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Climate Change in China – The Development of China's Climate Policy and Its Integration into a New International Post-Kyoto Climate Regime

Andreas Oberheitmann and Eva Sternfeld

Abstract: According to the IPCC's Fourth Assessment Report, global emissions of carbon dioxide have to be reduced by about 80 per cent by 2050 in order to stabilise the increase in global temperature at 2 to 2.4°C by 2100 compared with its pre-industrial level. An increase of only 2°C would bring about "acceptable" negative impacts on the eco-systems and the world economy. Without a reduction in CO_2 emissions in China, however, it will be hard to achieve this goal. Currently, China is already responsible for about 50 per cent of the worldwide increase in CO_2 emissions recorded over the past ten years. On the other hand, it is the industrialised countries that are mainly responsible for the greenhouse-gas emissions of earlier years. Taking the challenges of China's economic growth, its impact on future CO_2 emissions and the development of China's climate policy into account, this article develops a new post-Kyoto regime based on cumulative per-capita emission rights.

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Keywords: China, climate change, new post-Kyoto regime, CO_2 emission forecast for 2050

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1 Introduction

The results of the negotiations conducted at the Fourteenth Conference of the Parties ("COP 14") to the United Nations Framework Convention on Climate Change in Poznan were quite sobering: no confirmation of the minimum reduction targets the Intergovernmental Panel on Climate Change (IPCC) had recommended for industrial nations (25 per cent by 2020) was provided and there was no agreement about increasing the amount of financing or the generation of finances for the Adaptation Fund (Horstmann, Pegels, and Schmidt 2008). This was hardly surprising, however, considering the impending resolutions at the next Conference of the Parties to be held in Copenhagen in 2009 and a US administration that was then in a state of transition. The climate talks held in Bonn in June 2009 in the run-up to the Fifteenth Conference of the Parties in December 2009 in Copenhagen, at which decision ns are to be made about the climate change policy that will exist once the Kyoto Protocol has expired in 2012, resulted in no noteworthy progress either. On the contrary,

- Japan submitted shockingly low goals (a 15 per-cent reduction in the amount of its greenhouse-gas emissions by the year 2020 compared to 2005), which amounts to an 8 per cent drop, scarcely exceeding the obligatory reduction level of 6 per cent agreed on in Kyoto.
- Admittedly, the EU has declared its intention of reducing the amount of greenhouse gases it churns out by 30 per cent compared to 1990 figures, but its ministers of finance have only given a weak nod to providing the financial backing needed to cut down the world's greenhouse-gas emissions.
- Despite having a new president, so far the USA has declared reduction goals at the negotiating table that are far from ambitious (merely reducing the greenhouse-gas emissions to the level of 1990, not achieving a seven per-cent cut compared to 1990 as it promised in the Kyoto Protocol) and has pledged even less support for the financial package that is envisaged (Boldt 2009).

With this in mind, the developing nations and newly industrialised countries were unwilling to negotiate about the serious climate activities that are necessary. They expect the industrial nations to reduce their emissions by at least 40 per cent by 2020 compared to 1990.

A host of challenges have been facing us since Kyoto. According to the IPCC's 4th Assessment Report, the level of greenhouse-gas emissions

around the world would have to be reduced by 50-80 per cent by 2050 for the CO_{2eq} concentration in the Earth's atmosphere to be limited to 400-450 parts per million (ppm) (just CO_2) or 445-490 ppm (including the five other greenhouse gases as well (methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) plus the effect of aerosols, which reduce the net temperature) and consequently keep the rise in temperature at ground level down to "only" 2 to 2.4°C compared with the pre-industrial level (IPCC 2007). Only moderate negative effects on the environment would then have to be tolerated at the 2°C level (such as a rise in sea level, an increase in regional occurrences of extreme weather, a decline in biodiversity, etc.).

Empirical findings blatantly reject the current likelihood of attaining this goal. The amount of CO_2 emitted around the world between 1990 and 2007 did not fall, for example, but actually rose by 26.5 per cent (see figure 1).

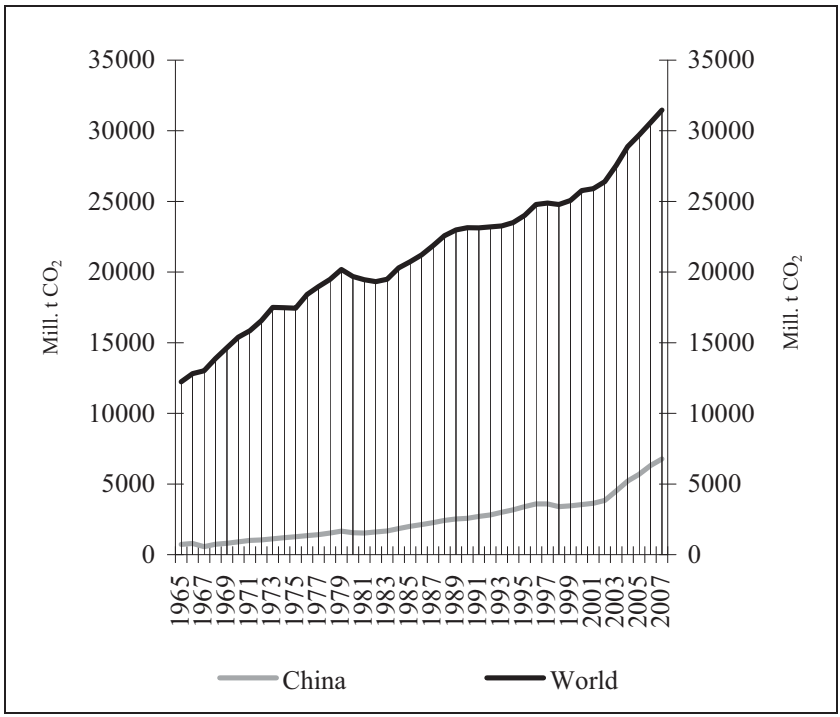
This global increase to the order of 6.6 billion tonnes of CO_2 over the last ten years is not only due to the OECD countries (with their 17.6 per-cent share), but also (and, in fact, largely) to China (48.5 per cent), with India (7.1 per cent) and other newly industrialised countries making up a smaller proportion (BP 2008). With this in mind, particular importance must be attached to involving China in a post-Kyoto climate policy and developing the country's environmental and energy policy.

