

Cooling needed!

In order to slow down global warming, substances other than CO₂ must also be reduced.



INNOVATIVE

Biosensor detects malaria quickly and reliably

INTEGRATIVE

New infrastructure networks research data

INFORMATIVE

Atlas shows Africa's hydrogen potential



Let's go!

With green caps and pink dot stickers: in the name of science, 1,500 volunteers dressed this way strolled, crammed and waited in the Mitsubishi Electric Hall in Düsseldorf for four days in the service of science. They were participating in the large-scale experiment as part of the CroMa project for which researchers from Jülich, Wuppertal and Bochum are investigating crowding effects on railway platforms. Cameras recorded the participants' movements; sensors collected further data such as stress and heartbeat. The extensive experiment aims to develop new concepts for getting a large number of passengers to, on and off trains safely and efficiently.

The Federal Ministry of Education and Research is funding the project.

More on the large-scale experiment at go.fzj.de/croma-EN

NEWS

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COVER STORY

Everything is interrelated



They do not last as long, but they are just as harmful to the climate as CO₂: methane, aerosols and the like. Jülich researchers are measuring and modelling their influence.

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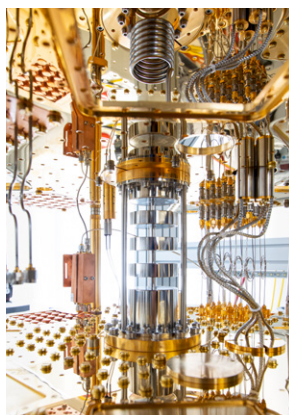
RESEARCH

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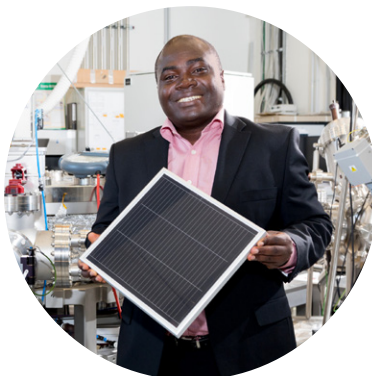


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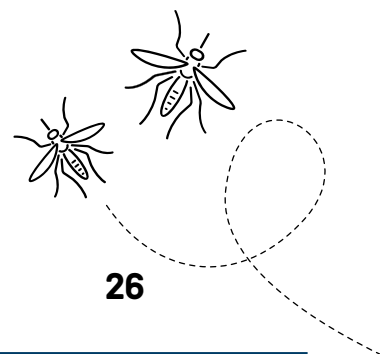
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Imports and domestic production could, in the future, be distributed to the southwest of Germany via NRW.

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A new biosensor can detect the disease quickly, easily and reliably.



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A national strategy is intended to make research data easier to find, better connected and more easily accessible.

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A new chapter

“It’s real. It’s us. Experts agree. It’s bad. There’s hope.” In these short sentences, Anthony Leiserowitz from Yale University (USA) summarized what we know about climate change and what needs to be done about it: namely to drastically reduce greenhouse gases.

This is true not only for CO₂, but also for a group of substances that is less well known outside the scientific community: short-lived climate-impacting substances. These include aerosols, methane, hydrocarbons and soot. In total, they have warmed the atmosphere by just as much as CO₂. The latest report of the Intergovernmental Panel on Climate Change (IPCC) has dedicated a separate chapter to them for the first time. Jülich researchers led by Prof. Astrid Kiendler-Scharr, the chapter’s lead author, have been working on these substances for a long time. Our cover story shows how closely interrelated the substances are and how data and models help to understand these interrelations as well as to make predictions for tomorrow’s climate.

Other Jülich researchers also have their sights set on the future: for example, they are working on the computers of tomorrow – quantum computers – as well as helping to bring Germany and Africa together on the subject of hydrogen.

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BIOECONOMY

Barley for times of drought

Barley is one of the most important types of grain.

Its uses range from beer-brewing to groats, pearl barley, barley flakes and barley flour. However, droughts and climate change are worsening the growing conditions.

An international team with Jülich participation has discovered a promising starting point for breeding resistant varieties: the team identified a gene that makes the roots of some rare barley plants grow much deeper downwards than normal. This allows the roots to better access water and nutrients at much further depths in the soil.

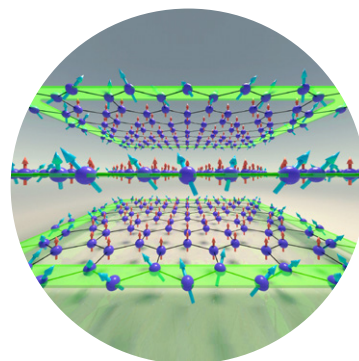
- INSTITUTE OF BIO- AND GEOSCIENCES -

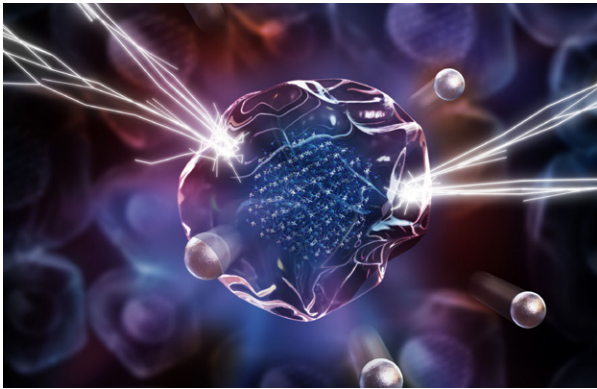
INFORMATION TECHNOLOGY

Exotic property with technological potential

So-called two-dimensional (2D) van der Waals materials are seen as the hope for electronic components of the future. 2D materials are only one or a few atomic layers thick. Eventually, they could render bendable and paper-thin electronic devices possible; these would consume little energy and have both fast computing power and enormous storage capacity. An international research team with Jülich participation has provided evidence for a new property in two of these magnetic 2D materials: certain wave-shaped magnetic disturbances – known as magnons – do not propagate in the entire sample; they only do this along their edges. With these materials, a particularly energy-saving information technology could be realized, since magnons can be used to transmit information without transporting electrical charge.

- PETER GRÜNBERG INSTITUTE -





BATTERY RESEARCH

Boundaries have a positive effect

Safer and better range: solid-state batteries are considered the next generation of mobile energy storage, such as in the case of electric cars. However, these systems still bring many challenges. Take, for example, the electrolyte: in conventional batteries, the charge carriers float through a liquid during charging and discharging. In the solid-state battery, they travel through solid grains, which are “baked together” and covered by a boundary layer.

Until now, researchers assumed that this boundary layer was detrimental, so they were trying to minimize it. A team of researchers from Berlin, Munich and Jülich has now been able to show that the layer is actually beneficial. A targeted design could make the batteries last longer.

- INSTITUTE OF ENERGY AND CLIMATE RESEARCH -

ALZHEIMER'S RESEARCH

The sourer, the clumpier

They are prime suspects in the search for the causes of Alzheimer's dementia: the so-called A β -oligomers, small aggregations of the body's own protein amyloid β .

However, it is still unclear how and where the protein clumps form. Researchers from Jülich, Düsseldorf and Cologne have found that the clumps form 8,000 times faster in a weakly acidic environment than at neutral pH. The environment is weakly acidic in endosomes and lysosomes, for example, small vesicles inside nerve cells that transport and break down substances.

- INSTITUTE OF BIOLOGICAL INFORMATION PROCESSING -

BRAIN RESEARCH

Recognition

The EU has listed the EBRAINS digital platform of the Human Brain Project (HBP) among the strategically important research infrastructure measures, the so-called ESFRI Roadmap. As the first portal of its kind, EBRAINS offers, among other things, access to comprehensive data on the human brain and powerful tools, for example for simulations. An important component is the three-dimensional brain atlas “Jülich-Brain”. “We are delighted with this confirmation of the great scientific potential of EBRAINS,” says Jülich brain researcher Prof. Katrin Amunts, scientific research director of the HBP.

- INSTITUTE OF NEUROSCIENCE AND MEDICINE -





BRAIN RESEARCH

Distinction

Prof. Svenja Caspers' research at Jülich includes changes in the ageing brain. The scientist has now been elected a member of the Leopoldina, Germany's National Academy of Sciences. Membership is a special honour: only researchers who have distinguished themselves through significant scientific achievements are admitted.

- INSTITUTE OF NEUROSCIENCE AND MEDICINE -

24

million euros

have been awarded to the iNEW research project, short for "Inkubator Nachhaltige Elektrochemische Wertschöpfungsketten" (sustainable electrochemical value chains incubator), by the Federal Ministry of Education and Research. Among other things, the project coordinated by Jülich deals with the question of how the greenhouse gas carbon dioxide can be used industrially and become an opportunity for a sustainable circular economy. The goal: bringing innovations to market maturity quickly and thus supporting structural change in the Rhineland region.

- INSTITUTE OF ENERGY AND CLIMATE RESEARCH -

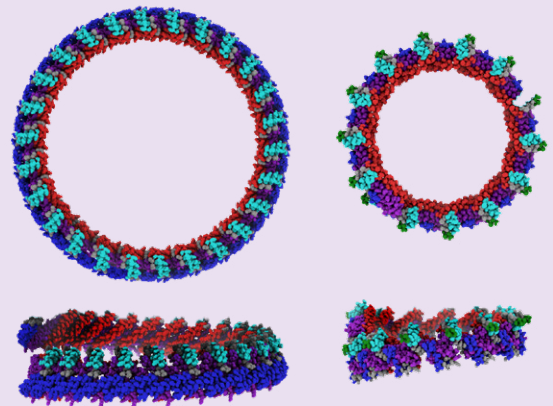
STRUCTURAL BIOLOGY

Astonishing similarities

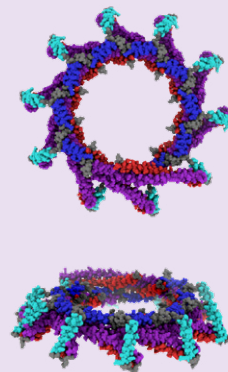
Humans and bacteria are fundamentally different at first glance. There are, however, fascinating similarities. As Jülich and Mainz researchers have discovered, certain membrane proteins of both organisms are similar in structure and function. This surprising finding provides exciting insights into evolution. This was made possible with the help of special electron microscopes that allow specialists to examine snap-frozen biological samples. The equipment belongs to the Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons on the Jülich campus.

