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Renewable Energy Future for the Developing World

White Paper

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under contract to the International Solar Energy Society

http://whitepaper.ises.org

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Foreword

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Renewable energy in various forms has been used in human activities since time immemorial. The history of the human race and the progress of civilization have had much to do with the use of energy, but in the last 200 years rapid transitions have taken place essentially from a regime based on renewable sources of energy to those forms that have a finite stock across the globe. It was really when some voices in the 1960s and '70s in some corners of the world articulated concerns on the limits to growth that the inexhaustibility of the earth's finite resources was called into question. However, concerns of this nature were quickly dismissed by those who saw them as a futile reinvention of Malthusian economics by pointing to the power of technology and innovation. It was contended that technological change has established the ability of human beings to counter scarcity of any input in the production process through innovation and substitution between different resources.

It was after the oil price shock of 1973 - 74, triggered by some unusual geopolitical forces, that the world started look-0ing at the limits of global resources at least in respect of energy. Consequently, it was in the mid 1970s, that this field attracted funds and concerted efforts for the development of technological means by which untapped renewable resources could be harnessed on a large scale as possible substitutes for fossil fuels. The enthusiasm for renewable energy use continued through the mid 1980s, but with the crash in oil prices in 1985, a season of neglect set in, which has lasted almost two decades. Even though in real terms oil prices today are lower than what was registered as a peak at the end of the 1970s, they have risen sharply enough to require a reevaluation of global strategies for the production and use of energy across the globe. The new interest in renewables is also driven by projections of the future, with the spectre of continuing growth in demand, particularly in the U.S, China and India, and perceived sluggishness in the growth of global oil reserves and production capacity.

The human race is, therefore, ready to look at renewable energy within this new context, particularly since a great deal of growth in the demand for energy will come from the developing countries. Since the infrastructure being put in place and the economic options being exercised in the developing countries do permit some choices for greater use of renewable energy, an assessment of the future that lies ahead and the opportunities that exist for bringing about a transition to new sources of energy needs considerable debate and discussion. The White Paper developed by ISES, embracing various aspects of this subject, provides an extremely useful document for debate and discussion, which could be of value not only in exercising public policy choices, but also for business and industry in evaluating opportunities for long-term investment decisions. Hence, it is indeed heartening that ISES has developed this White Paper, which fits very well into the need for an authoritative document, that could stimulate further debate and analysis to assist in the transition towards a sustainable energy future in the developing countries and the whole world. However, it is important to emphasize that any discussion and debate has to lead to action and implementation of renewable energy programmes, by which a transition is achieved in reality towards greater use of renewable energy sources.

Executive Summary

For the hasty reader:
The essence of the White Paper is contained in the section on "Policies to Accelerate the Application of Renewable Energy Resources in Developing Countries".

This White Paper presents a rationale for apposite and effective governmental policies on renewable energies in the developing world. It also provides adequate scientific information to make rational and accountable energy policy choices within this context, in support of sustainable development.

While fully acknowledging the substantial barriers restraining the developing world, the paper also highlights the momentous and unique window of opportunity, as well as the concomitant grave responsibility this places on the shoulders of present energy policy decision-makers. A potential role of the industrialised nations in our common future is indicated.

The paper endorses the thesis of the earlier global ISES White Paper titled "Transitioning to a Renewable Energy Future", stating that "a worldwide effort to generate the renewable energy transition must emerge at the top of national and international political agencies, starting now".

A *Summary of Policies* is presented, followed by *Renewable Energy Defined: Energy from the Sun* describing that essentially all energy derives from the sun, including the fossil fuels that have been the base of a short-lived and energy-flagrant period in our history.

The *Aim, Scope and Delimitations* sets the definitions and context of the developing world in the global village, which is illustrated by the worldwide reaction to the Tsunami catastrophe of December 2004. Our common future has not reached that level of newsworthiness – yet.

The *Introduction – The Developing World in the Global Energy Transition* explains that developing nations have underdeveloped energy infrastructures, but need not follow the western pattern of centralised power stations with extensive, costly and vulnerable networks.

While the developing world has uneven fossil resources, it is blessed with more evenly distributed underdeveloped (and largely unmapped) renewable energy sources.

This offers a unique opportunity of technological leapfrogging, using the Kyoto Protocol's Clean Development Mechanism where advanced and technical know-how and resources of the industrialised nations can facilitate the growth of domestic work opportunities, thereby helping to achieve sustainable development and the millennium goals in the developing world.

Artificial and persistent market distortions ignore the social, environmental and military costs of fossils. Where developing countries indulge in nuclear adventures, the costs always by far exceed public tax monies invested in sustainable energy. Their insurance is not covered by private companies, but by the unsuspecting citizens.

A combination of energy conservation, energy efficiency and renewable energy seems to be indicated in a world of material want where it is not always easy to practise global solidarity. The inevitable transition to renewable energies has to be immediate, rapid, orderly and sustained. This requires suitable policies as suggested in this White Paper.

Why it is Essential to Transform the Developing World Energy Systems Now treats the new key drivers: energy poverty and poverty eradication, risk avoidance and energy volatility, as well as the protection of the natural life supporting systems. Government policy options include the creation of a supportive climate for the necessary policies and legislation by creating more energy awareness, energy labelling of appliances, using the Kyoto Protocol, and ensuring the national and regional security of supply through renewables.

Renewable Energy Resources: Technology, Status and their Sustainable Potential provides essential information for policy purposes. About two thirds of the global hydropower potential is located in the developing world. However, there are serious caveats, as documented by the World Commission on Dams (WCD 2000). The technology is mature.

Bio-energy is the energy mainstay of many developing countries, and is increasingly being harvested in an environmentally unsustainable way. Conventional bio-energy use is mostly inefficient, socially inequitable and detrimental to health.

Wind energy has become cost competitive with conventional energies in leading countries. It has shown rapid development and cost reductions. The intermediate term potential in the developing world is considerable.

Of all renewables, solar thermal energy is considered to be practically unlimited in the long-term, and is a very abundant resource in the developing world. Concentrated solar thermal power plants produce most of the world's energy derived from direct radiation. The prospect for these technologies and solar upwind chimneys are good.

Grid-connected application is the fastest growing sector of photovoltaics (PV). While the service life is more than twenty-five years, its modularity renders it suitable for incremental applications. Further cost reductions are projected. The fact that PV systems are currently not cost-competitive with subsidised grid electricity has led some developing countries to introduce stand-alone PV systems in impoverished remote rural areas where service, maintenance of batteries and social acceptance must be expected to be difficult.

Solar water heating is an established technology that can be manufactured in the developing world, provided standards are maintained. The capital costs are higher than conventional gas and electric push-through or storage geysers, but the life cycle costs are lower. Combined solar water and space heating (combi) systems are not yet established in the developing world.

Geothermal energy can be used in near-surface applications through the mature heat-pump technology. Underground heat below 100 °C is applicable in space heating, and – at higher temperatures – for electricity generation. Considerable waste heat streams occur.
Solar cooling of buildings, agricultural products, food and medicine is critical in the developing world. Yet, the technology is underdeveloped.

Solar buildings are of great importance because of their long life cycles (longer than power plants) and the combined effect of urban and global warming on inefficiently designed air-conditioned buildings can be dramatic.

The landlord dilemma and inadequate building regulations (codes) aggravate this problem. Regulations should stipulate CO_2 emissions. Integrated resource planning balances the supply, storage and consumption (demand-side management) of resources like water, material and energy services. The old wasteful paradigm of government-driven energy supply is still prominent in many developing countries.

Transport energy consumption in dispersed developing countries is mostly supplied by imported fossil fuels with a notable impact on national economies. Policy options are domestic fuel production, technology improvements, information technology, mode switching and energy conscious spatial planning of towns and regions.

National and International Drivers of Renewable Energy Application: Setting National Targets within Global Guard Rails highlights poverty alleviation through job creation as a primary policy driver. Renewable energies produce considerably more jobs than fossil energies.

Distributed generation is more cost-effective, more environmentally benign, more secure and more energy-efficient because it reduces line losses and uses both electricity and rejected heat. Solar Rural Enterprise Zones can facilitate sustainable development.

National renewable energy and energy productivity targets should be challenging as to attract academics, entrepreneurs and investors. They must also be of sufficient long-term scope for the inertia of bureaucracy and the educational system.

Market liberalisation and privatisation of national energy systems is not the panacea.

National transition paths to sustainable energy should be bounded by Global Guard Rails or limits of socio-economic and environmental damage that should not be exceeded. An illustrative roadmap highlights eradication of energy poverty, revision of World Bank policy, promotion of socio-economic development, combined regulatory and private initiatives, protection of life-supporting systems, improved energy productivity, 20 % renewable energy by 2020, and phasing out nuclear by 2050.

Policies to Accelerate the Application of Renewable Energy Resources in Developing Countries are drawn from appropriate international experience. *This section represents the core of this White Paper to which the reader's attention is directed with special reference to implementation.* Long-term stability of targets and transparent, simple policies endorsed by a White Paper are highlighted as success factors. Where electric power is mostly derived from fossil fuels, the renewable energy pricing systems (grid-feeder law) is a proven success and more suitable for developing countries than the quota system because of their achievement of targets, investor friendliness, job creation in domestic industry, geographic and ownership equity, diversity of technology, diversity of supply, costs, prices and competition, financial security, ease of implementation and flexibility. However, the pricing system has not been applied to off-grid energy technologies.

The Kyoto Protocol is an opportunity to be grasped by developing nations.

Financial support in the form of payments, tax credits, low interest loans, lowered import duties should preferably focus on energy production rather than subsidies to investments on the supply side. They should be tied to technology standards. The playing field should be levelled for renewable energies.

Standards for renewable energy generation sites and for buildings are a necessity. Government can and should facilitate the transition by its own procurement programmes.

Education, training, information and demonstration should be increased, preferably with international partnerships.

Buy-in of stakeholders (individuals, cooperatives, business) enhances progress and obviates time-consuming and costly delays.

The need for Research, Development and Demonstration motivates the urgency of renewable energy R&D, which had more than halved from 1980. Seventy percent went to nuclear fission and fusion research, yielding disproportionably low outputs. The budget share of renewables was less than 10 %, and was only a fraction of the budget for fossil fuel R&D. The funding for renewable energy R&D has to be increased by one order of magnitude. Non-technical and technical research themes are identified, including cooperative priorities.

Examples of National Policy Models illustrates the German and Chinese renewable energy laws, with comments.

Conclusions, Acknowledgements and References conclude the paper.

Summary of Policies

Key stakeholders have to be aware of the interactions of energy with poverty, the environment and peace. Campaigns prioritising energy conservation, energy efficiency and renewable energy need to be addressed to energy decision-makers. Developing countries have specific policy priorities and options. After having assessed the national renewable and non-renewable energy resources, as well as the energy services needed, including the traditional ways of satisfying these needs, the following policies are applicable:

1. Establishment of transparent, consistent long-term targets and regulatory frameworks

- The Kyoto Protocol offers unique opportunities of integrating development and energy aims.
- A national and regional Renewable Energy and Energy Efficiency White Paper guides other stakeholders in the public and private sectors, and attracts both national and international energy investors.
- It is important to obtain buy-in from the key stakeholders, and publicise the White Paper widely, using the most appropriate communication media for the local and international audience.
- Orderly rural energisation through integration of cost-effective grid extension and equitable access to renewable energy services in off-grid areas, supporting development in production, health and education should be planned and implemented.
- Integrated resource planning, including the subsets of Integrated Regional, National, Provincial and Local Energy Planning are necessary stepping-stones in the energy transformation.

2. Financial interventions and incentives

- Governments have the power and obligation of building domestic capacity and job creation through renewable energy production payments, rebates, low-interest loans and guaranties fixed to technology standards.The playing field between entrenched and emergent renewable energies should be levelled.

3. Government supported renewable energy technology

- Government and regional authorities should encourage renewable energy technology standards and energy efficiency appliance labelling.
- Governments as prominent owners of buildings and other energy consuming systems should lead by example.
- Government should encourage and legislate obligatory site reservations for renewable energy installations, grid connection, and low carbon building codes.
- Government should introduce revenue neutral environmental taxes, replacing income tax in an orderly long-term plan.

4. Research, Development and Demonstration, and education.

- The greatest part of public energy reasearch, development & demonstration (RD&D) should be allocated to energy efficiency and renewable energy, with special emphasis on opportunities of leapfrogging with respect to building new long-term infrastructure, e.g. transport, buildings and distributed cogeneration.

5. Encouragement of stakeholder/ public ownership, participation and pride

- The transition to sustainable energy systems needs to be understood and implemented on a broad base. This requires the sustained buy-in of all key stakeholders, and their commitment and pride.

Renewable Energy Defined: Energy from the Sun

Ever since we first saw earth from space, our mind-set changed fundamentally: We now appreciate our beautiful and fragile blue planet floating in hostile space, precariously balanced in orbit by our life-supporting sun.

The sun's energy is *THE energy source*. It is certainly not an alternative energy. All terrestrial life, and most marine life, depends on the sun's generous energy.

It also drives the gigantic energies of the ocean currents. All wind energy is really solar energy. The immense energy of all rivers and waterfalls comes from the sun driving the great evaporation cycle to form rain clouds, which are transported by solar energy driven winds. The replenishing source of hydropower is solar energy. So is tidal, wave and future ocean current power.

Photosynthesis is energised by solar energy and plants are at the base of our food chain, supporting all levels of life, including our own. All organic or biomass materials derive from solar energy.

The sun has been, and will be, the primary energy source on earth and our solar system.

On the other hand, man has devised methods to extract energy that is not derived from the sun. Currently, nuclear energy contributes about 6.8 % to the world's primary energy, and geothermal 0.112 %. For ages, humankind lived by the daily rhythm of the sun. The discovery of fire brought a revolutionary way of using the sun's energy stored in firewood. Today, this is the dominant form of conveniently concentrated sun energy used in many developing countries.

The beginning of the industrial revolution was energised by solar energy in the form of mechanical power from windmills and water wheels, later replaced by wood-fired steam. Coal, oil and gas have become the main primary energy carriers during the last century and are concentrated forms of solar energy that has been stored over 500 million years. It took only about one century for humankind to spend the easily accessible part of this finite resource in a rather inefficient way. A significant dependent infrastructure has been built around this, from the oil exploration to extraction, refineries, pipelines, filling stations and engines.

When we talk about coal, oil and gas "production" we tend to mislead ourselves because energy cannot be produced. Removing these finite resources from the earth's crust is "exploiting" or "robbing", as the coal miners say more honestly.

Our current commercial energy system uses concentrated and finite resources, which are in the hands of a few. The technology to exploit these diminishing resources has become cheaper during the course of the last century through economies of scale, supported by government protection and infrastructure investments.

With solar energies, the natural resources are diffuse, and more evenly spread over the world. The resources are freely available to all and sundry. But the capital costs of the technologies to harness the free energies are currently often a barrier because the economies of scale have generally not yet taken effect.

The pressing challenge and top priority to humankind is to move away from squandering the sun's stored energy by transitioning to the universal use of renewable energy from the sun.

Aim, Scope, Delimitations

This White Paper is inspired by the ethic of the responsibility placed on the decision-makers of the developing nations. In a world of present material want, it is not always easy to practice global solidarity on issues about the future.

The purpose is to highlight the growing worldwide momentum in renewable energy policies and application, to share the lessons learned that are applicable to the developing countries, to identify the benefits already known to accrue from these early steps, and to assess the most appropriate policies to guide the transitioning of developing countries. The scope of the White Paper pertains exclusivwely to developing countries.

There are various ways of defining these. The World Bank (2003) uses world development indicators, one of which is the annual gross national income per capita. This indicator is then used to group nations into “low income”, “lower middle income”, “upper middle income” and “high income” categories.

The United Nations Development Programme (2003) categorises 137 “Developing Countries”, 49 ”least developed countries”, 27 “central and eastern Europe and the Commonwealth of Independent States” (CIS), 30 “OECD countries”, and 24 “high-income OECD countries”. For the purpose of this White Paper the UNDP term “developing and least developed countries” will be used (Annexure A). The term “developing world” is used to describe a total group, while “developing nations” is understood as a synonym. Some writers also refer to the “third world”.

Geographically, the developing countries are concentrated in Latin America, Africa and southern Asia, where about three fifths of the world’s population live.

Many are former colonies, speaking English, French, Portuguese and Spanish next to their indigenous languages.

This White Paper is written for an international organisation, and builds on experience gained in both worlds.

The paper is mainly addressed to the energy policy decision-makers, but also to stakeholders interacting with them. Therefore, technical details have been kept to the essentials needed for informed debate and decision-making.

While great care has been taken to present objective data obtained from many scientific sources, the style deliberately avoids overkill with references. Essential sources have been given at the end of this paper.

Structure of what follows

The introduction is followed by contextualising the developing world in the global energy transition, and the motivation of its urgency. This is followed by an outline of the relevant technologies and their current status, as well as an explanation of the drivers towards renewable energies and the need to set national targets within global guard rails.

The main part of the text pertains to policy options and market based incentives. The contribution of research, development and demonstration is indicated, followed by examples of national renewable energy policies.

Terminology, units, and conversion factors

The International Standard Organisation’s (ISO) Système International (SI) units have generally been used. In energy parlance, work performed at a rate of 1 Joule/second (J/s) is one Watt (W) of power. One Watt over one hour is one Watt-hour (Wh). One thousand Watt-hours is one kilowatt-hour (kWh). While this is the familiar unit of electricity, the SI consistently uses the Joule, in increments of thousands:

kilo = 10^3
Mega = 10^6
Giga = 10^9
Tera = 10^{12}
Peta = 10^{15}
Exa = 10^{18}

One kWh is 3.6 MJ or 3.414 Btu (British thermal unit).
One kWhe is one kWh of electrical energy.
One kWht is one kWh of thermal energy.
One Quad (1015 Btu) converts to 1.055 EJ.
One Million-tonnes-oil equivalent (Mtoe) is 41.868 PJ.

Temperatures are measured in degrees Celsius (°C); temperature differences in Kelvin (K).
Where United States dollars (US$) are mentioned, the values relate to the context time.
UK spelling is used.
Abbreviations have been reduced to a minimum and are found at the end of the White Paper.

Introduction: The Developing World in the Global Energy Transition

The majority of the global population lives in the developing world. It is in the direct global interest that the renewable energy transition be immediate, rapid and orderly. This requires shouldering the responsibility of both national policies and international cooperation.

It has often been stated that if the developing world were to follow the energy profligate example set by some industrialised nations, the global impact would be devastating. The developing nations accuse the industrialised nations of destroying the environment by over-consumption, while the industrialised nations accuse the developing nations of destroying the environment by over-population. Both are right.

Biomass Supply as a Percentage of Total Primary Energy Supply, 1971 and 2001

Region	1971 [%]	2001 [%]
OECD	2	3
Non-OECD Europe	4	5
Latin America	31	18
Asia	48	25
Africa	62	49

(IEA, 2003 in Karekezi, 2004)

As the world moves towards the global village in terms of modern communication, the sense of sharing one planet increases, as illustrated by the worldwide reaction to the recent Tsunami catastrophe. Concerns about our common future have not reached that level of newsworthiness yet.

There are very pronounced dissimilarities between developing countries with respect to prosperity and stability resulting from foresight, methodical planning, initiative, tenacity, responsibility, entrepreneurship and discipline. There are such large dissimilarities in the rate and direction of change that the term developing countries becomes questionable. On the other hand, there are similarities:

The economies of developing countries are heavily dependent on agriculture – often at the subsistence level, with mining where mineral resources have been explored. Beneficiation through secondary industries is rarely found, but tourism plays an important role.

Infrastructure is often elementary, with a scarcity of skills in engineering and technical or professional skills to execute its design, building and maintenance.

Renewable Energy Markets in Developing Countries

Application	Indicators for existing installations and markets (as of 2000)
Rural residential & community lighting, TV, radio & telephony	Over 50 million households are served by small-hydro village-scale mini-grids. 10 million households receive lighting from biogas. 1.1 million households have solar PV home systems or solar lanterns. 10 000 households are served by solar, wind and diesel hybrid mini-grids. There are 200 000 household wind generators in China.
Rural small industry, agriculture, and other productive uses	Up to 1 million water pumps are driven by wind turbines, and over 20 000 water pumps are powered by solar PV. Up to 60 000 enterprises are powered by small-hydro village-scale mini-grids. Thousands of communities receive drinking water from solar PV powered purifiers and pumps.
Grid-based bulk power	48 000 MW installed capacity produces 130 000G Wh per year (mostly small hydro and biomass, with some geothermal and wind). More than 25 countries have regulatory frameworks for independent power producers.
Residential & Commercial cooking & hot water Transport fuels	220 million households have more efficient biomass stoves. 10 million households have solar hot water systems. 800 000 households have solar cookers. 14 billion litres per year ethanol vehicle fuel is produced from biomass. 180 million people live in countries mandating mixing of ethanol with gasoline.

(Adapted from: Martinot et al, 2002 in Johansson, 2004)

The human cultural aspects and arts of language, crafts, politics, religion are often more appreciated and nurtured. This includes the fine art of manipulating potential donors.

Unsurprisingly, statistics and data in the developing world are problematic. Agricultural products are often bartered; income statistics of the secondary economy are hard to come by. Surveys are infrequent and discontinuous, since small businesses have no incentive to respond to surveys, let alone report their incomes.

While the primary energy source for many millions in the developing world is firewood and biomass, it is increasingly being used unsustainably. The transition to sustainable energies and the simultaneous elimination of material poverty poses a huge challenge to the developing world – and the industrialised world.

It should be stressed that the developing world is not simply a poor man's version of the industrialised world. It is not a world predominantly driven by the belief in the protestant work ethic, entrepreneurship and personal responsibility or by the money value of time. It does not believe that all human issues can ultimately be solved in a technological manner. In general, women are the maintainers of traditional culture values where the weal of the family in the household plays the central role.

In stable communities, the religious grouping or the tribe is often the ultimate reference and authority, while the household with the extended family is the last resort when things fall apart.

The insight that the developing world does not necessarily have to follow down the energy route of the industrialised nations, but can learn from their experience and mistakes, offers a unique opportunity. This is enhanced by the Kyoto Protocol's Clean Development Mechanisms.

Combining the rapid advancement of renewable energy technologies in the industrialised world with the largely untapped renewable energy resources, while building local capacity in the developing world, will demand a concerted effort of both parties.

