Heinrich Arnold

Robert Döpel and his Model of Global Warming

4. Ed.

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Preface to the 4th Edition

Compared to the preceding edition, some important publications are included that confirm ROBERT DÖPEL's calculations and statements from 1973 about limits of growth for energy consumption.

Moreover, his former pioneer work on nuclear energy is discussed in more detail, as had been done in my contribution[1] on occasion of the 30th anniversary of DÖPEL's death on december 3, 2012. This day was also the 70th anniversary of the first time a nuclear reactor became critical in Chicago. In spring of the same year, 1942, HEISENBERG and DÖPEL had realized for the first time an effective neutron multiplication in their “Uran-Maschine” - which was destroyed by a chemical explosion later – at Leipzig. This accident has been mentioned in the 3rd Edition “*in proof*” due to the Fukushima oxyhydrogen explosions from March 2011, and it will be discussed here in more detail.

In addition to the persons mentioned gratefully in the acknowledgement section (No. 6), I have to thank Professor PETER SCHARFF, rector of the Ilmenau University of Technology, very much for his interest - and especially for supporting this printed Edition.

Ilmenau, April 2013

HEINRICH ARNOLD

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[1] *Zu einem autobiographischen Brief von Robert Döpel an Fritz Straßmann. (About an autobiographical letter from Robert Döpel to Fritz Strassmann.)* http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2012200288 (2012)

Preface to the 3rd Edition

This English text is a corrected and improved version of the German 2nd online edition[2] from 2010 that followed the 1st printed (and online) edition[3]. Again it contains a series of complements regarding additional literature. In this context it should be mentioned that the *"German Science Year 2010"* had been devoted to the "*Future of Energy*". For a sense of responsibility as it was represented by ROBERT DÖPEL, this future will extend to a few centuries at least - and not only to a few years or decades, at best, as in politics.

I would be obliged for all activities supporting a more fundamental treatment of the problems and their solution by appropriate institutions. Especially advancements of the more general informatory concerns that are aimed primarily at advanced scholars and at students would be gratefully acknowledged.

Ilmenau, March 2011.

HEINRICH ARNOLD

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[2] *Robert* DÖPEL *und sein Modell der globalen Erwärmung. Eine frühe Warnung - und die Aktualisierung.* 2. Auflage: http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2010200125 .

[3] 1. Auflage: Universitätsverlag Ilmenau 2009. ISBN 978-3-939473-50-3. http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2009100044 .

Robert Döpel

was born in 1895 in *Neustadt an der Orla,* a small town in Thuringia, Germany. After the school leaving examination, he took part in the First World War and became seriously injured in 1918. From 1919 to 1924, he studied physics and additionally mathematics, chemistry and philosophy at the universities of Leipzig, Jena (1920-21), and Munich. Here, in 1924 he received his doctorate under the NOBEL Laureate in Physics WILHELM WIEN. Thereafter he became ROBERT WICHERT POHL's teaching assistant at the University in Göttingen. From 1925 on he worked in a private laboratory in Planegg, just west of Munich, where he continued his philosophical studies. In 1929 he became a teaching assistant and in 1932 a private lecturer at the University of Würzburg. In 1938, he was appointed as an extraordinary professor of radiation physics at the University of Leipzig.

The time that follows is described in more detail in section 3.1. In summer 1945, together with other nuclear physicists DÖPEL had to go to Russia, from where he returned in 1958. Until 1962 he was a professor for electrical engineering at the *Hochschule für Elektotechnik Ilmenau* (today *Technische Universität*), and thereafter he still worked in his laboratory until 1975. He passed away in Ilmenau in 1982.

Content

1 Introduction and Synopsis

Pursuant to our subheading, *"An Early Warning"* has been given by ROBERT DÖPEL whose climate paper appeared in 1973, between the first two reports to the *Club of Rome* from 1972 and 1974 on global growth limits including anthropogenic warming aspects[4]. More than three decades later, a film by Al Gore – a Nobel Peace Prize laureate in 2007, together with the International Panel of Climate Change (IPCC) – has been titled *"An Inconvenient Truth – A global Warning"* [1].

This IPCC with its hundreds of direct and even more indirect coworkers published the 4th of its Assessment Reports[5] in 2007 ("AR4"). Thereby it contributed again decisively to a politically resilient consensus on global warming and its mitigation. The way of coordinated scientific work in that extent is unique so far, which results in problems, too[6]. The report of working group I from 2007 [2], which is the most

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[4] In [3], Döpel covered only the anthropogenic waste heat as a source for global warming, while the Club of Rome included also the greenhouse effect, which completely dominates today's discussion. Thereby, the time horizon is only decades versus centuries in [3]. Not only in the English-speaking world, but also in the German-speaking countries Döpel's early warning was totally overlooked to this day. This holds even for recent publications [65, 68] that confirm his work.

[5] The main parts of these reports [2] are formed by reports of three Working Groups (WG I-III) titled "The Physical Science Basis", "Impacts, Adaptation and Vulnerability", and "Mitigation of Climate Change". Prepended to each Assessment Report is the Synthesis Report (SYR), the Technical Summary (TS) and the Summary for Policymakers (SPM). – An updated statement facing the 2007 report (corresponding to the knowledge from 2005/2006) has been given in November 2009 by a panel of experts [13b].

[6] Apart from the problems connected with our special DÖPEL themes; see in particular the first subsection in 3.4.

important part of AR4 for our model considerations, contains nearly 1000 pages on its own.

Due to the controversies on the anthropogenic green house effect that dominated for many years (and are not finished so far), warning on global warming due to other global problems have been noticed insufficiently. Primarily, the physicist ROBERT DÖPEL quantified the influence of exponentially increasing anthropogenic heat release by comprehensive model calculations, based on an impressively simple analysis [3]. This delivered only lower limits for the global temperature increase of surface temperatures.

In chapter 2, for a better subsumption of DÖPEL's results and their update, some important stages on the way towards the actual state of discussion about climate change are considered. This chapter_can be read independently from the calculations given thereafter. Some older events that younger people have not witnessed and the seniors often have already forgotten[7] are treated more critically and in detail, because they are scarcely accessible by electronic media.

Important works of ROBERT DÖPEL are appreciated especially in section 3.1, starting with his first professorship in Leipzig and ending with his last years in the Thuringian Ilmenau, where he worked at the

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[7] An example is the damage of the ozone layer by fluorochlorohydrocarbons, the atmospheric concentration of which culminated in the middle of the nineteen-nineties and then became reduced. PAUL CRUTZEN, who got the NOBEL price for chemistry (1995) for work in this area, stated in an interview that this former danger which was small compared with the present danger of climate change is ignored. (The newspaper "taz": http://www.taz.de/?id=start&art=4609&id=umweltartikel&src=AR&cHash=cf119839ae 2007.) - See also section 2.3 that contains more about the ozone hole in correlation with the greenhouse effect.

(today's) University of Technology. His most important former achievement was in the field of nuclear physics and technology together with his wife and with the theoretician WERNER HEISENBERG [3a] at Leipzig. On the 100th birthday of ROBERT DÖPEL, a booklet [4] was published by scientists from the Leipzig university in which his time at Ilmenau is described comprehensively, too. Here, he developed the geophysical model described in section 3.2 together with updated calculations.

After generalization in 3.3, the results are discussed together with results from actual publications on computer simulations of the anthropogenic greenhouse effect in 3.4. Actually, this effect is much more fatal. Due to its complexity it can be treated there only very simplified. In this context, insight is given into the climate problems, together with usual notions and quantities that belong to fundamental knowledge in geophysics and climatology. - At last, DÖPEL's concept proves to be a special case of the international usual attribution of global temperature changes to the climate forcing[8], which is a driving force for global warming.

The requirements in mathematics and natural science for our quantitative treatment do not go beyond the level of secondary (university-preparatory) schools[9]. The model considerations in sections 3.2 - 3.4 that have been treated in a short English contribution [14a], too, are

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[8] Briefly: "Forcing", in the sense of the Climate Research Committee within the National Research Council (USA) [5a], and of [66].

[9] The presentation is based on the author's experience from 1978 to 1999 at the *"Technische Hochschule Ilmenau"* (since 1992 *"Technische Universität"*) mainly with students of technical sciences (also beginners) and last 2008 in an one-week *"Ilmenauer Physiksommer"* on *"Energy and Climate"* for selected pupils. The theme can be treated in a special seminar for students of *"Technical Physics", too* .

useful especially for those engaged in “MINT Sciences”. This is an abbreviation[10] for **M**athematics, **I**nformatics and **N**atural and **T**echnical Sciences.

The results presented below show that, if energy production continues to grow, the global warming due to the anthropogenic greenhouse effect becomes dominated by the additional influence of the heat release. The comprehension of Fig. 2 (sect. 3.2), that is fundamental in this context, requires no detailed knowledge of the calculations on which it is based on.

The concluding chapter 4, which is purely verbal again, starts with considerations on nuclear technology. Thereafter, also referring to DÖPEL’s work [3], in section 4.2 some social and cultural aspects of the climate debate are discussed, as far as they were not yet included in chapter 2. This section can be skipped if the reader is interested mainly in quantitative considerations. On the other hand, readers not interested in such considerations can omit sections 3.2 and 3.4. – The sequence of sections was chosen so, that not only DÖPEL’s model calculations in today’s sight will become plain, but also his personality as well as the circumstances and antecedents of his work at Ilmenau.

A science-writer presentation with good term explanations especially for the extended historical background of the following chapter 2 is given in the paperback [5].

[10] “MINT” comes from German speaking countries; see for example http://www.educ.ethz.ch/mint , http://www.mint-ec.de and http://www.mintzukunftschaffen.de/ .

2 Facts and Discussions on Global Warming

2.1 The Time from FOURIER to ARRHENIUS

ALREADY IN 1822, JEAN-BAPTISTE FOURIER described (or "supposed", as Gassmann [7] says) the global greenhouse effect as "l'effet de serre"[11] in the course of his fundamental thermodynamic works. Following further precursors[12], the Swede ARRHENIUS (NOBEL price in Chemistry 1903) from 1896 on delivered the pioneering findings [8a]. The atmospheric "global average temperature" at the surface of the earth[13] with sunshine would be much lower without the heat congestion by the atmosphere (see section 3.2). This comes from absorption of the emitted heat by clouds, water vapor, carbon dioxide and other trace gases. These atmospheric absorbers adopt the role of a glass roof, whereas the similarity with conditions in a greenhouse is rather limited, of course [9].

SVANTE ARRHENIUS also recognized the anthropogenic intensification potential for the greenhouse effect. In 1908 he wrote about the increase of carbon dioxide, which he expected, however, at first in a few cen-

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[11] The *"Handbuch der Physik"* from 1957 [6] that is cited by DÖPEL [3] uses *"Glashauswirkung"* or *"greenhouse effect"*. – In some American debates on environmental issues, the latter becomes confronted with a *"White House effect"* that can act on global temperatures in the same or in the opposite direction, depending on the resident of that house.

[12] A chronological literature report on the greenhouse effect is given by WISNIAK [8] with comprehensive comments.

[13] For this average global temperature he used 15°C, as it is usual since that time [9]. However, 14,5°C were not exceeded until 2010 [10a] (cf Fig. 1a).

turies [8b], that this would give hope on times in which the earth would give multiple crops *"in the benefit of the quickly growing human race"*. So, ARRHENIUS has inaugurated the debate on global warming.

2.2 The Time between ARRHENIUS and Formation of the IPCC

The broad public, and large parts of the scientific community too, scarcely considered the enlargement of CO_2 concentration (Fig. 1b) to be a possible cause of global warming (Fig. 1a) until the beginning of the nineteen seventies. But then in the first two *"Reports for the Club of Rome"* in 1972 [11] and 1974 [12], among the global problems that were going to limit growth, the anthropogenic climate changes by CO_2 increase as well as by industrial heat release[14] were mentioned. About the latter JOHN P. HOLDREN, who became the US presidents advisor for Science and Technology in 2009, wrote in a study [11a] cited in the 1st report,

"… that global thermal pollution is hardly our most immediate environmental threat. It could prove to be the most inexorable, however, if we are fortunate enough to evade all the rest."

Popular-science paperbacks [13] which appeared shortly afterwards warned against both causes for warming, too. In view of the contemporary annual growth of the energy production by 6% p.a., plain effects of heat release "within one to two centuries" have been predicted therein.

[14] In the updates from 1992 and 2006 [12a], the warming by energy production has no more been mentioned, which can be explained by strongly reduced growth rates (section 3.2) and by the limitation of their computer simulations on the 21st century. Now, the CO_2-problems for the growth limits were discussed in more detail, invoking the IPCC reports [2].

A report of the PUGWASH conference in 1974 on "World Problems and Science" [13a] has mentioned[15] "*noticeable **regional** or **local** disturbances of climate … due to combined effects of CO_2- and dust particle emissions*" that could take place much earlier than "a far-reaching disturbance of the world climate by heat release to the environment" due to the anthropogenic energy production. This "*is to be expected presumably at the fifty- or hundredfold of the present consume of energy (corresponding roughly 80 to 100 years with a growth of 5% per year)*".

Such statements can become surpassed estimating the increase of temperature that would be expected at this exponential growth by DÖPEL's model from 1973 (section 3.2). It shows a continued exponential growth to be unjustifiable, as it has been shown by the authors of the Club of Rome on a broader basis for other influences polluting the environment. These statements meant as warnings against exponential growth are often misunderstood and disapproved as prognoses until today. However, the discussions are dominated as before by the correspondingly constant growth rates[16].

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[15] Bold type in the original text.

[16] Sometimes transitions to linear growth are discussed as desirable [36d]. This is part of the initial phase in our later considerations (on Fig. 2c). Therefore it is not discussed separately.

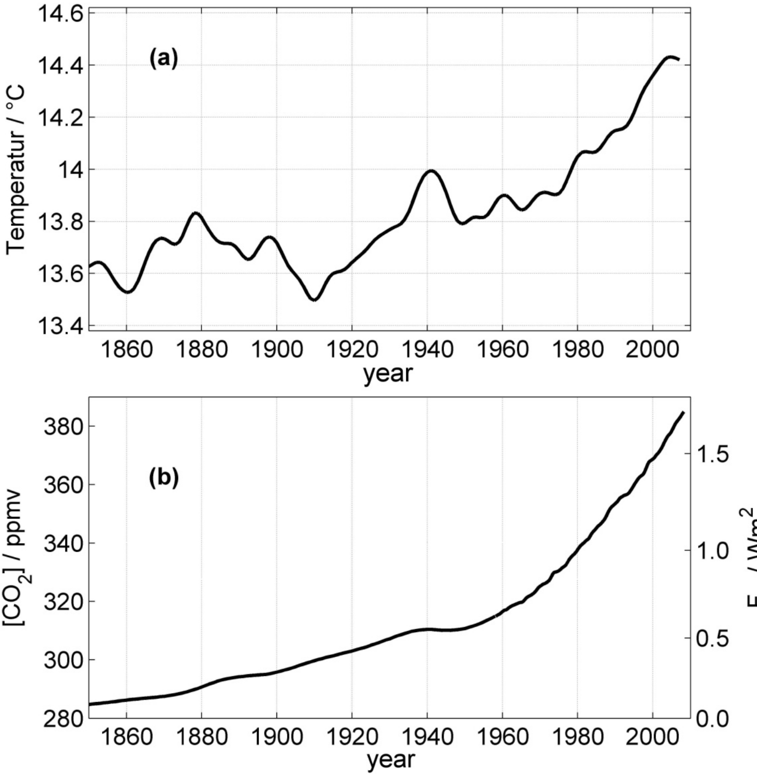

Fig. 1

(a) Averaged global atmospheric surface temperature in dependence on time. (Data from [10a].) The 2012 average was 14,6 °C [10c].

