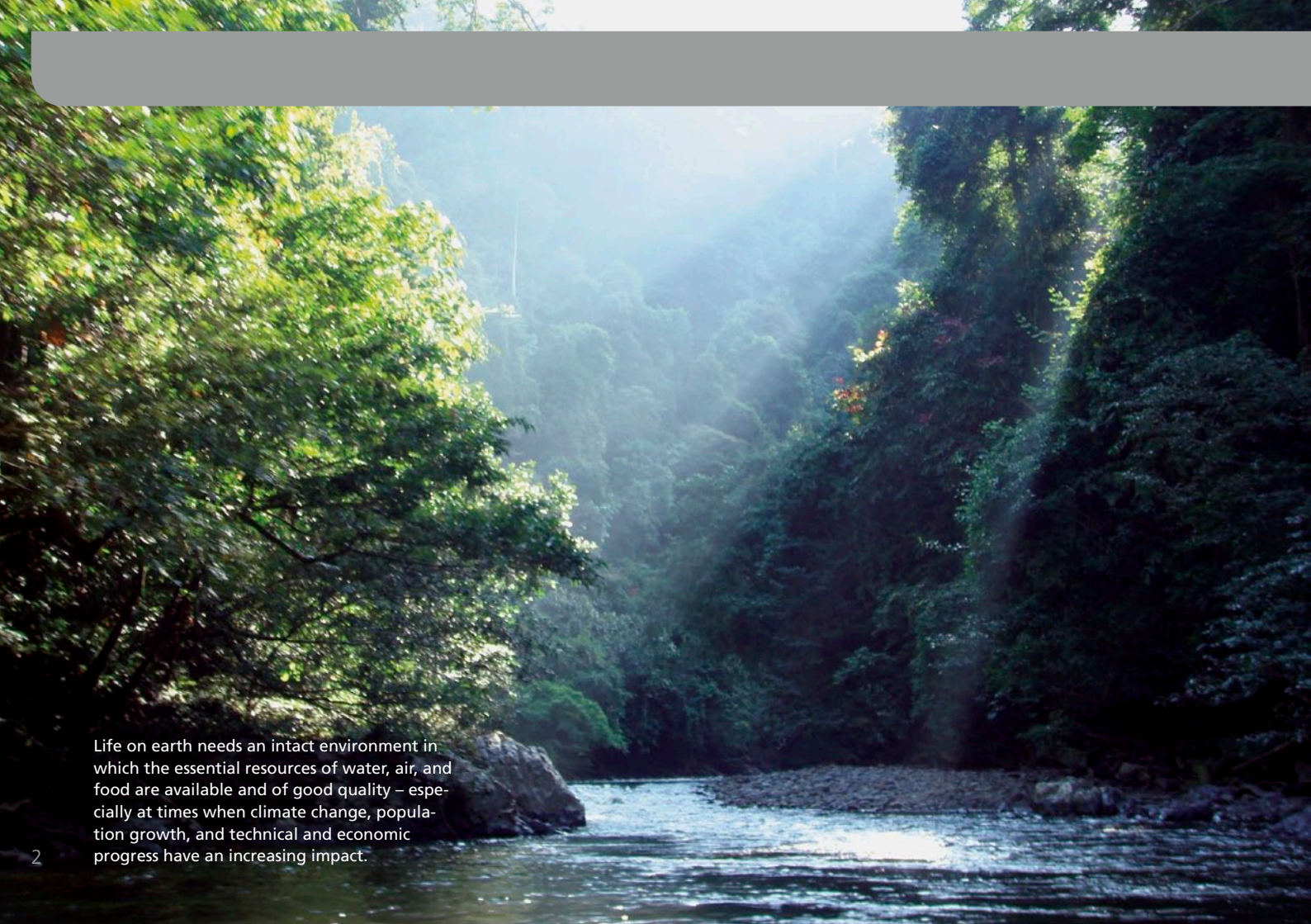
Karlsruhe Institute of Technology

For an Environment Worth Living

KIT CLIMATE AND ENVIRONMENT CENTER

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

www.kit.edu



Life on earth needs an intact environment in which the essential resources of water, air, and food are available and of good quality – especially at times when climate change, population growth, and technical and economic progress have an increasing impact.

Climate and Environmental Research at Karlsruhe Institute of Technology

Climate and environmental change, as well as demographic, economic, and technical developments are changing living conditions on earth in the 21st century as never before. Availability and quality of the essential resources of water, air, and food depend on these changes. Hence, climate and environmental research is facing significant new challenges.

