

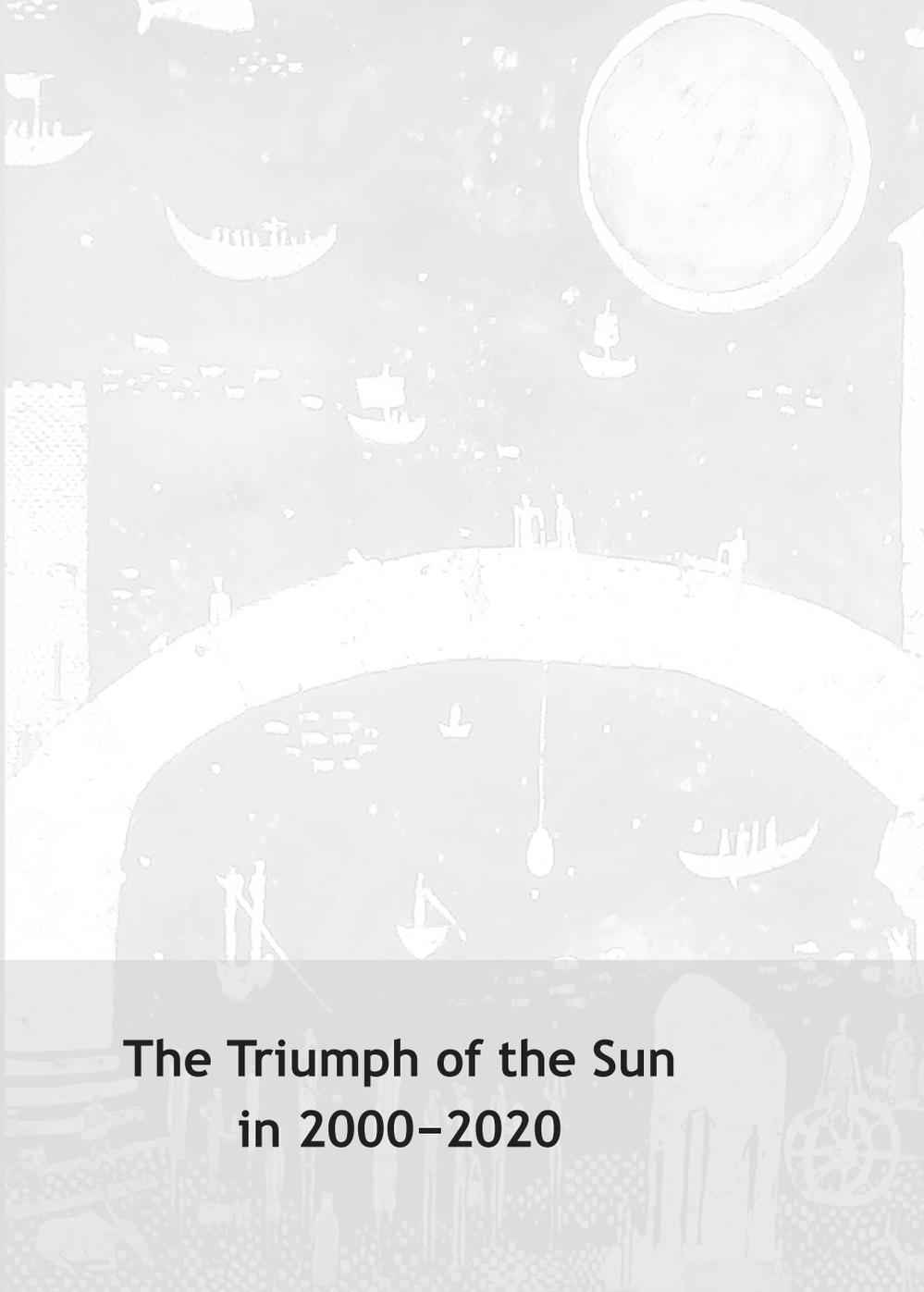
Jenny Stanford Series on Renewable Energy — Volume 11