(b) Averaged global concentration of CO_2 in dependence on time. (Data from [10b].) ppmv = parts per million by volume, i.e. volume parts on one million. Additionally, the inscription of the ordinate on the right gives the CO_2-forcing as a logarithmic measure for the ratio of the actual concentration to the "pre-industrial" 280 ppmv in 1750 [2], calculated by eq. (15) in section 3.4.

In the PUGWASH example from 1974 (with 5% growth p.a. for energy consume and heat release), computations as in section 3.2 give some tenths of a degree for the second half of our century[17]. To become impressed by this, one must have the disposition of a lumber jack who looks in advance for several generations, as it means the old silvicultural aim of sustainability.

The time horizon is similar for an energy production by nuclear fusion (see section 4.1). Their conveyors belong also to the target audience of DÖPEL's warnings. Thereby he has completely ignored the intensification of the greenhouse effect, that has recognized meanwhile as mainly responsible for global warming, which already amounts 0.7℃ ([13d], Key Message 3).

However, the course of temperature is by no means as monotonous as that of the CO_2 concentration, which is illustrated in Fig. 1. Indeed, carbon dioxide is decisive for the actual temperature increase, and the long time trends both are largely parallel for the past 10^5 years, at least ([1]; [7] Fig. 9). But the "*global warming*" has been interrupted by a "*cooling*" between the beginning of the nineteen forties and the middle of the nineteen seventies, for the last time [2-1990]. This resulted in controversial debates [11b] especially at the end of this time interval, when DÖPEL wrote his work [3], in which he prudently ignored these controversies. As the cardinal reasons for the cooling are to be considered air pollutions by aerosols and volcanic influences ([2], Fig. 9.5). Without

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[17] This can be read from DÖPEL's Fig. 1 from [3] for the annual growth coefficient q = 1.05. The actualized Fig. 2c in our section 3.2 gives similar results, albeit the real q = 1.02 has been used for 1970 to 2000, corresponding to 2% growth p.a. Maintaining this lower growth, this model gives some tenths of a degree not until the beginning of the 23rd century.

these influences the actual global warming would be remarkably stronger.

2.3 From Formation of the IPCC until Today

After all, the assumption that the global climate was in danger led to the formation of the initially mentioned *International Panel of Climate Change* by the *United Nations* together with the *World Meteorological Organization* (WMO) in 1988. The atmospheric increase of greenhouse gases became characterized as anthropogenic and alerting already in the 1st report [2-1990].

Fundamental for internationally coordinated measures against the climate change is the *United Nations Framework Convention on Climate Change* (UNFCC) [13c] that passed in 1992 and became obligatory to international law in 1994. It corresponds to the principle newly generated then for the Community of states to respond on strong menaces to global environment even with lack of full scientific certainty. In §3, *"serious or irreversible damage"* to which the anthropogenic greenhouse effect belongs, becomes especially accentuated. This is contradictory to the wrong but still often used plea with respect to this effect, *"that more efficient mitigation can occur in a future richer world"* [44b].

The annual *United Nations Climate Change Conference or "Conference of Parties"* (COP) shall put the UNFCC into action. Thereby, the *Kyoto Protocol* was adopted in the Japanese Kyoto in 1997, entered into force ultimately in 2005 and expired in 2012. Now it is hoped to be continued as "Kyoto II" until 2020 together with the largest emitters that were not included so far [24g].

More successful (also with respect to the anthropogenic greenhouse effect, see below) was the international struggle against the ozone hole[18], that has been discovered in 1984. Already in 1987, in this context the *Montreal Protocol* has been passed as the first global agreement on environment at all. It has been blessed as *"perhaps the single most successful international agreement to date"* by KOFI ANNAN, Nobel Peace Price laureate and secretary-general of the UN from 1997 to 2006. Together with the revision protocols, it has stopped the damage of the stratospheric ozone layer, the relaxation of which begins to show already and could become complete in the second half of our century [16]. In the "30-Year Update" [12a] of "*The Limits of Growth", the "Ozone Story"* is given under the headline "*Back from Beyond the Limits"* as a classical example for transgressing a limit with the danger of a collapse and with its avert. - In-between, for the greenhouse effect a transgression of limits is also emerging, the reduction of which is the main task of climate politics.

Since the halocarbons that cause the ozone hole are strong acting greenhouse gases[19] as well, global warming has been delayed markedly by their reduction[20]. Due to calculations of the Dutch environmental centre MAP (Milieu en Natuur Planbureau) [17], this compensated one

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[18] Cf. [14], includig history. See also footn. 7 and sect. 4.2.

[19] This also holds for Fluoro-Hydrocarbons (HFCs) that have been introduced for example in refrigeration after the Fluoro-Chloro-Carbons were forbidden. An application for the 22nd Meeting of Parties to the Montreal Protocol in 2010 to prohibit HFCs too had been adjourned. - Refrigeration without any halocarbons is offered by the Greenfreeze style technique, which works in nearly 400 million refrigerators sold up to 2010. In 2011 it was introduced in the USA as the last industrial country [15].

[20] The other way round, the greenhouse effect acts on the ozone hole, but the amount is uncertain yet [16].

decade of the actual CO_2 increase. This is much more than the eligible result of the commitment by industrial countries to reduce their emissions of greenhouse gases from 2008 to 2012 by 5,2% in the average, compared to the level of 1990.

This (too) low value has been caused not at least by the USA negotiation for the Kyoto protocol with the leadership of Vice President GORE. Asked for this later, he pointed to the real power distribution in the state in which he had been *"the second man only"* [18]. This commemorates fatally the arguments of the Soviet negotiation leader in Montreal 1987, which almost ruined the ozone agreement in last minute: The extent of halocarbon production was fixed by the five-year plan until 1990, which by the constitution wasn't allowed to be changed [19]. At least thanks to GORBACHEV, this problem has been solved with exception clauses. In contrast to this, the CO_2 problem is by far more extensive with respect to economics and power politics, and it is scientifically much more complex, which caused permanent conflicts.

Additionally, the changed international situation in the nineteen nineties raised enhanced claims to reduce the expense for environmental protection [20]. Thereby, the realization that a belated reaction causes higher costs still has been suppressed. In the foreword to the *"30-Year Update"* of *"The Limits of Growth"* [12a], the reduced environmental protection is shown by contrasting the UN Conference on Environment and Development 1992 in Rio de Janeiro with the *"Rio + 10 conference"* 2002 in Johannesburg and by the course of violating the limits in the meantime (Fig. V-1 in the *"Update")*. Symptomatically is the formulation from the foreword to a collection of so-called *"environment errors"* that firstly appeared in 1997 [21]: *"The first wave of environmental protection had much success. But it is irrecoverable."*

Trying to prove the latter statement, the authors of this several times reprinted bestseller list disagreements, among others in the climate debate or “climate hysteria”, respectively. This is done in great detail – and not without success. Thereby, not only other journalists and politicians or the “morale multi” Greenpeace become savaged. They polemize also –and first of all - against scientists and their institutions, as the IPCC or the Max Planck Institute for Meteorology, *“rearmed to the German High Performance Computing Centre for Climate- and Earth System Research”* at Hamburg [21].

Within a concluding list of books, the similarly unrealistic account of an American *“eco optimist”* from 1995 with more than 700 pages [21a] is recommended. Such writings which were widely spreaded have contributed to a *“business as usual”*.

Particular in the mass media, the term *“climate change doubter”* (or “… *denier”)* became common for those who gainsay the anthropogenic influence on climate, or declare it to be irrelevant (see section 4.2). Traditionally, in the United States whose CO_2 emissions are the highest (neck-and-neck with China) they have a more significant role than in Europe, not at least due to support from business. Especially, “The Heartland Institute” in Chicago is *“the world’s most prominent think tank promoting skepticism about man-made climate change”*, as it says on the homepage. A similar facility, the “European Institute for Climate and Energy” (EIKE), has its headquarter in Jena, Germany (Thuringia).

[21] This Max Planck Institute <http://www.mpimet.mpg.de> is only one of several users of the *Computing Centre*. Besides the *Max Planck Society*, three other associates are carriers of this service facility which is at the international forefront of computing capability [22].

Its “5th International Conference on Climate and Energy (ICCE-5)” was arranged in Munich[22] together with the 8th International Conference on Climate Change (ICCC-8) organized by the Heartland Institute from November 30 to December 1, 2012. This time placement during the time of the UN Climate Change Conference (COP 18) at Doha [24g] was of course meant to be an affront.

However, German media mostly refer rather to scientific presentations e.g. from the COPs. - Prominent climatologists have contributed popular science presentations in the most favorable sense, e.g. [25-25b].

[22] One of the prominent lecturers was the Chief Executive Officer of the German *Union of Chemical Industries (VCI).*
(See http://www.eike-klima-energie.eu .)

3 ROBERT DÖPEL, his Climate Model, and the Actualization

3.1 Important Life Stages and Works of DÖPEL

ROBERT DÖPEL (1895-1982)[23] wrote at the age of 78 years - motivated by a strong sense of responsibility – at Ilmenau his first and only work on climate [3]. As a *"late entrant"* in this field, he came from the (nuclear) energetic side. Most important was his experimental proof of an effective neutron increase in April 1942 at Leipzig. He achieved it together with his wife and WERNER HEISENBERG (1901-1976, NOBEL Price in Physics 1932) as theoretician [3a].

At the end of July of the same year, the group around ENRICO FERMI also succeeded in the neutron increase within a reactor-like arrangement. Whereas FERMI had an "*unique double aptitude for theoretical and experimental work*" in the 20th century [28], the success at Leipzig resulted from the cooperation between the theoretical physicist and the experimentalist, as which DÖPEL had taken up his first professorship in 1938. Even in 1982, a few months before his death, he recollected within a letter [4F] to H. RECHENBERG :

"That was the most pleasant working time I experienced in Leipzig at all. … Sitting together with the most eminent theoretical physicist of that times in the laboratory or elsewhere, all talks were so pleasing light-hearted that all was as ideal

[23] See also the short biography preceding the table of contents and the more detailed ones from [14a] (also in Englisch) and [4-A]. An autobiography regarding the first life stages (including the years in Leipzig) is contained in the letter facsimile from footn. 1.

as one could wish. … But HEISENBERG *occasionally overestimated – or underestimated – the experimental possibilities."*

DÖPEL's wife KLARA [3e] took over *"the conversion of the results of measurement in order to answer the theoretical questions"*.[24] In 1933, she had given up her job as a jurist for political reasons. After their marriage, she attended to physical studies at Würzburg, where her husband was a private lecturer up to 1938. At Leipzig, she cooperated gratuitously in the experiments on nuclear fission, and she has been the first person who *"realized by appraisal of the experimental results, that an urane machine is possible"*.[25]

From Eastern Germany, DÖPEL wrote on 28 December 1966 to HEISENBERG: "*Nowadays, here in the GDR nobody knows anymore, that then such results were achieved."* In-between, the priorities became clarified without ambiguity, but even now they are often presented wrong or reduced. A statement in the epilog of a book from 1967 [29c][26] has contributed mainly to clarification:

"Indeed, the Germans were the first physicists in the world, with their Leipzig pile L-IV, to achieve positive neutron production, in the first half of 1942."

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[24] Letter of 7 March1976 from ROBERT DÖPEL to ELISABETH HEISENBERG.

[25] Statement of DÖPEL, reported in [29] about the works at Leipzig. They also continued work [29b] from Würzburg, that contains an early and important contribution to analytics by neutron activation.

[26] The second title with the *German atomic bomb* is misleading. As is well known, already in an early stage of the war the attempts to construct nuclear weapons were postponed by the Nazi leaders as illusory for Germany. Only the continuation of the project on energy generation was possible, as HEISENBERG reported to the Minister of Armaments ALBERT SPEER on 4 June 1942 [28], and some days later a corresponding governmental decree has been issued.

In June 1942, DÖPEL's "*Uran-Maschine*" was destroyed by a chemical accident with hydrogen [3c] which finished the work on this topic at Leipzig [4-C]. This was the first accident that disrupted a nuclear energy assembly (cf. sect. 4.1).

Already afore, a shift of the main works of HEISENBERG towards the *Kaiser-Wilhelm-Institut für Physik* (KWI) in Berlin was decided. In foresight of personnel policy problems[27], the DÖPELs didn't follow him despite his request, and they retired thereby from the uranium project. The Berlin KWI and its extern branches, despite increased expenditures, didn't succeed in getting a reactor critical. However, this was realized by the FERMI group in December 1942, so that the German advantage was definitively lost.

In the so far most popular biography of WERNER HEISENBERG[28] from DAVID CASSIDY [29a] the statement about *"*DÖPEL *who was closer*

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[27] In his letter to H. RECHENBERG from 1982 [4-a] DÖPEL wrote: "*Unfortunately, Mr.* HEISENBERG *also at inevitable staff decisions let not off from the gentleness of his methods, even when their unsuccessfulness could be seen from the outset.*" Planning the relocation to Berlin, he had not involved ERICH BAGGE, a member of the Nazi Party, for the KWI. This however "*had no problem to let his transfer to Berlin be commanded by his Nazi comrades of the Army Ordnance Office*". (The full name from the handwritten letter has been inserted here, as in the letter from BAGGE to C. KLEINT from 5 may 1995 [3b] with unfounded criticism on DÖPEL. (See also footn.1.) The political atmosphere in the Leipzig Institute at the end of the 1930's has been aptly described by another PhD student [29e].

[28] Far more detailed and thorough is the new biography of HELMUT RECHENBERG, the first part of which covering the years until 1932 [28a] appeared so far. The second part, more important for our considerations, will cover the Nazi and the post-war period. - The time from World War II on is covered by the book of the American science historian CATHRYN CARSON [28b].

to the power source than was the Berlin team" is misleading[29]. He had been summoned and cautioned by the *Gestapo* after political disputes [4-E]. In a bestseller on nuclear energy from 1956 [29d] he was nevertheless explicitly called "*Nazi"*. This insult was banned for later editions, but that changed little in the spread of this insult, especially in the English language area.

In April 1945, a few days before the U.S. invasion, KLARA DÖPEL was killed in an air raid in Leipzig while her husband made a short visit with his parents in Thuringia.

In the Soviet Union

In August 1945 DÖPEL went to Russia[30] where he had to work together with other German scientists in a research institute near Moscow on the production of heavy water. It is said, however, *"that he could hardly work, mentally destabilized by the death of his wife"* [4-E]. Probably he has been removed already in 1948 from the Soviet nuclear program.

Of course he was only allowed to comment on his work without telling details. But overlooking the fragile *"balance of horror"* with mutual assured destruction of the blocs he uttered to see himself on the weaker - as the right - side, corresponding to all his nature. M. HÖTZEL [4-E] wrote further: *"Since* DÖPEL *refused selfish ownership and consumerism he*

[29] For the German edition of [29a], this has been translated as:
"*...Döpel, der dem Zentrum der Macht näherstand als die Berliner Gruppe, ... "*.