The KIT Climate and Environment Center: Mission and Strategy

The focus lies no longer on eliminating the causes of environmental problems alone, but increasingly on adapting to changed natural and anthropogenically affected environmental conditions. It is, therefore, essential to acquire basic knowledge on the processes involved and their interaction at local, regional, and global levels, as well as the climatic, ecological, and economic impacts and to develop adaptation strategies on this basis.

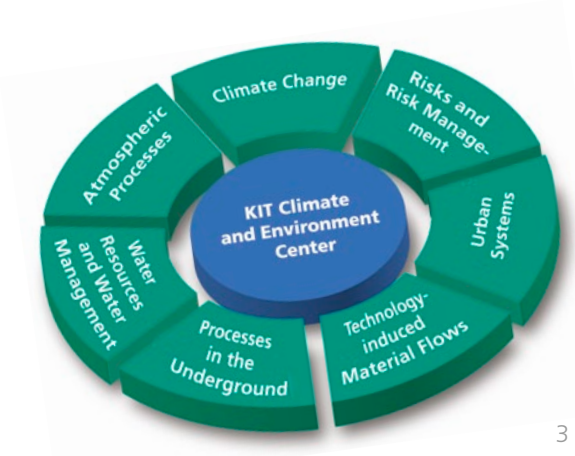
The KIT Climate and Environment Center combines a variety of competencies in natural sciences, engineering, and social sciences. In multidisciplinary networks, researchers develop adequate technologies to secure the natural bases of life.

The work of the KIT Climate and Environment Center covers seven topics:

- Atmospheric Processes
- Water Resources and Water Management
- Processes in the Underground
- Technology-induced Material Flows
- Urban Systems
- Risks and Risk Management
- Climate Change

Knowledge Triangle

Like the European Union, KIT focuses on the knowledge triangle of research-teaching-innovation. Proximity to top research makes studies at KIT highly attractive. At the same time, KIT uses its enormous innovation potential when cooperating with industry, the objective being a rapid transfer of excellent research results to marketable products.



Exact analysis: The MIPAS infrared spectrometer developed by KIT for the detection of atmospheric trace gases is installed on board of the European environmental satellite ENVISAT.

Atmospheric Processes

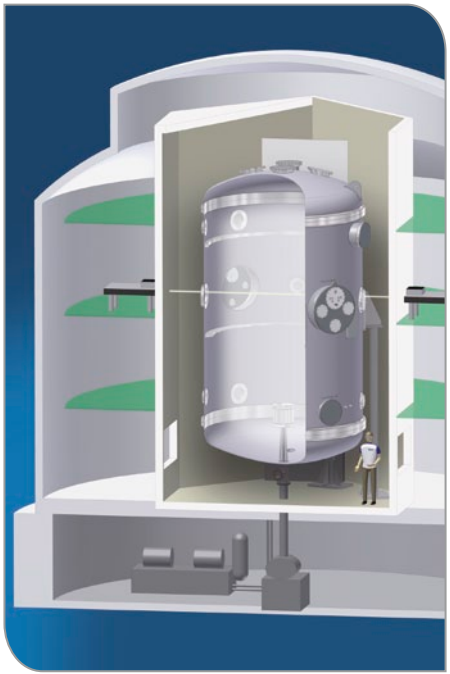
Compared with the earth, the atmosphere is a gauzy gas layer, without which life on earth would not be possible. In this layer, weather develops and precipitation forms. It supplies creatures with fresh water and clean air and protects them against radioactive radiation from the universe and UV radiation of the sun.