Wolfgang Palz

The Triumph of the Sun in 2000–2020

How Solar Energy Conquered the World





**The Triumph of the Sun
in 2000–2020**

Jenny Stanford Series on Renewable Energy

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Wolfgang Palz

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How Solar Energy Conquered the World

Wolfgang Palz



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*A tribute to
my good friend, the late Hermann Scheer, MP
Alternative Nobel Prize Winner (1999)
Hero of the Green Century (US Time Magazine, 2002)*

A Tribute to the Glory of the Sun

Strauss, Richard. "Sonnenaufgang" (Sunrise), *Also sprach Zarathustra*. Perf. Herbert von Karajan and the Berliner Philharmoniker, 1984, Berlin.

<https://www.youtube.com/watch?v=6Hi5xbguTJk>.

Also sprach Zarathustra is a symphonic poem by Richard Strauss, composed in 1896 and inspired by Friedrich Nietzsche's philosophical novel of the same name. The first part of the poem is called *Einleitung, oder Sonnenaufgang* (Introduction, or Sunrise).

Stravinsky, Igor. *The Firebird*, Perf. Pierre Boulez and Orchestre de Paris, 2009, Paris.

<https://www.youtube.com/watch?v=pTbwQ6G-bP0>.

The Firebird is a ballet and orchestral concert work by the Russian composer Igor Stravinsky. It was written for the 1910 Paris season of Sergei Diaghilev's company Ballets Russes; the original choreography was by Michel Fokine, with a scenario by Alexandre Benois based on the Russian fairy tales of the Firebird and the blessing and curse it possesses for its owner.

van Beethoven, Ludwig. *Sonata No. 21*. Perf. Emil Gilels, piano, 1971, Ossiach.

<https://www.youtube.com/watch?v=5U0LWqMPU20>.

Beethoven's *Piano Sonata No. 21 in C Major, Op. 53*, known as the *Waldstein*, is one of the three most notable sonatas of his middle period. It is also known as *L'Aurora* (The Dawn) in Italian, for the sonority of the opening chords of the third movement, thought to conjure an image of sunrise—daybreak.

Paganini, Niccolò. *La Campanella*. Perf. Clara Jumi Kang, violin, 2015, Saint Petersburg.

https://www.youtube.com/watch?v=4200EZkeQ_c.

The *Violin Concerto No. 2 in B Minor, Op. 7*, was composed by Niccolò Paganini in Italy in 1826. In his Second Concerto, Paganini holds back on the demonstration of virtuosity in favor of greater individuality in the melodic style. The third movement of Paganini's Second Concerto owes its nickname "La Campanella" or "La Clochette" to the little bell which Paganini prescribes to presage each recurrence of the rondo theme.

Mozart, Wolfgang Amadeus. *Piano Concerto No. 23*. Perf. Armen Manassian, piano, 2013, Moscow.

<https://www.youtube.com/watch?v=qpT7XDWhiA4>.

This concerto in A major is a composition for piano and orchestra written by Mozart. It was finished, according to Mozart's own catalogue, on 2 March 1786, two months prior to the premiere of his opera, *Le nozze di Figaro*. It was one of three subscription concerts given that spring and was probably played by Mozart himself at one of these.

Brahms, Johannes. *Piano Quintet Op. 34*. Perf. Quatuor Simon and Ionel Streba, 2014, Paris.

<https://www.youtube.com/watch?v=RPmKKqX5xV0>.

The quintet in F minor was completed by Brahms during the summer of 1864 and published in 1865. It was dedicated to Her Royal Highness Princess Anna of Hesse. The work, "often called the crown of his chamber music," began life as a string quintet. Brahms transcribed the quintet into a sonata for two pianos (in which form Brahms and Carl Tausig performed it) before giving it its final form.

Note: All annotations are from Wikipedia. Readers can listen to these works by following the given links.

