ISSN 1861-2741 74714

SUN & WIND ENERGY

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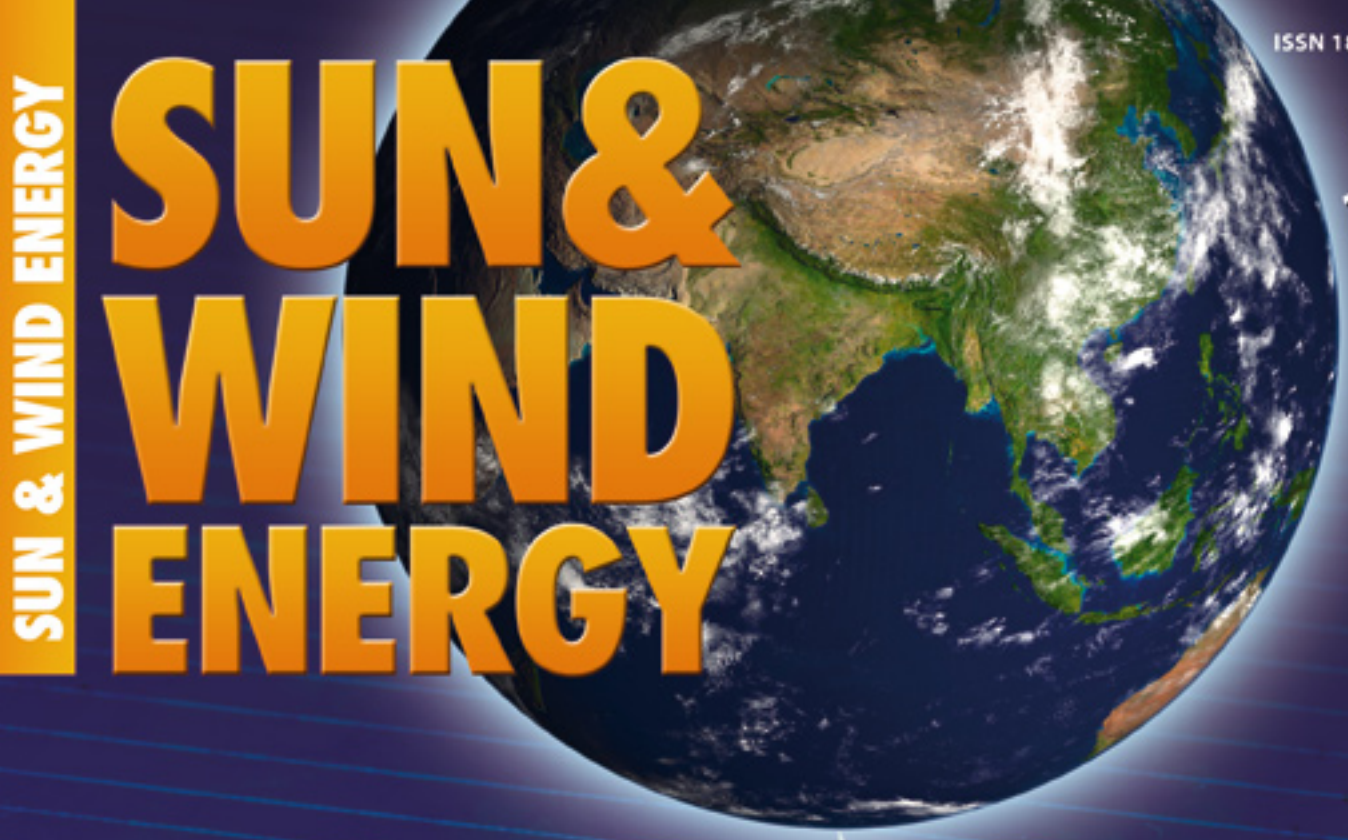
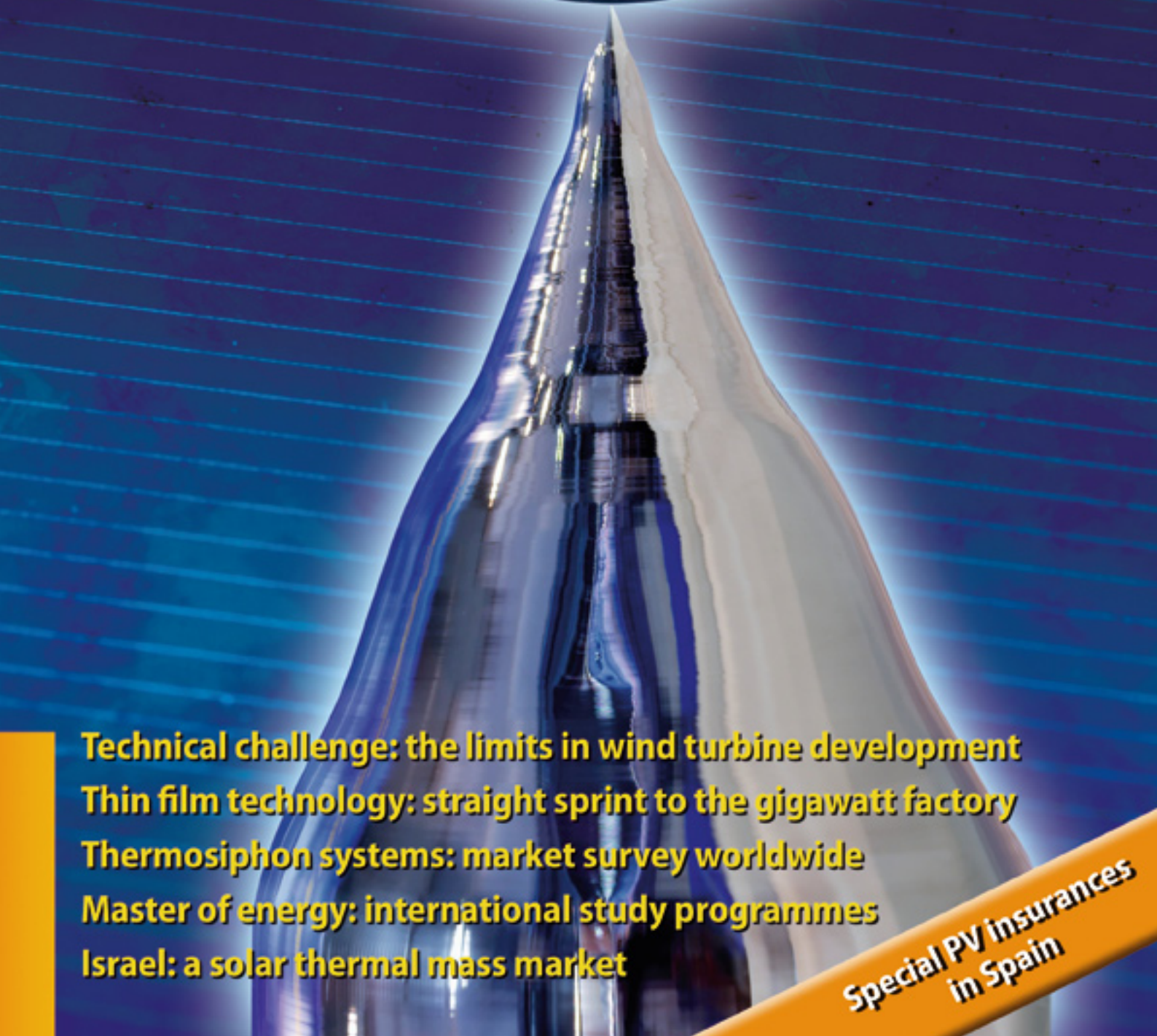
International issue
1/2008
€ 9,50





Technical challenge: the limits in wind turbine development

Thin film technology: straight sprint to the gigawatt factory

Thermosiphon systems: market survey worldwide

Master of energy: international study programmes

Israel: a solar thermal mass market

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Light and shade

When people speak or write about solar technology they usually mean solar electricity generation. The modules sparkling in the sunshine, still and silent, but generating electricity nonetheless: These have won the hearts of bankers, journalists and investors alike. Hot water generation using solar power has a shadowy existence in comparison, however. The reasons are straightforward:

Solar thermal manufacturers finance the expansion of their factories themselves. Unlike their colleagues in the photovoltaics and wind power sectors, they don't swarm onto the stock market trading floors to a blaze of flashguns from the press. Solar collectors also never made the high-flying move into space and thus had to make do without research grants for decades. And finally, even today there is no support mechanism for renewable heat anywhere in the world which is comparable to the Renewable Energy Act in the field of electricity.

The conclusion: Solar thermal does not get the attention which it deserves, despite being one of the oldest renewable energies alongside biomass. Its birthplace was in Australia, where in 1953 the company Solahart manufactured the first flat plate collectors. 30 years later in Sydney the breakthrough was then achieved in vacuum tube technology. Professor Zhiqiang Yin from China and the Australian scientist Geoffrey Lester Harding patented a sputtered selective aluminium nitride coating in 1984, which could be applied to glass (see page 66). This was the starting point for the triumphal march of vacuum tube collectors in China.

Today, almost half of the world's thermal power capacity is installed in China. At the end of 2006 the global collector capacity in operation was 127 GW_{th} (181 million m^2). If one assumes an average annual yield of 440 kWh/m^2, then all of these solar harvesters together saved the impressive sum of almost 7 million tonnes of oil in 2006. The true environmental relief can be better understood, however, when you realise that thanks to solar heating 70 fewer oil tankers were required to transport their dangerous loads across the world's oceans. Better still: Almost 600,000 tanker loads fewer were required on the roads, delivering the CO_2-intensive energy source to end customers. Lined up bumper-to-bumper this number of loads would stretch 4,400 km.

As a comparison: According to the European Photovoltaic Industry Association (EPIA), the 6.6 GW_p PV capacity installed worldwide by the end of 2006 only saved a quarter of this amount of oil. Assuming an average yield of 1,000 kWh/kW_p and a factor of 3 for conversion into primary energy, solar electricity from 6,6 GW_p substituted only 1.7 million tonnes of oil in 2006.

Solar thermal technology has thus achieved effective climate protection in the past – even without the political and public support which electricity generation from renewables has received. Solar heating would be able to reach new heights in climate protection if a support mechanism like the Renewable Energy Act were to be finally created, and if ample research grants were to go to the as yet still unexhausted fields of solar cooling and the use of process heat. ✹

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SUN & WIND ENERGY

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Print:
Klingenberg Buchkunst Leipzig GmbH,
An der Hebemärchte,
04316 Baalsdorf/Leipzig, Germany
Website: *www.Klingenberg-online.de*

SUN & WIND ENERGY is an independent journal published six times a year.
Subscription costs are 51 € per year plus shipping costs.

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Photo: Sven Tetzlaff

Photo: SDA

Photo: Red Eléctrica de España (REE)

Photo: Joachim Berner

Photo: PPRE

A great diversity of students participate in the master study programme at the north German university of Oldenburg. The Postgraduate Programme Renewable Energy (PPRE) is one of the oldest courses of study worldwide in the field of renewable energies. **Page 100**

Photo: Oerlikon

Thin-film technology is ready for mass production: Largely responsible for that are the process equipment suppliers. Opinions are divided as to the ideal substrate size. **Page 124**

Photo: Energiekontor

Wind energy is advancing rapidly in Portugal. This country does not by any means share similar market conditions with other leading wind nations. Investors have to reckon with a great variety of market structures. **Page 156**

»It´s not easy to be a manufacturer«, U.S. American analyst Paula Mints points out. Especially problematic is the raw material shortage which is influencing the PV markets worldwide. **Page 120**

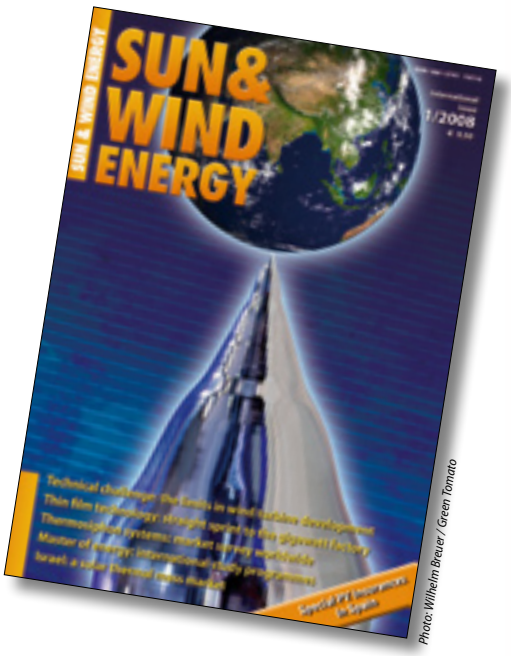
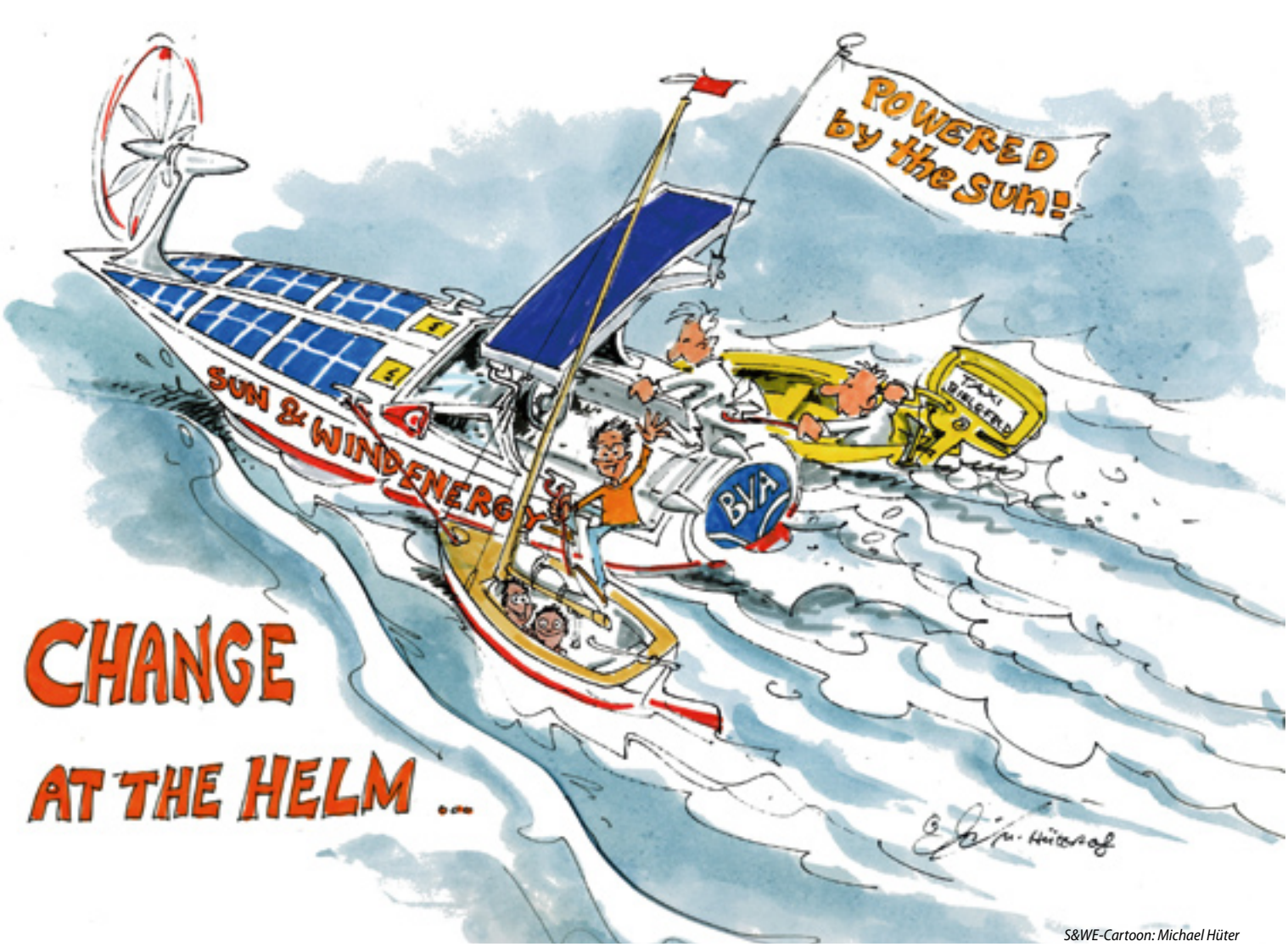


Photo: Wilhelm Brauer / Green Tomato



S&WE-Cartoon: Michael Hüter

Good-bye

You should always stop when things are at their best. *Sun & Wind Energy* is moving at a pace. A network of correspondents spans the globe and provides the readership with exciting background reports from the key renewable energy markets USA, India and China. With a print run of 23,000 we reach the sector professionals on all five continents. After each edition we receive responses from all over the world.

I know that things are going to continue to get better. Things will be roaring along even faster in the future because the global solar thermal, photovoltaics and wind power markets are growing extremely fast. But still, I am leaving the ship, and with this edition I am handing over the position of chief editor of *Sun & Wind Energy*. I am taking a break to be able to look after my children (1 and 5 years old) more intensively – after a good eleven years of journalism at the Bielefelder Verlag. At the end of 1996 I started as an apprentice at the German sister magazine *Sonne Wind & Wärme*, gained experience in various posts, and have most recently been the editor responsible for the international *Sun & Wind Energy* magazine.

The two magazines are contemporary witnesses of the breathtaking development of renewable energies. In the last decade the sector has developed itself further enormously. Here some examples:

- In 1998 PV systems with a total power of 12 MW_p went up on German roofs. No-one back then imagined that ten years later the figure would be some one hundred times higher. The U.S.-American PV analyst Paula Mints estimates the German market volume in 2007 at 1.2 to 1.5 GW_p (see interview on page 120).
- In 1997 brave, visionary businessmen set up PV factories using the machines from the module factory closed one year earlier at the north German town of Wedel, back then the last of its kind on German soil, and thus started the »Gründerzeit« of photovoltaics. Today, approximately twenty module manufacturers, around ten cell manufacturers, five wafer manufacturers and a growing number of thin-film PV specialists are jostling for position within the country.
- In 1999 the regional solar exhibition Solar99 – the predecessor of today's Intersolar – still fitted into the town hall of the small south German town of Pforzheim and had 140 exhibitors. From this evolved Europe's largest solar fair, which last summer almost burst the seams of the Freiburg exhibition centre – with 638 exhibitors and 34,000 m^2 of gross exhibition space.
- The speed of technological change is also breathtaking. While in 1995/1996 turbines of the 1.5 MW class were the giants among the wind turbines, just ten years later the 6.0+ MW generation is at the prototype stage.

On the international scene things are moving no less rapidly; annual collector sales in China trebled between 1999 (3.4 GW_{th}) and 2006 (12.6 GW_{th}). In the U.S.A the PV and thermal sectors are growing exponentially at a rate of 80 to 90 % a year. And in India, announcements of a feed-in tariff in the state of West Bengal are also generating momentum.

I therefore wish *Sun & Wind Energy* a roaring ride and you too – the professionals in the sector– all the very best! ✹

Bärbel Epp

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Alpine Island

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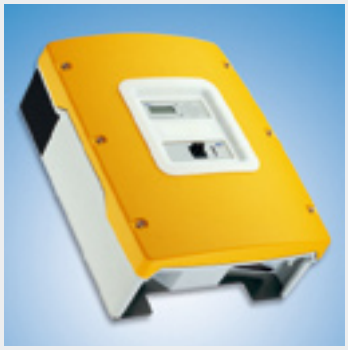

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SMA

Incentive schemes worldwide

Selected countries with new incentive schemes
GDP = Gross Domestic Product
PV = Photovoltaics
ST = Solar Thermal
Figure: Green Tomato, Source: national institutions, own research

+ + + Greece + + +

In September of last year, the feed-in tariff for electricity from photovoltaic systems in Greece was increased slightly as a result of the annual revision. The tariff is regularly adjusted according to the inflation rate and the prevailing electricity price level. Usually, the feed-in tariff in Greece is guaranteed for twenty years, and for systems with a capacity of 100 kW_p or more it is lower than for smaller installations. There is, however, one news item that might have a negative effect on the solar industry in Greece: The public investment grants for commercial photovoltaic installations have been reduced considerably. Previously, the possible support amounted to up to 55 % of the sum invested, but from now on only 20 to 40 % will be subsidised. This reduction was explained by the high level of demand for the limited funds. Companies that invest actively in other forms of renewable energy, such as wind or biomass, still have the possibility to get a refund of up to 60 % of the invested amount.

Hellenic Association of Photovoltaic Companies (HELAPCO): *www.helapco.gr*

PV system size	Mainland grids	Autonomous island grids
≤100 kW_p	2007: 0.45282 €/kWh	2007: 0.50282 €/kWh
>100 kW_p	2007: 0.40282 €/kWh	2007: 0.45282 €/kWh

Modified feed-in tariffs in Greece 2007
Source: HELAPCO

+ + + France + + +

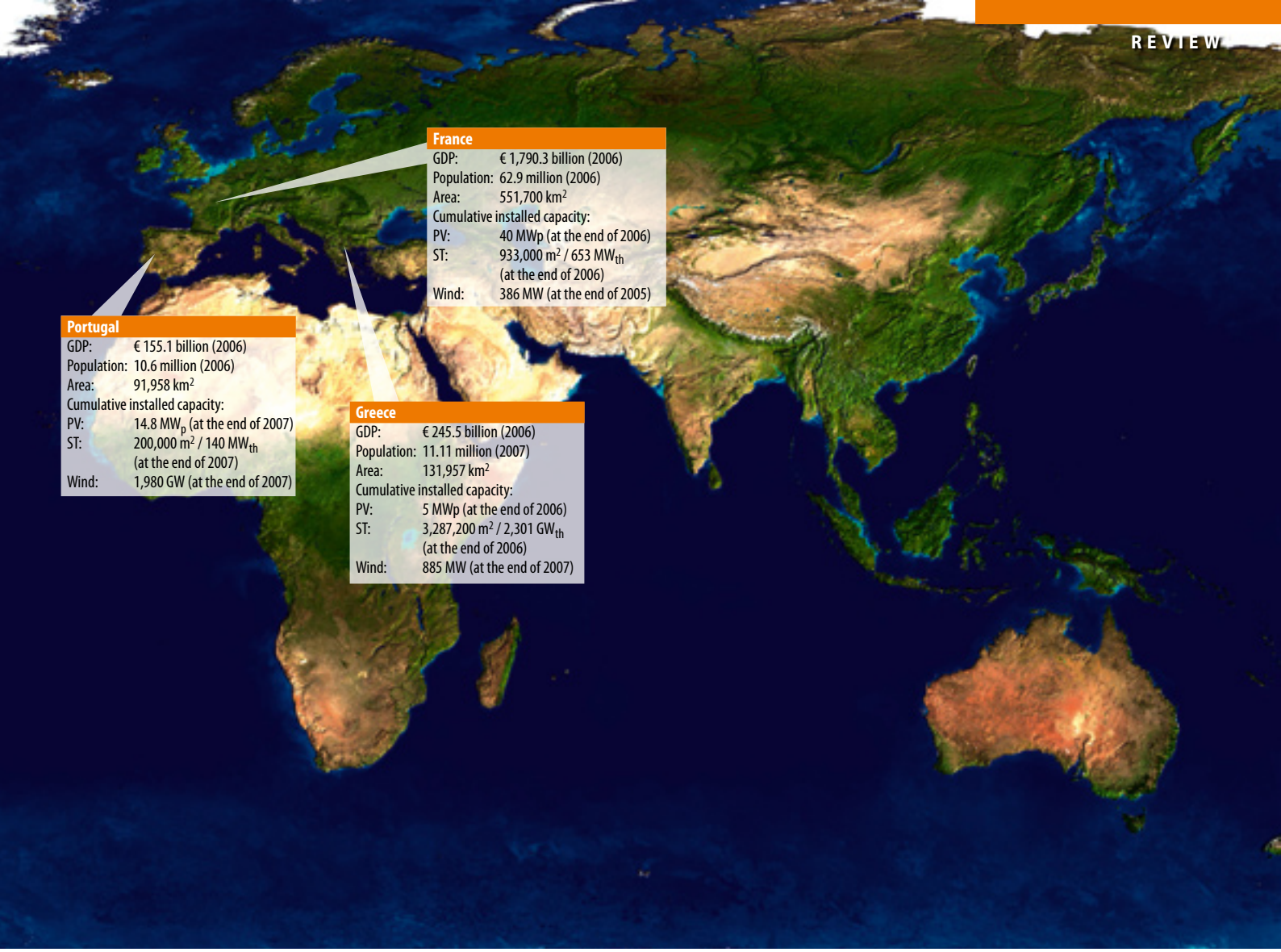
An indirect form of support for photovoltaic systems was put through in France at the end of last year. After the value-added tax rate for photovoltaic installations had previously been raised from 5.5 to 19.6 %, the »Direction de la Législation Fiscale«, which is in charge of taxation changes in France, announced in December that the VAT would be lowered to 5.5 % again with immediate effect.

Association Professionelle de l´Energie Solaire: *www.enerplan.asso.fr*

+ + + Portugal + + +

From the spring of 2008 onwards, Portugal is going to increase its support for small-scale photovoltaic systems. On 2nd November 2007, the »Decreto-Lei Nr. 363/2007« was passed. After the implementation phase, this decree, which is also known as the »Microgeração Act«, is expected to become binding in April of this year. For small-scale systems of up to 3.68 kW_p, it grants a feed-in remuneration of 65 €Ct/kWh for a maximum of 5 years. This support, however, is subject to several limitations: A maximum capacity of 10 MW_p may be installed annually. As soon as this figure is reached, a reduction of the feed-in tariff by 5 % is automatically triggered. Additionally, the capacity of the individual systems may not exceed 50 % of the power the respective household has reported to the energy supplier as its own requirement and on the basis of which the electricity supply contract was concluded. The reason for this is that in Portugal the power to be purchased must be laid down in advance by contract with the electricity company. Furthermore, the maximum connected power of the PV systems at the medium voltage transformer is limited to 25 % of the transformer's rated output.

Association of the Portuguese Solar Industry, APISOLAR (Associação Portugues da Inustria Solar): *www.apisolar.pt*
Portuguese energy agency, Adene (Agência para a Energia): *www.adene.pt*



+ + + El Salvador + + +

In November 2007, the Salvadorian parliament passed an act in which two methods of support for investments in renewable energies are scheduled. Firstly, the import of components for renewable energy systems is exempt from duty, and secondly, a tax relief scheme has been introduced for medium-scale power plants. Installations with a capacity of up to 10 MW are exempt from taxation for ten years. For plants with a capacity of up to 20 MW, the tax relief is limited to five years.

Support is focused on medium-scale plants because they can be erected quickly and without major environmental impact. The intention is to give an extra boost to the electrification of rural areas. The aim of the act is to motivate national and international investors to put money into El Salvador's energy sector. At present, regenerative energy technology is still in its very beginnings in the central American country. At the same time as the act was passed, a proposal was made to set up a fund to support electricity generation from renewable energy sources, the main aim of which would be to speed up the development of projects in the field of solar energy.

Superintendencia de Electricidad y Telecomunicaciones (SIGET): *www.siget.gob.sv*

+ + + Massachusetts + + +

In the U.S., an extension of the federal investment tax credit, which will expire at the end of 2008, was rejected by a Senate decision on 13th December. This tax credit allowed tax reductions of up to 30 % of the acquisition costs for a renewable energy system to be claimed. One day later, however, the Federal State of Massachusetts pushed through an extension of its own solar support schemes under the title Commonwealth Solar Initiative (CSI). Thus, an additional amount of US$ 68 million is available over the next four years for the installation of new PV systems. Of this amount, just under US$ 40 million will be funded by the Renewable Energy Trust. The remaining US$ 28 million will come from Alternative Compliance Payment Funds. The CSI is an investment grant for public and private plant operators. It complements the already existing »Small Renewables Initiative«, which offers instalment payment incentives for PV systems to those interested in generating solar electricity. It is planned to combine the two incentive schemes in order to speed up the application process for the installation of PV systems. The state hopes that by means of this programme an installed capacity of almost 27 MW_p will be reached in Massachusetts by 2012. ✹

Northeast Sustainable Energy Association: *www.nesea.org*

EuPD European Press Service

Please report any news concerning incentive schemes (feed-in tariffs, certificate trading, tax rebates, solar obligations) to: sf@sunwindenergy.com.

International fairs

Announce your events

Sun & Wind Energy offers you the announcement of your fairs and conferences – up to date and free of charge. Just feel free to send us your conference information regularly. In return we would appreciate to provide you with free copies of our international magazine for distribution at your event. Please contact:

Silke Funke, phone: +49/521/595569,
e-mail: silke.funke@bva-bielefeld.de

Global Renewable Energy Summit 2008 (GRES)
February 12 -13, 2008
Lisbon, Portugal

At GRES 2008 key issues pertinent to the industry will be addressed by nearly 20 global experts that will be traveling from all over Europe, North America, and Asia. By attending this summit the industry leaders speaking will let you know the shape and direction that the market is heading towards, and what this market must do to prosper in the future. Participants will hear how to make profit out of the inevitable change and what is really going to happen at this critical moment in the market's history. These are huge questions that need to be answered if governments, corporations, investors and customers are to continue to support this market and enable it to continue as a live and growing market.
Contact: IIR Portugal, Lisbon, Portugal, phone: +351/ 21/7932989, geral@iirportugal.com, www.iirportugal.com

PV Expo 2008
February 27 – 29, 2008
Tokyo, Japan

International Photovoltaic Power Generation Expo (PV EXPO) is organised by Reed Exhibitions, who annually is responsible for 36 trade fairs in Japan. PV Expo wants to position itself as an inevitable venue for serious business discussions among the PV specialists. The event attracts participants from around the world such as China, Taiwan, Korea, Germany and the U.S. and will enhance business through opening the pathway to Japan. The international exhibition is specialised in all kinds of devices, materials, equipments and technologies related to photovoltaic power generation, solar cell manufacturers, system manufacturers, electric-related companies, house construction-related companies, cogeneration-related companies as well as universities and national institutes.
Contact: PV Expo Show Management, Tokyo, Japan, phone:+81/3/3349-8576, pv@reedexpo.co.jp, www.pvexpo.jp

2nd International Conference on Solar Photovoltaic Investments
February 19 – 20, 2008
Frankfurt on the Main, Germany

This two-day conference in the financial city of Frankfurt organised by the European Photovoltaic Industry Association (EPIA), is addressed both to the photovoltaic industry and the financial sector. The conference is an opportunity for the two sectors to meet and create new business ties. This event is aimed at rising further interest from potential or existing investors in the photovoltaic sector because the successful development of the photovoltaic industry and market is dependant on the creation of adapted financial instruments. The conference is a follow-up of the first edition workshop dedicated to the same subject and audience, held in February 2007 with 130 participants. This first edition has set the basis for fruitful cooperation between the photovoltaic and the financial communities.
Contact: EPIA, Brussels, Belgium, phone, +32/2/465-3884, com@epia.org, www.epia.org

Washington International Renewable Energy Conference (WIREC)
March 4 – 6, 2008
Washington, United States

Hosted by the United States Government, in cooperation with the American Council on Renewable Energy (ACORE), WIREC 2008 is the third global ministerial-level conference on renewable energy. The event will build upon the outcomes of the conferences in Bonn (2004) and Beijing (2005) to foster increased political support and public awareness for renewable energy, new and innovative actions to promote widespread adoption of renewable energy, and advanced tools for collecting and disseminating best practices to end users. The conference focuses on four pillars necessary to support renewable energy industries: agriculture and rural development, technology research and development, finance, and market adoption deployment. Each track will examine how public policies and private efforts can most effectively advance renewable energy across the globe.
Contact: ACORE, Washington DC, USA, phone: +1/202/393/0001, ext 7582, weirich@acore.org, www.wirec2008.gov

World Sustainable Energy Days 2008
March 5 – 7, 2008
Wels, Austria

The World Sustainable Energy Days, the largest annual conference in this field in Europe, offer a combination of events on sustainable energy production and use, covering energy efficiency and renewable energy sources for buildings, industry and transport. Seven conferences and seminars – which present the latest technology trends, outstanding examples and European strategies – and the »Energiesparmesse«, a leading exhibition and trade show on energy efficiency and renewable energy sources with more 100,000 visitors and 1,600 exhibitors (2007) offer ideal opportunities to establish new partnerships. The conference makes an important contribution to awareness raising for green energy and energy efficiency. In 2007 the conference attracted more than 1,000 participants from 61 countries.
Contact: O.Ö. Energiesparverband, Linz, Austria, phone: +43/732/7720-14380, www.esv.or.at, office@esv.or.at

2008 Asia Solar PV Exhibition
March 5 – 7, 2008
Shanghai, China

2008 Asia Solar PV Exhibition is to provide a good international exchange platform for domestic and foreign enterprises. The organiser expects more than 300 exhibitors (30 % from abroad) and about 12,000 professional audiences to visit this year's event. The exhibition will cover a wide range of products from raw materials to manufacture equipment, from solar cells and modules to complementary systems of wind power and PV electricity generation, and showcase the most advanced technology. In 2007 Asia Solar PV Exhibition attracted companies from more than 20 countries and

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regions, more than 6,500 visitors were counted, of which 1,900 came from abroad.
Contact: Shanghai Pudong International Exhibition, Shanghai, China, phone: +86/21/65922447, postmaster@aiexpo.com.cn, www.asiasolarexpo.com.cn

Energethica
March 6 – 8, 2008
Genoa, Italy

Energethica, the Exhibition for Sustainable and Renewable Energy, is a project designed to boost the development of the renewable and sustainable sources of energy and involves the second show for businessmen of the sector and the general public. The products exhibited follow the philosophy lying behind the show's goals, i.e. to get the offers on ethical energy closer to the increasing demand by residential owners, small businesses, administration offices, industry, etc. holding costs at bay while caring for the environment. Also big energy producers and traders are within the scope of the event. A simultaneous 3-day congress addresses professionals and investors. Energethica intends to address not only the north-western region in which it takes place but also the neighbouring countries. With that aim in mind, the organiser has developed a European network of agencies.
Contact: emtrad srl., Alba (Cn), Italy, phone: +39/0173/280093, info@energethica.it www.emtrad.it

Clean Energy Power (CEP)
March 7 – 9, 2008
Stuttgart, Germany

The international trade fair and innovation conference for renewable energy & energy efficient building and renovation takes place for the first time in the New Stuttgart Trade Fair Centre. The ten year successful Boeblingen trade fair »Erneuerbare Energien« with »Passiv-Haus« will be brought together with the Berlin Clean Energy Power (CEP) which took place for four years in the International Conference Centre in Berlin. Approximately 14,000 visitors from all corners of the world are expected to attend. Especially for aspiring international companies, the International Business Exchange Forum (IBEF) offers the opportunity to present company's products, services, innovations and get in contact with future potential business partners. The trade fair and conference programme for the CEP will cover the complete scope of the renewable energy and energy efficient building and renovation sectors.
Contact: REECO, Reutlingen, Germany, phone: +49/7121/30160, redaktion@energie-server-de, www.cep-expo.com

Clean Business 2008
March 11 – 12, 2008
Dubai,
United Arab Emirates

Clean Business 2008 is the only B2B forum in the Middle East will bring together Middle East venture capitalists, investing banks, and individual investors that are interested in investing in clean technology, and business people that are looking for joint venture, partners, dealerships, representations, and distributorship in the emerging clean businesses. It addresses all companies that are involved in clean technologies and are interested in doing business in the Middle East or are looking for investment and want to tap into the booming financial resources in the region. Also represented will be governmental officials who are in charge of regional projects in renewable energy, waste and water management, Clean Development Mechanism (CDM), and environment protection.
Contact: Energative, Ypsilanti MI, USA, phone: +1/734/434/9315, cleanbusiness@energative.com, www.me-fuelcells.com

Renewable Energy & Water Libya (REC 2008)
March 11 – 13, 2008
Tripoli, Lybia

REC 2008 in association with the 1st Conference on Renewable Energies and Water Desalination Technologies are important events for the future of Libya. REC will feature an exhibition showcasing the latest technologies and equipment related to renewable energy utilisation and water desalination. The event is organised by WAHAexpo Company, the leading trade event organiser in Libya. The Academy of Graduate Studies has put together an all encompassing selection of conference topics which cover all aspects of the Libyan water and energy industry.
Contact: WAHAexpo, Tripoli, Lybia, phone: +218/21/360-6082, rec2008@wahaexop.com, www.wahaexpo.com

Mostra Convegno Expocomfort
March 11 – 15, 2008
Milano, Italy

MCE is an integrated system where the whole worldwide production and distribution line of the HVAC and plumbing sector comes together. The 36th edition will show as usual the new trends in its four main sectors: heat, energy, cold and water.

The essential target of MCE is to further increase quality and presence of Italian and international trade visitors, compared to the results obtained in 2006. The last edition achieved a turnout of about 170,000 trade visitors, 30,000 of whom came from 134 different countries and saw the consolidated participation of 2,750 exhibiting companies. MCE 2008 will offer a series of important initiatives with a rich calendar of conferences to debate industrial and technical issues, increasing new business contacts between professional trade operators and exhibitors. Next Energy, the trade show dedicated to energy efficiency and renewable sources is in its fourth edition. It is not just an area of MCE but a further business opportunity for exhibitors.
Contact: Fiera Milano International, Milan, Italy, phone: +39/02/485501, info@mcexpocomfort.it, www.mcexpocomfort.it

World Biofuels Markets Congress
March 12 – 14, 2008
Brussels, Belgium

The World Biofuels Markets Congress annually attracts all the major companies from the entire global biofuels value chain to Brussels. 2007 saw Al Gore address over 1,300 participants from 58 different countries. For 2008 in addition to the commissioner, attendees will hear from Vinod Khosla, an ex founder of Sun Microsystems and leading U.S. venture capitalist, industry pioneer Jeff Broin (CEO at Poet Energy), leading biofuels plant developer Giuseppe di Carpegna (CEO at Desmet Ballestra Oleo) and leading next generation scientist Per Falholt (CSO at Novozymes).

With 5 pre-congress conferences and 4 highly focused streams, the event is one of the largest, annual gatherings of international biofuels industry experts. The congress also features Europe's largest dedicated biofuels equipment and services networking exhibition with over a 100 companies exhibiting.
Contact: Green Power Conferences, United Kingdom, phone: +44 (0) 20 7801 6333 info@greenpowerconferences.com, www.greenpowerconferences.com

GLOBE 2008
March 12 – 14, 2008
Vancouver, Canada

The tenth in the series, GLOBE 2008 will host 10,000 participants, 2,000 conference delegates, 400 exhibitors, 200 speakers and international delegations from over 70 countries. This series of events is dedicated to bringing together professionals from the environment sector. Every two years, corporate executives, government representatives, environmental senior managers, urban planners and financial executives meet to discuss emerging priorities and opportunities in the business of the environment.

The conference will focus on major themes such as corporate sustainability, climate change and energy, finance and sustainability, building better cities, and the future of the automotive industry. The GLOBE 2008 trade fair will showcase the latest technologies and services from across the world in areas of interest to environmental companies: waste management, water pollution, green buildings, renewable energies.

Contact: The GLOBE Foundation, Vancouver, Canada, phone: +1/604/775-8027, info@globe2008.ca, www.globe2008.ca

European Wind Energy Conference & Exhibition (EWEC 2008)
March 31 – April 3, 2008
Brussels, Belgium

Building on the success of previous events EWEC 2008 gives participant the opportunity to bring their knowledge of wind and electricity issues right up to date. Combining increased political support for wind energy with a dynamic conference programme EWEC 2008 offers a chance to engage with the business leaders, scientists and policy makers at a high level. Over 5,000 people attended the 2007 event. In an increasingly competitive marketplace, up-to-date industry knowledge and access to the leading players is vital to sustain competitive advantage.

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Contact: EWEA European Wind Energy Association, Brussels, Belgium, phone: +32/2/400-1079, info@ewec.info, www.ewea.org

Concentrated PV Summit
April 1 – 2, 2008
Madrid, Spain

CPV today aims to become the preferred information source for news, events, updates, information and reports for the fast growing concentrated photovoltaic industry. CSP today caters for professionals working within the CPV industry and runs an industry specific social network. More than 120 senior level executives from the concentrated photovoltaic chain, from the big players to newcomers, will be attending the Concentrated Photovoltaic Summit.

The event will bring together the companies that have the know-how and the organisations that are in constant R&D, the state of the art technology, and the main players in the industry. CPV wants to informs participants how to build, maintain and run a profitable CPV plant and how to develop a strategy to reduce costs and raise profitability.

Contact: First Conferences, London, United Kingdom, phone: +44/207/3757555, belen@csptoday.com, www.cpvtoday.com

European Energy Forum '08
April 16 – 18, 2008
Barcelona, Spain

The third edition of Energy Forum is the meeting point where professionals, experts and representatives of national and international administrations analyse the energy policies of Europe and the world, such as the changes in the sector. More than 80 informative stands will fill the exhibition area of 3,800 m^2 and will inform about their products and services such as the innovative technologies to solve the necessities of the market. At the same time, during these three days experts will analyse the energy policies and the challenges that people of the sector have to face. After the success of the two other editions, the attendance expectation is high. It is estimated that around 3,500 visitors will show up at the exhibition to know first hand the solutions given by the companies of the sector, their principle activities and the ultimate new technologies.

Contact: Montané Comunicación, Barcelona, Spain, phone: +34/913/519500, info@enerforum.net, www.enerforum.net

Pioneer with a solar vision

Solar architect with heart and soul for 30 years: the U.S. American Steven J. Strong *Photos (4): SDA*

He is the most out-spoken proponent of solar power for buildings in North America, the architect, author and engineer Steven J. Strong. For more than three decades, Strong created notable projects with building integrated solar systems for public as well as for private buildings.

For the vast majority of Americans, the inner sanctum of the White House in Washington, D.C. is light years away. Not so, though, for Steven J. Strong, U.S. architect, author, engineer and a renowned authority on the integration of renewable energy systems in buildings in North America. After serving as energy systems engineering consultant on the Alaskan pipeline in the 1970s, Strong became convinced that there were easier, cheaper and more environmentally desirable ways to provide comfort and convenience to the consumer. »Going to the ends of the earth to extract the last drop of fossil fuel« was a credo he chose not to accept for the decades to come.

Instead, Strong became one of the most out-spoken proponents of solar power for buildings in North America, trying to propel it into a new era of sustainable architectural development. According to Strong, he »fell in love« with solar energy when he realised that »you could put a thin sliver of silicon, with no moving parts and no waste, in the sun and generate electricity forever«. Early on in his career with Solar Design Associates (SDA), the Massachusetts-based firm he founded in 1974, this »Environmental Hero for the Planet« – as *Time Magazine* respectfully named him around the turn of the century – quickly achieved what most never manage: an invitation to the White House.

Solar comeback for White House

As result of the two major oil shocks of the 1970s that sparked widespread interest in finding energy alternatives, President Jimmy Carter, a strong advocate for »energy conservation«, had the domestic water heating system for parts of the White House powered by a rooftop solar thermal collector system. Along with selected other peers, SDA President Strong was invited to the dedication ceremony at the White House in June 1979. This White House event made for splashy headlines as it took place on top of the solar-powered roof itself. Although Carter's successor Ronald Reagan had the system removed early on in his Presidency, Strong and SDA were called in again just a few years ago: »Symbolically, returning to the White House (after some 25 years) was a major triumph,« Strong recounts in an interview with *SUN & WIND ENERGY*.

At present, two drain-back solar thermal systems (see photo on page 21) heat the water for the First Family's spa and outdoor swimming pool, as well as the domestic water. »We have always preferred water as a working fluid for our solar space and water heating systems,« Strong says, because »it provides a much better rate of thermal transfer, requires less pumping energy, needs no maintenance or attention and is nearly free.« In addition, a grid-tied photovoltaic system that covers the roof of the maintenance facility provides electricity for the White House, including the presidential Oval Office where Washington politics are shaped. Having the White House again powered by solar energy is »an important milestone in building awareness for solar

Milestone of solar architecture: 1982 Steven J. Strong planned and built the »House of the Future« with a solar roof – the first of its kind in Brooklyn, Massachusetts.

Milestone of building integration: This PV south façade of the university business school in Eugene, Oregon, was the largest vertical BIPV application in the U.S. at completion.

energy usage in residential and commercial buildings, and a step in the right direction in promoting energy independence,« says Strong.

Steady stream of architectural »firsts«

While the »solar comeback« at the White House may be foremost in many public minds, Strong's peers in the architectural world laud this early U.S. pioneer of solar power integration in buildings for an amazingly long string of other »firsts«. As early as 1979, for example, Strong implemented what was at that time the largest solar thermal system in the New England States (see photo on page 16). A collector system with a surface of 697 m^2 on the roof of a multi-unit housing complex near Boston provided hot water for the residents. For the centre wing of this huge building complex, SDA also designed and engineered a photovoltaic system that became the first utility-interactive PV system for a solar-powered high-rise building in the United States.

Other successes followed suit. In the same year the renowned Massachusetts Institute of Technology (MIT) in Boston, situated in close proximity to Strong's SDA in nearby Harvard, and the U.S. Department of Energy (DOE), commissioned him to design the first private residence in the world to be completely powered by solar energy. This first solar electric house, the »Carlisle House«, as it became later known, featured passive solar heating and cooling, a roof-integrated solar thermal system and a 7.5 kW_p utility-interactive solar electric system.

In 1996, Strong also worked with the Olympic Village architects in Atlanta (Georgia) to power the aquatic Natatorium Complex with solar electricity, thereby designing and engineering the largest rooftop PV power system in the world at the time of completion (see photo on page 18). Since then, says Strong, all Olympic Games have been trying to top the Atlanta example in order »to outshine and out-green its predecessor«.

In addition to other notable projects, Strong is also known for designing and engineering the seven solar electric systems on the U.S. Mission to the United Nations in Geneva (see photo page 24). This Swiss-American public-private sector partnership of 2004 was the first United States diplomatic building with a building-integrated solar electric (BIPV) system on both façade and roof. »The challenge,« says Strong, »was much larger here as (the system) did not only have to be fully functional, but had to be aesthetically pleasing as well.«

Accolades for architectural icon

To those who have followed U.S. developments since the post-Carter years in the 1980s and 1990s, these many »firsts« and his life-long commitment to advocating the rise of solar and wind power systems against all odds make Strong without doubt an icon in his own right. At a time when »energy conservation« sank back into oblivion in the United States because cheap energy from fossil fuels became abundantly available again on world markets, Strong steamed onward. Americans »have been quite content to sleepwalk into the future with regard to energy concerns« for the last 25 years, says Strong.

This project features the largest solar thermal system in the New England States at that time with 697 m². It supplies approximately 80 % of the hot water needed annually in the complex. The housing complex also features the first utility-interactive PV system for a solar-powered high-rise building in the United States – visible on the centre wing of the complex. *Photo: SDA*

Notwithstanding this lack of general support, however, he received many professional accolades over the course of his career, among them the coveted Charles Greeley Abbot Award of the American Solar Energy Society in 2001 for his outstanding lifetime achievement in the advancement of solar and other renewable energy systems in the world of architecture. The American Audubon Society, a renowned environmental organisation, for example, heralded him as Entrepreneur of the Year in 2003. »Strong has based his professional life on two design principles that he repeats like mantras – solar energy and energy efficiency,« Christopher Hallowell of *Time Magazine* wrote in 1999. To counteract what Strong calls »blissful ignorance« of solar energy among architects and policymakers, Strong still criss-crosses the United States to give lectures and workshops to drum up acceptance of and stronger interest in renewable energy systems.

To build a career on renewable energy sources was not exactly a smooth ride, however. For an architect specialising in solar and wind energy in the 1980s and 1990s, the hurdles were manifold. Utilities rigorously opposed any net-zero energy building project that exported surplus power because »it would harm the grid«, as arguments went in those days. Others lamented that solar or other renewable technology was not proven, would not last, or that it was driving up building costs. But, Strong, this »solar zealot« – as he once dubbed himself publicly – always adopted a longer-term view of things. While being aware of the fact that the use of solar power can indeed increase building costs by about 15 %, Strong did not get tired of pointing out that such an initial investment would more than pay its own way over the course of a 40 to 50 year lifespan of the building.

His main breakthrough came in the 1980s when Mobile Tyco Energy Corporation, a manufacturer that is no longer in business under this name, built his »building-integrated« solar roof – the first of its kind, according to Strong. The large-area PV-modules displaced conventional roofing materials and structure and thus provided an alternative to costlier and often clunky looking solar panels that are just slapped onto rooftops. In 1983, the utility Boston Edison (now called NSTAR) contracted Strong to custom design a so-called »House of the Future«, which was built in Brookline (Massachusetts), a leafy suburb of Boston (see photo on page 14/15). Strong's new signature solar roof also included an integrated solar thermal system to supply hot water. This was the prototype for all future building-integrated applications in both residential and commercial scale systems. »The sponsors of this project wanted to see us demonstrate trends in technology and design that would be commonplace in 30 years,« Strong recalls. The futuristic house itself, if measured by 1980s solar architectural building standards, became the feature of a 26-week U.S. TV series on the public channel PBS Network.

Re-awakening for renewable energy sources

Nowadays, events seem to be proving Strong right. Partly driven by the success of ex-vice president Al Gore's Oscar-crowned film »An Inconvenient Truth« about the dangers of global warming, the slogan »going green« has finally reached mainstream America. Now, the three fear factors that fuelled continued interest in renewable energy sources in Europe early on are holding America in its grip, according to many market analysts. Energy insecurity due to scarcer resources and

1979

Granite Place

Location:	Near Boston (Massachusetts)
Building type:	moderate-income housing complex
Solar system:	solar heating system (697 m^2); grid-connected PV system
Manufacturer of the collectors:	Daystar Solar, a division of Exxon (USA) *

higher global demand, rising energy prices, and sweeping geopolitical dangers have come home and are the catalyst for a new drive for energy conservation, efficiency and the use of alternative, renewable energy sources.

Strong extends gratitude to Germany, Europe

Without Europe and Japan, however, North America would be, to a large degree, at a loss in this new unfolding era: »The world owes a debt of gratitude to Europe and Japan,« Strong emphasises. While solar power only retained its popularity among a relatively small group of people in the United States in the post-Carter era, Germany, Denmark and Japan kept on improving existing renewable technology systems and continued to push for solar and wind energy in the 1980s and 1990s. »We would not have the reliable, proven technology and industry base of today,« if Germany, for example, had not continuously improved technologies and had not created »the largest solar market in the world«, he says. As a result, American solar and wind energy proponents can now easily point out the fact that those renewable energy sources are indeed reliable and complementary to traditional energy sources.

To Strong, therefore, it was not surprising that the Technical University (TU) of Darmstadt, Germany, earned top honours and won the »2007 Solar Decathlon«. The U.S. Department of Energy in Washington, D.C. has now organised this international university competition for sustainable, energy autonomous buildings for the third time since its inception in October 2002. »Congratulations, Germany,« said Strong and continued by pointing out that the TU Darmstadt team had modelled its net zero-energy building entry according to a very European perspective, where environmental and energy concerns were foremost in people's minds. Indeed, various jury sections were full of praise: This house »pushed the envelope on all levels«, the architecture jury noted. The engineering jury gave the TU Darmstadt team an innovation score that was as high as you could go, and said that nobody did the integration of a PV system any better.