The Atmosphere as a Complex Dynamic System

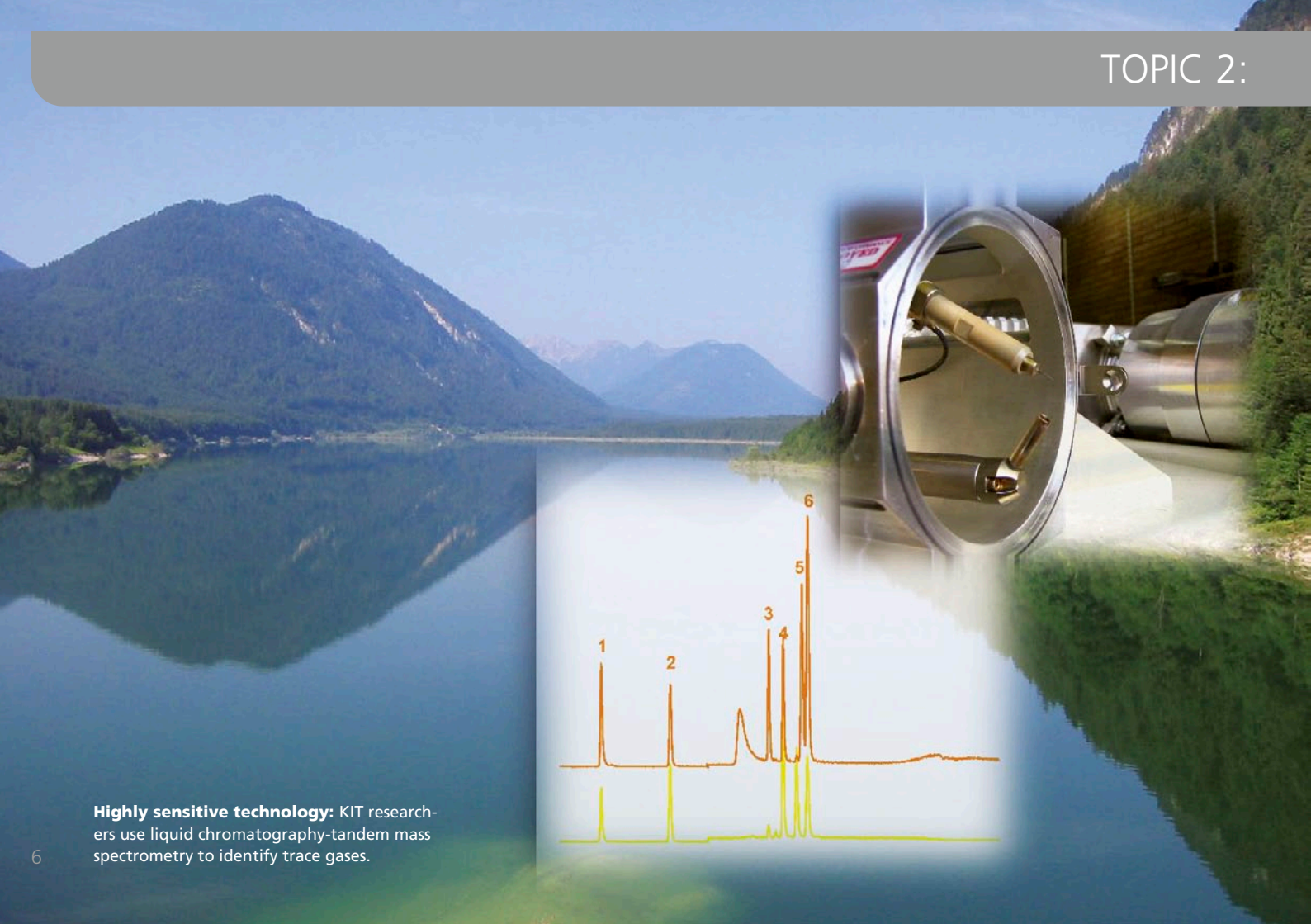
Physical and chemical processes provide for the self-cleaning of air or for the formation of clouds and precipitation. Under special conditions, these processes cause extreme events, like storms and thunderstorms. Protection of the atmosphere and its vital properties in times of increasing interference of man with the natural cycles requires an in-depth understanding of them. Only then can the forecasting of weather and extreme events be improved.

From Experiment to Simulation

KIT researchers working on the topic of "Atmospheric Processes" conduct laboratory studies of atmospheric processes under controlled conditions. In these experiments, the processes are analyzed in detail using latest experimental methods, such as laser spectroscopy. By means of instruments on board of satellites or airplanes and by using remote sounding methods, KIT researchers observe and analyze the real atmosphere. Computer simulations model the atmosphere system to predict its development. These simulations are based on the experimental findings obtained.



Unique worldwide: The AIDA aerosol and cloud simulation chamber allows us to study cloud processes under realistic atmospheric conditions.



Highly sensitive technology: KIT researchers use liquid chromatography-tandem mass spectrometry to identify trace gases.

Water Resources and Water Management

All life on earth depends on water. Increasing demand, competing uses, and impacts of climate change make it necessary to preserve the quality and quantity of water resources and to manage them sustainably.

Processes in Cycles of Water and Matter

KIT researchers focus on basic processes of cycles of water and matter that play a major role in the renewal of water resources and in extreme events. The scientists develop both highly sensitive technologies for trace gas analysis as well as adapted models for the balancing of the water cycle, mass transport, and mass transformation. Moreover, they study extreme events and their impacts on the quantity (floods, water shortage) and quality (nutrients, organic trace substances) of water.

Innovative: Water supply technology in a karst cave in Indonesia.