Music selection: Courtesy of

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About the Author

Dr. Wolfgang Palz is a German physicist. For over 50 years, he has been one of the global leaders of the development of solar energy and all the renewables. After obtaining a PhD from the University of Karlsruhe, Germany, he became an official at the French National Space Administration (CNES) with responsibility for the development of solar PV. In 1977, he became head of division at the EU Commission in charge of the development of solar energy and renewables for Europe and the world. He kept that position for 20 years before moving to the EU Commission's Directorate of Aid. From 2000 to 2002, he was a member of an "Enquête Commission" of the German Parliament on the German energy perspective on the horizon 2050. Later, he worked under consultancy with the EU Commission on PV programmes for the underprivileged in Latin America. He was also involved in various French national programmes, including one on investments for the future, which was just recently completed. Dr. Palz has received numerous awards, including the International Solar Energy Society (ISES) Global Leadership Award in Advancing Solar Energy Policy (2011). He is a bearer of an Order of Merit of the German Republic.

Preface

With the turn of the century in 2000, the world started to turn its back on the wrong-headed developments of the past with global pollution and the misery it entails, a climate getting out of control, the threat of a nuclear war, all of which was a result of the unsustainable use of fossil and atomic resources.

Not everybody may have realised it, with the 21st century, we have resolutely engaged ourselves again on the route towards a life in harmony with nature, with the Sun. This book is not about ecological dreams and wishful thinking for a better world. It is simply a report about what happened, in facts and figures.

Going definitely now with the Sun and its benefits, everybody is a winner, not only the climate. Thanks to innovation and mass production, the power derived from the Sun now beats the conventional world with its own strength: socio-economy. In our new world, solar energy has become cheaper than the conventional ones. We got a booming economy that is sustainable, with millions of new jobs for everyone.

The book starts from fundamentals and discusses the key role of the Sun for nature and our lives. It reports what happened when the foundation for a cleaner world was laid towards the beginning of the new century, detailing the efforts of the people who brought about the change.

This edition has been considerably extended to include the many developments on solar energy from 2018 and 2019. It focuses on the accelerating growth of solar PV and wind power in the global markets and their new independence from financial support schemes. The book is a new demonstration of the leadership of solar in all known energy markets. It lays renewed emphasis on the question of the solar energy's role in combating climate change and pollution, an essential concern in the political arenas of today.

The book is dedicated to a key figure who spearheaded this change to a better world, a solar world: the late Hermann Scheer.

The author, Wolfgang Palz, is an independent expert on energy matters and the economy. The book provides a summary of his global views on a solar revolution to which he contributed, his satisfaction that eventually the pioneers' aspirations were crowned with success.

Acknowledgements

The author expresses his sincere thanks to Arvind Kanswal of Jenny Stanford Publishing for his tremendous contribution in the preparation of this book. The author is also grateful to his friend Peter Varadi for his continuous encouragement.

