

TRIPOD

Consulting Engineers Specialised in Wind Energy

Whether you are

- ★ a wind turbine manufacturer,
- ★ a wind turbine owner or owner 'to be',
- ★ a wind farm developer,
- ★ a financing institution,
- ★ a wind turbine operator,
- ★ an insurance company,
- ★ a donor organisation, or
- ★ another wind energy stakeholder



you may benefit from consulting the TRIPOD Group. The Group offers numerous services in the wind energy society covering all phases of wind energy projects including wind resource assessment, studies, project evaluation, wind turbine development, performance measurements, proof of concept, farm siting (macro and micro), second opinion, tendering and contract preparation, cost-benefit analysis, foundation design, trouble shooting, and much more.

Most of the activities are carried out within the two companies TRIPOD Wind Energy ApS and TRIPOD Engineering ApS.



TRIPOD WIND ENERGY ApS

Activities of Tripod Wind Energy ApS fall into two main categories: Wind resources and wind turbine testing.

WIND RESOURCES

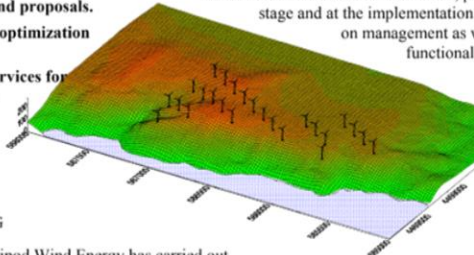
The activities include:

- ★ Planning of wind resource assessment programmes.
- ★ Wind measurements.
- ★ Analyses of wind measurements.
- ★ Preparation of feasibility studies.
- ★ Evaluation of studies and proposals.
- ★ Micro siting and other optimization tasks.
- ★ General consultancy services for wind farm developers, owners and other clients.

A major portion of our overseas engagements consists of wind and wind resource measurements, data analyses, and micro siting.

In this respect Tripod has been involved in that 75 wind farm projects representing more than 5,000 wind turbines ranging from 40 kW to 1.65 MW. The activities have given us considerable experience in handling and assessing large amounts of data and have provided us with a thorough knowledge of the wind turbine industry.

Government institutions, financing companies, insurance companies and power utility companies make use of our services at the initial, planning stage and at the implementation stage as well as on management as well as on functional issues.



WIND TURBINE TESTING

Using mobile test stations Tripod Wind Energy has carried out numerous measuring jobs on wind turbines inside and outside Denmark in accordance with internationally recognized recommendations. Test periods vary from less than a week to more than a year. Long test periods may be desirable when the test results are used in an iterative development process. DANAK, Danish Accreditation — a member of EA, the European cooperation for Accreditation has accredited Tripod Wind Energy ApS to carry out the following measurements:



- ★ Measurement of power curve.
- ★ Determination of mechanical properties:
 - Measurement of yaw efficiency for wind turbines in operation.
 - Determination of natural frequencies for wind turbines in operation.
 - Determination of structural loads for wind turbines in standstill and in operation. Statistical processing, Fourier-analysis and equivalent load calculations.
- ★ Functional and safety test: Efficiency of aerodynamic, mechanic and electric brakes; measurements of safety system functioning etc.
- ★ Measurement of power quality: In-rush currents and harmonics.



In accordance with the general requirements and of DANAK's other criteria Tripod Wind Energy ApS and confi

- ★ That Tripod Wind Energy ApS
- ★ That Tripod Wind Energy ApS required technical know-how.
- ★ That Tripod Wind Energy ApS operates under a Quality Control System according to the EN 45001 criteria.

The accreditation comprises international norms and standards, and our measurements are, hence, internationally applicable. It is our aim continuously to expand the scope of our accreditation on basis of the requirements of our customers. The coming IEC standards on power quality and load measurements are, of course, obvious areas for this expansion.

