

Rethinking Development in a Carbon-Constrained World

Development Cooperation and Climate Change

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MINISTRY FOR FOREIGN AFFAIRS

Does Human Development Really Require Greenhouse Gas Emissions?

The greenhouse gas emissions take-off in rapidly industrialising countries and possibilities for averting it

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Introduction

It is commonly assumed that greenhouse gas emissions are inextricably linked to human and industrial development. This is based upon the historical experience that countries able to embark on industrial development rapidly increased their greenhouse gas emissions.

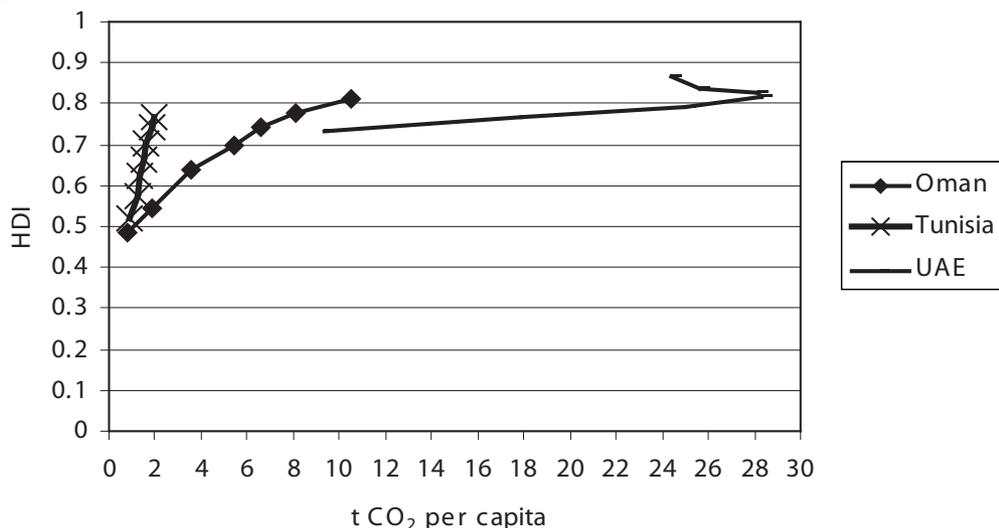
A key question in current climate policy is whether today's developing countries need to follow the same development path, or whether high levels of human development can be reached at low levels of per capita emissions. A large body of literature has tried to determine an environmental "Kuznets Curve" relating per capita income to per capita greenhouse gas emissions (see e.g. Holtz-Eakin and Selden 1995). However, so far no level of per capita income has been found that would unambiguously determine a maximum level of per capita emissions (see Moomaw and Unruh 1997, Azomahou et al. 2006). Some researchers even say that per capita emissions would continue to increase with per capita income (Galeotti et al. 2006).

Income is only a partial indicator for the degree of human development. Therefore, it is desirable to delink the discussion from the level of per capita income, by asking whether the level of human development is also linked to per capita greenhouse gas emissions. Here, the UN Human Development Index (HDI) will be used as a generally accepted measure of human development¹, and an assessment will be made of the extent to which improvements in the HDI were accompanied by increases in per capita emissions. The take-off phases of per capita greenhouse gas emissions in rapidly industrialising countries will then be analysed to determine the drivers for emissions increases. Subsequently, different policy options for slowing down emissions growth during rapid industrialisation processes will be considered. Finally, we discuss whether high levels of human development can be reached and sustained with low greenhouse gas emissions. In this context, the role of consumption patterns will be highlighted.

Links between human development and greenhouse gas emissions

For the period 1975 to 2005, data for HDI and per capita emissions are readily available for over 100 countries (HDI data from UNDP 2007 and per capita CO₂ emissions from fossil fuel combustion from IEA 2007). This period is sufficiently long to show success stories in development. Our data comprise all countries with an improvement of HDI by more than 10 percentage points, which will be called a “development success”. Looking at the pattern of development of the HDI in relation to per capita emissions, three main patterns can be distinguished: emissions-extensive development, emissions-intensive development and a pattern where emissions-extensive development over time becomes emissions-intensive (see Figure 1 for typical country examples from the Middle East/North African region)-

Figure 1. Emissions-extensive versus emissions intensive development 1975-2005



Note: emissions-extensive: Tunisia; emissions-intensive: United Arab Emirates (UAE); transition: Oman. The vertical line denotes world average per capita emissions in 2005.