[30] In anticipation of East-West alternative to work after a lost war, soon after the war began DÖPEL decided in favor of the East, as WILHELM HANLE reported who decided in favor of the West [32]. Both were still lifelong friends. Against this background, the TH Ilmenau 1990 awarded a honorary doctor title to HANLE, who is known by the effect named after him.

must have felt comfortable among Russian people." In connection with a letter from 1981, H. WADEWITZ [4-B] reported from a conversation with DÖPEL, that *"his decision to go to the Soviet Union in 1945 was encouraged by the fact that Russian assistants had supported digging up the corpse of his wife after the air attack on the Leipzig Institute".*

At first opportunity, Werner Heisenberg sent him a solicitous letter[31] to Russia. After memories of the domestic meetings of the two couples, he wrote:

"Your decision to go to Russia seems after all what we have previously discussed human understandable and logical, and You'll probably just think the same way about the fact that we sit here in Göttingen." [The following text was made illegible by the soviet censorship.]

In 1980 DÖPEL wrote to Mainz (Western Germany) to FRITZ STRASSMANN, the co-discoverer of nuclear fission: *"I don't know whether productivity of socialist systems will reach ever that of capitalism; but I believe that no system where selfishness of the individual, private groups freely can affect, will meet the future problems in the coming century. Of course must also all organizations which want to build a new society learn much that socialism and communism are not the same."* [32]

From 1952 until 1957 DÖPEL worked as professor of experimental physics at the university in Voronezh. Here he married his second wife Zinaida, Ukrainian and widow of an officer, who was victim of World

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[31] Posted on the 22.10.1946 and printed as a supplement to the letter to H.. RECHENBERG of the 2.8.1982 [4-F].

[32] Translated from the letter whose facsimile is reproduced and commented online: See footn. 1. In [3], DÖPEL hoped for a *"lasting harmonious solution".* After the Prague Spring of 1968, he supported the smashed Czech *"socialism with a human face"* – of course in individual talks merely.

War II. As he said later, perhaps they would still be there if the promised construction of laboratories for nuclear physics would not have been delayed. Such laboratories were promised him later by the German *Hochschule für Elektrotechnik Ilmenau*. Although this promise was not met, in 1959 he refused a renewed call to Voronezh considering his age of 64.

The Years in Ilmenau

The promise given to DÖPEL of a nuclear engineering education and research in Ilmenau is called mostly thoughtless and he himself overcredulous, because he relied too much on it [4-E]. But still in October 1957 a minister signed the application on his appointment for the subject *"Experimental Nuclear Physics"* [31]. Only in December, when he had already started his work, the *"off"* came from the *Secretary of State for Higher Education*. This included the extensive nuclear engineering projects planned with the government before the contacts with DÖPEL. The main reasons for the fights that resulted were so due to problems caused by the East Berlin Government.

Furthermore, a decision of the University Senate to extend DÖPEL's period of service until 1963 according to the previous minimum commitment was not met. This resulted in renewed, violent conflicts[33].

Finally, he received further but reduced job opportunities at the institute because otherwise he could not have supervised his five PhD students was not possible. He did experiments until 1975 although his vision had greatly declined. Because he payed a lab assistant out of

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[33] This is shown, for example, by a letter by DÖPEL from 26 September 1962 [4-F]. In spite of the report of a special commission that confirmed his view the Senate had declared the matter as closed on 11 September 1962.

pocket he was accused to show "capitalist airs" by the communist university management. He wrote this to the Minister of higher education still in 1981 in thanks for the congratulations to his 85. birthday [4-E][34].

His research area at Ilmenau was the physics of gas discharges which had earlier been a *"second pillar"* for him and that now experienced a renaissance [4-D]. From here he sought - as before from nuclear physics - the connection to astrophysics where he also made himself a name [32, 4-D].

His creativity and the love he felt for scientific work still in old age[35] were fascinating and charismatic. Moreover he had great human richness as well as broad intellectual and cultural interests, see the last section 4.2. - He died in 1982 on the day before his 88. birthday in Ilmenau.

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[34] Here one has to object to the incrimination that DÖPEL caused his *"own isolation"* [4-E]. It came from the communist party whose secretary had requested his exclusion from the faculty and caused his resignation (and the resignation as Vice Dean). His opposition against the politically motivated removal of students from the school also played a role. - WILHELM HANLE (see footn. 30) aptly described his friend as a *"Gerechtigkeitsfanatiker"* (fanatic for justness).

[35] In the letter of 26.9.1962 [4-F], at the age of 67, he stated for spectral analysis: *"A spectrum is for me not only a physical document, but in addition almost something like a kind of music."* And 1968 he wrote on his former Ph. D. student J. KLEIN [54] about his *"small group of unsettled natures... on a bank of the boundless sea of the unknown": "What satisfies them and moves, this is an eternal longing for new insight; it gives them wings and strength and joy and it is the real meaning of their life. Well, now you will possibly laugh over the old romantic ... ."*

In 1995 a memorial on occasion of DÖPEL's 100th birthday[36] with the Rector DAGMAR SCHIPANSKI took place at the redesigned tomb on the Ilmenau cemetery, followed by a lecture event at the University. After CHRISTOPH SCHNITTLER's speech as the *spiritus rector* of the memorial, two lectures were given by authors from Leipzig about subjects of their papers [4-C] and [4-E].

On occasion of the 30th anniversary of DÖPELs death (see the preface), in december 2012 a lecture evening was arranged at the TU Ilmenau within the lecture series "*Current problems of electric power engineering*". The memorial address from Manfred Kahle was followed by speeches by the author on DÖPEL's climate model and by Reinhard Steffler on actions in the case of accidents with uranium powder at Leipzig 1941 and 1942 [3f].

In the next section, DÖPEL's treatment of climate problems and also his thoughts on energy policy are reflected. The politically especially important nuclear energy, in that the nuclear physicist DÖPEL had share very early, is treated separately in section 4.1, and in the last section 4.2 we come back to his personality in relation to cultural aspects.

3.2 Döpel's Model Calculations and their Update

First, the geophysical balance model from the manual article [6] used by DÖPEL is presented with updated parameters, as it is needed in the next section.

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[36] Reports on the ceremony and its preparation are available in the *Ilmenau University News* (IUN) **39** Nr.1/1996 and **38** Nr.4/1995 are available: http://zs.thulb.uni-jena.de/receive/jportal_jparticle_00140315 and http://zs.thulb.uni-jena.de/receive/jportal_jparticle_00139142 .

In the radiation balance between earth and space, averaged globally and over time, the incoming solar radiation is energetically equal to the reflected and scattered radiation by Earth with its atmosphere plus long wave radiation emitted into space (preferably by higher atmospheric layers) [9]. The latter can be calculated approximately with the STEFAN-BOLTZMANN law for a black body, corresponding to a layer with the effective radiation temperature T_e. That provides the left side of the energy balance equation:

$$\sigma \, T_e^4 = (1 - A) \, l_o / 4 \qquad (1)$$

$\sigma = 5.67 \cdot 10^{-8}$ W$m^{-2}K^{-4}$: STEFAN-BOLTZMANN-Constant.

T_e = 255 K : Effective balance temperature of a fictitious, acting as black emitter atmosphere layer.

A = 0.30 : Planetary reflection coefficient, according to a planetary albedo of 30%.

$l_o = 1\,367 \; W \; m^{-2}$: Solar "constant".

The WMO (World Meteorological Organization) agreed on this reference value in 1982. It matches well with more recent measurements of radiation flux density, which was thought to be constant at the upper edge of the atmosphere [9] and describes the intensity of the solar radiation at the average distance of the earth.

In the denominator of the right side of the first equation, 4 is due to the conversion of the cross section area of Earth into the surface of the globe. The additive contribution of anthropogenic heat release is neglected here.

For the effective equilibrium temperature 255 K or -18°C result using this radiation balance model. DÖPEL used 250 K from the Handbook of Physics [6], corresponding to a higher albedo A = 0.35. This temperature for the black emitter is attributed empirically to a height of approximately 6 km, that *"one can accept as medium ceiling of clouds"*.

This attribution is however problematic because of greenhouse gases that are effective mainly in the cloud gaps, and it is not necessary. Instead, the upper limit of the troposphere that is on average 11 km [9], is essential for newer representations relating to the concept of forcing (section 3.3). Up to this limit, the tropopause, the average temperature decreases to 218 K . Then it remains constant within the stratosphere for some kilometers, and starts growing above. This inversion is a significant limit on the weather. Its intricate details are totally neglected in the radiation balance.

The medium temperature difference between the air at the earth's surface with a mean temperature of 15°C and the fictive layer acting as a black emitter is [15+18] K = 33 K (vs. DÖPEL's [15+23] K = 38 K). It is due to the greenhouse effect.

As easy as the radiation balance approach is DÖPEL's set-up for assessing the impact of anthropogenic heat release F_w on the effective temperature T_e. He assumes F_w to grow exponentially with an annual enhancement coefficient q (corresponding to 100 (q - 1) % p.a.). With the starting value $F_{w,o}$, after $\Delta t = t - t_o$ years we arrive at

$$F_w = F_{w,o} \exp\left([q-1] \cdot \frac{\Delta t}{a}\right) = F_{w,o} \cdot q^{\Delta t/a} \quad (2)$$

For the second part of the equation, $ln\, q \approx q - 1$ has been used. The net solar radiation flux density to the earth is the right hand side of eq. (1) or

$$I_s = 239 \frac{W}{m^2} . \qquad (3)$$

After the time Δt the effective temperature is

$$T_{e,t} = T_e \left(\frac{l_s + F_{w,o} \cdot q^{\Delta t/a}}{l_s} \right)^{1/4} \qquad (4)$$

DÖPEL used $F_{w,o}$ = 0.016 W/m² for his first year 1970. It has been neglected in the denominator t versus l_S.

Updates

For the updated calculation $F_{w,o}$ = 0.023 W/m² for the first year 2000 is used instead. This results from detailed tabular representation of the German Advisory Council on Global Change (WBGU). Of the entire waste heat given there[37], 13% for renewable energy were subtracted which come from the sunlight and do not contribute to net warming. With the binomial approximation it is:

$$\Delta T_e = T_{e,t} - T_e = T_e \frac{F_{w,o}}{4 \cdot l_s} q^{\Delta t/a} \qquad (5)$$

$$= \frac{T_e}{4 \cdot l_s} F_w = 0.27\, F_w \frac{\mathrm{K\, m^2}}{\mathrm{W}} \qquad (6)$$

This describes direct proportionality between temperature increase and the current F_w with the factor

$$\lambda_e = 0.27 \frac{\mathrm{K\, m^2}}{\mathrm{W}}. \qquad (7)$$

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[37] Tab. 4.4-1 in the WBGU report 2003: *World in Transition – Towards Sustainable Energy Systems*. Earthscan London 2003 and: http://www.wbgu.de/en/home .

Eq. (6) can be considered as an application of the forcing approach[38], which in a generalized manner is the subject of section 3.3 (eq. 12).

Terminology and Attribution Problems

Unlike the infrared active greenhouse gases and other influences (section 3.4) which provide a *"radiative forcing"* the waste heat does not directly interfere with the global radiation budget. So it contributes to the "*forcing"* commented in footnote 8 with a *"nonradiative forcing"*. This latter term from the Climate Research Committee within the US National Research Council [5a] is merely mentioned in the IPCC report [2] (section 2.5.1), where it is replaced by *"the similar term 'non-initial radiative effect'"*. Especially on our topic it is stated: *"Anthropogenic heat release is not a radiative forcing, in that it does not directly perturb the radiation budget; the mechanisms are not well identified, and so it is here referred to as a non-initial radiative effect"*.

Furthermore, under the later heading *"Anthropogenic heat release"* (section 2.5.7) the global energy production 0.03 W/m² for 1998 is given. Unlike for urban regions, there is little importance awarded on a global scale, without mentioning perspective possibilities. These could still be left aside in 2001 in the 3rd Report [2-2001] with its limited time horizon until 2100. But in the 2007 report AR4 this was not justified anymore, since it regarded the time until the end of our millennium (in other context, see Fig. 2, sect. 3.2).

As will be shown below, global warming by waste heat can be calculated with the concept of forcing which may break down for (other)

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[38] By differentiating eq. (1) with respect to T_e and equalizing the derivative to the difference quotient, with $\Delta l_s = F_w$ one gets directly eq. (6) and (7).

"non-initial radiative effects" [39]. Such a breakdown would be a better criterion for speaking of an *effect* rather than of a *forcing*. - The latter term (or *climate forcing*) is used for the waste or anthropogenic heat flux (*"AHF"*) in computer simulations [66] without comment.

Even the actual AHF of 0.03 W/m² is clearly greater than some other anthropogenic forcings that have been listed in [2] (table 2.13, with the associated Fig. 2.21). So, the actual contribution of 0.01 W/m² delivered by contrails from aircraft is included in a summary representation (Fig. SPM.2 in [2]) as the smallest radiative forcing[40].

The general concept of forcing will be considered further in section 3.3, and other IPCC deficiencies follow in the first Subsection of 3.4. Prior to this, Döpels results are presented and compared with the literature.

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[39] Such effects (e.g. diffusion, or cooling by evaporation) are discussed in a German *"learning server"* http://wiki.bildungsserver.de/klimawandel/index.php/Strahlungsantrieb , but no translation for the English term is offered. – In the German 2nd edition (footn. 2), more is said about translation problems, whereas here the general terminological aspects are accentuated.

[40] "*What role do condensation trails play in our climate?"* This FAQ from the website of the Max Planck Institute for Meteorology < http://www.mpimet.mpg.de > (see footn. 21) is answered there elaborately with the quintessence, that their effect *"cannot be ruled out as being a future player in climate change"*. On the other hand, the answer to another FAQ *"Is waste heat produced by human activities important for the climate?"* starts with *"No."*, and perspectives are not mentioned in this case. This inequity which is independent of the assignment to forcing, remains at the website since years, in spite of several critical comments. As will be seen below, also publications from the last 5 years are ignored thereby.

Results until the Year 3000

The section 10.7 of the IPCC report [2] contains model results until the end of our millennium that are compared in Fig. 2 to what the updated DÖPEL model yields.

This figure is fundamental for the following sections, too. It contrasts the pure waste heat effect from the bottom part (c) with the IPCC model representations on CO_2 in parts (a) and (b) that would hold without waste heat. These are commented in section 3.4 with general model considerations for the anthropogenic greenhouse effect. The effort for such calculations can only be indicated there since it surpasses by far that for our elementary waste heat calculations.

The coat lines of Fig. 2c show the increase in the effective temperature according to equation (4) or (6), where the mathematical approximations are nearly without influence on the image. Comments on the dotted lines follow in the next subsection *"Feedback Considerations"*.

The difference between the temperature T_e of the fictitious atmosphere layer (that effectively acts as a greenhouse roof) and the floor temperature T_s acts as a driving force for transporting the solar energy absorbed preferably on the ground to the fictitious layer upwards. This temperature difference related to the feedback effects cannot grow at all if the anthropogenic heat is fed additionally to the ground. Therefore, ΔT_e for the increase in temperature at the surface represents a lower limit.

This is crucial for the comparison with statements on the anthropogenic greenhouse effect as they are shown in Fig. 2b, for example. They ignore the waste heat without having mentioned the implied restriction of growth of energy production to vanishingly low values. Due to Fig. 2c this had to be less than 0.5% p.a. and renewable energies could merely adjourn, as it is shown at the end of this section.