- ERNST RUSKA-CENTER FOR MICROSCOPY AND SPECTROSCOPY WITH ELECTRONS -

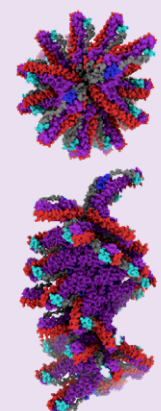
Human proteins



Bacterial protein



Yeast protein



Everything is interrelated

Man-made global warming is progressing. The most important countermeasure is to blow less CO₂ into the atmosphere. There is also another parameter, however: short-lived climate forcers such as methane, soot and ozone. They, too, are part of the big picture. If these substances are reduced, warming of 0.8 degrees Celsius could be avoided by the end of this century. This assessment by the Intergovernmental Panel on Climate Change is also based on data, findings and models from Jülich researchers.



In August 2021, the Intergovernmental Panel on Climate Change (IPCC) published the first part of its latest assessment report. The verdict is clear: climate change is progressing rapidly, and every region of the world is already affected. Without immediate and comprehensive countermeasures, our atmosphere is likely to warm to 1.5 degrees Celsius above the pre-industrial temperature over the next 20 years. The consequences of the currently plus 1.1 degrees are already showing up in weather extremes such as heat waves, droughts or heavy rain.

The top priority, therefore, is rapid CO₂ neutrality. This is because temperatures have been rising continuously with the amount of CO₂ emitted into our atmosphere since pre-industrial times. CO₂ is a very long-lived substance. Every gigatonne that we release into the air today will stay there for hundreds of years, heating up the climate for an equally long time.

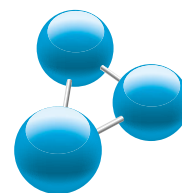
However, there is another way to flatten the Earth's temperature curve even further – and, above all, more quickly: the reduction of short-lived climate forcers. These remain in the atmosphere for a few hours only up to a maximum of around ten years. They include methane, ozone, hydrocarbons, aerosols, halogenated compounds and soot. In total, these substances contribute

to global warming about as much as CO₂. The IPCC concludes in its assessment report that substantially reducing emissions could rapidly allow further warming to be avoided, that is to say, diminished by 0.8 degrees by the end of the century.

Jülich researchers have contributed important information to the report: data they collected in extensive measurement campaigns; previously unknown reaction pathways they discovered through elaborate calculations; also, new and improved global climate models – incorporating their insights into the complex world of atmospheric chemistry. However, it is precisely this complexity that makes it difficult to make reliable statements: through various reactions and processes in the atmosphere, many substances depend on and influence each other. Three examples show everything that needs to be considered.

TREND OR FLUCTUATION?

“A good example of how strongly individual substances and processes influence each other is ozone, the most important anthropogenic greenhouse gas after CO₂ and methane,” says Dr. Andreas Petzold from the Jülich Institute of Energy and Climate Research (IEK-8). It starts with the formation: the trace gas is not emitted directly, but is formed in the lower regions of the atmos-



Ground-level ozone (O₃)

Lifespan:

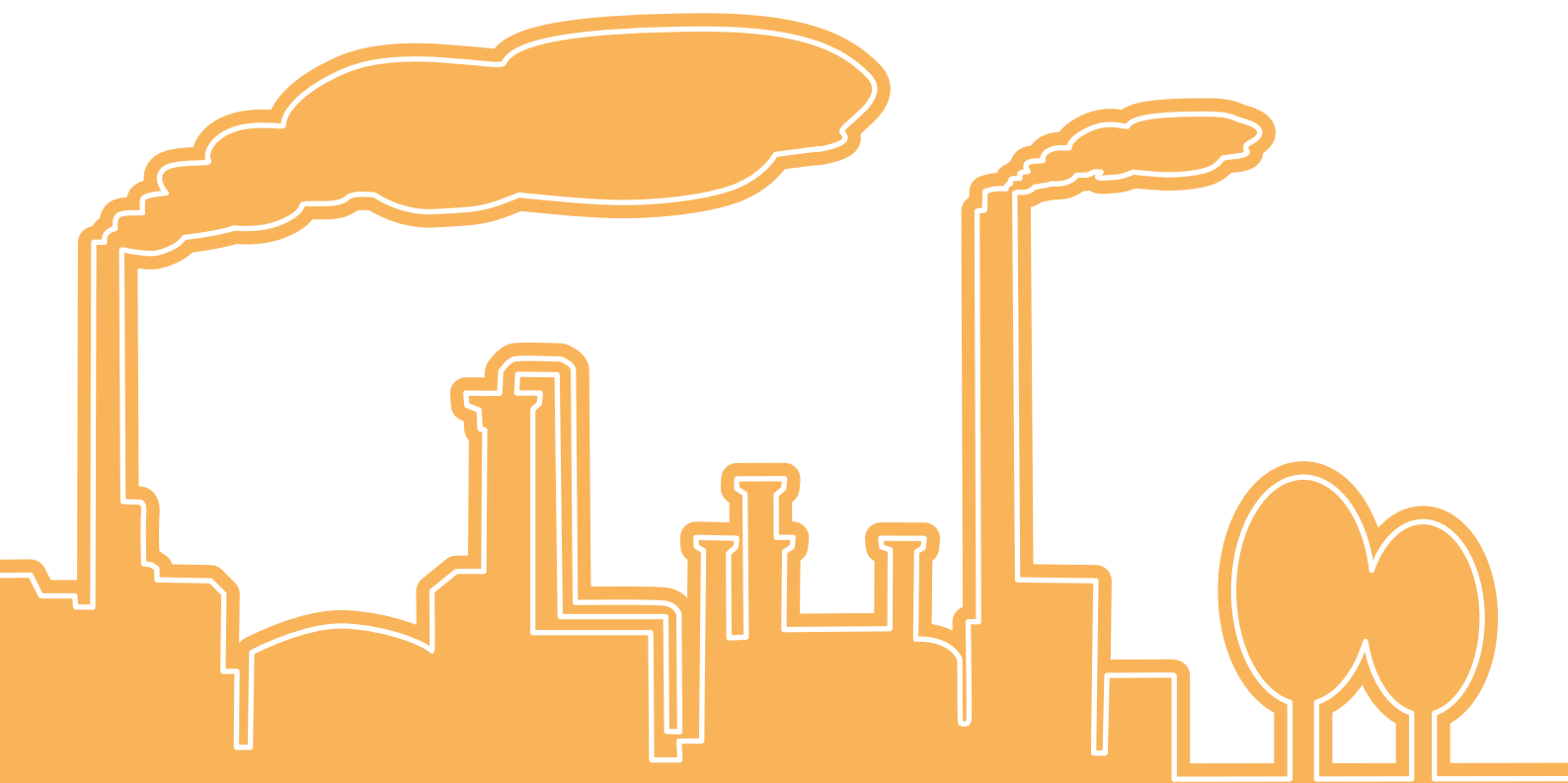
A few hours to several weeks

Sources:

Formed by UV light from precursor substances such as hydrocarbons – methane, for instance – and nitrogen oxides, for example from the transport sector, fossil-fuel power plants, heating systems, refineries and other industries

Effect:

Absorbs radiant energy that ultimately does not escape into space, but heats up the Earth's atmosphere; damages the health of all living creatures and leads to crop losses



phere through the photochemical degradation of hydrocarbons originating from road traffic, but also from industry and plants.

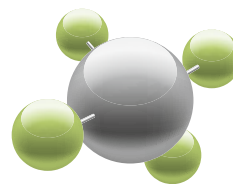
Petzold and his team have been collecting data on many different substances in the atmosphere for decades. He coordinates the European project IAGOS, short for “In-service Aircraft for a Global Observing System”. “The participating institutions’ equipment has been travelling around the world in commercial airliners for almost 30 years. While in flight, they measure short-lived greenhouse gases such as ozone, water vapour and methane, trace gases such as carbon monoxide and nitrogen oxides, as well as fine dust, ice and cloud particles, not to mention the long-lived carbon dioxide.

“These long-term measurement series enable us to distinguish long-term trends from short-term fluctuations and to understand interrelationships in the complex climate process,” says Petzold. For example, the data show that the seasonal peaks in ozone in the lower atmosphere are shifting.

“They occur earlier and earlier in the course of the year,” explains the Jülich researcher. The researchers attribute this trend to climate change: “It gets warmer earlier in the year and there are more hours of sunshine,” he explains. “Both encourage the formation of ozone: the higher temperature gives all ozone formation processes a boost, and the UV light provides the energy for this.”

MORE OZONE THROUGH SHUTDOWN

Another important link emerged during the lockdown in the corona pandemic. In the months of March, April and May 2020, which were particularly affected by the economic shutdown, ozone levels near the ground rose by up to 41 per cent at night and up to 19 per cent during the day. “The lockdown meant that there were fewer traffic exhaust gases as a source for ozone, but at the same time the ozone probably lacked another substance from the exhaust gases as a reaction partner: nitrogen monoxide. As a result, less ozone



Methane (CH₄)

Lifespan:

