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THE ROLE OF DECENTRALIZED RENEWABLE ENERGY TECHNOLOGIES IN ADAPTATION TO CLIMATE CHANGE IN DEVELOPING COUNTRIES

SYNOPSIS

The paper analyses the positive impact of Decentralized Renewable Energy Technologies on enhancing climate change adaptation capacity in developing countries facing climate change-related increasing hazards. The paper concludes with some recommendations for implementing decentralized renewable energy technologies for climate adaptation in developing countries.

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EXECUTIVE SUMMARY

1. This paper discusses the role of Decentralized Renewable Energy Technologies (DRETs) in enhancing adaptation to climate change impacts and implementing reduction of GHG emissions in developing countries.

2. Now and over the next decades, developing countries are and will be disproportionately affected by climate change negative impacts and suffer higher costs because of their greater vulnerability to natural hazards. Over the long term, there is a serious risk that further global warming could have a net and persistent negative impact on the development prospects of developing countries and amplify the challenges posed by ecosystem fragility, economic dependence upon agriculture, and population growth in developing countries.

3. One of the reasons of developing countries' vulnerability consists in energy poverty. The energy poor are not surprisingly more exposed and sensitive to external stresses because of higher incidence of extreme poverty, malnutrition, diseases, mortality, education deficit and gender inequality. Access to energy represents an important input to human development. Therefore, the improvement of adaptation capacity in developing countries is premised, among other things, on the enhancement of access to energy resources and services – in particular renewable energy.

4. On the other hand, the reinforcement of adaptation to climate change needs a strong effort to shift toward a low-carbon energy pathway – both in terms of the energy infrastructure and the energy production and consumption patterns – that nevertheless would continue to support continued sustainable development in developing countries while lessening the level of their GHG emission increases. In this context, DRETs may represent an important way for developing countries to support adaptation and enhance development, representing a more ecological development pathway with emphasis on the introduction and use of clean and resource-efficient technologies, social and environmental sustainability and improved social equity.

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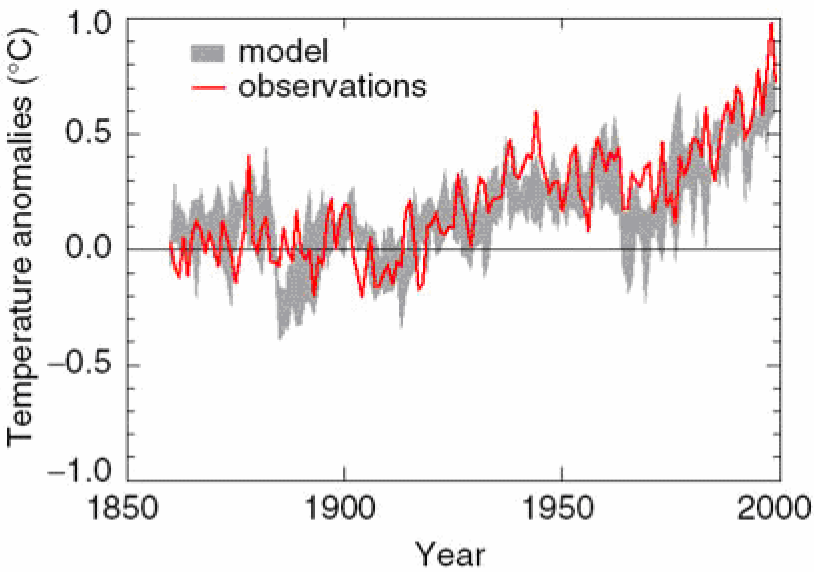
1 Climate Change and Global Warming

1. In October 1986, scientists and climatologists were gathered by the World Meteorological Organization (WMO), the United Nations Environment Program (UNEP) and the International Council of Scientific Union (ICSU) at an international conference in Villach, Austria, to discuss the problem of anthropogenic interference in the Global Climate System (GCS). At the end of the conference, they declared jointly that the atmospheric concentration of greenhouse gasses (GHG) due to the intensive industrial activity in developed countries is the origin of the long succession of temperature anomalies recorded by climatologists since the beginning of 20th century and will probably further stress the sensitivity of the GCS during the 21st century[1].

Figure 1: Global temperatures and temperature anomaly. Source: IPCC, Working Group I, 2001.



2. Two years later, the WMO and the UNEP established the Intergovernmental Panel on Climate Change (IPCC), a scientific body tasked to evaluate the real magnitude, the risks and the possible impacts of climate change. The main mission of the panel is to collect and expose into special reports all pertinent information on climate related topics coming from scientific authorities and relevant to the implementation of the United Nation Framework Convention on Climate Change

* The South Centre acknowledges the research contributions of Mr. Yann Bovey to this paper.

[1] The Villach conference and the 29th SCOPE report historically represent the first scientific consensus around the idea of a human-made Climate Change and are an important foresight of the Global Warming. Cf. BOLIN, B., et al., eds., *The Greenhouse Effect, Climate Change, and Ecosystems*, SCOPE 29, Chichester, Wiley, 1986, 541 p.

(UNFCCC), the international treaty produced during the UN Earth Summit of Rio de Janeiro in 1992.

3. Since the date it was established, the IPCC has produced four assessment reports, respectively in 1990, 1995, 2001 and 2007. All reports assessed the unequivocal warming of the GCS because of the growth of anthropogenic GHG emissions and concentration. Thanks to the work of the IPCC, today climate change has been recognized as a major global challenge of our time and an increasing consensus in the political community is rising over the magnitude of risks the world is facing and the urgency of measures needed to stabilize atmospheric GHG concentrations to avoid an excessive climate heating.

4. In the *Fourth Assessment Report*[2], published in 2007, the Working Group I, which deals with the scientific bases of climate change, forecast a probable mean temperature rise between 1.1°C and 6.4°C[3] (see Figure 2). Working Group II, which deals with the actual knowledge about impacts of climate change, adaptation strategies and vulnerabilities, enhanced in a very meaningful way our knowledge about the probable feedbacks that we are expected to experience during the next decades from the climate rising variability and global warming. The global Heart Ecosystem, in other terms the *Biosphere*, will be more and more affected by the radical change in the GCS energy balance and equilibrium in a way that we can hardly forecast today. In fact, human-made GHG emissions are forcing the GCS into a phase of temporary imbalance between the global absorbed energy radiations and the global emitted energy radiations: more energy is captured inside the atmosphere than the energy that is able to escape back to the open space (infrared radiations). Thus, the Earth system gradually warms by the absorption of the exceeding heat until it comes back to equilibrium. This transition from an equilibrium state to another is accomplished chiefly by the heat absorption capacity of oceans, which plays a fundamental regulatory function inside the GCS.

5. The *Climate Response Time*, which is the time needed to respond to an imposed external forcing and achieve the "jump" from one equilibrium step to another, depends on many factors, in particular on the time needed by oceans to store the heat and on the complex interaction between positive and negative feedbacks which could contribute to accelerate or decrease the global phenomenon[4]. Beside that, the time expected to equilibrate the global energy ratio depends obviously from human policy decisions and capacity to reduce substantially their GHG emissions in the next years. As IPCC shows in its *Special Report on Emissions Scenarios* (SRES)[5], in all hypothetic future storylines the stabilization level of GHG concentration into the atmosphere and the temperature rise during the next century depends fundamentally on the rapidity of the human response in terms of reducing dangerous GHG emissions during the next ten years.

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[2] The contribution of the WG II can be consulted at http://www.ipcc-wg2.org/

[3] For more information on Working Group I activities, please consult http://ipcc-wg1.ucar.edu/

[4] Feedbacks can be fast, coming into play immediately as temperature changes, like growing water vapour concentration into the atmosphere magnifying the climate response or changes of cloud and snow cover, and slow, amplifying millennial climate changes, like polar ice melting.

[5] Please see http://www.grida.no/climate/ipcc/emission/

6. IPCC calculates that an energy imbalance of 1.6 [0.6 to 2.4] W/m^2 is currently on the run[6]. The radiative imbalance is chiefly provoked by the global concentration of carbon dioxide, methane and nitrous oxide pumped into the atmosphere during the past 200 years of industrial activity and intensive agriculture. The main implication of that fact is that even if all policy measures oriented to reduce GHG emissions and mitigate Climate Change were put in place right now, there would still be a residual climate forcing that has not yet been absorbed by the Earth and the temperature will eventually warm further[7].

7. Concerned by the climate inertia, James Hansen of the Goddard Institute for Space Studies, a division of the NASA Goddard Space Flight Center, talks about "residual climate forcing" as the consequence of the long time it takes the ocean to warm[8]. According to him, the implication of that imbalance is that, even if the GHG concentration into the atmosphere does not change further, the expected warmth will be by the order of 0.4-0.7°C[9].

1.1 GHG future emissions and energy scenarios

8. Forecasting future global warming needs to take into account three key parameters: a) the sensitivity of GCS to external forcing; b) the forcings that humans are exercising on CGS by putting into atmosphere dangerous GHG; and c) the time needed by GCS to respond to external forcing. With reference to the first and the third point, climatologists generally agree with the fact that even if mitigation policies were immediately put in place, the current slow absorption rate of the Oceans determines an unavoidable inertia of the GCS, that means that an inevitable amount of additional global warming of 2ºC due to the historic emissions is already "in the pipeline"[10]. Figure 2 shows that temperatures on the average are slowly growing since the middle of the 20th century and that projected future rise in temperature will at least be by 2ºC, that is represented by the lower part of the predicted temperature rise rank.

9. Conversely, the upper part of the range depends upon the forcings that humans will introduce into GCS, namely upon future GHG emission paths. Most global energy scenarios indicate that during the next three decades the global primary energy demand is expected to grow and that, according to the International Energy Agency (IEA), if current energy policies are carried on as they actually are, the world's energy needs in 2030 will be of 50% higher than today.

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[6] The mean value of 1.6 W/m^2 results after the ponderation of the different radiative forcing provoked by the concentrations of different GHG. Cf. WG I contribution to the IPCC's *Fourth Assessment Report*, cap. 2: http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch02.pdf

[7] Ibid.

