TRAINING FUTURE PROFESSIONALS

Dr. Ir. Jan van der Tempel[*], Dr. Gerard van Bussel[**]
[*]Section Offshore Engineering, [**] Section Wind Energy
Stevinweg 1, 2628CN, Delft, The Netherlands
+31-15-2786828 j.vandertempel@tudelft.nl

SUMMARY
The development of offshore wind energy has only just started. The market is rapidly growing and needs capable people to make the growth sustainable. Delft University of Technology has been doing research on the topic of offshore wind for over 20 years and has been translating scientific and project knowledge to its educational system over the last five years, resulting in new courses, BSc and MSc thesis projects and a growing number of "offshore wind engineers".
To become competitive in this world, offshore wind needs to establish a foothold in the training centers of our future professionals. Make them see, feel, touch, taste offshore wind.
Delft University of Technology has a long tradition in doing research on offshore wind. Nowadays, the University has grouped all wind energy related research in the institute DUWIND comprising 5 faculties with a total of 60 people. The institute participates in many Dutch and EU programs and works closely together with the international industry.
The focus of DUWIND is currently shifting from nearly 100% research to a more balanced mix including education. Over the last years, several courses on generic wind energy aspects have been aligned and grouped to a Minor. Furthermore the introduction to wind energy course has rescheduled within the BSc program of the faculty of Aerospace Engineering and several new courses have been developed for the Aerospace Engineering MSc curriculum. This gives Aerospace Engineering students the possibility to perform an MSc programme with a focus on wind energy.
In the field of Offshore Engineering, the DUT has created a separate Master of Science program since 2005. The curriculum now has 4 main themes: floating, dredging, sub-sea and bottom founded structures. In the latter theme, a specialist course on offshore wind is given: Offshore Wind Farm Design. This course, which has been taught for 4 years now, focuses on the entire development with emphasis on the technical design of the support structure.
Next to these structural incorporations of offshore wind in the system, more and more students tend to do their BSc and MSc thesis on offshore wind energy. Through the close co-operation with industry, most of them get to spend time there to see and feel the real working environment.
This paper shows the structure of the current system and gives the blueprint of the developments of an independent Master in Wind Energy and a fifth theme within Offshore Engineering: Offshore Renewables.

1 INTRODUCTION

Where double digit growth has become standard for wind energy in general, the European industry is still running in highest gear to keep up with it. And as a supplier of the engineering work force, universities scramble to offer proper programs to train the future professionals. But at the same time, the market is perfect for anyone with an MSc in Engineering: they can pick the job they want: any place, any job, any salary. And when wind energy tries to compete with the mainstream technology multinationals, it simply lacks being an option to consider. Wind is not a career, wind is not mainstream. That is, not yet.
With the EWEA projections for offshore wind, one thing becomes clear: if we are to reach even the low estimate of 20 GW in 2020, we need people and the "filling of the gap between education, research and innovation [1]".
Delft University of Technology has a long history in research and innovations. And also in wind energy education several courses have run for decades now. But to face the challenge of

offshore wind, we are changing our strategy: building programs, rather than single courses. Making offshore wind a career option students can chose. Putting offshore wind up in the major league; making it mainstream.

2 DUWIND: DELFT UNIVERSITY WIND ENERGY RESEARCH INSTITUTE

The Delft University of Technology comprises 8 faculties from theoretical to applied. Five of these faculties have research groups that do work in the field of wind energy: wind energy, aerodynamics, materials, offshore, control, electric conversion, grids, policy. These groups are working together under the Delft University Wind Energy Research Institute "DUWIND". Figure 1 shows the organization chart. DUWIND co-operates closely with ECN, the Energy Research Centre of The Netherlands. Both institutes have complementary skills and work closely together in many fields.

