International Small Wind Turbine Contest (ISWTC)
Gerard Schepers,
University of Applied Sciences, Hanze
ECN part of TNO
TUDelft, Lunch colloquium, 21-12-2018
Hanze University of Applied Science

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• 2019!

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Hanze University of Applied Science/Entrance

Source: http://www.traciwhitephoto.com/
Hanze University of Applied Sciences

Professionally oriented higher education
- 26,500 students
- 2,700 employees

70+ bachelor programs, 18 master programs
  22 studies with an energy route
  7 professorships with topic energy
  3 energy master programs (one under development)
Eurec Master Renewable Energy
Energy testing ground EnTranCe

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Eurec Master Renewable Energy
(3 Semester Master)

Semester 1: Core
• Hanze University of Applied Sciences, Groningen, the Netherlands (English)
  generally 20~30 students/year
• Ecole des Mines de Paris, France (French)
• Zaragoza University, Spain (Spanish)
• Loughborough University, UK (English)
• Oldenburg University, Germany (English)

Semester 2: Specialisation
• Sustainable Fuel Systems for Mobility (Hanze UAS, Netherlands)
• Wind Energy (National Technical University Athens, Greece):
  generally 20~30 students/year
• Photovoltaics (University of Northumbria, UK)
• Grid Integration (University of Zaragoza, Spain)
• Solar Thermal (University of Perpignan, France)
• Ocean Energy (IST Lisbon, Portugal)

Semester 3: Thesis

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October 2015: Opening by King Willem Alexander

EnTranCe is open
https://geoneer.files.wordpress.com/2015/04/pga_contouren.png

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Entrance: Focal Areas

- Saving energy conservation, specifically in business
- Supporting local innovative initiatives
- A new energy system (*energiesysteem 2.0*)
- Generating renewable energy
3. Partners

[Logos of various partners]
MONITOR YOUR ENERGY

To gain insights in your energy, the first step is becoming aware of where it is being used. Environ takes you into the mind of how energy you are using today. And make collective impact on tomorrow.

The Environ app allows you to monitor your energy consumption and storage in real-time so you can make more informed energy choices. Some of the insights the Environ app offers are:

SHARE YOUR ENERGY

When you are producing energy and not using it, why not sell it directly to your neighbours? When you are not producing energy, why not buy it directly from your neighbours? You get the price for which you want to buy and sell energy directly from your local community.

The Environ app also provides you with feedback on your household energy consumption and energy efficiency, so you can make necessary adjustments to ensure you are never out of power.

CONTROL YOUR ENERGY SYSTEM

Dig deeper into your energy system and balance your own energy production, consumption and storage. Environ is currently developing technology to let several of your appliances "talk" to each other. This way, you can use all of your energy as efficiently as possible.

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Energy Academy Europe

- International centre of excellence
- Bringing together initiatives, partners and networks to work on energy transition
- 3 pillars: education, research and innovation
The contest: The starting point:
*NHL 2nd years assignment: Design and build small wind turbine and test it in OJF*
ISWTC: General description

Since 2013: A contest is organized between student teams of Universities which design and build a small wind turbine. The contest is held on an annual basis. Until 2017 the contest was organised by NHL, The University of Applied Sciences Leeuwarden in the Netherlands, now it is organised by The University of Applied Sciences Hanze in the Netherlands. The turbines are tested in the Open Jet Tunnel of Technical University Delft in the Netherlands. An external jury is appointed which assesses designs and underlying design report.
Goal of the contest

• **Education**: Several aspects in the design process of small wind turbines are the same for large MW wind turbines
  Multidisciplinary design optimisation
    • Aerodynamics
    • Materials
    • Structure
    • Loads and stability
    • Electrical system
    • Control/Safety etc
    • Reduce Cost of Energy
• ‘Quality push’ for small wind turbines
• **FUN!!!**
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Contest procedure

Organizer: University of Applied Sciences NHL, Leeuwarden, Now University of Applied Sciences Hanze (Northern Netherlands)
Contest procedure

- Open for Bachelor/Master student teams (generally 3-25 students per team)
- Supervision by graduated teachers and/or PhD’s is allowed
- Until now very informal registration:
  - All teams (<10) were accepted by simple email
  - For 2019 we have > 20 interested teams (HELP!!!!)

