Ethics of Science and Technology Assessment 47

Carl Friedrich Gethmann · Georg Kamp · Michèle Knodt · Wolfgang Kröger · Christian Streffer · Hans von Storch · Thomas Ziesemer

Global Energy Supply and Emissions

An Interdisciplinary View on Effects, Restrictions, Requirements and Options

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Preface

In 2012, the Institute for Advanced Study at the University of Siegen, Germany, began planning and started preliminary studies for the establishment of an interdisciplinary working group on questions of global energy supply. The intention was to broaden the energy policy perspective from a purely national German perspective to European and global view. As a interdisciplinary project group, "Societal challenges posed by the interactions between energy system transformation, raw material demand and climate change in a global perspective (GlobEn)" was funded.

The project group was composed of:

- Carl Friedrich Gethmann (University of Siegen; ethics of science) (chair)
- Georg Kamp (Research Centre Jülich; philosophy)
- Michèle Knodt (Technical University Darmstadt; political science)
- Wolfgang Kröger (ETH Zurich; mechanical engineering sciences)
- Hans von Storch (Institute for Coastal Research of the Helmholtz Centre Geesthacht; climate research)
- Christian Streffer (University Clinics Essen, medical faculty; medical radiobiology)
- Thomas Ziesemer (Maastricht University; environmental economics).

Furthermore, Harry van der Laan (University of Utrecht, astrophysics; climate research) and Karl Josef Koch (University of Siegen; economics) have participated in early stages of the discussion of the project group. At times, the project was supported by the research assistants Jan Mehlich, Jochen Sattler and Hendrik Kempt active.

The group held a total of 19 plenary meetings in Siegen, Cologne and Zurich in the years from 2013 to early 2018. The aim was to produce a monograph based on the concept of interdisciplinary cooperation with transdisciplinary objectives developed within the framework of the European Academy Bad Neuenahr-Ahrweiler.[1] The authors take responsibility for the text in collective

[1]C.F. Gethmann, M. Carrier, G. Hanekamp, M. Kaiser, G. Kamp, S. Lingner, M. Quante, F. Thiele, *Interdisciplinary Research and Trans-disciplinary Validity Claims,* Heidelberg u.a. 2015.

authorship. Some of the members of the GlobEn working group had previously presented a study on nuclear disposal, among other things, within the framework of the Europäische Akademie Bad Neuenahr Ahrweiler.[2]

The authors would like to thank the Institute for Advanced Study of the University of Siegen for the financial support of the study and Springer-Publishers for their cooperation in preparing the publication of the study.

Inevitably, there has been a time gap between the end of the scientific work and the time of publication. At the same time, the subject area is developing at an accelerated rate. The authors have made every effort to keep the data stock up to date. However, not in every area could the latest developments be taken into account.

On behalf of the authors:
Carl Friedrich Gethmann

Siegen, Germany
February 2020

[2]C. Streffer, C.F. Gethmann, G. Kamp, W. Kröger, E. Rehbinder, O. Renn, K.-J. Röhlig, *Radioactive Waste. Technical and Normative Aspects of its Disposal,* Berlin: Springer 2011. Further preliminary work: U. Steger, W. Achterberg, K. Blok, H. Bode, W. Frenz, C. Gather, G. Hanekamp, D. Imboden, M. Jahnke, M. Kost, R. Kurz, H.G. Nutzinger, Th. Ziesemer, *Nachhaltige Entwicklung und Innovation im Energiebereich,* Berlin 2002 (*Sustainable Development and Innovation in the Energy Sector,* Berlin 2005); C. Streffer, C.F. Gethmann, K. Heinloth, K. Rumpff, A. Witt, *Ethische Probleme einer langfristigen Energieversorgung,* Berlin 2005; B. Droste-Franke, H. Berg, A. Kötter, J. Krüger, K. Mause, J.-C. Pielow, I. Romey, T. Ziesemer, *Brennstoffzellen und Virtuelle Kraftwerke. Energie-, umwelt- und technologiepolitische Aspekte einer effizienten Hausenergieversorgung*, Berlin 2009; B. Droste-Franke, P. Paal, C. Rehtanz, D. U. Sauer, J.-P. Schneider, M. Schreurs, T. Ziesemer, *Balancing renewable electricity. Energy Storage, Demand Side Management and Network Extension from an Interdisciplinary Perspective*, Berlin 2012; C.F. Gethmann, G. Kamp, "Globale Energiegerechtigkeit. Ethische Fragen", in: J. Nida-Rümelin, D. von Daniels, N. Wloka (Hgg), *Internationale Gerechtigkeit und institutionelle Verantwortung,* Berlin 2019, 311–340.

