INNTERESTING

SUSTAINABILITY STAKEHOLDER CONSULTATION MEETING

10/09/2020
10:00 – 12:00

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 851245

WELCOME! ON BEHALF OF THE INNTERESTING CONSORTIUM

ikerlan

Mireia OLAVE

vito
Energy Ville

Karolien PEETERS

Wai Chung LAM

Sofie DE REGEL

Carolin SPIRINCKX

Cluster Energía
BASQUE ENERGY CLUSTER

Marcos SUAREZ

Jone IRIGOYEN

AGENDA

1. General introduction of the INNTERESTING project – *Mireia*
2. Social acceptance of wind energy technology – *Karolien*
   based on findings of a literature review
3. Environmental requirements for (future) wind energy technology – *Wai Chung*
   based on findings of a literature review
4. Life Cycle Sustainability Assessment (LCSA) of three reference wind turbines
   findings of environmental Life Cycle Assessment (LCA) – *Wai Chung*
   findings of economic Life Cycle Costing (LCC) – *Sofie*
   findings of Social Life Cycle Assessment (S-LCA) – *Karolien*

SOME PRACTICALITIES

- Participants will be muted, please switch of your video when muted
- If you have a question:
  - Please “raise hand”, to be called upon to speak

  - Or type in your question in the chat
- Questions will be handled per block

- The slides will be made available on the project website
- Minutes of this meeting will be included in the first ‘Report on stakeholder engagement and activity’ which will be available on the website in December
- To support the process of making the minutes we will record this session

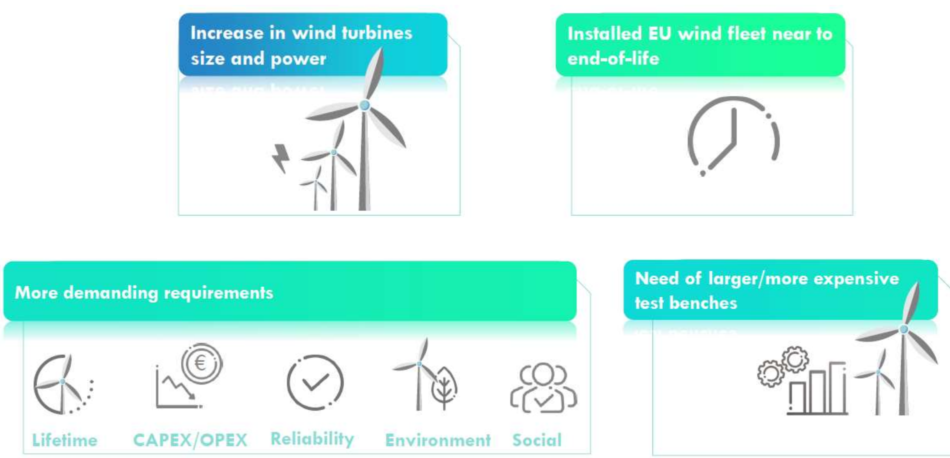
INNTERESTING

INTRODUCTION OF THE PROJECT

CHALLENGES TO FACE

INNTERESTING

TECHNOLOGICAL CHALLENGES WILL WE FACE IN THE WIND SECTOR IN THE FUTURE (2030-2050)



MAIN OBJECTIVE

- ***The INNTERESTING project aims to develop a novel hybrid methodology and breakthrough design tools to assess reliability of larger wind turbine critical components without the need of building larger test benches in the future.***

3 COUNTRIES

4.8 M€ BUDGET

8 PARTICIPANTS

36 MONTHS

INNTERESTING HYBRID TESTING METHODOLOGY

- The INNTERESTING hybrid testing methodology combines results from simplified physical tests and advanced virtual testing through smart fusion process and upscaling techniques to robustly predict realiability, lifetime and failures of full-scale wind turbine components.

CURRENT TESTING PYRAMID

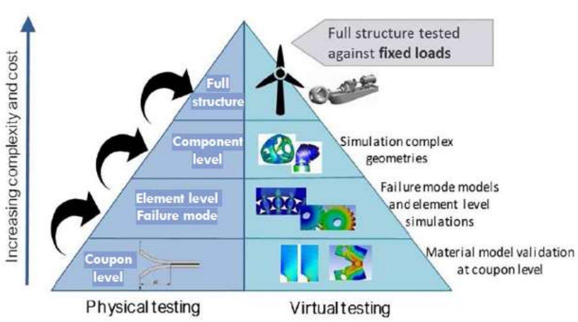


FIGURE 1: CURRENT TESTING PYRAMID COMBINING PHYSICAL AND VIRTUAL TESTING

INNTERESTING HYBRID TESTING METHODOLOGY

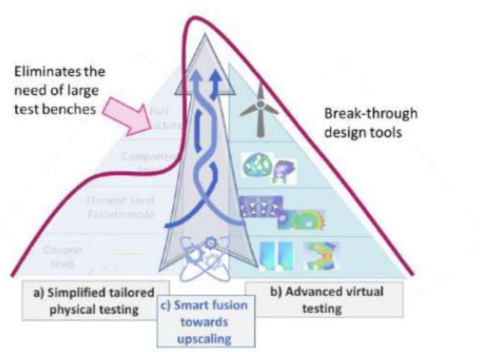
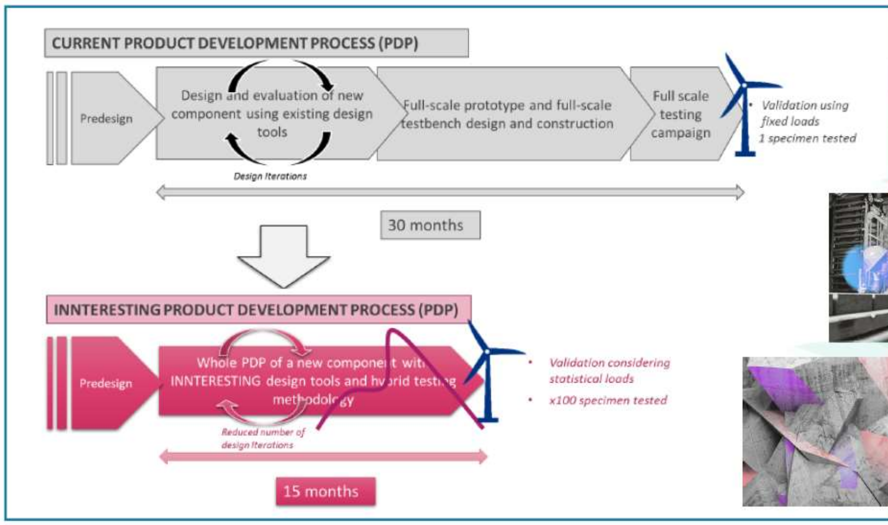