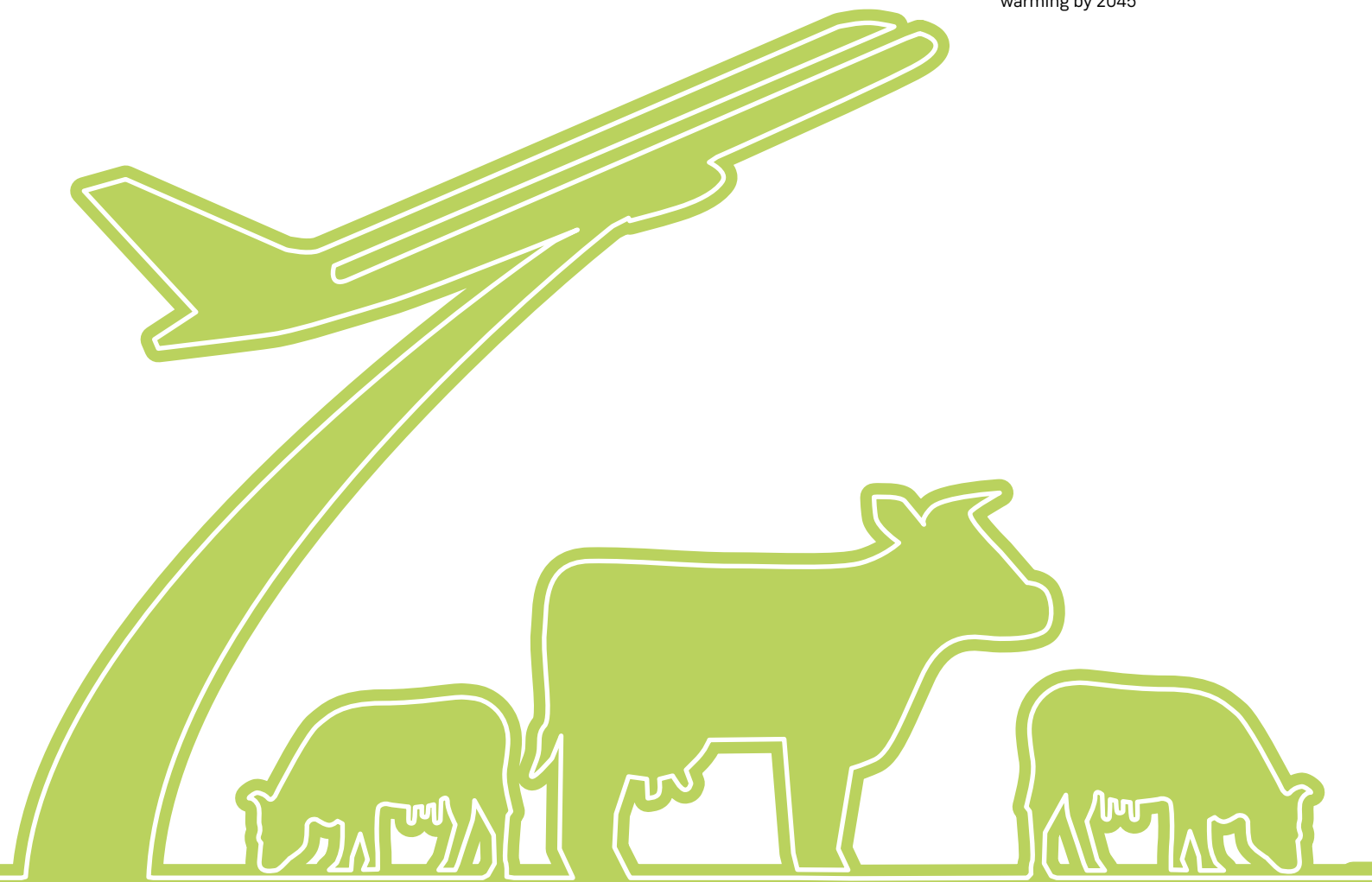
8 to 12 years

Sources:

Fossil fuel use, gas pipeline leaks, landfills, livestock (especially cattle), rice fields, swamps, thawing permafrost

Effects:

Absorbs radiant energy, which consequently does not escape into space but rather heats up the Earth's atmosphere; has a climate effect that is 25 times stronger than that of CO₂; contributes to the formation of ground-level ozone; reducing it by 45 per cent would mean 0.3 degrees Celsius less warming by 2045



was broken down and, on balance, the ozone concentration in the conurbations rose slightly,” analyzes Petzold. According to the researcher, this is an important indication that short-lived climate forcers react very quickly to changes, but at the same time can only be considered as parts of an overall system. It also means that as a result of a mobility transition, ozone levels in the cities could initially rise. “However, if the other strong climate drivers such as methane and hydrocarbons are reduced concurrently, the trend will be reversed after about 20 years. By 2100, a total of 0.8 degrees of global warming could be avoided. This is what the IPCC calculations show,” says Petzold.

It gets even more complex with aerosols, a widely ramified family of short-lived climate forcers. They are a mixture of tiny solid or liquid airborne particles. Aerosols come from emissions from biomass burning, exhaust fumes, desert dust or sea spray. They can also form through chemical reactions from substances that plants release into the atmosphere. “In general, we assume that aerosols predominantly cool the climate, but in climate research, aerosols continue to be the great unknowns. Due to the complex interrelations, many questions are still open, such as whether the particles reflect or absorb solar radiation depending on their composition, whether they have a warming or cooling effect, and to what extent they are involved in cloud formation,” says Dr. Alexandra Tsimpidi from IEK-8. She and her team have set themselves the task of making organic aerosols more predictable for climate research.

A challenging goal, as can be seen when looking at the properties that determine how the aerosols work: “This ranges from their physical state, liquid or solid, to their chemical composition and the property of being water-loving or water-repellent,” lists Alexandra Tsimpidi. Scientists must also bear in mind that aerosols go through life cycles: “They are oxidized, accumulate, break apart, absorb other substances on their journey, react with them and lose others. Previous climate models do not take all this into account to a sufficient degree,” says the researcher.

Reducing short-lived climate forcers

Measures to reduce short-lived climate forcers are already available today: particulate filters, systematically switching to modern heating technology and renewable energies, insulating buildings, repairing gas leaks, saving electricity, reducing meat and milk consumption and using public and alternative transport. In order to meet the target of 1.5 degrees Celsius, the nationwide implementation of the measures would have to reduce methane emissions by 40 per cent and soot emissions by 70 per cent by 2030 compared to 2010, and halogenated hydrocarbons would have to be reduced by 90 per cent by 2050.

Many short-lived climate forcers have a massive impact on air quality and thus on the health of people and nature. Among other things, they cause cardiovascular diseases, asthma and lung cancer and are associated with strokes and dementia. The World Health Organization estimates that air pollution causes 7 million premature deaths per year. In addition, ozone, for example, damages plants in many ways and causes annual crop losses amounting to 50 million tonnes.



However, the Jülich researchers have succeeded in uncovering the fundamental processes that determine how aerosols form and grow. To this end, they are conducting experiments in the Jülich atmospheric chamber SAPHIR. In the huge volume of the chamber, a wide variety of air mixtures can be recreated almost naturally, from clean forest air to heavily polluted city air. In these scenarios, researchers then analyze how aerosols form and from which precursors they do so, how they age, with which other substances they react and whether they are suitable as cloud nuclei. “We have applied these and other findings to our global models and can now calculate how air pollution and natural airborne particles affect air quality and the climate. In subsequent simulation calculations, we can then derive forecasts for various future scenarios,” says Tsimpidi.

The measuring platforms

IAGOS: Measurements with the help of commercial aircraft from the ground up to an altitude of 12 kilometres during flight

Zeppelin NT: Measurements from the ground up to 1,000 metres

SAPHIR: 270 m³ atmospheric simulation chamber

MobiLab: Road traffic measurements

Weather tower: local weather and air measurements

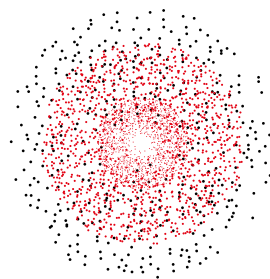
Weather balloons: Measurements up to an altitude of 29 kilometres

JOYCE: Observatory for cloud evolution

NATURE'S WASH CYCLE

Not only the climate pollutants need to be considered, however, but also substances that ensure their chemical degradation. An important substance in atmospheric chemistry is the OH radical, which is also known as the “detergent” of the atmosphere. It has the ability to react with almost all atmospheric trace and pollutant gases. Depending on the nitrogen oxide load, it creates or destroys ozone molecules and breaks down traffic emissions as well as methane, the front-runner among the climate-impacting substances. “In order to make reliable predictions about short-lived climate forcers, there is no way around the OH radical,” says Dr. Hendrik Fuchs from IEK-8.

There are always new insights into complex relationships here, too, that then have to be taken into account in the models. For example, Jülich researchers have succeeded in clarifying discrepancies between measurement results and model calculations and, based on their findings, in improving the predictions of global models. The new approach now allows the OH values – and thus the purification capacity of the atmosphere – to be calculated more concretely.



Aerosols

Liquid or solid airborne matter

Lifespan:

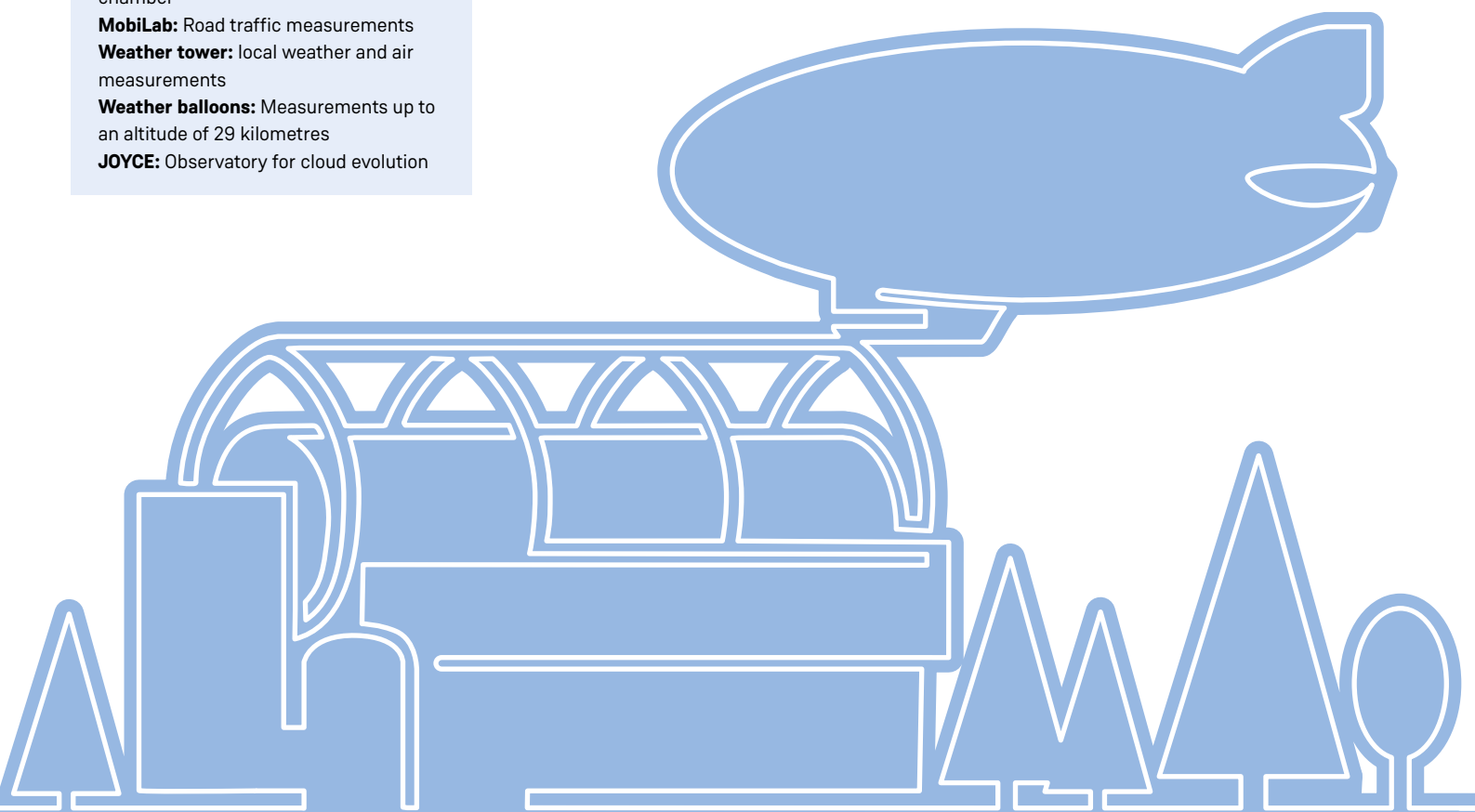
Minutes to weeks

Sources:

Plants, transport, energy supply, synthetic fragrances, volcanic eruptions, desert dust, sea spray

Effect:

Reflect or absorb sunlight depending on their composition; have a cooling or warming effect; can serve as cloud nuclei



The major differences were discovered during campaigns conducted by Jülich researchers together with colleagues from Peking University in China. The measured OH levels were up to five times higher than the model predictions. The researchers then re-examined their models and considered possible missing reactions.