Tripod Wind Energy ApS furthermore offers:

- ★ Measurements of other mechanical properties like movements and vibrations.
- ★ Flicker-measurements.
- ★ Wind resource measurements.

With the experience gained from the wide variety of measuring jobs we have developed criteria for type approval of wind turbines in Denmark, having contributed this experience to the Danish recommendation for wind turbine power performance measurements and in collaboration with the Riso National Laboratory for the Danish recommendation for type tests of wind turbines.

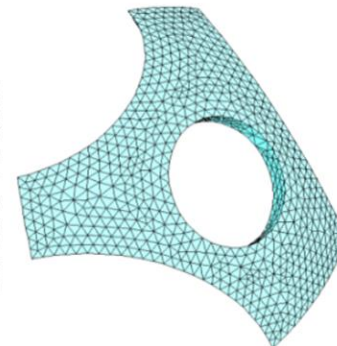
TRIPOD ENGINEERING ApS

The activities of Tripod Engineering ApS are more traditional engineering activities related to proof of concept, calculations, load modelling etc. Among the activities are:

- ★ Static and dynamic proof calculations of wind turbines and sub-elements.
- ★ Aeroelastic load simulations.
- ★ Finite element analysis.
- ★ Technical trouble shooting.
- ★ Design of wind farm foundations.

As expertise both on load measurements and on load calculations is present in the TRIPOD Group, an important speciality is comparison and verification of calculated and measured loads used in connection with certification and/or calibration of load modelling codes.

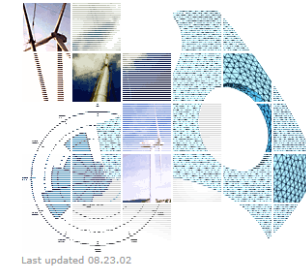
As an independent consultant serving the whole wind energy industry, the TRIPOD group is not involved in the design of wind turbines. However, TRIPOD Engineering ApS assists the manufacturers in assessing their design of wind turbines and sub-elements with respect to strength, lifetime, dynamic behaviour etc.



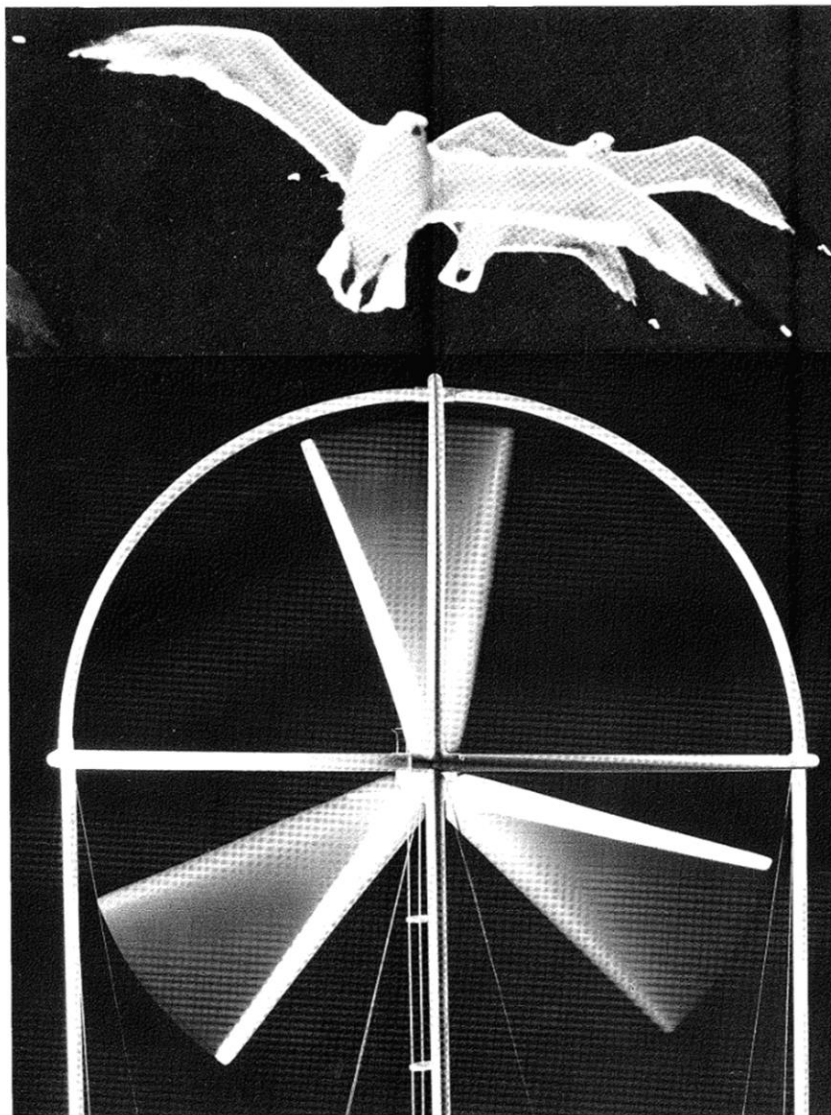
Consulting Engineers
Specialized in Wind Energy
22 Years Experience