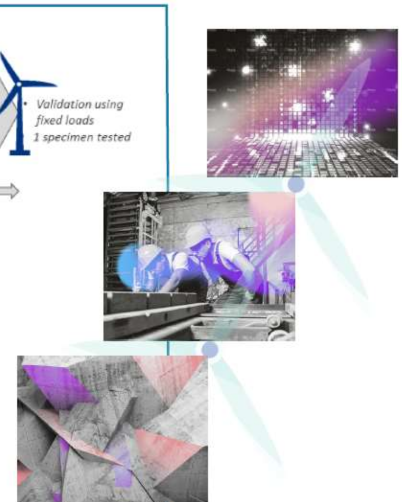
FIGURE 2: INNTERESTING TESTING METHODOLOGY WITH THE HYBRID TEST CONCEPT

Technology readiness level of the project: **TRL 4**

INNTERESTING HYBRID TESTING METHODOLOGY

- INNTERESTING aims to eliminate the need of building large test benches in the future by simplifying the product development process (PDP) of new wind turbine components, reducing costs and time.

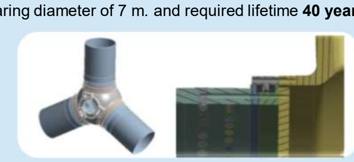




CASE STUDIES

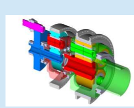
Pitch bearing for a 20 MW offshore (2030-2050)

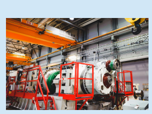
- CS1 is based on a pitch bearing that will be installed in a **20 MW wind turbine** from the year 2030 onwards.
- Reference wind farm with a size of **2.04 GW** and **102 turbines**
- The wind turbine will be based on the 20 MW RWT (from upscaling the DTU 10 MW reference wind turbine), with a hub height of 160, rotor diameter of 276 m
- Pitch bearing diameter of 7 m. and required lifetime **40 years**.



Novel journal bearing and gearbox concept For a10 MW onshore WT (2030-2050)

- CS2 is based on a new gearbox concept that will be installed in a **10 MW onshore** wind turbine from the year 2030 onwards.
- Hub height of 119, rotor diameter of 202 m.
- Torque density up to level of **200 Nm/kg**.
- The wind turbine will be installed in Germany, in a farm size of **100 MW** (**10 turbines**).
- Lifetime requirement: **30 years**

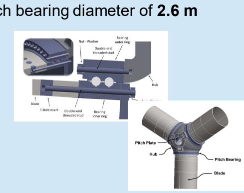




Novel existing pitch bearing lifetime extension concepts

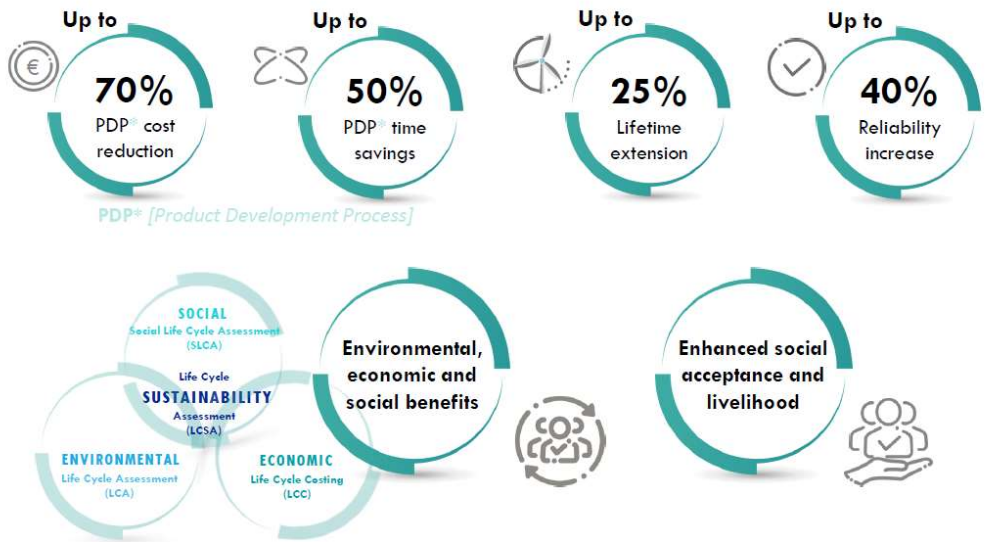
- CS3 is based on a pitch bearing that will be installed in a 3.4 MW WT in 2020 in Spain.
- unitary power of **3.4 MW** and a total wind farm size of 68 MW (20 turbines).
- Rotor diameter of Ø130 m and a hub height of 110 m. Pitch bearing diameter of **2.6 m**
- Lifetime requirement of **20 years**.

Considering a target life of 20 years, a crack initiation would arise on the bolt hole surface during the 4th year, thus making the bearing fail prematurely.



The solution must:
- **Reparation of failed bearings** in order to slow crack propagation down.
- **Stiffening of serviceable bearings** in order to delay crack initiation.