Looking ahead: opportunities and challenges

Strong already predicted in the early 1990s that decentralised distributed photovoltaic systems that provide electricity at the point of use will be the first to reach widespread commercialisation. Not surprisingly, building-integrated use of PV cells and modules, often serving as the exterior weather skin, became one of Solar Design Associates' design and engineering signatures. The biggest challenge the solar world is facing today, according to Strong, is to keep up with the surging worldwide demand. »Ramping up the production« while the industry is struggling with backorders in the 4 to 6 months range, is now the largest hurdle to faster, more widespread commercialisation of solar power, he says. Relief could come with a more widespread production of thin-film materials. The battle with the electronics sector for highly-priced silicon on the world markets could become less fierce; and soaring prices for solar energy products might be reigned in as a result, notes Strong.

As in the past, high costs are often still detrimental to widespread use of solar power and wind energy, which Strong considers to be »symbiotic in many ways« in North America. With one of his latest projects, the Sonoma Mountain Village in California planned by developers Codding Enterprises, Strong hopes to push solar and wind-powered energy further into the spotlight and make them the cornerstone of mainstream, sustainable »green building« with renewable energy sources in America. Located less than an hour's drive north of San Francisco, an entire community with apartment complexes, houses and retail stores will be built according to environmentally conscious and energy-efficient designs. The ground-breaking ceremony for the biggest phase of this ambitious project is planned for later this year. A 7.5 million US$ system with a power of 1.14 MW_p and consisting of 5,844 photovoltaic panels to service commercial tenants already went online in fall 2006, according to the developer. To Strong, however, the overall concept is more important than individual pieces of the whole layout. »For the first time a developer has set course to create an entire town built according to principles of sustainability, while keeping it competitively priced,« says Strong and continues: »This is solar for the people.«

Anke Wienand

Anke Wienand is president and CEO of International Economic and Ecological Services (I-Eco-S, Inc.), a media communications and consulting environmental company she co-founded in 2001 in Bethesda, Maryland, specialising in international know-how and technology transfer.

All firms in the tables marked with a (*) are either no longer in business under this name or have ceased to exist.

System design engineers for all projects described in this article: Solar Design Associates (SDA), Harvard (Massachusetts / USA); SDA founder and president: Steven J. Strong

Further information:
ACORE American Council On Renewable Energy: *www.acore.org*
American Solar Energy Society: *www.ases.org*
American Wind Energy Association: *www.awea.org*
Chicago Architecture Foundation: *www.architecture.org*
Ecobuild America: *www.ecobuildamerica.org*
Solar Design Associates: *www.solardesign.com*
Solar Energy Industries Association: *www.seia.org*
Sonoma Mountain Village: *www.sonomamountainvillage.com*
Technical University of Darmstadt: *www.tu-darmstadt.de*
U.S. Department of Energy: *www.doe.gov*
U.S. Energy Information Agency: *www.eia.gov*
U.S. Green Building Council: *www.usgbc.org*

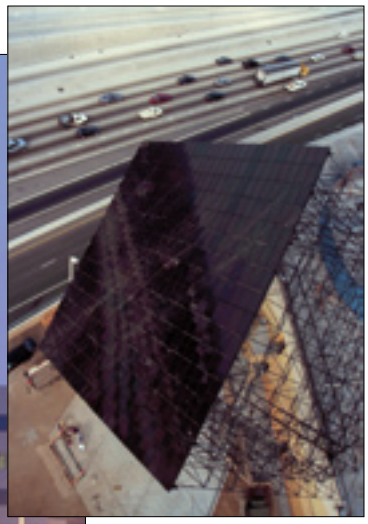
1996

Located on Georgia Institute of Technology's campus, the main roof of the Olympic Natatorium features a large PV array with 2,832 120 W_p PV modules mounted above the steel roof deck to allow for the free flow of cooling air and to power this aquatic centre. With an area of some 32,750 m^2, the Olympic PV array was the largest roof-top solar electric system in the world upon completion. In addition, SDA designed an arched-glass PV portal as the entrance to the Olympic venue. This was the first U.S. application of large-area PV modules as overhead architectural glazing.

Photos: Courtesy of the Georgia Institute of Technology 2007

Georgia Institute of Technology Atlanta

Building type:	Sports Natatorium (aquatic centre)
Solar system:	roof-top PV (342 kW_p); solar thermal system to warm swimming pools; building-integrated arched-glass PV portal
Manufacturer of the modules	Solarex (USA) *
of the inverters:	Trace Technologies (USA)



This »icon of the future« showcases a 12-story high, custom black-anodised, geodesic space-frame solar cube that towers over Anaheim's Main Street with a highly visible display of the renewable energy in use at the Discovery Centre. The giant cube is 46 m tall and tilted at 50 degrees for maximum visual impact. The solar modules serve as an architectural glazing element, replacing a »conventional« glass skin. When completed, the Giant Solar Cube was the largest application of Building-Integrated Photovoltaics (BIPV) in the United States. *Photos (2): SDA*

Giant Solar-Powered Cube

Location:	Discovery Science Centre Santa Ana, California
Building type:	Science Museum
Solar system:	PV power system on south face of giant cube (43.9 kW_p)
Manufacturer of the modules	Solarex (USA) *
of the inverters:	Omnion Power Engineering (USA) *

1999

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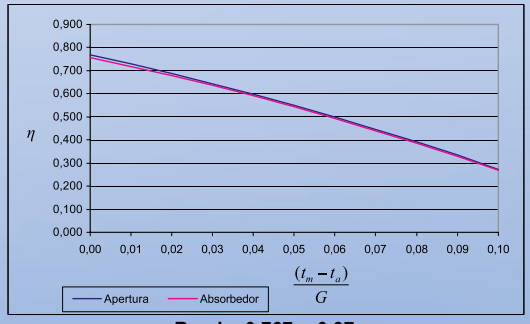

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2002

Both systems displace utility power at the retail rate while serving as real-time teaching tools for the training programme of The International Brotherhood of Electrical Workers (IBEW), providing apprentices and journeymen direct hands-on experience with renewable energy systems. For IBEW it was the first facility powered by both wind and solar energy.

Photos (4): SDA

Workers' Union (IBEW) Training Centre

Location:	Boston, inner harbour (Massachusetts)
Building type:	IBEW Regional Training Centre
Hybrid system:	commercial-scale wind turbine (100 kW); façade-mounted solar electric array (7.9 kW_p)
Year completed:	solar: 2002; wind: 2006
Manufacturer	
of the wind turbine	Fuhrländer (Germany)
of the modules	Evergreen (USA)
of the inverters	SMA (Germany)

This net-zero energy house is typical of all the all-solar residencies that SDA designs, irrespective of geographic and climate zones. The integral solar roof powers heating, hot water, electricity and »passive« solar cooling systems for hot, humid summers and milder winters. Air-conditioning, dehumidification and back-up space heating are delivered by a ground-coupled, geothermal heat pump. Surplus solar power is exported to the local utility grid as part of the »North Carolina Green Power« programme. The Martin House residents receive a premium price of about 200 % for sharing their surplus harvest with the community.

Martin Residence

Location:	Charlotte, North Carolina
Building type:	residential house
Solar system:	building-integrated PV (9.9 kW_p); roof-integrated solar thermal (56 m^2)
Manufacturer of the modules	RWE Schott Solar (Germany)
of the inverters:	Xantrex Technologies (Canada)

Upon request, Strong and his SDA team had the PV array recessed in a new cabana roof such that the modules glazing would be in the plane of the finished roof and become the weathering skin. This is one of Solar Design Associates signature design elements. Many buildings feature fully integrated thermal and PV arrays as their roof.

White House

Location:	Washington, DC
Building type:	presidential residence
Solar system:	photovoltaics; drain-back solar thermal system
Manufacturer of the modules	Evergreen (USA)
of the collectors:	Sunearth (USA)

2003

University of Oregon

Location:	Eugene, Oregon
Building type:	Lillis Business School
Solar system:	PV flat roof array (28.8 kW_p); PV penthouse roof array (6.5 kW_p); PV skylight array (2.7 kW_p); PV curtain wall array (16.6 kW_p)
Manufacturer of the modules	Siemens (Germany) *, Saint-Gobain (Germany) *, Uni-Solar (USA), Sharp (Japan)
of the inverters:	SMA (Germany)

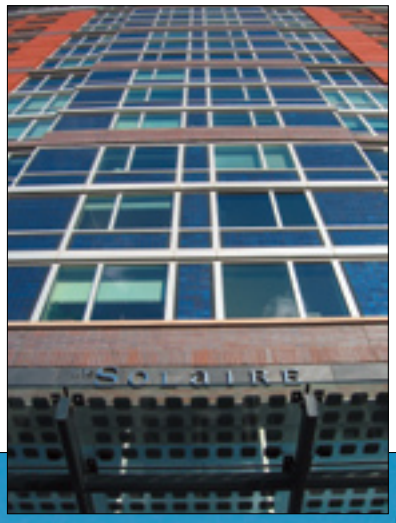
This university business school facility features a five-story building-integrated (BIPV) curtain wall for the south façade that was the largest vertical BIPV application of electric glass in the United States at completion. The »electric glass« was designed with a varying density of solar cells to limit unwanted solar glare and allow transparency at the floor level. There is also electric glass in the skylights to reduce glare while generating electricity. In addition, all the available roof space harvests solar power too.

Photos (5): SDA

Located in highly desirable Battery Park City on the lower west side of New York, this first solar-powered high-rise residential tower in the United States features a building-integrated PV façade and a custom architectural glass PV canopy overlooking the Hudson River, among additional solar elements. The project attracted wide-spread attention, which prompted the developers to name their building the »Solaire«.

Solaire

Location:	New York City, New York
Building type:	residential apartment tower
Solar system:	canopy PV array (600 kW_p); façade PV array (12.7 kW_p); south and west penthouse PV arrays (21.5 kW_p)
Manufacturer of the modules	Saint-Gobain (Germany) *, Astropower (USA) *
of the inverters:	Xantrex Technologies (Canada), SMA (Germany)



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2005

With a building-integrated »solar skin« the U.S. Mission to the United Nations in Geneva, Switzerland, is the first solar-powered American diplomatic post in the world. SDA's design included façade- and roof-mounted arrays, sloped glazing and integrated sunshades on the southeast and southwest facades. *Photos (2): Courtesy of U.S. State Department*

U.S. Mission to the United Nations

Location:	Geneva, Switzerland
Building type:	diplomatic post
Solar system:	PV arrays (sunshades, sloped glass, vertical façade, horizontal)
Manufacturer of the modules	Sharp (USA), Powerlight (USA), RWE Schott (Germany), Shell (The Netherlands) *
of the inverters:	SMA (Germany)

World-known golf champion Tiger Woods called this solar-powered learning centre his »most important legacy«. The centre features two solar electric systems – a rooftop array for bulk power harvesting and a custom, curved building-integrated PV curtain wall to showcase solar technology. This wall is also sloped, requiring modules of differing sizes and shapes that vary in light transmission from 5 % to 30 % top-to-bottom – like the tinted band on a car windshield. *Photos (3): SDA*

Tiger Woods Learning Centre

Location:	Anaheim, California
Building type:	multi-purpose learning centre
Solar system:	building integrated photovoltaics (3.3 kW_p), flat roof array (6.8 kW_p)
Manufacturer of the modules	Schott (Germany), Astropower (USA) *
of the inverters:	SMA (Germany)

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2006

In order to harvest the energy from sunlight falling on the multi-acre and potentially »MegaWatt« solar roof tops of a huge warehouse complex in New Jersey, SDA designed and built a PV system for the entire flat roof. Senior management at River Terminal Corporation contracted SDA on a turn-key basis to deliver a complete installation, providing a single source of responsibility for the entire project. With combined state and federal incentives, as well as high local electricity rates, this corporation investment is expected to deliver a simple payback time of less than six years – a formidable result even without factoring in any future rate escalations.

Photos (5): SDA

River Terminal

Location:	South Kearney, New Jersey
Building type:	warehouse complex
Solar system:	flat roof PV system (607 kW_p)
Manufacturer of the modules	Sharp (Japan)
of the inverters:	Satcon (USA)

Despite the harsh winter climate and modest solar resources, this 21st Century Farmstead, a north-eastern residence, gets its heat, hot water and electricity from renewable energy with sufficient surplus solar-generated electricity also meant to charge plug-in hybrid cars and provide local transportation for the owners.

21st Century Farmstead

Location:	Tamworth, New Hampshire
Building type:	residential house
Solar system:	roof-integrated PV (16 kW_p); building-integrated solar thermal (102 m^2)
Manufacturer of the modules	Schott Solar (Germany)
of the inverters:	SMA (Germany)
of the collectors:	Sunearth (USA)

2007

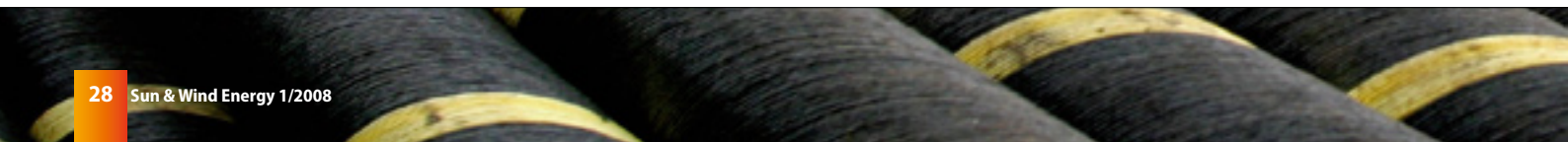
AT+T Park

Location:	San Francisco, California
Building type:	baseball stadium
Solar system:	awning PV on the port walk; flat roof PV on the executive office building; PV system on the new roof of the Willie Mays Ramp
Manufacturer of the modules	Sharp (Japan)
of the inverters:	Solectria Renewables (USA)

In the context of a general rush of support for renewable energy in San Francisco, SDA was retained by the area's largest utility (Pacific Gas and Electric) to use solar electricity sources that would be most visible to the public. In addition to a PV array mounted right on the scoreboard of this baseball stadium, among other points of use, a series of PV awnings were mounted along the Port Walk.

Solar power

from the Sahara – a vision?



Transcontinental grid: Spanish grid operator Red Eléctrica de España (REE) connects a power cable under the Strait of Gibraltar between Spain and Morocco. *Photos (4): REE*

Parabolic trough power stations are popping up all over the world. While the U.S. and Spain are considered the main drivers, the technology is moving into sunny areas everywhere. The first projects south of the Mediterranean have been launched almost simultaneously in Morocco, Algeria and Egypt. For a number of visionaries, this is the first step towards an international energy partnership with north Africa: In just a few years, solar power from the Sahara is to be transported to Europe via a transcontinental power grid. But a closer look reveals that northern African countries are not that interested in exporting power to Europe, which itself has some reservations about the megaproject in the meantime.

Groundbreaking ceremony in the Algerian desert: At the beginning of November 2007, energy minister Chakib Khelil breaks ground for the construction of his country's first parabolic trough power plant, which will offset gas consumption in a conventional gas and steam turbine.

Photos (2): NEAL

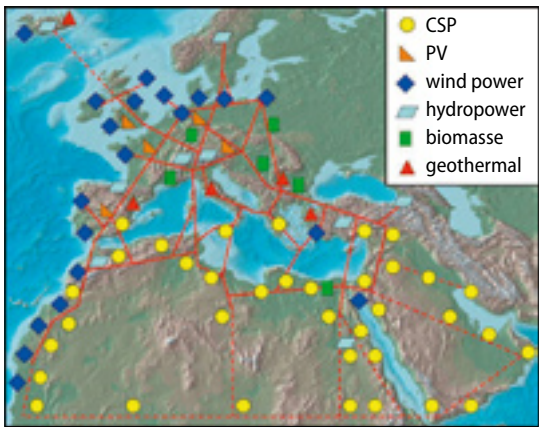
Were it not for the discovery of Africa's largest natural gas field in 1956, Hassi R'Mel would probably have remained an unknown spot in the Algerian desert. Today, the dusty town 400 kilometers south of the country's capital, Algiers, is the center of Algeria's gas industry. The production equipment of natural gas firm Sonatrach covers a tremendous area. The powerful state-owned firm – »Algeria's wallet« – extracts gas, refines it, and sends it to Europe through two large pipelines. The Transmed pipeline connects Algeria to Sicily through the Mediterranean Sea before it heads on to the heart of Europe via the Italian Peninsula, while the Maghreb-Europe pipeline cuts off to the west and connects Morocco to the Iberian Peninsula at the Strait of Gibraltar. Though the Algerian economy depends on Hassi R'Mel, it's no secret that this source of income will one day dry out. According to current estimates, gas reserves will last another 50 years, but annual production rates are increasing, which means that reserves will be used up faster. At least in the long term, Algeria will have to come up with a new strategy if it wants to retain its position as a major energy supplier to Europe.

Algeria: The gas giant becomes a solar pioneer

Though perhaps only symbolically, the north African country's energy policy is already changing. On November 03, 2007, Algeria's Energy Minister Chakib Khelil broke ground in Hassi R'Mel for the country's first concentrating solar power plant – SPP1 (Solar Power Plant I). The installation of 180,000 m^2 of collectors right next to the natural gas facilities in Hassi R'Mel rather than elsewhere in Algeria was not, however, intended to send an energy policy signal, but merely reflected economics: The natural gas at Hassi R'Mel will be partly used as a fuel for the power plant. In other words, SPP1 (gross capacity 146 MW) is a conventional gas power plant with a 34 MW concentrated solar power (CSP) component serving to reduce gas consumption.

Morocco and Egypt chip in

Such Integrated Solar Combined Cycle (ISCC) power plants are quite popular these days in northern Africa. Morocco and Egypt are following the example set by Algeria and have resolved to install their own similar hybrid solar/gas power plants. Because their projects are still under construction, it is very likely that Africa's first concentrating solar power plant will go online in Algeria. But it will still take some time for the Algerian

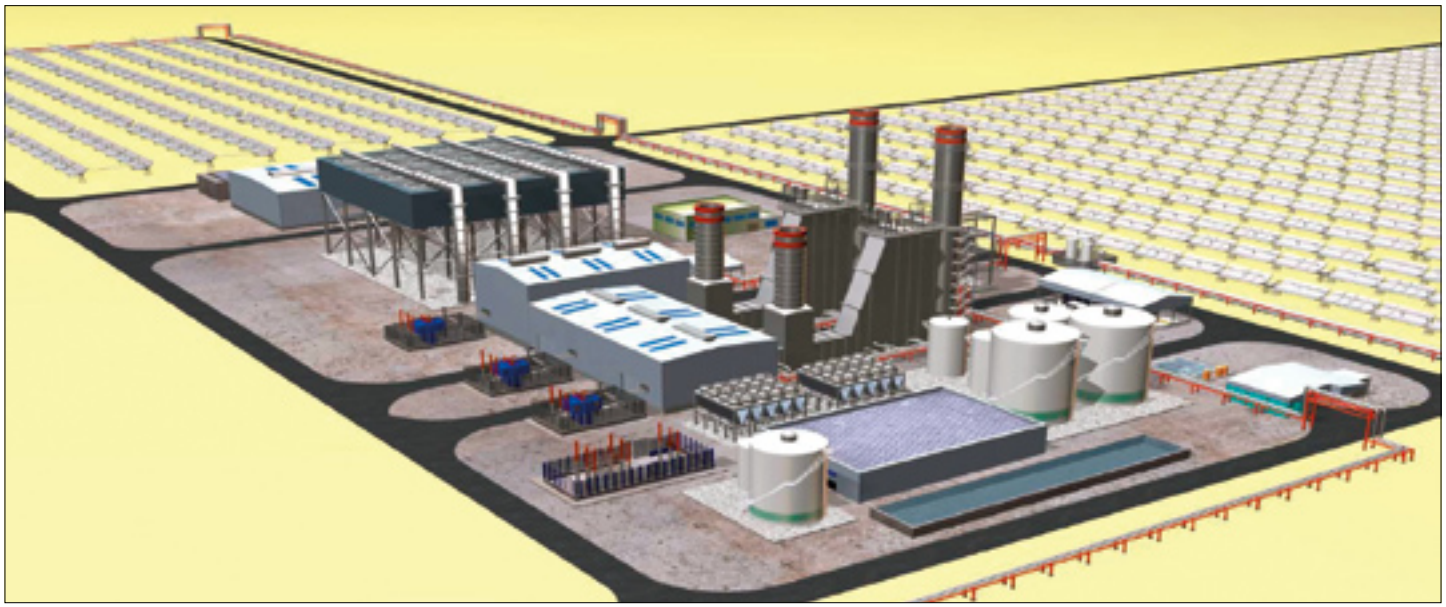


Colorful visions: The Trans-Mediterranean Renewable Energy Cooperation (TREC) plans to install 400,000 MW of concentrating power plant capacity in the deserts south of the Mediterranean to provide power for the entire economic sphere (Europe, Middle East and north Africa). *Figure: TREC's website*

project to be completed. Mohamed Derriche, project manager at operator New Energy Algeria (NEAL), a subsidiary of gas giant Sonatrach, estimates that the power plant will go into operation after 33 months of construction, which puts us in 2010. ISCC power plants take a long time to complete because the global boom in technology both for conventional turbines and parabolic mirrors has resulted in long delivery times. To make things worse, the power plants themselves take a long time to install: Derriche has set aside six months just to align the mirrors. NEAL's technology supplier and partner is Abener, a subsidiary of Spanish technology firm Abengoa of Seville. The Spanish firm seems to have established itself successfully in the Maghreb: In addition to Algeria, the Spanish already have contracts for the Moroccan solar power plant in Ain Beni Mathar (total capacity 472 MW, of which 20 MW are parabolic mirrors). The contractor for this project is the national electricity provider ONE (Office National d'Electricité). Unlike Algeria, where the consortium of NEAL and Abener operates as an independent power producer (IPP), the Moroccan utility has insisted on operating the power plant itself. Because Morocco does not have any natural gas, the conventional part of the plant is fired with gas from the Algerian Maghreb/Europe pipeline. Egypt, the third country in the league of Arab solar pioneers, produces its own natural gas. At Kuraymat in central Egypt, construction will soon begin for an ISCC power plant with a net output of 150 MW, 20 of which is solar. Egypt's New and Renewable Energy Agency (NREA) is in charge of the project and will be acting as an IPP to sell this power to Egypt's grid operator at a rate not yet specified. NREA will procure the solar technology for Kuraymat from a consortium under the leadership of Egyptian construction firm Orascom Construction Industries (OCI). Germany's Flabeg GmbH is also participating; it will be providing the parabolic mirrors. Contracts be-

Construction boom in Spain: At present, five parabolic trough power plants and two tower power plants are being constructed in the country.

Photo: Solar Millennium



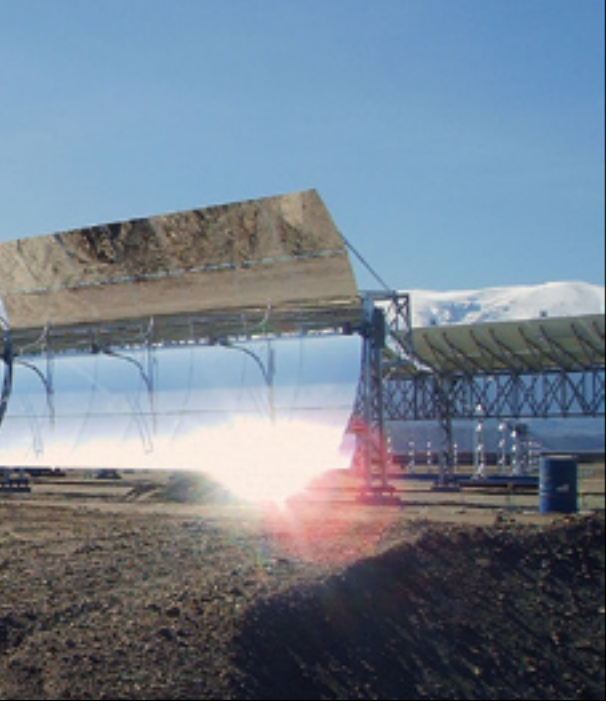
180,000 m² of parabolic collectors provide 5.3 % of the energy needed to drive the SSP1 gas and steam turbine at Hassi R'Mel in the Algerian desert.

Figure: NEAL

tween the various project partners were signed in October 2007. Fathy Ameen, NREA's vice-chairman of technical affairs, says that construction could begin in February or March of 2008.

Can the technology belt work with the Sunbelt?

A lot seems to be going on in northern Africa, whose solar potential has often been praised in studies and at numerous conferences, but which has itself never showed much interest in taking advantage of this tremendous potential. Proponents of the Trans-Mediterranean Renewable Energy Cooperation (TREC) will be especially pleased to hear about the new projects. For some time, they have been conducting an intensive campaign to expand concentrating solar thermal in Sunbelt countries south of the Mediterranean. The idea behind TREC, which is supported by the German Association, the Club of Rome and lobbyists from the CSP industry, is simple: High-voltage direct current (HVDC) lines would transport solar electricity directly to urban consumption centres in central Europe. By 2050, Europe could be getting 10 to 25 % of its power from deserts, with wind power, hydropower, and biomass taking care of the rest in a future European power supply that practically does without coal and nuclear plants. Fancy PowerPoint presentations already show maps that include the locations of potential solar power plants and the routes of power lines (see chart on page 31). Up to 400,000 MW of installed CSP capacity is to be created in deserts to provide electricity for the EU-MENA (Europe, Middle East, and northern Africa) economic sphere. TREC proponents say that everyone would benefit from collaboration between »countries on the technology belt and countries on the Sunbelt«: Europe would get clean electricity, and poor countries south of the Mediterranean would finally benefit from economic growth and greater prosperity. But sceptics have a few questions about the project, which optimists are idealistically also selling as a »bridge between Islam and Christendom«. Who is going to pay for it? And what do the countries in northern Africa think about the project? Are the plans compatible with conditions on their electricity and energy markets, and does the megaproject make economic sense for them in terms of added value?



Gas turbines with a little solar

The three pilot projects currently underway in northern Africa actually only represent a tiny, symbolic first step toward such a plan. When it comes to solar electricity production, the planners have obviously not set very ambitious goals for their hybrid solar/gas power plants. For instance, according to preliminary calculations, Egypt's ISCC power plant in Kuraymat will only be getting 4 % of its power production from the parabolic field, with the rest coming from natural gas. The Moroccan project performs even worse at only 1.1 % solar. The term »solar power plants« does not seem very appropriate, here. Only the ISCC power plant in Hassi R'Mel is to get more than 5 % of its power from solar, because Algeria has a Renewable Energy Law which foresees a feed-in-tariff for solar power only for ISCC plants with more than 5 % solar production (see box on page 36): »We are trying to move beyond the 5 %,« promises NEAL's project manager Mohamed Derriche. We will only know whether he has succeeded when the plant is in operation.

Why are such unimpressive production targets being discussed when the output figures for the power plants (see table on page 38) seem to suggest greater potential? The problem stems from the special technology used in ISCC power plants, which utilise the waste heat from the gas turbine to power a second steam turbine downstream. For the solar parabolic field to feed heat at temperatures up to 400 °C into the steam circuit, the steam block has to be over-dimensioned for the gas turbine. At night, the waste heat from the gas turbine does not suffice to maintain the operating temperature for the steam turbine without energy from the parabolic mirrors. Therefore, the steam circuit has to be heated with additional gas, thereby leading to the low share of solar in the overall production figures. One insider is even concerned, that a number of other design flaws in current ISCC projects could ma ke things even worse. He says that »negative gas savings« would be putting it mildly: In other words, the use of solar fields might paradoxically increase the net gas consumption in the power plants.

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*see 2007 third quarter forecast report

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Facing the sun: Concentrating power plants have great potential in all of the world's deserts, from Nevada to northern Africa and China.
Photo: Solar Millennium

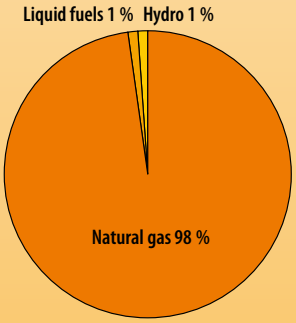
In light of such frightening concerns, one can only wonder why planners opted for dubious ISCC technology in northern Africa in the first place. But the answer is relatively simple: Aside from Algeria – the only country that seriously plans to test the technology (and finance the project on its own) – other northern African countries showed little interest in adventuresome solar experiments with uncertain outcomes. Indeed, Morocco and Egypt were practically forced to enter into the projects. Only after the World Bank's Global Environmental Facility had thrown in US$ 50 million could the countries be convinced to add a solar component to their current power plant projects. Without this external funding, the countries would have built gas and steam turbines without the »troublesome« parabolic mirrors.

Power shortages from Casablanca to Cairo

To a certain extent, the scepticism is easy to understand. After all, while Europe can afford to ponder the niceties of carbon-free power supply, planners in northern Africa have much different concerns. They simply have to make sure that their countries get enough power over the next few years. Demand in northern Africa is increasing by 7 to 10 % annually due to a population surge and strong economic growth. The power grid can hardly withstand the load between Casablanca and Cairo, with one demand peak following the other. The situation is especially dramatic in Algeria, where several nationwide blackouts have occurred in the past few years. North African utilities desperately need every installed watt – and there is few interest whether the power

Algeria: mandated rates for renewables

In 2004, Algeria became the first country in Africa to adopt a law promoting renewables. Its Decree 04-92 specifies detailed rates for power fed to the grid from wind turbines, dams and solar generators. The rates are based on a reference rate per kWh specified by regulatory authority CREG (Commission de Régulation de l'Electricité et du Gaz). 300 % of the base rate is paid for wind; only 100 % for hydropower. The bonus is paid in addition to the reference rate. Unfortunately, renewables will nonetheless not be growing by leaps and bounds because the base rate is currently only around DZD (Algerian Dinar) 3.5 (US$ 0.052). Generators that »exclusively produce power from solar energy«, such as photovoltaic panels, get the short end of the stick. The Decree also only specifies 300 % of the base rate. Hybrid CSP/gas systems fare better. Here, payment is based on the percentage that comes from solar. Systems that get 5 – 10 % of their output from solar (SPP1 in Hassi R'Mel falls into this category) get a 100 % bonus on top of the reference rate. This bonus is paid for a power plant's entire output, not just the share of solar. The rate is thus a golden handshake for operators of power plants who add on a small solar field to offset gas consumption.

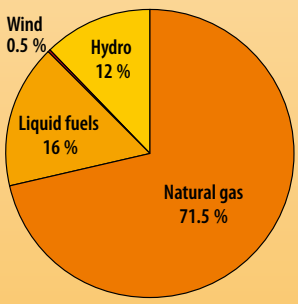


Algeria – electricity production

Algeria – electricity data	
Population	33 million
Total electricity production (2006)	35 TWh
Electricity consumption per capita	1,060 kWh/year
Demand increase (2006)	4.2 %
Electricity generation park (2007)	7,900 MW
Total installed wind capacity (2007)	0 MW
Electricity interconnections (2007)	Morocco: 200 MW (225 kV_{AC})

Egypt: nuclear power to solve energy problems?

30 years ago, it was already becoming clearer that power from the Assuan dam would not provide enough power much longer for the quickly growing population. Since then, Egypt has been thinking about going nuclear. However, in 1986 plans were mothballed after the catastrophe in Chernobyl; since then, the country has put up countless new gas turbines. But recently, the nuclear option has been put back on the agenda. At the beginning of last October, President Hosni Mubarak announced that the old nuclear plans would be rolled out again. Within 10 years, a nuclear power plant would be completed at Dabaa on the Mediterranean to cover 20 % of the country's electricity supply. And yet, Egypt is ideal for renewables: The country has vast tracts of unused desert with excellent solar radiation, not to mention some of the world's best locations for wind turbines. Zafarana on the Red Sea alone has potential for a wind farm with an installed capacity of 3,000 MW, though only 230 MW are currently installed. Conditions for the integration of renewables in the national grid should be improved soon when the electricity sector is reformed. Now, it is up to the renewables industry to show that the country's power supply can be ensured with the aid of solar and wind.



Egypt – electricity production

Egypt – electricity data	
Population	78 million
Total electricity production (2006)	108 TWh
Electricity consumption per capita	1,380 kWh/year
Demand increase (2006)	7.3 %
Electricity generation park (2006)	20,500 MW
Total installed wind capacity (2006)	230 MW
Electricity interconnections (2007)	Libya: 180 MW (220 kV_{AC}) Jordan: 300 MW (400 kV_{AC})

comes from environmentally friendly sources or not. That explains also the low reservations of the decision-makers about nuclear power, which France is currently and openly throwing its weight behind.

Little interest in power exports

In light of the precarious power supply, no one is even thinking about exporting electricity. It is therefore unlikely that the large HVDC power lines envisioned by TREC will be set up anytime soon. However, a conventional AC line already connects Africa to Europe. With a transmission capacity of 1,400 MW, the cables installed between 1997 and 2006 lie at the bottom of the sea at the Strait of Gibraltar. Unsurprisingly, power mostly flows from Spain to Morocco. Spanish grid operator REE (Red Eléctrica de España) says that only »very randomly« does power flow from Morocco to Spain. On balance, Morocco gets a full 9 % of its electricity supply from the Spanish grid. Indeed, electricity is now the main export item that Spain sends to Morocco. Power lines also connect Egypt to its neighbours. For instance, an underwater line through the Red Sea leads to Jordan. While Egypt can afford to send a small part of its energy through that line at the moment, Egyptians are not that excited about the prospect of a large HVDC connection to Europe: »This is maybe interesting in the far future, but first we have to match the demand in Egypt,« NREA's Fathy Ameen throws a wet towel on expectations for green power exports from his country.

Stronger regional grids, not electricity highways

Egyptians are far more interested in the Mediterranean Ring Project (MedRing). In this project, countries south of the Mediterranean plan to work together to expand connections between their grids and successively equip them with more powerful ties: »We have different load curves, and could shift the demand peaks from one country to the other,« Ameen explains. MedRing is to create a seamless grid around the Mediterranean. Currently, the ring is being connected to the UCTE grid in Europe via Jordan, Syria, and Turkey. But even this project is only slowly progressing: Financing and coordination problems, inefficient structures, and a lack of transparency are putting a damper on the project in Arab countries. And there are political problems: Although it would make sense, Israel cannot get involved in the project if Syria is to stay in. If such »small« projects face such great obstacles, how will the grand visions of more than 30 states working together ever be realised?

Criticism of energy security and central production

Furthermore, more and more Europeans are voicing their doubts about these technocratic ideas. One of the main arguments of opponents is energy security. There is a fear of dependence on imports from areas that might be politically unstable – in addition to fears of dependence on large power firms. Fabio Longo, board

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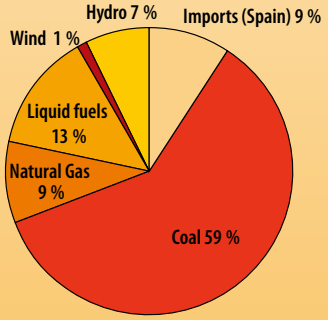
Morocco: restructuring the energy sector

Morocco's energy sector faces reforms demanded from those at the very top. In his annual royal address in July, King Mohammed VI declared the expansion of renewables an elementary component of the country's energy policy. Now, the government elected in September is working to reach these targets. The Energy Ministry has been merged with the Environmental Ministry, and a law to promote renewables has been adopted. The law, which will probably go into effect in 2008, is unfortunately quite vague, with little along the lines of possible support mechanisms. Such detailed floor prices as specified in Algeria are not included. At the moment, experts are working up detailed regulations to give investors an idea about where the new law will take Morocco. Insiders say that the scenario that planners prefer will support biomass and wind farms, though concentrating solar power plants could also receive preferred treatment in Morocco's future energy policy. Electricity exports will be admissible under the new law provided that they do not detrimentally affect the nation's power supply.



Morocco – electricity production

Morocco – electricity data	
Population	31 million
Total electricity production (2006)	21 TWh
Electricity consumption per capita	677 kWh/year
Demand increase (2006)	8.1 %
Electricity generation park (2007)	5,400 MW
Total installed wind capacity (2007)	124 MW
Electricity interconnections (2007)	Spain: 1,400 MW (400 kV_{AC}) Algeria: 200 MW (225 kV_{AC})

Country	Algeria[1]	Egypt[2]	Morocco[3]
General Data			
Project name	SPP1	Kuraymat Solar Thermal Power	Centrale Thermo-Solaire Ain Beni Mathar
Location	Hassi R'Mel	Kuraymat	Ain Beni Mathar
Implementation	New Energy Algeria (NEAL)	New And Renewable Energy Authority (NREA)	Office National d'Electricité (ONE)
Current status	under construction	contracts signed	contracts signed
Contractor for CSP-part	Abengoa/Abener	Orascom	Abengoa/Abener
Technical Parameters			
Solar irradiation	2,900 kWh/m²/a	2,400 kWh/m²/a	2,290 kWh/m²/a
Gross capacity	146 MW	150 MW	472 MW
Capacity of solar part[4]	34 MW	20 MW	20 MW
Capacity of gas turbine[4]	92 MW (2 x 46 MW)	80 MW (2 x 40 MW)	– [5]
Capacity of steam turbine[4]	81 MW	76 MW	– [5]
Net electricity production	1,276 GWh/a	850 GWh/a	3,538 GWh/a
Solar electricity production	68 GWh/a	34 GWh/a	40 GWh/a
Solar share	5.3 %	4.0 %	1.1 %

[1] data: NEAL
[2] data: NREA
[3] data: World Bank
[4] gross capacity of subpart
[5] gross capacity of conventional part (gas+steam): 452 MW

Overview on north African Integrated Solar Combined Cycle Plant (ISCC) Projects

chairman at Eurosolar, is concerned that a »centralistic grid spanning Africa and Europe« would only further strengthen the monopoly power of large electricity providers. Indeed, it is hard to imagine how to collect the billions in investments needed for CSP power plants and transmission lines if major players in the energy sector are not involved. For instance, German power provider EnBW has already voiced its theoretical approval of the TREC plans, though it remains to be seen whether the company wants to seriously get involved. At the moment, the firm seems to be using the trans-Mediterranean and green power project mostly as an argument against the unbundling of transmission grids and power plant capacity currently being discussed in the EU for utilities. The argument goes like this: If the utilities had to spin off divisions, no one would be left to complete such intercontinental electricity projects. It will be interesting to see how the current discussion continues. The TREC initiative, which may have some appeal for politicians at first glance, runs the risk of being hijacked by a lobby that is less interested in renewables than in maintaining the status quo on European energy markets.

Few are talking about how little Europe has done to integrate renewables in its own grids, nor is there much recognition that the countries of northern Africa will have to upgrade their own electricity infrastructure first. The German Centre of Aeronautics and Space (DLR) created the study on which the TREC concept is based; not surprisingly, the concept is mainly characterised by the visions of »German« engineers and scientists. The study would have benefited greatly from more macroeconomic analysis, including input from experts on development and infrastructure from the target countries; no doubt, a number of other aspects would have been brought into the foreground had this been done.

But one thing is certainly clear: Lots of concentrating solar power plants are to be built in desert countries. As long as they are not only a minor appendage to gas turbines as in these initial pilot projects, they are the perfect technology for northern Africa. Other projects are needed to demonstrate the technology's true strengths – for instance, concentrating solar power plants that do without gas firing, relying instead on molten salt to store heat so that power generation can be extended into the night. Another practical application is desalination. Much work remains to be done, and countries south of the Mediterranean will certainly continue to welcome support from Europe for meaningful projects. Experts need to continue to consider ways of transporting solar power one day from the desert to Europe. But at the moment, such projects are hardly in demand, nor would they be helpful. Instead, we need to focus on current problems and put the visionary plans of power exports on the back burner. They can always be pulled back into the foreground later when they are truly needed – and have been studied more closely.

Bernhard Brand

Bernhard Brand is a *S&WE* author based in Berlin, Germany, and a specialist in the field of developing cooperation.

Further information:
NEAL: *www.neal-dz.net*
NREA: *www.nrea.gov.eg*
ONE: *www.one.org.ma*
REE: *www.ree.es*
TREC: *www.trecers.net*

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POWERING YOUR FUTURE

Big steps forward

The year 2005 was a turning point for the concentrating solar power (CSP) industry in the U.S. A few surprising announcements in 2005 led to the construction of the first new CSP plant – Nevada Solar One – which has been online since June 2007. In addition, nine other plants have been announced, proposed, or are being built since that time. Meanwhile, several start ups have pushed into the market.

Before 2005, everyone was saying, forget solar, it's too expensive,« says Paul O'Hop, a partner with the international law firm Squire, Sanders and Dempsey, which specialises in renewable energy. For many years, only nine CSP the so called Solar Electric Generating System (SEGS) plants – located in California and built by Luz International – were up and running. The owners went bankrupt and in early 2005, FPL Energy of Florida, one of the leading clean energy providers in the U.S., purchased a stake in some of the plants, becoming the largest operator of CSP in the U.S., with 310 MW.

And then came the big surprise. In August 2005, the project developer Stirling Energy Systems, Inc. (SES), based in Arizona, announced that it had signed an agreement with the electric utility Southern California Edison (SCE) that would result in construction of a 4,500 acre (1,821 hectare) CSP station in southern California that would become the world's largest solar facility, with a capacity of 500 MW, expandable to 850 MW. »This was huge. It shook up the market to have a company like Stirling doing a big CSP project. Once you start doing big projects, there are economies of scale,« O'Hop says. About the same time, the California utility Pacific Gas & Electric (PG&E) announced that it had signed an agreement with Solel-MSP-1, a subsidiary of Israel-based Solel Solar Systems Ltd., to purchase 553 MW of solar power from the Mojave Solar Park. »The year 2005 we saw a big step up,« O'Hop adds.

Two years later, ten plants are online with a total output of 418 MW. They include the SEGS plants with a capacity of 354 MW, and Nevada Solar One with 64 MW. Developers and utilities have either announced, proposed or are now building nine additional plants with a total output of about 3,000 MW (see table on page 42). All of the activity is taking place in sun-kissed California and the Southwest. A number of factors contributed to these big steps in the industry, says Michael Fritsch, president & chief operating officer of the California based Confoe Inc., which helps solar manufacturers build their manufacturing plants more efficiently.

Solar energy during peak hours

Many states by 2005 had renewable portfolio standards in place, chief among them California. California's aggressive Renewable Portfolio Standard (RPS), which took effect in January 2003, requires utilities to increase sales of renewable energy resources by at least 1 % of retail sales per year so that 20 % of retail sales are served by renewable energy by 2010. The governor has set a long-term goal of 33 % by 2020. Twenty-one states and Washington, D.C. now have RPS in place (see *www.dsireusa.org*). Arizona's RPS calls for 15 % renewable energy by 2025.

Also driving the growth is the U.S. Department of Energy's (DOE) goal of installing 1,000 MW of CSP in the Southwest by the year 2010, with the hopes of driving prices down, Fritsch says. »This level of deployment, combined with research and development to reduce technology component costs, could help reduce CSP electricity costs to 0.07 US$ct/kWh,« defines the U.S. DOE's National Renewable Energy Laboratory (NREL). »At this cost, CSP can compete effectively in the Southwest's energy markets.« NREL is partnering with the Western Governors' Association to promote CSP in Arizona, California, Colorado, New Mexico, Nevada, Texas and Utah, which have the best solar resources in the U.S., NREL says.

In these sunny states, a big plus of CSP is its ability to provide energy during peak hours. »One of the great things about solar: When it's strongest in California, it correlates with peak energy demands,« PG&E spokeswoman Jennifer Zerwer points out. »CSP is also great in terms of providing utility-scale solar.« That's important to helping meet the requirements of California's RPS. »We're working to meet Calfornia's RPS requirements for 2010. As part of our commitment, we are looking at a variety of technologies, and solar thermal holds a lot of promise,« Zerwer adds.

Unlike photovoltaic systems – which produce electricity directly from sunlight – CSP technologies use the sun's heat to produce electricity in much the same way that conventional power stations create it. A series of mirrors or parabolic troughs focus the sun's rays on a central receiver containing a liquid. As this liquid heats up, it passes through a heat exchanger and generates steam, which is then used to drive a turbine. Solar thermal's ability to use a traditional turbine is a big plus for the technology, says John O'Brien, an associate in the energy group with financing provider KeyBanc Capital Markets. And that's not the only plus. »It's proven technology, you can use a traditional turbine, you can scale it up easier than PV,« he says. Southern California Edison (SCE) chooses CSP for similar reasons as PG&E. SCE likes CSP's ability to produce power when customers most need it, explains Vanessa McGrady, a SCE spokeswoman. In the utility's efforts to meet the requirements of the California RPS, SCE is technology-neutral and does not choose one versus another, she says. »With SCE's interest in renewable energy, it is more likely that SCE would contract with one technology in addition to another, rather than choosing one versus another.«

FPL Energy, which has said it will invest US$ 1.5 billion in new solar plants in California and Florida, is interested in CSP in large part because it's becoming more cost-competitive, says Steve Stengell, spokesman for FPL Energy. FPL owns 147 MW of the 310 MW of the SEGS plants (SEGS 3-9) under its operation. »If you look at wind power, it's still the most economic renewable resource out there today,« explains Stengell. »But solar is becoming more cost competitive. The price is moving in the right direction.

Challenges for new players

Given the potential for CSP to help utilities meet the requirements of state RPS, diversify their energy supply and meet growing electricity demand, a number of new players have entered the field in the U.S. They include Sky Fuel, Energy Innovations, Bright Source Energy, Ausra, Acciona (based in Spain), and a Colorado-based subsidiary of Abengoasolar (see box on page 44).

However, these companies – and the utilities working with them – face three main challenges, points out Bill Felsher, vice president of project sales for Sky Fuel,

Israeli parabolic trough technology: The California utility Pacific Gas & Electric announced that it had signed an agreement with the manufacturer Solel to purchase 553 MW of solar power from the Mojave Solar Park.

Photo: Pacific Gas & Electric Company

Name of project	Location	Type of CSP	Capacity	Dates	Partners	References
Plant in operation						
Solar Energy Generating Systems (SEGS)	San Bernardino County and Mojave Desert, California	parabolic trough	9 plants totalling 354 MW	online; commissioned between 1984 and 1990	owned by Sunray Energy Inc (SEGS I & II) and FPL Energy (SEGS III-IX)	*www.energy.ca.gov/siting/solar/index.html www.fplenergy.com/portfolio/contents/segs_viii.shtml*
Nevada Solar One	Boulder City, Nevada	parabolic trough	64 MW	online June 2007	U.S. Department of Energy; Acciona Energy & National Renewable Energy Laboratory; Solargenix Energy (now a subsidiary of Acciona)	*www.ens-newswire.com/ens/jun2007/2007-06-05-09.asp#anchor2*
Application for construction (AFC) filed						
Carrizo Energy Solar Farm	San Luis Obispo County, California	compact linear fresnel reflector	177 MW	AFC filed October 2007	Carrizo Energy LLC; Pacific Gas & Electric; Ausra	*www.news.com/8301-11128_3-9810199-54.html?part=rss&subj=news&tag=2547-1009_3-0-10 www.energy.ca.gov/siting/solar/index.html*
Unnamed	Imperial Valley, San Bernardino County, California	dish	300 MW with contract options expanding to 900 MW	20-year agreement signed Octobe r 2005; AFC filed August 2007; under review	Stirling Energy Systems; San Diego Gas & Electric (SDG&E)	*pesn.com/2005/10/12/9600186_Stirling_300MW www.energy.ca.gov/siting/solar/index.html*
Victorville 2 Hybrid Power Project	Victorville, California	parabolic trough	50 MW	AFC filed February 2007; under review	City of Victorville	*www.energy.ca.gov/siting/solar/index.html*
Ivanpah Solar	Ivanpah, San Bernardino County, California	power tower	3 plants totalling 400 MW	AFC filed September 2007	Solar Partners / Bright Source	*www.brightsourceenergy.com/BrightSource_Press_Release_AFC_09-07-2007.pdf www.energy.ca.gov/siting/solar/index.html*
Projects announced						
Mojave Solar Park	Mojave Desert, California	parabolic trough	553 MW	agreement signed July 2005; fully operational 2011	Solel with Pacific Gas and Electric Company	*www.ynetnews.com/articles/0,7340,L-3430085,00.html*
Unnamed	Mojave Desert, California	dish	500 MW with option to expand to 850 MW	agreement signed August 2005; initial phase online 2009, projected completion 2012	Stirling Energy Systems & Southern California Edison	*pesn.com/2005/08/11/9600147_Edison_Stirling_largest_solar www.stirlingenergy.com/breaking_news.htm*
Unnamed	to be determined, Nevada	dual axis tracking tower / thin-film lenses	100 MW	announced February 2006	International Automated Systems Inc. & Solar Renewable Energy-1 LLC	*www.iaus.com/news02092006.aspx*
Barstow Solar Thermal Electric Hybrid	Barstow, San Bernardino County, California	parabolic trough	59 MW	development commenced October 2007; permitting phase	Solar MW Energy Inc. & Ecosystem Solar Electric Corporation	*www.stirlingenergy.com/breaking_news.htm*
Unnamed	to be determined, Florida	compact linear fresnel reflector	initial capacity 10 MW expanding to a total of 300 MW within 4 years	announced September 2007; projected online in 2011	Florida Power & Light; Ausra	*www.sptimes.com/2007/09/27/State/FPL_unveils_plans_for.shtml*

Today ten plants are online with a total output of 418 MW. Developers and utilities have either announced, proposed or are now building nine additional plants.

Source: own research

which is based in New Mexico. In November Sky Fuel was awarded a US$ 435,000 grant to develop its advanced CSP system, called the linear power tower, for utility-scale power plants. The first challenge, says Felsher, is obtaining components in a timely fashion.

»The natural resource is not the limiting factor; it's how fast you can build these plants. The limiting factor is the supply chain for the critical components,« he explains. In fact, a September 2007 study by Black and Veatch Corporation for Arizona Public Service Company and Tucson Electric Power Corporation says that solar resources in Arizona are much larger than the potential near-term demand. The main factor limiting CSP development is equipment availability, the report found. For Sky Fuel, critical equipment includes mirrors and collection elements, specifies Felsher. Sky Fuel acquires its heat collection elements overseas. It will make its own mirrors in the U.S. using U.S. equipment. »The capacity of the industry to manufacture those two things is limiting,« he adds.

What's more, Sky Fuel expects that it will become more difficult in the future to find skilled workers. »It's not trivial to be able to capture the sun and focus it and collect heat,« Felsher says. »We need human resources with expertise in designing collectors and power plants. There are not many people who can do that.«

»Transmission is a stumbling block«

In addition, the solar industry – like the renewable energy industry in general – faces transmission constraints. »Virtually all new renewable projects represent transmission challenges, as most projects are far away from where the energy is consumed,« states SCE's McGrady. »Also, the interconnection queue is congested, which is leading to delays in renewable project schedules.« In fact, she says, it's unclear when SCE's renewable energy projects will come online, given the transmission roadblocks.

To help relieve the problem, the California Public Utilities Commission in March approved SCE's application to build segments 2 and 3 of the Tehachapi Renewable Transmission Project. When completed, the project will include new and upgraded high-voltage transmission lines with the capacity to deliver 4,500 MW of electricity from wind farms and other generating companies that are proposed for northern Los Angeles and eastern Kern counties in southern California. To help move electricity from its Mojave Solar Park to customers PG&E will use some of the transmission infrastructure originally built for the now dormant coal-fired Mojave Generation Station, PG&E announces.