Wind measurement
Wind study, micro siting, and energy
production calculation
Feasibility study
Tender and contract
Project management
Wind turbine measurement
Foundation calculation
Wind turbine calculation

Home
Company Profile
Tripod Group
Tripod Team
Accreditation
References
Download
Contact
Website map
Links



Last updated 08.23.02



Noter til VINDENERGI-SYMPOSIUM 1985

Trimningsmåling
v. Søren Gjerding

Tripod Consult har siden foråret 1983 med egne målestationer udført feltmålinger på vindmøller, herunder systemgodkendelsesmålinger for RISØ og trimningsmålinger for Teknologirådet og forskellige firmaer.

Den væsentligste erfaring er, at det ved målinger på forventet færdige møller har vist sig, at de oftest ikke var optimale. Fabrikanten er på dette stadium ofte ved at køre træt. Det er følgende svært at overbevise fabrikanten om, at møllen ikke er helt så god, som denne troede - eller mere positivt: den kan forbedres.

M.h.t. de konkrete målingsresultater henvises til rapporterne, som er nævnt nedenfor.

Nogle enkelte punkter kan fremhæves:

- Det er et spørgsmål, om en- eller to-generatordrift konsekvent bør foretrækkes.
- Vingendstilling m.h.t. effektbegrænsning kan fravige fra fabrikantens opgivelser.
- Automatisk styring af omdrejningstal for netuafhængige møller bør udvikles.

Gjerding konkluderede, at trimningsmålinger er særdeles relevante for især mindre fabrikanter. De har i princippet et fysisk færdigt produkt, men mangler den sidste finish/afpudsning.

De allerede gennemførte målinger har også ført til konkrete produktforbedringer.

Der var blandt symposiets deltagere udbredt tilslutning til at lade trimningsmålinger gå forud for dokumentationsmålinger (systemgodkendelsesgrundlag).

Rapporter:

Trimningsmålinger

(TR nr. 1983-133/001-83412)

