



Bavarian State Government



Climate Protection Bavaria 2020



Reducing greenhouse gas emissions
Adapting to climate change
Research and development



Bavarian Climate Programme 2020

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Foreword



Climate Protection for a Sustainable Bavaria in Harmony with the Environment

Nature and the environment are important in Bavaria, and the State's environmental policy is guided by the belief that God's creation must be protected; this means that Bavaria seeks to draw attention both to the value of the natural environment, and to sources of danger to it. In its actions, Bavaria's State Government follows the principle of sustainable development: we intend not only to preserve the ecological, economic, and social foundations of our region, but also to harmonise them with one another in order to make sure that both current and future generations can continue to enjoy a high quality of life and the benefits of affluence. In view of this, reducing emissions of greenhouse gases, adapting to the unavoidable consequences of climate change, and transitioning to climate-friendly green energy are some of the most pressing challenges facing us today.

In 2009, Bavaria was the first of the German federal states to present a comprehensive climate adaptation strategy containing both options for future action and concrete measures which can be taken to protect both people and the environment from the consequences of climate change; adaptation is already being implemented in a range of initiatives in areas such as flood defences, changes to forestry, and the stabilisation of bio-diversity. By producing strategies and technologies for dealing with climate change, businesses which will be affected can both better prepare themselves to face risks and to take full advantage of opportunities – green renewable energies are clear winners in the drive to protect our climate and offer us

chances to modernise structures which are already in place (e.g. by means of electric transport, smart grids).

Bavaria is determined to be among the first and foremost in the move towards renewable energy sources and to take an active role in the green energy transition; this is a goal we intend to achieve by throwing ourselves into the construction of infrastructure for regenerative energy generation, distribution, and storage. Bavaria is a pioneer in the use of renewables, and our aim is to produce 50 percent of our electricity requirement from non-fossil sources by 2021, because countries and regions which fail to succeed in the green energy transition will not be able to guarantee their population sustainable wealth in the future.

By setting important investment signals in the direction of innovation and technological progress, an ambitious climate protection policy is a key driving force behind the conversion of our energy supply infrastructure. In our innovative energy concept (*Energie Innovativ*), we have underlined our goal of bringing per-capita CO₂ emissions from energy generation markedly under the threshold of six tonnes annually by 2020.

Between 2008 and 2011 alone, Bavaria invested three quarters of a billion Euros in climate protection within the scope of the Bavarian Climate Programme 2020, putting it ahead of all other German federal states. In the medium term through to 2016, we are planning to invest another billion Euros in climate, energy, and innovation initiatives: in the two-year budget for 2013-2014, we have already made 260 million Euros available for

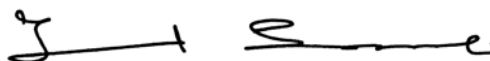
green energy transition and climate protection projects, with a clear focus on providing funds for research and technology development, as well as for converting knowledge and technology into practical applications.

The measures taken in Bavarian climate policy are having an effect: since the end of the 1990s, CO₂ emissions from energy generation have sunk by more than 10 million tonnes to around 76 million. At six tonnes of CO₂ per capita annually, energy-generation emissions in the State of Bavaria are already one third lower than the German national average (around 9 tonnes of CO₂ per person per year), and on a global scale, Bavaria is already a world-leader in climate protection among industrialised regions (e.g. the USA emits around 17 tonnes of CO₂ per inhabitant annually).

Nevertheless, a look at the figures makes it clear that we cannot afford to relax our efforts to decrease emissions noticeably. Around three quarters of greenhouse gas emissions are linked to energy production, which gives energy efficiency a key role in effective climate protection. Reducing greenhouse gas emissions will require us to change our life-style, but not our living standards, and there are already a range of innovative environmental technologies available which help us to save energy while actually enhancing quality of life. As an example, a structure built to the passive house standard requires only one tenth of the energy consumed for heating in a conventional building, but offers a higher level of comfort; the increased costs for building to this standard are compensated in the long term by lower heating costs. Modern regulated heating pumps, meanwhile, perform to the same

standard as their predecessors while using only one quarter of the electricity; the same is true of new lighting systems, which can cut electricity use by more than 80 percent. The decisive factor is that each and every one of us can contribute – so let's make a game out of energy efficiency! To win, we will need energy-saving devices and products, and if only enough of us ask for them, industry will produce them.

To achieve these goals, Bavaria is counting on broad cooperation with strong partners, especially the Bavarian Climate Alliance. Together, we will do everything to create awareness, inform, and act. People are ready to do something about climate protection, and Bavaria is ready to seize the initiative in sustainable development and to start bringing our economy and our natural environment into symbiosis. Climate protection will remain a key priority for our State Government.



Horst Seehofer

Minister-President of the Free State of Bavaria



Dr. Marcel Huber MdL

*Bavarian State Minister of
the Environment and Consumer Protection*

Foreword by the Bavarian Climate Council

The climate is one of the natural resources on which our lives depend: without water, warmth, sunlight, and food, human life cannot survive, and all of these factors are determined by the climatic parameters of solar radiation, temperature, and precipitation. If the climate changes, the sources of life in nature and for all of humanity will be affected, and in view of the man-made climate change which is already taking place globally, policy-makers in all countries – and in a federal state such as Bavaria, too – must work to implement the central goal of the United Nations Framework Convention on Climate Change: stabilising the concentration of greenhouse gases in the atmosphere at an acceptable level in order to avoid catastrophic climate change.

By setting up a Climate Council for the Bavarian State Government and attaching it to the State Ministry of the Environment and Public Health, as Minister-President Stoiber did in early 2007, the State of Bavaria has created an academic support body for the Bavarian Climate Programme 2020 which has allowed for close interaction between the advisors and political decision-makers. Further to this, from its very beginning the Bavarian Climate Programme 2020 was predicated on reducing greenhouse gas emissions and adapting to the changes to our climate which, even if global climate policy is rigidly applied, are now unavoidable. The financial resources accorded to the Bavarian climate programme are unparalleled in Germany.

In the Cabinet meeting on the Zugspitze mountain on 24th April 2007, the Climate Council's suggestion that its goal of reducing annual energy-generation-related carbon dioxide emissions to five tonnes per inhabitant by 2020 be made public was accepted. The State Government has set the target of "markedly under six tonnes by 2020" and has made known that the next target will be five tonnes by 2030.

The report on the first phase of the Bavarian Climate Programme 2020 shows that, with a reduction from around 7.5 tonnes per inhabitant per year in 2000 to around six tonnes currently, Bavaria is on the way to achieving this goal. Furthermore, it was a wise decision to apply the annual emissions per capita formula, accepted as an appropriate measure by the United Nations, rather than the absolute amount of carbon dioxide emitted in Bavaria, inasmuch as this prevents the successes achieved by both the government and society at large from being masked by other factors such as an increase in population which affect the sum total of emissions.

With decisions taken by the Federal Government and the German Bundestag in summer 2011 to implement a transition to an overall dominance of renewable energy, a further challenge has been set. The German goals for emissions reductions go far beyond the agreement of the European Council in March 2007 to emit twenty percent less carbon dioxide in 2020 than in 1990: Germany's target is now to generate at least 80 percent of its energy from renewable sources by 2050. The measures required by the green energy

transition, i.e. a balanced package of energy-efficiency initiatives and renewables expansion, represent an enormous opportunity to accelerate climate protection.

In comparison with most other German federal states, Bavaria has advantages in terms of the availability of hydro power, solar energy, and biomass, as well as geothermal energy (especially as a heating source). Policy-makers must now create legislative frameworks to encourage an increased link-up between energy supply systems across central Europe, and indeed further afield, as well as innovative energy storage. Aiming for energy self-sufficiency at either a regional or national level would be counter-productive and would render the goals of the green energy transition virtually unachievable; this also means that the Bavarian State Government will work at national and EU level to make sure that external effects of the use of fossil fuels are accounted for internally, as this would remove the need for subsidies of some renewable energy sources and allow the green energy transition to develop its own momentum. This momentum is already gathering pace, however, as the production costs for photovoltaic electricity generation have fallen below the retail purchase price for grid electricity, which encourages both consumption and storage of self-produced energy.

Although the Bavarian Climate Programme 2020 makes little mention of the use of solar cell energy, as this sector is regulated by the provisions of the federal Renewable Energies Act (EEG), the massive increase in this form of energy, especially in Bavaria, ought to be used as an opportunity to place the role of cross-border energy storage in the foreground. Measured against all other forms of energy storage to date, pumped storage hydroelectric power stations are the most efficient, and given that high-voltage cables to such hydroelectric facilities in neighbouring countries such as Austria already exist, the potential for a rapid increase in the efficiency of solar power use is there to be exploited. Bavaria could once again take on a pioneering role, not only in this aspect of cross-border networking, but also in extending such projects within its own geographical area.

We should also be careful not to forget that there is much potential for climate protection in nature and the landscape itself: simply recreating the natural environment of drained moorland is as effective in reducing emissions as all other measures undertaken in agriculture put together, and represents a contribution to preserving bio-diversity. Accordingly, the moorland conservation in the Bavarian Climate Programme 2020 to date has been a success, and should be pursued further. On the other hand, the use of biomass to generate energy ought in part to be viewed more critically than was the case at the beginning of the Climate Programme: this form of supplying energy can only contribute to climate protection if bio-gas is fed into the gas network or if waste heat from bio-gas plants is used – especially if the

base materials from which the gas is produced are substantially made up of agricultural waste. Here too, the overall goal of preserving biodiversity must not be neglected.

Let us consider a brief summary of recent academic research. Firstly, in contrast to the depictions of many media outlets, the rise in global temperatures has continued during the last decade by roughly 0.16°C on average. Secondly, in almost every year since 2005, the amount of sea ice remaining in the arctic at the end of the summer has reached a new record low: models used thus far have actually been underestimating the real-world changes. Thirdly, instances of extreme precipitation have been increasing, including in regions with a declining or constant overall level of precipitation. Fourthly, the rise in sea levels since 1992 of slightly over 3mm per year has been underestimated by calculations to date as the contribution from the melting of the great ice sheets, until recently relatively low, has increased rapidly. The sensitivity of the climate to an increased greenhouse effect is consequently higher than has been assumed up to now.

This makes measures to combat climate change more urgent than ever.



**Prof. Dr. Dr. h. c. mult.
Hartmut Graßl**

(Chairman of the Bavarian Climate Council and former Director of the Max Planck Institute for Meteorology [Hamburg] and former Director of the World Climate Research Programme)



Prof. Dr. Dr. Peter Höppe

(Head of the Geo Risks Research Division of the Munich Re Group)



Prof. Dr.-Ing. Ulrich Wagner

(Member of the Executive Board of the National Aeronautics and Space Research Centre [DLR], Head of the Coordinating Office of the Hydrogen Initiative in Bavaria)

The Bavarian Climate Council advises the Environment Ministry in scientific, environmental, and economic matters pertaining to climate protection; the Ministry is the body responsible for this remit. The Climate Council's statutes stipulate that it should consist of three full members.

Bavarian climate policy



The principles and goals of Bavarian climate policy

Climate protection is a way of conserving resources. The State of Bavaria pursues a far-sighted, sustainable, and coherent climate protection policy in accordance with the insight that dangerous climate changes can only be counteracted by a united front composed of the business community, policy-makers, and society at large. Natural resources of all kinds are of pronounced importance to Bavaria's economy and for its quality of life, from sources of energy such as the sun or the wind, to elements such as the soil and water, and biological resources including bio-diversity and cultivable land.

The Bavaria 2020 climate protection strategy is based on three key pillars: **further reducing greenhouse gas emissions**, **adapting** to the unavoidable consequences of climate change, and supporting these two goals through **research and development** in order to create a solid basis of data for further strategic decision-making.

Climate change is a global problem with a regional impact. With its delicate Alpine region, Bavaria will be affected more than most: in recent decades, the median annual temperature in the Alps has gone up twice as much as the global average. Besides the glacial melt already visible today, the rise in temperatures will lead to reduced replenishment of groundwater, with decreased precipitation in summer and increased precipitation in winter. In this regard, climate change is already modifying our surroundings to a considerable degree, with both positive and negative consequences for long-term business planning and commercial decision-making. Companies in sectors such as transport, energy, and tourism are all affected, and they can prepare themselves for

future risks all the better by developing strategies and technologies for dealing with the unavoidable results of climate change. Climate adaptation processes are preventive measures which reduce the vulnerability of the environment and human society and which could become the driver behind sustainable management and, in this respect, climate protection sets important signals for investors in the direction of innovation and technological progress.

Ambitious goals for reducing CO₂ emissions are an important factor in pushing new forms of supplying energy. As an export-orientated high-tech region, Bavaria stands to benefit from the substantial markets and promising future prospects generated by environmentally-friendly technologies. In order to conserve resources, the ecological and economical imperatives are to reduce the consumption of fossil fuels by using them more efficiently and replacing them with renewable energy sources.

All forms of resource exploitation have effects on the environment to a greater or lesser degree. Soil, energy, raw materials, and water must all be used more efficiently in general in order to make sure that coming generations also have the option of using them. This confronts Bavaria with the challenge of not only securing but further improving the high material wealth and living standards of its population on limited resources, all the while ensuring that the natural environment is not allowed to deteriorate. These aims do not stand in conflict, but rather complement one another when viewed from a cross-generational perspective. Further growth and wealth across the globe can only be achieved by a

marked increase in resource efficiency – and Bavaria intends to take on a leading role in sustainable use of resources.

In the Bavarian Climate Programme 2020, our goals are set out through to 2020. According to our plans to change electricity provision, as detailed in the *Energie Innovativ* concept of 2011, natural gas will take on a larger share of energy generation; this could lead to an increase in CO₂ emissions from energy generation in Bavaria (approx. six to eight million tonnes annually) and will have to be compensated by redoubled efforts in energy savings and efficiency in the heating and transport sectors to avoid compromising the climate protection goals. The innovative energy concept of 2011 already made it clear that the ambitious goal of reducing energy-generation related greenhouse gas emissions to a level well below six tonnes per inhabitant per year by 2020 will be retained even in the event of a complete cessation of nuclear power generation; in the longer term, the target should be five tonnes.

Bavarian Climate Protection Targets

The Bavarian State Government has been underpinning its climate protection policy with specific targets for some time, with the overriding aim behind them being to integrate climate protection into all areas of everyday life and business. Bavaria is to maintain its position as a forerunner in climate protection and retain its status as an example to others.

- Reduction:
 - Reducing annual CO₂ emissions from energy generation to markedly below six tonnes per inhabitant by 2020
 - Increasing energy productivity by 30 percent through to 2020
 - Doubling the share of renewables in final energy consumption to 20 percent
 - Increasing the share of renewables in electricity consumption to 50 percent by 2021
 - Using the potential to increase electricity production from hydro power with due consideration to the needs of water resource management and nature conservation
 - Increasing the percentage of deep geothermal energy up to almost one percent of the total energy generated and around 0.6 percent of electricity consumed by 2021
 - Increasing the percentage of biomass in electricity consumed to roughly ten percent
 - Reducing the heating energy requirements of buildings by 20 percent and industrial process heat by 15 percent through to 2021



- Adaptation:
 - The best possible adaptation for all climate-sensitive and vulnerable areas of Bavaria to deal with the impact of climate change.

Starting from the observation that the direct and indirect consequences of climate change can affect any area of society and the economy, in 2009 the State Government presented the **Bavarian Climate Adaptation Strategy (BayKLAS)**, the central goal of which is to motivate all stakeholders to take action to combat the challenges of climate change. This is to be achieved using modern, practical instruments such as networking everyone involved, instigating dialogue, disseminating information, and targeted research, education and training, as well as financial support. With this paper, the State Government is building on the German national adaptation strategy for climate change adopted by the federal government in December 2008.

Businesses too are engaging with the new challenges presented by climate change. Companies in sectors such as transport, energy, and tourism are all affected, and they can prepare themselves for future risks and opportunities all the better by developing strategies and technologies for dealing with climate change. Climate adaptation processes are preventive measures which reduce the vulnerability of the environment and human society and which could become the driver behind sustainable management. Bavarian companies can make an especially effective contribution to global climate protection by developing climate-friendly technologies and bringing them to the world market.



Bavarian Climate Alliance



Climate protection is a matter for society at large and plays an important part in all sectors, from energy supply and industry through to commerce, agriculture, transport and individual households. Protecting our climate is a task which requires cooperation from all sections of society, and that is why in 2004 the Bavarian State Government, together with the Bavarian Conservation League (*Bund Naturschutz*), set up the Bavarian Climate Alliance to allow strong multipliers room to inform and act in such a way as to raise awareness for climate protection in society as a whole.

Members of the Bavarian Climate Alliance

Each of the members of the Alliance signs up to a joint declaration of cooperation in climate protection and consults with the State Government on the contents of its declaration. The Bavarian Climate Alliance has now grown to include 23 parties, proving itself as the cooperative platform for the State Government and non-governmental entities.



State Minister Dr. Marcel Huber, President Peter Aicher, and State Minister Joachim Herrmann signing the joint declaration on climate protection

Members of the Bavarian Climate Alliance (as of 1st September 2013):

- *Bund Naturschutz in Bayern e.V.* (Bavarian Nature Conservation Association)
- The Lutheran and Catholic Churches in Bavaria
- *Bayerischer Landkreistag*, umbrella organisation of Bavarian counties
- *Verband der bayerischen Bezirke* (Association of Bavarian Districts)
- *Bayerische Architektenkammer* (Bavarian Chamber of Architects), *Landesverband Bayern des Bundes Deutscher Architekten* (Bavarian Section of the German Architects' Association) and *Bayerische Ingenieurkammer Bau* (Bavarian Association of Civil Engineers)
- *Bayerischer Landes-Sportverband e.V.* (Bavarian Sporting Association)
- *Bayerischer Gemeindetag* (Local Government Organisation of Bavarian Municipalities)
- *Landesbund für Vogelschutz in Bayern e.V.* (Bavarian Society for the Protection of Birds)
- The South Bavaria, North Bavaria, and Swabian Branches of the German statutory pensions insurance scheme *Deutsche Rentenversicherung*
- Bavarian section of the umbrella organisation *VBIO – Verband Biologie, Biowissenschaften und Biomedizin in Deutschland*, the German Life Sciences Association
- *Bayerischer Städtetag* (Assembly of German Towns and Municipalities)
- *Bayerischer Jugendring* (Bavarian Youth Organisation)
- *Bayerischer Sportschützenbund e.V.* (Bavarian Sport Shooting Association)

- *Deutscher Alpenverein e.V.* (German Alpine Society)
- *Sparkassenverband Bayern* (Bavarian Association of Building Societies)
- *Bundesverband CarSharing e.V.* (Federal Alliance for Car Sharing)
- *Landesverband der Campingwirtschaft in Bayern e.V.* (Bavarian Camping Industry Association)
- *Landesinnungsverband des Bayerischen Zimmererhandwerks* (Bavarian Carpenters' Association)
- *Landesverband der steuerberatenden und wirtschaftsprüfenden Berufe in Bayern e.V.* (State Association of the Tax Consulting and Accounting Professions in Bavaria)
- *Landesinnungsverband für das Bayerische Kaminkehrerhandwerk* (State Guild of Bavarian Chimney Sweeps)

Aims and Projects of the Climate Alliance

The members of the Bavarian Climate Alliance and the Bavarian State Government are pursuing ambitious climate protection goals such as energy savings, increasing energy efficiency, green energy production, and environmental education. Projects are brought to life which increase awareness of climate protection, offer a range of information, and explain possibilities for taking action, all the while including as broad a cross-section of society as possible and encouraging different groups to unite in taking active steps to protect the climate in the long term. Networking and cooperation among members of the alliance also has the effect of strengthening climate protection efforts in Bavaria.