MAIN EXPECTED IMPACTS

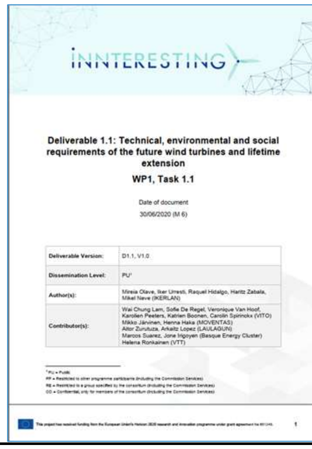


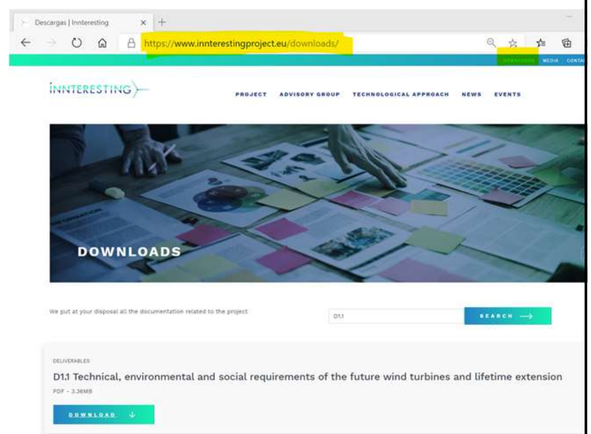
SOCIAL ACCEPTANCE

SOCIAL ACCEPTANCE

Findings of a literature review

Section 4+5 of D1.1





SOCIAL ACCEPTANCE

Definition

a favourable or positive response (including attitude, intention, behaviour and — where appropriate — use) relating to proposed or in situ technology or social technical system by members of a given social unit (country or region, community or town and household, organisation)

Lack of social acceptance might lead to

- Increased costs
- Longer development time

SOCIAL ACCEPTANCE

NIMBY

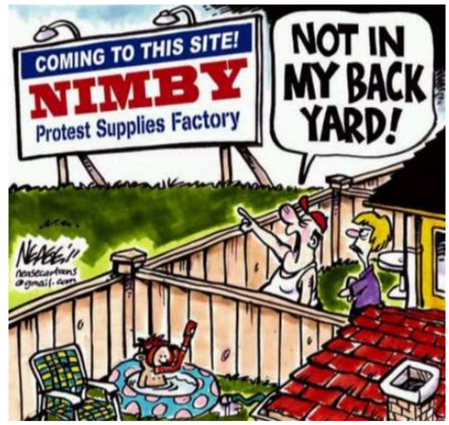
too simplistic way of explaining all variables involved!

Question of social acceptance has many components, e.g.:

- the general attitude towards wind power in the population as a whole,

- the acceptance in the population who will experience the local impacts,

- the conflict management strategies and economic involvement



SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes
- Relationships
- Contextual issues
- Perceived impacts
- Process related issues

• Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes →
  - Age, gender etc.
  - Strength of place attachment
  - Political beliefs and voting preferences
  - Emotional response
  - Prior experience of wind turbines
  - Attitudes to environmental issues
  - Psychological factors including perception of social norms
  - Individual roles (consumer, landowner etc.)
  - Familiarity with wind energy
- Relationships
- Contextual issues
- Perceived impacts
- Process related issues

- Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes
- Relationships →
  - Type and level of social capital
  - Trust in government other public agencies and developers
  - Proximity to, and visibility of, turbines
  - Technology-society relationships
  - Time, reflecting the dynamic nature of social acceptance
  - National-local policy
  - Regulator-developer links
  - Discourse within and between communities
- Contextual issues
- Perceived impacts
- Process related issues

- Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes
- Relationships
- Contextual issues →
  - Project design: turbine height, colour number and massing
  - Specific siting issues
  - Place attachment
  - Range and mix of actors
  - Ownership of proposed project
  - Cumulative impacts
  - Policy regimes
- Perceived impacts
- Process related issues

- Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes
- Relationships
- Contextual issues
- Perceived impacts →
  - Noise
  - Landscape
  - Shadow flicker
  - Property values
  - Level of economic benefit
  - Biodiversity: bats, birds
  - Infrasound
  - Navigation lights
  - Health concerns
  - Levels of economic benefit
  - Disruption of ‘place’
  - Efficiency of turbines and wind energy
  - Distributive justice
- Process related issues

- Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Key influences on social acceptance of wind energy projects: 5 issues:

- Individual attitudes
- Relationships
- Contextual issues
- Perceived impacts
- Process related issues →
  - Trust in institutions involved
  - Transparency and openness
  - Procedural justice
  - Expectations and aspirations of public participation
  - Availability and quality of information
  - Power in the participation process
  - Value places on lay and expert knowledge
  - Timing
  - Discourses of community, developer, regulatory body
  - Fait accompli

• Source: Ellis, G. & Ferraro, G. (2016). The social acceptance of wind energy. Where we stand and the path ahead. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

Some conclusions from JRC report*

Difficult to derive an overview due to complex range of studies, variables, measurement techniques…

There is a need to increase the overall acceptance **at society level**, not only **at the level of individual projects**.

Actions in individual projects can increase acceptance of host community, e.g.

- Organizing effective public participation
- Increasing the economic benefit for the host community

* Ellis, G. & Ferraro, G. (2016). *The social acceptance of wind energy. Where we stand and the path ahead*. JRC Science for policy report. EUR 28182 EN, doi 10.2789/696070

SOCIAL ACCEPTANCE

European research projects:

WISEPower
WE Engage Toolkit

WinWind
Increasing the acceptance of Wind Energy

Fostering social acceptance for wind power

Toolkit with guidance for Developers, Communities, Local Authorities, Others.