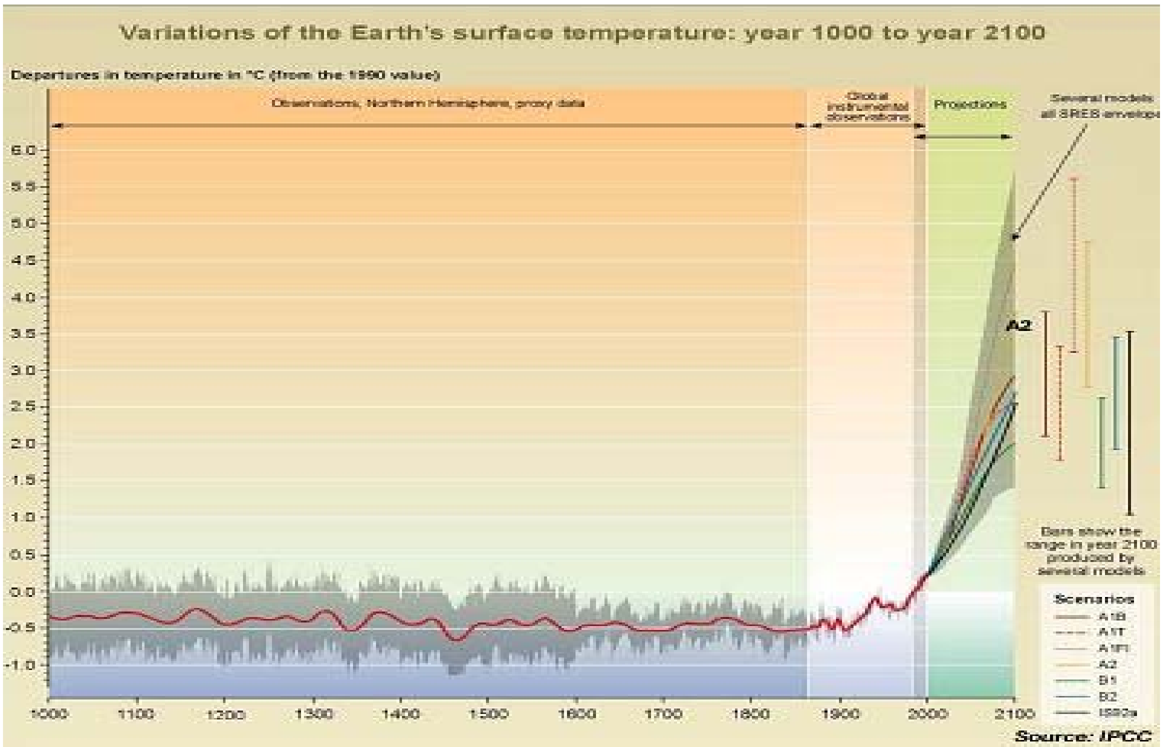
[8] Oceans, air, land and ice represent energy sinks which contributes, each one with its respective radiative characteristics, to the absorption of excedent heat. Normally, air and oceans, which are respectively the two "easiest" elements to warm, do the most of the job. But if radiative imbalance should rise further, ice would become an important energy sink and melt even faster than it does today.

[9] HANSEN, J., *Can we defuse the global warming time bomb?*, NASA Goddard Institute for Space Studies, and Columbia University Earth Institute, New York, 2003. http://www.sciam.com/media/pdf/hansen.pdf . See also HANSEN, J., et al., "Earth's energy imbalance: confirmation and implications", *Science*, 2005, 308, http://www.sciencemag.org/cgi/content/abstract/1110252v2

[10] Cf. HANSEN, J., 2003, op. cit. See also WG I Contribution to the IPCC's *Fourth Assessment Report*, cap.10: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

10. More than 60% of that growth is expected to come from fossil fuels, in particular oil and natural gas. The use of coal is probably likely to increase its share of global fossil fuel mix if oil prices will continue to grow at the actual rate[11].

Figure 2: Variations of the Earth's surface temperatures. Source: IPCC, Working Group I, 2001.



11. IPCC's SRES forecasts that if current global driving forces for global warming persist, in particular carbon-intensive development policies and population growth, GHG emissions are likely to increase by a range of 9.7 GtCO2-eq to 36.7 GtCO2-eq between 2000 and 2030. That would mean that atmospheric concentration of carbon dioxide will probably reach and exceed 550 Parts per Million of Volume (ppmv)[12] that is two times the "natural" concentration (280 ppmv) and one third more than actual concentration (380 ppmv).

12. Two thirds to three quarters of such growth in GHG emissions are expected to come from non-Annex 1 countries, which are basically all developing countries. These countries are expected to experience higher economic and demographic growth rates and consequently increasingly contribute to the global energy consumption growth tendency more than other regions on the globe. Developing countries could increase their global energy demand share from today's 40% to around 50% in 2030 because of economic development, improved lifestyles and an

[11] For further information about future energy scenarios, please consult the IEA statistics and reports: http://www.worldenergyoutlook.org/2005.asp

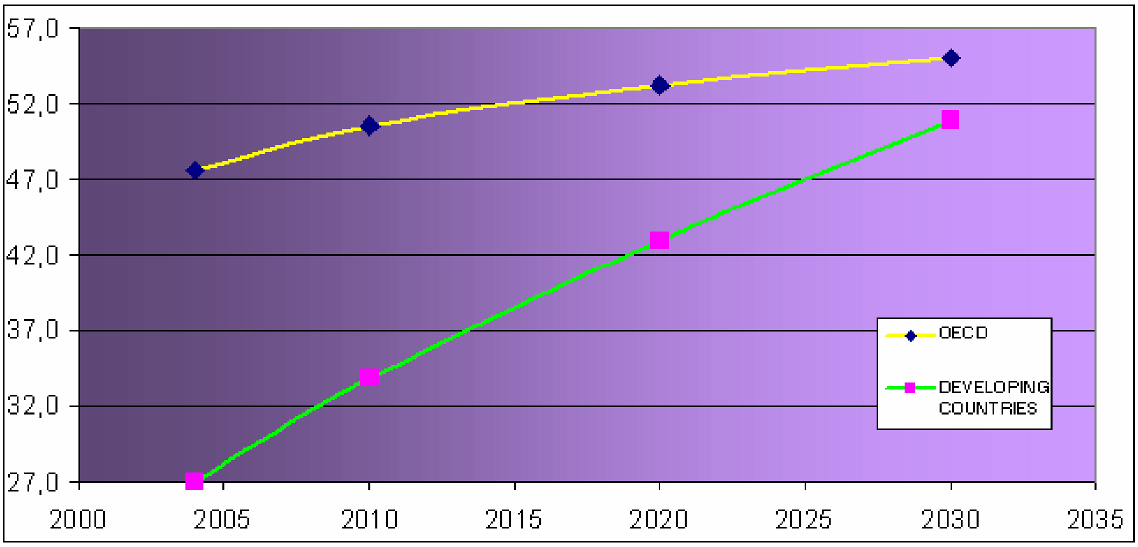
[12] IPCC Special Report on Emission Scenarios, which is part of the Fourth Assessment Report, is available at http://www.grida.no/climate/ipcc/emission/

enlarged consumption per capita[13]. But it should be noted that despite such growth, energy use per unit of GDP in non-Annex 1 countries will likely continue to be less than in developed countries.[14] In developing countries, the per capita CO2 emissions will continue to remain considerably lower (less than one third) than those in Annex 1 countries because of the significant difference in terms of demographic size and growth. Projections from the UN are that by 2030, global population will be 7.8 billion, with developed country populations remaining stable at 1.2 billion and populations in developing countries growing from the current 4.6 billion to 6.6 billion.[15]

Table 1: World oil demand 2004-2030 (Mb/d). Source: OECD/IEA, *WEO*, 2005.

World oil demand 2004-2030 (Mb/d)					
	2004	2010	2020	2030	2004-2030
OECD	47,6	50,5	53,2	55,1	0,6%
TRANSITION ECONOMIES	4,4	4,9	5,6	6,2	1,3%
Russia	2,6	2,9	3,3	3,5	1,2%
DEVELOPING COUNTRIES	27,0	33,9	42,9	50,9	2,5%
China	6,2	8,7	11,2	13,1	2,9%
India	2,6	3,3	4,3	5,2	2,8%
Latin America	4,7	5,4	6,5	7,5	1,9%
Africa	2,6	3,3	4,5	5,7	3,0%
Middle East	5,4	6,5	8,1	9,4	2,2%
WORLD	82,2	92,5	104,9	115,4	1,3%

Figure 3: World oil demand 2004-2030 (Mb/d). Source: OECD/IEA, *WEO*, 2005.

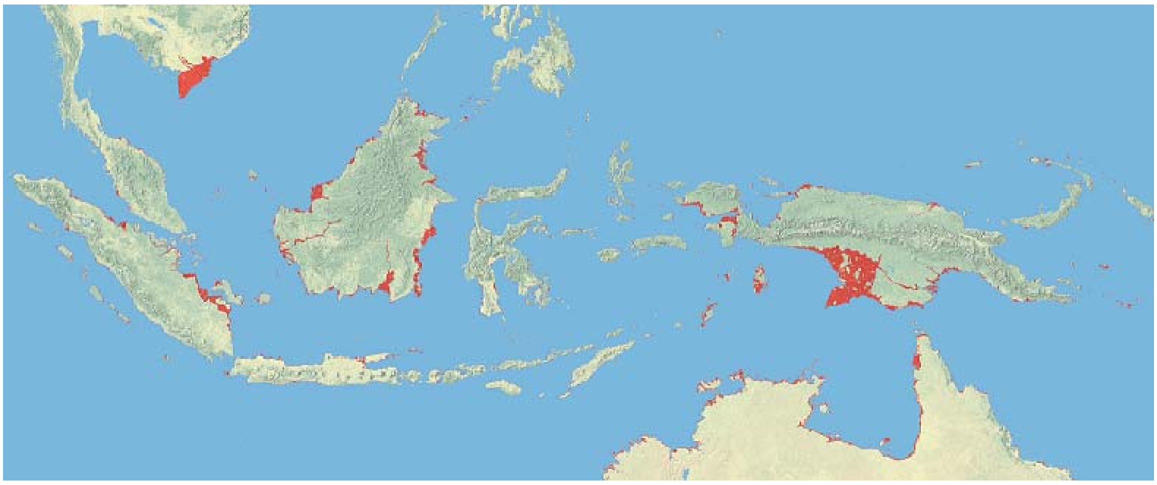


[13] Cf. IEA, *World Energy Outlook 2005*, Paris, OECD.
[14] Ibid.
[15] See UN Population Fund, at http://www.un.org/esa/population/publications/wpp2006/English.pdf.

13. Anthropogenic atmospheric concentration of GHG and the magnitude of climate change are expected to get worse during the next decades. The results will be higher main temperatures, much more instability in weather and precipitations, amplification of the extreme climatic events like hurricanes, tornadoes, temperature extreme and droughts, a dramatic loss of biodiversity and important sea level rise connected with thermal expansion and ice melting – most of which will more adversely affect developing countries than developed ones. For some, sea level rise is considered as the key-issue in the global warming debate[16] because of the serious damages it could produce to the millions of people and to the trillion dollars of infrastructures that are placed within a few meters of altitude and that would be severely affected from that phenomenon. In fact, the amount of heat required to melt enough ice to raise the sea level one meter above the actual point is about 12 watt per year, an energy that could be accumulated in only 12 years if the planet has an imbalance by 1W/ m² .[17]

14. The image below, taken from the Center for Remote Sensing of Ice Sheets (CReSIS)[18], shows the forecasted impact of a one meter sea level rise in South East Asia, New Guinea and northern Australia. The red zones represent the inundated areas. By the end of the twenty-first century, if sea levels do rise by one meter, the areas in red below may well be inundated.

Figure 4: Forecasted inundations for a one meter sea level rise. Source: CReSIS.