The State of Bavaria supports members of the Climate Alliance in working towards their climate protection goals, including initiatives such as "Climate Check" (*Bayerischer Landes-Sportverband e.V.*, *Bayerischer Sportschützenbund e.V.*), the Lutheran Church's "Low Flame" project, and the "Climate Detectives" (*Bayerische Architektenkammer*). The aim is to strengthen these initiatives by offering start-up financing and helping them to develop further independently.

Climate Check

The Bavarian Ministry for the Environment is supporting the Climate Check projects of the Bavarian Sporting Association (*Bayerischer Landes-Sportverband*) and the Bavarian Sports Shooting Association (*Bayerischer Sportschützenbund*). This initiative allows Bavarian sports clubs to access a competent, neutral energy consultancy package and valuable information, advice and recommendations at no cost with regard to building, running, and maintaining their sports facilities, as well as on how to achieve long-term reductions in energy and resources consumption. Alongside an increase in the use of renewable energy and notable reductions in energy consumption, the project also aims to spread climate protection awareness in sports and among young people at a formative age. Since the project began in 2009, around 500 Bavarian sports clubs have used this free service.

Bavarian Climate Week

Surveys show that the majority of the population considers climate change to be one of the most important issues of our time. Yet when it comes to their personal actions, many of those questioned admit that they could do a lot more to protect our climate. This contradiction between people's general understanding and their own actions prompted the Bavarian Climate Alliance's joint initiative to anchor climate protection even more firmly in people's minds.

With this aim, since 2008, the yearly Bavarian Climate Week has been held as the central event for the partners in the Climate Alliance across Bavaria. The range of activities on offer is broad and attractive to all age groups and sections of the population; it includes nature excursions, interesting lectures, informative exhibitions, energy advice, and workshops with the aim of encouraging participants to think about and participate in climate protection of their own accord. The 2012 Climate Week was opened in cooperation with the Bavarian Youth Association (*Bayerischer Jugendring*) in the Benediktbeuern Monastery as part of the study event held there, which drew in over 30,000 visitors.



International climate protection cooperation

Climate change does not stop at national borders. It is a global challenge and as such requires a global response, and that is why Bavaria is happy to share its expertise in energy-efficient planning and construction with delegations from abroad (e.g. from its Chinese partner province of Shandong) and to work with regions from other countries within the scope of the European Alpine Space programme.

The aim of the State Government is to offer effective support for national and European Union measures and to complement them with further initiatives, while maintaining Bavaria's leading position as an example to others in environmental matters. The focus of Bavarian climate protection policy lies on:

- at the international level, developing the Kyoto Protocol into an effective, global climate protection agreement with absolute emission reduction targets in the long term for all developed nations and a reasonable contribution from emerging and developing countries;
- at the national and regional level, supporting the three-pillared strategy of reduction, adaptation, and research, with consistent reductions in greenhouse gas emissions, to be achieved in particular with an intelligent energy policy as a driver for innovation and employment on the one hand and adaptation to the consequences of climate change which have already become unavoidable on the other.

The Climate Group

Bavaria is a member of The Climate Group, a worldwide network of leaders from governments and businesses working together to promote a Clean Revolution towards a prosperous low-carbon economy. Members from the world of business include Nike, Ikea, Dell, Philips, Swiss RE and Hewlett-Packard, regional political entities in the Group include the States of California and New York, the Province of Quebec, Brittany, the Basque Country, Scotland, South Australia, São Paulo and Gujarat, as well as the German States of Baden-Wuerttemberg and North Rhine Westphalia.

The "States and Regions Alliance", The Climate Group's network specifically targeted to sub-national governments, brings together regional entities to raise their ambition through joint commitments and advance their policy development through mutual learning and best practice exchange.

Through their example, the Alliance also raises the bar for policy development at the national and international level, providing powerful illustrations of the benefits of a low-carbon economy for regional development, job creation and sustainable growth. For example, the States and Regions **Clean Revolution** Report presented during The Climate Group's Clean Revolution Summit at the Rio+20 United Nations Conference on Sustainable Development in Rio de Janeiro in June 2012, highlighted best practices of innovative low carbon policies already successfully implemented in sub-national governments around the world.

Virtual Observatory of the Alps (VAO)

The Alpine region is affected by climate change more than most, which means that cross-border cooperation is a pressing matter. Changes to the mountain environment are already visible, and the increasing natural hazards, as well as the need to produce prognoses for the whole region, integrate national strategies for minimising the effects of climate change, and implement preventive measures all make international exchange and interaction based on comparable quality criteria crucial to success.

In view of this, the State Government has been supporting the Schneefernerhaus Environmental Research Station on the Zugspitze mountain since 2009 in its negotiations with other high-altitude research stations across the Alpine area and other climatically comparable mountainous regions with the aim of increasing cooperation and networked infrastructure in these fields of scientific study.

To date, agreements have been signed with the Sonnblick Observatory (under the Austrian Central Institution for Meteorology and Geodynamics *Zentralanstalt für Meteorologie und Geodynamik – ZAMG*), the International Foundation Jungfraujoch and Gornergrat High Altitude Research Stations (*Hochalpine Forschungsstation Jungfraujoch & Gornergrat – HFSJG*), the European Academy of Bozen-Bolzano (EURAC in Italy), and the Arctic Lidar Observatory for Middle Atmosphere Research – ALOMAR (Norway). Negotiations are currently underway with the observatories of Haute-Provence (France), Krvavec (Slovenia), and Abastumani (Georgia). The medium-term goal is to create a Virtual Observatory of the Alps (VAO), a network funded by the European Union which will be open to all important high-altitude research stations (cf. p. 82).



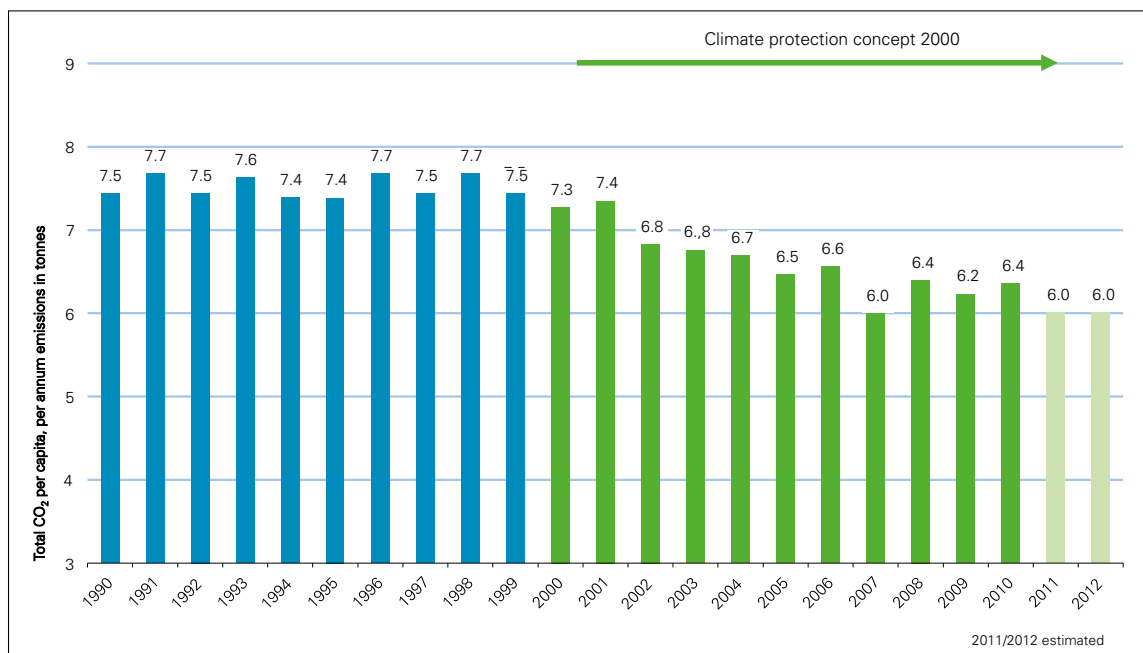
Bavarian Climate Policy: Results and Prospects

Since the end of the 1990s, annual CO₂ emissions from energy generation in Bavaria declined from over 90 million to 75 million tonnes in 2007 (or 5.99 tonnes per inhabitant). Due to the economic cycle, energy-generation related CO₂ emissions fluctuated in the following years, but Bavaria's target for 2010 of 80 million tonnes (or 6.4 tonnes per inhabitant), set in 2000, was reached despite an increase in CO₂ emissions as a result of the economic upturn during 2010 itself; emissions in 2012 are expected to total 75.2 million tonnes.

With six tonnes of carbon emissions from energy generation per capita per year, Bavaria takes first place among the German federal states.

Nevertheless, a look at the figures makes it clear that further efforts will be required in order to bring CO₂ emissions down to markedly below six tonnes.

There is further potential to decrease CO₂ emissions by **implementing energy-saving measures in public buildings**. The special programme for energy-saving refits of state properties, the second federal economic stimulus package, and the investment pact for energetic refurbishing of social welfare infrastructure allowed Bavaria to mount an offensive on carbon emissions from buildings under State control whilst creating demand in the Bavarian construction industry. Over one third of energy consumed today in Bavaria is



CO₂ emissions in Bavaria (per inhabitant per year)

Source: Bavarian State Office of Statistics and Data Processing and the Bavarian State Ministry of Economic Affairs, Infrastructure, Transport, and Technology (2010 and estimation for 2011)

accounted for by buildings, which means that further optimisation of building shells and technical equipment needs to be carried out and regenerative energy solutions implemented in a targeted manner. The stated aim remains to achieve the maximum reduction in CO₂ emissions with the financial resources available.

The targeted financial support schemes for small and medium-sized businesses to implement geothermal heating systems and CO₂ emissions reduction represent another set of economic impulses towards reducing greenhouse gas emissions with innovative and efficient technological solutions. The Economics Ministry has made a total of four million Euros available in the form of grants for developing sustainable technologies in efficient energy generation and consumption; grants were also available to increase the uptake of geothermal energy in Bavaria, including projects in Unterföhring, Pullach, Aschheim, Garching and Unterhaching.

Reconstituting energy provision is a matter for society as a whole and as such needs to be predicated on a broad societal consensus: this is the idea behind not only the Bavarian Environment Pact and the Bavarian Climate Alliance, but also the **Energy Efficiency Pact**. The goal must be to uphold the social contract by tackling the challenges resulting from changes to energy supply in a spirit of solidarity, promoting cooperative solutions, and fostering a willingness to accept some inconveniences (e.g. during construction on new energy infrastructure).

Within the framework of the **CO₂ reduction programme**, the State of Bavaria supports local authorities and other public entities (e.g. churches) in carrying out measures with the purpose of reducing the CO₂ emissions of their property and thus contributing considerably to climate protection. Financial support is available primarily for planning projects and, depending on the resources available in the State budget, for some implementation on a case-by-case basis. Costs incurred by smaller communities for external climate consultants ("Climate Protection Managers") and their services, such as implementing integrated climate protection and energy efficiency concepts, qualify for financial backing. In order to support the federal energy transition initiative, the successful CO₂ reduction programme will be continued beyond 2012, while the principles behind financial support will be further developed so as to make funding available to local authorities for projects with high standards of energy efficiency and low carbon footprints; participation in quality management and climate protection certification processes should also be funded in future.

Another successful support initiative is the Agricultural Ministry's **BioKlima** programme for biomass heat generation projects. Between 2009 and 2012 alone, over 100 environmentally-friendly heating plants were built in Bavaria, leading to carbon emissions savings of over 140,000 tonnes.

Moors, grassland, intact river banks and woods are **organic carbon reservoirs**, and can continue to perform this function if they are used sustainably, i.e. in accordance with their natural

state and with due consideration for their role in climate protection. These biotopes are rich both in carbon and in species diversity, and if they are subject to changes in use (e.g. draining moors, ploughing up grassland), these eco-systems can emit large amounts of CO₂. For this reason, permanent grassland should not be converted into farmland, especially if it is composed of moisture-heavy substrates, as this can lead to the loss of up to 60 percent of the carbon in the soil (between five and forty tonnes of carbon per hectare of topsoil).

The target through to 2020 is to return fifty moors to their natural state, and 8.8 million Euros have already been invested in Bavaria since 2008 to **restore moorland**. Ten areas were redeveloped, with measures planned or started in a further thirty moorland areas. When returned to nature, raised bogs and transition moors bind around fifteen tonnes of carbon dioxide or equivalent gases per hectare per year (in Bavaria, their total area is around 50,000 hectares); in the case of lowland moors (approx. 150,000 hectares), which are intensively exploited across Bavaria, ecological restoration and climate-neutral use would take around 30 tonnes of carbon dioxide and equivalents out of the atmosphere per hectare and year. Projects have been set up in all regions of Bavaria to preserve, and contractually bind landowners to tend to, grassland (e.g. through BayernNetzNatur structures).

Within the framework of the Bavarian Climate Programme 2020, it has been possible to achieve a notable increase in **forestry initiatives**. In the period between 2008 and 2012, over 29,000 hectares of forest have already been improved, but in order to reach the 100,000-hectare 2020 target, forest improvement will need to continue at a rate of 8,000 to 9,000 hectares annually. A by-area, acute needs-based approach is particularly promising as it achieves significant improvements to forest areas across the region, especially when carried out in an innovative manner bringing together a range of external project partners such as local authorities, forestry committees, businesses, and hunters. To build on this success, projects are being launched in further areas with a pressing need of forest improvement; these areas are to be considered as seed crystals which will eventually engender blanket forest improvement across all of Bavaria.

With a total of around 30 project areas across the Bavarian Alpine landscape, the **mountain forest initiative** is a complete success, enjoying a high degree of acceptance and a positive resonance both among the forest-owners concerned and in the general population. Its reliance on participation means that it requires careful preparation, but is also its key strength.

Additional funds from the Bavarian Climate Programme 2020 (50 million Euros in total between 2008 and 2011) made it possible to invest some 150 million Euros a year in flood defences, and this highly successful **flood control programme** is to be continued and adapted to meet the challenges of climate change as and when they arise. Recent floods have unmistakably underlined the importance of adequate flood defences: drainage basins for mountain torrents must be developed, and a hazard-based maintenance strategy for existing defences needs to be produced in conjunction with an up-to-date, adaptable expansion plan to counteract the consequences of natural disasters.

Bavarian universities and research institutes boast a broad range of competencies and research activities in climate sciences and on assessing the impact of climate change, and in order to offer targeted support to Bavarian scientists in their efforts to attract external research funding, the State Government initiated a **programme for participation in federal and EU research programmes** (2008 –

2011) within the scope of the Bavarian Climate Programme 2020 which made available funds for co-financing and starter grants for international cooperation. Further funds were also provided during this period to other entities including three **inter-disciplinary research alliances**, which are focussing on the impact of the climate on eco-systems and climate adaptation strategies, as well as on energy and resource efficiency (see p. 63 and p. 78).

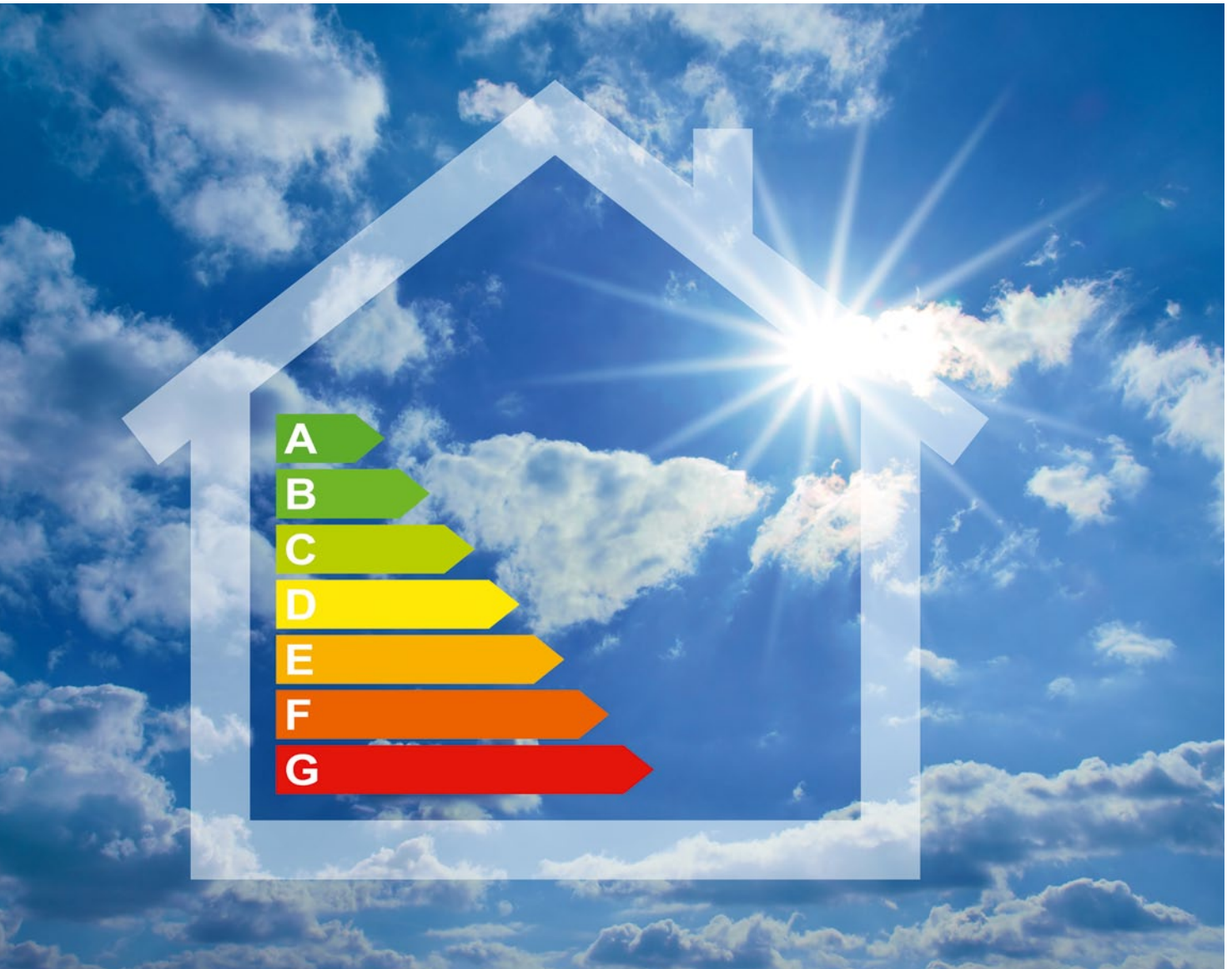
In order to strengthen Bavaria's ability to act and its competitiveness in the face of the effects of climate change, innovative technologies and strategies will also have to be promoted in future, e.g. for climate adaptation in cities or preserving bio-diversity. By monitoring sensitive eco-systems and landscapes in Bavaria, the data basis on which adaptation strategies are designed will be improved. Contributions to help establish model climate protection regions will continue to be offered.



