# This print is made from www.tvindkraft.dk

Print friendly

## Tvind introduced the modern windmill wings

Here you can read a translation of an article by Preben Maegaard, director of Nordic Folkecenter of Renewable Energy about the creation of windmill wings and the political lessons to be learned from the Windmill History

## What can we learn from the Windmill History?

*Preben Maegaard, director of Nordic Folkecenter for Renewable Energy.*

www.folkecenter.net

**Among the public and in much history recording focus is directed against sequences of events that were the winners, i.e. the "good" history. Siemens and Vestas are proudly singled out as the flagships of the global windmill history while the basic conditions in the history of modern windmills are forgotten or preferred to be ignored. This history is so filled with coincidences, obscure corners and variants that members of today's government committees for growth, innovation or globalisation would flee in terror if asked to promote the kind of initiatives which from 1975 till 1979 created the basis for what later became the windmill industry.**

**Nonetheless the windmill adventure is used as a model when in these years ambitious visions and plans of new big industries within hydrogen, photovoltaics, wave power, fuel cells and bio fuels are put on the table. They want the result, but are they prepared to go the way? This question is worth asking in a Government period where research grants, centralisation and advanced technology are seen as the only road to societal innovation.**

**The windmill industry got its breakthrough in the alternative communities with no big grants, without the participation of the established industry, without state controlled research, but with lots of resistance from the part of society who would like to see the windmill adventure repeated today. Also other countries tried to create a modern windmill industry and used far more resources than what we had at our disposal.**

**Therefore, there is every reason to focus on this part of Denmark's industrial history, in ever greater detail, so eventually it can be pieced together into a whole where the many parts find their right places.**

# The wings are the core of it all.

*Preben Maegaard, director of Nordic Folkecenter for Renewable Energy.*

# It is no use for you to be able to make a windmill, but you have no wings.
# Luckily already in the 1970's, independent wing producers came forward who were ready to deliver wings to everyone who would like to build windmills. It is a matter of vital importance to understand this when looking for the explanation of how the basis for a modern windmill industry was successfully created in the 1970's. A windmill industry, which was to become leading globally.

*Preben Maegaard, director of Nordic Folkecenter for Renewable Energy.*

A couple of decades ago it was relatively easy to construct windmills and establish oneself as a windmill producer when using standard components. The reason is that a concept, the component windmill, had been introduced, presented by the author of this article in one of the very first wind meets, arranged by the newly founded OVE, the Organisation for Renewable Energy, at Brandbjerg Folk High School on November 20th, 1976.

The word innovation was not part of the Danish language at the time, but the structural division of a windmill into individual components was the innovation which would give Denmark decisive comparative advantages as regards the windmill production. It was far more manageable and much cheaper to buy the components than on your own having to develop and test all the parts, and to construct and build production plants for all the components, including the wings. This is mainly true as regards the many small companies, but also big companies failed trying to do all by themselves.

The idea of the independent wing producer first appears in an article in the daily paper Information on March 22nd, 1976. Here *Amdi Petersen* from Vestjysk Energikontor in Tvind says that *" ....our next step will be the development of some quite concrete models, For example we can make moulds in which people can make their own wings. The wings are often the biggest problem. So we will start doing that very soon ... That is quite in the spirit of the wind. It cannot be monopolised. We would also like to prevent the use of it from being so. So nobody needs to hold back. Just come ... all our experiences are there for the benefit of everyone else."*

With their own means Tvind was building one of the biggest windmills in the world, which started running in 1978. It is still running. But Tvind looked beyond and with their openness worked on the same ideological basis as did the Danish co-operative movement at the end of the 1800's. At the passing of the first Patent Bill in 1895, the forerunners of the time made sure that agricultural processes and technology could not be patented. Inventions were not to enrich individuals, but be at the disposal of the whole people. Especially Poul La Cour turned this production philosophy into reality. He was no Bill Gates. La Cour's concept resulted in thousands of Danish farm windmills. The mechanising by the power of the wind created progress and prosperity in the rural districts for the benefit of the whole population.

p. 23

*Picture: The first Tvindmill wing being hoisted on November 16th, 1977. The picture on the left as well as the previous one is from "Lad 100 møller blomstre", 8th revised edition, Dec 1977, Skipper Klement Publishers.*

**The significance of Tvind**

It is not "politically correct" in Denmark to give Tvind the credit of having created the basis for the Danish windmill industry. So written stories about the Tvind windmill tend to point out the fact that Tvind received professional assistance from Denmark's Technical University and Risoe (Denmark's former nuclear test station). Also often in the history of windmills links are skipped and touching stories about individuals, who worked hard in the windmill team or carried out important calculations to turn research into workable windmills, are told.