In addition, California has established a renewable energy transmission initiative aimed at developing a

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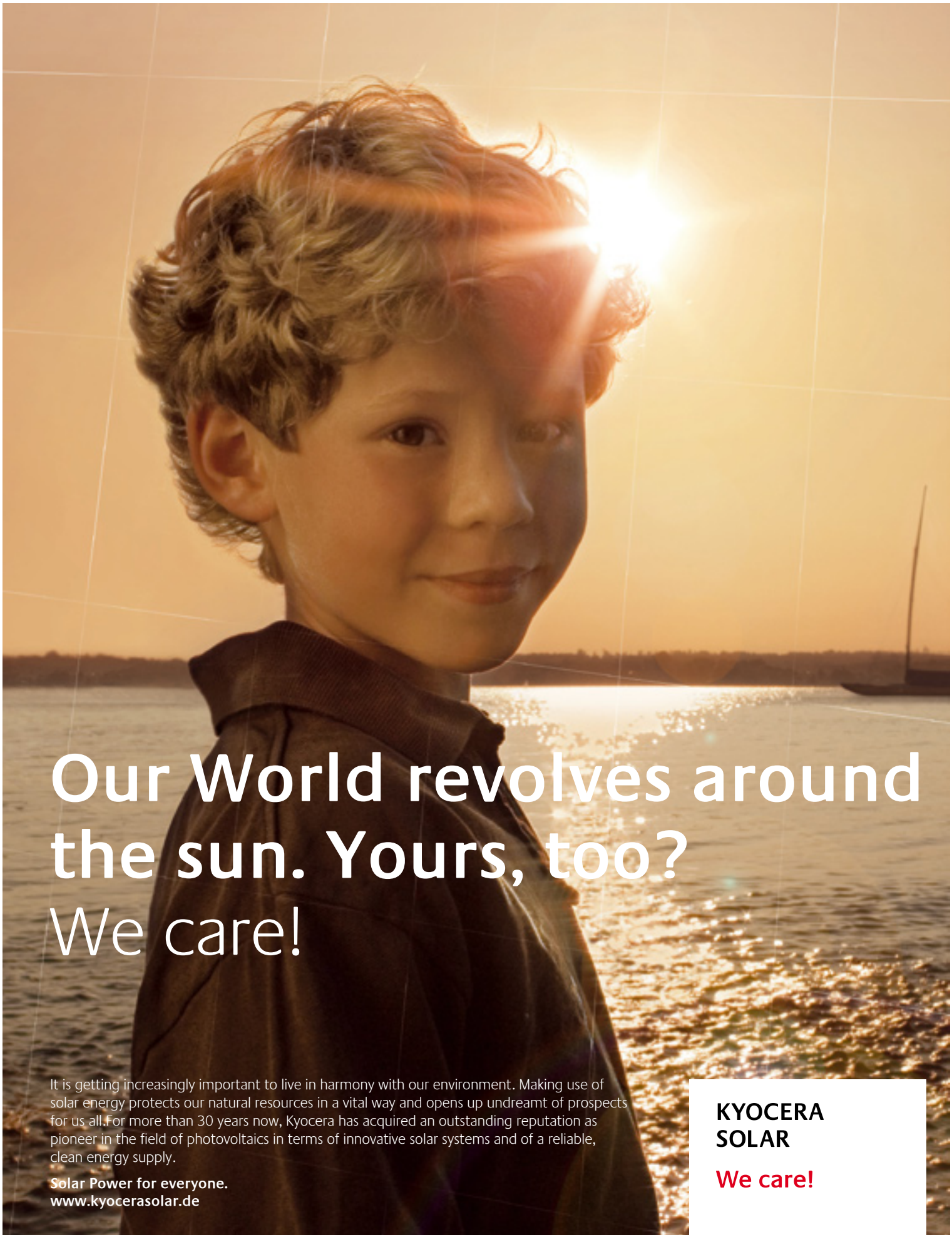

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Plans of new players in the sector of concentrating solar power in the U.S.

The Spanish utility **Acciona** is the owner and operator of the Nevada Solar One project, online since June. »We look forward to additional projects in the future,« says Lena Stinsa, a spokeswoman for Acciona Energy North Amercia Corporation.
www.acciona.com

Abengoa Solar's U.S. unit, based in Colorado, is actively pursuing projects, says Hank Price, vice president of technology development. The company with a Spanish mother is bidding on utility request for proposals, he adds. »We came here because the market is growing in the U.S.«.
www.solucar.es

Project developer **Ausra**, based in California, has filed with the California Energy Commission an application to build a 177 MW plant in Carrizo, central California. Construction will begin in 2009, with the plant online in 2010. In November, Ausra signed a power purchase agreement with PG&E, according to Emily Chamberlin, a spokeswoman for Ausra. »We have additional plants in the planning process,« she says.
www.ausra.com

In September the Californian **Bright Source Energy Inc.**, filed with the California Energy Commission an application to develop a 400 MW solar power plant site. Bright Source plans to build three separate solar plants on a site in California known as Ivanpah, about five miles southwest of Primm, Nevada. The plant will use »Distributed Power Tower« solar field technology developed by Luz II in Israel, a wholly owned subsidiary of Bright Source Energy. The company is negotiating with California utilities for the purchase of the power. Charlie Ricker, senior vice president for marketing and business development, declined to discuss projects other than the Ivanpah plant.

Bright Source Energy was founded as Luz II in 2004 by Arnold Goldman and renamed to Bright Source in 2006. Goldman was the founder and CEO of Luz International Ltd., which built the nine SEGS plants in the 1980s in California.

In 2004, Goldman reassembled a number of members of the original Luz International executive and technical team and founded Luz II. In 2006, the name of the company was changed from Luz II, Inc. to Bright Source Energy, Inc. The Luz II name was retained by Bright Source's wholly owned subsidiary in Israel, which is responsible for engineering and development, and the supply of solar fields for BrightSource plants.
www.brightsourceenergy.com

The start up engineering group **Energy Innovations, Inc.**, based in California, is developing a concentrating PV system that is not yet in commercial operation, says Steven Chadima, executive vice president of external affairs.
www.energyinnovations.com

FPL Energy, one of the leading suppliers of clean energy and owner of portions of the SEGS plants, plans to invest US$ 1.5 billion in new CSP plants in Florida and California over the next seven years, according to Stengell. »We will start out with 10 MW projects and will work up to 300 MW projects,« he announces. »We're looking at a couple of locations in southern California and a couple in the southwest,« he says.
www.fplenergy.com

New Mexico-based start up **Sky Fuel** received the U.S. Department of Energy's (DOE) grant to develop a highly efficient and low-cost parabolic trough concentrator. The linear power tower called »Sky-Trough« utilises a lightweight space frame and a glass-free reflective surface that significantly reduce the cost of the solar thermal system, says a company press release. The DOE grant provides funding for the next generation CSP system.
www.skyfuel.com

Stirling Energy Systems, Inc. (SES), a developer and owner of alternative energy solutions, is developing the 500 MW CSP plant in the Mojave Desert. Laura Hecker, a spokeswoman for Stirling, declined to provide details about the status of the project or about the company's future plans.
www.stirlingenergy.com

comprehensive plan for addressing the transmission requirements of renewable energy, says Adam Browning, executive director of California's The Vote Solar Initiative. »Solar will have a seat in this process,« he declares. New Mexico has a renewable energy transmission authority. »The idea here is to figure out ways to develop the industry most sensibly,« he says.

FPL Energy's Stengell agrees that transmission is a stumbling block. »This is especially true if you're looking at places like California that have transmission challenges to begin with. It's an issue for us whether we're developing a wind project or solar projects,« he differentiates. However, solar has one advantage over wind power when it comes to finding transmission, specifies KeyBanc Capital Markets' O'Brien. If developers build solar thermal plants along with natural gas-fired plants, they can maintain a flat level of output that makes it easier and less expensive to obtain transmission. »With wind, the wind could or could not be blowing. So when you're working with transmission, it's harder. You have to reserve space on a line, and you might not have the electricity. If you co-site solar with natural gas, you can have a good idea of how much energy you might have,« adds Pat Stanton, vice president of clean energy markets for the Massachusetts-based Conservation Services Group, »a power plant project that can be dispatchable – meeting the grid demand any time of day – is more attractive. I hear this from project developers as an argument for supporting large solar thermal projects.«

Along with transmission, the price of CSP is still a roadblock to large-scale implementation, However, many industry players remain confident that the price will drop to competitive levels in the near future. »We're optimistic that the costs are going to continue to move in the right direction and that we're going to see some new solar built,« states FPL's Stengell.

However, Fritsch says that CSP scores well against other technologies when utilities consider its leveled cost of energy. »This makes it an attractive RPS choice,« he points out. The DOE projects the leveled cost of large photovoltaic installations to be 0.22 US$/kWh in 2007 and between 0.08 and 0.10 US$/kWh in 2020, CSP, on the other hand, is expected to be less expensive – 0.20 US$/kWh in 2007 and 0.05 US$/kWh in 2020. »We've also seen estimates that the leveled cost of energy from a CSP plant in the first deployment phase is estimated to be 148 US$/MWh, which is lower than a simple cycle natural gas plant at 168 US$/MWh,« Fritsch adds.

In fact, CSP is seeing a »renaissance« especially in the sun-kissed Southwest, according to a recent study from Emerging Energy Research, a research and advisory firm analysing clean and renewable energy markets. CSP is the fastest growing utility-scale renewable energy alternative after wind power. Up to US$ 20 billion will be invested in solar CSP over the next five years, the study says. ✹

Lisa Cohn

Further information:
Solel Solar Systems Ltd: *www.solel.com*
Southern California Edison (SCE): *www.sce.com*
The Vote Solar Initiative: *www.votesolar.org*

Portland-Oregon based writer Lisa Cohn specialises in energy. Visit her at *www.realenergywriters.com*. Intern Sarah Beecroft contributed to this story.

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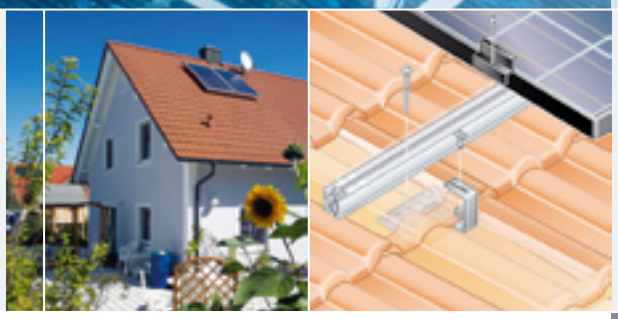

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Guaranteed

Sunny perspectives in France: Guaranteed Solar Results are supported by subsidy schemes.
Photo: Wilhelm Breuer

The solar thermal industry is offering guaranteed energy yields to convince housing associations, hotel owners, and hospital operators to install solar collectors. »Guaranteed Solar Results« (GSR) are designed to reduce investment risk. But up to now, they have not ensured the success of solar technology outside of France, where the government offers subsidies for GSR.

solar yield

French housing association CUS Habitat takes care of its tenants and the environment. Seven years ago, it conducted a brainstorming competition to find out new ways of lowering utility costs and increasing environmental protection. More than 500 residents answered. Many of them proposed that water be heated with solar collectors. As a result, CUS Habitat installed it's first solar thermal unit in the Alsatian town of Ostwald in May of 2003. With a capacity of 284 kW_{th} (406 m^2), it covers 35 % of the hot water demand in 328 apartments in 12 buildings. It was the first solar thermal system set up by the public sector in Alsace.

The housing association opted to use solar technology partly because of an agreement for Guaranteed Solar Results (GSR). CUS Habitat was promised that the system would produce at least 186,000 kWh (458 kWh/m^2) of solar heat over the year. If the solar collectors do not generate the contractually agreed amount of heat, CUS Habitat's contracting partner has to remedy the flaws that cause the shortfall or pay damages. GSR agreements provide housing associations such as CUS Habitat with financial security and effective quality assurance to ensure that their solar units reliably meet the energy yield target. A system's monthly energy yield is determined for a preset level of heat consumption using

Examples of GSR agreements, SES: Solar Energy Supplied, SEG: Solar Energy Guaranteed
Source: own research

Country: responsable organisation	System size	Contracting party	Guaranteed value	Contractual period	Calculation of compansation [€/kWh]	Agreed measurements
Austria: sample contract multi-story apartment building	–	installer, operator	350 kWh/m²	–	L * C * (SES - SEG) [1]	heat counter in solar circuit
Eastern Europe: GSR	> 50 m²	contractor, owner	contractual amount of annually solar energy production calculated by contractor	4 years	(1 - SES / SEG) * TSP [2]	measurement of the useful solar hot water energy and of the useful hot water backup energy
France: Tecsol	> 50 m²	installer, planner, collector manufacturer, maintenance provider	80 % of the annual solar yield calculated with the SOLO programme (available at *software.cstb.fr*)	5 years	System price * (1 - SES / SEG)	measurement of the useful solar hot water energy
Germany: Solarzentrum Hamburg	> 30 m²	installer, owner, monitor	400 kWh/m²	3 years	fixed compensation of 0.2	heat counter to record solar energy yield and flow meter to record hot water consumption

[1] L: service life of system (15 years recommended), C: average cost of backup heat within the guarantee period (€/kWh)
[2] TSP: Total System Price (incl. system design, materials and components, installation, monitoring system, maintenance service)

knowledged computational method or simulation programme. Generally, a guarantee is provided for 80 to 90 % of the value calculated. In doing so, the agreement takes account of changes in the weather that influence operational results.

Success in France

During the defined guarantee period, solar heat yields must be measured. GSR thereby provides owners of systems with a reliable monitoring system. If the measurement data are automatically transferred to the system monitor by e-mail or the Internet, the monitor can assess them and react to any malfunctions that occur. But such a monitoring system also makes solar thermal more expensive. Luc Greliche says the investment pays for itself. »Solar thermal units that are monitored provide more heat than those that are not because you notice poor operational results faster.« Greliche works at Tecsol, which signed the first GSR agreement with a hospital in Castres, southern France, in 1988. Nowadays, the French consulting firm supervises GSR agreements for 150 solar thermal systems.

It is not just an accident that one of the companies with the most experience with GSR is a French firm. The principle of GSR agreements was developed in France as a reaction to the large number of improperly operating systems from the 1980s. These flawed systems put solar technology in a bad light and made it clear how important quality assurance, maintenance, and customer service are. GSR agreements became a standard for large solar thermal systems in the Plan Soleil subsidy programme. It stipulates that large systems with collector surfaces exceeding 50 m² must be monitored to receive a state subsidy. The French industry benefits from the quality agreements because customer acceptance of solar technology increases, especially in large projects. Large systems make up more than 10 % of the market in France – an exceptionally large figure. In Austria, one of the most relevant solar thermal markets in Europe, solar collectors are found on one out of five single-family homes, but they only provide environmentally friendly heat to one out of 50 multi-family dwellings. The situation is similar on Europe's largest collector market: Less than 4 % of all of solar thermal units installed in Germany have a collector surface exceeding 20 m².

New hope in Germany

In Germany, the Berlin-Brandenburg Chapter of the German Society of Solar Energy (DGS) launched a quality seal for solar thermal systems at the end of the previous millennium. The gist of it is a guaranteed energy yield from the solar unit. The project seemed promising in the beginning, but demand dropped after the first five systems were certified in 2000 and 2001. »Housing associations did not accept the quality seal,« explains DGS director Uwe Hartman. There were several reasons. First, most housing associations did not know much about the benefits of solar thermal, so they had never even thought of installing solar collectors. And since the investment costs of a solar unit could not be added onto the rent, there was no economic advantage. Second, this GSR procedure was »not that simple«, as Hartmann admits. Numerous people had to sit down at a table and agree to the details: representatives of the housing association, the planner, the installer, and finally the expert who would monitor the unit. The process costs extra.

Markus Metz, a solar thermal expert at the DGS, nonetheless believes that interest in the quality seal will continue to grow. »To begin with, rising oil prices are drawing more attention to solar thermal. Second, new legislation for heating will soon be passed in Germany. Third, large systems with at least 40 m² of collector surface are already eligible for an attractive loan from the KfW Banking Group.« In addition, he says the industry is also starting to deal with the issue. »Nowadays, solar firms are calling me up asking for information about our

	Data transmission	Website
	system operator	*www.austriasolar.at*
	remote data transmission	*www.solareast-gsr.net*
	remote data transmission	*www.tecsol.fr / www.ademe.fr*
	remote data transmission	*www.solarzentrum-hamburg.de*

GSR: Research report proposes backup heating demand as guaranteed value

At the moment, most GSR agreements specify the solar yield of the system as the guaranteed value. But in 2000, the research report »Guaranteed heat supply from residential solar thermal systems« called that concept into question. After all, system losses may make solar output irrelevant: Just because solar collectors have great heating yields does not necessarily mean that the entire solar thermal system works properly. If the components used are not well coordinated or if the storage tank is of poor quality, then much of the solar heat in the system will dissipate before it can be used.

Under the direction of the Austrian Working Group for Renewable Energy (AEE), the project partners conducted measurements and found that great system losses provide a higher output of the collector system. In other words, contractors can fulfil their part of the agreement by installing a very inefficient hot water system. Obviously, this approach runs contrary to the spirit of such agreements. The focus should therefore be on replacing conventional fuels with solar energy to the extent possible. As the report puts it: »If the goal is to reduce fossil fuel consumption, then we need to look at the overall hot water supply system (from the collectors to the consumer), not only the collectors themselves.« The report therefore recommends that guarantees are to be based on measurements taken at the fossil-fired heating system, not at the solar thermal system's secondary water circulation. The value then determined would be the »maximum demand for backup heating«.

Source: Research report »Garantierte Wärmelieferung aus thermischen Solaranlagen im Wohnbau« (only available in German): www.aee-intec.at/0uploads/dateien22.pdf

Benefits and drawbacks of Guaranteed Solar Results (GSR)

Source: www.solar-net.info

	Benefits	Drawbacks
For investors and system operators	no investment risk	complicated agreements
	transparency	higher costs
	operational reliability	clarification of liability if target is not met
	greater quality	
	third-party financing possible through contracting	
For providers of solar units	customers more willing to invest	complicated agreements
	openness increases acceptance	performance is verifiable
	greater sales	

Eastern Europe: GSR to step up the market

Guaranteed Solar Results (GSR) is a way of assessing a solar thermal system's technical and economical quality. In the agreement, the installers guarantee that system owners will receive a certain amount of energy from the system. In other words, the agreement provides owners with investment security. The industry benefits because customer acceptance increases, especially in large projects. GSR has proven successful in France, Greece, and Austria, where it has enlivened the market for large solar heating systems.

In the EAST-GSR project, international institutions plan to use GSR agreements to set up solar thermal markets in Eastern Europe. Pilot projects and feasibility studies will be conducted to show that GSR speeds up the development of the market in Bulgaria, Poland, Romania, Slovenia, and Slovakia at the same time as it ensures quality. France's Environment and Energy Management Agency (ADEME), which came up with the first GSR agreements back in the 1980s, is coordinating the three-year project. Its partners include Austria's Arsenal Research, CRES of Greece, Germany's DENA energy agency, KAPE of Poland, OVM-ICCPET of Romania, SEA of Slovakia, and SEC of Bulgaria. The University of Ljubljana and France's Tecsol are also involved in the project.

Further information: *www.solareast-gsr.net*

system monitoring,« Metz says. Installers from Hamburg are calling his colleague Bernhard Weyres-Borchert of the local DGS section for good reason. In addition to the federal subsidy worth 105 €/m², the city of Hamburg offers an additional 160 €/m² and a bonus of 90 €/m² for systems in Hamburg that have at least a 30 m² of collector surface and a minimum solar energy yield of 400 kWh/m2 annually. The Hamburg Solar Center already monitors 12 systems to make sure the GSR agreement is upheld. »But another 25 systems are about to be added to our monitoring system,« Weyres-Borchert explains the success of the campaign. In Austria, more and more builders are also opting to have solar yields guaranteed in simple standardised contracts. The annual minimal value is usually at least around 350 kWh/m².

Problems in general

In contrast, GSR agreements are generally complex, with heat / hot water consumption and the way measurements are taken being precisely defined. Compensation is generally calculated using a formula based partly on the price of the unit; the cost items taken into consideration in the process must be specified beforehand. Aside from contractual modalities, Christian Holter, executive director at Austrian solar thermal planning bureau Solid, says companies that offer guarantees face additional obstacles in large projects: »Actual consumption profiles that differ from the system's design. New buildings that only slowly reach full occupancy. Poorly coordinated transfer stations.« These external factors that planners cannot influence nonetheless impact a solar thermal unit's operating results. In such cases, the guarantors may lack the leeway they need to optimise the operation of the unit. While Holter, whose firm monitors 3.5 MW of solar heating capacity with GSR agreements, welcomes guarantee method as a means of establishing quality standards on the market, he prefers contracting models in which a service provider finances the solar thermal system in a residential building and then sells the energy produced to the residents.

Stéphane Pouffary of the French Environment and Energy Management Agency (ADEME), which helped develop the GSR concept from the beginning, has discovered new potential for GSR contracts in solar contracting: »A quality approach is often a mix of both components because the profitability of the external energy provider is linked to the system performance optimisation.« Except for solar contracting, Pouffary would like to expand the GSR concept to smaller systems between 20 and 50 m² of collector surface. »Keeping in mind that medium-size installations represent a significant proportion of the installed surface, and regarding monitoring needs, the objective is now to create conditions for a broader application of the GSR approach.« Instead of having complicated, expensive measurement equipment the solar yield could simply be reported by the system operators to the service provider each week. If so, a simple, inexpensive thermal counter would be all the equipment needed. ✹

Joachim Berner

Joachim Berner is a long term *S&WE* author based in Munich, southern Germany. He is a specialist in solar thermal and biomass.

Further information:
France's Environment and Energy Management Agency (ADEME): *www.ademe.fr*
German Society of Solar Energy (DGS) Berlin Brandenburg: *www.dgs-berlin.de*
Solid Solarinstallation & Design GmbH: *www.solid.at*

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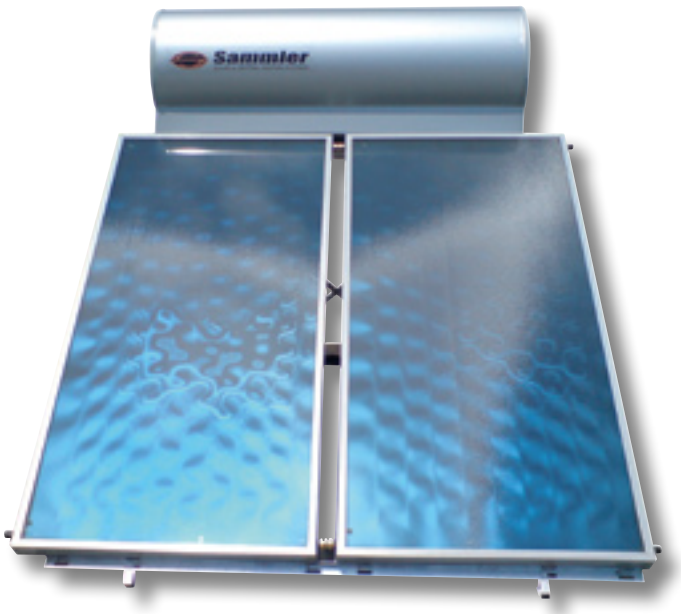
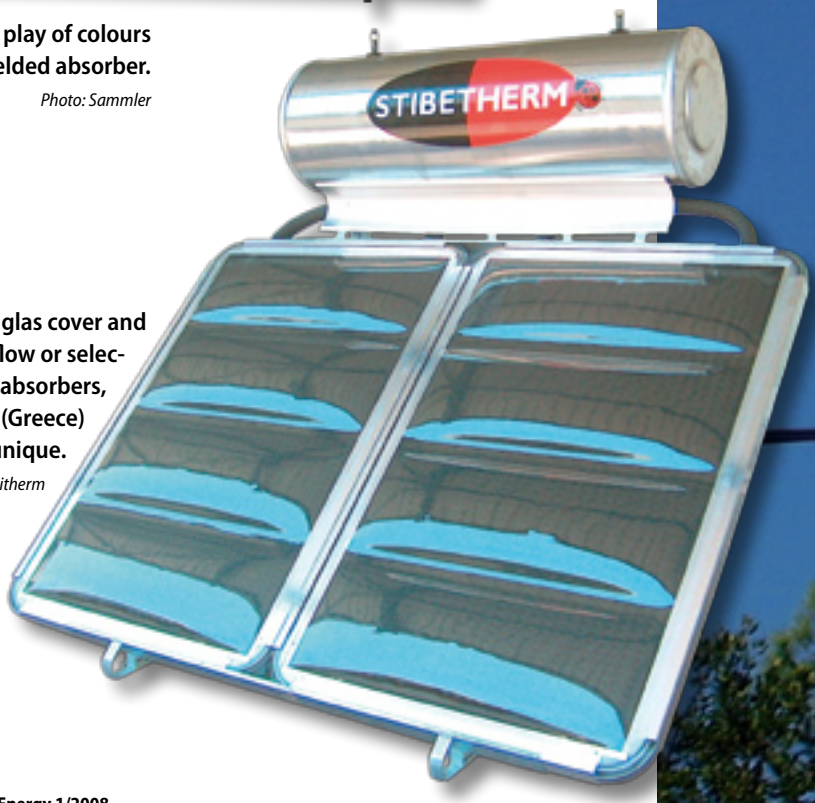
Quality standards are rising

The average lifetime of a high-standard thermosiphon system lies between 15 and 20 years. And quality is in demand when it comes to systems for solar hot water generation. This is one of the findings of a worldwide survey carried out by *Sun & Wind Energy*.



The typical play of colours from a laser-welded absorber.
Photo: Sammler



With a plexiglas cover and steel multi-flow or selective copper absorbers, the Elitherm (Greece) system is unique.
Photo: Elitherm

A simple wooden stand can replace a mounting system.
Photo: De Sol a Sol

What are the technical standards for thermosiphon systems? *Sun & Wind Energy* surveyed well over 100 suppliers worldwide at the end of last year. 41 of these took part in the survey. The strongest response came from Greece, followed by Turkey, Spain and Germany. We asked the companies to provide information on one system with a high standard and one with a low standard. Table 1 on page 56/57 shows the data for the high standard systems and details of companies which only supply one type of system. Only a few manufacturers make systems with significantly differing standards. The following evaluation is for the high standard systems represented in table 1.

Four of the surveyed companies exclusively manufacture thermosiphon systems with vacuum tubes. Three others have both flat plate and tube collectors in their product range. All of the vacuum tube products use the Sydney thermos flask principle. Some systems have direct flow tubes and others use heatpipes.

Collectors: ultrasonic welding predominates

Among the flat plate collectors, ultrasonic-welded absorbers predominate (fig. 1). Over half of the suppliers use these absorbers in their collectors. Laser welding is catching up, however, and is the second-most important connection technology for absorber plates and tube registers. Other connection technologies such as rollbond or soldering are only occasionally being used. Brazil is an exception; here clamping is the preferred technology.

Various methods are used for manufacturing the collector frames. Riveting is the most common. Screwing, sticking and jamming are also popular methods. Welding and soldering are only occasionally used as frame connection technologies, however. The Turkish manufacturer Ezinç, for example, uses a mono-block soldered frame. Nobel, from Greece, uses a frame which is stamped from an aluminium sheet. »We use a non-corrosive Al-Mg-sheet, which is resistant to seawater,« says Xilinakis Dimitra (Nobel). The Indian manufacturer Kotak Urja uses an interlocking aluminium profile with a drain down facility for fog or condensation.

For the absorber coating, eight companies exclusively use highly selective blue PVD coatings (fig. 3 on page 58). On the other hand, ten companies don't use this type of coating at all. Black chrome is the standard coating used by many of these companies on the high-standard systems. Brazil is once again an exception, where black paint is standard. This time it is joined by the African, French and US-American respondents to the survey, however, for whom black paint is also the most commonly chosen absorber coating.

While there is no clear trend towards the »blue« coatings, closed systems with a separate solar loop are on the up (fig. 2). Fourteen companies exclusively supply closed loop thermosiphon systems. For a further 14 companies these make up over 80 % of sales. Open loop systems dominate the market in Brazil.

The Indian supplier Kotak Urja is one of the few companies which supply both systems with flat plate and vacuum tube collectors.
Photo: Kotak Urja

Storage: enamelled or stainless steel

Over 50 % of the companies use storage tanks of enamelled steel (fig. 4 on page 61), while almost 40 % use stainless steel tanks. Two suppliers sell systems with a copper tank. Eduardo Monteiro from the Portuguese manufacturer De Sol a Sol says: »Our copper tanks have an internal tin-plating, which doesn't endanger people's health.« For insulation there is a clear standard. Apart from three exceptions, all use PU foam. 50 mm is the most common thickness of the insulation, within a tank insulation range spanning from 25 mm to 100 mm. The other materials used are rockwool and polystyrene (PS). The Turkish manufacturer Ouraset provides rockwool insulation alongside PU, and some customers prefer this. Over 90 % of the tanks sold last year were made using PU foam, however. To protect the insulation from the elements, companies such as De Sol a Sol and Wikora from Germany cloak their tanks with stainless steel. The Greek supplier Cosmosolar uses aluminium: »Our aluminium outer cover is without any external riveting,« says Taskaris Vanghelis (Cosmosolar). At Kaushal the stainless steel tanks have an epoxy external coating. The Indian company also makes products using rockwool insulation. Here, to avoid corrosion problems due to condensation, the first layer of the resin-bonded rockwool, which makes contact with the tank surface, is laminated with aluminium foil.

Several materials are available for the link between the collector and the storage tank. Around three-quarters of the suppliers use copper pipes; the others use stainless steel or plastic piping. At 40 %, less than half of the thermosiphon systems have insulation for these links. Systems with vacuum tubes do not have a pipe link; the tubes enter the storage directly. In open loop systems

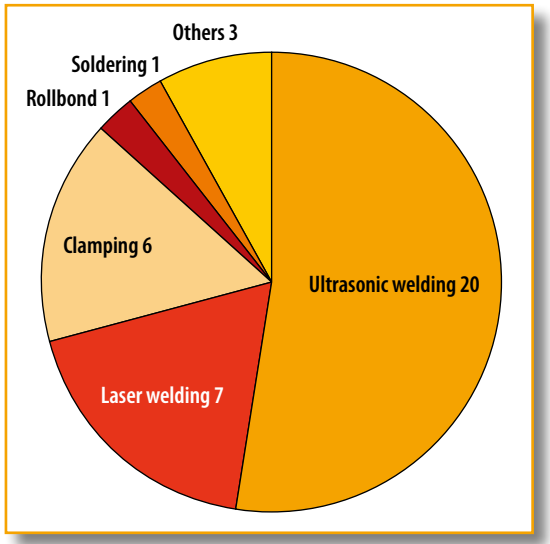


Figure 1: Over half of the manufacturers of flat plate collector systems listed in table 1 on page 56/57 use ultrasonic welding as a connection technology for the absorber and tube register (36 respondents).

Source: S&WE market survey

the water flows through the pipes and storage in one loop. In closed systems, such as with heatpipes, the heat is transferred to the storage via a copper condenser. Tsinghua also supplies tubes with glass condensers.

Mounting systems: simple and flexible

For the mounting system material approx. 60 % of the companies prefer normal steel. A minority answered with aluminium here. Stainless steel is rare, with just two mentions. Jiao Jiwen from the Chinese manufacturer Tsinghua prefers aluminium: »Aluminium alloy is bet-

Manufacturer	Type of system	Year of launch	Collector type	Collector surface [m²]	Absorber tube connection [1]	Absorber coatings	Tank volume [litre]	Tank material	Tank insulation, thickness [mm]	Sacrificial anode	Material of pipe between the tank and the collector
AMK-Solac, Switzerland	closed	2005	heat pipes	n/a	n/a	blue	150 / 180 / 200	stainless	PU, 50	optional	insulated copper
Batec Solar, Denmark	closed	1975	flat	4.4	Cu-strip roll bond	black chrome	300	enamelled	PU, 50	yes	copper
Bosch Thermotechnik, Germany	closed	2007	flat	2.37	ultrasonic welding	black chrome	200	enamelled	PU	yes	insulated copper / rubber hoses
CD Solar, Italy	closed	2003	flat	2.24	ultrasonic welding	blue	160	stainless	PU, 100	yes	copper
Chromagen, Israel	closed	n/a	flat	n/a	ultrasonic welding / soldering	blue / black chrome / black paint	n/a	enamelled	PU	yes	insulated copper/ insulated stainless steel
Calpak - Cicero Hellas, Greece	closed	2005	pipes / flat	n/a	laser welding	blue	300	enamelled	PU, 60	yes	insulated copper
Cosmosolar, Greece	closed	2000	flat	n/a	laser welding	blue	250	enamelled	PU, 50	yes	insulated stainless steel
Dagsan Solar, Turkey	closed	2003	flat	1.85 / 2.5	ultrasonic welding	blue	100 / 150	enamelled [9]	PU, 50	yes	insulated copper
De Sol a Sol, Portugal	closed	2005	flat	4	welding	black chrome	190 to 350	copper	PU, 50	no	stainless steel
Dimas, Greece	closed	2004	flat	2.9	laser welding	blue	195	enamelled	PU, 60	yes	stainless steel
Elitherm, Greece	closed	2006	flat	n/a	ultrasonic welding	blue	220	enamelled	PU	yes	plastic
Enalter, Brazil	open	1990	flat	6	clamping	black paint	600	stainless	PU, 35	yes	insulated plastic and insulated copper
Ezinç Metal, Turkey	closed	1992	flat	2.3 / 4.6	ultrasonic welding / clamping	blue	170	enamelled	PU, 50	yes	insulated stainless steel
Gamesa, Spain	closed	2005	flat	n/a	soldering	blue	160	stainless	rockwool	yes	insulated copper
Greenonetec, Austria	closed	n/a	flat	n/a	ultrasonic welding	blue	150	enamelled	PU, 50	yes	insulated copper
Helioakmi, Greece	closed	n/a	flat	4.2	ultrasonic welding	blue		enamelled	PU, 50	yes	stainless steel
Heliotek, Brazil	open	2003	flat	1.5	utrasonic welding	black paint	200	stainless	PU	no	copper
Intersolar, Greece	closed	2007	flat	2.5	laser welding	blue	200	enamelled	PU, 50	yes	plastic
Kaushal Solar Equipments, India	n/a	2003	flat	4.17	ultrasonic welding	black chrome	2 x 146	stainless	rockwool, 120 [7]	yes	copper
Kotak Urja, India	closed	1998	direct flow pipes / flat	n/a	ultrasonic welding	blue / black chrome	100 to 3,000	stainless	PU	yes	copper
Kuzeysan, Turkey	n/a	2007	direct flow pipes	n/a	n/a	blue	160 / 200	stainless	PU	no	plastic
Maltezos A.B.E.E., Greece	closed	1977	flat	n/a	ultrasonic welding	black chrome	200	stainless	PU, 70	yes	copper
Nobel (Xilinakis D.& Co), Greece	closed	1975	flat	n/a	ultrasonic welding	blue	160	enamelled	PU	yes	insulated copper
OCV, Spain	closed	2007	flat	2.25 / 4.3	ultrasonic welding	black chrome	170 / 300	enamelled	PU	yes	insulated copper
Ouraset Solar, Turkey	closed	2005	flat	4.2	ultrasonic welding	blue	300	enamelled	PU, 50	yes	insulated copper
Rand Solar Energy Systems, Israel	closed	2004	flat	n/a	ultrasonic welding	black chrome	150	enamelled	PU	yes	copper
Sammler Solar, Greece	closed	n/a	flat	4	laser welding	blue	260	enamelled	PU, 40	yes	insulated stainless steel
Sigma, Greece	closed	2000	flat	4	ultrasonic welding	black chrome	200	enamelled	PU	yes	copper
Solahart, Australia	closed	1982	flat	n/a	steel absorber welding	black chrome	300	enamelled	PU	yes	copper
Solardome, South Africa	both	n/a	flat	n/a	ultrasonic welding	black paint	150 / 300	copper / epoxy laminate	PU, 55	no	insulated copper
Solar Research Design, Malaysia	closed	1994	indirect flow and direct flow pipes	4.2	n/a	blue	150 / 260 / 360	stainless	PU, 70	no	copper or borosilicate glass [8]
Sole, Greece	closed	1973	flat	2	laser welding	blue	150	enamelled	PU, 50	yes	copper
Soletrol, Brazil	open	2002	flat	1.6	clamping	black paint	400	stainless	PU, 25	no	copper
Sun Earth, USA	closed	1982	flat	n/a	soldering	black paint	180 / 305 / 450	stainless	PU, 25 to 75	no	copper
Sunrain, China	n/a	n/a	all kind of pipes	n/a	n/a	blue	80 to 500	stainless	PU, 45 to 75	no	insulated copper
Sun Ray, France	open	n/a	flat	4	clamping	black paint	300	stainless	PU, 40	no	copper
Sunset, Germany	closed	2006	flat	4.7	ultrasonic welding	blue	200	enamelled	PU, 40	yes	copper
Termicol Energia, Spain	closed	n/a	flat	3.8	ultrasonic welding	blue	300	enamelled	PU	yes	insulated copper
Tsinghua, China	closed	1992	heat pipes	n/a	n/a	blue	200 to 1,000	stainless / PPRC-coated	PU	no	insulated copper
Tuma Industrial, Brazil	open	1975	flat	4	clamping	black paint	400	stainless	PU, 45	optional	copper
Wikora, Germany	closed	2004	flat	4	laser welding	blue	300	enamelled	PU, 50	yes	stainless steel

Table 1: High-quality standard thermosiphon solar water heaters

Source: manufacturers' instructions

	Type of mounting system	Material of mounting system	Maintenance rate collector [years]	Maintenance rate tank [years]	Tested for conformity with which standard / norm	Noncommittal gross final customer price [€]	Available in which countries	Website
	all	aluminium	none	1	EN 12975 [2, 6]	3,000	Europe, New Zealand	*www.amk-solac.com*
	all	galvanised	none	20	n/a [2]	2,000	n/a	*www.batec.dk*
	all	aluminium	2	2	EN 12975, EN 12976 [2]	1,653 [10]	Spain, Portugal, Italy, Greece, Turkey	*www.bbt-thermotechnik.com*
	all	galvanised	5	5	EN 12975	1,900	Italy, Spain	*www.cdsolar.it*
	all	galvanised, aluminium	3	2	EN, SRCC Australian/New Zealand Standard [2]	n/a	35 countries	*www.chromagen.biz*
	roof	stainless	6	4	EN 12975 [2]	2,100	Spain, Portugal, Italy, France, Greece, Germany	*www.calpak.gr*
	all	aluminium	none [5]	2	EN 12975	n/a	Greece, Italy, Spain, Romania, Portugal	*www.cosmosolar.com*
	all	galvanised	10	1 to 5	to be applied soon	620 / 780	mainly Turkey	*www.dagsan.com.tr*
	all	aluminium	2	2	– [2]	1,800 / 2,640 [11]	Portugal, France, Spain	*www.colectoriberico.com*
	roof	galvanised	3	3	EN 12976 [2]	n/a	everywhere	*www.dimas-solar.gr*
	roof, flat roof	galvanised	1.5	1.5	EN 12976	2,078	Europe, North Africa, Middle East	*www.elitherm.com*
	roof	aluminum	n/a	n/a	–	1,713 [12]	Brazil, USA, Canada, Angola, Portugal	*www.enalter.com.br*
	all	galvanised, aluminium	1	1	– [2]	n/a	EU, Middle East, Africa (15 countries)	*www.ezincmetal.com*
	all	galvanised	1	1	n/a	2,500	Spain, Portugal	*www.gamesa.es*
	roof, flat roof	galvanised	3	3	n/a	n/a	Italy, Spain	*www.greenonetec.com*
	all	galvanised	n/a	n/a	n/a	n/a	n/a	*www.helioakmi.gr*
	roof	galvanised	10	10	Inmetro Brazil / ABNT [14]	720	Brazil, Portugal, Spain, Chile, Argentina	*www.heliotek.com.br*
	all	galvanised	25	2	EN 12976 [2]	1,400	Greece, Italy, Spain	*www.intersolar.gr*
	flat roof	galvanised	8	8	BIS [15]	820	India	*www.kaushalsolar.com*
	all	aluminium	3	3	Indian Standard IS-12933 Part – 1 & DIN Standard 86-227-2069 [2]	380	India, Great Britain, Africa	*www.kotakurja.com*
	roof, flat roof	aluminium	5	5	TSE	550	Turkey, Cyprus, Syria, Bulgaria, Germany	*www.kuzeysan.com*
	flat roof	galvanised	n/a	n/a	EN 12976 [2]	2,500	Europe	*www.maltezos.gr*
	flat roof	galvanised	5	2	EN 12975-2	1,000	Greece, Cyprus, Africa, Middle East, Balkan States	*www.nobel.gr*
	flat roof	galvanised	1	1	EN 12976	1,700 / 2,500	Spain	*www.ocv.es*
	all	galvanised	2	2	EN 12976 [2]	n/a	Spain, Italy, Portugal, New Zealand, France, Romania, Bulgaria	*www.ouraset.com*
	flat roof	galvanised	1	2	EN 12975	1,800	Europe, South America, Asia	*www.rand.co.il*
	all	galvanised	10	2	EN 12976 [2]	n/a	Spain, Italy, France, Portugal, Austria, Cyprus, Great Britain, Malta, Bulgaria, Slovenia, South Africa	*www.sammler.gr*
	all	galvanised	3	3	– [2]	n/a	Greece, Italy, Spain, Portugal	*www.sigma-sa.com*
	all	aluminium, steel	n/a	5	AS 27/2 SRCC [2, 4]	n/a	South Africa, Europe, Asia	*www.solahart.com*
	all	aluminium	5	5	SABS	1,000 to 2,500	South Africa	*www.solardome.co.za*
	all	stainless	4	4	n/a	600	USA, Europe, Australia, New Zealand, South Africa, Malaysia	*www.microsolarsystem.com*
	roof, flat roof	galvanised	20	2	EN 12976-2	n/a	Greece, Denmark, Italy, Spain, Malta, Cyprus, Iran, Hungary, Portugal, Germany, United Arab Emirates	*www.eurostar-solar.com*
	roof	galvanised	2	2	Inmetro Brazil	950	Brazil	*www.soletrol.com.br*
	all	aluminium	5	5	SRCC og -300	4,000 to 5,000	USA	*www.sunearthinc.com*
	all	all	n/a	n/a	EN 12975, Chinese standard [2, 3]	200 to 3,000	more than 80 countries	*www.lygtyy.com*
	roof, flat roof	galvanised	n/a	n/a	CSTB	n/a	n/a	*www.sun-ray.fr*
	all	aluminium	1	1	– [2]	1,985	Europe, Africa	*www.sunset-solar.com*
	roof, flat roof	galvanised	n/a	n/a		2,500	n/a	*www.termicol.es*
	roof	aluminium	1 to 2	no	EN 12975 [2]	200 to 1250	Europe, East Asia	*www.thsolar.com*
	roof	aluminium	1	1	PBE-Inmetro Brazil	3,000 to 3,500	South and Central America (complete system), Spain and Portugal (only collectors)	*www.tuma.ind.br*
	all	galvanised	5	1	EN 12975-2, SEI-ST-84, UK ST–1091 [2]	2,862 [13]	Europe	*www.wikora.com*

[1] only for flat plate collectors
[2] Solar keymark label existing
[3] Chinese Golden Sun label existing
[4] SRCC = Solar Rating and Certification Corporation
[5] periodical cleaning and joint controll needed
[6] in process
[7] PU-foam with 50 mm optional
[8] heating tube is directly connected to the tank
[9] stainless optional
[10] list price Spain
[11] € 1,800 for the system with 190 litres, € 2,640 for a system with 350 litres
[12] converted from price in US$ 1,164
[13] excl. VAT
[14] ABNT = Associação Brasileira de Normas Técnicas
[15] BIS = Bureau of Indian Standards

Cosmosolar from Greece uses laser-welded absorbers.

Photo: Cosmosolar

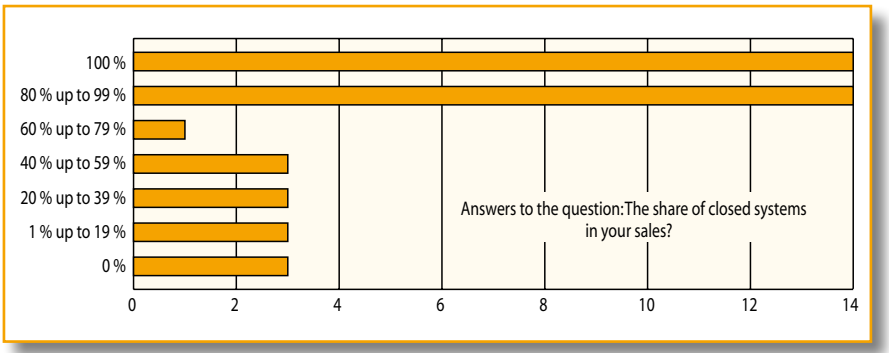


Figure 2: A majority of thermosiphon system manufacturers sell mainly closed-loop systems. For approx. two-thirds of the 41 companies taking part in the survey they account for over 80 % of sales. Data relate to the complete product spectrum of the companies and not only to the high-standard products listed in table 1.

Source: S&WE market survey

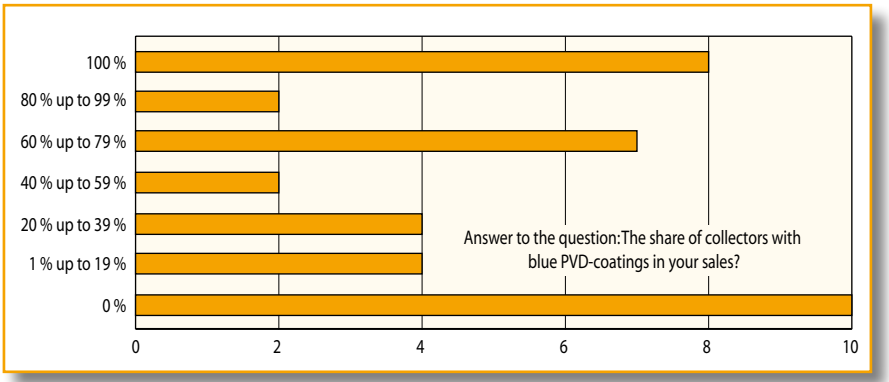


Figure 3: Although eight companies exclusively use highly selective PVD coatings on their absorbers, ten companies don't use this type of coating at all (of 37 responses). Black chrome and black paint are still very common. Data relate to the complete product spectrum of the companies and not only to the high-standard products listed in table 1.

Source: S&WE market survey

ter than zinc coating.« Ouraset combines the materials: »The galvanised structure is complemented with extruded aluminium header profiles. It brings together the advantages of both materials by using the strength and cost advantages of galvanised frames with the flexibility and mounting advantages of a rail-mount,« says Ouraset spokesperson Utku Tansuğ.

Most of the companies provide mounting systems for sloped roofs, flat roofs and free-standing locations. Take CD Solar from Italy, for example: »Our aluminium mounting system is universal. With different assembling it is suitable for tiled roofs, flat roofs or ground mounting,« says CD Solar spokesperson Armando De Dominici. Or Tuma from Brazil: »Our systems are easily adaptable to any roof, also for houses that haven't previously had hot water pipes, and can be mounted in modulated sizes,« says Tuma spokesperson Frederico Dantas. At Solardome from South Africa, cylinders and collectors are clamped onto a rail system with brackets and cradles. They can thus be mounted on almost every type of roof.

Care is taken to make assembly especially straightforward. An installer of systems by the German company Bosch Thermotechnik needs only one tool to mount the aluminium frame. With the Turkish manufacturer Dagsan the installer needs a pair of pliers and two number 10 spanners. Pre-mounted systems are even easier. »Our Profit Light system, which has the tank integrated on the back of the collector, is pre-mounted. It just needs to be erected and connected,« says Peter Personn from Dagsan.

Kutay Ulke from Ezinç also says that the mounting system must be easy to handle, light and strong at the same time. Iordanis Paradissiadis from the Greek manufacturer Intersolar describes his system as being »user friendly«: »In the case of tile mounting, the weight does not rest on the tiles,« he says. The Indian supplier Kaushal sees no need for special mounting techniques, as most systems are mounted on flat terraces or on sloping roofs.

For Kyriaki Samouil from the Greek supplier Sigma a variable angle setting is very important. »For sufficient collector performance it is necessary to set the slope so as to receive as much solar radiation as possible during the whole year. It is recommended that the slope be between 25 and 45 degrees. A high slope maximises the performance during winter months, when the sun is low, while a low slope maximises performance in summer months when the sun is high.«

The mounting should also be robust so that the thermosiphon system can also withstand storms. Only four suppliers provided details on which wind speeds a system has been designed to cope with, however. Systems by Dagsan and the Austrian manufacturer Greenonetec are designed to cope with 150 km/h winds. Intersolar stated that the maximum wind load is 0.5 kN/m^2, while Nobel put it at 3.5 kN/m^2.

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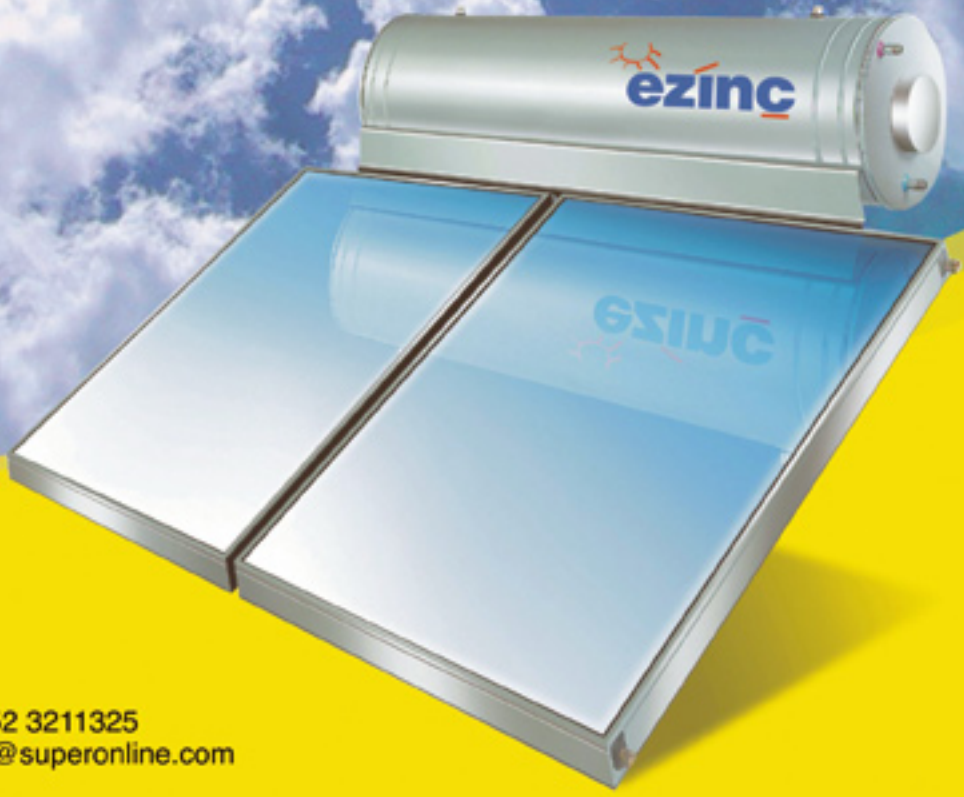

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Generally, two workers are required to install a thermosiphon system. Only Kaushal says there should be three. The installation time which the companies stated ranged from 20 minutes to 12 hours. 2 to 3 hours is the range most often provided as an answer. How quickly a solar system can be installed obviously depends a lot on the type of mounting. Dominici from CD Solar assumes that a flat roof assembly only takes 2 hours, while on a tile roof he reckons it takes an average of 6 hours to get the system up and running.