15. This panoply of Dangerous Anthropogenic Interferences (DAI)[19] should alert the political community in a very meaningful way and push stakeholders –

[16] HANSEN, J., "A slippery slope: how much global warming constitutes a dangerous anthropogenic interference?", *Climate Change*, 2005, 68(1-2), pp. 269-279).

[17] HANSEN, J., op. cit., p.12-13; see also LEVITUS, S., et al., "Warming of the world Oceans", Science, 287, 2225, 2000, http://www.sciencemag.org/cgi/content/abstract/287/5461/2225.

[18] See https://www.cresis.ku.edu/research/data/sea_level_rise/index.html.

[19] UNFCCC goal is to "achieve stabilization of greenhouse gases concentrations in the atmosphere at a level that would prevent **dangerous anthropogenic interferences** with the Global Climate System". The problem is that the definition of DAI is not unequivocal and can be subjected to multiple interpretations. See UNFCCC, art. 2, http://unfccc.int/resource/docs/convkp/conveng.pdf.

especially the developed countries that have historically caused global warming – to take the necessary steps required of them under the UNFCCC to reduce GHG emissions to show that they are indeed, as Art. 4.2(a) of the UNFCCC puts it, "modifying longer-term trends in anthropogenic emissions." For developing countries, the "pipeline" impacts of global warming that has already occurred will require a greater focus on adaptation as the means for ensuring that their development prospects will not be adversely affected.

2 Adaptation to Climate Change

2.1 Key vulnerabilities

16. Adaptation is a key concept of evolutionary sciences. It refers to an endogenous change in the structure or functioning of an organism that makes the organism itself better suited into its environment. It refers also to the capacity of an organism to react to stresses and pressures coming from the environment by addressing its main vulnerabilities and increasing its resilience capacities. In this sense we can also talk in terms of acclimation.

17. In the special case of social organisms like complex societies, adaptation is to be considered as a dynamic process inherent to the intricate relations between societies and their natural environment. For that reason, we will talk about *socio-ecological systems* which mean that natural aspects are as important as natural aspects in determining adaptation processes. This idea reflects the fact that each human action, both as an individual or as part of a complex society, is integral into the natural system that surrounds him. Therefore, through the wider conceptual perspective of socio-ecological system, vulnerabilities appear more as a problem of relationship between humans and their natural environment than one of natural or social factors only[20].

18. Piers Blaikie et al. highlight the fact that disasters never have their roots only in "natural factors" but have always a "social cause". In other terms, they depend principally upon two main reasons: one reason is exogenous, natural hazard, and one is endogenous, social vulnerability[21]. In fact, if people do live or work in potentially dangerous places, the motivation is always because social systems, social pressures or social values lead them to do so in a more or less explicit way. People can be forced by economical reason to move to a dangerous area (weak social causes) or for political reasons (strong social causes). Therefore, addressing future disasters provoked by climate change and developing an adaptation strategy requires an important effort in terms of forecasting climate related hazards and dealing with key vulnerabilities.

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[20] Cf. ADGER, W. N., 2006, "Vulnerability", *Global Environmental Change*, 16 (3):268-281

[21] Cf. BLAIKIE, P.M. et al., 1994, *At Risk: Natural Hazards, People's Vulnerability, and Disasters*, London, Routledge. Blaikie et al. define vulnerability as the "characteristics of a person or a group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards", p.11.

2.2 *Adaptation policy*

21. National governments are major players in facilitating adaptation strategies through well-oriented public policy measures. As a policy strategy and action, adaptation to climate change should be included into a broader risk management approach and deal with all key vulnerabilities inside a society[22]. In fact, most of the steps needed to adapt to climate change impacts goes in the same direction with those necessary to reduce vulnerabilities and improve human and economic development[23]. Preventing disasters and adapting to climate hazards is linked with the development path (in particular with poverty eradication). Therefore, the type of development path to be used will represent a crucial element of each adaptation strategy that will be put in place in developing countries.

22. Adaptation to climate change should deal not just with climate change-associated natural disasters (climate shocks) but also the incremental changes in climate patterns that affect long-term development (climate trends). Shocks related to abrupt and extreme phenomena like hurricanes, floods, draughts etc. Trends relate to those phenomena which gradually and structurally influence the society like more instable weather seasonality, prolonged famines, changes in main regional temperatures etc. Adaptation should cope with both shocks and trends, and policy should find solutions which include short term as well as long term strategies.

23. On the social side, an adaptation policy framework should address: a) livelihood, namely access to incomes and food; b) health; c) self-protection and quality of locations; d) social protection and social networks; e) governance, in terms of power distribution between stakeholders, f) institutional arrangements, like property rights, market access, capabilities and so on.

24. A local-oriented approach is needed to make sure that the responses undertaken under the adaptation policy framework are effective, considering that the effects of climate change may be very variable across regions and demographic groups[24].

25. To do this it is very important that central governments involve into the political process of decision making stakeholders like the local authorities, the civil society, the business and the private sector, the academic research, the working unions, the citizens and all the organizations and associations who play a fundamental role inside the local-based communities.

2.3 *Limits to adaptation*

26. Actions oriented to adaptation could be retarded because of competing goals and cost-effectiveness issues. The main problem facing decision makers in this area is

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[22] There is a huge literature on risk management and natural hazards. For a first look, see BLAIKIE, P., et al., 1994, *At risk: natural hazards, people's vulnerability, and disasters*, London, Routledge; BOHLE, H. G., T. E. DOWNING, and M. J. WATTS, 1994, "Climate change and social vulnerability: the sociology and geography of food insecurity", *Global Environmental Change* 4:37-48; O'BRIEN, P., and R. LEICHENKO, 2000, "Double exposure: assessing the impacts of climate change within the context of economic globalization", *Global Environmental Change*, 10 (3):221-232.

[23] Cf. SCHERAGA, J. D., and A. E. GRAMBSCH, "Risks, opportunities and adaptation to climate change", *Climate Research*, 10:85, 1998, pp. 85-95.

[24] Cf. SCHERAGA, J. D., and A. E. GRAMBSCH, op. cit.

to set clear priorities, particularly if there is a situation of multiple stresses. Several researches underline[25] the fact that non-climate pressures upon the policy agenda could affect the potential for adaptation capacity. Multiple stresses also affect the public capacity to value the importance of paying for adaptation costs. Climate change may often be perceived as a distant problem, less pressing than other more immediate difficulties people, especially poor people, are facing every day[26].

27. The evaluation of potential adaptation responses has to consider a variety of criteria[27]. Some of them are: the economic efficiency in terms of the cost/opportunity evaluation of the investment; its cost-effectiveness; the flexibility of the response to the entire range of potential impacts; the real urgency (or the perceived urgency) of the response; the equity of the response etc. All these questions become more urgent if the country's agenda is exposed to other stresses and competing needs.

28. The main difficulty in climate change issues is to deal with future projections. Normally, economic actors who may decide between investing now or in the future are helped in their decision-making by the cost-benefit analysis. This microeconomic approach facilitates the evaluation of the suitability of an investment by discounting the expected benefits at the present value so that we could compare two or more possibilities of investments. In the case of climate change, such logic is not acceptable because hazards grow not in a linear and predictable way. The Amsterdam Declaration on Global Change stated in 2001 that "interactions and feedbacks between the component parts [of the Earth system] are complex and exhibit multi-scale temporal and spatial variability […] Global Change cannot be understood in terms of a simple cause-effect paradigm. Human-driven changes cause multiple effects that cascade through the Earth system in complex ways. These impacts interact with each other and with local- and regional-scale changes in multidimensional patterns that are difficult to understand and even more to predict"[28].

29. This means that, in particular, adaptation policy measures should be integrated into a country's broader sustainable development agenda. This is especially true in the case of developing countries. Sustainable development should be the framework objective that ties together all the adaptation responses needed to deal with climate change-related stresses. Hence, if sustainable development is the key to adapting to climate change, then the carbon-intensive economic development model that has been used by today's developed countries, and which has given rise

[25] Cf. YOHE, G.W., et al., 2007 : Perspectives on climate change and sustainability. *Climate Change 2007 : Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC*, Cambridge University Press, Cambridge. http://www.ipcc-wg2.org/. See also TITUS, J. G., "Strategies for adapting to the greenhouse effect", *The journal of the American Planning Associations*, Summer: 311-323 (1990), http://www.epa.gov/climatechange/effects/downloads/adapting_japa.pdf

[26] An important point to stress up is the role of informal sector in developing countries. This sector could represent a real problem for governments who try to put in place a serious policy to implement an adaptation strategy because of the difficult to handle with it.

[27] TITUS, J.G., op. cit.

[28] The Amsterdam Declaration is the output of the meeting hold in 2001 in Amsterdam between the four international global change programs, the International Geosphere-Biospere Program (IGBP), the International Human Dimensions Program on Global Environments Change (IHDP), the World Climate Research Program (WCRP) and the international biodiversity program DIVERSITAS. The full text of the declaration is available at http://www.essp.org/index.php?id=41.

to today's global warming, is not the right development model that developing countries should follow if they are to sustainable develop and adapt effectively to climate change.

2.4 Climate vulnerability of developing countries

30. It is very likely that all regions will be affected by future climate hazards but impacts and disasters will probably not be evenly distributed across the globe. For small increases of temperature, impacts could be diverse, both positive for some sectors and regions and negatives for others, but on the average we should expect a net decline of global benefices, in particular in the low-latitude regions whose ecosystems as well as populations are much more reactive and less resilient to small changes.

31. The Stern Report[29], for example, pointed out that developing countries, in particular Least Developed Countries (LDCs) and Small Island Developing States (SIDS) are expected to experience a disproportionate charge in terms of human and financial negative impacts and adaptation costs[30]. Climate change will pose major obstacles to poverty eradication and development in developing countries.

32. Over the long term there is a serious risk that climate change could have a net and persistent negative impact on economic growth, both on a macro and a micro scale, human development and sustainability. This would probably reduce further the financial resources needed to cope with adaptation and bring the countries into a vicious downward spiral[31]. In fact, climate change will seriously affect the three main factors that contribute jointly to the economic output and the income production capacity: labor capacity, environmental quality and capital availability. Economic impacts and human costs will very likely amplify all those challenges posed by ecosystem fragility, economic dependence upon agriculture and demographic growth to the development of developing countries[32]. Impacts will probably be much stronger where economies are less diversified.

33. Human life and human economic activity depend upon all those services provided by natural ecosystems: water for human consumption and agricultural irrigation, wood for burning and building, biomass for heating and cooking etc. Therefore, ecosystem fragility and natural resources depletion enhance the exposure and sensitivity of many Developing countries facing climate challenges.

34. Some developing countries are particularly exposed to climate change because of their geography or socioeconomic situation:

- Small island countries, like Maldives and many South-Pacific countries, as well as countries with low-lying coastal areas, like Bangladesh, whose

[29] The Stern Report represents an attempt to evaluate the damages announced by the IPCC reports in monetary terms. In particular, it considers the damages as *externalities* and the global climate as a *public good*. The full Stern Report is available at http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

[30] Cf. Stern Report, Part II, *The Impacts of Climate Change on Growth and Development*.

[31] Ibid.: p. 107.

