TURNING UP THE HEAT WHILE LOWERING THE TEMPERATURE

Editor's note: Please note that the views expressed in this paper are those of the author and do not necessarily reflect the position of the UNFCCC secretariat

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EXECUTIVE SUMMARY

- Africa's essential problem is to break out of a vicious cycle of worsening underdevelopment. One hundred years of global development has established that for Africa to succeed, it must substantially increase both the quantum and quality of energy use in its social and economic activities.

- The technologies that present Africa with its best chances also turn out to be the major sources of greenhouse gas emissions. At the same time, many of the 'climate-friendly' technologies which can facilitate Africa's progress are in the hands of the developed countries, the biggest emitters of greenhouse gases.

- The challenge is to find mechanisms which will ensure that Africa does not just know about climate-friendly technologies, but is also able to get hold of and use them effectively to facilitate the resolution of its key developmental problems. This is captured by two broad questions: **1) "What technologies will enable Africa to develop as rapidly as it needs with the least GHG emissions?" ; and 2) "How can Africa's access to these technologies be facilitated?"**

- Climate change introduces the latest international dimension that Africa must take into account in its imperative search for solutions that will enable it to improve the quality of life for its people in a sustained manner. However, the truly global effects of climate change also present a unique opportunity for a meaningful and effective international approach to dealing with the twin problems of reducing emissions of greenhouse gases without putting the brakes on Africa's need to accelerate its development, **i.e. to lower GLOBAL temperature while turning up Africa's DEVELOPMENTAL heat**

- Energy holds the key to the successful solution of Africa's development problems. It is imperative that the continent raises its per capita consumption of energy by a substantial factor. However, Africa needs to shift from its dependency on low-quality and unsustainable biomass to Environmentally Sound Technologies(EST). Africa's energy transition presents several opportunities to introduce technological solutions which will facilitate sustained development with minimal greenhouse gas emissions.

- Biomass accounts for between 60-70% of Africa's current energy supply. However, it is characterized by very low energy values, inefficient conversion and emission of greenhouse gases. Africa's biomass supply base is already badly eroded, and though biomass technologies hold very promising prospects as ESTs to address both energy and climate change issues, Africa has to shift to other energy supply sources, in order to allow a breathing space for reforestation and restoration of its vegetative and natural forest cover.

- Electricity is rapidly assuming the role of the dominant form in which energy is converted for various end uses. Even though Africa's current consumption of electricity is low, in line with global trends, it should be expected to take over from biomass and fossil fuels as the dominant secondary source which drives energy end-use technologies.

- From a purely GHG avoidance perspective, the most promising power generation technologies for Africa are: hydro-electricity, nuclear power and biomass pyrolysis and gasification. However, each has undesirable limitations which make them seem unattractive in the short to medium term scenarios.

- The built environment presents the biggest challenges as well as opportunities for transforming Africa's development. The experience of practice elsewhere suggests that the built environment is the first area for the transformation from basic to higher quality energy technologies as people move up the development ladder.

- At the most basic level, per capita energy use for cooking could be reduced by accelerating the introduction of a number of technologies which are already in use, such as: 1) improved cooking stoves; 2) switching from firewood and charcoal to kerosene; and 3) use of electric stoves. The lighting needs for the home, which is the dominant use of electricity in Africa, could be improved dramatically by switching to compact fluorescent bulbs which give better lighting for a near four-fold reduction in electricity consumption.

- There are two mature ESTs which can be applied to the built environment to meet developmental and climate change needs, namely passive solar energy and non GHG refrigerants. Passive solar energy technologies come in two basic types: 1) passive solar design and natural ventilation; and 2) photovoltaic power generation.

- Public transport has broken down in all but a few countries, replaced by very inefficient small vehicles which have clogged up most of the already over-burdened cities. In order to meet the transportation challenges of the Climate Change Convention, motor vehicles used in Africa must be cleaner (with lower tailpipe emissions) and more efficient (with greater fuel economy) and their power must be supplied from environmentally sound technologies. Unfortunately, **most vehicles in Africa are ›environmental rejects' from the developed world.**

- Industrialization holds the key to Africa's ability to break out of its vicious cycle of worsening poverty. Fortunately, industrialization is one area of massive development of mature environmentally sound technologies. From process heating systems, through to refrigeration, heat recovery systems, heating ventilation and cooling, electric motors, mineral extraction and mineral processing, very efficient end-use technologies are available to propel Africa's industrialization drive. Unfortunately, as with the other

sectors, Africa seems to be attracting 'reject technologies' which are both high energy guzzlers as well as big emitters of GHG.

- Environmentally Sound Technologies have been the focus of international cooperation efforts for almost three decades. For most of the period, conventional wisdom has been that the way forward is to facilitate the transfer of appropriate technologies from the developed to the developing countries. The prescribed role of international cooperation efforts was to facilitate the North-South transfer of whatever technologies were believed were essential to address the developmental fad of the time.

- At the heart of matter is whether we are dealing with **TECHNOLOGY TRANSFER OR ACCESS TO TECHNOLOGY**. Even though much is made of Africa's lack of capacity in various technological fields, a great many African countries are deploying and enjoying services, such as cellular telephony and digital satellite TV, that employ the latest cutting-edge technologies. There is an on-going massive transfer of near obsolete and high GHG emission-producing technologies from the North to Africa. Heating and cooling systems and vehicles with high exhaust pollution emissions, and other goods and services now banned in the North have become major features in African countries as poor people seek to make the transition from subsistence to developed status.

- The two situations bring up two fundamental questions: **1) Is Africa really not ready to take up technologies or is it rather a case of the majority not being able to get access to them?; and 2) If GHG-unfriendly technologies are already being transferred to Africa on a massive-scale, what needs to be done to substitute these with EST equivalents ?**

- One other conceptual issue which must be dealt with is that of WHAT problem is really at hand and WHEN should WHAT be done. The critical issue here is to make sure that the right solutions are applied at the right time. **"Firstly, it must be recognised that no developmental problem is an island onto itself"**; and **secondly, we must not push experimental and frontier technologies as the solutions for immediate problems.** The task at hand is to deal with Africa's key developmental challenges. We need APPLICABLE SOLUTIONS not EXPERIMENTATION.

- It is essential, nay imperative that the immediate thrust must focus on making available proven CC-friendly technologies (i.e. those that are being already applied in the North) to solve Africa's urgent and critical developmental problems, even if it is believed that larger benefits may eventually come from still experimental technologies.