With reference to the report of the Intergovernmental Panel on Climate Change (IPCC), Bavaria intends to produce a comprehensive **Bavarian Climate Report** which will be able to offer conclusions on which future action can reliably be based. Regional climate modelling especially, as well as the effects of changes to the climate on agriculture and forestry, biodiversity, energy supply, transport, tourism, and health are all important matters; the goal is both to combine and examine existent data (e.g. from the KLIWA reports on the consequences of climate change for water management) and to close gaps in knowledge. The Bavarian Climate Report is intended to produce for the first time a comprehensive basis on which decision-makers at a regional level can take action.

Bavarian climate policy is composed of a range of measures which were subject to cost-benefit analyses and a comparison with national measures in order to make sure that financial resources are used in the most cost-effective way. The finance-intensive measures and targets mentioned in this brochure can only be implemented inasmuch as the monetary and human resources required are provided by the State budget or third parties. In individual fields of action, it is often necessary to adjust offers to fit with other direct or indirect funding options available – especially those provided by the Federal Government: Bavarian funding ought to be used where there are gaps to be filled and where the use of State resources appears to be both reasonable and necessary.

Reducing greenhouse emissions

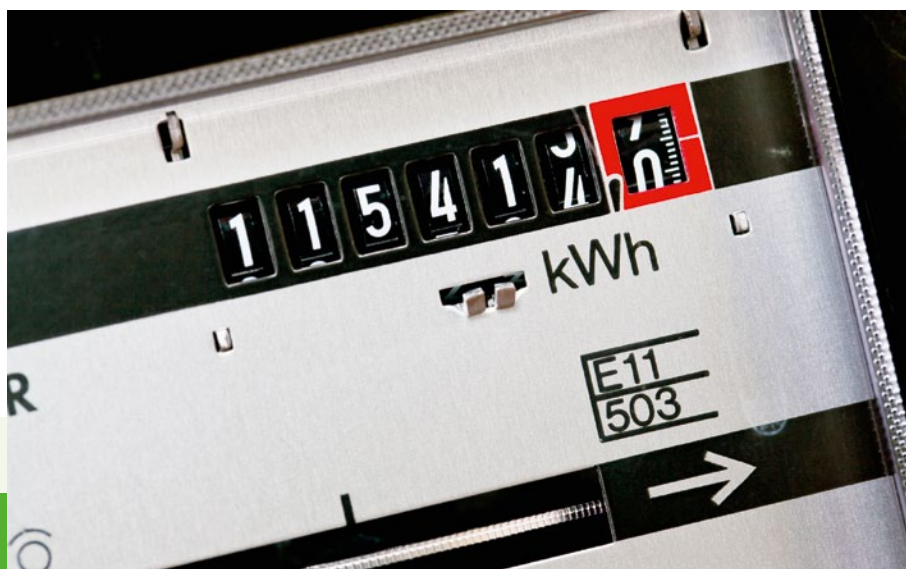


Around three quarters of German greenhouse gas emissions are related to energy. This means that the conversion, transmission, and consumption of energy are central fields of action for climate protection: climate-friendly energy provision means using resources in an economical way, and this in turn lowers dependency on imports. The crucial approach with which Bavaria's good standing in climate protection can be maintained and further advanced is a consistent drive to save energy and make energy generation and consumption as efficient as possible. As stated in the Innovative Energy concept, Bavaria's overriding aim is to keep electricity consumption at its present level of around 85 billion kilowatt hours annually through to 2021, despite increases in uses for electricity (e.g. electric vehicles); Bavaria intends to introduce a package of measures to save electricity and cut the heating requirements of buildings by 20% by 2021.

Saving energy and energy efficiency are the most environmentally-friendly, socially equitable, and economical forms of climate protection and green energy transition. Energy efficiency does not entail any loss of comfort

or economic output, but can in fact increase both – for example due to reduced waste heat and longer battery life for laptop computers. The potential to save energy is enormous: a 2011 study produced by the Bavarian Conservation League (*Bund Naturschutz*) comes to the conclusion that forty percent of the electricity produced today could be saved by 2030, and the potential is even higher in buildings, where with techniques already available today, heating requirements could be reduced by more than 80%. In view of these facts, a working party from the Environment Ministry, the Conservation League, and the Bavarian Alliance for the Protection of Birds (*Landesbund für Vogelschutz*) produced a twelve-point plan of action for energy efficiency and conservation, with recommendations for households, businesses, local authorities and the State. To make sure this plan is implemented within its remit, the Bavarian Environment Ministry has made two million Euros available for the 2013 and 2014 financial years.

→ www.stmug.bayern.de/umwelt/klimaschutz/zwoelf_punkte_aktionsplan/index.htm



Energy savings in buildings

The reconstitution of electricity supply will lead to an increased use of natural gas as a source of energy, which causes CO₂ emissions. This means that, in order to still reach climate protection goals, higher energy and carbon savings need to be made outside of the electricity supply sector – above all in heating. Around forty percent of Bavaria's entire energy consumption and thirty-five percent of the State's CO₂ emissions come from buildings, and ninety percent of these figures comes from heating and hot water provision.

State construction projects

The State of Bavaria sets a good example in its own construction and refurbishment projects, going to considerable efforts to boost the energy efficiency of its buildings. New administrative buildings will in future be built to passive house standards as a general rule; all other State construction projects, both new buildings and changes to existing stock, will generally be built to be below the average requirements of the energy savings regulation of 2009 by at least thirty percent with regards to the structure's exterior shell. This will help the Free State to lead from the front in terms of reducing greenhouse gas emissions and to underline its role as a pioneer among the German federal states.



Bavarian State Parliament, extension in the northern court: this building was constructed to passive house standard.

Special programme for energy-efficient refitting of State-owned buildings

Between 2008 and 2011, 150 million Euros were made available in the special programme for energetic refurbishing of State-owned buildings. The works which were accelerated as part of this programme included both those on buildings themselves and those carried out on technical equipment, and the use of regenerative energy sources was increased. The energy-efficiency optimisation now applied to around 450 State-owned buildings are saving more than 32,000 tonnes of carbon emissions annually, which corresponds to a reduction of 105,000 megawatt hours of energy consumption every year; this also has an effect on the operating costs of the buildings which, when calculated at 2012 prices, are up to 10 million Euros a year lower as a result.



*Technische Universität München (TUM)
Freising-Weihenstephan: Energy-efficiency refit as part
of the special programme*

Old-build housing stock

A majority of Bavaria's roughly 1.8 million residential buildings completed through to 1978 (comprising around 3.8 million dwellings) has not yet been upgraded to energy-saving standards. This cohort of housing stock consumes a particularly high level of heating energy: pre-1979 residential buildings produce around 15.6 million tonnes of CO₂ emissions annually, which computes to half of all household and consumer emissions. By applying comparatively cost-efficient measures, this energy consumption can be decreased, resulting in significant potential carbon savings.

Given the new provisions for housing funding, as of the beginning of 2012, it has been possible to increase grants for the creation or modification of residential rental space for low-income families if specific energy-efficiency measures are implemented above and beyond the minimum legal requirement. Moreover, the State of Bavaria also supports landlords and residents in saving energy and reducing the carbon footprint of existent residential space with its modernisation programme. Low-interest loans from the Federal development and investment bank KfW are further reduced using funds from the Bavarian regional building society, BayernLabo.

Social infrastructure

A large proportion of social infrastructure such as schools, day-care facilities, and (school) gymnasias is in urgent need of energy-saving upgrades; at local authority level, especially, there is a considerable investment back-log. As a part of the second federal economic stimulus package, Bavarian municipalities have modernised some 1,500 nurseries, schools, and administrative buildings since 2009 with funds from the Federation and the Free State. Thanks to these upgrades alone, over 320 million kilowatt hours will be saved per year in the future in Bavaria; in addition, this investment significantly strengthened the domestic economy during the international financial crisis. The investment pact agreed between the German federal, state, and local government bodies for energy-saving refitting financed another 150 refurbishing projects at

local authority level through to 2011, with 60 million Euros of funds made available for the pact in 2008 (30 million from federal and 30 million from State resources) and 47 million in 2009 (40 million federal, 7 million State).



Dürrwangen Primary School, given an energy-efficient refit as part of the second economic stimulus package

CO₂ reduction programme for local authorities

Since 1998, the Bavarian Environment Ministry has been supporting local authorities to carry out measures to lower the energy consumption of public buildings and reduce their carbon footprint; in 2000, this support was extended to other public entities such as the Churches. This programme contributes both to the green energy transition as well as to climate protection; around 400 projects to date have been subsidised with a total of some six million Euros, with around 80% of the programme funds (measured both in terms of resources allotted and cases supported) going to rural areas; around one half of the rural areas supported are classified as economically weaker areas. The following measures are worthy of particular mention here:

- **Pilot project to reduce carbon emissions by saving energy and better exploiting water heat energy in the thermal baths at Bad Füssing**

By introducing an energy management system and recovering additional heat energy from pool out-flow, among other measures, CO₂ emissions from thermal bath I were reduced by more than 400 tonnes per annum. This pilot project was subsidised with 325,000 Euros and was awarded the 2005 environment prize of the *Bayerische Landesstiftung* (Bavarian State Foundation).

- **Pilot project to heat the Reichertshausen school and local library using geothermal energy**

By laying ground heat exchangers across an area of approx. 8,000m² using the soil-sensitive method of “ploughing in”, the heating system was switched from oil-burning to geothermal. This project, subsidised to the tune of 160,000 Euros has produced a CO₂ reduction of around 150 tonnes per year.

- **Pilot project to build a sports hall with a total primary energy requirement of less than 100 kW/m²a**

This wood-built sports hall was constructed to passive house standard for the Söchering Sporting Association and has led to energy savings of almost 90 percent, meaning that the photovoltaic solar panels on the roof of the building actually produce more energy than is needed to run the building. The money earned by selling electricity into the national grid will be used to finance repairs and upkeep of the building. This pilot project, subsidised with 100,000 Euros, was awarded the 2012 energy-efficiency prize by the regional electricity supplier Lechwerke.

– **Pilot project to build a new swimming pool and water park following passive house principles**

The “Bambados” project in Bamberg, which received 400,000 Euros in subsidies, is Europe’s first covered swimming pool to be built and certified to passive house standard. Its compact design features a highly insulated shell, and the building is airtight: compared with a conventionally built swimming pool, Bambados requires sixty percent less energy and produces eighty percent fewer carbon emissions. In 2012, the German Energy Agency (dena) highlighted Bambados as a good example of energy efficiency at local authority level.

– **Concept initiative to refit the listed Alte Schäfllerei of the Benediktbeuern Monastery for increased energy efficiency**

The energy-saving refit of the Alte Schäfllerei, a coopery listed as a building of historical importance, is intended to show how a range of energy-efficient changes can be made to old and protected buildings. Following the works, subsidised with 400,000 Euros, the heating system in the Alte Schäfllerei will require about eighty percent less energy than it currently consumes and the Fraunhofer Institute for Building Physics will be setting up a European competence centre for energetic refurbishment of old and protected buildings in the Alte Schäfllerei.



State Secretary Melanie Huml presenting the check for Bambados to Bamberg’s Mayor Andreas Starke



State Minister Dr. Marcel Huber and State Minister Thomas Kreuzer congratulating winners of the European Energy Award

Pilot project: European Energy Award

Between 2006 and 2009, Bavarian local authorities were supported in participating in the European Energy Award® (eea) programme in order to identify and implement energy efficiency measures. The costs covered by the Ministry of the Environment for the pilot project – acquiring use rights, awarding an incentive grant, organising the project – ran to a total of around 150,000 Euros. There are currently 23 Bavarian municipalities taking part in the eea, 16 of which have already received awards, with the Ascha community even securing gold.

Beacon project: Green Hospital Lichtenfels

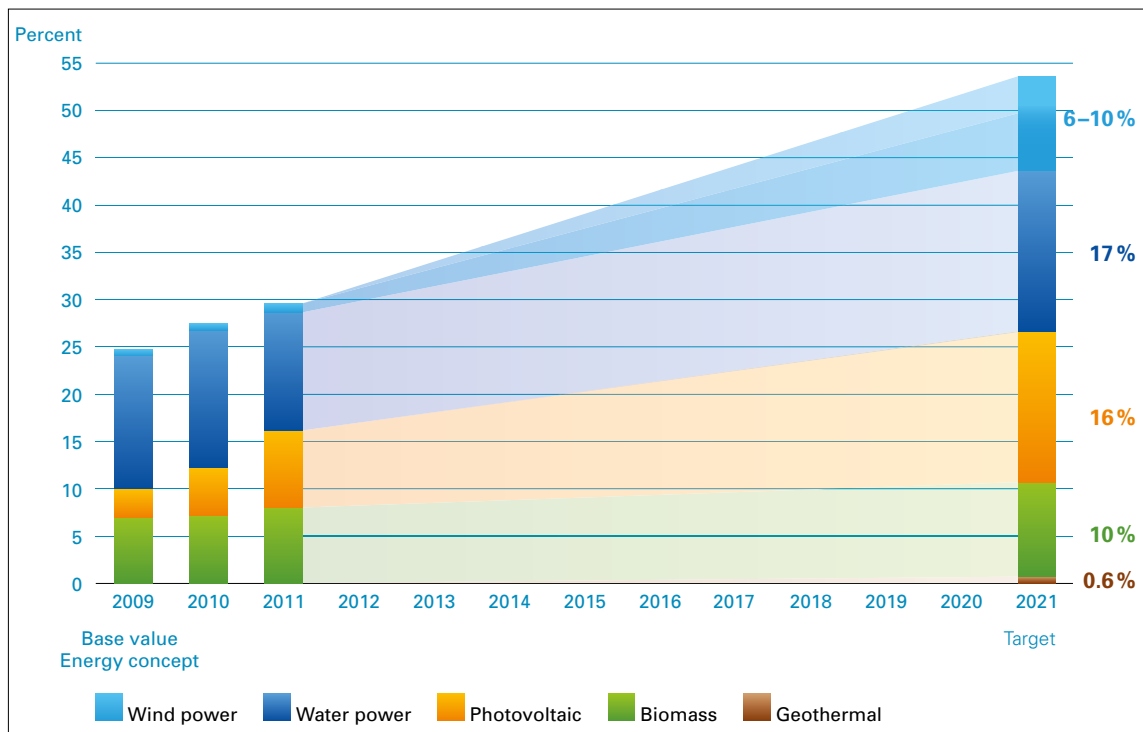
Bavarian hospitals, too, are making a contribution to the fundamental reorientation of energy production and consumption. Accordingly, the holistic Green Hospital Bavaria approach combines necessary construction work in hospitals with ecological goals, while taking economical considerations into account. With the Green Hospital Lichtenfels beacon project, the strong environmental focus of the new-build clinic is intended to set new standards for sustainable hospital buildings. Compared to the current clinic structure, the new building is set to reduce carbon emissions by around seventy-four percent; as part of the Bavaria on the Move initiative, this project is also receiving a further eight million Euros in State funds.

Renewable energy

Real acceleration of renewables expansion

Renewable energy sources – wind, water, and solar power, ambient heat, and geothermal systems – provided approximately 13.3 percent of the total energy consumed in Bavaria in 2011 and nearly 30 percent of electricity consumption. 2011 and 2012 both saw above-average rises in the proportion of renewables in the energy mix, and further dynamic increases can be expected.

As part of its Innovative Energy concept, the State Government has set a target of 20 percent renewables in the overall energy mix by 2021. To achieve this, the energy sources in question will need to be used and extended in accordance with their technical availability and economic acceptability. Almost half of the green energy target is due to come from biogenic sources, with the target for the proportion of renewable energy in electricity consumed set at 50 percent for 2021.



Electricity generation from renewable energy sources in Bavaria: changes to the proportion of renewables in gross energy consumption (Source: ENERGIE INNOVATIV Bavarian Energy Agency – www.energie-innovativ.de)

Water power

With a share of around 15 percent in renewable energy production at present, hydro power is one of the key pillars of regenerative energy in Bavaria. Thanks to its long tradition, it is in fact the most important green energy source in the State – and thus one with less potential for further development than other renewables. Nevertheless, through new, nature-sensitive and environmentally-friendly projects and the modernisation and upgrading of existing plants, its current share is to be substantially increased through to 2021. New hydro-power infrastructure will be added to dams and barrages already in place or installed during overall waterway improvement works; existing barriers will be examined by the

authorities responsible on their suitability for power generation on a site-by-site basis in accordance with Sec. 35 par. 3 of the Federal Water Management Code. Potential increases in hydro-power generation resulting from modernisation and improvements of existing structures and waterway upgrading works will be collated to produce an area plan to be published in the Bavarian Energy Atlas. This process will ensure that water power is developed at suitable sites, while defining areas of particular ecological importance in which the conservation or development of the natural eco-system is accorded priority as a fundamental principle



Walchensee power station

More wind-generated electricity

The target for wind energy is to cover 6 to 10 percent of electricity used in Bavaria by 2021, and this is to be achieved with 1,000 to 1,500 new wind power structures; in 2011, Bavaria recorded a significant increase in wind farm construction, amounting to around 32 percent of the wind power-generation capacity installed to date. The wind farm pool in service in 2011 had a capacity of around 680 MW installed and produced around 790,000 megawatt hours of electricity in that year.

In order to drive the expansion in wind power exploitation in Bavaria, regional planning associations are working concertedly on new by-area steering concepts for wind power use and updating existing plans in order to meet the requirements of the green energy transition. The new [wind energy statute](#), produced by all of the State ministries concerned, is a comprehensive set of measures for increasing the speed and standardisation of plan approval processes: it contains extensive, well-founded guidelines on planning and granting permission for wind farms; particularly worthy of note are the simplified distance clearances and regulations for compensation, the introduction of permit applications for landowners (to date only wind farm operators could apply to install generation capacity), and the potential to introduce wind power to protected landscapes and nature reserves, including a streamlined bio-diversity conservation review process.

The [Wind Power Areas Planning Concept](#) developed by the Bavarian Environment Agency (LfU) offers an overview of space across the State that might be suitable for wind farm developments. The aim of this document is to channel wind power projects onto sites where they can be run profitably without having a detrimental effect on the people, nature, or aesthetic value of their surroundings; as such, it is an indispensable planning aid for local authorities, regional planning associations, and other governmental bodies concerned.



