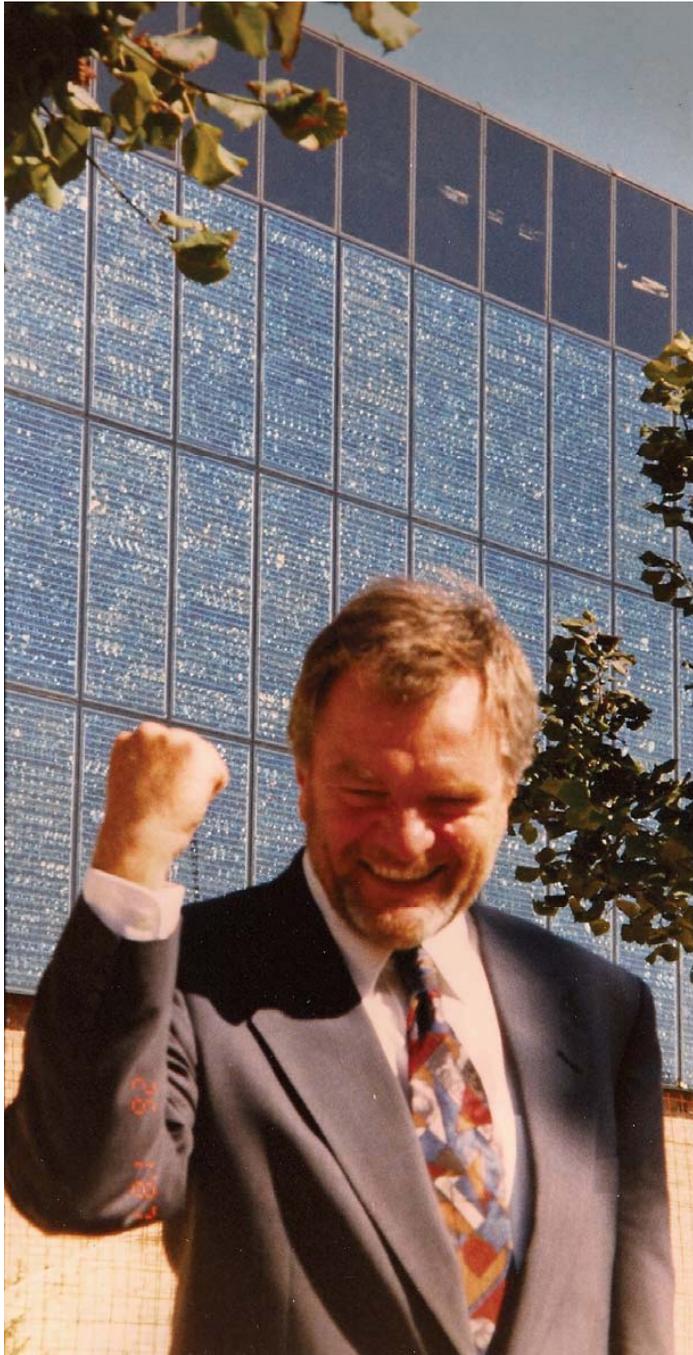


**Power for the World**



Wolfgang Palz in front of the PV façade of the public library of Mataró, Spain, in 1992. It was one of the first semitransparent solar façades in Europe, co-financed by an EU programme.

# **Power for the World**

**The Emergence of Electricity from the Sun**

Wolfgang Palz

World Council Renewable Energy

**With Contributions from 41 International Solar Pioneers**

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**POWER FOR THE WORLD**

**The Emergence of Electricity from the Sun**

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## **Wolfgang Palz**

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Palz holds a PhD in physics (Dr.rer.nat.) of University of Karlsruhe, Germany, from 1965. In 1965–70 he was a Professor for semiconductor physics in Nancy, France. 1970–76 he was in charge of power systems development at the French National Space Agency CNES in Paris. In 1973 he was co-organiser of the UNESCO Congress ‘The Sun in the Service of Mankind’ in Paris. In 1976/78 UNESCO published his book ‘Solar Electricity’ in seven languages.