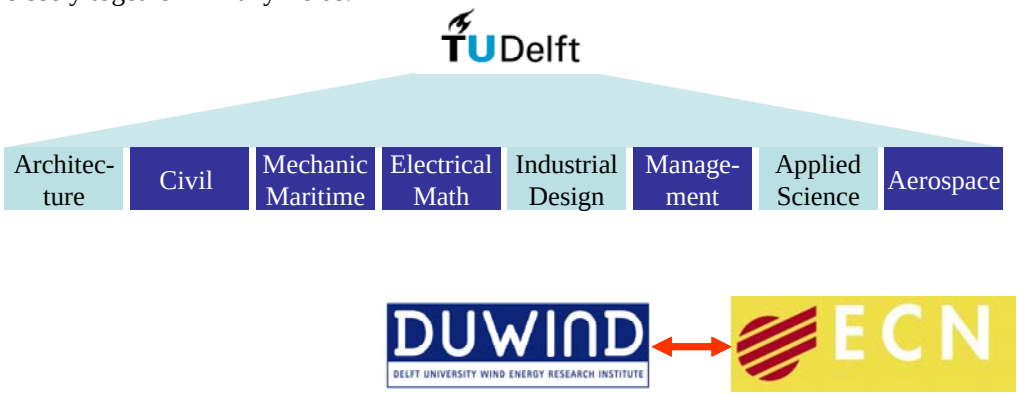

Figure 1 Delft University of Technology comprising 8 faculties of which 5 participate in DUWIND and co-operating with ECN

The focus of DUWIND has been mainly on research. The group has worked in various EU Framework programs, Dutch programs and in Joint Industry Projects. Through this research oriented approach, the group consists of 60 FTE of whom 30 PhD's. To focus this PhD group, DUWIND drafted a core-skill matrix in 2002: the disciplines in which Delft is very skilled (or should be) and the program themes arising from market developments. The matrix is shown in figure 2. It helped define 15 PhD positions, which have been filled twice over the last 5 years. At this moment, DUWIND is re-drafting the matrix for the next 5 years.

Disciplines / Programs	Rotor aerodynamics & construction	Control of turbine and power station	Support struc-ture, transport & Installation,	Operation & maintenance	Electric conversion & grid lay-out	Economy	Environmental conditions
	A1 Rotor wakes & wake interaction						
A: Unsteady Aerodynamic loads	A2 Unsteady B1 aerodynamic characterist.						
	A3 Aero- B2 elasticity						
		B5 Active vibration reduction					
B: Smart dynamic control ('smart structures')	B3 Design and testing of a smart structure rotor						
	B4 Advanced materials & construction	B6 Advanced C1 control of modern syst.		B7 Robust C2 component fault detect.	C4 Large scale wind power integration in the electricity supply system		
C: Offshore Design methodology			C3 Structural reliability w.r.t. fatigue		C5 Wind + H2 Storage (with DISE)		C6 Combined wind/wave loading
					C8 local grid & D1 connection to main grid	C7 Short term wind forecast, lead: Univ. Wageningen, + KNMI, ECN)	
					D3: New DD generator concepts		
D: Concepts and components	D2: New concepts of offshore designs, including rotor, nacelle, support structure, maintenance & installation procedures, C9 based on integrated design methods.						

Figure 2. Core-skill matrix for DUWIND in 2002, defining 15 PhD positions

As a research group, DUWIND is very successful and unparalleled in the wind energy community. But with the challenge of a booming market, priorities are shifting. Through the in-depth knowledge of what is required on the frontiers of R&D and through good connections with industry, DUWIND has the perfect position to play a key role in training the future professionals. Especially when being part of a large University that has a strong history in engineering and has changed the core language of all MSc programs to English and has a student population of over 13,000.

3 TEACHING, PREVIOUS EXPERIENCES

"Introduction to Wind Energy" has been a course for decades. It gave a general overview of the technology and was an elective for students of all engineering faculties. The course was attended by some 25 students per year, some of whom were to pursue an MSc thesis subject in the field.

From 2003 on, education became more of a focus to DUWIND. The gathered knowledge in different fields was not in any program, and yet students would venture into these fields during assignments and MSc theses, requiring staff to teach them as they went along. The first course to be built was Offshore Wind Farm Design. This course presented all DUWIND knowledge up to that moment to boost the training level of students whishing to steer their study career in the direction.