Lifetime: the tank is the decisive factor

What about the lifetime of a high-standard thermosiphon system? Here there was clear agreement amongst the manufacturers; it should last 15 to 20 years (fig. 5). »We have designed our system to have a twenty year lifetime,« says Jiwen. His company Tsinghua has only been manufacturing pressurised systems for around six years now. »So we really don't know how many years it can be used on average.« Almost a quarter of suppliers assume that their systems will last for over 20 years, with some estimated to last for up to 30 years.

If one looks at the collector and storage tank separately, it is noticeable that the collectors are assumed to have a longer lifetime. Around a third of respondents calculate that the collector will last for between 20 and 30 years. Only a few are confident that the tank will last that long. As for the system, 15 to 20 years is the most commonly stated timespan. The tank thus limits the lifetime of the whole system. Some storage tanks have broken down after a shorter period, however. »The defect of boilers within the first 8 years (between year 5 to 8) is less than 8 %. Most problems occur in open loop systems,« says Tansuğ from Ouraset.

The manufacturers are in complete disagreement over estimating the lifetime of the supplementary electric heating. The responses range from 6 months to 25 years. There are two large clusters here; one group estimates a lifetime for the heating element of 2 to 4 years and the other group is confident that the components they use will last for over ten years. A number of companies gave no response here because the durability of a heating element depends so much on the quality of the water that no general statement can be made.

The most important factor determining the lifetime of a thermosiphon system is water quality, say most of the companies. At Kaushal most systems are installed in urban areas where, unlike in rural areas, hard water problems do not exist. They have systems that have been in operation for 16 years. Apart from the hardness of the water, the salt concentration, especially the chlorine, and the pH value play a large role. In closed loop systems the process water quality affects the lifetime of the tanks, while in open loop systems aggressive water may corrode the collector.

A pre-requisite for a long lifetime is, of course, proper installation. The quality of the materials used must also be right. Tansuğ (Ouraset) refers to the importance of quality control: »All boilers and panels pass 5 quality control stations during production.« For a long collector lifetime Bosch Thermotechnik says that the ventilation

In the Profit Light system by Dagsan (Turkey) the tank is integrated into the rear of the collector.

Photo: Dagsan

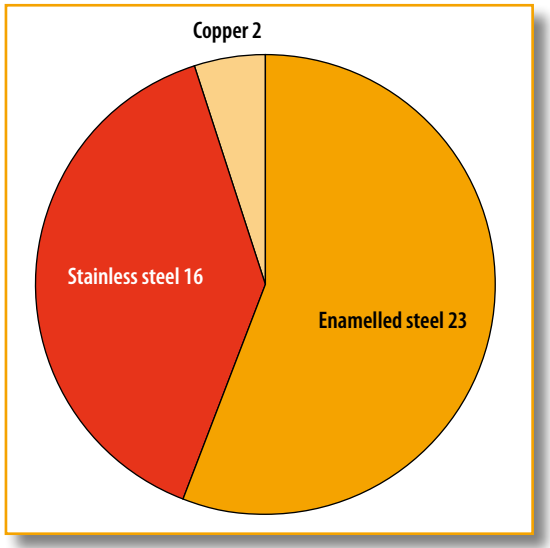


Figure 4: Enamelled steel is the most common material for the tanks of the systems listed in table 1. Still, 16 out of 41 suppliers use stainless steel.

Source: S&WE market survey

and draining holes must be properly designed. For Eli Shilton from the Israeli manufacturer Rand regular maintenance is an especially important criterion.

Maintenance: regular check-ups

Although most respondents agree with Shilton (Rand) and think that regular maintenance is necessary, there are other opinions. For Williams Danger from the French supplier Sun Ray it's a case of »no maintenance required«. The majority of companies think a maintenance cycle of one to two years is sensible. »Normally the maintenance consists of cleaning the glass of the flat plate once a year,« says José Raphael Bicas Franco from the Brazilian manufacturer Soletrol. Somewhat more attention is recommended by Ezinç, for example. The company advises checking the magnesium sacrificial anode and changing the electric heating element once a year.

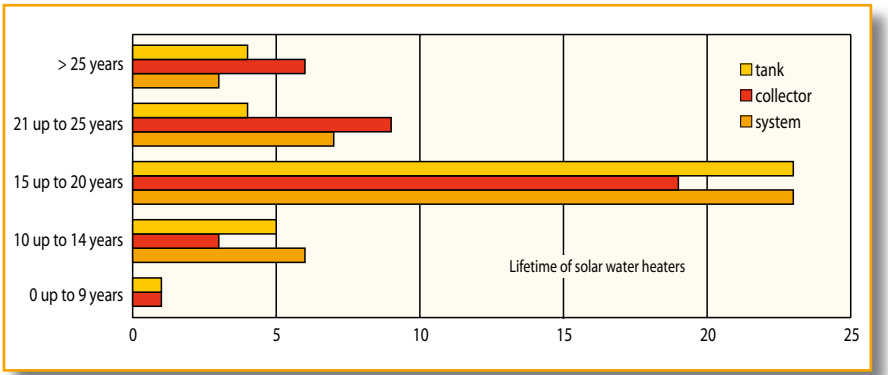


Figure 5: Most companies listed in table 1 put the lifetime of their systems at 15 to 20 years. On average, collectors last somewhat longer than storage tanks.

Source: S&WE market survey

Three handymen installing a system with two collectors in Portugal. Ouraset (Turkey) puts the tank in the middle.

Photo: Ouraset

Changing the anode is one of the most important maintenance tasks. At Nobel and Cosmosolar they assume that the anode must generally be replaced every two years. The Greek manufacturer Sole reckons with a replacement every three years, Calpak (Greece) every four years. Additionally the tank must be cleaned regularly in order to remove limescale, salts and mud deposits. Nobel considers a two-year cycle to be sufficient. AMK from Switzerland disagrees: »We suggest cleaning the tank once a year,« says their spokesperson Corsin Cavigelli. A cleaning flange for this purpose enables the tank to be emptied and cleaned.

Where systems are operated with frost protection the glycol solution must be checked regularly. Solardome from South Africa recommends replacing the fluid every five years. Others advise shorter cycles: »The antifreeze must be checked every two years and replaced if necessary. The same goes for the safety valves,« says Monteiro (De Sol a Sol). »Apart from checking the valves, the pipe insulation should be checked too,« says Jiao Qingtai from the Chinese supplier Sunrain. Bosch Thermotechnik also lists checking all connections and screws as a maintenance task. Cosmosolar agrees, saying it is important to check pipe connections and the mounting system.

While most manufacturers assume the professional services of a handyman for maintenance tasks, Sigma also gives the user responsibilities. »There are various actions that can be done by the user; other actions must be carried out by the manufacturer's licensed service crew,« says Samouil from Sigma. According to their instructions the user should make a visual inspection of the system twice a year and check for leaks and loose screws. The condition of the pipe insulation between the tank and the collector should also be checked, as well as the collector glass. »In case of glass cracking, the glass should be replaced immediately, as there is a risk of collector corrosion,« continues Samouil.

Beating stagnation

To guarantee a long lifetime for a thermosiphon system which uses antifreeze, it should be allowed to stagnate as rarely as possible. Sizing the system correctly is thus extremely important. But it is not possible to completely avoid periods of stagnation. The tank manufactured by Sammler from Greece, example, is made to withstand higher pressures. The jacketed heat exchanger tank is often designed to be able to take up the rise in pressure caused by stagnation. Water-filled systems can release pressure and heat by expelling hot water via the safety valve, with cold water being let into the tank to replace it. Closed loop systems have a second safety valve in the solar loop.

It is possible to prevent the release of water with an integrated expansion tank; this is required in any case for systems which use other fluids. Almost three-quarters of suppliers equip their closed loop systems with expansion tanks. 13 manufacturers integrate the expansion tank into the storage tank. The others have it externally mounted in the system.

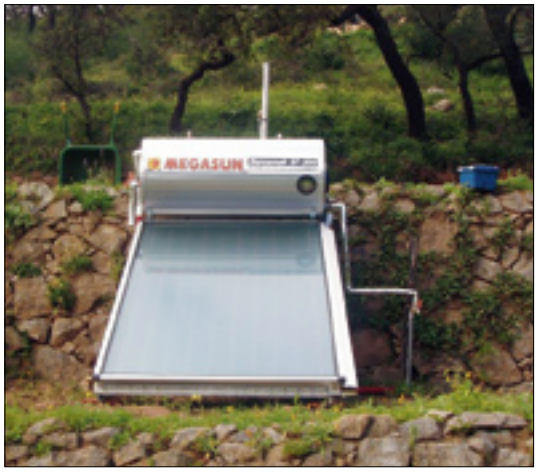
When the sun shines brightly, the water in the tank heats up a lot. In order to stop the user from scalding him- or herself, a safety faucet can be put in to limit the temperature of the water at the tap to a set value by mixing in cold water. Ten suppliers have a safety faucet as standard (fig. 6 on page 64). A further 20 have it as an optional extra. Many companies also have a special control unit designed to prevent the system from freezing. Thermostats are standard for controlling the electric heating element. Only a few suppliers list them as being optional.

Simple standard

As mentioned above the surveyed companies were asked to provide details of one high-standard system and of one low-standard system. The result: Only two companies manufacture systems with a range covering considerably different standards. The low-standard system supplied by Rand has an absorber with a black paint coating and the absorber is clamped to the tube register. The system has a considerably shorter lifetime, has been tested according to the Israely 579.1-4 standard, and is more than € 1,200 cheaper than the high-standard product. The simple system by Tsinghua has an open loop, direct-flow system, which hasn't been tested according to EN 12975, but rather according to the Chinese norm, and carries the Golden Sun label. It

The tank should be cleaned annually. This is the advice the manufacturer AMK from Switzerland gives its customers. *Photo: AMK*

Bosch Thermotechnik (Germany) sells the thermosiphon system under various brand names, such as Junkers or Vulcano. *Photo: Bosch Thermotechnik*

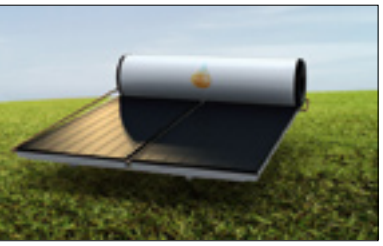


Most mounting systems by Helioakmi from Greece are also suitable for ground mounting. *Photo: Helioakmi*

Many systems are put up on flat roofs. *Photo: Solardome*

Kotak Urja, based in Bangalore, India, offers solar water heating systems already for many years.

Photo: Kotak Urja



The French supplier Sun Ray uses absorbers coated with black paint.

Photo: Sun Ray

Quality by Chromagen: The water pipe on the roof, coloured to match the tiles, is hardly noticeable.

Photo: Chromagen

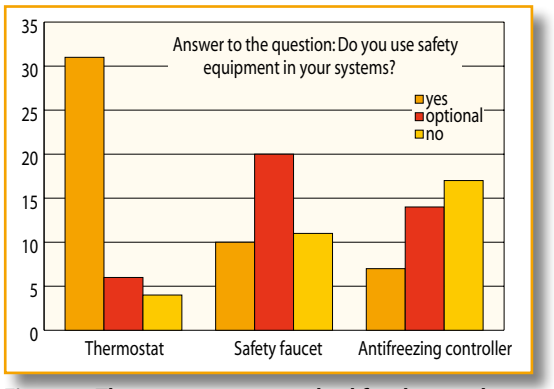


Figure 6: Thermostats are standard for the regulation of the electric heating element (31 out of 41 companies use them). Safety faucets, however, are only automatically included in the system by ten manufacturers. Most have them as an optional extra. A series of companies also have a regulator for frost protection on offer. Most do away with this option, however. Data relate to the complete product spectrum of the companies and not only to the products with high-standard listed in table 1.

Source: S&WE market survey

costs between € 200 and € 1,250 and is thus considerably cheaper than the high-standard product listed in table 1.

For all the other companies the differences between the systems are marginal. Greenonetec, Ouraset, Sammler, Nobel, Elitherm, Sol and Intersolar also manufacture systems with a black paint coating alongside the ones with the highly selective »blue« coating. Otherwise the thermosiphon systems do not differ from oneanother. The price difference at Intersolar is € 200. At other companies there are other small differences apart from the coating. At Ezinç and Calpak the black paint version doesn't have an expansion tank, Chromagen clamps the absorber, and at Cosmosolar and Dimas the collector-tank connection is made of plastic. Dimas and Calpak both state a lower lifetime for the low-standard systems.

Maybe other manufacturers also make simple systems, but which they didn't mention when responding to the survey. Take Dagsan, for example: »The open loop and lower standard systems are definitely being phased out. I'm not going to provide information on these systems. They have become unsellable in Europe and are slowly becoming so in Turkey,« says Personn, explaining his response.

Jens-Peter Meyer

Jens-Peter Meyer is a long term *S&WE* author and an expert in solar thermal.

Correction

In the table »manufacturers of solar coatings« in *S&WE* 4/2007 page 50/51 we overlooked a fault. The absorptivity of Vega AB, the coatings of the Italian company Almeco Spa, is ≥ 95 und ≥ 92. Unfortunately in the table it says ≤ 95 and ≤ 92 which is not correct. We apologise for this mistake.

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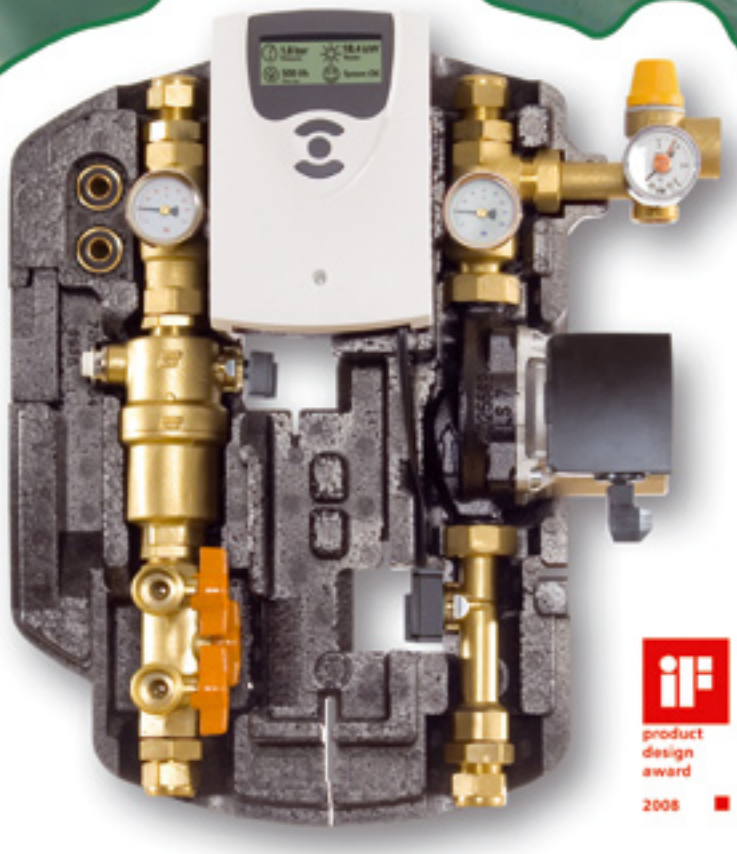

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Once upon a time

The history of solar thermal technology in China is closely linked to the name Zhiqiang Yin. The professor at Tsinghua University in Beijing can look back at 30 years of solar research and industrial development. It is the story of a solar pioneer who is himself endowed with boundless energy.

73 years old but no sign of tiredness. Zhiqiang Yin, professor at the Department of Electronics at the famous Tsinghua University, seems to possess an infinite amount of energy. At the ISES conference in Beijing in September 2007 he did not step back from explaining certain exhibits at the vacuum tube manufacturer Tsinghua Solar Ltd. in person. He also gave numerous presentations at the conference, sat in the audience at various others, and still found time to do a tour of the fair with *S&WE*.

A visit to his place of work and lab at Tsinghua University is a trip to the past. Yin does not greet his visitors with the phrase »Ni Hao« (welcome), but with the greeting »You are standing in the grounds of Yuan Ming Yuan«. Yuan Ming Yuan Garden is an electrifying place for anyone Chinese. The garden – in its time the most beautiful on Earth – was destroyed and plundered in 1860 by English and French troops during the Second Opium War. Since then the park, stemming from the Qing Dynasty, is a symbol of the Chinese defeat against the West. The campus is partly in the grounds of the Yuan Ming Yuan garden. This is an important point if one wishes to fully understand the motivation of the people at Tsinghua University. The historic place is certainly also a reason for the worldwide success of the research centre, whose main entrance is adorned by a veritable Who's Who of the global economy: Microsoft, Deutsche Bank, Google, ATI and many more. Tsinghua University is without a doubt China's most important university.

A historic person in a historic place: Professor Zhiqiang Yin in the Yuan Ming Yuan Garden, which is part of the campus at Tsinghua University. This park – destroyed by English and French troops in 1860 during the Second Opium War – is a symbol of the Chinese defeat against the West.

Photo: Sven Tetzlaff

»Very exciting« was how Professor Zhiqiang Yin found the development work on tube prototypes at the Beijing lab in 1980.

Standing by their research with body and soul: Dr. Geoffrey Lester Harding and professor Zhiqiang Yin at the solar simulator at the University of New South Wales in Sydney, Australia, in 1982. Sometimes the solar scientists slept beneath the apparatus in order to be able to monitor the data streams. Today Harding works as a consultant for the solar thermal manufacturer Jiangsu Sunrain Solar Energy.

Solar thermal challenge of the future: a system for solar cooling in the town of Tianjin

USA: birthplace of the »Sydney tubes«

And Yin is certainly the most well-known and successful solar scientist in the realm. His career in solar technology began in 1978. Back then the 43-year-old was given the job of developing a coating for vacuum tubes by professor Jin Kun Bei at Tsinghua University. It should be efficient and easy to manufacture industrially. The scientist can still clearly remember what led up to this: In 1973 the long-established U.S.-American company Owens-Illinois developed the first tube collectors with a vacuum tube using the thermos flask principle, which were later given the name »Sydney tubes«. »Things quickly became clear: The principle was good but the main problem laid in the coating,« recalls Yin. In 1978 the Australian scientist Geoffrey Lester Harding took the tubes with him to the University of New South Wales in Sydney, in order to study the problem more closely. At the same time Bei took a tube to China.

Economic boom and spirit of optimism

Yin found he had the perfect conditions for the task he had been given. He had a clearly defined assignment, the necessary funding and complete freedom in his research. His start coincided with the opening up of the country. Xiaoping Deng took over the leadership of the Communist Party and decreed that more economic and technological development should take place in the country. This was the start of the economic boom in China, which has now been going on for 30 years.

This spirit of optimism at the end of the seventies also carried over onto Yin' s research team. »We were really enthusiastic and put all of our available energy into this project,« recalls Yin. And they had the backing of the Chinese government – a pretty exclusive position to be in back then no matter where you were. At the same time in Germany, for example, the first collector manufacturers were taking their steps towards collector manufacture without any government support at all.

Yin points out, however, that the Chinese solar economy came into being without any significant manufacturing support. Research and the setting up of companies was what got funding. The »collector« as a product had to become competitive against electric boilers and gas heaters in a very short space of time. Solar hot water generation had to achieve a valued status so that people would achieve this gain in comfort through increased prosperity.

Bridges between Australia and China

Yin and Harding have known each other personally since 1978. They exchanged research results and it soon became clear that keeping in touch made sense and would maybe speed up development. In 1982 Yin went to Sydney – something unthinkable in earlier times. His wife got an offer from the University in Sydney at the same time and was able to travel with him. For two years Yin worked together with professor R.E. Collins and professor Harding until the main aspects of the coating became clear. In 1984 Yin and his wife returned

Yin's forecasts for solar thermal market development in China:

by 2010
- solar water heater distribution ranges from small towns to large cities
- expanding market for combined systems (hot water and space heating)
- new product development, large scale production, improved quality control systems
- pilot plants for concentrating solar power (CSP)

by 2020
- 500 million m^2 of solar collectors in operation, 370 m^2 / 1,000 inhabitants
- realisation of solar air conditioning as well as applications in industry and agriculture
- increasing export of solar thermal technology
- CSP on the way to becoming a key technology

by 2030
- 900 million m^2 of solar collectors in operation, 640 m^2 / 1,000 inhabitants
- solar systems for hot water, space heating and air conditioning
- large scale series production of solar thermal components
- solar thermal applications in industry and agriculture
- several CSP plants constructed

by 2050
- 1.5 billion collectors in operation, 1 m^2 / person
- industry and agricultural applications now mature
- CSP plants make an important contribution to electricity generation

Yin's lab from 1983 to 1988. The first vacuum tubes with the Al-N/Al coating developed by professor Zhiqiang Yin were installed on the »solar house« by the scientists.

Professor Zhiqiang Yin's team in 1985: Most of the Tsinghua researchers from back then now work as experts in Europe or the U.S.. *Photos (8): Tsinghua University*

Practical test: Installed in 1989, this is the first system with Al-N/Al tube collectors to be installed outside the university.

to Beijing. Harding, Collins and Yin licensed their patents to each other and the Chinese scientists could then start to transfer their knowledge over to a technical process. This may sound trivial today, but it wasn't back then in China, for the conditions even in 1984 were still somewhat »rustic«. Yin recalls that he would personally ride the goods bike around the campus and Beijing in order to get the necessary supplies.

Industrial implementation

Once he was back from Australia Yin started to look for a strong and fit company able to implement the scientific results industrially. He found an ideal industrial partner for Tsinghua University in the Beijing Glass and Instruments Ltd. A joint venture carrying the name Tsinghua Solar Ltd. was set up and started to produce 500,000 vacuum tubes a year according to the specifications in the patents Yin had helped develop. This was the initial spark of the unparalleled Chinese solar boom. Today Tsinghua manufactures approx. 7 million tubes a year, or 300,000 solar water heaters.

For a time, Yin was the general manager of the joint venture. But his heart always stayed close to research and his long stays abroad also made it impossible for him to deal with the operational side of the business. Thus the manufacturer also profited from Yin's creative power in the following years and took up further innovations such as the triple-layer tube (see *S&WE* 3/2007) and full-glass tubes.

For Yin it is clear that the development of tubes and flat plate collectors is still not nearing an end. He believes the most important next steps are improving the coating

Scientific couple on holiday: Professor Zhiqiang Yin and his wife enjoy holidaying on the Pacific coast at Sanya in Heinan province.

Inauguration ceremony in 1994: The research group around professor Zhiqiang Yin (5th from the left) celebrating the start-up of the first test production line on the Tsinghua University campus.

and increasing the output. Tsinghua is thus currently working on a concept for fully automated production.

An exceptional scientist with his feet on the ground

In August 2005 the ISES presented the scientist with the »Christopher A. Weeks« Award (The Achievement through Action Award). The jury praised four outstanding services in their presentation of the award:

- for his pioneering work introducing high performance solar heating technology to China;
- for establishing a solar laboratory at Tsinghua University innovatively combining academia and industry;
- for introducing the Al-N/Al selective coating technology in China;
- for initiating the spread of vacuum tube collector factories throughout China

Yin is an exceptional scientist with both feet firmly on the ground, who hasn't hidden himself away in the ivory towers of science. Yin has written solar history and presented it with humour and in an easy-going manner. ✹

Sven Tetzlaff

Yin's selective coatings

Graded Al-N/Al (aluminium nitride on aluminium bare layer) selective absorbing surface developed by professor Zhiqiang Yin, is deposited onto the outside of the inner glass tube using single cathode cylindrical magnetron sputtering technique. It is necessary to have the heat treatment 1 hour at higher than 400 °C in vacuum during the evacuation processing of collector tubes. Optimum solar absorptance for the heat treated surface has up to 0.92 (AM1.5) and the emittance is 0.06. Three generations of cylindrical single cathode magnetron sputtering systems have been developed in Tsinghua University, Beijing, China, since 1985:

- The first generation in 1985: A prototype production of horizontally cylindrical magnetron sputtering batch coater with axial magnetic field formed by solenoid for coating tubular substrates.
- The second generation in 1991: vertical, periodic permanent magnetic field
- The third generation in 1998: vertical, rotating permanent magnetic field. The utilisation rate of cathode material is five times higher than the second generation.

Source: Status of Solar Thermal Conversion in China. Abstract for the ISES Solar World Congress 2007 in Beijing.

»We were obsessed with our task«

Professor Zhiqiang Yin is China's solar pioneer. In 1978 he started his career as a scientist at the renowned Tsinghua University, developed the first selective coatings and took part in setting up the first production line for all-glass evacuated collector tubes at Tsinghua Solar. *Sun & Wind Energy* talked to the 73-year-old winner of numerous awards about his work and the Chinese solar thermal market.

S&WE: *Professor Yin, you played a substantial role in the ISES decision to hold the Solar World Congress in China. Are you satisfied with the conference?*
Yin: In 2003, I met professor Anne Grete Hestnes in the Swedish city of Göteborg at the ISES Solar World Congress. After the congress, there was a meeting at which the potential hosts of the ISES Conference 2007 presented themselves. I gave a ten-minute talk to present China as a venue for the congress. After a discussion within the committee, Anne announced »China wins!«. She said to me: »For me, it was clear that in 2007 it is China's turn, this is the right place at the right time.« This decision was absolutely correct, and I am very satisfied with the conference.

S&WE: *Your scientific solar career started in 1978 at the renowned Tsinghua University. What was the situation like at that time?*
Yin: I did not have to give any interviews ... (laughs). We could concentrate fully on research. No conferences. During critical experiments, I slept in the laboratory. In order to deliver the needed parts to the institute, I set off with a heavy transport bicycle. We were obsessed with the task.

»The gap between flat plate collectors and tube collectors will widen further«

At that time, China started to open up. All of a sudden, we had lots of new opportunities. However, we did not know then where all this would lead. Who could have predicted at that time what would happen within the next 15 years? After the Cultural Revolution, there had been no science, research and development – I was already 43. At that time, my boss said »The Sydney tube is good«, and he asked me: »You have developed light bulbs so far – can you develop a coating for the tube?«

S&WE: *You are regarded as the inventor of selective absorber coatings in China. How did you proceed?*
Yin: The first coating we used was a galvanic process. Thus, we already had at least a tube that could be used north of the Yangtze River. The flat plate collectors of that time were unsuitable for this purpose. Here in Beijing, for example, they were only of use during 5 months of the year.

I had an idea and followed it stubbornly. Before I went to Australia in 1982, I already knew that I would need partners in industry. When I returned two years later with the complete patents for a sputtered selective coating, I found the company Beijing Glass Ltd., which later founded the joint venture »Tsinghua Solar Ltd.« together with Tsinghua University. I think this was very good timing.

A youthful 73 years of age and still doing service to the university and to solar technology: Professor Zhiqiang Yin works for the Department of Electronics at the Solar Science Institute at Tsinghua University.

Photo: Sven Tetzlaff

S&WE: *How will the relationship between flat plate collectors and tube collectors develop in the future?*
Yin: 30 years ago, the flat plate collectors in China were of very poor quality. The coating was not selective, the glass sheet had a solar transmittance of 0.8, and the frames were also bad. These collectors broke very rapidly. At that time, there was no glass industry worth mentioning in China that was capable of producing tubes or cover panes for flat plate collectors. Today, very good coatings and reasonable glass come from Europe. Therefore, I do not expect the flat plate collector to disappear, but its importance is going to change. With regard to air conditioning or architectural applications, it faces new demands. Thus, the gap between flat plate collectors and tube collectors will widen further.

S&WE: *Does building integration play a role in China in the solar thermal sector?*
Yin: The flat plate collectors will find their place in this niche. There is no solar roof technology yet in China. If you look in a dictionary, you will not find any difference between integration and combination in Chinese. But these are two different applications. At present, I recommend the combination. Why? Architects and the solar industry have to come together. The concepts existing so far are not complete. The Chinese still do not like systems that they cannot take with them when they move to another location. Currently, there is too much in motion. Later on, we might change from combination to integration, for example of the flat plate collectors into the façade or into the roof as a solar roof. At the moment, it is not the right time for that in China.

S&WE: *What is the situation like for solar cooling and solar heating?*
Yin: These will be the most important applications in the near future. A large proportion of the energy is consumed for heating and cooling. This task can be carried out very well by solar thermal systems. Within two years, solar heating will be widespread in China. Solar air conditioning will establish itself by 2020. In the Tsinghua Solar Ltd. office building, we have had solar underfloor heating for 700 m^2 of office space since 2002. The surface area of the collectors is only 170 m^2. This shows very clearly the potential, but also the commercial possibilities of such a system. There are also already a lot of examples in China of solar cooling by means of tube collectors. In this field, however, quite a lot of research still needs to be done. It is not so much about how to do it, but rather about the search for the cheapest techniques.

S&WE: *What do you think about government support?*
Yin: It is very important to understand one thing – there were no support incentives for customers in China. Is this good or bad? It is not bad (laughs).

What is crucial is the main policy. The main policy is the development of the economy. If the people have the money to improve their lives – for example for taking warm showers – they will buy the solar systems. This process is affecting the cities first, but increasingly also the rural areas. Farmers can afford this technology now. We were forced to develop »economic« systems right from the beginning – the good ones, not the best ones! Therefore, we have not bothered about pressurised systems, as are common in Germany for example.

Researchers at work: Professor Zhiqiang Yin (on the left) with his research team at the Tsinghua University.
Photo: Tsinghua University

»We were forced to develop 'economic' systems right from the beginning – the good ones, not the best ones«

S&WE: *Do you envisage solar legislation in China?*
Yin: Yes, of course. In fact, we already have it. The installation of solar water heaters is already compulsory in some cities. In principle, this is a good thing. On the other hand, people must be able to afford it. This is especially a task for the architects. In China, architects still do not know enough about the possibilities solar technology has to offer.

S&WE: *People like to ignore and exploit your patents at home and abroad. Does this annoy you?*
Yin: Well, most of my patents are university patents, which means that I do not make any profit on them. But I am not the only one that this applies to. The University of Sydney gave the licence of the patent for the tube to Japan for very little money. It is not so much about money for me personally here, but about the fact that a company or a team spent a lot of time and effort in order to achieve something. We think of that as theft.

»The violation of international patents is bad, no matter who commits it«

On the other hand, it is clear that primarily companies from China take up our patents and maybe develop them further, maybe just exploit them. The patent situation in China is not easy. As you know, our legislation is incomplete. And the people in China »wouldn't like to loose the fish from the hook«. But the solution to the problem is actually very simple. The western countries have had 200 years to install an international intellectual property rights system. Nowadays, this system works reasonably well. Effectively, China has had only 20 years so far for this development. Even as far as my own patents are concerned, I am very patient.

S&WE: *But you certainly know that several companies in the EU are orientated closely on your patents?*
Yin: Really? No problem – just give me their names, and I will try to open up a company together with them (laughs). But seriously, the violation of international patents is bad, no matter who commits it. ✹

The interview was conducted by Sven Tetzlaff.

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Demonstration project: In Madrid, a Climatewell unit provides air-conditioning for a single-family home. The waste heat is used to heat the swimming pool. *Photo: Conergy*

Almost market-ready

Solar air-conditioning is progressing smoothly. At the moment, a number of new pilot projects are underway, and the range of small air conditioners on the market has grown considerably.

These are critical years for solar air-conditioning,« says Alberto Coronas of the University of Tarragona, Spain. The director of the 2nd International Conference Solar Air-Conditioning organised by the non-profit East Bavarian Technology Transfer Institute (OTTI) in mid-October 2007 in Tarragona points out that a number of pilot projects are on the brink of a market launch. However, if the projects are to succeed they will first have to demonstrate that developers have designed the systems properly and are able to provide workable hydraulics and controllers.

In Tarragona, it was clear that a lot of work remains to be done towards these ends. Not all pilot systems are working as desired. Roel De Coninck of the Belgian firm 3E analysed the solar cooling system used in the European Renewable House in Brussels, Belgium. The building is home to a number of European renewables associations. De Coninck found that the temperature exceeded the envisaged maximum temperature of 23 °C for more than 500 hours. In addition to unexpectedly high demand for cooling, the main reason was that the Yazaki lithium-bromide absorption unit only reached a cooling capacity of 9.5 kW instead of the nominal 35 kW. It turns out that the collectors did not reach the average operating temperature of 82 °C that the system was designed for. The actual average operating temperature of the field, which consists partly of panel collectors and partly of vacuum tube collectors, was only around 73 °C. While the system does have a pellet-fired boiler as a backup that can be switched on simply by changing the control parameters, the amount of air-conditioning covered by solar would then plummet.

Welcome to the real world

Similar problems cropped up in Ingolstadt, Germany. In the past few years, researchers at the local university's competence centre for solar technology have been

EAW managing director Gregor Weidner says turnkey solutions are the answer. *Photo: Jens-Peter Meyer*

monitoring the HVACR equipment (heating, ventilation, air-conditioning and refrigeration) used in a multifunctional building inaugurated in 2005. Here, a DEC (desiccant and evaporative cooling) system was installed to cover peak demand for cooling. While the building remained as cool as expected, a number of flaws in the system meant that almost none of the cooling came from solar power in the summer of 2006. The sorption rotor ran too slowly, calcification in the water feed line prevented the air from being properly humidified, and the controllers in the heat pump and the DEC system were not properly coordinated. To make matters worse, leaks were found in the sorption rotor's sealing during comprehensive maintenance last March, and a valve was found to have been improperly installed. »Without our monitoring, these failures would never have been discovered,« Christoph Trinkl of the competence center points out how important it is to monitor such complex systems. But even after improvements were made, the system did not run as hoped in the summer of 2007. Rather, it fell far below its capacity of 25 kW, providing only 12 kW of cooling power. As a consequence, Trinkl called on the participants of the solar cooling conference in Tarragona to spend more time on controllers and planning guidelines for their systems.

Constantinos A. Balares, a member of the conference's scientific council, was hardly surprised by this recommendation. »Welcome to the real world,« he simply put it. Maintenance plays a crucial role and must be taken into consideration when the costs of solar air-conditioning are being calculated.

Wide range of cooling units

As these two example projects illustrate, solar air-conditioning is not yet fully developed. Nonetheless, the progress made in the past few years is enormous. Demand is also rising – slowly, but noticeably. »We did not expect such high demand,« says Gregor Weidner, exec-

Advancing solar cooling: Otti's executive director Eckhardt Günther and conference director professor Alberto Coronas.

Photo: Jens-Peter Meyer

Manufacturer	Capacity [kW]	Type of machine	COP_{th}	Website
Climatewell AB	10	absorption H_2O/LiCl	0.68	*www.climatewell.com*
EAW Energieanlagenbau Westenfeld GmbH	15	absorption H_2O/LiBr	0.75	*www.eaw-energieanlagenbau.de*
Solarnext AG	10	absorption NH_3/H_2O	0.64	*www.solarnext.de*
Sonnenklima GmbH	10	absorption H_2O/LiBr	0.75	*www.sonnenklima.de*
Sortech AG	5.5	adsorption H_2O/silica gel	0.6	*www.sortech.de*
Rotartica	5	absorption H_2O/LiBr	0.7	*www.rotartica.com*
Yasaki Europe Ltd.	17.5	absorption H_2O/LiBr	0.7	*www.yazaki-airconditioning.com*

The range of commercial solar-powered cooling units of only a few kW has grown considerably.

Source: own research

utive director of EAW Energieanlagenbau GmbH, a manufacturer of cooling units based in Westenfeld, Germany. He is optimistic – so much so that he even speaks of a breakthrough. EAW's success comes from its decision to offer complete systems, including all components from collectors to tanks to cooling units, as plug-and-play packets. »That was the right decision,« Weidner says.

The number of providers of solar-powered cooling units has also risen. EAW faces a number of competitors, especially in the field of small units. Like EAW's 15 kW units, Cologne-based Yazaki Europe Limited's 17.5 kW machine uses lithium-bromide (LiBr) as an absorption medium, as does the 10 kW absorption cooling unit developed by Phönix Sonnenwärme and sold by Berlin's SK Sonnenklima GmbH. This year, Sonnenklima put up two new field test systems in France. One of them is in the Haribo Museum in Uzès.

ZAE has set up another machine in the Bavarian town of Garching, Germany. There, researchers are testing a new concept for desiccant recooling with latent storage. A large amount of heat is created in solar cooling, and the system has to somehow dissipate it into its surroundings. A cooling tower effectively cools with water, which is not available inexpensively everywhere. Furthermore, Legionella prosper in such systems. Neither of these problems occur in desiccant cooling, though this requires higher cooling temperatures, which in turn necessitates for the same cold water temperature a driving temperature higher than the level that conventional collectors can handle. Latent heat storage is therefore being used. It reduces the cooling temperature during the day and regenerates at night. Such systems contain calcium chloride hydrate, a phase-changing material that melts at 28 to 29 °C.

The Chilii PSC absorption cooling unit made by Solarnext AG of Rimsting, Germany is a newcomer to the market. Developed in cooperation with Pink GmbH, this cooling unit contains water as the absorption medium and ammonia as the working medium to provide a thermal coefficient of performance (COP) of 0.64 at a driving temperature of 75 °C, a cold water temperature of 16 °C, and a cooling water temperature of 29 °C. The first pilot project with a 10 kW unit is now underway in

In the French town of Uzès, a solar air-conditioner cools down a museum.
Photo: Phönix Sonnenwärme

Austria. The new training centre operated by Bachler Austria GmbH has more than 40 m^2 of collectors, a hot water tank with a volume of 4,500 litre, a Chilii PSC unit, and a 27 kW cooling tower.

Solarnext is only working on one type of cooling unit at the moment, with systems that will provide up to 1 MW of cooling power. All four cooling techniques are used: absorption, adsorption, DEC systems, and fluid sorption. Machines made by Yazaki, EAW, and India's Thermax Ltd. are also used.

Like EAW, Solarnext also sells complete systems with small nominal capacities to ensure quality. »We have to make sure that improper installations do not ruin the market for us similar to the way things went with heat pumps in Germany in the 1980s,« explains Solarnext's Uli Jakob. At the moment, a complete solar powered cooling system costs between € 5,000 and 7,000 per kilowatt of cooling power. Jakob expects greater sales of the machines to bring prices down to around 4,000 €/kW soon. »At around 3,000 €/kW, the units are competitive – after all, they not only provide cool air in the summer, but also hot water and heat in the winter,« Jakob reminds us (see article on page 82 for more information on costs).

In addition to its own absorption units, Solarnext also uses the 5.5 kW absorption cooling unit made by Sortech of Halle, Germany. The company has already set up one system with this machine in southern Germany, and cooperation partner Citrin Solar, Germany, has installed three additional cooling systems itself. One of them is in operation at its headquarters in Moosburg. Silica gel circulates as the absorption medium in the machine that Solarnext sells as Chilii STC. The average COP in Moosburg is 0.5. Sortech is already using 30 of the machines, including some in Austria and Spain. Sortech developer Thomas Büttner says that recovering coolness is the key to the device's further development. He is working on a hybrid cooling process that

At the Peracamps building in Barcelona, Spain, a Yazaki WFC-SC10 absorption unit with a cooling capacity of 35 kW provides air-conditioning for offices and laboratories. A mere 80 m² of collectors provide the driving energy. Two 3 m³ tanks store the heat, while a 1 m³ tank stores the coolness. The system covers 20 % of the thermal energy needed for cooling, hot water and heating.

Photo: Aiguasol

Collectors at the façade: The solar air-conditioning system of this office and training centre of the company Bachler Austria is based on a NH_3/H_2O absorption machine.

Photo: Bachler Austria

combines dry and moist. In addition, he wants to market a 7.5 kW machine.

The smallest unit on the market in terms of nominal capacity also uses LiBr as the absorption medium. The 4.5 kW machine made by Rotartica of Basauri, a Spanish town near Bilbao, is a bit different in that it has a spinning rotor that contains the absorption medium. The first demonstration projects have been realised in Spain already with the support of Spanish energy agency IDAE. Italy also already has its first such system. In a test building, researchers from Politecno of Milan have set up a cooling system with 20 m² of collectors to test Rotartica's unit and improve its controller strategy.

Numerous projects in China

China also has a long tradition of solar cooling. The first system was set up way back in 1987; it also used a Yazaki cooling unit. As Yanjun Dai from the Jiao Tong University in Shanghai explains, more than 14 demonstration projects have been realised in the past 10 years. Some of them used absorption, some of them adsorption systems, and one had a DEC system. In 2004, a 10 kW adsorption cooling unit that used silica gel as its adsorption medium was developed at the Jiao Tong University and has since been tested in numerous pilot projects. It achieves a COP of 0.4 under typical conditions, such as a driving temperature of 85 °C, a cooling water temperature of 32 °C, and a cold water temperature of 7 °C.

Broad Air Conditioning Company of Peking offers directly fired double-effect LiBr absorption cooling units with capacities ranging from 10 to 50 kW. These units have a COP of 1.2. They require parabolic trough collectors because the driving temperature has to be around 150 °C. China is currently operating a number of solar cooling pilot systems based on these machines with a capacity of 16 to 500 kW. »However, the big systems are not easy to install; reliability could be the main issue to solve,« Dai says.

Chinese developers are also working on single-effect LiBr absorption cooling units. In Rushan in the province of Shandong, 540 m² of vacuum-tube collectors provide a driving temperature of 88 °C for a 100 kW system. The system's average COP is 0.57. The researchers say that the vacuum tubes can only provide the driving temperature for three to four hours a day, which greatly limits the time span in which solar cooling is available.

Increasing COP

Participation at the conference in Tarragona showed that solar cooling is drawing a great deal of attention worldwide. Some 300 researchers and industry representatives from all continents met in the Spanish coastal town to share their research findings and project experience. Germans made up the largest group with a 27 % share of participants, followed closely by the Spanish at 25 % and Italians at 10 %. In addition to operating experience with commercially available machines, new approaches were naturally the focus of attention. Yanjun Dai is working on a two-staged DEC system for solar air-conditioning with a range of 2.5 to 5 kW. In the lab, his system attains a COP exceeding 1 with the driving temperatures from 50 to 90 °C. At the moment, the two stages are installed in two subsequent sorption rotors. To keep the dimensions small, the Chinese team of researchers is working on getting both stages in one rotor.

Steam jet technology also promises a high COP. Clemens Pollerberg of the Fraunhofer Institute for Environmental, Security, and Energy Technology (UMSICHT) in Oberhausen, Germany, has developed a model of the technology and simulated the behaviour of a hypothetical machine. Using the climate data of Egypt, his model has an average COP of 1.1 over a whole day. In his model, parabolic trough collectors provide driving temperatures up to 200 °C. UMSICHT is planning to develop a real live 10 kW version as well as one with a capacity of 80 kW.

In contrast, Wilfrido Rivera Nacional Autónoma University of Mexico is less concerned about a high COP as long as the system is robust and inexpensive. He is developing an off-grid cooling unit so that fishermen, for example, can keep their catch cool. Working with an ammonium-lithium-nitrate medium, the machine has a simple parabolic trough collector and a solar lacquer absorber to provide temperatures below zero within the cooling chamber.

Developers and researchers are also working intensively on controller strategies for thermally driven cooling units. Simulations conducted by Dirk Pietruschka of the University of Stuttgart, Germany, show how important optimised controllers are. Controlling the speed of the cooling tower's ventilator is indispensable. If it runs at a constant velocity, the system's power consumption may double in extreme cases. This effect is especially grave with desiccant coolness recovery. A temperature difference controller for the cold water pump is just as important in reducing power consumption. In the simulations, a system that also had a variable generator temperature between 70 and 90 °C was the most efficient in terms of primary energy consumption with a COP of 2.1.

Whether it comes to new sorption rotors, new technologies such as steam jet units, or off-grid systems, research in the field of solar cooling covers a wide range of issues. It will be interesting to see the results and trends two years down the road, when the 3rd International Solar Air-Conditioning Conference takes place in Palermo; Spain, at the end of September 2009. ✷

Jens-Peter Meyer

Jens-Peter Meyer is a long term *S&WE* author and an expert in solar thermal.

Further information:
3E, Belgium: *www.3e.be*
Broad Air Conditioning Company, China: *www.broad.com*
Citrin Solar, Germany: *www.citrinsolar.de*
Phönix Sonnenwärme, Germany: *www.sonnewaerme-ag.de*
Pink GmbH, Germany: *www.pink.de*
Thermax , India: *www.thermaxindia.com*

Wegra German absorption cooling unit manufacturer EAW has installed a solar cooling system with the cooling capacity of 15 kW at its headquarters.

Photo: EAW

What solar cooling costs

Today, solar cooling systems cost between 1,300 and 7,000 € per kilowatt of cooling capacity. The greatest savings come from peripheral components. In addition, you can save a penny or two in operating costs, especially for maintenance.

Cost have to be lowered. If solar cooling is to break through on the market, lowering costs is the first commandment. In the European research project »Reduction of Costs of Solar Cooling System« (Rococo), a research team from France, Spain, and Austria took a closer look at the systems currently used[1]. Back when the study was conducted in June of 2007, the authors found 97 systems on the market in Europe. That number has increased greatly since. By the end of 2007, the authors say that some 200 solar cooling systems were used in Europe, with some 250 to 300 in operation worldwide.

Most of the systems are installed in Germany and Spain (Figure 2). Aside from Spain, the Mediterranean is still reluctant to use the technology although the climate there is perfect for solar cooling. More than half of the systems air-condition offices (Figure 3). Another common application is air-conditioning for laboratories. These projects are for pilot and demonstration purposes, so it is not surprising that so many of them have been installed in state institutions, such as universities or, to pick a specific example, the German Press Bureau. In addition, manufacturers of solar heating systems – such as Citrin Solar (Germany), Viessmann (Germany), Solution (Austria), Gamesa Solar (Spain) and Isofotón (Spain) – have also installed pilot systems at their offices, as have manufacturers of cooling systems, such as EAW (Germany) and Rotartica (Spain).

The Rococo team took a look at the costs of 37 of the 96 systems on the European market in June 2007. All four types of cooling technologies (absorption, adsorption, DEC solid, and DEC liquid [DEC = desiccant evaporative cooling]) were represented in the sample population. »Most systems in Europe use absorption technology,« explains Amandine Le Denn of France's Tecsol, which heads the Rococo project. Not surprisingly, 22 of the solar cooling systems studied used absorption.

What does solar cooling cost now? The answer to this question depends on several factors. First, the loca-

tion is crucial. Installation costs are much lower in Spain than in Germany, so that similar absorption systems on the Iberian Peninsula cost around 3,500 €/$kW_{cooling}$ including material and installation, while the same system further north would cost 5,000 €/$kW_{cooling}$. The costs also depend greatly on the size of the system. For instance, the authors found that the specific costs for Rotartica's relatively small 5 kW absorption unit were just under 5,500 €/$kW_{cooling}$ on the Mediterranean. In contrast, a midsized system, such as Yazaki's 105 kW absorption unit, only costs around 3,000 €/$kW_{cooling}$ even on the middle of the continent. The data are the best for absorption units that cool offices. In this segment, costs range from 2,600 to 6000 €/$kW_{cooling}$.

What do the individual components in a solar cooling system cost? The main cost contributor is the collector surface area, which makes up about 35 % of the pie (Figure 4). But even here, costs vary greatly, ranging from 13 to 62 % (Figure 1). Interestingly, no trend could be made out based on the size of the system. The chiller is generally responsible for around 20 % of total costs. This figure rises to exceed 30 % if the system is small. One exception is a Greek project with 105 kW, whose chiller also makes up more than 30 % of the total cost. On the average, peripheral components take up 20 % of the pie, with peripherals on the solar side being especially costly. Storage (listed under »Auxiliary equipment«) and backup equipment (either for heating or cooling) does not play a major role in investments. Finally, electronics, controls, and monitoring systems al-

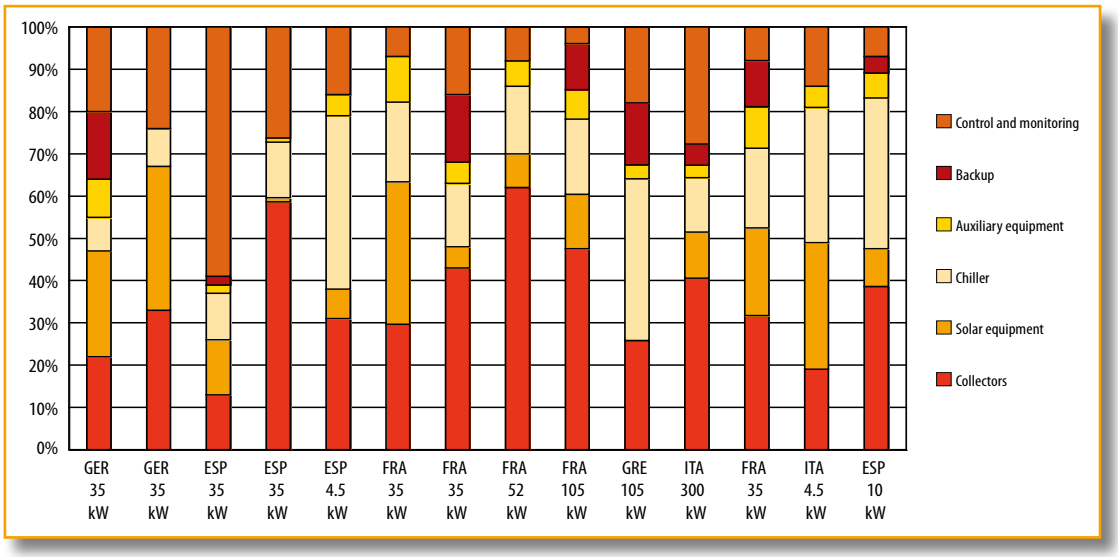

Figure 1: Solar collectors are the main cost item in solar cooling. The chiller may have a large or small slice of the pie depending on the system's size. GER = Germany, ESP = Spain, FRA = France, GRE = Greece, ITA = Italy. The figure in kW is the capacity of the chiller.

Source: Tecsol SA, France, Project Rococo

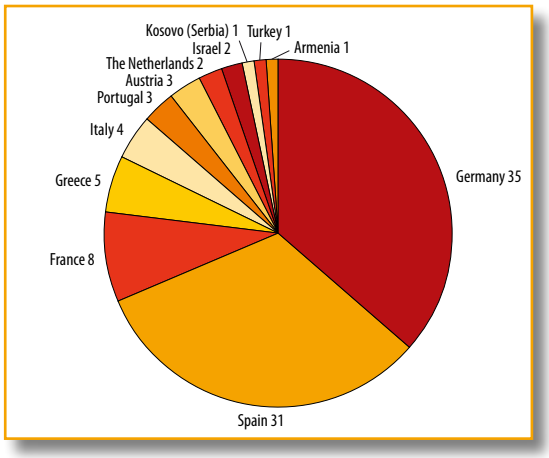

Figure 2: Solar cooling in Europe. The Rococo study found that 96 projects were in operation last summer. Most of the systems are installed in Germany or Spain. The rest of the Mediterranean has shown less interest.