The aim of this article is to develop a new post-Kyoto regime and analyse the role that China could play in it in view of the challenges the Kyoto process poses and the development of the country's environmental-protection policy.

Various post-Kyoto regimes are presented that are currently being discussed internationally. This is done while bearing in mind how China is now involved in the Kyoto process, how its present-day policy of environmental protection has developed and been shaped (section 2), and what challenges it will face in the future, particularly due to its increasing consumption of energy and the growth in CO_2 emissions associated with it (section 3). The biggest disadvantage of the approaches taken so far is that they fail to take the historical emissions caused by the industrial nations into account in their reduction commitments and equally fail to make allowance for the fact that newly industrialised countries such as China and India are becoming increasingly responsible for the future concentration of CO_2 accumulating in the atmosphere. At the same time,

however, the approaches employ a fair mechanism for allocating emission rights in terms of per-capita allowances. With these facts in mind, a new post-Kyoto policy regime is proposed in section 4 that is based on cumulative per-capita CO_2 emission rights and resolves the disadvantages inherent in the approaches taken to date. The implications for the development of emissions in China and the Annex I countries are particularly derived from this. A summary rounds off the article (section 5).

Figure 1: CO_2 Emissions in China and the Rest of the World (1965-2007, in Millions of Tonnes)



Source: BP 2008.

2 China's Current Involvement in the Kyoto Process: The Development and Shaping of Its Environmental-protection Policy

China is an important player in the Kyoto process (section 2.1). In order to integrate China, India and other large emitters of greenhouse gases into a post-Kyoto climate regime, the emissions created prior to 1990 also have to be added to the picture. The fact that the industrial nations used fossil fuels to a considerable extent in the past in order to promote their economic growth is an important argument that many newly industrialised countries voice against accepting reduction commitments. The poor results of the last round of climate talks held in June 2009 in Bonn (see above) have shown that this is a particularly good starting point for involving China in a post-Kyoto policy in which it has its own greenhouse-gas emission targets. The way in which China has engineered its current environmental-protection policy reveals that the country is beginning to get active in the climate-protection field (see section 2.2). As part of the practical shaping of current energy and climate policy (see section 2.3), among other things, concrete targets are being set for increasing energy efficiency by 2010 (even if the targets are not actually internationally binding) and long-term objectives are being defined regarding the use of renewable sources of energy in order to counter global climate change.

2.1 Involving China in the Kyoto Process

China is one of the nations that signed the agreement made in June 1992 at the UNCED's Framework Convention on Climate Change in Brazil and it also ratified the convention in December 1992. China signed the Kyoto Protocol on 29 May 1998 and ratified it formally on 30 August 2002. As a non-Annex I country, China does not have any quantitative obligations of its own to reduce its emissions in line with the Kyoto Protocol; all it has to do is report on its emissions in a national communication, stating the steps the country is taking or planning to take in order to implement the UN Framework Convention on Climate Change.

In line with the basic principle of "joint but different commitments", the necessary content of these national communications and the schedule for their submission differs for Annex I countries (i.e. industrial nations and transition countries in Central and Eastern Europe) and

non-Annex I countries (developing countries). Non-Annex I countries are expected to submit their first national communication

- within three years of the Framework Convention on Climate Change being implemented for this party or
- provide it when sufficient financial means are available.

The PRC submitted this on 10 December 2004 (The People's Republic of China 2004).

As a non-Annex I country, however, China is able to participate in projects under the Clean Development Mechanism (CDM). This instrument of the Kyoto Protocol entails Annex I countries conducting greenhouse-gas reduction projects in non-Annex I countries and offsetting their own quantitative reduction targets by means of emission certificates as a result of them decreasing their emissions. The National Development and Reform Commission (NDRC) approved the "Beijing Anding Landfill Gas Collection and Utilization Project" in 2005 – the very first CDM project in China (UNEP Risø Centre 2009).

A total of 1,521 Chinese projects were in the pipeline at the CDM Executive Board (CDM EB) by 1 November 2008, with a cumulative expected emission-reduction volume of 1.5 billion tonnes of CO_{2eq}. The expected reduction in emissions is equivalent to more than twice the current level of CO_2 emissions in Germany. With respect to the figure of 1.5 billion tonnes of CO_{2eq}, the Executive Board has so far registered 362 projects to the value of 663 million tonnes of CO_{2eq} or 663 million Certified Emission Reductions (CERs) by 2012. CDM projects with a total volume of 851 million tonnes of CO_{2eq} have been submitted to the CDM EB for approval and registration. China is by far the largest market in the world as far as the CDM goes – it currently has a 34 per-cent share of all the CDM projects registered and some 58 per cent of the world's CERs in the UN pipeline (UNFCCC 2009). A small but growing proportion of the Chinese CDM projects are now being turned down due to their lack of additionality, however. How this situation will develop remains to be seen.

The Chinese government has expressly stated its interest in the CDM continuing once the Kyoto Protocol has officially ended in a white paper on environmental protection (State Council Information Office 2008). Currently, though, it is still hesitant regarding a programmatic CDM approach, for instance (i.e. combining various CDM projects into a single programme) as the country wants to await the results of the

forthcoming Conference of the Parties, which is to be held in Copenhagen in November 2009.

2.2 Development of China's Climate Policy as Part of the Kyoto Process

During the initial phase of the Kyoto process, China issued very few signals to indicate that active environmental protection had a high priority in its environmental policy. In fact, environmental protection was primarily understood to be an instrument of energy security policy.[1] China's president, Hu Jintao, stressed the following at the G8 Summit in Heiligendamm in the summer of 2007: "Climate change is an environmental issue, but in essence, it's a development issue" (Rommeney and Yu 2008). China pursued a relatively inflexible policy at international climate conferences for many years, rejecting any and every attempt to commit it to setting concrete reduction goals by declaring it was necessary for the country to promote its own economic development. The PRC's negotiators argue that China's share of the global CO_2 emissions that have accumulated in the atmosphere over the last 100 years is a mere eight per cent, whereas the industrial nations, whose greenhouse-gas emissions have been building up in the atmosphere for more than a century, bear the historical responsibility for climatic change, a fact that should be borne in mind at climate negotiations (State Council Information Office 2008). Chinese sources also argue that approximately a quarter of the emissions currently caused by China (a figure equivalent to the total amount of CO_2 emitted by Japan) originate from the production of goods destined for export (Long 2009).