Furthermore, the section Wind Energy was embedded in the Faculty of Aerospace Engineering and was required to expand the educational efforts. Again, the courses were logical next steps in making R&D fields accessible to students: Rotor Aerodynamics, Wind and Site Conditions and Windturbine Design. The generic Introduction Wind Energy course was shifted to the Aerospace BSc program, now attracting over 90 students. Figure 3 shows the courses taught by the Wind Energy and the Offshore Engineering Sections.

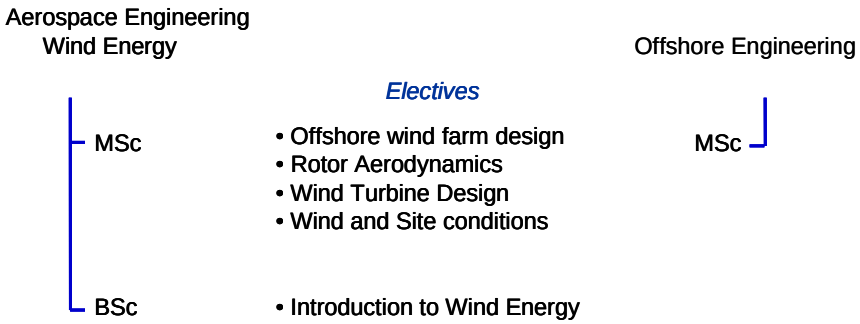

Figure 3 Five courses currently being taught in wind energy

4 EXAMPLE: COURSE OFFSHORE WIND FARM DESIGN (OWFD)

The goal of the Offshore Wind Farm Design course is as simple as it is grand: design an offshore wind farm. The course has just been taught for the fourth time. Student numbers have slowly increased from 12 to over 20 this year. The course is a fifth year elective within the Offshore Engineering MSc, also open to students from other engineering faculties. The course consists of four weeks of lectures (3/week) and 4 weeks of doing an assignment. An overview of the lectures is shown in table 1.

Next to the standard lectures, guest speakers are invited from Industry. Representatives of Shell, A2Sea, Ballast Nedam and Mammoet van Oord have visited Delft to give the students the real-life background to the theory they are learning.

Table 1 Lectures of OWFD

wk	**Lecture**
1	Introduction to wind energy
	Introduction to wind energy
	Design considerations I & II
2	Wind climate
	Wave, current and combined statistics
	Foundations
3	Loads, dynamics and structural design
	Loads, dynamics and structural design
	Installation
4	Wind farm aspects
	Maintenance

The goal of the assignment is to design an offshore wind farm. The only requirement is a pre-set EEZ, this year the German sector. The students are to decide all other parameters:

Site	Layout	O&M
Turbine type	Cabling	Installation
No. of turbines	Transformation	Support structure

The design of the support structure is the main focus, but by having to develop the full wind farm, the students learn the interaction between the softer issues of site selections on the hardcore engineering of pile size.
To be able to complete this assignment, the students have all professional tools at their disposal. For real wind, wave and current data they have access to www.waveclime.com (sponsored by Argoss). They have all DUWIND tools developed for Ansys and SESAM. All turbines that have been modeled by DUWIND researchers in Bladed and a digital sea map including tidal information. To support their design efforts, they have the latest versions of GL and DNV design standards. Figure 4 shows screen shots of the different tools and the student War Room.