The combination of experiments in the Jülich atmospheric chamber SAPHIR and extensive chemical calculations then revealed the secret of the additional OH radicals: “The cause is isoprene,” says Hendrik Fuchs, referring to the most significant hydrocarbon released by plants into the atmosphere. “If there are no other reaction partners available, such as nitrogen oxides from traffic, the OH radical reacts with isoprene in a previously unknown cascade of reactions, at the end of which considerably more OH is produced than was previously thought,” Fuchs explains. His colleague Dr. Domenico Taraborrelli has packed these findings into the new global model for atmospheric chemistry, so that measured values and model calculations now match. The new model was used, for example, to evaluate data from measurement flights with the Zeppelin NT over Europe. This showed that there are considerably more OH radicals in forested regions than previous models had predicted.

THE CLIMATE OF THE FUTURE

“The examples show how important every detail is in atmospheric chemistry. The more precisely we understand how individual substances are interrelated and which reactions are linked, the more reliable forecasts for the future will be,” says Prof. Astrid Kiendler-Scharr, director at IEK-8.

Residence time of air pollutants in the atmosphere

 O₃
 Aerosols
 BC
 CH₄
 HFCs
 CO₂

She is lead author of the current IPCC report's chapter on short-lived climate forcers, so the data, findings and models of the Jülich researchers are an important basis for the statements of the IPCC.

“Thanks to the findings and increased computing power, we can now carry out simulations with which we can calculate in detail the temperature development of the next 80 to 100 years, for example. This is exactly what was done for the IPCC report,” says Astrid Kiendler-Scharr. The result: if mankind continues on as per usual, the unabated emission of short-lived climate forcers will contribute 0.8 degrees to the temperature increase by 2100. “If we only take the reflecting aerosols out of the system, there will be a slight warming of the climate. Removing methane, soot and halogenated hydrocarbons, on the other

 Hours to days
 Minutes to weeks
 Several weeks
 12 years
 Around 15 years
 100–1,000 years



“It will take a few years for all reductions to gradually take effect.”

PROF. ASTRID KIENDLER-SCHARR

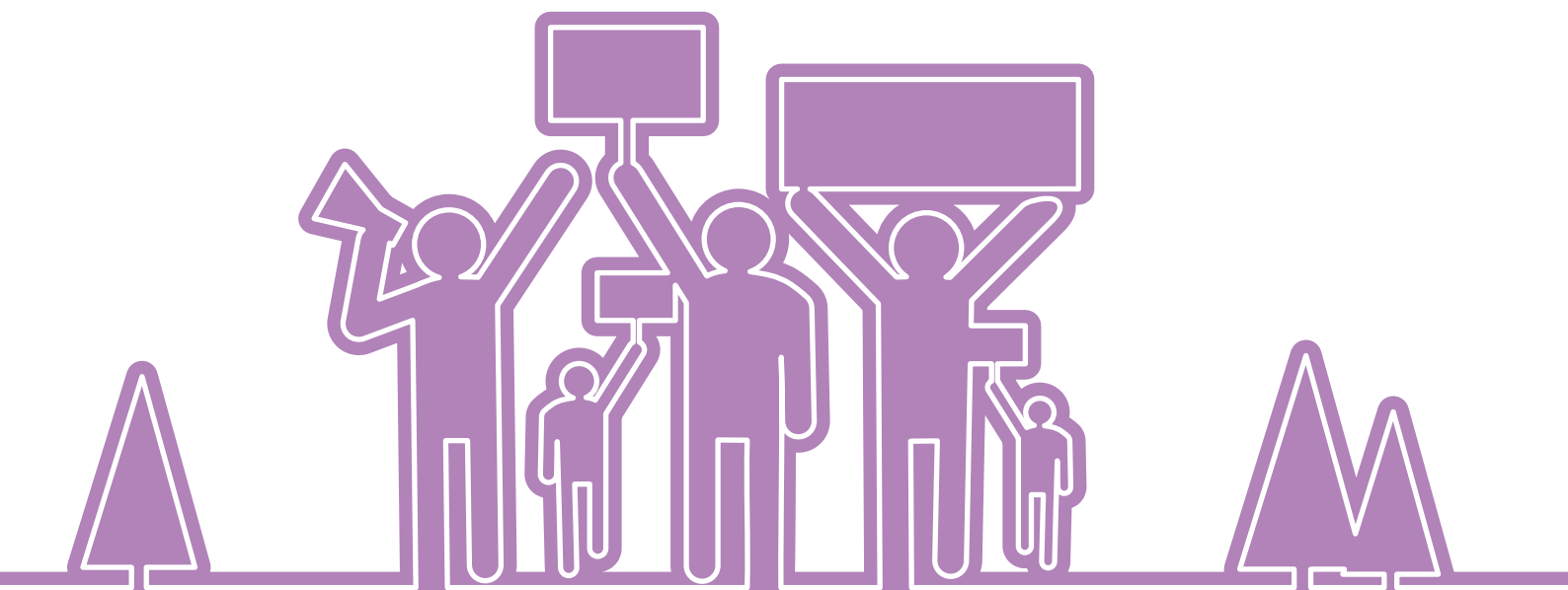
hand, would lead to a reduction in temperature of around 0.6 degrees. If we reduce all short-lived climate forcers, we could even go down by 0.8 degrees,” summarizes the Jülich researcher.

However, even if all requirements were implemented immediately, it would continue to get warmer until 2040 before a sustainable cooling effect would set in. This has to do with the different life cycles and reaction processes of the substances: “It will take a few years for all the reductions to gradually take effect, but the model calculations show it is possible,” Kiendler-Scharr emphasizes. Now it is up to politicians to draw conclusions from the findings and take action.

BRIGITTE STAHL-BUSSE



↑ Astrid Kiendler-Scharr is Director of the Institute of Energy and Climate Research (IEK-8) and Chairwoman of the Board of the German Climate Consortium (DKK).



3 questions for ...

... Jülich researcher Prof. Astrid Kiendler-Scharr, lead author of the chapter on short-lived climate forcers in the current IPCC report.

What do a few tenths of a degree more or less of warming mean?

The number and intensity of extreme events, such as heat waves, droughts and heavy rainfall with devastating floods, increases with every tenth of a degree.

Can the global 1.5 degree target still be met at all?

Yes, under two conditions: we still have a CO₂ budget of 400 to 500 gigatonnes. Mankind currently emits about 40 gigatonnes per year, so it's clear that we don't have much time left. Only a systematic CO₂ neutrality will stabilize the climate in the long term. In addition, we also need to reduce the short-lived climate forcers.

How do you rate the decisions of the World Climate Conference that were adopted in Glasgow in November?

The sharpness with which almost all member states express their political will to become climate neutral in just a few decades leaves me optimistic. This is the only way to slow down climate change. The new pledges, for example to reduce methane or stop deforestation, do have the potential to stabilize warming at around two degrees Celsius. While this is not yet satisfactory, it is a significant step forward compared to the situation right after the 2015 Paris Agreement. Even so, a goal without a plan is no more than a wish. If we really want to achieve the proclaimed goals, all countries must act immediately and decisively advance implementation over the next ten years.

1.1

degrees

Celsius is the extent of global warming since weather records began in 1881, according to the IPCC.