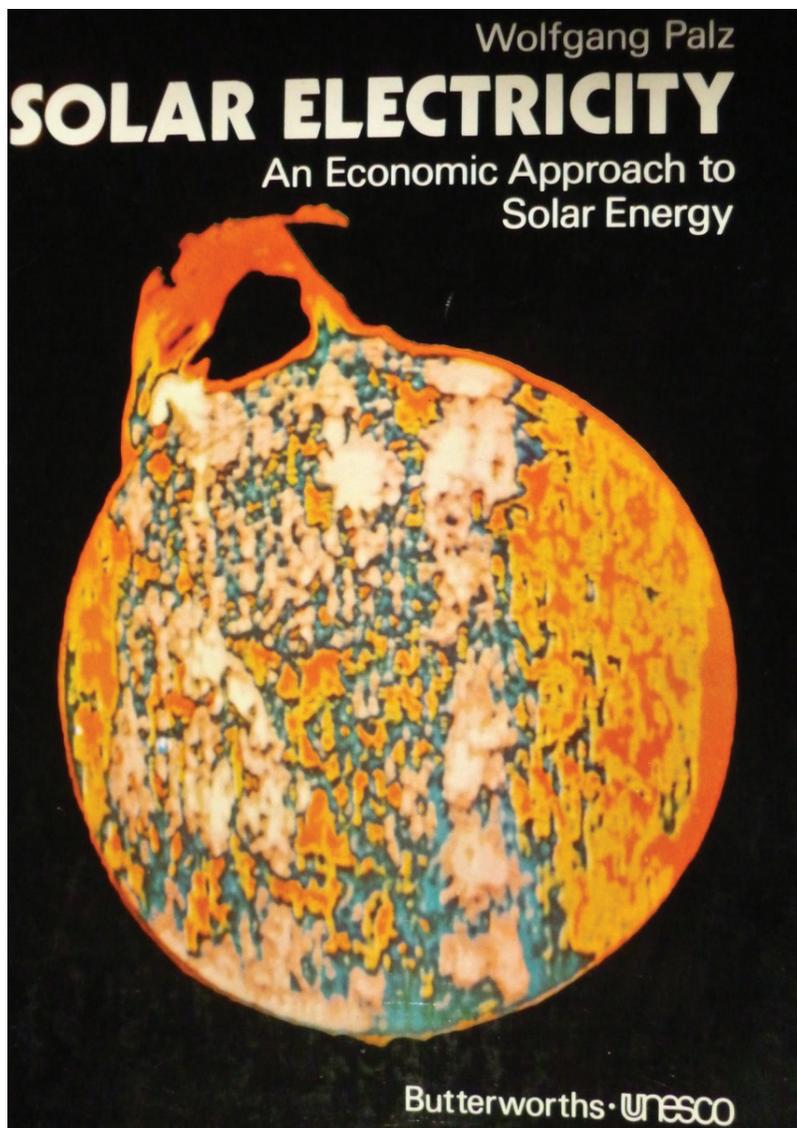
Prologue: A Vision of the Future from the 1970s

Nuclear power and coal had their heyday in the second half of the last century. In particular, since the oil-price shock of 1973, industrialised countries were anxious to preserve energy independence. Hundreds of nuclear power stations were set up in a record time.

Yet solar electricity and wind power had their adepts looking back to a long tradition in Europe. Interest had arisen in particular in the administration of the United States, too. President Carter did his best to support the new solar technologies, but in vain. While hundreds of Gigawatts of new atomic power was installed around the globe, solar PV was kept down at best to a few megawatts. “Too expensive,” they said.

In 1977–1978, I published with UNESCO in Paris the book *Solar Electricity: An Economic Approach to Solar Energy*. It intended to summarise the understanding and mood of the solar experts in the field in Europe and the United States. The US administration had done a lot of investigations. A “Project Independence Report” had been looking in all detail into the prospects of the renewables. But it was kept unpublished for the general public. Hence, the book I published with UNESCO in English and a few other languages was for many a first encounter with solar energy. Following are a few excerpts of that farsighted book.

“There is only one way to diminish the various types of pollution brought about by man’s large-scale consumption of energy, namely: direct use of the energy that dominates Earth’s climate. Useful energy can be produced from Solar radiation in such a way that neither thermal nor chemical pollution whatsoever is caused”.



The author's book on solar energy published in 1977 with UNESCO in Paris.

“All the known ways in which the Sun’s radiation can be converted into useful power are discussed. Attention is focused on the direct conversion of light into electricity by means of Solar cells”.

“The energy available in the form of Solar energy is evenly distributed. Thus, every country owns more potential energy it would ever need, renewed every year by the Sun. Solar energy is a homemade reserve”.

“The development of Solar energy applications does not mean the beginning of a new economic world. On the contrary, the new energy systems must first win their place in the overall energy market, they must be made competitive with oil, coal, or nuclear energy, whether for reasons of depletion of conventional resources, thermal or chemical pollution of the natural environment, greater independence from foreign suppliers or simply lower cost”.

“The technical and economic problems associated with the large-scale use of Solar energy are explored”. “Assessment of Solar energy’s large-scale potential for the future: Evidence is given that the “present” high cost of solar cells is by no means inevitable and that a large-scale reduction of manufacturing costs down to the level required for cost-effective central power plants can be expected in the next 10 to 15 years”. “Economy of scale”. “Progress in industrialisation”.

“In 1975 PV terrestrial market was only 100 kW against a yearly installation rate of conventional power of hundreds of MW”.