Since the 2007 United Nations Climate Change Conference held in Bali, however, there has been some indication that the Chinese stance on negotiations no longer categorically rules out the country playing a more active role in climate protection that even includes mitigation commitments. This is a great step forward despite the parties not having been able to agree on quantitative figures in Poznan. The issue of climate

1 This was partly apparent from the fact that the Chinese delegations that attended the international climate negotiations were always led by a vice-chairman of the NDRC, the authority responsible for energy and economic planning. This economic justification possibly made it easier to push climate-protection measures through more effectively than would have been the case if ecological issues had been the sole motive behind environmental protection.

change has been addressed openly particularly since the publication of the National Climate Report (at the end of 2006) and the IPCC's 4th Assessment Report (IPCC 2007), which both predict dramatic effects on China due to climate change. The National Climate Change Programme, which was presented in June 2007, explicitly refers to the white paper issued by the Chinese State Council in October 2008 prior to the Poznan Conference, which, in turn, refers to the unfavourable forecasts made in the aforementioned reports (State Council Information Office 2008).

In the coming decades, climatologists expect China to experience a rise in temperature considerably higher than the global average. As a consequence of this, we shall see an increase in extreme weather, more frequent droughts, greater desertification, and a growing lack of water, particularly in northern and north-western China. In particular, experts expect negative repercussions for agriculture, with yields of crops possibly declining by up to 10 per cent. The glaciers of the Tibetan highland plateau, the area where the sources of the largest rivers in Asia are to be found and in whose drainage basins more than half of humanity lives, are already directly – and, indeed, massively – affected by global warming. China's government is worriedly watching environmental developments as the country's most important economic zones on the east coast will be acutely affected by the rise in sea level that has been predicted (up to 60 cm). Climatic change is not only going to cause huge ecological damage, but will result in high economic costs being incurred as well. The World Bank presumes the cost of environmental-protection activities in China will amount to six per cent of the country's GDP (The World Bank and State Environmental Protection Administration 2007). Nevertheless, the IPCC has calculated that global efforts at stabilising the concentration of CO_2 in the atmosphere at 445-535 ppm – or stabilising the average rise in temperature at ground level at 2°C – would cost approximately three per cent of the world's entire economic output (IPCC 2007). This net cost and the benefits to China are arguments that ought to have been adopted by the Chinese government by now.

Internationally, the Chinese government feels it is under pressure to get more actively involved in the international efforts to protect the climate. At the same time, it supports a proposal for the industrial nations to provide one per cent of their GDP for technology transfer to support developing countries. A fund is conceivable that is similar to the Global Environment Facility (GEF), which is financed from monies provided by the industrial nations and from which developing countries could pay

for environmental-protection measures. China would be a recipient in a system like this rather than a donor. This pressure has been growing particularly quickly ever since 2007 when China surpassed the USA as the world's largest producer of CO_2 (BP 2008). Since then, Chinese scientists have been talking about step-by-step plans for involving the PRC in a climate regime entailing certain commitments in the long term, including quantitative ones (Zhang 2009).

2.3 Concrete Formulation of China's Current Energy and Environmental-protection Policy

The topic of climatic change has only been on the Chinese leadership's agenda for the last two years or so. After the first National Report on Climate Change was published (at the end of 2006), the National Climate Change Programme was implemented (in June 2007) and a national policy group headed by Premier Wen Jiabao was set up to deal specifically with climate change. The State Council then issued its white paper in October 2008. The 11th Five-Year Plan (2006-2010) currently points the way ahead regarding the implementation of the country's energy policy. It states clear targets concerning the development of renewable and clean forms of energy as well as for improving energy efficiency.

2.3.1 Implementation within the Scope of the National Reports and Environmental-protection Programmes

In China, policies of relevance to climate protection are primarily discussed in conjunction with

- the exploitation of so-called "clean" forms of energy, including nuclear power,
- the exploitation of renewable sources of energy, but most of all with
- efforts to improve energy efficiency.

Priority is given to energy security and the reduction of environmental pollution caused by coal. At the same time, environmental programmes are being conducted on a grand scale across the whole country, such as "Grain for green", a reforestation scheme in which the Chinese government has been investing billions since the beginning of the century in order to protect marginal areas from erosion and destruction. Recently, these have also been promoted as climate-protection measures.

According to the latest assessments made by the NDRC, China will be drawing up to 20 per cent of its primary energy from renewable resources by the year 2020 (SCMP 2009b). Plans exist to increase the amount of power generated by hydroelectric plants to up to 225 GW, for example. However, the devastating earthquake of May 2008, which also affected more than a thousand dams, is likely to cause a number of plans to be reviewed and put on the back burner (Feng 2008). Wind power, photovoltaics, and modern biomass do not play a significant role in power generation yet, but they have great potential for development. CDM projects promote the rapid expansion of wind farms, in particular. The planned target for 2010 (5 GW) was already achieved at the end of 2007. Experts assume that China is going to catch up with the world leaders in wind-power generation – the USA and Germany – in the next few years. An installed capacity of up to 80 GW is thought to be possible by 2020, which is far larger than the figures in government development plans (Li 2007). The removal of current barriers preventing greater use of wind power is necessary for the implementation of these ambitious plans, however. Feed-in tariffs at a national level are still absent in China's Renewable Energy Act, for example. So far, these can only be agreed on at a local level.

Decentralised photovoltaic systems and solar power plants will also play a greater role in the future. Currently, China is the world's leading manufacturer of PV technology. It largely makes these products for the export market, however. The falling price of raw materials, especially polycrystalline silicon, which has to be imported, could create some major openings for this technology in its home market, though (Wong 2009). The construction of solar power plants in the sun-rich desert regions of the country may be the way of the future. At the beginning of 2009, journalists wrote about a solar power plant the construction of which had just been started in the Qaidam Basin of Qinghai Province. The plant is intended to become the largest of its kind in the world, having a planned output of 1 GW (*Spiegel online* 2009).