The neo-colonial treatment meted out by some of the industrialised nations to the developing nations has led to growing bitterness. In this framework the one–sided interpretation of "liberalised

Women in the South

Women carry a physical and metaphorical burden in energy provision. In rural areas, it can mean spending several hours a day collecting fuelwood loads of 20kg or more. In urban areas, it can mean juggling with tight household incomes to buy charcoal or kerosene. Many of these tasks are demanding of both human energy and time, and they disproportionably affect women's health compared to men's. For example, the higher level of lung and eye diseases suffered by women as compared to men are attributed to the longer hours of exposure to smoke in kitchens (Smith, 1999). Fuel collection also reduces the time women have available for contributing to other aspects of livelihood strategies.

Women in the South are also responsible for a number of other survival tasks needed to sustain the household, such as water collection and food processing. Again, many of these tasks are demanding of both human energy and time. Energy interventions, many using renewable energy, are available that would do much to reduce the drudgery involved in these daily household activities. A number of the tasks would easily be served by diesel engines for example; the preparation of many staple root crops takes an hour of vigorous pounding, which could be simply replaced by milling. The renewable energy community needs to play more attention to the promotion of bio-fuels, such as biogas and vegetable oil, as a diesel substitute. The whole issue of women's time and effort saving (that is, the reduction of drudgery) seems not to receive the attention it deserves. Reducing women's drudgery by providing improved access to energy services for lighting, cooking and productive activities should have a significant positive effect on women's education, literacy, nutrition, health, economic opportunities, and involvement in community affairs which, in turn, will benefit all family members.

(Clancy, 2004)

Energy and women in the developing world

Of the 1.3 billion people who live in poverty, 70 % are women; and approximately one third of households in rural areas have female heads. Many of these women are more disadvantaged than men in similar circumstances, for example women's access to and control over resources such as land, cash and credit is more limited than men's. Women's technical skills are often less than men's, for example compared to men, women's reading levels are lower and they have less experience with hardware. This means that when making energy interventions to help people move out of poverty, the ability of women to respond is more restricted than men, and special elements need to be included in projects and programmes to address these gender differences to ensure that anyone who wishes to participate and benefit is not excluded on the grounds of lack of assets.

(Clancy, 2004)

Energy Project Contributes to Women's Empowerment in Kenya

Thirteen women's groups (200 people) have been trained in making stoves in the Rural Stoves West Kenya project, and many have also benefited from business management training. Production is estimated at 11 000 stoves annually; the profit generated by the stoves is comparable to wages in rural areas. As a result, the women potters have gained in status, self-confidence, and financial independence.

(ITDG, 1998 in Clancy 2004)

trade", where powerful nations see themselves as being above the international law, unilaterally abrogate international conventions and regard the world's natural resources as their birthright, has undermined the esteem that the industrialised world used to enjoy. In this vein, the question arises what developmental benefit will remain in the developing oil rich countries once the precious black gold has been exploited. The irony is that these countries happen to have exceptional renewable energy potential.

Fortunately, the governments of a few industrialised nations have taken the lead of the inevitable energy transformation that is likely to bring sustaining benefits to the developing nations. The early birds will not be sorry.

A global race towards renewable energy (RE) has already started. Some nations and some international corporations are positioning themselves to take advantage of the inevitable transition, and of the concomitant new technologies. There is no time to be lost, since the peak of oil production is most likely to occur within the current decade (Heinberg, 2003). The later the transition, the more painful it will be.

The cycle of change in energy technologies has been shown to last about half a century, or two human generations. That is the planning horizon of wise governments. Long-term thinking is what sets the true statesman apart from the mere politician.

In contrast with the private sector, governments think of both the short- and long-term risks and opportunities. It will be shown that the long-term risks of renewable energy policies are significantly lower than policies built on fossil fuels. Since renewable energy technologies have been tested for feasibility in the world markets, and since apposite policies have been tried and tested, the near-term risks of adoption are lower than those of procrastination. Laggards in the transition are not retarded by techno-economic or resource barriers, but by a lack of awareness, information and political vision or will.

Initially, the visible growth of a new energy technology seems imperceptively slow. When it reaches about 16 % market penetration, development happens in leaps and bounds until saturation is reached. By 2030 we can expect to observe renewable energies in the mainstream.

Women's Time and Physical Energy, not Fuelwood, are the Key Needs

A study by Mehretu and Mutambira (1992) measured the time and energy used by different family members in transport connected with regular household activities. Chiduku Communal Area in eastern Zimbabwe is a resource deficient area with a high population density. There is no electricity, and kerosene, which is used only for lighting, is very expensive.

Seven routine trip-generating household activities were considered:

Activity	***Total week's household*** *[kWh]*	***Female share of time*** *[h]*	***Female Contribution*** *[%]*	***Energy*** *[kWh]*
Fetch water	*10.3*	*9.3*	*91*	*2.15*
Do laundry	*1.3*	*1.1*	*89*	*0.26*
Fetch firewood	*4.5*	*4.1*	*91*	*0.92*
Graze livestock	*7.7*	*3.0*	*39*	*1.44*
Water livestock	*6.9*	*2.3*	*39*	*1.28*
Visit local market	*15.0*	*9.5*	*63*	*3.08*
Visit regional market	*0.3*	*0.2*	*61*	*0.07*

(Clancy, 2004)

Kenya Ceramic Jiko (Improved Charcoal Cookstove)

The Kenya Ceramic Jiko (KCJ) is one of the most successful African stove projects. It is made up of a metal cladding with a wide base and a ceramic liner. At least 25 percent of the liner base is perforated with holes of 15mm diameter to form the grate. The stove has three pot rests, two handles, three legs and a door controlling the airflow. The standard model weighs about 6kg, which means it can be carried around easily (KENGO, 1991; Karekezi and Kithyoma, 2002).
This stove is used for cooking and space heating. The KCJ directs 20 to 40 percent of the heat from the fire to the cooking pot, replacing stoves with only 10 - 20 percent efficiency. Open cooking fires, yield efficiencies as low as 10 percent (Kammen, 1995). The cost of the stove is about US$ 2, which makes it accessible to the majority of the urban population in Kenya, although this cost does not include fuel costs (charcoal).
Manufacturing the KCJ is now a relatively mature cottage industry. As expected, the level of specialisation in the manufacture of the stove has increased, as has the level of mechanisation. A division of labour is now discernable. Shauri Moyo is the principal artisan production centre in Nairobi, where there are artisans who purchase clay liners and metal claddings, assemble and retail complete stoves to customers. There are mechanised manufacturers and semi-mechanised producers in Nairobi. It is estimated that mechanised producers are manufacturing close to 3 200 liners a month. Semi-mechanised producers are now producing an estimated 10 600 liners per month.
Based on achievements to date, the KCJ is considered to be a success story. However, there are constraints, with quality control being one. It is estimated that the market penetration in Nairobi is 50 %.
(Karekezi, 2004)

When coal fired steam engines were in general use, the first petrol driven machines were met with ridicule. Powerful vested interests in the established technology tried to influence public opinion and government decision-makers to believe that future will be very much like the present, only more so.

Today, we know that the tide is turning inexorably towards renewable energies. There will be winners and losers, and the major losers will be the ones dominant today.

To the developing nations – too often at the receiving end of global trends – this transition offers unique opportunities.

- Significant population or business growth happens in many parts of the developing world, but relatively low investments have been sunk in infrastructure. Instead of now investing in the technology of the past, developing nations can leapfrog to the application of the most modern renewable energy technologies (RETs). Using cellular telephones instead of expensive and vulnerable old copper wired landlines, illustrates the point. The concept of big centralised coal or gas-fired power stations is likely to be outmoded for the developing world, regardless of what their pundits may say.

- Developing countries stand to benefit from the Kyoto Protocol and Clean Development Mechanism (CDM). It is still too early days to see how this agreement unfolds in reality, but it is to be expected that CDM projects will increase the use of renewable energies. The downside is that governments might hesitate to implement sustainable energy policies for fear of falling prey to the "additionality " clause of CDM.

- Most developing countries are situated in areas with high renewable energy resources, notably wind and solar radiation.
- Solar radiation and other renewable energy resources are more equally distributed than oil, coal, gas or uranium. This means that by transitioning to renewable energy, developing nations are less exposed to imported energy costs. Renewable energies also reduce the pressure on fossil fuels and are therefore less exposed to armed conflicts over scarce resources.

- Developing nations generally have invested little in energy R&D. This represents a disadvantage because patents and royalties have to be paid for. Many contending patents that will shape the next decades have already been developed and registered. But the developing nations do benefit from mature technologies without having contributed to the R&D costs.

The transition to renewable energies has been retarded by the inertia of established systems and by artificial government endorsed market distortions persistently subsidising the fossil and nuclear industries. Today's fossil based energies appear to be cheap because they do not account for the real social, environmental or military costs of these energies. Accounting for these factors would double fossil energy prices in many parts of the world (van Horen, 1996).

Furthermore, governments routinely grant massive direct as well as indirect subsidies through protecting monopolies, granting financial backups, ignoring the value of chemical feed-stocks and the value to future generations.

Where developing nations indulge in nuclear ventures, their costs to the taxpayer always by far exceed public monies invested in sustainable energies. Nuclear energies can never hold their own in free energy markets. Meanwhile, the serious accidents of Three Mile Island and Chernobyl have happened in supposedly sophisticated countries, where levels of technological and safety awareness are said to be higher than in developing countries - not to mention the risks of terrorism and unresolved problems with decommissioning and spent fuel storage. The insurance of such venture is not carried by private insurance companies, but by the unsuspecting citizens.

Nuclear hydrogen production used to be proffered as a future possibility. However, less expensive methods through renewables have been found.

It seems that nuclear not only has a bad press but also has rather limited justification in the developing world where it is unsuitable for rural energisation. Rural energization is linked to poverty eradication, the major priority of the developing world.

A combination of energy conservation, energy efficiency and renewable energies presents a much more environmentally, socially and economically sustainable energy path in the developing world.

Why it is Essential to Transform the Developing World Energy Systems Now

The key drivers of the transformation in the developing world are poverty eradication, risk avoidance and protecting of natural life supporting systems. These concerns are shared with the industrialised world, but the priorities differ radically. In the developing world the most pressing issue of poverty overshadows other considerations.

Energy and poverty

Improved access to clean modern energy in developing countries is a fundamental step to poverty reduction and key to attaining the United Nations Millennium Development Goals. About 2.4 billion people, notably in rural areas of Asia and Africa, depend on traditional biomass in the form of firewood, charcoal, harvest residues and dung used for cooking and heating.

About 35 % of the energy typically derives from these sources. In parts of Africa, it reaches 90 %. As a rule, this biomass is burned with low efficiencies of only 10 to 15 %, while high levels of indoor pollution from open fires lead to health problems of the persons exposed, mostly women, children and the elderly.

According to the World Health Organization, air pollutants and emissions from burning biomass and coal cause the death of 1.6 million people annually, significantly more than the number of deaths ascribed to malaria.

Women, who have to bear the household chores of firewood gathering, forfeit the opportunity of education and the potential of gainful employment. Better education of women and higher household incomes are powerful factors in stabilising the number of children born into the poverty trap.

The unsustainable use of firewood is a contributing factor to desertification, which again accelerates the downward poverty spiral.

Poverty in rural areas hampers access to electricity that is associated with modern communication and information technology. It also constrains the productive application of energy, especially in the secondary and tertiary value adding sectors.

Renewable energy has been demonstrated to deliver clean, sustainable and cost-effective energy services, providing a necessary - albeit insufficient - base for poverty reduction and development.

A rapid and sustained transformation to energy efficiency and renewable energy is an absolutely essential stabilising step towards development and the improvement of the quality of life.

Risk reduction

Conventional energies and systems have associated risks. These may relate to price volatility, economic and socio-political instability, insecurity, development and technical failure.

Most developing nations are coal and oil importers, exposed to the volatility of markets. The risk of price volatility to macro-economies is considerable and can destabilise whole regions (Awerbuch, 2003).

There are currently no reasons to believe that the prospects for lower oil price volatilities and prices are auspicious. Therefore, developing countries producing their own renewable fuels are better buffered.

In addition, imported fossil fuels (or nuclear energies) entail money flows leaving the country. A primary reason for the national debt of developing countries is attributable to imported fuels, which

Large Cardamon

Researchers at The Energy and Resources Institute (TERI), New Delhi, have now perfected an entirely new way of drying and curing the spicy Large Cardamom cash crop. Presently, over 250 systems could be found in the fields of Sikkim. Used widely in India as a main spice ingredient in Mughal cuisine and other non-vegetarian dishes throughout the country, large cardamom is currently priced around Rs 70 000 a ton. Pakistan, Afghanistan and the middle east are the main export markets.

The traditionally, popular large cardamom curing techniques result in inordinate amounts of wastes of both raw material and fuelwood. An estimated 20 000 metric tonnes of fuelwood is wasted every year for drying large cardamom in Sikkim alone, owing to the primitive curing technique, which involves burning of big logs of wet wood in traditional 'bhatti' – brickwork or masonry ovens – and passing the resulting smoke through a thick bed of cardamom placed on a mesh structure made of bamboo lattice. Apart from consuming large amounts of fuel wood, the traditional technique results in non-uniform drying, leading to poor quality cardamom that has a charred and smoky appearance, low oil content, and burnt smell. Besides, the primitive smoking method, the risk of raw material catching fire is high, as flame control is very poor.

The results of this new technique are astounding:

Rich natural colour (reddish) to the fruit, 35 % more oil content, absolutely no burnt smell, large batches, and an incredible 50 - 60 % saving of the fuelwood. Using similar low cost gasifier-based systems for thermal applications in rural agro-based industries like ginger, tobacco, cashew, can go a long way in alleviating the problem of rapid deforestation caused by inefficient use of fuelwood. It can also create additional income in these sectors.

(Karekezi, 2004)

effectively amounts to job opportunity losses to the national economy. Unemployment deepens poverty and often adds to social and political instability.

Those developing nations that are rich in fossil energy resources have often made the bitter experience that their national security is at risk. Political and military interventions by powerful interests present an undeniable threat to smaller nations, and to world peace. Reducing dependency on regionally concentrated oil reserves represents a contribution towards reducing the risk of local and global armed conflicts. Ironically, such armed conflicts are extremely energy intensive and eventually have to be paid for.

Conventional centralized power stations, especially nuclear power stations, transmission lines and substations present the risk of easy targets to terrorism. Developing nations are not immune to such attacks. Distributed energy generation through renewable energy is practically invulnerable, since potential targets are distributed, small, modular and easily replaced.

Many dispersed renewable energy power producers not only reduce the risk of terrorism but also ensure buy-in of numerous small-scale stakeholders who directly benefit from feeding energy into the grid.

This reduces the risk of NIMBY (Not In My Back-Yard) or BANANA (Build Absolutely Nothing Anywhere Near Anything) objections to independent power producers. Where local farmers, cooperatives and individuals are encouraged to feed renewable energy into the grid, local resistance is much reduced. Mini PV power stations on consumers' roofs do not expose utilities to the risk of prolonged, acrimonious and very costly land acquisition and approval procedures.

While many developing nations may have aspired to the "ideal" of the nineteenth century technical approach of the electricity grid, the dramatic blackouts in the United States on 14 August 2003 made people aware of the risks involved. Within about 150 minutes five key transmission lines, three coal-fired power plants, nine nuclear power plants, and an important switching station, were not functioning. Eventually over 100 power plants (including 22 nuclear) in the US and Canada were off line. No less than 50 million Americans and Canadians were without power, leaving a wake of US$ 5-6 billion damage. An investment of US$ 6 billion in renewable energy would not only have avoided the loss, but also would probably have put the US on the map as a renewable energy nation. Barely one month later it was Italy's turn, leaving 58 million Italians without power. Both the USA and Italy are highly industrialised countries with excellent renewable energy resources. Technical failures of prolonged blackouts and brownouts are commonplace in the developing world, adding an element of frustration and risk to grid power users and potential investors.

Protection of natural life supporting systems

Subsistence and commercial agriculture, as well as (eco)tourism are the economic life-blood of most developing countries.

According to the world's most knowledgeable scientists of the Intergovernmental Panel on Climate Change (IPCC), the bulk of global warming of the last 50 years is attributed to human activities and is strongly fossil energy related.

The impact of climate change on agriculture, tourism, health (tropical diseases) will be more severe in developing countries than on the rest of the world. This was illustrated by the recent floods highlighting how rising water levels and sudden climate events can take developing countries by surprise. Such climate changes will cause large-scale uprooting and migration of entire regions' populations.

While of the worst global polluters situated in the northern hemisphere might even benefit from a warmer climate, they will find themselves swamped by climate fugitives who literally have nothing to lose.

The long phase delay of the global climate system conceals its insidious nature. By the time the voting citizens realise the irreversible impact of climate change, it is much too late for political action. Therefore the precautionary "no regrets" principle imposes an obligation on governments to act without delay. It is not inconceivable that neglecting this obligation today may lead to litigation in future.

Government policy opportunities

Developing countries enjoy unique policy opportunities of using the Kyoto Protocol and the growing global energy awareness to implement their own developmental and security of supply agendas.

The Kyoto Protocol officially came into force on 16 February 2005. It is designed as a mechanism, which can help industrialised nations to achieve their agreed Greenhouse Gas (GHG) reduction targets by buying into relatively cheaper carbon reduction initiatives in the developing world, thereby also making a contribution to much needed development.
It is not intended to replace Development Aid of Direct Foreign Investment. A Designated National Authority (DNA) has to be appointed by the host country to ensure that the Clean Development Mechanism (CDMs) does satisfy the national sustainable development criteria. Local Non-Government Organisations (NGOs) normally play a crucial role in representing civil society's voice. An important further aspect is the "Additionality" condition, stating that it must be shown that the project is additional, meaning it would not have happened without CDM support. However, the understanding is that this clause should not discourage developing nations from introducing renewable energy policies. The current phase needs to be renewed in 2012, and the expectation is that the scope will have to be enlarged if it is to make a significant impact. While there is presently not much experience to learn from, it seems that transaction costs are high. This initiative has the potential to become a major driver of change towards renewable energy and energy efficiency.

As *energy awareness* increases, people become more discerning buyers of energy consuming products. The fuel consumption of motor vehicles illustrates the point: Energy efficient vehicles successfully take market share from gas-guzzlers.

Energy labelling of appliances, motors and even buildings contributes to lowering the national energy intensity, and hence improves the international competitiveness of those proactive nations. Governments have an opportunity to enhance their international competitiveness by introducing mandatory CO_2 ratings on energy consuming systems. This improves efficiency while ensuring the national growth of work opportunities.

The production of all commodities and consumables, from bricks to tomatoes, requires energy. This is called the *embodied energy* content. Products that are made energy efficiently, using locally produced renewable energy, or recycled materials obviously contribute to the national energy stability and economic growth.

The prices of conventional fuels do not tell the truth, because they do not reflect the *"external" costs.* These are the long- and short-term health costs, environmental costs and lost opportunity costs borne by all society, whether they benefit from the energy consumption or not. Currently we choose to ignore this real cost. Ironically, a society that could put men on the moon contended that external costs are too difficult to calculate. Governments have an opportunity to establish and update the externality costs of conventional energies. If the true external costs are included in fossil fuel prices on a net present cost basis, then even more renewable energy technologies are cost competitive than the current ones.

For governments in the developing world there is a distinctive advantage in having objective *baseline* figures of external costs, including carbon dioxide equivalent emissions, as this greatly expedites CDM procedures.

The above instrument can be used to enhance the *national security of energy supply* through renewables.

Energy efficiency improvements

In the near future, the amount of primary energy required for a given energy service could be cost-effectively reduced by 25 to 35 percent in industrialised countries (the higher figure being achievable by more effective policies). In transitional economies, reductions of more than 40 percent will be cost-effectively achievable. And in most developing countries – which tend to have high economic growth and old capital and vehicle stocks – the cost-effective improvement potential ranges from 30 to more than 45 percent, relative to energy efficiencies achieved with existing capital stock. However, when this potential is made use of there will still remain 20 to 40 percent in 20 years time due to technological progress.
(Johansson et al, 2004)

Renewable Energy Resources: Technology Status and their Sustainable Potential

This section provides an overview of renewable energy technology options and their potential contribution to energy sustainability, as well as their impacts. The German Advisory Council of Global Change (WBGU 2004) recently published a detailed global analysis, which is used in the following:

Hydropower

Worldwide, about 45 000 large dams have been built for electricity generation, flood protection, water storage, agricultural irrigation, navigable waterways and recreation. As a result of economies of scale, approximately 97 % of hydroelectric plants have a capacity in excess of 10 MW.

The potential in the industrialised world has mostly been utilized, delivering 19 % of the world's electricity and the lion's share of today's commercial renewable energy. This constitutes about one third of the global potential of 150 EJ, whilst the remainder is untapped in the developing world, mainly South America, Asia and Africa.

Strategic Principles in the Construction of Dams

1. Gaining Public Acceptance
Wide public acceptance of key decisions is imperative for equitable and sustainable water and energy resources development.

2. Comprehensive Options Assessment
Alternatives to dams do often exist. Needs for water, food and energy should be assessed and objectives clearly defined. Furthermore assessments should involve a transparent and participatory process, applying economic, social and ecological criteria.

3. Addressing Existing Dams
Opportunities exist to improve existing dams, address remaining social issues and strengthen environmental and restoration measures.

4. Sustainable Rivers and Livelihoods
Understanding, protecting and restoring ecosystems is important to protect the welfare of all species and foster equitable human development.

5. Recognising Entitlements and Sharing Benefits
Negotiations with adversely affected communities can result in mutually agreed and legally enforceable mitigation and development provisions. However, affected people need to be among the first to benefit from the project.

6. Ensuring Compliance
Public trust and confidence requires that the governments, developers, regulators and operators meet all commitments made for the planning, implementation and operation of dams.

7. Sharing Rivers for Peace, Development and Security
Dams with a trans-boundary impact require constructive cooperation and good faith negotiation among riparian states.

(World Commission on Dams, 2000 in Johansson et al, 2004)

Hydroelectric technology is mature and extremely reliable, but requires very high initial investments, with low maintenance cost. Its design life is more than a century. Natural and pumped storage dams are suitable for peak electricity demand. Hydropower is cheap – if calculated in the conventional manner.

Unfortunately, large dams do have negative side effects: Land and ecosystems are lost, drainage systems and sedimentation are radically altered. Annually, 0.5 - 1 % of capacity is lost through siltation, which is also lost downstream, impacting significantly on its biodiversity and estuary stability. Organic material, rotting in shallow reservoirs of warm regions, releases GHGs. Modern dams have a failure rate of 0.5 %, excluding the effects of climate change, war and terrorism. In warm climate areas, dams lead to a tenfold increase in bilharziosis. Other increased health risks are malaria, encephalitis, Rift Valley fever, filariosis, blue-green algae and mercury leachate poisoning.