However, the fact is that without the controversial Tvind people**,** it is doubtful whether Denmark would hold our position as world leader within the production of windmills. Only the fact that Tvind generously invested money in both a very big and a small windmill in the 1970's is important. It is a fact that the industrial establishment did not believe in a future for wind power. Both the big 2000 kW Tvind windmill and the small 18 kW one were of great technical and symbolic importance for the development of windmills. The Tvind people were innovative and courageous, which inspired many others to work with wind power, which over a number of years grew into a popular movement.

**The "winning" wing concept**

Most decisive for the Danish windmill industry was the concept used for the 27-m long wings of the Tvind windmill. Amdi Petersen insisted that exactly that solution be used, and so it was. The concept was German, developed and tested in practice on windmills and helicopters by professor Ulrich Hütter from *"Deutsche Luft- und Raumfahrt Institut"* at the Technical University in Stuttgart. His wing technique was characterised by the way in which the wings were fastened around the hub bolts at the wing roots with fibre glass strands (picture below). The wing root is the weak point of the windmill wings, as is also described in detail in the UN conference report *"New Sources of Energy"* from 1961.

Tvind was assisted by Risoe and Denmark's Technical University in calculating the details, but leading national laboratories preferred wing concepts quite different from Tvind's.
These are to be found in two versions on the Nibe windmills, on the DWT 15 and 265 kW windmills and later on the 2 MW Esbjerg windmill. None of these constructions – contrary to Tvind's – led to the "winning" concept to become industrial products. Neither did big foreign companies and prominent institutes, well-equipped with researchers and hundreds of millions of Danish kroner for research and development, find a sustainable product.

*Picture: The Nibe A windmill (above) had a welded hub construction with three strutted wings, the Nibe B windmill had a sustaining steel beam with fibre glass shells.*
*On the right is seen the wing root of the 2 MW Esbjerg windmill. Steel flange and wings are glued and bolted together.*

24

It was Tvind who in 1976 introduced the wing technology which would become standard and

which led to the decisive breakthrough for Danish windmill producers. This is either not known or not acknowledged. Even technological development is prejudiced and the Danish establishment prefers to focus on Tvind's ideologies. But in those years Tvind took some technological and innovative steps which are of such vital importance that in my opinion Tvind's founder and prime mover, Amdi Petersen, as a *Rudolf Diesel* of windmills, ought to be given the Initiative Price of the Danish Industry or the Windmill Industry or a similar form of public honour. Especially the shareholders and employees in the windmill industry owe much to Tvind. Had it been a private inventor, a Mads Clausen, or an institute who had created the breakthrough, they would long since have gotten the medals out. By the way, there is still time.

## The component windmill

At the wind meet in November 1976 the idea of the component windmill took a further step. At the meet a number of wind groups were formed, one being about fibre glass wings. Her I suggested *".... that 20 windmill builders join to invest in and build a mould, for example for an 8 meter wing."* In the group were among others *Rio Ordell, Erik Grove-Nielsen, Jens Gjerding, Claus Nybroe and Peter Andersen.* The latter volunteered to do wing calculations.

Jens Gjerding from Tvind doesn't wait. Here they make a downsized 4.5-m version of the big windmill's wings to be tested on a small 18 kW windmill, the so-called *PTG windmill*. PTG means Practical Theoretical Basic Course, a course on general education, including a course on how to build windmills. Tvind does not aim for industrial production but allows private builders to have a wing for copying. Four pioneers at Kolding produce a mould and a few months later a 4.5-m Tvind wing has been produced.