Innovative Technologies and Optimized Plant Concepts

Water management plants influence the water cycle and water resources on the local or regional level. In line with changing global framework conditions, KIT scientists develop flexible dimensioning concepts and management strategies for complex networks and optimize them in terms of energy efficiency, climatic compatibility, and environmental compatibility. Work in the field of water technologies focuses on the development and use of efficient methods and new materials for the removal of pollutants as well as for storage and distribution systems. Particular attention is paid to the processing of drinking and process waters, as well as to wastewater treatment.

Integrated Water Resources Management

Concepts of integrated water resources management consider meteorological, hydrological, hydraulic, hydrochemical, and biological processes as well as socioeconomic and cultural aspects. In threshold countries in particular, there is an acute need for action. KIT staff operates all over the world and develops regionally adapted concepts and technologies for a sustainable management of vital water resources.

Degassing of the earth: Gases from the underground have a major influence on climate and environment of our planet. Volcanic escalations - for example, shortly after the eruption of the Papaandayan in Indonesia – are rather striking. Apart from the release of steam, carbon dioxide and hydrochloric acid into the atmosphere, yellow sulfur deposits are visible.

Processes in the Underground

In view of the rapid growth of the world's population, sustainable management of the underground is of increasing importance. Congested areas need technical and social concepts to ensure a safe and environmentally compatible use of the underground. Researchers at the KIT Climate and Environment Center develop integrated systems solutions.

Storage and Resources

KIT scientists study how the greenhouse gas CO_2 can be stored safely in deep rock layers and investigate aspects of the disposal of radioactive, chemical, and toxic wastes. In addition, investigations cover the efficient use of underground heat sources for heat supply.