State Minister Dr. Marcel Huber presenting the Wind Power Areas Planning Concept together with representatives from the local authority associations (District Commissioner Jakob Kreidl, Mayor Michael Sedlmair, and Mayor Rudolf Heller)

[Wind Power Bases](#) can play a central role in pushing the sustainable development of wind power by bringing together local authorities, energy providers, the wind power industry, and researchers; if all of these stakeholders work in concert, bundling their competencies, regional potential for wind energy will be easier to realise. The first such Wind Power Base initiative is located in the district of Neumarkt

(Upper Palatinate), selected due to its plentiful natural wind resources, the local wind power generation capacity already installed and in planning, and the wind farm components manufacturing facilities located there. The next bases will be the Wunsiedel municipality, the community of Wildpoldsried, and the town of Schweinfurt, each of which will receive around 150,000 Euros in funding from the State of Bavaria. Further Wind Power Bases are currently being prepared.

The new Bavarian [funding programme](#) for municipalities and citizens installing sustainable electricity generation capacity offers support for feasibility studies, preliminary projects, and legal advice. Through to 2014, the State Government will be making a total of six million Euros available to local authorities and citizen groups planning to install wind energy infrastructure.

Electricity, heating, and transport: biomass energy in Bavaria

The most important source of renewable, climate-neutral energy in Bavaria is biomass. Biomass is a multi-faceted energy source, helping to cover demand for electricity, heating, or transport whether as solids, liquids, or gas. The key advantage of biomass as against other renewable energies is that it is always available to generate energy as and when required; as a general rule, complex energy-storage or new energy-storage technologies are not necessary, and since 1995, biomass' contribution to primary energy consumption has increased more than three-fold; it is sure to increase further. Today, biomass is already making a considerable contribution to climate protection efforts, with more than seven million tonnes of greenhouse gas emissions avoided every year: this saving corresponds to around nine percent of total Bavarian greenhouse gas emissions.



Despite its importance, biomass for energy generation is not a limitless resource: agricultural land should only be used to produce raw materials for biomass energy once the supply of high-quality foodstuffs for the population is assured; the wood-processing industry also requires wood as a raw material and represents an important economic factor in many rural areas. Neither of these important uses for biomass can be ignored, and this means that intelligent solutions combining biomass with energy savings and other regenerative sources are the order of the day.

High-performance biomass electricity

Around eight percent of Bavaria's electricity demand is currently covered by biomass, regardless of whether the sun is shining and the wind is blowing, and in the medium-term, this proportion could well be increased to around ten percent. At present, a large proportion of this electricity is generated by a decentralised pool of more than 2,000 biogas plants; a particularly climate-friendly form of biomass electricity generation is when waste products and silage are used as fermentation substrates, as the heat produced can then be used to provide heating. Another important source of energy for electricity production is residual and waste timber, which is generally used in large-scale combined heating and power plants.

Indispensable for climate protection: heat from biomass

Around forty percent of the total energy consumption and around thirty-five percent of the CO₂ emissions in Bavaria are accounted for

by buildings, of which in turn around ninety percent is caused by heating and hot water provision. One of the most important alternatives to fossil fuels in this case is wood: the two most common processes for generating heat biogenically are firing wood-based solid fuels and using waste heat from biogas electricity generation; in recent years, there were considerable rises in both processes, which resulted in an important contribution to climate protection. Wood is one of the most important sources of energy in Bavaria, and in 2011, one out of every four new buildings had a primary or secondary wood-fired heating system. In residential properties, wood can be burnt in an environmentally-friendly manner as logs, chips, or pellets. State-of-the-art wood-fired central heating, especially with automatic woodchip or pellet feed, offers a level of comfort comparable to an oil or gas boiler.

The BioKlima programme

In terms of fuel costs, wood is superior to fossil-fuel alternatives, but investments in biomass plants remain higher – and this is where the Bavarian BioKlima funding programme comes in to help prepare the way to avoiding gas emissions which are dangerous for the climate. This programme is principally used to offer targeted support to smaller heating plants in rural regions of Bavaria, and it is necessary as it is very difficult for many investors to add higher investment costs onto the heating price, especially in the case of cutting-edge, highly efficient biomass plants for district heating systems. This successful programme led to carbon savings of roughly 140,000 tonnes between mid-2009 and the end of 2012, and now the programme is being

developed further, with new aspects with regard to increased efficiency being added. The overall aim is to use Bavaria's wood energy resources as best as possible.

Photovoltaic

Its particularly favourable solar conditions have made the State of Bavaria Germany's leader in terms of photovoltaic energy. The target is to increase solar energy capacity to 14,000 MW by 2021, generating enough electricity to cover around sixteen percent of Bavaria's requirement, and in recent years, the use of photovoltaic energy has been rising notably faster. While only three percent of the Bavarian electricity mix was solar in 2009, in 2011, this proportion had already climbed to eight percent. The total capacity installed by 2011 was 8,125 MW, which produced around seven million megawatt hours in that year. Solar energy in Bavaria mainly comes from domestic installations (e.g. roof panels), and in 2011, around two thirds of the total capacity in place was provided by plants of up to 100 KW – the

average size being 23.6 KW (as against a nationwide average of 34.8 KW).

"Old burdens, new energy"

Deposits of waste from prior years such as decommissioned landfill sites often require continuous upkeep – and some such sites are also suited to solar energy production. Nevertheless, planning and building on brownfield sites is more costly, meaning that many projects lose their financial justification and are never implemented. The "old burdens, new energy" (*Alte Lasten – Neue Energie*, ALNE) programme was set up to deal with this situation and consists of two subprogrammes to identify polluted areas of land and decommissioned sites which would be suitable for solar energy generation and to provide funding to build photovoltaic plants on such sites. The results from the site search, with feasibility studies and business cases, allow the municipalities involved to be included in further plans for photovoltaic plants; reuse of old polluted areas and decommissioned landfill sites for



solar energy plants is supported to the tune of approximately two million Euros annually from the ALNE programme

Geothermal energy

Bavaria, especially South Bavaria – offers favourable conditions for harnessing hydrothermal energy using deep heat-pumps. This has made the best possible use of this geothermal potential a priority in Bavarian climate protection policy. Although geothermal energy can be used both to produce electricity and to generate heat, high initial investment costs, especially for heating distribution, mean that it is frequently not cost-effective; further to this, an optimal density of heat users around the geothermal plant is not always present. Finally, in contrast to green electricity generation, which is promoted by the provisions of the Renewable Energies Act, geothermal heating supply does not benefit from comparable federal subsidies: this gap was filled by a State programme adopted in July 2009.

The temperature and the yield of the thermal water reservoirs to be tapped are the decisive factors for the success of deep heat-pumps, and a lack of knowledge with regard to actual sub-surface conditions results in risks with regard to planning access to the thermal water, to optimising interaction between neighbouring geothermal energy projects, and to ensuring sustainable use of the thermal water, which is actually a finite resource. Reliable geological studies are essential in order to reduce these risks, and since 2011, the large volume of data already available has been collated to a computer-based 3D subterranean map and an improved 3D temperature model; to begin

with, the principal focus is on areas of the Bavarian Molasse basin in which geothermal energy projects are considered practicable based on the current state of research: the Fünfseenland, the five lakes in the west of Upper Bavaria and the Inn-Salzach region in the east. From 2013 onwards, work is set to continue in areas outside of these two regions using resources from the GeoMol project financed by the European Structural Fund.

Geothermal Energy in Bavaria programme

- Bavarian programme to boost the expansion of deep heat-pump geothermal heating systems.

Reducing the risks of accessing and using hydrothermal energy

- “Deep geothermal energy in the Bavarian Molasse basin – 3D subterranean model and improved 3D temperature model” (project period 2011-2013)
- “GeoMol – Assessing sub-surface potentials of the Alpine Foreland Basins for sustainable planning and use of natural resources” (EU project, running from 2012 to 2015).

Transport

Currently, the transport sector accounts for around one third of both the total energy consumed and the CO₂ emitted in Bavaria. Increases in transport services, the trend towards higher-performing engines, and improved safety and comfort in vehicles have combined so that, despite impressive technical solutions to improve energy efficiency, the overall energy consumption and carbon emissions of the transport sector have not declined by the amount that could have been expected. The aim must be to reduce tensions between economic, ecological, and social aspects by minimising the drawbacks caused by transport.

Renewable energy sources

The EU has set up a binding commitment by which 10 percent of the energy used in transport in each member state must come from renewable sources by 2020; biofuels will make up the largest proportion of this green energy. From 2018 onwards at the latest, new energy sources will need to emit at least 60 percent less greenhouse gases than fossil fuels to reach this target, and as of 2011, ambitious requirements have been in effect regarding the sustainable cultivation and use of biofuels: this means that the technical impera-

tive is to continue to research and develop cleaner, innovative biofuels.

Shifting transport

Both with a view to taking pressure out of the road network and lessening effects on the environment, as much traffic as possible needs to be transferred to the railways, to waterways (wherever practicable), and to public transport of every kind. The State Government is making every effort to support the upkeep and expansion of an attractive and high-performing public transport system as the foundation of sustainable mobility; appropriate urban planning also has a role to play in reducing pressure on transport systems. Nevertheless, it is not simply a matter of increasing the share of public transport by road and rail in overall journeys made, but also of improving conditions for pedestrians and cyclists.

Optimising transport chains

Each mode of transport is best suited to different use cases, and this means that the aim of transport policy must be to deploy the strengths of each mode in the most efficient way to create sustainable journey and distribution chains. Moreover, process-optimised, envi-





Environmentally-friendly green logistics can make better use of infrastructure already in place. Introducing an ecological footprint for each product is also a way of optimising transport flows and minimising impact, and raising awareness of the ecological effects of individual journeys also has a role to play.

Potential for technical improvements to vehicles

Technical improvements to vehicles still have the potential to reduce their climate and emissions footprints in ways that are both commercially viable and feasible; a strategy based on technological progress can also be an important factor in maintaining the competitive edge of the European automotive industry.

Biofuels: well established on the market

At present, climate-friendly, low-pollutant individual transportation is only available to a limited extent, and despite the fact that this segment of the transport sector offers considerable potential for reducing greenhouse gas emissions, there have been no great successes to date. A range of biogenic fuels suitable for use in conventional combustion engines are at a mature stage of development and available on the market for some years; these fuels are subject by law to specific sustainability requirements to guarantee at least a 35%-saving measured against fossil fuels, and some ethanol plants are already reaching reductions of fifty to sixty percent.

While sales of biofuels as components in mixed fuels have been rising continuously, this is not always enough to compensate for the downturn in the turnover of pure biofuels. By way of example, sales of biodiesel mixed in

low volumes with conventional diesel (B7 blend) went up across Germany at the same time as the pure organic diesel biofuel B100 declined; an even more unfavourable instance is that of straight vegetable oil/pure plant oil fuels (SVO/PPO), sales of which have ground to a halt after the lower rates of energy tax applied to them were abolished. One consequence of this development is that many decentralised vegetable oil purification plants, which couple the production of foodstuffs with energy generation in an exemplary manner, have ceased activity. As well as producing fuel, many of these small-to-medium-sized plants produce high-quality animal protein feeds, and an increased use of SVO/PPO would be a boon both from the sustainability standpoint and as a way of tapping the potential found in Bavaria's regions.



Industry and commerce

Innovation and new technology from the industrial and commercial sectors represent further key contributions towards greater energy efficiency and a rationalised energy consumption, thus endowing companies with a competitive advantage on the global market in the form of cost savings and a more innovative product offering.

Emissions trading

The most important instrument which the European Union has in order to fulfil its Kyoto obligations in climate protection is carbon emissions capping and trading between companies. Besides this scheme, the Kyoto protocol also endorses other flexible systems as suitable instruments to reduce greenhouse gas emissions such as joint implementation (JI) of projects and clean development mechanisms (CDM), as well as an international trade in emissions certificates between countries.

The European Union has linked JI and CDM to the emissions trading system. This allows these flexible mechanisms to be applied to companies in the EU member states in order to create emissions permits in other countries with which they can then fulfil their annual duties.

Bavarian CDM Initiative

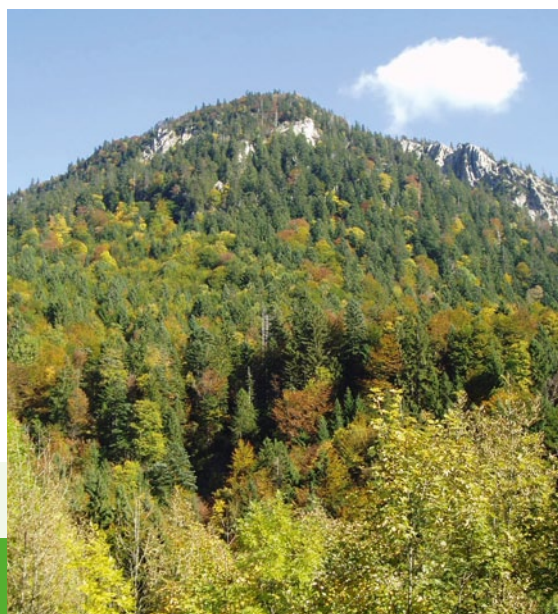
The Bavarian CDM Initiative provides small and medium-sized companies with easier access to project-based instruments, above all during the third trading period (2013-2020) in which the reduction across the board in emissions certificates assigned to companies operating in a range of sectors will result in insufficient emissions rights and necessitate buying in to fill quotas.



Agriculture and forestry

In this manner, the Bavarian CDM Initiative will lead to a long-term increase in SME competitiveness. The aim is to offer participants an additional low-cost source of emissions rights by purchasing certificates directly from CDM and JI projects; by tightly coordinating synergy effects among participants, the CDM Initiative will be able to reduce transaction costs and risks for each company – an effect from which SMEs in particular are set to benefit. This initiative is of particular importance in Bavaria because so many of our small companies with carbon emissions are subject to registration in the Europe-wide emissions trading scheme and their transaction costs would be disproportionately high.

Due both to land under cultivation and animal husbandry, agriculture and forestry have a range of possibilities to bind or avoid emitting carbon and other greenhouse gases. Climate-friendly ways of managing the countryside and structural improvements (e.g. using land consolidation instruments) can increase the energy efficiency of agriculture and forestry while reducing their greenhouse gas emissions. The effects on the atmosphere of keeping farm animals can be further reduced by better feed and fertiliser management and by performance optimisation, while the optimisation and minimisation of nitrogen fertilising in agriculture, as well as further development of (already extensive) organic farming will lead to further decreases in greenhouse gas emissions. The Bavarian Wood and Forestry Cluster Initiative is also being continued, mobilising sustainable use and environmentally-friendly, intelligent management concepts in the State's forests and wood-processing industry. Research efforts in energy crop production will lead to methods of cultivating new strains of plant to be used as organic raw materials for energy generation.



Support, information, and environmental education

Forests and wood – protecting the climate

A research project in 2012 produced an overall carbon footprint for Bavaria's forests and wood-processing industry, showing their positive effects in climate protection and comparing a range of possible use concepts. According to the study, in 2002 the States forests and wood products were storing around 744 million tonnes of carbon, and between 2003 and 2008, the climate protection effect of increasing carbon storage in wood products was roughly 29 million tonnes of CO₂ (taking into account the base storage level), as well as roughly 76 million tonnes of CO₂ in material and energy substitution; this gives a total of 105 million tonnes of CO₂ stored additionally over six years – or roughly 22 percent of all energy-generation-related carbon emissions in Bavaria. The comparison of various use concepts shows that the highest benefit to the climate in the long term is to be found in managed forests with a slight increase in stocks and an intelligent wood harvesting plan (cascading principle).



LandSchafttEnergie

The LandSchafttEnergie support team

In order to increase the availability of support and information in rural areas, the Ministry of Agriculture has set up an independent expert team under the name *LandSchafttEnergie*, with its main competence centre in Straubing; it offers advice independently of commercial interests. Besides energy savings in agriculture (e.g. on farms) and efficiency increases (e.g. biogas plants), its activities are mainly concentrated on increasing the use of biomass and on other agricultural issues.

Informational campaign: energy savings in buildings

As early as 2004, the State Building Administration set up an inter-disciplinary working party on energy-efficient construction. Its functions – creating an overarching network with a platform for information and knowledge exchange, as well as initialising and imple-



State Minister Helmut Brunner with the staff of the LandSchafttEnergie expert team outside the Straubing Technology and Competence Centre

menting individual measures – have proved particularly valuable in the context of the federal move to the green energy transition. Besides senior State planners, the working party also comprises representatives from the State Ministries for the Economy, Agriculture, and the Environment, seven local authorities, the architects' and civil engineers' chambers, the central municipal bodies, the Bavarian housing association and the State's energy agencies. The following initiatives are worthy of mention:

- Almost all Bavarian county district authorities have designated a contact person for consumers with questions relating to energy use and efficiency; these officers can answer basic questions about energy-saving refits and offer contacts to trained energy consultants in the local area.
- There has been a concerted informational campaign about energy-efficient construction and refurbishing (publications, events, assistance with legal requirements by cooperating with the planning ministers' project group responsible for energy conservation regulations on a federal level).
- Expanding the information about buildings and energy available on the internet, including updates with best-practice examples.

Energy saving in school

The State Building Administration, the Bavarian Chamber of Architects, and the Ministries of Education and of the Environment have produced a brochure presenting twelve schools selected from across Bavaria with the most effective energy-saving modernisations.

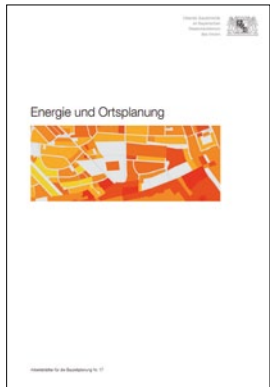
Besides the quality of the exterior shell upgrade and the building equipment, important criteria for selecting the schools were the user-friendliness of the newly installed equipment, the familiarisation of pupils with energy saving, and the extent to which teachers, parents, and pupils were included in the planning process.

Exhibition on energy-efficient planning and construction

In terms of energy-optimised buildings, Bavaria can boast a broad range of impressive solutions – from high-profile architecture projects, innovative technical building concepts and products, through to integrated town-planning schemes, state support programmes, and model projects, as well as research initiatives and new degree courses at the State's universities. This specific Bavarian competence is documented in an exhibition on energy-efficient planning and construction, produced in cooperation with the Department of Building Climatology and Building Services at the Technische Universität München. It was conceived as a moveable exhibition, updated in 2012, and also presents the Bavarian State Government's energy concept of May 2011.



The Energy-Efficient Planning and Building exhibition



Energy and town planning

Sustainable, climate-friendly concepts for town planning are future-proof and need to be driven forward and supported. In its brochure on energy and town planning, the State Building Administration in the Ministry of the Interior offers information to local authorities, planners, and citizens on sustainable urban design and features exemplary developments which will give town planners ideas for their own energy-efficient concepts.

- www.stmi.bayern.de/buw/staedtebau/energieundklimaschutz/siedlungsstruktur/index.php
- www.innenministerium.bayern.de/bauen/baurecht/staedtebau/17222/ (until 1st May 2013)

authorities to help them make decisions about how to switch over their local energy provision to renewables, to harness potential in the area, and to reduce consumption.

