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The Tvind windmill showed the way

In this 7 page article Preben Maegaard, Director of Nordic Folkecenter of Renewable Energy describes how Tvindkraft came to inspire and provide technical knowhow for the budding Danish Wind industry in the 1970's. You can read it here

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By Preben Maegaard, February 2009

The Tvind windmill showed the way

By Preben Maegaard, director of Nordic Folkecenter for Renewable Energy
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The Tvind windmill (Tvindkraft) has become legend. It is the materialisation of an idea at the Tvind Schools in Western Jutland in Denmark. Here teachers and students designed and built their own power plant for their own schools in the 1970's – at the time the world's biggest wind power plant. With their own money. They built it for the sake of natural energy, for the sake of a human society - against monopolisation within the energy sector, and against nuclear power.

From the beginning the project was looked upon as a crazy, foolhardy experiment. It was out of the question for lay people to be able to think and build anything so big, so different from what was at the time and still is the established social order. When several hundred people cut the first sod on 29. May 1975, all experts within energy agreed that the project was impossible. National newspapers had leading experts state that the huge experimental windmill would simply topple in the first really windy weather.

It didn't happen. On the Tvind windmill's 30th anniversary the Barsebäck nuclear power plant (Sweden) had been closed down for good, while the Tvind windmill is still there producing electricity; you might say in majestic solitude, as all other big ambitious test windmills from that time, Danish and foreign, are gone. This is a special reason why the story of Tvindkraft must be remembered and told.

The historical dimension.
There is general agreement that the cradle of wind power is to be found in Denmark. Throughout the past hundred years the exploitation of the power of the wind was turned into practical realities by personalities such as Poul la Cour and Johannes Juul. History is being written about this, whereas until now there has been extreme fear of contact concerning Tvindkraft's significance for the development of windmills in our times. This in spite of the fact that Tvindkraft holds a number of technical solutions that go straight into the windmill industry of the 1980's, whereas, in fact, hardly any technical and functional solutions or materials were passed on from earlier windmill epochs.
In spite of Tvindkraft's 30 year anniversary it is more modern compared to the windmills produced by the windmill industry until the mid 1990's. From about 1976 windmills had an asynchronous generator, fixed wings and they were stall regulated, which was the conceptual heritage from J. Juul. The epoch ends with Nordtank's very elegant designer

windmill of 1.5 MW from 1995, which, however, was caught up by the dinosaur effect technologically. The rationale of J. Juul's concept couldn't be stretched to such lengths.

If we then look upon the innovation within windmills over the last ten years, it is much more similar to the technological mix introduced by Tvind already 30 years ago, which they actually made work. It was lasting in more than one sense; it didn't break and the technology could be transferred to other windmill projects. For example, Tvindkraft was born with pitchable wings, which has later become standard on all big windmills. Like regular power plants, it has a synchronous generator, which more and more producers change to. They can be multi-pole like in Enercon, Vensys, WinWind and Siemens' test windmill, or it can be a combination of a gear and a synchronous generator, which is the newest design from GE Wind and DeWind. Where the asynchronous generator prevailed because revolutions and effect were easy to control, irregular wind conditions place very different demands on the control system in windmills with synchronous generators. But also this problem had an early solution in Tvindkraft, which was far ahead of its time. So was Tvindkraft's dealing with the phenomenon of surplus power, where step-by-step switching on of immersion heaters for a central heating system is used, which is exactly what in 2009 seems to be the obvious way of disposing of the surplus electricity which co-generation plants and windmills together deliver to the grid.

This is how Danish windmills got wings.

However, the most important finger print on the later windmill industry is Tvindkraft's significance for the development of the modern composite wings. This is true both concerning the aerodynamic shape, the structure, and the fact that the knowledge of wing construction was generously placed at the disposal of a new generation of independent wing producers, thus creating the basis for the prevailing concept, the component windmill. Within few years more than twenty Danish companies were able to establish themselves as windmill producers, because they could buy the all important components, control systems, towers, and most important, wings from specialised contractors. Once you have the wings, the companies could figure out the rest. And Tvindkraft took care of the wings.

