



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.



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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 m² of solar collectors in operation, 370 m² / 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 m² of solar collectors in operation, 640 m² / 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 m² / person
- industry and agricultural applications now mature
- CSP plants make an important contribution to electricity generation

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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



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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.



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»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.

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

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



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

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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 m² of office space since 2002. The surface area of the collectors is only 170 m². This shows very clearly the potential, but also the commercial possibilities of such a system. There are 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



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

Photo: Tsinghua University

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.

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

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 lose 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.

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



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