CROSSWIND

CRoss-border Open-Source Small-WIND

Hochschule Flensburg
University of Applied Sciences

SDU Centre for Industrial Mechanics CIM

Interreg
Deutschland - Danmark

EUROPEAN UNION

Dieses Projekt wird gefördert mit Mitteln des Europäischen Fonds für regionale Entwicklung.

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CROSSWIND

Project details

Project duration:	01.01.2021 – 31.12.2021
Project budget:	113.648,00 Euro
INTERREG Priority:	2 - Sustainable development

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Project website:	LINK

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INTERREG 5A
Region

Germany	Danmark
Nordfriesland Flensburg Schleswig-Flensburg Rendsburg-Eckernförde Kiel Plön Ostholstein Lübeck Neumünster	Region Syddanmark Region Sjælland

Map INTERREG Region 5a
Source: https://www.interreg5a.eu/en/

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Targets of CROSSWIND as network project

- Pre –study to develop a cost optimised small wind turbine concept
- Insights on the market
- Insights on permissions through building authorities
- Implementation of a small wind turbine in simulation software
- Strengthen international collaboration of universities in education and research
- Reduce existing cross border prejudices to promote project and network partner

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Definition of small wind turbines

	Criteria	Limit	sub category		
IEC 61400-2	swept area	≤ 200m²	–	–	–
EEG	rated power	≤ 50kW	–	–	–
BWE	rated power	≤ 100kW	Category 1: Mikro: 0 – 5kW	Category 2: Mini: 5-30kW	Category 3: Mittel: 30 – 100kW
BVKW*	swept area	≤ 200m²	Micro: 0 – 1,5kW, max. 6m²	small: 1,5 – 6kW	≤ 200m²
IWES	swept area & rated power	≤ 200m² max. 50kW	Category XXS: 1,5kW, max.	Category XS: 10kW, max. 40m²	Category S: 75kW max.200m²
BWEA	rated power	≤ 100kW	Micro: 0 – 1,5kW	Small: 1,5 – 15kW	Medium: 15 – 100kW
AWEA	rated power	≤ 100kW	Island: 0 – 0,9kW	Home: 1 – 10kW	Business: 11 – 100kW
EWEA	rated power	≤ 100kW	Pico: 0 – 1kW	Micro: 1 – 7kW	Mini: 7 – 50kW Midi: 50 – 100kW
DWEA	swept area	200m² / 1000m²	Small (200m² --> max. ~50kW)	Medium (201-1000m² --> max. ~500kW)	–

Source: http://bundesverband-kleinwindanlagen.de/definition-kleinwindanlagen/

Benchmarking

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- 78 international manufacturer
- 169 small wind turbines ≤ 30kW
- available details documented
  - Basic parameters, materials, type of tower, electrical components, controlling, cost etc.
- Target was to investigate the specific cost
  - ~ 4.300€/kW
- Additional:
  - Power curve extraction of 52 small wind turbines
  - Required to determine annual energy production

Regulations in DK and GER

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Germany	Denmark
Free installation to Tip height 10m, rotor diameter max. 3m in rural, industrial, small residential areas …	Definition max tip height 25m & max swept area 200m²
simplified building permit process for SWT 10m to 30m tip height	Permission relies on local community
Distance of small wind turbine to nearby buildings by 1x of height. Distances must be maintained, but no concrete declaration	Guidelines available with advises and recommendations
Limit of sound level regards TA-Lärm for normal and small residential areas: day time 55 dB(A), night time 40 dB(A)	Installation in rural areas possible with permission of the municipal or city council
Shadow determination, exist for large wind turbines. No measures available for small wind turbines.	EIA not required
Installation in areas of a natural reserve is prohibited	Shadow, max 10 hours of shadow on buildings nearby, visual impact must be predicted
High cost for certificates, requested by building authority	Distance to buildings etc. min. 4x height, but overall assessment relies on the visual impact
No inquiry accepted, if no realistic construction project is planed	Limit of sound level @ 6m/s 42dB(A) and @ 8m/s 44 dB(A)
Questions: - Why is no uniform guideline available ? - Why react the building authorities differently?	Questions: - Guidelines up-to-date regards the law & regulations? - Which guideline for land zone permit? - Necessary of proof for visual on environmental impact?