Other renewable energy sources producing the same energy output, like wind and solar energy, would cover less land than the Assuan Dam in Egypt.

During the last century, 30 - 80 million people were adversely affected by large dams. More than 1.1 million people will be evicted by the Three Gorges Dam in China. Awareness of the social and ecological risks of large dams and the political resistance to them has increased. The World Commission on Dams (WCD 2000) highlights the sustainability problems and preconditions.

Dams with a capacity of less than 10 MW are considered to be less precarious. Given the above considerations, the current hydropower could be increased sustainably by 12 EJ/a by 2030 and 15 EJ/a by 2100 (WBGU 2004).

Bioenergy

Only one percent of the radiation falling on plants is used in photosynthesis. Yet, this is the basis of the food chain on earth and the enormous source of bioenergy.

A major part of the developing world survives on freely collected traditional bioenergy in the form of firewood, harvest residues and dung. This is a far cry from the sustainable use of modern bioenergy technologies like biodiesel, bioethelene, wood pellets, municipal and industrial waste gas, biogas, methane and energy crop agriculture.

Of the global potential land area, deserts (19 %) and sloped land areas steeper than 30° (11 %) as well as agricultural land (12.5 %) must be excluded. This effectively leaves 322 million hectares (2.5 %), yielding 6 - 7 t/a dry weight on average (WBGU: 60).

The sustainable potential is about 100 EJ/a, of which 40 % would come from wood, and 36 % from energy crops. A notable 38 % of the global potential is already being utilized. (Table 3.2.9 WBGU: 60)

Biomass is being used unsustainably when consumption is higher than the natural replacement rate. In Asia the non-sustainable use is 20 %, in Africa 30 %, and in Latin America 10 %. This destroys forests, degrades soils, reduces biodiversity and harms watercourses, the destruction of which impacts on natural life-supporting systems, including human existence.

Indoor air pollution from open fires causes intolerable health effects on about half the world population, mostly women and children. About 1.6 million die annually. For every child that dies as a result of air pollution in Europe 270 die in Southern Africa.

The global longer-term production potential of traditional biomass is estimated at 5 EJ/a.

Potential Energy Savings in Developing Countries from Improved Cookstoves

	Rural household bioenergy use [Mtoe]	Efficiency Improvements [%]	Energy savings [Mtoe]	Maximum fuel-wood savings [Mtoe]
China	198	20-30	40-59	180
India	168	20-35	34-59	178
Latin America	28	10-40	3-12	36
Africa	116	30-40	35-46	141

(IEA, 2001 in Karekezi, 2004)

Biomass-based Power Generation in Developing Countries

	1995	2010	2020
China			
Biomass-based power generation (TWh)	-	0.4	0.7
% of total electricity generation	-	1.7 %	1.8 %
Biomass used in power generation (Mtoe)	-	0.1	0.2
East Asia			
Biomass-based power generation (TWh)	0.3	0.6	1.5
% of total electricity generations	0.0 %	0.0 %	0.1 %
biomass used in power generation (Mtoe)	0.3	0.7	1.7
South Africa			
Biomass-based power generation (TWh)	-	4.6	7.3
% of total electricity generation	-	0.4 %	0.4 %
Biomass used in power generation (Mtoe)	-	2.0	3.1
Latin America			
Biomass-based power generation (TWh)	9.6	13.1	17.1
% of total electricity generation	1.2 %	0.9 %	0.8 %
Biomass used in power generation (Mtoe)	3.3	4.5	5.8
Africa			
Biomass-based power generation (TWh)	0.3	0.6	0.6
% of total electricity generation	0.1 %	0.1 %	0.1 %
Biomass used in power generation (Mtoe)	0.4	0.8	0.8
Total developing countries			
Biomass-based power generation (TWh)	10.2	19.3	27.1
% of total electricity generation	0.3 %	0.3 %	0.3 %
Biomass used in power generation (Mtoe)	4.0	8.1	11.7

(IEA, 1998 in Karekezi, 2004)

Electricity production from biomass

Bagasse is the by-product from sugarcane crushing; It corresponds to around 30 % (in weight, 50 % wet, LHV=1 800 kcal/kg) of sugarcane. This is used for cogeneration (thermal/electric energy) in the sugar/alcohol mill. Because bagasse production is high (for an average Brazilian production of 300 million tonnes of sugarcane, 90 million tonnes of bagasse are produced), its use has always been inefficient. Low-pressure (20 bar) boilers and low efficiency steam turbines are common in most Brazilian mills. Also, both thermal and electric energy consumption in the sugar/alcohol process are high: Around 500 kg of steam (at 2.5 bar) and 15 - 20 kWh of electricity per tonne of crushed cane.

Until the end of the 1990s there was no interest from the owners of sugar mills in selling surplus electricity generation to the grid. Local utilities also did not consider this option seriously. Despite the commercial availability of more efficient cogeneration systems, cultural aspects and the lack of an institutional framework hampered implementation. Today the situation in Brazil has changed. The Brazilian Development Bank (BNDES) launched a programme, allowing special credits for biomass power plants selling electricity to utilities or engage in its direct commercialisation, encouraging the introduction of more efficient technologies.

In the interlinked system, the energy sector's reformulation process, conceived at Federal level, has accorded special status to renewable energy sources. A recently approved Federal Law 10438/02 creates incentives for alternative electricity generation (PROINFA - Programa de Incentivo a Fontes Alternativas).

The PROINFA plan is divided into two phases. In the first two-year phase, long-term contracts (of 15 years) are supposed to be made over 3 300 MW by the Eletrobrás (Holding of the Brazilian Power System). The fixed amount is supposed to be achieved equally by the following energy sources: wind power, small hydropower projects and biomass. Acquisition of this energy will be defined by the economical value for each specific technology. This value is set by the Ministry of Mines and Energy, but has to represent at least 80 % of the average national tariff to the end user.

After the first 3 300 MW, the second phase will begin. A programme is designed so that the wind energy, small hydropower and biomass will achieve 10 % of the Brazilian power production. This goal is aimed to be reached within the next 20 years, as in the first phase with contracts over 15 years. The price of the purchased energy is determined by the economic value of the reference competing energy source, defined by the average costs of owner production by new hydropower projects with an installed capacity over 30 MW and new gas power stations. Again, the Ministry of Mines and Energy determines the price. The regulation of the PROINFA has been established in December 2003, and presents some inconsistent points, such as the definition of the economical value and environmental issues. (Coelho et al, 2003)

In Argentina there is a similar programme, which aims at a target of 8 % renewable energy in the national mix by 2013. It includes wind, solar, geothermal, tidal, small hydro (up to 15 MW) and biomass. (Salvatori, 2003)
(Karekezi, 2004)

Wind energy

In the developing world, very good wind sites are found in the Southern tip of Latin America, with good coastal sites elsewhere. Many wind sites in the developing countries have not been assessed. In some cases weather stations' data are unreliable as a result of surrounding urbanisation, or lack of calibration.

Small wind speed differences make a very big difference because the energy contained in the wind increases with the cube of the wind speed. A maximum of about 59 % of the energy can be extracted (Betz number). For this reason, good wind sites are important, and this has contributed to the interest in offshore wind parks. Modern horizontal axis machines have thin aeroplane type blades whose tips are moving faster than wind speed. The nacelle contains the generator, with some designs needing no gearbox. Their mean rated capacity has grown within three decades from 30kW to 3MW, with 5MW units in the offing. Owing to wind fluctuations, the average annual output is 20 - 25 % of the rated power on land sites, and 30 % offshore. Operating wind speeds are from 3 - 25m/s, and the average service life is twenty years.

Other, more familiar, branches of wind energy technology are the American windmill and small-scale wind chargers. The former has enabled agricultural activities, wild life conservation and human habitation in many areas of the developing world.

The footprint land-use of this technology is minimal since the land can be used for agriculture, often providing welcome local incomes. Modern turbines have already greatly reduced noise pollution, which is less than traffic noise. The impact on birds has been studied extensively, and is significantly less than that of existing transmission lines and motorised traffic. Opponents have objected to the visual intrusion of large scale moving objects in the landscape. Shadows and reflections have also been regarded as visual interference.

Even under current distorted market conditions, wind generated electricity is cost competitive in many areas and its energy payback period is short. Despite a stagnant phase of the world economy, the wind industry showed very strong growth.

Of the global technical wind energy potential (1 000 EJ) about 140 EJ may be sustainable.

Solar energy

In contrast with the previous technologies, direct solar energy is regarded as being practically unlimited. It is also abundant in the developing world, where its distributed nature is a bonus, given the underdeveloped state of the service infrastructure and man-made energy distribution networks.

Concentrated solar heat (CSH)

The largest existing centralized systems use parabolic troughs that focus sunlight onto evacuated glass tubes carrying the heat to conventional steam turbines via a heat exchanger. They produce cheaper centralised power than photovoltaic systems (PV). Other variants directly generate steam in the focal pipes. Another variant uses flat mirrors in a Fresnel arrangement, focussing sunlight on passive absorber units. Yet another has static primary troughs with mobile secondary reflectors achieving very high solar concentration ratios. All these systems are eminently suitable for combined heat and power generation (CHP) and take advantage of the established mass market of the conventional steam cycle. Supplementary power can be provided by gas or, preferably, by any suitable renewable energy.

Parabolic dish power plants

Parabolic dishes track the sun and focus the radiation on, say, a sterling engine that drives a pump or generator. Most current units are stand-alone systems of 10 kW nominal capacity. This capacity represents a useful size for remote rural applications and farms. Currently, units cannot yet be bought off the shelf.

Solar power towers

An extensive field of three-dimensionally movable mirrors (heliostats) concentrates solar radiation onto a central receiver situated on top of a tower. There the heat exchange medium (air, water, salt) is heated to 500 - 1 000 °C, driving a gas turbine or combined cycle plant. Molten salt is envisaged as a heat storage medium in some cases. Typical grid-connected units would be 200 MW_e.

Solar chimneys/Green Towers

A large greenhouse surrounding a high chimney heats air that moves up the chimney, driving a wind turbine at the base.

In the Green Tower variant the greenhouse doubles up as an agriculturally productive unit. Thermal storage enables 24-hour energy delivery. The units would be 200 MW_e, grid-connected.

Photovoltaics

Photovoltaic (PV) cells make up modules, are placed in arrays and convert sunlight into direct current electricity without any moving parts. The semiconductor materials are encapsulated and sealed hermetically. A long service life of more than 25 years and usually equal warranty periods make this modern technology increasingly attractive. With suitable electronics, PV systems can be grid-connected or stand-alone, where they can also be used for water pumping or other mechanical work. A storage battery is normally optional for grid-connected systems, but is a necessity for stand-alone systems that need autonomy. No battery is required for water pumping and other daytime work.

PV arrays do not emit vibrations, noises and pollutants during their operation. This means they can be integrated into new and existing buildings, which then become energy exporters instead of consumers.

PV cells are made of silicon, the second most abundant material on earth. However, scarce indium and tellurium are used in some cells. In sunny developing countries the embodied energy payback period is 18 months – an extremely short time in view of its proven service life.

It is relatively easy to add PV units to an existing system, as demand grows (high modularity).

The fact that PV systems are not cost-competitive with subsidised grid electricity has lead some developing countries to introduce stand-alone PV systems, also called solar home systems (SHS) in impoverished remote rural areas where system maintenance and social acceptance must be expected to be problematic. By contrast, excellent market penetration is being achieved internationally in grid-connected applications of less sunny countries, where government policy provides an enabling environment. In the developing world with frequent grid brownouts and blackouts, PV uninterrupted power systems (UPS) make sense.

Solar Water Heating

In developing countries, water heating constitutes 30 - 40 % of the household energy consumption. In most cases, this is achieved by inefficient wood fires, gas or fossil fuel generated electricity. Instantaneous ("push through") water heaters are more efficient, but add considerable peaks to the municipal distribution system. Many electrical storage heaters in developing countries have high annual energy standing losses in excess of 25 %. Such poor performance is tolerated where energy prices are cheap or subsidised, where there is no energy labelling, or where users do not pay for the value of hot water.

Solar Water Heaters (SWHs) normally consist of a collector and a water storage unit. There are various established types:

Unglazed collectors consist of simple black plastic absorbers through which water flows, driven by a thermosyphon or a circulation pump. In low temperature applications of swimming pools, agricultural applications and space heating, such systems achieve high efficiencies of 70 % for low temperature rises at low cost. Unglazed collectors can also be used for night cooling.

Glazed flat plate collectors have a slightly lower efficiencies than unglazed collectors at low temperature, but with higher temperature differences between the inlet and outlet temperatures, they perform significantly better. If the collector surface is treated with a selective coating, radiation losses are reduced. The average nominal efficiency of collectors is 67 %.

Evacuated tube collectors are collectors with an outer glass mantle maintaining a vacuum. The inner collector may be a single blackened tube containing the heated medium (wet tube), two tubes (feed and return) or an adjustable selective fin with a heat pipe. Evacuated tubes can reach the boiling point of water and have almost constant efficiencies of 67 % across all temperature differences between inlet and outlet temperatures.

General

Direct or open loop glazed flat plate systems can be used in thermosyphon, pumped and integral units. With direct systems the water in the collector and the storage unit is the same. This is cheaper, but may cause frost, corrosion and scaling problems, unless suitable precautions are taken.

In indirect systems a closed fluid loop circulates through the collector, preventing frost, clogging and erosion, but its initial capital cost is higher.

With solar combi systems the services of domestic hot water and space heating are rolled into one. This innovation reduces the need for summer backup water heating, but this is not yet established in the developing world.

All water heaters, including solar water heaters, require maintenance of varying degrees.

The technology is mature and standards are available, yet conventional plumbers may not be familiar with them.

Although the availability of piped hot water is often thought to be a low priority in low-income households, the hygiene implications should not be underestimated. Clean hot water for clothes washing and food preparation can hardly be classed as luxuries.

Geothermal

Underground heat below 100 °C can be used for water and space heating purposes. At higher temperatures steam can be used to generate electricity, but considerable waste heat streams occur. Alternatively, cold water can be pumped into hot rocks or into deep mines, whence it returns as hot water. Where steam or hot water emerges naturally, the used water should be returned, since it often contains CO_2 and other contaminants. Some of these technologies are under development.

Another approach uses near-surface heat through heat pumps, whose technology is mature. These systems should have a Coefficient of Performance (COP) of at least 3.6 if coal fired electricity is used in order to make up for the energy transformation losses. In addition, the environmental impact of extracting/adding heat to the environment should be considered carefully. The global geothermal potential is estimated at 30 EJ/a.

Solar cooling

A high cooling load triggered the peak demand problem in California. The space cooling demand grows as income levels and comfort demands increase, and is compounded by global warming and urbanization. It is not unusual that fairly inefficient air conditioners are used to cool thermally inefficient buildings. Many scenarios postulate that the developing nations will follow the same route.

Solar space cooling would offer the attraction of the maximum cooling demand coinciding with the maximum solar radiation. Regrettably, the technology is underdeveloped. Solar cooling for food and medicine would satisfy an urgent need in hot and tropical countries. **Cooling of food** and **medicines** requires little energy, but has a significant impact. A heat pump must reject heat to the environment. Therefore the machine must be driven at a higher temperature than the ambient temperature (the condensers of fridges emit heat). If the same heat pump is used for heating, then there is no heat rejection. Therefore, cooling by one degree Kelvin requires about three times more energy than heating by one degree Kelvin.

Modern Biofuel Use in the Latin America Transportation Sector

Examples of the use of biofuels for transportation sector in Latin America Countries can be found in Brazil (with the alcohol programme) and in Argentina (with the biodiesel programme). Brazil's alcohol programme has recorded notable successes.

The Brazil programme was initiated in 1975 with the purpose of reducing oil imports by producing ethanol from sugarcane. It now delivers significant environmental, economic and social benefits. It has become the leading biomass energy programme in the world. Ethanol is used in cars as an octane enhancer and oxygenated additive to gasoline (blended in a portion of 20 to 26 % anhydrite ethanol in a mixture called gasohol), or in dedicated hydrated engines. Since 1999, the Brazilian government eliminated control on prices, and hydrated ethanol is sold for 60 to 70 percent of the price of gasohol at the pump station, due to significant reductions in production costs. These results show the long-term economic competitiveness of ethanol fuel when compared to gasoline (Goldemberg et al, 2002).

The world leader on alcohol production continues to be Brazil, where alcohol prices are competitive, and the development of the new flexible fuel cars (FF) promotes greater ethanol use by providing flexibility to consumers. Ethanol has made a valuable contribution to the development of the country's agro-industry. Moreover, the increased use of alcohol as a transport fuel appears to have contributed to the reduction of air pollution in mega-cities such as Sao Paulo (Coelho, 2003).

The Brazilian initiative experienced ups and downs as a result of the world oil and sugar markets. This seems to indicate that it would be prudent to diversify the alcohol feedstock into non-food producing plants. According to the Bariloche Foundation, there are four biodiesel plants in Argentina using sunflower, cotton and soybean as feedstock (www.bariloche.com.ar/fb).

A Federal Law in Columbia requires the addition of 10 % of ethanol to standard gasoline. By 2006, the seven largest cities in Colombia are expected to switch to gasohol. Gasohol fuel will be introduced in other cities of the country in tandem with the development of sugar-alcohol agro-industry. About 700 million litres of ethanol will be required per year, corresponding to 150 thousand hectares of sugarcane crops (Campuzano, 2003).
(After Karekezi, 2004)

Solar in Buildings

From cradle to the grave, buildings are responsible for a significant proportion of the international energy consumption and peak demand. The procurement of raw materials, production of building materials, transport, cutting to size, placement, maintenance, demolishment and recycling all consume energy. Some building materials/components are inordinately energy intensive, like aluminium, plastics, cement and clay products. Other materials like wood, thatch and earth are environmentally and energy-wise more neutral.

Buildings are energy consumers with longer life cycles than most power stations. Edifices constructed up to two thousand years ago are still in use today. The energy and maintenance cost incurred during a building's life are many times more than the initial erection costs.

With the advent of artificially cheap, fossil generated electricity in the developed world, architects started designing environmentally questionable buildings that had to be made habitable by mechanical and lighting engineers. They found these interesting and lucrative business opportunities. There was neither chance nor incentive for the engineering fraternity to enlighten the architects because the professional fee structure and the professional risk minimization both reward over-design of artificial lighting and air conditioning plant, instead of rewarding energy efficiency and the use of renewable energy.

This way of designing prestigious buildings was transferred to the developing world, symbolising progress and modernity. Consequently, we find the same inappropriate building design from the sub-artic to the tropical regions.

Traditional rural houses in warm and cold regions incorporate the climatic building knowledge of generations.

These buildings require a minimum of energy over their life cycles.

Town planning and industrialization mind-sets of the previous century led to energy intensive urban settlements with ineluctable long-term fossil fuel driven commuting built in.

Today, building tradesmen and energy intensive building materials are transported to remote building sites to erect buildings that are cheap to build but expensive to run. The problem is deepened through the landlord-tenant dilemma, where the tenant suffers the consequences of energy-inefficient buildings.

Informal or illegal settlements like shantytowns or favelas typically have buildings of poor thermal performance. Residents resort to highly polluting wood, coal, dung fires, or stolen electricity. Such “non-technical losses” also add to high electrical peak demand problems. Curitiba in Brazil has demonstrated attractive and energy efficient alternatives.

Solar water heaters and combi systems, combining water and space heating can reduce the national peak electricity demand by 18 %. The resultant GHG saving is substantial.

Using renewable energy and energy efficiency in buildings is techno-economically feasible, and significantly cheaper than building new power stations. New glazing and insulation materials are entering the market. Daylighting produces less unwanted internal heat than most electric lighting. The unwanted reject heat of inefficient appliances and machines like printers and photocopiers has to be removed by air conditioners in office buildings in warm climates. Town planning and integrated resource planning offers great opportunities, especially in countries with underdeveloped infrastructures.

Transport

Worldwide, few nations produce their own transport fuels. This has significant impacts on national economies, notably in the developing world. In principle, one can focus on the improvement of current vehicle technologies, development of new technologies, harnessing of information technology, mode switching and spatial planning.

Improvement of current vehicle technologies through more efficient drive technologies is a standard planning strategy of all European motor-vehicle manufacturers (optimised combustion, ceramic components, refined ignition, valve management, turbo chargers). A further enhancement of 50 % is considered techno-economically feasible. Reductions of mass and rolling resistance may produce CO_2 reduction of 6 % and 1 % respectively. Some of these technology gains may be lost by a snap-back, in that people would be

Ethanol Production in Africa

In Africa, ethanol production from maize crops, called SATMAR, was undertaken in South Africa during the 1940s. Sasol’s coal-to-synfuel production, later, superseded this production. Experimental biodiesel production from sunflower seeds by the SA Department of Agricultural Engineering was not followed up.

Large-scale ethanol production has also been implemented in Zimbabwe, Malawi and Kenya, countries that do not have indigenous oil reserves and rely on oil imports. Ethanol production in Zimbabwe started in 1980 at Triangle Ltd, a sugar company located in the north-eastern Zimbabwe with an annual production capacity of 40 million litres. On commissioning, the blending target of ethanol/gasoline for the country was 15:85. But by 1993, the blending ratio stood at 12:88. The ethanol production programme has contributed significantly to the Zimbabwean economy. Benefits include reduced gasoline imports by about 40 million litres, increased incomes of about 150 cane farmers and availability of a market for molasses, which was formerly a waste product (Scurlock et al, 1991b; Hall et al, 1993)

In Malawi, the Ethanol Company Limited (ETHCO) is the sole producer and distributor of ethanol. Commissioned in 1982, ETHCO has a distillery capacity of 17 million litres annually, producing 13 million litres a year. Originally, it was mandatory for all the gasoline used in the country to be blended with ethanol. In 1993, the blending ratio was 15:85. However, this ratio has not maintained due to differences between ETHCO and the oil industry concerning acceptable market shares and pricing of ethanol in relation to imported gasoline. Available evidence demonstrates that the plant has helped to reduce use of scarce convertible currency revenues on oil imports and assisted in solving the sugar company problem of safe disposal of molasses, which was previously a hazard to the environment (Kafumba, 1994; Gielink, 1991).