[32] The UNDP expresses much concern regarding the threat to the achievement of MDGs represented by climate change, in particular those related to eliminating poverty and hunger and promoting environmental sustainability. Please see http://www.undp.org/climatechange/adap01.htm.

exposition to sea level rise and their demographic size make them particularly vulnerable;

- Countries with arid and semi-arid areas liable to drought and desertification, like the Sahelian countries, which risk experiencing a severe drop or a higher variability in rainfalls during the next decades that will harshly impact their national agricultural production;
- Tropical countries, whose ecosystems are structurally more fragile to external shocks, according to Naordhaus[33]. Extreme weather events like floods can contribute to the soil erosion as well as high temperatures could speed up the lost of biodiversity;
- Countries where agriculture and related activities provide the most of the income capacity. Difficulty in water availability can be amplified even after slight variations in the seasonal rainfall and can provoke high costs for the crop production, in particular in regions where the rainfall season is alternated to a long dry season;
- Countries with high rates of demographic growth and where a large part of household and subsistence depend directly upon ecosystems' services. That could amplify deforestation, depletion of soil fertility and lost of biodiversity.

35. Many developing countries' dependence on the agriculture sector, in particular in the case of low-income and subsistence rural economies, make them particularly vulnerable to increasing climate variability. The concentration of economic activities in the rural sector, the most of the time upon few commodities and monocultures, limits their flexibility and increases vulnerability to climate stresses. The more the agriculture share in GDP is important, the more the entire economy is likely to be more vulnerable to global warming and climate change[34]. A country that had chosen to orient its agriculture production toward monoculture and export crops will suffer proportionally more than a country that had chosen to differentiate and orient its production to its internal market. On a microeconomic point of view, livelihoods that are based on a one-income-source, like small farmers or non-industrial fishers, are more vulnerable to climate change than others. Hence economic diversification – i.e. improving the number of productive sectors or activities in the national economy -- will be a major component in improving adaptation capacity, both on a macro and a microeconomic scale, in developing countries.

2.5 Energy poverty and economic marginalization

36. "Energy poverty" is the lack of equitable distribution of energy resources and services, which is different from the concept of "energy deprivation", which means the absolute lack of energy. Therefore, energy poverty should not be considered in fixed terms but always in relative terms and be linked to the concept of social and/or geographical *economic marginalization*.

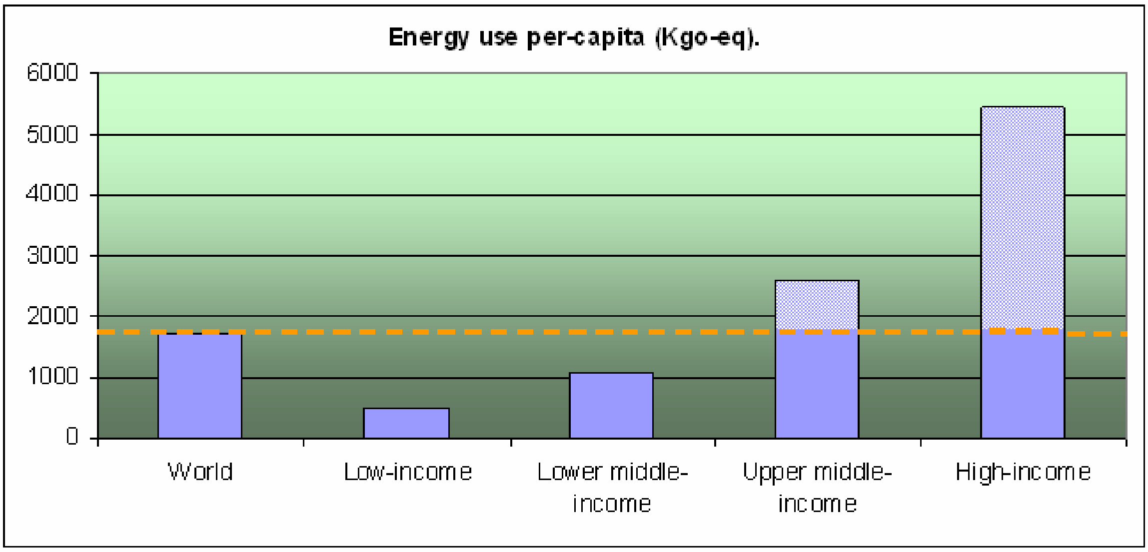
[33] NORDHAUSE, W., 2006, "Geography and macroeconomics: new data and new findings", PNAS, 103(10): 3510-3517.

[34] BOKO, M., et al., 2007: Africa. *Climate Change 2007; Impacts, Adaptation and Vulnerability. Contribution of the Working Group II to the Fourth Assessment Report of the IPCC,* Cambridge University Press, Cambridge UK, 422-467.

37. Both climate vulnerability and the development process are linked to *energy poverty*. The lack of access to reliable and affordable essential energy resources and services is not primarily a result of "underdevelopment" but rather is more a causal factor of economic poverty, malnutrition, chronic health fragility and location insecurity. Affordable access to energy resources and services impacts positively on the quality of life, sustains livelihood, increases the economic opportunities and consequently reduces demographic pressure on ecosystems, thereby improving adaptation capacity. This is the reason why a more equitable distribution of energy supply in developing countries should be seen as an important component of sustainable development and climate change adaptation.

38. Most of the energy poor live in middle- and low-income countries. In 2005, global annual per-capita energy consumption was 1734 Kg of oil equivalent (Kgo-eq) on the average. High-income countries (15% of the world population) consumed 5410 Kgo-eq, middle-income countries (47% of the world population) 1372 Kgo-eq while low-income countries (37% of the world population) only 501 Kgo-eq[35]. North American per-capita primary energy consumption was more than five times China's per-capita consumption and 17.5 times higher than Africa's per-capita consumption. In 2006, EU27 globally used about 1900 Mto-eq while the entire African continent consumed only 315 Mto-eq.[36]

Figure 5: Energy use per-capita (Kgo-eq). Source: World Bank, *The Little Green Data Book*, 2006.

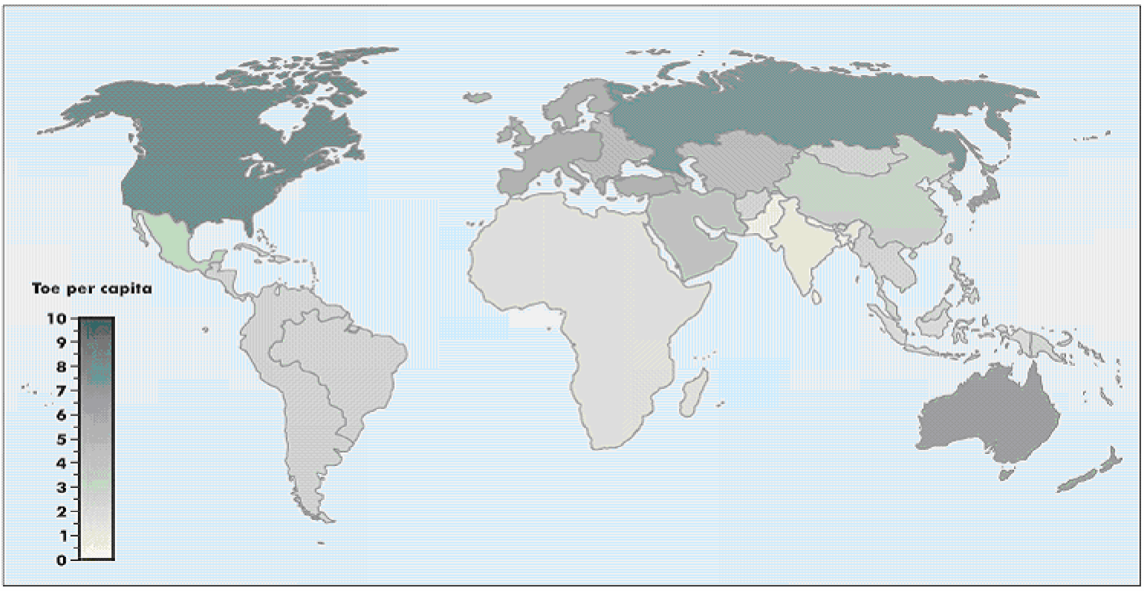


39. Most the energy poor live in Africa, Latin America and South Asia (see Figure 6[37]), three critical regions which will probably remain during the next decades far behind the rest of the world in terms of access to energy services. In these regions,

[35] World Bank, 2006, *The little Green Data Book*, Washington DC. The document is available at http://siteresources.worldbank.org/INTEEI/936214-1146251511077/20916989/LGDB2006.pdf.
[36] BP Statistical Review 2007.
[37] Source: IEA, *WEO 2004*: p.67

the main source of energy for the poor continues to be traditional biomass and waste representing still more than 50% of total primary energy consumption (90% in some countries)[38], both of which contribute heavily towards damaging ecosystems like forests and soils and which also affect women's and children's health with indoor pollution. Many countries in these regions are likely to see their populations growth, with consequent increases as well in the use of such traditional biofuels for energy. In rural and marginal urban areas like slums, which are not appropriately connected to the national grids, communities badly suffer from the lack of electricity. In 2005, South Asian and sub-Saharan countries consumed respectively 513 Kwh and 394 Kwh per capita on average, as compared to an average of 9503 Kwh per capita in developed countries. Lack of electricity deprives people of many vital needs, in particular for food conservation and hygiene.

Figure 6: Primary energy use per capita by region. Source: IEA, *WEO*, 2004.



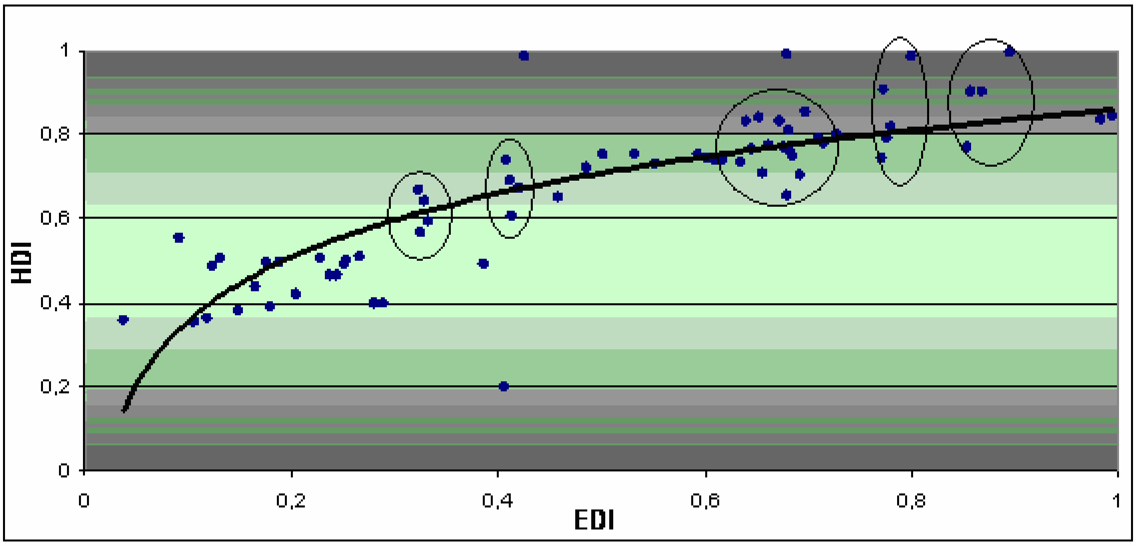
2.6 Energy and MDG's

40. Access to energy resources and services plays a crucial role in improving human living conditions and welfare. In fact, energy enables human needs to improve and contributes to social and economical development. The correlation between human development and access to energy was highlighted in an IEA report (its *World Energy Outlook 2004)* where it proposed an Energy Development Index (EDI)[39] that shows where energy development can overlap, with some important exceptions, with the UNDP's Human Development Index (see Figure 8). In fact, improved energy services represent not only an output of economic development

[38] Traditional biomass generally includes fuel wood, crop residues and animal waste. Often, for the poorest segments of the population these fuels represent the only source of energy for heating and cooking that is available (cf. World Bank, 2006).
[39] International Energy Agency, *World Energy Outlook 2004*, Paris 2004, p.342.

but also an essential input for cutting extreme poverty and hunger, improving education and health services, empower women and improve gender equality[40].