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About the Authors

Carl Friedrich Gethmann, studied philosophy at Bonn, Innsbruck and Bochum and obtained a lic. phil. in 1968 from Institutum Philosophicum Oenipontanum—Universität Innsbruck. He obtained his Dr. phil. from the Ruhr-Universität Bochum in 1971. In 1978, he completed the habilitation in philosophy at the University of Konstanz. In 2003, he received the honorary degree of doctor of philosophy (Dr. phil. h.c.) from the Humboldt-Universität Berlin. In 2009, he was appointed as an Honorary Professor at the University of Cologne. During his career, he has served as a scientific assistant (1968), Professor of Philosophy at the University of Essen (1972), a private lecturer at the University of Konstanz (1978) and as Professor for philosophy at the University of Essen (1979). He also held numerous lectures at the universities of Düsseldorf and Göttingen. Invited to join the Board of Directors at the Akademie für Technikfolgenabschätzung Baden-Württemberg and to receive a full professorship of Philosophy in 1991, he refused. He refused full professorship offers from other universities. In 1991, he accepted the offer of Full Professorship at the University of Essen. Since March 2013, Gethmann has served as Professor at the Institute for Advanced Study at the University of Siegen. Between 1996 and 2012, he was Director of the *Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen GmbH*, Bad Neuenahr-Ahrweiler, Germany. He has also been Member of the Academia Europaea (London), of the Berlin-Brandenburgische Akademie der Wissenschaften and of the German National Academy of Sciences Leopoldina (Deutsche Akademie der Naturforscher). Between 2000 and 2013, Professor Gethmann has served as a member of the Bioethics Commission of Rhineland-Palatinate, Germany. From 2006 to 2008, he was President of the German Association for Philosophy "Deutsche Gesellschaft für Philosophie e.V.". Since 2008, he has been a member of the German Academy of Science and Engineering (German: Deutsche Akademie der Technikwissenschaften) "Acatech." He is currently a member of the German Ethics Council (2013–2021). His main fields of research include: linguistic philosophy and philosophy of logic; phenomenology and practical philosophy, ethics of medicine, ethics of environment and technology assessment.

Georg Kamp, carried out an apprenticeship and worked as a retail salesman between 1979 and 1984. During 1987–1993, he was studying philosophy, German literature and linguistics in Bochum, Duisburg and Essen. From 1993 to 1998, he served as a scientific assistant at the Institut für Philosophie at the Universität Duisburg-Essen. In 1998, he completed his Ph.D. studies at the University of Essen with a thesis about logics in normative contexts. From 1999 to 2002, he served as a member of the scientific staff of the *Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen GmbH*, in Bad Neuenahr-Ahrweiler, Germany. During 2002–2005, he worked as a freelance consultant, lecturer and editor. During 2005–2006, he attended a cooperative education program on "Master of Mediation" at the Fernuniversität Hagen. During 2007–2012, he worked as an assistant lecturer in philosophy at the University of Duisburg-Essen. Since 2005, he has been active as a scientific coordinator, participant and manager of numerous interdisciplinary projects on sustainability and energy topics. Moreover, he was a staff member of the Niederrhein University of Applied Sciences (2005–2006) and of the Europäische Akademie in Bad Neuenahr-Ahrweiler (2006–2015). Since 2015, he has been a staff member of the Jülich Research Centre.