1977–2002 he was an official of the EU Commission in Brussels, the executive body of the European Union. 1977-1997 he managed the development programme of the Renewable Energies; it included policy development and contracting to European industry and academia of the Commission’s budget (almost \$1 billion over that period). The R&D programme comprised the sectors of Solar Architecture, Solar Energy, Wind Energy, Biomass, Ocean Energy.

In 1997 he became an EU Commission Counsel for renewable energy deployment in Africa and, besides, advised the EU Commissioner for Energy on the EU White Paper RE issued that year 1997. From 2000 to 2002, Palz was member of an Energy Committee (‘Enquête Commission’) of the German Parliament, the Bundestag in Berlin, to establish an energy strategy for

Germany on the time horizon 2050. In 2005/2010 he was consultant of the EU Commission for PV programmes in Latin America. Palz is bearer of an Order of Merit of Germany (Bundesverdienstkreuz), has been recognised a wind energy pioneer in Britain, and received the European Prizes for Biomass, Wind Energy and Solar Photovoltaics respectively.

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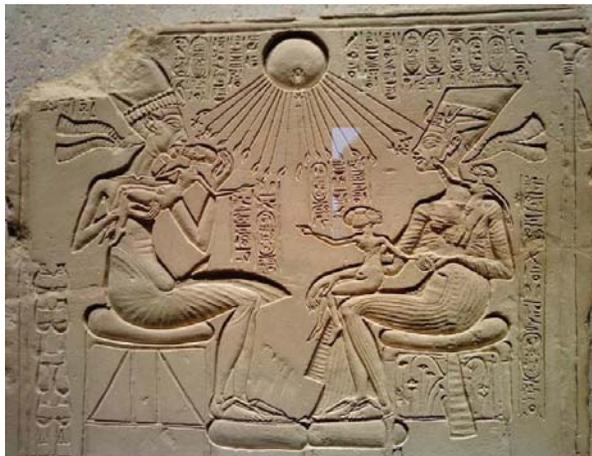
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## Hymn to the Sun

Your rays feed the fields  
You shine and they live  
They are abundant for you  
You have created the seasons  
So that all you have created can be alive  
The winter for cooling,  
The heat

How numerous are your actions  
Mysterious in our eyes!  
Only God, you who has no likeness  
You have created the Earth as per your heart  
When you were alone,  
Man, all animals, domestic and wild,  
Everything on Earth marching on feet  
Everything in the sky flying with wings  
The foreign countries, Syria and Nubia  
And the land of Egypt

*Akhenaton Pharaoh of Egypt 1378–1362 before our time*



Nofretete, Echnaton and family, 14th century BC, Neues Museum, Berlin.

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# Foreword

## Hermann Scheer

Member of the German Bundestag, Berlin; President of the Association EUROSOLAR, Bonn and General Chairman of WCRE

Emancipation means liberation from mental and physical dependencies so that people can go their own free way. Unless this concerns merely one individual goal, emancipation must be possible for everybody. This means: emancipation must be possible for everybody — along the lines of the philosopher Kant's central directive, his "categorical imperative": "Act only according to that maxim whereby you can at the same time will that it should become a universal law." This imperative is the basic value for any humane civilization. Many believe that the ideal state this implies, involving enhanced individual freedom coupled with an orientation to the common weal, is desirable, yet never attainable. In the energy area, though, it is largely attainable, namely by using photovoltaic technology.



This is a unique gift for humanity — a gift whose far-reaching significance many have still to appreciate. With photovoltaics, it will be possible for roofs, façades and — soon — windows as well to generate power; electricity will be produced in equipment cases, in the bodies of cars, on the outer hulls of ships, on the noise-protection walls of roads, on the outer surfaces of greenhouses, or on outdoor terrain with vertical PV modules, under which grass cultures can grow that remain suitable for grazing. Villages or even whole towns can thus be supplied, either completely or very largely, with electricity. The dual functions of the various usable surfaces mean that the cost of power generation will become minimal: everywhere on Earth and affordable for everyone — enabled by the unique possibility of direct conversion of photons into electrons. We will then need fewer and fewer power lines and no longer require gigawatt power plants — thanks to electricity production without emissions, without noise and with no need for water.

