



**IAEA**

International Atomic Energy Agency

*Atoms for Peace*

# CLIMATE CHANGE AND THE ATOM



"Climate change...rewrites the global equation for development, peace and prosperity."   
United Nations Secretary-General Ban Ki-moon, September 2009.

# UNCOVERING THE SCIENCE OF CLIMATE CHANGE

*People around the world are experiencing first hand the catastrophic effects of climate change: heat waves, floods, storms, fires and droughts. These are already affecting their health, living standards, economic development and safety.*

*While climate change can be attributed both to natural variability and to human factors, scientists agree that emissions of greenhouse gases (GHGs) are a principal cause of these changes today. The main GHG culprit is carbon dioxide (CO<sub>2</sub>), which is generated daily on a planetary scale due to ever rising human demands for energy, food, raw materials and manufactured goods. Ahead lies the Herculean task of changing fundamental aspects of our lives that we may take for granted, such as the way we produce and use our energy, the way we grow our food and how we use our water.*

*Our ability to make such changes — whether through the use of low carbon energy, more efficient use of our natural resources or other means — will depend heavily on the tools made available to us through human ingenuity and the advancement of science and technology.*

*In keeping with its "Atoms for Peace" mission, the International Atomic Energy Agency (IAEA) is engaging its scientists and engineers, and experts around the world, in a growing effort to use nuclear science and technology to help deliver solutions to the challenges of climate change.*

Developing the right responses to climate change requires that we understand our climate and the science behind it. The United Nations Intergovernmental Panel on Climate Change (IPCC) has identified this as a top research priority, and nuclear technology offers powerful tools for conducting such research.

## *Learning from the past*

This work begins with forensic efforts to establish the world's climate history. An accurate picture of this history is needed to understand the extent to which current changes deviate from the Earth's natural climate variability. Specific types of atoms — called isotopes — found, for example, in ancient marine sediments and freshwater ice cores, allow us to unlock extensive archives of the world's past climate. Using these isotopes as fingerprints, scientists can precisely analyse these sediments and cores to help reconstruct history.

## *The World Ocean*

Similarly, isotopes are tools for understanding and monitoring key phenomena that help regulate today's climate and offer important information about ongoing climatic shifts. Such phenomena include the cycling of tremendous amounts of heat and carbon through the body of the world's seas and oceans — the World Ocean. These cycles act as natural climate stabilizers, but they cannot indefinitely accommodate the increasing amounts of atmospheric heat and carbon that are

being absorbed by the oceans. Rising ocean temperatures and carbon concentrations are currently destabilizing key marine ecosystems, such as coral reefs and mangrove systems, and the food webs upon which millions of people depend for both their sustenance and their livelihoods.

## *The hydrological cycle*

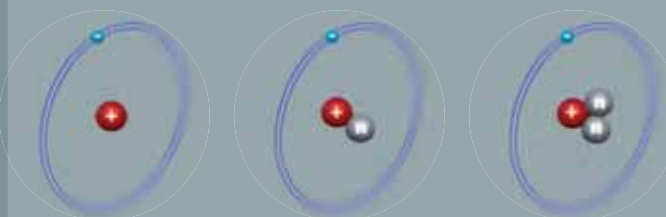
Another key phenomenon is the hydrological cycle, which moves water from the oceans to the atmosphere through evaporation, to land through precipitation, and back to the oceans through rivers and other water pathways. This critical conveyor belt of water also reflects the state of our climate. Already, it is being substantially impacted by changes in temperature and weather patterns, with widespread and harmful impacts on many freshwater resources and the communities that rely on them.

## *The IAEA's role*

Through its Environment and Water Resources Programmes, the IAEA helps Member States use isotope techniques to study and understand climate phenomena and the Earth's climate history. The data collected through these activities are used worldwide for the testing and validation of global climate models and by the IPCC in its global climate assessments. These models and assessments represent the critical first step in developing informed policy responses to climate change.

In their nucleus, atoms of a particular chemical element always contain the same number of protons (positively charged particles), but sometimes contain different numbers of neutrons (uncharged particles). Atoms of the same element with different numbers of neutrons are called isotopes. Some isotopes are stable, while others change over time due to radioactive decay.

Scientists use both stable and radioactive isotopes to study and model natural processes such as the water and carbon cycles, while radioactive isotopes can be used additionally to determine the ages of organic and inorganic materials, such as fossils, minerals and water. In recent decades, isotopes have made crucial contributions to our knowledge of our climate, ecosystems, natural resources and natural history.