The waste heat has been neglected also in newer model calculations on the greenhouse effect until the year 3000, 4000, and 12 000 [44a - d][41]. They use time-dependent concentrations of CO_2 after the year 2100 that are based on very different emission scenarios instead of the constant concentration in Fig. 2a. Its fiction of a far-reaching irreversibility of the atmospheric CO_2 content over centuries and millennia is thereby justified in principle[42].

The permanently exponential growth for Fig. 2 c had to be replaced in optimistic scenarios by the gradual transition to constant energy production postulated by DÖPEL. The logistic function could be used as a fictional analytical expression as usual for population dynamic models[43]. The differences of the temperature trajectories in Fig. 2c to DÖPEL's figure 1 in [3] are small[44]. Between 1970, the first year used in DÖPEL's calculations, and 2005 for example in [35] a medium growth of energy consumption of 2% p.a. is given. Therefore the difference between the course in his Fig. 1 and the continuation from the year 2000 in our Fig. 2 c for q = 1.02 is particularly small[45].

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[41] With respect to a comparison of waste heat with [44d] see subsection *"Global Stocks …"* in 3.4.

[42] The same applies for corrective statements in [44d] on conditions in the model calculations for Fig. 2b.

[43] See for example [14] (sect. 3.3-3.5) to the more probable limit violation or transgression from [12a].

[44] His two curves for each q value for the temperature (in °C) coincide in our representation of temperature differences and correspond to the coat curves.

[45] These differences are caused in part by a higher albedo (A = 0.35 instead 0.30 in eq. (1)). But most importantly, DÖPEL's starting value $F_{w,o}$ (from the *Geneva UN Conference of nuclear Energy*) is too high. This results with a 2% growth and comparison with the year 2000 value below eq. (4).

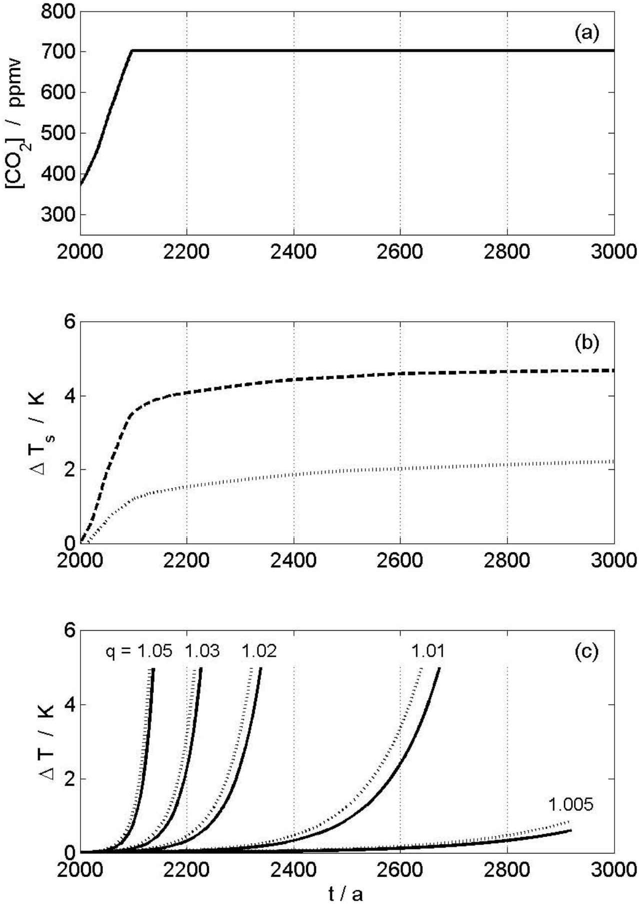
800
700
600
500
400
300
[CO2] / ppmv
(a)
2000
2200
2400
2600
2800
3000
6
4
2
0
Δ Ts / K
(b)
q = 1.05
1.03
1.02
1.01
1.005
Δ T / K
(c)
t / a

Fig. 2

(a) Atmospheric CO2 concentration in dependence of time (based on data from Fig. 10.34a in [2]). Until the year 2100 it corresponds to an emission scenario of type A1B [30] with a concentration of 700 ppmv which is thereafter assumed to be constant.

(b) Global temperature increase ΔT_s at the earths surface due to the fictitious course (a) from two IPCC model calculations of 2007 to the greenhouse effect:
dashed = Model CLIMBER-3\alpha,
dotted = Model LOVECLIM
from [44] and [45] with data in [2], Fig. 10.34b. (There are 6 more between these two curves from the modeling of other authors. The complete Fig. 10.34 is given with further comment in [14a].)

(c) Effects of anthropogenic heat without taking into account the greenhouse effect and without counter measures.
Coat lines: Change $\Delta T = \Delta T_e$ of the effective radiation equilibrium temperature T e earth/space (255 K), newly calculated from eq. (6) with DÖPEL's model. The parameter q is the annual enhancement coefficient q of nonrenewable energies (corresponding to 100 (q - 1) % per year). DÖPEL considered ΔT_e as the minimum value for the increase ΔT_s in the global surface temperature Ts (288 K) due to waste heat.
Dotted lines: Change $\Delta T = \Delta T_{ob}$ as a more realistic minimum value for the Ts increase ΔT_s that has been estimated according to a "*surface variant*" of DÖPEL's model with eq. (9).

For the remaining q values their difference from the updated 1.02 value between 1970 and 2000 results in slightly larger deviations for the continuations. They remain still well below the influence of the enhancement coefficient q even at its highest values. These were favored in DÖPEL's discussions - according to the high growth rates in the developed countries at that time. Only q = 1.07, which was omitted here, he considered "maybe too ambitious".

At the bottom of the scale, q = 1.005 has been added. In this case the particularly far-reaching linear initial course shows that growth limitations are to be expected at sub-exponential rates, too.

Feedback Considerations

Feedbacks shall be considered in going beyond DÖPEL's determination of a lower limit for global warming by waste heat. He mentioned only the increased evaporation of oceanic water associated with increased albedo of then denser clouds, but he did not take this feedback into account explicitly.

On the other hand, for Fig. 2b in the IPCC model calculations all known feedbacks[46] [2] have been included. These mainly cause the large differences in the results of the eight models mentioned in the legend of this figure.

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[46] In the review [38 c] by BONY, the *"PLANCK response"* described in the simplest case by our eq. (1) is called *"the most fundamental feedback in the climate system"*. Even though SANDRINE BONY was a *"Lead Author"* for the relevant chapter 8 of [2], this attribution to feedback was not adopted there (especially in footnote 6) and generally in the literature. See also our sections 3.3 and 3.4 in context with eq. (14) and tab. 3.

Similar in size are the differences between values of the temperature rise in fictive concentration doubling compared with pre-industrial in the IPCC report [2] from a far larger number of model calculations. This *"Climate Sensitivity"* is further considered in section 3.4, where *"equilibrium"* values are given in column 2 of table 3. Without any feedback it amounts to 1.0^o in the simplest case, and the actual value gives the feedback factor as a measure for the feedback influence. This rough estimation includes a changeover from the effective temperature T_e of atmospheric radiation balance to the surface temperature T_s.

A factor of 1.5 was used for a so-called surface variant of the DÖPEL model[47] to calculate the dotted curves in Fig. 2c as ΔT_{ob}. This corresponds to the *"very likely"* lower limit of the *"Climate Sensitivity"* and shall give a vague idea of the lower limit for ΔT_s. With

$$\frac{\lambda_{ob}}{\lambda_e} = 1.5 \qquad (8)$$

results analogous to eq. (6):

$$\Delta T_{ob} = 1.5 \cdot \Delta T_e = 0.41\ F_w\ \frac{K\,m^2}{W} \qquad (9)$$

$$\text{and} \qquad \lambda_{ob} = 0.41 \frac{K\,m^2}{W}\,. \qquad (10)$$

[47] In our 1st edition (from footn. 3), the factor 1.5 for Fig. 1c was primarily deduced from another uncertain source without lower or upper limits. The forcing is unchanged in this surface variant. It has nothing to do with a *"surface forcing"* that is used sometimes (preferable for aerosols) in addition to the radiative forcing in the IPCC reports. Both quantities may vary with time opposite to each other ([2], Fig. 2.23).

The small differences of the calculated dotted curves compared to the solid curves in Fig. 2c demonstrate that changes in the pre exponential factor have relatively little impact as long as one keeps waste heat growing exponentially. It has to be noted, however, that the feedback factors from section 3.4 of the substance specific anthropogenic greenhouse effect of CO_2 were calculated. This involves e.g. the material transfer between atmosphere and hydrosphere (sect. 3.4), while here only the heat transfer has to be taken into account.

On the other hand there are older feedback calculations for fictive variations of the solar constant or an unknown *"ghost forcing"* [38a]. They provided comparable factors such as the greenhouse effect, but are not substance-specific such as the waste heat.

The increase in the surface temperature in Fig. 2 c is therefore not only above the coat ΔT_e corresponding to DÖPEL but very likely also above the dotted ΔT_{ob} surface variant, but significantly less than an order of magnitude. The latter is suggested by the feedback factor 3 for the *"best estimate"* as the doubled 1.5 for the *"very likely"* lower limit of the climate sensitivity in table 3.

A much earlier heat-related temperature rise than for the ΔT_{ob} courses is therefore not expected. This is the message of our rather complicated and uncertain feedback comments.

Prospects for Energy Production and Population Growth

Today's growth forecasts for energy production (with varying percentages of nonrenewable energies) until the middle of the 20th century group around 2% per year[48]. Thus, a further doubling arises with the approximate equation for the doubling time of exponential growth

$$\frac{t_{dop}}{a} = \frac{\ln 2}{q-1} \approx \frac{70}{2} = 35$$

until 2040. In the 2003 report of the German Advisory Council on Global Change from footnote 37 it is even forecasted to triple by 2050, according to nearly 3% growth p.a. But the forecast of the *World Energy Council* [35] corresponds to an increase of 1.4% p.a., and in the commentary on a *"Total Concept for Energy Economics 2030"* from 2008 [36] an increase *"until the middle of this century by more than two-thirds of the current state"* is assumed, which means abundant 1% p.a.

This increase has to be seen in the light of the world's population growth. It increases from currently about 7 billion after a medium-sized UN scenario [36a] to around 9 billion in the middle of our century. Then it iterates through a flat maximum, to increase again after an also flat minimum (to almost 9 billion in 2300) [36b]. The current leading industrialized countries contribute less and less to the growth of global energy and the world's population while the current emerging economies already establish the majority. The latter are summarized together with the *"least developed"* to the *"less developed countries",* which are faced to the current industrialized as the "*more developed countries*" [36a]. These groups and labels are still preserved in the more distant future[49]. Essen-

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[48] This value can be found for the period until 2050 in table TS-3 from [34] for scenarios of type A1B, which applies to Fig. 2a. Thereafter (until 2100) slightly declining values are used.

[49] That is also problematic due to increasing migration flows, as they are to be expected from the less developed to the more developed regions in consequence of climate changes and of the economic wealth gap.

tially they agree with the *"Annex 1"* and *"Non Annex 1 parties"* of the UNFCCC [13c].

A significant difference between the two is already achieved with respect to the demographic transition, i.e. a slowed population growth with following entrance on a plateau or maximum [14]. In the more developed countries this has already happened in the two last centuries, while in less developed countries the process started not earlier than in the previous century and will continue at least until the middle of our century. The living standards increased in the more developed countries, which is called the demographic-economic paradox compared to the original demographic theory [36 c].

Regarding the possibilities for continuing this phenomenon follow information and estimates of per-capita consumption of energy[50] for 2005 and 2050 [32, 36a] in the more developed and less developed countries (**megawatt hours per year**):

Table 1:

	more developed countries	**less developed countries**
2005	64	10
2050	72	16

Despite the projected growth of the world's population by 150%, which mainly takes place in the less developed countries, per-capita energy consumption grows there approximately to the same extent.

[50] As in the global forecast used above, again the primary energies from [35] are used that include losses in producing the final energy for the consumer from the primary energy.

It achieves by 2050 only 1/4 of the value of the more developed countries[51] by 2005. Even if the accompanying raise of living standards should be enough to start the demographic transition there would still be a considerable need to catch up, if less developed countries insisted on the same standards as the more developed countries. That the global performance of such claims would lead to a global collapse, knowing at the least since the first report to the Club of Rome [11].

The level of economic growth is still used as an indicator of successful policy [36d] because it positively affects unemployment and seems to be essential for social peace. But there are clear signs that the growth of the economy and of energy production are decoupling[52] in the more developed countries [36f]. Together with other environmentally harmful influences this was investigated in a Swiss study for some European countries, Japan and the United States [36e]. The comparison shows the lowest decoupling progress in Switzerland. That is linked among others to their early, extensive use of opportunities to save energy, which probably encountered limits[53].

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[51] Among these, the USA with an average 93 MWh/a rank high while Germany is in the lower midfield of the *"developed"* countries. The other extreme are *"least developed countries"* like Haiti with less than 3 MWh/a: http://www.worldenergy.org/publications/Energy_Policy_Scenarios_to_2050/default.asp. The global average is 20 MWh.

[52] For example, the less developed China specifically strives this decoupling by increasing energy efficiency. Incidentally, its double-digit percentage growth cannot prevent an unemployment rate by 10% (http://socio.ch/internat/t_reiser.htm , 2008).

[53] For Germany refers are mentioned to special features, related to the reunification. For example, per-capita energy consumption in East Germany was 125% of the Federal Republic of Germany value last [37a].

Speculation about how the nuclear fusion technology affects the growth of energy production after the mid-century are covered in section 4.1. If it can be realized all possibilities of the DÖPEL growth scenarios are open.

More Recent Publications on Waste Heat Influences

Simple model calculations on the same foundations as DÖPEL'S (see footn. 38), but without taking into account his work and especially his lower limit considerations for heating, have been published by the astrophysicist CHAISSON at first in 2007 [65]. For the 2% annual growth of nonrenewable energy production he reported a 3^0 C rise within about 280 years (or 8 doubling times). This value lies slightly above the lower limit from our Fig.2c for q = 1.02.

Thereby, CHAISSON used an Albedo of 31% (cf. Footn 45). More important than such small differences is DÖPEL's additional argument concerning the difference between earth surface and effective atmospheric temperature outlined above in the subsection *"Results until the year 3000".*

"*More realistically*", CHAISSON used the following scenario (which may be compared with those from our previous subsection): World population reaches a plateau at 9 billion by 2100; developed countries increase nonrenewable energy use at 1% annually, and developing countries do so at 5% annually until east-west energy equity is achieved in the mid-22nd century, after which they too will continue at 1% annually. Then a 3^0 C rise will occur in about 320 years.

FLANNER [66] elaborated state-of-the art climate simulations with and without anthropogenic heat flux from nonrenewable energies (AHF), "*supporting recent work by CHAISSON"* from [65]. For his complex earth system model, he coupled an atmosphere model from the US National

Centre for Atmospheric Research (NCAR) to a *"slab ocean model"*. Limiting the time horizon to year_2100, but taking into account regional differences, the role of AHF warming has been shown for large industrialized regions already at the end of our century. *"Statistically significant continental-scale surface warming (0.4 - 0.9° C) produced by one 2100 AHF scenario"* are reported, in difference to year 2040 estimates. The highest temperature increase resulted for East Asia, whereas lower results hold for the United States and Europe. - Regional differences were not covered by Döpel and by Chaisson. The global average rise in temperature is distinctly lower, mainly due to the lower values above the oceans with approx. 70% of the global area.

