Outlook Earth

Research on global change

Special Issue

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International research on global change in the service of climate

Photo: Fotolia

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The new role of research in the inter

The Paris Climate Agreement has entered into force in November 2016 and for the first time obliges all nations to make a contribution towards climate protection. But this goes much further than just the reduction of emissions. The international community has also decided to divert global finance streams into sustainable investments and to bring them into harmony with climate-friendly development. Efforts to adapt to unavoidable climate change are to be reinforced.

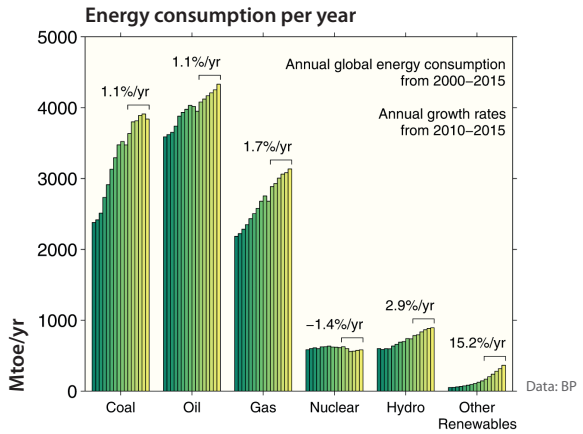
The Paris Agreement establishes binding global targets in the fields of mitigation, financing and adaptation. But it is not only the industrialized nations that come under obligation. For the first time, all nations must contribute, based on their national circumstances; the poorest receive particular support to fulfil these targets. Because climate change does not stop at national borders.

According to the Paris Agreement, the increase in the global average temperature should be limited to well below 2 °C; pursuing efforts to limit the increase to 1.5 °C. In national climate plans, nations show how they will make their contribution towards achieving these targets. In Germany this is supported by the Climate Action Programme 2020. However, fulfilment of these plans is not obligatory.

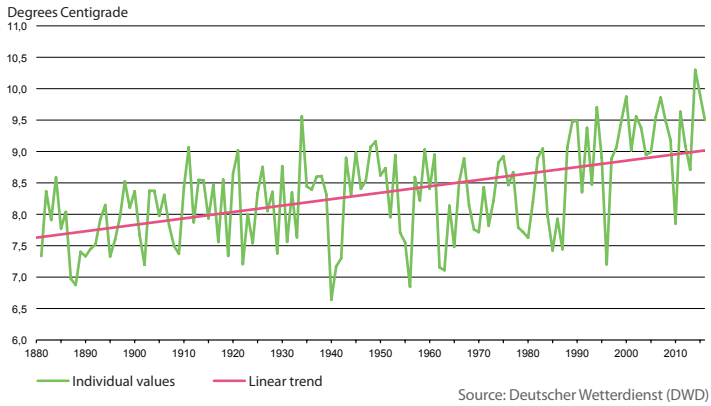
In Paris it has already become clear that the mitigation pledges will not yet be sufficient to comply with the upper limit of 2 °C. Thus it has been decided that from 2020 onwards, nations must update and increase their contributions every five years.

The Paris Agreement has established the appropriate mechanisms for this. Every five years there will be a "global stocktake" (GST, see page 5). Cutting-edge research is essential for the best possible assessment of progress.

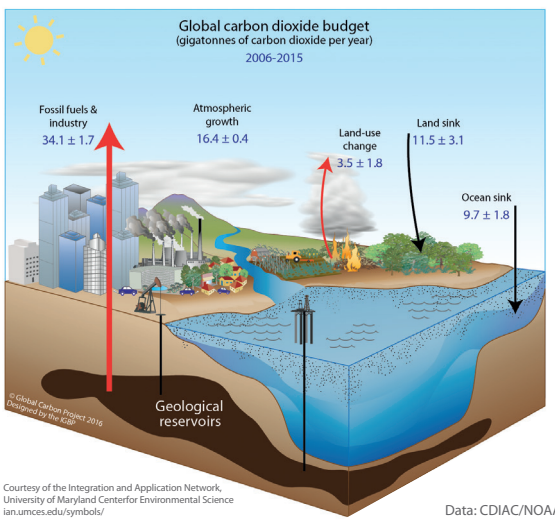
With its framework programme "FONA – Research for sustainable development", the Federal Ministry for Education and Research (BMBF) promotes numerous research initiatives so that the targets of the Paris Agreement can be achieved. FONA helps to close research gaps and to answer open questions about climate change and the handling of the climate crisis. In this issue, we would like to present several examples of these research projects.