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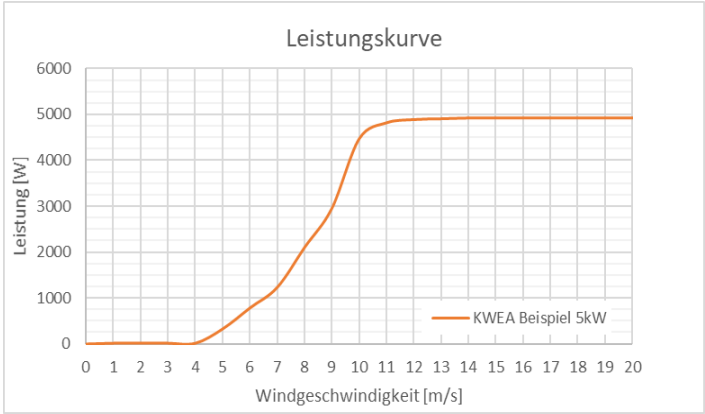
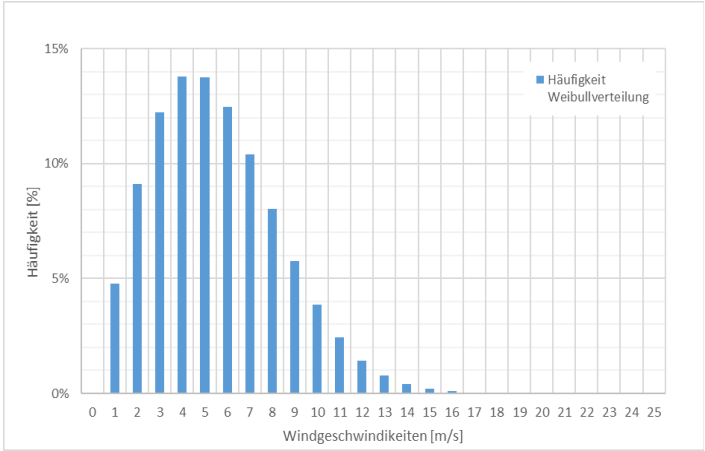
Economic cases in Germany

- Small wind turbine example
  - Rated power: 5 kW
  - Retail price: 4.300 €/kW * 5 kW = **21.500 €**
- Wind conditions near coastline in Schleswig Holstein
  - Weibull a-value : 6,23 m/s
  - Weibull k-value: 2,04
  - Height: 10 m
- Annual energy production
  - **9.300 kWh/year**



Power curve 5kW example



Weibull wind distribution

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Economic cases in Germany

	1.) Island / 100% self consumption	2.) Self-consumption and grid integration	3.) 100% grid integration	4.) 100% grid integration	5.) 100% grid integration
Produced energy	9.300 [kWh/year]	9.300 [kWh/year]	9.300 [kWh/year]	12.500 [kWh/year]	20.000 [kWh/year]
Used energy	9.300 [kWh/year]	5.000 [kWh/year]	0 [kWh/year]	0 [kWh/year]	0 [kWh/year]
Feed in to grid	0 [kWh/year]	4.300 [kWh/year]	9.300 [kWh/year]	12.500 [kWh/year]	20.000 [kWh/year]
EEG-supplement	No	No	No	Yes	Yes
Purchase cost	-21.500 [€]				
Annual maintenance max. 3% of purchase cost	-645[€/year]				
Price of energy 31 [cent/kWh]	+2.883 [€/year]	+1.333 [€/year]	0 [€/year]	0 [€/year]	0 [€/year]
Feed in tariff 7,79 [cent/kWh]	0 [€/year]	+345 [€/year]	+725 [€/year]	+973 [€/year]	+1.558 [€/year]
EEG-supplement 40% shortend 2,6 [ct/kWh]	0 [€/year]	0 [€/year]	0 [€/year]	-325 [€/year]	-520 [€/year]
Annual profit	= +2.133€/year	= +1.033€/year	= +80€/year	= +3€/year	= +393€/year
Payback periode	11,7 years	20,8 years	268,8 years	= - - years	= 54,7 years