FLANNER's results were denoted in [66a] as *"reasonably close"* to those obtained using a *"large scale urban consumption of energy model"* (LUCY). FLANNER's heat emissions are lower, because his *"global model did not include the contribution from vehicles or metabolism"*. However, the latter has not to be included at least on a global or continental scale, because it ultimately comes from the solar energy, like renewable energies.

As CHAISSON, FLANNER has not considered DÖPEL'S work [3] from 1973, but both confirmed the long-term forecasts and the warnings concerning "thermal pollution" from the nineteen seventies (sect. 2) that had been largely forgotten. The time horizon for climate risk perception became shorter since then. Especially in industrialized countries, where the permanent disposal of nuclear waste is questioned in the mean time by the demand for security for up to 10^6 years, this is hard to understand. - For the reports to the Club of Rome, the time horizons have become shorter, too: First significantly more than one [12] and then a brief century [12a] (approximately up to 2100), and finally 40 years only [12b].

It should be added that simulations using early General Circulation Models [67] were published already in 1972 (one year before DÖPEL [3]) with and without anthropogenic thermal energy input. However, they produced merely changes of the same order as the *"natural"* fluctuations of the models.

Global Resources for Sustainable Energies

Based on his article [65] discussed above, ERIC CHAISSON published in 2010 a popular scientific "*Opinion Essay*" for the journal "*The Scientist*" [65a]. He emphasized that a global heating of 3°C is regarded as a tipping point for survival by the IPCC, but that *"civilization has always run on energy and it always will"*. Further it is said that there was *"enough solar energy to power civilization, … and more."* This belief is as widespread as wrong, as will be shown below in context with DÖPEL's growth limits for solar energy exploitation.

"Most intense technical exploitation of irradiated solar energy": With these words DÖPEL captioned his section 5.3, treating only the photovoltaic production of electrical energy. He recognized their efficiency with a maximum of 20% that should be exceeded in the future. The usable part of the mainland area, 30% of the globe, he estimates to be 10%, which seems quite ambitious.

With this result[54] $5 \cdot 10^{14}\ W$ are achieved, a half order of magnitude more than the latest IPCC assessment of 10^{14} W ([2-2007] WG III,

[54] For the solar radiation arriving at the Earth's surface here half of the radiation in the atmosphere has been inserted, as usual today [9]. This is $I_o/8$ = 171 W/ greater by a factor of 1.3 which is insignificant for further lower estimates.

table 4.2)[55]. The utilization coefficient for the whole irradiated solar energy is then

$$K = 0.2 \cdot 0.3 \cdot 0.1 = 6 \cdot 10^{-3}\,.$$

By inserting in eq. (2) results:

$$\frac{F_w}{I_o} = \frac{F_{w,o}}{I_o}\, q^{\Delta t_k/a} = 0.75 \cdot 10^{-3} \qquad (11)$$

with the global energy demand F_w and its seed F_{wo}. The global temperature would remain constant if photovoltaic electricity is used exclusively until this value is reached. But then a further growth of energy demand must be covered from other sources.

If these additional contributions F_{wz} would be unsustainable, minimum temperatures would rise again after the time Δt_k according to eq. (5) or (9), but with F_{wz} instead of F_w. It is used to estimate[56]:

$$\frac{\Delta t_k}{a} = (\ln q)^{-1} \ln \frac{0.75 \cdot 10^{-3}\, I_o}{F_{w,o}} \approx \frac{4}{q-1} \qquad (11a)$$

[55] The specified source is updated each year: http://www.ren21.net with *"Renewables Global Status Report"*, "… *Global Futures Report"* and further links, also for discussions of the IPCC assessment report. For more general considerations see [36 g] – with the misleading labeling of infinite resources for renewables.

[56] In the short English version [14a] a corrected expression is needed to substitution in eq. (11a). The resulting approximations for Δt_k remains however unchanged.

Resulting value pairs are, for example:

Table 2:

q	$\Delta t_k/a$
1.05	80
1.02	200
1.01	400
1.005	800

The (rounded) times of constant temperature Δt_k shall apply also from the year 2000 chosen for Fig. 2c as a start[57]. Would non-regenerative sources be used through these periods rather than solar energy, the increase ΔT_{ob} would become less than 0.5°C. The corresponding stated DÖPEL for ΔT_e, and with his starting value $F_{w,o}$ for 1970 similar times Δt_k arose as above.

DÖPEL's computational procedure has been rediscovered in 2011 [68], and the results are similar. For example, with an increase in consumption of 2.3% p.a. and a land use of 100% (instead of DÖPEL's 10%), 275 years of constant temperature resulted „*from today*". This has to be compared with 294 years from 1970 according to DÖPELs formula with the same assumptions, but slightly changed initial value of consumption. (An annual growth of 2.3% was chosen in [68] because of the factor of 10 for 100 years.)

[57] Each further bisection of annual percentage growth increases Δt_k about to double (due to $\ln q \approx q - 1$).

Having in mind much longer timeframes than the current climate debate, DÖPEL says that *"also the most intense exploitation of solar energy changes practically nothing in the state of affairs"*. More general, his conclusion in the summary is:

"The only way to prevent that threatening increase of temperature lies in a global, gradual transition to the complete constancy of total energy production".

Referred to as zero growth - that has been extended to the entire economic growth - this conclusion[58] temporarily entered some Green party platforms during the nineteen eighties in Western Europe. A politically correct name from economics for the lack of growth is stagnation. This will probably not be called for, but can only be endured, as well as a shrinking economy. Indeed even the authors of the Club of Rome [11, 12] distinguished between different types of growth, and they knew how to defend themselves against the accusation of *"Doomsday Prophecies"* [12, 12a].

In addition to photovoltaics, again under the motto *"Exploitation of solar energy"* electricity generation by solar thermal power plants shall be mentioned here, which has technically been possible for decades but only starts now[59]. Within the "Sun belt of the Earth" similar efficiencies

[58] Among the East German regime, striving for unbroken growth, which wanted to overtake the West such conclusions were very suspect. The zero growth was called an *"utopian reactionary political conclusion"* [37] and DÖPEL's publication [3] considered irresponsible by the management of the Institute of Technology Ilmenau.

[59] Already in 1992 by the competent "Enquete Commission" of the German Bundestag [23] the *"in almost 20 years research and development has been achieved"* referenced and strongly recommended a thermal power plant pattern in a southern partner country. Such power plants are now built and one hopes for early economic competitiveness.

as with photovoltaics are possible, and the techniques can also be combined. The solar thermal ability to save daytime heat, which can be released if necessary has advantages. - Especially in the Mediterranean region, great opportunities are possible with the DESERTEC power project[60].

Considering the comparison made above, DÖPEL's estimate of solar resources is smaller than those in table 4.2 from [2-2007] WG III by a factor of 1/5. In this range are the wind energy [24l] and further renewable energy resources registered in the table - except for geothermics, having the triple value of solar energy. It is however important to distinguish between the shallow geothermal energy, used exclusively for heating by a heat pump, and deep geothermal energy. Only the latter can contribute significantly to the global energy production. It has to be taken into account in the anthropogenic heat[61], whereas shallow geothermal energy belongs to the sustainable sources.

Thus we remain within the rough but yet internationally agreed estimates of the IPCC table in [2-2007] for all sustainable energy specified in the table after eq. (11a) times as a ceiling. At the latest from then on energy that provides waste heat would be needed again.

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[60] For supply of Europe, the Middle East and North Africa: http://www.desertec.org/en/concept . Apart from political difficulties, for Europe the energy transfer over long distances by *High Voltage Direct Current (HVDC)* is a challenging problem.

[61] It comes from 400 meters depth at least (according to the glossary in [36 g]). This source of energy can be described as *"almost renewable"*. - The radioactivity of earth crust contributes to global warming as little as the so-called residual heat from the earth creation. DÖPEL [3] noted its insignificance in the natural heat flux in a footnote to the global radiation balance equation. Thus the terrestrial heat flow as a whole is negligible, including the contribution of geysers.

For clarification it is specified that the calculated ceiling would almost be halved if the the use of sustainable energies would grow by 2% p.a., if per-capita consumption worldwide would adopt the value of the United States given in footnote 51 . The children of children living today could still experience this limit.

In 2009, the *"Plan to Solve the Climate Crisis"* [56a] by Al Gore[62] again offered many important arguments against the climate change deniers, but it is still focused on growth. Especially, it reflects the widespread belief in future availability of *"virtually unlimited amounts of electricity from solar, wind and geothermal generators..."* as he writes in a concluding vision[63].

Should however the current global per-capita consumption become placed to his own height, so something more than the $5 \cdot 10^{14}$ W of sustainable energy would be needed, that have been estimated ahead of eq. (11) for Earth as a whole. Not only the worldwide acquisition of living standards of developed countries and especially of today's ruling class, but also a corresponding consumption of sustainable energy only thus leads to absurd consequences.

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[62] In 2008 AL GORE urged his country to cover the complete electricity from renewable energy sources within 10 years: http://www.algore2008.com . Referring to this vision, a University study 2009 appeared in California [56c], whereby the entire energy need on earth could be covered by renewable energies (including geothermics) within 20 years.

[63] Sustainable growth is a main environmental concern of Al Gore in "*The Future*" [56b]. With the the actual "Climate Silence" in the United States in mind, he comments: *"Mapping the future is a risky undertaking. Perhaps the only thing riskier is doing nothing."*

The growth limits for solar energy exploitation as well as those for non-renewable energy use from [3] have been made available early in 2009 by the repository "Digitale Bibliothek Thueringen", including updates (footn. 3) with a short English version [14a]. A reasonable international assessment of these achievements from 4 decades ago, which until now was missing in the new publications with similar (but not better) content, is to hope for.

Before section 3.4 treats some important aspects of the enhanced greenhouse effect and its modeling, in 3.3 common conceptual issues are discussed.

3.3 The Concept of Forcing and the Sun

Forcing reconsidered

When the equality between the solar radiation of the Earth's atmosphere and the emitted infrared temperature radiation (described by eq. (1)) is disturbed, the difference of radiation flux densities acts as *"start driver"* or forcing for the reinstatement of radiative balance. The driving force decreases during this process to zero while the initial value is always given for the forcing.

Following a *"standard definition"* (in [2, 38]) the forcing is generally given by the net radiation flux density into the troposphere at its upper limit, the tropopause. As described above by eq. (2), a temperature minimum with an overlying *"inversion cover"* is given in this border area for the weather. This is a relatively well defined situation. Moreover, the thermal equilibrium setting in the stratosphere[64] and above is much faster than in the troposphere.

Its greater thermal inertia is mainly due to the coupling to the oceans. Without this coupling, less than a month would result for the troposphere balance setting. But involving the upper it takes years to decades and with the deep ocean and ice sheet centuries to millennia (according to [2], box TS. 9).

For the forcing F applies the fiction of an unchanged temperature gradient within the troposphere. As a thought experiment all processes are in thermal equilibrium, their respective forcings add to F. This increases the temperature of the earth's surface to

$$\Delta T_s = \lambda \cdot F \qquad (12)$$

as the *response* in this *forcing-response relationship*. λ is the (climate) sensitivity parameter[65] and represents the global average annual temperature due to a change of the forcing by one unit.

Of course, the concept of forcing is not strict at all. For example, it can be softened by a time dependence of λ (see sect. 3.4) or by deviations from the proportionality between response and forcing [38]. But it is

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[64] The forcing F that thereby results is also called *stratospheric adjusted forcing* (F_a in [38] Fig. 2; see also [2] Fig. 2.2). It is a little different from the original *instantaneous forcing* (F_i) neither used here nor further variants from these sources.

[65] Not to be confused with the *climate sensitivity* as a special CO_2 forcing from section 3.4. Unlike our terminology from the glossary in Appendix I of [2] this is called e.g. in [7] climate sensitivity *parameter*, whereas in [38] conversely λ as *climate sensitivity* is being declared. The dimension clarifies here. (See footn. 66, too.)

widely accepted at least as a first approximation, and it is entirely sufficient for a rough treatment of waste heat effects.

The case with $\lambda = \lambda_e$ from eq. (7), but ΔT_s instead ΔT_e from eq. (6), results without any feedback [38b] and is called the simple form of the *"Planck response"* on the black body radiation[66] in [38 c] (see our footn. 46). This form is applicable if the forcing *"does not notably alter the vertical temperature structure",* e.g. for solar flux and surface albedo influences, *"but does not work simply for CO_2"* [38b], where somewhat larger λ values are used (sect. 3.4, table 3).

A not delayed setting of radiation balance with the current forcing F is thereby assumed. Such a *"change at permanent equilibrium"* (precisely: *steady-state at quasi stationarity* [14]) was assumed for our *"surface variant"* estimation with eq. (9) and (10).

The Sun

For the natural change of solar radiation flux density from eq. (3) to a forcing F_{sol} applies without feedback [38b]:

$$\Delta T_s = \Delta T_e = 0.27\ F_{sol}\ . \qquad (13)$$

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[66] The parameter given there and in footnote 6 of chapter 8 in [2] is $\lambda_P = -1/\lambda_e$. Corresponding to the glossar in Annex I of [2], it is a *"Climate Feedback Parameter"* with the general symbol Λ (units $m^{-2}K^{-1}$) , whereas the lowercase λ (with inverse units) is used for the Climate Sensitivity Parameter here as mostly in the literature (and in [2] page 133, for example).
Such formal disparities - even within the IPCC report [2] - complicate the clarification of factual issues related to climate sensitivity (sect. 3.4).

For the 11-year cycles of sun spots with a difference of 0.08% from maximum to minimum radiation flux density [2], according to a $\Delta T_{sol}^{cyc} = 0.2\ W/m^2$, results without feedback:

$$\Delta T_{sol}^{cyc} = 0.05\ ^{\circ}C\,. \qquad (14)$$

The same scale (between 0.02 and 0.08 degrees) results from this trial also for the contribution to the increase in global temperature since 1750, which is still poorly understood [2]. Uncertainty exists also with regard to secondary effects such as a modified number of nuclei for the cloud droplet formation by variation of the cosmic radiation as a result of the earth's magnetic field modulation. Thereby it holds, however [25]:

"During the strongest warming over the past 25 years, the Sun has not contributed".

The opposite is announced in [39] by a meteorologist with judicial attitude, whereupon carbon dioxide becomes "acquitted". In contrast to this, the *Max Planck Institute for Solar System Research* states in a press release *"that the Sun is not the cause of the present global warming",* whereas the earlier influences *"must still be investigated"* [40]. – It has been observed *"that the Sun is currently in the longest and deepest sleep phase for almost a century"*. Even if this phase continues until the end of the 21st century, no significant reduction of the temperature rise (by more than 10%) is expected, calculated for continuingly increasing greenhouse gas emissions until then [40a].

Because of the uncertainties in the solar forcing (as a reference magnitude used in earlier publications), it has been replaced e.g. in [38] by the better understood CO_2 with the greatest anthropogenic forcing. It is preferred also by the IPCC and discussed in the next section.

3.4 Inclusion of the Anthropogenic Greenhouse Effect

In view of the very extensive documents about the causes and consequences of current global warming can this section only give background information on Fig. 2a and b (sect. 3.2) as well as general comparisons. Possibly they are useful because some gaps between technical and popular "greenhouse literature" and climatology and "simple physics" [25a]. Uncertain influences and facts that are particularly stressed in current research presentations are taken into account here not (explicitly).