1.6

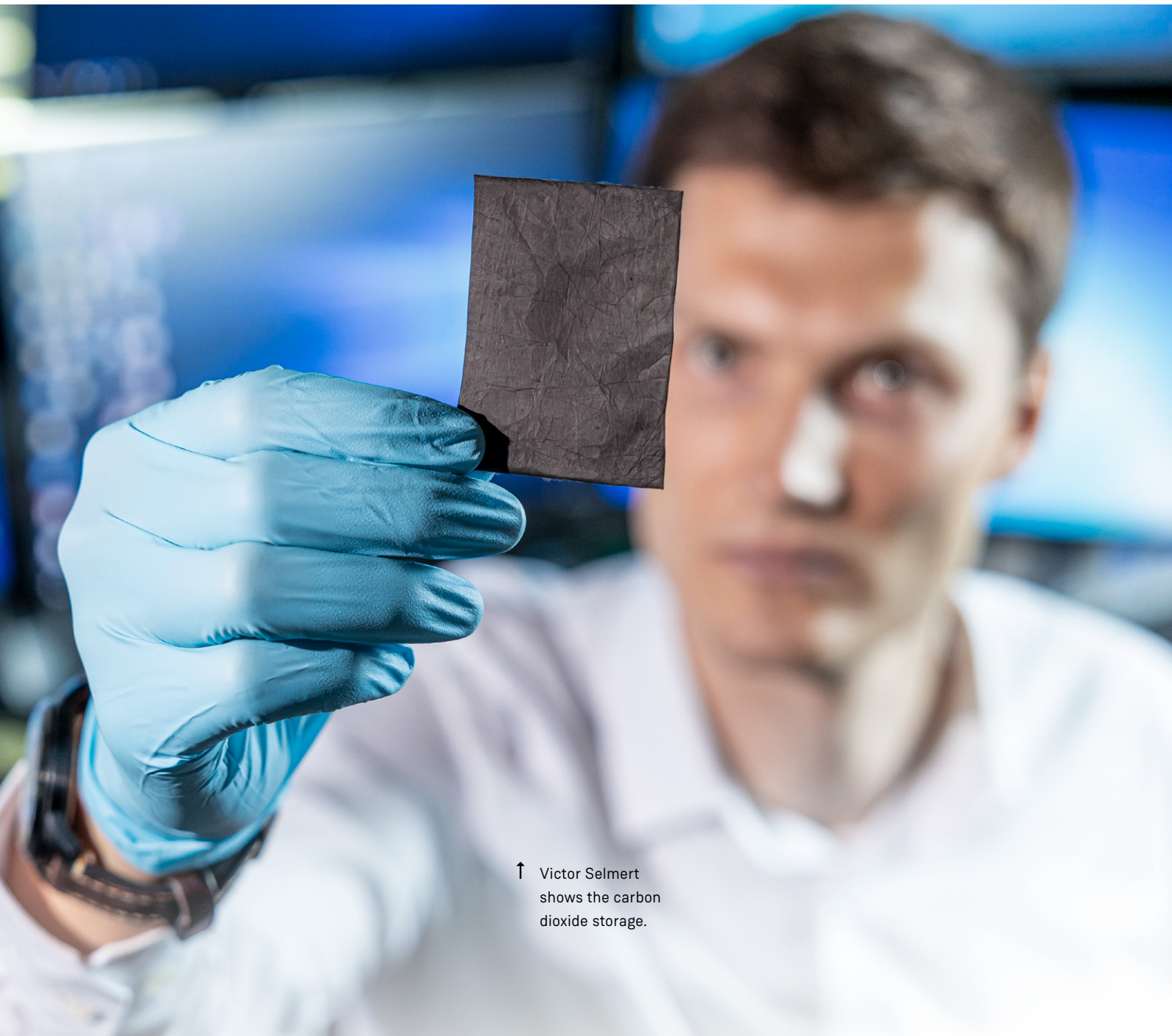
degrees

Celsius is the extent of warming in Germany during the same period, according to data from Germany's National Meteorological Service (DWD).



A sponge for greenhouse gas

The finest carbon fibres can selectively bind CO₂ in order to efficiently remove the greenhouse gas from industrial waste gases.

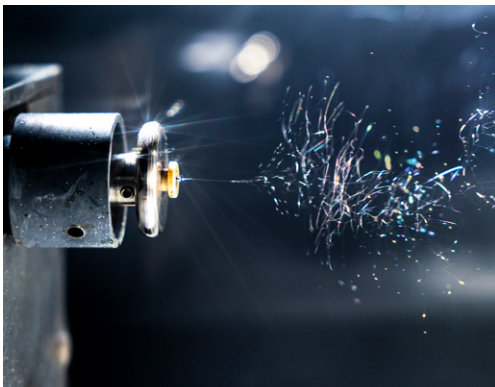


↑ Victor Selmert shows the carbon dioxide storage.

The object that Victor Selmert is holding in his hands looks like a plain piece of black cardboard. “This material could help keep global warming in check,” explains the researcher from the Institute of Energy and Climate Research (IEK-9). “This is because in order to limit the global temperature rise to one and a half degrees Celsius, it will be necessary to capture carbon dioxide systematically – preferably before, for example, exhaust gases from cement plants, glass factories or biogas plants disperse it into the atmosphere.”

The dark, brittle material is ideally suited for this purpose: “It soaks up the unwanted greenhouse gas like a sponge. Other components of the exhaust gas flow hardly stick to it,” says Ansgar Kretzschmar, doctoral researcher at IEK-9. Once saturated, the carbon fibres can later release the CO₂ in its pure form, either to store the gas or, with the help of renewable electricity, to convert it into valuable chemicals.

The material is thus markedly superior to an established CO₂ trap: activated carbon. While the latter is inexpensive and easy to regenerate, it also soaks up other compounds from the exhaust gas flow, which is detrimental to the separating effect. In order to be able to process the carbon dioxide further, however, it must be obtained in as pure a form as possible.



↑ Close-up of the electrospinning device used to produce the carbon fibres



↑ Ansgar Kretzschmar (left) and Victor Selmert are looking for materials to remove CO₂ from exhaust gases.

The novel material from Jülich is also made of carbon, but its secret lies in its inner structure: “It consists of extremely thin carbon fibres, only 200 nanometres in diameter. That is more than a hundred times thinner than a human hair,” explains Victor Selmert. The vast number of these nanofibres results in a large total surface area, which allows them to bind high amounts of carbon dioxide. This is made possible by a special manufacturing method: electrospinning.

“A plastic solution is spun under high voltage in an electric field. This gives us a very fine mesh of filigree polymer fibres,” Selmert says. In the absence of oxygen, the polymer is then converted into carbon at temperatures of up to 1,200 degrees Celsius. “This creates slit-shaped, thin pores in the surface,” explains Ansgar Kretzschmar. “The CO₂ molecules fit right into them. And that is exactly why our material binds so selectively to carbon dioxide.” These two properties – the large surface area and the precisely fitting pores – make this material a superior CO₂ sponge.

ARNDT REUNING



Read a longer article on this here (in German):
go.fzj.de/CO2-separation

The dawn of a new IT age

Researchers at Jülich are in the process of establishing computer technology on a completely new foundation. Their numerous findings pave the way to the quantum computer.

Planning flights optimally

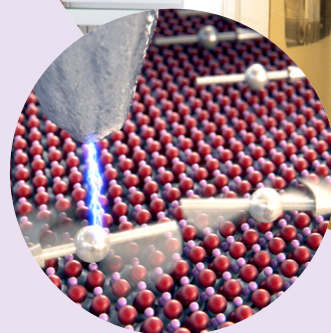
Major airlines operate more than 1,000 flights a day to more than 100 cities worldwide. Their planning is difficult and decisive for an airline's economic success. Personnel and machines must be used as efficiently as possible. Jülich researchers, in collaboration with partners from the European OpenSuperQ project, are already developing calculation methods for future quantum computers to create optimal flight plans with unique speed. They test these calculation methods with quantum computer simulation software, among other things.



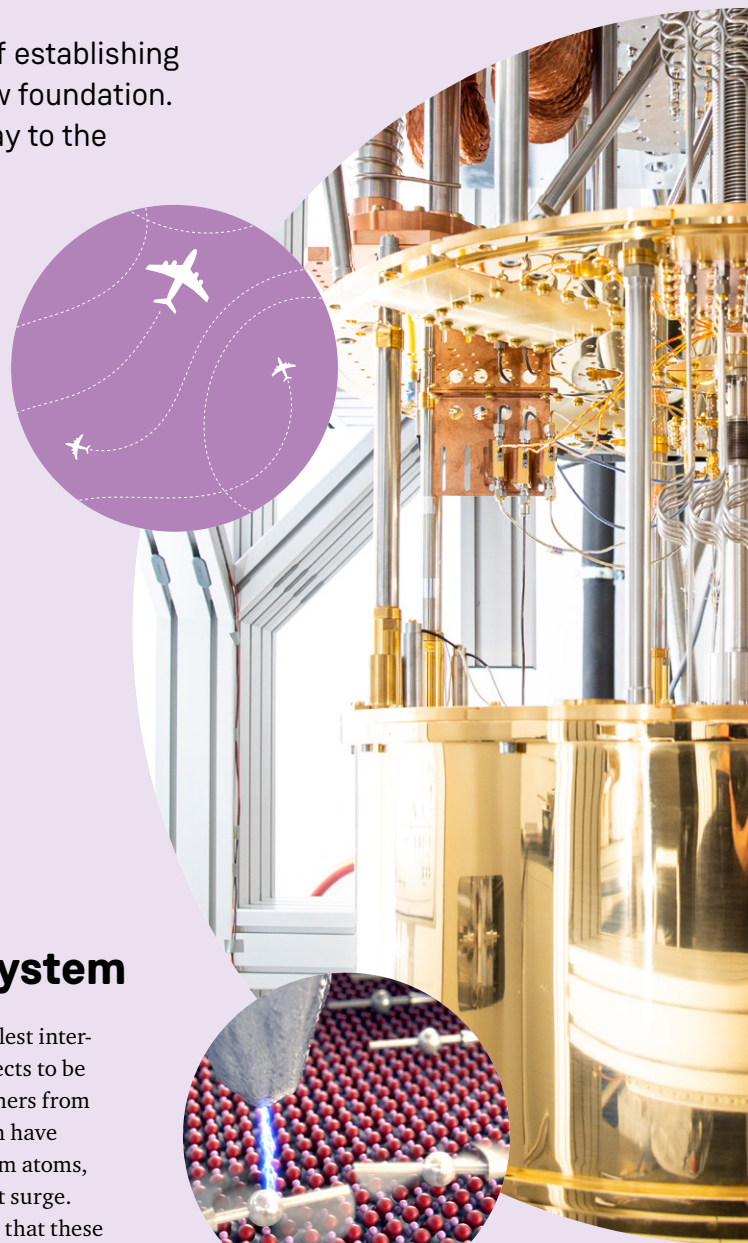
More details in the video (YouTube):
go.fzj.de/flightplan

An amazingly stable quantum system

Quantum systems are considered extremely fragile. Even the smallest interactions with the environment can cause the sensitive quantum effects to be lost. However, this does not always seem to be the case, as researchers from TU Delft, RWTH Aachen University and Forschungszentrum Jülich have discovered. In a quantum system consisting of two coupled titanium atoms, the quantum information was retained even after a sudden current surge. The result was cause for some discussion among experts. It may be that these quantum states can be created with a little less care than previously thought. The researchers now want to test whether if the result also applies to larger quantum systems.



↑ Artistic representation of the experiment with the two coupled titanium atoms



QUANTUM COMPUTING



Quantum AI for the automotive industry

Software that is capable of learning and that can do without fixed rules for every situation is already common in the automotive industry and other high-tech sectors. However, this artificial intelligence (AI) often requires a lot of computing time. The Q(AI)2 project, which is coordinated by Forschungszentrum Jülich, is exploring the extent to which quantum computers can accelerate applications in the automotive industry with AI, such as optimizing flexible production processes or steering self-driving cars through traffic without collisions. The consortium includes, among others, the car manufacturers BMW, Mercedes-Benz and Volkswagen as well as the supplier Bosch and the German Research Center for Artificial Intelligence.

Quantum transport speed limit

Not even the special rules of the quantum world allow information to be transmitted arbitrarily fast. An international team with Jülich quantum physicist Prof. Tommaso Calarco on board has now determined the highest speed at which this can be achieved. This is significant for quantum computers in which atoms serve as qubits and thus as carriers of information. In order to perform calculations, these atoms must be shifted in the processors of such a quantum computer.

This must happen as swiftly as possible, since the qubits lose their quantum state after a certain amount of time, thus losing the information they contain. With the speed limit determined, it is now clear how often an atom can be moved in this time span, that is, how many complex quantum operations a quantum computer can perform.

