ISES

International Solar Energy Society

Transitioning to a Renewable Energy Future

White Paper

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Executive Summary

This White Paper provides a rationale for effective governmental renewable energy policies worldwide, as well as sufficient information to accelerate effective governmental policies. It is the thesis of this White Paper that a worldwide effort to generate the renewable energy transition must emerge at the top of national and international political agendas, starting now.

In the history of human energy use, the White Paper records that sustainable resources were the sole world supply, even in nascent industrial development well into the 1800s, and that the world will necessarily again have to turn to sustainable resources before the present century is over. The fossil fuel period is therefore an "era", not an age, and highly limited in time in comparison with the evolution, past and future, of civilizations and societies. Accordingly, it is critical for governments to view what remains of the fossil fuel era as a transition.

The White Paper reveals that policies now in existence, and economic experience gained by many countries to date, should be sufficient stimulation for governments to adopt aggressive long-term actions that can accelerate the widespread applications of renewable energy, and to get on a firm path toward a worldwide "renewable energy transition", so that 20 % of world electric energy production can come from renewable energy sources by 2020, and 50 % of world primary energy production by 2050. There can be no guarantee this will happen, but the White Paper presents compelling arguments that show it is possible, desirable, and even mandatory.

The window of time during which convenient and affordable fossil energy resources are available to build the new technologies and devices and to power a sustained and orderly final great world energy transition is short – an economic timeline that is far shorter than the time of physical availability of the "conventional" energy resources. The White Paper argues that the attractive economic, environmental, security and reliability benefits of the accelerated use of renewable energy resources should be sufficient to warrant policies that "pull" the changes necessary, avoiding the "push" of the otherwise negative consequences of governmental inaction. There is still time left for this.

The White Paper presents three major conditions that are driving public policy toward a renewable energy transition:

1) newly emerging and better understood environmental constraints;
2) the need to reduce the myriads of risks from easy terrorist targets and from breakdowns in technologies on which societies depend; and
3) the attractiveness of the economic and environmental opportunities that will open during the renewable energy transition.

The renewable energy transition will accelerate as governments discover how much better the renewable energy policies and applications are for economies than the present time- and resource-limited policies and outmoded and unreliable centralized systems for power production and distribution.

Today, it is public policy and political leadership, rather than either technology or economics, that are required to move forward with the widespread application of the renewable energy technologies and methodologies. The technologies and economics will all improve with time, but the White Paper shows that they are sufficiently advanced at present to allow for major penetrations of renewable energy into the mainstream energy and societal infrastructures. Firm goals for penetrations of renewable energy into primary energy and electrical energy production can be set by governments with confidence for the next 20 years and beyond, without resource limitations.

Specifically, with regard to the renewable energy technologies, the White Paper shows the following:

- *Bioenergy:* about 11 % of world primary energy use at present is derived from bioenergy, the only carbon-neutral combustible carbon resource, but that is only 18 % of today's estimated bioenergy potential. Estimates for world bioenergy potential in 2050 average about 450 EJ, which is more than the present total world primary energy demand. Fuel "costs" for the conventional resources become instead rural economic benefits with bioenergy, producing hundreds of thousands of new jobs and new industries.

- *Geothermal Energy:* geothermal energy has been used to provide heat for human comfort for thousands of years, and to produce electricity for the past 90 years. While geothermal energy is limited to those areas with access to this resource, the size of the resource is huge. Geothermal energy can be a major renewable energy resource for at least 58 countries: thirty-nine countries could be 100 % geothermal powered, with four more at 50 %, five more at 20 %, and eight more at 10 %. Geothermal energy, along with bioenergy, can serve as stabilizing "baseload" resources in networks with the intermittent renewable energy resources.

- *Wind Power:* global wind power capacity exceeded 32,000 MW by the end of 2002, and has been growing at a 32 % rate per year. Utility-scale wind turbines are now in 45 countries. The price of wind-produced electricity is now competitive with new coal-fired power plants, and should continue to reduce to where it will soon be the least expensive of all of the new electricity-producing resources.
  A goal of 12 % of the world's electricity demand from wind by 2020 appears to be within reach. So is a goal of

20 % of Europe's electricity demand by 2020. This development pace is consistent with the historical pace of development of hydroelectric and nuclear energy. The 20 % penetration goal for the intermittent renewable energy resources is achievable within present utility operations, without requiring energy storage.

- *Solar Energy:* The energy from the sun can be used directly to heat or light buildings, and to heat water, in both developed and developing nations. The sun's radiant energy can also directly provide very hot water or steam for industrial processes, heat fluids through concentration to temperatures sufficient to produce electricity in thermal-electric generators or to run heat engines directly, and produce electricity through the photovoltaic effect. It can be used directly to enhance public safety, to bring light and the refrigeration of food and medicine to the 1.8 billion people of the world without electricity, and to provide communications to all regions of the world. It can be used to produce fresh water from the seas, to pump water and power irrigation systems, and to detoxify contaminated waters, addressing perhaps the world's most critical needs for clean water. It can even be used to cook food with solar box cookers, replacing the constant wood foraging that denudes ecosystems and contaminates the air in the dwellings of the poor.