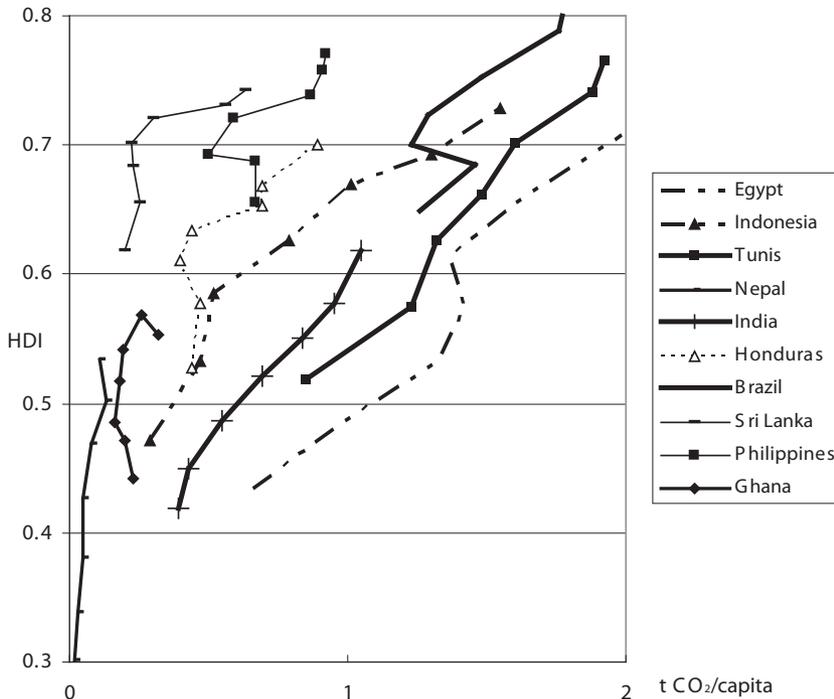
Source: HDI data from UNDP (2007), per capita emissions data from IEA (2007)

These three different patterns will be analysed below to try to explain why countries have chosen such different emissions paths at similar levels of development. We begin with the *emissions-extensive* category which is defined as countries that reached a HDI level of at least 0.5 and kept their per capita emissions level below 2 t CO₂

(Figure 2). This group includes countries from all continents, ranging from very large (India, Brazil, Pakistan) to small. Latin America is somewhat overrepresented. The most intriguing feature of the graph is a group of four countries with negligible per capita emissions: Bangladesh, Cameroon, Ghana and Nepal. Sri Lanka belonged to that group until the mid 1990s even at a HDI of over 0.7, but has since switched to a more emissions-intensive path. A number of small Latin American countries has remained in the bracket of 0.5 to 1 t CO₂ per inhabitant, while several large countries in the group (India, Pakistan and Egypt) appear to be in transition to a more emissions-intensive development.

How do countries achieve an emissions-extensive development path? The main reason seems to be a low carbon energy system. Most countries in the group have a high share of hydropower in electricity generation. Moreover, they do not have heavy industry and are not fossil fuel producers. The notable exceptions are countries with a large population which is still mainly engaged in subsistence agriculture. This is the case for India, Indonesia, Pakistan, Bangladesh and Egypt. India is the outlier in terms of a sizeable heavy industry as well as a very carbonintensive electricity generation system; however, these factors are still small with respect to India's sheer population size.

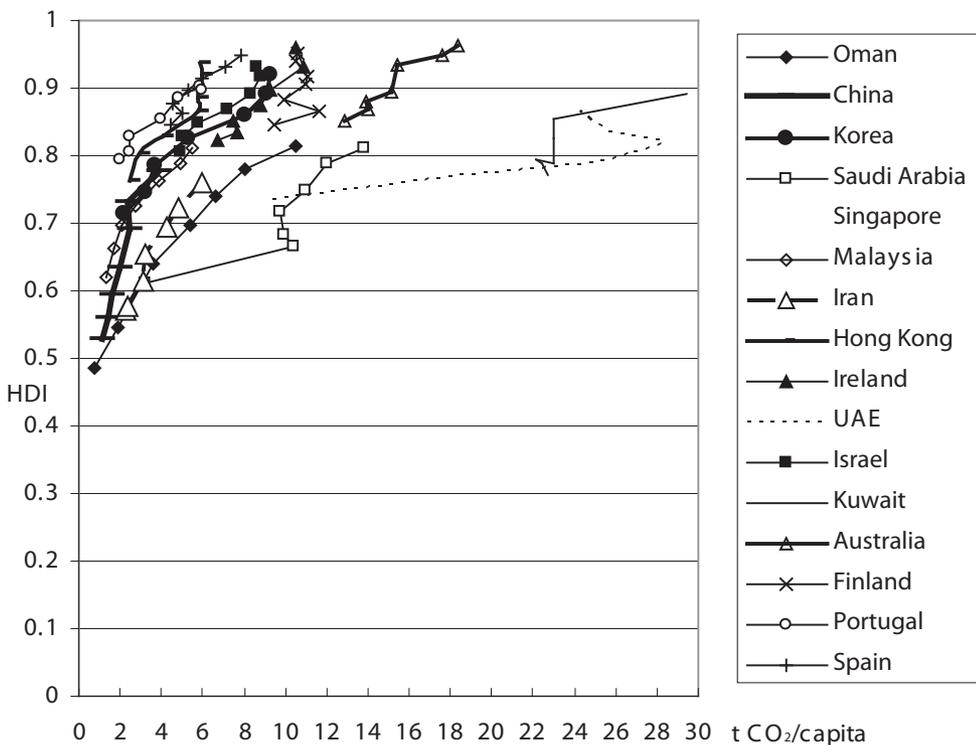
Figure 2. Emissions-extensive development