Source: Rococo study, June 2007

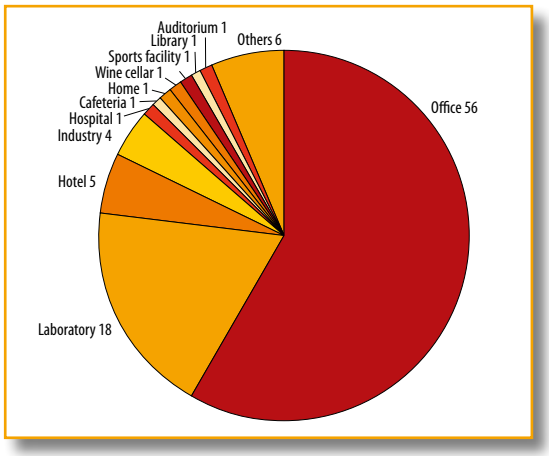

Figure 3: Most of what gets cooled by solar power is offices and laboratories. (Total number of projects: 96)

Source: Rococo study

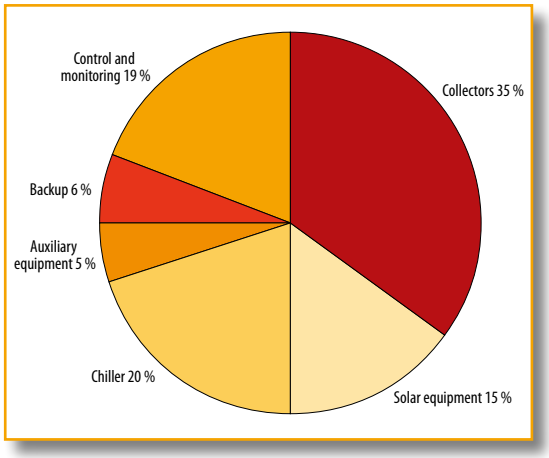

Figure 4: The average itemisation of costs for individual components (material and installation) in absorption technology. Peripheral components and hydraulics do play a major role. Here, the authors of the study say that there is great potential for savings.

Source: Tecsol SA, France, Project Rococo

so take up a large chunk at 19 % on the average. However, one system deviates greatly from the norm and has therefore increased the average for this item.

But costs do not end with investment. Operating costs should not be underestimated. A typical system has the following annual costs:

- € 3,000 for maintenance (with water preparation)
- € 1,200 for monitoring
- € 800 for the chiller's power consumption
- € 350 for the cooling tower's water consumption.

In addition to the system's location and size, the cooling technology chosen also affects costs. The least expensive solar air-conditioning method is DEC with solid sorption media. This technology allows systems to be sold starting at 1,300 €/$kW_{cooling}$. At the same time, some of these systems also have specific costs of 5,600 €/$kW_{cooling}$. The authors picked a typical example and found that a 213 m^2 air collector only made up 10 % of the system's total cost. This cooling unit with a sorption rotor took up three quarters of the amount invested. DEC technology generally lowers costs because less collector surface area generally needs to be installed per kilowatt of cooling capacity (0.8 to 1.5 $m^2/kW_{cooling}$). In contrast, some 2 to 4 $m^2/kW_{cooling}$ must be installed for adsorption and absorption.

It should be kept in mind, however, that the authors of the study only looked into costs. Their findings therefore tell us nothing about whether the systems they looked at also provide satisfactory results in operation. After all, an inexpensive system is not worth buying if the cooling capacity is insufficient or if the available solar energy does not suffice to keep a fossil-fuel backup system from having to run frequently.

Jens-Peter Meyer

[1] A. Le Denn, D. Mugnier, A. Preisler, L. Soso-Miro, M. Berger, R. Ungerbock, J. Rovira, J.-C. Noel; »State-of-the-art of existing solar cooling systems and literature for costs reduction potential assessment«, Proceedings of the 2nd International Conference Solar Air-Conditioning, Tarragona, Ostbayerisches Technologie-Transfer-Institut e.V. (OTTI), 18 to 19 October 2007, page 579 to 584, ISBN 978-3-934681-61-3.

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Solar, what else?!

Water heating in Israel means heating water with solar. Nine out of ten Israeli households take showers using solar energy. A 28-year-old building obligation for solar systems has made this possible. In this country special, *Sun & Wind Energy* reports on how a mass market works and why, despite this, there are hardly any solar systems at work in factories.

Israel can point to a long and successful solar history. The beginnings are associated with one name in particular: Harry Tabor. The physicist had emigrated from Great Britain just a few months after the state was set up in 1948. In the newly set up Research Council of Israel he was responsible among other things for bringing order to the system of measurements in the new country. Suggestions from the population kept landing on his desk on how the young country could advance technologically, including some on how the power of the sun could be harnessed.

Because he didn't know much about solar technology he began to read whatever literature he could find on the subject. Although there were already a few solar systems in Israel at the time, they delivered only poor results. Tabor looked into why their efficiency was so low. Then he had an idea and access to competent colleagues, who were able to turn it into an industrial process: a selective absorber layer of nickel-chrome. He and his team finished their development in time for the first World Congress on Applied Solar Energy in Arizona, USA, and were able to exhibit there. And the year... 1955!

Solar locations in Israel: The map shows the four major collector manufacturers, two PV system suppliers and the most important solar research institutes.

Figure: Eilers-Media

The solar systems on these pretty houses in Shimshit near Nazareth are different from many others in Israel: The collectors are mounted directly on the roof.

Photos (4): Joachim Berner

The El Ad project by Chromagen includes seven buildings. On each of them collectors supply 21 individual spiral storage tanks with hot water. *Photo: Chromagen*

Solar collectors also heat the shower water in high-rises. Architects like to hide them behind a skirting wall.

Photo: Amcor

View on Haifa: In Israel solar systems dominate the townscape.

Israel is one of solar's top duo

Today the sale of solar systems in Israel is a bulk market in which the replacement of old, clapped-out solar water heaters by far exceeds the annual new installation rate. Last year approx. 18,000 solar systems were installed on new buildings and 130,000 existing systems were replaced. At 498 W_{th} cumulative installed collector power per 1,000 inhabitants, the country was ranked second in the collector statistics of the International Energy Agency (IEA) in 2005, behind Cyprus on 657 W_{th}. In third, fourth and fifth places come Austria with 205 W_{th}, Barbados with 200 W_{th} and Greece with 192 W_{th}. Solar heating makes up 3 % of primary energy consumption in Israel. According to government figures this saves Israel 8 % of its electricity consumption.

But back to the history: In the years following Tabor's development a small solar market developed in Israel, for the country provides the best of conditions. In the south of the country the sun shines for 360 days a year, and in the north for 300. A building obligation for solar systems brought the breakthrough in 1980. Since then the hot water in all new private dwellings, hotels, old people's homes and boarding schools with fewer than nine storeys must be generated using solar energy. Even though new building activity has slowed down considerably in the last few years, and in comparison with the height of the wave of immigration from Russia in the nineties by more than two-thirds, the replacement market alone guarantees the Israeli solar suppliers with a stable sales volume of approx. 245 MW_{th} (350,000 m^2 of collector area).

Solar systems in Jaffa, the ancient port city located south of Tel Aviv on the Mediterranean. Today Jaffa is a neighbourhood of the city.

Solar Obligation in Israel

The obligation applies to all new buildings, except those used for industrial or trade purposes or as a hospital, and those higher than 27 metres. The required daily heat output of the solar system differs according to the use of the building and on the kind of solar system installed.

- The storage tank capacity must be according to the regulation:
- For residential units of one room at least 60 litres
- For residential units with two or three rooms at least 120 litres
- For residential units with four or more rooms at least 150 litres
- The system must provide 172 kJ/day for each litre of storage tank volume for open loop systems and 192 KJ for closed loop systems.
- For hotels, guest houses, elderly homes, boarding schools and similar, the obligation is defined in terms of daily solar output per litre of hot water consumption: 126 kJ for open and 142 kJ for closed loop systems.

Source: ESTIF

Solar systems are a mass-market product

For Israelis it goes without saying that their hot water comes from solar energy. It is so natural that nobody thinks much about it. If the system doesn't work any more, which given the sometimes very cheap and poor quality thermosiphon systems available can happen after just a few years, they just promptly buy a new one. They pick a trader or installer from the Yellow Pages, and these can usually supply and install products from various Israeli manufacturers. Larger businesses stock two or three suppliers, smaller businesses often stock even more than this. Brand loyalty, as can be found in some parts of Europe, is virtually unheard of in Israel. The largest collector manufacturer in Israel, Chromagen of Sha'ar Ha'amakim in the north of Israel, has confirmed this in a survey of end customers: »Since we are a solar country and a purchase mostly takes place when a crises arises – 'no hot water in the shower' – only 37 % of the clients recall a name without help,« explains Chromagen marketing expert Rakefet Shimon, talking of the results from the unaided recall test.

What counts in the purchasing decision is the price. The system must be cheap. Families can buy a typical thermosiphon system with 2.5 m^2 of collector area and a 150 litre tank for 2,000 Israeli New Shekel ILS (360 €). For this price they get the very simplest of systems: a metal absorber with metal tubes squeezed into place, coated with solar paint and covered with plain glass. Systems with ultrasonic-welded copper absorbers, tempered glass and a selective coating, usually of black chrome, cost around 3,500 ILS (625 €). Because solar hot water generation is cheap, most consumers don't change the type of energy carrier when they replace their old solar system. »The solar market in Israel behaves like every other market. Some clients want the cheapest system, some a well-known one and some the best quality,« says Shimon Geva, export manager at Amcor Solar Energies of Ashdod.

In a mass market the price is decisive

In order to protect the consumer from bad quality, the state introduced norms for collectors and storage tanks, as well as a compulsory guarantee period of five years. Systems which do not meet these standards may not be manufactured or sold in Israel, nor imported into it. 93 solar collectors from twelve Israeli manufacturers currently meet the requirements. However, systems which haven't been checked are still available on the market.

The low-cost suppliers are a thorn in the side to Eli Shilton. »Our problem: There is no control in the replacement market. We are competing in an unfair competition. There are so many small companies without certification,« says the solar expert, who has been head of the solar system manufacturer Rand Solar Water Heating Systems in Petach-Tiqva for 15 years. He estimates that a third of all collectors in the replacement market come from such companies. For this reason, Rand used to only do business with building contractors. Because the new-build sector collapsed in the mid-nineties,

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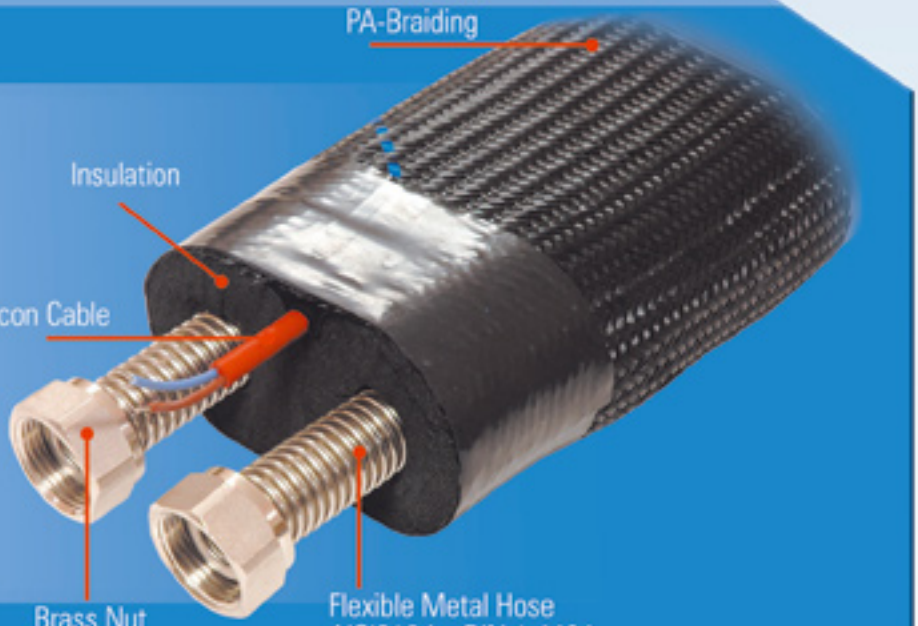

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To prevent the thermosiphon system from spoiling the visual characteristics of the building, it is hidden behind a three-sided wall.

Photo: Chromagen

Even though it doesn't look like it, this system in Jerusalem is still working.

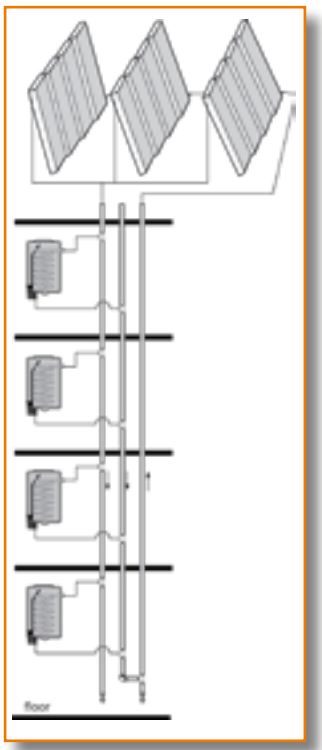
Rand also entered the private market. »Now you can't live without it.«

Chromagen has reacted to the intensified price by increasing its marketing activities. The company wishes to establish its products as a brand name and thus improve product recognition. It has come up with a catchphrase (»Catch the sun power«), has its advertising on buses and has taken up advertising on a popular television sports channel. »Once you have decided to have a brand, you need marketing actions,« explains Rakefet Shimon. »We are looking for high quality and are working on high and severe standards. Maybe we are the most expensive, but we deliver best quality.« In order to underline this quality claim Chromagen provides an eight-year guarantee on its products. Additionally the company has brought a new premium system onto the market with the distinctive name »High-tech«. The system is the Porsche among solar systems and comes at a price: 7.200 ILS (1,285 €).

Special system concept for apartment blocks

In apartment blocks with fewer than four storeys each family usually has its own open-loop thermosiphon system. Accordingly, things can look pretty chaotic on Israeli roofs. In the system tanks there is always an electric heating element for colder, cloudy days. Normally the collectors provide 80 % of the annual hot water requirement. In higher buildings, forced close-loop collector systems provide the energy for heating water in the apartments. Each family has its own polyurethane-insulated storage tank with an in-built heat exchanger.

So that the solar system delivers the same amount of energy to each apartment, whether it be on the tenth or the first floor, the pipes are laid in a particular way. The hot water from the collectors flows through a first set of pipes to every floor and through the heat exchangers in the tanks. The cooled water from the heat exchangers flows into a second set of pipes, not straight back to the collectors, however, but first down to the lowest floor. It is from there that a third set of pipes takes the water back to the solar collectors. The water from every heat exchanger must thus travel the same distance. This concept is called a reverse return system and delivers the heat evenly to the individual tanks. It prevents the first tank in the system on the top floor from getting more hot water than the others.



Schema of a solar hot water heating system in an apartment block: This so called reverse return system which three pipes delivers the heat evenly to the individual tanks.

Figure: Nimrod

Companies such as Amcor, Chromagen and Rand have employees who have specialised in the planning of such systems. »This is an added value of our company. As a small company we can't compete in prices but in engineering. This is our service,« explains Shilton from Rand, for example. There is also not much competition in this sector because only the good companies are active in it. Amcor automatically does business in the new-build sector directly as a result of its company allegiance. For some years now the company has belonged to the Ashtrom Group Ltd., one of Israel's largest construction companies.

Energy experts call for an expansion of the solar ordinance

Despite its success, the solar ordinance has had its disadvantages: It has limited the solar market mainly to private dwellings. »There is no reference in the law to the industrial sector, which consumes process heat for producing hot water or steam,« explains Gershon Grossman, head of the Energy Engineering Research Centre at the Israel Institute of Technology (Technion) in Haifa. At the end of January 2007 experts at an energy forum at Technion thus formulated some recommendations for the government. Among others they call for the enforcement of the construction and planning regulation by the local or national planning committees as in the domestic sector. The catalogue of recommendations also says: »It is clear now that it is possible to use this technology at buildings taller than nine floors. Therefore, the government has to consider the application of the regulation to such buildings as well.« They also initiated a national study in order to identify the potential of applying solar heat systems in the business and industrial sectors.

But still: The building obligation has provided Israel with a successful home market and thus the base for a strong home industry, one which is now starting to present its products abroad at exhibitions and fairs, like Tabor for instance. ✹

Joachim Berner

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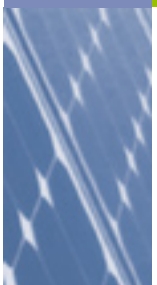

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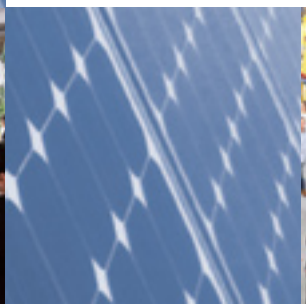

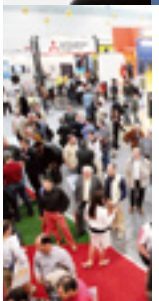

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The big four

Amcor Solar Energies, Chromagen, Nimrod Industries and Rand Solar Water Heating Systems are among the best-established collector manufacturers in Israel. Following on behind the market leader Chromagen, the other suppliers are now also increasing their export activities.

One way in which solar collectors can be architecturally integrated into apartment blocks. *Photos (3): Amcor*

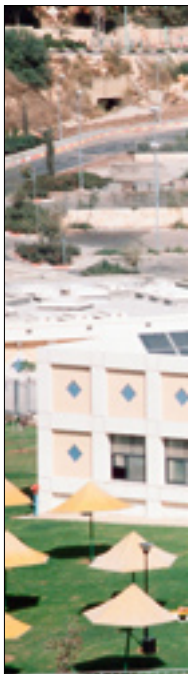
Amcor: backed by a construction company

Amcor Solar Energies shows that the Israeli manufacturer has long since started doing business in exports. Already in 2003 the company supplied 77 collectors for a Spanish swimming bath. To this end it provides a wide range of products. For example, Amcor manufactures solar collectors with ultrasonic-welded copper absorbers, coated either with solar paint or black chrome. The collector size ranges between 1.4 and 3.8 m^2. Amcor makes its collectors with either aluminium or painted galvanised steel section housings. Polyurethane foam provides the necessary insulation, and toughened glass sufficient transmission. The solar tank volume ranges between 80 and 300 litres and the electrical tank volume ranges between 15 and 200 litres. All products are certified to European standards.

The company has many years of experience with solar technology. It began doing business with solar energy 45 years ago and seven years ago it was taken over by Ashtrom Group Ltd., one of Israel's largest corporations. Amcor exports mainly to Italy, Greece, Spain, the U.S. and Eastern Europe. »Usually we sell under our name but OEM is also possible,« says export manager Shimon Geva on their export strategy. *www.amcor-solar.co.il*

Yossi Solomin (left) is responsible for quality and makes sure production standards are high in the new Chromagen collector factory in Ziporit near Nazareth (photo on the left). Micky Carmel is a development engineer responsible for product design. Both live in Kibbutz Sha'ar Ha'amakim. *Photos (8): Joachim Berner*

Solar heating for bathers (photos on the right): Chromagen employee Reuben Noga (second from left) and Eraz Bar (second from right) talking about solar system technology with Haim Azulai (right), owner of the swimming baths in Nazareth-Illit, and its caretaker Slomo David.



Like other large Israeli solar thermal manufacturers, Amcor also manufactures solar storage alongside solar collectors.

Absorber manufacturing: An Amcor employee solders an absorber tube.

Chromagen: from local to international player

Chromagen is now not only one of Israel's but also one of the world's largest companies in the solar thermal sector and exports to more than 35 countries, according to its own figures. The company was founded in 1962 by Kibbutz Sha'ar Ha'amakim and already has several spectacular reference systems abroad. In 2002 it supplied collectors for a hotel on the Greek island of Crete. At 1.75 MW_{th} (2,500 m^2 collector area) it is one of the largest solar systems in Europe. 30 collectors from northern Israel also adorn Greece's first energy-self-sufficient building in Athens.

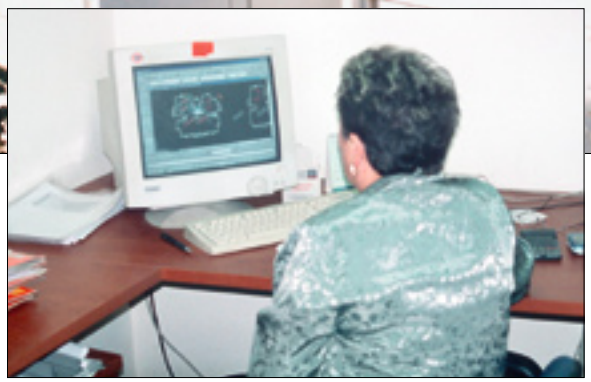
Chromagen has just recently presented a thermosiphon system specially developed for the south of Europe. The closed loop system »Chromagen 300« has a much more attractive design than is normal in Israel and the transversally mounted storage tank contains a double-jacket heat exchanger. »Our strategy is to develop from commodity products perspective to designed systems and next year to solutions«, explains Chromagen's CEO Haggai Shefer on the Israeli market leader's future company strategy. By this he means that Chromagen is to provide systems designed for domestic use as well as more complex central systems for commercial applications. Chromagen is thus aligning its systems technology with European system concepts. An Israeli investment fund has supplied the necessary capital for this expansion strategy, and has taken up a 26 % share in the company. *www.chromagen.biz*

Rand: success with planning know-how

»We are maybe the fourth largest manufacturer in Israel, but in exports we are the number two,« says Eli Shilton on the importance of Rand Solar Water Heating Systems, a subsidiary of Israel's leading gas provider Amisragas. Shilton ran the solar manufacturing business for 15 years. He recently handed the running of the company over to the younger Efi Luzon and founded his own company Elsol Solar Energy Systems, an engineering and marketing company specialised in solar technology. But he still visits the Rand building in Petach-Tiqva on a weekly basis. He is responsible for exports at the company, which was founded in 1947 as a manufacturer of household goods.

Apart from the products, Shilton also praises the engineering know-how of the company. As at home, in exports his eye is on projects. »We don't go to installers when we export, because there is competition without benefit.« The solar specialist prefers to supply to projects, such as this year to the solar system with 224 kW (320 m^2), installed at the Aparthotel El Duque near Tenerife. *www.rand.co.il*

At the Netanya boarding school Rand has installed 120 thermosiphon systems on various buildings. They deliver their energy to several large tanks.



Large solar thermal manufacturers such as Rand employ their own staff to plan large solar systems for construction companies.

Expansion plans: Export manager Mario Waisman wants to make Nimrod solar systems known internationally.

Nimrod: a traditional family-run business

Nimrod Industries has also been active abroad recently, mostly in Europe, Australia and Central America. »We decided to build up our international business two years ago,« says export manager Mario Waisman. In the coming year he wants to present his products at a foreign fair for the first time, »when we are done with certification«. The family-run business was founded in 1967 and mainly does business in Israel with private customers. Waisman self-confidently announces the expansion thus: »We can do it at the same level of quality, but we can do it cheaper.« Nimrod has made significant investments for improving the production procedures and technologies for manufacturing its products. An advanced process for cleaning the tanks and applying an internal enamel coating is one of them.

As is the case with other international Israeli manufacturers, the tanks are also equipped with an electric heating element, surrounded by a fast-heating sleeve. When hot water is required on days without sufficient hours of sunshine, the heating element is normally switched on. The heat accelerator, fitted as a sleeve around the electric heating element, quickly heats up a small amount of water for immediate use.

www.nimrod-solar.com

One tank per apartment: Eli Shilton from Rand explains the system technology of solar systems in high-rises.

Finishing work: Rand employees sticking signets onto solar tanks

Tel Aviv: Collectors don't have to get in the way even on artistically decorated buildings.
Photo: Joachim Berner

»We have had a break«

The success of solar heating technology in Israel can overshadow the fact that the country hardly uses other forms of renewable energy. This is not due to a lack of research efforts by the universities, explains Abraham Kribus, professor at the Faculty of Engineering at Tel Aviv University and president of the Israeli section of the ISES, during a discussion with *Sun & Wind Energy*.

S&WE: *How would you describe the situation of renewable energy research in Israel?*
Kribus: For almost 20 years the level of research activity was very strong, except for the solar water heaters, which are already an established technology. For all the other aspects like electricity production by photovoltaics or solar thermal power plants there was some research in academic institutions, but there was very little funding from the government and there was almost no industrial activity. In the last two years we have had research, people are becoming interested again.

S&WE: *Why?*
Kribus: The reason is that the interest is worldwide. So people are noticing that this is the new area where you can make money. It started with entrepreneurs and academic researchers who are trying always to break the glass ceilings and start something. But in the last two years there has also been a lot of interest from the people with money and from the government. This is the real difference.

S&WE: *So now the state gives money?*
Kribus: The government does not yet give a lot of money. But there are starting to talk about it. This is the change. This is a situation like in the United States two or three years ago when they just started to notice and then maybe one year later big investments began. Even the federal government, which was opposed to renewable energy, is now giving some incentives. So it takes time for the government to really do something. But if they are talking about it, that's already a big change.

S&WE: *You talk of a new start. In which fields of renewable energy?*
Kribus: The leading field in Israel is research in solar energy. And maybe a second one is on biomass. In solar energy usually most people work on concentrating solar power technologies and on photovoltaic concentrator systems. In both areas there are very strong research groups. We have a big solar tower at the Weizmann institute, the international center of scientific research in Rehovot. There are also several concentrating technologies that are using a very large dish at the Ben Gurion National Solar Energy Centre.

»In terms of solar energy technology we have been leaders in the world since the 1950's«

S&WE: *Israel is today famous for high-tech applications. Are you confident that in the future it will also be famous for clean-tech?*

Kribus: In terms of solar energy technology we have been leaders in the world since the 1950's. The revolution of the water heaters started in Israel because the selective coating was developed here by Harry Tabor. He was one of the founders of ISES. He worked in the National Institute of Physics in Jerusalem. The first company to build large solar power plants in California was also an Israeli company, Luz. The technology was developed here, actually it started at the same laboratory in Jerusalem. So far these are the biggest solar power plants in the world. So this is also an Israeli technology.

S&WE: *So, Israel has just been taking a break?*

Kribus: Yes, we've had a break, because of let's say loss of interest from the government and from the industrial community. But we still have a good infrastructure of research and academic institutions. It will be very easy for the Israeli community to regain its position in the leadership. *It would be nice if we would have the same kind of i*nstitutional support like you have in Europe. We have to work on that.

S&WE: *Solar thermal technology is widespread in Israel. But it is focussed on solar hot water in private households. What is the situation for solar thermal use for process heat or solar cooling?*

Kribus: There are many industrial consumers that consume a lot of heat and they burn some kind of fuel, heavy fuel oil or whatever. They could have the same kind of heat from solar collectors. In Israel this is a topic of debate that we always raise and there is never a solution, because it's not a technological problem, it's a tax problem, an administrative problem. It turns out that if an industrialist buys oil and burns it to get the heat he will get a tax credit as an expense for this cost of the fuel. But if he installs a solar collector he gets nothing. So actually this is more expensive for him.

S&WE: *What about solar air conditioning?*

Kribus: There have been many studies, in Europe and in other places that show that if you have solar thermal collectors that are feeding an absorption machine the cost of a kWh of cooling is not competitive against conventional cooling. So at the moment there are no applications. There is some hope at least from my perspective because of some work that we have done. It is at the moment still theoretical but I think it offers a great opportunity. The idea is to collect the heat which is generated by concentrating photovoltaic systems and to use it as a by-product for desalination or absorption cooling.

The cost of the heat is nothing or almost nothing, because you build the system in order to make electricity. We made a complete analysis of how much energy can be produced and what the costs would be. It seems that it is much more competitive than the conventional approach to solar air conditioning or solar desalination. But this is on paper. When you start building something it's a different story.

Abraham Kribus, professor at the Faculty of Engineering at Tel Aviv University and president of the Israeli section of the ISES

Photo: Joachim Berner

Research of PV concentrator systems in Tel Aviv

Professor Abraham Kribus at the University in Tel Aviv is developing photovoltaic concentrator systems using advanced cells with very high efficiency (multiple junction cells). His special approach: The system has one single large concentrator, like a dish, and in its focus there are many cells side by side. Alternatively concentrator systems can consist of many units of a reflector and a single cell in front of it. The advantage of Kribus' approach: There is only one compact place with cells where all the questions of electricity and heat removal need to be dealt with. So this makes the realisation of an active cooling system for the cells easier, and the heat collected from the active cooling system can be used for additional energy products such as air conditioning. On the other hand, the advantage of the individual cell approach is that you have a small module that is repeated in large quantities, meaning you can have mass production and reduce the costs. But both systems are being developed and the market will say who the winner will be.

Three years ago the professor established a start-up company, Distributed Solar Power, to develop this technology. Kribus expects that in about one year a few of these systems will be manufactured, installed and tested. The company plans to have a demonstration system in Israel. In the European sixth framework programme two demonstration systems, one in Italy and one in Spain, should be installed within the next two years.

Further information: *www.disp.co.il*

S&WE: *What about the use of other renewable energies in Israel?*

Kribus: Israel is a dry country. There is one hydropower facility on the Jordan river that has 300 kW. This is all the hydro potential of Israel. There is some potential for wind, not so much, but there are some sites that have reasonable wind in the north. Another source is biomass. We have a lot of agriculture in different areas. You know in the area of biomass there is a big controversy that is saying if we use biomass for fuel this raises the cost of food and creates a lot of problems. One of the approaches that started in Israel is to have plants that grow in areas that cannot be used for food. If you grow some plant in the desert, one that does not require good water, maybe brackish water, this is a reasonable application. So there are some research groups that are developing plants of this kind. ✹

This Interview was conducted by Joachim Berner.

More sunshine for electricity

Israel has so far hardly used the power of the sun in order to generate electricity. New feed-in regulations and an international tendering for solar power stations in the Negev Desert will improve this situation in the future. Politicians are also beginning to recognise the potential and opportunities from solar-generated electricity.

Historic places like the Temple Mount in Jerusalem are spoiled with sunshine but this energy is not yet used to produce electricity.
Photo: Joachim Berner

In the field of hot water generation the solar age began in Israel decades ago, but for electricity generation it is still being planned. While the country plays a leading role internationally in solar heating, in solar electricity generation it is lagging behind. Despite the enormous potential, photovoltaic systems with a total power of just 1.3 MW_p have so far been installed, of which a mere 25 kW_p are grid-tied. The largest array is in the Negev Desert and has only 6 kW_p. And yet the sun could help to reduce the country's energy dependence. Israel has to import 93 % of its primary energy demand in the form of oil, write the authors Amit Mor and Shimon Seroussi from the Israeli consultancy Eco Energy Ltd. in a current report on the state of renewable energies in Israel. »Since its pioneering efforts to develop rooftop solar water heating, Israel has done little to develop a renewable energy industry that can substantially reduce that energy dependency,« they conclude.

Photovoltaic companies thus find things tough in Israel. With its seven employees, Solarpower Ltd. from Netanya counts as the biggest PV company in the country. It shares the market mainly with Interdan Ltd. from Haifa. Both companies plan and install PV systems (see map on page 97). There are no manufacturers of photovoltaic components in Israel. The country does have a lot of scientific know-how, however. »But many promising renewable energy developments have remained at the research stage because of the lack of resources and policy coordination necessary simply to make the initial assessment of their commercial viability,« complain the Eco Energy employees in their report.

Lots of research, little application

The analysts give further reasons for the so far cautious use of renewable energies other than low-temperature solar heating. For one, the Ministry of National Infrastructures, which has primary responsibility for energy policy, has not developed comprehensive implementation plans for renewable energies. Additionally, the research centres have had to deal with extremely low levels of public investment in research and development. The Ministry of National Infrastructures provided 300,000 Israeli New Shekels ILS (53,000 €) for PV related research during 2006. Much of the research and training is funded by universities such as Ben-Gurion University in Beersheba and the Weizmann Institute in Rechovot. Furthermore, the Israel Electric Corporation (IEC) has stymied PV growth by creating formidable procedural roadblocks for photovoltaics to obtain the required authorisations to interconnect with IEC's grid. The International Energy Agency (IEA) completes the description of the thus-far bleak situation: »There were no key PV policy initiatives, promotional activities (commercial and non-commercial) or any other market drivers of significance in 2006 which affected the market.«

But the frameworks for the generation of solar electricity are improving. The Israel Public Utility Authority (PUA) issued guidelines and regulations in August 2006 providing premium payments to private electricity producers using renewable technologies. Tariffs of 0.70 and 0.876 ILS/kWh (0.12 and 0.16 €/kWh) were established for installations according to two size ranges: from 100 kW_p to 20 MW_p and above 20 MW_p. Smaller systems (under 100 kW_p) have since then also been taken into consideration. »In June 2007, the minister of national infrastructures announced a policy change regarding small installations for own-use, with transfer of surplus to the grid. This change was a result of lobbying in favour of facilitating private users' connection to the grid, and is expected therefore to have a great effect on the future of this market,« reports the IEA. The minister declared that he wishes to promote installation of about 50 MW_p over a period of five years. The PUA has therefore been instructed to establish the mechanism and tariffs, and it has set a target to complete this by the end of 2007. The PUA has already prepared a draft proposal, and made it available to the public for review and response. »The expected feed-in tariff for systems smaller than 50 kW_p is 2 ILS/kWh (0.36 €/kWh) for 20 years,« says Solarpower's general manager Alon Tamari.

The state provides financial help for start-ups

At the end of October, the director general of the Ministry of National Infrastructures announced during the environmental fair WATEC that Israel aims to be generating 5 % of its electricity from renewable sources within the next seven years. By 2020 this is to reach 10 %. It is an ambitious target, as energy experts such as company and government consultant Amnon Samid from AGS Technologies Ltd. assume that the country will have to double its electricity generating capacity to 20,000 MW in the coming years in order to be able to meet the growing demand. Solar thermal power stations are also to play a part here. In September the Israeli government approved the Ministry of National Infrastructures' plan to build two or three solar power stations with a total capacity of 250 MWp in the northern Negev Desert. A tender, expected in the first half of 2008, will invite local and international solar power technology companies as well as integrators to submit proposals. »In spite of the early intention to open the tender only for trough technology, which is the only mature and proven technology for commercial applications, it has now been decided to also invite all other technologies, including power towers, parabolic trough, parabolic dish and concentrating photovoltaics,« explains Samid. He hopes that the winners can be announced at the end of 2008 and that the power stations will be providing electricity as of 2012.

One of the market leaders in the parabolic trough technology, Solel, actually comes from the country, too. Solel is providing the key technology for new solar power plants currently under construction in the U.S. and in Spain. It now owns most of the assets of Luz Industries that built three of the world's largest solar power plants in the Mojave Desert in South California at the end of 1980s. »We have the capability to become a world leader as a renewable energy technologies provider,« says Samid confidently. The state wants to help the industrial base by providing financial help to start-ups. In April 2007, the Israel Ministry of National Infrastructures announced its new preseed funds »Startergy« for support of start-ups in the field of clean energy. It is part of a new policy approach announced by the minister regarding all renewable energies, photovoltaics included. Three of the seven companies which are benefiting from the bridge funding scheme are involved with photovoltaics or solar thermal power plants. ✷

Joachim Berner

Further information:
AGS Technologies Ltd.: *www.cleanenergy.co.il*
Ben-Gurion National Solar Energy Center: *cmsprod.bgu.ac.il*
Eco Energy Ltd.: *www.ecoenergy.co.il*
Interdan Ltd.: *www.interdan.com/english.asp*
International Solar Energy Society – Israeli Section: *www2.technion.ac.il/~ises*
Israel Electric Corporation (IEC): *www.israel-electric.co.il*
Israel Public Utility Authority (PUA): *www.pua.gov.il*
Ministry of National Infrastructures: *www.mni.gov.il/mni/en-US*
Solarpower Ltd.: *www.solarpower.co.il*
Weizmann Institute: *www.weizmann.ac.il*

A great diversity of students: Altogether 33 students began their studies of renewables at the University of Oldenburg in October 2007 – 17 of them are PPRE-students, 16 are registered for the EUREC programme.

Photos (4): PPRE

Master of energy

The Postgraduate Programme Renewable Energy (PPRE) at the north German University of Oldenburg is one of the oldest international courses of study in the field of renewable energies. For 20 years, students from all over the world have been learning the theory and practice of the different technologies.

It is already working in the laboratory. Later on, the PPRE students want to make use of their knowledge worldwide.

Jagwe Wycliff does research. In his home country Uganda, he is installing several pyranometers on one of the Lake Victoria islands. Wycliff wants to determine the incoming global solar radiation. There are plans for a PV-driven pumping station to supply the island with running water. In the course of his work, he found out that some of the coastal areas have considerable wind levels. This immediately gave him the idea of also erecting wind power plants, thanks to his studies at the north German University of Oldenburg.

Andrew Peel, on the other hand, is a consultant – he advises representatives of the English construction industry on the topic of passive houses. He also teaches architects and house planners how to reduce the energy requirement of their buildings. »I have just started my new job, so there is still a lot for me to learn. But my learning curve is going steeply upwards,« says Peel. Actually, he is of Canadian origin. Via Oldenburg, he has found his way to the Building Research Establishment (BRE) in Watford, England.

Peel and Wycliff have just finished their studies in Oldenburg successfully, and have thus obtained interdisciplinary knowledge of all the renewable energies. The Postgraduate Programme Renewable Energy (PPRE) was set up at the Carl von Ossietzky University in the North German city of Oldenburg back in 1987. In the 20 years since, around 350 international students have graduated from the course. This master programme is 10 years younger than the field of »alternative energy research«, which was established at Oldenburg University in the late seventies – at a time when this subject was still being laughed at. It was this research department that launched the corresponding course of study. One of its intellectual fathers was Ekkehart Naumann, who, after several years as the director of the course of study, is now installing solar energy systems in Pakistan. In 2005 the German Solar Award in the category »education« was conferred on this master programme. The German Solar Energy Society (DGS) accounted for this decision by pointing out the unique and innovative structure of the programme, which is taught in English.

Renewable education at work: Jagwe Wycliff from Uganda, one of the former PPRE students, installed several pyranometers to determine the global solar radiation in his home country.

In 1987, the first six international students became familiar with environment-friendly energy technologies in Oldenburg. Twenty years later, the PPRE, offering the degree Master of Science (MSc), is one of the oldest and most acknowledged courses of study worldwide in the field of renewable energies. Meanwhile, several other universities around the globe offer similar study courses (see table on page 102). It includes English-language post-graduate study programmes that are open to applicants from all over the world and that cover the whole range of regenerative energies.

Of teaching and learning

This is also the case in Oldenburg. Wind energy, energy meteorology and photovoltaics are some of the core subjects of the course. But the students also spend time on other renewable energy sources such as geothermal energy in Kenya or biofuel made from the tropical jatropha nut. The students are supposed to get to know every form of renewable energy.

In the latest round of admission, 20 lucky students were selected from 170 applicants for admission to the PPRE in Oldenburg in 2007. A successfully completed degree, high motivation, visions for the future, good references and preferably some professional experience in development cooperation or in the field of energy issues are necessary in order to have a chance of obtaining one of the much sought-after places. In Oldenburg, the students learn about renewable energies over a period of 16 months, first in theory, then in practice. Parallel to mugging up on the physical basics of the different energy sources, they put their skills to the test in the laboratory. From the second semester onwards, things get more practical, with experiments, projects and simulation workshops – applied technology becomes the focus. In addition, companies are visited and internships in the industry or in research institutions are completed.

In the future it is planned to give aspects of social science greater consideration as well, since practice has shown that projects are often insufficiently adapted to the local social structures and traditions. What use is a solar cooker if meals are only prepared in the evening? In such cases, it is also no help that the students were able to test their cooking skills at a solar lunch in Oldenburg. The consideration of social conditions »is particularly important if one is active in quasi pre-industrial structures of society,« Michael Golba is convinced. The physicist, together with the scientific assistant Konrad Blum, directs the MSc programme. »So far, it has not been common for an engineer to deal with the structure of the society for which, and in which, he is working,« says Golba. Therefore, the challenge is »to synchronise the electricity supply with the social structure«.

Great diversity of students

Over the past 20 years, the University of Oldenburg has welcomed students from over 70 countries. »For most of them, the international context is the highlight of the programme,« says Edu Knagge, the PPRE coordinator. »They sit right next to each other here for 60 hours a week. The intercultural exchange is an impor-

Country	Institution	Programme name	Objective	Target group	Duration	Mode	Fees (Euro)	Website
Europe	EUREC Agency, 8 R&D institutions / universities	EUREC Master	RE technology	engineers and natural scientists with experience in the energy sector	16 months	on-campus, three different locations	6,500 (EU), 10,000 (internat.)	*www.master.eurec.be*
Germany	Aachen University of Applied Sciences, Jülich Campus: Department of Energy Technology	Master of Science in Energy Systems	new energy technologies, energy efficiency, solar technology, photovoltaics, fuel cells, advanced power plant technolgy	Bachelor of Science/Bachelor of Engineering/Dipl-Ing./Dipl.-Ing. (FH) degree or equivalent in mechanical engineering, electrical engineering or chemical engineering	24 months	on-campus	154 (social and student contribution – amount is determined each semester) + 500 (tuition)	*www.juelich.fh-aachen.de / www.fh-aachen.de/ energysystemsmast.html*
Germany	Flensburg University	Sustainable Energy Systems and Management (SESAM)	technology and management of RE	engineers, natural scientists and economists with experience in the energy sector	18 months	on-campus	7,500	*www.uni-flensburg.de/sesam*
Germany	University of Oldenburg	PPRE: Postgraduate Programme Renewable Energy (MSc)	RE – principles, systems, economy	engineers and natural scientists with experience in the energy sector	18 months full-time	on-campus	3,000	*www.ppre.de*
Great Britain	Loughborough University	Renewable Energy System Technology (REST)	RE systems and technology, policy	engineers or physicians or equivalent qualification	12 months full-time, 26 months part-time	on-campus or distance learning	5,270 (EU), 16,650 (internat.)	*www.lboro.ac.uk/crest/ education.html*
Great Britain	University of Reading	RE: Technology and Sustainability	RE and environment	graduates with numerate science-base d degrees such as engineering, agricultural engineering, physics, environmental science	12 months full-time	on-campus	4,873 (EU), 12,256 (internat.)	*www.rdg.ac.uk/energy*
Sweden	KTH Stockholm	SEE – Sustainable Energy Engineering	sustainable energy engineering – specialisation in RE	mechanical engineers, applied physicians, other related	24 months	on-campus or distance learning	0	*www.energy.kth.se/index.asp?pnr=15&ID=222&lang=0#Practical%20Information*
Australia	Murdoch University	MSc in Renewable Energy	RE systems, sustainable energy policy and economics	engineers, scientists, environmental scientists and policy analysts	24 months	on-campus or distance learning	21,800	*www.eepe.murdoch.edu.au/ Curriculum/courses/Master_of_Science_in_Renewable_Energy*
Thailand	Asian Institute of Technology (AIT)	Energy field of study (MSc)	technology, planning and management in the energy field with respect to environment and climate change	students with bachelor in the related field	24 months	on-campus	13,023	*www.serd.ait.ac.th/ep/ep.html*

Table: English-language Master of Science (MSc) study programmes worldwide in the field of renewable energies

Source: University of Oldenburg/own research

Deeply symbolic site: The »Energy Laboratory«, a low-energy house built in 1980 that is supplied by regenerative energies, is the central PPRE venue.

tant aspect – and the contacts thus established continue to have an effect on everyday working life.«

Most of the students have already held qualified positions abroad – and usually they return to these or to even higher qualified posts. Worldwide, the alumni work in responsible positions – in politics or companies, in research or teaching. »It is not only about small-is-beautiful projects any more,« says Golba. »Unlike 20 years ago, renewable energies today are no longer a niche technology.«

Originally, the PPRE primarily addressed participants from Africa, Asia and South America, but meanwhile an increasingly western or worldwide orientation has emerged. It is not the aim of the study programme to recruit specialised staff from abroad to work in Germany. On the contrary, the graduates are supposed to accelerate the growth of renewable energies all over the world. Their job prospects are good. None of the graduates from the last five years has remained without a job, reports Knagge. Things looked different for Knagge himself back in 1991: »After graduating, I occasionally also applied internationally, but I didn't exactly run through open doors.«

In an international comparison, the current study fee of € 3,000 for the promising study programme is rather cheap. Since the students mostly do not come from the richest regions, the German Academic Exchange Service (DAAD) helps with grants – so do other support institutions, and in many cases also the local governments.

A network like a spider's web

Maintaining an active alumni network is a trademark of the Oldenburg philosophy. Approximately 80 to 85 % of all the PPRE graduates are active in the network. The annual newsletter, now comprising 80 pages, offers much more than one might expect. Apart from news from Oldenburg, the careers of the graduates are followed closely. Thus, the network has also turned into a job and contact platform. In different regions of the world, there are regular regional alumni meetings.

The network also functions for technical issues. A discussion list based on e-mail makes this possible – a question from a former student from Mongolia in Asia is answered by a tip from Patagonia in South America. After all, it can become quite cold in both regions. The topics that are debated include insulation technology as well as thermal use of solar energy. The network also helps Jagwe Wycliff to cope with any trouble his inverters cause him.

Be it in England or in Uganda, be it the energy minister of Madagascar or the project coordinator of a United Nations climate programme in Albania – the PPRE produces the most diverse professionals and brings together the most different personalities. But there is one thing that all the students have in common: They want to ensure a sustainable and clean energy supply around the globe – Peel in England and Wycliff in Uganda.

Katharina Garus

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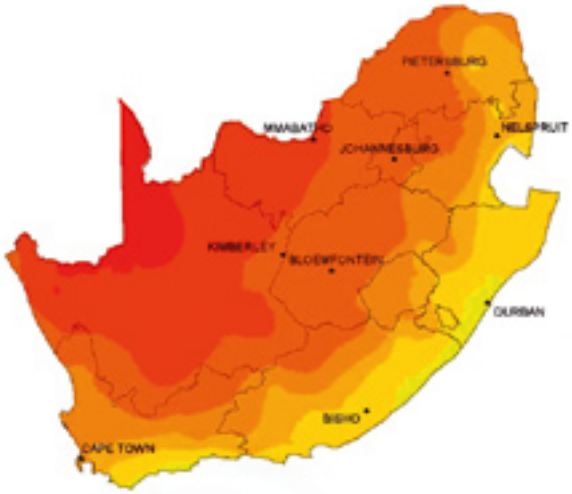
Solar energy –

The country at the southern tip of the African continent offers, thanks to its high solar radiation, outstanding conditions for establishing photovoltaics and solar thermal energy. Particularly with regard to the FIFA World Cup 2010, having a sufficient and secure electricity supply is becoming all the more important.

a chance for South Africa



Annual global solar radiation on a horizontal surface:

- 1,667 – 1,805 kWh/m²
- 1,806 – 1,944 kWh/m²
- 1,945 – 2,083 kWh/m²
- 2,084 – 2,222 kWh/m²
- 2,223 – 2,361 kWh/m²
- 2,362 – 2,500 kWh/m²
- 2,501 – 2,639 kWh/m²

Average radiation values of between 1,600 and 2,600 kWh/m² are characteristic of Africa's southern most nation.

Source: Council for Scientific and Industrial Research Eskom (CSIR) / Department of Minerals and Energy (DME)

Photo: Ralf Pickenhakn, Pitopia

On a global comparison, sunlight is one of the greatest resources in South Africa. Although the country offers a great number of different climate zones – from extreme desert to subtropical conditions – the average solar radiation level in South Africa, thanks to its location on the tropic of Capricorn, stands at between 1,640 and 2,370 kWh/m^2 per year. In Germany, for example, the sunniest regions only reach solar radiation levels of around 1,100 kWh/m^2, and yet solar energy is booming there. With an area of 1.2 million km^2, South Africa is more than three times the size of Germany. Despite this, the »Rainbow Nation« makes little use of solar energy, and the total proportion of renewable energy sources in the country's primary energy stands, for the time being, at only 9 %. The most significant proportion of this is the traditional use of biomass such as firewood for cooking and heating. In view of the changing climate and the growing demand for electricity, however, South Africa must also give thought to an alternative electricity supply, and this is where the use of photovoltaics and solar thermal energy can come in.

Long view: In Cape Town – seen here from Table Mountain – pilot projects for the use of solar-powered traffic lights are delivering successful results.

Photos (2): Michael Forst

Rising electricity demand – insufficient supply

South Africa is the largest energy producer in the continent of Africa. Its installed capacity for electricity generation amounted to 43 GW in 2006, which makes the local electricity supplier Eskom, with a net installed capacity of 39.8 GW, one of the largest electricity producers in the world. With a share of 90 % of the South African electricity consumption, it also holds a monopoly on the domestic market. According to the report »Energy policy framework conditions for electricity markets and renewable energies« from the German Agency for Technical Cooperation (GTZ), Eskom produces around 6 % of this electricity from hydroelectric power plants and gas turbines, and 4 % from nuclear power. The main energy source, with a proportion of 90 %, is the environmentally-damaging resource coal, since South Africa has the world's seventh-largest coal reserve at its disposal. With around 47 million inhabitants, the Republic is also Africa's largest energy consumer. In 2006, its electricity consumption stood at 208.3 TWh. This can be attributed, on the one hand, to the relatively low price of electricity compared to other countries. In 2006, the price per kilowatt hour of electricity for private households was around just 0.40 Rand/kWh (approx. 0.06 US$/kWh). Industrial consumers only paid around 0.14 Rand/kWh (approx. 0.02 US$/kWh). For this reason, energy wastage is widespread. On the other hand, the major cities, which have been growing quickly in recent years, are increasing South Africa's energy consumption. »We can expect that, due to good economic prospects, the electricity demand will also rise by 4.2 % per year in the long term,« confirms Angelika Wasielke, a project worker with the GTZ. Despite this, Eskom has not connected any new power stations to the grid in the past few years. Added to this is the fact that the power grid is more than 60 years old in some parts, and has to deliver power over great distances. South Africa is thus faced with three problems:

- In terms of CO_2 emissions, the country stands 15th highest in the international rankings. However, the Republic did enter into the Kyoto Protocol in 2002, and is striving to reduce its environmental pollution through greater energy efficiency and the expansion of renewable energy sources.
- Its high electricity consumption leads to an excessive demand on the electricity grid, and above all to electricity blackouts during peak loads. In metropolitan areas such as Johannesburg or Cape Town, for example, traffic light failures regularly lead to chaos on the roads. Hospitals have resorted to emergency generators, and industry sometimes comes to a standstill. This also damages South Africa as a land for investment, says Dieter Holm from the International Solar Energy Society (ISES), an NGO which has been campaigning on an international level for the establishment of renewable energy sources since 1954. Holm has been living in South Africa since the seventies. »If the investors and large production firms such as BMW and Mercedes cannot rely on a secure infrastructure here, eventually they will simply turn their attention to other countries,« he explains.
- Added to this is the problem of insufficient electrification in rural areas. Electrification has been expanded in recent years: Whilst in 1994 only one third of households had access to an electricity supply, by the end of 2006, according to data from the GTZ, this figure was already up to 72 %. However, 3.4 million households were still without power at this time. The hardest hit in this respect are the poor classes in the townships and rural provinces. According to the German development bank KfW, which has supported local electrification projects, around 70 % of rural households in the Eastern Cape province, for example, still have to get by without electricity. The main reasons for this are the distance to the grid, the small amount of power used by the few, mostly private households, and their limited capacity to pay for power.