Kenya’s interest in ethanol was spurred by the oil crisis in the early 1970s, when the country was keen to exploit locally available energy sources. Consequently, the Agro-Chemical and Food Cooperation (ACFC) was established in 1978, with the objective to utilise the surplus molasses. Located in Murohoni, near three sugar factories, ACFC had an installed capacity of 60 000 litres a day with a daily average output of 45 000 litres. The target blending ratio was 10:90. The plant created both direct and indirect employment for about 1 200 people. In addition, it partially reduced dependence on imported fuel supplies. Major challenges that have faced the programme include drought and poor infrastructure, affecting yield and transportation of the cane to processing points. Above all, lack of government commitment and absence of clear-cut production, blending and marketing policies eventually led to the cessation of ethanol use for transportation purposes (Omondi, 1991; Kyalo, 1992; Okwatch, 1994; Baraka, 1991).

(Karekezi & Ranja, 1997; Karekezi, 2002 in Karekezi, 2004)

inclined to drive more kilometres because the costs per kilometre have been lowered.

Development of new technologies is evident in hybrid drives and batteries already appearing on the market, potentially doubling the fuel efficiency. These are important stepping-stones to the full fuel cell technology.

Fuel cell vehicles will reduce emissions by nearly 100 %. Hydrogen produced by renewables is the ultimate goal. The current production of hydrogen is energy intensive.

Natural gas is a cleaner fuel than coal, petrol and diesel. This just might buffer a transition to sustainability. Leaking gas pipes may be more than a mere theoretical risk in the developing world. Harnessing of information technology has already produced better traffic flows and can also enhance goods handling logistics. There is the chance that better traffic efficiency will lead to an increase of road traffic.

Effective mode switching and integration should lead to a higher market share of the more energy efficient rail mode, as a national policy. Spatial planning and modern settlement planning offers opportunities to pedestrianise use bicycles, efficient public transport, densification and mixed land-use.

Summary

The technologies of hydropower, sugar cane ethylene, landfill gas, passive solar building design, solar water heating, wood pellets and wind energy have been demonstrated to be cost competitive, even with the current skewed market. Concentrating solar power, tidal wave and ocean power, green tower, biodiesel and innovative renewable energy driven vehicles are in intermediate development stages. The renewable energy based hydrogen technology is still under development. Photovoltaics are cost competitive in rural areas, but the largest current market penetration and growth is in urban grid-connected applications. Building integrated PV (BIPV) offers opportunities of Balance of System (BOS) cost reductions.
Global renewable energy resources are practically inexhaustible. While current techno-economics are generally less of a constraint than socio-political issues, it is expected that the eventual resource limitation of some technologies, together with environmental considerations may lead to ceilings of renewable energy technologies, except solar energy and, perhaps, ocean energy which are unlimited for all practical purposes.

National and International Drivers of Renewable Energy Application: Setting National Targets within Global Guard Rails

Poverty alleviation through renewable energy jobs

Reducing poverty and unemployment are high priorities in the developing world. It is beyond dispute that the rising tide of renewable energies offers more new work opportunities than the fossil and nuclear technologies. The full implications of this fact still have to be realised by the developing nations.

By definition, developing nations have underdeveloped energy infrastructures, offering a golden opportunity to create new sustainable jobs in the modern renewable energies technologies, rather than investing in sunset technologies or accepting cheap discarded technologies from the developed world.

Potentially, creating jobs in new renewable energy infrastructure in the developing world can be combined with the Clean Development Mechanism of the Kyoto Protocol.

Locally manufactured water heaters create low capital and low risk work opportunities, with the greater job creation opportunities being situated in the business side of selling, installing and servicing SWHs. Jobs in manufacturing SWHs are costlier and less secure. Main barriers to higher market penetration in the developing world are lacking awareness of policy makers, plumbers and end users; lack of trained installers/service craftsmen; lack of national standards/test facilities, and lack of means to overcome the initial cost barrier.

CDM financing at US$5/ton CO_2 would reduce the cost by only 10 %, which seems disappointingly little. Replacing conventional all-electrical geysers with combi SWHs would typically reduce the national peak demand by 18 %. Since SWHs are cheaper than building new highly mechanised generation capacity, it is in the national economic interest to implement this least cost job creating option.

Ironically, the best-publicised examples of renewable energy job creation come from the developed world where natural resource conditions are less favourable. In Germany about 40 000 new renewable energy electricity jobs have been created in only 12 years to 2002, while the nuclear industry supplying 30 % of that country's electricity only employed 38 000 people. Germany expects to create 250 000 to 350 000 new renewable energy jobs by 2050.

In the US the potential employment of 300 000 people by 2025 in PV alone is comparable to major computer industries like Dell Computer of Sun Microsystems.

If the US State of Wisconsin bought fossil fuel energy it would be forfeiting 45 000 local jobs – a severe blow to the state economy. By producing local renewable energy, 2.5 US cents kWh would be ploughed back.

With each direct new job that is created, there is an economic multiplier that reflects the induced spin-off by indirect jobs created. A study by the US Department of energy revealed that a 10 MW_p PV fabrication plant near San Francisco would produce a multiplier effect of 500 %. These multipliers also bring regional developmental benefits as well as tax incomes to state coffers.

If South Africa generated just 15 % of the total electricity use in 2020 by using renewable energy technologies, it would create 36 400 direct jobs, without taking any work away from the coal-based electricity industry.

Over 1.2 million direct and indirect new jobs would be generated, if a portion of South Africa's total energy needs, including fuels, were sourced with renewable energy technologies by 2020.

Summary of direct and indirect jobs from renewable sources in 2020

Technology		Direct Jobs	Indirect Jobs	Total Jobs
Solar thermal	*(10 % of target)*	*8 288*	*24 864*	*33 152*
Solar Photovoltaic	*(0.5 % of target)*	*2 475*	*7 425*	*9 900*
Wind	*(50 % of target)*	*22 400*	*67 200*	*89 600*
Biomass	*(30 % of target)*	*1 308*	*3 924*	*5 232*
Landfill	*(5 % of target)*	*1 902*	*5 706*	*7 608*
Biogas *Where 150 000 residential biogas digesters are installed in rural areas*		*1 150*	*2 850*	*4 000*
Solar Water Heaters *Includes the manufacture and installation of the equivalent of a 2.8 m² solar water heater on each house in the country*		*118 400*	*236 800*	*355 200*
Biofuels *Includes 15 % ethanol and diesel substitution*		*350 000*	*350 000*	*700 000*
TOTAL		***505 923***	***698 769***	***1 204 692***

(Banks & Douglas, 2005)

New energy infrastructure

Developing nations may soon find that renewable energy powered Distributed Generation (DG) and Combined Heat and Power (CHP) Plants Cogeneration create local jobs, are environmentally more benign, and are not dependant on the weaknesses (maintenance, theft, sabotage, terrorism, political manipulation) of a centralised generation system with a network that becomes prohibitively expensive as it moves into remote rural areas.

The typical energy conversion chain losses of conventional systems (from mined coal to water heated by an electric storage geyser) are significant: only about 10 % of the coal's original energy ends up in the hot water as useful energy. With conventional incandescent lighting the useful percentage may be less than 2 % in light energy service. All the rest is pollution in the form of ash, SO_x, NO_x, CO_2 and other greenhouse gases, as well as reject heat.

Distributed generation plant can be built in smaller increments, closely following the demand profile. By contrast, this is impossible with conventional power plants, which come in big chunks, tying down big chunks of capital, long before it is actually needed. National resources that have not been sunk in useless surplus generation capacity can be used for much-needed development programmes.

By developing DG in rural areas it is possible to start secondary industries in rural areas, thereby assisting beneficiation, adding value to local products and creating local jobs. This, in turn, may stem the tide of rural depopulation and urban squatters – both serious social issues with developing nations.

DG systems generate heat and power at, or close to, the point of consumption and are much more efficient than the old centralised fossil-fired power plants because they use the electricity as well as the heat that is normally rejected at fossil plants. They also reduce line losses dramatically. These line losses typically range from 10 % to as much as 50 %, not counting "non-technical losses" (euphemism for power theft).

This concept aims to adapt available modern technology of distributed generation to the needs of the developing nations instead of trying to convince developing nations to buy ready-made western world technology models. In this way, renewable energy contributes towards sustainable development and the democratisation of power in both senses of the word.

Solar Enterprise Zones (Nicklas, 1998) integrate technical, social and environmental benefits. Such Solar Enterprise Zones start with Distributed Generation Systems, and then link these by mini-grids, which eventually are interlinked with national or regional networks, adding diversity of supply.

Cogeneration in Mauritius

The Mauritanian experience in cogeneration is a success story in Africa. Through extensive use of cogeneration in Mauritius, the country's sugar industry is self-sufficient in electricity and sells excess power to the national grid. In 1998, almost 25 % of the country's electricity was generated largely using bagasse, a by-product of the sugar industry (Deepchand, 2001). By 2002, electricity generation from sugar estates stood at 40 % (half of it from bagasse) of the total electricity demand in the country (Veragoo, 2003).

Government support and involvement has enabled the development of a cogeneration programme in Mauritius. The Sugar Sector Package Deal Act (1985) was enacted to encourage the production of bagasse for the generation of electricity, while the Sugar Industry Efficiency Act (1988) provided tax incentives for investments in electricity generation, and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritanian Government abolished the sugar export duty, which served as an additional incentive to the industry. A year later, foreign exchange controls were removed and the consolidation of the sugar industry was accelerated. These measures have resulted in the steady growth of bagasse-based electricity in the country's electricity sector.

This has reduced dependence on imported oil, enhanced diversification in electricity generation and improved efficiency in the power sector in general. Using a wide variety of innovative revenue sharing measures, the cogeneration industry has worked closely with the Government of Mauritius, ensuring that substantial benefits flow to all key stakeholders of the sugar economy, including the poor smallholder sugar farmer. The equitable revenue sharing policies of Mauritius may provide a model for ongoing and planned modern biomass energy projects in Africa.
(Veragoo, 2003; Deepchand, 2001 in Karekezi, 2004)

National Renewable Energy Targets within Global Guard Rails

Responsible governments consider our common future - and have a strong hand in shaping it.

A sign of good leadership is the gift of setting inspiring long-term goals. These determine the framework, challenging the best national forces to come forward. Targets must be sufficiently demanding to justify long-term commitments of entrepreneurial person power, resources and money by industry and academia. They must also be of such duration as to allow the educational and bureaucracy systems to adapt.

It seems that in the past many developing nations were inclined towards centralist, rather than decentralised decision-making models. This tended to go along with centralist government utility monopolies that were forced to deliver electrical power at non-sustainable prices, serving political expediency. Inevitably, ends did not meet and corners were cut, leading to brownouts and blackouts at great national costs.

Interestingly, the alternative model of radical market liberalisation and privatisation forced down the throat of many developing nations, while initially producing cheaper energy and discouraging end-user frugality, did not seem to fare much better in the long run. It is not the panacea.

International organisations with energy agendas	
The Global Environmental Facility (GEF)	*The GEF (through implementing agencies) operates more than 100 programmes for the promotion of energy production and consumption from RE (backed by private sector development and sometimes by energy sector reform), mainly with a domestic scope. Projects do not address issues such as taxation, subsidies or trade law on a global scale.*
The UN system	*The Un Regional Economic Commissions play an important capacity building role in the respective regions (e.g. United Nations Economic Commission for Europe (UNECE) or the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). Globally, the United Nations Development Programme (UNDP) is an important actor (cf. the Global Network on Energy for sustainable Development, the UNDP Initiative for Sustainable Energy (UNISE), and the World Energy Assessment. Many other specialised UN agencies have addressed* *RE within their niche (for example the United Nations Department of Economic and Social Affairs (UNDESA), the World Health Organisation (WHO), the United Nations Educational, Scientific and Cultural Organisation (UNESCO), and the Food and Agriculture Organisation of the United Nations (FAO)). UNDESA has developed RE projects in the context of Agenda 21, and signed an agreement with e7, founded by global electricity companies, and dedicated to develop rural energy. The Commission on Sustainable Development (CSD) includes energy as a major component of its work plan for the coming years. The recently established Global Village Energy Partnership (GVEP) focuses on access to modern energy services by the poor. The UN considered energy as one of five key areas for particular focus ("WEHAB"): Water, Energy, Health, Agriculture and Biodiversity) for the Johannesburg World Summit on Sustainable Development (WSSD).*
The World Summit on Sustainable Development (WSSD) and its Plan of Implementation (and the Resulting "type II" partnerships)	*The WSSD Plan of Implementation, while not binding, is the international instrument with the most extensive references to renewable energy and energy efficiency yet produced by the world community. It focuses on development, implementation, technology transfer and rapid commercialisation of RE. It sees energy as key to the eradication of world poverty, and to change of unsustainable consumption and production patterns. An example of a governmental initiative coming out of WSSD is the Johannesburg Renewable Energy Coalition. More than 20 type II (public-private) partnerships are active in RE, for example the Renewable Energy and Energy Efficiency Partnership (REEEP). Another multi-stakeholder organisation is the International Sustainable Energy Organisation (ISEO).*
Non-Governmental Organisations (NGOs)	*The NGO community ranges from green advocates (most environmental NGOs have a work programme on energy and climate change), to NGOs focusing specifically on energy, to consumer interest groups. Examples are the International Solar Energy Society, the World Energy Council, the World Council for Renewable Energies, the World Wind Energy Association, the International Network for Sustainable Energy. Some charitable foundations also support RE activities.*
The research community	*This group includes a wide variety of actors, ranging from fundamental research at universities to applied research to technology development specifically for commercial purposes.*
The private sector	*Individual companies involved in energy supply (utilities, increasingly working in more than one country), technology supply and research and development (R&D), but also groups such as industry associations (e.g. Eurelectric) and the World Business Council on Sustainable Development.*

(After Steiner et al, 2004)

Global guard rails for sustainable energy policy

Socio-economic guard rails

- *Access to advanced energy for all*
  It is essential to ensure that everyone has access to advanced energy. This involves ensuring access to electricity, and substituting health-endangering biomass use by advanced fuels.
- *Meeting the individual minimum requirement for advanced energy*
  The Council considers the following final energy quantities to be the minimum requirements for elementary individual needs: By the year 2020 at the latest, everyone should have at least 550 kWh final energy per person and year, and by 2050 at least 700 kWh. By 2100 the level should reach 1 000 kWh.*
- *Limiting the proportion of income expended for energy*
  Poor households should not need to spend more than one tenth of their income to meet elementary individual energy requirements.
- *Minimum Macroeconomic development*
  To meet the macroeconomic minimum per-capita energy requirement (for energy services utilised indirectly) all countries should be able to develop a per-capita gross domestic product of at least about US$ 3 000, in 1999 values.
- *Keeping risks within a normal range*
  A sustainable energy system needs to build upon technologies whose operation remains within the "normal range" of environmental risk. Nuclear energy fails to meet this requirement, particularly because of its intolerable accident risks and unresolved waste management, but also because of the risks of proliferation and terrorism.
- *Preventing disease caused by energy use*
  Indoor air pollution resulting from the burning of biomass, and air pollution in towns and cities resulting from the use of fossil energy sources causes severe damage worldwide. The overall health impact caused by this should, in all WHO regions, not exceed 0.5 per cent of the total health impact in each region (measured in DALYs = disability adjusted life years).

Ecological guard rails

- *Climate protection*
  A rate of temperature change exceeding 0.2 °C (0.2 K) per decade, and a mean global temperature rise of more than 2 °C (2 K) compared to pre-industrial levels are intolerable parameters of global climate change.
- *Sustainable use*
  10 - 20 per cent of the global land surface should be reserved for nature conservation. Not more than 3 per cent should be used for bioenergy crops or terrestrial CO_2 sequestration. As a fundamental matter of principle, natural ecosystems should not be converted to bioenergy cultivation. Where conflicts arise between different types of land use, food security must have priority.
- *Protection of rivers and their catchment area*
  In the same vein as terrestrial areas, about 10 - 20 % of riverine ecosystems, including their catchment areas, should be reserved for nature conservation. This is one reason why hydroelectricity – after necessary framework conditions have been met (investment in research, institutions, capacity building, etc.) – can only be expanded to a limited extent.
- *Protection of marine ecosystems*
  It is in the view of the Council that the use of the oceans to sequester carbon is not tolerable, because the ecological damage can be major, and knowledge about biological consequences is too fragmentary.
- *Prevention of athmospheric air pollution*
  Critical levels of air pollution are not tolerable. As a preliminary quantitative guard rail, it could be determined that pollution levels should nowhere be higher than they are today in the European Union, even though the situation there is not yet satisfactory for all types of pollutants. A final guard rail would need to be defined and implemented by national environmental standards and multilateral environmental agreements.

(WBGU, 2004)

* Comment: This may be on the high side for warm Latin American Countries, if improved energy efficiency is accounted for

The international context: Global Guard Rails

National targets are not set in a vacuum, but are informed by the international context.

The German Advisory Council on Global Change (WBGU) produced a comprehensive report "World in Transition – Towards Sustainable Energy Systems" (2004), introducing the innovative concept of Guard Rails bounding the paths towards global energy sustainability. "Guard Rails" are those levels of damage, which can only be crossed at intolerable cost, so that even short-term utility gains cannot compensate for such damage. There are six economic and five ecological guard rails. These are readily understood (see box).

Global guard rails are not goals. They represent minimum requirements that need to be met if the principle of sustainability is to be adhered to.

A test run demonstrates that turning energy systems towards sustainability is technically and economically feasible.

Independently of the WBGU, Donald W Aitken, PhD, of the Union of Concerned Scientists (2005) comes to the same conclusion.

His suggested pace is 10/20/50 % of renewable primary energy by 2010/20/30. This has also been corroborated by the European Renewable Energy Council, stating that renewable energy could supply even 50 % of the global energy by 2040. (www.erec-renewables.org)

Key findings of the WBGU study are:

- The transition will only work with intensified capital and technology transfer from industrialised to developing countries. Market maturity of renewable energy (RE) and energy efficiency (EE) needs to be accelerated in the industrialised countries for instance, through raising and redirecting R&D resources, demonstration and implementation strategies. This aims to reduce the entrance barriers to all, especially the developing nations.

- Worldwide cooperation and convergence of living standards are likely to facilitate rapid technology development and dissemination.

- Binding CO_2 reduction commitments are a prerequisite.

- Further GHG reduction policies by other sectors (e.g. NO_x and NH_4 from agriculture) are required.

- 450ppm of CO_2 may not be sufficient for climate stabilisation, and should not be taken as a safe stabilisation level.

- An alternative reduction path by fossil and nuclear energy entails substantially higher risks and environmental impacts, and is more costly, mainly because of CO_2 sequestration costs.

- In a system with a long time lag, the next two decades offer a rapidly closing window of opportunity. Procrastinating will cost disproportionately much more and cause more social, political, economic and environmental problems. We can only guess what irreversible damage the current decision-makers will have to answer for.

- The currently most cost-effective technologies like wind and biomass have to be used to the hilt in the short and medium term.

- Efficient use of fossil fuels is part of the transition, in particular the efficient use of natural gas.

- A certain amount of carbon sequestration in geological caverns will be necessary during this century.

A roadmap with goals and policy options for the transformation highlights the following

- Eradicating energy poverty and establishing minimum global supply,

- Establishing a new World Bank policy to integrate energy in poverty reduction strategies as well as strengthening regional development banks,

- Promoting socio-economic development,

- Combining regulatory and private sector initiatives,

- Protecting natural life-supporting systems. This means reduced global CO_2 emissions by at least 30 % from 1990 levels by 2050. For industrialised nations this entails a reduction of 80 %, while developing and newly industrialised countries' emissions should rise by no more than 30 %,

- Improving energy productivity (GDP to energy input ratio) of initially 1.4 % annually improvements is required, followed by 1.6 %, to reach triple current productivity by 2050 from 1990 levels. This requires international standards of fossil-fuelled power stations, and 20 % renewable energy based electricity in the EU by 2012; mandatory labelling; phased-out non-renewable energy subsidies and primary energy targets for buildings,

- Expanding renewable energy substantially from the current 12.7 % to 20 % by 2020, and

- Phasing out nuclear by 2050, with stricter monitoring of all sites.

Land availability for Food and Fuel

The availability of land for the production of biomass in developing countries is determined by the demand on land for food production. With increasing population, food production and consumption in developing regions is expected to increase (FAO, 1995). Estimates by the Response Strategies Working Group of the IPCC indicate that the use of land for food production in developing regions (Asia, Africa and Latin America) will increase by 50 % by the year 2005 (IPCC, 1996). In addition, the demand for biomass energy is also expected to increase with population increase. Estimates by the WEC indicate that by 2100, about 1 700 million hectares of additional land will be needed for agriculture, while about 690 - 1 350 million hectares of additional land would be needed to support biomass energy requirements (UNDP, 2000). The challenge, therefore, is sustainable biomass supply to meet growing energy demand, without taking up land for food production. Some of the options for avoiding the competition for land between food and fuel are: increasing food production on current agricultural lands; the establishment of large tree plantations and, the use of modern forestry practices (IPPC, 1996).

(Sudha & Ravindranath, 1999 in Karekezi, 2004)

International actor organisations in RE

Intergovernmental organisations, whose primary activity is energy related	*Examples include the International Energy Agency (IEA, affiliated with the OECD), the Organizacion Latinoamericana d' Energia (OLADE) and the energy Charter Conference and Treaty. On the one hand, these organisations have expertise, a governmental support base, and in some case the authority to make binding rules. On the other hand, membership of most of these organisations is limited geographically or otherwise (though their activities and studies undoubtedly influence also non-members), and none have RE as a main focus.*
The World Bank Group (including the International Finance Corporation), and the Regional Development Banks	*These are significant players, with an important RE impact in developing countries. They finance a significant number of RE projects throughout the world, ranging from technological assistance to energy sector reform, sometimes with private sector co-financing. A well-known project of the International Bank for Reconstruction and Development (IBRD) is ESMAP (Energy Sector Management Assistance Programme), promoting an environmentally responsible role of energy in poverty reduction and economic growth.*
Regional organisations	*Examples include the European Union (EU), the Association of Southeast Asian Nations (ASEAN), the Southern African Development Community (SADC), and Asia-Pacific Economic Cooperation (APEC).*

(Steiner et al, 2004)

Policies to Accelerate the Application of Renewable Energy Resources in Developing Countries

Our current global and national energy situation is the result of past energy policies and subsidies that largely persist into the present. Fossil fuel and nuclear prices are not the result of free market mechanisms, nor do they reflect their true costs.

Energy users benefiting from current cheap energy prices typically do not bear the cost and consequences of externalities and modern warfare.

Such market distortions built up serious and pervading barriers to renewables. Further cost barriers lie in their relatively higher capital cost, import duties, current lack of economies of scale, lack of access to affordable credit, selective punitive grid connection costs, lack of standards, and lack of training and awareness.