Source: Global Carbon Project 2016



Source: Deutscher Wetterdienst (DWD)



Source: Global Carbon Project 2016

national climate policy

Solution-oriented: German climate research

The Paris Agreement was an important milestone for climate research: it has provided the knowledge basis and now plays a crucial role in achieving the targets of the Paris Agreement. This applies to Germany and worldwide. It is important that scientists, decision-makers and those affected on site work together.

"Climate research must continue to reach politics so that ambitious climate protection can be supported by scientific facts."

Prof. Johanna Wanka, German Federal Minister of Research

The BMBF funds climate change research with around 70 million Euro per year. This flows into funding programmes for climate system research, climate projection and regionalisation of climate knowledge, into climate impact and adaptation research, and climate services. Overall, the result should support an integrated assessment of climate policy and the costs, risks and opportunities of mitigation and adaptation. The aim is to understand the chain of effects from the causes of climate change to possible consequences to concrete options for action when dealing with climate change and then to integrate this knowledge into the work of politicians and administrators, companies and local authorities.

German climate researchers are among the best in the world. They enable politicians and society to react quickly and flexibly to the challenges of climate change. This is because the transformation to a climate-friendly society, as agreed in Paris, requires knowledge and innovation. The new framework programme "Research for sustainable development (FONA^3)" also shares these aims.

Climate research after Paris

The objectives of the Paris Agreement can be achieved only through a push for innovation in all areas of life and production. Germany has a modern and diverse climate research landscape with great potential to set impulses and offer orientation. The BMBF therefore acts precisely at the interface between climate policy, climate research and practice. Current research programmes are geared towards concrete knowledge and structuring needs from politics, economy and society. Central issues revolve for example around the integrated assessment of damage and adaptation costs, the impact and financing of climate policy instruments, the analysis of distributional and competition effects and the social consequences of ambitious climate policy.

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The target of limiting global warming as far as possible to 1.5 °C also confronts science with new issues. The most recent IPCC assessment report indicates only a few practicable ways here. And these apply only under far-reaching assumptions about mitigation and so-called negative emissions. The BMBF is therefore funding a wide range of research projects to broaden the knowledge base, e.g. whether or how climate impacts and damage from a temperature increase of 1.5 °C differ from greater temperature increases and under which political, economic and social conditions very ambitious mitigation can fairly and effectively be realised.

"The Paris goals can be achieved only if we tackle the phasing out of fossil fuels worldwide."

Prof. Ottmar Edenhofer PIK Potsdam Institute for Climate Impact Research

Time and again, the BMBF must open up new topics so as to implement climate policy within differentiated and effective research policy. In the future, the issue will increasingly be how the implementation of the Paris Agreement can be supported by science. This requires continuity in keeping climate research focused on central knowledge gaps, because knowledge gains remain the basis for credible and convincing climate policy.

Closing research gaps

Obvious signs are the funding programme for continual further development of climate models and research infrastructures, for the monitoring of greenhouse gas emissions and the reliable estimation of future climate trends and impacts. How much the global average temperature is likely to rise in the long term has been known from the IPCC reports for a long time. Less precise to forecast is the temperature or the intensity of precipitation in several years or decades. But it is precisely these planning horizons that are particularly interesting for the economy and politics, and the need for reliable statements on medium-term climate trends increases all the time. The same applies to the question of whether extreme weather events are becoming more frequent and more severe. Extended heatwaves, violent storms or floods present great challenges primarily in urban areas. Cities therefore need efficient planning instruments and urban climate models for adaptation. Improved regional forecasts are important for agriculture. There are still significant research gaps to be closed here.

