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## Preface

*There is anxiety throughout the world concerning reserves of energy. The demand for electricity has increased of late years at an exponential rate, and if the demand for coal oil and gas has nearly followed a straight-line law, the slope of the line has been such as to cause concern among individual nations as to when their own supplies of fossil become exhausted, and to the world in general as to possible sources of energy when there is no more coal or oil . . . In consequence of this position, there is the greatest activity all over the world to eke out coal reserves by using other sources of energy.*

From *Nature* 5 August 1950

- 1. If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next 100 years. The most probable result will be a sudden and uncontrollable decline in both population and industrial capacity.*
- 2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his or her individual human potential.*
- 3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success.*

Résumé of “*The Limits of Growth*,” Meadows *et al.* 1972

Since the article in *Nature* more than half of a century, since the résumé of the report to the “Club of Rome” more than a quarter of a century has passed. Meanwhile — after heavy discussions in the seventies and early eighties — these theses are accepted even by former vehement opponents. It even seems that these formerly so called “panic makers” are common sense

nowadays. On the other hand, it looks as if we have already passed the limits mentioned – the rise of global temperature and the accumulation of natural catastrophes in the last decade are indicating it – despite better technology, stronger environmental laws, many conferences and a more ecological common sense. 1998 was by far the warmest year since worldwide records began. Mean global temperature reached a level that exceeded any of those recorded in the last 130 years and confirmed the pronounced trend (Munich Re Insurance 1998). Resignation doesn't bring us closer to the fulfillment of the needs mentioned by the report. This book has been written as a small contribution to the setting up of a sustainable development. I sincerely thank all those who helped to improve it: Dr. Paul Grunow from Q-cells, Dr. Christoph Baumann and Dr. Dieter Merkle from Springer Scientific Publications, Keith Parsons from NYU, and all the students who contributed considerably to the research projects. Particular thanks to Dr. Franz Alt and to Dr. Hermann Scheer for their encouraging forewords, and to Prof. Martin Green for his brief history on photovoltaics.

Rio de Janeiro & Fortaleza, October 2005

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## Foreword by Dr. Franz Alt

TV-Journalist, editor and bestseller author.

German Solar Award 2004 and 1994, Human Rights Award 2003, Newsletter Award 2003, Environment Online Award, "Top Business Site" 2002, European Solar Award 1997, Environment Award "Golden Swallow" 1992, Siebenpfeiffer-Award 1987, Karl-Hermann-Flach Award, Drexel-Award, Hans-Thoma Medal 1983, Adolph Grimme Award 1979, Bambi TV-Award 1978.

### The Solar Energy Change is Possible

At the last UN World Summit the condition of our planet has been described as follows:

- half of the world's population has to survive with less than 2 € a day
- 26,000 people are dying each day of hunger and of lack of water
- the industrialized countries consume as much coal, gas and oil per day as nature generates within 500,000 days
- each 32 hours the US is spending for military and wars as much money as the UN's annual budget
- due the greenhouse effect almost a hundred species of animals and plants are becoming extinct every day
- every day humanity grows by a quarter of a million people
- the four richest men of the US possess more money than the poorest billion of the planet

Are we insane? Can we be rescued?

This book will search for answers on that central question of the future.

We are in front of the largest moral, economic, and social challenge in human history. We are already fighting several great wars at the same time:

- wars for the last resources of our planet, e.g., oil in Iraq
- a World War against nature and thus against us

Climatic change may turn into climate collapse and thus be life-threatening for humanity. Consequences of global warming that occurred just in the recent months: flooding in Bavaria, Austria, and Switzerland with billions of euros of damage, typhoons in East Asia, which caused 150 lives, the hurricanes in the south of the United States with several thousands of deaths and damages of 200 billion dollars and increasing hurricane activities in the whole Caribbean region.

The climate researchers predicted those situation amazingly accurate. We didn't want to know about it and repressed the hazard. Greed, ignorance and indolence have been stronger than comprehension, humbleness to the laws of nature and our willingness to change.

Even more dramatic for the future of the humanity and for all life on our planet is the fact that in the future all of the 6.5 billion people want to live like the 800 million in the industrial countries. We know that the planet will not bear that development. On the other hand that development cannot be stopped. The past "have-nots" will claim their fair right to live like we do.

## **Citizens Towards the Sun, Towards Freedom – the Solar Age Begins**

The most human vision for 21<sup>st</sup> century is called the Solar Age. We are able to achieve a 100% renewable energy supply within the next 40 years. We do not need oil from the Middle East, nor gas from Siberia, nor uranium from Australia. We have all energy carriers that we shall need for the future at our doorstep: sun, wind, hydro power, geothermal energy, biofuels from farmlands and woods.

According to a study from the European Commission world's energy supply in the year 2050 could look like this:

- 40% Solar power
- 30% Biomass
- 15% Wind power
- 10% Hydro power
- 5% Oil

A path towards an economic, ecological, peaceful and forever sustainable energy supply is demonstrated in that study. Multinational oil companies such as Shell and BP have internally elaborated similar energy scenarios.

Oil, gasoline, coal and gas are getting more expensive, are destroying the environment will be depleted within a few decades. It is more intelligent to shift duly, than to further ruin the planet. It is true that the change towards solar energy will cost us some money, but no energy-change will cost us our world.

Sun, wind, hydro power, geothermal energy and biofuels are available forever for a fair price. And all will profit: The climate, the economy, the jobs, you and me, and all the more our children and grandchildren.