- Technology transfer has got stuck in a spiral of illusions which has operated on the premise that the ultimate end is a wholesale acquisition of every conceivable capability

for indigenous manufacture of appropriate solutions. But are we after the transfer of technological capability or using technologies to effect solutions?

- The key to the effective deployment of ESTs in Africa is to establish a knowledge transfer mechanism process that facilitates the ranking of the 'what should be transferred to whom at what time' process. It is within this context that one attempts to answer the question: **"How can Africa's access to these technologies be facilitated?"**

- Africa's industrialisation programme should adopt 'leap-frogging' as its key strategic weapon. One way to overcome technological capacity barriers will be to develop sub-regional or regional industries that combine the skills and know how with viable markets to achieve synergy in both production and competitiveness.

- If ACCESS is the critical issue, then money rather than technological capability is what will decide whether 'Poor Africa' can turn the WHAT & HOW into SUSTAINABLE SOLUTIONS. This is where the Climate Change Convention and, especially the Clean Development Mechanism (CDM) under the Kyoto Protocol could be ever so useful.

- The enlightened self-interest of showing pre-emptive benevolence provides an opportunity to secure the necessary capital within a framework of two key questions: **1) Is Africa aware of the role ESTs can play to accelerate its social and economic development?; and 2) Will the North stick to its target reductions of greenhouse gas emissions?**

- The questions are for the negotiators to grapple with. This paper has simply tried to set out some ideas to facilitate the process.

I. INTRODUCTION

1. Africa's essential problem is to break out of a vicious cycle of worsening under-development. However, the technologies that present Africa with its best chances also turn out to be the major sources of greenhouse gas emissions. Therefore, for Africa to become fully committed to playing its fullest role in achieving the goals of the United Nations Framework Convention on Climate Change (UNFCCC), it must be assured that the convention facilitates the solution of its most fundamental developmental problems in a sustainable manner.

2. One hundred years of global development has established that for Africa to succeed, it must substantially increase both the quantum and quality of energy use in its social and economic activities. However, the Climate Change objective of reducing global temperatures requires that the energy technologies that Africa deploys must also be sensitive to the climate. Accommodating the two seemingly contradictory goals of reducing global temperatures and increasing energy use in Africa is the paradigm encapsulated by the title of the paper: "**Lowering the temperature while turning up the heat"**.

3. The 'oil crises' of the 1970s and 1980s brought about substantial innovation in energy technologies which provide opportunities for fostering Africa's development and contributing to the CCC objectives at the same time. However, many of the 'climate-friendly' technologies which can facilitate Africa's progress are in the hands of the developed countries, the biggest emitters of greenhouse gases. Recent experience of tackling international development problems does indicate that while applicable technological solutions have almost always been found and utilised in developed countries, Africa, which has often borne the brunt of the problems, has had very limited success in getting and effectively using the novel technologies

4. The challenge, therefore, is to find mechanisms which will ensure that Africa does not just know about climate-friendly technologies, but is also able to get hold of and use them effectively to facilitate the resolution of its key developmental problems. Thus, the principal task this paper seeks to accomplish is to establish the basis for answering two broad questions, namely: **1) "What technologies will enable Africa to develop as rapidly as it needs with the least GHG emissions ?"; and 2) "How can Africa's access to these technologies be facilitated ?"**

5. The paper proposes to address the above two questions through four (4) essential mechanisms, namely:

5.1 To identify the major challenges that Africa NEEDS to overcome in order to uplift and sustain its social and economic development

5.2 To establish the deleterious impacts that these challenges are having on Africa, with particular reference to the issues and concerns of the Climate Change Convention

5.3 To define a framework for identifying technological solutions to Africa's developmental problems which offer good prospects for minimizing, if not entirely avoiding, GHG emissions; and

5.4 To propose practical measures that will optimize the acquisition of an African capacity to effectively transfer and apply optimal CC-friendly technological solutions to achieve sustainable development.

II. CLIMATE CHANGE & THE CHALLENGES FOR AFRICA'S DEVELOPMENT

II./ 1. The challenges for Africa's development

6. Africa has been beset by serious and worsening crises for more than three decades. The continent has simply failed to come to terms with hunger, poverty, disease, illiteracy, shelter and ecological degradation. Try as it has, Africa's attempts to solve these problems have been very unsuccessful so far. Indeed, the problems have become so intrinsically linked that Africa is now said to be caught up in a **"Crisis of sustainability"**, in which solutions only seem to exacerbate the problems.

7. Africa's crisis of sustainability can be attributed largely to the continent's inability to come to terms with the dynamics between population, agriculture and energy. A rapidly growing population is putting undue pressure on increasingly fragile lands to produce inadequate food and cash crops of dwindling economic value. The demands for basic energy services for cooking & heating come from denuding more of the already fragile natural forests. The mounting pressures in the rural communities drive more and more people into a few over-crowded cities, which quickly become characterized by bad housing, poor sanitation, poor health and choked roads.

8. So far, Africa has attempted to overcome its developmental challenges by importing solutions to plug the widening gap between what is needed and what the continent

produces. This approach has meant raising convertible currency to finance the imports, requirements of which have increased with the widening gap. The financing gap is widened even more as Africa's largely primary commodities exports lose value at the same time that the imported solutions become more and more expensive.

9. The attempt to plug the ever widening financing gap creates a vicious cycle of exploitation of more marginal lands to grow more export crops and more food, cut down more trees and foliage to meet energy needs, drive people from poverty and the barrenness of rural areas to seek better life in urban areas, increase pressure on urban shelter and sanitation, and increase the use of fossil fuels and other imports, which widen the financial gap even further. Ergo, more hunger, more poverty, more illiteracy, poor health, growing inequity, which all lead to worsening under-development.

10. Increasingly, the unsustainable solutions are creating enormous problems for Africa's environment. Desertification and deforestation are getting worse by the day. Urban areas are suffocating from overflowing garbage and worsening sanitation. Choking traffic and low efficiency industrial processes are causing intolerable and dangerous levels of air pollution.

II./2. The climate change dimension

11. Climate change introduces the latest international dimension that Africa must take into account in its imperative search for solutions that will enable it to improve the quality of life for its people in a sustained manner. However, unlike earlier international development concerns, climate change brings its own peculiar but very interesting twist to the search for sustainable solutions to Africa's developmental problems. On the one hand, the technologies that offer the best hope for overcoming Africa's development challenges have been identified as the principal culprits for the emission of greenhouse gases. By the same token, the truly global effects of climate change also present a unique opportunity for a meaningful and effective international approach to dealing with the problem.