Over a century ago, the general emergence of electricity proved that it is a cultural power. With PV technology, it is now turning into an emancipating cultural

power. Yet the fact is that hardly anybody recognised this cultural potential in the early days of PV technology, although the world's best-known founding father of electrical engineering — Thomas Alva Edison — had already described his vision of power being produced in every house, i.e. on a decentralised basis. In the first century of the history of electricity, however, it was the opposite approach that practically won the day: ever larger power plants were built with ever longer power lines, i.e. more and more centralisation. In Italian usage, power production itself even became synonymous with major power stations, and a power plant is called *centrale*.

Major power stations became the focus of thinking and action, as if their evolution had been based on a natural law of economic energy. This was true even of most PV specialists back in the early days of the 1950s, 60s and 70s. They developed PV technology for specific applications — like the power supply for satellites sent into space. They failed to realise that they were working on a technology that harbours the potential to revolutionise energy supply. Any technology is only ever worth as much as there are people with enough imagination to appreciate its actual utility and with a will to launch it into the real world. This does not happen by itself, as is shown by the numerous examples of ignored and suppressed inventions. The reasons for ignoring them usually lie in an underestimation of their value and in mental barriers erected by conventional ways of thinking and by past experience. Those who have power and markets to lose when a new development is sighted generally have grounds for suppressing it.

Later, when wide-spread application of the new development is taken for granted, people will ask why it took so long. Their questions will include: Who ignored this technology, and why? Who got it on the road, and what were the human sources of the emancipation from energy which is provided by big nuclear and fossil-based power plants? As for who has been stonewalling, the answer is clear: the losers in this development, i.e. the big electricity companies and primary-energy suppliers who will inevitably lose their supply monopoly. Besides them, however, there are many others who lack the imagination to appreciate that autonomous producers with countless PV systems could replace the few major producers. And there were, and still are, many decision-makers who are all too closely involved with the energy companies. For PV technology, what is needed is social imagination and, above all, emancipatory motivation.

So, if society were to be mobilised for PV, the public would have to be informed, thus laying bare the motives behind the stalling tactics. This required courage and powers of persuasion, since the mere articulation of comprehensive and long-term perspectives, and the refutation of the abundant disinformation about PV were considered an attack on established energy interests. Hence, political concepts had to be developed and put in place, smashing through the manifold privileges granted to nuclear and fossil energy. The breakthrough for PV application called for all-round activities. It took pioneering work on many fronts. A new idea, after all, will only get off the ground if it has active supporters. An aphorism

by the satirist Stanislaw Lec runs: “Those who are ahead of their time often have to wait for it in uncomfortable quarters.” In the technocratic discussion about potentials, the only questions usually asked are those about the natural, technological and economic potentials of PV. But the most important potential issue is that of the human potential: Who was, and who is motivated to mobilise the technological potential and to open and enter the channels for its dissemination? Who spotted and seized the opportunity to enable PV to power the emancipation from existential energy dependence?

The driving forces taking PV from lab to roof — in other words, the first big steps on the road to practical applications — were local action groups, committed to environmental protection and self-determination. They were no longer willing to wait around for government initiatives. They had a justified distrust of the big energy companies who were talking the public and governments into believing that there are no alternatives to nuclear or coal-fired power stations. The action groups wanted to prove that life can be different. They not only provided information about the alternative, but also set landmark examples with practical projects. They called upon and urged the political authorities to take initiatives of their own. In a nutshell: they declared PV to be a public task that should no longer be left to the big energy companies. That’s how it started in Germany: first of all in just one city, and then in more and more cities. This trickle turned into a swelling civil movement in the 1990s that placed the ethical demand for zero-emission and independently produced electricity before the question of cost. These people were thinking not only of the present, but also of the future, of individual freedom and the common weal, of autonomy instead of heteronomy.

The spirit behind this emerged in the 1960s — in the movement that is generally referred to in Germany as the “68er”. It was an emancipation movement, demanding equal civil rights for all races and genders, and rejecting bureaucratic and technocratic patronage, war and the exploitation of people. The protests against the Vietnam war were the cement in this movement, from the US to Western Europe. Many movements with different focuses emerged from this spirit: the civil-rights movement, the peace movement, the feminist movement, the third-world movement, the environmental movement. The jointly shared experience was that, even in countries with democratic constitutions, governments were not willing to do what had to be expected of them. Without this background, it is not possible to explain the process that led in Germany to a popular movement for renewable energies that helped create the democratic basis for legislation to mobilise PV. But it was necessary to have players who would channel the spirit of this new civil movement into PV — and renewables in general.