In developing countries the barrier of perceived investor risk is even higher due to political, regulatory and market stability uncertainties.

In addition, well-intended donor projects, inconsistent short-term government interventions, poor technology and maintenance, and unrealistic promises of universal grid access have also distorted markets for renewables in many developing countries.

Policies and measures have to cope with these realities and must not only overcome the barriers, but also provide an enabling environment for the sustained growth of renewable energies. Such an enabling environment entails the conditions of the macro-level national market, the meso-level energy market and the micro-level sustainable energy market.

Each supra-system sets the boundary conditions for its sub-systems. For example the legal, political, financial, infrastructural, bureaucratic and economic macro-economic supra-framework determines the boundary conditions to a national energy market sub-system. In turn, the national energy market sets the boundary conditions to its sub-system, the sustainable energy market. Conversely, each sub-system feeds its supra-system with resources, energy and information.

It follows that an intervention at only one level working in only one direction (either only bottom-up or top-down) is doomed to failure. The developing world bears witness to many well-intended local bottom-up NGO-driven grassroots project failures, and as many abandoned top-down government-driven restructuring programmes – often advised by international interests. Countries that are transforming successfully have enabling policies at many levels (IIEC). A sustainable renewable energy market prospers when there is not only a renewable energy push from the supply side, but also a demand pull from the energy consumers' side. Sawin (2004) prepared an authoritative paper on lessons learned.

Lessons learned

Before discussion details of policies, it should be noted that there is a substantial body of knowledge that has been accumulated by the world leaders in renewable energy. Developing nations can profit from that experience by ad justing it to their own local contexts.

- **Long-term commitment, targets and consistency**

The renewable energy transition does not happen automatically once a policy has been formulated. Experience has shown that considerable, consistent interventions of all types into energy markets were needed before meaningful renewable energy results started to be in evidence.

There are several case studies in the developed and developing world illustrating the harmful effect of on-again-off-again renewable energy policies. The US Production Tax Credit has been allowed to expire several times, creating cycles of boom and bust. This sent ripple effects of worker lay-offs and loss of institutional memory down the system. Potential investors tend to shun such uncertainties (Gipe, 1998).

In India, conflicting and inconsistent state policies, aggravated by state electricity board regulations, delayed renewables development (CSE, 2002).

By way of contrast, Germany has learned to develop more consistent policies. These were rewarded with remarkable market development, in spite of less auspicious environmental and world economy conditions. Consistent policies foster domestic industries and job growth. This, in turn, contributes to political stability and to the national economy. Consistent policies are also cheaper to administer. Both savings eventually accrue to stakeholders in the national economy.

With the globalization of the economy, investors have a large choice where to be involved. They invariably buy where they perceive long-term stability and consistent government policies.

For developing countries that are often perceived to be politically less than stable, the important lesson is to counteract this reputation by unequivocal, firm policy commitments.

- **Good laws and consistent enforcement**

Good intentions are not good enough. The effectiveness of positive interventions depends on whether they are taken seriously. If a developing nation does not have the political will and capacity to implement them, then the best policy models are of no value. Therefore, renewable energy policies should be easy to understand and implement, otherwise they will harm more than help. While there is a certain degree of agreement on the desirability of sustainable energies, the individual means of moving toward that goal are legion.

■ Develop reliable, predictable market conditions

Denmark, Germany, Japan, Spain, and Brazil have demonstrated that the secret to steady and meaningful renewable energy price reductions lies in the creation of transparent and steady markets. Under such conditions, small and medium enterprises can afford to enter the arena. These enterprises provide the core of employment, and invest in significant research and development. They also represent the drivers that lower the domestic price-learning curve, which may differ from international markets.

■ Redress market failures

Energy markets never have been fully open or competitive. “Liberalizing the national energy market” as propagated by some quarters, is often a way of selling national assets to larger international players. Typically, the result has been a temporary drop in energy prices until the surplus generating capacity was eroded, while “sweating the assets”. Then system collapses or price shocks threaten – not to mention the local work places lost – a clear sign of market failure. At that late stage, government has to intervene to control the damage – often in a crisis management mode.

Renewable energy supportive policies are not only justified because of social and environmental benefits, but also to redress other market distortions favouring fossils and nuclear in the past century.

■ Renewable Energy Feed-in (pricing) systems most successful

To date, feed-in policies have achieved the greatest market penetrations of renewable energy, produced the most cost-effective renewable energy, established local industries, built domestic markets, created work places, and attracted small and big private investors as well as bankers.

By contrast, quota systems have been more volatile, tending to boom and bust markets where foreign industries, backed by steady policies in their home countries, have an edge over the locals. Quota systems could not achieve cheaper energy prices.

■ Feed-in systems most suitable for developing countries

While quota systems demand intricate tendering procedures and are not immune to corruption, feed-in systems are characterized by simple, transparent and cost-effective procedures most suitable for developing countries. These transparent systems effectively combat the reputation of political instability and fraud that developing countries often have to contend with.

Policy mechanisms

There are five categories of relevant policy mechanisms.

1. **Regulations governing market/electric grid access and quotas mandating capacity/generation**
2. **Financial interventions and incentives**
3. **Industry standards, planning permits and building regulations (codes)**
4. **Education and information dissemination**
5. **Public ownership and stakeholder involvement**

These will now be considered in more detail.

1. Regulations governing market/electric grid access and quotas mandating capacity/generation

Preferential access to the grid is as important as initial incentives to the introduction of renewables. There are two general types of regulatory policies for grid access: One mandates the price, the other mandates quotas.

1.1 Feed-in tariffs or pricing systems

According to the feed-in law, electricity grid operators (or utilities) are obligated to accept electricity generated by renewable energy, and pay fixed minimum tariffs (prices). Prices are related to the specific renewable energy production costs that generally are higher than current fossil fuel generated power.

Prices are differentiated according to technology, size and location. This avoids that only the currently cheapest technology (e.g. wind energy) is promoted. It also prevents that only certain areas (e.g. sunshine belts) are developed. Finally, it also encourages equitable access to all investors, ranging from the poor single parent household with PV on the roof, to the multi megawatt offshore wind farm developer.

Payments are guaranteed over typically twenty years, declining annually, and are adjusted bi-annually to new entrants. The declining price reflects the price-learning curve, keeping industry on their toes. This attracts long-term investors and also encourages participants to join early – a decisive developmental consideration.

Utilities also qualify for the grid-feeder prices.

There is a standard contract between the grid-feeder and the grid distributors, who then simply distribute the extra cost over all national end users.

This pricing system is in use in many countries including Denmark, Germany, Spain, Austria, Portugal, Greece, France, Ireland, South Korea, Brazil, Czech Republic and is in the process of being implemented in a modified form in China.

By far the best renewable energy market successes have been achieved where pricing systems are in place. Pricing systems did not take off where the duration of contracts was too short, the tariffs were too unattractive, the site conditions were too restrictive or the connecting charges were exorbitant.

"Net metering" or "reverse metering" is a variant of the above, whereby excess renewable power is fed into the grid at the going retail price, which is less than the renewable energy feed-in prices. In some cases, producers receive payment for each kilowatt-hour, in others they are only paid up to the point where their production equals consumption.

Understandably, the net metering system without other financial incentives, does not suffice for significant market penetration, and could be considered a transitional phase to the full grid-feeder pricing system. Japan, Thailand, Canada and many US States use net metering.

If the system peak demand coincides with the maximum production of grid-connected PV systems, for example, it would be more attractive to base net metering tariffs on time-of-use.

1.2 *Quotas - mandating capacity/generation*

This is the reverse of pricing systems. Instead of government fixing the price, it fixes the target and trusts that the market will determine the price. A government may mandate a minimum share (quota) of capacity or energy to come from renewables. This mandate can be placed on producers, distributors or end consumers.

Quotas can be applied to grid-connected and off-grid electricity, as well as other renewable energies like biofuels or solar thermal energy. Compared to the feed-in system, there is relatively less experience with electricity quotas, and none in the developing world.

There are two variants for electricity generation: obligation/certificate/Renewable Portfolio Standards (RPS) systems and tendering systems. The RPS system is used in 13 US States whereby generators are obligated to produce a target (quota) of renewable energy-based electricity, either leaving the choice of technology to the producer or by prescribing specific renewable energy technology shares. Producers receive credits "Green Certificates (CERTs)", "Green Labels" or "Green Energy Credits (RECs)" for the renewable energy produced. Credits have to be verified independently and may be tradable or sellable to even out deficits/surpluses of obligations. If a producer does not meet his obligation at the end of the period, he has to pay a penalty. This leaves the option to the producer of either producing the green power or of paying the penalty, if this costs less. He can also choose to go out of business at the end of the period. Governments will only see what happened at the end of the period.

With the tendering system, government sets targets as well as a maximum electricity price. Tenderers (bidders) submit offers for these contracts. The abandoned Non-Fossil Fuel Obligation (NFFO) of the UK was such a system. Governments may set separate tenders for various renewable energy technologies, if they do not wish to propagate an energy monoculture. Normally, tenders are assigned from the lowest one upwards until the quota is filled. Government subsidises the difference between the market reference and the winning tender. Both RPS and tender systems are of shorter duration than the typical twenty-year pricing system. Quota systems are in use in Japan, the UK, Italy and Australia.

1.3 *Discussion of systems*

Some of the discussions about the pricing and quota systems seem to be more of an ideological nature, with capitalistic-minded protagonists punting for the quota system in the belief that the market is the final arbiter, while socio-environmentally orientated ones tend towards the pricing (grid-feeder) system, in the belief that the market fails to recognise the common good. Developing nations cannot always afford the luxury of such debates. The question is rather what fits and what works in the real world.

1.3.1 *Renewable energy capacity and generation*

Seen from the government perspective, it appears that prices are determined with pricing systems, while energy output is said to be uncertain. Conversely, quotas are determined with quota systems while prices are said to be uncertain. To governments of developing nations, steady energy prices are more important than precisely achieving predetermined renewable energy quotas at a predetermined date. In addition, policies can be adjusted if governments wish to adjust the pace of renewable energy market transformation through a pricing system.

With quota systems there is a risk that the politically determined pace of renewable energy introduction might be grossly unrelated to the techno-economic state of the technology in a given country.

Fact is, that countries with pricing systems have regularly outperformed the national targets.
Furthermore, governments are not the only participants in the energy game. National and international investors, developers and entrepreneurs are needed in the developed, and even more so in the developing world. These people remain in business because they understand how to assess risks. Pricing systems are less risky to entrepreneurs than quota systems. Since the developing world tends to have poor risk ratings, it makes sense to opt for a system that is also favoured by developers and investors.
Even in developed countries this is the case. While more than 45 countries built wind turbines – some in very good wind regimes – during the 1990s, just three of these, with pricing systems (Germany, Denmark, Spain) accounted for nearly two thirds of the new additions during the decade. After the introduction of the price system in 1994, Spain raced to the second position in world ranking by 2002.
Interestingly, PV was not as successful in Spain, although the grid-feeder law was similar to Germany's, but major barriers of utility grid-connections and an obstructive law demanding PV owners to register as generating businesses added enough bureaucracy to stymie progress. Likewise, onerous building approval procedures, turbine spacing rules and capacity ceilings hampered development in France.

1.3.2 Innovation, domestic industries and benefits accrued

It has repeatedly been argued that price systems discourage innovation and competitiveness. In reality it appears that, once companies achieve a level of income, they start investing in R&D to enhance their competitive edge and increase profits, thereby furthering radical innovation. This happens at no cost to government – that is the taxpayer.
Under quota systems, the surplus – if any - tends to accrue to the end-user, with the producer not having sufficient margin to invest in the uncertain future inherent in the quota and tender systems.
Even worse, overseas companies that have grown strong on pricing systems at their home base, compete successfully in foreign countries with quota systems.
The transaction costs and stop-and-go nature of quota systems discourage the establishment of national industries and limit the growth of jobs within the country.
Of the persons working in wind energy worldwide, approximately 75 % live in the EU, and about half are in Germany.

1.3.3 Geographic and ownership equity

Under quota systems the cheapest projects dominate, gravitating to the geographic areas where the cheapest renewable energy sources and renewable energy technologies are available. It also tends towards the momentarily most cost effective technology, leaving other potentially better future technologies under-capitalised.
The RPS also favour large, capital-intensive companies who can afford to manipulate the market in order to eliminate smaller competitors.
These are serious issues in developing countries with weak and nascent industries.
The price system does not have these disadvantages. The Netherlands started a voluntary quota system, but soon found that the lion's share of contracts went to foreign bidders, and stopped the system. The fact that pricing laws lower the market entry barriers to small producers, while at the same time welcoming large investors, is of immense interest to developing countries wishing to attract foreign investors while fostering the smaller domestic industries.
Pricing laws also enhance the participation of local farmers and communities. This grows local ownership and buy-in, while reducing the NIMBY syndrome.

1.3.4 Technology and diversity and diversity of supply

Because quota systems focus on the cheapest technology, there is little or no diversity of energy supply. This implies that learning curves of other technologies remain static. It also means that a nation is exposed to vagaries of the climate. An over-reliance on wind energy may entail a serious risk if there happens to be a poor wind year. Similarly, an over-exposure to hydropower bears great risks, as has repeatedly been illustrated in a number of cases with African hydropower schemes. This exposure is increasing with the effects of climate change in the developing world. There is not enough experience with diversified quota systems to justify their use by developing nations.

1.3.5 Costs, prices and competition

In theory one would expect a lack of competition and higher energy prices with the feed-in law system. However, in real life the economies of scale and the better predictability of the market led developers to invest in R&D, enhancing competitiveness and cost reductions. In addition, the declining tariffs of the feed-in law ensure lowering electricity prices. Several studies confirmed this: a BET-study estimates

that the extra cost to German electricity consumers attributable to the pricing law was only 0.11 €cent/kWh in 2000, and is predicted to be only 0.19 €cent/kWh in a decade if the renewables share doubles (Lackmann, 2003).
This amounts to € 8 annually per household (EoG, 2003). A third study (Uh, 2003 & 2004) estimates the additional costs at 0.25 € cent/kWh in 2001. These are figures that disappear in the noise. Environment Daily (2003) analysts find that feed-in renewables are cheaper than those produced by quota or green-certificate systems. Nitsch et al (2001/02) present evidence that national initiatives like the feed-in law reduce prices more rapidly through the national learning curves. This encourages local manufacturing, competition and secondary business. It also avoids the need for a plethora of subsidies, e.g. in agriculture. By spreading the costs over all national electricity consumers, the light burden is carried equitably.
The rapid reductions of bid prices ascribed to the quota system (from US$ 0.189/kWh to US$ 0.043/kWh [Wiser et al, 2000]) must, in part, be ascribed to the feed-in policies in other countries were costs were driven down by R&D (Moore & Ihle, 1999) and in part, because the NFFO conditions were improved, including longer project periods (Kleiburg, 2003). Also, using the NFFO bids as a gauge may be misleading because many bids never materialised, either because of local resistance, or bidders found projects less attractive as more detail emerged.
Quota systems tend to reduce participation to a limited number of players, which can lead to cartels and abuse of market power (Epey, 2000). Quota-based systems are not inherently cheaper, nor are pricing systems inherently more costly (Sawin, 2004:13). A more recent comparison by Cambridge University (Butler and Neuhoff, 2004) in the wind energy sector between the UK quota system with the German pricing system (RE feed-in law) - allowing for the better wind regime in the UK - conclusively found the German prices to be lower.

1.3.6 Financial security

Under the pricing system, the long-term certainty resulting from guaranteed prices (typically 20 years) causes companies to invest in technology R&D, to train staff, and maintain resources and services with a longer-term perspective. This in turn makes it more attractive to financiers. For example, in Germany banks lobbied the Bundestag for a continuation of the pricing laws in 2000.
By contrast, quota systems harbour political and procedural uncertainties. The stop-go renewable energy politics of many countries are disruptive to industry and unnerve potential investors. Preparing tenders adds an element of risk and cost that many potential developers cannot afford (Menanteau et al, 2003). This is of great concern in developing countries where the local industries are underdeveloped and often cannot compete with established global players in a capital-intensive environment. The fact that government officials in developing countries are often challenged by tender procedures, exposes local bidders and developers to additional uncertainty.
Certificates can fluctuate significantly with the volatility of the marketplace, the stock market or the vicissitudes of weather conditions. Adding floor and ceiling prices to certificates may help to stabilize prices (Meyer, 2003). But then, this means moving towards the pricing system. It also increases the complexity and cost of the system.
In summary, it appears that pricing systems provide greater security than quota systems, particularly in developing countries, because there is greater doubt about future markets in renewable energy certificates (Frost, 2003). Targets set under the quota system are too dependent on political stability, adding to the perceived and real investor hazard in developing countries. With pricing systems the future price and terms are known.

1.3.7 Ease of implementation

Pricing laws are easy to administer and enforce, and they are highly transparent. For obvious reasons, this is absolutely crucial to developing nations. In Germany, independent research institutes facilitated the setting of tariffs for each renewable energy technology and their future decrements over time. Government only has to oversee the process.
Under the quota system, the requirements are much more demanding. First, realistic target have to be established. This requires detailed market surveys, renewable energy resource assessments, future energy demand and price analyses and scenario planning. Developing nations typically do not have the data, expertise, resources and time for these exercises.
The risk of setting the quota target too low is that local economies of scale will not be attained, meaning that national industries never reach critical mass. Jobs are lost and the costs to the national economy are consequential.
If the target is too high, prices will be pushed up dramatically while long-term investors will not neces-

sarily be attracted because they know that the next round will be much lower. Setting quota targets demands knowledge of cost and learning curves of various technologies for developing renewable energy technologies – not a mean feat (Barry & Jaccard, 2001).
After this, governments, or their agencies, must certify producers, issue certificates, monitor compliance, institute penalties and act in case of non-compliance, including concomitant litigation. This supports the argument that quota/certificate systems, by their nature, are more complex, difficult to administer, and open to manipulation – and that such problems could even be more pronounced in developing countries (Frost, 2003).
On the other hand, the cost-equalizing aspects of the grid-feeder law have also been attacked as being neither transparent nor simple (Saghir, 2003).
In summary, bidding processes are bureaucratic, cause high transaction costs, and are time-consuming for both developers and public authorities (Wagner, 2000; Goldstein et al, 1999). This makes them inappropriate for developing nations.

1.3.8 Flexibility

Pricing systems fix prices of new entrants into the market. This means that new entrants have certainty about the price over the contract duration. Should a government find that the price was too high/low, it can easily adjust the price to new entrants.
With the quota system it is not as easy to tamper with targets and timetables because lead-times of several years are required.

1.4 Summary

Pricing (feed-in) systems

Positive	Negative
■ Most successful at developing renewable energy markets & domestic industries with social, economic, environmental and security benefits ■ Encourages establishment of large – as well as small – and medium-scale participants ■ Low transaction costs ■ Ease of entry ■ Low cost to government ■ Ease of financing ■ Flexible to changes in technology and market ■ Appropriate for developing countries	■ Tariffs need adjustment to reflect learning curve ■ Not applied for non-electrical renewable energies

Quota system

Positive	Negative
■ Favours currently cheapest technology only ■ Aims for definite renewable energy market share ■ Attractive to established global market players ■ Applicable to all renewable energies	■ High risk and low margins retards innovation ■ Favours big global players, disadvantages small domestic participants ■ Misses opportunities for domestic job creation, equitable economic development in rural areas and local environmental improvement ■ Concentrates on areas of best resources, missing out on distributed access, and evoking NIMBY ■ Tends to stop-and-go cycles, damaging domestic development ■ Target sets upper limit for development ■ Complex design, administration and default enforcement ■ High transaction costs ■ Poor flexibility in short-term changes ■ Unsuitable for developing nations ■ Higher energy costs than feed-in energy

2 Financial incentives

Financial incentives are one way in which governments can address the energy market failures, thereby attempting to level the playing field.
These incentives may take the form of tax credits, rebates, investment or production support as implemented in most developed countries.

2.1 Tax relief

2.1.1 Investment and production tax credits (PTC)

These can cover either the total installed costs or the plant costs only. They are designed to encourage investment in renewable energy technologies.
Reductions of the income tax burden are only interesting to those with a relatively high income – hardly the dominant problem in the developing world.
In the USA (1980s) and India (1990s) investment tax breaks helped to jump-start the wind industry, but also lead to fraudulent practices and the use of substandard design. The tax cycle – and not the renewable energy market demand – tends to influence the flow of investments in renewable energy. PTC only worked in those US States with additional incentives (Sawin, 2001). As a result of this experience there has been a general move towards production incentives, which are output-related, rather than input-related. Output-related incentives also tend to ensure better performance and maintenance.
The exception may be technology innovation where PTC seems appropriate.

2.1.2 Other forms of tax relief

Relief of environmental taxes or carbon taxes is a more impact related incentive, as is accelerated depreciation. Import duties can be reduced on renewable energy technologies until domestic industries are sufficiently established, but have to be within WTO lines.

2.2 Rebates and payments

Japan has provided rebates on the price of PV capacity installed, combined with low interest loans and public education. These must be tied to technology standards.
California initiated production payments per kWh output. Provided such payments are high enough and are guaranteed over a sufficiently long period, these payments have a similar effect as pricing systems (Sawin, 2003).
Payments and rebates are preferable to tax breaks because they accrue to all income levels. They produce a more even growth than the sudden income tax reduction/ evasion driven end-of-tax cycle investments. Rebates and payments on their own do not suffice to stimulate the market (Haas, 2002).
Rebates and payments should also be output related.

2.3 Low-interest loans and guaranties

It has been argued that finance, rather than technology innovation drives down the renewable energy cost curve. In Germany long-term low-interest bank loans are refinanced by the Federal Government (Twele, 2000).
In the developing world many, many more poor people could have access to renewable energies, if they had access to reasonable loans. Renewable energy loans are feasible if the monthly loan repayments are comparable to the current monthly expenditure on candles, paraffin (kerosene) and appliances. Without such finance only two to five percent of the population in the Dominican Republic, India, Indonesia and South Africa could have access to modern energy, while it would be 50 % with suitable loans (Eckart et al, 2003). This is a tenfold increase.
Such schemes tend to be country and culture specific. Vendor driven lay-byes or credits normally have no quality assurance or product quality guaranties. Regular monthly cash instalments cannot be expected in agricultural and fishing communities where the income is seasonal.
The fee-for-service system driven by government appointed concessionaires in South Africa received a mixed reaction from government.

