Sweden, where wood is particularly important as a raw material, is another.

And what about Schurr's own research project? This spring, safflower will be cultivated on a much larger scale in several open-pit mines. The company that initially wanted to produce lubricants from the safflower seed oil has been joined by several other parties interested, for example, in using the safflower oil for cosmetics. The plant's fibers could also be an interesting raw material for paper or packaging. In any case, the perennial, deep-rooted plants improve the quality of the soil and protect it from erosion.

"Our projects across the region are starting to have an impact," Schurr says. "That's very satisfying." Whether it's enough? Only time will tell.

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