Source: HDI data from UNDP (2007), per capita emissions data from IEA (2007)

At the other end of the classification, all countries that have exceeded the average global per capita emissions level fall into the *emissions-intensive* category. Such a development path is frequently built on the extraction of fossil fuels. The archetypical examples are the sparsely populated countries in the Persian Gulf region which were catapulted from a medieval zero-emissions lifestyle towards world record per capita emissions levels almost overnight. For example, already in 1975, Kuwait's per capita emissions were above 20 t CO₂! For the more populous countries such as Iran and Saudi Arabia, emissions increased consistently over time as emissions-intensive industrial and domestic infrastructure was commissioned. Moreover, highly subsidised energy prices led to wasteful behaviour. Outside the oil producing-countries, Australia exhibits a similar pattern.

Figure 3. Emissions-intensive development



Source: HDI data from UNDP (2007), per capita emissions data from IEA (2007)

Another group that has recently emerged in the emissions-intensive category are the rapidly industrialising countries who build their success on a large manufacturing base. This development approach was pioneered by Korea, whose emissions increased from 2.1 to 9.3 t CO₂ per capita between 1975 and 2005. Korea focused on heavy

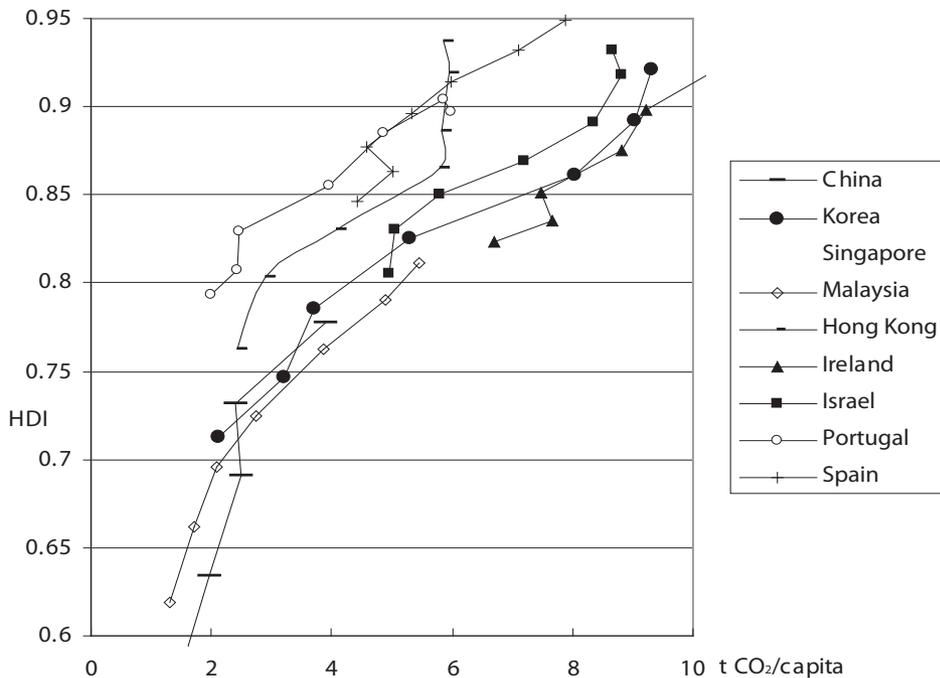
industries such as basic chemicals and shipbuilding. Only recently has it switched to higher value-added productions, and thus emissions growth has slowed. China is now following on the same path as Korea, and it is intriguing to see how Chinese emissions growth has accelerated within the last 5 years. Interestingly, also the European states of Portugal and Spain also follow this pattern: once per capita emissions have reached around 4 t CO₂, they rapidly increase.

Even the city states Singapore and Hong Kong exhibit similar emissions-intensive features: a rapid emissions growth after reaching a HDI level of 0.8, which stops once the HDI approaches the level of 0.9. Probably this emissions growth was linked to the substantial increase in private car and apartment ownership and stopped as policy measures were introduced to rein in utilisation of private cars.

The takeoff of per capita emissions in rapidly industrialising countries

What are the reasons for the spurt of per capita emissions in rapidly industrialising countries which is shown in Figure 4 in more detail?