“PV large-scale production volume of 10 GW leads to a cost of \$0.20 to \$0.50”. “The cumulative production volumes associated with a reasonable learning curve can in fact be achieved”.

“If central PV power plants are integrated in an extensive power grid no special problem will occur since the situation is the same as for conventional power plants”. “Only as an independent power generator it is preferable to add an electrical storage device”.

“PV power generators employing very low-cost Solar cells will be cost effective at almost any power level, even at some Watts or kW. Thus it is possible to envisage individual generators for homes, community plants for villages, shopping centres, industrial production plants, agricultural processing and farms—as well as central power plants”.

“Solar generators installed close to the consumers may prove to be attractive because they avoid excessive transmission costs, and when mounted on roof tops or other available structures

eliminate the need for land purchasing, site preparation, and supports”.

“An array of 45 m² would fit on the roof of most family houses in the United States. If a lead acid battery is used for storage it would have a capacity of about 200 kWh, its volume would be 4 m³. Such a system would give complete autonomy to the house”.

Prologue: From the Triumph of the Iron to the Triumph of the Sun

The Triumph of the Iron

This was the motto of the big “Exposition Universelle de Paris” in 1889—with the brand new Eiffel Tower standing proudly in the middle. It actually was the year zero of the world’s development that we have seen since then.

The first automobiles came to the roads in Germany at that time, and just a few years earlier, Thomas Edison had started operation of his first electric power plants in England and the United States. By the way, he also attended that World Exhibition in Paris, the City of light. Can you imagine today a world without electricity and without automobiles? That was the time before 1889, on the doorsteps of the 20th century.

The explosive growth of electricity supply that followed entailed an equally explosive growth of the consumption of dirty coal to feed the hundreds of new power plants. Things degraded further when in the 1970s atomic power plants got the favours of the politicians: Nuclear was in those days “unlimited amounts of energy for free”. Four hundred of them have been built and installed until the turn of the century in just 30 years. When one looks back, it appears like a nightmare.

Forbes Magazine wrote in 1985, “The failure of the US nuclear power ranks as the largest managerial disaster in business history, a disaster on a monumental scale—only the blind or the biased can now think that the money was spent well”.

In the last century, a few other things went wrong as well. Two World Wars with millions of innocent deaths, two dictatorships bringing misery and death to more millions of people, a world economic crisis with disastrous consequences. The world’s

population grew to an almost unsustainable size, and pollution of the natural environment, the air, the ground, and the seas affected the world on a scale never seen before, with climate change only one of the consequences. Mountains of millions of tonnes of plastic waste, the air in many cities around the world hardly breathable. Has the 20th century started an Anthropocene?



The Eiffel Tower in Paris (picture by the author).

The new century eventually brought a radical change. The discredit of solar energy and the renewables came to an end. What finished the nuclear option off was the explosion of two plants in Ukraine and Japan. Was it criminal in the first place to start running all those plants while nobody had the slightest idea where to dispose of all the dangerous nuclear waste produced, the explosions were too much and became the final straw for nuclear. As far as coal was concerned, it had its markets growing further into this century. However, eventually the pollution it entails and the risk of climate change for which it is most responsible put its development also to a standstill more recently.

Since the year 2000, the global production of electricity from nuclear plants has been turning down. In Europe, no new nuclear plant was put into operation in this century. The same holds for the United States, where, except the one that came online in 2016, several old plants were, by contrast, disconnected from the net. India and China put a few new ones in operation, but the expected revival of nuclear desperately expected by its supporters just did not take place. The world's nuclear industry—Areva, Westinghouse, Toshiba—is virtually bankrupt.

The world's consumption of coal has well made inroads into our new century; it has doubled since 1990. However, since 2013 it is no more increasing but stabilising. Since that year, the consumption of coal in US power plants stopped its growth. In 2016, it dropped to the level last seen in the 1970s. In the United Kingdom, coal output has fallen 82% between 2013 and 2017. China is the world's leader in coal consumption and it operates three times more coal capacity than the United States: However, China burned in 2016 the least amount of coal in 3 years. Bloomberg, the financial information provider, noted that it is the end of the era of coal: "Coal production is in freefall".