"We will be able to harvest the fruits of our labour only after a few decades. It's like in a car: if you drive at high speed, the braking distance is extremely long. So there is no more time to be waisted."

Prof. Mojib Latif GEOMAR Helmholtz Centre for Ocean Research Kiel

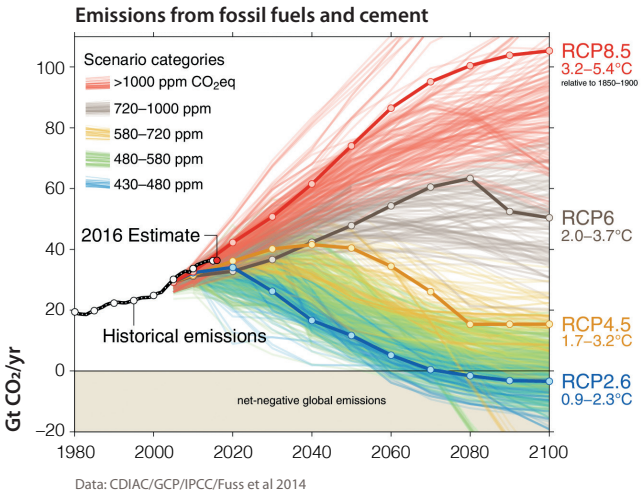
By focusing on basic uncertainties in understanding the climate system (clouds and precipitation processes) and the carbon cycle as well as long-term reconstruction of the palaeoclimate (with regard to natural climate variability), the understanding of the processes of the climate system will also be placed on a new footing.

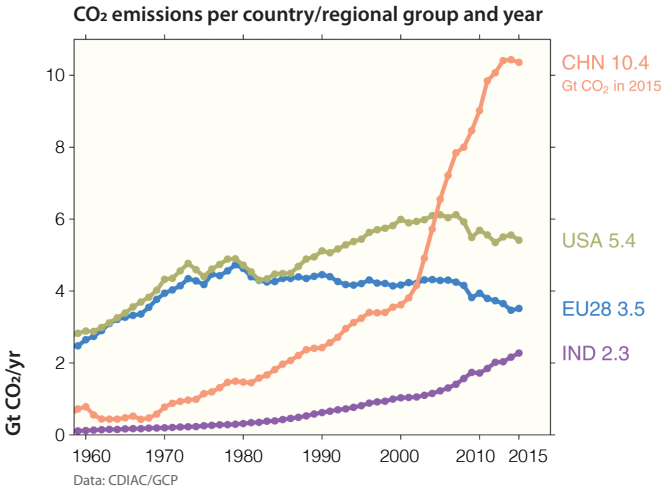
Reliable information on climate change is ultimately a crucial knowledge base for the adaptability of our society and for decisions in politics, administration, the economy and the public. Therefore, many research projects aim to provide decision-makers with simplified access to the current state of research through climate services, for example regarding changes in precipitation, temperature distributions or wind conditions for selected regions.

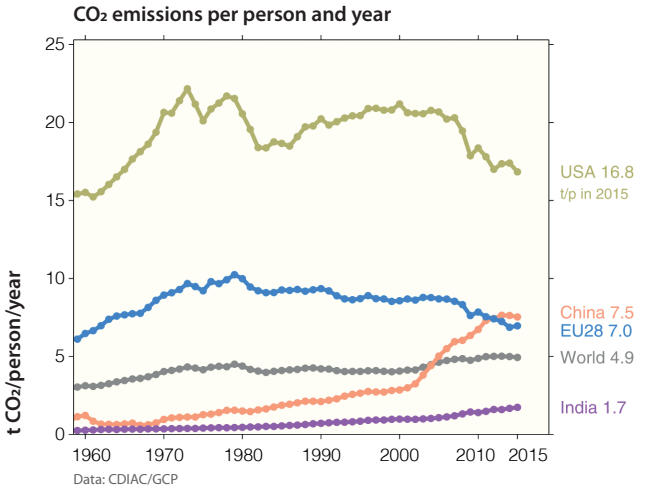
"Climate data are very important for future planning. This applies to critical infrastructure for electricity supply just as much as to agriculture or worldwide delivery chains."