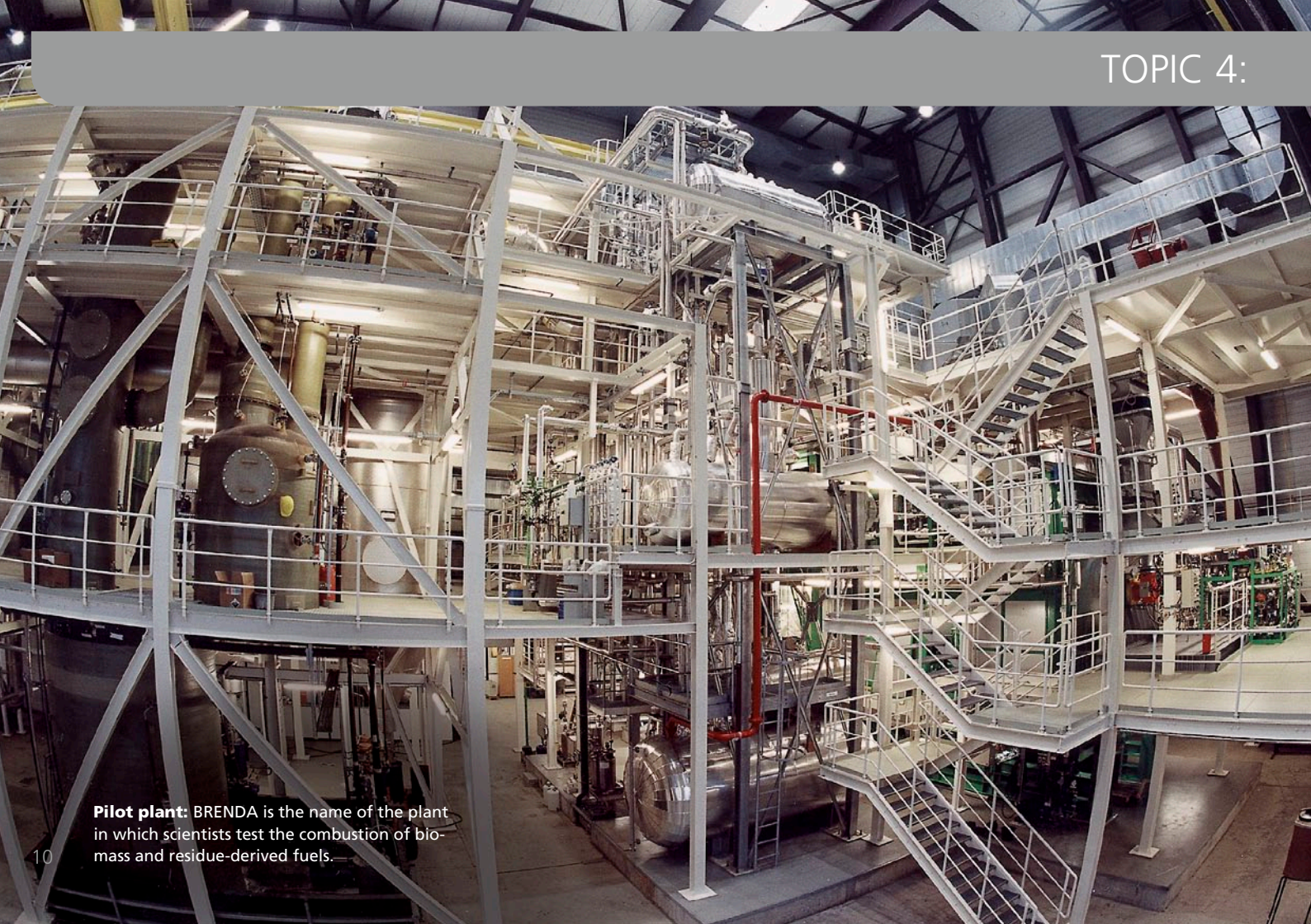
Monitoring and Control

To explore resources like water and heat and to assess the safety of landfills reliably, new and further development of innovative technologies is required, e.g. monitoring techniques for quality assurance and long-term control of underground facilities. For instance, KIT researchers design in-situ sensor systems that measure important physical and chemical characteristics in boreholes with high resolution and supply these data to the observer in real time.

Pollutant Dynamics and Remediation Technologies

KIT researchers are facing the great challenge of identifying and quantifying complex transformation and transport processes from the molecular up to ecosystems scale. The findings obtained shall be used to support processes of storing or decomposing greenhouse gases or toxic wastes and to develop innovative remediation techniques to minimize the mobility of such materials.

Analyses of rock: Detailed studies allow conclusions to be drawn with respect to the storage capacity of deep rock layers.



Pilot plant: BRENDA is the name of the plant in which scientists test the combustion of biomass and residue-derived fuels.

Technology-induced Material Flows

Use of resources like energy, raw materials or soils is associated with flows of materials and energies that influence our environment and can be controlled by man's action. Economical and efficient handling of resources is essential for sustainable development. To reduce emissions from energy conversion and industrial processes and manage the increasing shortage of resources, detailed knowledge of material flows caused by man and its interaction with the environment is needed. This is the task of researchers working on the topic of "Technology-induced Material Flows".

To save resources: Economical handling of natural materials is essential for sustainable development.

Exploration of Resources, Conversion, Process and Environmental Technologies

Research focuses on new processes and applications to explore and use raw materials. When scarce resources are saved, they will suffice for a longer time. New methods increase the efficiency of processes of using energy and materials in industry, agriculture, and forestry. There is also work done on avoiding or reducing pollutant emissions and other negative impacts.

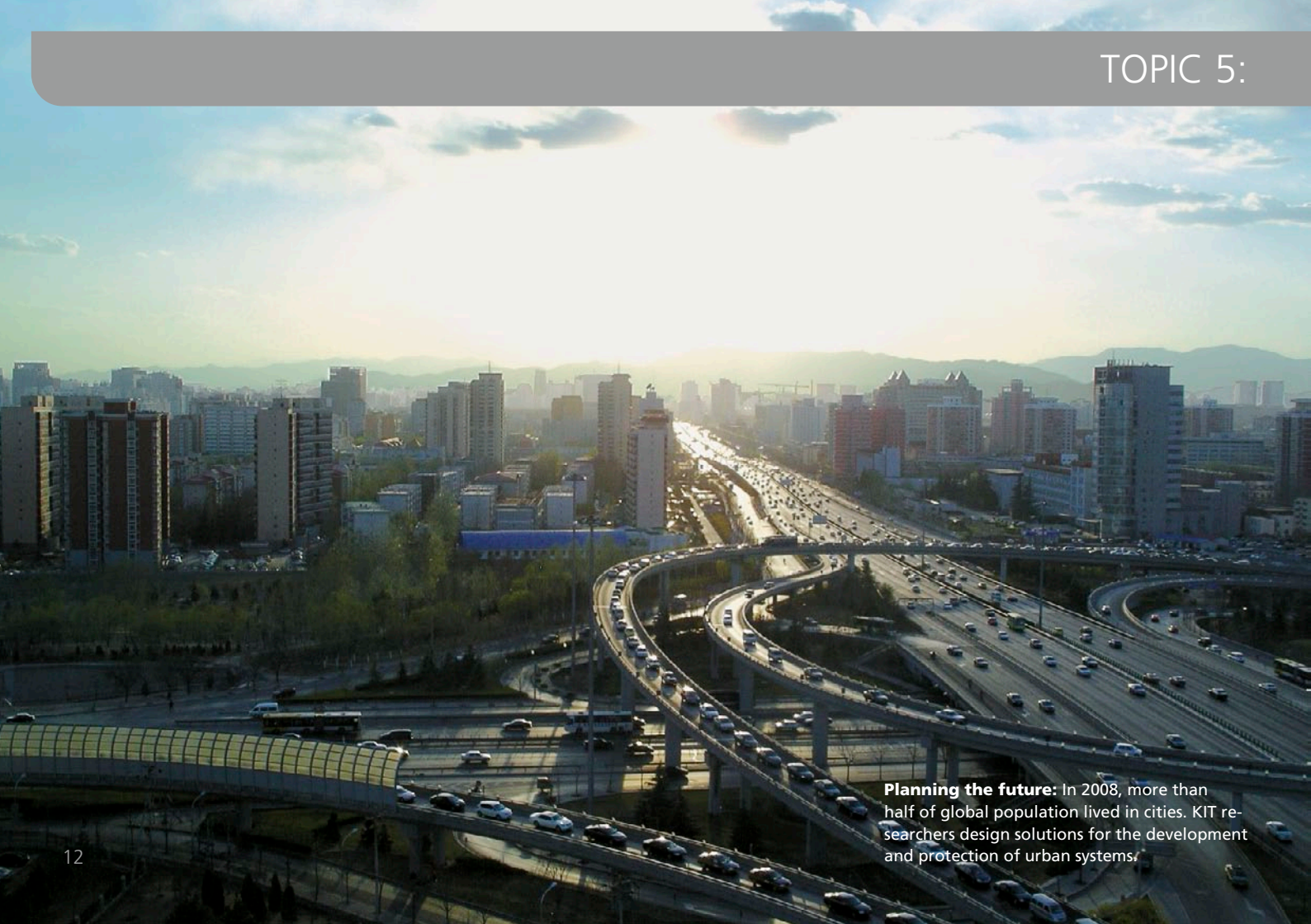
Environmental Monitoring, Material Flow Analysis and Assessment