Michèle Knodt studied political sciences at Technische Universität Darmstadt (TU Darmstadt) and completed there her Master in political science in 1992. She received her Dr. phil. from the University of Mannheim in 1997 and worked as a research assistant at the Mannheim Center for European Social Research (MZES) (1997–2000). She completed her habilitation in political sciences in 2005 at the University of Mannheim. In 2000, she was appointed Assistant Professor at the University of Mannheim. In 2005, she obtained Full Professorship from TU Darmstadt, where she has been serving as Professor for Comparative Politics and European Integration to date. She was a guest professor at University of Massachusetts Boston, USA (1998), at the Institut d'Etudes Politiques de Lille, University of Lille, France (2003), at the Institute for Advanced Studies (IHS), University of Vienna, Austria (2007) and at the University of Pondicherry, India (2010). In 2011, Prof. Knodt was awarded with a Jean Monnet Chair *ad personam* from the European Commission. She is Director of the Jean Monnet Centre of Excellence "EU in Global Dialogue" (CEDI), Vice-Director of the Energy Center (German: Profilbereich Energiesysteme der Zukunft) at TU Darmstadt, Co-Leader of the Loewe Centre of Excellence "emergenCITY" at TU Darmstadt as well as Co-Leader of the DFG Research Training Group (GRK) KRITIS. She is currently leading the Cost Action ENTER "EU Foreign Policy Facing new Realities" (17,119). She is also President of the German European Community Studies Association (ECSA-Germany) and has been leading several international and interdisciplinary projects supported by DFG, VW foundation, EU Commission, BMBF, BMWI, among others. She published around 50 peer-reviewed journal articles, co-authored 8 monographs, co-edited 16 books and wrote more than 100 chapters in edited volumes. Her main fields of research include energy governance, EU multi-level governance, energy transition and participation.

Wolfgang Kröger studied mechanical engineering, specializing on nuclear technology, at the RWTH Aachen. He completed his diploma degree in 1972, his doctoral degree in 1974 and the habilitation in 1986. From 1974 to 1989, he worked at the Institute for Nuclear Safety Research at the German Research Center Jülich, leading research projects aimed at the development of advanced reactor concepts, and on related methods for comprehensive safety assessment. In 1990, he became Full professor of safety technology at the ETH Zurich. Simultaneously, he was appointed director of the Research Department on Nuclear Energy and Safety at the Swiss National Paul Scherrer Institut (PSI). At ETH, as director of the Laboratory of Safety Analysis, he contributed to the development of risk and vulnerability analysis methods of complex cyber-physical systems, including energy supply infrastructure. He has been approaching risk assessment and interdependence issues in a multidisciplinary, trans-sectorial way, and shaped the concept of sustainability and resilience. On his initiative, the International Risk Governance Council was established in Geneva in 2003, and he became Founding Rector. After his retirement in 2011, he was nominated Executive Director of the ETH Risk Center.

Professor Kröger is currently working as a senior scientific advisor and member of distinguished national and international committees, such as the Swiss Academy of Engineering Sciences (SATW), the International Review Group of the Japanese Nuclear Safety Institute (JANSI), and the project of "energy systems of the future" (ESYS). Senior Fellow of the Institute for Advanced Sustainability Studies (IASS) Potsdam, Distinguished Affiliated Professor at TU Munich, he is also author and co-author of numerous publications, including books.

Christian Streffer studied chemistry and biochemistry at the universities of Bonn, Tübingen, Munich, Hamburg and Freiburg. He received his Ph.D. in biochemistry in 1963. He was a postdoctoral fellow at the Department of Biochemistry, University of Oxford. In 1971, he was appointed Professor for Radiobiology at the University of Freiburg, Germany. From 1974 to 1999, he served as a full Professor for medical radiobiology at the University of Essen. During 1988–1992, he was Vice-Chancellor of the same university and received the title of Emeritus in 1999. He was Guest Professor at the University of Rochester, N.Y., USA, in 1985, and at the University of Kyoto, Japan, in 2000. As an Honorary Member of several scientific societies, he received an Honorary Doctor from the University of Kyoto in 1995. Professor Streffer is a member of the Institute for Science and Ethics of the University of Bonn and an Emeritus member of the International Commission on Radiological Protection (ICRP). He received several scientific awards, such as: the Roentgen Plakette (English: Roentgen Medal) by the City of Remscheid (1985), a prize awarded to people who have made great contributions to the progress and usage of X-ray in science and practice; the Bacq–Alexander Award of the European Society for Radiation Biology in 1996; the Sievert Award of the International Radiation Protection Association (IRPA) in 2008; and the Distinguished Service Award of the Radiation Research Society, USA, in 2009.

Professor Streffer's main research interests include: radiation risk, especially during the prenatal development of mammals; genomic instability after radiation exposure; combined effects of radiation and chemical substances; and experimental radiotherapy of tumors and especially individualization of cancer therapy by radiation.