“However, the existence of the speed limit does not mean that quantum computers may not compute as fast as previously thought,” Calarco emphasizes. The decisive factor is that they need far fewer operations to master a certain task than classical computers.

↑ Tommaso Calarco is director at the Peter Grünberg Institute in Jülich and professor of theoretical physics at the University of Cologne.



Read more about the quantum speed limit in the interview with Tommaso Calarco:

t1p.de/fzj-quantum-speed-limit



↑ Prof. Ruslan Temirov (right) and his colleague Dr. Taner Esat at the Jülich quantum microscope

Quantum microscope: “Made in Jülich”

Many a bizarre property of the quantum world can be observed under a scanning tunnel microscope. Jülich physicists have further developed such a device in order to gain even more precise insights. Scanning tunnel microscopes portray materials with atomic precision and are much-used instruments for exploring the nanoworld. “We have spent years developing a microscope with magnetic cooling. This distinguishes our device from all the others in much the same way as an electric car differs from a car with a combustion engine,” says Jülich physicist Prof. Ruslan Temirov. Thanks to the new cooling system, the microscope works almost vibration-free at extremely low temperatures. It is therefore far more suitable than conventional devices for exploring the unusual properties of quantum materials near absolute zero, which is -273.15 degrees Celsius (0 Kelvin). Special quantum phenomena often manifest themselves at such temperatures, which scientists need to understand precisely in order to advance quantum computing. “Our next step is to develop a commercial prototype,” says Prof. Stefan Tautz, director at Jülich’s Peter Grünberg Institute.



Picture gallery on the quantum microscope in the effzett web edition: effzett.fz-juelich.de/en

Cooperation on exotic qubit candidates

There are several ways to realize qubits for quantum computers: for example, superconducting circuits, ion traps or semiconductor quantum dots. Candidates also include topological insulators in a superconducting Josephson bridge. Topological insulators are a special class of materials: their interior acts as an insulator while the surfaces conduct current almost without loss, since the angular momentum and the direction of movement of the electrons are coupled there. If this material is incorporated into a so-called superconducting Josephson bridge – in which an insulator lies between two superconductors, itself acting as a superconductor under certain conditions – exotic, very stable quantum states are created. Such components could help slash disturbances that arise during computing operations with current technology and lead to errors in the calculations. Julius-Maximilians-Universität of Würzburg and Forschungszentrum Jülich have been working closely together for several years on research into topological material systems. In the future, the Free State of Bavaria will fund the cooperation with €13 million for the development of quantum computing applications.



More about Jülich quantum research online at go.fzj.de/quantum-EN and in the cover story of effzett 1-21 “Quantum cosmos adventure” at effzett.fz-juelich.de/en/1-21/in-superposition



↑

What are you researching right now, Mr Musall?

**Dr. Simon Musall, Helmholtz Young Investigator Group Leader
at the Institute of Biological Information Processing, IBI-3: Bioelectronics**

“I am investigating how the brain makes decisions. To do this, my team and I examine how this process works in mice. More specifically, we examine which regions in the brain are active and when. We see these as luminous, shifting surfaces – as in the pictures behind me. The shifts show us the paths that the information takes and which nerve cell groups are involved. This helps us to test theories about decision-making in the human brain and to postulate new theories about it.”

Let there be light!

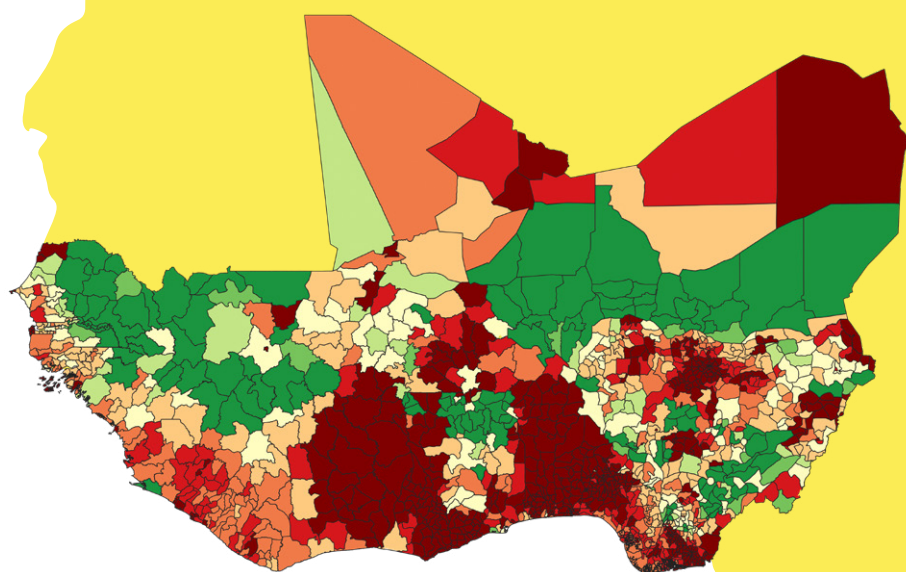
Electricity was not part of his everyday life during his childhood in Nigeria: today at Jülich, 46-year-old Solomon Agbo coordinates the H₂ Atlas Africa, which aims to bring more light to his continent – and with it, new opportunities.

No electricity, no light: “I grew up in an area where there was seldom electricity,” says Dr. Solomon Agbo. Instead, flickering paraffin lamps and candlelight lit up the dark evenings and nights for his family in their native Nigerian village.

Yet there is plenty of sunshine in the region, which would allow for energy to be generated: the African continent has the most solar resources in the world. According to the International Energy Agency (IEA), however, despite great progress in recent years, around 580 million people in Africa – out of a population of around 1.3 billion – still have no electricity.

As a teenager, Agbo was already racking his brain as to why his country was unable to collect the sun’s energy. After all, he is convinced, “Electricity means education, development and opportunities.” From then on, the idea of ‘more light’ determined his professional career: in 2007, after studying physics, Agbo joined Delft University of Technology as a doctoral researcher. His focus: the development of solar cells and solar cell materials. In 2015, he joined a photovoltaics research group at the Jülich Institute of Energy and Climate Research as a Humboldt Fellow.

However, the Nigerian did not find it sufficient to generate knowledge in the lab – his childhood memories of the acrid and heavy petroleum air, of doing homework



Hydrogen production

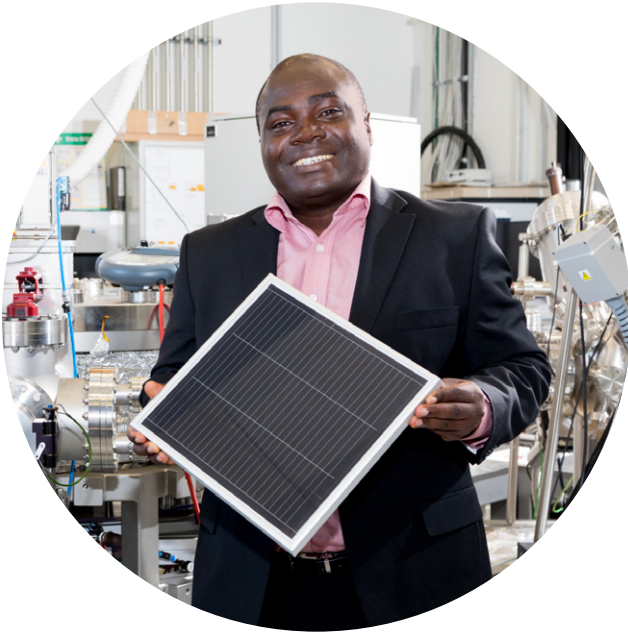


This is how much hydrogen could be produced annually in the regions of West Africa – shown as the amount of energy stored in H₂ (in kilowatt hours per m²). Restrictions due to land use and the availability of groundwater, wind and sun are taken into account here.

Source: H₂ Atlas Africa

AFRICA

580
million people
in Africa still have
no electricity



↑ A matter of the heart for Solomon Agbo: building a sustainable hydrogen industry in Africa

in the dark, were rooted too deeply. Agbo wanted to pass his know-how on to society. So in 2018, he changed to science and project management at Forschungszentrum Jülich's Corporate Development. His dearest project: to build a sustainable hydrogen industry in Africa in order to finally bring more light to his continent – and with it more opportunities. The name: H₂ Atlas Africa.

The project led by Jülich marks the start of a cooperation between the Federal Ministry of Education and Research (BMBF) and 31 African countries in the sub-Saharan region. The ultimate goal: to find the best locations for green hydrogen infrastructure in the southern and western parts of Africa.

“We need such a project for several reasons,” Agbo explains. There is climate change, which affects Germany just as much as Africa. “We can only stop it with the aid of renewable energies,” explains the physicist. After all, there is much more sunshine in Africa than there is in Germany. West and Southern Africa could produce enough renewable energy – and from it, in turn, green hydrogen – to supply their own countries as well as Germany. To date, the atlas already provides an interac-

tive map showing the best production hotspots in West Africa. The ongoing project will continue to supplement it. “Once we have gathered all the information, we will know exactly in which places, in which regions, we will be able to produce green hydrogen in what quantities and, above all, at what costs,” Agbo describes. This is crucial information for German and African companies, but also for governments. Solomon Agbo holds a key position. As project coordinator, he is the German-African intermediary. He talks to the people on site while also knowing the mentalities of scientists and German authorities. The people from the African countries involved trust their compatriot: “They talk to me very openly. This is important because we have to take into account the interests of each individual country,” Agbo explains. For example, both water and land are needed for the solar plants and wind turbines to produce green hydrogen. Yet, it would not be acceptable if, as a result of their hydrogen production, Africans could no longer plant vegetables or have groundwater for irrigation or drinking. “We take these needs into account to ensure sustainable development,” Agbo emphasizes. For example, the decision was made to use mainly desalinated seawater for hydrogen production.

Before Africa becomes a hydrogen exporter, however, the countries involved are first to be sustainably electrified on a permanent basis. According to Agbo, that

Imports needed

Hydrogen plays a central role in energy transition in Germany, for example as an energy carrier for fuel cells, as an energy storage medium and as a basic material for industry. This is the intention of the Federal Government's National Hydrogen Strategy. However, Germany will not be able to produce enough hydrogen on its own. Jülich researchers from the Institute of Energy and Climate Research (IEK-3) have calculated a demand of around 414.4 terawatt hours for the year 2045, almost half of which will have to be imported. The German government is seeking cooperation with countries where green hydrogen can be produced. Potential candidates are windy or sunny regions such as the south and west of Africa. Identifying the potential of these regions with the help of the H₂ Atlas Africa is one of 38 measures of the National Hydrogen Strategy.