## The Økær Wings

These are used on the windmill of electrician Leif Nielsen in Gredstedbro, but already in the summer of 1977 the windmill loses a wing and the interest in self-made fibreglass wings wanes. The wing mould is bought by *Erik Grove-Nielsen*, Økær at Viborg, and he commercialises the Tvind wing. These are the first wings from an independent wing supplier and thus the component windmill has become a reality. From now on interested windmill producers can buy wings where the wing producer has the copyright and supplies the wing. At a stroke this makes it much simpler to take a windmill to the market place, but business-wise there is the disadvantage that a wing is used which others can also buy. This in itself intensifies competition among windmill producers.

*Pictures: The bolt flange of the 5 m Økær wing and the mill top of the 22 kW NIVE windmill, which used the first 5-m wings in 1978.*

The first set of 4,5 Økær wings is delivered at the end of 1977 to mechanic Svend Adolfsen in Knudstrup at Viborg, who has built an 11 kW windmill with a truck hind axis - a downwind windmill with active yawing. This windmill type gets a long life as the Kuriant, the Bosted and the Genvind windmills. But the 4.5 wing has two important shortcomings. It has no air brakes, it runs fast and is noisy. This is not satisfactory for the users, and soon the newly established wing supplier has no customers.

This might have been the end of the independent sector of wing production, had Erik Grove Nielsen given up at this point, where his financial basis was extremely weak. But various forces interacted. In Thy they were starting a local production of 22 kW windmills instead of buying from Riisager, the most important producer of the 1970's. An alliance within NIVE (Northwest

Jutland's Institute for Renewable Energy) consisting of two engineers, blacksmiths, teachers from the technical school and interested users with me as coordinator had decided to construct a windmill from scratch: A modern upwind windmill with an asynchronous generator, a Fenner gear, electrical yawing and own development of tower, control system and wings.
p. 25
We could construct and produce it all locally - apart from the wings. Under no circumstances were we going to use the noisy Tvind wings from Økær and therefore, at the later Folkecenter, Ian Jordan and myself embarked upon building the mould for a 5-m wing with specifications similar to those from the Gedser windmill from 1958 but scaled down. Which meant no experiments. We had also found an experienced fibre glass producer in Vinderup, who would like to produce the wing. The development work had gone far when we got in contact with Erik Grove-Nielsen who politely and quite correctly pointed out that there was no reason for anyone to launch more wing projects. He could not sell his products and had a workshop in Økær fitted precisely for wing production.

We wanted a 5-m wing, but he was not going to invest in a new product running the risk not to be able to sell the wings afterwards. In a week orders were made of five sets of wings. So there was a happy end all over. NIVE got its wing - using Tvind technology construction-wise and *J.Juul's* wing with respect to the optimal wing. The first windmill with the new wings was erected east of Thisted in 1978, and it was no longer the wings but the gear that was the noisiest.

Thus this part of the history is complete: From now on no one has to hold back. Amdi Petersen's vision within industrial policies turned out to give Denmark world leadership within the most victorious of the clean energy types of the future. It was the first step on a long march. Denmark had an independent supplier of wings, others could supply control systems, i.e. specialised subcontractors, whom future windmill producers could work together with. They soon seized the opportunity. The Herborg windmill became an important training ground for future windmill constructors with Vestas as a direct result.

**Brake problems and OVE's security committee.**
It has often been said that the Gedser windmill is the mother of Danish windmills. But on one point did the new generation of windmill builders depart from their parent. They ignored or forgot to mount air brakes on the windmills - which were the most important part of the security equipment. Neither did the authorities demand it, even though the Gedser windmill had been researched with participation of Risoe and with American funds.
*Picture: After a number of breakdowns in the autumn of 1976, the 5-m Økær wings were fitted with air brakes in the shape of pitchable tip , the same principle as in Juul's Gedser windmill.*

Until 1978 the new generation of windmill builders thought it was possible to construct safe, mechanical brakes, which in all predictable circumstances would be able to prevent the windmill from over speeding, something anyone working with windmills fears with good reason. But several serious breakdowns with the 5-m Økær wings in 1987 seriously put the brakes on the agenda.