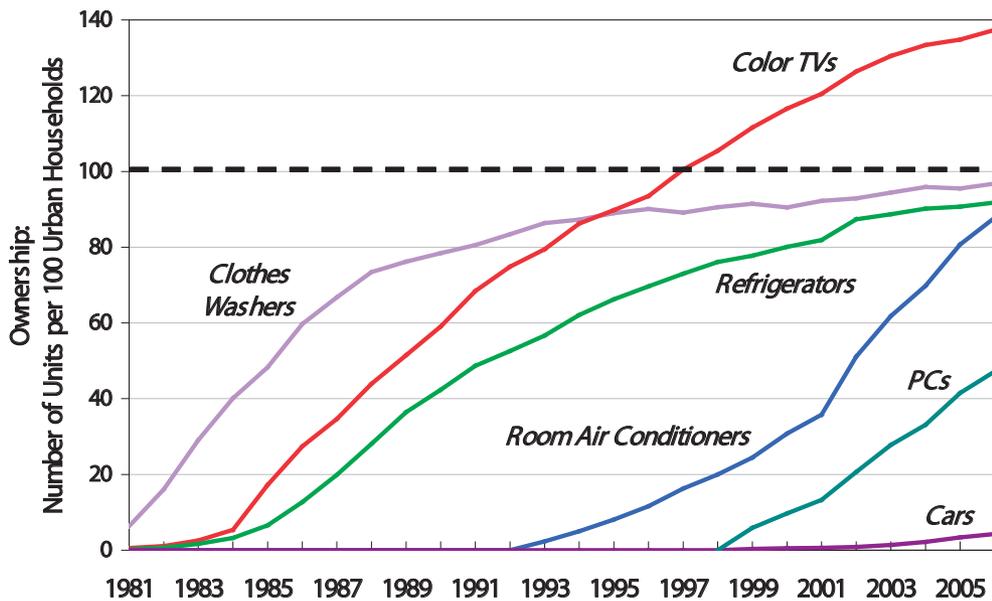
Figure 4. The transition to high per capita emissions for rapidly industrializing countries



Source: HDI data from UNDP (2007), per capita emissions data from IEA (2007)

There are evidently two main reasons. Once industrialisation has reached a certain level and wages begin to increase, there will be a rapid growth of a middle class. Typically, this middle class lives in or moves to cities and quickly adopts energy-intensive lifestyles. This trend is documented by the explosive growth in electricity-consuming household appliances and private cars in China (see Figure 5) and all over South East Asia. In China, all urban households acquired air conditioning within a decade. This occurred during a period in which urban population grew by 150 million people (Allard 2007, p. 3). The same phenomenon is now starting in India, where air conditioner sales grow by 20% per year. Neill and Letschert (2008, p. 7) predict a take-off of air-conditioner sales at around USD 4000 per capita GDP.

Figure 5. Penetration of household goods in urban China



Note: According to current trends, penetration in rural areas starts 10-15 years later.
Source: Fridley et al. (2007, p. 8).

Given the low purchasing power of populations in developing countries, appliance manufacturers try to keep sales prices as low as possible, while not putting any focus on energy efficiency. The average energy efficiency of Chinese air conditioners in 2005 reached just 53% of Japanese air conditioners of the same type (Koizumi 2007). In addition to the direct demand for appliances, the shift to more value added production in industry (see Price 2008), and the growth of cities and the middle class in general, leads to a strong demand for infrastructure improvement. Building up an

Infrastructure	Increase 1990-1995	Increase 1995-2000	Increase 2000-2004
Residential buildings (billion m ²)	1.1	1.3	5.2
Commercial buildings (billion m ²)	0.7	0.6	2
Heated space (billion m ²)	0.4	0.5	1.1
Road surface (km ²)	360	550	1620
Gas pipelines (1000 km)	17.5	14.5	99.6
Wastewater pipes (1000 km)	53	32	77