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Contest procedure

February-June: Design and Building turbines
June 1st: Handing in design reports for jury
End of June/July:
  • Testing turbines in Open Jet Tunnel of TUDelft
  • 2-3 hours per team (→ 2-4 day tunnel time in total)
  • Preparation of tests are done outside the tunnel building
Contest regulations, general

– Rotor area $A \leq 2 \, \text{m}^2$ (D $= 1.6 \, \text{m}$ of HAWT)
– Performance for design wind climate at hub height with Weibull parameters:
  • $A = 4.5 \, \text{m/s}$ ($V_{\text{ave}} = 4.0 \, \text{m/s}$),
  • $k = 2$
– Maximum velocity 15 m/s
– Self-starting
Contest regulations, safety

• Independent superior protection system that automatically protects the turbine from single failures or faults in any component.
• Provisions for a manual emergency stop and for blocking of the rotor.
• Emergency stop must be demonstrated before the performance test.

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Contest regulations, structural integrity

Demonstrate ultimate loads from aerodynamic, gyroscopic, centrifugal and gravitational forces at following load cases

<table>
<thead>
<tr>
<th>Design combinations</th>
<th>Vsur</th>
<th>Vmax</th>
<th>Vrated</th>
<th>Gust</th>
<th>Shift</th>
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</thead>
<tbody>
<tr>
<td>Internal conditions</td>
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<td>3.13.1</td>
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<td>3.13.6 Normal operation</td>
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<td>3.13.7 Normal stop</td>
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<td>3.13.8 Loss of load</td>
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<td>3.13.9 Blocked rotor</td>
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</table>

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Design report

Design report based on regulations
Description of design, motivation of design choices
Safety
Structural integrity
The Wind Tunnel (courtesy TUDelft)

Wind Tunnel: Open Jet Facility  
TUDelft

NHL records current and voltage  
Standard interfaces for mechanical mounting and electric connection  
to a controllable load (variable resistance controlled by NHL operators) such that maximum power is reached

Open Jet Facility (2009)  
\( V_{\text{max}} = 35 \, \text{m/s} \)  
test section 3.0 m \( \varnothing \) 13 m long

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After wind tunnel testing: Price ceremony,

Award ceremony at NHL University of Applied Sciences
Open to public
Agenda of editions 2013-2017
  Oral presentations of student teams
  Presentations from guest speaker
    2013 Jos Beurskens, ECN
      (History of innovations in wind energy)
    2014: H. Seifert UAS Bremerhaven (Small versus large)
    2015: H.J. Kooijman, GE Wind Energy
      (The value of wind energy)
    2016: P. Schaffarzyck, UAS Kiel (The value of CFD)
    2017: G. van Kuik, TUDelft (Are we ready?)
  Announcement of winner by jury
  Reception
2018, Price ceremony combined with symposium wind energy region Fryslân

• **Poster** presentations by student teams
• **Symposium:**
  • T. Spijkerboer, EAZ, *KiloWatts’s at Farmhouses*
  • H. J. Kooijman, EWT: *MegaWattss in the Frysian Area*
  • E. Korterink, Gemini: *Multi MegaWatts in the water*
Jury members (over the years):

C. Fereira (Assistant professor of TUDelft)

Z. Parker (NREL, US Collegiate Wind Competition)

E. de Vries (Journalist, Technology Watcher)

Jos Beurskens (former head of Unit Wind at ECN)

J. Kuikman (CEO Fortis Wind Energy)

M. Schubert, former CTO of Repower

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Jury members, ctd:

Leo Machielse, formerly unit Wind Energy, ECN

Lee Jay Fingers
NREL, USA
Key member of US collegiate wind competition

Rob Rudolf
Former coordinator of UAS Flensburg team, now Vestas

Laura de Vries/Mathieu Colon
Epomat

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Jury members 2018:

Jessica Holierhoek
JEHO
Formerly ECN

Rob Rudolf
Vestas
Former coordinator of UAS Flensburg team

Bruce LeBlanc
PhD TUDelft
Formerly: Sandia USA

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Assessment criteria of jury

No professional scoring rubrics (YET) but often used criteria were:

- Energy yield for a specified wind climate
- Cost minimization
- Quality of design calculations
- Quality of theoretical research
- Uniqueness of designs
- Safety features
- Monitoring features
- Esthetics
- Organisation, management, PR

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• 2019!