Prof. Daniela Jacob GERICS Climate Service Center Germany

In order to pool research on climate services and other future topics at a European level and to improve scientific networks, the Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate) has been founded. Its aim is to align national programmes by jointly coordinating their climate research and funding new transnational research activities.







Source of all graphics: Global Carbon Project 2016

What is the "global stocktake"?

With the Paris Agreement, mitigation, adaptation and support in dealing with climate change have become an international obligation. The agreement establishes binding global targets, to which nations themselves must establish their contributions in national climate plans ("Nationally Determined Contributions" – NDCs). The fulfilment of these plans is not binding. At the same time, a transparency framework coupled with a monitoring and ambition mechanism ensures that the contributions are implemented and continually updated.

Scientific findings support the assessment of progress and the selection of the right measures for the implementation of the agreement. This is because the transformation to a climate-friendly society, as agreed in Paris, requires knowledge and innovation.

In order to adhere to the agreed upper warming limit of below 2 °C, the agreement obliges nations to update and increase their contributions every five years from 2020 onwards. A "ratchet mechanism" applies here: subsequent contributions must be more ambitious than the previous.

Two years before the resubmission of NDCs, a "global stocktake" will investigate whether all countries together are on track in the fields of mitigation, adaptation and support and that overall, the targets of the agreement are being achieved. The findings of the "global stocktake" should be taken into account when nations prepare their next NDC. The precise structuring of the "global stocktake" will be decided by the nations at the end of 2018.

The "global stocktake" will also use scientific information to assess the progress already made and the appropriateness of the presented national contributions. Findings from the natural sciences, e.g. the independent evaluation of emissions inventories or climate model simulations of future warming are necessary, as well as those from economic and social sciences, e.g. for the assessment of political measures.

The aim is to make the contributions of all states comparable and thereby create a trust in that the efforts of all stakeholders are fair and appropriate. Even though the "global stocktake" does not assess individual countries and does not result in any sanctions, it can however have a powerful influence on the reputation of a country at an international level.

ICOS: How much CO_2 actually escapes into the atmosphere?

Carbon dioxide (CO_2) and other greenhouse gases released by humans are the main cause of climate change. The rise in greenhouse gases in the atmosphere is causing the well-known greenhouse effect. Oceans, forests and soil currently still absorb a great deal of CO_2, thus slowing climate change, but for how much longer? What happens with the greenhouse gases in the sub-systems and how does the exchange of gases in the atmosphere actually work? The pan-European research mission "ICOS – integrated carbon observation system" helps to understand the biogeochemical processes in the global carbon cycle.

CO_2 measurements on water, on land and in the air

Until recently, long-term measurements of gases that influence the climate were taken almost exclusively on the basis of temporally limited research projects. So across the whole of Europe, there is a large number of well-equipped measurement stations that are in a position to carry out extended analysis of the complex interactions between climate changes and the carbon cycle.

The existing European measurement stations have therefore been developed into a permanent European research infrastructure, a measurement station network.

Now there are new opportunities to determine with precise measurements the changes in the carbon balance and so to make verifiable estimated emissions values of individual countries.

German researchers participate in all three ICOS observation networks for ocean, ecosystem and atmosphere: in eight towers, the greenhouse gas concentrations in the air are measured; in the ecosystem programme, researchers at 15 stations investigate the sources of and reductions in greenhouse gases in forests, fields and moorlands; and on a Baltic Sea ferry, the research ship Polarstern and an Atlantic freighter, the exchange of trace gases between the atmosphere and the ocean is measured.