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Economic cases in Denmark

1. Net settlement of consumption and production means that you do not pay for the consumption that you can produce yourself, as you are exempt from "public obligations" (the PSO tax).
   - Option 1: hourly settlement, electricity production sold and consumption bought.
   - Option 2: hourly settlement, surplus production can be stored. Decision by owner: surplus production sold to grid
   - Option 3: Instant selling. Surplus production sold to grid immediately

2. Surplus production sold at the spot market price to an “energy supplier".

   Until 2020, it was possible to receive a significant "price supplement" from the state,

   That pool has been used and no extension of this support from the state is planed

Comparison of HAWC2 to openFAST

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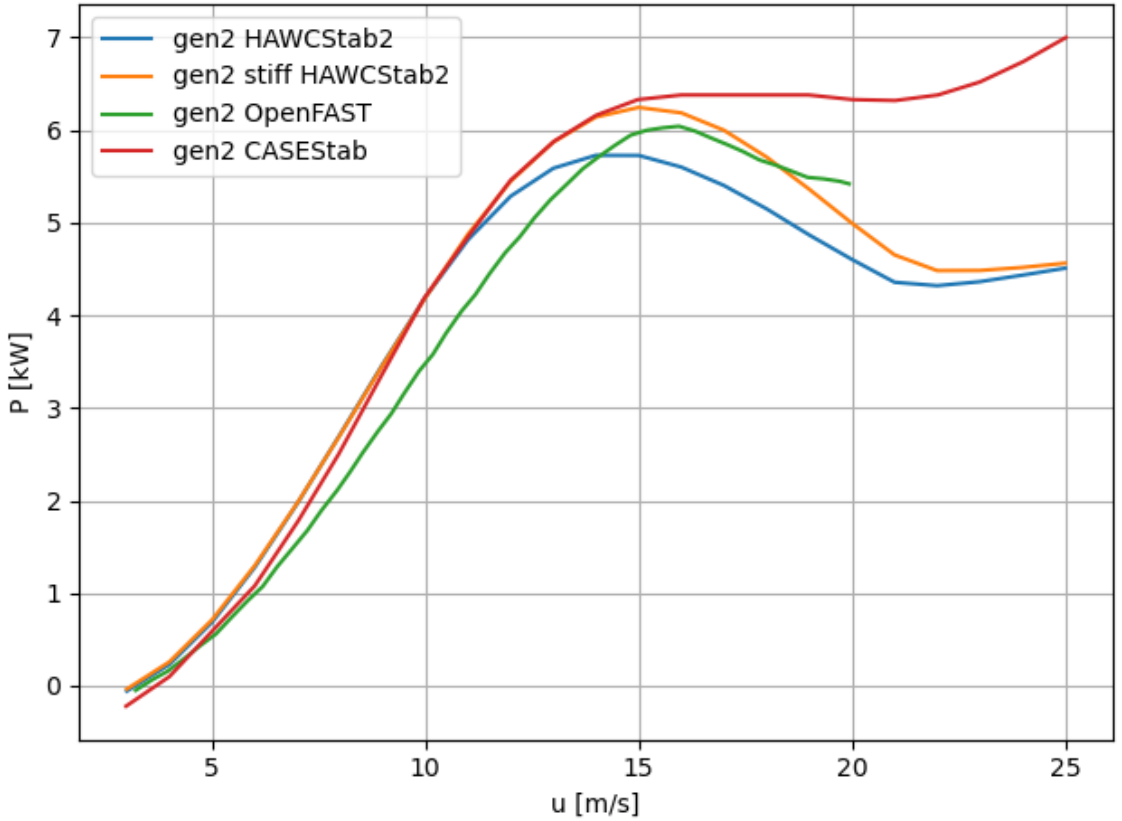
- Used software for load simulations
  - openFAST
  - HAWC2
  - “CASEStab”
- steady state simulations (constant wind field)
- HAWC2 compared to openFast
  - ~ 0.4 kW difference
  - Solution agree well to state of the art tool HAWC2
  - Improvements are still required