Green energy: 10,000 GWh in 2013

As early as 1998, the South African government submitted the White Paper on Energy Policy, which determined that renewable energy sources were to be developed. In November 2003, the country cemented these plans with the »White Paper on the Promotion of Renewable Energies and Clean Development«. This speci-

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Waterfront of Cape Town: Sunshine is one of the greatest resources in South Africa.

Area:	1.2 million km²
Capital:	Pretoria
Inhabitants:	about 47 million
Real annual growth rate (2006):	4,5 % (est.)
Per capita gross national product GNP (2006):	US$ 13,300
Average solar radiation level:	1,640 – 2,640 kWh/m² per year
Main energy source:	coal
Share of renewables in primary energy:	about 9 %
Cumulative installed PV capacity (end of 2007):	12 MW_p
Targets for renewables:	10,000 GWh by 2013, approx. 4 % of the electricity demand by 2013
Price per kilowatt hour of electricty	
for private households (2006):	approx. 0.40 Rand/kWh (0.06 US$/kWh)
for industrial consumers (2006):	approx. 0.14 Rand/kWh (0.02 US$/kWh)
No access to electricity supply (end of 2006):	3.4 million households

Key figures of South Africa

Source: CIA / EuPD/ own research

fies that the use of renewable energy sources – wind, solar power, biomass, hydropower, solar thermal water heating and the use of biomass fuels – should be expanded to 10,000 GWh by 2013. Additionally, it proposes the creation of financial incentives and regulative frameworks for renewable energy sources. One aim, for example, is to draw up suitable price and tariff structures in order to ensure fair competition. Furthermore, it cites the creation of standards and guidelines for renewable energies. »A strategy paper for implementation was announced for 2005. The introduction of a feed-in tariff was also discussed in this context. Up to now, however, nothing has been published or concluded,« reports Wasielke from the GTZ. Nevertheless, in 2005, the Department of Minerals and Energy (DME) submitted a programme of renewable energy source funding for the first time. It is operated by the Renewable Energy Finance and Subsidy Office (REFSO), set up especially for this purpose. The programme envisages one-off capital grants from the government between 2005 and 2008 for renewable energy projects with a capacity of more than 1 MW, or a corresponding value in litres for biofuels. The funding can offer up to 20 % of the investment, which is not allowed to exceed Rand 1 million (approx. US$ 146,000). In the 2005/6 finance year, however, only a very small proportion of the Rand 4.5 million (approx. US$ 661,000) which had been made available for the project, could be distributed. This was due, according to the GTZ, to administrative reasons. In the 2007/8 finance year, the project is to continue with a budget of Rand 14.2 million (approx. US$ 2 million).

The market needs clarification and a feed-in tariff

Thus, with the White Paper, the South African government set out their energy goals, but the funding programmes have so far been insufficient. »I expect that the rising oil and electricity prices and the common blackouts will eventually lead to a rude wake-up call for the South African population and government. By this point, we may have to purchase the necessary technology at a high cost from Europe, because we need it in a hurry and have missed the chance to develop and produce it ourselves in time,« warns Holm. In his presentation on the South African solar market at the Africa/Middle East Renewable Energy Summit in Cairo in November 2007, Holm also stressed that the information available and the awareness of renewable energy sources amongst the public urgently need to be improved upon. He hopes to push on further with the establishment of renewable energy sources with the ISES Solar World Congress 2009, which will take place in Johannesburg.

In cooperation with the Sustainable Energy Society of Southern Africa (SESSA), the ISES, according to its own data, is also pushing ahead with the introduction of a feed-in tariff. »The future of photovoltaics in South Africa depends on the introduction of a feed-in tariff,« says Holm. Gregor Küpper, managing director of Solarworld Africa, sees the situation similarly: »Only when a feed-in tariff is introduced, or a usage obligation for public buildings is passed, will the market be able to grow with greater strength.« At the moment, however, no fundamental change of direction is expected to come from the side of the government. President Thabo Mbeki, after two terms in office, is not able to stand for presidency again in the 2009 parliamentary elections. His designated successor Jacob Zuma, however, has not yet announced any decisive changes of economic policy.

The FIFA World Cup as a chance

In the run-up to the FIFA World Cup 2010, South Africa faces the challenge of making the electricity supply more reliable, whilst at the same time satisfying the sharply rising demand. Up to now, the Republic has concentrated most of its efforts on expanding conventional energy sources. The existing coal power stations in particular should, according to those in charge, be modernised and subsequently expanded. In addition, there are plans to build more conventional power stations, confirms Annette Langhammer, South Africa expert from KfW. As to what significance the upcoming football World Cup in 2010 will have for a sustainable energy policy in South Africa, opinions are divided. It is clear, however, that the publicity brought about by this sporting mega-event will draw attention to the region and its problems of infrastructure. There are many views on how this platform could be made useful for the country's own economic, ecological and political goals.

For the time being, however, most companies do not believe there will be an explicit promotion of solar energy in conjunction with the FIFA World Cup. »Up to now, the government has not indicated any measures in this regard which will affect the solar energy market. But I am sure that, through the World Cup, people will become more aware of the increasing insufficiency of the electricity supply, and of global warming, and that more of them will take an interest in alternative energy sources,« hopes Colin Mackay, founder of the South African solar company Cmac Power Solutions. Floris Bonthuys from the firm Lumentech in South Africa takes a similar view: »We should use the World Cup as a platform to make the world aware of the potential of the sun in our country.« The German solar manufacturer Solarworld, for example, plans to set up so-called Sun TV during the World Cup. In 100 South African villages, the games are to be shown on theft-proof solar-powered screens underneath solar sails. »In the same way that other people go to the cinema, these villagers will be able to follow the games and partake in the World Cup. Our plans have already been very well received by football greats such as Oliver Bierhoff,« reports Frank Asbeck, chairman of the board at Solarworld. This is a chance to improve the image of photovoltaics. Solar energy has great potential in South Africa, and expertise in the country is currently being pushed forward. However, in order to develop this potential accordingly, the photovoltaics and solar thermal industries need the active support of the South African government and the local electricity suppliers.

Verena Vorwerk

Verena Vorwerk works as a journalist with the German media service provider Europressedienst (EuPD), which specialises in renewable energies.

Further information:
Central Energy Fund: *www.cef.org.za*
Department of Minerals and Energy: *www.dme.gov.za/energy/renewable.stm*
Sustainable Energy Society of Southern Africa (SESSA): *www.sessa.org.za*
International Solar Energy Society (ISES): *www.ises.org*

»In African terms, PV is extremely expensive«

Cheap electricity and high investment costs for renewables are the main obstacles for the fast development of solar technology in South Africa, argues John Ledger, chairman of the Sustainable Energy Society of Southern Africa (SESSA). However, the price of electricity is expected to rise rapidly over the next few years.

Dr. John Ledger, chairman of the Sustainable Energy Society of Southern Africa (SESSA)

Photo: SESSA

S&WE: *How would you describe the differences of the South African solar thermal market in contrast to the photovoltaics market?*

Ledger: The photovoltaics market is restricted to off-grid applications such as remote schools, farms clinics and communities. There is also a market for photovoltaic installations in game lodges and game farms. The only big projects are those driven by government or foreign donors. In the past, some of these were characterised by corrupt procurement procedures. All the South African installations use battery storage, making these systems very expensive. South Africa has the cheapest electricity in the world (0.38 to 0.42 rand/kWh in Johannesburg) and photovoltaics do not make economic sense in any areas served by the grid. There is also a perception among many rural communities that photovoltaic electricity is inferior to grid electricity from Eskom, the national electric utility.

The solar thermal market has also been constrained over the years by cheap electricity, a very strong plumbing industry with vested interests in replacing failed electric geysers with new electric geysers, and the latter underpinned by a home insurance industry that is wedded to electric water heaters.

S&WE: *What are the main problems and advantages of the solar thermal development for rural and urban areas?*

Ledger: Some problems have been raised under the first answer. Main advantages: South Africa has abundant sunshine. Despite cheap electricity and Eskom's market leadership, the Republic has run out of power plant capacities. The price of electricity is expected to rise rapidly over the next few years as Eskom seeks to raise revenue to build new power stations. An increase of 18 % has been requested by Eskom; however, the National Energy Regulator has suggested that 14 % is more reasonable. So electricity will become more expensive for all South Africans, rural and urban, and solar thermal correspondingly might become more attractive. With electricity shortages, Eskom is applying rolling blackouts; people with solar thermal systems will have hot water more often than those who do not. For people in rural areas with no access to grid electricity, solar thermal is the best way to supply hot water.

S&WE: *And what about the pros and cons of photovoltaics – especially regarding the low electricity prices?*

Ledger: Photovoltaic electricity is simply too expensive and cannot compete with grid power in South Africa. There are no advantages for PV in urban areas, other than for security against rolling blackout – even then, it is more economical to have a mains-charged battery system for standby rather than a PV system. Applications are mainly remote farms and settlements far from the grid. The sustained demand for PV from countries like Germany where the feed-in law has resulted in a huge expansion of the industry has meant that demand for PV exceeds production and prices remain very high. In African terms, PV is extremely expensive.

S&WE: *How are the South Africans accepting the development of solar energy and what role does SESSA play?*

Ledger: There is a growth in interest about solar energy, especially as more people are exposed to power cuts, which never happened in the past. SESSA has been in existence since 1964, and has done its best to pro-

The largest PV plant in the country: Three years ago, the oil concern BP installed an 86 kW_p PV plant in Cape Town.

Photos (2): BP

mote renewables. However, renewable energies has been a very specialised field in South Africa. There has been little or no government support until recently.

S&WE: *So what is new in terms of governmental support?*
Ledger: The South African government has produced a White Paper on renewable energy and set certain targets which, in the opinion of many, are very modest. Support in the form of municipal by-laws requiring solar water heating on new buildings would make a big difference. The City of Cape Town is developing such a by-law, and it is expected that other municipalities will do so in due course. Most countries that have experienced major PV take-up are those that have introduced a feed-in tariffs. This means that consumers do pay more for electricity. South Africa's economy is very sensitive to the electricity price, and in economic, social and political terms we are living on a knife-edge. Very high rates of unemployment result in high crime rates which affect consumer and investor confidence. Any increases in electricity costs that result in unemployment in any sectors of the economy are dangerous for South Africa. In summary, the South African government is unlikely to introduce measures to improve uptake of solar energy if it will result in an increase in the cost of electricity.

S&WE: *So you think that a feed-in tariff like in Germany or France may not be introduced in South Africa?*
Ledger: It is unlikely in the short term, although more likely in the medium term. The imminent expansion of the solar thermal domestic market through the introduction of an incentive programme by Eskom is good news. Eskom also has firm plans to build a 100 MW concentrating solar power plant in the central part of the country. Although a lot of talk is going on about »Greening the World Championship«, this is unlikely to involve any significant PV installations. Most large businesses in South Africa are installing standby diesel generation plants to secure themselves against Eskom blackouts. It seems that the soccer stadiums will also be fitted with emergency generators.

The interview was conducted by Verena Vorwerk.

Photovoltaics – its poor reputation in South Africa

Getting photovoltaics off the ground in the Rainbow Nation has proved a tough task up to now. Problems arise due to high rates of criminality in the country, and negative experiences. A few companies have nevertheless specialised in a particular type of photovoltaic installations, thus filling a hole left by conventional energy suppliers.

South Africa exemplifies the fact that the best opportunities for using photovoltaics are not only to be found in the installation of large-scale plants. Rather, the chance for solar energy in Africa's southernmost country lies in recognising and compensating for the weak points of the local electricity supply. In Cape Town, for example, photovoltaic systems have been put to the test. All eight traffic lights at a busy crossroads were equipped with electricity supply modules. These ensured the normal operation of the traffic lights, even during the common blackouts which the country experiences during peak loads, and thus guaranteed the trouble-free flow of traffic. Barry Bredenkamp, project leader at the National Energy Efficiency Agency (NEEA), the organisation responsible for increasing energy efficiency in South Africa, was thrilled with the results: »These kinds of traffic lights are important for our country, and their use should be more widespread. As well as the obvious advantage of improved safety for road users, the solar-powered traffic lights are more environmentally friendly, and they also take some of the strain off the power grid. However, up to now, such projects have only been carried out in individual cases.« Photovoltaic systems which are not connected to the grid are deployed most frequently in hospitals and schools, in order to allow work to continue unaffected in case of blackouts.

Another tailored solution is provided by Solar Home Systems (SHS). These are small stand-alone photovoltaic systems installed in homes, hospitals or schools that cannot be connected to the public grid because they are too far away. In order to increase the low level of electrification in rural areas, the Integrated National Electrification Programme (INEP), overseen by the Department of Minerals and Energy (DME), has been underway since 2001. This programme intends to provide an electricity supply to every household by 2012. Alongside international donors, the government finances the programme through its National Electrification Fund. According to the German Agency for Technical Cooperation (GTZ), in the 2005/6 financial year the budget stood at Rand 1.2 billion (approx. US$ 176 million). This was enough to connect up to 150,000 households, 500 schools and 28 clinics. Almost Rand 60 million (approx. US$ 8.8 million) went into supplying households via Solar Home Systems, according to the GTZ. The government began its National Electrification Programme using SHS as early as 1999. It aimed to install a total of 350,000 photovoltaic systems, each with a capacity of 50 W_p, in remote households. The programme specified that one private license holder should be found in each of seven regions of South Africa via a call for tender. The license holder was to install and look after the SHS, as well as to retain ownership of them. Up to 80 % of the investment costs for an SHS were covered by grants of Rand 3,500 (approx. US$ 513). The KfW, for instance,

Preparations for the FIFA World Cup 2010 in South Africa: The German PV manufacturer Solarworld can envisage installing solar sails for television screens in 100 South African villages for the mega event.
Photo: Solarworld

made a contribution of € 15.9 million (approx. US$ 2.33 million) to the investment costs for 27,000 SHS in the regions of Eastern Cape and North West Province. The remaining costs are meant to be covered by monthly fees of Rand 58 (approx US$ 8.50). The government pays Rand 40 (US$ 5.80) of this amount in almost all regions so that the poor rural population can also take advantage of the electricity which has been made available.

The Cape of Good Hope has a positive ring to its name, but a poor reputation owing to the thousands of boats which have sunk here over the centuries. Photovoltaics is in a similar situation. The South Africans have not always had favourable experiences with this technology.

Photo: Matthias Kniese

The only PV plant on the continent: The French group Tenesol has been producing PV modules in South Africa since 1999.

Photo: Tenesol

Photovoltaic modules: a prize loot

At this point, however, the allocation of licenses has almost been discontinued, criticises Dieter Holm from the International Solar Energy Society (ISES), which campaigns for the use of solar energy in South Africa. »Establishing photovoltaics in the countryside is simply problematic.« This was also the experience of the first license holder, the joint venture Shell-Eskom. In an initial phase, it set about establishing electrification for 6,000 households in the Eastern Cape province. According to the GTZ, only 4,700 of the 6,000 Solar Home Systems were still in operation in 2002. The problems which emerged included unwillingness to pay for the electricity, but the common instances of theft were the main issue.

For despite the efforts of the government to counter these problems, South Africa has one of the highest crime rates worldwide. One reason for this can be found in the large gap which separates the rich population in the towns and cities, and the poor in the townships and rural areas. Photovoltaic modules have proved rich pickings for thieves. Systems that were not adequately secured upon installation are removed from traffic lights, telephone installations, and even roofs of houses. »The modules are sold in neighbouring countries such as Namibia and Mozambique. Photovoltaic products are better known there, and they attract a higher price,« suspects Holm.

No trust in photovoltaics

Another problem faced by photovoltaics in South Africa is its image problem due to the first phase of the Solar Home Systems programme, explains Holm. »At the beginning, many faulty modules were installed, or repairs were not made after the modules had been damaged. This weakened people's trust in the photovoltaic systems.« In addition, many South Africans associate SHS with poverty and isolation, as the initial intention and funding was aimed primarily at households which could not afford a connection to the electricity grid. »Solar energy is often considered second best, because the people living in the countryside see connection to the grid as a step forwards,« confirms Rafael Wiese, head of the Office for Rural Electrification at the German Solar Energy Federation (BSW-Solar), which supports the electrification of rural areas in developing countries. »An energy feed act should have been decided upon when the SHS were first introduced. Then the rich would have taken an interest in photovoltaics too, and it wouldn't be synonymous with poverty, as it is for many people now,« says Holm.

Installers as wholesalers

In 2007, according to data from the GTZ, the total installed photovoltaic capacity stood at only 12 MW_p. Expert opinions are divided as to the rate at which new capacity has been added in previous years. By way of example, the building of the BP headquarters in Cape Town has been equipped with a 68 kW_p system, the largest grid-connected photovoltaic installation in the continent, since 2004. The company itself is not active in South Africa's photovoltaics market, but it has made itself an example as a user. Janet Moss, spokesperson for BP South Africa, explains that the system is part of an all-round concept for the building which puts energy efficiency and sustainability in the foreground.

Companies wishing to promote the establishment of renewable energy sources in the country have joined forces in the Sustainable Energy Society of Southern Africa (SESSA). The chairman of the society, who also supports the establishment of photovoltaics, is John Ledger (see interview on page 110). It is stand-alone systems which have generated the most sales in the country up to now. Installation of Solar Home Systems is a crucial pillar of the company Cmac Power Solutions CC, for example. »In addition, we supply photovoltaic electricity to holiday homes and safari lodges,« reports managing director Colin Mackay. The firm Omnisolar has also specialised in serving customers who cannot be connected to the electricity grid, or do not wish to be dependent on it. »We mainly deliver photovoltaic systems to farms, schools and clinics,« explains Koos Alberts from Omnisolar. Like most installation companies in South Africa, Omnisolar is also in the wholesale business and, just like the inverter manufacturer Lumentech, already has around ten years of experience in the solar industry in South Africa. Finding enough specialised staff is no problem for the local companies. »Either there are enough qualified personnel available, or we can train the employees ourselves. However, we do rely on an exchange of expertise with experts from Germany or Switzerland when it comes to installing large-scale systems,« says Floris Bonthuys, founder of the solar company Lumentech. The cooperation between Lumentech and Solarworld testifies to this situation. The German company has taken over the Shell branch offices in South Africa, and is currently setting up its office in Cape Town. »In South Africa, we mainly sell modules with a capacity of 50 to 80 W_p for special solutions such as the Solar Home Systems or telephone transmission towers,« reports Gregor Küpper, managing director of Solarworld Africa. The French

module manufacturer Tenesol, which founded a branch office in South Africa as early as 1996 under the name Tenesa, does not restrict itself to just sales. Since 1999, the company has been producing photovoltaic modules locally. Tenesa has now reached an annual production capacity of 60 MW_p. However, the company exports 95 % of what it produces, and only 3 % is intended for South Africa, primarily for supplying electricity to telephone installations. The other 2 % is sold to neighbouring countries. »South Africa is attractive for us as a location because the labour costs are lower here. On top of this, the cost of exporting to Europe makes up just 1 % of the entire production budget. This does not affect the quality of the modules,« explains Jaques Lafosse, managing director of Tenesa.

The market is still too small

Not all foreign companies, however, take such a positive view of investing in South Africa. Holm from the ISES believes that the Black Economic Empowerment Act is one of the reasons for this: »Foreign and experienced companies often shy away from projects in South Africa because here they are obliged to fulfil certain requirements of this law, and to employ a certain proportion of black workers, who may not be sufficiently qualified.« This is confirmed by Alberts from Omnisolar: »Installers and companies which do not fulfil the policy requirements are excluded from large-scale projects.« For some companies, on the other hand, the South African market is simply still too small. The complete system supplier Sanyo, for instance, does have a branch office in South Africa, but has not yet generated any sales volume to speak of: »Last year, in the whole of the African continent, our sales amounted to a total capacity of 2.5 MW_p. In South Africa, our systems are mainly to be found on schools and hospitals,« explains Win Kurzyca from Sanyo SA. The Japanese module manufacturer Sharp has also restricted its activities to observation of the market up to now. »The South Africans are only just getting familiar with renewable energy sources. It does not seem to be clear whether photovoltaics and wind power will find a place in the energy mix of South Africa in the near future. The South African market has therefore not been a focus of attention for us so far,« says Karim Asali, marketing coordinator of the Solar Systems Group at Sharp Europe. The German company Solar-Fabrik has gone so far as to withdraw from the South African market altogether. The reason given by Andrea Ocker, spokesperson for the company, is that the market is predominantly open to stand-alone systems, whilst Solar-Fabrik specialises in grid-connected systems: »We came to South Africa very early on, in 1999, and have participated in a variety of pilot projects. These projects made it clear that the SHS, above all, require different development concepts for use in different countries, and this did not correspond with the way our company is specialised.« The photovoltaics market in South Africa is thus still in its infancy. It remains to be seen whether sufficient funding will be introduced by the government in order to accelerate the development and actually make use of the plentiful resource provided by the sun.

Verena Vorwerk

Further information:
National Energy Efficiency Agency (NEEA): *www.savingenergy.co.za*
Department of Minerals and Energy: *www.dme.gov.za/energy/renewable.stm*

Photovoltaic companies:
www.bp.co.za
www.cmacpower.co.za
www.lumentech.co.za
www.solarworld-africa.co.za
www.tenesol.co.za
www.sanyosa.co.za
www.omnisolar.co.za
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www.kgelectric.co.za
www.mltdrives.com
www.solarite.co.za
www.willard.co.za

Solar thermal energy awakens in South Africa

Solar energy has been used to heat water in South Africa since as early as the mid-seventies. Some companies are already established on the market. It is only in recent years, however, that standards for solar systems and installer training have been introduced. The government has recognised the advantages offered by solar thermal energy. Large-scale projects are in the pipeline.

Ready for market growth: freshly trained solar installers in Johannesburg
Photos (2): John Ledger

Solar thermal collectors for water heating are still a rarity. Those which do find buyers are unglazed solar absorbers which can be used for solar-supported swimming pool heating, and in these cases the users are predominantly from the affluent sections of society. The market for glazed collectors for domestic water heating on the other hand, which could relieve a decisive load from the overstrained electricity grid, is still only developing slowly. In spite of this, South Africa is home to numerous firms, some of which possess over 20 years experience in the field of solar energy systems. Atlantic Solar, for instance, with its two managing directors Henry Hoy and Helmut Hertzog, has an equal presence on the market as a manufacturer, dealer, and installation company. The firm reports having installed more than 3,000 solar heating systems in recent years in the area around Cape Town. Tertius Lindenberg, too, whose company produces solar cylinders and solar absorbers under the name Solardome SA, has already been in the business for several years. »We mainly supply to private households,« reports Lindenberg. Divwatt Ltd. from Johannesburg also offers products it has developed itself. Not long after founding the company in 1993, those in charge set about developing a solar-powered water pump as part of the Solastar project. The final product, the submersible Solastar water pump, was made market ready after a development and construction phase of just two years, and was promptly named »Product of the Year« by the Institute of Engineers. Restor Africa does not offer its own technology, but it markets quality products from nearby countries. As a sales agent for the Australian firm Edwards Hot Water, Restor Africa sells solar-powered hot water systems for households of three to nine persons. It also offers commercial solutions, however, with collector surfaces of up to 120 m^2.

Heightened interest in solar thermal energy

Foreign suppliers also appear to be taking an ever-increasing interest for the solar thermal market in South Africa. The large German solar thermal suppliers, for instance, are still keeping a low profile in South Africa for the time being, but John Ledger, Chairman of the Sustainable Energy Society of Southern Africa (SESSA), which campaigns locally for the establishment of renewable energy sources, expects to see growing interest (see interview on page 110). In his view, the rising membership figures of the solar water heating branch of SESSA alone give a clear message. »Whereas we had only 12 members in the solar water heating branch at the start of 2007, there are now around 50.« This may also be attributed to the initiatives of the energy supplier Eskom. According to Ledger, the energy giant Eskom is expecting a market for 900,000 solar water heaters within the next five years. »This would provide a huge impetus for the SWH industry. In anticipation of this market growth, many suppliers are now preparing to enter into the South African market. These include European companies such as Schüco and Sonnenkraft from Germany,« says the society chairman. According to Ledger, Solahart and Jacques Giordano from France have also been active in South Africa for several years.

The awakening interest of the South African government in giving greater consideration to solar thermal systems as a resource in the future can be explained, once again, by the country's ramshackle infrastructure. The government hopes that the use of solar water heaters will, in a similar way to photovoltaics, bring lasting relief to the power grid during peak loads. In addition to the medium-term plan of attaining the country's climate-protection targets, the short-term aim is to pro-

Solar training: Students from the university in Witwatersrand visit a solar demonstration project.

vide a more stable electricity supply in order to reduce the frequency of nationwide blackouts. The government has already initiated its first projects.

Isolated solar thermal projects in the townships

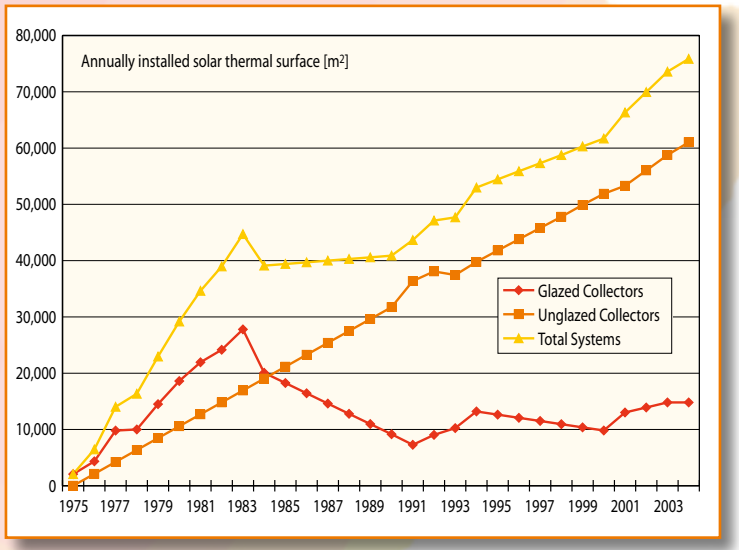
The project »solar water heaters for low-income housing in peri-urban areas« has been guided by the Central Energy Fund (CEF), a company run by the Department of Minerals and Energy, since March 2007. This project is aimed primarily at low-income households, and, as well as state funding, is concerned with establishing uniform standards in the solar thermal sector and improving the training of installers. After carrying out a detailed market analysis and developing new standards for collector manufacture, it also aims to improve installer training. Ledger explains why: »Up to 2007 there was not a single test laboratory for solar water heaters in South Africa, even though a standard for such systems (SABS 1307) had already been developed some time before. Yet, in addition to the consumers, the insurance companies and town authorities in particular have now begun to demand that solar installations bear a label from the South African Bureau of Standards (SABS).« Up to this point, however, Ledger continues, only one supplier has actually received this test label.

500 solar power systems were then installed in the practical phase of the project, primarily on new buildings. The average cost of these systems was between Rand 10,000 and 20,000 (approx. US$ 1,440 and US$ 2,880). »166 solar water heaters were maintained in each of the three provinces. The state funding amounted to between Rand 3,000 and 6,000 (approx. US$ 440 and US$ 881) per unit, depending on its size and the date it was purchased,« says Nadia Moosa, project manager at the Energy Development Corporation, a division of the Central Energy Fund (CEF). Another 9,000 systems are now to be installed in the second phase of the project. The CEF is planning follow-up projects in Port Elizabeth, too, notes Ledger. In addition to this, another 2,300 systems are to be installed in Cape Town. Discussions are still underway in Cape Town regarding a possible obligation to equip new buildings with solar water heaters as standard.

Solar thermal energy is also being used ever more frequently on public buildings. The trade chain Woolworth, for instance, has 30 solar panels for water heating in operation on a branch outside of Johannesburg. Dieter Holm from the International Solar Energy Society (ISES), which also campaigns on an international level for

Smart architectural solution: solar shower with a vacuum tube collector planned by the South African company Omnibus Engineering

Photos: Omnibus Engineering



Break in 1985. A chilly night disturbed a big number of thermosiphon systems in South Africa. Since that time the market segment of glazed collectors never exceeded the 20,000 m² level. *Source: Dieter Holm*

the development of solar energy, sees advantages of solar thermal energy over photovoltaics in that the energy produced can be easily stored, and that it has a better image, since it is already being used by the well-off South Africans. Furthermore, the SABS standards have already been determined for solar thermal energy – but not yet for PV systems.

Verena Vorwerk

Further information:
Sustainable Energy Society of Southern Africa (SESSA):
www.sessa.org.za
Department of Minerals and Energy:
www.dme.gov.za/energy/renewable.stm
South African Bureau of Standards (SABS): *www.sabs.co.za*

Solar thermal companies:
www.atlanticsolar.co.za
www.allpower.co.za
www.divwatt.co.za
www.its-solar.com
www.restor.co.za
www.solardome.co.za
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»It is not easy to be a manufacturer«

PV expert Paula Mints is the principal analyst of the »PV Service Programme« with the U.S. American market research firm Navigant Consulting, the executive editor of the Solar Outlook Newsletter, and an associate director in Navigant Consulting's Energy Practice. Her clients include government research organisations, photovoltaic technology manufacturers, start up organisations and investors. Paula Mints studied literature and business and earned an MBA at San Jose State University in Kalifornia.

Photovoltaics is her life. »I do this, seven days a week 365 days a year«, says Paula Mints and laughs. She loves what she is doing, this becomes clear when talking with her. She is devoted to her clients and devoted to the PV industry, the study of which has been a significant part of her life for ten years now. Paula Mints is the principal analyst for the »PV Services Programme«, a market research practice at Navigant Consulting. Navigant Consulting Inc., is a U.S. based consulting organisation with a wide range of disciplines and a strong renewable energy department.

Mints began researching the PV industry at the market research office Strategies Unlimited in 1998, working with Bob Johnson, who was at that time Vice President of the Strategies' photovoltaic programme. When Paula joined the Strategies' practice, Bob Johnson already had thirty years experience in the photovoltaics industry. After his retirement in 2002, Mints took over the »PV Services Programme« and moved it over to Navigant in 2005. *S&WE* spoke with her about her work and the trends in the PV sector.

S&WE: *Ms Mints, you analyse and forecast the global PV markets. What is your approach?*

Mints: My specific focus is the shipment of cells/modules from the technology manufacturer to the first point of sale in the market. That means I survey 100 % of the supply side, which is not so hard to do, because the photovoltaics industry is still fairly small, I am looking for what was shipped into the market. I count technology sales to the first point of sale in the market – whatever that point is. The double check is the demand side. The market research discipline requires primary survey of the supply and demand sides of the market you are studying, all along the value chain from raw material through to the end user. The demand survey, which covers the PV industry globally, takes about six months. For the 2007 calendar year, my colleague Dan Tomlinson and I began survey work in November 2007, and will not finish until May.

S&WE: *So you do not rely on data of industry associations or other researchers?*

Mints: Market research is based on primary data not on secondary data, that's why I cannot consider the analysis of others in my own work. I actually have to stay away from looking at other reports, so that nothing confuses my perspective and takes me out of being objective. The »PV Services Programme« started in 1974, so I have price, cost, and shipment data from the beginning of the program to the current day. As you can imagine, this is a detailed and valuable database.

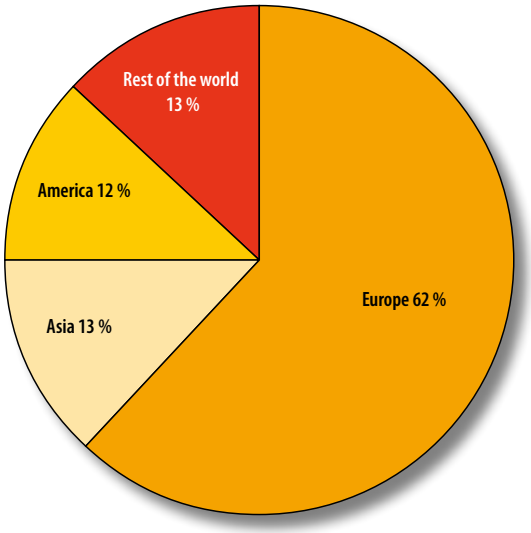
S&WE: *So you follow each cell and module on its way around the globe?*

Mints: Typically, we email, telephone or fax each demand and supply participant for their information. We make responding to our surveys as easy as possible for our survey partners, and also promise the demand side survey participants complete confidentiality. The demand survey backs up the supply survey. I work very hard to factor out double shipments – modules and cells move around a lot in this industry – so that I can accurately characterize the size of the market.

S&WE: *For what reason do industry or wholesale give you their confidential business information?*

Mints: On the demand side, they answer me, because I never release their specific information and they trust me not to do so.

On the supply side it's a bit different. You only survey once or twice a year and at that point I ask the manufacturers specific detailed questions and I give them a copy of the newsletter that comes out at the beginning of the year about the shipment.



PV demand 2010 in different continents: Europe still dominates the world market thanks to the feed-in tariffs in Germany, Spain, Italy, France and Greece. The pie chart is based on the figures of the table. It shows the conservative scenario with a total of 6,873 MW_p

Figure: S&WE; Source: Navigant Consulting

Countries	2010 industry demand conservative estimate	2010 industry demand accelerated estimate
Germany	2,813	3,550
Japan	494	561
US	850	1201
Spain	699	1120
Italy	560	728
Greece	82	121
France	120	168
China	111	144
South Korea	148	157
India	165	259
Rest of the world	831	1,313
Total	6,873	9,322

Amount of PV technology shipped into various PV markets in 2010 [in MW_p]. These figures are estimates (state: beginning of January 2008). The official forecast of Paula Mints will be ready by February this year.

Source: Navigant Consulting

S&WE: *So how many PV modules have been shipped in 2007 globally according to your estimation?*
Mints: Before I begin my analysis, I also have to have a good idea of raw material availability, and I am highly confident in my raw material numbers. The survey is not yet done but I have a fairly good idea. It was in the area of 2.9 GW_p. In 2007, thin films will likely have about 12 % shipment share.

S&WE: *And what about the German market?*
Mints: At that point today I can only give you a rough figure, since the demand survey just started in November. The German market lies between 1.2 or 1.5 GW_p in 2007.

S&WE: *What is your estimation for the U.S. market 2007?*
Mints: I am surveying for this now and so, am not truly prepared to give you a good answer. However, my forecast for 2007 was between 292 and 326 MW_p. I expect it will be about 300 MW_p given early returns.

S&WE: *Is it possible for the U.S. to continue experiencing accelerated growth if the federal investment tax credit is not extended?*
Mints: Probably not. The federal tax credit is very important – especially for big fields. But there will be a fight to bring up new legislation this year – problematic as it is an election year.

S&WE: *How are the prices developing on the U.S. market?*
Mints: Modules prices are flat right now. My average price in the U.S, based on returns from the market is 3.20 U$$/W_p for large buyers and 3.65 US$/$W_p$ for power module buyers. Smaller buyers pay close to 5.00 US$/$W_p$.

S&WE: *You often remind the industry that PV is an incentive driven market. What is your advice to the industry?*
Mints: I have a lot of conversations with people in and out of the industry on this subject. If the incentives go away, you will see an immediate shrinking of demand with obviously consequences: There will be expensive inventory, expensive overcapacity and extremely low module prices.

S&WE: *The Chinese PV industry shows the most rapid growth. How do you assess its influence in the years to come?*
Mints: I think that Suntech will be a force.

S&WE: *Which role will the national Chinese PV market play in the future?*
Mints: The Chinese market is problematic. It has a huge potential – probably a stronger potential for off-grid than for on-grid, but the government needs to offer an aggressive incentive program in order to build a market to match its industry.

S&WE: *In 2006 you calculated an average utilisation of capacity of 61 % in the global PV market. Is this a healthy situation?*
Mints: The PV industry has had, at times, high utilisation of its manufacturing capacity. Probably 80 % to 85 % would be quite healthy. But there are many factors that influence a manufacturer's decision to increase, or not increase, capacity. Examples are continuing raw material constraints, demand issues, the cessation or beginning of government incentive programmes, and government support in general. It is not easy to be a manufacturer. ✹

The interview was conducted by Bärbel Epp.

* Mid-December 2007 the U.S. Senate fell one vote short of extending the solar tax incentives from the end of 2008.

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The KAI 1200 PECVD unit from Oerlikon processes 20 glass substrates in one coating operation – that works out as 20 m² of module surface area.

Photo: Oerlikon

The technology: a search for the ideal approach

The production of thin-film solar cells is complex, as is shown by the development times, which sometimes last whole decades. However, some technologies are now ready for mass production. Largely responsible for that are the process equipment suppliers. Opinions are divided as to the ideal substrate size.

Centrotherm spokesman of the board Robert Hartung is a pragmatic thinker: »Not many thin-film technologies have yet become economically relevant. That's why we're concentrating on CIGS technology for the time being.«

If an industry expert is asked about the mega trend in photovoltaics which defies all short-term currents, the answer that is bound to follow is: Everything is getting bigger. Indeed, the solar cell has been growing steadily and continues to do so today. However, whilst the development is clawing its way along inch by inch with crystalline technology – today's standard silicon cell has an active surface area of exactly 0.024 m^2 the dimensions are in another category with thin-film technology. Here, the amount added by each new generation measures by the square metres – at least in the case of some suppliers of amorphous or micromorphous silicon technology. There is some debate around this question, however, which will be explored later.

The technological leader in large formats is Applied Materials (Amat). This is not a matter of chance: The Californian company was founded 40 years ago as a supplier for the semiconductor industry, and acquired Applied Films for half a billion US$ in 2006, a specialist in flat-screen displays and coating processes. In turn, Applied Films had incorporated shares of Leybold AG in 2000 – essentially for the large surface coating technology which had seen an enormous upsurge since the 1980s due to the development of flat-screen displays.

Large surface coating technology is in the eighth generation now, according to the industry's own count. Specifically, this means that coatings up to a substrate size of 5.7 m^2 are possible. The process of choice is plasma PVD (Physical Vapour Deposition) – deposition sputtering or vaporisation from the gas phase. Applied Materials technical director Winfried Hoffmann calls it a »whirlwind development«. The next generation is already knocking at the door: Substrates of 10 m^2 have apparently already been coated in the U.S..

The manufacturing process for the flat-screen displays is largely equivalent to that used in photovoltaics. The 3 mm thick flat glass substrates are first cleaned and then fed into the 120 metre long sputtering system. The TCO (Transparent Condensat Oxide) layer, which has been specially adjusted for the micromorphous layer, is applied before the photoactive layers made of amorphous and micromorphous silicon. Finally, several lasering steps separate the active layer into cells and manageable modules. »This is carried out according to customer specifications,« says Hoffmann, who can imagine his large modules being used in ground mounting systems and architectural applications. Amat has already sold eight production systems in 2007. The buyers include Moser Baer from India, T-Solar Global from Spain, and Sunfilm from Saxony, Germany. The investment costs for these systems – without the building – stand somewhere between € 100 and 200 million. All of these lines with annual capacities of 40 to 80 MW_p produce a substrate measuring 5.7 m^2 – big is beautiful.

Oerlikon deliberately does without large substrates

Is substrate size really the sacred cow of thin-film production? Interested customers have a genuine choice in this matter because the Swiss competitor Oerlikon is taking an entirely different path. »Our module measures 1.1 x 1.3 m^2, making 1.4 m^2. We could make it bigger, but we don't want to,« says marketing manager Jürg Steinmann. Is Oerlikon not refusing to take the ideal route towards cutting costs in thin-film production? »Certainly not,« is the confident response from Switzerland. »We have a good understanding of what is important.«

»Applied Materials comes from a background of display technology,« continues Steinmann. »Of course they know that it is basically cheaper in TFT LCD production to deposit onto larger substrates.« But what is good for display technology would constitute a false step for solar energy, think the Oerlikon strategists. »The bigger is cheaper attitude does not apply to solar thin-film production,« explains Steinmann. »Size was the key factor in the development of display technology. In order to make corresponding formats profitable, I need a substrate which is six times bigger than what the end customers will eventually find in their products.« For all intents and purposes, a basic principle of display technology is to deposit onto a surface six times larger in order to make the smaller format profitable. This manufacturing strategy is related to the possibility of particles causing pixels to fail. This would lead, according to Steinmann, to the entire display in the affected area of the coated substrate becoming unusable. It seems that, economically, the odd loss caused by an imperfection from a total of 16 % could still be dealt with.

»It's different with solar modules,« says Steinmann. »More imperfections decrease the performance of the module, but you don't get malfunctions of entire areas.« It thus seems to be a question of forcing up the coating quality as high as possible. Large substrates would bring other disadvantages, Steinmann continues: »The larger the reactor for the coating process, the harder it is to work with a high plasma frequency. Yet this is a necessity in order to get a good coating quality whilst maintaining a high deposition rate.« The plasma in a PECVD (Plasma Enhanced Chemical Vapour Deposition) reactor is not at all homogenous indeed, it is rather affected by »waves and valleys« depending on the plasma frequency, i.e. phases of lower and higher intensity. According to Steinmann, there are certain »tricks« in order to even out these discrepancies – it is no good asking for the details. In the case of very large reactors, a »stationary wave« comes about, i.e. fixed areas where the plasma quality varies, and thus areas of better and poorer deposition. »With these reactors it is nigh on impossible to effectively compensate for this.«

Because, according to Oerlikon, using very large substrates does not result in lower costs all things considered, the company is following a fundamentally different production strategy: not cost-reduction with giant substrates, but higher yields thanks to well-adapted smaller formats and increased efficiency through high-quality deposition. In order to further increase coating quality, Oerlikon therefore runs its PECVD systems with a plasma frequency which is three times greater – 40 MHz rather than the standard 13 MHz.

However, there are also experts who do not view the substrate size as a fundamental issue. Amongst them is Lars Waldmann, spokesman for Schott Solar, Germany.

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Through thick and thin…

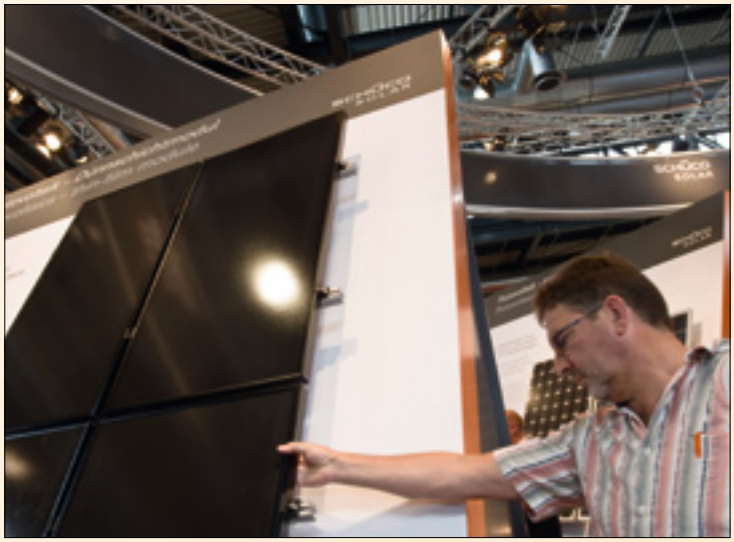
Most advanced with regard to both production technology and market penetration are the thin-film technologies: CdTe (cadmium telluride) and CIS (copper indium diselenide)/ CIGS (copper indium gallium diselenide) or a-Si (amorphous silicon as well as tandem cells made of amorphous and micromorphous silicon). These three technologies have proven, after pilot programmes lasting for years in some cases, that they can be mastered on a large scale. The difference between the production processes lies mainly in the way the photoactive layer is manufactured:

CIS/CIGS
... is subject to different approaches. It can be produced by way of co-vaporisation, i.e. by vaporising all CIS elements at the same time at high temperatures. A second option consists of applying the materials copper, indium, selenium, or sulphur as initial layers by way of cathode sputtering, pressurising or electroplating processes, and then »baking« everything together in a hydrogen selenide or sulphide atmosphere. The photoactive layer thus only crystallises during this thermal treatment with an increased substrate temperature. The CIGS process works in a similar way.

CdTe
... is accomplished using three methods: electrochemical deposition, application of paste followed by sintering, and thermal vaporisation. The most common method, which is also used by the commercially-relevant manufacturers, is thermal vaporisation over a short distance – known as Closed Spaced Sublimation (CSS). In this process, the output material, high-purity CdTe granulate, is sublimated at 650 °C from a crucible onto a pane of glass which slides over it. CdTe grows p-type, CdS (cadmium sulphide) grows n-type via the same process, both without further doping steps. All processes are followed by a thermal activation process.

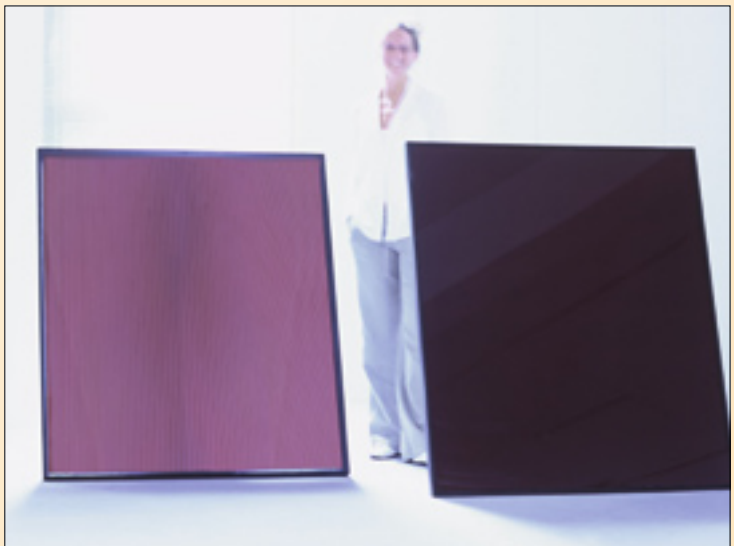
a-Si/micromorphous-Si
... is produced directly from the gas phase at temperatures of 100 to 300 °C. The method of choice is PECVD (Plasma Enhanced Chemical Vapour Deposition). This plasma-enhanced deposition makes low substrate temperatures possible – important for the substrate material glass. However, many substrate materials may be used.

CIS modules for roof-integrated systems from the German manufacturer Würth Solar.
Photo: Würth



CIGS thin-film modules from the Japanese manufacturer Showa Shell Solar on the stand of the German system supplier Schüco at the Intersolar industry trade fair in summer 2007 in Germany.
Photo: Wilhelm Breuer

Critical eye over the finished product: a cadmium telluride module of First Solar, USA
Photo: First Solar



First appearance in Milan, Italy: The Swiss systems manufacturer Oerlikon made its first presentation of a 1.3 x 1.1 m² thin-film module made of micromorphous silicon (on the right, an amorphous module on the left).
Photo: Oerlikon

Several years ago, his company chose Unaxis – which later became Oerlikon – because at that time there were almost no alternatives on the market. Schott is perfectly satisfied with the current substrate size, though, he says. »There's no need to decide for one and against the other. The substrate size depends on the way the modules are deployed. We want a product for which there are distribution routes available. The module size of 1.4 m^2 is suitable for both roof and ground mounting systems.« The larger substrates, on the other hand, suit clients in building and glass technology, says Waldmann.

Oerlikon, however, is not the only company to turn towards smaller substrates. German Centrotherm's spokesman of the board, Robert Hartung, is equally an advocate of »small is beautiful«. The smaller the substrate, the easier it is to monitor the process, he says. For Hartung, the quality of the coating is the decisive factor.

Cost-reduction through higher throughput and tubular targets

United in their goal, divided in their approach. Improving coating quality is, at the end of the day, just another lever for reducing production costs indirectly via the increase in efficiency. The »big is beautiful« advocates are chasing the same goal, as there is one main reason for the orientation towards large substrates: higher throughput. »With regard to throughput, the coating width is the most important parameter,« agrees Michael Powalla, head of the photovoltaics sector at the Stuttgart Centre for Solar Energy and Hydrogen Research (ZSW). »If you increase the substrate width from 600 mm to 1,200 mm, you have twice the throughput. The example here is the glass industry, which coats thermal insulation glass up to 3,200 mm.« Robin Schild, managing director of Von Ardenne Anlagentechnik GmbH, Germany, specifies a cost saving of 30 % gained from the use of large substrates alone.

This by no means exhausts the cost-saving potential of thin-film manufacture, however. The sputtering experts at Ardenne have set their sights on the process itself. What pushes up costs in the cathode sputtering are the so-called targets. These are flat plates with ample substrate widths which are made of the material that is to be deposited – without any impurities. This requirement makes the targets expensive. »They make up 60 to 70 % of the total costs of the coating process,« says Schild. And they are getting more expensive all the time. According to a statement from Plansee SE, one of the world's largest suppliers of sputter targets based in Austria, the price of molybdenum, for instance, has tripled in the last few years. The reason for this is the high demand from the steel industry, which uses large quantities of this metal for steel refinement.

However, Schild does not only blame the pure material price for this inconvenience. »Targets with a flat shape can only be exploited to 45 %,« he explains. This is apparently due to the special degradation profile which leads to a few particular areas reaching total degradation quickly. This quick degradation, says Schild, limits the usability of the target. One possible solution to the problem is provided by cylindrical targets. »These tubular targets have a lifetime three times longer than the flat targets,« continues Schild. That means that their utilisation degree is increased to 70 %. These tubular targets have been in use in large industrial dimensions in the photovoltaic sector for around two years, but by no means for all materials. Certain ceramic and metallic materials – nitrides, aluminium, certain oxides – still cause problems. ✹

Jörn Iken

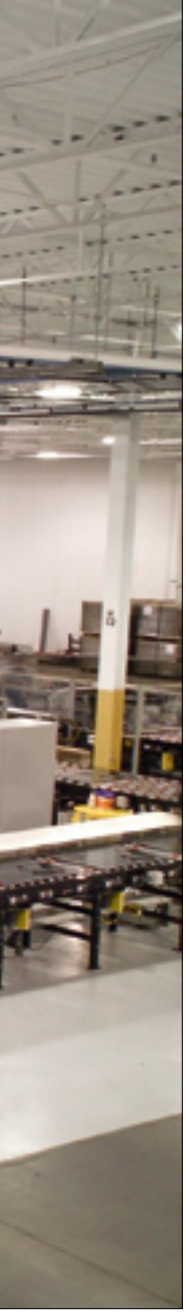
Jörn Iken is a long term *S&WE* author based in Hamburg, northern Germany. He is a specialist in wind energy and photovoltaics.

The market: a straight sprint to the gigawatt factory

The turnovers of PV production equipment suppliers are absolutely skyrocketing – a consequence of the worldwide PV boom. Thin-film manufacture is growing at a faster rate than silicon technology in its early stages.