Furthermore, with its calibration and radiocarbon laboratories, Germany forms a central core of the European infrastructure. In total, 13 German research facilities and universities participate in ICOS.

By the end of 2016, all measurement facilities were completely installed and calibrated and since then have been observing the carbon cycle in practical operation.

Previously calculated only roughly, the estimated CO_2 emissions and their impact on the global carbon cycle are to be proven meteorologically by the ICOS. The planned long-term measurements will make it possible to ascertain changes, for example in the storage capacities of oceans and forests. The independent measurements should furthermore show whether the climate policy measures are actually succeeding in reducing CO_2 output.

Photo: Arne Körtzinger

Photo: Werner Kutsch

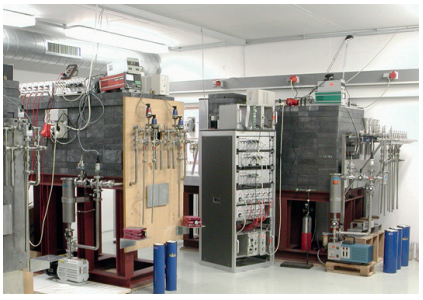


Photo: Bernd Kromer

Measuring in water and on land - evaluation in laboratory.

Funding
16 mill. Euro
2012 - 2016

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ATTO: Tall Tower Observatory in the Amazon rainforest

While the Amazon rainforest is one of the most sensitive ecosystems on Earth, the "green ocean" also plays an important role in the stabilisation of the Earth's climate. As the largest continuous forest area in the world, the Amazon forest stores a significant amount of CO_2. Due to the evaporation of water, this vast forest also has a significant impact on the world's water cycle. New data have to be collected in order to better understand the significance of the forest for the climate and to be able to assess potential risks. To this end, German-Brazilian cooperation constructed the world's largest observatory tower in the heart of the Amazon region.

The world's tallest climate measurement tower is situated in a remote location, far away from human impacts. After six years of planning and construction, the 325-metre high Amazonian Tall Tower Observatory (ATTO) was inaugurated in August 2015 by representatives from Brazil and Germany.

Researchers call it a dream come true: Its height alone means that the tower is able to deliver data on greenhouse gas fluctuations and on the interactions between land surface and atmosphere that have not been collected to date. It will now be possible, according to Jürgen Kesselmeier, "to examine the transport and fluctuation of air masses through the forest over a distance of many hundred kilometres". Jürgen Kesselmeier is the former project manager at the Max Planck Institute for Chemistry, which will operate the tower jointly with the Max Planck Institute for Biochemistry, the Brazilian National Institute for Amazon Research (INPA) and the Amazon State University (UEA).

The technique and part of the intended measuring instruments are installed so that now as part of a pilot research project the first data will start being collected and evaluated. The scientists' initial aim is to better understand the formation and elimination of greenhouse gases like carbon dioxide, methane and nitrous oxide. So far, researchers do not know enough about the role the rainforest plays in the formation of aerosol particles and thus the formation of clouds. Kesselmeier calls it a "web of secrets" that may be unravelled. Since the measurements will be performed in higher layers of air with a more continuous collection of data, more reliable information about the development of the atmosphere can be expected. This will permit more detailed weather forecasts and climate predictions. At the same time, this data can be used as a basis for environmental policy regulations to promote a sustainable development of the Amazon and other rainforests around the world. Details about the influence of the Amazon region on global events can now be more thoroughly analysed and ultimately even appreciated: "We want to understand the forest, in order to ultimately help and protect it", says Jürgen Kesselmeier.

ATTO will be integrated into an existing network of smaller measurement towers run by the Max Planck Society and the Brazilian National Institute for Amazon Research. The costs for the construction of the tower and for the first five years of operation will be around 8.4 million Euro. Germany and Brazil will co-finance the project in equal parts. The tower is planned to be in use for 30 years.

Photo: Susanne Benner

View from the ATTO over the rainforest.