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Cross-Linking Synergies in education

Wind Energy Technology Institute	Center for industrial mechanics
Electrical Engineering for Controller	Machine Learning: Modelling of dynamic systems and identification, tools for machine learning, machine learning for dynamic tuning
Mechanical Engineers	Fatigue: Basic fracture mechanics, theory & practice of fatigue characterisation and prediction, fatigue analysis of stochastic systems, rainflow counting, linear damage theory, effect of mean stress state, and experi-mental fatigue testing
Design for Wind Turbines and Wind Farms	SPRO4B Power Conversion Systems: The project for the semester is based on the development of a mechanical product that involves different power conversion systems
Modelling & Simulation of Wind Turbines	
FE & Fatigue Analysis	
Computational Fluid Dynamics	
Control and automation of wind power plants	
Green Entrepreneurship	

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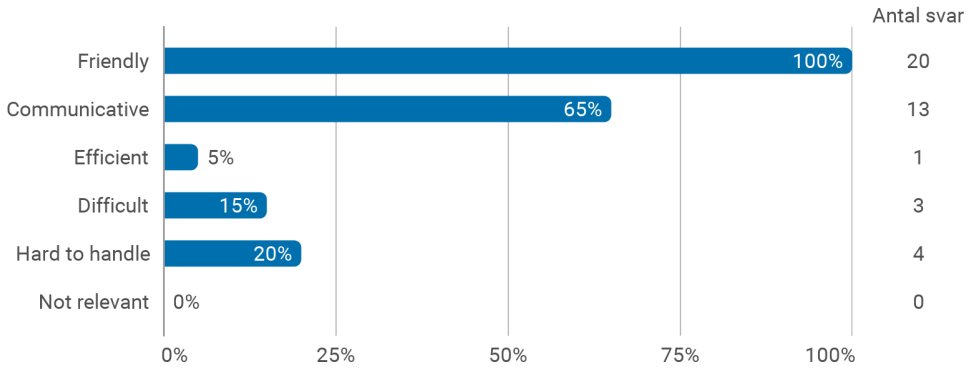
Cross-Linking of project & network partner

- Investigation of the working cultures
  - Business: C3 Consulting:
  - Private and business: SMK
  - Public institutes: ???

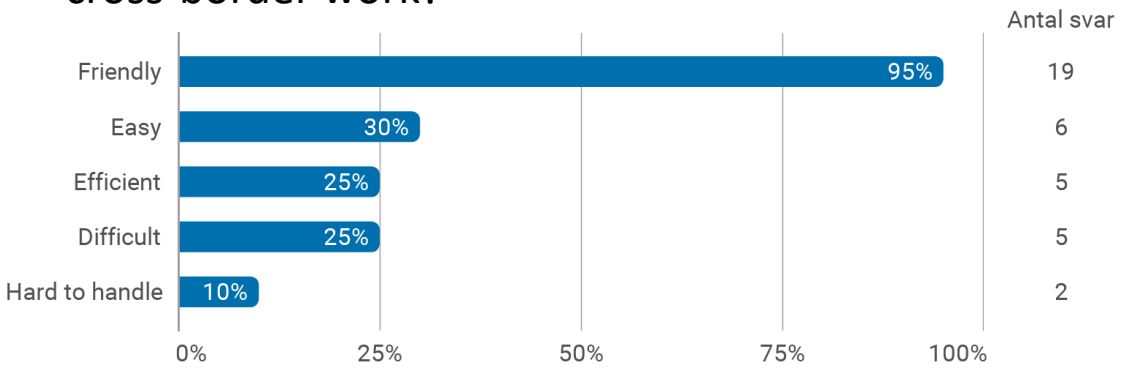
- Working cultures in academic sector of public institutes
  - Survey established
  - Possible participants of 37 of INTERREG project members
  - 4 subcategories