- *Buildings:* in the industrial nations, from 35 % to 40 % of total national primary use of energy is consumed in buildings, a figure which approaches 50 % when taking into account the energy costs of building materials and the infrastructure to serve buildings. Letting the sun shine into buildings in the winter to heat them, and letting diffused daylight enter the building to displace electric lighting, are both the most efficient and least costly forms of the direct use of solar energy. Data are mounting that demonstrate conclusively enhancements of human performance in daylit buildings, with direct economic and educational benefits that greatly multiply the energy-efficiency "paybacks". The integrated design of "climate-responsive" buildings through "whole building" design methods enables major cost-savings in actual construction, normally yielding 30 % to 50 % improvement in energy efficiency of new buildings at an average of less than 2 % added construction cost, and sometimes at no extra cost.

- *Solar Energy Technologies:* serious long-range goals for the application of solar domestic water and space heating systems need to be established by all governments, totaling several hundred million square meters of new solar water heating systems worldwide by 2010. A worldwide goal of 100,000 MW of installed concentrating solar power (CSP) technology by 2025 is also an achievable goal with potentially great long-term benefits.

Photovoltaic (PV) solar electric technology is growing worldwide at an amazing pace, more than doubling every two years. The value of sales in 2002 of about US$ 3.5 billion is projected to grow to more than US$ 27.5 billion by 2012. PV in developed and developing nations alike can enhance local employment, strengthen local economies, improve local environments, increase system and infrastructure reliability, and provide for greater security. Building-integrated PV systems (BIPV) with modest amounts of storage can provide for continuity of essential governmental and emergency operations, and can help to maintain the safety and integrity of the urban infrastructure in times of crisis. PV applications should be an element of any security planning for cities and urban centers in the world.

The White Paper stresses the importance of governmental policies that can enhance the overall economic productivity of the expenditures for energy, and the great multiplier in the creation of jobs from expenditures for the renewable energy resources rather than for the conventional energy sources. Utilities are not in the job producing business, but governments are, supporting the need for governments to control energy policies and energy resource decisions.

National policies to accelerate the development of the renewable energy resources are outlined, emphasizing that mutually supporting policies are necessary to generate a long-term balanced portfolio of the renewable energy resources. Beginning with important city examples, the discussion moves to national policies, such as setting renewable energy standards with firm percentage goals to be met by definite dates. The specific example of the successful German "feed-in" laws is used to illustrate many of these points.

Market-based incentives are described in the White Paper, to compare with legislated goals and standards, and discussed in terms of effectiveness. It is shown that various voluntary measures, such as paying surcharges for "green power", can provide important supplements to funding for renewable energy, but that they cannot be sufficient to generate reliable, long-term growth in the renewable energy industries, nor to secure investor confidence. Reliable and consistent governmental policies and support must be the backbone for the accelerated growth of the industries.

It is also shown in this White Paper that the energy market is not "free", that historical incentives for the conventional energy resources continue even today to bias markets by burying many of the real societal costs of their use. It is noted that the very methodologies used for estimating "levelized" costs for energy resources are flawed, and that they are not consistent with the more realistic economic methodologies used by modern industries. Taking into account future fuel supply risk and price volatility in net present valuations of energy resource alternatives paints a very different picture, one in which the renewable energy resources are revealed to be competitive or near-competitive at the present time.

Even though this White Paper emphasizes the readiness of the renewable energy technologies and markets to advance the penetration of these resources to significant levels in the world, an important component of any national renewable energy policy should be support for both fundamental and applied R&D, along with cooperation with other nations in R&D activities to enhance the global efficiency of such research. It is both significant and appropriate that the European Commission has agreed to invest for the next five-year period in sustainable energy research an amount that is 20 times the expenditure for the 1997-2001 five-year period.

Governments need to set, assure and achieve goals to accomplish simultaneously aggressive efficiency and renewable energy objectives. The implementation mechanisms for achieving these goals must be a packaged set of mutually supportive and self-consistent policies. The best policy is a mix of policies, combining long term renewable energy and electricity standards and goals with direct incentive and energy production payments, loan assistance, tax credits, development of tradable market instruments, removal of existing barriers, government leadership by example, and user education.

The White Paper concludes with the presentation of two comprehensive national energy policies to demonstrate the method of integration of various individual strategies and incentives into single, long-range policies with great potential returns.