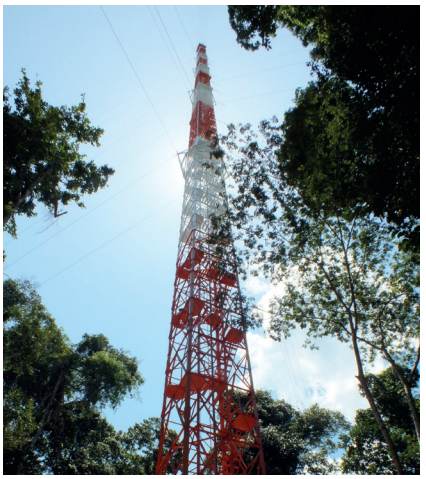

Photo: Susanne Benner

ATTO: 325 metres high.

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Links

www.mpg.de/9358794/atto-inauguration

www.fona.de/en/atto-19809.html

Kopernikus projects: Fresh ideas about energy transition

The "Kopernikus projects" are the largest research initiatives on energy transition of the BMBF (German Federal Ministry of Education and Research). They are looking for answers to the most important research questions about tomorrow's energy system: What should the power grid of the future look like? What is the best way to store renewable energy? How do we adapt the industrial processes to the fluctuating power supply? And how can all sectors of the energy system cooperate better? The projects run for a maximum of ten years and are funded with a total of up to 400 million Euro.

"Until 2025, we are launching new energy concepts that can be applied on an industrial scale and are also supported by society," stresses Karl-Eugen Huthmacher, responsible department head at the BMBF. The research topics of the four Kopernikus projects ENSURE, P2X, SynErgie and ENavi have established a comprehensive participation process from representatives of science, business and civil society. With the energy transition, Germany is faced with major technological and social challenges. Because the conversion of the energy system is a very demanding task, the BMBF has launched the Kopernikus projects. The name stands for the necessary paradigm shift in the energy system. The Kopernikus projects are the largest and most important energy transition research initiative of the BMBF.

Photo: ThinkstockPhotos

The Kopernikus projects lay the foundations for the energy system of the future.

The scientists are working on four central topics:

1. The development of power grids that are adapted to a high share of renewable energies (ENSURE),

2. the storage of renewable energies through its transformation to other energy sources, such as hydrogen (P2X),

3. the realignment of industrial processes towards a fluctuating energy supply (SynErgie),

4. the optimisation of the interaction of various sectors of the energy system (electricity, heat, mobility) to safeguard supply reliability, economic efficiency and climate as well as social compatibility under real-life conditions (ENavi).

High hopes are associated with the new funding concept: by 2025, according to the BMBF, the four Kopernikus projects will have paved the way for a technologically advanced and economically viable energy system. The important part is that society is responsible for results and that they meet expectations and needs of citizens in particular. For this reason, representatives of civil society and social scientists are involved in the projects right from the start.

The Kopernikus projects have an unusually long time frame of up to ten years. This is designed to ensure close integration of research from basics to application, and from initial testing to market launch. If possible, the energy transition will also lead to successful export opportunities. The BMBF will provide about 130 million Euro for the first funding phase by 2019. Another 280 million Euro will be made available by 2025. The projects started their work in 2016.

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Small and medium-sized enterprises change a lot

Small and medium-sized enterprises (SMEs) have at least as many creative heads as large companies. 99.7 percent of the 3.6 million enterprises in Germany are SMEs. They are the pioneers of technological progress in many areas. The BMBF supports top-level research in small and medium-sized enterprises with the funding initiative "Innovative SME". The costs associated with this research can hardly be handled by small companies on their own. Therefore, the BMBF decided to simplify access to research funding in important future areas with "Innovative SME". This applies to all SMEs who want to develop marketable solutions and technologies for climate protection and energy efficiency.

Energy from eco-waste is the Business idea of the company from Düsseldorf.