As Chairman of OVE I arranged the half-yearly wind meets, and in one of these we formed the *OVE Committee for Windmill Security.* It had eight members. Among these were two people, Erik Grove-Nielsen and Henrik Stiesdal, who would have a decisive influence on the development of wind power in Denmark in the years to come. There were also some individuals building their own windmills, and a couple of the pioneers behind the Tvind windmill. No official authorities

were represented in the self-established committee, which drew up general security guidelines for windmills.

The committee soon identified the decisive principles which were printed in a security leaflet in 1979. One of the most important principles was that the windmill must have at least two mutually independent braking systems, and that one of them must be based on air power and released centrifugally.

Wing and windmill producers soon started modifying the technology to make the windmills comply with OVE's security principles. The organisation of windmill owners, Danish Wind Power Plants, established in 1978, actively advised their members against buying windmills without air brakes - which were also mounted on already existing windmills.

The rules were largely adopted as norm by Risoe in their recognition of windmills, and indisputably contributed to ensuring the good reputation of Danish windmills.

**The windmill industry goes international**

The Danish wing concept was now fixed and concentration could be focused on improving details and building a production capacity. As early as 1980 Økær Wind Energy moved to Mønsted and a year later a licence agreement was made with a big fibre glass company, Coronet Boats, in Slagelse.

p. 26

## Picture:  Choose AeroStar First … or Second

## The ultimate solution in Rotorblades

*The development in the Californian market in the beginning of the 1980's made not only Danish windmills, but also Danish windmill wings an export article. The picture is from a 1986 advertisement explaining how exchanging the original wings on 12 Dutch Polenko windmills in California with Danish AeroStar wings meant 30% increased production.*

The brand is renewed. In Nordic catalogue of windmills from 1983 the same wing has three different names: AeroStar, Coronet and Altenergy. In the beginning of the 1980's the Californian

market opens up, a market which can buy all which can be supplied. Even though there were many windmill producers, among these many small ones, where wings were concerned it was mass production: thousands of wings were made.

Due to the high demand, Altenergy placed part of their wing production with a number of subcontractors. But there were problems with quality management. There was a serious breakdown on a 55 kW windmill in Hinnerup in the November storm in 1981, and this meant that their main buyer, Vestas, decided to replace the wings on sixteen 55 kW windmills and to insource their windmill production. The problems of the 7.4-m wing were chronic. After few years of operation the wing root often became soft and elastic and had to be reinforced.

Erik Grove-Nielsen showed a marked talent for innovation and in Aeoroform regime developed a complete repertoire of wings from 2.5-m upwards. Especially the 7.4-m wing is a hit. It was mounted on the popular 55 kW windmills from 1980 and onwards, paving the way for the modern wind industry and enriching the industry. Later followed the development of even longer wings of 9, 10, 11, and 12 metres. Development and testing stayed in its native area where Erik Grove-Nielsen had built a fine testing centre in Sparkær, essentially a public task. Not until 10 years later does the governmental Risoe buy it after having rented it for some years. It would be the official Denmark's service agency for the wing industry till 2006 when a much bigger place for testing will open at Ålborg harbour.

Altenergy's 12-m wing from about 1986 was the end of it. Only a few of these were made. One went into operation in Vitsø on Ærø on a 200 kW Dencon windmill constructed by the Folkecenter. This wing had no quality problems, almost 20 years later it is still running. But with the shutting down of the American market the crisis in the windmill industry was total at the time, and all windmill factories apart from Bonus went bankrupt, so there was no power for developing a new generation of windmills. At the time other wing producers, who in due time had organised effective quality control, had also come forward. The production of wings had developed into a mature industrial sector where establishing new factories and developing bigger, lighter and more efficient wings became routine.