12. The major sources of greenhouse gases, namely carbon dioxide (CO_2), chlorinated fluorocarbons and nitrous oxide are all products of a developmental path that has successfully propelled the economies and lifestyles that have allowed some countries to achieve the status of being termed 'developed.' The question is: **Can and should Africa move away form the well-trodden, fossil-fuel-based paths associated with the high level of development that has been achieved by industrialized societies?** In the absence of ready, credible and cost-effective alternatives, Africa seems to have little choice but to travel down the same road that others have used so successfully.

13. However, global warming is the first truly global phenomenon that cannot be contained within 'interest group' boundaries. Its effects cannot be isolated or compartmentalized. A molecule of CO_2 released anywhere in Africa will have a climatic effect all round the world. Therefore, should Africa follow the 'successful' developmental model, it would be difficult for the targeted reductions in global temperatures, under the Framework Convention, to be achieved, no matter how successful the developed countries are in reducing their own greenhouse emissions. **Therefore, climate change offers an opportunity for the developed world to exhibit enlightened self-interest and offer "preemptive benevolence" to help Africa to overcome its challenges.** The way forward will be to foster ready access to innovative technologies which can both propel Africa's development and also minimize or eliminate emission of greenhouse gases. **It is in this respect that the Clean Development Mechanism(CDM) which has been defined in the Kyoto Protocol could be seen as a potentially powerful mechanism for the effective application of Environmentally Sound Technologies(ESTs) in Africa.**

III. ENVIRONMENTALLY SOUND TECHNOLOGIES FOR AFRICA'S DEVELOPMENT

14. The essential pre-requisites for technological solutions to satisfy Africa's prioritized development needs are that they must be able to:

1) increase the provision of basic needs for adequate food, shelter, good health, literacy and mobility;

2) facilitate the development of capacity and infrastructure to increase the value-added of its goods and services and eliminate the import/export financial gap that perpetuates and exacerbates the vicious cycle of untenable solutions;

3) provide a platform for creating and facilitating opportunities for Africa's sustained social and economic growth;

III./1. The energy imperative & the strategies for technology assessment.

15. Energy holds the key to the successful solution of Africa's development problems. It is imperative for the continent to raise its per capita consumption of energy by a substantial factor. However, in order to address the continent's own peculiar environmental problems and also take account of climate change concerns, there has to be a major transition in energy conversion and end-use technologies in Africa. The transition presents several opportunities to introduce technological solutions which will facilitate sustained development with minimal greenhouse gas emissions. Africa must shift from its present dependency on low-quality and unsustainable biomass to energy sources that are built on Environmentally Sound Technologies(EST). However, in the

short to medium term, as fossil fuels will continue to play a significant role in Africa's energy mix, it would be essential to improve their per capita value of output through massive increases in the efficiency of their transformation and use.

16. A workable strategy which will ensure Africa's successful transition to ESTs will be founded on the following five (5) paths to technology development and utilisation, namely:

1) ***Avoidance of GHGs emissions altogether:*** This entails the application of technologies that avoid the production of GHGs as by-products. In the ideal world, this is the most desirable and best scenario solution. The idea here is to achieve a desired developmental end without creating other problems which then have to be solved by GHG producing technologies. For example, incorporating passive solar architectural principles in new buildings, such as natural ventilation and natural lighting, can eliminate or drastically reduce the need for air conditioners and artificial lighting.

2) **Substitution of GHG emitting technologies:** Technologies are emerging which can substitute for GHGs to achieve the same purpose. The most obvious example is the substitution of chlorinated fluorocarbons (CFCs) with hydrofluorocarbons (HFCs) for refrigeration and air conditioning uses under the Montreal Protocol. However, it is being suggested that HFCs could be as dangerous for climate change as CFCs and this has led to the promotion of the new so-called "Greenfreeze" technology which replaces HFCs with hydrocarbons. Another option here is the direct substitution of fossil fuels with mature renewable energy technologies.

3) ***Shifting to higher productivity but lower-emission GHG technologies:*** This is a switch to a technology that delivers more useful output for the equivalent production of GHGs or achieves a desired end-use with lower emissions of GHGs. Examples are:
1) switching from charcoal and firewood to kerosene and LPG for cooking; 2) using natural gas instead of coal/petroleum products for power of electricity; 3) achieving more efficient transportation of people by switching from fossil-fueled cars to mass transit systems powered by 'clean' fuels.

4) ***Increasing the per capita output of end-use by increasing the efficiency of energy conversion and use:*** Here, the idea is to replace obsolete devices with more efficient substitutes to carry out the same

task or perform the task better with a lower input of energy. This is where the major technological developments from the energy crises of the 1970s and 1980s can be brought to bear immediately on Africa's development. Examples are: 1) the introduction of low wattage compact flourescent bulbs for lighting; 2) the use of more efficient motors in industrial and manufacturing processes; 3) the substitution of low energy consumption chips into electrical and electronic machinery and consumer products.

5) ***Introducing GHG removal technologies:*** These are technologies which can both reduce the levels of already emitted GHGs and at the same time deliver high quality energy services. For example, regenerated and sustainable forest and biomass plantations can absorb GHGs and also be substituted for fossil fuels in high tech energy supply solutions. Indeed, this is a most attractive post-transition solution for Africa as it will allow the continent to shift from fossil fuels without sacrificing efficiency and quality, and at the same time provide reliable sinks to absorb CO_2, the major GHG.

III./2. Matching technologies to needs

17. Since the pre-requisite need is to achieve a substantial increase in Africa's per capita energy use at the least damage to the climate, the SUPPLY issue must be at the fore-front of any assessment of energy technologies. However, since the desire is to use energy technologies to solve developmental problems, it is equally important for the technology assessment process to be carried out in relation to Africa's principal developmental NEEDS. Thus the question **"WHAT TECHNOLOGIES WILL ENABLE AFRICA TO DEVELOP AS RAPIDLY AS IT NEEDS WITH THE LEAST GHG EMISSIONS?"** can be answered under the following four broad headings, in order of relative developmental importance and likely impact on the GHG issues:

1. TECHNOLOGIES FOR ELECTRICITY PRODUCTION
2. TECHNOLOGIES FOR THE BUILT ENVIRONMENT
3. TECHNOLOGIES FOR TRANSPORTATION
4. TECHNOLOGIES FOR INDUSTRIALIZATION

III./3. Technologies for energy supply & conversion.