Increasing the acceptance of wind energy

Handbook: A WinWin(d) for all. The handbook for socially inclusive wind energy

SOCIAL ACCEPTANCE

INNTERESTING SOLUTIONS

MAIN EXPECTED IMPACTS

PDP* [Product Development Process]

UP TO **70%** PDP* COST REDUCTION

UP TO **50%** PDP* TIME SAVINGS

UP TO **25%** LIFETIME EXTENSION

UP TO **40%** RELIABILITY INCREASE

Life time extension

Less maintenance and idle time

SOCIAL ACCEPTANCE

INNTERESTING SOLUTIONS

Public participation so far concentrates on the phases of planning, permitting and construction and **little experience has been shared about the late phases of a wind farm life cycle** (operation and maintenance, decommissioning and repowering)*

Enevoldsen and Sovacool report that less maintenance and thus less idle time *may* lead to stronger acceptance**

A case of social acceptance of repowering mentioned in literature***:

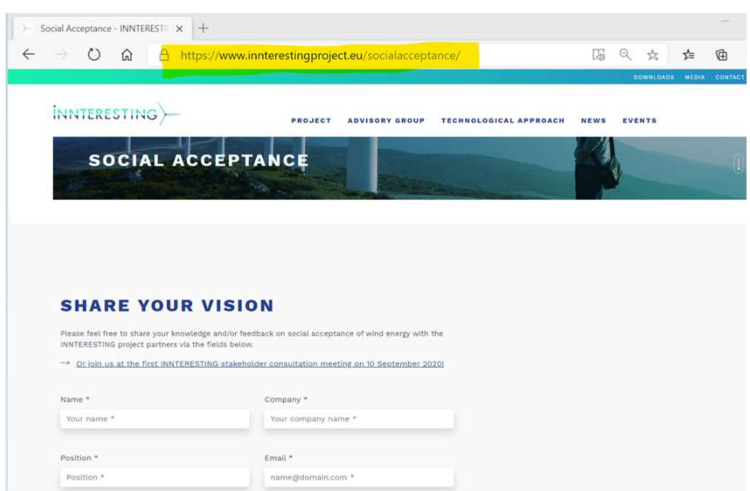
- Repowering of Abruzzo wind farm in Italy, highly effective in achieving social acceptance due to consolidation of existing benefits

*Dütschke E. & Wesche J.P. (2015). *Status quo of social acceptance strategies and practices in the wind industry*. Deliverable D2.2 of WISEPower Project. Available at http://wisepower-project.eu/.
**Enevoldsen & Sovacool (2016). Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. Renewable and Sustainable Energy Reviews, 53, 178-184.
***https://winwind-project.eu/fileadmin/user_upload/Resources/Posters/WinWind-case-study-poster_Abruzzo.pdf

SOCIAL ACCEPTANCE

Share your vision:

https://www.innterestingproject.eu/socialacceptance/

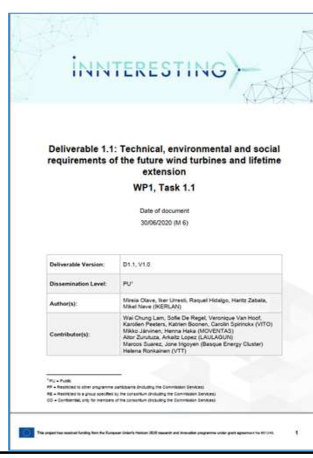


ENVIRONMENTAL REQUIREMENTS

ENVIRONMENTAL REQUIREMENTS FOR FUTURE WIND TURBINES

Findings of a literature review

Section 3 of D1.1


INNTERESTING

Deliverable 1.1: Technical, environmental and social requirements of the future wind turbines and lifetime extension

WP1, Task 1.1

Date of document

30/06/2020 (M 6)

Deliverable Version:	D1.1, V1.0
Dissemination Level:	PU[1]
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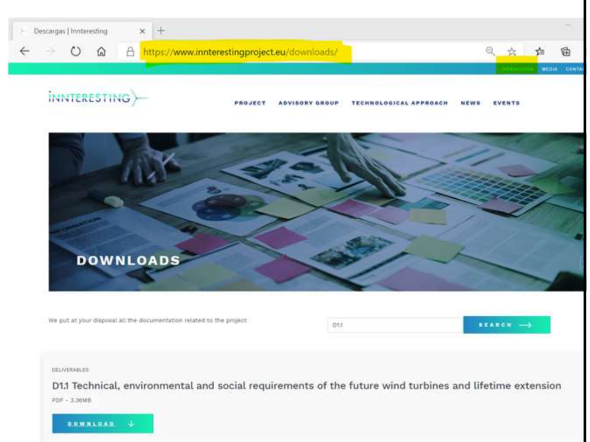


FINDINGS REGARDING WIND TURBINE NOISE

- Due to adverse health effects, World Health Organisation conditionally recommends reducing noise levels produced by wind turbines:
  - L_{den} < 45 dB[A]*
  - $L_{night,outside}$ of 40 dB (interim target 55 dB)**
- The more powerful the wind turbine generator (WTG) and the larger the WTG rotor diameter, the more noise it tends to emit ***
- Sound power level and nominal electric power generally increase together ****
- References on wind turbine noise of modern large scale turbines of 10 MW or even bigger than 3 MW are difficult to find
- Environmental regulations are expected to stay as they are
- Noise can be considered as one of the most significant factors affecting social acceptance of wind energy
- Mechanical reliability of the gearbox and the confidence against tonal free wind turbine behaviour needs to be considered

* World Health Organization, WHO Regional Office for Europe. (2018). *Environmental noise guidelines for the European Region*
** World Health Organization, WHO Regional Office for Europe. (2009). *Night noise guidelines for Europe.*
*** Crawford, M. (2014). *Overwhelming grounds for rejecting requested modification 2 for proposed Capital II wind farm.*
**** Møller, H. & Pedersen, C.S. (2011). Low-frequency noise from large wind turbines. *The Journal of the Acoustical Society of America*, 129(6), 3727-3744.

FINDINGS REGARDING IMPACT ON FLORA AND FAUNA

- Effects/conflicts depend on the flora and fauna present, and on the design and layout of wind farm
- Bird interaction specifically: potential positive and negative effects, e.g.
  - − bird electrocution and collision mortality, alteration of habits
  - + provision and protection nest sites and ancillary facilities
- Different type of bird interaction mitigation measures exists
  - Not related with the developments within the INNTERESTING project
- For future wind farm designs: fewer larger turbines may be preferred over many smaller turbines to reduce the number of structures in the wind farm

Manwell, J.F., McGowan, J.G., & Rogers, A.L. (2002). *Wind energy explained: theory, design and application.* Reprint, John Wiley & Sons, 2006
Smallwood, K. S., Rugge, L., & Morrison, M. L. (2009). Influence of behavior on bird mortality in wind energy developments. *The Journal of Wildlife Management*, 73(7), 1082-1098.