The *Leitfaden Energienutzungsplan* of July 2011 and the shorter nine-page brochure *Energienutzungsplan: Kurzinformation* (available since September 2012) offer this information as well as advice on how to describe performance criteria. The guideline was developed as part of a joint model project between the Ministries of the Interior, of the Environment, and of the Economy along with six model communities around Munich.

- www.energieatlas.bayern.de/kommunen/energienutzungsplan.html



Energy use plan

Given the complexity of future-orientated energy developments, it can be helpful to provide local authorities with a concept for energy and for how to cooperate on this matter across community borders: i.e. an energy use plan. This plan is used by local



Environmental education for consumers

Climate protection can only be effectively implemented if it is accepted and practised by each and every citizen as an important part of their everyday behaviour. The aim of environmental education for consumers is therefore to make sure that citizens are equipped with the knowledge and critical awareness necessary to make the right decisions, strengthening their feeling of responsibility for their own behaviour. Learning and acting by and for themselves is something that must be inculcated in children and adolescents from an early age, and then continually enabled and developed on a life-long basis.

- Increasing the density of the Bavarian network for extra-curricular environmental education facilities under the Environmental Education in Bavaria initiative (*Umweltbildung Bayern*), extending the climate protection offering.
- Supporting climate protection as a part of school environmental education through energy-saving competitions and pupil participation in energy-efficient refurbishments of school buildings.
- Implementing State-wide model projects to network, bundle, and communicate climate protection measures.
- Joining up existing networks for the environmental education of consumers
- Extending cooperation with high-performing partners (including municipalities and businesses).

Bavarian Green Hospital Initiative

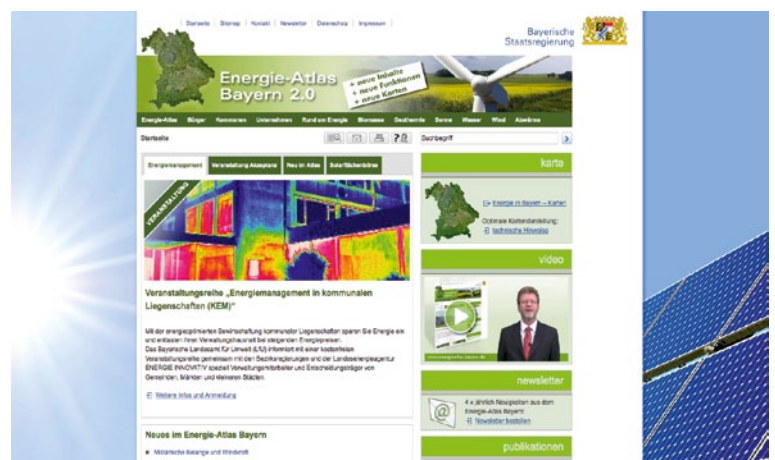
Besides the Green Hospital Lichtenfels beacon project, the Ministry of Public Health provides an online best-practice database as a contribution to a wider implementation of the sustain-

able hospital concept. Medical care and treatment centres which are particularly environmentally-friendly are awarded prizes; further initiatives are being planned.

→ www.krankenhausversorgung.bayern.de

Bavarian Energy Atlas

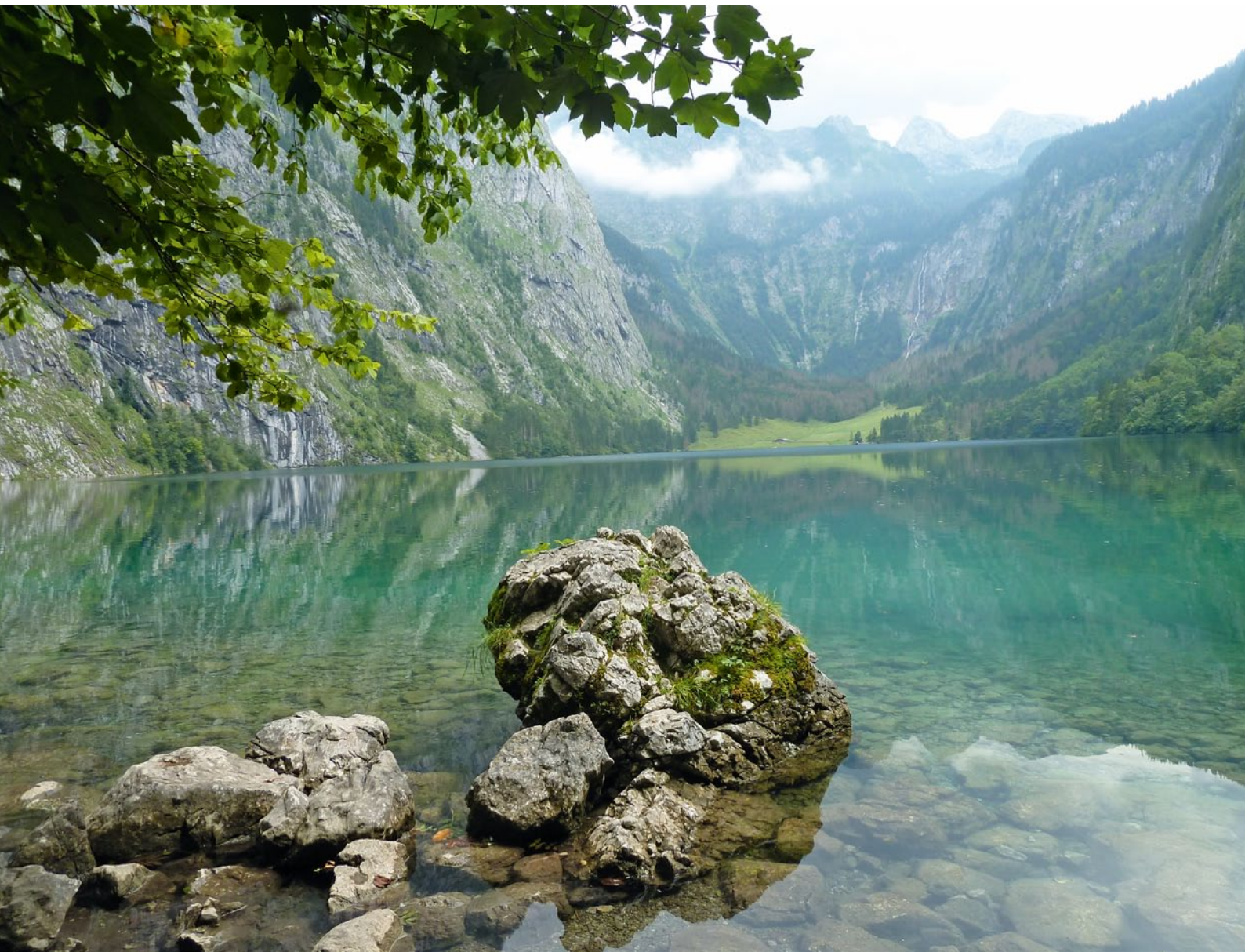
The Bavarian Energy Atlas is a central energy portal of the Bavarian State Government, making it a core element of online information and communication about the green energy transition. Developed under the leadership of the State Ministry of the Environment, this portal offers citizens, companies, and municipalities a range of complimentary information about saving energy, increasing energy efficiency, and installing or extending renewable energy in the form of tightly integrated, interactive maps with text elements. Exchanges for solar-panel spaces and waste heat use opportunities are on hand to engage users, and the Bavarian Energy Atlas will be continuously updated and extended.



Screenshot from "Energie-Atlas Bayern"

→ www.energieatlas.bayern.de

Adapting to climate change



Water management

Bavaria was quick to recognise that climate change cannot be effectively combatted by reducing greenhouse gas emissions alone, and this makes developing and implementing regional adaptation strategies across all sectors of society to deal with the unavoidable consequences of climate change as part of the national plan an important component of Bavarian climate policy.

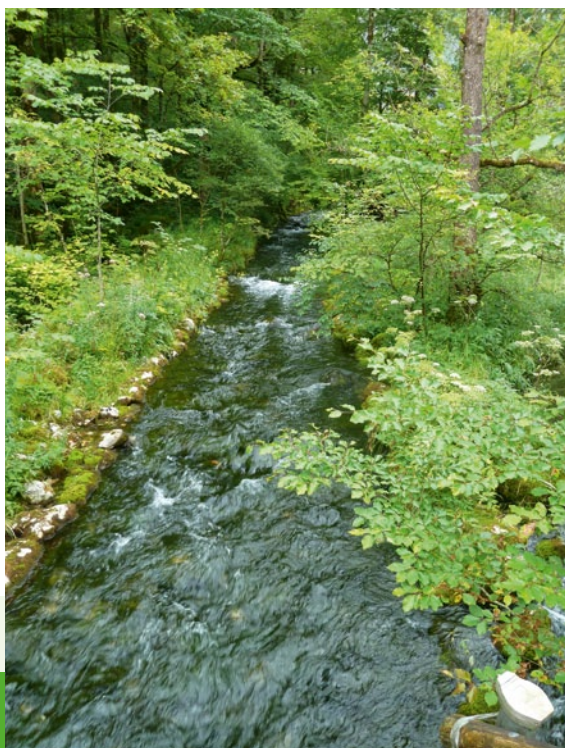
The most serious consequences for society of climate change, both direct and indirect, are expected in the water sector. For this reason, climate change demands an integrated raft of adaptation measures in water management across the following areas of action.

Basic research, monitoring, early warning

The KLIWA project on climate change and its effects on water management is to continue and expand current work focussing on low water levels, drought, and extreme precipitation; alterations to the overall amounts of water available caused by climate change are to be monitored more intensively.

Flood control

Climate change represents an entirely new challenge not just in terms of managing low water tables (e.g. how to make effective use of low groundwater reserves, rivers and lakes during dry periods), but also in terms of protection against water surges. Experts predict that climate change will lead to more frequent occurrences of torrential rainfall and high waters, and sustainable protection from flooding will become increasingly important for Bavaria. Flooding represents a hazard both to people's lives and their property including residential buildings, commercial and industrial premises, and vehicles, giving rise to non-quantifiable (intangible) monetary costs such as lost productivity, emergency services and disaster relief, clearing and repairing after flood waters have receded, and so much more.





Flood defences are one of the elementary responsibilities of the State in order to be able to secure a functional delivery of public services. This is why the State of Bavaria has set two aims in its Flood Control Programme 2020: reducing the potential for damage and providing sufficient flood defences. These aims are pursued in three fields of action:

- natural water retention
- technical flood defences
- flood prevention

Optimum flood protection is only possible if these three elements are tightly interwoven.

Floods in towns and cities come from the surrounding countryside, and so this is where effective flood defences must begin. A crucial element is natural water retention across the entire drainage basin of major rivers, in each of its tributaries and across its floodplains. Technical flood defences are constructed to prevent water overflow up to a given water-mark – in Bavaria this mark is generally set at a once-in-a-century event – and thus protect buildings and high-value infrastructure from flooding or waterlogged ground (erosion). As studies predict a clear rise in high water levels through to 2050 due to climate change, new flood defences planned since 2004 have included a climate-change supplement of 15 percent. Flood prevention measures in areas such as open space and building planning as

well as training and risk awareness can limit or even entirely avoid damage from flooding and reduce the unavoidable residual risk.

The Flood Control Programme 2020 will have to be adapted to climate change as it happens, particularly with reference to setting the height of flood defences (i.e. the climate change factor), to increasing water retention across the countryside, to reducing residual risks at flood defence installations at risk of flooding, and to keeping emergency overflow areas as reservoirs above and beyond general high water management processes. The flood risk management guidelines will evaluate and consider scenarios above and beyond the once-in-a-century class of high water event.

Out of the 2.3 billion Euros budgeted within the framework of the adaptation programme, 1.5 billion Euros have been spent to date on the following measures:

- an additional 400,000 inhabitants have received flood protection;
- around 55km of dykes have been moved away from the water, around 25km of new dykes built, and around 70 percent of the dykes erected before 1945 wholly or partially upgraded;
- water development concepts for waters of the first and second order are 78% complete;
- around 24 million cubic metres of retention space has been reactivated and 8.6 million cubic metres of retention volume created around waters of the third order;
- 764km of 2,500km of waterways and 1,883 hectares of 10,000 hectares of riverbank have been restored to their natural state;

- around 230 hectares of flood plain have been afforested;
- 78km of new flood defence walls have been built.

Preparing for droughts and dry periods

The current imbalance in the spatial and seasonal distribution of precipitation in Bavaria requires first and foremost increased protection for the supply of drinking water on a local and regional level by linking facilities or alternative ways of gaining water as fall-backs, especially in Franconia as well as the Bavarian and Upper Palatinate Forests, all of which suffer water shortages. Further to this, useable groundwater reserves and sensitive above-ground bodies of water need to be protected on a sustainable basis. Continued work on heat-wave and low-water management plans must be a priority.

The extremes of drought and flooding require secure water resources and an increasingly

integrated management strategy; securing large water retention areas both as flood protection and a means of replenishing the water table is of particular importance. The majority of these measures are planned in rural areas.

In order to be able to react to droughts in good time, low-water information services need to be expanded further in order to forecast and manage water table lows on a permanent basis. A total of 1.1 million Euros was spent between 2008 and 2011 to develop a low-water information service, and its internet presence at www.nid.bayern.de is being continuously broadened.

Water provision statement

In order to make the public provision of drinking water more resilient, the bodies responsible for water at a local authority level are being advised on where measures to improve the situation must be taken as a first



priority and which changes to supply infrastructure are needed from both an environmental and an economic point of view. To create an up-to-date knowledge base common to the State and local authorities, the water management offices have been coordinated by the Bavarian Environment Agency to record and evaluate public water provision. The health authorities and the local government bodies are involved in this project, begun in 2008 and planned to be completed in 2015 with a water provision statement for each administrative district. Total costs are estimated at around 3 million Euros, with around 0.9 million disbursed from the climate programme and another 1 million to date from the State budget (resources for water supply and groundwater protection). The resulting 2025 Water Provision Statement is already available for Lower Franconia and highlights the need for changes to individual water supply and water replenishment systems. Overall, it appears as if relatively isolated, small-scale measures taken on a local or regional level will suffice to provide Bavaria with the level of water supply security required far into the future.

Surveying groundwater

Another way of putting a figure on drinking water resources is to create an up-to-date overview of groundwater resources which have not yet been used but which are suitable for public water provision. In order to do this, the Bavarian Environment Agency, working together with water management offices, checked the groundwater survey areas from an earlier programme on measuring groundwater in Bavaria. This project was funded with 220,000 Euros from the Bavarian Climate Programme 2020.

Groundwater model for Middle Franconia

To create clarity regarding the long-term sustainable supply of drinking water in Middle Franconia, which suffers from water shortages, the Ansbach water management office has had a groundwater model produced for the underlying Keuper sandstone formations; this work received a grant of around 60,000 Euros from the Climate Programme.



Agriculture and forestry

Protecting groundwater

In order to support the sustainable protection of useable groundwater reserves in the best possible manner, a groundwater protection initiative to encourage sustainability and preventive action across a wide range of spheres has been opening up new avenues for integrated groundwater protection in Lower Franconia since 2011 and since 2008 in Upper Franconia. Future-orientated concepts were developed for communication and public relations work, sustainable development education, and less water-intensive farming methods. One such successful concept in Lower Franconia was the “water school”, which has since been extended across Bavaria; to date, around 6.4 million Euros from the State budget have been provided for this initiative, around 1.7 million of which is from the Climate Programme.

Covering more than 80 percent of the surface area of Bavaria, agriculture and forestry both stand to bear the brunt of the effects of climate change. Developing and implementing suitable adaptation strategies across all productive sectors of agriculture and forestry in order to secure their economic performance (combined revenue of 58 billion Euros annually) and maintain them both in their role as human landscapes and functioning ecosystems is a considerable challenge.

The focus of activity is on building up future-proof forests, protecting bio-diversity, and using water and land in a sustainable way. Results from research projects must be inputted into consultation for the agricultural industry.

The success and progress of forestry measures are dependent on which decisions are taken by the roughly 700,000 landowners with forest on their property in Bavaria. The Bavarian Forest Administration has a comprehensive assistance policy to help forest-owners help themselves.

Forest conversion projects

The aim is to convert around 100,000 hectares of the total of 260,000 hectares of acutely endangered spruce forest in private and publically-owned forests into climate-safer mixed forest by 2020.

From 2008 through to the end of 2012, over 29,000 hectares of new location-adapted mixed forest was created, with support from State funds. This process involved going new

paths, including holding regional forest-owner conferences, starting regional forest conversion projects with intense participation on the part of all stakeholders, and developing quick-reference “climate risk cards” to help forest-owners choose tree species. The newly-developed location information system will be a considerable boon to these efforts as of mid-2013.



Reaching and motivating forest-owners: Forestry Minister Helmut Brunner (left) on a fact-finding forest excursion

Alpine forests as protection (Bergwald initiative)

The aim is to maintain the alpine forests and their vital protective function in a sustainable manner in the face of major alterations to the climate by taking intensive care of and upgrading them in combination with effective hoofed game husbandry; a State-wide information system will allow for targeted reactions in regional risk areas.

In this context, the successful “Bergwald initiative” for alpine forest conservation is experiencing broad resonance among both

forest-owners and the general public. Through to the end of 2011, over 900 individual measures were implemented across thirty project areas, and the participation-orientated approach of the local groups newly-created to oversee projects increases acceptance of the initiative and helps to find solutions for conflicts of interest; the use of project managers as central points of contact and coordinators has proven to be especially effective.

Initiatives accompanying the alpine forest conservation programme include securing provision of hardy high-altitude seeds and plants, as well a forest information system for the north Alps (WINALP) financed via INTER-REG to provide information about the performance of all of the alpine forests in the region.

The positive momentum and the extent to which forest-owners and other stakeholders have been involved must be used to implement further measures in existing project areas and launch new projects.



“Bergwald initiative” – a comprehensive package of measures across broad swathes of forests, e.g. on Grünen in Allgäu

Nature protection

For decades now, nature has been subject to severe disruption due to losses of space, intensified human use, the compartmentalisation of living spaces, the extension of waterways and drainage: and now climate change represents a new category of threat to eco-systems – in particular those of the Alps, higher parts of the uplands, wetlands, and floodplains. This stands to have a considerable impact on the important functions of these eco-systems such as the shielding role of alpine forests, or water retention and carbon-binding in the moors. With the various effects of climate change, the danger of extinction becomes ever greater: forecasts of plant and animal species which will be lost due to changes in the climate in Germany over the coming decades range from 5 to 30 percent, and the danger is present that the eco-systems affected will no longer be able to fulfil their services to human society (soil fertility, water purification, air filtering, base materials for medicines, food production, etc.) to the same extent as is currently the case.

Due to climate change, the habitat of many species is set to shift, and this makes strengthening conservation measures crucial to maintaining eco-systems and their functions into the future. In order to preserve bio-diversity, the State-wide network of biotopes which are listed as conservation areas, involved in *BayernNetzNatur* projects or otherwise protected through contractual agreements, must be developed further.