2.4 Addressing subsidies and prices of conventional energy

During the mid 1990s, US$ 250 - 300 billion of subsidies were paid each year to the fossil fuel and the nuclear industries of the world (UNDP, 2000). Even current global subsidies for conventional energies remain many magnitudes higher than those for renewable energies (Geller, 2003).
Surprisingly, about 80 to 90 percent of these global subsidies to the fossil fuel and nuclear industries are paid out by the developing world (Sawin, 2004). Those countries that can least afford it thus keep their energy price unrealistically below the true costs of production and delivery.
Eight developing countries that account for one quarter of the world's energy use, subsidize fossils by US$ 257 billion, equalling 11 % of their combined economic output (OECD/IEA, 1999).
Even small subsidies for petroleum products in developing countries can send out the wrong signals and direct nations down unsustainable energy paths, eventually trapping the poor. Subsidies, if at all granted, should have sunset clauses and should enable the recipients to a transition to renewable energies.
The developing world spends US$ 20 billions each year on high-risk paraffin lamps, candles and batteries. Of the diesel transported to remote regions, two thirds to three quarters is spent on transport (Perlin, 1999). US$ 50 to 60 billion

are projected to be spent on subsidised power projects in the developing world until 2030 (UNEP, 2000). Even if all subsidies on fossils were to be stopped forthwith, the inertia of the government subsidies in existing infrastructure is still biased towards nuclear and fossils.
Mostly it would be better policy to channel resources towards energy efficiency, energy conservation and renewable energies. Instead of trying to find new money streams to subsidise established sunset technologies, the existing streams should be reallocated to renewables.
Governments in developing countries are large energy consumers through their energy inefficient buildings, vehicles, transport systems, military and infrastructure. It follows that they could lead by example.

Innovative Finance mechanisms and Partnerships for Energy Provision

UNEP's African Rural Energy Enterprise Development (AREED) initiative, funded by the United Nations Foundation, seeks to develop sustainable enterprises that use clean, efficient and renewable energy technologies to meet the energy requirements of the poor. AREED provides enterprise development services to entrepreneurs and early-stage funding, in the form of debt and equity, to help build successful businesses that supply clean energy technologies and services to rural African customers.

The Renewable Energy and Energy Efficiency Fund (REEF), which became operational in March 2002, was launched by the World Bank together with support from the Global Environmental Facility and several other private and public sector groups. It is the first global private equity fund devoted exclusively to investments in emerging market renewable energy and energy efficient projects.

GEF funding for the Grameen Shakti organisation in 1998 enabled it to offer improved credit terms, increasing the payment period for solar home systems from one to three years. This had a significant effect on demand between 1997 and 1998. Grameen Shakti sold 1 500 systems in 2000, it installed 2 000 to 2 500 systems. Grameen Shakti believes that after three or four years of profitable growth, it will be able to obtain financing from commercial banks. Thus, use of GEF financing to support a high risk project, which is unable to attract commercial financing on its own, can result in significant growth and provide the means by which organisations can obtain commercial financing.

The Public-Private Advisory Infrastructure Facility (PPIAF), a multi-donor technical assistance facility aims at helping developing countries to improve the quality of their infrastructure through the use of private sector resources. This has now been operational for three years and has attracted support from twelve donors, including the UK Department for International Development (DFID). Current demand exceeds resources, and DFID is seeking to build on this success.

DFID launched the Emerging Africa Infrastructure Fund (EAIF) in January 2002, with and initial capital base of US$ 300 million, in order to provide long-term debt finance for infrastructure in sub-Saharan Africa. The feasibility study for the facility showed an immediate need for US$ 11 billion of investment. There is obviously scope to increase the capital base of EAIF and to establish a similar mechanism to cover urgent needs in the poorer countries of Asia (and possibly elsewhere).
(DFID, 2002 in Christensen, 2004)

3. Industry standards, planning permits and building codes

Developing nations have reasons for their fear of becoming dumping sites of inferior energy technologies. The essential standards for promoting renewable energies are technology standards and certification, siting and permit standards, grid connection standards, and building regulations (codes).

Industrial standards foster fair competition and build investor confidence. New technologies like PV and wind turbines demand new standards of performance, durability, safety and compatibility with existing systems. They also facilitate export and import, which necessitates widespread agreement like the EU Solar Keymark for solar water heaters or the ISO standards. Some cultures are less keen on standardisation, arguing that it stifles innovation by being too prescriptive. Hence the modern Nordic trend is towards the integration of performance and deemed-to-satisfy standards.

Siting standards and environmental impact assessments can delay the process of establishing renewable energy technologies. For instance, all kinds of objections have been lodged against wind turbines, some with ulterior motives, and some with genuine concerns. In one country, the Government's own Wind Energy Demonstration Project was delayed no less than four years, costing about € 3 M. To avoid repetitive and fruitless efforts, of both protagonists and opponents, standard procedures have been developed. Both Denmark and Germany have required municipalities (local authorities) to identify renewable energy sites – e.g. for wind turbines – in advance, and have placed restrictions on their proximity to buildings, lakes and other sensitive areas.

These proactive policies have been a major positive factor in reducing uncertainty and fruitless expenditure of time and money. The opposite happened in the UK. A Code of Practice developed by the Australian Hydro Association may also help.

Grid-connection standards are needed for safety and technical reasons, but also because both the consumer and renewable energy producer loads can vary, if produced by intermittent sources. Favourable renewable energy sites may not necessarily be located at the point of consumption. In the past, some utilities tried to block renewables by imposing onerous connection or wheeling conditions. Some had creative line charges for access, even if it is not used. Governments, acting in the national and global interest must establish standards under which renewable energy developers pay only the direct grid connection costs, not for the line upgrades necessitated by the additional capacity. Feeders to the grid should also only pay for the transmission service they actually use. Finally, renewable energy based electricity (except biofuel-based, ocean current, geothermal hot dry rocks (HDR) and – potentially – solar up-wind chimneys) should always have priority grid-access because it cannot be deferred. Other dispatchable sources like open cycle gas turbines, hydro and – possibly – compressed air as well as gyroscopic dynamic storage can easily be ramped down as required. Conventional coal fired power stations have poor load following characteristics. Good grid interconnectedness and better demand and supply prediction are required.

Building regulations (codes) should promote energy efficiency and the use of renewables, calculated over the cradle-to-grave life cycle of all buildings. Energy intensive materials/components should be used with discrimination, and should be recycled as far as practical. The use of local and natural low energy materials leads to buildings with lower embodied energy, and should be encouraged by policy, research, training and regulation.

In the warmer developing countries, domestic water heating and food preparation are predominant in housing, while space and water heating take the first position in colder regions. It is a common fallacy to assume that all low latitude areas are hot. In fact, average temperatures conceal the reality that inland deserts are bitterly cold at night, and high mountains within the latitudes 30°N and 30°S even used to carry snow.

Barcelona, Spain instituted an ordinance requiring that all new or to be altered buildings satisfy 60 % of their hot water consumption by SWH. Alternatively, buildings must be wired for PV installations.

The effects of this law are dramatic and carry no costs to the fiscus.
Energy efficient appliance rating is a way of achieving efficiency, and enhancing energy awareness. In addition, this simplifies the introduction of renewable energies. Buildings represent investments with a longer lifetime than most power stations, and can be distributed energy generators in their own right instead of being consumers. For this purpose, it is necessary to have solar access regulations.

The use of daylighting and energy efficient compact fluorescent lights (CFL) renders the use of PV significantly less costly.

Governments often are embarrassed by informal settlements, which are seen to be hotbeds of crime as well as a visible evidence of failed social programmes. However, bulldozing such settlements does not remove the reason for their growth, which lies in the necessity of the low-income population to be close to work opportunities or surmised work opportunities. This is denied to them by the dogmatic and out-moded town planning that forbids mixed land-use, pontificating that you must not live near your work.

Integrated resource planning optimises the long-term use of all resources, be they natural (water, earth, energy, waste), social (expertise, patents, commitment) or economic (money, credit). Legislation aimed at integrated resource planning in urban settlements and architecture is a common good to be considered at the local, municipal, provincial, national and international levels.
Energy is used in buildings to achieve certain energy service levels (illumination, comfort). These target levels should be climate and season adjusted, realistic for the given task, and not solely industry-driven.

In artificially conditioned buildings, the use of economy cycles and variable speed drives should be mandatory. National building regulations should

Egypt:

The New and Renewable Energy Agency (NREA) was established in 1998 as a government R&D body working under the Ministry of Electricity. The primary objectives in establishing NREA were:

- *to contribute to Egypt's need for increasing the share of renewables in the power supply mix*
- *to conduct various research projects on issues pertaining to renewable energy technologies*
- *to act as a renewable energy focal point and counterpart agency for all international organizations interested in the renewables sector in Egypt*
- *to advise the Ministry of Electricity on renewable energy technologies and their applications in the country*
- *to collaborate with other government and non-government institutions in various research projects.*

(Christensen, 2004)

encourage performance-related designs aimed at peak demand, and CO_2 reduction. This will enhance innovation in insulation materials (vacuum insulation has ten times the thermal resistance of conventional insulation), better glazing, phase change materials, thermal storage and day-lighting, as well as energy efficient artificial lighting and appliances. The use of obligatory energy efficiency labels of buildings creates energy awareness, reduces fruitless consumption and creates jobs.

Solar rights (solar access) should be legislated.

The use of energy efficient transport like rail, efficient vehicles, speed limits and multi-use planning must be regulated.

4. Education and information dissemination

The mere availability of renewable energy resources, incentives, technology, capital, expertise and government policy does not suffice if there is insufficient end-user awareness. Germany has less sunshine than France, and less wind resource than the UK. But its application of renewable energies is so much more because of the general awareness of the German population (Hua, 2002).

Initial failures have created negative perceptions in some countries. These can be overcome by concerted information efforts by governments, NGOs and industry.

Gender Approach Leads to Greater Project Efficiency: Case Study PV Solar Homes in Guatemala

Fundación Solar, while operating a PV project in Guatemala, found that mostly men attended the training sessions on equipment maintenance, and those women who did attend, merely stood by and watched while their husbands got involved in hands-on activities such as changing the batteries. As a consequence, when the PV system needed maintenance, such as topping up the batteries, and the men were not at home, the women did not have the skills or confidence to take the appropriate action, which had a negative influence on the long-term durability of the system. Fundación Solar saw much better overall system care (and hence project performance) when they took specific action to train the women in system maintenance. This was achieved at home while the men of the household were out. By taking this approach to training, the NGO created an environment in which the women were not afraid to make mistakes or to ask questions.
(Wides, 1998 in Clancy, 2004)

India

The rising price of oil led to the revival of interest in renewable energy in India. In 1981, the Government of India established a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology. In 1982, a separate Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy. Ten years later, in 1992 a separate Ministry was founded, the only country in the world to have an exclusive Ministry for Non-Conventional Energy sources (MNES). The primary role of MNES in the Renewable Energy sector is to

- *promote renewable energy technologies*
- *create an environment conducive to promoting renewable energy technologies*
- *create an environment conducive for commercialisation of RETs*
- *renewable energy resource assessment*
- *research and development*
- *demonstration*
- *extension*

(Christensen, 2004)

Educational institutions have a task of enlightening the new generation about energy's role in socio-economic development and the environment. For example the Indian Solar Finance Capacity Building Initiative enlightens Indian bank officials about solar technologies, encouraging investment. Likewise, communication and information initiatives are in place.

The International Solar Energy Society contributes to knowledge dissemination through conferences, workshops, publications, and summer schools. It also maintains international electronic networks for the dissemination of information. Finally, it recognises and awards exceptional achievers in furthering the science and application of renewable energies.

5. Public ownership, cooperatives and stakeholders

Many developing nations have a strong tradition of communal public ownership and cooperative initiatives. This does not yet seem to be the general trend with renewable energy generation in the developing world.

In Denmark and Germany cooperatives play an important role as owners and developers of renewable energy. There is even a woman cooperative called "Windfang". Local farmers pool resources and obtain an additional harvest from renewable energy. This greatly enhances local buy-in and support.

At least 340 000 German individuals invested about € 12 million in renewable energy projects (PREDAC, 2002/03). Middelgrunden is co-financed by a utility and thousands of Danes.

Munich's large roof-mounted PV plant was financed by enthusiastic private citizens (Maycock, 2003).

Public buy-in engenders public pride and avoids obstruction or vandalism. It also supports government renewable energy policies when these periodically come under pressure from vested less environmentally friendly energy lobbies.

Local participation in solar mini-grid projects in Nepal and Indian islands have played a decisive role in avoiding theft (BBC News, 2000).

Stakeholders in energy for sustainable development	
STAKEHOLDER	*FUNCTION/ACTIVITIES*
1 Legislative authorities/ elected officials	***Set national political priorities; social, economic, and environmental goals; legal framework conditions.***
2. Government macroeconomic and development planners	***Define development goals and macro policy; general economic policies; crosscutting issues; subsidies and trade policy; sustainable development goals, and frameworks.***
3. Government energy authority or ministry	***Set sectoral goals; technology priorities; policymaking and standard-setting functions; legal and regulatory framework; incentive systems; federal, state, and local level jurisdiction.***
4. Energy regulatory bodies	***Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives.***
5. Market coordination agencies	***Dispatch entities; have operational coordination functions, interface with industry investors; information brokers.***
6. Non-energy governmental authorities/ ministries	***Sector policies; crosscutting issues; interrelation with energy policies; public sector energy consumers; require energy inputs for social services provision.***
7. Energy supply industry	***Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D.***
8. Entrepreneurs and productive industries	***Business development; economic value added; employment generation; private sector energy consumers.***
9. Energy equipment and end-use equipment manufactures	***Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D.***
10. Credit institutions	***Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers.***
11. Civil society/ non-governmental organisations	***Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations.***
12. Energy specialists and consultants	***Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing.***
13. Academia and research organisations	***R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation.***
14. Media	***Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency.*** ***(Bouille & McDade, 2002 in Christensen, 2004)***

Conclusions and recommendations

Developing nations wish to occupy their rightful place in the concert of nations. Renewable energies will play an important role in their transition path to sustainable development.

To fulfil this role, apposite policies are indicated. To date, pricing systems (feed-in laws) have accounted for the most rapid and sustained market transformations, while creating work places and driving down the cost through technology advancement, economies of scale and cost-effective finance. This has triggered private investments, thereby lightening the load on government. Quota systems have not fared as well, having a preponderance to stop-and-go markets. The two systems are not compatible.

Complementary combinations of well-matched policies are required. Reducing real and perceived risks is a crucial component.

Not all stereotypes of the developing nations are necessarily correct. For instance, it cannot be assumed that all developing nations inherently strive towards a current western value system. Nor can it be assumed that the provision of electricity automatically leads to development. Furthermore, there is widespread confusion about energy and electricity, which are assumed to be synonyms. This confusion has been deepened by expectations created by populist political over-promises like the slogan “electricity for all”.

In a developing country with a large, highly dispersed and poor rural population the political slogan “electricity for all” is understood to mean “grid electricity for all”. However, the realities of the cost of grid extension, the low productive consumption and low-income levels tend to render this a promise that cannot be fulfilled. Creating expectations that cannot be fulfilled is a dangerous game. Rural communities expecting “real grid power” tend to reject solar home systems as an “inferior” option. They do not see these being used by

Rural Electrification

The two largest outside supporters of rural electrification (REL) programmes have been the World Bank (WB) and USAID. During the 1970s and 1980s these two agencies lent or granted some US$ 1.9 billion for 40 REL projects in twenty countries, accounting for some 60 percent of the actual expenditures of US$ 11.5 billion for these projects. Because of lingering doubts about their economic soundness, the two agencies undertook a thorough review of these projects in the early 1990s. While the rationale for this evaluation and the detailed findings have been published elsewhere, a number of useful lessons were drawn by this study:
Unfortunately, as it turned out, in the majority of cases the various projections of beneficial results were far too optimistic and, in addition, often based on faulty methodologies. As a result, even the far more modest net benefits identified after the event, compared with predicted expectations, were subject to doubt and, in several important cases, strongly negative.

Taking into account the experiences of the past, as well as those of the present, such as the massive multi-million households South African Electrification Programme, it is clear that electrification by network expansion into low-density, rural areas faces severe cost constraints and cannot be supported economically. This is so because consumption by these users is limited to the high-value spectrum of electricity uses, which, by themselves, cannot justify the high cost of network connections. As a five-year longitudinal study of the Eskom electrification programme has shown, "The most frequently bought appliance is a television set and entertainment equipment, such as hi-fi, radio and tape recorder, whereas the switch to electrical cooking appliances is very slow." These uses of electricity, however, can be comfortably accommodated by lower cost, freestanding Solar Home Systems (SHS). They do not require network electricity supplies.

These findings are of fundamental importance for the planning of electrification strategies for low income, low-density (or rural) regions of the world. Rather than proceeding with costly, and, in most cases, non-economic strategies of network-by-wire expansions, individual household installations, focussing on hose families who financially are able and interested in obtaining the benefits of electrification, appear to be much more sound and far more sustainable.

Given this conclusion, four issues must be stressed:

- *Supplies should be prioritised* to those families and households who both appreciate the value of the services provided and who are willing to pay for them from their own, discretionary income. This suggests selectivity – rather than full area coverage.*
- *To identify those selective potential users, some form of "sacrifice" is needed as an expression of interest on their part, i.e. a significant down payment on or prior to installation, to indicate their future willingness to pay for the services provided. This principle holds regardless of the question whether or not the installation is partially subsidised by the government, donor aid agencies or development foundations, or by other electricity users (through utility cross subsidies, for example).*
- *Where credit sales of equipment (or leasing arrangements) are part of the off-grid electrification programme, means must be found to protect the supplier from non-payment. The recent French and South African technological development of time dependent metering equipment and micro-chip anti-theft devices hopefully will help to achieve this objective.*
- *Needs for heat energy (e.g. cooling and/or refrigeration), have to be met from other sources. The systematic development of LPG or kerosene distribution networks (including credit sales of respective appliances), preferably in conjunction with a systematic PV programme, should be able to satisfy these needs.*

Once the above development principles are taken into account, a number of specific policy approaches and directions become apparent.

- *Limit system expansion by wire to those (largely urbanised or urbanising areas) where current income and expected income growth of the population promise to cover at a minimum the operating costs of the system, with strong indication that within the life expectancy of the installed reticulation and house connection equipment average demand and resulting revenue will grow sufficiently to cover the initial capital expenses as well.*
- *For all other regions, develop off-grid utility systems that are based on the use of PV equipment (both local battery loading stations and freestanding home PV units have demonstrated favourable economics in selected applications). Where warranted and where concentrated local demand is high enough, small grid systems based on PV, wind, biomass, small hydro or hybrid units may offer cost-effective solutions.*
- *To increase market penetration, credit systems should be developed (including extended leasing arrangements), that enable households to participate in the programme. These credit systems (minus public subsidy contribution, if any) must be based on a rigorous assessment of the willingness and ability to pay by each of the prospective users. This requires pre-electrification socio-economic surveys. It also means that the complete area coverage of all households should be rejected as an objective of off-grid electrification programmes. If this selectivity principle is not adhered to, the chance of having many non-paying customers is very high, increasing average system costs to unsustainable levels. This risk of non-payment is independent of any theft protection devices or time related metering equipment that may be incorporated into the credit-financed equipment.*
- *A balance must be found, by experimentation, of the required size of the initial down payment, the type and timing of periodic payment (which may be income related – e.g. after harvesting in agricultural areas, but not monthly) and the credit duration. The objective should be to capture in a given region as many households as possible that are willing and able to pay, in order to reduce average after-service and maintenance costs.*
- *Where possible, PV developments should be combined with household cooking equipment programmes (LPG or kerosene, mainly) to provide cooking heat under the same credit rules that apply to the PV equipment. This would provide a secondary income source for the after-service, maintenance and supply infrastructure that is essential for the survival of the programme.*

(Schramm in Holm & Berger, 1998)

*This sensible recommendation may not be palatable to those populist politicians who like to go electioneering with "electricity for all", while fully knowing that this is a false promise.

the well-to-do population sector. SHSs cannot provide the heating energy services. If grid extension suddenly appears in areas that had recently been provided with solar home systems after lengthy deliberations, the credibility of the authorities and their policies become questionable.

In developing countries the priority of electrification should be for productive uses (industry, business), health (clinics, hospitals), education (schools, training), with social and amusement and residential provisionally last.

People of the developed and developing world require energy services like heating, cooling, lighting, and/or moving objects. The energy service of heating may be provided by the sun, a fire or electric heating. Of these, electricity is the most highly ordered and most expensive form. Therefore it makes better sense to use other clean energy forms like solar and clean biofuels for energy services of heating buildings, water and food.

Electricity by itself does not provide new income sources. As has been shown repeatedly, electricity follows rather than leads economic development (Schramm, 1998).

While life without easy access to electricity seems unthinkable today, we acknowledge that current civilisation is but a short period in the course of the human race of about a million years. The great past achievements of China, the Americas and the Mediterranean, including North Africa, cannot be ascribed to the use of electricity.

That much is certain: the developing world cannot follow the energy path of the USA, even if it wanted to. There are simply not enough fossil resources, nor can the world absorb the environmental impact. This insight, combined with the fact that the energy infrastructure in developing countries is presently underdeveloped, gave rise to the concept of technology leapfrogging. Leapfrogging has been successfully demonstrated by modern cell-phone technology that does not require the huge investment of the old-fashioned landlines.
Once the potential resources and needs are known, and given sufficient stakeholder awareness and political support, the priority policy recommendations for developing nations are:

1. **Establish transparent, consistent long-term renewable energy targets and regulatory framework,** preferably a pricing system (grid-feeder law), creating an investor friendly environment. This could start with net metering. Internalise externalities in the pricing system. Set targets, not ceilings.

1.1 The Kyoto Protocol opportunity
Although the Kyoto Protocol can be criticised in many ways, it offers an opportunity to developing nations.

- Accede to (sign) the Kyoto Protocol
- Establish a Designated National Authority with dedicated, well-trained staff and powerful linkages to the ministries of energy and environment
- Establish the Carbon Emission Baseline and disseminate to stakeholders
- Establish the National Development Criteria, avoiding political opportunism, and disseminate to stakeholders
- Encourage programmes rather than projects
- Reduce the very high transaction costs by facilitating and supporting national NGOs and consultancies, and by enhancing competition
- Carefully consider "Additionalities", and monitor it closely.
- Publicise results widely.
- The window of opportunity of major CO_2 emitters like China, India and South Africa may be over by 2012. Use it now.

1.2 Renewable Energy and Energy Efficiency White Paper
A national White Paper demonstrates the intentions of government. It is an important document to other ministries as well as to international and national players.