I am part of this emancipation movement from the 1960s. In 1969, I was one of the leaders of the student movement at the University of Heidelberg where I was president of the student parliament. Heidelberg was — alongside Berlin and Frankfurt — one of the hotspots of student unrest in Germany, like the University of Berkeley in California. This spirit marked my personal and social attitudes.

Nor did it forsake me in 1980 when I was elected to the German parliament — the Bundestag — to which I have belonged ever since without interruption. In my early years in parliament, I was a committed backer of nuclear disarmament. As early as 1982, I became spokesman of my parliamentary group, and was later chairman of the Subcommittee on Disarmament and Arms Control. I was a member of the Foreign Affairs Committee and had a reputation as a great foreign-policy talent. In 1986, I published my book “Die Befreiung von der Bombe” (Liberation from the Bomb), in which I described a possible route toward a world free of nuclear weapons. It met with a spectacular response; Germany’s leading political magazine *Der Spiegel* — the German equivalent of the *TIME Magazine* — called it an “icebreaker”.

Still, I was not only against nuclear weapons, but against nuclear-power plants as well. I was also increasingly concerned with the issue of alternatives, since I was aware that a future with fossil energy was no option either. In 1981, I had read one of the earliest books on the looming CO<sub>2</sub> climate disaster. My immediate conclusion was: we must focus our efforts on renewable energies. But here were the energy experts saying that the potentials would not suffice to allow us to do without nuclear power and/or fossil energy. My critical spirit, honed back in the 1960s, told me not to believe this. I became curious about renewables. And a mere second glance showed me: a world without nuclear power and fossil energies is an option.

I asked politicians — in my party, in parliament or in the government — who were responsible for energy policy why they did not focus their policy on this perspective. I asked environmental organisations, but they, too, thought this perspective was unrealistic. I contacted the few solar scientists around, and my impression was that they as well were underestimating the potential — or that they did not have the courage to formulate a more comprehensive perspective. One told me: “If we manage to cover 10% of our energy needs from renewables by 2050, you can consider yourself lucky.” I felt that all of this was faint-hearted. So, I wrote my first article on solar energy in the mid-1980s, at a time when there was talk everywhere of the “Star Wars” programme — the Strategic Defense Initiative (SDI) of US president Reagan. My article bore the title “For an ecological SDI — the Solar Development Initiative”: just as new armament technologies were being driven forward costing billions, so, too, must solar energy be driven forward — as a political mission to defend our environment. Now I was accused of morphing from realist to dreamer by embracing such an unrealistic cause. One friend told me: “Why are you suddenly concerned with such an unimportant issue?”

I increasingly came to realise that the precondition for a successful political initiative to promote solar energy was to create a public climate that would enable it to tear down the walls in people’s minds. And it also became clear that this subject must not simply be left to the big energy companies, the energy politicians and conventional energy science. This is why I set up EUROSOLAR in 1988 — the European Association for Renewable Energy — and became its president, which

I still am today. The founding document talked of the “reality-based vision” of a solar age: the vision of a complete substitution of nuclear and fossil energies with renewables. Politicians, scientists and entrepreneurs became members of EUROSOLAR. The two most important tasks we set ourselves were to enlighten the public about this reality-based vision, and to work on political concepts for action as well as draft legislation to promote renewable energies. A short time later, I withdrew from my foreign-policy offices in parliament and focused entirely on being a source of public and political inspiration for the historic energy turnaround. The year 1989 brought the first political success: I authored a resolution for parliament which was to prioritise the promotion of solar energy in research and development policy. This resolution was passed unanimously by the Bundestag. Although it was never implemented in its entirety, one immediate practical consequence at least was the 1000 Roofs Photovoltaic Programme of the German Federal Government — the first systematic PV market-launch programme — as well as the 250-MW wind energy programme. I launched an in-depth round of lectures with about 200 talks a year — at party assemblies and for action groups, environmental organizations and universities. Media attention increased, with Franz Alt, a TV journalist, and his programmes becoming pioneers. Among the environmental organisations, too, calls for political promotion of solar energy grew louder. Also, the number of my colleagues in parliament — especially from my own party — who had become curious now grew, and I was asked to give talks in their constituencies. In this way, the support base expanded in public and in my party, the Social Democrats (SPD), one of the two major parties in Germany.