Figure 7: HDI and EDI in developing countries. Source: IEA, WEO, 2004.



41. As we can see in the figure above, which crosses data taken from UNDP's HDI and IEA's EDI for developing countries, the relation between the two indexes is relatively straight-forward. Moreover, the figure shows that some countries having the same energy development lies above or under the tendency curve, that means they have higher or lower levels of human development. Many of the countries that have higher levels of human development are Latin American countries like Argentina, Cuba, Brazil, Uruguay, Peru; other are South Asian and Pacific countries like Vietnam, Myanmar, Sri Lanka, Philippines and Indonesia, some are African like Togo and Kenya. In its calculations above, the IEA used three different indicators; one of them calculates the electrification rate of each country. That shows how much can be done in terms of human development by enhancing equitable energy distribution.

42. Finally, this figure shows that the relation between HDI and EDI is not linear but the two indices decouple at higher levels of human development suggesting that even small increases in energy access, distribution and shares represent a huge improvement in the quality of life for the poor[41].

[40] Cf. U.K. Department for International Development, 2002, *Energy for the Poor: Underpinning the Millennium Development Goals*, London; see also REN21, 2005, *Energy for Development. The potential role of renewable energies in meeting the MDGs*, Washington, DC, Worldwatch Institute; and MODI, V., 2004, *Energy Services for the Poor*, paper commissioned for the Millennium Project Task Force, New York.

[41] Cf. MODI, V., op. cit.

3 Renewable Energies and Adaptation

43. Improved access to energy resources and services plays a crucial role in the sustainable development of developing countries and therefore in improving adaptation capacity[42]. Energy and technology choices toward a low carbon intensive energy mix are crucial in addressing climate change both in developed and developing countries, in particular as a way to meet GHG emissions reductions commitments in developed countries in order to modify longer-term trends in their emissions and energy consumption patterns, and in order to support sustainable development in developing countries as the foundation for their adaptation to climate change. The carbon-intensive development path that has been used by developed countries is not the way to deal with climate change. Instead, a diversified and low carbon intensive energy portfolio is imperative to the improvement of a coherent long term climate adaptation strategy in developing countries.

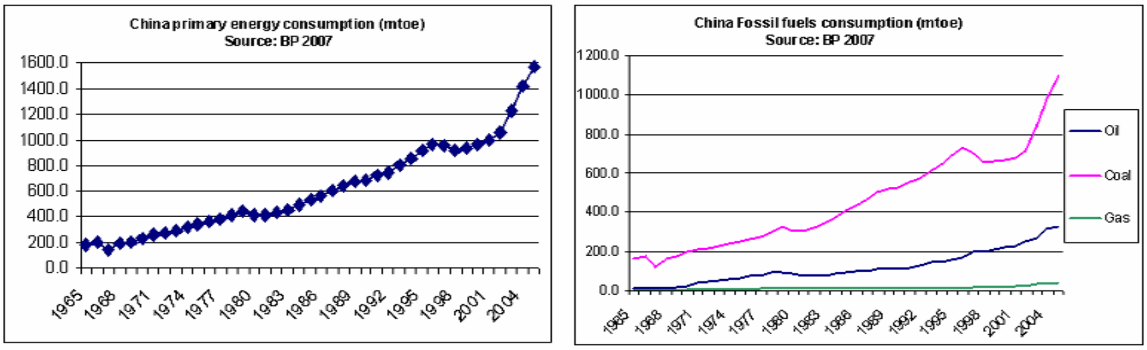
3.1 Adaptation to climate change is not technologically neutral

44. Double-digit trends during the next decades in global fossil fuel demand in the medium-term will probably be in large part due to demand by developing countries in order to sustain and increase their current levels of economic development and address the energy needs associated with population growth. If a policy as usual scenario should persist, developing countries, in particular China, India and other fast-growing economies, could account for 49% of the world primary energy demand up to 2030.[43] But it should always be noted that developing countries collective will have almost 85% of the world's population. Hence, assuming the policy as usual scenario, by 2030 85% of the world's population (those living in developing countries) will share 49% of global primary energy demand while 15% (those living in developed countries) will share 51% of global primary energy demand. Energy demand in developing countries is growing at a very fast rate and the fuel supply capacity will very likely be predominantly fulfilled by traditional sources as coal and oil.

45. In 2005, China's primary energy consumption was 1.6 Billion Tons of Oil Equivalent (GtO-eq), 62% more than in 2000, seven times more than in 1970. Ninety three percent of this consumption was shared by hydrocarbons (1.5 GtO-eq), with 69% from coal (1.1 GtO-eq)[44]. Considering carbon dioxide emissions from fossil fuel combustion, in 2005 China contributed about 18.9% of world global carbon dioxide emissions, remaining nonetheless well below developed countries in terms of emissions per capita (4.07 tCo2 against the US's 20.14 tCo2)[45] [46].

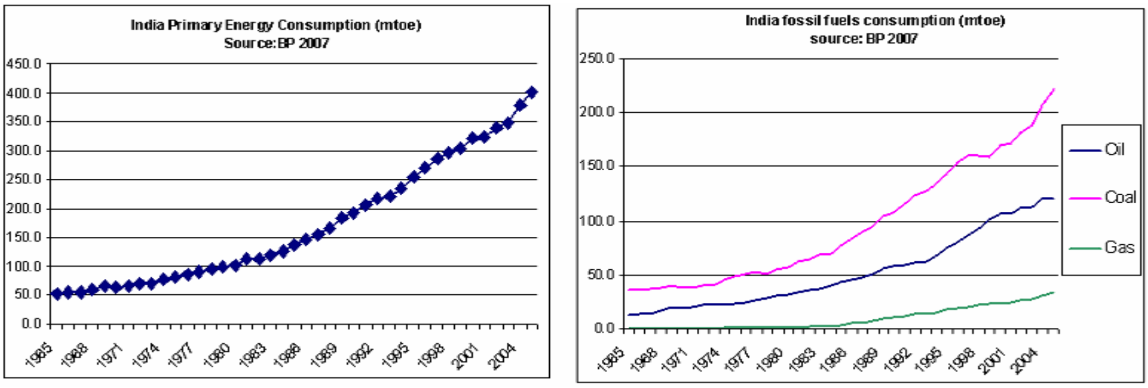
[42] Cf. UN Millennium Project Task Force, http://www.unmillenniumproject.org/reports/reports2.htm
[43] IEA, *World Energy Outlook 2005*, OCDE, Paris: p. 79.
[44] Source : BP Statistical Review 2007
[45] Source: EIA, *International Energy Annual 2005*.
[46] China's main carbon dioxide emission increment came from the cement production, strictly linked with its increasing demographic trend and urbanization, contributing to about the 4% of total CO2 emissions in 2006. For further information, please consult http://www.mnp.nl/en/dossiers/Climatechange/moreinfo/Chinanowno1inCO2emissionsUSAinsecondposition.html

Figure 8: China primary energy consumption and fossil fuel consumption (Mto-eq). Source: BP, *Statistical Review of World Energy*, 2007.



46. India shows a very similar path. The fossil fuels consumption was 3.8 GtO-eq in 2005 (32% oil, 59% coal, 9% gas) contributing globally to the 93% of the primary Indian energy consumption (4.0 GtO-eq)[47] and is expected to grow during the next decades. India's emissions were 1.165,72 GtCo2 but only 1.07 tCo2 on a per capita basis.

Figure 9: India primary energy consumption and fossil fuel consumption (Mto-eq). Source: BP, *Statistical Review of World Energy*, 2007.



47. Between 1990 and 2005, China has been the third main emitter on a national aggregate basis after the US and EU27; India emitted the same quantity of GHGs as Germany ad more than many other EU27 countries. The Third Working Group of IPCC states in its *Fourth Assessment Report* that if current development paths were to be maintained throughout the next decades, GHG emissions are expected to grow between 2000 and 2030 by 25 to 90% of actual level, which means between 9.7 and 36.7 GtCO2-eq more emissions and concentrations in the atmosphere. In particular, the non-Annex I countries will contribute to a large share of such increment for an

[47] Source: BP Statistical Review 2007. Data on non-Annex I countries are available at http://unfccc.int/resource/docs/2005/sbi/eng/18a02.pdf.

amount between 2/3 and ¾, even if their emission/per capita levels are projected to remain lower than those in Annex I because of their demographic size[48].

48. Because of the need for developing countries to increase energy use as a consequence of their first and overriding objective of economic and social development and poverty eradication, the focus of developing countries' contribution to addressing the problem of climate change must be on more effective climate adaptation. This complements the focus that must be given in developed countries to effectively mitigate GHG emissions in accordance with their commitments under the UN Framework Convention on Climate Change and the Kyoto Protocol. Realistically, with low per capita GHG emissions levels, the extent to which developing countries can undertake GHG emissions reductions whether on a national or per capita level is limited by the extent to which they would actually require increasing energy use as a result of their chosen development pathway. Hence, the most appropriate contribution for developing countries to addressing the climate challenge is to seek to lower the rate of emissions increases associated with development by embarking on low-carbon development pathways and, corollarily, prioritizing the use of renewable energy sources rather than fossil fuels.

Figure 50: Global CO2 emissions. Source: IEA Statistics [49].