Climate-friendly energy from organic waste – that was the idea. The safe disposal of sewage sludge, a waste byproduct from wastewater treatment, is an urgent global problem, which is associated with steadily rising costs due to growing environmental requirements. At the same time, sewage sludge offers an enormous potential for the production of renewable energy and for the recovery of valuable nutrients for plant fertilization.

The medium-sized clean-tech company Terranova Energy received 543,000 Euro in funding from 2009 to 2010 by the BMBF to develop the "Hydrothermal Carbonation" (HTC).

In HTC, the sewage sludge is "carbonized" within a few hours at a temperature of approx. 200 °C and a pressure of 20 to 35 bar with an air seal and addition of a catalyst, thus turning into innovative fuel.

Compared to the sewage sludge, this fuel hardly contains any water anymore and can therefore be burnt due to its high energy content for energy generation and the reduction of energy requirements in cement plants or waste incineration plants.

Additionally, HTC supplies another product: the water extracted from the sewage sludge. This HTC filtrate is low-pollutant, sterilized and nutrient-rich because it contains a large portion of the phosphorus stored in the sludge.

The phosphorus is recovered as part of the process and can be used as a particularly powerful organic fertilizer, which was demonstrated by practical comparisons with commercial fertilizers. If the sewage treatment plant has a digestion process, then the digester gas yield is increased by 10 percent by recycling the energy-rich filtrate and the generated electrical energy is thus used for the self-supply of the sewage treatment plant. Since April 2010, a pilot plant in Kaiserslautern has been producing up to 600 tonnes per year of regenerative fuel from sewage sludge. In 2016, a commercial industrial plant in Jining/China was put into operation with great success.

Photos: TerraNova Energy

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WaterPower: Water management in Accra, Ghana

Sustainability at a global level is one of the greatest challenges of the 21st century. This includes breaking down of structural inequalities in terms of access to resources, living space and carbon reduction as well as societal and economic development and enabling the worldwide transformation to sustainability. The handling of energy and water resources plays a central role here. So as to record these exchange relationships between society and nature, the "WaterPower" project is based on the concept of the social metabolism and it expands on this with considerations from political ecology.

"A lack of water is not exclusively a natural phenomenon, but is often societally and politically structured," says Antje Bruns, Professor at the University of Trier. "This can be seen clearly in the example of the West African city of Accra." To date, the scientific discussion about the global water crisis has focussed primarily on falling precipitation quantities or increasing water use due to population growth. Under the management of Antje Bruns, political and societal causes are also being investigated in the "Water Power" project.

"The capital of Ghana is an investigation site in the project, which is supported by the BMBF to the tune of around 1.4 million Euro. "WaterPower" analyses the interplay of local and global crisis phenomena, such as societal dislocations, population growth, increasing resource use, environmental pollution and climate change. One of the first important findings that justifies the comprehensive approach is that in Accra, there is sufficient water. However, it is not of sufficient quality and is also poorly distributed. Settlements of the former British colonial rulers for example have the necessary water infrastructure and treatment plants. In the rapidly growing slum areas and on the edges of the city, people must however buy water in buckets or bottles and this is expensive and often dirty. The problem is exacerbated by new environmental influences. Through the financial crisis, gold mining has once again increased in importance. Mercury is frequently used here and this enters not only the rivers but also the drinking water.

In field research as well as in the acquisition of data, Antje Bruns and her team work closely with scientists from the University of Ghana and local administrators. Together they are trying primarily to answer one question: Can the collision of these many trends lead to an undermining of handling and control capabilities and therefore thwart future development options? The aim of the project in the "Junior Research Group for Global Change", which is to last at least four years, is to better understand human-environment interactions and to disseminate this knowledge as widely as possible. This requires a strict interdisciplinary approach. "For complex crisis phenomena like in Accra to be understood, sustainability science must critically scrutinise existing fundamental concepts," says Bruns and suggests that the traditional universal structures must be changed. This reformist attitude has not done her any harm. On the contrary: as a Junior Professor, she took on "WaterPower" at Humboldt University in Berlin and in 2015 was recruited by the University of Trier.