165,000

terawatt hours

of green hydrogen could be produced in Africa per year at the maximum, according to the H₂ Atlas Africa. This is about 1,500 times as much as Germany's hydrogen demand that the National Hydrogen Strategy assumes for 2030.

takes time: "People first have to be familiarized with the technology and trained accordingly." One of the biggest challenges is to convince the various governments to invest in the green hydrogen infrastructure. "Many still rely on coal or gas," Agbo explains. A lot of educational work is necessary,

but Agbo is looking ahead. The BMBF wants to launch the first pilot projects as early as 2022. These are intended to improve the situation in the various countries and show how an economically viable green hydrogen supply chain can be realized. The physicist is convinced: "In the long run, this cooperation is a sustainable win-win situation for Africa and Germany."

Katja Lüers

NRW as a national hydrogen hub

Hydrogen is to be leveraged on a large scale to make Germany greenhouse gas neutral. A Jülich study shows that North Rhine-Westphalia (NRW) plays a decisive role in the future national hydrogen supply.

Germany wants to reduce its greenhouse gas emissions to almost zero by the middle of the century. To succeed in this, the energy system of NRW, the most populous state in Germany, must also be transformed in all areas – this applies to the energy conversion sector itself as well as to the end consumers in industry, transport and buildings. The NRW state government has defined the path to this goal in its Hydrogen Roadmap NRW. The results of an accompanying scientific study by Jülich energy system researchers led by Prof. Detlef Stolten have been incorporated into the roadmap. Making use of an entire family of computer models, they have calculated this comprehensive conversion step by step – on the understanding that it should cost as little as possible.

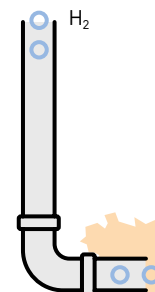
The results of the calculations show that Germany will need around five times as much hydrogen in 2050 as it does today, namely 9 to 13 million tonnes. NRW will account for one third of the demand. The industry there

will use the hydrogen to produce steel, cement and basic chemical materials without using carbon-based energy sources and resources. The hydrogen will also serve as fuel for fuel cell trucks and cars. According to the study, industry and transport will each account for around half of the demand for hydrogen in NRW in 2050.

The calculations indicate that, in 2050, the federal state itself will only be able to produce about ten per cent of what it needs. The reason is that NRW does not have enough suitable sites for wind power and photovoltaic plants to generate the renewable electricity needed to produce hydrogen.

It is therefore important to connect – via pipelines – NRW to the North Sea coast in particular. This is because many domestic hydrogen production plants are settling there and hydrogen imports from sunny regions such as Africa (see p. 22) will arrive at the North Sea ports. The Netherlands, too, is becoming an impor-

THE NETHERLANDS



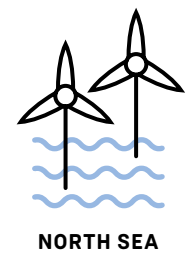


“NRW already has an excellent energy infrastructure that can be reassigned to hydrogen.”

PROF. DETLEF STOLTEN

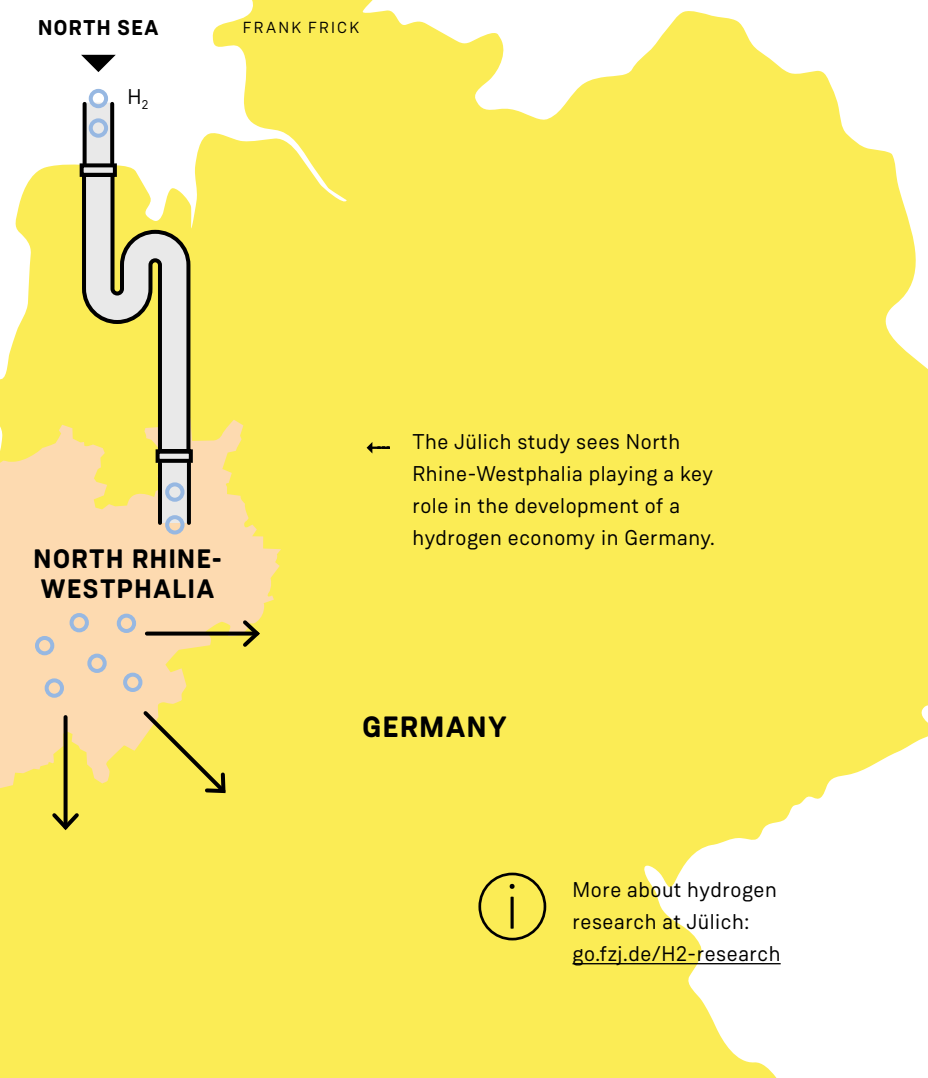
tant supplier, which is why the study recommends that pipelines also be built or reassigned between NRW and the Netherlands.

NRW has a central role to play in the development of a hydrogen infrastructure in Germany. “This infrastructure will connect Northern Germany and the Netherlands with Southwestern Germany and turn NRW into a kind of national hydrogen hub,” says Detlef Stolten. NRW could benefit from the fact that its existing natural gas networks and gas storage facilities are already excellently developed and that these can be reassigned to hydrogen.



NORTH SEA

FRANK FRICK



GERMANY

← The Jülich study sees North Rhine-Westphalia playing a key role in the development of a hydrogen economy in Germany.

The Rhineland region as a model region

Forschungszentrum Jülich is establishing a Helmholtz cluster for hydrogen economy, known as HC-H2 for short, in the Rhineland region. Its aim is to develop new technologies for green hydrogen, thus contributing to the creation of a pioneering hydrogen economy with 130,000 new jobs in NRW, as announced in the state's Hydrogen Roadmap. The federal government is funding the HC-H2 lighthouse project with €860 million from funds for the structural transformation of coal regions over an estimated 17-year period. NRW is also contributing state funds.

The cluster covers all aspects of a future hydrogen economy: the production, use and logistics of green – i.e. CO₂-free – hydrogen. It concentrates on technologies that draw on existing transport and storage infrastructures such as pipelines and tank farms, or on those that are quick and cheap to install.

Demonstration facilities are to be built across the Rhineland region. Among other locations, research will be based in a new Jülich institute for sustainable hydrogen economy. “By closely linking research and demonstration projects, we hope to accelerate the transfer of knowledge from research to practice,” says Prof. Wolfgang Marquardt, Chairman of the Board of Directors. He is convinced that HC-H2 will strengthen the Rhineland region as an attractive location for innovative energy companies, industrial settlements and start-ups.



More about hydrogen research at Jülich:
go.fzj.de/H2-research



A start-up for malaria testing

Malaria is one of the most common infectious diseases worldwide. An innovative rapid diagnostic test from Jülich can detect it quickly and reliably. This increases the chances of recovery.



↑ Mosquitoes of the genus *Anopheles* transmit malaria from person to person.

A small prick of the needle in the finger is all it takes: the new test device analyzes the drop of blood welling up and immediately determines whether the tested person has malaria with the same easy and quick technique as blood sugar tests. Around 220 million people worldwide contract malaria every year, mostly in Africa. According to the Robert Koch Institute, over half a million people die, mostly children under five.

One of the most effective strategies to change this would be nationwide rapid testing. If an infection with a malaria parasite is detected early enough, it can be treated and cured. Biomedical engineer Dr. Gabriela Figueroa Miranda from the Institute of Biological Information Processing (IBI-3) is developing a new biosensor that general practi-

tioners or even patients themselves can use to do a test without complicated pre-treatment. "The device is intended to be easy to use by anyone at home, in schools and hospitals. It consists of a single-use chip sensor that is dipped into the patient's drop of blood and a small and reusable portable reader that a doctor can carry in his or her coat pocket at all times," says Figueroa Miranda.

The most reliable detection method to date has been PCR tests, but these are not very suitable for rapid detection. They require cleaning steps, analytical equipment, reagents and are also time-consuming. Other rapid diagnostic tests that detect malaria through antibodies only provide reliable results from 200 parasites per microlitre. The malaria biosensor developed by the Jülich



researchers has already succeeded in detecting 50 parasites per microlitre, thus exceeding the standards required by the World Health Organization.

LITTLE HELPERS

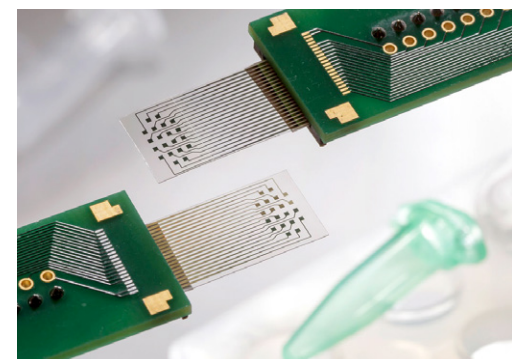
For her new rapid diagnostic test, Figueroa Miranda relies on so-called aptamers, which she has been researching for six years. Behind this somewhat unwieldy name is an artificially created DNA molecule that, like antibodies, attaches itself to proteins and generates a measurable signal. The researcher uses a special aptamer that detects malaria. It attaches itself to proteins of the plasmodium parasites responsible for triggering the febrile illness. In contrast to antibodies in previously common rapid diagnostic tests, aptamers are very stable over a long period of time and insensitive to environmental influences.