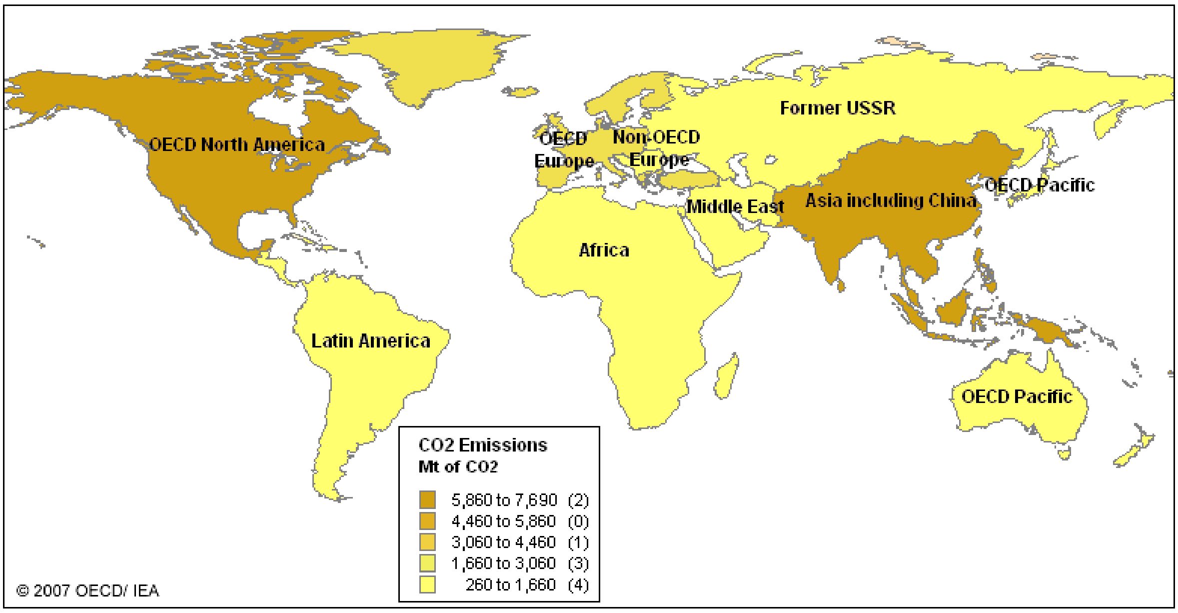
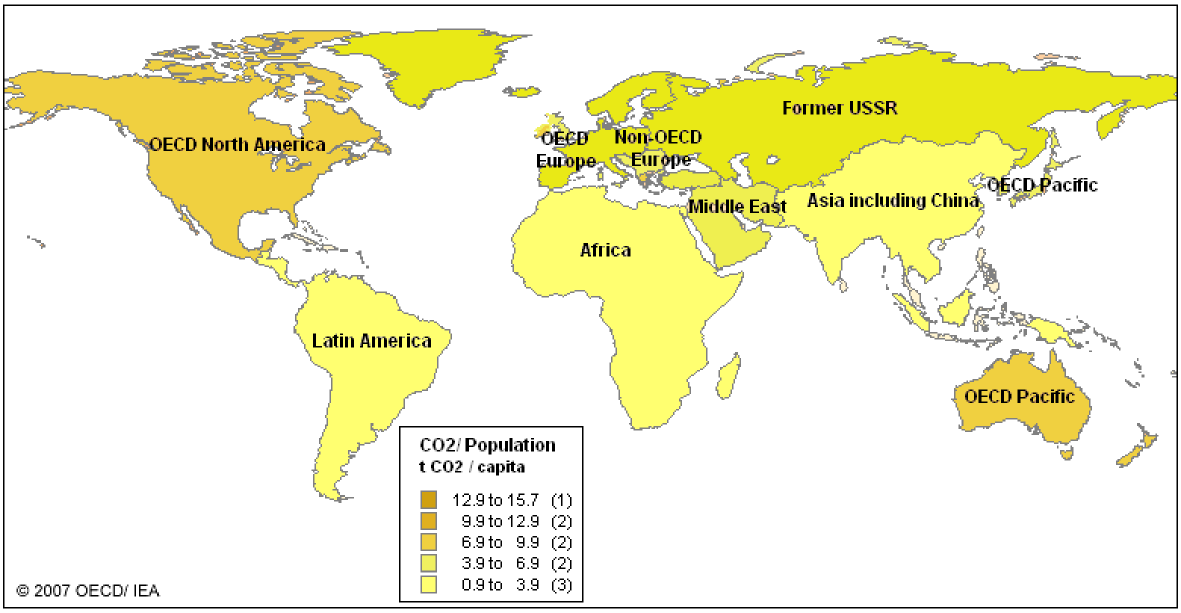


Figure 61: CO2 emissions per capita. Source: IEA Statistics[50].

[48] Cf. IPCC, WG III contribution to the Fourth Assessment Report, 1.3, 3.2.
[49] http://www.iea.org/Textbase/country/maps/world/co2.htm



4 Adapting to climate change with off-grid renewable energies

49. The development of developing countries remains the primary challenge facing the global community. Poverty eradication remains the core issue of international development agenda. For developing countries, economic and social development and poverty eradication cannot be achieved in the absence of adequate energy resources. In this regard, progress has been made in many countries for enhancing the development of the renewable energy sector, especially in fast-growing nations. According to *REN21*, currently developing countries share more than 40% of global existing renewable power capacity, 70% of existing solar hot water capacity and 45% of biofuels production[51]. China is first in the top five countries for existing renewable power capacity, small hydro and solar hot water; India is fifth in total renewable power capacity and fourth in wind power capacity; Brazil is second in biomass power and fifth in small hydropower; Philippines is second in geothermal, followed by Mexico, and third in biomass power; Turkey is second in solar hot water capacity[52]. During the last decades, China has worked hard to develop an autonomous and local renewable energy equipment industry, in particular in hydropower, solar and geothermal, becoming also an important exporter of such technologies. India's government has also actively financed its domestic renewable energy sector, in particular wind power and other alternative sources currently contributing to the 5% of generation capacity. The third fats-growing country, Brazil, became a world leader in renewable energies thanks to his long tradition in the bio-ethanol industry[53]. Developing countries, especially fast

[50] http://www.iea.org/Textbase/country/maps/world/co2_pop.htm
[51] See REN21, 2007, "Renewable 2007 Global Status Report", Washington DC. Full text available at http://www.ren21.net/pdf/RE2007_Global_Status_Report.pdf
[52] Ibid.: p.8. See also UNEP, 2007, "Global Trends and Sustainable Energy Investment 2007". The report is available at http://www.unep.org/pdf/SEFI_report-GlobalTrendsInSustainableEnergyInverstment07.pdf
[53] Ibid.: p.43-48.

growing developing countries, should persist in their effort and expand the share of renewable energies in their energy mix.

50. However, such statistical data do not give the full picture in terms of real impacts of renewable technologies on development and adaptation capacity in developing countries. In fact, the suitability of a particular technology, especially energy technologies, depends chiefly on the scale, on the need being met and on the context of need[54]. Energy poverty should be measured in terms of marginalization and inaccessibility to grid-connected energy services more than in terms of total national power generation. Thus, public energy policies should orient its efforts for a more equitable distribution of energy services to enable poor communities to benefit from them. In this regard, the high capital cost and the long time it needs to extend centralized energy grids to currently off-grid communities often make it a cost-ineffective option for many developing countries. In this sense, then, decentralized and off-grid renewable energy technologies like solar photovoltaic, small and micro hydropower, biogas digesters and gasifiers, small wind turbines, and biofuels from non-food crop sources could become viable alternatives to enabling a fair access to renewable energy supply for off-grid communities and thereby enhance the climate adaptation capacities of the poorest parts of developing countries.

51. Decentralized Renewable Energy Technologies (DRET) are very cost-effective and efficient solutions to the problem of social and economic development[55]. In fact, DRETs provide to a large part of human daily energy needs as heating, lightening, power generation, irrigation and electricity, as we can see on the table below.

Table 2: Common existing applications of Decentralized Renewable Energy Technologies. Source: REN21, *Energy for Development*, 2005.

Common existing applications of renewable off-grid energies	
Cooking	• Biomass direct combustion • Biogas from small scale digesters • Solar cookers
Lighting and other small electric needs	• Small hydropower • Biogas from small digesters • Small biomass gasifiers and gas engines • Wind turbines • Solar-home systems

[54] Cf. REN21, 2007, op. cit., p. 12.
[55] Cf. VENEMA, H. D., and M. CISSE, 2004, *Seeing the Light. Adapting to climate change with decentralizes renewable energy in developing countries*, Climate Change Knowledge Network, Winnipeg (Canada), International Institute for Sustainable Development; http://www.cckn.net/pdf/seeing_the_light_dre.pdf.

Power generation	• Small hydro and electric motors • Biomass power generation • Biomass gasification
Water pumping for home use and irrigation	• Mechanical wind pumps • Electricity from hydropower • Solar PV pumps
Heating and cooling	• Biomass combustion • Biogas combustion • Solar crop dryers • Solar water heaters • Cooling through small electricity systems

52. Other relevant elements to be mentioned are:

- DRETs impact positively on human development without increasing global GHG emissions;
- By addressing multiple development priorities, DRETs are an excellent solution in a multiple stress context, which is one of the main limits to the implementation of adaptation policies;
- Even small increases in energy supply represent a huge improvement for human development, making DRET's investments considerably cost-effective.

4.1 Renewable energies' positive impacts on adaptation capacity

53. By the enhancement of human development, DRETs impact positively on adaptation capacity at the community level[56]. Off-grid renewable energy reduces exposure by:

- A better management of biodiversity and ecosystems: improved agricultural production, better administration of water for irrigation, and enhancement in post-harvest processing can severely reduce pressure on soil and decrease deforestation;
- Ensuring and enlarging access to safe water: electricity can be used for pumping deep ground-water through wells;
- Biogas and improved biomass use provide a safer renewable fuel for cooking and consequently reduce exposure to indoor pollution and toxic by-products

[56] VENEMA, H. D., and M. CISSE, op. cit.: pp.17-21. See also REN21, 2005, op. cit. For more information on the economic potential of off-grid renewable energy, please see the website of the World Alliance for Decentralized Energy (WADE), http://www.localpower.org/

of combustion. This is particularly important for women's and children's health;

- Bio-energy may drastically reduce natural disasters such as droughts and floods. In fact, lower deforestation helps soils to improve their water drainage;
- Renewable energy creates more energy independence, in particular from fossil fuels price volatility and unpredictability, and may mitigate resource-based conflicts.

54. Decentralized renewable energy services impact positively on decreasing vulnerability to climate hazards by improving development prospects and adaptation capacity:

- A safer environment and an enhanced resource management increase food availability and quality and may reduce extreme hunger; more electricity supply permits more economic activity, more productivity, enhanced livelihood and better revenue opportunities, thereby reducing poverty;
- Better energy access promotes education by shrinking the labor burden on mothers and children, particularly young girls and electricity services may improve scholastic services; a by effect may be better gender equality and a women empowerment;
- Better life conditions reduces child mortality and improves health;
- Sterilization and refrigeration powered by off-grid renewables improves health services and reduces the probability of HIV/AIDS infections;
- Energy consumption is one of the core elements of the demographic pressure on resources. Off-grid renewable energy services and technologies receive their energy input directly from existing local energy flows and natural processes turning them into energy services to meet the need of individuals and communities. This factor contributes to maintain a safer environment.

55. To meet adaptation needs in developing countries at the local level, policies should focus on a community-oriented approach leading to a well-distributed and diversified renewable energy mix – i.e. through an enhanced off-grid renewable energy technologies allocation policy.