**LM - wing giant**

LM in Lunderskov makes a very discrete entry as wing supplier in 1982. Their starting point was many years' experience with fibre glass as an industrial product – a background which was to prove just as important as knowledge of windmills. They start cautiously with 7.5 and 8-m wings, which are largely compatible with the then dominating wing product. The first LM wings on 55 and 75 kW windmills appear on *Wind-Matic* windmills, who had given up further work with strutted hybrid wings made from a laminated wood beam and fibre glass shells, derived from cooperation with *Chr. Riisager*. At the time, a 3.5 m LM wing can also be found on the Wind-Matic 7,5 kW Folkemølle (People's Windmill). LM tailor themselves to the situation of their customers and also supply to Sonebjerg Maskinfabrik different sizes of wing shells for Riisager clones.

After that LM made steady progress. The wings grew in size and in 1986 they could deliver 11-m wings for 150 kW windmills. You find them on windmills from Bonus, Vindsyssel and others. What was special about LM's wings at the time was that they were designed to turn anti-

clockwise, i.e. to the left. They had air brakes of the spoiler type at the back of the wing, whereas other fibre glass wings turned clockwise and had tip brakes like the Gedser windmill.

But LM succumbed. The spoilers disappeared and in the long run the public could not tolerate that windmills turned in different directions. So from 1988 onwards LM made wings that turned clockwise, which in a historic perspective really is the wrong way. Because the wooden windmill wings of the past turned to the left because the natural twist of the wood was determined by the sun passing over the sky from east to west. Learning from other experiences with fibre glass wings LM started out producing extremely solid wings. Therefore today a number of 8-m LM wings are still turning on

p. 27
old 75 kW windmills with a calculated life expectancy of 70 years. However, the dimensions were later adjusted to a more realistic life expectancy.

*Picture: LM wing being tested (Photo: LM)*

At the end of the 1980's the Danish windmill factories were seriously weakened after the collapse of the American market and hesitated to develop new, bigger windmills. But at LM they were ready for the next step, where the size jumped from 200/300 kW to 500 kW. This led to cooperation with the Folkecenter about specifications and testing of new wings. Thus the specifications of the 17.2- m wing were decided in a 500 kW development project, which the Folkecenter and the German windmill factory, Tacke, together fetched money for in Brussels. In 1991 these were giant windmills, a size which from then onwards the whole industry could deliver with LM wings.

Generally speaking, a wing factory such as LM has set the tempo of the growth of windmill sizes far more than the windmill producers themselves. If a Danish windmill factory hesitates to introduce a new wing type, it may well be suddenly turning with a foreign competitor. Those are the relentless conditions of competition, over which also the Danish windmill industry has no say.

Up to 24-m each new generation of wings increased by one metre, but from the late 1990's when MW windmills see the light, several meters are added to each new wing type. In 2004 LM made another world record by supplying a wing of 61.5-m for a 5 MW German Repower Windmill which was erected at the Elbe estuary.

LM is the world's biggest producer of windmill wings with seven factories in five countries. 70% of the wings are sold outside of Europe, which used to be the most important market. The wings have become so big that they are expensive and difficult to transport. That is one of the reasons why wings are produced in the site country when the market is big enough for a local production to be profitable. Often there is also a demand that a specific part of the value of the windmill be locally produced.

LM is wing contractor for a large number of windmill factories all over the world. They are dependent on a supplier, just as well as LM has an interest in there being many purchasers for their wings, which is an often unnoticed but important part of the Danish windmill success. In the years to come the LM wing factory in Baoding in China will quite certainly be supplying wings to windmills of Chinese origin, which could become fierce competitors to the Western European industry. Many developing countries are on the threshold of using wind power. For them creating work places and building new industries is often of prime importance, and here it would be of

mutual interest asking a company such as LM to build a wing factory.

**Vestas want to construct wings themselves**

As mentioned above, it is part of the history that Vestas, being one of the first and biggest users of Økær wings, around 1981 found themselves in a difficult situation after several wing accidents. The company acted accordingly and started their own wing production with their own design, root system, etc. Since then Vestas have been self-sufficient in wings.

After some tentative years they started out with a 7.5-m fibre glass wing for the 55 kW windmill, which was later lengthened in two stages with some extreme wing extenders, which were a sight for sore eyes. Wings were needed for the 75 and 90 kW windmills, and therefore the 7.5-m wing was given "stilts". Since then Vestas has always been in front as regards wing design and advanced production technology. In May 2000 Vestas opened a new, big wing factory in Nakskov. It is situated in the former shipyard area from where it is convenient to deliver the very long wings for the future offshore windmill parks. They started in Nakskov with 32-m wings. But the windmills of the future will demand ever bigger wings.