The variety of functions which ecological systems can fulfil is not only a key factor in maintaining bio-diversity, but also serves to lessen the effects of changes to the climate; this makes preserving bio-diversity a contribu-

tion to active and to preventive climate protection in equal measure and represents far better value than carrying out technical “repairs”. These aims must be anchored in all areas of policy-making.

Special programme for stabilising biological diversity and eco-systems

- Linking habitats to create migratory paths for animals and plants
- Intensive link-ups for *BayernNetzNatur* projects with the European Natura 2000 ecological network (EU Habitats Directive and Bird Reserves)
- Mitigating the effects of barriers and dividers such as roadways, waterways, and intensively cultivated agricultural or forest areas
- Increasing the variety of niches and structures in standard countryside by means of local biotope link-ups supported by the Ministry of the Environment’s and the Ministry of Agriculture’s agricultural environment programmes
- Securing and developing areas of State-wide importance (nature reserves, protected areas of countryside, etc.) as core areas, links, and stepping stone biotopes
- Targeted measures to maintain species under acute threat



- The Ecological Alpine Alliance of Bavaria/Salzburg/Tyrol/Vorarlberg within the framework of the nature protection and landscape conservation protocol of the Alpine Convention; in preliminary discussions at the end of 2012, the regions involved agreed to use a geographical information system to identify the key areas for an Alpine alliance along a corridor extending to 50km along borders and to use these areas as a basis to develop a catalogue of measures.

Precautions for preserving natural carbon deposits and improving microclimates

- Maintaining and restoring natural flood plains
- Restoring 50 moors to their natural state by returning their water levels to a typical level by 2020 (2.5 million Euros earmarked annually)
- Measuring emissions of gases which affect the climate across a selection of test areas and monitoring biotic parameters (e.g. vegetation, macrobenthos)
- Supporting the development of climate-friendly agricultural practices on lowland moors, including reconvertng farmland back into wet grassland
- Improving microclimates in large conurbations, preserving and strengthening inner-city green areas and fresh air corridors such as meadows and valleys

Benninger Ried

The Benninger Ried is Bavaria's largest hard-water spring fen and is home to an endemic thrift (also called marsh daisy, of the *ameria maritima* family). This broad marshy area, rich in limestone and tuff rock, offers refuge to other endangered species, with 87 plants or animals on the red list. Due to groundwater drainage, these wetlands were drying out at an ever faster pace; between 2009 and 2011, the State of Bavaria and the Federal Government invested a total of 5.2 million Euros from the second economic stimulus package (25 and 75 percent respectively) to restore groundwater levels, meaning that the Benninger Ried now receives enough water to maintain its function as a reservoir of carbon and water into the future; this makes the Benninger Ried project an exemplary case of wetland restoration.

Contractual protection

In addition to securing upland moors, the conservation of marshy areas at lower altitudes (fens, lowland moors) as carbon reservoirs is also of considerable importance. Using contracts to protect nature by compensating for hardship, at present around 11,000 hectares of wetland are being preserved at a cost of 5.7 million Euros annually.

BayernNetz-Natur projects

Many of the current 378 *BayernNetz-Natur* projects have the aim of conserving upland or lowland moors, floodplains and their grassland ecosystems, or riparian forests; all of these environments have an important role as carbon reservoirs.

Protecting moorland in forests

Further potential is offered by protecting moorland in forests. The Ministry of Agriculture will, after implementing preparatory measures, take further action in the medium term, including:

- additional large-scale moor restoration in wooded areas;
- optimising existing restored moorland;
- accompanying research projects (e.g. greenhouse gas effect, climate-friendly use of lowland and transitional moors in forests).





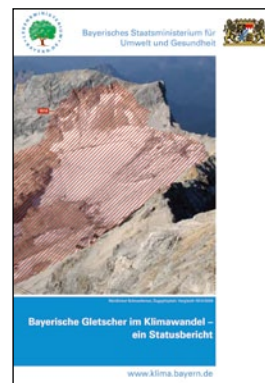
The Alps

Climate change is already making itself felt in Bavaria, especially in the Alps, where temperatures have risen twice as fast as the global average over the last 100 years. If “business as usual” continues, there is real danger that the Alps will experience temperature increases of 3 to 5°C in summer and 4 to 6°C in winter; this would have dramatic effects on the unique Alpine eco-system and its function both in water storage and as a recreational area.

Bavarian glaciers and climate change

As reservoirs of drinking water, as climate archives, and as (almost) untouched wonders of the natural world, glaciers are an important part of the geographical and ecological systems of the Alps. The earth’s glaciers are also warning signs of climate change, reacting as they do with unparalleled speed to alterations in the global climate system. Climate change is also a threat to the five alpine glaciers in Bavaria, which have lost volume, surface area, and length since the beginning of the industrial age in Germany around 1850. In 1820, the maximum extent of the Bavarian glaciers reached roughly four kilometres squared; today, at 0.7km², less than one quarter of them remains. The consequences are especially visible in this environment due to its variety of sensitive areas and undeveloped natural

landscapes within a relatively small space, and these consequences are increases in alpine hazards, threats to stores of drinking water, more intense flooding, and endangered mountain torrents, forests, and alpine flora and fauna.



The Bavarian Academy of Sciences has produced a status report about the Bavarian glaciers collated from the results of research to date on behalf of the State Ministry of the Environment.

→ <http://www.stmug.bayern.de/umwelt/klimaschutz/klimawandel/index.htm>

Alpine space projects – European cooperation between regions

Local authorities, businesses, government agencies, universities, associations and a range of other Bavarian organisations have already used the financial support offered by the European INTERREG initiative in order to work across borders together with partners from other European countries. INTERREG engages with a wide spectrum of topics and areas of activities, from preventive flood protection through to improved transport

infrastructure and activities to encourage tourism, as well as measures to reduce carbon emissions and to adapt to climate change.

Adapting to climate change in the Alps (AdaptAlp project)

From 2008 to 2011, the Bavarian Ministry of the Environment was the leading partner in the AdaptAlp project (Adaptation to Climate Change in the Alpine Space), the aim of which was to understand the effects that climate change is having in alpine regions and how natural hazards can be faced sustainably as they occur in order to protect human life, habitats, and infrastructure. Within the scope of the project, common strategies were developed which could be applied in response to climate change in the Alpine space and acting in concert across the region from the trans-national down to the local level.

- Project timeframe: 09/2008 – 08/2011
- Project budget: 2.9 million Euros
- 16 partners from 6 Alpine countries
- www.adaptalp.org

Processing and using knowledge to adapt to climate change in the Alpine region (C3-Alps initiative)

Based on the insights gained from AdaptAlp and other previous projects, the EU C3-Alps project (Capitalising Climate Change Knowledge for Adaptation in the Alpine Space) aims to synthesise findings and transfer them into an easy-to-use range of tools for decision-makers in the region. Its results make it easier for the Alpine countries participating to use knowledge about the effects of climate change on the Alpine region and to implement a joint adaptation strategy. Within the framework of the project, Munich University has been commissioned by the Ministry for the Environment to develop a "climate change readiness test" (*Klimawandel Fitness Check*), using two selected communities as examples. The results are to be made available to other communities as checklists and case studies.

- Project timeframe: 01/2012 – 12/2014
- Project budget: 3.1 million Euros
- 17 partners from all Alpine states
- www.c3alps.eu



Alpine building culture and energy efficiency (AlpBC project)

The AlpBC project (Alpine Building Culture and Ecology) is developing sustainable regional approaches to maintaining and further developing the Alpine building culture as one of the region's outstanding heritage aspects and with reference to its efficient use of energy and a range of other current challenges. Taking regional cultural identities as its starting point, the project fosters economic development, qualifies regional stakeholders to take part, and helps to maintain and increase the appeal of the Alps as a space in which to live and to holiday. AlpBC researches the potential for closed, intra-regional economic circuits which could be used in the construction industry and supports their development: as such, this project strengthens the sustainable use of regional building materials and furthers the take-up of renewable energies. As well as offering its share of financing, the Bavarian Ministry of the Environment will support the Munich and Upper Bavaria Chamber of Trades and Crafts as the lead partner in this project.

- Project timeframe: 09/2012 – 06/2015
- Project budget: 2.9 million Euros
- 12 partners from 6 Alpine countries
- www.alphouse.de

Developing and implementing sustainable energy concepts in the Alpine region on local level (SEAP_Alps project)

The aim of the SEAP_Alps project (Sustainable Energy Plans in the Alpine Space Area) is to make energy planning in the Alpine region easier. The Bavarian Ministry for the Environment will support eza! (Allgäu Energy and Environment Centre), the Bavarian organisation involved in the project, by means of a co-financing model.

- Project timeframe: 10/2012 – 05/2015
- Project budget: 2.2 million Euros
- 11 partners from 5 Alpine countries
- <http://seap.proto-type.de>

Soil conservation and geological risks

Preventive measures in soil conservation are especially necessary to preserve the soil's function as a filter and buffer zone, preventing pollutants from entering groundwater and maintaining the productive capacity of land used in agriculture and forestry. The research basis for these measures needs to be produced and adaptive strategies developed with a view to combatting possible increases in erosion, the release of CO₂ due to the decay of organic substances following humus depletion, changes to the water table in the soil, and acidification. This includes developing methods of working the earth and cultivating crops which conserve topsoil and are suited to the location in question, as well as setting out criteria with a solid research backing for the sustainable cultivation of renewable resources.

Geological risks such as slope movement, avalanches, mudslides, rock and stone-fall, subsidence, and sink-holes have always been a latent danger to life, property and infrastructure in the Alpine region particularly, but also in other parts of Bavaria; with the higher frequency of extreme weather events as a consequence of climate change, these risks are expected to increase in future. Geological risk factors are especially hazardous inasmuch as they are generally spontaneous, the exact moment of their occurrence is not easy to predict, and they have the potential to cause extreme destruction on a local scale. On the whole, there is no way of giving early warning and there are no general safety measures which can be taken. This means that only

precaution possible lies in identifying the potential hazards ahead of time, entering into intensive risk discussions, and avoiding hazards in the long term.

Project: Humus in Bavarian soils during climate change (2010 – 2013)

- Detailed breakdown of the components of humus in soil types
- Impact assessment of climate changes on humus

Geological risks: preparation and information programme

- Continuing the digital geological risks registry for the entire territory of the State of Bavaria to increase the level of preparation (risk categories: slope movement, avalanches, stone-fall, dolina, subsidence, sink-holes).
- Producing reference cards for geological risks with exact hazard prognoses and risk assessment for the Alpine region; continued from 2011 for other vulnerable areas of Bavaria such as the Alpine foothills and the Swabian-Franconian Jura.
- Maintaining constant risk dialog with the communities and citizens affected; entering information into the Bavarian soil information system (*Bodeninformationssystem Bayern*, BIS-BY) and building up an online reference by location for geological risk factors.
- Examining rockfalls on the permafrost border in a permanent observation station in the Zugspitze Massif, integrating data collected into the EU-wide research and recording network PermaNET.

Trade and industry

Business and climate change

Climate change and its effects also present a challenge to the business community, which will require strategies and techniques to deal better with the unavoidable consequences of climate change. Adaptation is a way of preparing for and taking precautions against future risks; it should be remembered that the processes of adaptation may also become the driver of sustainable management.

Climate adaptation for innovation

The effects of climate change will be felt strongly in particular by companies in the hospitality trade and transport sector, but the financial services and insurance sectors as well as manufacturing industries will feel that they too are being hit overproportionally. Businesses are focussing overwhelmingly on classic areas such as energy and materials savings (reducing emissions), but adaptation strategies such as a new product portfolio are not yet of any relevance in most companies.

Trade and industry are dependent on access to water, energy, and functional transport infrastructure. Natural hazards occurring with increased frequency either at business locations or where employees, suppliers, or customers live and work can lead to reductions in and interruptions to production; periods of low water could hinder the delivery of raw materials by ship, while a temporary lack of water – especially for cooling – can interfere with industrial processes. Highly perishable food products place particular demands on manufacturing, processing, storage and transport facilities, and logistics companies will be affected directly. Technologies and products such as cooling systems and air filters will have to be adapted to changed conditions (i.e. water supply, temperatures), while possible responses such as using solar cooling or waste heat bring with them a huge potential for innovation. Companies which invest in environmental technologies will profit from adaptation to climate change.

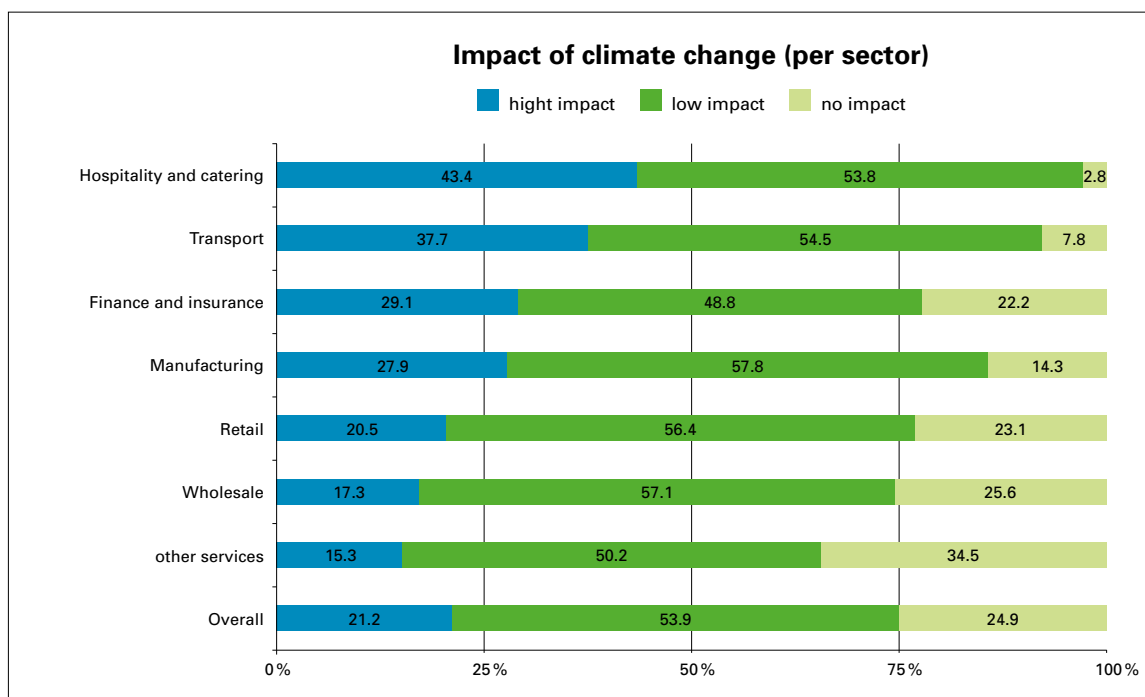




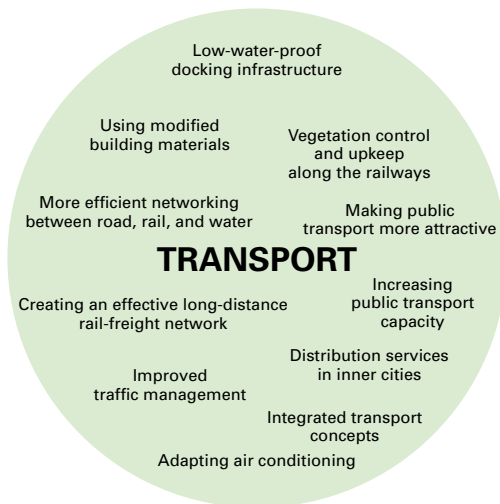
Sector-specific climate agendas

For the first time, the Bavarian Ministry of the Environment and the Bavarian Chambers of Commerce and Industry have produced sector-specific climate agendas, taking tourism, transport, and energy providers as examples. A climate agenda takes a scenario as a basis on which to elucidate the consequences of climate change for a specific sector of trade and industry and the risks and opportunities

proceeding from them, as well as ideas on formulating strategies and innovations. These agendas will help companies navigate their way through climate change and offer them advice on how to face up to the challenges posed by it. This project was carried out as part of the Bavarian Environmental Pact and is to be extended to cover other sectors.



Impact of climate change per sector according to a survey of more than 1000 companies in Upper Bavaria commissioned by the Bavarian Ministry of the Environment and the Chamber of Commerce and Industry for Munich and Upper Bavaria (2009)

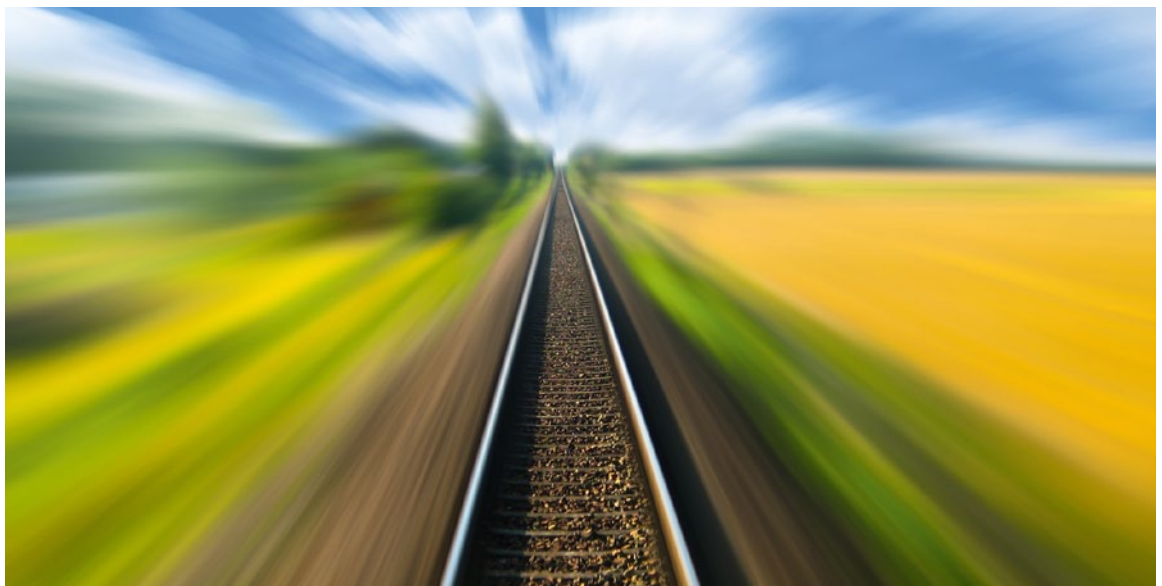


Overview of potential measures for the transport sector

The Climate Dialogue Network

In order to provide a permanent setting for dialogue and exchanges about adapting to climate change, the Climate Dialogue Network

was set up in 2011; it is being built up and run by the Bavarian Industry Association (co₂ncept plus). The aim of this network is to link every stakeholder affected by climate change, to raise awareness within companies, to highlight areas in which action can be taken, and to inject momentum into climate adaptation measures. This network is open to all members of the business community, but is especially aimed at participants in the Bavarian Environmental Pact.