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Participating teams
They first came from all over Europe
Participating teams,
They now come from all over the world!!
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• 2019!
Good weather (always)
Some highlights 2013

3 Teams:
1. UAS Flensburg/Kiel: 3 bladed HAWT
   – Robust design from bought components
2. TUDelft: VAWT:
   – Insufficient starting torque
3. NHL: 3 bladed HAWT
   – Exploded (not to blame the students!!!)
Some highlights 2014

6 Teams

- Unfortunately only 2 out of 6 turbines produced power:
  - UAS Flensburg/Kiel: 4B HAWT
    - 3D printed components, glued reinforcements, $P_{\text{max}} = 250$ W
  - UAS NHL, 3B HAWT:
    - $P_{\text{max}} = 150$ W
  - University of Sheffield: 3B HAWT
  - DTU: 3B HAWT
  - DTU: 3B VAWT
  - UAS Bremerhaven, 2B HAWT

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2014, some pictures

Sheffield

Flensburg

NHL

DTU, VAWT

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Highlights of 2015

6 Teams

• Good performance of all turbines
• New technologies/concepts
Highlights of 2015

1. UAS Flensburg/Kiel: 4 bladed HAWT
   - Active pitch
   - Simple CNC hot wire cut foam with glass fiber reinforcement
   - $P_{\text{max}} = 500$ Watt

2. DTU: 3B HAWT
   - Carbon aramid material.
   - Active as well as passive pitch systems
   - Extensive monitoring system
   - $P_{\text{max}} = 350$ Watt
Highlights of 2015

3. UAS NHL, 3B HAWT
   – Redesign of hub and blades (3D printed)
   – Extensive monitoring
   – $P_{\text{max}}$ 300 Watt

4. DTU 3B VAWT
   – Optimized design in terms of blades and pitch angles
   – Optimized start up algorithm
   – $P_{\text{max}} = 95$ Watt
Highlights of 2015

5. University of Sheffield, 3B HAWT
   - Redesigned blades
     (3D printed, carbon rod reinforcement)
   - $P_{\text{max}} = 45\ \text{Watt}$

6. UAS Bremerhaven, 2B HAWT
   - Extremely simple and cheap design:
     Blades are profiled aluminium plates!
   - $P_{\text{max}} = 40\ \text{Watt}$
Flensburg
2016, Highlights

4 Teams:

– University of Lodz, 3B HAWT
  • AEP = 82 kWh/yr, $P_{\text{max}} = 400$ kW, $C_{p_{\text{max}}} = 0.225$

– UAS NHL, 3B HAWT
  • AEP = 47 kWh/yr, $P_{\text{max}} = 260$ kW, $C_{p_{\text{max}}} = 0.14$

– DTU, 3B HAWT
  • AEP = 44 kWh/yr, $P_{\text{max}} = 270$ kW, $C_{p_{\text{max}}} = 0.20$

– DTU, 3B VAWT
  • AEP = 66 kWh/yr, $P_{\text{max}} = 100$ kW, $C_{p_{\text{max}}} = 0.1$

DTU cyclic pitch mechanism for VAWT. Each blade is connected to the off-centre tab (the black dot) by arms of fixed length (green lines) [Gunnar Ettestøl, ETTE Elektro, 2002].

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DTU
2017: Highlights

6 teams

• University of Lodz (Poland) “Gust” 3B HAWT
  – AEP = 214 kWh/yr, $P_{\text{max}} = 293$ kW, $C_{p\text{max}} = 0.337$

• Danish Technical University, DTU, 3B HAWT
  – AEP = 293 kWh/yr, $P_{\text{max}} = 400$ kW, $C_{p\text{max}} = 0.241$

• Danish Technical University DTU, 3B VAWT
  – AEP = 45 kWh/yr, $P_{\text{max}} = 239$ kW, $C_{p\text{max}} = 0.1$

• Ain Shams University (Egypt), 3B HAWT
  – AEP = 10 kWh/yr, $P_{\text{max}} = 8$ kW

• NHL-Stenden University of Applied Science Leeuwarden (Netherlands), 3B HAWT
  – AEP = 36 kWh/yr, $P_{\text{max}} = 281$ kW, $C_{p\text{max}} = 0.1$

• Inholland University of Applied Science, 2B VAWT

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2018: Highlights

7 Teams
1. University of Lodz (Poland) “Gust”, 3B HAWT
2. University of Lodz (Poland) “Gust”, 3B VAWT
3. University of Manitoba (Canada), 3B HAWT
4. Danish Technical University, DTU, 3B VAWT
5. Danish Technical University DTU, 3B HAWT
6. Ain Shams University (Egypt), 3B HAWT
7. NHL-Stenden University of Applied Science Leeuwarden (Netherlands), 3B HAWT

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### 2018, Performance 4 HAWT