## *The importance of isotopes*





# ADAPTING TO TODAY'S CLIMATE

While working to understand and predict climate change more accurately, we must also urgently address its damaging impacts. These impacts include drought, water scarcity and desertification as well as soil erosion and degradation. Particularly in the developing world, such changes are considerably impairing the ability of many communities to grow food, raise livestock and secure enough water for drinking and agriculture.



## *Producing more food while preserving natural resources*

Promoting more sustainable and resilient agricultural production is essential in helping communities to adapt to the impacts of climate change.

Nuclear techniques offer unique contributions to such efforts, at the same time being safe and cost effective. For example, they can be used to compare and measure the efficiency and efficacy of different agricultural land and water resource management practices. Identifying and refining the best of these practices is crucial to the long term preservation of natural resources such as arable soils and water, which are under increasing pressure due to climate change.

Nuclear techniques can also make valuable contributions to the development of new crop varieties able to provide higher yields and to tolerate drought, reduced soil quality and the harsher weather patterns wrought by climate change. This can include crops produced for human and livestock consumption.

Protecting crops and livestock from insect pests, some of which carry dangerous animal diseases, will be another adaptation challenge, as warmer temperatures will result in the geographic spread of such pests. This will put more crops and livestock at risk of destruction and disease, with potentially damaging effects on food security and economic development. Nuclear techniques can help control these insect populations both while crops are in the field and after harvesting.

## *Water is life*

Water is perhaps the most precious of natural resources, and the resource most threatened by climate change.

Already under significant stress worldwide due to expanding populations and economic activity, freshwater resources in many regions are suffering a double blow due to climate change. This is placing many communities at risk and demands greater efforts to promote sustainable resource management and increase water availability.

Isotope techniques provide highly effective, cost efficient and safe means to collect precise information about freshwater resources such as location, size, flow origins and replenishment rate. This knowledge is necessary to help water authorities manage their resources in a more sustainable manner. It is of even greater importance with regard to aquifers, as communities are increasingly forced to turn to these underground resources due to the diminishing availability of surface water.

## *The IAEA's role*

By promoting more sustainable agricultural production and water resource management through these and other techniques and technologies, the IAEA's Food and Agriculture and Water Resources Programmes are helping Member States respond to some of the most dangerous impacts of climate change. This assistance, provided in part through the IAEA's Technical Cooperation Programme, includes training courses, technology transfer, the promotion of scientific exchange and networking, and applied research.



*Making more water  
available through  
nuclear power*

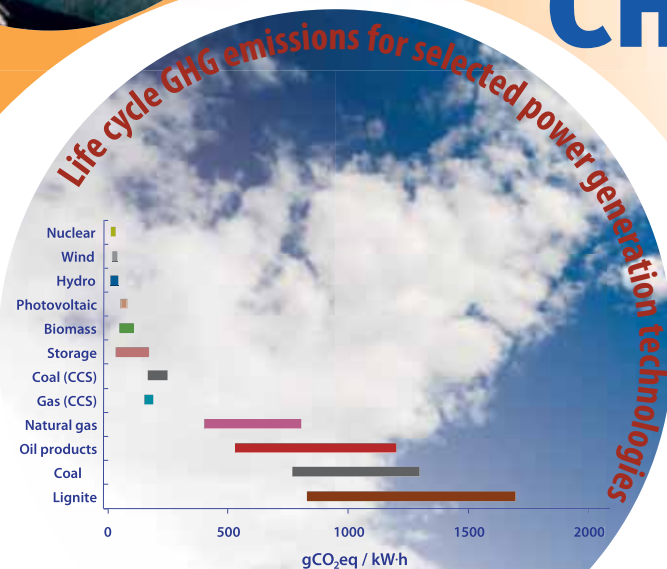


*Stresses on future freshwater supplies can be alleviated by the desalination of seawater and saline groundwater. Modern desalination plants are powered by the combustion of fossil fuels, which generate GHG emissions. Nuclear power is a low carbon alternative that can be used for desalination with no negative impact on the climate. Nuclear desalination, therefore, can be effective in both adapting to and mitigating climate change.*

*Through its Nuclear Power programme, the IAEA assists countries interested in desalination to conduct feasibility studies and economic evaluations of integrated power and desalination systems.*