About IPCC Reports

The particularly important for this section IPCC reports [2] are extremely extent with four-digit page numbers. That is due striving for consensus[67] and lower voidability of presentations, also from outside of science. However, the strict *Principles Governing IPCC Work*[68] are as a result, hardly consistently meet.

Criticism[69] placed in the media just before the important climate summit in Copenhagen 2009 brought losses of public trust in the IPCC and

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[67] This may be a reason for the inadequate AR4 definition of *(Radiative) Forcing* which resulted in the *"Terminology and Attribution Problems"* from our section 3.2.

[68] http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf with Appendices A - C.

[69] http://en.wikipedia.org/wiki/Criticism_of_the_IPCC_Fourth_Assessment_Report and http://en.wikipedia.org/wiki/Climatic_Research_Unit_email_controversy .

more “climate fatalism”, in spite of self-criticism[70]. Reform considerations to avoid such breakdowns and more general problems followed. The UN Secretary-General entrusted in march 2010 the international umbrella organization of science academies (IAC) as an independent supervisory board with the IPCC consulting.

Preparations for the 5th Assessment Report to be published completely until autumn 2014 are reported continuously[71].

Greenhouse Gases and their Effects

Forcings from the two previous sections were to be added as additional contributions to the short-wave solar radiation flux density on the right side of the radiation balance eq. (1). In contrast, the forcing resulting from the anthropogenic greenhouse effect is to be subtracted from the long wave contribution on the left. Thus an inequality results again (according to eq. (1): left < right).

The effect is primarily due to infrared active gas molecules containing more than two atoms with varying dipole moment [41]. They absorb part of the thermal radiation emitted by the Earth's surface. By their emissions they contribute much both to surface heating by reflection and to the radiation into space (together with the clouds).

The calculation of the forcing connects to the natural greenhouse effect and uses the well-known molecular spectra in one-dimensional radia-

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[70] E.g.: http://www.ipcc.ch/pdf/presentations/himalaya-statement-20january2010.pdf .

[71] http://www.ipcc.ch/news_and_events/press_information.shtml . For example, more than 500 experts are involved for each of the three AR5 Working groups.

tion transport models [9] for power transfer. Thereby is averaged globally on length- and width-dependent vertical profiles [42].

So e.g. for the global CO_2 forcing the proximity expression results that was accepted by the IPCC since its 3rd Assessment Report [2- 2001][72]:

$$F_c^3 = 5.35 \frac{W}{m^2} \ln \frac{[CO_2]}{280 \text{ ppmv}} . \qquad (15)$$

In Fig. 1b (sect. 2.1), the right hand side (logarithmic) ordinate scale corresponds to this function with 280 ppmv as pre-industrial initial value[73] from 1750. Comparison with the non-monotonous temperature curve in Fig. 1a shows: The relation between response and forcing is by far more complicated than one would expect with a time-independent sensitivity parameter λ in in eq. (12) from section 3.3, and with CO_2 as the sole actor. As both expectations are not fulfilled, we have to go into the details.

[72] In previous years, a logarithmic factor 6.3 instead of 5.35 in eq. (15) has been used [2-1994]. This was in our 1. Edition (see footn. 3) incorrectly interpreted.

[73] The concentration varied over the years from 1000 BC until 1750 only between 275 and 285 ppmv [2]. Therefore, 280 ppmv are preferred over the 291 ppmv for 1880 instead used sometimes (e.g. in [38]).

For 2005 the CO_2 forcing was F = 1.66 W/m². This largest in total 13 contributions[74] is practically equal to the (anthropogenic + solar) resulting forcing F_{res}:

$$F_{res} = 1.6\,\frac{W}{m^2} \approx F_c^3\,.$$

Accidentally, all the other contributions largely compensate. Thereby, the uncertainty range resulting for F_{res} is much greater than for F_c^3 (cf. [2], Fig. SPM 2). The next smallest positive contributions are due to methane, tropospheric ozone[75] and the halogenated hydrocarbons. The reduction of the latter for the time being brought the strongest slowdown of the anthropogenic greenhouse effect (see sect. 2.3 in context with stratospheric ozone). Through increased back scattering (directly or through clouds), the aerosols supply the largest subtractive contribution. More upon the several contributions can be found in [25] and [2] (FAQ 2.1).

For the future development also the individual effective lifetimes [14] of species are important. They differ due to their different chemical resistance and atmospheric residence time by orders of magnitude . Together with the natural conditions which include also unforeseeable events such as volcanic eruptions, human activities determine the development of emissions.

[74] The functions for the other greenhouse gases are completely different from (15) [42]. This complicates the generalization as well as the different residence times when using the so-called equivalent concentration. This has the same forcing as a mixture of CO_2 with other greenhouse gases (and possibly aerosols; see [2], SYR-Topic 2.1).

[75] About their interaction as well as about other physicochemical aspects of the greenhouse effect see [14].

For the policy-specific emission scenarios, already a wide range of computer simulation has been tested ([34], [2-2007]). As an aid for predictions serves the Global Warming Potential (GWP), that is referred to CO_2 with a GWP of 1. It results from the product of the effective lifetime with the time integral forcing of a unit of mass of the respective atmospheric species in relation to those from CO_2 . Multiplication with the perspective emitted mass gives the *"equivalent CO_2 emission"*. -The Kyoto Protocol was based on the values for a period of time of 100 years.

Due to the *"forcing-response relationship"* (eq. (12)), the ultimate interesting global temperature development over time is determined primarily by the forcing. Secondly the sensitivity parameters λ in general also contributes to the time dependence of ΔT_S , while it originally as a time constant proportionality factor (as in eq. (7), or (9)) was designed. First of all it depends on the specific climate model. To its calculation, in addition to the radiative transfer the convection processes with tactile and latent (evaporation) heat transport as well as various feedbacks (sect. 3.2 with [38c]) must be taken into account.

For example, the H_2O content of the troposphere increases (according to the vapor pressure curve) with the temperature which greatly increases the greenhouse effect[76]. Relating to the interaction with the ocean, the material transfer is to be considered here additionally besides the already mentioned heat transfer . The solubilities are temperature dependent, and for the CO_2 they are co-determined by the formation of carbonic acid and its dissociation [14]. This increases the acidifica-

[76] This is not taken into account within the forcing, because H_2O as the only greenhouse gas both with the liquid and solid state coexists. - To the natural greenhouse effect H_2O together with the clouds contributes more than half.

tion of the ocean where the impacts on the marine carbon cycle are serious but still uncertain ([2] box 7.3).

The oceanic and terrestrial CO_2 reservoirs act as sinks and absorb more than half of the total emissions of CO_2 [13b]. - For modeling the processes in the biosphere quantities and parameters mostly are set out so far, whereas the geophysical processes are described by system quantities that can adapt to the global change during the simulation.

About Climate Models

In contrast to the one-dimensional models mentioned in context with eq. (15), three-dimensional circulation models are used for climate simulation ([9], section 11.5; [14], section 1.3.7). The related, comprehensive equation systems, which include a full description of the physical processes in principle, can only be solved numerically. Highest computing power is required for that. In taking into account the nature and extent of physical, chemical and biological processes the global circulation models (GCMs) differ within the hierarchy of varying complexity ([2] box TS. 8).

Especially for larger time horizons "EMICs" (Earth System Models of Intermediate Complexity) have proved successful, as have been used for Fig. 2b in global simulations until the year 3000. They are in the hierarchy below the atmosphere ocean circulation models (AOGCMs) with the highest complexity. These are relatively limited in the time horizon due to their computational expense and beneficial for example for regional considerations which are not at issue here. For table 8.3 and Fig. 10.34 in [2], underlying our figure 2b, they delivered curves to the year 2300 that are not plotted there. They are more in the upper temperature range of the EMIC results.

The IPCC scenario A1B used until the year 2100 for all 8 EMICs is further characterized in [34]. Among the three types of the A1 family it occupies a moderate position between the *"fossil-intensive"* and the *"not fossil"* type. The A1 family is in turn among the three families that are preferred for longer-term considerations (e.g. for Fig. 10.4 in [2]) the moderate between family B1 and A2. (See also [2-2007] WG II, box 2.8.)

The climate of the distant past – as far as it is accessible from paleoclimatic data - is described correctly by the models in principle. With its extreme events it is used for testing purposes ([2], sect. 9.3.4). For the industrial age ensembles of model calculations supply different temperature profiles with and without anthropogenic greenhouse effect ([2], Fig. 9.5). In the latter case the agreement with the measurements becomes increasingly worse especially after 1970, whereas the first case as before corresponds to the measured curve from Fig. 1a (sect. 2.1). Confidence in the predictive ability of the models is strongly supported by these results ([2], FAQ 2.1).

Climate Sensitivity

As a more descriptive alternative to the climate sensitivity parameter λ for CO_2 the Climate Sensitivity S is often given today. It is specified as temperature increase at doubling atmospheric CO_2 concentration compared to the pre-industrial value, this is to 560 ppmv. Especially the Equilibrium Climate Sensitivity S^{eq} ([2], box 10.2) holds for a so-called equilibrium (balance) case in which the temperature does not change noticeably anymore according to the respective model.

With eq. (15) results F_{do}^{3} = 5.35 ln2 W/m^2 = 3.71 W/m^2 (upper index 3 again from 3rd Assessment Report [2- 2001]) and

$$S^{eq} = \Delta T_{s,do}^{eq} = \lambda^{eq} F_{do}^{3} = 3.7 \cdot \lambda^{eq} \frac{W}{m^2} \qquad (16)$$

S^{eq} and λ^{eq} enable comparisons of the different models that are independent of the emission scenarios. With $\lambda^{eq} = \lambda_e$ from eq. (7) results row no. 1 in table 3. As already mentioned to eq. (12) (sect. 3.3), this holds without any feedback and only for influences which affect surface and atmospheric temperatures uniformly. But this does not hold for CO_2 , where an approximation is used from GCM calculations for an *uniform temperature response* [77]. This results in a factor 1.2 compared to the *simple response* and is given in row no. 2 in table 3 as the reference case for all (other[78]) CO_2 feedback factors.

For the values *"around 1.2* ℃*"*, in [2] together with [38c] from 2006 the more than two decades older source from row 3 of table 3 has been cited. However, the similarity of the results come merely from a compensation effect[79]. This has been mentioned already by MONCKTON [38d] together with unjustified polemics[80].

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[77] This condition cannot become fulfilled exactly in the calculations due to footnote A1 in [38c].

[78] These are separated in footnote 6 of chapter 8 in [2] from "the *'uniform temperature'* radiative cooling response" $\lambda_P \approx -3.2 \frac{W}{℃\, m^2} \approx -\frac{1}{\lambda^{eq}}$ in our tab. 3, row 2. The index P is adopted from [38c] with the reference to PLANCK (see our footn. 46).

[79] The comment of the 1.2 ℃ value with a long tradition [25] or with laboratory measurements [25a] is accordingly not appropriate.

[80] Other examples from this most prominent British denier of anthropogenic climate change related to the UN Climate Conference 2010: http://scienceandpublicpolicy.org and http://sppiblog.org/?s=monckton&submit=go .

The remaining rows no. 4 to 7 in tab. 3 contain generalized results from numerous model calculations and their statistical analysis ([2], box TS1 and 10.2), where *[very] likely* means a [90% respectively a] 66% probability. These results have been mentioned in our *feedback considerations* of section 3.2 with eq. (10) for Fig. 2c, where $\lambda_{ob} = \lambda^{eq}$ from row no. 4 as a guide value. The considerations questioned the direct transferability of feedback results for CO_2 with reference to row no. 2 on the heat release, where row no. 1 has been used without feedback. But the disparity by a factor $1/1.2 = 0.8$ is insignificant compared to the other uncertainties. The *best estimate* of no. 6 assists our former statement that DÖPEL's lower warming limit meets the right order of magnitude for the waste heat effect.

Table 3:

	$\Delta T_{s,do}^{eq}$ (K)	λ^{eq} $(\frac{K\,m^2}{W})$	**Comment**
1	1.0	0.27	BONY [38c] 2006: *"Simple response"*
2	1.2	0.32	[38c], [2]: *"Uniform temperature response"*
3	1.2 – 1.3	0.29	HANSEN 1984 [38b] with $F_{do} > F_{do}^{3}$
4	> 1.5	> 0.41	*very likely* (after [2]; also:)
5	> 2	> 0.54	*likely*
6	3	0.8	*most likely:* Best estimate
7	< 4.5	< 1.2	*likely*

The equilibrium values S^{eq} and λ^{eq} are temperature independent by definition. However, in the effective climate sensitivities S^{eff} and in the appropriate parameters λ^{eff} a temporal variability (i.e. an increase) occurs[81] mainly because of inertia of the climate system.

After stabilization of the forcings a temperature increase by 0.5^o and more is still to be expected, occurring mainly within the next hundred years ([2], section TS. 5. 5). From the curves in Fig. 2b (sect. 3.2) for the fictitious constancy of the CO_2 concentration from the year 2100 that is clearly visible.

In this context, an estimate to the currently active anthropogenic greenhouse effect and its future impact can be rescheduled. Below eq. (15) the forcing that occurred since the beginning of the industrial revolution was given as $\mathsf{F}_{\text{res}} = 1.6$ W/m². With the measured temperature rise by 0.7^o this gives a $\lambda^{\text{eff}} = 0.5$ vs. $\lambda^{eq} = 0.8$ K m²/W from row 6 of table 3 as the best equilibrium estimate. The difference is due to the so-called *"Long-Term Commitments"* ([44a], [2] sect. 10.7). Especially the CO_2 remains in the atmosphere for long times[82]. The duration of climate change commitments is particularly important for the "2-degree target" in the subsection after next.

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[81] By [2] for example in the section 10.7.2 nonlinearities in the feedback are discussed at AOGCMs, and in section 10.5.2.2 sensitivity for certain EMICs is considered to be a fittable parameter. - Maintaining the forcing-response relationship (9) as a basis for discussion is in such cases useful, but of course not mandatory.

[82] Cf. particularly Fig. S2 in the online supplement of [44b].

CCS and Geo-Engineering / Climate Engineering

For fossil fuel combustion, *Carbon Dioxide Capture and Storage* (or Sequestration, CCS) [2-2007, 24e] rapidly develops worldwide[83]. The feasibility of similar chemical processes has been known a long time before[84]. In the light of imminent or already occurring climate damage significant costs will apply at least in rich countries. They reduce the market advantage over sustainable energies. However, geological storage capacity could be limiting within decades for many industrial countries. Storage on the ocean floor is more problematic and expensive [24a].

Storing of CO_2 by CCS is by geology assigned to geo-engineering (in distinction to the procedural CO_2 capture) [24b]. On the other hand, in the IPCC report ([2-2007] WG III) CCS is not listed under *"geo-engineering",* that is characterized by *"Technological efforts to stabilize the climate system by direct intervention in the energy balance of the Earth for reducing* global warming" in the glossary[85]. More specifically, but under the title

[83] The U.S. and Canada have the most projects, but China is the fastest-moving nation now on CCS, according to the Global CCS Institute: http://www.globalccsinstitute.com/publications/global-status-ccs-update-january-2013 .

[84] For example, the separation of CO_2 after *"coal gasification"* is practiced long in the industrial hydrogen production and now tested for power plant operation as *"pre-combustion capture"*. For a permanent CO_2 storage (sequestration) there exist experiences after its separation from natural gas in the North Sea [24].