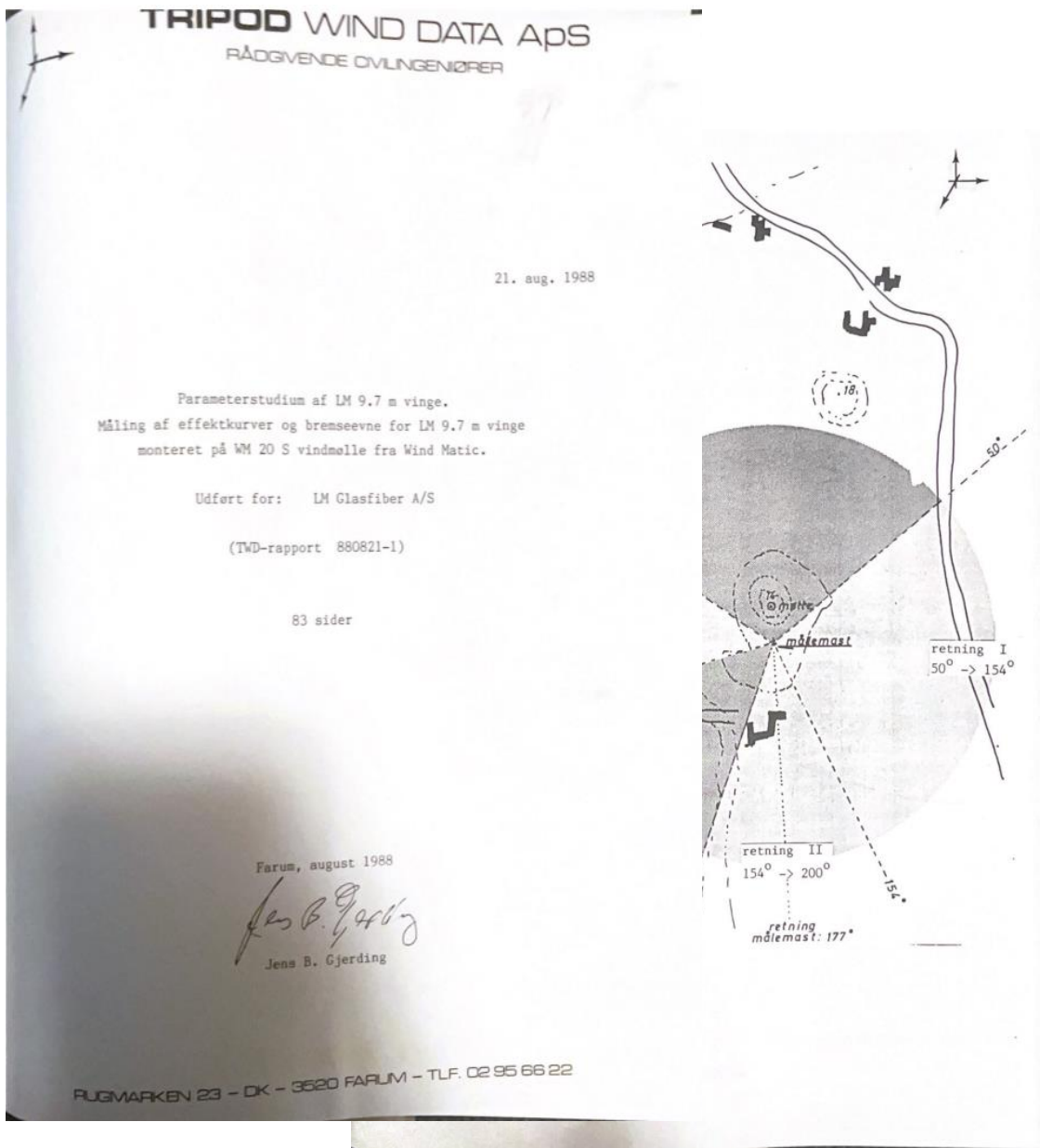
Måling af driftsforhold for 75 kW Pademo-mølle

(TC-rapport 850404)