FINDINGS REGARDING VISUAL IMPACT

- Influenced by e.g. visual clarity, harmony, order, hierarchy, distance, contrast and movement*
- Visual impact of offshore wind parks is lower due to the distance from the coastline, however special attention could be needed in case of the highly valued uniqueness of coastal landscape**
- Visual impact mitigation measures not related with the developments within the INNTERESTING project
- For future wind turbine designs: turbine size is one of the important design characteristic related to the visual impact***

* Bishop, I. D., & Miller, D. R. (2007). Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables. *Renewable Energy*, 32(5), 814-831

** European Wind Energy Association (2009) *Wind Energy - The Facts: A Guide to the Technology, Economics and Future of Wind Power.*

*** Stanton, C. (1995). The visual impact and design of wind farms in the landscape. In *Wind energy conversion* 1994. Proceedings

FINDINGS REGARDING ELECTROMAGNETIC INTERFERENCE (EMI) EFFECTS

- Key parameters influencing extent of EMI caused by wind turbines: type of turbine, dimensions, turbine rotational speed, blade construction material, blade angel and geometry, tower geometry*
- Trend of more complex electronic monitoring equipment for large wind turbine**
- EMI effects not related with the developments within the INNTERESTING project

* Manwell, J.F., McGowan, J.G., & Rogers, A.L. (2002). *Wind energy explained: theory, design and application.* Reprint, John Wiley & Sons, 2006

** European Wind Energy Association (2009) *Wind Energy - The Facts: A Guide to the Technology, Economics and Future of Wind Power.*

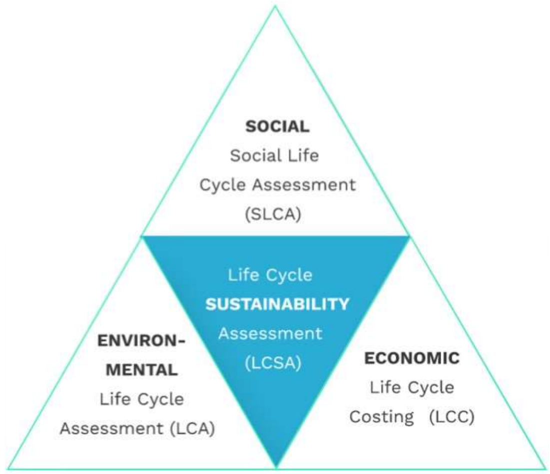
FINDINGS REGARDING SHADOW FLICKERING

- Mitigation measures, such as downtime at specific time periods, careful siting, bigger distance between turbine and closest neighbour, or careful use of materials for the blades, are not related with the developments within the INNTERESTING project

LIFE CYCLE SUSTAINABILITY ASSESSMENT (LCSA)

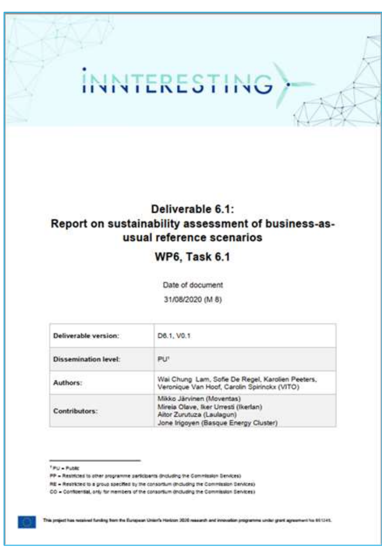
GENERAL APPROACH

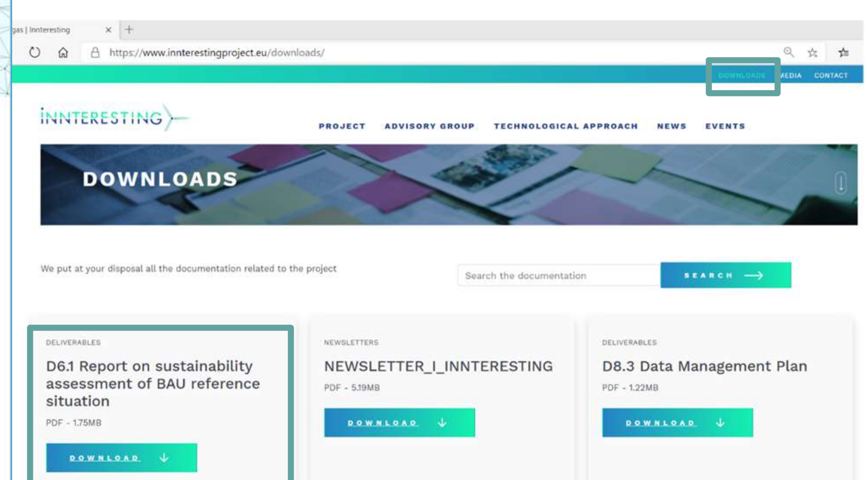
Performed via Life Cycle Sustainability Assessments (LCSAs) iteratively throughout project



FIRST DELIVERABLE AVAILABLE

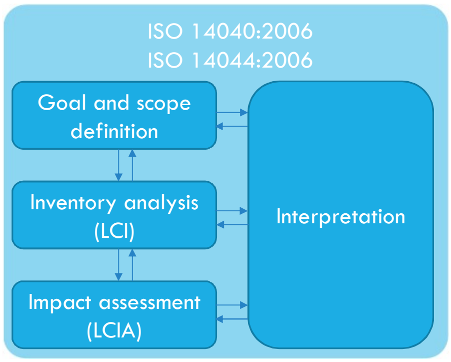
D6.1 LCSA of business-as-usual (BAU) reference scenarios





APPLIED OVERALL CONCEPTUAL METHODOLOGICAL FRAMEWORK

ISO 14040:2006 and 14044:2006



THREE BUSINESS-AS-USUAL REFERENCE SCENARIO

One specific reference scenario (RS) per case study

RS1 - 20 MW offshore wind turbine with a service life of 25 years
source generic LCI data: 20 MW common research wind turbine model by T. Ashuri et al. (2016)