[85] A corresponding headline is 11.2.2: Ocean fertilization and other geo-engineering options.

"Climate Engineering", such interventions are declared in a German[86] research project [24 d]: "*Climate engineering or geoengineering* denotes scientific concepts aiming at manipulating the global climate system either by intervening in the global carbon cycle or by shielding solar radiation".

Climate engineering could CCS include better, what but rarely happens though the engineering term implies no limit on manipulating concepts or procedures. So the long-winded headline of this subsection was applied that shows again *terminology and attribution problems* as in the second subsection of 3.2.

H. GRASSL [25] accepts CCS yet most likely in a chapter "*Geo-engineering - Manipulation bei Halbwissen"* (*manipulation with half knowledge*) adverse other proposals. The main reasons are that thereby international repercussions are hardly to fear and that the reduction of CO_2 emissions must get first priority at present. This objective is endangered by daring hopes on *"Ersatz"* for the reduction strategies. International coordination problems with regionally varying interests and *"largely absence of global governance"* [24 c] have been very clear at the UN Climate Conferences 2009-2012 (COP15-18).

A much discussed proposal from PAUL CRUTZEN (cf. footn. 7) is compensating global warming according to the *"global cooling"* (as it inadvertently occurred in the nineteen seventies within the lower troposphere, see sect. 2.2) and to the effects of volcanism by targeted production of aerosols with sulphuric acid in the stratosphere. This would deplete the ozone layer (sect. 2.3), which would but accept CRUTZEN. -

[86] To avoid translation problems (see the German version from footn. 2), in a report of the *Deutsche Forschungsgemeinschaft* [24 c] it is spoken of "*Geo-engineering im Sinne eines* (in the sense of a) *Climate engineering*". – This has not to be confused with *Geotechnical engineering* which corresponds to the German *Geo-Ingenieurwesen.*

Further suggestions include the oceans with regional and hence even harder enforceable measures.

Nevertheless research on cloud production by fumigation of sea water as well as on the stratospheric aerosol entry was graded *"Very Good"* by a panel[87] of five "Top Economists" (including three NOBEL laureates). In contrast, proposals for emission taxation and trade got the classifications *"Poor"* or *"Very poor"* (4, or 5 as the worst category).

This small selection shows that opinions are far apart. It is feared that a short-range economy gets the upper hand also in this field, when it cannot be counteracted according to international law. At a round table discussion of the *"Deutsche Forschungsgemeinschaft"* in 2009 [24 c] such research was supported only to see a kind of *"emergency technology"*. It would be initiated if CO_2 mitigation measures against global warming were insufficient, or if sudden unforeseen effects [13b, 43b] accelerate climate change.

The 2-Degree Target

The *UN Framework Convention on Climate Change [13 c] contains the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"* in article 2 as a final destination. Soon after its legal validity in 1994 a target of 2 degrees above the pre-industrial value was proposed. This became binding with the Cancun (COP 16) agreement from 2010 which has been accepted by 193 of the 194 participating parties. However, the

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[87] *Top Economists Recommend Climate Engineering*, by E. Bickel (Lead Author). Press Statement (Washington DC, 4. 9. 2009) of the *"Copenhagen Consensus"* , acting since 2004: http://fixtheclimate.com . This group is not to be confused with [13b] and with the so-called *"Minimal Consensus of Copenhagen"* [24f].

commitments of the parties entered into by then can mark only the beginning towards a Post Kyoto Agreement envisaged as of 2015 in Doha (COP 18) [24g].

Have a look at Figs. 2a and b[88] as well as table 3 show that the CO_2 increase must attach far below a doubling (560 ppmv) compared to the pre-industrial concentration. By the researchers of *Copenhagen Diagnosis* in 2009 [13b] calculations have been made with three scenarios for an emission reduction that is required for compliance with the 2-degree limit (with 67% probability). Correspondingly, the emission peak must be achieved not later than 2020, and virtually no greenhouse gas may be emitted once a cumulative emissions budget has been consumed (prior to 2040).

Because today the temperature rise is already 0.8 degrees compared to the pre-industrial level only 1.2 degrees may be added if 2 degrees are allowed. Moreover, with this global medium value significant but unsafe regional differences are to be regarded. Because the temperature increases are smaller over the oceans, they are considerable higher over the mainland due to the global area proportion of about 30%. The effect increases also with latitude, so it can be several times over the equatorial value in arctic areas ([2] Fig. 10.6 and Fig. 10.8).

Important implications and dangers can be read on a scheme of the *Federal Environment Agency* of Germany [43a] depending on the global temperature rise. They make understandable that the 2-degree target is considered as insufficient especially by vulnerable countries. Inter-

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[88] Even the lowest CO_2 scenarios of the IPCC ([2], table TS. 2) by the Federal Environment Agency (UBA) of Germany were characterized in terms of the 2-degree target inadequate [43].

national support is particularly important for these on mitigation measures.

Global Stocks for Unsustainable Energies

After the sustainable energy resources were discussed in a subsection to 3.2, the same should be done here for the other energy sources. Thereby, fossil fuels under this section are the main problem for the anthropogenic greenhouse effect.

Distinction is made between the currently proven and recoverable *reserves* and the *resources* that include also suspected and still not economically and technically recoverable stocks. Current values are listed in [36 h] (tab. 1.1) by pointing out that such figures are *"often interest guided"*. The averaged *"static reach"* [89] of fossil reserves that results with constantly maintained consumption amounts to about 90 years**.** Values for the *"Dynamic reach"* [14], resulting for exponential growth in consumption with different scenarios would currently more realistic and shorter.

DÖPEL [3] announced that fossil reserves *"are going to end between 2100 and 2200"* against the background of the high growth rates in the nineteen seventies. For oil and natural gas this is already expected earlier whereas coal will possibly be exhausted after this period.

Interesting model calculations have been made to the extreme scenario of combustion of fossil resources up to the year 2300 [44d].This would give a maximum increase near to the year 3000 in global temperature of almost 8 degrees unless countermeasures are taken. This was calculated

[89] So the header 9.1.1 reads in [36 h], where the problematic character of this quantity is highlighted.

using a cumulative emission of $2 \cdot 10^{19}$ g CO_2 according to data from the nineteen nineties. In contrast, there result $4 \cdot 10^{19}$ g with the more up to date resources from [36h] and the CO_2 equivalent of energy from oil, gas and coal specified in [2-2007] (WG III, table 4.2). This corresponds to a cumulative energy of $1.6 \cdot 10^{20}$Wh .

If it would continuously and uniformly be released during a fictitious period of 100 years, the corresponding forcing was $F_w = 0.36\ W/m^2$. This gives a lower limit for $\Delta T_s = 0.1^o$ with λ^{eq} from row 1 in table 3, and 0.3^o with the *best estimate* from row 6. So, even with complete *Carbon Capture and Storage* fossil fuels would contribute some to global warming which amounts currently to 0.8^o from the greenhouse effect. In addition the contributions of other unsustainable energies would have to be regarded.

For nuclear fission fuels (section 4.1) the energy reserves are below those of oil and gas and their resources are located in between [36h]. Thereby, the dangerous reprocessing has not been included, capable of providing an order of magnitude more ([2-2007] WG III Tab. 4.2). Thus the nuclear fission resources can lie in the range of coal energy resources. Thus, the time indicated above for fossil inventories can - again speak with DÖPEL - *"be extended for about a century"* [3].

Conveying deep geothermal energy (footn. 61) is geographically limited, can but virtually be done indefinitely. The latter also applies in realization of nuclear fusion technology (see section 4.1), since there hardly is a restriction on the raw material base. - Even without *"such speculation"* DÖPEL's statement by the end of his introduction in [3] applies:

"From the aspect of existing energy supplies is no barrier for a continued increase of industrial energy consumption for several hundred years".

As then, so there is today no indication that humankind has other realistic barriers in perspective.

About Weather Forecast

To what has been said above in the subsection "About climate models", a complementary comparison of weather forecasts with prognoses of climate (as a means of weather over long periods of time) follows here. Both use the same system of physical equations, and often using everyday uncertainties of weather forecasting as an argument against climate prognosis.

After the famous mathematician JOHN VON NEUMANN (1903-1957) predicting the weather is – behind predicting human behavior - the second hardest prediction problem [9]. 1963 the meteorologist E. W. LORENZ instituted a rapid development of the science of chaos with his simple equation system of a chaotic weather model (see e.g. [7, 14]). This is determining also for the atmospheric dynamics and reveals fundamental limits for weather forecasting.

But such limits do not apply to a climate prognosis. As an apt analogy from the human sphere, [2] (FAQ 1.2) contrasted the difficulty to predict accurately the mortality age of a certain man with the exact predictability of his average life expectancy (currently 77 years in a developed country as a scenario). However, the emission scenarios underlying the climate scenarios combined to a climate prognosis, depends on humans. Thus ultimately the existing for their behavior prediction problem after v. Neumann is concerned, which is the main subject of the humanities (see sect. 4.2).

Simple Simulation Possibilities on Climate Issues

This section ends with references to further possibilities of the system dynamic simulation for readers with computer ambitions. Easiest are interactive by the American *Sustainable Institute* that are provided online[90] . They treat the time-based greenhouse gas emissions and the resulting concentrations, regional and associated global emissions with variable targets etc.

In-depth considerations with even more programs are included in a broad-based course by HARTMUT BOSSEL [46]. It is suitable according to the preface also as a compendium for independent project work in school, college or research guide. The programs also include surroundings of the climate problems (such as demographic development and chaos dynamics). The narrower set of problems of our section 3.4 includes simulation models like *"Global carbon cycle"* (Z302) and several following on the carbon dioxide problem in *"System Zoo 2"*.

Further global problems are treated in "System Zoo 3", among others based on the well known *"world model"* WORLD 3 [12a]. Such models that are not as simple as that from DÖPEL, but they can be understood and varied far better than the large research models accessible only for experts**.**

[90] http://www.sustainer.org : As a non-profit organization founded by DONELLA MEADOWS (1941-2001), leading scientist in system dynamics and co-author of reports to the *Club of Rome* [11, 12a]. For more simulations: http://climateinteractive.org/simulations .

4. Final considerations

4.1 Nuclear Energy?

In the previous section, statements on nuclear energy reserves and resources and their temporal reach under the subheading "*Global stocks of unsustainable energy*" were given. , including the predications from DÖPEL [3]. As has been mentioned in Sect. 3.1, originally in Ilmenau a professorship of Experimental Nuclear Physics had been provided for him [31], and a similar proposal came from Russia. - The question of our headline will be discussed separately for fusion and for fission.

Nuclear Fusion

Since 2007 the contract about the jointly funded experimental reactor ITER[91] is in force, and the prototype is built in France. In addition to the Continental-European EURATOM countries joined the United States, South Korea, Japan, Russia, India and China. The acronym is often interpreted as the Latin *iter*, "the way". There is a long previous history.

ROBERT DÖPEL was one of the first who dealt intensively with the idea to exploit the energy of nuclear fusion [32]. In the nineteen thirties he investigated for example the yield of nuclear processes especially with light elements in the interior of stars [4-C]. The technological use of such processes and their hardly limited resource base has been discussed in the introduction to his climate publication [3].

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[91] International Thermonuclear Experimental Reactor: http://www.iter.org/default.aspx .

For ITER the common fusion principle with Russian abbreviation TOKAMAK is used. It has been created in 1952 by I. J. TAMM and A. SAKHAROV, the later human rights activist and NOBEL Prize Laureate for Peace (1975). He was involved in the Soviet clone of the American hydrogen bomb, too. This is based on same physical principle, and is ignited by a fission bomb. Without such ignition, i.e. in the future fusion reactor, there is no security risk which is comparable to a melt-down in the fission reactor as it occurred in 1986 at Chernobyl.

Because the reactor development broadly just empirically can be taken forward with step by step growing plants, $10^9 - 10^{10}$ € p.a. are consumed worldwide. A power generation in fusion plants is expected as of mid-century if the remaining tests are successfully ([46a; 2-2007] WG III Tab. 4.2).

If the price of electricity would finally be similarly low as fission [24] far higher growth rates could be possible compared to the values discussed until 2050 in section 3.2. Already for a medium growth of 5% p.a., which is still lower than at the time of DÖPEL's forecast, already towards the end of the 20th century the waste heat would be noticeable for the global temperature, according to Fig. 2c.

Fusion reactors could then play the same role in global warming as currently the fossil power plants. Basically it holds that the fusion is desirable to bridge in CO_2 avoid. But then the growth limits must be observed even more which was discussed following eq. (11). Fusion once again shows that the next centuries deserve greater attention in the interest of the much heralded sustainability.

Not only because their heat emission, but also because of radioactive waste[92] fusion is not a sustainable technology. This is however often claimed in public and even in academic debate. Due to this belief it has been promoted for decades with very high sums. In Germany for example[93], these are in the same range as for all sustainable energy technologies together [50a Bundestag]. But in contrast to fusion they wear already now, although still far too little to reduce the current CO_2 problems. Moreover, they could be considerable cheaper than the fusion technology after the middle of our century.

Nuclear Fission

DÖPEL's "Uran-Maschine" (Sect. 3.1) and its damage by chemical explosions have been milestones in the history of nuclear fission technology. Also because the risk perception [14] is outstanding for this technology, the remainder of this section is dedicated to that topic. Chemical aspects of the reactor accidents are particularly considered by the author as a physical chemist.

Analyzing the very different accidents with nuclear facilities in Leipzig 1942, Chernobyl 1986, and Fukushima 2011, R. STEFFLER stated in his

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[92] Both the quantities of radioactive inventory in the fusion reactor and waste that arises in particular by enabling its inner walls and regularly disposed must be, are comparable with those of a fission reactor of the same performance. But the toxicities of radiation and the decay times are much lower. The percentage of fusion waste that must be sent in a geological repository is given as between 30 and 3% [50a], or null [49].

[93] The amount on a global scale is difficult to compare because of the different national and international conveyance instruments. All unsustainable energy promotion together significantly predominates in the EU and the USA the sustainable: http://www.ren21.net/Portals/97/documents/GSR/RE2005_global_status_report.pdf .

prolog [3d] with respect to the purely chemical damage in Leipzig: *„This was the world's first accident in the long line, where hydrogen has played a crucial role."* Moreover, a major German newspaper headlined in 2012, commemorating the 70th Anniversary for Leipzig: *"The Big Bang"* [69].

However, there are different statements with respect to the question, if there were oxyhydrogen explosions, or if it were explosions at all, that have been stated clearly by DÖPEL [3c]. Approving both, in the paper cited in footnote 1 a detailed analysis was given of the primary interaction of the uranium powder with moisture, followed by several explosions within the Uran-Maschine during many hours. This may be compared with coal dust explosions, initiated by methane (instead of hydrogen) as black damp in mines. The repetition of explosions could be a sign of periodical autocatalytic reactions.

In 2011, R. STEFFLER [3d] made also a comprehensive comparison with the Fukushima disaster, especially with respect to the oxyhydrogen influences. In contrast to Leipzig, in the Fukushima power plants after the primary catastrophe the reactor buildings were destructed by hydrogen explosions, which led to the final, disastrous failure of important equipment. The Minister responsible for Fukushima said before a Japanese parliamentary Committee about the reactions immediately after the tsunami catastrophe [70]: *„Nobody had ever thought of a possible hydrogen explosion at that time."*

The report to the Diet from July 2012 said that the crisis at the Fukushima nuclear plant was "*a profoundly man-made disaster*". The same holds for the Chernobyl catastrophe[94] 25 years ago, where water gas ($CO + H_2$) instead of hydrogen caused the explosions that preceded the nuclear meltdown. The general message is:

From the first nuclear arrangements to the Fukushima plants, sufficient safeguards were missed, including precautions against gas explosions.