Working Culture Survey

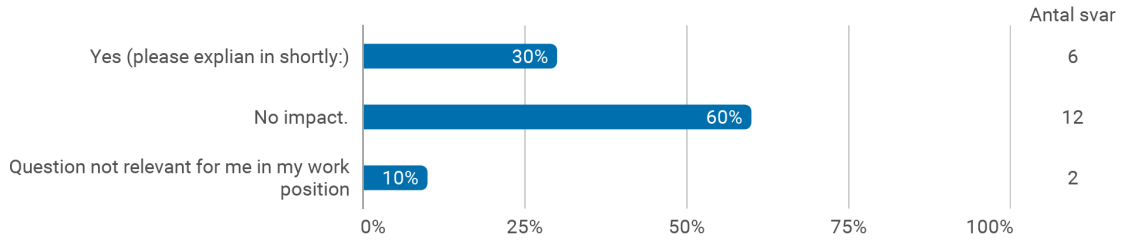
How was your specific working environment in cross-border work?



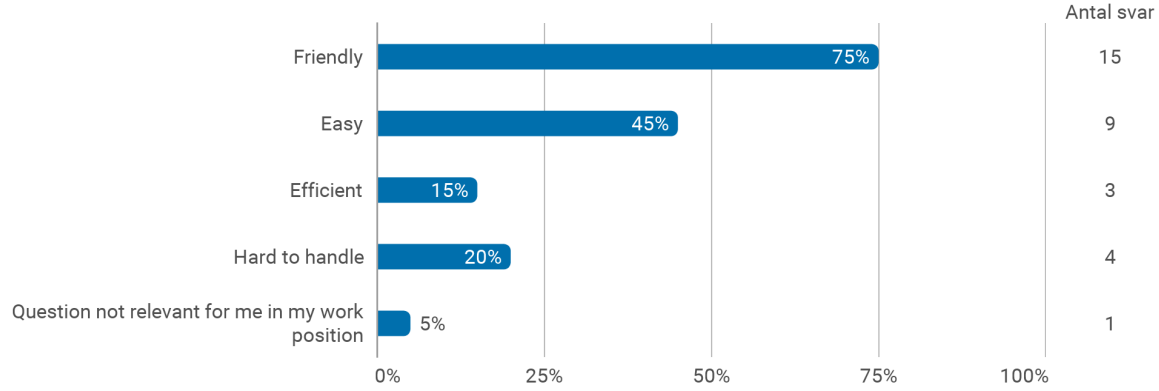
How was your specific working communication in cross-border work?



In respect to meetings, is the cross-border working culture affecting majorly the structure of such project meetings?



How was the communication about new ideas, which were not part of the project description in the beginning?



Targets for following research proposal for INTERREG 6 program

- **Target: development of cost optimized small wind turbine concept for the INTERREG 6A region as open-source**

Work packages	Required competences
1 – Project Management (mandatory by INTERREG)	Economics
2 – Public Relations (mandatory by INTERREG)	Coding for open source tool
3 – Economics of Small Wind Turbines	Simulation for FEM / CFD → openFoam (open Source)
4 – Design development	Engineer for designing in FreeCAD (open Source) Aerodynamics / Mechanic / Electric
5 – Prototyping, Manufacturing & Testing	Manufacturing of protoypes
	Hardware testing On site (Fokecenter in DK / Testfeldnord in GER) Wind tunnel test (FH Kiel)