Together with the world's stabilisation of coal burning, CO₂ emissions have been stabilising for the past few years as well. Climatologists will like it.

In 2020, with only 20 years of age, our new century has just hardly become adult. And already it has swung the door open to an industrial revolution, the solar age. Since the turn of the century, we have indeed seen **the Triumph of the Sun**.

The Triumph of the Sun

It all started in Germany, Europe's largest economy. Why and how? We are going to see later. It would be worth a book on its own. In the year 2000, solar PV together with wind power and a few other renewables started there a breathtaking development. By 2017, electricity generation from the renewables has increased 10-fold to 38% of the total German consumption. Wind and PV now produce more electricity than coal and nuclear there.

In the European Union, more renewable power capacity has been installed since 2000 than the capacity of fossil and nuclear power. In 2016, 86% of all power capacity additions were of the renewable type.

Since 2008, renewable power has made up more than half of all new power capacity installed in the United States. In 2016, PV and wind power accounted for 60% of all new capacity installations. PV was number one ahead of wind and natural gas power.

Since the year 2013, China has been leading the world on renewable energy matters: on new wind power installations, PV, hydro, and solar thermal. In China, it is also PV that has recently become number one for new power installations.

In 2018, two thirds of worldwide power capacity additions were of the renewable type, with PV on the top. In 2019, a third of all global capacity installed was renewable; most of it was installed since the year 2000. Virtually all countries are concerned. As an example, in 2016 nine countries in North and South America, Asia, and Europe each had already over 10 GW of wind power installed. In 2015, the global capacity of wind power passed for the first time that of nuclear power. Following the International Energy Agency (IEA) in Paris, global renewable power capacity passed for the first time that of coal fired in 2015 as well: The world renewable capacity reached 1985 GW (31% of the total world power capacity) and coal power plants stood at 1951 GW.

"This is a whole new world".

Since the turn of the century, the renewables attracted over \$3 trillion (3000 billion) of private capital investment. As PV and wind were newcomers on the markets, political support had to be expected. It is important to realise, however, that the

conventional energies benefited and still benefit today from much higher support—and that one in cash. In Germany alone, national coal exploitation received since 1957 €200 billion in subsidy. Recently, the G20 heads of state decided to discontinue all energy subsidies by 2025. However, such declarations are not legally binding.

It is profitable to invest in the renewables. They are cheaper than the conventional fossil and nuclear energies. That explains their success in the world markets.

The various activities involved in the renewables exploitation, marketing, production, installation, operation and maintenance are rich in terms of job creation. Since the turn of the century, 10 million jobs have been created worldwide. In the United States, nowadays 260,000 people are working in the solar PV business compared to 50,000 in the coal business. And it is better for your health to work on clean solar panels than it is to work on dirty coal.

The massive introduction of solar energy and the renewables opens new perspectives for our lives. In Europe, the United States, Japan and Australia, well over 6 million families have gained some new energy autonomy with the recent installation of PV on their homes. This means better protection against the anonymous providers of the centralised conventional energies and their investment decision on production and distribution of energy we may disapprove. The renewables offer more transparency, freedom of decision and a sense of well-being when connected to clean energy instead of the dangerous and polluting conventional ones.

With PV, we are part of the modern semiconductor world. It goes even beyond the “silicon valley” with smartphones and the immediate communication via the Internet. It involves benefiting from important new satellite applications beyond GPS, communication and observation. It means a more convenient life at acceptable cost—living in more comfortable homes and sustainable city structures combining work and leisure in one place.

The world of bio-energy that we have to address later as well is a very important aspect. New perspectives of biomass production in agriculture and sustainable treatment of biological waste streams have to be considered. The new opportunities for the development of the poor in the “Third World Nations” are

perhaps the most important aspects of solar energy that deserves its name.

What we want to address, too, are the more obvious relations we are going to have, as solar energy adepts, with nature, with our Sun, with the Universe.