<table>
<thead>
<tr>
<th></th>
<th>Ain Shams</th>
<th>DTU</th>
<th>NHL-Stenden</th>
<th>GUST</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP kWh/yr</td>
<td>308</td>
<td>238</td>
<td>284</td>
<td>271</td>
</tr>
<tr>
<td>max power:</td>
<td>368</td>
<td>570</td>
<td>581</td>
<td>487</td>
</tr>
</tbody>
</table>

Cp- values 4 HAWT teams

- **Ain Shams**
- **DTU**
- **NHL-Stenden**
- **GUST**

![Chart](chart.png)

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NHL: Mobile testing facility

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• 2019!
Summary/Conclusions

Much progress has been made:

- Lessons have been learned on organisational issues
- We start to become serious (not forgetting the fun..)
- 2013: 1 producing turbine (33%)
- 2014: 2 producing turbines (33%)
- 2015: 6 producing turbines (100%)
- 2016: 4 producing turbines (100%)
- 2017: 5 producing turbines (83%)
- 2018: 7 producing turbines (100%)
- Many design improvements (Partly incremental to previous years)
Summary/Conclusions

• $P_{\text{max}}$ increased from 50 W (2013) to 581 W (2018)
• $C_{p_{\text{max}}}$ increased from 0.1 (2013) to 0.35 (2018)
• Three contests are won by the UAS Flensburg and three are won by University of Lodz
Summary/Conclusions

A large variety of concepts and techniques have been considered by the students:

- Simple (cheap) design to advanced (expensive) design
- Most components are made by student teams, generators are sometimes bought from the shelf (but tested by students)
- Blades: Profiled plates, Vacuum infusion blade halves in mould, milled, cut, 3D printed
- VAWT, HAWT
- 2 blades, 3 blades, 4 blades
- Active/passive pitch, stall control
Summary/Conclusions

Students have enjoyed the participation very much:
  Learning experience
  Good cooperation between different teams
Good reviews received from industry on this contest

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Collegiate Wind Competition

• Sponsored by Department of Energy (DOE) and organisation National Renewable Energy Laboratory (NREL)
• Competition held together with American Wind Energy Conference
  – University contest and Kid’s competition
  – 12 University teams
  – Undergraduate students
• 2 mobile wind tunnels (built by NREL) in exhibition hall of conference
• Jury’s for design, business and deployment strategy

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Collegiate competition vs ISWTC

- Many teams, many students, large organisation committee
- Connection to American Wind Energy Conference
  - Exposure
  - Interaction of students with industry
- Oral presentations and design reports assessed by 3 jury’s, not only on technology
  - Technology
  - Business
  - Employment
- Own made mobile wind tunnels, limits diameter of turbine to 60 centimeters

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‘Junior’ wind turbine contest

• ‘Lesbrief’ from PABO and research group wind energy at NHL for primary schools with which a small wind turbine is built
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• 2019!

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And now the 2019 contest

Tunnel time reserved for July 1st-July 4th 2019

Complicating factors:

• Move from NHL->Hanze, we need to build up a new organisation, so please be patient

• >20 interested parties, tunnel time for 11: Selection needed
  o Main criterium: confidence on participation
  o Deposit ~500 Euros?

• Tunnel costs of 5 kEuro have not been erased yet by Nando...

Some small changes in regulations

Scoring rubrics will be professionalised

21-12-2018
Expected scoring rubrics 2019

AEP will become the most important criterium!

Bonus kWh’s e.g.:
- X kWh for making own blades or own generator,
- Y kWh for a working real-time RPM (and/or torque/voltage/current) measurement
- Z kWh for good design report
- Etc etc

Penalties (-kWh) in case requirements from regulations are not met.

21-12-2018
Price ceremony

- At Hanze UAS in Groningen
- Tent camp at Campus might be organised for overnight stay
- Possibly combined with a general symposium
- Poster presentations of student teams
- Jury members TBD
And then 2020!

“On Tuesday the 19th of June 2018, at the European Academy of Wind Energy’s Board meeting, TU Delft was awarded the right to host the prestigious EAWE Torque conference in 2020. The conference will be held between the 26th and 28th May 2020 and will coincide with the International Small Wind Turbine Competition hosted annually at TU Delft”


Also see:
https://www.youtube.com/watch?v=7pySO3ppixs&feature=youtu.be

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International Small Wind Turbine Contest

Interested in joining? Send an email to:

d.c.vanderhoek@tudelft.nl
Thank you for your attention