Environmental monitoring helps to identify causal relationships in complex systems in order to model and analyze them. In this way, indicators can be generated and processes compared and assessed in terms of environmental compatibility or sustainability.

Technology Assessment, Operational Environmental Management, and Environmental Policy

KIT researchers analyze and assess the impacts of the use of technology. With the help of instruments to control plant and interplant material flows, such as material flow models and ecobalancing, they develop strategies in the fields of engineering, economy, and politics.

TOPIC 5:



Planning the future: In 2008, more than half of global population lived in cities. KIT researchers design solutions for the development and protection of urban systems.

Urban Systems

Since 2008, more than half of global population has been living in cities. Worldwide, cities are a dominating factor for flows of materials and energies that have a major impact on climate development and the environment. Viability of urban systems depends on the sustainable management of these materials and energy flows.

Climate Change, Natural Disasters, Environmental Pollution

KIT researchers study the impacts of climate change, natural disasters, and environmental pollution. On the basis of their results, they design solutions for the development and protection of urban systems.

Ecosystems

Urban ecosystems, their development, and integration in urban planning processes are another major field of research.

Atmosphere and Urban Climate

KIT researchers focus on securing fresh air supply, a salubrious urban climate and clean air. They also study the aerodynamics of buildings and the environment.

Management of Water Resources, Material Flows, and Energy Flows

KIT researchers work on the sustainable design of watercourses. They study the management of groundwater and rainwater and the balancing of substances entering surface waters. In addition, scientists focus on the use of close-to-surface geothermal energy and residue-derived fuels, as well as on minimizing energy consumption of buildings.

Important findings: Meteorological and air hygiene studies, for example with a measurement bus, are required to improve the environmental situation in cities.

Infrastructure

KIT scientists study waste management and wastewater treatment, optimize water supply networks and transportation systems, and develop sewage cleaning methods.

Social Vulnerability

Economic, demographic, and social change aggravates social vulnerability of cities. KIT researchers develop concepts for its minimization.

Urban Development Scenarios

The KIT Climate and Environment Center develops planning instruments to increase the energy efficiency of cities and reduce their consumption of resources.

Considering the impacts: Lows with strong precipitation in central Europe cannot be avoided in the future. Scientifically based risk management, however, can reduce the damage.

Risks and Risk Management

Risk research in the coming decade will be dominated by the topics of climate change and urbanization. It is feared that risks will increase in many regions of the world. At the same time, innovative technologies allow us to study changing risks, to monitor and partly to forecast them, as well as to reduce the damage that they cause. Such technologies include dense measurement networks on earth and in the atmosphere, satellite-borne observations, and the simulation of complex processes on high-performance computers.