18. Biomass accounts for between 60-70% of Africa's current energy supply. However, it is characterized by very low energy values, inefficient conversion and emission of greenhouse gases. Even though there are technologies, mature and emerging, which can improve the productivity of biomass energy resources, and even help to address the greenhouse gas problems, this is not a practical proposition in the immediate to medium terms. Africa's biomass supply base is already badly eroded, and the pressure of high population growth rates, is causing further denudation. Thus, even though biomass technologies hold very promising prospects as ESTs to address both energy and climate change issues, they must be substituted with other energy supply sources, in order to allow breathing space for reforestation and restoration of African's vegetable cover .

19. Africa's energy supply options must be looked at as two distinct technologies. The first and most dominant is what I term **"centralized production with dispersed distribution technologies,"** comprising large scale power production plants and oil refineries. The second set of technologies are **"in-situ supply and end-use technologies"** where the energy supply technology is produced and applied at the immediate end-use location. For both sets of supply situations, electricity is the dominant secondary energy form that is applied to end-uses. However, to bring more rationality to the assessment process, centralized power technologies are discussed discretely, while in-situ power and secondary oil technologies are included under the four end-use categories.

III./4. Electricity: the Energy King of the future

20. Electricity is rapidly assuming the role of the dominant form in which energy is converted for various end-uses. So far, there is every indication that the influence of electricity will grow in leaps and bounds, especially with the rapid and increasing importance of telecommunications and allied electrical applications. Even though Africa's current consumption of electricity is low, in line with global trends, it should be expected to take over from biomass and fossil fuels as the dominant secondary source which drives energy end-use technologies.

21. Electricity is produced from a variety of sources. In Africa, the two main sources for electricity generation are hydro-electric power and fossil-fuel thermal power plants. Over the years, hydro-power has become the dominant electricity production system in Africa, even as it is estimated that Africa has not exploited more than 15% of its hydro-electric potential. The principal fossil-fuel used for power generation in Africa is oil, though coal is used in a few countries which have indigenous stocks. Africa's other big plus is that it is endowed with generous amounts of solar energy which can be converted directly into electricity. Mature or market-ready solar technologies are now available for power production in the form of photovoltaic arrays, micro and mini hydro plant, biomass pyrolysis, gasification equipment and wind aero-generators. Power

generation from nuclear energy is a very mature, if somewhat controversial technology, which is not used anywhere in Africa at the moment.

22. From a purely GHG avoidance perspective, the most promising power generation technologies for Africa are: hydro-electricity, nuclear power and biomass pyrolysis and gasification. However, each has undesirable limitations which make them unattractive in the short to medium term scenarios. Large dams are controversial for the serious human and environmental problems they have already created in Africa and elsewhere. Even the developed world has still not worked out how to get rid of serious safety problems associated with the operation of nuclear power stations and the management of spent fuels. Quite apart from the immediate problem of an unsustainable resource base, biomass power generation technologies are still very much in the low level or frontier stages of development.

23. It should be emphasized that the environmental problems associated with these technologies are not insurmountable nor do they lead automatically to their exclusion as viable candidates as major power generation technologies for Africa in the immediate or longer-term future. Indeed, the combination of Africa's rich endowment with hydro-power resources, coupled with the fact that it is still a continent with large expanses of unoccupied land (notwithstanding the high population growth rates), and the relative simplicity of the power generation technology does favor hydro-power to play an increasingly major role in Africa's electricity supply mix.

24. Thermal power generation will continue to be an important factor in Africa for a considerable time yet. Indeed, the short-term prognosis is for a massive increase in oil and coal-fired power stations, in many cases, acting as complements to hydro-based generation. However, this is not all gloomy news for the Climate Change agenda. Gas-fired power generation technologies are mature and in use to substitute for coal and oil. Even though natural gas is also a fossil fuel, its use for power generation offer the combined advantages of lower carbon emissions and removal of a major GHG, natural gas, better known as methane. This technology, especially useful in oil producing countries which have hitherto flared their natural gas, is being actively explored in West Africa, where a project is underway to build a regional pipeline that will make Nigeria's gas available to other West African countries for power generation and other energy conversion applications.

25. Nuclear power generation is an enigma in Africa's power supply scenario. At first sight, it should be dismissed immediately on environmental and technological capacity grounds. Nevertheless, one cannot discount the fact that in South Africa, Africa has a country with reportedly demonstrated nuclear capability, which can operate and maintain, if not construct, nuclear power plants. There is the added factor that countries in the Southern African region are already operating an inter-connected power supply system which has linked most of countries into a single integrated grid system. This

fact alone offers a unique prospect of South African nuclear-powered electricity the meeting bulk of the region's needs. Of course, until the issue of safe disposal of spent fuel is adequately addressed, the prospects of nuclear power around the world will continue to diminish, unless of course its GHG-diminishing advantages becomes the spur that offers research and development funds to lick the disposal problem.

26. Mature renewable energy technologies for centralized power generation systems are now available in the form of micro and mini hydro plant, biomass pyrolysis and gasification equipment, wind aerogenerators and photovoltaic arrays. Additionally, dramatic capital cost reductions have been achieved in many of the mature renewable energy technologies. For example solar thermal power generation costs have dropped by more than 50% in the last ten years and are forecast to drop by another 25% in the next ten years. Land-based wind power has fallen correspondingly 30-50% and is predicted to fall by another 20-35% . Photovoltaic power costs have fallen by 40% in this decade and a further 40-50% drop is predicted for the next decade.

27. Current comparative costs (in US $/kWh) for thermal and renewable energy power technologies, using the most advanced plant in use, in terms of the delivered energy, are estimated as :

Land based wind farms	**US$ 0.04**
Solar thermal power	**US$ 0.09**
Grid-connected PV	**US$ 0.35**
Large gas-fired power plants	**US$ 0.035**
Small diesel power plants	**US$ 0.10**
Biomass/land fill gas power	**US$ 0.24**

28. In spite of the encouraging developments in renewable energy power generation systems, there are little prospects for near-term large-scale centralized application in Africa. Notwithstanding Africa's massive solar energy resources solar thermal power is just about moving from 'frontier' to 'mature status, with still several years of trials. Biomass-based gasifier/gas turbine technologies offer good opportunities to transform biomass from its present low grade status into a high grade modern energy form. However, except for integration into biomass-based industrial processes, such as sugar-cane, paper and pulp, biomass power generation systems will only take off when Africa's forests and other biomass resources have been resuscitated and produced in a sustainable manner. Nevertheless, biomass power generation offers a synergistic medium to long-term solution for Africa's developmental challenges within the framework of climate change concerns.

III./5. Technologies for the built environment.