In the daily paper *Information*, March 22. 1976, Amdi Petersen from Vestjysk Energikontor (West Jutland Energy Office) in Tvind presented his industrial policy vision: The next step we "will take is the development of real models. For example, we could make moulds in which people can make their wings. Most often the wings are the biggest problem. So we will very soon start doing that … It is quite in the spirit of the wind. It cannot be monopolised. So we would like to prevent the use of the wind from being so. No one needs to hold back. You can just come ... all experiences should benefit everyone else". At this stage the tower was completed and the real challenges, the wings and the windmill house, were going to be started.

Amdi Petersen insisted that a special wing solution be used, and so it was. This shows that among high-flying plans and paroles there was recognition of and respect for the boundary surface of research. Compared to the researches in other contemporary big windmill projects in Denmark and abroad, the Tvind people were humble about the truthfully very tasking challenge it is to design and build a very large windmill. The wing solution was German, developed and tested in practice on windmills and helicopters by Professor Ulrich Hütter from the Deutsche Luft- und Raumfahrt Institut at the Technical University in Stuttgart. Hütter's construction with fibre glass strands turned around the hub bolts, solved a well-known weak point in windmills. In addition to using the technology on the big windmill in Tvind, it was also used on the small 20 KW PTG windmill from Tvind, whose wing mould was placed at the disposal of people who wanted to build their own windmill. It was Erik Grove-Nielsen, whose brother Johannes was an important person in the windmill team, who with the Oekaer wing transferred the experiences from Tvind into industrial production. From him Vestas, Bonus, Nordtank and many others could soon buy wings for their windmills. Also Alois Wobben from the German Enercon,

which would later become Germany's biggest windmill producer, used them. But it was Tvind who got the technology to Denmark.

Tvind got important help from Helge Petersen, Per Lundsager and Peter Steen Andersen from Risoe (Denmark's nuclear test station) for developing the wings, and from professor Ulrik Krabbe from Danmarks Tekniske Højskole (Denmark's Technical University) for the development of the control system. But looking back we cannot accredit leading national laboratories with the success of Tvindkraft. The official experts of the time preferred wing concepts quite different from Tvind's when their state projects, the Nibe windmills, DWT 15 og 265 KW and later the Esbjerg windmill of 2 MW, were designed. Contrary to Tvindkraft did neither of these concepts lead to the prevailing concept and to an industrial product.

Neither did large foreign potent industrial concerns and distinguished institutes, well equipped with researchers and hundreds of millions Danish kroner, discover any sustainable concept. This fact must be known although not acknowledged in inner circles. Also within technological development there is prejudice, and sober-mindedness faltered in the face of Tvind's ideology. However, speaking of technological vision and innovation, decisive steps were taken in Tvind during those years.

The West Jutland windmill builders acknowledge that they to know nothing about wind energy. This gave them the necessary courage and energy to go out in the world to seek and involve anyone who would like to lift Tvind's windmill project. Another important aspect was that they built the windmill with their own money and there was a huge pressure of expectations from within as well as from without, a consequence of being vociferous about Tvindkraft's role as a specific reason why the population would denounce nuclear power, which was the Danish establishment's answer to the energy supply of the future.

With their openness Tvindkraft worked on the same ideological basis as the pioneers of the Danish coop movement at the end of the 1800's. At the passing of the first patent law in 1895, they made it part of the law that processes and agricultural technologies could not be patented. Inventions should not gild individuals but be at the disposal of the people. Especially Poul La Cour turned this production philosophy into reality. He was no Bill Gates. The fact that Tvindkraft has a similar significance for the industrialisation of wind power is generally ignored in writings of the history of modern windmills.