Hans von Storch is Director Emeritus of the Institute of Coastal Research of the Helmholtz Zentrum Geesthacht (HZG), Professor at the University of Hamburg and Guest Professor at the Ocean University of China (Qingdao). From 1987 to 1995, he was Senior Scientist and leader of the *Statistical Analysis and Modelling Group* at the Max Planck Institute for Meteorology. He also served as Director of the Institute of Coastal Research. His research interests included climate diagnostics and statistical climatology, and regional climate change and its transdisciplinary context. He published twenty books, including "Statistical Analysis in Climate Research," co-authored with Francis Zwiers and "Die Klimafalle" (English: The Climate Trap), co-authored with the ethnologist Werner Krauss. He also authored numerous articles. Editor-in-chief of the Oxford Research Encyclopedia of Climate Science, Oxford University Press, he is also a member of a number of editorial and advisory boards. He was the lead author of Working Group I of the Third Assessment Report and of Working Group II of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and chaired the efforts for a climate change assessment for the Baltic Sea Catchment (BACC II). Professor Hans von Storch is also a foreign member of the Polish Academy of Sciences and holds an honorary doctorate from the University of Göteborg. The significance of his work was also recognized with the Order of Merit of the Federal Republic of Germany in 2019.

Thomas Ziesemer has been serving as Associate Professor of Economics at Maastricht University, the Netherlands, since December 1996. After studying economics at the universities of Kiel (1974–1975) and Regensburg (1975–1978), in Germany, he was employed at the University of Regensburg (1982–1989), where he completed his doctoral dissertation on the topic of "Economic Theory of Underdevelopment" in 1985. Starting in December 1989, he has been successively appointed Assistant Professor of International Economics, Associate Professor of Microeconomics and Associate Professor of Economics, from the School of Business and Economics at Maastricht University. In November 1996, he completed his "Habilitation" at the Freie Universitaet Berlin. He also serves as Senior Researcher at United Nations University—Maastricht Economic and Social Research Institute on Innovation and Technology UNU-MERIT. His fields of interest include development, international and environmental economics, growth and technical change.

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Chapter 1
Introduction

1.1 Initial Situation

A secure and at the same time cost-effective, environmentally friendly and resource-saving energy supply is an important prerequisite both for the further development of the countries of Asia, South America and Africa and for maintaining living conditions in the industrialized countries. This entails a wide range of national and regional design tasks, but also those which, in view of the competition for resources on a globalized market and in view of the consequences of the release of emissions during the production and consumption of useful energy, can only be adequately considered in the light of global developments. At the same time, there is a need to broaden the view of more complex interrelationships that go far beyond energy supply issues. For example, the provision of energy in dry zones close to the coast allows the extraction of fresh water, which can be used for agricultural purposes and to develop settlement areas. This is expected to have an impact on social, economic, political, and demographic developments, which may have a direct impact on living conditions in industrialized countries in the form of a reduction in migration movements and an increase in trade activities. At the same time, the type and extent of energy production and use have an impact on climatic developments, which, according to the current state of knowledge, will in turn influence the expansion and distribution of dry zones, among other things. This means that national energy policy decisions and measures, if they are to be taken not just for the sake of short-term effects but prudently and responsibly, must be based on a foundation that goes far beyond the technical interrelationships and the respective requirements of regional markets and incorporates ideas of longer-term global development.

If these challenges are to be met, then both the supranational steering possibilities and the specific local conditions, the disparate goals and the diversity of options, the unequal distribution of potential (e.g., technical, financial, social and cognitive resources), and the unequal distribution of opportunities and risks must be considered. For this purpose, scientific input on a broad interdisciplinary basis

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is indispensable, which should be carried out from a scientific-technical, political, social science, economic and philosophical perspective on the basis of representative selected regions (China, India, Brazil, and Europe), especially in the fields of science, technology, politics, economics, and philosophy. For this, the following outline will be followed: (i) critically reconstructing the target systems and the technical, economic, ecological, and social conditions for achieving the targets, (ii) developing and refining criteria, benchmarks and methods for responsible energy policy decisions and their effective implementation, and (iii) developing cross-disciplinary, coordinated, sustainable, and promising recommendations for action for a prudent and long-term energy policy from the perspective of all disciplines involved.