Table 1: Increases in infrastructural elements in Chinese cities 1995-2004

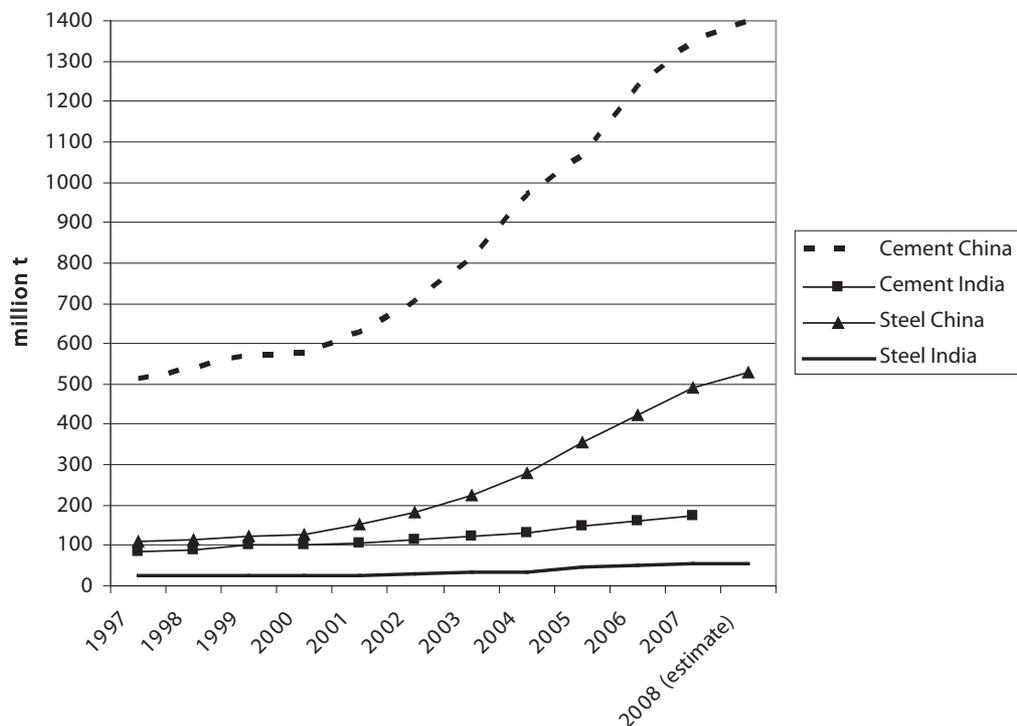
Source: Allard (2007)

infrastructure is very resource intensive and thus leads to high emissions. The Chinese urbanisation process provides very impressive figures (see Table 1).

Nevertheless, the average floor space by inhabitant in China has only increased from 10 to 14 m², so further growth can be expected. Given the frenetic speed of building, the quality of the new buildings is often doubtful and thermal insulation non-existent.

Roads have also been built at a frantic rate in China, making car use attractive. Total length of paved roads increased from 0.69 million km in 1990 to 1.09 million in 2000, and 1.54 million in 2006. Motorway length literally exploded from 500 km in 1990 to 16,300 km in 2000 and 45,300 km in 2006 (National Bureau of Statistics of China 2007). As one can see in Figure 6, private cars have begun their take-off in Chinese cities, where as late as the mid-1990s, two-thirds of all trips were made on foot or bicycle. Although urban car ownership averaged only 4% of households in 2005, Beijing had already reached over 10%. In 2007, the number of cars in China grew by 15 million to reach 57 million (Chinese Car Times 2008). This development corroborates research by Chamon et al. (2008) who have found a remarkably stable relationship between GDP per capita and car ownership. Up to per capita incomes of about USD 5000, car ownership is low; it then takes off very rapidly. China is currently nearing this threshold; India is still quite far from it. However, the recent announcement of the Indian car manufacturer, Tata Motors, of their new mini car set at a price of USD 2200 might shift the Indian car take-off threshold to a lower income level.

Production of steel and cement is a necessary requirement for building urban and transport infrastructure. Figure 6 shows the enormous increase in production of those carbon-emissions intensive commodities (see also Zhou et al. 2008). It also shows the difference between China and India, where urbanisation and development of transport have not yet reached the take-off level.

Figure 6. Cement and steel production in China and India 1997-2008

Data sources: Steel: International Iron and Steel Institute (2008), China cement: US Geological Service, Mineral Commodity Summaries, different issues of the journal *Cement*, India cement: Government of India, Department of Economic Affairs, Economic Division: Monthly Economic Report from certain months of each year.

Policy options to prevent emissions takeoff

What can be done to prevent a take-off phase of emissions on a level similar to that of Korea in the past and China in the present? A cornerstone of a low-emissions path would be an integrated planning policy that prevents haphazard urbanisation and related take-off of car traffic. While not numerous, there are some successful examples of such policies. The Brazilian city of Curitiba was able to keep car use at 25% of comparable cities by developing an urban master-plan that prevented urban sprawl, along with a high-capacity public bus system (Rabinovitch and Leitman 1996). In Tokyo, Seoul, Singapore and Hong Kong, early restraint of car ownership and/or use, which began before car ownership reached 10% of households, provided a time period in which high quality public transport could be built, and in which a public transport-friendly urban infrastructure could develop (Barter and Kenworthy 1997).

Hong Kong has been able to limit per capita emissions to 6 t CO₂ despite a fossil-fuel dominated electricity generation system (see Figure 4). Obviously, such a path requires public transport infrastructures, but these can be relative emissions-extensive as the rapid bus transport system of Curitiba shows.