29. The built environment presents the biggest challenges as well as opportunities for transforming Africa's development. This is where the greatest efforts have to be made to address the most critical basic needs concerns of the majority of the people. It is also the area where the solutions could trigger the largest emissions of greenhouse gases unless a lot of imagination is applied to the transformation process. The experience of practice elsewhere suggests that the built environment is the first area for the transformation from basic to higher quality energy technologies as people move up the development ladder.

30. The experience of developed countries indicate that energy use in domestic and commercial buildings could account for as much as 50% of a country's CO_2 emissions. Ironically, by dint of the predominant role of low level biomass fuels in Africa's current energy mix, the built environment is also said to be Africa's biggest source of GHG emissions. However, the big difference is that the transformation from low to high per capita use could increase the GHG emissions several fold unless EST technologies are used to intervene at the right points within the solution curve.

III./5.1 ESTs for basic needs.

31. Over 70% of sub-Saharan Africans live in the rural areas where the supply of petroleum products is irregular and access to electricity is minimal. Firewood and agricultural residues are the predominant fuels in the rural areas, with kerosene lamps providing rudimentary lighting. Charcoal is the primary cooking fuel in cities; though the urban firewood demand for small-scale industrial and commercial activities is increasing significantly. The pressures of growing populations and increasing commercial activities is leading to a substantial increase in the use of electricity and petroleum products in the urban areas of Africa. However, it is also true that the transformation is taking place in a frighteningly unsound manner, with wholesale importation of inappropriate and often obsolete technologies, which may end up doing nothing more than to shift the sources of greenhouse gas emissions from the developed to the developing countries.

32. There are several mature technologies that can transform the built environment and achieve substantial improvements without adding significantly to the GHG problem. At the most basic level, per capita energy use for cooking could be reduced by accelerating the introduction of a number of technologies which are already in use, such as: 1) improved cooking stoves; 2) switching from firewood and charcoal to kerosene; and 3) use of electric stoves. The lighting needs for the home, which is the dominant use of electricity in Africa, could be improved dramatically by switching to compact fluorescent bulbs which give better lighting for a near four-fold reduction in electricity consumption. It must be stressed that while these technologies may be thought of as

rudimentary, they present the most effective solutions in the short-term as they are directed at the most critical areas of concern.

III./5.2 Refrigeration and air-conditioning

33. Refrigeration, air conditioning and consumer products present the real challenges for the introduction of ESTs into Africa's development. It is estimated that almost half of electricity production in Africa is going into air-conditioning of commercial and domestic buildings. The problem is getting worse as more and more buildings are constructed in the form of 'sealed capsules' which can only be made comfortable through mechanically-operated air conditioning. Unfortunately, much of the refrigeration and air-conditioning use in the biggest growth sector, i.e. domestic and small commercial, relies on chlorinated fluorocarbons(CFC) as refrigerant, in spite of the Montreal Protocol and the substitution of CFCs with more benign technologies.

34. There are two mature ESTs which can be applied to the built environment to meet developmental and Climate Change needs, namely passive solar energy and non GHG refrigerants. The big plus for passive solar energy is that it can be applied in both the avoidance and substitution forms. It is a solution that is a good example of effective 'in-situ' matching of supply and end-use technologies. Passive solar energy technologies, which are the most mature and effective of avoidance technologies, come in two basic types: 1) passive solar design and natural ventilation; and
2) photovoltaic power generation.

35. Solar photovoltaic power, which converts sunlight directly into clean electricity, is a simple, reliable and commercially-proven technology. To date, it is the only electricity generating renewable technology that can be mass deployed in the urban environment. Solar photovoltaic can be substituted for existing building materials such as facades, glass roofing, parapets and glazed stairwells, and incorporated into new or existing buildings. Any area of a building which is exposed to the sun is suitable for solar photovoltaic. Because most demand for electricity in a commercial building electricity is during the day, this offers an excellent correlation between the electricity produced by solar photovoltaic and the air-conditioning demand of a commercial building.

36. The use of domestic refrigerators and air-conditioning equipment is increasing rapidly in Africa. Unfortunately, much of the equipment being deployed are 'cast-offs' from the developed countries which have been banned because of their use of CFC as refrigerant. Much of the old equipment are also 'energy-guzzlers'. Although CFCs are being phased out under the Montreal Protocol, the replacement HFCs are said to pose potentially greater threats to the climate.

37. HFC is a high-tech solution which requires very sophisticated production conditions to maintain quality control. **Repairing of HFC-134a compressors is extremely difficult,**

and field-based servicing can lead to complete compressor failure which cannot be repaired anymore, when HFC-134a-based appliances are recharged following a compressor blockage. These problems, due to the hygroscopic nature of the synthetic ester oil, is especially pronounced for developing countries in warm and humid climates. It may in fact have a devastating impact on the service community, which in most African countries, is primarily from the informal sector and may simply not be able to maintain the required quality standards to prevent contamination.

39. HFC-134a is projected to be used at a level that poses significant risk to the climate system. Estimates of the potential impact of all HFCs upon the atmosphere indicate that by the year 2040, the total global HFC market could be around 1.35 million tonnes a year, which would be the equivalent to 15% of current fossil fuel emissions. Consequently, under the Montreal Protocol to Control Ozone Depleting Substances, governments agreed to an international phase-out schedule for CFCs, and on the need to replace CFCs with new substances and technologies. It is suggested that HFC-134a must only be used as transitional substance, which should be phased out in each sector as soon as safer technologies are available. In the domestic and small commercial refrigeration sector there is absolutely no need for its continued use.

40. One of the new technologies being promoted as a benign replacement for CFC is the "Greenfreeze" technology. Greenfreeze hydrocarbon technology in domestic refrigeration is said to be the most sustainable refrigeration EST that is currently available in the world. Greenfreeze uses a mixture of propane (R290) and isobutane (R60Oa), or isobutane as a pure gas, for the refrigerant, and cyclopentane for blowing the insulation foam. While hydrocarbons are flammable, the content of propane or butane in a domestic Greenfreeze refrigerator only equals the content of two cigarette lighters.

41. Since 1992, Greenfreeze has become the dominant technology in North Western Europe, having taken over nearly 100% of the German market. There are over 12 million hydrocarbon refrigerators in the world today, and it is estimated that by the year 2000, over 40 million Greenfreeze refrigerators will have been built in Europe alone. Projected share of the market for hydrocarbon refrigerants in Western/Northern Europe is 80% by 1997, up from 40% in 1995. HFC-134a is expected to have a share of 20% of the market in 1997, down from 50% in 1995.