The potential of thin-film technology is generally considered »great« – and the business prospects for the equipment suppliers are correspondingly positive. Michael Powalla, head of the photovoltaics sector at the Centre for Solar Energy and Hydrogen Research (ZSW) in southern Germany, forecasts a production capacity of 1,500 MW_p for CIS technology alone by 2011, and of 6,000 MW_p for all thin-film technologies. »That's what the operators' announcements indicate at least,« says Powalla. »Of course, it remains to be seen what is actually achieved.« Whether it is a matter of 4 or 6 GW_p – this still represents a challenge for the suppliers of production equipment. The development as a whole is moving along more quickly than that of crystalline technology. Estimates speak of annual turnover volumes for machine and system manufacture exceeding US$ 10 billion in as little as three years.

But this stage has not been reached yet. For the moment, the market for production systems for thin-film manufacture is still in its infancy. The German production equipment supplier Roth & Rau was able to announce record-breaking incoming orders of over € 220



First Solar – shown here is the production plant in Ohio – has built its own production lines up to now. The machines for the process technology are bought from elsewhere. *Photo: First Solar*

million for 2007. The majority of this, however, was accounted for by its »traditional business« of non-reflective coating systems and turn-key crystalline cell production facilities. For the time being, thin-film technology has only made itself noticed with € 7 million.

It could not be any other way, since the first thin-film production facilities – here we are talking about the economically relevant technologies CIS, CdTe and a-Si/micromorph – only completed their pilot phase relatively recently. Thin-film manufacture on a large scale is underway at firms including First Solar in Frankfurt, Oder (Germany), United Solar in Michigan (USA) and the Japanese companies Kaneka, Mitsubishi and Sharp. Precise details regarding the production equipment at these factories are unknown. It may be assumed that First Solar have created their production plant in Frankfurt, Oder independently whilst purchasing the high-tech components. Enquiries with First Solar are met with a friendly but firm refusal. »Unfortunately I can't answer these questions. This is a subject which we treat with great confidentiality,« is the reserved response of managing director Stephan Hansen. The same goes for the Japanese firms.

Where is all the action?

Despite having declined in relative importance due to the rapidly rising demand from India and China, Europe remains the main market for the suppliers. The Swiss machine supplier Oerlikon Solar, for instance, sold the majority of its systems to Europe – presumably Germany – most recently a 33 MW_p line for micromorphous thin-film modules to Inventux in Berlin. Other known customers are the German PV manufacturers Schott Solar and Ersol in Thüringen. A likely but unconfirmed customer is the Q-Cells subsidiary CSG. CMC in Taiwan is in the portfolio of foreign clients, amongst »others« – suppliers are a discreet kind. Quiet but diligent activity is to be noted in the Arabian region, reports Detlev Koch-Ospelt, head of Swiss Oerlikon Solar Thin Film. This is a somewhat surprising development as up to now the oil-rich Gulf States had not emerged as a significant source of demand in the global PV industry. »Gulf States such as Dubai are preparing themselves for the post-oil era,« says Koch. They are now giving thought to which energy sources they will be able to use in 20 or 30 years. Not least because of their financial power, investors in this region are interested in the complete package: producing photovoltaic systems themselves, operating them themselves, and using the electricity they produce themselves, too.

There are also talks underway – equally intensive – with American investors. »There are not yet any concrete plans, though,« says Koch, who is not able to identify a »hotspot« in the U.S., at least as of yet. He is nevertheless certain that »these talks will yield results in six to twelve months«.

A First Solar employee sets up a machine: People are something of a rarity in the fully-automated world of thin-film manufacture.
Photo: First Solar

Piracy fears

Product piracy is a problem which particularly affects the supplier industry – in some Asian countries it is more the rule than the exception. This is because the piracy is hard to prove. Whereas with end user products it is relatively easy to compare the original and the copy and then to react to the counterfeit attempt, with a production system this is far more difficult – if not impossible. No manufacturer invites curious individuals into its facilities, least of all if they are from the supplier of the original which has been copied. This fundamental flaw cannot be eliminated through a patent and a commitment to prosecution either – what cannot be determined beyond doubt cannot be punished. Attempts to prevent experts from switching sides or going into self-employment are equally ineffective. The companies try to help their cause with »special employee obligation measures«. In short, those who know a lot are given bonuses. Since even this does not provide protection against the attempts of competing firms to copy products, a considerable number of companies refuse to shift parts of their production abroad, where it is supposed to be cheaper. For instance, Oerlikon – with a production depth of 50 % – can imagine shifting production capacities abroad, but not to China, not even for low-tech components. »There will be no Oerlikon component manufacture there,« stresses Oerlikon manager Koch-Ospelt. The company has already had a negative experience with a far-east company that copied replacement parts for a production plant in which Oerlikon had invested a lot of engineering work.

The relative reluctance of the suppliers, compared with PV manufacturers, as regards orienting themselves towards the foreign market is also tied to the strength of the German market. Admittedly, international business has now become indispensable, but the core activities remain in Germany. The domestic market continues to offer great potential especially for smaller equipment suppliers who come from the German machine and system manufacturing industry. Take the firm German Gerold Maschinenbau: It supplies the conveyors and handling technology for the front-end and back-end sections of a thin-film production line for the German thin-film manufacturers Johanna Solar in Brandenburg and CSG in Thalheim, Germany, amongst others. The commercial manager Jürgen Weiss has so far viewed international business activities with some caution: »Preliminary enquiries have been made, but no intensive talks with interested parties from abroad have been taken place as of yet.« One possible explanation for this could be that the interested parties first turn their attention to those companies which offer complete lines – and so far there are only a handful of these among them Oerlikon, Amat, Centrotherm, Roth & Rau from Germany and Ulvac from Japan (see company profiles on page 134).

Company strategies: diversification and integration

A short digression: According to the general consensus, the photovoltaic industry is currently in a phase of consolidation. A surplus of demand is still present, which makes the economic situation extremely comfortable for almost all companies, but the times of plenty are drawing to a close. The market will turn in the foreseeable future: A surplus of supply, over-production and intensified competition will be the climate conditions of the market. The PV companies are reacting to this challenge in two ways: Either they integrate other stages of the value creation chain into their business, as demonstrated by Solarworld AG in Bonn, Germany, for example, with many others following suit, or they diversify in terms of technology. Q-Cells AG may be cited here as an example of a company which has now gathered together all relevant cell concepts in its subsidiaries at its premises in Thalheim, Germany.

The situation is no different for the suppliers of production equipment – both strategies are basically open to them, too, and they are making use of the options available. A particularity amongst the suppliers is the large number of collaborations which they enter into in order to be able to provide the most comprehensive range of solutions. ACI-Ecotec from southern Germany is a good example: This relatively small firm with 60 employees is a specialist in cell contacting at the back-end,

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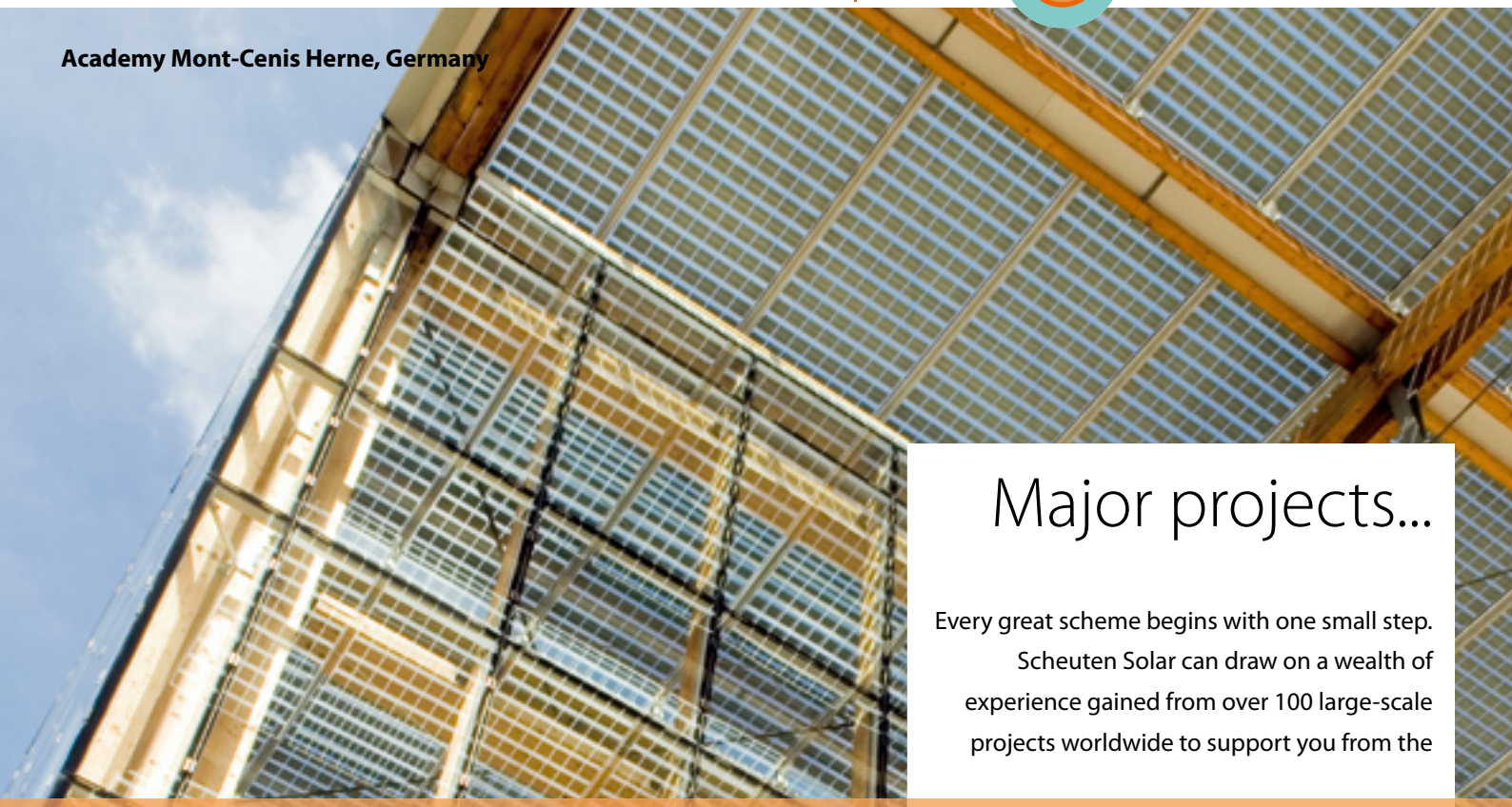

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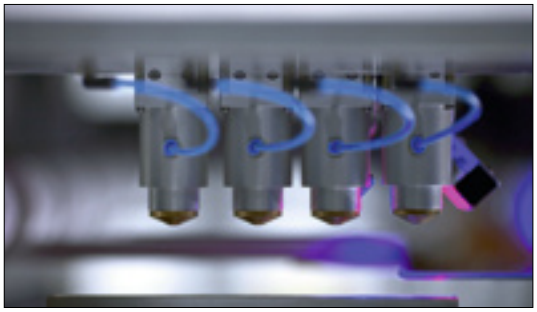
On the right is the coating unit, the substrates come from the left. A robot does the job of loading.
Photo: Oerlikon



The laser unit at the Oerlikon factory consists of four heads and is used up to three times in the manufacture process to structure the thin-film cells.

i.e. in a small section of the production line. In order to increase its own desirability and to play a role on the international stage, ACI entered into a collaboration with the lamination specialist Bürkle and the glass handling expert Olbricht, and can thus offer a considerable portion of the production line. This German consortium is often called upon by Oerlikon, for example. The turnkey production line suppliers profit from these kinds of collaborations since they reduce interface problems.

Furthermore, this vertical integration comes about, even more than in photovoltaic production, through large and small company acquisitions, and less out of companies' own power gained through the development of expertise. An example from the very recent past is the acquisition of FHR Anlagenbau GmbH by Centrotherm Photovoltaics GmbH in Upper Swabia, Germany. Just a few weeks after the stock market floatation which filled the coffers, the Swabians struck purchasing at a price of € 22 million the small to medium-sized company whose field of activity ranges from system and appliance manufacture via comprehensive services in vacuum and coating technology right through to trading activities. Amongst the core competences of FHR – 90 employees, a good € 11 million in turnover – are PVD (Physical Vapour Deposition) processes such as sputtering, vacuum processes, inline transport systems and the deposition of thin-films onto large-surface substrates.

Attentive industry observers might pick up on something at this point: Why does Centrotherm require a specialist for PVD processes and large-surface substrates? Up until recently, the company from Blaubeuren had still presented itself as an equipper for the crystalline manufacture of solar cells – and they do not carry out sputtering, or deposition of anything onto a large surface. With this step, Centrotherm plumped for the second option alongside vertical integration: technological diversification. The Upper Swabian firm has not just decided to move into thin-film technology, this move has already been implemented: They have already sold a CIGS production line to the Taiwanese CIGS producer Sunshine, a subsidiary of the Centrotherm client Solartec AG, Germany. This puts the FHR acquisition into a new light.

»With FHR, we were able to gain a strong partner for the further expansion of our thin-film activities and extend our portfolio of technology and system manufacture for sputter systems – an essential component in turn-key thin-film production lines. Our teams of experts are already working on joint development projects,« explained spokesman of the board Robert Hartung. The decision to take the first steps into thin-film technology was a reaction to the demands of Hartung's cell customers. That is how it has to be: The technological diversification of the PV producers themselves brings the diversification of the suppliers in tow – at least if the company relations are right. From the point of view of the PV producers, there is actually less risk involved if they continue to work with tried and tested suppliers, even with other cell technologies, and to have them keep up with the diversification. It all goes

Who is active on the market?

The market is still in its infancy, the first manufacturing systems for thin-film production all come from this young century. Suppliers are springing up like mushrooms. At this point let us take a (by no means exhaustive) overview:

ACI-Ecotec
... resides in the Black Forest, Germany. The original firm, when it was founded in 1980, took up a traditional business segment: precision clockwork and fine mechanics. After being taken over by ACI in 2004, the company turned its attention to photovoltaics, and now offers, in cooperation with other companies, complete back-end sections. ACI made a turnover of € 8 million with 60 employees in the last year.
www.aci-ecotec.de

Advanced Energy
... is one of the leading suppliers of monitoring and control systems for the gas and energy supply of thin-film production lines. Founded in 1981, the company with its headquarters in Colorado, USA, made just 6 % of its 2006 turnover of US$ 410 million with systems for the solar industry – but this is on the increase. AE currently employs 1,700 staff.
www.advanced-energy.com

Ardenne Anlagentechnik
... with its headquarters in Dresden, Germany, emerged from the Manfred von Ardenne research institute in 1991. Today, the company is amongst the world's leading suppliers of electron beam and plasma technologies including the appropriate equipment. In 2006, its 320 employees generated a turnover of around € 104 million.
www.vonardenne.biz

Applied Materials
... was founded in 1967 as a high-tech company with its headquarters in California, and has developed into one of the world's largest companies in the electronics industry. Its areas of business are the equipment for producing semiconductor chips, flat-screen displays and solar cells. Its research and development activities were recently centralised in Alzenau, Germany. Its turnover stood at € 9.6 billion in 2006, Applied Materials currently has 14,000 employees.
www.appliedmaterials.com

Centrotherm Photovoltaics
... is a young company from the Centrotherm group. The company has become active on the market by providing services and production technology for the PV industry, including turn-key production lines for crystalline and thin-film technology. In 2006, some 100 employees generated a turnover of € 109 million for the company.
www.centrotherm-pv.de

Energy Photovoltaics
... is amongst the pioneers of thin-film manufacture. The New Jersey company was founded in 1991, and immediately entered into the business of manufacturing a-Si thin-film cells. The company is present on the market with its Integrated Manufacturing System (IMS), a batch manufacturing process. Operating figures for the company are unknown.
www.epv.net

Kuka
... is a robot specialist from Augsburg, Germany. Founded in 1898, Kuka evolved from a supplier of welding systems and vehicle mounts into one of the world's leading companies for robotics and system technology. Kuka employs 3,670 people, and generated (as Kuka Group) a turnover of € 832 million.
www.kuka.com

Gerold Maschinenbau
... has been one of the main suppliers for production systems in the international flat glass industry since being founded in 1968. The German company supplies manufacturers of thin-film modules with conveyors and handling technology for linking process equipment. Gerold employs 50 people, and generated a turnover of more than € 10 million in 2006.
www.gerold-mb.de

Rofin-Sinar
... is, according to its own data, the global market leader in lasers which are employed in industrial material processing. Since the end of the 1990s, the American firm has been supplying lasers for cutting, scribing and edge insulation of solar cells using crystalline or thin-film technology. 1,600 employees generated a turnover of US$ 490 million for the company in 2006.
www.rofin.com

Roth & Rau
... develops and manufactures systems using plasma and ion beam technology. The company started in the solar industry as a specialist in non-reflective coating systems, and now offers complete solutions for crystalline solar cell production and thin-film manufacture. In 2006, Roth & Rau and its 180 employees generated a turnover of € 135 million.
www.roth-rau.de

Oerlikon
... supplies complete thin-film production lines. The company is ranked amongst the large Swiss machine and plant manufacture groups; its history goes back over a century. After having grown up making textile production machines, it began to move into thin-film technology in 1946. For some time, the company was called Unaxis. In 2006, its solar activities were brought together in its own »Solar« business segment.
www.oerlikon.com

Ulvac Technologies
... was founded in Japan over 50 years ago as a specialist supplier for vacuum technology, and evolved over subsequent decades into one of the leading suppliers of production equipment for display manufacture. For thin-film manufacture, a segment which Ulvac recently moved into, the company offers PECVD and sputtering systems. Ulvac employs 1,600 staff worldwide.
www.ulvac.eu

Robot access only: A robot assumes the task of loading and unloading the PECVD reactors.
Photo: First Solar

according to the principle: Everyone's new to the business, so I'll stick with those I know.

Centrotherm has already gained its first experiences with thin-film technology with Sulfurcell GmbH in Berlin, Germany. It supplied the Berlin firm with the »sulphur furnace«, which is responsible for the crystallisation of the sputtered coatings. Why did they turn to chalcopyrite semiconductors? Hartung's thinking is pragmatic: »Not many thin-film technologies have yet become economically relevant. The business of amorphous and micromorphous modules is occupied by two large suppliers, and the CdTe producers construct their systems themselves.« So the idea here is to occupy niches whilst they are still available. With the expertise of FHR, Centrotherm finally has all the deposition processes at its disposal, and with this ability it holds the key to the CIGS process.

In conclusion, the mega trend is towards the giga

The development trends in thin-film manufacture are largely in accordance with those of the crystalline technologies. Let us remind ourselves: The trends in crystalline production technology are towards the gigawatt factory, higher throughput, turn-key solutions from the suppliers and more automation.

The gigawatt factory is on the agenda of the thin-film producers. In view of the potential of this technology, no one could be surprised. What is much less expected is that it is already happening now – at a time when the most common technologies have only just completed pilot production, many more are yet to reach full production speed, and several are still looking for a piece of land for their factory. ZSW head Powalla is talking about CIS modules first of all when he says that the trend is moving towards larger manufacturing units of 30 MW_p – for the micromorphous and a-Si modules, this has already been the case for some time and on an even bigger scale. Sharp, for instance, wishes to increase the thin-film cell capacity at its factory in Katsuragi, Japan, from its current 15 to 160 MW_p by October 2008. The bar currently stands at the 100 MW_p mark – for crystalline technology, this took much longer.

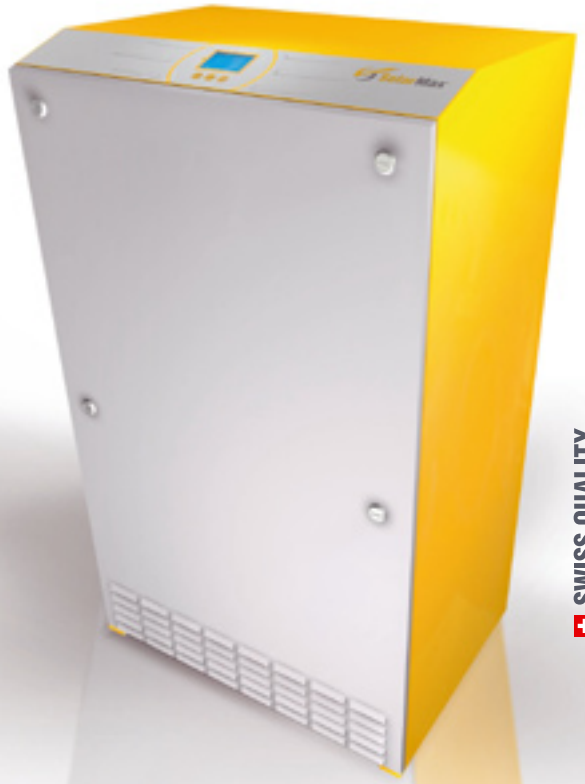
The product range of the equipment supplier industry is developing at a similar speed. Turn-key systems have come onto the market relatively quickly, which make it possible for investors who are unfamiliar with the industry and its technology to enter into the market. Equally quick to set in was the recognition amongst the thin-film suppliers that their role did not end with the installation of high-performance machines along with buildings. Turn-key means more. The companies which are ahead of the game are those who can offer both the equipment and the process. The customers expect the suppliers to guarantee the yields and the quality, to train the manufacturing personnel, and to run the process up to a guaranteed standard speed. This can take anything from a few months to a year. Important players on this market have to be able to do this, and that means worldwide for four or five clients at the same time.

With increased throughputs and yields, the fundamental decision still has to be made: large or small substrate? (see page 124) Otherwise, there is very little or nothing at all to be learned from the suppliers regarding the improvement of process parameters. This shouldn't be taken personally – at the end of the day, the process parameters are central to a company's ability to compete. Fundamental changes to the PVD (Physical Vapour Deposition) and CVD (Chemical Vapour Deposition) processes which are employed are not expected for the time being, however.

Automation is not a hot topic of conversation in the sales departments of the supply industry. There is a simple reason for this: thin-film manufacture, unlike the early stages of crystalline technology, hardly allows any manufacturer sales. With regard to the process technology, thin-film manufacture is much closer to crystalline cell production than crystalline module production – and it was the latter, after all, which brought a high proportion of manual labour into crystalline technology in the beginning. The step from the thin-film cell to the module – if one is to call it a step at all – is a short one: laser, laminate in some cases, and connect. The degree of automation of the thin-film production lines being created now is thus already so high that discussions over further automation steps are largely superfluous. ✹

Jörn Iken

Cool!



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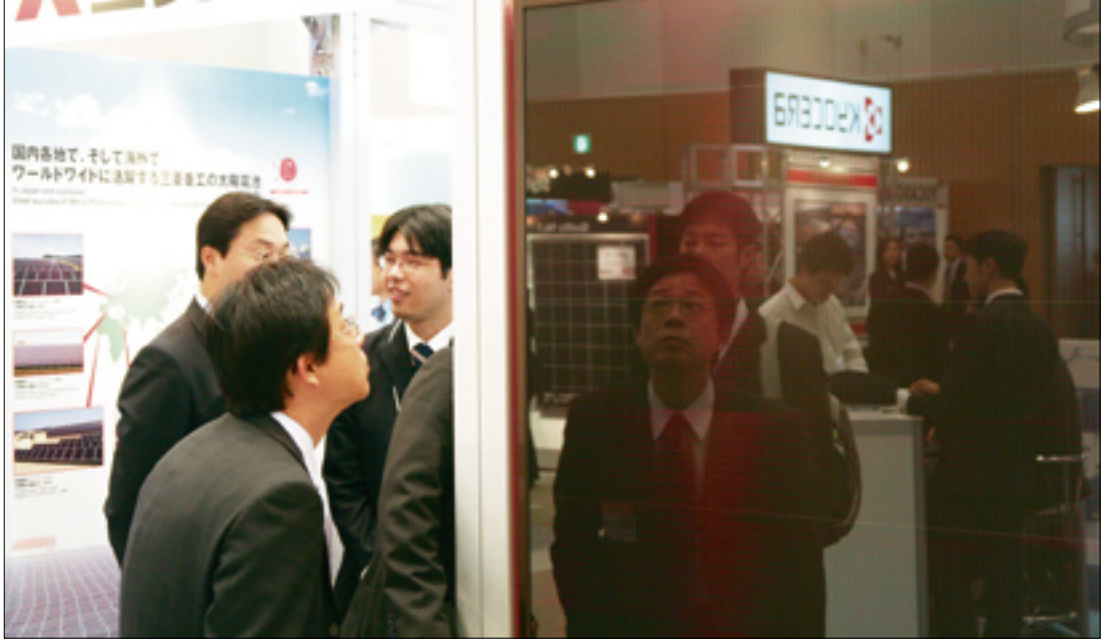

A skeptical look: The micromorphous tandem module from Mitsubishi Heavy Industries still has an irregular coating. The firm has therefore postponed the product launch until April 2008.

Photo: Johannes Bernreuter

Weakening base

The 17th International Photovoltaic Science and Engineering Conference held in Fukuoka, Japan, brought together innovative Japanese manufacturers and researchers. One of the main issues was the declining domestic market.

Takashi Tomita put it most succinctly. The former head of the solar division at Sharp Corporation who now handles the company's research and development displayed a bar graph for 2007 in his opening lecture, showing that the Japanese photovoltaics market shrank to around 215 MW_p in the previous year – 25 % less than the 287 MW_p installed in 2006.

Granted, the former PV pioneer still holds the title of world market leader in solar cell production. But the dwindling domestic market did not exactly provide ideal surroundings for the 17th International Photovoltaic Science and Engineering Conference (PVSEC), which took place in the first week of December in the Japanese port town of Kukuoka on the southern island of Kyushu. With just under 1,400 participants and not even 50 exhibitors, the Asian PV conference was much smaller than its European equivalent in Milan, Italy.

Since Japan's residential PV system dissemination programme expired in 2005, the country's photovoltaic market has mainly been limited to sales for new buildings that include solar panels from the outset. That did not change in 2007. Officially, Sharp's Tomita calls the trend a one-off effect in the construction industry. But if you ask him what his personal opinion is, he does not mince words: Japan needs to provide better incentives for solar panels.

Conference chairman Masafumi Yamaguchi, professor at the Toyota Technological Institute in Nagoya, said he would prefer a system similar to the feed-in rates used in European countries. But Osamu Ikki, the director of consulting firm RTS Corporation who was awarded the conference's special award, says such a change is unlikely given the power that utilities have in Japan. Yamaguchi says that the Japanese Photovoltaic Energy Association (JPEA) has not been able to get the Japanese Economics Ministry interested in a new incentive programme.

But the Japanese did not make their shrinking domestic market the focus of the conference. Indeed, PV lobbyists in Europe were all the more concerned. »I'm really worried,« explained Murray Cameron, head of operations at Phoenix Solar AG and vice president of the European Photovoltaic Industry Association. He said that if the Japanese market starts to contract, politicians in Europe would start asking questions – like why they should continue to support photovoltaics.

Kaneka and MHI: low output

The Japanese clearly dominated the conference in terms of research. They not only made up 55 % of participants, but also 46 % of the 672 posters and presentations. The research prize awarded in Fukuoka documented Japan's traditional strength in thin-film technology. It went to Kenji Yamamoto, senior manager of the Frontier Materials Development Laboratories in the research division of the Kaneka Corporation, for the development of a tandem module consisting of amorphous and microcrystalline silicon.

Kaneka brought this micromorphous module onto the Japanese market back in 2001 and has since improved it, adding an interlayer that reflects the blue spectrum of light back into the amorphous cell but lets the red spectrum reach the underlying microcrystalline layer. But all is not pie in the sky for Kaneka either: While the specifications for a sample on exhibit in 2006 at Intersolar in Freiburg, Germany, suggested that the module would have an output of 125 W_p, the data provided at the stand in Fukuoka only had a rated output of 110 W_p. With an overall surface of 1,240 x 1,008 mm^2, the efficiency is therefore 8.8 %. Last October, the first samples were shipped in Japan. Kaneka hopes that the new tandem module will also be available for overseas markets starting in April.

The startup difficulties that the company's competitor Mitsubishi Heavy Industries Ltd. (MHI) is having in the production of its micromorphous tandem module at the new 40 MW_p plant in Isahaya (prefecture of Nagasaki) also cropped up in Fukuoka. The exhibition included a sample module whose colours revealed an irregular deposition. By April, MHI plans to have solved the problem and start sales – a year later than originally planned. As with Kaneka, MHI's datasheet also listed a peak power of 130 W_p (8.25 % efficiency), far below the originally announced 150 W_p.

At least for the time being, industry leader Sharp does not have to deal with such problems. Its thin-film module consisting of one microcrystalline and two amorphous layers not only has an efficiency of 10 %, but the company also announced just a few days after the conference that production capacity at the plant in Katsuragi (prefecture of Nara) will increase from the current 15 to 160 MW_p by October of 2008. At the same time, Sharp broke ground on December 1st for a 1 GW_p thin-film production plant in Sakai (prefecture of Osaka), which is to go into operation in March of 2010.

Honda: efficiency exceeding 11 %

There were also some new announcements in Fukuoka concerning copper indium gallium diselenide (CIGS) thin-film modules. Japanese newcomer Honda Soltec, which only began mass production in October of 2007, presented its 125 W_p module both in a presentation and at its fair stand. The three substrates are switched in series to provide an especially high open circuit voltage of 280 V. Efficiency is at a respectable 11.1 %. No announcement has been made about when the modules will be on sale outside Japan.

U.S. startup firm Nanosolar Inc. was represented at the PV conference for the first time with a presentation by director of research Jeroen van Duren, who unfortunately did not deliver much new information about CIGS printing technology with nanoparticles. Fortunately, Vijay Kapur, head of competitor International Solar Electric Technology, Inc. (ISET) and a pioneer of the nanoparticle approach, was more forthcoming. He announced the launch of a 3 MW_p pilot production facility in Chatsworth near Los Angeles in the first quarter of 2008.

There was a clear trend in Fukuoka in classic wafer technology: Back-side-contact cells are the new up-and-comers. Kyocera posted a new record for efficiency at 18.3 % for its multicrystalline cell with what the company calls »metallisation wrap-through«. For monocrystalline back-side-contact cells with an efficiency of 20.1 %, Sharp is already experimenting with printed wire board on the backside. For this concept, Martin Späth of the Energy Research Center of the Netherlands revealed a new pilot line set up by Dutch firm Eurotron. It will be able to apply one cell per second to contact strips with conductive adhesive – six times faster than conventional application technology.

Johannes Bernreuter

Johannes Bernreuter is a long term *S&WE* author based in Würzburg, Germany. He is a specialist in photovoltaics.

Further information:
Energy Research Center of the Netherlands (ECN): *www.ecn.nl*
European Photovoltaic Industry Association: *www.epia.org*
Eurotron: *www.eurotron.nl*
Honda Soltec: *world.honda.com/HondaSoltec*
International Solar Electric Technology Inc. (ISET): *www.isetinc.com*
Japanese Photovoltaic Energy Association (JPEA): *www.jpea.gr.jp*
Kaneka Corporation: *www.pv.kaneka.co.jp*
Mitsubishi Heavy Industries, Ltd (MHI): *www.mhi.co.jp/power/e_a-si*
Nanosolar Inc.: *www.nanosolar.com*
Phönix Solar AG: *www.phoenixsolar.de*
PVSEC: *www.pvsec17.jp*
RTS Corporation: *www.rts-pv.com*
Sharp Corporation: *www.sharp-world.com/solar*
Toyota Technological Institute: *www.toyota-ti.ac.jp*

Insurance in Spain

The Spanish photovoltaics market is one of the fastest-growing in Europe. Insurance experts highly advise that investors take out a comprehensive risk policy on their systems. And yet, the number of insurance firms that cover photovoltaics is quite low.

Gone with the wind: In January of 2007, the windstorm called Kyrill greatly increased the number of damage reports that insurance firms received in Europe related to PV systems.

Photos (2): Mannheimer Versicherung

Most operators of solar systems are mainly interested in the return on their investment (ROI). But experts warn operators not to do without insurance coverage. Although there is no legal obligation to have photovoltaic systems insured in Spain, experts nonetheless advise that you do so voluntarily. Defects or malfunctions that cause the entire system to fail can sometimes be quite expensive to remedy. In such cases, the right policy makes sure that the operator's ROI expectations are met. »That's why a number of banks in Spain require their customers to sign a comprehensive insurance policy before they receive financing for their solar panels,« explains Oliver Passolt, a Madrid-based insurance broker who specialises in solar panels. Officially, Spain currently has an installed photovoltaic capacity of some 300 MW_p – more than 85 % of the market volume that the government had planned to reach by 2010. As a result, politicians are now discussing whether the feed-in rates should be extended – and how. Nonetheless, Spanish insurance firms are just now discovering the photovoltaics market. The German solar market research firm EuPD Research found that insurance firms are actually reluctant to provide information about premiums and terms for such policies. Fewer than half of the 30 Spanish and international firms they surveyed said that they offered policies that covered photovoltaic systems in Spain at all (see table). Fortunately, independent brokers are helping bridge the gap left open by insurance firms and coming up with special concepts for solar panels in Spain. Furthermore, some installation firms are acting as brokers by offering their customers policies that cover their solar panels as an additional service. In the meantime, policies are offered for solar panels to cover almost any risk both during installation and operation. Often, it is hard for consumers to decide which policy is right for them as each particular case has to be handled individually. For instance, the type and size of the photovoltaic system have to be taken into consideration, as do the installation site – is the roof slanted or flat? – and the customer's financial situation.

Installation insurance

The risks that can be covered do not begin when the solar panels have been installed. Installation insurance covers all unforeseen damage that can occur when the panels are being installed. Generally, such »acts of God« as lightning and hail are covered along with human error, theft, and damage caused by design or material flaws. Usually, such coverage is offered by the company handling installation. Such policies are only useful for system operators who already own the materials. Once the systems have been installed, these policies can be continued for a specified term to cover subsequent damage that stems from installation. For a typical 3 kW_p system on a private home, such a policy would generally cost € 100 annually.

Extended residential coverage as basic protection

Once solar panels have been installed, they can simply be included as part of the building covered by an existing policy. Generally, buildings are covered along with all permanently installed components. This model is especially useful for damage caused by bad weather or temperature fluctuations. After all, it is not unheard of for panels to be damaged by frost or storms. Insurance firms do not yet have enough experience to judge the damage that can be caused to photovoltaic systems, explains Antonio Llanos of Spanish insurance firm Grupo Muntadas of Barcelona. But we know from industry insiders and insurance firms on the German mar-

Up in smoke: Fire damage is rare, and usually PV systems cannot be repaired afterwards.

ket that damage from overvoltage poses a great risk. Although solar panels are generally properly earthed, if lightning strikes, panels and electrical components can be destroyed by overvoltage. In such cases, building insurance policies generally cover the cost of repairs up to the agreed limit minus the deductible. Keep in mind, however, that solar panels are then only covered for the same risks as the buildings on which they are installed. Whatever the case, the insurance firm should be informed that a PV system has been installed because the installation increases the value of the building, which then needs to be reassessed. But as Tomas Dias of the Spanish Asociación de la Industria Fotovoltaica (ASIF) explains: »It is not always possible to extend building coverage because some insurance firms do not want to include the elements of a photovoltaic system in current policies.« Nonetheless, most firms do cover PV systems and increase rates accordingly.

Special solar insurance

Extended building coverage therefore provides good basic protection from damage to installed photovoltaic systems. But if you want more comprehensive protection, you need special solar policies, which are usually based on electronics policies. All of the components of a solar power system are then covered, as are all of the components required for the system's operation. In addition to theft and vandalism, such technical risks as short circuits or broken glass are covered. »In particular, theft of such modules has greatly increased in the past few years,« reports Michael Heinemann of Germany's Association of Insurance Brokers (WIASS) based in the southern German town of Frammersbach; in addition to the German market, WIASS also specialises in Spain's PV insurance market. Special solar insurance is also highly recommended for operators who do not own the building on which their system is installed. In such cases, the damage that would normally be covered by building insurance can be included in the solar policy. In general, such policies are custom-made based on the operator's needs and financial means in addition to the size and location of the system to be insured. The rates charged for such policies vary accordingly. In 2005, a solar insurance policy offered by ASIF and international insurance brokerage Marsh cost the greater of 1.2 ‰ of the system's investment value or € 250. Often, the insurance provider's experience with photovoltaic systems

Name	Nationality / mother company	Installation insurance	Solar insurance (based on electronics policies)	Operator liability insurance	Contact
ACE	ACE European Group (Spain)	yes	yes	yes	*www.aceeurope.es,* Esther.bermejo@ace-ina.com, amparo.gasso@ace-ina.com, phone: 00 34/9 18 37 67 31
Aura Seguros	Allianz (Germany)	n/a	n/a	yes	*www.auraseguros.com,* info@auraseguros.com, phone: 00 34/9 33 91 56 04
Caser Seguros	Caser Group (Spain)	n/a	n/a	n/a	*www.caser.es, brivero@caser.es,* phone: 00 34/9 15 95 50 00
Grupo Catalana Occidente	Spain	yes	no	yes	*www.catalanaoccidente.com,* phone: 00 34/9 32 17 22 17
Grupo Expert	Spain	yes	yes	yes	*www.grupoexpert.com,* expertbcn@grupoexpert.com, phone: 00 34/9 02 90 26 20
HDI Seguros	HDI (Germany)	yes	no	yes	*www.hannover.com.br,* beatriz.ploss@hdi.es, Natalio.garcia@hdi.es, phone: 00 34/9 14 44 20 00
MAPFRE	Spain	yes	yes	yes	*www.mapfre.com,* joaquinhernadez@mapfre.com, phone: 00 34/9 15 81 87 14
Seguros Estrella	Generali (Italy)	yes	yes	yes	*www.laestrella.es,* clientes@laestrella.es, phone: 00 34/9 15 90 56 56
Seguros FIATC	Spain	yes	no	yes	*www.fiatc.es,* asecilla@fiatc.es, phone: 00 34/9 34 39 44 00
Seguros Vitalicio	Generali (Italy)	yes	no	yes	*www.vitalicio.es,* f.navarro@vitalicio.es, phone: 00 34/9 34 84 01 00

Table: Selected insurance firms with special offers for PV systems. Only eleven out of 30 surveyed Spanish and international firms said that they offer policies that covered photovoltaic systems in Spain at all.

Source: market survey EuPD

Status quo: December 2007

plays a decisive role in determining what premium will be charged.

The policy can also provide indemnities if the power yield falls short of expectations. Some insurance firms offer both types of coverage in one policy. But the main damage is caused when power production is interrupted due to storms, vandalism, or theft. Compensation is then provided, generally for a period of three months and retroactively, for lost power production resulting from damage covered by such policies. The compensation offered by insurance firms varies from 1 €/kW_p per day in the six months around winter solstice to 2 €/kW_p in the six months around summer solstice; furthermore, some policies offer flat rates of 3 €/kW_p per day.

Third-party liability

But the financial risks that operators face are not limited to damage that can occur to the photovoltaic system, but also include damage caused to third parties or their property. For instance, panels may come off of the roof and damage your neighbour's car. Here, comprehensive risk protection is worth thinking about. In Spain, damage caused by solar panels owned by non-commercial operators can be covered in their private liability insurance. However, insurance broker Heinemann always recommends operator liability coverage because private liability insurance often does not provide complete coverage. For instance, private liability insurance generally does not cover damage that a system causes directly to the power grid due to a defective inverter. In contrast, commercial operators are required by law to have operator liability insurance.

The Spanish exception: state insurance

Spain has a special regulation for damage caused by natural disasters, political unrest, or terrorist attacks: For each property insurance contract they sign for a building or for a solar panel system, private insurance firms collect an additional premium that they pass on to the »Consorcio de Companias de Seguros«, a state insurance firm. The amount payable is a percentage of the amount insured. There are various rates depending on the type of property insured. For instance, industrial companies pay 0.25 % of the values covered. Likewise, 0.25 % of the annual gross yield covered is payable for policies that provide compensation in cases of insufficient power yield. Each insurance contract contains a clause about the state insurance firm and the risks it covers. For instance, if state authorities recognise an extreme weather event as a natural disaster, the »Consorcio de Companias de Seguros«, not private insurance firms, covers the damage. However, these special terms do not apply for damage caused to third parties that is covered by liability insurance, nor do they apply for damage covered by installation insurance.

The choice is yours

A combination of these policies provides the best protection for all risks that the operation of a photovoltaic system entails during its service life. Spanish insurance firms now realise this. »This is why we generally use general-risk concepts in Spain,« explains Passolt, international director at Spanish brokerage firm Confide Seguros of Madrid. Nonetheless, it is usually hard for those wishing to invest in solar to find the right contracting partner. Special clauses often mean that there are far-reaching differences between the coverage that different insurance firms offer. After all, protection from risk is not only based on the amount of the premium, but also the scope of coverage. Among the insurance firms that cover a photovoltaic system, there are both international companies such as Allianz and HDI and smaller firms specialising in Spain, such as the Grupo Catalana Occidente (see table). Accordingly, the experience that the various insurance firms have also differs. Some of them have been doing business on the solar market for a few years now and can fall back on this experience when calculating their premiums and defining the scope of services provided. Other firms are just getting started in this field and lack such experience. One therefore finds insurance firms that offer liability, installation, and down-time policies, but no coverage of electronics. Others change their coverage concepts without notice or have to change their premiums.

In addition to insurance firms, more and more brokers are specialising in photovoltaics policies in Spain. They either combine the policies of different providers in their capacity as independent brokers, or they nego-

tiate comprehensive contracts with specific insurance firms to get special terms for their customers. Often, brokers come up with coverage concepts on their own based on many years of experience so they can offer their customers individual packages. As Passolt puts it: »That is our advantage. It allows us to find the best solution for each individual customer. Their individual financial wherewithal and our experience are included in the design of the contract.« A number of German insurance brokers are falling back on their experience on the mature German market as they enter the Spanish photovoltaics market. Germany's WIASS is one example. WIASS's Harald Brand explains: »On the Spanish market, we offer a package that includes all of the necessary coverage.« In contrast, other insurance brokers from Germany, such as Manfred Körber of Vilsheim, only offer policies to German operators in Spain. »We can then keep the venue for the settlement of disputes in Germany, draw up our policies in German, and offer investors the protection they are used to at home abroad,« he explains.

In addition, small installation shops are also starting to play the role of insurance brokers and working with insurance firms in the process. The shops are increasingly expanding the scope of services they offer to improve customer retention. Four out of six of Spanish installation shops surveyed by EuPD Research indicated that they have already included insurance policies in their service portfolio. »Some installation firms also guarantee a minimum performance level for their systems over a year to promote sales. This guarantee is then included in the price. But often, the price for the specific guarantee provided is not worth the money,« explains Dias of ASIF.

Insurance market dependent on power compensation

Spain's decree for the promotion of solar energy (661/2007) sets a cap of 371 MW_p by 2010 for the floor prices offered. In October of 2007, Spain's Industrial Ministry heralded in the 12-months transitional period that was to begin when 85 % of this power had been installed. At that point, the current floor price guaranteed by law for solar power fed to the grid would expire. This feed-in tariff is the reason why demand for solar electric systems and related insurance policies has been skyrocketing. »Uncertainty about the future of these floor prices is naturally affecting the Spanish insurance market,« Passolt reports. Now, the industry is hoping that the decree will be updated and the cap raised further. At the end of September, state secretary Nieto Magaldi proposed an upper limit of 1,000 MW_p for stand-alone systems and 200 MW_p for small systems. But the focus of the Spanish insurance market is on small systems. After all, »it is not always easy for us brokers to purchase sufficient capacity at market conditions when it comes to large systems. You first have to find a number of insurance firms who will work together, and that naturally slows down negotiations for special terms,« Passolt adds. »Nonetheless, in the next few years we will continue to gain experience about the kind of damage we cover so we can calculate our premiums more precisely,« the insurance broker forecasts.

Verena Vorwerk

Verena Vorwerk works as a journalist with the German media service provider Europressedienst, which specialises in renewable energies.

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is a publication of SONNE WIND & WÄRME
BVA Bielefelder Verlag GmbH & Co. KG
Ravensberger Str. 10 f, 33602 Bielefeld, Germany
phone: +49-521-595547, fax: +49-521-595556
e-mail: diekmann@bva-bielefeld.de
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SUN & WIND ENERGY 2/2008
will be published
in April 2008

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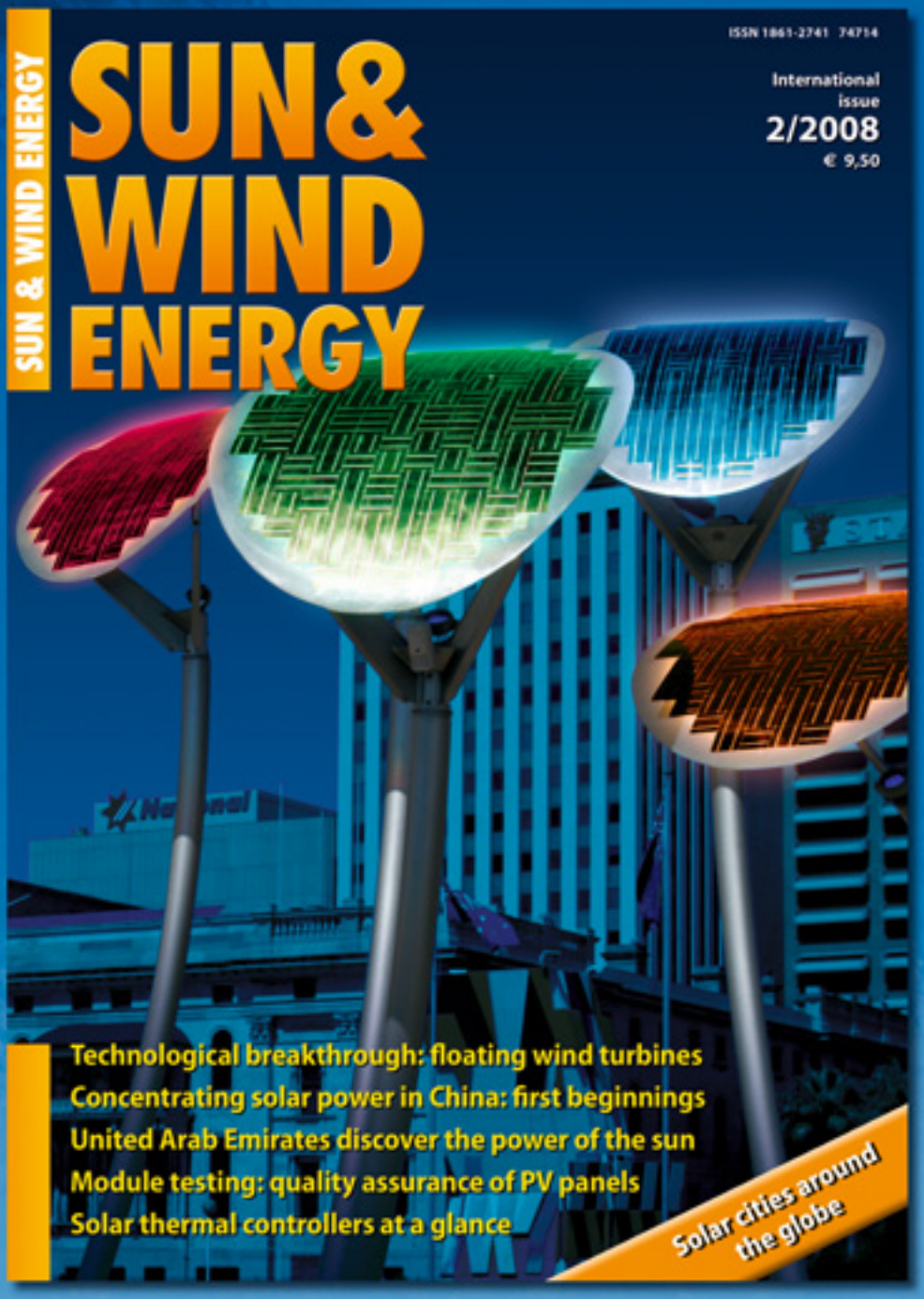

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Advertising deadline 3 March 2008

Technical and/or economic wind turbine size limits have been predicted already for decades. However, voicing such explicit size predictions is very tricky due to the many variables and uncertainties involved and perhaps grossly underestimates the power of innovation and ingeniousness.

The motherland of prototypes: Nearly all wind turbines with a power of 5 MW and above are to be found in Germany, including this Multibrid M5000, installed on a tripod at Bremerhaven in northern Germany. Rotor diameter: 116 m

Photo: Jan Oelker

Is there a limit to wind turbine size?

History shows many examples where existing technology is stretched to its limits, and is then succeeded by superior alternatives capable of again shifting boundaries in terms of size, costs, performance and reliability. Modern industrial scale wind technology covers a time span of only about thirty years and is no exception to this rule. During the past three decades the emerging global wind industry, on a largely evolutionary development path, has indeed produced many clever innovations that have resulted in new as well as upgraded technology concepts. A major part of these continuous wind technology developments have been multiple system up-scaling steps, in which the so-called bottom-up strategy has proved the most successful by far (see boxed text).

Limits

About thirty years ago the Dutch engineering journal *PT Aktueel* published an article in which the author – supported by impressive statistical evidence – argued that 500 kW was a »hard« upper wind turbine size limit. Twenty years later in a 1998 publication of the German magazine *Sonne Wind & Wärme*, an expert presented a 70 to 80 metre rotor diameter size range as an economic optimum »that will be hard to exceed«. He additionally predicted long-term competition between installations with stall-type power limitation and pitch-controlled equivalents.

Today an increasing number of suppliers offer 1.5 to 2 MW wind turbines with rotor sizes up to 92.5 m (see table 2). In the next generation, 2.5 to 3.0 MW class rotor diameters between 90 and 100 metres are common. And the upcoming 5 to 7 MW+ super class already has four suppliers, all based in Germany. At least two more contenders, US-based Clipper and GE Energy, have also announced a wind turbine in the 5 to 7 MW class. Enercon holds the size record with its E-126 prototype featuring a 127-metre rotor diameter. The power rating is 6 MW, but insiders suggest a 7 to 8 MW for the series product. The E-126 succeeds the 4.5 MW E-112 (2002; rotor diameter 114 m) that was later up-scaled to 6 MW. Repower recently announced an up-scaling of its 5 MW 5M turbine type to 6 MW, while maintaining a 126-metre rotor diameter.

A new ambitious offshore wind market entrant is Bremen-based Bard Engineering. The company recently installed a 5 MW VM prototype near the port of Emden, northern Germany, after a record-breaking combined product development and prototype completion period of only two years. Like the 5M and the E-112, the VM is considered a rather heavy turbine concept. The Top Head Mass (THM; nacelle + rotor) of both the 5M and VM is in the range of 415 to 420 tonnes, while E-112 THM is well above 500 tonnes. According to experts, the three turbine concepts above have substantial built-in (safety) design reserves. After testing and extensive monitoring these reserves can be utilised for further up-scaling in capacity and/or rotor swept area, and this is exactly what is taking place already.