Unemployment rates in Germany, Europe and the World are high, the economies are stagnating – but renewable energies are a growing branch of industry. Examples:

- China installed in 2004 more than 18 million square meters of solar thermal collectors
- Japan has the world's largest photovoltaic enterprises and created hundreds of thousands jobs by them (mainly using German solar technology)
- Germany is the world leader in production and application of wind turbines. Six percent of its electricity is already generated by wind power in 2005.
- California will produce, in the reign of its governor Arnold Schwarzenegger, a third of its energy necessities via renewable energy

sources and the Philippines will reach 40 percent by that time.

- Brazil is already generating more than 25 percent of its car fuel via regenerative raw materials.

### **Can That All be Financed?**

The great economic advantage of ecological energy generation is that sun, wind, hydro power and geothermal energy never will send an invoice. The matter is available almost everywhere where we need it – without the necessity of complex global transport routes. What we need is the mass production of the new energy technologies. The prices of those have fallen by 50 percent since 1995 - and the costs of the old energies doubled by that time period. The one who is burning wood-pellets nowadays instead of using fuel oil for heating pays about half the price.

You will become acquainted more with similar surprising examples in this important book by Stefan Krauter. The message of this book and the message of the *RIO 6* conference ([www.RIO6.com](http://www.RIO6.com)) is:

The Solar Energy Change is possible and the Solar Age has begun already.

Baden-Baden, October 2005

Dr. Franz Alt

[www.sonnenseite.com](http://www.sonnenseite.com)

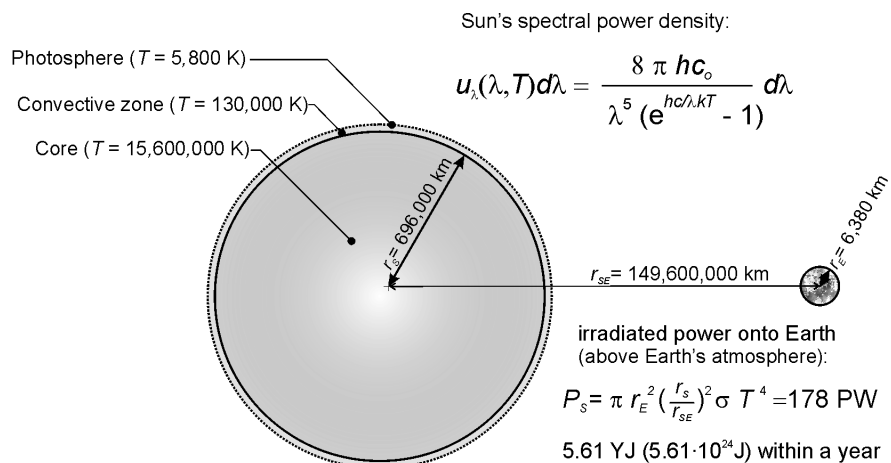
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## Foreword by Dr. Hermann Scheer

Member of German Parliament since 1980, President of the European Association for Renewable Energies, General Chairman of the World Council for Renewable Energies since 2001. Laureate of the World Solar Award 1998, Alternative Nobel Prize 1999, Word Award for Bioenergy 2000, “Hero of the Green Century” of TIME-Magazine 2002, World Award for Wind Power and Global Renewable Energy Leadership Award 2004.

### Sun’s True Energy Contribution

Solar energy already contributes to 94% of our planets energy use: it warms up Earth’s surface and its atmosphere from space’s -273.2°C to +14.5°C in average and is thus enabling all forms of life.



Without solar energy Earth would be a dead piece of rock in space with a temperature close to absolute zero. To allow a human habitat under that conditions, we would need approximately 15 times more commercial energy

than we consume today ( $15 \cdot 429.4$  EJ). All fossil fuel resources would be exhausted within a couple of years.

All existing fossil resources of energy such as coal, oil and gas are derived from biomass, photosynthesis and thus solar energy: Our planet has absorbed sunlight for hundreds of millions of years to create all those fossil resources that last just for 200 years of industrial human civilization.

### **Photovoltaics - the Most Versatile Application of Solar Energy**

Solar electric power generated via the direct conversion of solar radiation into electricity – Photovoltaics (PV) – enables humanity to make use of sunlight in a clean, ever lasting, and highly versatile way. Nowadays commercial PV converts 15% of the incoming solar irradiance for at least 30 years into sustainable electricity on all parts of the planet.

This book provides an ample amount of information treating human-caused climate-change, the potential of PV to reduce greenhouse gas emissions for different scenarios (on- and off-grid, applications in the Tropics and in Central Europe) and a Life-Cycle-Analysis, including recycling of system components. The results are based on an extensive model for the calculation of the actual electricity yield of PV power plants. That model considers all optical interfaces and layers passed by the sunlight from the sun into the solar cell, thermal layout of any PV module design and its heat transfer mechanisms, its actual photo-electric conversion efficiency, allowing an accurate calculation of the yield and the optimization of PV system components, thus reducing costs for solar electricity.

The book with its tables and reference data is a valuable source of information for PV system professionals, students of physics, engineering and environment, but also for everyone interested in the subject of solar electricity.

Berlin, November 2005

Dr. Hermann Scheer



Solar Electric Power Generation - Photovoltaic Energy  
Systems

Modeling of Optical and Thermal Performance, Electrical  
Yield, Energy Balance, Effect on Reduction of  
Greenhouse Gas Emissions

Krauter, S.C.W.

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