In order to stop supply bottlenecks from occurring in the power-hungry coastal provinces, a huge expansion of the nuclear-power sector is planned in the coming decades. This is explicitly regarded as a strategy for reducing the country's dependence on coal and thus as a contribution to environmental and climate protection. At present, China possesses 11 nuclear power stations with an installed capacity of 8.5 GW. Currently, 14 more of them are under construction. The NDRC plans to increase

the country's power-generation capacity to up to 70 GW by 2020, which is equivalent to around 50 new atomic power stations. Yet even after this huge expansion, nuclear power still would not make up any more than five per cent of the country's overall power requirements in 2020. The agency believes an installed generation capacity of up to 160 GW is realistic by 2030 (World Nuclear Association 2009). Security aspects and the still unresolved problem of long-term radioactive waste disposal are hardly mentioned in these planning games. While the global economic crisis continues to take its toll, the decreasing demand for energy in the coastal regions and financing issues could cause the implementation of these plans to be at least temporarily hampered.

Despite renewable sources of energy and nuclear power being used more intensively, coal is still set to remain the principal source of energy used for many years to come because it will be available for a long time (at least 150 years of static availability compared to approx. 20 years in the case of oil), it is in great supply (China has the third-largest coal reserves in the world and is the biggest producer of coal worldwide) and it is available at relatively low cost. With this in mind, improving energy efficiency is highly relevant for climate protection, especially as regards the use of coal. Half way through the Five-Year Plan, it looked as though the ambitious targets set in schemes like the Top-1000 Enterprises Energy Efficiency Programme could actually be achieved. This particular scheme concerns the efficient use of energy by so-called key industries (steel, cement, and the power sector), which jointly consume a third of the power used by China (Seligsohn 2008). As well as improving the energy balances in the industrial production sector, energy-efficient building is also particularly important here. According to estimates by experts in the field, two to three times as much energy is used for heating in northern China as it is in European countries with comparable climatic conditions. This problem is being addressed by the Chinese authorities, but so far it has been difficult to implement improvements.

From the point of view of environmental and climate policy, the development of so-called *clean coal* technologies is of great importance now (upstream or downstream CO_2 capture and storage, with at least a much higher degree of efficiency in coal-based power generation). It could mark the outset of a low-carbon age if these technologies prove to be technically and economically viable. China and Australia signed an agreement on 10 March 2008 concerning research and testing of clean coal technologies, for example. The Australian research organisation

CSIRO and China's Thermal Power Research Institute (TPRI) are going to set up a pilot plant for downstream capture and storage of CO_2 for the Huaneng Beijing Co-Generation Power Plant. By employing this technology, 85 per cent of the CO_2 produced in the power plant will be prevented from escaping into the atmosphere (Environment News Service 2008). Whether this technology can be used as an adequate CO_2 sink remains to be seen. This also depends to a large extent on the prevailing geological environment at the site of the power plant (Oberheitmann 2008).

The National Climate Change Programme puts the energy-policy measures mentioned above into an environmental-protection context and estimates the envisaged savings due to the measures at the conservative figure of 1.5 billion tonnes of CO_2. This could be achieved by developing nuclear power and renewable sources of energy, using coal-bed methane (CBM), modernising and upgrading coal power stations and by energy-efficiency programmes (National Development and Reform Commission 2007). Up to 50 million tonnes of CO_2 can be neutralised by forced reforestation, so it claims. The reduction of agricultural emissions by switching over to semi-dry rice cultivation and obtaining biogas from agriculture waste and intense animal husbandry are included in the scheme as well.

Adapting to climate change has a high priority in the national climate protection programme: national schemes to counter erosion, save water and create efficient irrigation were put in a climate-protection context along with woodland protection, desertification control and disaster prevention. However, despite the importance of adaptation measures, not very much is actually being done in reality. With a view to the long-term situation, China currently has more trust in technological progress, which is why research and development play such an important role. In June 2007, 14 ministries published a joint plan of action regarding scientific research and technological development to complement the National Climate Change Programme (Ministry of Science and Technology et al. 2007).

2.3.2 *Implementation within the Scope of the 11th Five-Year Plan*

The current (11th) Five-Year Plan (2006-2010) and the Medium and Long-term Development Plan for Renewable Energy presented by the NDRC in September 2007 both aim at reducing the energy intensity of

the entire economy and increasing the use of renewable sources of energy. On the one hand, this serves to increase the country's energy security (see above), while on the other, it promotes global environmental protection.

The 11th Five-Year Plan envisages reducing the energy consumed per unit of GDP by 20 per cent in 2010 as compared with 2005. This is equivalent to reducing the volume of CO_2 emissions by approximately 1.5 billion tonnes relative to the "business as usual" scenario while experiencing an eight per-cent increase in economic growth. Although the annual average of four per cent that was aspired to failed to be attained in 2006 and 2007, the global economic crisis caused specific energy consumption to drop by 4.6 per cent in 2008, which consequently caused less CO_2 to be emitted (down 4.4 per cent) and less SO as well (down by 5.9 per cent) (Pan 2009). All in all, the energy intensity for the entire Chinese economy fell by 10.1 per cent in the first three years up to 2008, according to the CCICED (CCICED 2009). Conversely, the intensity will have to drop by five per cent each year for the remaining two years, which will clearly pose a challenge to the PRC. Just what further influence the international financial crisis will have on the decline in GDP and the consumption of energy, for example, remains to be seen.

The "Medium and Long-term Development Plan for Renewable Energy" envisages increasing the proportion of renewable sources of energy among the sources of primary energy we use from 7.5 per cent (2005) to 10 per cent by 2010 and 15 per cent in the long term (2020). Table 1 contrasts government targets with the actual situation in 2005.

In 2020, using eight per cent more energy from renewable sources would be equivalent to saving approximately 0.8-1.3 billion tonnes of CO_2, depending on what suppositions are made about economic growth. 0.8 billion tonnes is roughly equivalent to the entire volume of genuine CO_2 emissions caused by Germany in 2007 (0.857 bn t CO_2) (*Welt Online* 2008).

Planners are aiming to generate up to 20 per cent of the country's power from renewable sources of energy by 2020. China is particularly keen on developing hydroelectric power (225 GW generated by large dams and 75 GW by small hydroelectric power stations), wind power (30-50 GW), biomass (30 GW) and solar power (12 GW). The NDRC has estimated that investments will be needed to the order of 180 billion USD to expand the renewable-energy sector in the future. If these figures are employed to calculate the potential that these measures have to

mitigate CO_2 emissions, a value of approximately 480 million tonnes is obtained for 2010 and around 1 billion tonnes for 2020 (see table 1).