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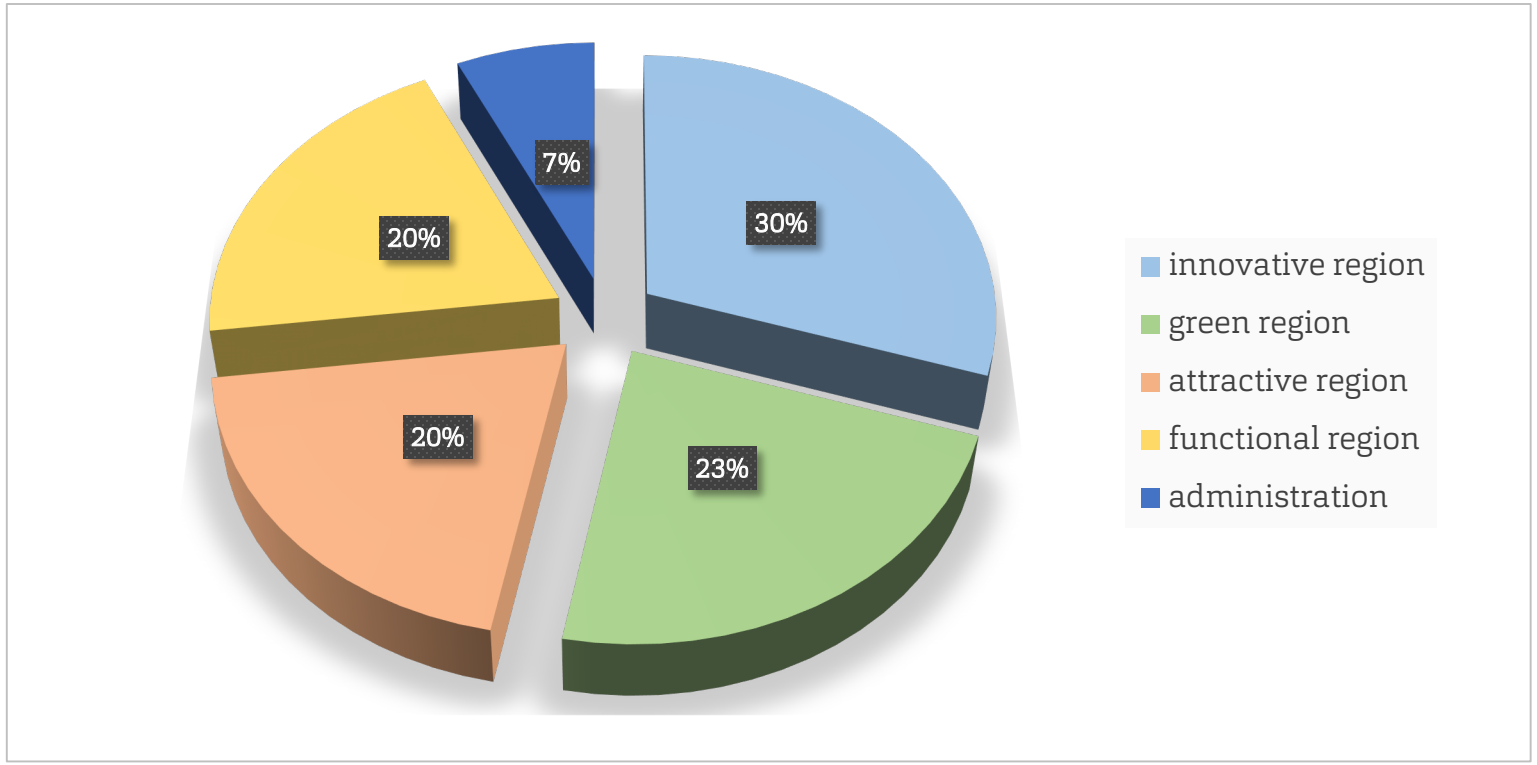
- The expected funds of 90 million euros will be divided into four thematic priorities in the German-Danish program area:

Map INTERREG Region 5a
Source: https://www.interreg5a.eu/en/



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CROSSWIND Tool
renewable energy calculator

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