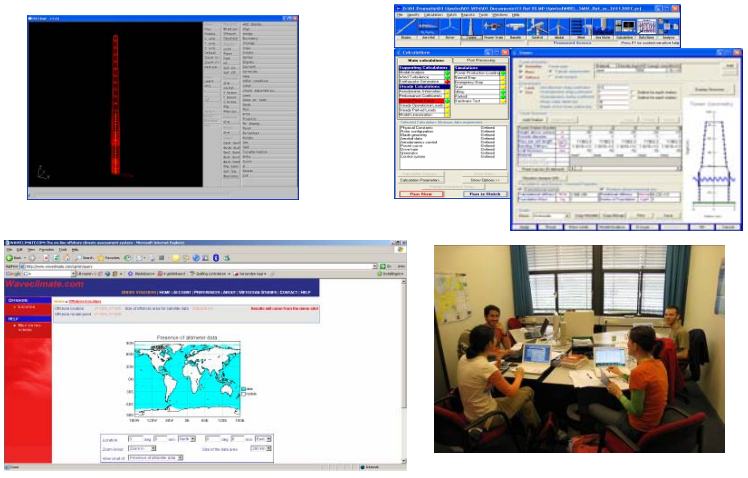

Figure 4 Tools for OWFD: SESAM (offshore FEM), Bladed (turbine design), www.waveclimate.com (wind-wave-current database) and student War Room

The course ends with a concise presentation to the teachers in which the students present their design and explain their technological choices within the framework of the wind farm. OWFD is a crash course in engineering. Many students have difficulty grasping the enormity of the

assignment at first and the freedom of choice and tools. But most of them come around to actually appreciate the more engineering angle where the enemy of good is better and time to optimize a single item threatens completion of the entire assignment.

5 FUTURE DEVELOPMENTS AT DELFT UNIVERSITY OF TECHNOLOGY

With five courses up and running, it was time for reflection. More and more students (especially international students) would like to have a more focused MSc degree in Wind Energy, but not a generic Aerospace Engineering MSc. With the current number of classes, the Section of Wind Energy has nearly enough critical mass to make this MSc a fact. This also supported by the Deans of the DUWIND faculties: focus on a specific engineering field and building it into a separate MSc program.

In the Offshore Engineering Section, which is already a stand-alone MSc open to Civil, Mechanical and Maritime Engineering Bachelor graduates, four themes currently exist: Bottom Founded Structures, Floating, Sub-Sea and Dredging. To give a profile to the Offshore Wind efforts, a fifth theme will be created in the next two years: Offshore Renewables. The focus is not only on offshore wind to make a clearly different program from the MSc in Wind Energy. The theme builds on developments in the industry where the Offshore Engineering design knowledge of support structures is also called upon by wave and tidal structure design. The theme will therefore consist of 3 specialty courses. First, in the next academic year, the OWFD course will be separated in a generic course on wind farm level and a specialist course on support structure design. The next year a wave and tidal structures course will be added, together with the already exisiting course on site conditions in Wind Energy. The plans on the Wind Energy MSc and the Offshore Renewables theme are shown in figure 5.

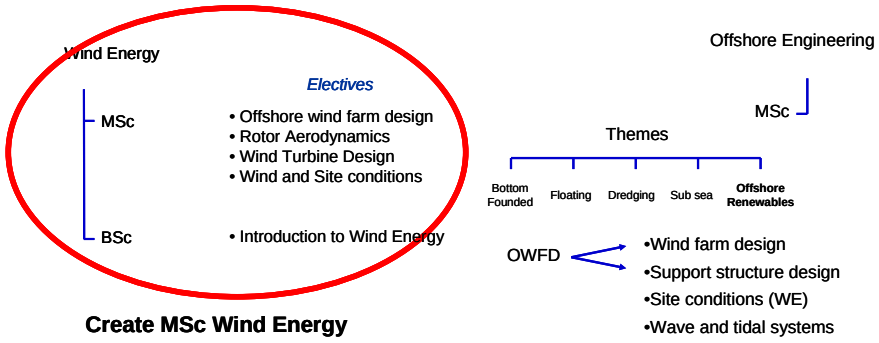

Figure 5 Future plans: MSc in Wind Energy and an Offshore Renewables in the Offshore Engineering MSc

6 TEACHING BEYOND UNIVERSITY

Next to creating teaching programs on MSc level within the Delft University of Technology, DUWIND also participate in external training of industry, in European MSc programs under the European Academy of Wind Energy and in training the workforce of builders in the Windskill program. An overview of these activities is shown in figure 6.