- Provide Motivation for White Paper e.g.:
  - a) Sustainable social development
    - – Poverty reduction through domestic job creation
    - – Gender issues
    - – Health issues
  - b) Sustainable economic developments
    - – Diversity of energy supply
    - – Reduced price volatility of imported energy
    - – Security of domestic supply
    - – Growth of domestic industry, export and expertise
    - – International competitiveness
    - – Reduced risks of armed conflict and terrorism
  - c) Sustainable environmental development
    - – Protection of tourism assets
    - – Improvement of health (diseases, air pollution)
    - – Protection of water and agricultural resources
    - – Contribution to global climate stabilisation

- Set renewable energy targets, not ceilings e.g.

year	*Minimum renewable energy target*	*Minimum final energy per capita*
2010	*10 %*	*100 kWh/a*
2020	*20 %*	*500 kWh/a*
2050	*50 %*	*700 kWh/a*

- Set targets and dates for improving national energy productivity (reducing national energy intensity).
- Set targets and dates for orderly phase-in of revenue neutral environmental tax.
- Set targets and dates for fossil and nuclear phase-out – if any.

- Establish pricing policy (feed-in law) for grid-connected renewable energy, including future price reductions.
- Establish energy (not investment) tax credits with future reductions.
- Establish renewable energy production tax rebates or refunds linked to technology standards.
- Facilitate/provide long-term low interest loans with government refinance to renewable energy technologies, tied to standards.
- Equalise the subsidy playing field for grid-connected and non-connected fossil and renewable energies, by redirecting funds to renewable energy.
- Set technology standards, aligned with EU and ISO renewable energy standards.
- Mandate municipalities/local authorities to identify renewable energy sites and to execute environmental impact scoping studies.
- Establish energy efficiency and renewable energy building regulations (codes) adapted to local climates.
- Streamline consultants' professional fees based on CO_2 reductions, not on mechanical plant expenditure
- Establish policy for all levels of government to lead by example in government procurement programmes, based on life cycle energy use.
- Commit to a renewable energy and energy efficiency strategy, prioritising local conditions. Do not attempt to introduce renewable energy technologies in remote rural areas before they have been thoroughly tested, promoted, accepted and established in grid-connected areas.

1.3 Publicise and workshop the draft White Paper widely, obtaining buy-in of the national stakeholders and drawing the attention of international donors, investors and developers

Before Rural grid Electrification (REL) this was expected to:

- *Act as catalyst for agricultural, industrial and commercial development of rural areas, including electricity for irrigation pumping;*
- *Replace more costly and qualitatively inferior energy sources, such as kerosene for lighting, diesel for engines, irrigation pumps and generators;*
- *Improve the standard of living of the rural poor;*
- *Stem out-migration from rural to urban areas; and*
- *Redress urban/rural biases.*

(Schramm, 1998)

After REL, it appeared that:

- *Electrification by itself had not been a catalyst to economic development. In fact, what could be deduced from a comparison of the more with the less successful REL schemes is that is that electrification should follow, rather than attempt to lead, regional economic development.*
- *The impact of REL on agricultural growth was often overestimated as it was, for example, in Thailand, Indonesia, India and Bolivia.*
- *There was little evidence that electricity by itself resulted in new agro-industries, commercial or small-scale industrial activities.*
- *The provision of network electricity was by far the most costly form of energy supply for low-density, low-demand rural areas, compared with other options. If its real costs would have been charged to users, it would have been unaffordable to most of them, unless they already had a reasonable and growing income base of their own.*
- *REL in general did not contribute to the alleviation of poverty. It benefited mainly the higher income groups.*
- *Electricity did replace more costly energy sources in some cases: however, this was only so because in almost all cases electricity was heavily subsidised, while the alternatives generally were not. One result of this subsidisation was that observed demand growth was more rapid than it would have been otherwise, making REL projects in physical terms (i.e. number of connections) appear to be more successful than they would have been without subsidies.*
- *The large subsidies for REL imposed a heavy financial burden on the utilities (or their other customers through cross subsidies) even in those cases in which projects were justified economically. REL tariffs rarely covered more than 15-30 percent of estimated costs of supply.*
- *Real costs of electricity supplied through REL projects were very high, averaging 20 US cents/kWh; in addition, in most cases these costs were still underestimated because the low REL load factors, large distribution losses and the additional burden imposed during peak periods which, as, for example, in supply-constrained systems such as in India and Pakistan, contributed heavily to power rationing and outages. Such outage costs to other users were close to US$ 1/kWh or more in many cases.*
- *REL improved the perceived quality of life for those able to afford it.*
- *There was no impact of REL on stemming migration from rural to urban areas; indeed, the opposite could well be true, largely because the increased access to information pointed to greater opportunities elsewhere.*
- *REL did not contribute to the conservation of fuelwood because electricity was rarely used for cooking or heating; where it was (by a few higher income households) its use would probably have been substantially reduced if tariffs had been adjusted to cover the actual costs of electricity supply.*

From that it was concluded that a disaggregation of rural energy into their sub-components may well have shown that a mixture of other supply options (including a judicious, small amount of electricity from decentralised sources for highly specific and limited uses) might have been far more cost effective than network REL in regions with low population and at as low stage of economic development.

(Schramm, 1998)

2. **Institute supportive finance mechanisms** through production payments rather than tax credits on investments. Institute long-term, low interest loans rather than investment tax credits. Fix rebates to output units, not to cost percentages. All subsidies should be tied to standards and gradual reduction/phase-outs. Introduce revenue neutral environmental taxes according to a long-term plan, and adhere to it.

3. **Establish, maintain and enforce standards** for technology, siting, buildings and grid-connection. Lead by example.

4. **Support Research, Development and Demonstration of renewables** as well as education and dissemination. Acknowledge failures and learn from them. Create centres of excellence.

5. **Encourage stakeholder/public ownership, participation and pride** in the process and products.

Implementation strategy

The transition from policy to strategy is not always clear-cut. Many actions can be developed in parallel:

- Launch targeted awareness campaigns aimed at decision makers.
- Conduct baseline study to establish energy usage, and benchmark with comparable best practice
- Involve grass-roots stakeholders and potential renewable energy cooperatives. Their buy-in is crucial.
- Include regional stakeholders of neighbouring countries
- Develop a Long-term National Integrated Energy Plan within the National Integrated Resource Plan, taking care not to confuse energy service requirements with energy carriers or energy technologies.
- Prioritise energy awareness, energy saving measures and energy efficiency. They are more cost effective than providing new generation capacity.
- Implement energy labelling for energy consuming systems and buildings by using internationally established labels and proven campaign methods.
- Integrate grid-connected electrification with rural energisation strategies, rapidly introducing renewable energies through the grid-feeder law. This establishes renewables in a market sector where the public can afford it and is more open to innovation. By association, renewable energy technologies become status symbols. Grid-connected installations require little back up, and are within easy reach of installers for repairs and maintenance.
  Capacity, standards and reliability of industry are built faster and more sustainably.
- Identify areas of grid extension and publicise, using GIS maps.
- As soon as sufficiently confident capacity has been established through grid-connected renewables, initiate comprehensive rural energisation (not only SHS) in concentrated solar enterprise zones.
- Set and insist on proper technology standards and codes of practice of buildings, appliances and equipment.
- Integrate education and research.
- Implement financial incentives.
- Initiate joint ventures.
- In rural areas, focus on energy services for income generation, health improvement and education. Extend mini-grids from workshops, clinics and schools. These are serviced by dedicated resident staff.
  Initially use the selective ownership model for houses, assisted by subsidies equal to grid-connected ones, plus financial incentives listed under “policy priorities”.
  Once the ownership market has been saturated, consider “fee for service” model for energy services.
- Measure and GIS maps:
- Identify potential consumers
- Assess RE potential
  – Tidal/wind map
  – Hydro map
  – Solar map
  – Geo thermal map
  – Gas map
    a) landfill
    b) biofuels
    c) natural biogas
  – biofuels, woodlands, agriculture, peat and waste
- Appoint independent evaluators, and feedback regularly at agreed intervals to policy makers. Admit mistakes and recognise successes.
- Promote local production.

The Need for Research, Development and Demonstration

Research, Development and Demonstration (RD&D) are the foundation for progress and change toward sustainable energy systems that eradicate energy poverty in the developing countries, protect the global life-supporting systems and reduce the risk of geopolitical conflicts over fossil fuel resources.

Countries with the most visionary RD&D initiative will be the future technology leaders. Motivated by the world oil shock of 1973, the European Union saw energy as a high priority and dedicated the largest investment block of the five-year frameworks to energy research. The energy research budget of 23 IEA member countries reached a maximum of US$ 13 billion in 1980, after which date it sank to only 38.5 % of its peak. About 70 % of this budget was spent on nuclear fission and fusion research, representing an enormous subsidy to those industries, which is in no relation to their output. Strangely, when confronted with a *TRANSPORT OIL* crisis, they went for *NUCLEAR ELECTRICITY*. Also, the budget allocated to fossil fu els has consistently been about twice the renewable energy budget, illustrating the influence of entrenched industry lobbies in the European Union where environmental awareness is said to be high and growing. Only 10 % went to renewables and energy efficiency. In view of the strategic importance of renewables, this is disconcerting.

The disaggregated budget for renewables also shows a maximum in 1980, falling to 30 % in 1998, with the relative share of biomass and PV growing. Understandably, there was a strong call at the Renewables 2004 Conference in Bonn that the renewables R&D budget should be increased by at least by an order of magnitude.

A few EU nations invest in the bulk of renewable energy R&D. Information on R&D activities in developing countries is quite limited. It appears that countries like China, India, Brazil, South Africa, Egypt and a few others do have individual energy programmes. However, no evidence could be found of concerted multinational research programmes by the developing world that reflect the strategic importance of renewables to the developing world.

Most developing nations are currently not on a sustainable energy path and are facing increasing energy and environmental pressures caused by populations with growing energy demands.

Luther (2004) has presented an updated overview of the RD&D challenges: Since the price experience curves (or "learning curves") of renewable energy technologies are also driven by R&D, it is imperative to direct concerted funding towards these research initiatives. Two main approaches need to be followed:

- New technologies for the developing world like biogenic bottled gas as decentralised sustainable energy carrier, low-cost energy efficient houses and buildings, additional storage schemes for high quality energy, and technology transfer.
- Significant cost reductions of existing renewable energy technologies: higher efficiencies, longer lifetimes, less maintenance, reduced environmental impact. This RD&D work has to be steered and synchronised with the markets because there is a considerable time lag between laboratory and market.

Research and Development is needed on non-technological and on technological aspects.

Non-technological aspects: e.g. economic, sociological, and political

- The market penetration of renewable energies is neither directly related to the availability of renewable energy resources, nor to the availability of renewable energy technologies. Other, partially undefined aspects seem to play a role. Therefore priority should be given to identify these drivers or barriers including R&D on:
  - The way innovation processes work
  - Development of sustainability in dicators
  - Model projects and dissemination (e.g. strategic EU/North Africa partnership, biogenic bottled gas infrastructure, energy efficient low-cost housing, rural energy, and one million hut energisation in developing countries)
  - Economics and financing
  - Optimal CDM & JI applications
  - Externalities of nuclear and fossil energy

Renewable Energy Paradigms

Old Paradigm	*New Paradigm*
Technology assessment	*Market assessment*
Equipment supply focus	*Application, value-added, and user focus*
Economic viability	*Policy, financing, institutional, and social needs and solutions*
Technical demonstrations	*Demonstrations of business, financing, institutional and social models*
Donor gifts of equipment	*Donors sharing the risks and cost of building sustainable markets*
Programmes and intentions	*Experience, results, and lessons*
Cost reductions	*Competitiveness on the market place*
$/kWh	*Energy services*

(Adapted from: Martinot et al, 2002 in Johansson, 2004)

– Effects of energy market liberalisation and globalisation
– Best practice benchmarking of national renewable energy policies, programmes, finance procedures
– Accelerated capacity building
– Awareness, acceptance, access and affordability
– Data, statistics and resource assessment
– Energy and human health
– Income-generating energy services

Technological aspects

Since there is no single silver bullet, renewable energy technology research has to follow an integrated broad-spectrum approach. Three categories are identifiable:

– Technologies that are currently applicable for world-wide cost-effective application (energy efficient buildings, off-grid PV, biomass, commercial solar water heating in warm countries)
– Technologies in need of minor development for entry into new or larger markets (solar thermal power stations, upwind chimneys, wind energy in developing countries, biomass-based synfuels)
– New technologies with a view to long-term energy sustainability (RE hydrogen, better batteries and other storage systems, as well as ocean current, wave and tidal power)

The first two renewable energy categories can be grouped under the headings of electricity generation, heating, cooling and daylighting, solar buildings, fuels, and crosscutting technologies.

- **Electricity generation**
  Existing renewable energy technologies require RD&D in specific areas:
  – Wind: off shore potentials, extreme climates, developing world adaptations
  – PV: cost reductions, optical concentration, innovation, building integration
  – Solar thermal: thermal storage, direct evaporation, hybrids, automation
  – Hydro power: risk assessment, environmental impacts
  – Biomass: cogeneration, stirling cycle, systems integration, food/energy
  – Geothermal: exploration, efficient low temperature converters, waste heat utilisation
  – Maritime: durability of tidal, wave, current, thermal systems

- **Heating, cooling, daylighting**
  – Solar water heating: long-term storage
  – Solar cooking: thermal storage, price reduction
  – Solar cooling: absorbents, systems, hybrids
  – Biomass: local species, alien invaders, system integration
  – Geothermal: cogeneration, improved heat pumps, long-term storage

- **Solar buildings**
  – Embodied energy: cradle-to-grave energy content, reduce, recycle, reuse
  – Shell insulation: vacuum insulation, benign insulation
  – Solar optimised windows: daylighting optimisation, improved insulation

Innovations on Brazilian charcoal production

Brazil has one of the best technologies for the implementation of dedicated eucalyptus forests in the world. Large-scale industrial use of eucalyptus includes pulp and charcoal production, and technologies were developed to reduce pulp and steel production costs. Due to favourable weather conditions, genetic selection, and improved planting technologies, average yields of about 22 t/ha.a (dry basis) are usual for eucalyptus.

The forest division of the steel industry, Mannesmann – MAFLA in Brazil – has developed a rectangular kiln of high capacity. This kiln has a tar condenser that allows recovery and further distillation of high-value by-products. Gases can also be recycled and used as fuel in the carbonisation process. In comparison with traditional kilns, the technology presents higher productivity, higher yields, improved charcoal quality and partial mechanisation. Most of the rectangular kilns developed in Brazil are large enough to accommodate trucks inside, reducing time for loading and unloading.

A conceptually similar kiln was developed by the steel industry Belgo Mineira between 1991 and 1998. In comparison with traditional kilns, results of the R&D programme show that the new technology reduces initial capital costs and labour, while improving charcoal quality.

On the other hand, the steel industry ACESITA developed a programme to modernise charcoal production and consumption. This programme included the development of a continuous carbonisation retort, i.e. a kiln in which heating is promoted by circulating gas. During testing, the measured yield was 35 percent, while the maximum yield for charcoal production – depending of the wood composition – is estimated between 44 and 55 percent (dry basis). The same company developed a rectangular kiln with a charcoal production cost 15 percent lower than traditional kilns. As a part of the same R&D programme, a continuous process of pyrolysis for charcoal production and liquids recovery was developed until the mid 1990s. Theoretically, continuous kilns allow better control of the process and, as a consequence, production of better quality charcoal. Gases produced by pyrolysis are recovered and burned, supplying energy for the process, while liquids are also recovered – including tar – and can be used in the production of chemicals. According to test results, the yield of charcoal was estimated as 33 percent (dry basis). It is important to mention that this R&D programme was conducted while ACESITA was a state-owned company; the pyrolysis plant, for instance, was dismantled after the company's privatisation.

(Coelho & Walter, 2003 in Karekezi, 2004)

- Heat/cold storage: phase-change, air-ground heat exchangers, night ventilation
- Heating, ventilation, air conditioning: efficient compact solar units

■ Fuels

- Biogenic fuels: cheaper biodiesel, biogas separation, fuel cell feedstock
- Hydrogen: solar methane reforming, advanced electrolyses
- Solar chemistry: photo-biological/ chemical hydrogen and energies

■ Cross-cutting technologies

- Distributed generation/grid design: advanced DSM, electronics, fluctuations, and also investigations into means of adding high penetrations of intermittent RE generators into the electricity distribution and transmission networks.
- Off grid systems: advanced diagnostics, metering, maintenance
- Energy meteorology: satellite prognosis, smart pro-active buildings
- Impact assessment: recycling technologies, material resources
- Energy storage: innovative batteries, hydrogen storage, kinetic storage, superconductors
- Energy efficiency: labelling, improved motors, LED lighting, testing
- Planning: solar access right, integrated resource planning, solar cities
- Standardisation: international standards, codes of practice
- Education: centres of excellence, research partnerships, curricula, systems
- Cooperation: R&D partnerships, joint programmes, internet fora

Today, developing countries generally are not strong in research and development. There has been a tendency to rely on imported technologies, patents and expertise. This often brought along with it a reliance on imported fuels. The transport technology complex illustrates the point.

However, developing countries like Brazil have managed to build their own indigenous renewable energy synfuel technology as well as its associated vehicle technology. South Africa continued to develop the German Fischer-Tropsch process for producing liquid fuels from coal. This has now been extended to cleaner natural gas-to-liquid applications and is extendable to renewable energies.

The Chinese solar water heating market transformation with evacuated tube technologies from Germany is another illustration how research and development partnerships can lead to resounding successes.

The growth of research and development capacity of renewable energies in the developing world can fortuitously be integrated with CDM initiatives.

Examples of National Policy Models

This section covers one regional and two national policy models.

Latin America

Political Commitments

The Latin American and Caribbean region agreed in May 2002 on the following proposal for target and timeframes on renewables to:

“Increase in the region the use of renewable energy to 10 % as a share of total by 2010” (Draft of the Final Report of the 7th Meeting of the Intersectional Committee of the Forum of Ministers of Environment of Latin America and the Caribbean, Sao Paulo, May 2002)

Paragraph 19 of the World Summit on Sustainable Development (WSSD) Plan of implementation adopted in Johannesburg reads as:

19. Call upon Governments, as well as relevant regional and international organisations and other relevant stakeholders, to implement, taking into account national and regional specificities and circumstances, the recommendations and conclusions of the Commission on Sustainable Development concerning energy for sustainable development adopted at its ninth session, including the issues and options set out below, bearing in mind that in the view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. This would include actions at all levels to:
    c) Develop and disseminate alternative energy technologies with the aim of giving a greater share of the energy mix to renewable energies, improving energy efficiency and greater reliance on advanced energy technologies, including cleaner fossil fuel technologies.

d) Combine, as appropriate, the increased use of renewable energy resources, more efficient use of energy, greater reliance on advanced energy technologies, and the sustainable use of traditional energy resources, which could meet the growing need for energy services in the longer term to achieve sustainable development;
    e) Diversify energy supply by developing advanced, cleaner, more efficient, affordable and cost-effective energy technologies, hydro included, and their transfer to developing countries on concessional terms as mutually agreed. With a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply, recognising the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that the energy policies are supportive to developing countries’ efforts to eradicate poverty, and regularly evaluate available data to review progress to this end.“

(Karekezi, 2004)

The German Renewable Energy Grid-Feeder Law

This Act has a proven and very successful track record, and could be emulated with great benefit: Items in square brackets pertain specifically to Germany.

Act on Granting Priority o Renewable Energy Sources

(Renewable Energy Sources Act)

Section 1: Purpose

The purpose of this Act is to facilitate a sustainable development of energy supply [in the interest of managing global warming and protecting the environment and to achieve a substantial increase in the percentage contribution made by renewable energy sources to power supply in order at least to double the share of renewable energy sources in total energy consumption by the year 2010, in keeping with the objectives defined by the European Union and by the Federal Republic of Germany.]

Section 2: Scope of Application

(1) This Act deals with the purchase of, and the compensation to be paid for, electricity generated exclusively from hydrodynamic power, wind energy, solar radiation energy, geothermal energy, gas from sanitary landfills, sewage treatment plants, mines, or biomass within the territorial scope of this Act or [within Germany's exclusive economic zone], by utility companies which operate grids for public power supply (grid operators). [The Federal Ministry for Environment, Nature Conservation and Nuclear Safety] shall be authorised to lay down rules – in agreement with the [Federal Ministry of Food, Agriculture and Forestry as well as the Federal Ministry of Economics and Technology] – by adopting an ordinance. Which shall be subject to approval by [the German Bundestag]. Said ordinance shall specify what substances and technical processes used in connection with biomass fall within the scope of application of this Act; in addition, the ordinance shall lay down the relevant environmental standards.

(2) This Act shall not apply to electricity

1. produced by hydro-electric power plants and installations fuelled by gas from landfills or sewage treatment plants with an installed electrical capacity of over 5 MW, or by installations in which electricity is generated from biomass, with and installed electrical capacity of over 20 MW, and
2. produced by installations of which over 25 per cent is owned by the [Federal Republic of Germany or one of Germany's federal states], and
3. produced by installations for the generation of electricity from solar radiation energy, with an installed electric capacity of over 5MW. In the case of installations for the generation of electricity from solar radiation energy which are not attached to or built on structures which are primarily used for purposes other than the generation of electricity from solar radiation energy, the upper capacity limit specified in the first sentence above shall be 100 kW.
4. New installations shall be installations, which were commissioned after [add: date of entry into force of this Act]. Reactivated or modernised installations shall be considered as new installations if major components of the installations were replaced. Modernisation work shall be deemed to be major if the modernisation costs amount to at least 50 per cent of the investment cost required to build a completely new installation. Existing installations shall be installations, which were commissioned prior to [add: date of entry into force of this Act].

Section 3: Obligation to Purchase and Pay Compensation

(1) Grid operators shall be obliged to connect to their grids electricity generation installations as defined in Section 2 above, to purchase electricity available from these installations as a priority, and to compensate the suppliers of this electricity in accordance with the provisions in Sections 4 to 8 below. The obligation shall apply to the grid operator, whose grid is closest to the location of the electricity generation installation, providing that the grid is technically suitable to feed in this electricity. A grid shall be considered to be technically suitable even if – notwithstanding the priority to be granted pursuant to the first sentence above – a grid operator needs to upgrade its grid at reasonable economic expense to feed in the electricity; in this case, the grid operator shall be obliged to upgrade its grid without delay if this is requested by a party interested in feeding in electricity. Grid data and data of the electricity generation installation shall be disclosed where this is necessary for the grid operator and the party interested in feeding in electricity to do their planning and to determine the technical suitability of a grid.