# MITIGATING CLIMATE CHANGE



*In its Fourth Assessment Report on Climate Change, the IPCC concluded that, of the various power generation technologies available, nuclear energy has the greatest carbon mitigation potential at the lowest cost. Half this potential would be realizable at 'negative costs'. In comparison with higher GHG emitting technologies that may be more politically acceptable, investment in nuclear power is often more cost effective on economic, environmental, public health or other grounds, even in the absence of climate considerations.*

The scientific conclusion that the danger of irreversible climate change increases dramatically for atmospheric GHG concentrations above 450 parts per million, or global warming of 2°C above preindustrial levels, is being adopted by a growing number of governments, reflected in official policy worldwide.

These targets require a peaking of global GHG emissions as soon as possible, and a reduction of 50 per cent in global emissions by 2050 from 1990 levels.

## Reducing GHGs in electricity production

Energy related CO<sub>2</sub> accounts for almost two-thirds of current GHGs, with 30% of these emissions coming from power generation. Under current conditions, electricity generation is projected to remain the sector with the fastest growing GHG emissions for at least the next two decades. This growth will be driven by increased industrial activity in developing countries and by the need to provide power to the estimated 1.6 billion people worldwide who currently have no access to electricity.

As a nearly carbon-free energy source, nuclear energy is a potent climate change mitigation option. Existing nuclear power plants already reduce the global CO<sub>2</sub> burden by 2 gigatonnes (2 × 10<sup>9</sup>) per year. Over a nuclear power plant's life cycle, nuclear energy emits roughly the same amount of CO<sub>2</sub> per unit of electricity generated as wind and hydropower, and less than renewable sources such as biomass or solar. Significantly, it does so at an equal or lower cost per unit of electricity generated.

## Energy systems analysis and planning

Effective decision making on which energy technologies to use, taking into account climate, cost and other considerations, requires comprehensive energy systems analysis and planning at the national level. Such analysis helps policy makers to study the cost and effectiveness of different GHG mitigation options and to chart long term scenarios of sustainable energy development. It also helps them to test various climate change policies and response strategies — including flexible mechanisms under the Kyoto Protocol, such as the Clean Development Mechanism (CDM), Joint Implementation (JI) and emissions trading.

These analyses also hold significant value for other stakeholders — such as utility and power companies, research centres and investors — as they engage stakeholders in a broad energy dialogue and contribute to their long term strategies and planning.

## The IAEA's role

The IAEA helps Member States build national capacity in conducting independent energy and environmental analysis and in developing strategic national energy plans. This assistance involves transferring analytical and planning tools, and training national experts in their use to support energy and electricity demand and supply studies as well as the analysis of cost effective GHG mitigation options. Through these and other activities, the IAEA advises countries and helps them to identify the most suitable and feasible national energy mix for their needs, whether or not this includes nuclear power.

## Turning GHGs into fertilizers



Nodules on leguminous crops can fix nitrogen from the atmosphere.



A neutron moisture meter used for measuring water content in soil.

*In the atmosphere, CO<sub>2</sub> and other GHGs such as nitrous oxide (N<sub>2</sub>O), can cause global warming. In soils, however, carbon and nitrogen can improve the water usage of crops and enhance soil resilience against desertification and degradation, while providing additional nutrients.*

*Through its Food and Agriculture Programme, the IAEA is developing and evaluating land management practices designed to capture atmospheric CO<sub>2</sub> and N<sub>2</sub>O in soils and reduce N<sub>2</sub>O emissions, to mitigate climate change while fuelling crop growth. Also through this programme, the IAEA is working to develop crop varieties able to absorb additional CO<sub>2</sub> from the atmosphere and to utilize soil nitrogen more effectively.*

Policies  
intended to reverse  
current global climate trends  
will depend considerably on science  
and technology for their implementation.

Nuclear science and technology offer significant  
contributions in the areas of climate science, adaptation  
and mitigation, and can thereby provide strong support to  
policy initiatives.

Environmentally benign and affordable energy services  
and technologies are essential to the success of any climate  
protection regime. All credible scenarios of future energy  
demand and supply show that the more stringent these  
regimes become, the more nuclear energy will be needed.

As confirmed by the IPCC and the International Energy  
Agency, nuclear energy can make valuable  
contributions to both climate change  
mitigation efforts and economic  
development.

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