Precautions: Ground- and satellite-based monitoring of unstable regions helps preventing catastrophes like the landslide at Nachterstedt.

Types of Risks

KIT researchers study geological risks (landslides, earthquakes), atmospheric risks (storms, strong rains, and heavy thunderstorms with hail, lightning, and squalls), hydrological risks (extreme precipitation and runoff events as well as droughts), and hydraulic risks (extreme flow speeds and solid transport in floating waters and on buildings).

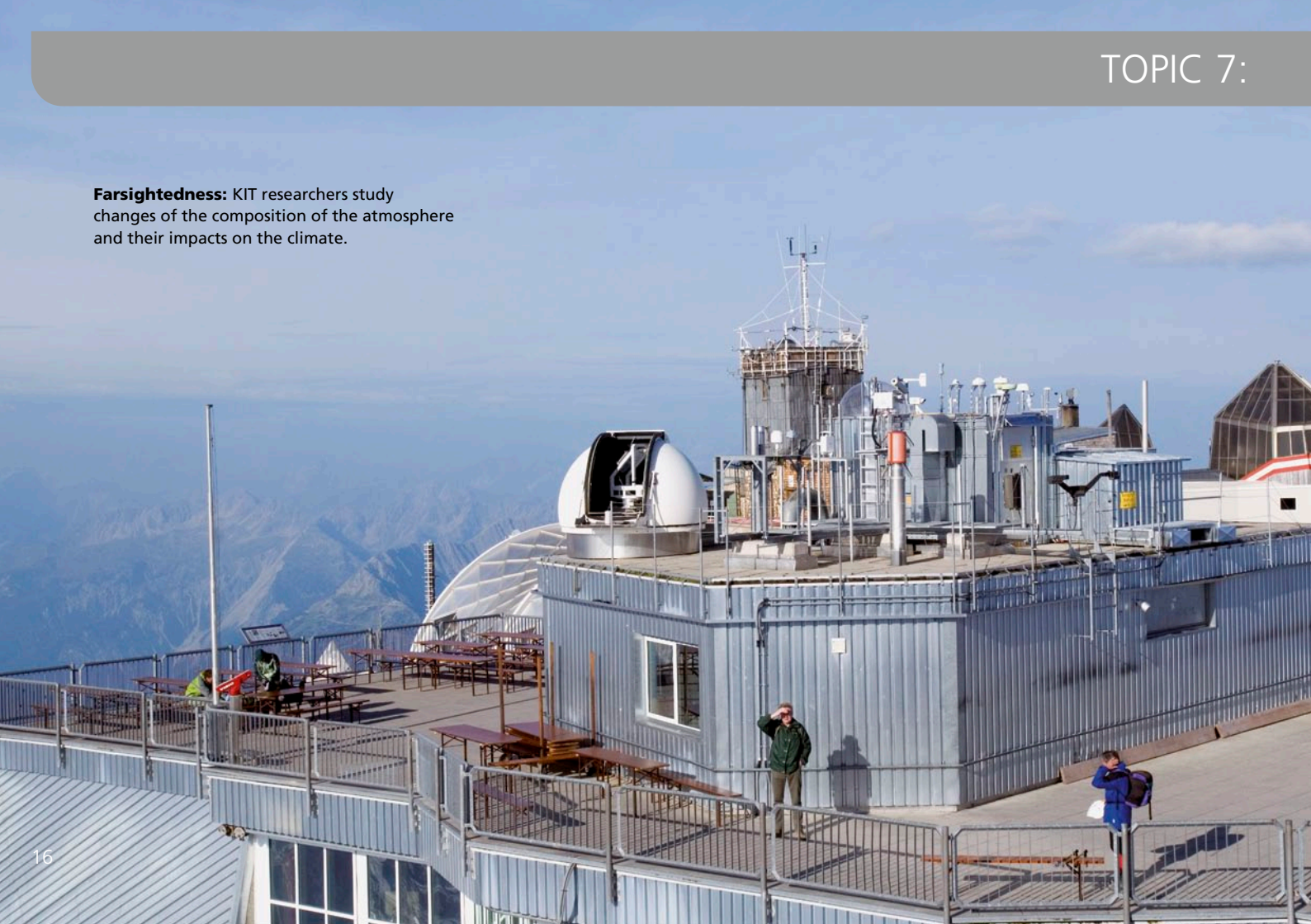
Synergy effects result from developing methods of damage reduction, disaster management, and safety research, if natural risks and technologically induced risks are considered in parallel.

Impact on Infrastructure Facilities

Analysis of the vulnerability of critical infrastructure facilities, such as electricity and energy supply networks, water supply, transportation and traffic paths, as well as stationary and mobile communication networks, is of particular importance.