42. The use of hydrocarbons in polyurethane foam blowing and as refrigerants has been approved by the Executive Committee of the Multilateral Fund of the Montreal Protocol. Worldwide, of all the conversion projects approved under the Multilateral Fund, up to June 1996, out of a total of 8,070,800 refrigerator units, 5,884,400, or approximately 70% will have hydrocarbon (cyclopentane) as blowing agent for the insulation. Greenfreeze refrigerators are available in many sizes, and a wide variety of models, including no-frost freezer compartments. There are over 100 different

Greenfreeze models on the market. Greenfreeze refrigerators are now on sale in most parts of Europe. All of the major European companies, Bosch/Siemens, Electrolux, Liebherr, Miele, Quelle, Vestfrost, Whirlpool, Bauknecht, Foron, AEG are marketing Greenfreeze. The technology has also spread to other parts of the world. Greenfreeze is produced in Australia. Kelon, the largest company in China, will produce up to 700,000 Greenfreeze units in 1997, and plans to convert other production lines to using hydrocarbons. Four other companies in China also have plans to convert to hydrocarbons with funds from the Multilateral Fund of the Montreal Protocol. Six companies in Argentina are in the process of converting their production facilities to Greenfreeze.

43. The Greenfreeze hydrocarbon technology is said to offer many benefits to developing countries, including :

- independence and sovereignty in supply of non-patented foaming agents and refrigerants
- lower operating costs for foaming agents, refrigerants and lubricants
- avoidance of the costs of a two step conversion which include retrofitting equipment, changing production lines, and training of personnel
- easier maintenance and servicing than HFC-134a technology
- technology applicable in both domestic and small commercial refrigeration

III./6. ESTs for transportation.

44. Transportation has become a major environmental headache in African countries. Public transport has broken down in all but a few countries, replaced by very inefficient small vehicles which have clogged up most of the already over-burdened cities. Unfortunately, the problem is set to get worse as the lack of public transport for rapidly growing urban populations push more and more people to acquire personal vehicles. In order to meet the transportation challenges of the Climate Change Convention, motor vehicles used in Africa must be cleaner (with lower tailpipe emissions) and more efficient (with greater fuel economy) and their power must be supplied from environmentally-sound technologies. Regrettably, the actual situation is the reverse. **Most vehicles in Africa are 'environmental rejects' from the developed world.**

45. Although the gasoline-powered internal-combustion engine has dominated the transportation landscape for most of the 20th century, and will continue to do for the foreseeable future, a wide range of vehicles and fuels are now becoming available which

can be applied to minimize the mission of greenhouse gases within an expanding transportation sector in Africa.

46. Cars, small buses and diesel-powered trucks make up the bulk of Africa's transportation system. Therefore, the first stop in the evolution of a cleaner transportation system for Africa is to systematically introduce vehicles which progressively achieve lower tailpipe emissions, have greater fuel economy and ultimately run on EST fuels. A family of vehicle technologies-including battery-powered electric vehicles, fuel cell vehicles, and some hybrid-electric vehicles which feature high efficiency, clean operation, and the ability to run on alternative fuels are already at very mature stages of technological development.

47. In the end reducing driving is still the single best way to minimize the transportation problems. This means getting people out of cars and into buses, trains and trams. Shifting to mass transit not only decreases emissions of carbon dioxide, but also reduces air pollution, lowers oil imports in most countries, and curtails congestion. There are new mass transit buses which use modified diesel-engine technology to burn ethanol, methanol, propane, bio-diesel, or natural gas. The next stop is hybrid and electric buses. Hybrid buses combine a combustion engine with electric motors and batteries. These are still in the demonstration stage, but they promise lower emissions and higher fuel economy than traditional combustion buses.

48. The most promising stop in the evolution of bus technology is fuel cell buses powered by hydrogen. Using electric engines that combine hydrogen and air to produce electricity, fuel cell buses release no pollution-the only by-product is water. However, heat-trapping gases may be emitted indirectly as a result of the process that produces hydrogen for the fuel cells. When the hydrogen is harvested from natural gas, the indirect emissions associated with fuel cell buses are roughly half those of diesel buses. When the hydrogen is harvested from water, using energy from renewable energy sources like solar power, the indirect emissions are eliminated completely. Commercial application of fuel-cell technology in buses will pave the way for a technology that holds tremendous promise for the automotive and even electric power markets to serve our driving needs.

III.3/5. ESTs for industrialization.

49. Industrialization holds the key to Africa's ability to break out of its vicious cycle of worsening poverty. Africa has to transform its terms of trade by adding value to its primary produce to turn them into finished goods of competitive export quality. Fortunately, industrialization is one area of massive development of mature environmentally sound technologies. In particular, vastly improved energy efficiency

technologies, most of which were developed to meet the challenges of the 'energy crisis' are being utilized on an almost routine basis in the developed countries.

50. From process heating systems, through to refrigeration, heat recovery systems, heating ventilation and cooling, electric motors, mineral extraction and mineral processing, very efficient end-use technologies are available to propel Africa's industrialization drive. The other plus for Africa is that there is very little industrialization at the moment, which therefore presents an opportunity for 'leap-frogging' from zero to the state of the art. Unfortunately, as with the other sectors, Africa seems to be attracting 'reject technologies' which are both high energy guzzlers as well as big emitters of GHG.

51. The drastic reductions in the energy use per capita of industrial output has brought on additional opportunities in the areas of energy conversion systems which drive the industrial products. The production of hot water and process steam using solar thermal collectors is now a mature technology which is being exploited within combined fossil-renewable energy systems. Solar water heaters are also being used as pre-heating devices for steam and direct heating devices in industrial applications. Solar photovoltaic systems are being deployed as mature and cost-effective power sources for telecommunications and broadcasting applications in both remote areas and as part of integrated solar/conventional hybrid systems in many African countries.

IV FROM 'FRIENDLY' TECHNOLOGIES TO SUSTAINABLE SOLUTIONS

IV./I. Transfer or access: the critical path

52. Environmentally Sound Technologies have been the focus of international cooperation efforts for almost three decades. From the Stockholm conference which led to the establishment of UNEP, to the Nairobi Conference on New & Renewable Sources of Energy and finally to Rio's Earth Summit, the core issue has been the same. The goal has been how to foster international cooperation to make the tremendous technological achievements of the 20th century have a positive difference on the lives of the poorest majority and also ensure the survival of the planet that we live on.
For most of the period, conventional wisdom has been that the way forward is to facilitate the transfer of appropriate technologies from the developed to the developing countries. The prescribed role of international cooperation efforts was to facilitate the North-South transfer of whatever technologies were believed were essential to address the specific issue of concern at the time.