Popular movement and inspiration for the industry

When analysing Denmark's position as world leader within the production of windmills, it is impossible to ignore Tvindkraft. The very fact that Tvind generously invested funds in the development of a very large as well as a smaller windmill in the 1970's was of great technical as well as symbolic importance for the development of windmills.
100.000 people visited Tvindkraft during the building work. They talked to the windmill builders and got answers to their questions about windmills and the energy supply of the future. They saw with their own eyes how the Tvind people were innovative and courageous, which inspired many others to start working with wind power, which for a number of years turned into a popular movement, where Tvindkraft was an important and vital argument in the energy debate. When people at a school with their own and rather meagre means, and by using existing knowledge and materials were able to construct a large windmill and produce electricity for themselves with the power of the wind, there was no reason at all to consider nuclear power. This argument had a penetrating power with the public and won.

In the book Vedvarende Energi i Danmark, OVE's Forlag, 2000,

(Renewable Energy in Denmark, OVE Publishers) the persons who had technical importance within the budding windmill industry declare how much they owe to the windmill in Tvind. Henrik Stiesdal, technical manager in Siemens Wind Power, here comes across what in other environs would be called basic research. He had read about Tvindkraft in the press and *"during Christmas 1976 my father and I therefore went to Tvind for the first time, and like everyone else were fascinated by this group of obvious amateurs, who from something that appeared to be absolutely square one, were building the world's biggest windmill. During the spring of 1977 we went to Tvind several times, and assisted by Jens Gjerding, in Vestjysk Energikontor and others, I got hold of various books on wind*

power".
In the same book Iben Østergaard from Tvind's windmill team quotes Birger T. Madsen, a former manager at Vestas, the world's biggest windmill factory, for saying that *"The significance of the Tvind windmill was that a number of discussions were had during the project, that this involved a number of qualified persons, and that many possibilities and solutions were debated in theory and also tested in practice. This leg work meant much to the budding windmill craftsmanship, which thus did not start from square one. Thus many deliberations were made about synchronous/asynchronous generators, upwind or downwind, heat or power production, materials for and methods of wing production. Some experiences from Tvindkraft were negative as the technology used led into blind alleys, others presented directly usable principles, but all experiences were important for the continued work".* Also Egon Kristensen, a pioneer who was a vital person for the Bonus windmill to become a technical and commercial success from the start, says that *"Tvindkraft was a very important inspirational source, which everyone who were serious about windmills visited. And since then many of the people who joined the building of the windmill in Tvind have left their stamp on the development of windmills, either in the industry or in research and test institutes".*

The project group of young engineers at Risoe's test station for smaller windmills, who gradually became key persons within the official Denmark, say that *"Tvindkraft gave them not just the faith but also the proof that wind power was possible during times when large industrial conglomerates had given the proof that wind power did not work, and when the power companies and their own employers couldn't wait to introduce nuclear power".*

Idealists and professionals working together.
Many others become involved with Tvindkraft. Building their own windmill was the main principle, and a talented young engineer, Jens Gjerding from Tvind's Vestjysk Energikontor (West Jutland Energy Office) gathered a lot of the threads. But professional help was also brought in

from outside when the necessary expertise was not present. In the middle of a utopian project this in itself was an expression of self knowledge and sober-mindedness.
Thus Hans Jørgen Lundgaard Laursen was advisory engineer with respect to the calculations of the tower, Lars Svanborg was supervising engineer concerning the machinery, and chief welder Henning Jønsson was a combination of welding teacher and guarantee that the highly motivated teachers and students carried out the difficult welding seems according to regulations. And this they must have done, because even the welded hub has lasted the first 30 years on Tvindkraft. And in industrial windmills the hub is always cast as in principle it is impossible to calculate welded hubs due to the powerful, changeable loads.

Also the then Skibsteknisk Laboratorium, SL, (Laboratory for Maritime Technology) were involved with Tvindkraft with a measuring programme. Thus in the book "Vedvarende Energi i Danmark" Egon Bjerregaard says that the laboratory had received funds from the then "Teknologiråd" (The Technological Board)to carry out measurements on a large test windmill, which was supposed to be Tvindkraft. This was difficult to accept for Amdi Petersen as Tvind had been told by the very same Technological Board that they would not give financial support for building the windmill. However, an understanding was reached, and a measuring programme was carried out, which without any doubt was very important for SL as reference, as they at this stage became more and more marginalised by Risoe within the testing of windmills.