_As a consequence of the Fukushima catastrophe, in 2011 Switzerland and Germany decided on nuclear fission phase-out until 2034 and 2022, respectively [24h-24l]. Already the nuclear meltdown in the US American Three Mile Island (1979) and the 1986 Chernobyl disaster caused a number of countries to build no new nuclear power plants at all. On the other hand, important industrialized and developing countries adhere to the fission energy.

Mainly for older reactor equipments, risks for plane crashes into nuclear power plants and for terroristic attacks are associated with that of a meltdown [51]. The latter is impossible in the so-called pebble-bed reactor (PBR) using spherical fuel elements. It was developed in Germany and worked here until 1988 [52]. Several countries are working on its further development. For example, in 2003 the Chinese Government announced to build 30 such reactors until 2020. After delays due to project reexaminations after the Fukushima catastrophe, the con-

[94] Causes of the Chernobyl accident were discussed by MIKHAIL GORBACHEV in the annex to his book on environmental problems [47]. For more accidents with a level of 4 to 7 on the *International Nuclear Event Scale* (INES), see http://www.iaea.org/Publications/Factsheets/English/ines.pdf .

struction of a reactor for demonstration purposes[95] was started in December 2012.

The problems of the discharge of radioactive matter remain also for this reactor type, as well as the waste heat. The danger of proliferation of nuclear weapons seems to be higher for the "conventional" types, and it is a main reason for the restrained position e.g. of the IPCC (in [2-2007], WG III, section 4.3.2.3) to expand the fission technology. Aside from that, at least for densely populated areas, it is too dangerous.

4.2 Climate Change and the "Other Culture"

Cultural aspects of climate change already played an important role for ROBERT DÖPEL, who liked philosophy[96] and saw science and humanities as a whole [54]. In his climate paper [3], under the heading *"Perspectives"* he wrote relating to a call for radical restrictions of (energy) consumption:

"Whoever thinks that also the further development of culture have to suffer by this the should wonder just how many kilowatt-hours were necessary to make such as the culture from the time of GOETHE *and* BEETHOVEN*!"*

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[95] http://www.nuklearforum.ch/de/aktuell/e-bulletin/baubeginn-fuer-hochtemperatur-demonstrationsreaktor-china
(With the French version: Lancement de la construction du réacteur de démonstration haute température en Chine.)

[96] See the biographies cited in footn. 23. Already at an early age, DÖPEL loved philosophical reasoning, as his friend HANLE [32] reported in his memoirs on the time they were assistants in Gottingen: "*He was not only a great physicist, but also a great philosopher before the Lord.*" Thereafter he worked near Munich where he attended philosophical seminars at the University twice a week.

The Two Cultures

At that time, *"The Culture"* was in the Eastern hemisphere still given by the arts and the related ("soft") sciences. In contrast, in the West it is spoken since 1959 - and now all over the world - after a famous lecture of the chemist and novelist CHARLES PERCY SNOW of (at least) two cultures [53, 53b, 57a]. They are grouped around science[97] and humanities, respectively, and his goal was the reduction in the divide separating them.

This by no means disappeared[98], but now often repressed divide arose in the times of BEETHOVEN and GOETHE. The latter embodied the unity of all culture as a poet with comprehensive scientific and technical knowledge and ambitions as one of the last. In Germany, this was especially important in the debate about SNOW 's theses.

Among scientists, exceptionally the physicist and philosopher [53c] WERNER HEISENBERG who was gifted also for fine arts and music [28a] delivered *"an important contribution ... to bridge the divide between natural sciences and Humanities - a goal that certainly envisioned Goethe"*. So ends a treatise [55] of the HEISENBERG biographer RECHENBERG for the international *Goethe Society in Weimar*. This small but famous town was then East of the iron curtain, and as a West German board member HEISENBERG (as a successor of PLANCK) also contributed to political

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[97] Roughly speaking, this first group corresponds to the MINT subjects (footn. 10). From its point of view the remaining subjects belong together with art and literature to *"the other"* culture. - An example of a *"third culture"* is given in [53b], where SNOW's optimism about the closure of the divide is not shared.

[98] The historian JOACHIM RADKAU wrote in [53a], p. 22: *"The gap between CHARLES P. SNOWs 'two cultures '… runs also through the literature on ecology, although just the environmental movement contains particularly promising approaches to bridge this gap."*

bridge after World War II. At the 1967 meeting of that society Heisenberg gave an acclaimed speech *"Goethe's picture of nature and the technical-scientific world"* [30] in the crowded National Theatre in Weimar. Then he visited the nearby located *"Goethe-Stadt"* Ilmenau, and there was the last face-to-face meeting and domestic interchange of ideas with DÖPEL[99] .

While for the rest of the 20th century debates about the two cultures flourished also in Germany, the present-day German scholars know hardly anything about this topic[100]. In contrast to English speaking countries, here one learned little about the lecture of SNOW even to its 50th anniversary except from English journals, for example the special issue of 2009 of "Nature" [57a] with the editorial *"Doing Good, 50 Years on"* and three related essays. In Cambridge, the place of the original lecture, there was the "*2009* C. P. SNOW *lecture*" [57b], in which also *"the great issues of climate change and environmental destructions"* were brought up to that now follows more.

The cultural divide and the climate crisis

Following SNOW, the loss of communication between the two cultures is one of the major obstacles to solve critical problems of the world. For AL GORE, the gap has not decreased since 1959, and it represents a major problem *"in thinking about the climate crisis"* [1]. In an in-depth

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[99] Friendly connected as before, they had last 1966 to HEISENBERG's 65. birthday exchanged elaborated letters [4-F].

[100] In the course of a reform with reduction of the Humanities at the universities of the united Germany, the chairs of history of Science (and related domains) were further reduced. This *"born brace between the two fields of Sciences and Humanities"* [60] had partially fell victim to a university reform in East Germany in 1970.

presentation of 2007 [56] he examined also the resistance against specialist counseling by decision-makers.

The former Czech President VACLAV KLAUS sees freedom threatened through climate campaigns in his controversial book [57] with the risk of an *"Eco-Socialist dictatorship"*. According to the foreword global warming would be *"more a matter of human as one of natural science"*.

In the epilogue of the far more thorough and detailed book of a historian [58] also of 2007[101] in context with problematic dating methods for the earth's history it is written:

"Only by the historical chronicler it is possible to bring the 'exact' natural sciences on the right track. Humanists - that saying to the year of the humanities - are not used to such a lack of exactness."

"Strikes against the climate's tale" were made in the text, and ozone hole as well as forest dieback[102] are incorrectly classified as unnecessary *"environmental fears"*. However, in principle the approach of cultural history is important for predictions of climate change impacts if we want to think until the end of our millennium.

The discussed examples of *'climate change skepticism'* on the part of the humanities illustrate the - at least in this sector - growing divide between the two cultures. But there are also initiatives for co-operation in fighting climate change. Here only two examples from Germany will be given.

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[101] In Germany, this was the *"Year of the Humanities"*.

[102] Footn. 18 refers to the true history of ozone depletion, and without sustainable measures (mainly flue and car exhaust cleaning and chalk fertilizer) the dieback of forests [14] would not have been transformed into a forest decline.

The project [24d] on climate engineering (sect. 3.4) includes the cooperation of natural with social science and law as with psychology and philosophy. Another interdisciplinary association, the "ENERGY-TRANS Alliance" [24j], joins four Helmholtz Centers, three universities and the Centre of European Economic Research (ZEW). Its ultimate goal is to investigate the terms and conditions of the planned transformation of the energy system in Germany. It *"must be relined by social and cultural sciences",* as ORTWIN RENN, spokesperson of the Alliance, has pointed out in a physicochemical magazines leading article [24k].

JOACHIM RADKAU, the historian cited already in footnote 98, recommended in an interview [71] after the inconclusive climate conference in Copenhagen (COP 15, 2009) a *"symbiosis of subglobal autopoietic systems"* against global warming and stated: *"I cannot imagine a successful world climate policy. There are no historical precedents."*

Whether the history of the ozone hole (sect. 2.3) could serve as a counter-example, is controversial discussed, as Radkau himself has pointed out in his later book [53a]. In the interview he said further: *"When people in the Third World think that we should recompense them for reducing emissions, then something has gone very wrong."* On the other hand, by the "ozone diplomacy" the third world was initially excluded from the restrictions. Furthermore, a Fund was created by the developed countries which helped them in replacing the ozone killers [53a].

The international issues that correspond to the much greater cost of combating global warming require the support of the Third through First World and the cooperation of all stakeholders.

More about Culture and Ethics

Finally, thoughts from DÖPEL's climate paper [3] (see the beginning of the current sect. 4.2) are taken up again. In the same spirit KLAUS

TÖPFER[103] , former chairman of the *United Nations Environment Program* (UNEP), predicted a *"significant change of consumer behavior"* and called for a stronger *"back binding in culture"* in his *"Weimar Speech"* of 2008 [61] . With regard to global solidarity and environmental ethics he referred to the *"World Ethos"* of the theologian and philosopher HANS KÜNG [62].

The recent development [63] underlines TÖPFER's call after an examination by the UN *"how powerful early warning systems make the prevention of looming disasters possible"*. He also emphasized the present *"renaissance of the regional"* and its importance and necessity for the cultural identity. The yet unused possibilities for the University and the region Ilmenau to remember ROBERT DÖPEL permanently as the region's most important scientist have to be pointed out.[104]. His merits and his ethos appear to be even higher when taking into account the socio-political life circumstances. Most of his life, he lived in war (heavy wounded in 1918) and with the threat of war - facing those present with their rich possibilities.

Relating to the first citation of DÖPEL of this section against undue consumption he wrote furthermore [3]: *"Often it seems even just the wealth of sparkling baubles which fly every day round muchly the people of the Western*

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[103] Now: *Institute for Advanced Studies* (Climate, Earth System and Sustainability Sciences) IASS e.V., http://www.iass-potsdam.de/people/prof-dr-dr-klaus-topfer .

[104] As a curiosity, the link to a site with 23 important people born in the *Grand Duchy of Saxe-Weimar-Eisenach* (1815-1918) to which Robert DÖPEL's birthplace Neustadt belonged is given. He is registered together with ERNST ABBE and CARL ZEISS and several writers and aristocrats: http://en.wikipedia.org/wiki/Category:People_from_Saxe-Weimar-Eisenach . - In this English encyclopedia mainly the part of DÖPEL's life before his last stage is covered, of course relating to the research with HEISENBERG and its critical assessment. But from today's perspective his late model calculations and positions to the climate problem are more important for future generations.

Hemisphere, downright dazzling closing the eyes before the entire wide range of inner values and objectives."

Now globalization spread worldwide both the negative and positive values of this hemisphere. Given the unrestricted financial flows K. TÖPFER saw *"dramatic, unrestrained global consequences for economic stability and living conditions"* [61]. However, the countermeasures taken imply a reinforcement of economic growth virtually without regard to the climate and future generations.

In the interest of these generations, the famous actor KARLHEINZ BÖHM, since more than three decades a protagonist against poverty in Africa, wrote [64]:

"It is important to act. And not to accept the world as it is."

5 Summary

(A very short summary is available under "Beschreibungen" in the online repository with the URL of this document[105] in English, too. - The **search function** for the file substitutes a **register**.)

After the introduction a short outline of facts and of debate history on **climate change** and of progress **until now is given**, starting with the discovery of the greenhouse effect. Graphical comparison of temperatures observed since then with the course of the atmospheric CO_2 concentration shows only allusively the correlation which is now clear for much longer time intervals.

This makes understandable that ROBERT **DÖPEL** ignored the anthropogenic increase of the greenhouse effect in his **work of 1973 on the waste heat influence** that was discussed contradictory at that time. Almost simultaneously both influences were reported by the Club of Rome as important to the climate, where the anthropogenic heat affects *"merely"* later generations – in contrast to the greenhouse gas emissions.

Following up the brief biography preceding the foreword, after the historical considerations important stages of **DÖPEL's career** are outlined, starting with his first professorship in Leipzig. There he scored the first effective neutron multiplication in nuclear fission worldwide together with his wife and W. HEISENBERG, the famous theoretician. Their *"Uran-Maschine"* was destroyed by a chemical explosion thereafter

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[105] http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2013100018
with the URN given below the impressum (p. 4).

in 1942. This is regarded in some detail, also from a chemical point of view with respect to later accidents (up to Fukushima).

During the last part of his life in Ilmenau DÖPEL created his simple geophysical climate model**.** He calculated lower limits for global warming by waste heat alone for several scenarios with constant growth rates of energy consume until the end of our millennium. This has been opposed graphically to model calculations of only the greenhouse action for the same period in the IPCC Assessment Report AR4 from 2007.

Afterwards, his concept has been reused by others in its simplest form, also with respect to growth limits for solar energy use. Assuming a continued growth rate for energy consumption of annually 2 %, a global heating of 3°C - that often is regarded as a biogeophysical limit for survival of mankind - will occur in nearly 3 centuries with non-sustainable sources. On the other hand, using exclusively solar sources with the same growth rate these will be outspent about one century earlier, at the end of the next century. - These publications occurred without knowledge of DÖPEL**'s** work from 1973, that has been available in an online repository since 2009, as well as its update by the 1st edition of this booklet and a short English version. After four decades, internationally there is **no public perception of DÖPEL's model calculations** at all that are more sophisticated than the similar later works.

By now, computer simulations including anthropogenic heat with and without enhancement of greenhouse action produced some tenths of a degree increase in 2100 on a continental scale. Thus, global warming scenarios at the latest from the end of our century have to take into account waste heat.

The **concept of forcing** served as a common thread for our simpler analysis of global warming influences. As by some others, the forcing definition had been extended opposite to the most recent IPCC report, where it is inadequate for anthropogenic heat fluxes. - For biological possible temperature increases by only a few degrees, DÖPEL's formalism is equivalent to the usual linear relation with the forcing as a driving force for global warming, approximated from the radiation balance with the STEFAN-BOLTZMANN law

The anthropogenic greenhouse effect has also been regarded in some detail for comparison. For **sustainability**, neutrality is necessary not only with regard to carbon for coal force with carbon capture and storage (CCS), for example. Different than usual, **heat neutrality** is postulated, too. So CCS, nuclear fusion, and deep geothermal sources may be bridge technologies for a transitional period, but they are unsustainable in that sense, i.e. for many generations in the sense of DÖPEL.

Despite improvements in energy efficiency, an increase in global energy production seems to be without alternative currently due to its coupling with economic growth, labor market and social peace**.** - The possibilities of *"Geo-Engineering* / ***Climate Engineering****"* are discussed controversially and could serve as emergency technologies**.**

Finally, after considerations on **nuclear fusion and fission energy** mental-cultural aspects for **changes of life style** were discussed in terms of sustainability, again following DÖPEL's reflections. Interdisciplinary approaches to problem solving must be strengthened so that not only the civilization, but also its culture is preserved against setbacks as they led in the past to the described shortcomings in combating climate change.

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This treatise would not be without the support of my wife, and our three sons were also motivating. They provided contributions from a mathematical, scientific and technological perspective.

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HEINRICH ARNOLD

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