53. However, several years of concerted international efforts to address specific concerns have yielded the same outcome. 'Decades' of environment, health, habitat, industrialization, water, etc., have had very little impact on Africa's condition. If we look back, we find the same issues, the same prescriptions and by now predictable

outcome coming up time and again. In almost every instance, innovative technologies evolved and were applied in the developed countries, but the process of effective transfer to the developing countries failed to materialise. The same 'holy grail' barriers and opportunities for effective transfer of technology from North to South have been recycled. Since they have failed to deliver salvation, perhaps it is reasonable to suggest that the whole matter of how developing countries get hold of the best available technologies should be subjected to radically new thinking.

54. At the heart of the matter is whether we are dealing with **TECHNOLOGY TRANSFER OR ACCESS TO TECHNOLOGY.** The distinction is extremely important since this is what drives the subsequent issues of barriers, opportunities and ultimately the appropriate international mechanisms which will facilitate sustainable solutions. The Transfer or Access conundrum can be illustrated by two very real situations in Africa today.

Conundrum 1

55. Even though much is made of Africa's lack of capacity in various technological fields, a great many African countries are deploying and enjoying services, such as cellular telephony and digital satellite TV, that employ the latest cutting-edge technologies. Ghana alone has five (5) cellular phone service providers and five (5) Internet service providers. DSTV and cable TV services are available in almost all African countries. So how is it that cutting-edge high technology is being deployed in Africa in the face of the seemingly major barriers of capacity and finance?

Conundrum 2

56. There is an on-going massive transfer of near obsolete and high GHG emission-producing technologies from the North to Africa. Heating and Cooling systems and vehicles with high exhaust pollution emissions, and other goods and services now banned in the North have become major features in African countries, as poor people seek to make the transition from subsistence to developed status. Given that there are many millions who are making this transition, and the reality that the effects of Global Warming transcend national boundaries, is there a possibility that the source of the problem is simply being transferred, rather than addressed?

57. The two situations bring up two fundamental questions : **Is Africa really not ready to take up technologies or is it rather a case of the majority not being able to get access to them?; and, If GHG-unfriendly technologies are already being transferred to Africa on a massive-scale, what needs to be done to substitute these with EST equivalents?** The very few privileged Africans can get the best technology available at any material moment they choose to do so. On the other hand, the majority, handicapped by poverty, are consigned to picking up ' hand me down' undesirable technologies. It is true that both national and international actions must

necessarily focus on the needs of the majority. Nevertheless, if the intent is to solve problems, then it becomes imperative to deal with the reality of intangibles rather than the desirability of established order.

IV./2. Wanted: solutions not experimentation

58. One other conceptual issue which must be dealt with is that of WHAT problem is really at hand and WHEN should WHAT be done. The critical issue here is to make sure that the right solutions are applied at the right time.

59. For example, faced with the "Energy Crisis" of the 1970s and 1980s, the developed counties realized that the issue was how to make oil cheaper and use it more efficiently. However, developing countries were made to believe that their salvation lay in experimental and unproven technologies, primarily renewable energy technologies and associated services. Like their Northern colleagues, African countries should also have focussed on the critical issue at hand, namely: how to break the stranglehold of having to spend 60% to 80% of their foreign exchange earnings on imported oil. Instead, they were being presented with solutions which were at least 10 years down the road. The consequence was that Africa fell even further behind in its development while the North's more immediate solutions of developing and applying more efficient energy technologies led to the collapse of oil prices and the end of the energy crisis.

60. There are important lessons and challenges for the climate change agenda. **"Firstly, it must be recognised that no developmental problem is an island onto itself**; and **secondly, we must not push experimental and frontier technologies as the solutions for immediate problems."** The import of the first lesson is that we are not solving climate change problems. The task at hand is to deal with Africa's key developmental challenges. The import of the second lesson is that we need APPLICABLE SOLUTIONS not EXPERIMENTATION. One of the major banes which has beset international cooperation on technology has been the undue emphasis on focusing on experimentation instead of injecting mature and ready technologies into appropriate solutions. More often than not, critical efforts and resources are pumped into demonstration projects when in fact they would have been better put to incorporation into mainstream efforts to address specific problems. This regrettable approach, which was a major feature in the 'Energy Crisis' era, appears to be creeping into the Climate Change agenda also.

61. It is essential, nay imperative that the immediate thrust must focus on making available proven CC-friendly technologies (i.e. those that are being already applied in the North) to solve Africa's urgent and critical developmental problems, even if it is believed that larger benefits may eventually come from still experimental technologies. This means within the key areas of concern, the selection and ranking of solutions for implementation must be on the basis of readiness and

cost-effectiveness of competing technologies, rather than the perceived potential for biggest impact.

IV./3. The way forward

62. Technology transfer has got stuck in a spiral of illusions which has operated on the premise that the ultimate end is a wholesale acquisition of every conceivable capability for indigenous manufacture of appropriate solutions. This has led to the classical laboratory approach of tinkering leading to local skill acquisition leading to effective adaptation and eventually to successful transfer and use. But then what is it that we are really after; is it to transfer technological capability or to use technologies to effect solutions? We already live with the reality that **technologies of all shades, sophistication and desirability are being utilised and will continue to be utilised in Africa without and within the formal international cooperation framework**.

63. **The acceptance of 'black box' technological solutions is as much a feature of the North as it is of the South.** The basis for such transfers is that of an informed buyer (a client backed up by the requisite technical support) procures a particular technology to solve specific problems. **There has never been and will never be a process which can transfer every facet of the solution from the owner to the buyer. It is as impractical as it is unfeasible.** A century of global development and application of technologies in the 20th century has laid down a path of the South adopting Northern technological 'black box' solutions, concurrently initially with knowledge to operate and maintain, followed by knowledge to diagnose, sometimes together with the capability to manufacture parts, and finally, though rarely, by self-sufficient indigenous manufacture. **While the present situation may be deemed undesirable, it should not divert us from the task at hand, which is to apply the best available technologies to solve problems, and not to see every developmental issue as yet another opportunity to home in on the North-South imbalance in scientific and technological capability and capacity, important as it is.**

IV./4. So, HOW should we go about it?