The second component of a low emissions path would be a far-reaching energy efficiency policy for domestic appliances. Even before appliance penetration starts, appliance efficiency standards should be set at levels comparable to those of industrialised countries. If China had used the Japanese top runner approach for air conditioners and had reached the average efficiency of the Japanese models, over 10 million t CO₂ per year for the 50 million installed units could have been avoided (Koizumi 2007). After achieving an almost 100% penetration of air conditioners, China is improving its air conditioner standards (see Fridley et al. 2007) and manufacturers are marketing their efficient models under the motto “Energy-saving, healthy, and stylish” (He and Wu 2008). A necessary condition for such a path is a high electricity price. At prevailing, subsidised Chinese electricity prices, investment in a higher efficiency air conditioner that costs USD 250 more than low-efficiency models would not make sense (Koizumi 2007). Given the initial low purchasing power of potential appliance buyers, creative financing models such as revolving funds would have to be developed (Taylor et al. 2008).

It should be noted that the window of opportunity for appliance energy standards stands is open for only a short period, because once saturation with appliances has been reached, replacement will take a long time. While for China, the window of opportunity seems to be already closing, in India it should remain open for another decade. Therefore, the future climate policy regime should focus on options that prevent emissions take-off. Given the financing challenges at the beginning of such a take-off phase, industrialised countries will be asked to provide financial and technical support. For example development of energy efficiency standards and a credible enforcement structure could be supported by development cooperation. German technical cooperation supported the Indian government in setting up a Bureau of Energy Efficiency, which is now developing efficiency standards. Currently, these Indian standards are still voluntary, but future cooperation could help with making them mandatory. Development of air conditioner efficiency standards has been done in Ghana with the support of the World Bank. For energy efficiency improvement of consumption goods, a revised version of the Clean Development Mechanism (CDM) could also be a good vehicle to provide the necessary financial flows. The first activity of this type has just started in India, where production of highly efficient refrigerators by the company Godrej will earn CDM credits. It uses a new, substantially simplified methodology for calculation of emission reductions.

One component of a low-emissions path depends on the availability of carbon-

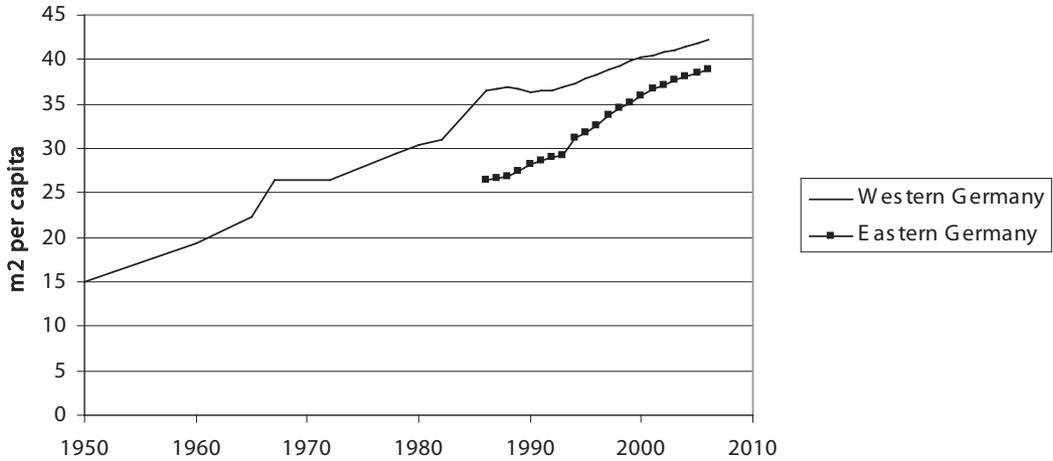
free energy sources. Countries with high hydropower potential are advantaged; in the future countries with a high potential in wind or solar thermal energy might have a similar advantage.

Obviously, countries that are the “workshop of the world” and provide cheap industrial goods will have a high emissions profile. Currently, it is impossible to operate heavy industry at a low carbon emissions level. Zhou et al. (2008) show this nicely in the Chinese case. This means that it is not possible to keep global emissions low if global consumption of industrial goods continues to increase, unless technological breakthroughs for carbon-free industrial production are made.

High human development with low greenhouse gas emissions: A dream or a real possibility?

As our data have shown, it is possible to achieve a medium level of human development at very low per capita emissions levels. A HDI of 0.8 has been reached by a number of countries at per capita emissions levels of 0.5 – 1.5 t CO₂. This however requires refraining from entering into the consumption age and keeping heavy industry at bay. As soon as an urbanised middle class develops, emissions surge. While there are policy options to limit this emissions increase, no country has managed to reach a HDI level above 0.9² at an emissions level below 5.5 t CO₂ per capita. This means that world emissions would have to grow by at least 30% if the goal is universal human development of over 0.9. People will always be able to invent new forms of consumption³ and thus all estimates of future emissions based on current consumption patterns will be too optimistic. However, all available scientific assessments indicate that to avoid a temperature increase of more than 2°C from preindustrial times, global emissions have to peak within the next 10-15 years and then decline in all regions (Gupta et al. 2007, p. 776). There are three possible options for achieving this: we can try to increase demand side energy efficiency, we can decarbonise all energy sources, or we can limit consumption of greenhouse gas intensive goods and services.