Table 1: Current Situation, Government Targets, and Estimated Share in Reducing CO_2 Emissions by Using Renewable Sources of Energy in China (2005, 2010, and 2020)

	Status quo	Reductions in CO_2 emissions (million tonnes)	NDRC goals	Reductions in CO_2 emissions (million tonnes)
	2005		2010	
Large-scale hydroelectric power plants (GW)	80	186	120	278
Small-scale hydroelectric power plants (GW)	35	81	60	139
Solar power (GW)	0.07	0	0.3	0
Solar power systems for water purification (million m^2)	80	5	150	9
Wind power (GW)	1.3	1	5	4
Electricity from biomass (GW)	2.3	2	no data	no data
Biogas (billion m^3)	8	17	19	39
Solid biomass fuel (pellets) (million tonnes)	no data	no data	1	1
Bioethanol (billion litres)	1.4	3	2	5
Biodiesel (billion litres)	0.05	0	0.2	1
Geothermal power generation (GW)	0.045	0	no data	no data
Direct use of geothermal energy (million TCE)	1.1	3	no data	no data
Tidal power plants (GW)	0.001	0	no data	no data
Sum total	-	298	-	477

	NDRC goals	Reductions in CO_2 emissions (million tonnes) 2020
Large-scale hydroelectric power plants (GW)	225	522
Small-scale hydroelectric power plants (GW)	75	174
Solar power (GW)	2	1
Solar power systems for water purification (million m^2)	300	18
Wind power (GW)	30	23
Electricity from biomass (GW)	20	15
Biogas (billion m^3)	40	83
Solid biomass fuel (pellets) (million tonnes)	50	68
Bioethanol (billion litres)	17.8	42
Biodiesel (billion litres)	6	16
Geothermal power generation (GW)	0.25	1
Direct use of geothermal energy (million TCE)	8	23
Tidal power plants (GW)	up to 5	up to 4
Sum total	-	990

Source: Our own calculations based on data from Bfai 2007 and Rommeney 2008.

3 Challenges for the Future – A Forecast about Energy Consumption and CO_2 Emissions in China and the World as a Whole

The biggest challenge facing China's future environmental-protection policy and the most important reason for needing to involve the PRC in a post-Kyoto climate policy is the country's increasing consumption of energy and its inherent increase in CO_2 emissions. The International Energy Agency (IEA) forecast that the world's consumption of energy will be 25.3 billion tonnes of coal equivalent (TCE) in its reference scenario for the year 2030. China's share of this figure would then be 21.6 per cent (it was ten per cent in 1990). According to the Agency's figures, the level of global CO_2 emissions will amount to 41.9 billion tonnes (IEA 2007).

The PRC's share of global CO_2 emissions is, in fact, considerably higher than the IEA's figures, which is largely due to the high coal intensity of the primary energy it consumes. It is set to rise from 12.5 per cent in 1990 to 30.6 per cent in 2030 (see table 2).

Table 2: Consumption of Primary Energy in China and the World as a Whole (1990-2030, in Million TCE and Per Cent)

	Reference scenario			
	Consumption of energy (million TCE)			
	1990	2005	2015	2030
Coal	763	1,563	2,670	3,427
Oil	166	467	776	1,154
Gas	19	60	156	284
Nuclear power	0	20	46	96
Hydroelectric power	16	49	89	123
Biomass and refuse	286	324	321	324
Other renewable sources of energy	0	4	17	47
Sum total for China	1,249	2,489	4,073	5,456
Sum total for the world	12,507	16,327	20,516	25,316
China's world share (%)	10.0	15.2	19.9	21.6
	CO_2 emissions (million tonnes)			
Coal	2,201	4,509	7,703	9,888
Oil	356	1,004	1,667	2,481
Gas	31	99	256	467
Sum total for China	2,588	5,612	9,627	12,836
Sum total for the world	20,688	26,620	34,071	41,905
China's world share (%)	12.5	21.1	28.3	30.6

Alternative scenario				
	Consumption of energy (million TCE)			
	1990	2005	2015	2030
Coal	763	1,563	2,490	2,631
Oil	166	467	740	933
Gas	19	60	180	321
Nuclear power	0	20	63	171
Hydroelectric power	16	49	107	156
Biomass and refuse	286	324	319	364
Other renewable sources of energy	0	4	20	74
Sum total for China	1,249	2,489	3,919	4,651
Sum total for the world	12,507	16,327	19,740	22,547
China's world share (%)	10.0	15.2	19.9	20.6
	CO_2 emissions (million tonnes)			
Coal	2,201	4,509	7,184	7,592
Oil	356	1,004	1,590	2,005
Gas	31	99	296	528
Sum total for China	2,588	5,612	9,070	10,126
Sum total for the world	20,688	26,620	31,893	33,890
China's world share (%)	12.5	21.1	28.4	29.9

Source: IEA 2007; own calculations.

If one bears the IPCC's recommendation about reducing emissions by 2050 in mind – at least a 50 per cent reduction compared with 1990 – then the goal for global emissions in 2050 is less than 11 billion tonnes. This is equivalent to the global emissions level at the beginning of the 1960s. The IEA predicts that China alone will emit 12.8 billion tonnes of CO_2 in its reference scenario for the year 2030. In an alternative scenario that sees China and the rest of the world as having a more active environmental policy, the picture is hardly any different. According to this, China's share of the world's CO_2 emissions would then rise to 29.9 per cent by 2030 (see table 2).

If one calculates China's proportion of the additional global emissions compared with 1990 on the basis of these figures, then the PRC's role in the development of climate change is even more important. By

2030, China will be responsible for 48.3 per cent of all incremental CO_2 emissions in the world in the reference scenario. In the IEA's alternative scenario, on average, the world's environmental policy is more effective than China's. The PRC's share of the global increase in emissions amounts to as much as 57.1 per cent in this scenario compared with 1990. Both of the scenarios proposed by the International Energy Agency emphasise the urgent need to involve China in a policy for reducing greenhouse gases when the first commitment period defined in the Kyoto Protocol comes to an end (2008-2012).