RS2 - 10 MW onshore wind turbine with a service life of 20 years
source generic LCI data: DTU 10-MW Reference Wind Turbine by Bak et al. (2013) & 10MW RWT Costs Models v1.02 by Chaviaropoulos (2016)

RS3 – 3,4 MW onshore wind turbine with a service life of 20 years
source generic LCI data: IEA Wind Task 37 3.4-MW Land-Based Wind Turbine by Bortolotti et al. (2019)

GOAL OF FIRST ITERATION OF LCSA

- Gaining insights in the contribution of the different components to the environmental, economic and social impact of wind turbines during their life cycle
- Assessing BAU reference scenarios per case study of which the results can be used for comparing potential environmental, economic and social performance of product systems (i.e. BAU versus INNTERESTING solutions)
- In order to support concept development of the INNTERESTING solutions via hot spot analysis and to assess the potential effect of certain design choices on the environmental, economic and social performance of the solutions

SCOPE

Wind turbine developed, produced, installed, used and decommissioned on the European market

- LCA + S-LCA limited scope: only the wind turbine
- LCC full scope: incl. balance of plant + all development costs
- Prototype testing not included yet

General functional unit

- 1 kWh of the total electricity output delivered to the grid over the service life by a wind turbine

ENVIRONMENTAL ASSESSMENT (LCA)

APPLIED LCA METHODOLOGY

EN 15804:2012+A2:2019

- Specifically developed for the construction sector
- No comprehensive LCA framework available for energy sector available

16 Environment impact categories

- 10 core impact categories
- 6 additional impact categories

Climate change [kg CO_2 eq]	Ozone depletion [kg CFC 11 eq]	Acidification [mol H+ eq]	Eutrophication, freshwater [kg P eq]	Eutrophication, marine [kg N eq]	
Eutrophication, terrestrial [mol N eq]	Photochemical ozone formation [kg NMVOC eq]	Resource use, minerals and metals [kg Sb eq]	Resource use, fossils [MJ]	Water use [m^3 depriv.]	
Particulate matter [disease inc.]	Ionising radiation [kBq U-235 eq]	Ecotoxicity, freshwater [CTUe]	Human toxicity, cancer [CTUh]	Human toxicity, non-cancer [CTUh]	Land use [Pt]

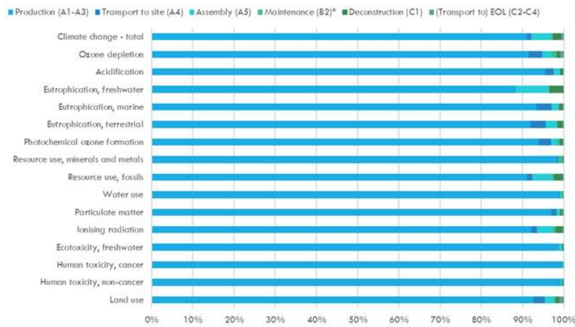
LCA RESULTS – ENVIRONMENTAL PROFILE OF COMPLETE WIND TURBINE

INN TER EST ING

- E.g. environmental profile of RS2 10 MW onshore WT

	Production (A1-A3)	Transport to site (A4)	Assembly (A5)	Maintenance (B2)*	Deconstruction (C1)	(Transport to) EOL (C2-C4)	Total life cycle
Climate change - total [kg CO2 eq]	6,62E-03	8,38E-05	3,49E-04	3,17E-05	1,49E-04	4,46E-05	**7,27E-03**
Ozone depletion [kg CFC11 eq]	5,35E-10	1,91E-11	1,32E-11	7,14E-12	5,19E-12	5,01E-12	**5,85E-10**
Acidification [mol H+ eq]	5,63E-05	1,20E-06	8,59E-07	1,35E-07	3,63E-07	1,05E-07	**5,89E-05**
Eutrophication, freshwater [kg P eq]	5,28E-07	5,44E-10	4,88E-08	8,85E-10	2,09E-08	2,62E-10	**5,99E-07**
Eutrophication, marine [kg N eq]	7,67E-06	2,91E-07	1,39E-07	2,03E-08	5,87E-08	3,17E-08	**8,21E-06**
Eutrophication, terrestrial [mol N eq]	8,03E-05	3,23E-06	2,23E-06	2,33E-07	9,47E-07	3,48E-07	**8,73E-05**
Photochemical ozone formation [kg NMVOC eq]	2,82E-05	8,92E-07	4,41E-07	2,09E-07	1,73E-07	1,09E-07	**3,01E-05**
Resource use, minerals and metals [kg Sb eq]	4,51E-07	1,16E-09	1,26E-09	4,06E-09	4,84E-10	4,08E-10	**4,58E-07**
Resource use, fossils [MJ]	8,84E-02	1,25E-03	4,45E-03	7,01E-04	1,87E-03	3,51E-04	**9,70E-02**
Water use [m³ depriv.]	2,52E-03	3,33E-06	1,12E-05	9,47E-06	4,60E-06	-7,36E-07	**2,55E-03**
Particulate matter [disease inc.]	4,29E-10	5,53E-12	3,06E-12	1,21E-12	1,28E-12	2,26E-12	**4,42E-10**
Ionising radiation [kBq U-235 eq]	3,44E-04	5,43E-06	1,41E-05	2,65E-06	5,90E-06	1,50E-06	**3,74E-04**
Ecotoxicity, freshwater [CTUe]	4,27E-01	9,34E-04	2,90E-03	5,41E-04	1,22E-03	4,54E-04	**4,33E-01**
Human toxicity, cancer [CTUh]	3,06E-11	3,43E-14	5,46E-14	4,18E-14	2,29E-14	1,47E-14	**3,08E-11**
Human toxicity, non-cancer [CTUh]	5,56E-10	9,46E-13	2,40E-12	3,72E-13	1,02E-12	8,00E-13	**5,61E-10**
Land use [Pt]	3,37E-02	1,02E-03	7,95E-04	1,52E-04	3,36E-04	3,94E-04	**3,64E-02**