Risk Management

Risk management research develops real-time information systems, systems to simulate the sequence of disasters, and tools for decision support. A central role is assumed by the Center for Disaster Management and Risk Reduction Technology (CEDIM, www.cedim.de), in which KIT and the GeoForschungszentrum Potsdam (GFZ) cooperate.



Farsightedness: KIT researchers study changes of the composition of the atmosphere and their impacts on the climate.

Climate Change

Global climate change and its regional impacts lead to serious problems, like the scarcity of resources, migration pressure, and conflict potential. Many of these problems are closely linked to a changed distribution and availability of water. KIT researchers analyze the interaction of climate, water, and climate-relevant greenhouse gases and aerosols extensively.

Climate Diagnosis: Monitoring and Trends

In the last decades, the composition of the atmosphere changed considerably due to emissions caused by man. To understand how these will affect future climate, they have to be measured in the long term on a global scale. KIT scientists develop and operate novel instruments and measurement techniques: satellite instruments, measurement devices on airplanes as well as sounding devices at ground-based stations from northern Sweden to South Africa and the tropics.

Exact Data: The HALO (High Altitude and Long Range) research aircraft has been used for measurements in the atmosphere up to 15 km height since 2009.

Regional Impacts of Global Change

KIT researchers refine global climate scenarios to smaller scales with the help of high-resolution regional climate models. Above all, they study how climate change affects flooding or drought, the development of vegetation and soils, as well as air quality in climate-sensitive regions (such as the Alps, the Middle East, and the Sahel region). For this purpose, they couple climate models with hydrological, biological, and chemical models.

Climate Assessment: Adaptation and Reduction Strategies

As far as economic consequences of climate change are concerned, quantification of external costs plays a central role. KIT researchers work on methods and models to determine damage and prevention costs and optimally allocate measures. Development of adaptation strategies also focuses on the handling of changed georisks, e.g. in flood protection.

The KIT Climate and Environment Center

The KIT Climate and Environment Center conducts finding-oriented research on a high level and develops innovative and sustainable technical solutions to meet the challenges of climate and environmental change. It pools fundamental knowledge, technologies, and systems analyses to derive practically viable solutions for handling natural and environmental risks. Work is based on internationally acknowledged

competencies in the research of the atmosphere, terrestric hydrosphere, biosphere, lithosphere, and pedosphere (rock mantle of the earth and uppermost layer of this mantle) as well as in the field of technological and socioeconomic systems. A focus lies on the regional level.

The KIT Climate and Environment Center comprises nearly 30 institutes and 500 employees of KIT. A member of the KIT board manages the Center and a steering committee and a scientific spokesman coordinate it with the support of an office. An international scientific advisory board gives advice on strategic planning, the scientific-technical assembly in decisions.

The activities of the KIT Center are based on well-established KIT facilities, such as the Institute of Meteorology and Climate Research (IMK), the Excellence Center CEDIM (Center for Disaster Management and Risk Reduction Technology, in cooperation with GeoForschungszentrum Potsdam) and cedim AG, several large-scale projects on integrated water resources management (IWRM), the Competence Center for Soil Moisture (CMM), and many significant research projects.

Some topics are closely related to topics of the KIT Energy Center, for instance, in case of the planned Karlsruhe Geothermal Energy Center; this is in cooperation with industrial enterprises. Multidisciplinary cooperative ventures open up new perspectives. The focus is on among others the safe storage of CO_2 in deep formations, on the development of measurement instruments and methods, on consulting services with respect to the extent of climate change or risk assessment, and on numerical forecast models and efficient software solutions.

Karlsruhe Institute of Technology (KIT)

The Karlsruhe Institute of Technology (KIT) is a merger of Forschungszentrum Karlsruhe, a national laboratory of the Helmholtz Association, and Universität Karlsruhe, a university of the state of Baden-Wuerttemberg.

With roundabout 8300 employees and an annual budget of EUR 630 million, KIT was established in Karlsruhe as one of the largest research and teaching institutions worldwide. KIT has the potential to assume a global top position in selected fields of research. The objective: KIT will become an institution of internationally outstanding research in science and engineering as well as a prominent location of excellent teaching setting standards in promotion of young scientists and advanced training. KIT is a primary innovation partner of industry. It is a leading European center of energy research and plays a worldwide visible role in nanosciences.

KIT is operating along the three strategic fields of action of research, teaching, and innovation.

Imprint

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Design, Layout Wilfried Schroeder, Eva Geiger (SCC-PPM)

Printing Wilhelm Stober GmbH, Eggenstein

January 2011