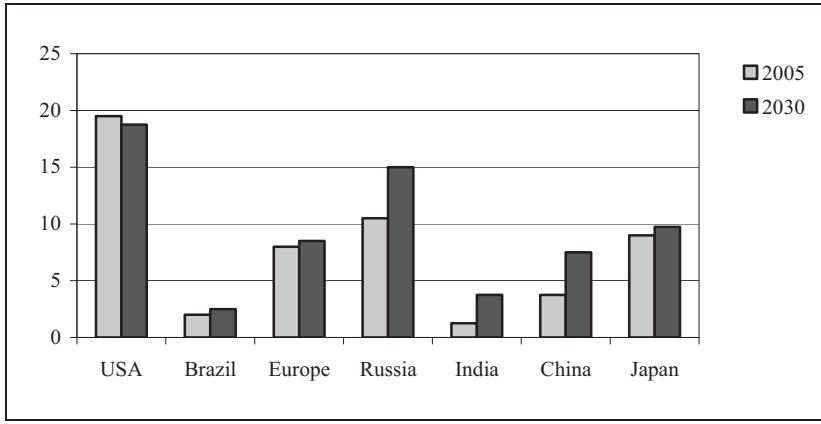
Global climate change cannot be stopped without limiting Chinese emissions. China must take responsibility for limiting its own emissions. This demand will only be taken seriously, though, if the industrial nations also take responsibility for the emissions they caused in the past. This is why a post-Kyoto policy has to be found in which every country shares the global responsibility for the climate. The following section outlines a new post-Kyoto climate regime that does justice to this "joint but differentiated responsibility".

4 Involving China in a New Climate Policy Based on Cumulative Per-capita CO_2 Emissions

Regarding the post-Kyoto period, the Chinese government is under increasing pressure to make quantitative commitments of its own about emissions mitigation. Over the last ten years, economic development – and the emission of greenhouse gases that accompanied it – has taken place much faster than people expected when negotiations concerning the Kyoto Protocol were being held.

In 1998 it was still assumed that China would overtake the USA as the nation with the highest CO_2 emissions around the year 2030, but this actually occurred in 2007. On the other hand, the average level of per-capita emissions is currently around four tonnes of CO_2 , which is still considerably below the western European average (approx. eight tonnes per capita) and well below that of the USA (approx. 19 tonnes per capita) (figure 2). China (7.5 t) will have caught up with Europe (8.5 t) and Japan (9.5 t) even more by 2030.

Figure 2: Growth in Per-capita CO_2 Emissions for Selected Countries (2005 and 2030, in t)



Source: Seligsohn 2008: 3.

Various approaches concerning a post-Kyoto climate policy are currently being discussed that entail "joint but differentiated commitments for mitigating greenhouse-gas emissions" (table 3). The biggest shortcoming these approaches have is that they

- fail to account for the fact that the industrial nations are largely responsible for the current concentration of CO_2 in the atmosphere and that newly industrialised countries like China and India are responsible for a rapidly growing proportion of the future concentration (unlike the Brazilian approach, for instance, which does do this)
- *and at the same time* they include a fair mechanism for allocating emissions rights on a per-capita basis.

Table 3: Overview of the Current Post-Kyoto Approaches

Convergence of per-capita emissions

This approach, which is largely based on the principle of egalitarianism, was developed in a dynamic perspective by defining emissions rights with respect to the convergence of per-capita emissions as part of a global emissions profile for greenhouse gases. In a convergence rule of this type, every country will have the same per-capita level at a chosen point in the future.

"Soft landing" for emissions growth
Essentially, the aims of this concept are to achieve a global emissions-reduction target and simultaneously reduce the limitations to individual regions of the world with a view to stabilising emissions in developing countries. The schedule for reducing the growth rates of current emissions is based on per-capita emissions and income. Further reductions in emissions are necessary for Annex I countries.

Global "share of preference" approach
This rule provides for emissions rights that are based on historical claims and a per-capita approach. A "share of preference" is created by adding the shares made up by each of the emissions calculated in the countries in question using the two methods and then weighting this with the share of the world's total population made up by each country that prefers the first or the second approach. It is assumed that Annex I countries will largely prefer the first approach, while non-Annex I countries will prefer the second one.

Historical contribution to climate change or the "Brazilian suggestion"
During the negotiations about the Kyoto Protocol, Brazil suggested that the emissions of the past ought to be taken into account in defining the industrial nations' reduction commitments in line with the "polluter pays" principle.

Financial solvency
This principle was developed to enable the non-Annex I countries to be integrated into a system of global emissions reduction on a step-by-step basis, the system being based on initial per-capita GDP. The consequent levels of reduction leading to a long-term climate goal largely depend on the per-capita GDP of each country.

Multi-level approach
The multi-level approach differentiates countries into various groups that have different levels of responsibility or commitments. The number of participating countries and their degree of commitment both increase in the course of time in accordance with predefined rules.

Source: CNRS/ LEPII-EPE et al. 2003.

A new suggestion was made in March 2009. An article by a research group from the State Council Development Research Center was published in the *Economic Research Journal* in which the group proposed a post-Kyoto regime based on cumulative, absolute greenhouse-gas emissions. Every country is supposed to be allocated an emissions allowance for 2050, for example. It is up to each country to decide how it is going to keep to its allowance. Excess emissions could be traded (Project Team of the Development Research Center of the State Council of China 2009).

The advantage of this policy is that historical emissions would be taken into consideration for all countries. It would take account of the justified criticism expressed by many developing and newly industrialised countries which claim that the industrial nations are largely responsible for the current concentrations of greenhouse gases in the atmosphere. The allowances, which would apply until 2050, would also take future emissions caused by developing and newly industrialised countries into account as well, however, which are responsible for a large part of the new emissions of greenhouse gases and will continue to be the major culprits in the future. The disadvantage of this policy as formulated above is that the allocation mechanism for the allowances lacks transparency.

With this in mind, a new approach has been developed in this article with respect to a post-Kyoto system, which is based on a combination of the "convergence of per-capita emissions" and the "Brazilian approach": a climate policy based on the cumulative per-capita CO_2 emissions rights that are required to meet the global-warming goal of 2°C exactly, or that are equivalent to a CO_2 concentration of 400-450 ppm in the atmosphere. The system can be expanded to include the other greenhouse gases in an additional step.