4.2 Off-grid renewable energies' impacts on GHG emissions reductions

56. The long-term goal of climate change policy should be to modify longer-term trends in anthropogenic emissions by changing production and consumption patterns through a shift from a carbon-intensive toward a low-carbon or de-carbonized economy. This applies especially to developed countries. The choices made during the next 10 years are fundamental in this sense and will affect positively or negatively the GHG future emission path and consequently the magnitude of expected climate change. The IPCC confirms in its last emission scenario that if humanity wants to maintain future global warming under the +2ºC benchmark, GHG atmospheric concentration should not exceed the limit of 550 ppm. According to the emissions data from the UNFCCC secretariat, energy activities are by far the most important GHG emitters. For developing countries a similar

dominance is estimated to be likely to increase during the next years, particularly in fast-growing nations[57]. Therefore, there is an urgent necessity to find resources and concentrate investments into low-carbon renewable energies to boost development, particularly in fast-growing nations like China, India and Brazil where energy demand is growing faster than elsewhere.

57. Off-grid renewable energy technologies' potential in terms of promoting development and adaptation on the community level, in particular for developing countries and rural and suburban areas, was discussed above. In addition, off-grid renewable energy technologies are environmentally friendly and excellent low- or no-emission alternatives. For that reason, the implementation of off-grid renewable energy technologies would play an important role in decreasing the rate of increase of developing countries' future GHG emissions. A development path that includes a large share of off-grid renewable energy technologies could contribute at the same time to the improvement of livelihoods, to the enhancement of adaptation and to the crucial goal of anthropogenic GHG emissions reduction. This would represent a more sustainable development pathway for developing countries with emphasis on the introduction of clean and resource-efficient technologies, social and environmental sustainability and improved social equity.

4.3 The problem of energy supply continuity

58. The principal limit of renewable energies is that supply continuity is not always assured. Fossil fuels provide a high degree of flexibility in supply that can meet demand variability. But this is often not possible with renewable energies since most renewable energy sources receive their input directly from natural flows which are "naturally" discontinuous. They often depend on seasonal irregularities, weather conditions, day and night alternation and so on. These irregularities in supply may be seriously deleterious when energy supply must meet peaks in demand, especially in an energy poor context.

59. Facing these irregularities means firstly a huge effort in recognizing the local specificities in terms of ecosystem services. A local based approach permits a better appreciation of potentialities in each area in terms of energy inputs and allow for a more rationale allocation of technologies. In fact, each different local situation might need to be linked to a specific and best adapted technology portfolio. Differentiating clean energy sources is the only way to promote the flexibility needed to afford supply irregularities and peaks in demand, and therefore avoid deleterious energy cuts.

60. In the medium term, efforts should be made to enlarge the grid-connected energy network so that off-grid and grid-connected supply turn out to be complementary. Within this complementarity, a certain quantity of traditional fuels could be tolerated but only as exceptional resort. Hydropower, whose importance has grown in many countries during the last decades, could also play an important role in responding to gaps between supply and demand although more research will

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[57] Please see UNFCCC, *Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention*, (FCCC/SBI/2005/18/Ad.2): p.9; available at http://unfccc.int/resource/docs/2005/sbi/eng/18a02.pdf.

need to be made into reducing the ecological footprint in particular of large hydropower projects.

61. On the other hand, according to the World Alliance for Decentralized Energy (WADE), a more dispersed electricity and energy generation service infrastructure (which would be the case for most renewable energies) reduces local vulnerability to blackouts and therefore may be more more reliable[58]. Undoubtedly, incremental on-site energy production would render the community less vulnerable to increasing energy prices due to international oil market fluctuations. Small, soft and decentralized energy technologies could also be more containable and manageable instead of huge and centralized energy plants, giving a large autonomy to local communities and the real possibility of a true alternative development path. Energy source differentiation and on-grid/off-grid complementarity are the two chief principles for a reliable and decentralized renewable energy-based infrastructure.

4.4 DRETs and energy efficiency

62. The debate around energy efficiency emerged during the 1970s after the oil embargo of 1973, when several countries began to implement energy-efficiency measure in response to the sudden growth of oil prices. Today, energy efficiency plays a fundamental role in mitigating GHG emissions. In fact, the improvement of energy efficiency is often seen as the most cost-effective means in the short-term – i.e. low-hanging fruit - to implement GHG emissions mitigation policies.

63. The largest part of energy is normally wasted because of the heat output associated with production (combustion, friction and other phenomena linked to industrial processes), transportation, industrial and commercial use, and end-use. Recovering this energy would improve dramatically the efficiency of energy transformation in mechanical work.

64. Centralized power plants are understandably less efficient because of: a) a higher difficulty in heat recuperation; b) a higher number of energy transformations (like fuel/electricity/heat); and c) the important losses that occurs during the transport of energy. These losses could drastically be reduced if energy is produced where it would be consumed. Therefore, decentralized energy generation might reduce by several times energy losses and augment sensibly efficiency trough recuperation and multiple uses.

4.5 Costs and benefits evaluation

65. Despite the positive impacts both in terms of adaptation and emissions reduction that DRETs may have in addressing climate change, most of the time renewable energies are perceived by policy makers and end users as expensive and cost-ineffective compared to fossil fuel energy sources. In reality, the capital cost of these technologies may be high on the short term, but in the long run, these solutions are truly cost-effective because of the very low operating costs through avoided fuel expenses, low externalities and a number of co-benefits.

66. Therefore, the positive impacts of renewable energies should be valued by policy-makers on a life-cycle basis, taking into account not only actual costs but also

[58] Cf. WADE, see http://www.localpower.org/ben_reliability.html.

future costs as well as social costs, environmental costs and other externalities which are normally not included in the traditional economic cost/benefit evaluation, co-benefits like avoided health expenditures, reduced energy import dependence, reduces burden on foreign exchange, internal capacity-building, improved education and increased economic activities. In other terms, the renewable energy's potential contribution to a broader definition of development is particularly important and should be considered as important as their strictly economic potential.

67. Climate change adaptation will have synergistic impacts on developing countries' development policies. To support renewable energy technologies in the long-term policy-makers need to integrate them into the non-energy, non-climate and cross-sector related issues through an institutional arrangement which takes in account all renewable energies' positive impacts, particularly in terms of social and environmental costs.

5 Conclusion: Policy Measures to Implement Decentralized Renewable Energy Technologies for Climate Adaptation

68. Promoting, facilitating and financing the transfer of and access to environmentally sound technologies and know-how together with supporting endogenous capacities and technologies is a core climate treaty obligation of developed countries under Art. 4.5 of the UNFCCC. In 2001 the 7th Conference of the Parties of the UNFCCC (COP-7), held in Marrakesh, reached the agreement known as the *Marrakesh Accord* where several point were clarified concerning Art. 4.5 of the Convention and developed an implementation framework around five main themes[59]:

- *Technology assessments* to identify and analyze country-specific technology needs;
- *Technology information* to enhance the flow of information on environmentally sound technologies and current R&D;
- *Enabling environment* to create and maintain a macroeconomic environment to support development of environmentally sound technologies;
- *Capacity building* to develop and strengthen existing scientific and technical skills, capabilities and institutions;
- *Mechanisms for technology transfer* to facilitate and promote financial, institutional and methodological activities to enhance coordination between stakeholders and engage them in cooperative efforts to implement UNFCCC Art. 4.5.

5.1 Technology assessment

69. Countries need to identify and determine their specific technology priorities and needs for mitigation and adaptation to climate change and reflect them in their

[59] See COP7, *Marrakesh Accord*, "Framework for meaningful and effective actions to enhance the implementation of article 4, paragraph 5, of the Convention, available at http://unfccc.int/cop7/documents/accords_draft.pdf.

national communications. Developing countries will be particularly affected by climate change because of their greater vulnerability. For that reason, technology assessments should be principally focused on adaptation needs in developing countries that would be consistent with developing countries' development priorities and supportive of a shift to low-carbon sustainable development pathways.

70. Focusing on addressing energy poverty is extremely important and should be highlighted as a priority. In fact, energy poverty is a cross-sector issue and should be integrated into a broad-based sustainable development agenda. To reach both an improvement of basic energy needs that enhances adaptation and the stabilization of GHG future emissions, energy needs should be met through renewable energy technologies. Therefore, energy poverty alleviation and renewable energy technologies development and diffusion need to be placed at the core of any technology assessment to implement UNFCCC Art. 4.5.

71. To meet the energy needs of the poor and the marginalized, a local-oriented approach to develop off-grid renewable energy technologies consistent with national development policy and planning is needed. Thus, any technology assessment should be based on a local-oriented approach so that the local needs, specificities and potentialities are emphasized through off-grid and delocalized technological solutions.

5.2 Technology information

72. Technology information defines the means to make possible the share of environmentally sound technology knowledge and goods between stakeholders. Technology information should be accessible to all stakeholders through databases, Internet and other information sources and networks currently available or likely to be developed.

73. Access to technology information needs to be free and equal for all stakeholders, based on the principle of the open source. Therefore, intellectual property rights are supposed to be subject to more flexible property regimes than those expressed by corporations and should not be based on commercial purposes to allow stakeholders, in particular developing countries, to benefit and actively participate to the building of such knowledge and know-how.

74. Technology information should not be a one-way flow from North to South. Developing countries could and are taking the lead in exploring and proposing alternative and low carbon-intensive development pathways based on their own experiences, traditions and knowledge. This means that the efforts of developing countries to undertake their own researches on innovative renewable technologies and share their knowledge with both developing and developed countries should be promoted and supported.

75. Many developing countries like China and Brazil have become during the last years leaders in R&D and implementation of renewable energy technologies. Improved levels of South-South cooperation with respect to climate technology would be an important component in the sharing of technology information.

5.3 Enabling environment

76. The macroeconomic environment in which technology development, transfer, and deployment take place is of crucial importance in terms of promoting the development of clean energy technologies and improving the effectiveness of the technology sharing between stakeholders and the development of such technologies within countries.

77. Nationally appropriate policies and regulatory frameworks therefore need to be put in place by governments in order to lower the costs of and to promote the use of renewable technologies and sustain technology transfer. There are essentially three kinds of barriers to cost-effective renewable energy technology diffusion:

- *Costs and pricing barriers* that make stronger the differences between renewable and conventional energies. The exclusion of the full costs of externalities and of the entire range of ancillary benefits make renewable energies generally less competitive than conventional, therefore policy should manage to include de full costs and benefits into the pricing structure.
- *Fossil fuel subsidies* are a further aspect of market distortion. Currently, subsidies to traditional fossil fuels are conservatively estimated to be $ 235 billion per year, four times more than the global cost of natural disaster recovery during the last year ($ 60 billion) [60]. The elimination of fossil fuel subsidies and allocating those budgets to the poor who need income support or to generate employment opportunities may help them to have more sustainable access to clean technologies. However, in many developing countries in which such subsidies are provided, any reduction or removal of such subsidies must be carefully calibrated and tailored to suit national circumstances;
- *Legal and regulatory barriers* could impose rules that discriminate against the market entry of renewable energy and facilitate fossil fuels persistence. Transparency is a further crucial factor in making attractive clean technology to national markets. Governments should implement regulatory interventions like standards, labeling and norms promoting clean technologies; reducing transaction costs and sustaining transparent information dissemination may be crucial to encourage supply and demand for renewable energy technologies.