The year 1990 saw the second success: in an effort mounted together with several members of parliament from the other major party (the Christian Democratic Union/Christian Social Union, CDU/CSU) and one member from the Greens (Wolfgang Daniels) — who had likewise become members of EUROSOLAR — the first feed-in tariff law for renewable energies came into being. In September 1990, the bill was adopted by parliament. It regulated guaranteed grid access for electricity from renewables supplied by independent producers and guaranteed a feed-in price of between 75% and 90% of the underlying electricity price. We had persistently urged that this law be passed — in the Bundestag and in the Bundesrat, the legislative chamber representing Germany’s federal states. Important support came from Reimut Jochimsen, the economics minister of North Rhine-Westphalia, Germany’s largest federal state. At the time, he was chairman of the conference of economics ministers, and I had persuaded him in several talks to support this law. This opened the road for a steady rise in wind-power investment. For PV electricity, though, the feed-in tariff was not yet attractive enough. Still, it was not possible to achieve any more in those days. Up to the very last minute, the big electricity companies tried to frustrate the legislation. It was later said that, had they known how important this law was to become, their resistance would have been insurmountable.

The next step was a pinpointed mobilization for PV's market launch. To this end, I presented for the first time in 1993 a draft for a 100 000 Roofs Photovoltaic Programme. It seemed utopian even to the representatives of the still very small PV industry. My argument was: if we wanted to gain more support for the solar perspective in politics and society, big steps would have to be demanded. After all, only few people are interested in small steps, and the underestimation of solar energy could not be overcome that way. This convinced my party's youth organization, to start with, and it mounted a solar campaign and declared my book "A Solar Manifesto" published in 1993 to be "required reading".

It dealt, not with technologies in renewable energies, but with a policy for such energies, the declared aim being a complete transformation of the energy supply toward the use of renewables: 100%! This book became a bestseller in Germany with a total of eight print runs. It gave a political voice to the commitment for renewable energy. It defined ignorance about renewable energies as a "mistake of the century", and revealed the disproportion between the political promotion of renewables at the lowest political level and the political promotion of nuclear power and fossil energies at the highest level. And it disclosed the reasons and methods behind the resistance and the obstruction of renewables, including the technological pessimism in their regard, which was in stark contrast to the technological optimism in favour of any other technology. This book evolved into a reference work for many players in political parties, for policy-makers at local-government level, for companies and also for scientists, all of whom were inspired by it. Above all, it offered stimulus for a solar movement. Such a movement had existed in California in the 1970s, but had largely withered away in the 1980s in the wake of the roll-back of renewable energies during the Reagan administration. In California, too, it had been marked by the spirit of the 1960s. What had died away there was now revived in Germany. And the most concrete, practical medium at grassroots level is photovoltaic technology.

When I brought the 100 000 Roofs Photovoltaic Programme into the public debate in order to open the doors for industrial mass PV production, the Federal Government's 1989 1000 Roofs Photovoltaic Programme had long since come to an end. But there was still no chance of a political implementation of this more far-reaching concept. Even Siemens-Solar, at that time the best-known German manufacturer of PV cells and modules, declared the concept to be immoderate. At local-government level, however, more and more activities were getting under way. People were setting up solar clubs. One of these was the solar-promotion club in Aachen in North Rhine-Westphalia run by Wolf von Fabeck, a former army officer, as the driving force. He called for a "cost-covering price" according to the feed-in tariff principle for people who had installed a PV system. The Aachen city council took this up in 1994 and decided that its municipal utility should pay DM 1.80 per kilowatt hour of solar power fed into the city's grid. But the new economics minister of North Rhine-Westphalia initially refused to grant his approval. I then talked to his prime minister, Johannes Rau, and was able to win him over