The cumulative CO_2 emissions in the year n are defined (in million t) as follows:

$$CO2_{WORLD,cum,t} = \left(\sum_{t=1750}^{n} \sum_{m=1}^{70} CO2_{coal,t,m} + CO2_{oil,t,m} + CO2_{gas,t,m} + CO2_{bunker,t,m} + CO2_{flaregas,t,m} + CO2_{cement,t,m} \right) - CO2_{WORLD,t-100} \quad (1)$$

They consist of the cumulative emissions due to the combustion of fossil-based substances ($CO_{2,coal}$; $CO_{2,oil}$; $CO_{2,gas}$) plus emissions due to the

bunkering of aircraft and ships ($CO_{2,bunker}$), the flaring of gas ($CO_{2,flagas}$) and the CO_2 emissions caused by cement production ($CO_{2,cement}$) minus the natural decomposition of CO_2 emissions over a period of 100 years ($CO_{2WORLD,t\text{-}100}$). In reality, part of the emissions are broken down naturally every year. Some of the CO_2 can remain in the atmosphere for several hundred years, however. For the sake of simplicity, we shall use the 100-year Global Warming Potential period here. This was also the basis for calculating the emissions of the six greenhouse gases mentioned in the Kyoto Protocol in terms of CO_2 equivalents. Table 4 shows the development of the world's cumulative CO_2 emissions.

If one takes the cumulative CO_2 emissions as an approximate value of the CO_2 concentration in the atmosphere, a concentration of 400 ppm is roughly equivalent to 1.6 trillion tonnes of cumulative CO_2 emissions ($CO_{2,cum}$), and 450 ppm is roughly equivalent to 2.3 trillion tonnes of $CO_{2,cum}$. Furthermore, if it is assumed that the world's population in 2007 (6.552 billion people) will remain constant over time, then every person on the planet would have emissions rights to the order of 246 t $CO_{2,cum}$ (400 ppm) or 351 $CO_{2,cum}$ (450 ppm) so as to limit warming at ground level to 2°C. Table 5 shows the cumulative per-capita emissions of CO_2 around the world and for specific countries.

Table 4: Global Development of Cumulative CO_2 Emissions (1750-2007, in Million Tonnes)

Year	Africa	Asia Pacific	China	India	Middle East	Central and South America
1750	0	0	0	0	0	0
1850	0	0	0	0	0	0
1900	0	0	0	0	0	0
1950	1,784	6,732	1,881	2,188	456	1,530
1960	3,178	14,337	5,114	3,106	1,052	3,830
1970	33,869	50,948	5,383	3,598	3,570	31,133
1980	62,946	99,472	11,854	5,037	8,624	58,477
1990	91,604	158,095	25,403	8,621	15,297	85,483
2000	119,184	238,705	51,320	15,763	25,492	113,013
2005	133,153	287,466	66,960	21,357	32,456	128,288
2006	135,948	299,686	72,386	22,558	34,080	131,226
2007	138,769	312,565	78,299	23,850	35,747	134,221

Year	North America	Europe and Eurasia	The World	OECD	Annex I Countries	Non-Annex I Countries
1750	0	0	0	0	0	0
1850	0	0	0	0	0	0
1900	0	0	0	0	0	0
1950	85,237	80,976	176,716	154,059	167,417	9,299
1960	114,772	113,628	250,797	206,376	231,668	19,129
1970	156,544	164,391	440,454	284,985	329,687	110,767
1980	212,954	237,839	680,311	395,723	470,163	210,149
1990	269,214	315,897	935,590	505,754	615,213	320,377
2000	326,624	376,857	1,199,874	616,404	741,309	458,566
2005	356,875	405,060	1,343,298	674,396	803,874	539,424
2006	362,798	411,088	1,374,827	685,910	816,571	558,256
2007	368,675	418,206	1,408,184	697,289	829,088	579,096

Source: Own calculations.

Table 5: Global Development of Cumulative Per-capita Emissions of CO_2 (1950-2007)

Country	1950	1960	1970	1980	1990
Africa	10	13	95	133	153
Asia Pacific	5	9	26	41	54
China	**4**	**8**	**7**	**12**	**22**
India	**6**	**7**	**7**	**8**	**10**
Japan	1	19	69	152	230
Middle East	14	22	54	93	118
Central and South America	11	22	135	203	241
Europe and Eurasia	171	198	242	340	413
Germany	427	496	579	706	833
North America	483	523	594	694	777
USA	578	636	737	883	1,004
World	87	97	131	164	188
OECD	286	320	373	452	526
Annex I countries	245	282	343	434	514
Non-Annex I countries	6	10	44	64	81

Country	2000	2005	2006	2007
Africa	152	150	149	148
Asia Pacific	71	81	83	86
China	**41**	**51**	**55**	**59**
India	**16**	**20**	**20**	**21**
Japan	322	371	381	392
Middle East	151	171	175	180
Central and South America	272	285	288	290
Europe and Eurasia	473	501	507	514
Germany	869	901	908	914
North America	835	851	856	862
USA	1,085	1,090	1,094	1,099
World	207	217	219	222
OECD	578	606	613	618
Annex I countries	610	643	650	657
Non-Annex I countries	97	106	108	111

Source: Own calculations.

If one takes 250 t $CO_{2,cum}$ per capita (400 ppm) or 350 t $CO_{2,cum}$ per capita (450 ppm) as the starting point for an evaluation of the emission reduction commitment that each country has, then it is obvious that the industrial nations have already more than exhausted their allowances. In 2007, the average US citizen consumed 1,099 t $CO_{2,cum}$, whereas the average German used up 908 t $CO_{2,cum}$ – well above the mean OECD figure (613 $CO_{2,cum}$ per capita). In 2007, China's per-capita consumption was 59 t $CO_{2,cum}$, while India's was only 21 t $CO_{2,cum}$.