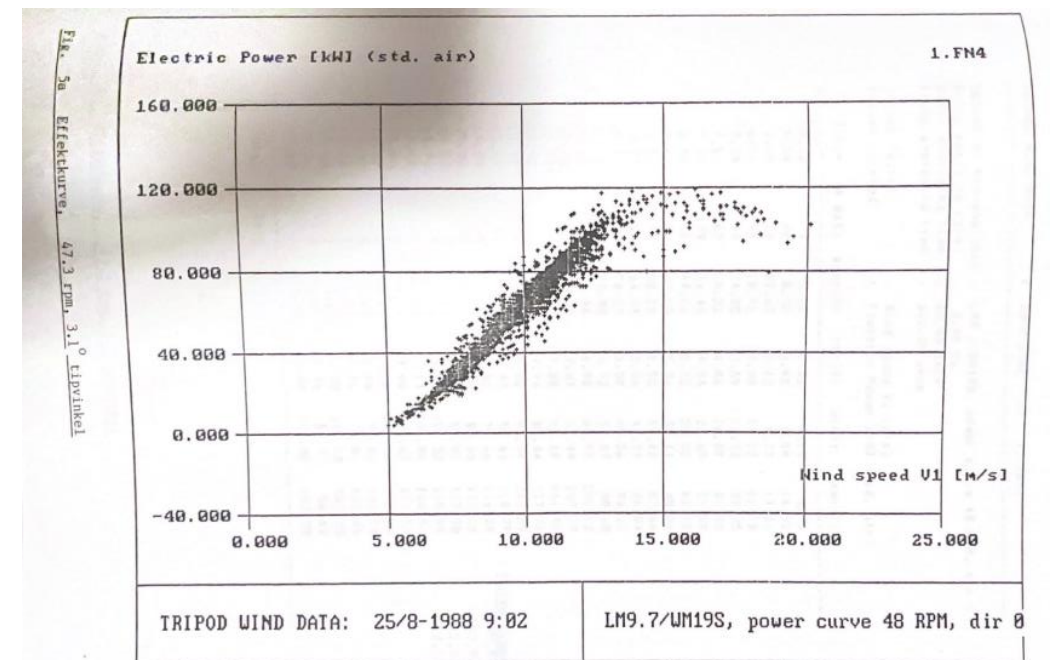
Måling af driftsforhold og effektkurve for 18 kW Kuriant-mølle i Boeslunde (TC-rapport 850810-1)

Måling af drifts- og effektkurve for 15 kW Kramsbjerg-mølle (TC-rapport 850909)

*TRIPOD
followed along
the wind
energy
adventure,
from the mid
70s to late 00s*



*Accredited power curve measurements +
design of measurement systems*



Participation to
standard
committees

RECOMMANDATION FOR WIND TURBINE
POWER CURVE MEASUREMENTS
to be used for type approval of wind turbines
in relation to
TECHNICAL REQUIREMENTS
FOR
TYPE APPROVAL AND CERTIFICATION
OF WIND TURBINES IN DENMARK
18. SEPTEMBER 1992

1. INTRODUCTION

This recommendation was made by a working group under the Energy Agency. The following persons have taken part in the work of the working group.

Troels Friis Pedersen, secretary	The test station, Risø
Søren Markkilde Petersen	The test station, Risø
Uwe Schmidt Paulsen	The test station, Risø
Ole Fabian	The test station, Risø
Bjarne Maribo Pedersen	Dept. Fluid Mech., Technical Univ. of Copenhagen
Per Velk	Danish Maritime Institute
Michael Brink	Danish Maritime Institute
Jens Gierding	Tripod
Sten Frandsen	Wind Engineering, Risø
John Olesen	Micon
Lars Budtz	Vestas
Michael Ariel Nielsen	Vestas
Henrik Stiesdal	Bonus
Klaus Ørsted Petersen	Bonus
Per Lading	Danwin/Wingineering
Lars Jørgensen	Danwin/Wingineering
Peggy Friis	Elsam Project

2. OBJECTIVES AND APPLICATION

The recommendation describes a procedure for measurement of the power curve of a wind turbine. The procedure is aimed at measurement of power curves on grid connected wind turbines concerning evaluation of their ability to produce electrical energy in relation to "Technical requirements for type approval and certification of wind turbines in Denmark", Danish Energy Agency, Ref. 1.