for an approval. In the course of the next four years, more than 40 towns and cities followed Aachen's example. One of the towns was Hammelburg in Bavaria, where a local action group had formed. Like many others, it had invited me to give a talk in their town. This is where I met Hans-Josef Fell in 1995. He was councillor there, a member of the Green party and the engine behind cost-covering prices in his community. He became a member of EUROSOLAR. These local initiatives made a crucial contribution toward launching a public wave of support for PV. They created a local base for a PV market. Without them, it is unlikely that the still-small PV industry of the 1990s would have survived in Germany. The "baby" had become a toddler.

1998 was the key year for the next big steps that were to make Germany a force to be reckoned with in PV. The outcome of the general elections brought a majority for the SPD and the Greens who together formed the new Federal Government. Previously — in April 1998 — I had succeeded in anchoring both the 100 000 Roofs Photovoltaic Programme and the feed-in law for renewable energies in the SPD's election manifesto. This nearly faltered because, just a few days before the meeting of the SPD executive that was crucial for this thrust, Greenpeace published a demand for a 50 000 roofs PV programme. So I was asked at the meeting of SPD leaders why the SPD should demand more than even Greenpeace, but I won the day with the argument that we should be thinking of industrial mobilization for such a very big step. Although I prevailed with my demand for 100 000 PV roofs, it was missing initially in the government programme drawn up by the SPD and the Greens after the election. I then demanded subsequent negotiations and was able to push this point through at the last minute. I realised that this was the time to act, and that the programme had to be translated into practice at once. But this, too, was extremely difficult, since the new government had resolved not to pass its new budget until June 1999, i.e. not until eight months later. That was dangerous for the PV industry. All those purchasing PV systems would then have an eight-month wait for the programme to start, so that there would be no orders for PV systems during that time. This is why I contacted the state-run KfW development loan corporation to ask whether it might be willing to pre-finance the programme so that it could get started straight away. This was accepted. Within a few days, I drafted the programme, together with the KfW, the finance ministry — Oskar Lafontaine, who supported the programme personally, had become the new finance minister — and two Green members of parliament. One of these was Hans-Josef Fell, who had been elected to the Bundestag in 1998 and who has since become my most important fellow campaigner in parliament. The programme started on 1 January 1999. This is the date of birth worldwide of industrial mass PV production. The first system under this programme was installed on my garage on 2 January, next to a system that I already had on my roof. By contrast, all other mass programmes that had been previously proposed remained on paper. My first proposal for a 100 000 Roofs Photovoltaic Programme from the year 1993 had been taken up in 1995 by Peter Michael Mombaur, MEP, who in a report for the European Parliament recommended

a 100 000 roofs programme for the EU. In 1997, US President Bill Clinton spoke out in favour of a one-million roofs programme, and Mechtild Rothe, MEP, demanded this for the EU as well. But none of these initiatives were ever implemented in practice.

The 100 000 Roofs Photovoltaic Programme was a zero-interest scheme, with the government paying the difference between zero interest and a loan's market interest rate. In the first two years, nothing had to be repaid, and repayments were to be made between years three and ten, at 12.5% each. The final instalment was to be waived. But this by itself was not yet enough to generate a wide movement on the market. To provide a further boost, we also wanted to increase the feed-in tariff. This needed legislation, and our aim here was to extend the existing Electricity Feed Act. From the government, there was no initiative to be expected for this. Oskar Lafontaine had resigned as finance minister. So, we had to take the initiative ourselves. Starting in the summer of 1999, four Bundestag members worked out a draft bill: Dietmar Schütz and I for the SPD parliamentary group and Michael Hustedt and Hans-Josef Fell for the Green parliamentary group. This was how the draft Renewable Energy Act (*EEG*) came about for which we were able to win over our parliamentary groups in the autumn of 1999. The final vote on the bill was scheduled for 25 February 2000. For PV — in addition to the grants for the 100 000 Roofs Photovoltaic Programme — we pencilled in a guaranteed price of 99 pfennigs per kilowatt hour. Even this seemed utopian to nearly everyone. To help ensure a majority in both government parliamentary groups, we limited this to the quantity of the already running 100 000 Roofs Photovoltaic Programme. This got us a majority. But the biggest political hurdle to be taken came out of the blue two weeks before the final vote in parliament: the cabinet called upon us to seek the approval of the EU Commissioner for Competition before we adopted the Programme. The reason given was that the Renewable Energy Act would violate the EU's market rules, and it was not compatible with European law. This was a last-minute attempt to torpedo the law.