The development of viable strategies for a sustainable energy supply raises not only questions of technical feasibility and economic viability but also manifold questions of ethical justifiability and political responsibility, which extend far beyond national borders and the present day and can often only be adequately answered on a global scale and in an intergenerational long-term perspective.

1.2 Energy Policy and Climate Targets

The International Energy Agency (IEA) puts the total volume of energy-related CO_2 emissions for 2018 at 33.1 Gt and gives a clear indication of the relevance of energy policy and energy management decisions for climate change, which can only be adequately considered a global phenomenon.[1]

This represents an increase of more than 40% over the 23.2 Gt reported for the year 2000, and since 2005 emissions have risen by more than 22% despite the economic downturn. The IEA has calculated an increase of 1.8% for 2018 alone. According to the UNEP "Temperature Briefing" (2010) "there is a medium likelihood to stay within the 2-degree limit if the following conditions are met:

- Global emissions peak sometime between 2015 and 2021.
- Global emissions in 2020 are approximately 40.0–48.3 Gt CO_2 eq/yr.
- By 2050 global emissions decrease by 48–72% relative to 2000".

According to the calculations of the Intergovernmental Panel on Climate Change (IPCC), in order to meet the 1.5 °C target set by the Paris Agreement, which came into force in 2016, there would even have to be negative emissions.[2] The resulting

[1] "Global energy-related CO_2 emissions grew 1.7% in 2018 to reach a historic high of 33.1 Gt CO_2" https://www.iea.org/reports/global-energy-co2-status-report-2019/emissions#abstract (accessed 13-Dec-2019).

[2] "All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the twenty-first century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5 °C following a peak (high confidence). CDR deployment of several hundreds of $GtCO_2$ is subject to multiple feasibility and sustainability constraints (high confidence). (IPCC 2018).

problems become even more apparent when comparing the developments in OECD countries and countries with accelerated catchup developments such as China, Brazil, or India: For the year 2019, the OECD countries' share of energy-related emissions is 35%.[3] However, they contribute only 25% to the rate of increase, with increases being recorded above all in non-OECD countries. Although their inhabitants produce only a fraction of the per capita emissions for which OECD citizens are responsible (10 t/a compared with 5.8 t/a in China, 1.9 t/a in Brazil or 1.6 t/a in India), in view of the rapidly growing populations and the accelerated mechanization of these countries, compliance with the projected targets will not be possible, or not only through abatement strategies within the OECD countries. Rather, energy policy measures should also be geared towards the development, testing, and refinement of options that offer competitive and attractive offers in the developing countries to achieve their prosperity goals while at the same time reducing climatic and other risks.

1.3 Energy Management and Energy Technologies

The choice of technologies for energy production and use has a central influence on climate development. At the same time, this raises questions of environmental protection and air pollution control, questions of resource availability and fair distribution, and elementary questions of generating and maintaining prosperity and development. Questions of safe and efficient energy supply, as they arise for modern civilizations, are particularly determined by over-complex decision situations. Even if the first warning cries raised in the 1970s turned out to be too premature and dramatic, there is no denying that in the long term, there will be a gradual shortage of essential resources, be it oil or rare earths required for the development of highly efficient turbines. At the same time, the world population has grown from about 1.6 billion people (around 1900) to 7.6 billion in little more than a hundred years—not least because of the progress made in many areas of life. The projections of the UN (Department of Economic and Social Affairs, 2017 revision) fluctuate between a shift of about 9.6 billion by the end of the century and a further increase in the world population to 13.2 by 2100 and a further increase beyond that.

The course of development will also depend to a large extent on the availability of energy: A secure and cheap availability of energy is necessary to turn the expected billions of people into producers who can provide for themselves and their families with what they produce and buy. Countries such as China, India or Brazil have in some cases made breathtaking developments here in recent decades and have caught up with the Western industrial nations, but have also increased the pressure on the demand for energy sources and contributed to the further scarcity of resources, to the increased volume of emissions and thus to an intensification of environmental problems.

[3] http://www.oecd.org/environment/environment-at-a-glance/Climate-Change-Archive-December-2019.pdfmber-2019.pdf (accessed 13-Dec-2019).