The power curve is defined as a table of data, consisting of connected values of net electric power from the wind turbine and the wind speed. The wind speed, and other meteorological parameters, are referred to the center of the wind turbine rotor, as they would be, if they were not disturbed by the presence of the wind turbine. The power curve shall be corrected, so that it is representative for a standard air density.

The power curve can be corrected to another average air density using the correction formula, described in this procedure.

ENERGISTYRELSEN'S
Regelbælg for
Godkendelse af Vindmøller

REKOMMANDATION
TIL OPFYLDELSE AF KRAV
TEKNISK GRUNDLAG
FOR
TYPEGODKENDELSE OG CERTIFIKATION
AF VINDMØLLER I DANMARK

1. Juli 1992

Rekommandation til Teknisk Grundlag

8.9 Referenceliste

- 1: Aage Herholdt m.fl.:
"Beton-Bogen"
CTO 2. udgave 1985
- 2: Peter Frank Andersen
"Udmattelsesbrud i elektrogas-hæftesvejste armeringsstål.
Komparativ og accelereret udmattelsesprøvning.
Litteraturstudium."
Dantest, august 1983
- 3: Peter Frank Andersen
"Udmattelsesbrud i elektrogas-hæftesvejste armeringsstål.
Komparativ udmattelseprøvning.
Forsøgsrapport."
Dantest, december 1983
- 4: Rambøll & Hannemann A/S
"Retningslinier for beregning af vindmøllefundamenter"
marts 1991
- 5: Jens B. Gierding
"Rekommandation for Fundering.
Godkendelsesordningen for Vindmøller.
Baggrundsdokumentation"
Tripod Consult ApS, juni 1991



TURBULENS

Fastlæggelse af turbulensbidraget fra skyggende møller i vindmølleparker.

(TWE-rapport 920605-1)
(45 sider)

Udført for:

Godkendelsessekretariatet,
Prøvestationen for Vindmøller, Risø

ZZ

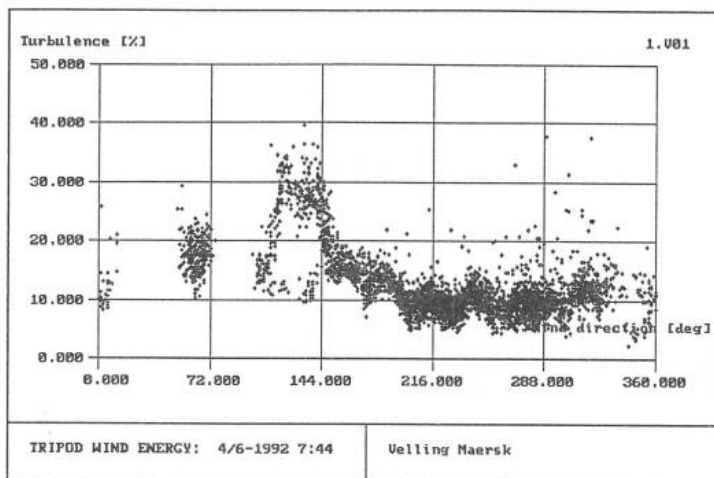


Fig. 3A Velling Mærsk - Turbulens vs. vindhastighed, plot

Referenceliste:

- [1] Tripod Wind Data:
Måling af effektkurve på Vestas V27 - 225 kW vindmølle opstillet i Velling Mærsk.
(TWD-rapport 890816)
- [2] Tripod Wind Data:
Måling af effektkurve på Danwin 180 kW vindmølle opstillet ved Kyndby.
(TWD-rapport 900411)
- [3] Tripod Wind Data:
Måling af effektkurve og krøjeevne på en Winddane 34, 400 kW vindmølle fra Danish Wind Technology A/S
(TWD-rapport 880704-1)
- [4] Tripod Wind Data:
Måling af effektkurve på Nordtank 130 kW vindmølle opstillet på Enge.
(TWD-rapport 881103)
- [5] Tripod Consult:
Måling af effektkurve på Vestas V27 - 225 kW vindmølle opstillet på Vedersø Kær.
(TC-rapport 910130)