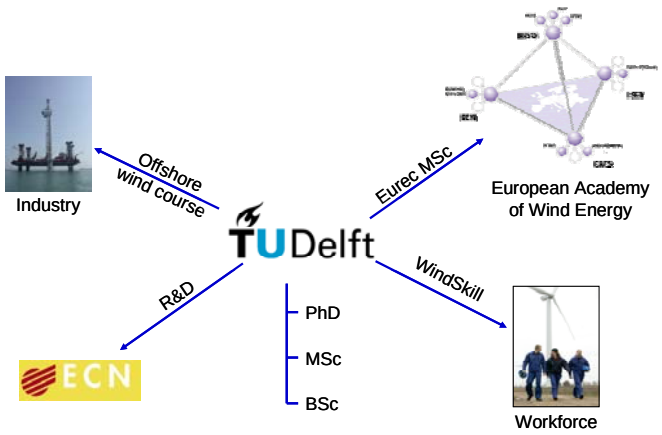

Figure 6 Teaching beyond the University: Industry Course in Offshore Wind, Eurec MSc under the EAWE and the WindSkill project training the EU workforce

Offshore Wind Course for Industry

The different research groups within DUWIND have created the course "Technology of Offshore Wind Energy". This course is aimed at project engineers and project managers in the offshore wind industry. It gives the background in technology of wind turbines, electrical infrastructure, O&M and offshore structures and installation. A new course is open for subscription on 27 and 28 March 2008 through the DUWIND website: www.duwind.tudelft.nl.

EUREC Renewable Energy Masters

The EUREC master in Renewable Energy was established in 2002 by the European Renewable Energy Centres Agency in Brussels [2]. The curriculum consists of a five month core section taught at specialized universities throughout Europe; a specialization section of five months and a final master project. The specialization section wind energy is provided by NTUA in Athens. Since little knowledge is available at NTUA together with its Greek research partner CRES the offshore wind energy module in this wind specialization is provided by DUWIND.

The first academic year 19 students joint this true European course of which 7 followed the specialization wind energy. In the following years the amount of students grew till around 30 students per year[3].

WindSkill

Windskill is an EU Intelligent Europe sponsored project which aims at overcoming the lack of sufficiently skilled and internationally qualified wind energy technicians[4]. One of the major problems is the currently unaligned national and regional qualification requirements. These unaligned requirements, cause artificial delays increase costs and reduce cooperation potential. The Windskill initiative targets are enrolling authorities and sector stakeholders in the development of a European Qualification Profile, develop an appropriate modularized curriculum and set up pilot training courses to meet these requirements.

Windskill is driven by three key objectives:

- Set up an industry-based skills network for the wind energy sector
- Deliver a European industry qualification standard for operational skills in the wind energy sector (on-shore and off-shore)
- Boost the skills capital of the wind energy sector

Following the set-up of the network work in the first year Windskill will in 2008 concentrate on the compiling of an inventory of all relevant but uncoordinated national and local

regulations pertaining to key work assignments. From that knowledge onward European Qualification Profiles will be established for wind energy technicians, and a modularised curriculum will be drafted [5].

7 CONCLUSIONS AND OUTLOOK

The Delft University of Technology has a long history in wind energy and offshore wind energy R&D with a current staff of 60 FTE working across 5 faculties, 30 of whom are working on their PhD. With the anticipated growth of offshore wind farm installations over the next decade it will be imperative to train many future professionals to make EWEA and EU projections reality. Delft is currently redefining their offshore wind teachings. Where in the past new courses were initiated in single fields of application, the emphasis is now on complete programs. An MSc in Wind Energy will be instated and a fifth theme within the Offshore Engineering Masters on Offshore Renewables will give Offshore Wind Energy the much needed profile for students to see and experience. The ultimate goal is to make offshore wind mainstream, a choice for a real career, making the students of today the future professionals of our Offshore Wind Industry!

Delft already co-operates with several universities in teaching. What we create is open for sharing. We believe the amount of engineers needed exceeds our capacity and we are very willing to share our experiences and material to make offshore wind happen.

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