(2) Pursuant to Sections 4 to 8 below, the upstream transmission grid operator shall be obliged to purchase, and pay compensation for, the amount of energy purchased by the grid operator in accordance with clause (1) above. If there is no domestic transmission grid in the area serviced by the grid operator entitled to sell electricity, the next closest domestic transmission grid operator shall be obliged to purchase and pay compensation for this electricity as specified in the first sentence above.

Section 4: Compensation to be Paid for Electricity Generated from Hydrodynamic Power, Gas from Landfills, Mines, and Sewage Treatment Plants
The compensation to be paid for electricity generated from hydrodynamic power and gas from landfills, mines and sewage treatment plants shall amount to at least [7.67 cent] per kilowatt-hour. In the case of electricity generation installations with an electrical capacity of over 500 kilowatts, this shall apply only to the part of the total amount of electricity fed in during a given accounting year which corresponds to the ratio of 500 kilowatts to the total capacity of the installation in kilowatts; the capacity shall be calculated as the annual average of the mean effective electrical capacity measured in the various months of the year. The price to be paid for other electricity shall be at least [6.65cent] per kilowatt-hour.

Section 5: Compensation to be Paid for Electricity Generated from Biomass
(1) The following compensation shall be paid for electricity generated from biomass:
   1. At least [10.23 cent] per kilowatt-hour in the case of installations with an installed electrical capacity of up to 500 kilowatts.
   2. At least [9.21 cent] per kilowatt-hour in the case of installations with an installed electrical capacity of up to 5 megawatts.
3. A least [8.70 cent] per kilowatt-hour in the case of installations with an installed electrical capacity of over 5 megawatts; however, this provision shall not be effective before the date of the entry into force of the ordinance specified in the second sentence of Section 2 (1).

The first clause of the second sentence in Section 4 above shall apply mutatis mutandis.

(2) As of [1January 2002], the minimum compensation amounts specified in (1) above shall be reduced by one percent annually for new installations commissioned as of this date; the amounts payable shall be rounded to one decimal.

Section 6: Compensation to be Paid for Electricity Generated from Geothermal Energy
The following compensation shall be paid for electricity generated from geothermal energy:
1. At least [8.95 cent] per kilowatt-hour if the installation involved has an installed electrical capacity of up to 20 megawatts, and
2. At least, [7.16 cent] per kilowatt-hour if the installation involved has an installed electrical capacity of over 20 megawatts.

   The first clause of the second sentence in Section 4 above shall apply mutatis mutandis.

Section 7: Compensation to be Paid for Electricity Generated from Wind Energy
(1) The compensation to be paid for electricity generated from wind energy shall be at least [9.10 cent] per kilowatt-hour for a period of five years, starting from the date of commissioning. Hence, the compensation to be paid for installations, which, during this period of time, achieve 150 per cent of the reference yield calculated for the reference installation, as described in the Annex to this Act shall be at least [6.19 cent] per kilowatt-hour. For other installations, the period mentioned in the first sentence above shall be prolonged by two months for every 0.75 per cent by which their yield stays below 150 per cent of the reference yield. If the electricity is generated by installations which are located at least three nautical miles seawards from the baselines used to demarcate territorial waters and if these installations are commissioned no later than [31 December 2006], the periods specified in the first sentence and in the second sentence above shall be nine years.
(2) For existing installations, the date of commissioning as defined in the first sentence of 1) above shall be [add: the date of the entry into force of this Act]. For these installations, the period defined in the first 3 sentences of (1) above shall be reduced by half of the operating life of an installation as of [add: the date of the entry into force of this Act]. If P-V curves are not available for such installations, an authorised institution as defined in the Annex may perform the necessary calculations on the basis of the design documents of the type of installation concerned.
(3) As of [1 January 2002], the minimum compensation amounts specified in (1) above shall be reduced by 1.5 per cent annually for new installations commissioned as of this date; the amounts payable shall be rounded to one decimal.
(4) For the implementation of the provisions in (1) above, the [Federal ministry of Economics and Technology] shall be authorised to adopt an ordinance laying down rules for the calculation of the reference yield.

Section 8: Compensation to be Paid for Electricity Generated from Radiation Energy
(1) The compensation to be paid for electricity generated from radiation energy shall be at least [50.62 cent] per kilowatt-hour. As of [1 January 2002], the minimum compensation paid shall be reduced by 5 per cent annually for new electricity generation installations commissioned as of this date; the amounts payable shall be rounded to one decimal.

(2) The obligation to pay compensation as specified in (1) above shall not apply to photovoltaic installations which are commissioned after 31 December of the year following the year in which photovoltaic installations, which are eligible for compensation under this Act, reach a total installed capacity of 350 megawatts. Prior to the discontinuation of the obligation to pay compensation as specified in (1) above, the [German Bundestag] shall adopt a follow-up compensation scheme which shall enable installation operators to manage their installations cost-effectively, taking into consideration the decline of marginal unit cost achieved by then in the field of system engineering.

Section 9: Common Provisions

(1) The minimum compensation amounts specified in Sections 4 to 8 shall be payable for newly commissioned installations for a period of 20 years after the year of commissioning, except for installations which generate electricity from hydrodynamic power. For installations, which were commissioned prior to the entry into force of this Act, the year [2000] shall be considered to be the year of commissioning.

(2) If electricity generated from various installations is billed via a common metering device, the calculation of the amounts of the different rates of compensation payable shall be based on the maximum effective capacity of each individual installation. If electricity is generated from several wind energy converters, the calculation of the compensation shall – notwithstanding the first sentence above – be based on the cumulative values of these installations.

Section 10: Grid Costs

(1) The costs associated with connecting installations as specified in Section 2 above to the technically and economically most suitable grid connecting point shall be borne by the installation operators. The implementation of this connection must comply with the grid operator's technical requirements in a given case and with the provisions laid down in [Section 16 of the Energiewirtschaftsgesetz (Energy Management Act) of 24 April 1998 (Federal Law Gazette 1, p. 730)]. The installation operator shall be entitled to have the connection implemented either by the grid operator or by qualified third party.

(2) The costs associated with upgrading the grid exclusively in order to connect new installations in accordance with Section 2 for accepting and transmitting energy fed into the grid for public power supply shall be borne by the grid operator whose grid will have to be upgraded. The grid operator shall specify the concrete investment required by presenting the costs in detail. The grid operator shall be entitled to add the costs borne by them when determining the charges for the use of the grid.

(3) Any disputes shall be settled by a clearing centre, which shall be established within the [Federal Ministry of Economics and Technology], with the involvement of the parties concerned.

Section 11: Nation-wide Equalisation Scheme

(1) Transmission grid operators shall be obliged to record any differences in the amount of energy purchase and compensation payments made under Section 3 above and to equalise such differences amongst themselves as specified in (2) above.

(2) By 31 March of each year, the transmission grid operators shall determine the amount of energy purchased in accordance with Section 3 above and the percentage share which this amount represents relative to the overall amount of energy delivered to final consumers either directly by the operator or indirectly via downstream grids. If transmission operators have purchased amounts of energy that are greater than this average share, they shall be entitled to sell energy to, and receive compensation from, the other transmission grid operators in accordance with Section 3 to 8 above, until these other grid operators have purchased a volume of energy which is equal to the average share mentioned above.

(3) Monthly instalments shall be paid in accordance with the equalisation amounts and payments to be expected.

(4) Utility companies which deliver electricity to final consumers shall be obliged to purchase and pay compensation for that part of the electricity which their regular transmission grid operator purchased in accordance with the provisions of (2) above. The first sentence shall not apply to the utility companies if, relative to the total amount of electricity they deliver, at least 50 per cent of the electricity as defined in Section 2 (1) in conjunction with (2) above. The part of the electricity to be purchased by a utility company in accordance with the first sentence shall be related to the amount of electricity delivered by the utility company will receive a relatively equal share. The compulsory amount to be purchased (part) shall be calculated as the ratio of the total amount of electricity fed into the grid under Section 3 to the total amount of electricity sold to final consumers; furthermore, it is necessary to deduct from this sum the amount of electricity

delivered by utility companies in accordance with the second sentence above. The compensation as specified in the first sentence above shall be calculated as the average compensation per kilowatt-hour paid by all grid operators two quarters earlier in accordance with Section 3. Electricity purchased in accordance with the first sentence shall not be sold at the compensation paid in accordance with the fifth sentence, if that electricity is marketed as electricity pursuant to Section 2 or as comparable electricity.

(5) Each grid operator shall be obliged to make available in good time to the other grid operators the data required to perform the calculations referred to in (1) and (2) above. Each grid operator shall be entitled to request that the other grid operators have their data audited by a chartered accountant or a sworn auditor appointed by mutual agreement. If no agreement can be reached, the chartered accountant or sworn auditor shall be appointed by the President of the Higher Regional Court, which has jurisdiction at the seat of the grid operator eligible to receive equalisation payments.

Section 12: Progress Report

By 30 June, every two years after the entry into force of this Act, the [Federal Ministry of Economics and Technology] shall submit a report – drafted in consultation with the [Federal Ministry of Food, Agriculture and Forestry] – on the progress achieved in terms of the market introduction and the cost development of power generation installations as specified in Section 2 to 8 and of their reduction rates, in keeping with technological progress and market developments with regard to new installations; furthermore, the Ministry shall propose a prolongation of the period for calculating the yield of a wind energy converter as specified in the Annex, based on the experience made with the period defined in this Act.

Annex

1. The reference installation shall be a wind energy converter of a specific type for which a yield at the level of the reference yield can be calculated on the basis of P-V curve (power wind speed curve) measured by an authorised institution at the reference site.
2. The reference yield shall be the amount of electricity which each specific type of wind energy converter, including the respective hub heights, would yield during five years operation – calculated on the basis of measured P-V curves – if it were built at the reference site.
3. The type of a wind energy converter shall be defined by the model designation, the swept rotor area, the rated power output and the hub height as specified by the manufacturer.
4. The reference site shall be a site determined by means of a Rayleigh distribution with a mean annual wind speed of 5.5 metres per second at a height of 30 metres, a logarithmic wind shear profile and a roughness length of 0.1 metres.
5. The P-V curve shall be the correlation between wind speed and power output (irrespective of hub height) determined for each type of wind energy converter. P-V curves shall be determined in accordance with the standard procedure defined in the [Technische Richtlinien fuer Windenergieanlagen (Technical Guidelines for Wind Energy Converters), rev. 13, as of 1 January 2000, published by Foerdergesellschaft Windenergie e.V. (FGW), Hamburg, or in the Power Performance Measurement Procedure, version 1, published in September 1997 by the Network of European Measuring Institutes (MEASNET), Brussels/ Belgium], P-V curves which were determined by means of a comparable procedure prior to 1 January 2000 can also be used instead of P-V curves as specified in the second sentence, providing that the construction of wind energy converters of the type of which they apply is not initiated within the territorial scope of this Act after 31 December 2001.
6. Measurements of the P-V curves and calculations of the reference yields of different types of wind energy converters at reference sites shall be carried out for the purpose of this Act by institutions which are accredited for the measurement of P-V curves as defined in 5) above in accordance with the [General Criteria for the Operation of Test Laboratories (DIN EN 45001) of May 1990. The names of these institutions shall be published in the [Federal Official Gazette by the Federal Ministry of Economics and Technology] for the information of interested parties.

The Promotion Law of Renewable Energy Development and Utilisation of the People's Republic of China
Draft March 2005

The State Council produced a comprehensive document, covering the application of renewable energy for electric power generation, liquid fuels, gas feed-in and heat generation.

1. **General Principles**
   The purpose, scope, rights and obligations of using renewable energies are explained. This is followed by the principle of combined government promotion and market orientation. Rural Energisation, R&D, Dissemination & Education, Environmental Protection, Sector Guidance, Honouring and Awarding and Responsibilities are outlined.

2. **Resource Management and Development Plan**
   A comprehensive renewable energy resource plan and an integrated renewable energy development plan including national, social, economic and environmental development are to be prepared and be open to the public.

3. **Industry Guidance and Technology Advancement**
   Awareness, standardisation, testing and certification, education, R&D, renewable energy centres, publicity, entrepreneurship and industry associations shall be facilitated.

4. **Dissemination and Application**
   Grid-connected power from renewable energy must be accepted at full price by utilities. Independent power producers are encouraged.
   Likewise, remote renewable power production for living or production is supported, as is biomass, biogas and heat, liquid fuels and solar thermal, as well as cogeneration.
   For areas with annual sunlight hours exceeding 1 500 hours, solar water heaters or piping must be installed on all new or upgradings of residences, hotels, restaurants, hospitals, schools and public buildings less than 11 storeys high.

5. **Price Management**
   Government decides on feed-in renewable energy prices by approving, bidding or designing a classified catalogue.
   Government approving pertains to government constructed and invested projects. Bidding is applied to conventional projects, while the classified catalogue is applied to renewable energy projects. This is related to the cost of comparable cost levels of the same kind.

6. **Economic Incentive**
   A Renewable Energy Development Fund shall compensate for the marginal renewable energy costs and shall serve for subsidies in rural areas, biomass, liquid fuels, resource assessment, technological diffusion, RD&D, pilot projects, equipment, education, training, international cooperation and communication are supported.
   Income for the Fund is to accrue from electricity, sales, fiscus, profit, donations, and others.
   Commercial banks are expected to offer favourable credits to renewable energy projects.

7. **Legal Responsibility**
   Penalties for defaulting are set between 500 000 (approx US$ 60 000) and one million Yuan (approx US$ 120 000) to power, grid and oil corporations, and at 100 000 Yuan (approx US$ 12 000) for defaulting estate developers.

Comments
The implementation of the new law manifests the awareness of the Peoples Republic of China. Responsibilities and budgets have been assigned unequivocally. Commitments to targets like " 10 %, 20 %, 50 % RE by 2010, 2020, 2050" are surmised to be in the offing. A long-term renewable energy pricing structure system is probably being prepared. If these crucial dimensions are integrated, the new law will be the most advanced renewable energy law in the world. The impact on the People's Republic of China and the rest of the world could be trend-setting.

Conclusions

It appears that in the future energy mix it is unlikely that a single renewable energy technology will be dominant. It would be unwise to bet on one winner, although proponents often would disagree.

Renewable energy is not an end in itself. It is one way of providing energy services in a socially and environmentally sustainable way at least life cycle costs. Integrated energy planning is a subset of integrated resource planning, where the supply of resources are matched with the demand.

Competition for resources within nations and between nations does not exclude cooperation. In nature, symbiosis and cooperation is more frequent than expected. Entities that are both flexible and energy efficient tend to be more successful competitors. Therefore, developing nations can improve their wellbeing by being more energy efficient and less reliant on fossil fuels. The use of renewable energies encourages this trend. In this way, it is possible to enhance one's own benefit while making a contribution to the common good.

It is not unconceivable that new energy related accounting systems could develop in future. A first step might be the triple bottom line.

Governments have a longer planning horizon than individuals and commercial interests. Their policies are – or should be – built on long-term future visions. Their own investments in buildings and other acquisitions should consequently reflect this perspective, based on least life cycle cost calculations, including the full externality costs.

Governments exist within regional, continental and international contexts, which bring with them mutual interactions and obligations. Some of these help the rapid, orderly and sustained energy transition, others hinder. In their interactions, wise governments have to think of, and create, win-win situations.

Although the market is a strong driver, market failures do occur in the field of energy. Thus, governments avoid and correct such market failures, knowing the price per kilowatt-hour does not reflect the value of an energy service.

By now, experience has also shown that one cannot rely on a single policy. An optimal system of complementary policies and measures is needed. Nor can one expect that Federal or Central Government can do it alone. Various levels of government as well as the private sector have to work in concert, or at least in constructive competition.

Even the best policies are of little use if they are not being applied consistently. In the developing world capacities are severely limited. It follows that renewable energy laws should be easy to monitor and enforce.

Many independent scientists confirmed that the transition to renewable energy is necessary, urgent and techno-economically feasible, although this may seem as unlikely to some as it was unthinkable not so long ago that man could walk on the moon.

Times of transition are always turbulent times. In such times the most natural human reaction is to panic and cling to the habitual, procrastinating in the fear of making the wrong decision. However, the decision to procrastinate is also a decision – most often the wrong one.

As the world transitions to the new era, it will not wait for the developing world to catch up. It is the own choice of individuals, families, communities, companies and nations whether they want to be losers or winners in the dawning solar age. Some people will look back at our times and smile.

Acknowledgements and References

The author wishes to acknowledge the help of Dr. Donald Aitken, author of the precursor ISES White Paper (2000), who kindly offered critique, advice and support.

Input from colleagues of the ISES Board and Headquarters are gratefully acknowledged.

Dr Monica Oliphant initiated and wisely guided this White Paper in her capacity of Vice-president for Public Affairs of ISES.
Henning Holm kindly shared his experience in the developing world to the benefit of this White Paper.
Prof Ricardo Rüther from Brazil is thanked for his constructive criticism.

As usual, the author takes the responsibility for errors.

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About the Author

Dieter Holm is a consultant in Sustainable Development in the Built Environment. He and his family live at the Hartbeespoort Dam near Pretoria in the first modern autonomous house in Africa built before the first 1970s energy crisis. Next to passive solar heating, heat rejection and day lighting their home also features rainwater harvesting, solar water heating and recycling as well as solar cooking and baking. PV panels power the household in addition to the office and his wife's woodturning workshop.

Dieter is an enthusiastic teacher, having been Head of the Department Architecture and later of Research and Postgraduate Studies at the University of Pretoria, South Africa. As a director of Holm Jordaan Holm Architects he coauthored many prize-winning competition entries, the latest of which being the new HQ for the Municipality of Pretoria. He publishes mainly on the application of passive design in buildings, and produced three books.

He is secretary of ISES, director of ISES Africa, president of the Sustainable Energy Society of Southern Africa, and chairman of the Solar Water Heating Division of SESSA.

His work in energy in low cost housing received the prize for the residential category with the Eskom Eta Award Competition for Energy Efficiency.

Professor Dieter Holm is a regular speaker at international and local conferences, radio interviews and TV specialist features.

Annexure A

Developing and least Developed Countries (UNDP 2003 Human Development Report: Millennium Development Goals: A compact among nations to end human poverty. New York, Oxford University Press)

Developing countries and 49 least developed countries (in bold)

Afghanistan
Algeria
Angola
Antigua and Barbuda
Argentina
Bahamas
Bahrain
Bangladesh
Barbados
Belize
Benin
Bhutan
Bolivia
Botswana
Brazil
Brunei Darussalam
Burkina Faso
Burundi
Cambodia
Cameroon
Cape Verde
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo
Congo, Dem. Rep. of the
Costa Rica
Côte d'Ivoire
Cuba
Cyprus
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Ethiopia
Fiji
Gabon
Gambia
Ghana
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong, China
India
Indonesia
Iran, Islamic Rep. of
Iraq
Jamaica
Jordan
Kenya
Kiribati
Korea, Dem. Rep. of
Korea, Rep. of
Kuwait
Lao People's Dem. Rep.
Lebanon
Lesotho
Liberia
Libyan Arab Jamahiriya
Madagascar
Malawi
Malaysia
Maldives
Mali
Marshall Islands
Mauritania
Mauritius
Mexico
Micronesia, Fed. Sts.
Mongolia
Morocco
Mozambique
Myanmar
Namibia
Nauru
Nepal
Nicaragua
Niger
Nigeria
Occupied Palestinian Territory
Oman
Pakistan
Palau
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Qatar
Rwanda
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa (Western)
São Tomé and Principe
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore
Solomon Islands
Somalia
South Africa
Sri Lanka
Sudan
Suriname
Swaziland
Syrian Arab Republic
Tanzania, U. Rep. of
Thailand
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Tuvalu
Uganda
United Arab Emirates
Uruguay
Vanuatu
Venezuela
Viet Nam
Yemen
Zambia
Zimbabwe
(137 countries/areas)

Abbreviations

Abbreviations	
°C	degree Celsius
BANANA	Build Absolutely Nothing Anywhere Near Anything
BIPV	Building Integrated Photovoltaics
BOS	Balance Of System
Btu	British thermal unit
CDM	Clean Development Mechanism
CERT	Certificate
CFL	Compact Fluorescent Light
CHP	Combined Heat and Power
CIS	Commonwealth of Independent States
COP	Coefficient Of Performance
CSH	Concentrated Solar Heat
DALY	Disability Adjusted Life Year
DG	Distributed Generation
DIN	Deutsche Industrienorm
DNA	Designated National Authority
DSM	Demand Side Management
EE	Energy Efficiency
EJ	Ekta Joule
EU	European Union
FAO	Food and Agriculture Organisation
FF	Flexible Fuel
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
HDR	Hot Dry Rocks
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISES	International Solar Energy Society
ISO	International Standards Organisation
K	Kelvin
KCJ	Kenya Ceramic Jiko
kWh	kilowatt-hour
LED	Light Emitting Diode
LHV	Lower Heat Value
LPG	Liquid Petroleum Gas
Mtoe	Million tons of oil equivalent
MW	Megawatt
MWe	Megawatt electrical
NFFO	Non-Fossil Fuel Obligation
NGO	Non-Governmental Organisation
NIMBY	Not In My BackYard
OECD	Organisation of Economic Cooperation and Development
PROINFA	Programa de Incentivo a Fontes Alternativas
PTC	Production Tax Credit
PV	Photovoltaics
R&D	Research and Development
RD&D	Research Development and Demonstration
RE	Renewable Energy
REC	Renewable Energy Certificate
REL	Rural Electrification
RET	Renewable Energy Technology
RPS	Renewable Portfolio Standard
SADC	Southern African Development Community
SHS	Solar Home Systems
SWH	Solar Water Heater/Heating
TERI	The Energy and Resources Institute
UNDP	United Nations Development Programme
WBGU	Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderung (German Advisory Council on Global Change)
WCD	World Commission on Dams
WWEA	World Wind Energy Association
WSSD	World Summit on Sustainable Development

The International Solar Energy Society gratefully acknowledges
Prof Dr Dieter Holm, Secretary of ISES, Director of ISES Africa, and President of the Sustainable Energy Society of Southern Africa, who drafted this White Paper with input from expert resources worldwide, and technical review and input by the Headquarters and the ISES Board of Directors.

Produced by:
ISES Headquarters

Design: triolog, Freiburg

Printed on 100 % recycled paper

"The developing world is not simply the poor man's imitation of the industrialized world"

"Because of its underdeveloped energy infrastructure and unique RE potential, the developing world - in partnership with the industrialized world - can leapfrog to RE technologies while benefitting from the Kyoto Protocol"

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