The days that followed were like a High Noon situation in a Western. The tie-breaker was how the SPD parliamentary group would respond, meaning the larger parliamentary group in the government. In this situation, the economics minister and the new finance minister suggested postponing the vote on the bill and negotiating with the EU Commission first. I knew only too well that this would spell the end of the bill. Things came to verbal blows between ministers and myself in the parliamentary-group session three days ahead of the envisaged final vote in parliament. I moved to bring the bill to the final vote unchanged and without delay, and won the vote by about 90%. The Act became effective on 1 April 2000. But the conflict was far from over. As early as 7 April, the EU Commission filed a lawsuit against the Act on which the European Court of Justice then had to pass a judgement. Eleven months later, on 13 March 2001, the Court of Justice dismissed the lawsuit. This meant that the Renewable Energy Act was off the ground — along with PV.

When the Act was up and running, there was total installed PV capacity of 50 MW in Germany. By comparison: new installations in the year 2009 alone were more than 3000 MW. Not only the German PV sector, but the worldwide PV industry, including America's, China's and Japan's, owe their upswing to the German market — and all of them are indebted to the Act for the last decade's rapid falls in prices, which are now already in the neighbourhood of grid parity. To get this far — always by way of parliamentary initiatives with ever-new joint thrusts along with Hans-Josef Fell and a growing number of other MPs, and always against the resistance of the electricity industry and one-dimensional economic-science institutions — we successively lifted the restrictions on PV in the Renewable Energy Act: first from 300 MW to 750 MW and then — starting in 2009 — without any quantity limitations. In the Bundestag, there was a EUROSO-LAR group of parliamentarians.

This also helped get the PV industry off the ground. I remember the European photovoltaic conference I chaired in Glasgow in May 2000. This conference was held after the start of the 100 000 Roofs Photovoltaic Programme and the Renewable Energy Act. Some of the PV firms attending the event showed initial reserve. For years they had been accustomed to producing for market niches, and they were used to that. Now they, too, were being called upon to act: with new investment in a market that was now widening up. But all too often, they had experienced political “go-and-stop” programmes. They didn't trust the new opportunities and suspected that another political stop was just around the corner. There were also many political attempts being made to halt this development again. They are still being made — even in Germany.

Political advocates in parliament have again and again successfully countered such attempts. For this, action was needed on all fronts of the conflict: at the political front in parliament, in the media, and also on the legal front. The energy companies tried for years to bypass the legal provisions. There were countless lawsuits before the courts. For this reason, it had become important to change the prevailing opinion among legal scholars and in legal literature. This prompted me in 1997, along with several lawyers and law professors, to found the law periodical *Zeitschrift für Neues Energierecht* (Magazine for New Energy Law), which has been appearing ever since. It has made a crucial contribution toward changing the legal culture in favour of renewable energies.

Our most important ally in the course of time was public opinion, which was now listening more to the many grassroots initiatives than to the warnings of the big electricity companies. The latter spent many millions on their disinformation campaigns to scare people away from renewable energies. We fought them with a better idea: with the higher humanitarian value of renewable energies for society. The PV systems on countless roofs that all of us see everywhere convey a new hope. It is the hope that many people can take their energy future into their own hands — and that they need not wait for the results of global climate negotiations. It is the now tangible opportunity for energy emancipation from big, anonymous