64. The key to the effective deployment of ESTs in Africa is to establish a knowledge transfer mechanism process that facilitates the ranking of the 'what should be transferred to whom at what time' process. This mechanism should provide a 'learning curve' that enables the fastest access to and use of CC friendly technologies in the key development areas. It is within this context that one attempts to answer the question: **"How can Africa's access to these technologies be facilitated?"**

IV./4.1. Immediate targets

65. The crisis of worsening poverty and deteriorating environment requires that immediate attention be focused on tackling the basic needs and concerns as a matter of utmost priority. The transition from low quality biomass to higher quality fossil fuels for cooking should be accelerated in both the rural and urban settings. Wherever this is possible, the preferred substitute fuel should be gas, whether Liquid Petroleum Gas (LPG), biogas or natural gas. Fortunately, stove technology for liquid and gaseous fuels is very well established and is easily adaptable for cost-effective local manufacture. A useful and ready source of gas in most countries will be oil producing wells (which tend to flare natural gas into the atmosphere) or more likely Liquified Petroleum Gas (LPG) which is a by-product of refinery operations. With the consumption of petroleum products in Africa set to increase substantially in the foreseeable future, there should be an increasing supply of both LPG and natural gas to facilitate the transition process.

66. The transition to higher quality fuels to meet basic needs must go side by side with long established programmes to increase the productivity and efficiency of the existing biomass fuels and end-use appliances. Even though many of the technologies, which are 'home-grown' in Africa, have become mature over the past two decades, there has been a lack of concerted policy to promote the widest diffusion and application. However, as these are said to be the biggest sources of greenhouse gas emissions in Africa, and will continue to be the cooking fuel for most people for a long time, there is a case or more effort being put into this.

67. Another area of basic needs concern is lighting. Most of rural Africa has no access to electricity, though the urban areas tend to have power, if somewhat of an erratic and unreliable form. Despite the lack of complete access, basic lighting is the major consumer of electricity in most African countries. As the drift from the rural to the urban areas intensifies, the demand for basic lighting is increasingly exponentially. Much of the lighting deployed is of the heat-generating, high energy consumption filament bulb. There is a wonderful opportunity to substitute efficient compact fluorescent bulbs which give the same or better lighting for less than 20% of the power needed. A major programme to switch to these bulbs could release tremendous electricity to meet both basic and other needs and could also delay the building of new power plants. Even though the technology has been around for a considerable time, this has not taken off in most countries because of the barrier of a prohibitive cost of the bulbs to most people.

68. Solar photovoltaic power is a very mature technology which can meet the basic lighting and other electricity needs of off-grid communities. The costs per delivered output are comparable to kerosene lamps and better than dry cell battery sources for consumer products. However, they have failed to make the necessary impact for two main reasons. Their provision has tended to put too much strain on the final consumer, who has been expected to be a technology-buff instead of a simple buyer. This has pushed

the second problem, which is that it has very often tended to be deployed in the isolated experimental project rather than being seen as an integrated mainstream solution. Therefore, if the provision of solar lighting is brought within the realm of national electricity provision, in which prospective users need know no more than how much they should pay each month, there will be a tremendous take-off for remote rural communities. This approach will also eliminate one of the main barriers to solar lighting, namely, relatively high capital cost for the equipment.

IV./4.2. Beyond basic needs.

69. The growth in refrigeration and air conditioning in the built environment should be tackled as a matter of urgency. It must start with an insistence that all new equipment which are installed must meet the highest current standards for environmental friendliness. Regarding the greenhouse rejects, it should be possible to intercept them at the point of entry and make the necessary changes in refrigerant and insulation to make them more CC-friendly. Perhaps international cooperative funding could be made available for the adaptation. Similarly, support could be given to joint ventures between established equipment makers and African countries to establish and manufacture 'green' refrigeration and cooling equipment.

70. In the medium-term, greater efforts must concentrate on promoting avoidance strategies. There is no question that Africa's built environment will be transformed substantially in the coming years, with the construction of many new buildings. It is absolutely imperative that every effort is made to introduce the maximum possible use of passive solar energy concepts into the designs, no matter how small or big. One way of doing this will be to incorporate a type of 'building energy account' statement into the procedures for obtaining building permits.

71. As very little can be done to stop the importation of 'green reject' vehicles into Africa, a short-term solution will be to rigidly enforce vehicle emission standards and ensure that vehicles do not 'overstay' their welcome in the countries. The hope is that every new generation of 'green rejects' will have better 'green credentials', which will in turn comparatively lower emissions of GHG for the same output. More realistically, Africa should take the opportunity to build up its public transport system. Many African cities could do with a revival of their mass transit systems, using principally buses running on cleaner fuels/more efficient engines as well as the introduction of electrically-powered trams. There are enormous possibilities and advantages in increasing the train networks to take up more of the freight and passenger traffic from over-burdened roads.

72. Africa's industrialization programme should adopt 'leap-frogging' as its key strategic weapon. This means scrapping much of the 'fossilised' plant that is found in many countries. Whenever a new industrial facility is to be built, the best available mature

ESTs must be incorporated. Established industries, especially mines and food processing, must upgrade their essential equipment to be able to increase their output while reducing emissions of GHG. This will ensure that the highest per capita output will be obtained from each additional unit of energy deployed. One way to overcome technological capacity barriers will be to develop sub-regional or regional industries that combine the skills and know how with viable markets to achieve synergy in both production and competitiveness.

73. Africa needs to expand its power production and use considerably. To address GHG concerns without stopping the march of progress, the short to medium term strategy will be to utilize base hydro systems complemented by state of the art thermal systems. An optimal approach will be one that promotes greater inter-connections of national grids, with generation concentrated at the most advantageous areas and distributed around a region or sub-region. For example, thermal power plants should be sited in countries with gas resources while hydro dams are sited in countries with the most competitive costs of generation. The interconnected grids of Western Africa and Southern Africa should be integrated and brought closer together to plan future generation expansion to meet both power and climate change concerns.

IV./5. How does it all hang together ?

74. If the issue is that of access, and the critical factor is money rather than technological capability, then how is 'Poor Africa' going to get the wherewithal to do all the good things that will facilitate its development and also address Climate Change concerns. This is the nub of an effective international cooperation effort that must be put together to turn the WHAT & HOW into SUSTAINABLE SOLUTIONS. This is where the Climate Change Convention and, especially the Clean Development Mechanism (CDM) under the Kyoto Protocol could be ever so useful.

75. The enlightened self-interest of showing pre-emptive benevolence provides an opportunity to secure the necessary capital within a framework of two key questions: **1) Is Africa aware of the role ESTs can play to accelerate its social and economic development?; and 2) will the North stick to its target reductions of greenhouse gas emissions?**

76. The questions are for the negotiators to grapple with. This paper has simply tried to set out some ideas to facilitate the process.