Health

Climate adaptation in construction (Building design and technical solutions)

Due not least to the expectation that they will offer their occupants adequate protection from external influences – above all weather conditions – high demands are placed on buildings and their technical equipment. Wind, lightning, rain and storms, snow, groundwater, sun, and the atmosphere all have their effects on buildings, and increases in stress factors such as wind, snow, and heat can lead to impairments in building functionality (interior climate) and damage to their structure (exterior shell, stability); the same is true of alterations to the ground conditions surrounding the building (ground consistency, increased surface water etc.). The changing influences and effects on the construction and use of buildings cannot yet be quantified, yet all those involved in the planning and construction processes must take account of alterations to the climate. One instance of adaptation to climate change is preparing for increased heat intake in the building due to higher average summer temperatures.

The population of Bavaria stands to be affected by climate change in a number of ways.

- In summer, heat-waves will occur with greater frequency and higher mortality is to be expected. The elderly and those in need of care, as well as people suffering from cardiovascular diseases, will be particularly affected.
- With higher water temperatures, aquatic micro-organisms will multiply, and this could represent an infection hazard. The water quality at swimming sites may decline overall.
- Rises in air temperature represent ideal conditions for insects such as ticks and mosquitoes, which are carriers of infectious diseases. Furthermore, new carriers and new pathogens may gain a hold, and an increase in allergic complaints should be expected.

Many of the negative effects of global warming on public health can be mitigated or even completely prevented by taking appropriate precautionary measures.

Heat-wave warning system

As of July 2007, health authorities, government agencies, radio and television stations, and care homes receive regional heat-wave warnings and heat forecasts directly from the German Meteorological Service.

Research and development for climate and environmental protection



Eco-systems and ecological balance

Research and development are the basis for developing well-founded strategies for adaptation, damage prevention, and precautionary measures. An important aspect of this is to examine the specific effects on Bavaria of the fundamental results of climate research in order to produce prognoses that are of use on a regional level, with due consideration to specific sub-regions such as the Alps.

FORCAST: the Bavarian research alliance for the impact of the climate on eco-systems and climatic adaptation strategies

The effects of global climate change are having an increased impact on a regional level, and this is the starting point of the Bavarian research alliance for the effects of the climate on eco-systems and climatic adaptation strategies (*Bayerischer Forschungsverbund FORCAST*), supported within the framework of the Bavarian Climate Programme 2020. Over the course of four years, this interdisciplinary alliance of around sixty academics across ten universities and external research institutions examined extreme climatic events. Serious consequences of climate change include increases in the frequency and intensity of extreme weather such as droughts, storm rainfall, and flooding, as well as long periods of frost; these extreme events are increasingly leaving traces in eco-systems. The focus of the research work was on eco-systems which define the Bavarian landscape – forests, grasslands, moors, water bodies – with basic concepts for how to adapt these eco-systems to climate change. FORCAST was the first group to research intensively in this area.

The results of this research are important to protecting the climate, the natural environment, and the species which populate it. They show that strengthening biological and genetic species diversity is a substantial plank in building up the resilience of eco-systems during climate change. The diversity of the Bavarian landscape is also of considerable importance to the survival of the State's species in a changing climate. The services

which eco-systems provide need to be stabilised further in order to keep protective mechanisms in place which strengthen themselves.

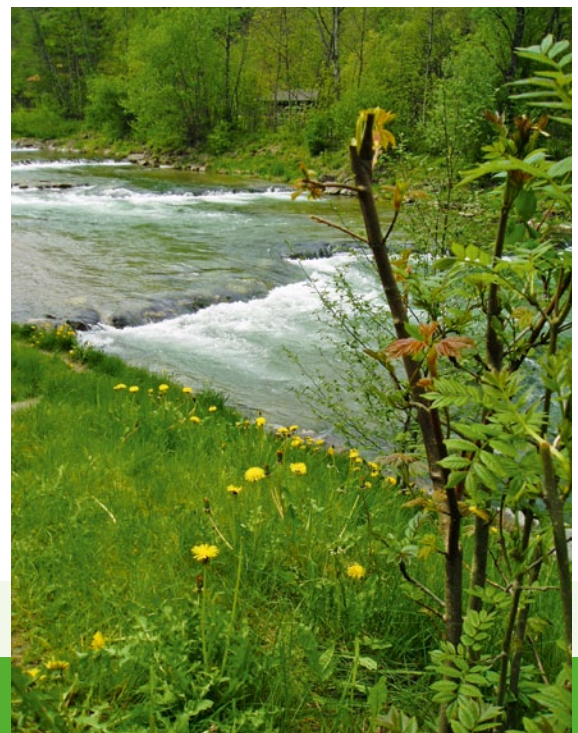
- The research shows that grasslands in Bavaria's low altitude areas have a high level of natural bio-diversity and therefore a high tolerance to changing climatic conditions; it is reasonable to assume that this resilience can be preserved, especially with extensive use of the land.
- In the case of the forests examined in the FORKAST initiative, the effectiveness of conversion measures already being taken – i.e. supplementing sensitive types of tree such as spruce with more tolerant species, especially in dry locations – was confirmed. Creating the conditions for a mixed oak forest interspersed with clearings and featuring lime, chequer, and sweet chestnut trees can be advantageous.
- Bavaria's soil also reacts sensitively to extreme weather events such as long periods of drought. The activity of micro-organisms in interaction with physical and chemical environmental conditions in the soil, however, enabled quick recovery in the areas investigated as soon as precipitation returned. The adaptability of the soil – the resilience it retained – is increased by extensive land use.
- Bavaria's bodies of water stand to be affected by a warmer climate. Increases in average water temperatures will have a lasting effect on aquatic colonies, with plants from warmer regions (neophytes) spreading often very rapidly along the banks and posing a threat to domestic flora.

The FORKAST research alliance has been of decisive importance both to climate research in Bavaria and on a national and international scale. Its results present policy-makers, society, agriculture, nature protection and, not least, follow-up researchers with a broad set of challenges.

→ www.bayfor.org/forkast

KLIWA – Climate change and its impact on water management

As a result of climate change and its regional effects, we must get used to an increase in extreme weather events. It appears almost certain that there will be not only more storm rain in the future, but also more periods of heat and dryness. For water management, this means estimating the possible effects and developing adaptation strategies to deal with them, finding ways for each area to adapt to these changes.





Since it was set up in 1999, 4.7 million Euros have thus far been spent on the KLIWA cooperation with the states of Baden-Württemberg and Rhineland-Palatinate (since 2007) and the German Meteorological Service.

Climate monitoring within the KLIWA framework has the aim of documenting the long-term behaviour of a selection of meteorological and hydrological parameters which can offer indications regarding alterations to the climate in southern Germany at regular intervals. To date, these long-term studies have been published as KLIWA reports and as a first monitoring report in 2008; the current climate monitoring report of 2011 contains up-to-date information about and analysis of changes to the regional climate and water stocks in Baden-Württemberg, Bavaria, and Rhineland-Palatinate through to 2010. The studies covered by this short report are the continuation of the long-term research projects KLIWA is carrying out and describe important events

with due consideration to the changes over the last ten years.

Bavarian Climate Report

Experts at the Bavarian Environment Agency have, for the first time, produced concrete climate projections for Bavaria based on the global findings relating to climate change. The results of their study were published in the Bavarian Climate Report (*Klimabericht Bayern*) and in nine regional reports orientated to river catchment basins (www.lfu.bayern.de/wasser/klima_wandel/index.htm). Their analysis shows a State-wide average annual temperature rise of more than one degree Celsius through to 2050 (as compared to the period between 1971 and 2000); some projections are even above two degrees Celsius. This is a continuation in the trend of previous decades, and the rise of the average annual temperature means fewer days on which the temperature drops

below zero degrees Celsius; conversely, there will be an increase in hot days on which the maximum temperature will rise to above thirty degrees Celsius. Especially in the six summer months, longer periods of drought are expected with higher frequency, with reduced drainage and low water levels in Bavaria's river systems; precipitation in the winter half of the year may increase slightly.

Climate research

All of the eco-systems which make up the Bavarian landscape will be affected by climate change: mountains and uplands, forests, grasslands, marshes and lakes. Protecting the animal and plant kingdoms using long-term monitoring, up-to-date research into controversial problems, and developing sustainable adaptation measures in these eco-systems stands as the guiding principle for the Ministry of the Environment's climate research. The

following projects are examples of its areas of focus.

Effects of climate change in the sensitive Alpine area

- With the help of a comprehensive network of climate stations in the Berchtesgaden National Park, atmospheric parameters in the highland mountains are being recorded and evaluated together with the results of phenological research into Alpine flora and fauna.
- Within the framework of the KLIMAGRAD project and cooperating with the Munich Botanic Garden and the Schachen Alpine Garden in the Zugspitze Massif, a group of researchers from Technische Universität München, the Ludwig-Maximilians University Munich, the University of Augsburg, and the Helmholtz Centre in Munich has been investigating how indicator plants at



high altitudes behave under the influence of climate change. The results show that the vegetation period of mountain plants, as well as the composition of species and their habitat, change. Long-lived plants with a slower rate of spread, as well as isolated species, face clear disadvantages as they are almost incapable of migrating to higher altitudes.

- Meteorological data and wind patterns in atmospheric depressions which can lead to extreme precipitation in the regions of the Alps and their foothills which drain into the Danube are being examined in a joint research project with Austria (abbreviation: WETRAX). The participants are the Federal Institute of Hydrology, the German Meteorological Service, the Bavarian Environment Agency, the Central Institute for Meteorology and Geodynamics (*Zentralanstalt für Meteorologie und Geodynamik* – ZAMG, Vienna) and the University of Augsburg.



- The vulnerability of the springs – and therefore that of the eco-systems in floodplains close to the springs and the groundwater – is being investigated by the hydrologic and botanic research of the University of Bayreuth in the northern Bavarian uplands.

Effects of climate change on water

- As research by the limnological station of the Technische Universität München conducted in cooperation with the National Aeronautics and Space Research Centre (DLR) has demonstrated, Bavaria's lakes stand to be affected by climate change. By distance logging of the spread of neophyte species and warm-climate plants, management measures for aquatic plants such as water nymphs (*Najas intermedia*) and waterweeds (*Elodea nuttallii*), this research produced a predictive model for the degree to which Bavarian lakes will be affected.

Effects of climate change on wetlands and moors

- In cooperation with the Bavarian Society for the Protection of Birds (*Landesverband für Vogelschutz in Bayern e. V.*, LBV) and in consultation with the Munich Reptile Sanctuary – both members of the Bavarian Climate Alliance – a study was launched to investigate the extent to which restoring the water table in moor and wetland areas used by agriculture and forestry encourages higher populations or the return of species living in this habitat threatened by climate change, such as the crossed viper (*Vipera berus*).

- Researchers in the Weihenstephan Centre of Life and Food Sciences of the Technische Universität München can detect evidence of extreme weather events resulting from climatic conditions far back into the past by taking soil profiles from the moors of the Ammer mountains. Their research shows how nature responded to extreme weather events in the past; from this, the researchers were able to elaborate principles for landscape management in the present which will increase the resilience of eco-systems affected.

Effects of climate change on grasslands

- Storm rain and other extreme weather events influenced by the climate such as long periods of drought can lead to impairments in the productivity and health of crops and plant associations in grasslands due to water-logging, lack of oxygen, dryness around roots. The Helmholtz Centre in Munich is investigating the defence mechanisms and tolerance of selected indicator plants such as leaf mustard (*Brassica juncea*) and is working on recommendations for using and adapting wet-dry farmland.
- Working under the heading of “Ecological potential in climate adaptation” both in greenhouses and in the field, the University of Bayreuth has been researching how plant associations in extensively used grasslands react to the switch between generally warmer winters and individual extreme weather events such frosts.

Effects of climate change on specific indicator eco-systems

- Using long-term wall and tree mapping, the Bavarian Environment Agency discovered that lichen in this habitat is an excellent bio-indicator for the consequences of climate change: it could be demonstrated that thermophilic species of lichen are climbing higher on walls and trees and that species adapted to mild temperatures are increasingly migrating into Bavaria. This project shows the importance of long-term monitoring of animals, plants, and other organisms in recognising the consequences of climate change better and earlier and introducing suitable adaptation measures.



Adapting to climate change in urban areas

Climate change poses major challenges to towns and cities: due to the density of buildings, constant inward migration, economic activities, and reliance on transportation, urban areas react particularly sensibly to climate change. By the same token, nature must be given more space within towns and cities, and urban greenery forms a part of the Bavarian climate adaptation strategy. Green spaces within built-up areas offer both a higher quality of life and protection for city-dwellers, and act as refuges for all forms of life. In view of climate change and the threat of heat-waves, urban greenery also provides valuable eco-system services such as shadow, moisture retention, fresh air corridors, and relaxation space – especially for the elderly – as well as bio-diversity preservation. Urban greenery requires both active design to help it adapt to alterations in the climate and the opportunity to expand naturally as a conservation measure.

Within the framework of a workshop titled “Green City Climate” in May 2012 drawing together experts from local authorities, Climate Alliance members, and universities, existing strategies in research and everyday practice regarding urban greenery were discussed. The needs analysis showed that action was required in advising and accompanying exemplary projects at local level, in making information available and collating suitable approaches as demonstrated by Bavarian towns, and in developing innovative and sustainable approaches to urban greenery and climate adaptation.

For this reason, the Ministry of the Environment has commissioned Technische Universität (TU) München to carry out a research project in this area of great importance for towns and cities today, aiming to produce a range of solutions which will recognise and use synergies between climate policy and natural assets. These include: eco-system services, value creation by means of energy-efficient and sustainable urban developments and landscapes, the wellbeing of urban populations in view of climate change and demographic change, nature conservation and protecting eco-systems in the city. This project aims to bring together architects, civil engineers, and scientists in an inter-disciplinary fashion.

Nuremberg’s Kaiserburg as an example of energy-efficient refitting in listed historical buildings

The Bavarian Ministry of the Environment is providing 75,000 Euros of funding to a research project with the Georg-Simon-Ohm



University of Applied Sciences in Nuremberg for a feasibility study on energetic refurbishing of listed buildings, using the city's castle as an example. This project is intended to show how climate protection, energy savings, and energy efficiency, as well as use of renewable energies and resource conservation, can be brought into harmony with the requirements of listing regulations for historical buildings.



The Kaiserburg in Nuremberg

Effects of climate change on sustainable approaches to infrastructure projects

Working with the Bavarian Chamber of Civil Engineers (*Bayerische Ingenieurekammer Bau*), a partner in the Climate Alliance, the Technische Universität München examined how sustainability and energy efficiency could be better integrated into the planning and implementation of large-scale construction projects (e.g. bridges), thus laying an important foundation for climate protection.



Agriculture and forestry research programme

Agriculture

The aim is for research projects to produce concrete advice for agriculture in practice and to create a basis for cultivating new strains of plants in order to secure plentiful and high-quality harvests even under altered climatic conditions.

The agriculture research projects focus on the following questions:

- nutrient and water levels in soils and plants, including how to optimise irrigation;
- the effects of new techniques in working the soil (preserving soil structure, optimising water intake, protecting against erosion);
- examining the reaction of genetic plant resources to climate stress.

Both the Bavarian Agricultural Institute (*Bayerische Landesanstalt für Landwirtschaft*) and the State Institute for Viticulture and Gardening (*Bayerische Landesanstalt für Weinbau und Gartenbau*) offer information on their websites about these research projects and further material:

→ www.lfl.bayern.de/arbeitsschwerpunkte/klimaaenderung/

→ www.lwg.bayern.de/37817/



Forestry and woods management

In order to convert forests and woods, climate-adapted recommendations for tree species are needed, and this requires a rapid reworking of the location cards used State-wide; concepts for forest management and conservation (preventing and combatting damage) must also be updated to fit altered climatic conditions. High-altitude wooded areas especially are at risk from climate change and can no longer exercise their protective functions: stocks in danger need to be identified in order to target the resources required to care for and upgrade them. The increased, sometimes first-time appearance of pests which can have economic consequences (e.g. bark beetles and oak processionary moths) necessitates further development of existing prevention and control strategies; the focus of forest research lies on the following areas:

- adapting existing location cards and tree species recommendations;
- identifying alpine forests which are at risk from climate change;
- pest prevention in forest environments.

From 2008 through to 2012, the forest administration supported or carried out around 25 research and development projects relating to forests and climate change, including:

- future-proof tree species (stress tolerance and cultivability, location transfer tests with selected domestic species, test cultivation of trees from abroad);
- a scientific basis for species-related quick-reference climate risk cards, along with a digital location information system (future mapping) and the INTERREG forest information system project for the northern Alps (WINALP);

- risks of forest fires and storm damage as well as pest infestation (hazard models and maps, monitoring systems);
- the potential of forests and wood products for binding carbon (climate benefit of woods and wood as a product, comparing a range of management strategies);
- new possibilities for using climate-tolerant species of deciduous trees (e.g. laminated beechwood)

The Bavarian State Institute of Forestry (*Bayerische Landesanstalt für Wald und Forstwirtschaft – LWF*) offers an overview and more detailed information on its website at www.lwfdirekt.de/klimasymposium.

It is now imperative to keep introducing these findings systematically into day-to-day practice, with a continued research focus on long-term forest climate change monitoring using state-of-the-art satellite-based remote observation, as well as examining tree species at the border of their habitats and investigating ash dieback from fungus.

A solid concept – using deciduous tree wood in construction

Climate change will make forest conversions necessary which will, in the long term, lead to more deciduous wood being available; beech especially will play an important role. For many forest owners, however, cultivating beech and other deciduous trees is, due to the frequently limited possibilities of using them, an unattractive business prospect; this means that forest owners and woodworking industries must be offered perspectives for the increased use of deciduous tree wood. For this reason, the

Ministry of Agriculture has initiated a research project at the Technische Universität München and is following it intensively: over years of research work, a new laminated beechwood product was developed and has now been cleared for use in the construction industry. Due to its higher strength as compared to coniferous wood, the laminate has considerable potential and allows for slimmer, architecturally more advanced wood-builds. This component was used for the first time on a large scale at an extension for the Bavarian State Institute of Forestry in Freising; the completed building acts as an example and a real-life reference, showing everyone in the chain of forest warden, timber industry, structural engineer, and architect what can now be done with beechwood.



Beechwood laminate

Health

Climate change is already tangibly affecting our environment: alterations to the climate do not only have an impact on people, but also on animals and plants: the number of small organisms which transmit infectious diseases through stinging and biting – known as vectors – is increasing, with ticks, sand flies, and tiger mosquitoes spreading.

Impact of climate change on vector borne pathogens

A study called “Vector borne Infectious Diseases in Climate Change Investigations” (VICCI) conducted research into the complex interaction of possible effects of climate change in relation to vectors and the micro-organisms they carry which act as pathogens for both human and animal diseases in Bavaria.

This initiative brought together human and veterinary medics, parasitologists, bio-geographers, and epidemiologists from both universities and other research institutions, as well as from the Bavarian State Office for Health and Food Safety (*Landesamt für Gesundheit und Lebensmittelsicherheit – LGL*) in collecting field data which was extrapolated across a range of climate models.