The first option has been paid lip service in many countries but it has not been possible to increase energy efficiency sufficiently to embark on a real downward emissions path. At best, energy efficiency has only just been able to keep up with the expansion of consumption. For example, the improvement of car engines was only able to offset the impact of increased engine strength required by consumer demand for heavier, more quickly accelerating cars. Similarly, the improvement of building energy efficiency in many industrialised countries has been eaten up by a strong increase in the per capita dwelling space (see Figure 7 for the case of Germany).

Figure 7: Development of per capita dwelling space in Germany 1950-2006

Data source: German Statistical Yearbook, various issues

Politically, the second option is the most palatable, but an energy system fully based on renewables has not yet been introduced successfully anywhere. The country that has come closest to it is Brazil, with an electricity system built on hydropower and a transport system built on ethanol from sugarcane bagasse. These two factors have allowed Brazil to keep its per capita emissions at less than 2 t CO₂. The recent turmoil on the food markets due to the attempts to increase the share of land devoted to biofuel production clearly shows the limitations of decarbonisation of transport fuels. While having made some inroads in industrialised countries, renewable electricity generation has not achieved cost parity with fossil fuel electricity production; and the storage problem for intermittent electricity sources remains unsolved. Currently, carbon capture and geological storage is seen as the magic bullet for decarbonisation of the electricity sector which would allow the continued use of coal in countries like China and India (Michaelowa 2005). However, its large-scale applicability is doubtful and its costs are likely to be high. Nuclear power is seen by some as a baseload carbon-free electricity source. The huge cost overruns in the recent Finnish reactor development project and the problems witnessed in nuclear power plant operation in Japan, as well as the still unsolved final waste disposal, show the limitations of this technology.

This leaves us with the third and rarely discussed option of limiting consumption (for an exception see Pan 2005, who however only addresses the issue from the angle of determining emissions commitments for developing countries). No politician in industrialised countries and even less in developing countries dares to propose such a

strategy to his voters. Even researchers are obfuscating the issue by framing it in terms of “sustainable consumption” (see e.g. Hobson 2002) or “lifestyle changes”. Usually, in assessments of greenhouse gas mitigation potential, neither the availability of new, hitherto unimagined consumer goods or services, nor the limitation of consumption, is taken into account.⁴ Eventually the climate challenge will confront us with the need to decide whether limitless travel, instant global communication, or a living space of 100 m² per person is acceptable. Pan (2005, p. 92ff) has listed basic needs for a decent level of human development; an in-depth discussion of this concept is required. We will need a “sufficiency revolution” to keep our planet in a climatic range that is manageable.

Conclusions

Reaching a decent level of human development is possible at a low per capita greenhouse gas emissions level, as has been shown by a number of countries. However, development of a typical, industrialised, middle class lifestyle with car-oriented urbanisation and penetration of low energy-efficiency appliances leads to a rapid emissions take-off. Such a take-off has occurred in China in the last decade and is likely to be repeated in India. Policies are urgently required that address urban planning and appliance energy efficiency before the take-off starts. The future climate policy regime and support strategies for rapidly industrialising countries should focus on such policies. Nevertheless, in the long run a limitation of consumption is inevitable to prevent a dangerous level of climate change.

References

- AFP (2008): Lifestyle changes can curb climate change: IPCC chief; download at <http://afp.google.com/article/ALeqM5iilVBkZpOUA9Hz3Xc2u-61mDirw0Q>, September 29, 2008
- Allaire, Julien (2007): Développement urbain chinois. Quelle contribution au réchauffement climatique ?, Note de Travail 10/07, LEPII, Grenoble
- Azomahou, Theophile; Laisney, Francois; Nguyen Van, Phu (2006): Economic development and CO2 emissions: A nonparametric panel approach, in: *Journal of Public Economics*, 90, p. 1347-1363
- Barter, Paul; Kenworthy, Jeffrey (1997): Urban Transport and Land Use Patterns Challenges and Opportunities of High Density Cities in East and Southeast Asia, Working Paper No. 81, Asia Research Centre, Murdoch University, Perth
- Chamon, Marcos; Mauro, Paolo; Okawa, Yohei (2008): Mass Car Ownership in the Emerging Market Giants, in: *Economic Policy*, 23, 54, p. 243-296

China Car Times (2008): Car Ownership up 32% in 2007, download at <http://www.chinacartimes.com/2008/03/10/car-ownership-up-32-in-2007/>

Fridley, David; Aden, Nathaniel; Zhou Nan, Jiang Lin (2007): Impacts of China's Current Appliance Standards and Labeling Program to 2020, LBNL-62802, Berkeley