Højstrup og Nørgård:
Tændpipe windfarm measurements 1988
Risø-M-2894, december 1990

Nybroe, Rasmussen & Lakkenborg
Måling på Sydvestmors Vindmøllepark
Folkecenteret, februar 1989

Energistyrelsen / Godkendelsessekretariatet:
Rekommandation til opfyldelse af krav i Teknisk Grundlag
kendelse og Certificering af vindmøller i Danmark.
Prøvestationen 1. juli 1992

Wake turbulence study for Risø

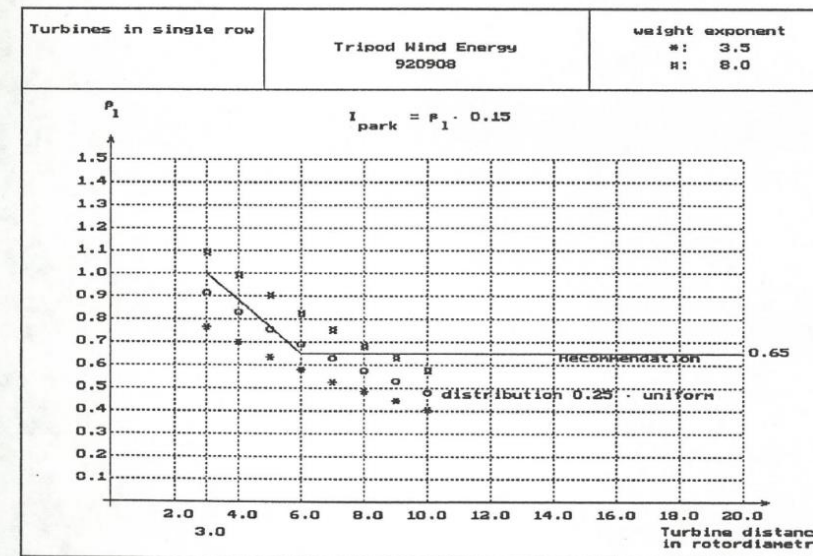


Fig. 18 Sammenligning mellem Rekommandation og resultater - møllerække

NYHEDSMAGASIN FRA COWI OM
INGENIØRTEKNIK, MILJØ OG SAMFUNDSØKONOMI.
JUNI 2010 NR. 26

Pionerernes rolle er oversat, mener vindmøllerådgiver Jens Gjerding

"Jeg er så heldig, at jeg har talt med
mig både at være idealist og besked-
tge mig med det, som jeg synes, er
allermest sjovt."

[illegible]

I dag er komu in af de 11 við-
gjafiðráðgjafi, þar er certi-
fikat af gæmsluvalingur þá



Two workers in hard hats and safety gear are working on a construction site. One worker is wearing a red hard hat and a light-colored shirt, while the other is wearing a green hard hat and a white shirt. They are both looking down at a task on the ground, which appears to be a wooden structure or formwork. The background shows more of the construction site with various materials and structures.

[illegible]

Jan 92

[illegible]

tid over livlind arbejdskraft, der kom fra nær og fjern, var lærere og studerende fra Trinidad og med til at projektere og bygge nye fæst for den nye pønge. Afslutningen i Trinidad var – og er stadig – at lænnen gik til fællesskabet, som betalte arbejds- omkostningerne. Et overordnede pønge blev blandede under bruger til at opføre møbler. Indtil var at fjerne Trinidadskerne med billig, ren og vedvarende energi.

[illegible]

'Jeg havde aldrig forestillet mig, at vindenergien kunne blive så stor'

„Jeg er stadig idealist“

Jens Gjeding har taget hele turen fra idealist på Tvind til professionel vindmøllerådgiver i cowi. Han undrer sig over, at fortalere for andre alternative energiformer ikke har taget ved lære af vindmøllepionererne