Contribution to impact category	X > 50%	25% < X < 50%	10% < X < 25%	2,5% < X < 10%	X < 2,5%



* Includes only maintenance of the gearbox, in RS1 and RS2 maintenance is excluded completely due to lack of LCI data

- General conclusions: all three RSs show comparable profile
  - the production stage is most contributing life cycle stage for all assessed impact categories
  - due to the mass of the tower (ranges 45-70%)

LCA RESULTS – ENVIRONMENTAL PROFILE PRODUCTION STAGE ALL COMPONENTS

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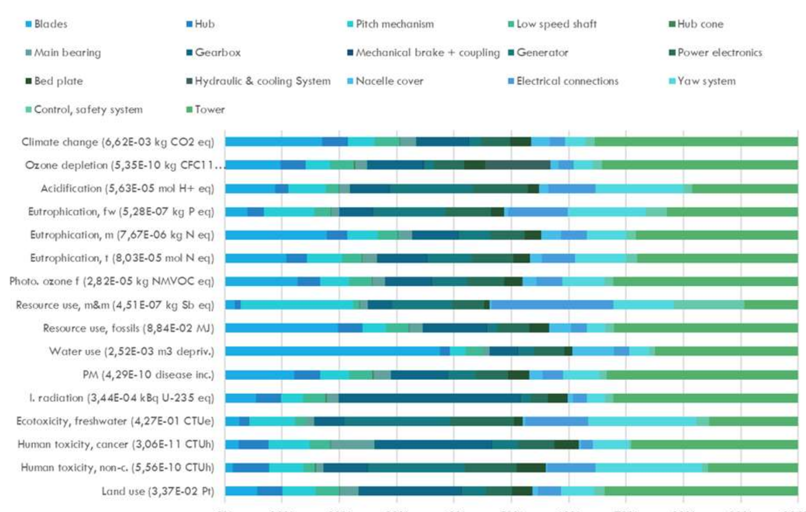
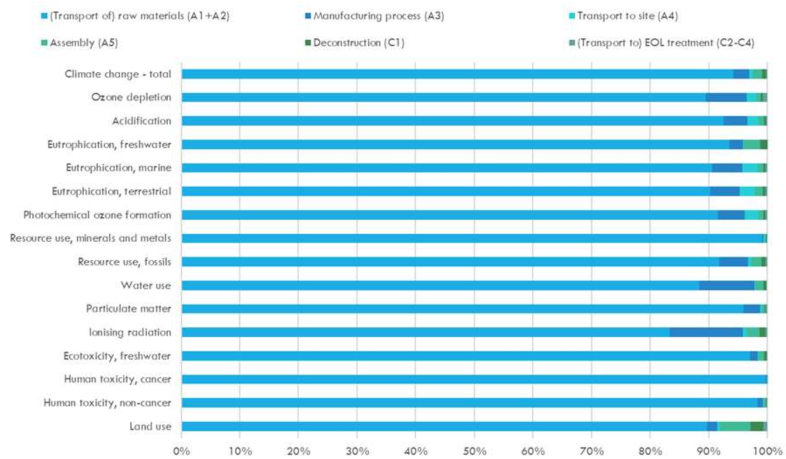
Other relevant contributing components to the environmental impact in the production stage are:

- Pitch mechanism (incl. pitch bearings)
- Gearbox
- Different electronics



LCA RESULTS – PITCH BEARING (RS1+RS2)

Raw materials contribute the most to the environmental impact



LCA RESULTS – GEARBOX (RS3)

Raw materials contribute the most to the environmental impact

Except for ionising radiation due to the part nuclear energy of the Finish electricity mix used for the manufacturing

ECONOMIC ASSESSMENT (LCC)

ECONOMIC ASSESSMENT

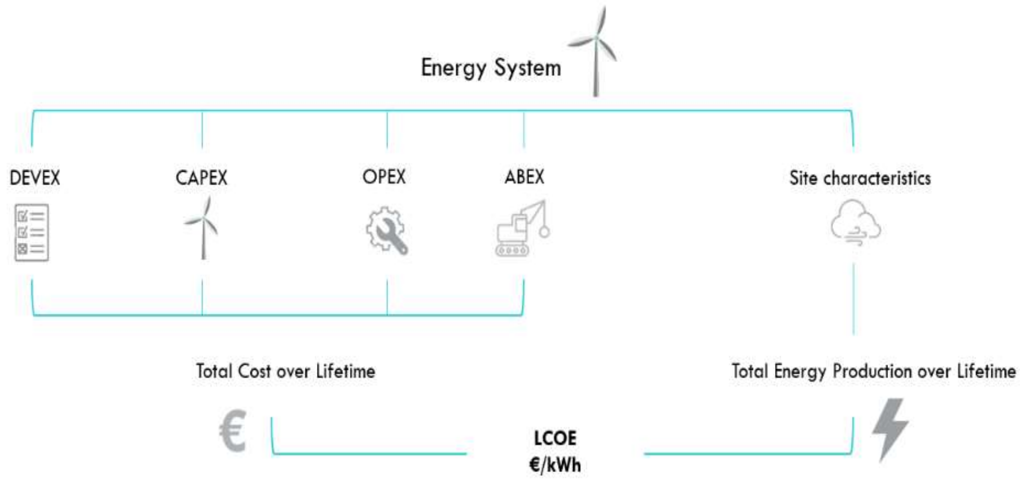
Life Cycle Costing (LCC)

All costs associated with the life cycle of a wind turbine that are directly covered by one or more of the actors in the system life cycle

Applied methodology: Levelized Cost of Energy (LCOE)
→ LCC results levelled by expected energy production

Applied model: based on LCOE model developed by Megavind (2015)

APPLIED LCC METHODOLOGY



DEVEX - Development Expenditures
CAPEX - Capital Expenditures
OPEX - Operational Expenditures
ABEX - Abandonment Expenditures