Galeotti, Marzio; Lanza, Alessandro; Pauli, Francesco (2006): Reassessing the environmental Kuznets curve for CO2 emissions: A robustness exercise, in: *Ecological Economics*, 57, p. 152-163

Gupta, Sujata; Tirpak, Dennis; Burger, Nicholas; Gupta, Joyeeta; Höhne, Niklas; Boncheva, Antonina; Kanoan, Gorashi; Kolstad, Charles; Kruger, Joseph; Michaelowa, Axel; Murase, Shinya; Pershing, Jonathan; Saijo, Tatsuyoshi; Sari, Agus (2007): Policies, Instruments and Co-operative Arrangements, in Metz, Bert; Davidson, Ogunlade; Bosch, Peter; Dave, Rutu; Meyer, Leo (eds.): *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, p. 746-807

He Zhenhong, Wu Li (2008): Air-con sector to raise threshold for efficiency, *China Economic Net*, download at http://en.ce.cn/Insight/200807/04/t20080704_16050803.shtml, September 29, 2008

Hobson, Kersty (2002): Competing Discourses of Sustainable Consumption: Does the 'Rationalisation of Lifestyles' Make Sense?, in: *Environmental Politics*, 11, 2, p. 95-120

Holtz-Eakin, Douglas; Selden, Thomas (1995): Stoking the Fires? CO2 Emissions and Economic Growth, in: *Journal of Public Economics*, 57, p. 85-101

IEA (2007): CO2 emissions from fossil fuel combustion 1971-2005, Paris

International Iron and Steel Institute (2008): Steel production statistics, download at <http://www.worldsteel.org/>

IPCC (2007): *Climate Change 2007: Synthesis Report. Summary for Policymakers*, Geneva

Koizumi, Satoru (2007): Energy efficiency of air conditioners in developing countries and the role of the CDM, IEA, Paris

Michaelowa, Axel (2005): Carbon capture and geological storage research – a capture by fossil fuel interests?, in: Sugiyama, Taishi (ed.): *Governing climate. The struggle for a global framework beyond Kyoto*, IISD, Winnipeg, p. 69-75

Moomaw, William; Unruh, Gregory (1997): Are environmental Kuznets curves misleading us? The case of CO2 emissions, in: *Environment and Development Economics*, 2, p. 451-463

National Bureau of Statistics of China (2007): *Statistical yearbook of China*, Beijing

Neill, Michael; Letschert, Virginie (2008): Future Air Conditioning Energy Consumption in Developing Countries and what can be done about it: The Potential of Efficiency in the Residential Sector, LBNL-63203, Berkeley

Pan Jiahua (2005): Meeting Human Development Goals with Low Emissions: An Alternative to Emissions Caps for post-Kyoto from a Developing Country Perspective, in: *International Environmental Agreements: Politics, Law and Economics*, 5, p.89-104

Price, Lynn (2008): The Challenge of Reducing Energy Consumption in China's Industrial Sector, download at http://eetdseminars.lbl.gov/download/L_Price091608seminar.pdf, Sept. 29, 2008

Rabinovitch, Jonas; Leitman, Josef (1996): Urban Planning in Curitiba, A Brazilian City Challenges Conventional Wisdom and Relies on Low Technology to Improve the Quality of Urban Life, in: *Scientific American*, March 1996, p. 46-53

Taylor, Robert; Govindarajalu, Chandrasekar; Levin, Jeremy; Meyer, Anke; Ward, William (2008): Financing energy efficiency. Lessons from Brazil, China, India, and beyond, World Bank, Washington

UNDP (2007): Human Development Report, New York

Zhou Nan; McNeil, Michael; Fridley, David; Jiang Lin; Price, Lynn; de la Rue du Can, Stephane; Sathaye, Jayant; Levine, Mark (2008): Energy Use in China: Sectoral Trends and Future Outlook, LBNL-161904, Berkeley

Endnotes

¹ The HDI measures the average achievements in a country in three basic dimensions of human development: a long and healthy life; access to knowledge; and a decent standard of living. Parameters are life expectancy at birth, adult literacy and combined gross enrolment in primary, secondary and tertiary education, and gross domestic product (GDP) per capita. The HDI scale ranges from 0 to 1. See UNDP (2007, p. 225).

² A HDI of 0.9 has been reached by 28 out of 177 countries and typically corresponds to a life expectancy of over 78 years, full adult literacy and full primary and secondary enrolment, as well as GDP per capita over 22,000 \$ (PPP, 2005) (UNDP 2007, p. 229-232).

³ Air travel and 24 hour internet accessibility are just the tip of the iceberg.

⁴ The IPCC (2007, p. 16) noted dryly that lifestyle changes were not addressed in its estimate of mitigation potential. Interestingly, IPCC chairman Pachauri raised reduction of consumption in an interview and called for less meat consumption and less car use (see AFP 2008).