Photo: Antje Bruns

Strandslum in Accra.

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"1.5 degrees": Can the great ice sheets still be saved?

Greenland and the Antarctic are covered by massive sheets of ice. How will these two ice sheets behave with ever increasing global warming? An irreversible collapse of the West Antarctic ice sheet would for example be connected with a rise in sea level of several metres. When could this tipping point be reached? The funding measure "1.5 degrees" is investigating how severely the melting of both ice sheets will affect the sea level with global warming of 1.5 °C and with global warming of 2 °C or more.

The Intergovernmental Panel on Climate Change (IPCC) confirmed in its most recent report (AR5) in 2014 that it is not only the temperature of the lower atmosphere that is increasing and the oceans that are warming but also that glaciers are thawing and ice sheets are losing mass. According to the Paris Agreement, efforts to limit the temperature increase to 1.5 °C should be pursued. What does that mean for the vast ice sheets of Greenland and the Western Antarctic?

Photo: Martin Leonhardt (AWI)

The first ice core from 100 metre depth.

What developments are there currently in Greenland?

In the past ten years, the Greenland ice sheet has lost significant mass and is therefore contributing considerably to sea level rise. On the one hand this is due to so-called outlet glaciers that lie on the edges of Greenland by the sea and are calving more frequently, i.e. large parts of the ice sheet are allowed to drop into the sea. On the other hand, snow accumulations and surface melts in summer are changing. While at the start of this trend it was mainly the south of Greenland that was losing mass, in recent years this loss of mass has spread to the north-west and has meanwhile approached the edges in the north-east. An adequate description of the development of the edges of ice sheet model is particularly significant for long-term forecasting.

When will a sea level rise of 10 cm, 50 cm and 1m occur? Every year, areas of Greenland experience surface melt. How are these changing? When will the entire Greenland ice sheet begin to experience surface melt? The sub-project "EP-GrIS" is researching these issues at the Alfred-Wegener-Institut in Bremerhaven. The research findings will also be incorporated into the IPCC special report SR1.5, which is to be completed in September 2018 and promptly presented to the COP 24.

What is happening in the Antarctic?

The exceeding of critical temperature values in the Southern Ocean can lead to an irreversible collapse of the West Antarctic ice sheet. This would be connected with a rise in sea levels of several metres and would influence global circulation in the oceans and thus have effects on the global climate. In this sub-project too, scientists from the Alfred-Wegener-Institut are investigating how global warming of 1.5 °C, 2 °C or even 4 °C would affect the West Antarctic ice sheet.

Research to date has shown that ocean circulation is changed by climate warming and that warmer water will thus be transported to the underside of the shelf ice. This process leads to the melting of shelf ice from below. The additional fresh water input further changes the ocean circulation and intensifies the melting process. If climate warming continues unimpeded, four metres of shelf ice could melt each year in the second half of the century. How high the sea level would rise from this is one of the expected findings of this project. A complete loss of the West Antarctic ice sheet would lead to a sea level rise of around three to five metres. However, it remains unclear within what time period this would occur.

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COP 23 | Bonn: Upcoming Events

"German Science Hour", German Pavilion 12.30 - 13.30 pm

6 Nov 2017	"Science of extreme events"
7 Nov 2017	"Climate of the past - climate of the future"
8 Nov 2017	"Communicating climate science"
9 Nov 2017	"The fate of greenhouse gases: the knowns and the unknowns"
10 Nov 2017	"Carbon pricing: making polluters pay or selling out our future?"
11 Nov 2017	"Our ocean future: marine ecosystems under climate change"
13 Nov 2017	"Science in times of fake news"
14 Nov 2017	"Phasing out coal - a policy perspective"
15 Nov 2017	"Transformation - turning the climate tide"
16 Nov 2017	"Failing the carbon budget - what's next?"

BMBF "Side Event", German Pavilion 10.00 - 11.30 am

8 Nov 2017	"Global stocktake: information from science"

Science Year 2016*17
SEAS AND OCEANS

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