Lightweight

Other companies by contrast have opted for lightweight wind turbine concepts. A good example is the 5 MW Multibrid M5000 featuring a THM of only about 320 tonnes. Other striking examples of lightweight concepts include the Vestas V90-3 MW and the Vestas V120-4.5 MW. The V90-3 MW has a THM of only 111 tonnes, making it the low-THM champion in general and in its class. The V120-4.5 MW (THM = 210 tonnes) is an upgraded former NEG Micon model envisaged to enter the wind market by 2009, but which was shelved instead.

The huge THM differences in the 4.5 to 5 MW class between especially the V120-4.5 MW and the only slightly bigger Repower 5M and Bard VM are hard to explain, according to wind experts. These last three wind turbines all feature a conventional gear-driven drive system, with pitch-controlled variable speed operation and three rotor blades.

Another question is which specific wind technology will be best equipped to become the ultimate wind turbine concept winner in terms of performance, system reliability and most importantly energy costs (€/kWh over 20 years):

- Conventional geared wind turbines featuring a multi-stage gearbox and a fast-running generator have for years dominated the world market with a share of 85 to 87 % (MW based).
- The remaining 13 to 15 % have drive systems featuring a large-diameter ring generator (no gearbox), in which the rotor and generator turn at the same speed. Enercon is market leader in this segment.
- Multibrid technology, comprising a single-stage gearbox and a slow-speed generator integrated in a highly compact cast housing, is considered the third distinct drive technology. Multibrid Entwicklungsgesellschaft of Germany and Winwind of Finland both manufacture these turbines under an Aerodyn license.

Torque

Generally, as a rule, when rotor size goes up, rotor speed has to be reduced. This is necessary because maximum blade tip speed has to remain under about 75 to 85 metres per second for reasons of noise. Aerodynamic noise as a phenomenon relates to the fifth power or higher of tip speed. Offshore a higher tip speed can be acceptable, as here noise is hardly a critical factor.

Table 1 shows the relationship between rated capacity, rotor speed and drive train torque. Based on rounded figures, the table shows a 36-fold drive train torque increase when a given wind turbine is scaled up from 500 kW to 4,500 kW. Increased torque requires thicker drive shafts, larger bearings, stronger and heavier machine castings, et cetera.

Wind turbine up-scaling is a highly complex process for many reasons and one of the inherent difficulties is dealing with »negative« effects of the so-called scaling or Square Cube Law (SQL). Think of a cube with all sides having a length of »1«. If you double all

New generation of 2004: Based on Bonus technology Siemens installed its prototype with a 3.6 MW turbine in Høvsøre, Denmark (on the top). The prototype of Repower 5M with a 5 MW turbine was built up in Brunsbüttel, northern Germany (in the middle).

Photos (3): Eize de Vries

A further development from 2006: The Enercon E-82 has a rotor diameter of 82 m.

the lengths, the volume (and therefore mass) of the object increases eight-fold ($1^3 = 1$ versus $2^3 = 8$). Without proper SQL counter-measures, wind turbine up-scaling processes can add excessive mass to the system. As a consequence the new larger turbine can become uneconomical to manufacture, as each additional kilogramme of steel or copper has to be paid for. In addition, extra nacelle mass is known to increase dynamic loads within the entire system. Wind turbine designers therefore try to use hollow structures and other weight-saving elements within the mechanical

Rated capacity (kW)	500	1,500	4,500
Relative rated capacity	1	3	9
Rotor speed (rpm)[1]	40	20	10
Relative rotor speed	1	0.5	0.25
Relative rotor torque	1	6	36

[1] Rounded rotor speed figures in the example indicate the range, but do not necessarily reflect actual product figures.

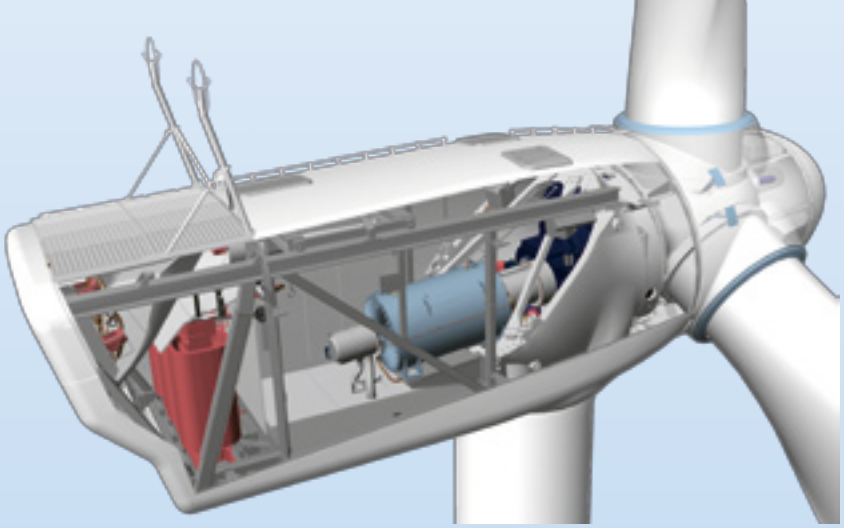
Table 1: Some implications of wind turbine up-scaling

structures. This is typically combined with the use of high-strength steel, superior computer design tools, and the introduction of load reducing (control) measures. Direct drive type wind turbines are at a SQL disadvantage compared to conventional gear driven wind turbines as they feature a large and therefore heavy ring generator. However, a favourable weight value is only one key wind turbine design variable and there are many factors to consider when comparing wind turbine concepts.

Finally, each time when a new leap forward is being made in wind technology and wind turbine capacity, there are a number of challenges to tackle. Among them is the manufacture of heavy and bulky cast components. Today's 5 to 6 MW class turbines, for example, feature 30 to 40-tonne rotor hubs, and mainframes with masses up to 70 tonnes. Only a few specialised foundries are today capable of casting such complex pieces, which require controlled cooling-down periods of up to six weeks. Other key challenges are in the manufacture, machining and (heat) treatment of large bearings and other heavy components. Another issue is the manufacture and handling of huge rotor blades with lengths of 60 metres and beyond. And while LM of Denmark ships the 61.5 m long rotor blades for the Repower 5M by road if necessary, Enercon has chosen to shift boundaries by manufacturing the E-126 blades in two sections. So far, in other words, each time when there has been a problem, a solution has been found. That has been the pattern in past decades and that is what we can expect for the future too.

Eize de Vries

Eize de Vries is an experienced journalist based in the Netherlands and specialised in wind energy.



A third-generation wind turbine: diagram of a Vestas V90-3 MW nacelle *Figure: Vestas*

Thirty years of evolutionary development

In the years following the first energy crisis (1973) a number of Danish manufacturing firms typically with roots in the agricultural sector started developing their first wind turbine models. These generally uncomplicated fixed-speed stall type installations made by small companies were in the 10 to 25 kW class. The low-tech »learning by doing bottom-up« approach of these pioneering firms is often referred to as a key example of successful product and industrial development. It contrasts positively when compared to high-tech multi-megawatt class prestige projects that took place during the same period in industrialised nations like the U.S., the UK, Sweden and Germany. Typically, the participating partners were large established industries, many with roots in aerospace. However, the bulk of prototypes they developed never made it into series products.

Several first-hour »bottom-up« pioneers disappeared, but others survived and their ranks were reinforced by a number of entrants from countries like the US, Germany, and the Netherlands. As a parallel development, the wind turbines they manufactured gradually increased in capacity. Initially, scaling up steps with increments of 20 to 50 kW were rather modest, but later 50 to 150 kW steps were made. By 1993/94 many suppliers had a 450 to 600 kW wind turbine in their product portfolio.

A huge leap in wind turbine up-scaling was made during 1995/96, when two Danish and two German pioneers with European Commission support each introduced a new 1.5 MW class concept (see table 2). The manufacturers involved were Nordtank (now Vestas), Vestas, Tacke (now GE Energy) and Enercon. All four had to take their previously largest 500 to 600 kW model as a technology development starting point. Nordtank, in line with company tradition, developed a fixed-speed turbine with »classic stall« power limitation. Vestas again relied on pitch-controlled optislip technology that enables limited variable speed operation. Tacke, by contrast, switched from fixed-speed stall to a variable speed pitch-controlled system based on a doubly-fed induction generator. And Enercon further built on experiences with its smaller variable speed pitch-controlled 500 kW direct drive E-40 turbine (1992). Rotor diameters of these four 1.5 MW turbines varied from 60 to 66 metres, which was at that time about the largest size that could be manufactured in series.

Ten years later the combination of »fixed-speed and classic stall« had lost its one-time dominance and nearly vanished from the wind market. More advanced »active stall« (pitch-enabled blades) technology also suffered the same fate, and faster than many expected, due to both noise issues and new electric power quality legislation. By contrast, the power conversion concept introduced by Tacke in April 1996 proved highly successful. The doubly-feed technology in fact turned into a semi-standard solution that has been widely adopted by many of the world's leading geared wind turbine suppliers. U.S. giant GE Energy became the third and current owner of what used to be Tacke in 2002. At the end of 2008 GE plans to pass the 10,000 installed turbine milestone for its 1.5 MW turbine series.

Optislip is today used only in the Vestas V80-1.8 MW for the North American market. Vestas made a switch in 2000 to variable speed operation based on employing doubly-fed generator technology. Finally, Enercon further developed the 1.5 MW E-66 in steps into the latest 2 MW E-82. For this model the German market leader claims a 70 % increase in energy yield, whereas the THM has only increased by 16 %. A distinct feature of the E-82 and all sister models, including the E-126, is the application of a new rotor blade design. Enercon claims 12 to 15 % extra yield for a similar swept area compared to »conventional« rotor blades.

	Capacity [MW]	Rotor diameter	Year of first erection
Prototypes with 1,5 MW			
Nordtank NTK 1500	1.5	60	1995
Vestas V63	1.5	63	1995
Enercon E-66	1.5	66	1995
Tacke TW 1.5	1.5	65	1996
Further development (selection)			
GE 1.5s/sl [1]	1.5	70.5/77	2000
GE 1.5xle [1]	1.5	82.5	2005
Vestas V66	1.65	66	1998
Vestas V80	2.0	80	2000
Enercon E-70	2.3	71	2003
Prototypes with 2 up to 3 MW (selection)			
Repower MM70	2.0	70	2002
Nordex N80	2.5	80	2000
Gamesa G80	2.0	80	2000
Nordex N90	2.3	90	2002
GE 2.5	2.5	88	2004
Vestas V90	3.0	90	2002
Bonus 2.0 MW [2]	2.0	70	1999
WinWinD WWD-3	3.0	90	2004
Clipper Liberty C-93	2.5	93	2005
Fuhrländer FL2500	2.5	90	2006
Further development (selection)			
GE 2.5xl	2.5	100	2007
Nordex N100	2.5	100	2007
Gamesa G90	3.0	90	2005
Repower MM92	2.0	92.5	2005
Enercon E-82	2.0	82	2006
Bonus 2.3 MW [2]	2.3	82.4	2002
Prototypes with more than 3 MW			
GE 3.6	3.6	100	2002
NEG Micon NM 110/4200	4.2	110	2003
Siemens SWT-3.6-107	3.6	107	2004
Enercon E-112	4.5	112	2002
Multibrid M5000	5.0	116	2004
Repower 5M	5.0	126	2004
Bard VM	5.0	122	2007
Enercon E-126	6.0+	127	2007

[1] former Tacke TW1.5s/sl
[2] later Siemens 2.0 MW / 2.3 MW

Table 2: Wind turbine development: Since the large European Union research support programme of 1995/1996, which brought about the 1.5 MW class, wind turbine technology has continued to develop in leaps and bounds. The newest generation has rotors twice the size and has three times the power.

Source: own research

Rise to join the world's elite

In 2006, China moved up to become one of the world's leading wind energy nations. The government is doing its utmost to support domestic production so that lasting growth can be expected.

The provinces Inner Mongolia and Hebei fill the top places as to the installed wind power. The map shows the newly installed wind power capacity in 2006 as well as the total installed wind power at the end of 2006.

Source: Chinese Wind Energy Association (CWEA) / China Wind Power Report 2007.

Graphic: Eilers Media www.eilers-media.de

It took a long time before China was able to expand its wind energy utilisation systematically. In the nineties, market development remained behind expectations, but since 2002 things have been accelerating rapidly (see figure 1). In 2006, a total of 1,337 MW was installed in China, moving the emerging industrial nation up to fifth place in the worldwide wind energy ranking list for new installations. The overall capacity that has been installed, however, is still fairly low: By the end of 2006, 3,311 wind power plants had been connected to the grid in China, and their total capacity had reached 2,601 MW, which is less than that of Denmark (3,136 MW).

Three phases of market development

The rapid increase in recent years has been made possible by a mixture of planned and market economics, as is typical for the vast, communist empire. The »China Wind Power Report 2007«, compiled with the assistance of Greenpeace and the Global Wind Energy Council (GWEC) [1], points out that the period of the impressive boom coincides approximately with the Tenth Five-Year Plan (2001 to 2005). Its targets might have contributed to putting an end to the difficult pioneering stage of wind energy development. The China Wind Power Report distinguishes three phases of development:

- In the demonstration phase (1986 to 1993), small wind farms were built, funded primarily by grants and cheap loans from development aid funds. At that time, government support was limited to securing the investment and providing grants for the development of individual wind turbines. The approx. 150,000 small wind turbines that

At the Dabancheng wind farm near Urumqi, in the outermost northwest of China, Goldwind has erected eight wind turbines without gearboxes, which originated from its joint venture with the German manufacturer Vensys.

Photo: Vensys

were installed in Inner Mongolia, with an average capacity of 100 W, are typical of this phase. The share of domestic production in the manufacturing of these small wind turbines had already reached 50 % at that time.

Today there are about 70 manufacturers of wind turbines in China, whose products mostly range from 0.2 to 1 kW in capacity. Their sales figures are impressive: Approximately 30,000 turbines were sold in 2006. In 2005, just under 6,000 were exported. These were off-grid systems, which are not included in the statistics presented here because they record only grid-coupled devices. In the case of the latter, success remained rather moderate in this first phase. Although the first wind farm (three Vestas turbines rated at 55 kW each) was installed as early as 1986, things proceeded only slowly. By the end of 1995, only 44 MW had been connected to the grid in China [2].

● The industrialisation phase (1994 to 2003) was initiated in 1993 by the »National Wind Power Work Meeting«, at which a wind power industrialisation programme was decided on. One year later, the energy suppliers were obliged to connect the wind power plants to the grid at the nearest feed-in point. The feed-in tariff which was planned at that time resembles the German Electricity Feed-in Act (1990): The feed-in tariff was determined by the costs of electricity generation, the interest and amortisation payments and a »reasonable profit«. It was planned that the costs arising from the difference between this price and the average electricity tariff would be distributed among all the users of the grid. These good intentions were not, however, implemented as desired. The report attributes this to the fact that at the same time the general electricity supply in China was being reformed and liberalised. Many wind farm projects could

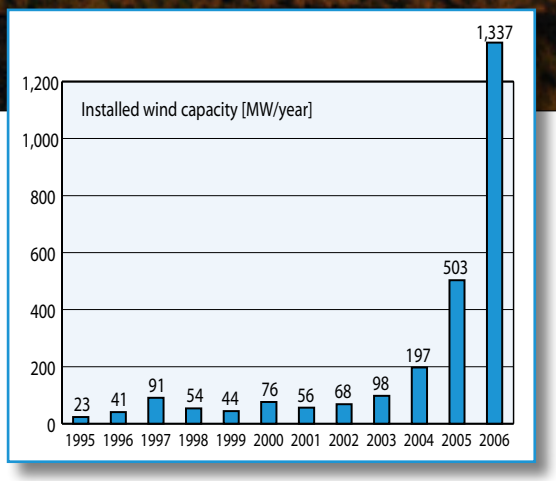


Figure 1: Waiting for the boom has been worthwhile. The capacity that is installed annually has grown considerably since the year 2002.

Source: BTM Consult

Manufacturer	Turbine type	Capacity
Gamesa, Spain	G52/G58-850	850 kW
GE Energy, USA	GE 1.5s/sl	1,500 kW
Repower North, Germany *	MM82/2000	2,000 kW
Suzlon, India	S64/1250	1,250 kW
Vestas, Denmark	V80/V90	2,000 kW

Source: China Windpower Report 2007 (GWEC et al.)
* Repower North: Joint venture (Repower 50,01 %, North Heavy Industries 33,34 %, Honiton Energy 16,65 %)

Table 1: Several large wind turbine manufacturers have founded their own production sites in China.

Source: China Wind Power Report 2007

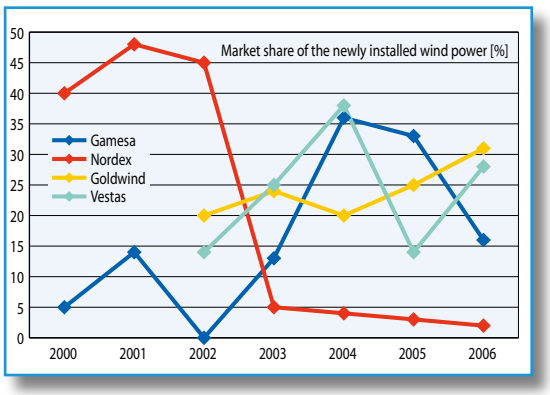


Figure 2: Market shares of the manufacturers Nordex, Goldwind, Gamesa and Vestas in China in the years 2000 to 2006

Source: BTM Consult

not be realised because the investments could not be secured. The capacity that was installed annually failed to exceed 100 MW throughout the entire industrialisation phase.

● The third phase is designated in the report as the »Scaling-up and Domestic Production Period« (2003 to 2007). In these years, the wind power plants and the factories were scaled up in order to enable the domestic manufacturers to produce ever larger units as independently as possible. The instruments of the planned economy were intentionally replaced by those of the market economy. The invitation of tenders for the projects (»Concession Tendering Programmes«) contributed greatly to this objective. Success was achieved soon. The market expanded quickly, and the market share of the domestic production rose to 41 % (2006).

Invitation to tender for projects aims at cost reduction

In the period from 2003 to 2007, the Chinese government conducted four rounds of tendering. Eleven projects (2,450 MW altogether) were put out to tender and were awarded to the supplier making the best offer. The selection criteria were a high proportion of domestic production and the lowest possible costs of electricity generation. By mid-2007, 650 MW had already been installed, and all the projects are expected to be connected to the grid by the end of 2009.

Supporting government measures ensured that the projects were attractive to investors: A fixed feed-in tariff for the first 30,000 hours of full load operation (10 to 15 years of operating time), the obligation of the regional electricity suppliers to connect the plants to the grid and to buy the electricity, the allocation of the cost differences (see above) to all the regional grids, as well as the obligation of the regional authorities to build roads that allow the wind farms to be accessed. In the fourth round of tendering, project developers and the wind turbine manufacturers of their choice competed jointly. According to the authors of the report, these measures made it possible that »the Concession Programme played a major role in supporting wind energy development and domestic production«.

Surprise at the trade fair Windpower Shanghai 2007: This prototype of the Chinese company Futiannordwind is equipped with a two-blade rotor. The two vertical generators are also unusual – this is obviously a truly independent development for which there is no European equivalent.

Photo: Sven Tetzlaff

Manufacturer	Turbine type	Capacity	Cooperation partner
Beizhong	80/D8-2000-80	2,000 kW	EU-Dewind (licence production)
CASC Wanyuan	AW 77/1500	1,500 kW	Acciona (joint venture)
Dongfang	FD 70B/1500 FD 77B/1500	1,500 kW 1,500 kW	Repower (licence production) Repower (licence production)
Goldwind	Goldwind 50/750 Goldwind 70/1500 Goldwind 77/1500	750 kW 1,500 kW 1,500 kW	Repower (licence production) Vensys (joint development) Vensys (joint development)
Hara XEMC	Z72-2000	2,000 kW	Harakosan (joint development)
Huide	55/FL1000	1,000 kW	Fuhrländer (licence production)
Mingyang	83/MY1.5se	1,500 kW	Aerodyn (joint development)
Nordex Yinchuan	S70/S77	1,500 kW	Nordex (joint venture)
Shanghai Electric	SEC 64/1250 SEC 82-2000	1,250 kW 2,000 kW	EU-Dewind (licence production) Aerodyn (joint development)
Sinovel	70/FL1500 77/FL1500	1,500 kW 1,500 kW	Fuhrländer (licence production) Fuhrländer (licence production)
Windey	WD 49/750 WD 54/800 WD 77/1500	750 kW 800 kW 1,500 kW	Repower (licence production) own development own development
Xi'an Nordex	N43/600	600 kW	Nordex (joint venture)

Table 2: These twelve Chinese companies produce large wind turbines in China, mostly in cooperation with European companies. The list is presumably incomplete and will certainly grow longer in the years to come.

Source: China Wind Power Report 2007, own research

Chinese manufacturers are growing

Of course, all the leading wind turbine manufacturers want to profit from the promising market. Five of them are represented in China with factories of their own (table 1). Of the large manufacturers, only the German companies Enercon and Siemens are not present. The German wind turbine manufacturer Nordex was involved in China from an early stage, but not with the aim of setting up a production facility of its own. As early as 1998, the Hamburg-based company founded a joint venture with the Chinese company Xi'an Aero Engine in order to produce turbines of the type N43/600. In December 2005, Nordex, together with a regional energy supplier and a power station operator, founded the Nordex Wind Power Equipment Manufacturing Co. Ltd. (Nordex Yinchuan) for the production of 1.5 MW plants of the type S70/77. The early commitment paid off: Until 2002, Nordex was the market leader in China – in a market, however, that was still very small at that time (figure 2). After that, competition from the companies Gamesa and Vestas became tougher and tougher, and finally the Chinese company Goldwind achieved the leading position.

The diversity of the Chinese wind energy industry is increasing. Most companies cooperate with European partners (table 2). Goldwind began with licence production (Repower) and has recently started an ambitious joint development programme with the German manufacturer Vensys. This involves a 1.5 MW plant without a gearbox and with a permanently excited generator, which was originally developed by Vensys. The intention is to build this in China in large numbers. As one can see, the 1.5 MW class is currently predominant. But this will change. Shanghai Electric, together with Aerodyn, is developing a 2 MW plant with a rotor diameter of 82 m, and other manufacturers will follow their example. ✹

Detlef Koenemann

Sven Tetzlaff

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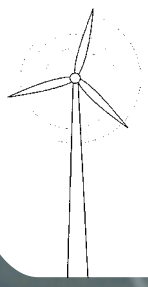

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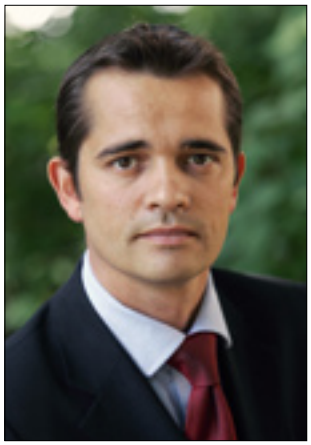
»Onshore success can be duplicated offshore«

In the run-up to the European Wind Energy Conference & Exhibition (EWEC) in Brussels, Belgium, at the end of March 2008, *S&WE* spoke with Christian Kjaer, CEO of the European Wind Energy Association, about developments on the international wind power markets.



Christian Kjaer, chief executive officer of the European Wind Energy Association (EWEA) is a sector expert with many years of experiences. In 1998 the Dane started working with the Danish Wind Industry Association, Copenhagen. Three years later he was sent to the European Wind Energy Association (EWEA) in Brussels. In the beginning he worked as a policy advisor, later as policy director and he was promoted to chief executive officer in March 2006. He is also director of the European Renewable Energy Council (EREC) and of the Global Wind Energy Council (GWEC).

Photo: EWEA

Christian Kjaer is generally optimistic with regard to the future prospects of wind power in Europe and the rest of the world. The optimism of the CEO of the European Wind Energy Association (EWEA) was reinforced by the overwhelming interest shown in the recent European Offshore Wind Conference & Exhibition that took place between 4th and 6th December 2007 in the German capital, Berlin. About 2,100 professionals attended the major event, recalls a satisfied Kjaer: »The EWEA was pleasantly surprised by this large number of participants, together with positive outcomes including binding political commitments made by several EU member states during the opening session. The fact that the emerging offshore wind sector is now broadening out among 'traditional' oil & gas industries and the financial sector is another positive trend. The oil and gas industry for instance brings in decades of experience. By teaming up, the two sectors are well positioned to find common solutions aimed at pushing offshore wind forward at the much faster pace required.«

When asked about the feasibility of the ambitious 40 GW offshore wind target set in Berlin for 2020, Kjaer says that onshore wind power has developed much faster than most expected. The offshore wind industry still faces many challenges, but if there is a strong will to succeed, the huge onshore wind success can be duplicated offshore. A figure of even 50 GW by 2020 is not impossible if the right conditions can be created, he says.

Examples

A true sign of innovation potential is that no less than two offshore wind industry entrants – Blue H from the Netherlands and Force Technology of Denmark – each presented a novel floating wind turbine concept during the conference. These floating wind technology development projects have come much faster than EWEA anticipated. Kjaer continues: »These two examples show the drive of many innovative people working in this still young wind industry sector.«

The European wind industry today supplies 70 % of total global wind capacity. In addition, many European engineering consultancy firms, scientific centres and technology institutes, equipment suppliers and others alike, have for years been developing dedicated products and transferring on request specific know-how to emerging suppliers. These are found especially in Asia, and to a lesser extent in places like the U.S., Canada and South America. Kjaer does not fear wind turbine manufacturing capacity growth outside Europe, but believes instead that the irreversible development is in general beneficial for established European suppliers. However, he has his concerns about the hardware quality some of these new entrants have to offer once they enter Europe's wind markets. Kjaer: »Due to the size, mass and complexity of many key components fitted in today's multi-megawatt size turbines, manufacturing and assembly ideally has to take place close to main markets. In addition, Europe still has the lead in terms of wind technology advancement, and it is of key importance to maintain that technology leadership position in the future. However, in order to achieve that goal the European Union needs to step up its R&D efforts. A partly related future wind industry challenge is finding solutions for the huge skilled manpower shortage, engineers, technicians, support staff and managers alike.«

Latecomer

With regard to European research funding dedicated to advancing different energy sources within the community between 1974 to 2007, nuclear power is the single big winner.»Of all European Commission (EC) energy research money spent during the past thirty years, we found that about 60 % went to nuclear and only less than 1 % to wind power,« says Kjaer: »That conclusion is solely based on comparative figures of the European Commission and perhaps the price wind power has to pay for being a latecomer!« With regard to future research priorities Kjaer favours a much stronger emphasis on a range of potentially promising energy storage methods. He says that the European Commission (EC) still has a single focus on strongly pushing hydrogen (storage) technology at the expense of other promising alternatives: »Hydrogen is only one future storage technology out of several and this fact should have been reflected by a more general push for supporting the development of different energy storage methods.«

Things within EWEA are also changing and there is increasing attention being paid towards important issues such as guiding power demand, so-called demand-side management, besides primarily promoting wind power interests. A second EWEA focus is on further optimising the use of existing grid infrastructure capacity, and a simultaneous push for an increase in grid inter-connectors. Kjaer: »In other words, financial energy trading is not the only answer. There should in addition be a much greater emphasis on expanding grid infrastructure across Europe. That project has to include sufficient inter-con-

nectors to eliminate barriers and to improve physical energy trading as an instrument to effectively balance power supply and demand onshore and offshore.« Besides, an especially strong demand for new turbines in the U.S. and China has led to a severe equipment shortage during the past few years, with delivery periods sometimes in excess of 1.5 to 2 years. The important U.S. wind market development has for years also been characterised by its »boom or bust« cycles dictated by either an expired or reinstated federal production tax credit (PTC) support scheme. This strongly fluctuating character of the U.S. market has made suppliers generally hesitant to invest heavily in new capacity. And even right now it is uncertain whether the PTC will be extended before it expires again at the end of 2008. Kjaer strongly believes that the situation today cannot be compared with the strong impact of past U.S. wind market cycles: »Today's global wind sector is far less dependent on single markets, as there is a much larger geographical spread of demand. In addition, gas prices in the U.S. are now much higher, and even without a PTC in place there will still be investors for wind in the U.S. On top of that, with today's high oil prices wind is becoming more and more attractive as a viable alternative to conventional power sources.«

Insufficient support

When looked at in isolation, the U.S. does not benefit sufficiently from what wind power has to offer its economy. Fuelled by uncertainty about long-term support for wind power in the country, investors are hesitant to plan new local production capacity. For that reason a large percentage of all turbines installed in the U.S. are still imports. Kjaer continues: »This, despite the fact that the current value of the U.S. dollar set against the Euro is low and European suppliers would thus love to invest in new manufacturing capacity in the U.S.«

Finally, with regard to a question on market chances for the latest generation of huge 4.5 to 6 MW+ class wind turbines at onshore sites, Kjaer does not see the visual impact of size as being much of a problem. He regards instead the transport infrastructure as the key limiting factor onshore and draws a parallel with the introduction of the Airbus A380. Before this, the Boeing 747 had for decades been the world's largest commercial airliner, and introducing the new giant also required several major changes to airports and other key support infrastructures. »The problem often lies within the planning stages, whereby individual perceptions can become a major obstacle to change. Here too, for real acceptance and a breakthrough for big turbines at onshore locations, pioneers with vision and first movers are needed,« he concludes.

Eize de Vries

Eize de Vries is an experienced journalist based in the Netherlands and specialised in wind energy.

Agreeing to disagree

The international wind power market is still dominated by a few leading nations. And yet, these countries do not by any means share similar market conditions for future wind power projects. Investors have to reckon with a great variety of market structures.

2007 was yet another successful year for the global wind power sector. At the time this article went to press, final figures were not yet available for 2007, but reports from the main markets – the U.S., China, Spain, and Germany – suggest that some 18,000 MW was added, around 20 % more than in the previous year (15,197 MW).

In addition to national market support policies, these impressive growth rates for the international wind power industry are mainly the result of three factors. First, oil and gas prices continued to rise in 2007. Experts expect the price of a barrel of crude oil to cross the US$ 100 threshold soon. Second, CO_2 emissions have become a true cost factor for companies. Since emissions trading began, the price for an emitted ton of CO_2 has more than doubled to € 23 as of December 2007. Companies can, however, receive credits for CO_2 emissions by investing in wind power projects. But according to a previously unreleased study by German financial institute HSH Nordbank, supply security is the most important factor behind the wind boom. On the one hand, the countries that export the most oil are politically unstable; on the other, the booming markets of China and India are draining the energy market. In the next few years, these factors will not only continue to influence the market; their impact will even increase. In addition to greater global power consumption, these factors ensure the long-term growth of the wind sector.

But the wind industry is not growing along the same lines everywhere. Rather, a distinction has to be made between the ten leading markets (see table) and the rest of the world. All of the countries in the top ten have the potential to reach or exceed an annual addition of 1,000 MW for the long term. France, Canada, Portugal, Great Britain, and Italy did not reach that level in 2006, but they may have done so in 2007. We will know more in a few weeks.

Exporters are therefore focusing on a select group of countries. But even then, both manufacturers and project managers face highly disparate market conditions partly due to the different histories of the various energy markets. For instance, Nordex of Germany has long been in China and recently reentered the U.S. market. Its sales department has to adapt to the needs of different customer groups. In China, sales are almost exclusively made to local and regional energy providers, but in the US the target group increasingly includes large conglomerates, such as infrastructure firm Iberdrola of Spain or investment firm Babcock & Brown. Furthermore, large insurance firms, such as Allianz, are becoming major players in a number of European countries.

The U.S. and China are currently the main growth drivers, but a number of other countries also play important roles on the international wind market. Each of these markets has a different set of rules.

Spain: where large investors reign

For the past 10 years, Spain has been the most important European wind power market along with Germany. At the end of 2006, the country had installed 11,615 MW. Interestingly, Spain's energy market has a structure that is not typical of a western European country: All relevant energy carriers have nearly equal shares of power production, with each lying between 20 % and just under 30 %. Renewables make up a big chunk thanks to the large share of hydropower in Spain. Spain has a total

power production capacity of 82,300 MW, with a good fifth of that – 16,700 MW – coming from hydropower.

Aside from hydropower, wind power is the largest source of renewable energy, with only bioenergy coming even close. And there is one other special thing about Spain: The main operators of wind farms and buyers of wind power are large infrastructure companies, some of whom have their own production capacity for wind turbines. For instance, the Acciona Group, whose logo is found on almost all major construction sites in Spain, had approximately a 20 % share of the market in 2006 with its recently established wind turbine division (Acciona took over Spanish wind turbine manufacturer EHN Ingetur).

At least it is easy for foreign investors to get a quick overview of the operator market: Four companies operate well over half of all of Spain's wind turbines. The Basque Iberdrola Group is the largest member of this oligopoly with more than 7,300 MW in worldwide its wind power portfolio, 4,400 MW of which is in Spain. Another Basque company, Spain's number one wind turbine manufacturer Gamesa, has close connections with Iberdrola in long-term rental contracts.

France: Europe's great hope

Wind energy is growing by leaps and bounds in Europe's main nuclear power country. Back in 2003, only 91 MW were added. A year later, the figure was 138 MW, which rose to 367 MW in 2005. Finally, in 2006 the French market was the third-largest in Europe behind Germany and Spain with 810 MW of newly installed capacity.

While these figures are impressive, we have to keep in mind that France's wind market is just emerging from its fledgling phase. As of mid-2007, only some 2,000 MW of wind capacity was installed in the entire country.

Nonetheless, the development is astonishing because France relies on nuclear power like few other countries in the world. An almost uncontroversial topic in France, nuclear power makes up a full 55 % of the country's installed generating capacity and 80 % of total electricity generation. Though it may seem unusual at first glance, renewables come in second with a 24 % share of installed capacity, but that figure makes sense when we realise that 95 % of that share is hydropower – the French are in love with grand technology.

German manufacturers such as Nordex and Repower are doing good business in France, which lacks its own wind turbine manufacturers. Naturally, the best wind sites in France are found along the Atlantic coast in the west of the country and along the English Channel to the north. Wind speeds of 8 to 9 metres per second are common at the height of the hub. On the other hand, offshore turbines will not be possible in most locations because the sea bed drops off swiftly along the coast. In France, wind turbine providers are faced with a relatively large number of calls for tenders from the state. EdF Energies Nouvelles, a subsidiary of the state electricity monopolist EDF, is heavily involved.

Country	Installed power in 2006 [MW]	Total power [MW]
USA	2,454	11,603
Germany	2,233	20,622
India	1,840	6,270
Spain	1,587	11,615
China	1,347	2,604
France	810	1,567
Canada	776	1,459
Portugal	694	1,716
Great Britain	634	1,963
Italy	417	2,123

Table: Wind energy markets top ten 2006 – the capacity installed in 2006 and total installed power up to December 31, 2006 are indicated.

Source: GWEC

Great Britain: the island of wind

The United Kingdom of Great Britain and Northern Ireland (UK) plays in the same league. In mid-2007, the UK had slightly more installed wind capacity than France at around 2,200 MW. The British get most of their energy from hard coal – 35 % of installed power plant capacity – and natural gas (38 %). Renewables only make up 4.5 % of total power plant capacity, and almost three quarters all of that is wind energy.

Nonetheless, many experts believe that Great Britain has the best wind resources in Europe, not only because of the average wind speeds, but also because the wind is so constant.

The British Isles also offer investors great offshore potential. The British already have around half of Europe's total offshore wind capacity. Major energy firms such as Scottish Power (now Iberdrola), Eon UK, RWE Npower and Scottish & Southern Energy plan and install wind farms offshore and on, thereby leaving their mark on market structures. Multinational oil firms such as Shell and Total are also involved, usually behind operator consortia and almost exclusively in offshore wind. HSH Nordbank believes that offshore wind farms will continue to grow by 30 % annually until 2010. However, the British quota system with certificate trading remains problematic for the further development of wind energy. Many utility companies are not willing to enter into long-term purchase agreements for wind power because they are not obligated to do so. If certificate prices drop, they can simply buy their way out of such obligations.

Caton Moore Windfarm in Lancashire County: This photo clearly shows that British authorities want turbines with relative small towers that are not overly visible in the landscape. *Photo: Jan Oelker*

Business is constantly improving for Repower on the British Isles. The photo shows the Ffynnon Oer wind farm in Wales with 16 MM70s (2 MW).

Photo: Jan Oelker

Wind energy is advancing rapidly in Portugal. A number of wind farms have gone up both on the Atlantic coast and in the mountains.

Photo: Energiekontor

Portugal: constant wind from the Atlantic

The constant westerly wind from the Atlantic is certainly one reason why Portugal plays such an important role on the European wind market. At the end of 2006, the country had installed 1,716 MW. Like Great Britain, Portugal gets a large portion of its energy from coal and natural gas, but it plans to reduce its dependency on imports by installing more renewables. In addition, the country is a long way away from reaching the targets it accepted in the Kyoto protocol. The government has therefore set up an ambitious project to increase the share of renewables in power generation to 39 % by 2010. As in France, this goal will mainly be reached by large projects initiated by the state with a capacity of up to 1,800 MW per tender. In October of 2006, a consortium including Enercon was awarded a contract for a 1,200 MW project; in July of 2007, a consortium including Galp Energia and Repower was awarded one with 400 MW. Energias de Portugal, the country's main energy provider, also plays a crucial role. By the end of 2008, the company plans to triple its installed wind power capacity up to nearly 3,000 MW.

India: the tiger leaps

The emerging southern Asian nation is a giant in every respect: in terms of size, population, and economic growth. Along with its neighbour China, India is driving the global economy with growth rates of 8 % and more. Its energy consumption is growing along with that. A look at the country's power production structure shows how much ground the country has to make up. India has some 135,000 MW of installed power plant capacity, with which it produces nearly 700 terawatt-hours (TWh) of electricity annually. While both installed capacity and gross power generation are roughly at the same levels as in Germany, India has 1,029 billion people – around 12 times as many as Germany. If Indians consumed as much power per capita as Germans do, the country would have to generate 8,400 TWh of electricity – twice as much as the U.S. currently does. These projections clearly show that India has to use every source of energy at its disposal. After all, electricity shortages are already slowing economic growth.

No wonder India has come up with the world's most comprehensive system for the measurement and evaluation of wind power. More than 500 areas have been set aside as good sites for wind farms in the country. Indian experts say that the country has a potential of 45,000 MW of installed wind capacity, though only a third of that is considered technically feasible. The main obstacle is the country's poor infrastructure, with the transportation and installation of large wind turbines often posing a problem, among other things. Nonetheless, 6,270 MW of wind power had already been installed by the end of 2006. HSH Nordbank estimates the average annual growth rate at 20 %. One special feature of the Indian market is that production companies install wind turbines for their own consumption. The Indian Electricity Act of 2003 allows them to do so. ✹

Jörn Iken

Jörn Iken is a long term *S&WE* author based in Hamburg, northern Germany. He is a specialist in wind energy and photovoltaics.

Further information:
The WWEA's study »Wind Energy International 2007/2008« can be ordered from the Internet (*www.wwindea.org*).

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Crisis on the German pellet market

After strong growth in the past few years, the German market has nearly collapsed in 2007 for manufacturers of pellet-fired boilers. The industry is looking for the cause of the problem – and a way out of the crisis.

Did the media cause the market to collapse, are not enough new buildings being constructed, or did pellet boiler manufacturers themselves do something wrong? Industry experts say there are many reasons why the market is shrinking, but the main ones seem to be the rising price of pellets, stop-and-go subsidies from the government, and the current debate on airborne particulates. To make matters worse, some pellets have recently been leaving behind a sticky residue that clogs up boilers.

Getting to the bottom

Until recently, Beate Schmidt, who chairs the German Energy Pellet Association (DEPV), was always able to report on the fast growth of the fledgling pellet market. Usually, sales of such boilers exceeded industry expectations. But this year, everything was different at Interpellets, Germany's largest trade fair for pellets, which was held in October in Stuttgart. Beate Schmidt spoke of »plummeting sales figures«; while the German heating market is suffering as a whole, the pellet sector is suffering the most.

The German Industry Association of Heating Technology (BDH) reported in September that while sales of conventional boilers were down 30 %, the market for biomass-fired boilers had collapsed by 70 %. The price of pellets remained relatively low in the summer of 2007, but neither that, nor the climate protection discussion, nor the boosting of subsidies from the German government's market incentive programme in August helped business pick up. The DEPV estimates that heating equipment suppliers would normally have installed 20,000 boilers and water-circulating stoves by the end of the year, but the German Office for Foreign Trade (BAFA) says that only 15,805 pellet heaters up to 50 kW were in the first ten months of 2007 (see figure on page 162).

Beate Schmidt thinks that the current situation is partly the result of the annulment of state subsidies for the construction of private homes; and in the first two quarters of 2007, only half as many people made such investments, so demand for heating equipment was reduced accordingly. Furthermore, the value added tax rate increased at the beginning of 2007 from 16 to 19 %, which probably shifted some sales to 2006. Finally, last winter was mild, and oil prices were low in the autumn of 2006. The DEPV chairwoman feels that the German government's inconsistent support policies and the ongoing discussion about particulate matter and prices are making potential pellet consumers wary. To revive the pellet boiler market, the DEPV is therefore working with the BDH on a press campaign called »Initiative Holz und Pellets« (Wood and Pellets Initiative). Both associations are optimistic about 2008 because, as Schmidt explains, a lot of catching up has to be done in the modernisation of German heating equipment, and consumers will soon have more spending power now that the German economy is picking up.

Paradigma Energie- und Umwelttechnik GmbH & Co. KG of Karlsbad, Germany, is addressing the market downturn actively. Sales director Martin Willige says that sales of boilers have fallen by 75 %. He thinks that manufacturers made a mistake by »just focusing on oil prices« in sales pitches for pellet boilers instead of emphasising environmental friendliness and quality. But Willige says all that is changing. »More and more customers are asking about pellet technology.«

Christian Rakos of the Propellets Austria Association compares the industry to an apple tree. As he puts it, fruit trees have to be cut back in the first few years. »Otherwise, they will not bear fruit.« In this case, the tree that has been cut back to a quarter of its size is the market for pellet boilers. But Rakos is confident that the tree will have strong shoots next year. »When you then put the budwood on the base, you get the best apples,« the hobby gardener explains. Indeed, pellet boiler manufacturers have been facing severe criticism lately and would be well advised to make sure that they only market very good products. On the other hand, Rakos points out that growth is only possible in the proper environment. »A tree needs a stake to grow up straight. Our stake is policies.« And if the right policies are provided, Rakos says growth can resume.

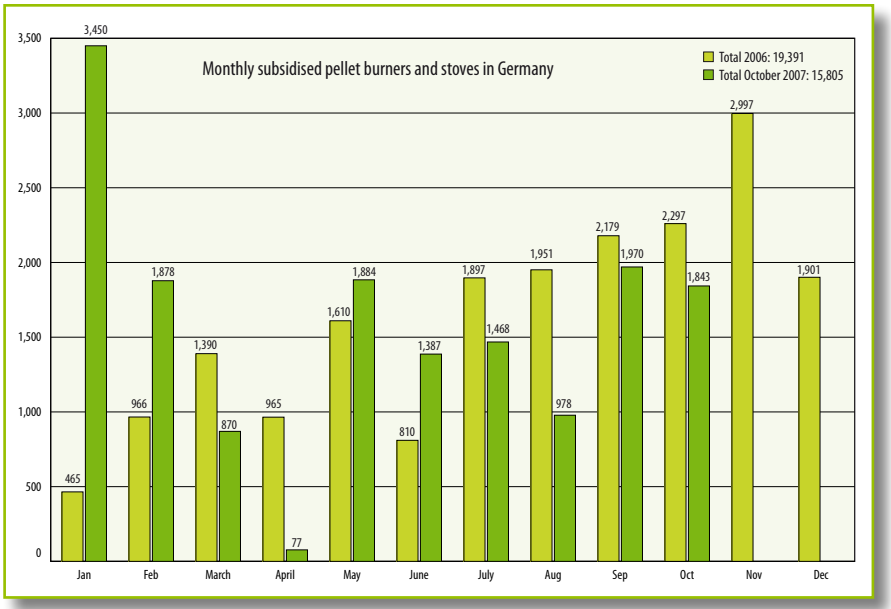
Querschiesser Unternehmensberatung GmbH & Co KG of Xanten, Germany, which has been providing consulting services to the HVAC (heating, ventilation, air-conditioning) sector for years, does not share this moderate optimism. Hans-Arno Kloep, who owns and directs the consulting firm, saw the market collapse coming way back in 2006, and he now says that his surveys of installers does not indicate that the market will recover in 2008. Querschiesser says he conducts a survey of 300 directors of heating installer shops each week to see which brands of boilers they use, how many items they sell, and why they chose a particular boiler manufacturer. In the process, he hears a lot of criticism. Based on his surveys, he says »They [the DEPV] will not reach their target.« Rather, his surveys reveal that the upswing in the overall German economy will not reach heating customers, who will still lack purchasing power.

However, Kloep says that the main reason why the market for pellet boilers is shrinking is that pellet technology is »a headache« for installers. As he puts it: »Installers don't like to have to do a lot of explaining. Discussions with customers about pellet prices and particulate matter take a lot of explaining.«

A diet for pellets

Pellet manufacturers have also recently had a lot of explaining to do in the recent discussion about the sticky residue that pellets have started leaving behind. It all started in the winter of 2006/2007, when the first customers reported that the pellets were creating a thick film that was stopping up their boilers. Slag was building up in the boilers, and figuring out why wasn't easy. The DEPV estimates that around 1,000 to 2,000 heating systems had such problems. And while even the upper estimate is less than 3 % of these 70,000 installed systems, the DEPV says it is taking the problem very seriously. In order to make sure that pellet customers are not left with such a sticky mess, the association has come up with a position paper in which pellet producers, retailers, and heater manufacturers jointly promise to remove defective pellets from the hopper for free if the problem occurs and cannot be remedied by lowering the boiler temperature.

In a process that experts call »sintering«, the pellets apparently do not burn cleanly, though no one has been able to explain why. A workshop was held at Interpellets to try to determine the cause. Günther Friedl of Austrian Bioenergy Centre GmbH in Wieselburg,



Subsidised pellets-fired boilers and stoves up to 50 kW

Source: German Office for Foreign Trade (BAFA), German Ministry of the Environment (BMU), Solar Promotion, data as of October 2007

On last years Interpellets, Germany's largest trade fair for pellets in Stuttgart, the sector for the first time was not able to report on fast growth. The manufacturers of pellet-fired boilers have to cope with a shrinking market. *Photo: Intersolar*

Austria, studied how the slag is created. His initial insight into combustion tests on pellets of varying qualities was that the fuel, and not the combustion technology, is solely responsible for such deposits. Because no materials that could create slag are used in state-of-the-art pellet processing plants, Friedl concludes that the problem solely results from the quality of the wood used. Using a glass filled with sand in a demonstration performed at the workshop, Hans Martin Behr of Germany's Holz-Energie-Zentrum Olsberg GmbH showed how that small amount of sand (silicate) would provide so much impurity in a ton of wood chips that the pellets made out of them would create slag. Behr says that you cannot tell whether wood chips or pellets will create slag simply by looking at them, but interestingly his experiments reveal that short pellets create more slag than long ones. Short pellets with a lot of abrasion are the result of long transport chains between delivery vehicles and consumer basements; they can also result when the pellets are blown into the storage containers without impact protection mats.

Experts suspect that the geographical origin of the pellets also plays a role: If the trees grew on poor sandy soil as in northern Germany, the wood may have a lower ash melting point and tend to create slag. Furthermore, more and more forest residue is being made into pellets, which changes their combustion properties. Behr says more research is necessary, however.

Solutions

Communications agency Bettertogether GmbH, which has offices in Austria, Germany, and Liechtenstein is handling crisis PR for Propellets Austria. CEO Bernhard Dostal says there are mainly two reasons for the crisis in the pellets industry: the first is their own fault – they did not make good on their promise to keep pellet prices down; the second is not – the debate on particulate matter. He says that the combination of the two has caused the public – and the media – to lose faith. Now, he says that journalists are asking questions like »are we being ripped off?« and »are pellet-fired stoves unhealthy?« Dostal is calling on the industry to refrain from making out the media as the bad guy and instead admit its own mistakes and respond to negative coverage with active communication.

But first, he says the industry will have to reach a consensus internally. »The industry has to work together reliably,« the communications expert demands. Only then can messages like »we made a mistake, but we've learned from it«, »we are victims of the particulates campaign«, and »ask us what you want to know about pellets, particulate matter, and the climate« be sent out to the media.

Dostal says that industry associations in Germany and Austria had to work together more closely to influence the media collectively. Furthermore, he thinks that greater contact to organisations who pursue the same goals, such as environmental groups and climate protection agencies, would help. Austria is an example of what he proposes: There, editors of economics and environmental issues desks were contacted in an awareness-raising campaign that produced a turnaround – positive headlines.

Germany's new Immission Control Ordinance (BImSchV) might also once again provide positive headlines when it comes to particulate matter. The revised version of the 1st BImSchV, which concerns biomass-fired heating systems with an output up to 1 MW, is to take effect in January of 2008. Then, Germany will have the strictest cap on emissions in Europe. Though the exact figures have not yet been officially announced, the caps for all solid fuel particulate immissions are expected to be reduced by a third, with a transitional term up to 2012 applying for the new limits.

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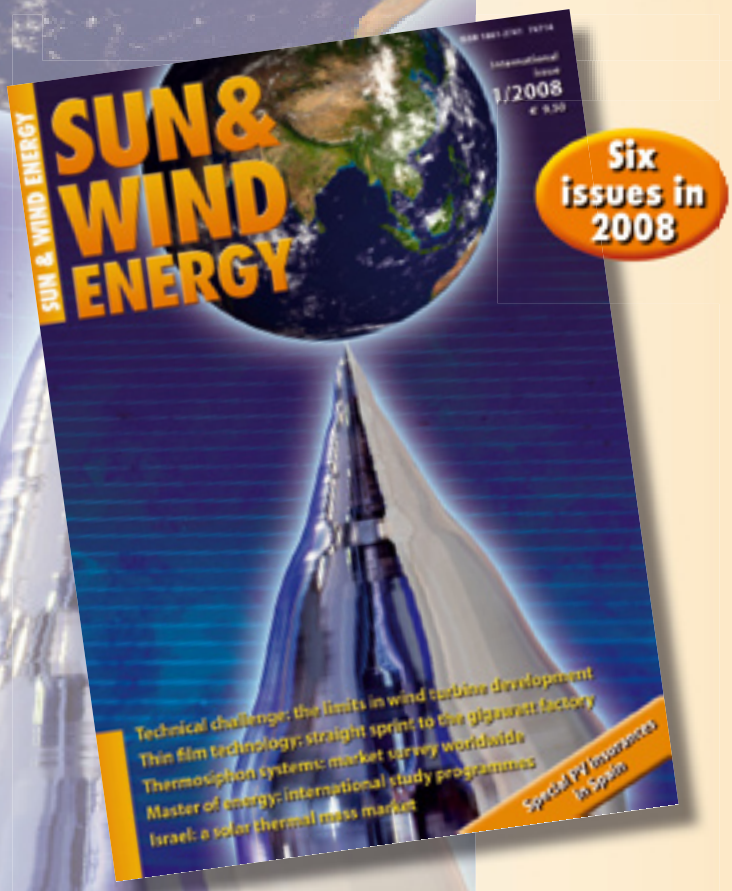

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