Besides tick-borne diseases such as Lyme disease (Lyme borreliosis), hantavirus spread by rodents and leishmaniasis transmitted by sand flies are infections which could increase as a result of climate change. The research also focussed on identifying risk areas and infection chains as a substantial basis for developing inoculations and therapeutic agents.

Dependent on further developments, it will be possible to produce prognoses for infectious diseases and, if necessary, to take preventative measures at an early stage.

→ www.lgl.bayern.de/das_lgl/forschung/forschung_interdisziplinaer/fp_vicci_index.htm

Background

Climate change is already happening. The complex biotopic structure of infectious diseases, consisting of host, pathogen, and vector (carrier) is being continually modified by climate change; at the same time, climate change and its impact represent a complex interplay of wholly diverse factors with both direct and indirect effects on human health, as well as on that of plants and animals, which has remained almost impossible to depict in its entirety.

Direct effects such as heat stress, air pollution, or increased pollen counts tend to weigh most heavily on those who are already in poor health; indirect effects are noted above all in infectious diseases transferred by vectors – especially biting insects and ticks – which affect the population as a whole. These vectors may benefit from climate change and be able to spread towards polar regions – i.e. from south to north in Europe.

A striking example is the rapid expansion of West Nile fever in North America after increases in average temperatures. In Europe, the extent to which the tiger mosquito has established itself serves as a warning, although it has remained seasonal and regionally limited to date.

A climate-related increase in tick numbers, too, is under discussion. Warmer winters may well allow ticks and other parasites to survive better, both raising their populations and extending their habitat northwards. An important index in this context is the extent and frequency of the tick-borne encephalitis (TBE) in Germany.

Just how markedly the public health consequences of climate change manifest themselves will depend more than anything on the adaptive capacity of the societies affected. As well as the availability of infrastructure and technological solutions and the design of public health policy, the development of monitoring and prediction systems will be an important foundation for an effective defence against future climate-related risks to public health.



Environmental technology

Innovative environmental technologies can make an important contribution to climate protection. In the transport sector, for instance, energy-efficient vehicles, innovative forms of clean biofuels, and new engines such as electric motors are important climate protection components.

Electromobility

Bavaria intends to be at the forefront of electromobility and is investing a total of over 100 million Euros within the framework of its proactive future-facing strategy (www.stmwivt.bayern.de/wirtschaft/industrie/zukunftsoffene-elektromobilitaet). Important areas of focus in research offer additions to federal and EU activities and include battery technology, lightweight construction, and engine development. The State of Bavaria funds innovative examples of electric transport in action in rural areas with more than 37 million Euros as a part of the model towns initiative in Bad Neustadt an der Saale and Garmisch-Partenkirchen as well as the E-WALD model region in the

Bavarian Forest districts of Cham, Freyung-Grafenau, Regen, Deggendorf, Passau and Straubing-Bogen.

Research emphases are being set by the Fraunhofer Institute for Integrated Systems and Device Technology (*Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie*, IISB) in the area of power electronics, the project group on electricity storage technology at the Fraunhofer Institute for Chemical Technology (*Fraunhofer-Institut für Chemische Technologie*, ICT) in Garching, and the Centre for Applied Electrochemistry's work in energy storage and conversion for transport at the Fraunhofer Institute for Silicate Research (*Fraunhofer-Institut für Silicatforschung*, ISC) in Würzburg. Other research priorities are carbon fibre technology at the users' centre of the Institute for Machine Tools and Industrial Management in Augsburg, the Technische Universität München with its centre for electromobility, the Friedrich-Alexander-Universität Erlangen-Nürnberg with its EIDrive-Centre, as well as the Universities of Applied



Sciences at Kempten and Würzburg-Schweinfurt and their technology transfer centres. Since 2009, the Bavarian electromobility programme has been supporting research and development projects and plans for cooperation within single companies which offer high innovation potential for testing electric vehicle prototypes or systems and components needed for them.

In addition to this, the States of Bavaria and Saxony are supporting an industry-driven project which has been selected by the federal government: "Electromobility connects" (*Elektromobilität verbindet*) is receiving 30 million Euros as a cross-state showcase project (www.elektromobilitaet-verbundet.de).

Regenerative diesel

With the innovative regenerative diesel fuel, the Ministry of the Environment is supporting a future-orientated, climate-friendly fuel, which has proven itself in a fleet test overseen by the University of Coburg, recognised across the world for its expertise in fuels. The Federal Ministry of Transport praised this pioneering project and thanked the State of Bavaria for its important contribution to the national fuel strategy. Regenerative diesel is a fuel made of hydrated canola mixed with up to seven percent biodiesel; it was tested in a large-scale fleet trial, with eleven VW and Audi vehicles from the fleets of the Ministry of the Environment and the University of Coburg filled up with regenerative diesel for a whole year, with

two OMV petrol stations in Munich and Coburg available for this purpose. All of the vehicles drove in everyday traffic with no problems occurring, saving around 50 percent CO₂ as compared to fossil diesel. The tests further showed that regenerative diesel emits considerably lower levels of hydrocarbons, carbon monoxide, and exhaust particles than conventional diesel fuel, and the Ministry of the Environment has funded this project to the tune of 120,000 Euros in a co-financing initiative with European Union resources. Regenerative diesel can be developed to market maturity and used to fuel existing diesel engines; it can also be sold via the existing network of petrol stations, and it is now the responsibility of market participants to start going down the regenerative route and helping to further optimise it.



State Secretaries Melanie Huml and Rainer Bomba (Federal Ministry of Transport)

Energy and resource efficiency

In order to strengthen climate protection in a sustainable way, the efficiency with which energy and resources are used must be raised; this is a challenge being tackled by many, including two interdisciplinary research alliances supported by the Bavarian Climate Programme 2020.

The Research Alliance for Energy-Efficient Technologies and Applications (FORETA)

Under the FORETA alliance, 13 university institutes and two non-academic institutions with 37 small-to-medium-sized businesses participating have spent three years working together on a series of exemplary solutions and applications to increase energy and resource efficiency in sectors affected with a view to sustainably decreasing their energy requirements. Due to the close cooperation between academia and businesses, the innovations created in the process are sure to find their way into everyday use quickly.

→ www.bayfor.org/de/foreta

The Power Stations of the 21st Century Research Alliance (KW 21)

The Power Stations of the 21st Century initiative - KW 21, shared between Bavaria and Baden-Württemberg, is an alliance bringing together a total of 23 research groups composed of academics from seven universities and research institutes with eleven companies in the power generation industry. Over eight years, more than 70 projects in all core areas of today's power station technology have been carried out, supplemented by energy-economic analyses and strategies conceived both from business and wider economic, as well ecological, perspectives. With its results, the alliance is providing a substantial contribution to making the power stations of the future more efficient, more cost-effective, and more environmentally friendly – especially with a view to reducing carbon emissions.

→ www.bayfor.org/de/kw21



Bavarian concept for technological research and development in the energy sector

The Bavarian concept for technological research and development in the energy sector comprises a range of initiatives examining energy and resource efficiency. Decisions made by the State Government on this matter (May 2012) are based on recommendations made by experts from academia and business, and by way of example it will suffice to mention the EIHome-Center, the Bavarian technology centre for resource-efficient and intelligent living (under the leadership of the Friedrich-Alexander-Universität Erlangen-Nürnberg), the Green Factory Bavaria researching less resource-intensive forms of production (Fraunhofer-Gesellschaft, Universität Erlangen-Nürnberg, Universität Bayreuth and Technische Universität München), the combined heat and power competence centre (headed by the Amberg-Weiden University of Applied Sciences), the initiative into strategic resource concepts for future-proof energy systems (University of Augsburg) or the Fraunhofer project group for materials cycles and resources strategy in Alzenau.

→ <http://www.stmwfk.bayern.de/forschung/energieforschung/>

Waste and sewage management

Both waste and sewage management possess considerable potential for climate protection in terms of saving energy and conserving resources, and exploitation of this potential must be intensified. Demonstration projects are intended to show how the energy requirements (electricity, heat) of sewage treatment plants can be reduced and how sewage and sludge can be used to generate energy. Improved use and recycling of materials, as well as a more effective input of materials, contribute to CO₂ reductions.

Climate protection in waste and sewage management

- Reducing greenhouse gas emissions by means of waste management measures (development and practice tests)
- Exploiting potential for reduced energy requirements in sewage treatment plants
- Using sewage and sludge as an energy resource



Hydrogen technology and sewage works

A study into producing and using hydrogen and oxygen at sewage treatment plants came to the conclusion that there is neither a short-term nor a medium-term economic or ecological benefit to erecting hydrogen infrastructure in sewage works. 48,000 Euros were spent on conducting this study.

Using the energy-saving potential of sewage treatment plants

The sewage plant of the future will be an integral part of public infrastructure and will have to do more than just purify water to the best standard possible in an energy-efficient way; it will also have to generate climate-neutral energy (electricity, heat) and recover elements such as phosphorus and make it

possible to use heat from sewage and sludge. A dedicated initiative to support energy efficiency analyses, set up to improve the energy efficiency of sewage treatment facilities, was used by 121 sewage treatment plant operators, who received a total of 1.021 million Euros in funding. The results have shown that, on average, energy savings of around 18% could be achieved and that electricity production from digester gases could be increased markedly. This initiative is complemented by three pilot projects funded by the Ministry of the Environment:

- pilot project on using sewage heat in the town of Straubing;
- pilot project into refitting the Bad Abbach sewage works with an anaerobic sludge treatment facility
- pilot project into ammonia removal at the Ingolstadt central sewage treatment plant.

Optimising the ecological efficiency of fermentation plants by integrating them into thermal use of waste

Waste facilities dealing with organic waste are sources of greenhouse gas emissions (methane, nitrogen), and in this research project, integrated fermentation concepts at the Bavarian incinerator power plants of Geiselbulach, Burgkirchen and Augsburg were investigated: these concepts included capturing climate-negative gases during the fermentation process and burning them in the incinerators.

The results revealed a wealth of positive synergy effects for the integrated fermentation concepts, especially in terms of improved ecological efficiency and reductions in the per-tonne waste disposal costs as compared to a standard Bavarian fermentation plant. The work also showed that the measures planned to reduce emissions and mobilise all combustible elements of organic waste had the additional effect of improving the overall environmental impact of the sites.

Both integrated processes and combustion had a positive environmental and climatic impact. If the resource efficiency aspect is also taken into account in the environmental evaluation, as provided by phosphorus from the solid fermentation residue, a clear advantage for integrated concepts can be discerned as against treating organic waste in a standard incinerator.



Schneefernerhaus Environmental Research Station

The Schneefernerhaus Environmental Research Station (*Umweltforschungsstation Schneefernerhaus*, UFS) is, together with the observatory on Hohenpeissenberg, Bavaria's centre for weather and climate research. At 2,650 metres' altitude, Schneefernerhaus is Germany's highest research station, and due both to this location and to its scientific and technical infrastructure, it is a unique platform for continuous observation and investigation of the atmosphere and for research into processes with relevance for the climate and for the weather.

Over the last ten years, scientists on Zugspitze have used cutting-edge methods of taking measurements to gain insights of no small importance; the results of their research have been in used in international projects run by both NASA and ESA, as well as the United Nations' World Meteorological Organisation (WMO).

Schneefernerhaus was opened as an environmental research station on 12th May 1999, creating a high-altitude research facility which has the potential to deliver scientific findings at the very highest level for use in developing a reliable climate protection strategy for the future.

In a meeting at Schneefernerhaus on 24th April 2007, the Bavarian Council of Ministers approved the overall organisational structure of the research station for the future; the high-point of this reorientation was the signing of the consortial agreement on 16th July 2007 which gave birth to the Virtual Institute for Environmental Research at Schneefernerhaus (*Virtuelles Institut Umweltforschungsstation Schneefernerhaus*, UFS). Several research organisations of worldwide reputation were among the first to sign up for this cooperation:



Schneefernerhaus Environmental Research Station

- National Aeronautics and Space Research Centre (DLR)
- German Weather Service
- Karlsruhe Institute of Technology,
- Helmholtz Zentrum, Research Center for Environmental Health and Environment
- Federal Environment Agency and
- The State of Bavaria, with its agencies, first and foremost the Bavarian Environment Agency

Further partners later joined the initiative:

- Technische Universität München (in 2007)
- Ludwig-Maximilians-Universität München (2008)
- Universität Augsburg (2009)
- Max Planck Society (also 2009)

The UFS receives financial support from the Free State as part of the Bavarian Climate Programme 2020; funds were used to extend the protection against rockfall and avalanches and to replace the old “new cable car” with an up-to-date research cable car system.

→ www.schneefernerhaus.de

Core research topics

The UFS was set up to address issues in the following areas:

- developing, demonstrating, and running innovative climate and atmosphere observation technologies
- quality assurance of satellite-based data sets and informational output
- analyses regarding understanding of processes in the climate system
- environmental and high-altitude medicine

- early detection of natural hazards
- environmental radioactivity and cosmic radiation

Observations of clouds, aerosols, radiation, and water vapour all enable us to increase the depth of our understanding of the climate system. These activities are interwoven into the international, NASA-coordinated Network for the Detection of Atmospheric Composition Change, NDACC.

Continuous measurements of climate-relevant trace gases are carried out within the framework of the Global Atmosphere Watch Programme (GAW) of the World Meteorological Organisation (WMO). Jointly with the Hohenpeissenberg Meteorological Observatory, the UFS holds the status of being a GAW global station.

The mesosphere, at the middle of the five layers of the earth’s atmosphere, is considered the part of the atmosphere most sensitive to climate change, meaning that recording the temperature in the upper mesosphere offers basis for a rapid judgement as to the effectiveness of climate protection measures taken. The UFS is the coordinating centre for the international Network for the Detection of Mesopause Change, NDMC.

A correcting variable of importance in the climatic system is the influence of cosmic radiation, but its interaction with the atmosphere has yet to be adequately documented. The UFS success in measuring the energy distribution especially of secondary neutrons in cosmic radiation is unique worldwide and sets global standards.

Climate change exercises an influence on public health, with alterations to temperature, humidity, and radiation or different concentrations of trace gases and biogenic particles (e.g. pollen) all having effects on the human organism. Research into allergies is carried out with a particular focus on respiratory and cardiovascular illnesses.

The Alpine region is characterised by extreme changes to environmental conditions across even the smallest of spatial scales, and this makes climate change particularly visible as a drastic modification of bio-diversity and the melting of glaciers and permafrost areas; as such, it provides urgent motivation to investigate climate sensitivity in the Alpine biological and geological spheres.

The UFS is also open to third parties for defined, non-permanent research projects, and this opportunity is currently being used by 15 groups of researchers, composed of partners from medium-sized businesses and from external organisations from both Germany and other countries acting as reviewers.

Climate research cooperation between Bavaria and Norway

With the Arctic and the Alps, Norway and Bavaria are two of the European regions particularly affected by climate change. Accordingly, the UFS on Zugspitze and the northern Norwegian Alomar Observatory research station in Andenes agreed to a programme of cooperation in 2009; the scientists at both research sites use radar and lasers to investigate the state of the atmosphere and its effects on global warming.

Virtual Observatory of the Alps

In order to preserve the Alpine region as one of the most sensitive natural spaces in the world, comprehensive cross-border research and stronger cooperation between European high-altitude research stations is indispensable. Detailed data and models as a basis for future-facing climate strategies are the foundations of responsible climate policy-making.

With this in mind, an infrastructure for a Virtual Observatory of the Alps is to be built up step-by-step over the coming years: these steps include acquiring technical equipment in order to make transnational data-exchange possible, installing a state-of-the-art laser scanner to capture in three dimensions the changes to the snow covering occasioned by climate change, movements within glaciers and their specific melting patterns. In parallel to this, the scientific goals need to be coordinated with the neighbouring Alpine observatories and joint research projects initiated. The aim of the Virtual Observatory is to intensify cooperation among high-altitude research stations in the Alps along with data exchanges in climate research and to conduct joint scientific projects. The Virtual Observatory is being supported with a grant of 876,500 Euros by the Bavarian State Ministry of the Environment and Consumer Protection (cf. page 16).

Conclusion

Climate change will remain a priority for the State Government, and with a view to the goal of reducing CO₂ emissions from energy to a level markedly below six tonnes per capita per year by 2020, the following tasks take on particular importance:

Reducing greenhouse gas emissions

1. [Energetic refurbishment of State-owned buildings](#) offers further potential for saving carbon emissions.
2. Within the support framework of the [CO₂ reduction programme](#), Bavarian local authorities should continue to receive State funding.
3. Bavaria must become a model for the new energy age; by 2021, Bavaria intends to cover half of its electricity needs from [renewable sources](#).

Adapting to the effects of climate change

4. In order to achieve the 100,000 hectare goal in [forest conversions](#) by 2020, upgrade projects need to be started in other areas with an acute requirement; these projects could well become the seed crystals of the general, State-wide forest conversion activities (“from beacon projects to a tightly woven mesh”).
5. The positive momentum of the [Bergwald initiative](#) should be used to implement further measures in project areas which are already active.
6. The successful [flood control programme](#) requires adaptation to climate change as and when it happens.
7. In order to offer [protection from drought](#) and to [secure water supplies](#), the adaptation strategies developed need to be imple-

mented in a focussed manner. A large proportion of the measures to secure water resources and to increase integrated management is planned for rural areas.

8. For high-altitude Alpine species at particular risk from climate change, mountain forests and torrents should be used in a form of [species rescue programme](#) to secure habitats and integrate them into a cross-border Alpine biotope alliance; this creates cross-links from climate adaptation to the implementation of Natura 2000 and the Bavarian bio-diversity strategy.
9. The target for 2020 is to [restore to nature](#) 50 moors.
10. The [digital geological risk registry](#) will be extended across the entire State, while the [hazard reference cards for geological risks](#) will be rolled out to other vulnerable areas of Bavaria, in particular the Alpine foothills and the Swabian-Franconian Jura.
11. Sector-specific [climate agendas for businesses](#) are to act as navigation guides and offer ideas for tackling the challenges of climate change.

Research and development

12. In view of the complex topics at issue, inter-university and cross-institutional cooperation in [research alliances](#) has proven to be beneficial. There is still a need for research into adaptation to climate change, with climate-friendly land use in Bavaria representing an important aspect.
13. In order to strengthen the data basis on which precautionary and adaptive measures are elaborated, specific questions should feed from practice and applications back into individual [research and development initiatives](#).

14. Through intensive cooperation and networking among existing research stations in the Alpine region to form the [Virtual Observatory of the Alps](#), the use of infrastructure and knowledge already available will be optimised.

15. The [Bavarian Climate Alliance](#) strengthens awareness of climate protection and, in so doing, draws in a wide cross-section of society into joint activities (e.g. the Climate Week). This alliance must be continued and expanded.



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Rosenkavalierplatz 2, 81925 München (StMUG)

Internet: www.stmug.bayern.de
www.klima.bayern.de

E-mail: poststelle@stmug.bayern.de

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