78. Delivering renewable energy to the poor requires public policy approaches to establish the environment that enables such technologies to develop and be diffused effectively and cost-efficiently. Market-based approaches in a developing country context might make it difficult for the poor to access such technologies. Governmental mechanisms might hence be required to serve as the conduit through which such technologies are made available to the poor.

79. The Millennium Task Force on Poverty estimates that public sector funding needed to promote the spread of renewable energy technologies to the poor will

[60] Cf. the New Economic Foundation (NEF) 2007 report *The Price of Power*, cited by BBC environment correspondent Alex Kirbi in his article *Fossil fuel subsidies 'must end'*; see http://news.bbc.co.uk/2/hi/science/nature/3818995.stm.

amount to around $ 14.3 billion per year, that is $20 per capita[61], a relatively small amount if compared with the current annual investments in traditional energy infrastructures ($ 200 billion) and the annual cost of conventional fuels consumption for poor people ($ 20 billion)[62]. Developing an off-grid renewable energy infrastructure is hence much more cost-effective than investing in traditional grid-connected energies.

5.4 Capacity building

80. Capacity building refers to the sustainment and reinforcement of existing scientific and technical skills, capabilities and institutions, and to the development of new skills to handle with new climate friendly technologies. Country-driven endogenous capacity building is crucial to the dissemination, application and development of clean and climate-friendly technologies[63].

81. The development of a renewable energy technology infrastructure in developing countries would require more participatory approaches to strengthening domestic capabilities and putting in place local solutions at all stages. This would also require the provision of technical and scientific assistance, investment, information dissemination and education[64]. Endogenous capacity to innovate, acquire and adapt technologies to local circumstances need to be built up in order to cope with unforeseen climate change impacts. Involving NGOs and creating private/private, public/private and public/public partnerships could improve the effectiveness of renewable energy projects and facilitate South-South and South-North flows of knowledge and technology in renewable energy.

5.5 Implementing technology transfer under the UNFCCC

82. The UNFCCC represents the international legal framework supporting developing countries' efforts to address climate change and receive international support with finance and technology[65]. The *Marrakech Accord* identifies three main mechanisms to facilitate and support technology transfer: a) enhancement of stakeholders' coordination; b) engagement of cooperative efforts to accelerate the diffusion of climate friendly technologies, know-how between stakeholders; and c) development of projects and programs to support such ends. But the political commitment reflected in the UNFCCC, the Marrakech Accord, and subsequent decisions of the COP with respect to the need to enhance technology transfer to developing countries to support their implementation of UNFCCC commitments, including with respect to adaptation, has not yet been fully implemented.

83. The question is one of effectiveness in the implementation of the UNFCCC's technology transfer provisions. To improve the technology transfer mechanism under the UNFCCC, the following suggestions might be in order:

[61] Cf. MODI, V., 2004, op. cit., note 5, p.57.
[62] Cf. IEA, 2004, op. cit., p.30.
[63] Cf. IPCC, *Methodological and Technological Issues in Technology Transfer*, available at http://www.ipcc.ch/ipccreports/sres/tectran/index.htm.
[64] Ibid.
[65] Cf. UNFCCC, art. 4.1(h) ; art.4.3 ; art.4.4 ; art.4.5 ; art.4.7.

- Establishing measurable review and assessment parameters for the conduct of technology transfer through the work of the UNFCCC Subsidiary Body on Implementation, including consideration of the information required to be provided by developed Parties under Art. 12.3 (national communications) with respect to "details of measures taken in accordance with Article 4, paragraphs … 5" and the work of the Consultative Group of Experts on reviewing Annex I national communications;

- Discussions relating to technology transfer need to be further complemented by concrete, practical, results-oriented actions in specific sectors and programs. In this context, reviewing and assessing the implementation of Art. 4.5 should also include looking at the extent to which current mechanisms and policy approaches, including financing mechanisms, are actually effective in terms of promoting and supporting actual, on-the-ground, development and transfers of technology in implementation of Art. 4.5;

- Of particular importance to developing countries would be a review and assessment of the extent to which technologies that are developed and/or transferred in implementation of Art. 4.5 are adapted or appropriate to the national environmental, social, and economic contexts of the recipient Party. This should include an identification of the opportunities for and barriers to (including market and policy conditions) such development and transfer of nationally- or locally-appropriate technologies;

- The review and assessment of the effectiveness of the implementation of Art. 4. 1(c) of the UNFCCC, which provide for promotion and cooperation of all Parties "in the development, application and diffusion, including transfer, of technologies, practices and processes" relating mainly to mitigation in all relevant sectors, clearly should depend on the effective implementation of Art. 4.5 of the Convention; and

- Any terms of reference for the assessment and review of the implementation of Art. 4.5 should include ways and means through which the specific needs and concerns of developing country Parties, listed in Art. 4.8, arising from the adverse effects of climate change and/or the impact of the implementation of response measures, and those of least-developed countries were given full consideration (with respect to Art. 4.8) and taken fully into account, with respect to Art. 4.9.

- Finally, the transfer of technology from developed to developing countries, especially those needed to support adaptation and mitigation measures consistent with the development needs of developing countries, must be measurable, reportable and verifiable, and be covered by effective enforcement mechanisms to ensure full compliance with the technology transfer provisions under the UNFCCC.

BIBLIOGRAPHY

ADGER, W. N., 2006, "Vulnerability", *Global Environmental Change*, 16 (3):268-281

BAER, T et al., *The right to Development in a Climate Constrained World. The greenhouse Development Rights Framework*, with the support of Christian Aid and the Heinrich-Böll-Foundation

BLAIKIE, P.M. et al., 1994, *At Risk: Natural Hazards, People's Vulnerability, and Disasters*, London, Routledge

BOHLE, H. G., T. E. DOWNING, and M. J. WATTS, 1994, "Climate change and social vulnerability: the sociology and geography of food insecurity", *Global Environmental Change* 4:37-48

BOLIN, B., et al., eds., *The Greenhouse Effect, Climate Change, and Ecosystems*, SCOPE 29, Chichester, Wiley, 1986, 541 p

BP, *Statistical Review of World Energy*, 2007

BUYS, P. et al., *Country Stakes in Climate Change Negotiations: Two Dimensions of Vulnerability*, Policy Research Paper 4300, The World Bank Development Research Group, Sustainable Development Team, August 2007

EIA, *International Energy Annual 2005*

HANSEN, J., "A slippery slope: how much global warming constitutes a dangerous anthropogenic interference?", *Climate Change*, 2005, 68(1-2), pp. 269-279)

HANSEN, J., *Can we defuse the global warming time bomb?*, NASA Goddard Institute for Space Studies, and Columbia University Earth Institute, New York, 2003

HANSEN, J., et al., "Earth's energy imbalance: confirmation and implications", *Science*, 2005

IEA, *World Energy Outlook 2005*, Paris, OECD

IEA, *World Energy Outlook 2004*, Paris, OECD

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), 2007, *Climate Change 2007: The Physical Science Basis. Contribution of the Working Group I to the Fourth Assessment report of the Intergovernmental Panel on Climate Change* ed. by S. SALOMON, D. QIN, M. MANNING, M. MARQUIS, K. AVERYT, M. A. B. TIGNOR, H. LEROY MILLER JR., Z. CHEN, Cambridge, United Kingdom: Cambridge University Press.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), 2007, *Climate Change 2007: Impacts, Adaptation and Vulnerability.. Contribution of the Working Group II to the Fourth Assessment report of the Intergovernmental Panel on Climate Change*, ed. by M. PERRY, O. CENZIANI, J. PALUTIKOF, P. VAN DER LINDEN, C. HANSON, Cambridge, United Kingdom: Cambridge University Press.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), 2007, *Climate Change 2007: Mitigation of Climate Change. Contribution of the Working Group III to the Fourth Assessment report of the Intergovernmental Panel on Climate Change*, ed. by B. METZ, O. R. DAVIDSON, P. R. BOSH, R. DAVE, L. A. MEYER, Cambridge, United Kingdom: Cambridge University Press.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), 2007, *Special Report on Emission Scenarios*, ed. by N. NAKICENOVIC and R. SWART, Cambridge, United Kingdom: Cambridge University Press.

LEVITUS, S., et al., "Warming of the world Oceans", Science, 287, 2225, 2000

MODI, V., 2004, *Energy Services for the Poor*, paper commissioned for the Millennium Project Task Force, New York

NEW ECONOMIC FOUNDATION (NEF), *The Price of Power*, 2007 report

NORDHAUSE, W., 2006, "Geography and macroeconomics: new data and new findings", PNAS, 103(10): 3510-3517

O'BRIEN, P., and R. LEICHENKO, 2000, "Double exposure: assessing the impacts of climate change within the context of economic globalization", *Global Environmental Change*, 10 (3):221-232

QUARANTELLI, E. L., 1989, "Conceptualizing disasters from a sociological perspective", International Journal of Mass Emergencies and Disasters, 7 (3):243-251

REN21, 2007, *Renewable 2007 Global Status Report*", Washington DC, Worldwatch Institute.

REN21, 2006, *Changing Climates. The role of renewable energies in a carbon-constrained world*, Washington, DC, Worldwatch Institute.

REN21, 2005, *Energy for Development. The potential role of renewable energies in meeting the MDGs*, Washington, DC, Worldwatch Institute

SCHERAGA, J. D., and A. E. GRAMBSCH, "Risks, opportunities and adaptation to climate change", *Climate Research*, 10:85, 1998, pp. 85-95

STERN, N., 2006, *The Economics of Climate Change*, Cambridge, United Kingdom: Cambridge University Press.

TITUS, J. G., "Strategies for adapting to the greenhouse effect", *The journal of the American Planning Associations*, Summer: 311-323 (1990)

UNFCCC, Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention, (FCCC/SBI/2005/18/Ad.2)

U.K. Department for International Development, 2002, *Energy for the Poor: Underpinning the Millennium Development Goals*, London

UNEP, *Global Trends in Sustainable Energy Investments*, 2007.

VENEMA, H. D., and M. CISSE, 2004, *Seeing the Light. Adapting to climate change with decentralizes renewable energy in developing countries*, Climate Change Knowledge Network, Winnipeg (Canada), International Institute for Sustainable Development

WORLD BANK, 2006, *The little Green Data Book*, Washington DC

WORLD, BANK, *Clean Energy and Development: toward an Investment Framework*, DC2006-0002, April 5, 2006, Washington DC

READERSHIP SURVEY QUESTIONNAIRE

South Centre Analytical Note

THE ROLE OF DECENTRALIZED RENEWABLE ENERGY TECHNOLOGIES IN IMPROVING RESILIENCE TO CLIMATE CHANGE IN DEVELOPING COUNTRIES

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