structures. PV as energy for the people, by the people. This struggle is not yet over. Now that electricity companies have failed with their original strategy of ignoring or ridiculing PV, they are now busy developing a new strategy. Large solar power plants and large wind farms — wherever possible off-shore — are set to replace the big nuclear and fossil power stations. These companies want to preserve their supply monopoly. The future will be marked by the conflict between centralised and decentralised systems. The companies were able to prevail for a century with their big centralised power plants because they could generate electricity at lower cost thanks to the large quantities generated. But these economies of scale cannot be ported to PV: for PV, the economies come from increasing quantities in material and cell production — irrespective of whether the modules are for decentralised installation on roofs or centralised on large surfaces. Indeed, a large-scale industry for solar cells cannot prevent solar modules being installed on a decentralised basis. This means: neither technical nor economic barriers exist to energy emancipation, and any barrier that exists is a neutral one. Decentralised or centralised: that is the offset between autonomy or dependence, freedom or compulsion. This is why PV technology and decentralization cannot be stopped. It will come because the need for freedom will win the upper hand — at all events when its implementation does not harm our fellow beings, but is also for their benefit. That is why PV is an opportunity for humanity.

# Introduction

This book is about power, electric power. Electricity is synonymous of light, it is something precious. Our whole civilisation is built on it.

Electricity for lighting became in general use only in the 20<sup>th</sup> century — when industrialisation started in earnest in the 19<sup>th</sup> century it took place in the ‘dark’.

After the electricity revolution that was started at the very end of the 19<sup>th</sup> century by Thomas Edison in New York, our 21<sup>st</sup> century that we just started will bring us another revolution: in the course of this very century our electricity will have become ‘Solar Power’. The ‘oil age’ that started in 1848 in Baku will be coming to its definitive end in the foreseeable future. It will be displaced by the ‘Solar Age’ for a more sustainable World.

The coming World of Solar Electricity will be dominated by ‘Photovoltaics, PV’. Just some years ago you would have immediately stopped going further on in this text: understanding electricity is already difficult enough — PV must then be something for the very specialised engineer.

By now things have changed. Millions of ordinary people from around the World have become involved in PV as investors, producers or buyers; over a hundred thousand new jobs were newly created in a global market in just a few years’ time. Some people even got very rich with it.

And this is just the beginning: the prospects for PV are tremendous; global business will soon reach 100 billion USD per year and more.

The Photovoltaic effect was already discovered in Paris in 1839 long before conventional electricity started to conquer the World. But it remained a dream of some enthusiasts. By now in 2010, with PV’s extraordinary market success, the time of the PV pioneers — in the technical, ethical, political, financial, industrial, commercial, or social sense — is coming to an end. Hence, it was timely to make the effort to keep at least some of it on record in this book.

But this book cannot more than to shed a little light on something tremendously big. You need an encyclopaedia to keep a full record of all the things that happened in PV and that are more than ever in progress: PV Conferences almost every day somewhere around the globe, newsletters, and meetings — the ‘CO<sub>2</sub> footprint’, as it is called by the environmentalists, is not so good for PV these days.

I was personally involved in PV since 1961 and never gave up my enthusiasm for it and never stopped working for its development. Already my thesis work as



Baku where the 'Oil Age' began in 1848. Picture taken in 2009 with W.Palz on the left, Walter Sandtner on the right and colleagues.

a physicist at Karlsruhe University in Germany was on PV. So today I have become one of the oldest experts still active in the PV business.

This book has been written for the interested layman; a complicated story made simple and entertaining. Obviously I had to include my own experience on PV — but this is by no means the story of my life; that would again be another story...

The PV experts, too, can learn in this book some facts and figures they cannot find on the internet or in the specialised meetings they are used to attend. I hope they will enjoy reading and find themselves more than gratified to have chosen PV for their professional life.

A great asset of the book are the original contributions from many pioneers around the World who were and still are convinced actors and fighters for our all ethical endeavour: Solar Power.

These texts are not edited and were contributed under the authors' own responsibility. They provide a lot of colour to our book, not only because of the many nice pictures that illustrate their own experience.

I am more than grateful that all these colleagues and friends accepted my invitation to make the effort to remember all their 'deeds'. I am sure you will have fun reading these articles that give a taste about PV also from angles you would never have thought of: what is the relation of PV with the cathedral in Cologne; or what is the relation of PV with piano builders in Cincinatti?

I also take this opportunity to thank the publisher in Singapore to put all that together. Without his insistence I would not have done it. And eventually I had great fun doing it.