In order to turn basic research into a marketable product, the scientist plans to found a start-up together with her colleague Dr. Viviana Rincon Montes. “I didn’t just want to develop a biosensor in the lab, I wanted to bring a wearable device to series production,” says Figueroa Miranda. The two are already working on turning the current laboratory device into a handy prototype about the size of a blood glucose meter.

FROM THE LAB INTO PRACTICE

Their rapid diagnostic test is to be used in countries that greatly suffer from malaria, especially in Africa, Asia and South America. She thus asked NGOs, research institutes and clinics what is important for it to be accepted. “Our test meets all the criteria mentioned. It’s robust, easy to use, displays accurate values and is also affordable,” says Figueroa Miranda. There is another advantage, however. While, with the previous tests, the persons tested could only find out whether or not they were infected, the new test also reveals the amount of the pathogen present and which of the two most common types of pathogens live in the blood – doing so even in the early stages of the disease. The Jülich researcher makes it clear: “With this knowledge, the doctor can treat the patient faster and with more appropriate medication.” This can save lives.

KATJA ENGEL



↑ A drop of blood is enough for the sensor developed by Gabriela Figueroa Miranda to detect malaria quickly, easily and reliably.

← Gabriela Figueroa Miranda (right) and Viviana Rincón Montes want to launch an innovative malaria testing device.

Gold detects pathogens

Tiny gold beads lie on a glass slide, covered with a drop of blood. Every now and then a small flash of light comes on. “This is the sign that the beads have just tracked down a protein of the malaria parasite,” says Dr. Dirk Mayer (pictured), group leader at the Institute of Biological Information Processing (IBI-3). He, too, is working on methods to detect malaria. However, he is taking a different approach than his colleague Gabriela Figueroa Miranda. His goal is not a test kit for quick, on-site diagnoses, but a concept for a fundamentally new method to detect even the smallest amounts of pathogens. He measures optical instead of electrical signals. To this end, he uses small metal spheres on which he attaches antibodies and aptamers as a kind of sniffer dog. If they detect a malaria pathogen, a tiny flash of light is produced. “The spheres are arranged in a honeycomb-shaped grid. This honeycomb field amplifies the small flashes of light so that even the slightest traces of infection are visually indicated,” he explains. His method detects the disease if there are 50 malaria parasites in one microlitre of blood. It measures whole-blood samples without complicated pre-treatment and is therefore simpler and faster than a PCR test.

Another advantage: “In principle, the method also works for high-throughput measurements, where tens of thousands of samples are tested simultaneously and automatically,” explains the Jülich researcher. It could also be used to quickly and simultaneously test many blood samples for other diseases caused by viruses and bacteria, such as influenza or COVID-19.



Networking data islands

Exchanging, comparing, reusing – this is often difficult with research data. They are often scattered, hidden or not comparable. The National Research Data Infrastructure (NFDI) is to change this in future.

In science, nothing works without data. They are the raw material for theories and insights. However, not all scientists have equal access to the mountain of data growing by the day. This is because the data is distributed in many places – as if on isolated islands, which are out of reach for many. Access is often only available to the institutes or working groups that have collected the valuable raw materials and stored them on their islands.



To counteract this, a network of data pipelines is not enough, however, because the collected data must not only be findable and accessible, but also comparable. That is exactly what is often the difficult part: “It starts with the details,” says Torsten Bronger from the Jülich Central Library. The research data manager supports scientists in their work with data: “A doctoral researcher wants to document her experiments. Should she create one file per attempt or several? What data does her measuring device provide? What information does she store? How does she name the files? Which file format does she choose? Does she store the data on a drive or in a database? Such things can be handled very differently by different institutes.” As a consequence, scientists from island A too often cannot do anything with the raw material from island B, let alone discover it in the first place.

This is not due to a lack of willingness to share and exchange, but mainly due to the lack of connections between the islands – the lack of pipelines for raw materials, so to speak. “For us researchers, this is a big disadvantage: it prevents us from comparing and merging data. This delays or prevents new findings,” says bioinformatician Prof. Björn Usadel, Director at the Institute of Bio- and Geosciences (IBG 4). Sometimes scientists even repeat the same or similar experiments because they cannot access the data from another island or do not know about it at all.



The National Research Data Infrastructure, NFDI for short, aims to change all that. Researchers from a respective discipline intend to form a consortium to build up this infrastructure. In this way, the isolated islands within a discipline are to be networked into island groups – of plant research or engineering sciences, for instance. Since there are no blanket solutions for the acquisition, storage and provision of raw materials, the members of the respective island groups are to develop common standards. This includes, for example, uniform rules for the preparation of data, its quality, its protection, and rules for the metadata. “Among other things, metadata describe the conditions under which an experiment was carried out, such as the measurement duration, the prevailing temperature or the air pressure. Without this information, the actual measurement data can hardly be compared,” says Björn Usadel. He is co-speaker of Data-PLANT, the NFDI consortium that aims to strengthen data sharing and collaboration in plant sciences.

FAIR data management

The “FAIR principles” are to be applied in the NFDI: data are to be handled in such a way that they are Findable, Accessible, Interoperable and Reusable.

In some disciplines, there are already approaches for such standardizations. These are to be integrated into the NFDI. In the end, data are expected to be available quickly and easily, with pipeline networks accessible worldwide and even linked across disciplines. That way, information from a wide range of topics can be taken into account regarding global challenges such as climate change. It is the wish of Torsten Bronger that “In the optimal case, the data will finally be so comprehensibly and completely organized, findable and accessible that even uses will become possible that one would not have dreamed of.”

JANOSCH DEEG

The NFDI

On the recommendation of the German Council for Scientific Information Infrastructures (RfII), the Joint Science Conference of the German federal government and the state governments decided in 2018 to establish a National Research Data Infrastructure (NFDI). It will consist of up to 30 specialist consortia, the selection and review of which will be coordinated by the German Research Foundation (DFG). The federal and state governments will provide up to €90 million annually until 2028 for the development of the NFDI. After two of a total of three rounds of calls, 19 consortia have been selected, nine of them with Jülich participation. The federal government and the states founded the NFDI Association in October 2020 in order to coordinate the activities within the NFDI.
www.nfdi.de/?lang=en



An overview of consortia in which Forschungszentrum Jülich is involved can be found online: <https://effzett.fz-juelich.de/en/3-21/networking-data-islands#c26607>



FLUORESCENCE

Some substances glow when irradiated with light. If the glow stops immediately when the light source goes out, this is known as fluorescence.



HOW DOES IT WORK?

Electrons absorb the energy of the irradiated light. In a fraction of a second, they emit a large part of it again — also in the form of light, only with less energy.

WHERE DO WE ENCOUNTER FLUORESCENCE?



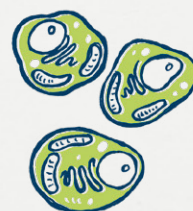
IN NATURE

Fish and jellyfish can fluoresce. The chlorophyll in plants glows in the nonvisible infrared range. Body fluids, such as blood, fluoresce when exposed to UV radiation.



IN EVERYDAY LIFE

Fluorescent dyes in toothpaste and detergents brighten teeth and laundry. Highlighters also appear to glow thanks to such dyes.



IN RESEARCH

Fluorescent molecules make individual cells and proteins in living organisms visible. In 2008, the Nobel Prize was awarded for what is referred to as the green fluorescent protein (GFP).

RELATED GLOWING

Some fabrics can glow for minutes or hours after the light source has gone out. This is called phosphorescence.



WHAT IS JÜLICH DOING?

Jülich researchers are using and developing measuring instruments based on fluorescence, studying, for example, plant photosynthesis, trace gases in the atmosphere and bacteria for biotechnology.



THUMBS UP

EXHIBITION IN BONN

The brain in art and science

At Jülich, we are researching the human brain. For example, scientists want to better understand the complexity of neuronal circuits, as well as reproduce brain functionality on the computer. Art also deals with our brain, our thinking, feeling and perception. In a coming exhibition, these two worlds will be brought together. It aims to expose errors and limitations of our conception of the brain and enable new views. Contributions to this include images and exhibits from the Jülich Institute of Neuroscience and Medicine (INM-1). The exhibition can be seen at the Bundeskunsthalle in Bonn from 28 January.

- BUNDESKUNSTHALLE.DE/EN -



WORLDS OF MATERIALS: ONLINE GAME

Studying in parallel universes

From lattice structures and the iron-carbon diagram to steels and non-metals – the online game “Welten der Werkstoffe” (worlds of materials) shows that you do not necessarily have to read thick books for materials science in engineering studies. The player slips into the role of the young student Nicole Nickel. Travelling through different parallel universes to free her professor, she has to answer specialist questions.

The game was developed by a small team of students and staff of the Cologne Game Lab. It was released in April 2021 and immediately won the category “Best Serious Game” at the German Computer Game Award.

- WELT-DER-WERKSTOFFE.DE (IN GERMAN) -

SCIENCE YEAR 2022

Questions in focus

With Science Year, the Federal Ministry of Education and Research and the Science in Dialogue initiative focus on a particular science topic each year. Next year will be a first: under the motto “Inquired!”, Science Year 2022 is not dedicated to a single topic, rather it calls on citizens to put their questions to science. Anyone can submit their concrete, everyday or visionary concern until April. In the subsequent months, the questions will be sifted, ordered and further processed – as a stimulus for science and politics.

- WISSENSCHAFTSJAHR.DE/2022 (IN GERMAN) -

RESEARCH IN A TWEET

One man, one birthday and 200 challenges.
@helmholtz_de celebrates its namesake and
shows what it is researching today.
#challenge200



The polymath Hermann von Helmholtz (1821-1894) tackled many a scientific challenge of his time. The results were instruments such as the ophthalmoscope, the Helmholtz resonator, the first electronic synthesizer and devices for measuring nerve conduction velocity. On the occasion of his 200th birthday, the Helmholtz Association is presenting 200 major challenges facing humanity today and how Helmholtz researchers intend to master them – from technology to climate and raw materials.

helmholtz200.de/helmholtz-heute/challenge-200 (in German)