All of those square meters of collectors and hectares of fields capturing solar energy, blades converting the power of the wind, wells delivering the Earth's thermal energy, and waters delivering the energy of river flows, waves and tides, will displace precious and dwindling fossil fuels and losses of energy from the worldwide phase-out of nuclear power. Sparing the use of fossil fuels for higher economic benefits, or using them in fuel-saving and levelizing "hybrid" relationship with the intermittent renewable energy resources (sun and wind), will contribute to leaner, stronger, safer societies and economies. And, in the process, carbon and other emissions into the atmosphere will be greatly reduced, now as a result of economically attractive new activities, not as expensive environmental penalties.

Summary of Policy Options and Implementation Mechanisms

- National multi-year goals for assured and increasing markets for renewable energy systems, such as "Renewable Energy Standards" (also called, in the U.S., "Renewable Portfolio Standards", or RPS), or the EU Renewables Directive, especially when formulated to support balanced development of a diversity of renewable energy technologies;
- Production incentives, such as “feed-in” laws, production tax credits (PTC), and net metering;
- Financing mechanisms, such as bonds, low-interest loans, tax credits and accelerated depreciation, and green power sales;
- System wide surcharges, or system benefits charges (SBC), to support financial incentive payments and loans, R&D and public interest programs;
- Credit trading mechanisms, such as Renewable Energy Credits (RECs) or carbon reduction credits, to enhance the value of renewable energy, to increase the market access to those energy sources, and to value the environmental benefits of renewables;
- Specific governmental renewable energy “quotas” for city and state renewable energy procurements;
- Removal of procedural, institutional and economic barriers for renewable energy, and facilitation of the integration of renewable energy resources into grids and societal infrastructure;
- Consistent regulatory treatment, uniform codes and standards, and simplified and standardized interconnection agreements;
- Economic balancing mechanisms, such as pollution or carbon taxes (which can then be diverted as “zero sum” incentives to the non-polluting and non-carbon technologies);
- “Leveling the playing field” by redressing the continuing inequities in public subsidies of energy technologies and R&D, in which the fossil fuels and nuclear power continue to receive the largest share of support.

Preface: Solar Energy from Then to Now and Beyond

Solar energy is *not* an "alternative energy". It is the original and continuing primary energy source. All life and all civilizations have always been powered by solar energy. Expanding the technical applications of solar energy and its other renewable energy cousins to carry civilizations forward is simply a logical extension of its historic role, but also the inescapable key to achieving sustainability for human societies.

The solar energy that is absorbed by the Earth and atmosphere drives the great cycles of weather and ocean currents, distributing the energy over the face of the Earth. Solar energy provides the evaporation engine, lifting moisture to the atmosphere from where it can fall, bringing clean, fresh water to plants and filling the ponds, lakes, aquifers, streams, rivers and oceans, spawning and supporting all forms of life. Solar energy is tapped by plants through photosynthesis to energize the growth, directly and indirectly, of all life on Earth. The solar energy stored in wood and woody crops has been released by lightning in fire to renew wild ecological systems. More recently humans have released that stored solar energy in controlled fires to provide comfort and cooking. And the sun's direct heat has been adapted into shelters to warm humans in cold climates for time eternal.

As human social groupings evolved into cities, the sun continued to provide support with ever expanding uses of its energy for life and commerce. Rivers filled by sun-provided water became transportation sources and locations for great cities. The solar-driven power of wind was tapped to grind grain in great windmills, and to power the sails across the oceans carrying explorers, settlers, and materials for commerce, and cross-fertilizing civilizations. Water falling over water wheels converted the sun's energy of evaporation to power for machinery, such as for the early printing presses and cotton gins, and then turned the early (hydroelectric) generators to bring electricity to cities.

The solar energy released in burning wood turned water to steam to greatly advance industry and transportation, and to provide for human thermal comfort in homes and buildings. Although the widespread use of coal developed in the second part of the 1800s, and oil was discovered in the 1800s, wood was still the primary energy used to power industrial civilizations into the early 20th Century.

From yielding the energy that powers the chemical, mechanical and electrical functions of all living things, and conditions their supporting environment, the sun's role in life and ecosystems has always come first, and will continue to do so for as long as life exists on this planet. Societies that accept this principle will flourish, while those that try to evade this truth for their own short-term economic benefit will fail.

It was only during this most recent century that human societies transitioned to the fossil fuels for their primary energy needs, forgetting, over time, that the energy in gas, oil and coal is also solar energy that had been stored in living tissue (biomass) that did not get a chance to decay, but rather was stored, compressed, heated, and turned into fossil fuels over the last 500 million years. The cheap access to coal in new coal-mining settlements, and then the convenience of oil and gas, caused the widespread abandonment of passive solar, daylighting, and other environmental design features for buildings. Although solar water heating was commercialized and common in a number of areas at the beginning of the 20th century, it, too, was replaced by the cheap convenience of gas and electricity. The direct use of solar energy has been replaced by the indirect use of stored solar energy. Yet solar energy it still is.