*Picture: 61.5-m wing, the world's biggest, leaving the LM factory. (Photo: LM)*

28
When they took over NEG Micon, they got a wing factory on the Isle of Wight into the bargain. Here they specialise in wood composite wings, which are being tested on a 4.5 MW windmill at the Høvsøre test site in Denmark. In 2009 it will enter market with a 120-m rotor. At that point Vestas will finally almost have caught up with the size of windmills which were erected in Germany with LM wings already in 2004.

Vestas has built a wing factory in the former DDR to be able to supply the German and Central European market from there. Also in China they are building a wing factory in Tianjin, thus being able to live up to China's demand of 70% local production. Even though in principle Vestas uses wings of their own make, in 2004 they also bought wings from LM for windmill parks with more than 140 windmills in India and China.

**A Sealandic wing factory**

Vestas were not the only ones to show an interest in producing their own wings in the 1980's. Micon had grown big during the American windmill adventure, and joined up with *Ole Larsen* in Ringsted and *Helge Petersen* to make a complete series of wings. The alliance, called MAT, *Micon Airfoil Technology*, was logical. Micon needed the wings, Ole Larsen had a reputation for delivering fibre glass work of high quality for the electricity works' big windmills, and Helge Petersen had gone the whole way from wing constructor with F.L.Smidt during the war, to Tvind, to DWT, Danish Wing Technology.

The wings were standard type and aerodynamic and of sufficient strength. The finish was perfect, but unfortunately they chose an untraditional type of air brake. Instead of the familiar pitchable tip, which was industrial standard already at the time, they got the problematic idea of using parachutes which were hurled from a lid in the wingtip for emergency braking. Naturally you run into trouble refitting such a bundle of cloth in the wing ready for the next release. That is what a windmill buyer would think. And so MAT disappeared from the market again, but they are an

example that due to such an error of judgement on a detail like aerodynamic brakes, an otherwise excellent product sank into oblivion. Today MATs production moulds and wings can be seen as museum pieces in the Folkecenter.

*Pict:*
*Daily sight on German Motorways: Danish windmill wings in transport. (This and other photos where nothing else is indicated: Jane Kruse, the Folkecenter)*

*Three 19.4-m LM wings and three10-m MAT wings in a row at the Folkecenter.*

**Increased production of own wings**

In recent years where the windmills have entered the MW class, several windmill factories have started in-sourcing their wing production. Where the factories used to buy the wings from independent contractors, the big factories now prefer to make their own wings. There are several reasons for this. And this development continues.

The windmill industry is a dynamic trade and the solutions that were right 25 years ago do not necessarily have to be so today. Hütter's shape of wing root, which was important for the development of the first fibre glass wings, has now been replaced with other constructions which are more fitting to present materials and production technologies. And the independent wing industry which played a decisive role in the fast development of the whole windmill industry both in Denmark and abroad could now become a restrictive factor.

It has become important to master the complete production technology, including the wing production, when entering foreign markets. It could be a condition that 50% or more of the value of the windmill derives from local production. Imagine that LM did not want to enter the market in question. The new market strategy meant that in 1998 NEG Micon bought a wing factory on the Isle of Wight, which is now part of the Vestas Company, and Bonus built a brand new wing factory in Aalborg. Here wings of an advanced design are moulded in one piece without the traditional glued joining for their megawatt windmills. After Siemens has taken over Bonus, they say that large extensions will happen in Aalborg, which, in addition to being home to the new test centre for wings, is turning into a mecca for windmill wings.

Sources;
Proceedings of the United Nations Conference on New Sources of Energy. Rome 21-31 August 1961, Vol 7. Wind Power. UN 1964
Vedvarende Energi i Danmark. OVE publishers, 2000 (Renewable energy in Denmark.)
Nordisk katalog over vindmøller, Risø 1983 (Nordic catalogue of Windmills)
Various newspaper cuttings, magazines, notes and reports.