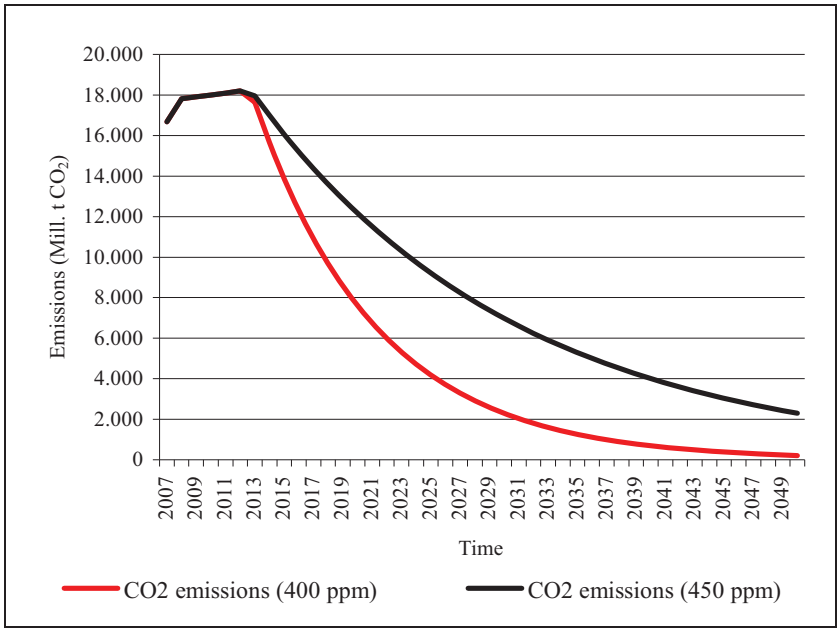
Population growth should not lead to an increase in the absolute level of CO_2 emissions, though, but rather to an incentive to improve energy efficiency and, if necessary, to a proactive population policy. Bearing this in mind, the cumulative per-capita emissions of CO_2 may be calculated for each country using the following formula:

$$CO2_{m,cum,t>2007} = \left(\frac{\sum_{t=1750}^{n} CO2_{m,t}}{POP_{m,2007}} \right) \qquad (2)$$

Judging by the estimates made in the Global Energy Demand and Greenhouse Gas Emissions Model (GED-GHG model) developed by the author of this article at the Research Center for International Environmental Policy (RCIEP), Tsinghua University, the 400 ppm limit will already be reached in 2012 – in other words by the end of the first commitment period defined in the Kyoto Protocol. In line with this policy, in a "business as usual" – or "BAU" – scenario (which corresponds to an average GDP growth rate of 2.8 per cent p.a. between 2008 and 2050), China will have to stabilise its CO_2 emissions at roughly the level of the cumulative emissions of 2026 to maintain the global target of 250 t CO_{2cum} per capita (400 ppm of CO_2). India will not even reach this upper limit by the year 2050. In a high scenario (3.7 per cent per-capita growth in GDP p.a.), China's emissions would have to stabilise at the level reached in 2025, while in a low scenario (with 2.1 per cent growth p.a.) these would not have to be stabilised until they reached the level of 2033. These paths may well be realistic. In a new Chinese study, the "2050 China Energy and CO_2 Emissions Report", the authors, including the Energy Research Institute of NDRC and the State Council Development Research Centre propose to peak China's absolute greenhouse-gas emissions by 2030 and reduce them to their 2005 levels by 2050 (SCMP 2009a).

The Annex I countries, on the other hand, would have to reduce their cumulative emission levels to those of the 1950s in a BAU scenario, for example. This could be achieved by the countries committing themselves to steadily reducing their CO_2 emissions to zero between 2013 and 2050 (see figure 3).

Figure 3: CO_2 Emissions of the Annex I Countries ("BAU" Scenario) (bn t, 2007-2050)



Notes: In mathematical terms, the function of emissions reduction for the target of 400 ppm is $CO2\_ANNI,_t = 12.8845 \cdot e^{-0.12 \cdot t}$ and for the target of 450 ppm it is $CO2\_ANNI,_t = 6.5000 \cdot e^{-0.06 \cdot t}$.

Source: Own calculations.

After 2050, the natural absorption of CO_2 would then reduce the cumulative level of CO_2 emissions in the Annex I countries to 246 t $CO_{2,cum}$ per capita (400 ppm). A longer time span can be chosen for reducing emissions to the target level of 450 ppm.

5 Summary

In view of China's importance and its share of greenhouse-gas emissions, international agreements in the post-Kyoto period will be unable to be made without involving the PRC in a larger way. As for the degree of commitment it shows, China will be strongly influenced by the behav-

iour of the new US administration. It is also necessary for us to take the Chinese government's call for greater "climate justice" and more differentiated forms of responsibility seriously. Even if the most pessimistic forecasts about the increase in China's share of greenhouse-gas emissions are taken into account based on the "business as usual" scenario, the average per-capita emissions there will only just reach the European level in 2030. The country is highly unlikely to agree to any commitments that might cause its economic development to slow down. Consequently, an international climate policy will only be successful if it is possible to detach economic growth from increasing greenhouse-gas emissions. China may have the potential to deal with matters in a new way.

National programmes show that the Chinese government is now aware of climate issues. It has been demonstrating a willingness to play more of an active role in environmental protection ever since 2007, if not earlier. Just how serious the Chinese government is about the matter will become apparent from the scope of the resources it provides for research and development in the future in the field of environmental protection. China can be expected to play a significant role in the development of applied technologies to avoid producing greenhouse gases (renewable sources of energy, avoidance of greenhouse gases in agriculture, etc.) as well as with respect to adapting to climate change (particularly in agriculture and disaster prevention).

The results of the climate negotiations held in Bonn particularly demonstrate that the reservation shown by the United States of America and Japan regarding commitments to emission-reduction goals is not the right way to persuade rapidly growing, newly industrialised countries such as China and India to take on reduction commitments of their own. This article therefore proposes a new post-Kyoto policy based on cumulative per-capita emissions rights – a policy that would achieve the goal of stabilising the rise in temperature at ground level at 2°C in the year 2100 providing the world's population remains stable. Justice is done to the idea of taking joint but differentiated responsibility for reducing climate change because the historical emissions of the industrial nations are taken into account as well as future emissions that every country causes. Population growth will then have to be balanced by gains in efficiency regarding the use of fossil fuels or by greater reliance on renewable sources of energy. What's more, the project-specific flexibility instruments provided in the Kyoto Protocol could still be employed in such a regime. If China, for example, were to commit itself to reducing its emis-

sions, one could still conduct projects there within the scope of the Joint Implementation (JI), as per Article 6 of the Kyoto Protocol. The JI scheme is nothing other than CDM projects in countries that have their own quantitative emission-reduction targets (OECD nations and transition countries in Central and Eastern Europe). The mechanism is the same as for the CDM. Many JI projects are being carried out successfully in the transition countries of Central and Eastern Europe.

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Contents

Introduction

Research Articles

Analyses

Contributors