So one way or another, civilizations have remained, to this day, powered by solar energy. (Of the two primary non-solar resources, nuclear energy contributed 6.8 %, and geothermal energy 0.112 %, to world primary energy in the year 2000.) Most often, though, we have used profligately and wastefully, and taken for granted, the limited resource of fossil fuels. The fossil fuels are being steadily depleted, and they *cannot* be replaced on any reasonable time scale of human civilizations. While the lifetime of oil and gas may stretch out through the first half of this century, the transition to sustainable alternatives must happen well before the physical or economic depletion of these valuable stored energy resources. *Civilization must begin to take seriously this transition.*

There is a readily available solution – *the renewable energy resources.* They are non-polluting, inexhaustible, operate in stable harmony with the Earth's physical and ecological systems, create jobs and new industries out of expenditures that previously had gone to purchase fuels, contribute to physical and economic self-sufficiency of nations, are available to both developed and developing nations, and cannot be used to make weapons.

We have turned to "yesterday's sunshine" stored in fossil fuels for about 100 years, after relying on "today's sunshine" for all of human history before that. Therefore, it is a thesis of this White Paper that the world must emerge from this brief fossil-fueled moment in human history with a renewed dependence on "today's sunshine" for the entire portion of human history yet to be written.

Framework, Scope and Limitations of this White Paper

Opening with a discussion of the new elements that are today driving public policy toward the renewable energy transition, this White Paper presents information on applications and policies for those renewable energy resources that are in great abundance worldwide, but which have barely begun to be developed to their full potential. The present status and rate of growth of each of the major renewable energy technologies is briefly summarized, to help inform the reader of their technical and market maturity and to demonstrate the potential for renewable energy resource development.

The "baseload" renewable energy resources (bioenergy and geothermal energy) are first presented, because of their widespread historical contributions to meeting the energy needs of the world and their promise for future large-scale expansion. This is followed by the "intermittent" renewable energy resources (wind and direct thermal and electrical applications of radiant solar energy).

The next section delineates the various policies that have been emerging to advance renewable energy technologies and applications worldwide, to outline the portfolio of options available today for governments and nations.

Policies for the development of new large-scale hydroelectric power projects are not presented. Hydroelectric energy has been long commercialized. And an argument can be made that, while hydroelectric energy remains a very important worldwide renewable (and sustainable) energy resource (producing about 2.3 % of world primary energy supply in 2000 and 17 % of global electricity production), few large rivers remain to be tapped, and those that do are revealing ecological benefits from running free that exceed the benefits of being corralled behind dams to impound water and to produce electricity. Small hydroelectric applications ("micro hydro") can still fill important local niches for power.

Existing hydroelectric power has great potential to complement, level, and even store the energy from intermittent renewable energy resources, thereby increasing the value and utility of both. So it will continue to be a valuable resource in the transition and beyond. But on a worldwide scale hydroelectric power is nearing its maximum potential development already.

Nuclear power is also not presented as a realistic policy option in this White Paper. Nuclear energy currently makes a small but significant worldwide contribution (6.8 % of world primary energy – that is, all energy consumed by end users – in 2000, and about 17 % of global electric energy production, both figures still less than those for renewable power and energy production). But it appears that the pace of nuclear plant retirements will exceed the development of the few new plants now being contemplated, so that nuclear power may soon start on a downward trend. It will remain to be seen if it has any place in an affordable future world energy policy. And even if it does, it would be incredibly foolish to place all of the world's hopes on just one resource, for if it fails, what then? As nature strengthens its ecological systems through diversity, so must governments seek policies that support a diversity of energy resources. For developing nations, the energy resources of greatest importance are those that are locally available, and which can be tapped and applied affordably by locally available human resources. Nuclear power fails all of these tests. The renewable energy resources pass them.

The ultimate definition of "sustainability" must accept as primary the maintenance and integrity of the solar-driven ecological and physical systems, or human societies and economies will surely perish.

In keeping with the aim of this White Paper – to accelerate the application of the *presently commercialized* renewable energy resources – future possibly important applications, such as ocean thermal energy conversion (OTEC), wave energy, and tidal power, are also not discussed. But one can expect that these, too, will sometime in the future take their places in the complete portfolios of opportunities to utilize nature's gift of renewable energies.

The following material presents just enough about each of the selected resources to be read by busy decision-makers, to support the types of policies available to them, to support the value of setting aggressive goals which are also realistic, and to suggest the kinds of benefits that will accrue from those policies. This paper focuses on generating and supporting the *process* of the renewable energy transition.

This White Paper owes much to the many informational resources, both people and publications, from which the material for this paper has been drawn. But this is intended to be a policy piece, not a research paper, so, with the exception of the figures, the following material is presented without specific source attributions. The principal resources are acknowledged at the end of this paper.