APPLIED LCC METHODOLOGY

$$\mathrm{LCOE} = \frac{Present\ value\ (Cost)}{Present\ value\ (Production)}$$

$$Present\ value\ of\ Costs = \sum_{t=k}^{T} \frac{DEVEX_t + CAPEX_t + OPEX_t + ABEX_t}{(1 + \mathrm{WACC}_n)^t}$$

$$Present\ value\ of\ Production = \sum_{t=k}^{T} \frac{E_t}{(1 + \mathrm{WACC}_r)^t}$$

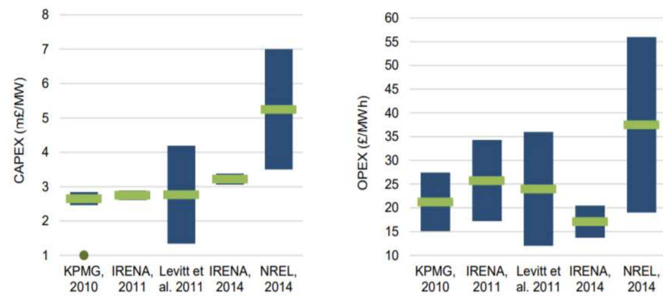
t	time period
k	earliest period
T	latest period
E_t	energy production at time t
WACC_r	real weighted average cost of capital
WACC_n	nominal weighted average cost of capital

LCC DATA

Specific cost data (gearbox and pitch bearings) collected through partners
General cost data (other WT components) collected through technical reports and scientific papers

Significant variation in economic data in available literature
→ uncertainty in the interpretation of LCOE results

Illustration of high degree of uncertainty for cost data



Source: ROMEO D8.1, 2018

LCC RESULTS

LCOE in EUR_{2019}

Full scope (including costs related to balance of plant)
Goal: comparison with LCOE of INNTERESTING solutions
Results depend on scope, input parameters and assumptions

	LCOE [EUR/kWh]	Numerator [EUR]	Denominator [kWh]
LCOE RS1 (20 MW offshore)	0,066	76 798 688	1 166 153 131
LCOE RS2 (10 MW onshore)	0,030	16 885 758	577 216 957
LCOE RS3 (3.4 MW onshore)	0,068	5 899 677	86 192 801

LCOE breakdown – Share of total LCOE

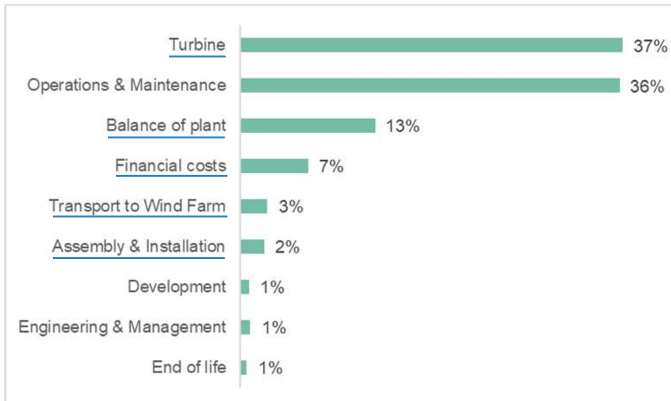
	DEVEX	CAPEX	OPEX	ABEX
RS1	3 %	57 %	38 %	2 %
RS2	2 %	61 %	36 %	1 %
RS3	2 %	71 %	26 %	1 %
		[57-71%]	[26-38%]	

LCC RESULTS

LCOE detailed breakdown

- CAPEX biggest share, followed by OPEX
- Similar conclusions for RS1, RS2, RS3

Detailed breakdown for RS2, costs discounted to 2019



LCC RESULTS

LCC findings related to pitch bearings

- specific cost data provided by Laulagun on cost of raw materials and energy use in the production process
- no specific data on operational expenses
- production costs of pitch mechanism account for 6 % of total production costs of WT

LCC findings related to gearbox

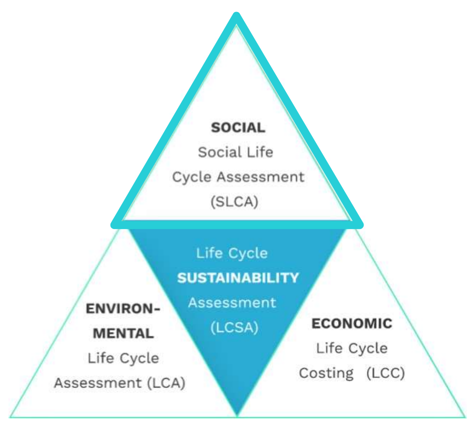
- specific cost data provided by Moventas on
  - cost of raw materials & energy use in the production process
  - recuperation of production waste
  - maintenance processes
  - residual value after decommissioning
- production costs of gearbox account for 17 % of total production costs of WT
- operational costs of gearbox account for 6 % of total maintenance costs of WT

SOCIAL ASSESSMENT (S-LCA)

SOCIAL LIFE CYCLE ASSESSMENT

Social LCA

Technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling and final disposal



SOCIAL LIFE CYCLE ASSESSMENT

Goal and scope

SOCIAL LIFE CYCLE ASSESSMENT

Framework

UNEP/SETAC Life Cycle Initiative (2009) Guidelines for Social Life Cycle Assessment of Products edited by Catherine Benoît and Bernard Mazijn

UNEP/SETAC Guidelines for social life cycle assessment, draft version 2020

Screening life cycle assessment

Aim to identify social hotspots in the life cycle of the reference turbines.

SOCIAL LIFE CYCLE ASSESSMENT

Social indicators – 5 stakeholder groups:

- Workers
- Consumers
- Local community
- Society
- Value Chain Actors

SOCIAL LIFE CYCLE ASSESSMENT

Social indicators – 5 stakeholder groups, divided into subcategories:

Workers	Child labour Discrimination	Forced labour Health and Safety	Social benefits, legal issues Fair Salary	Working time Worker's right
Consumers	Health and Safety	Transparency	End of life responsibility	
Local community	Local employment Migration	Access to material resources	Respect of indigenous rights	Safe and healthy living conditions
Society	Contribution to economic development	Health and Safety	Prevention and mitigation of conflicts	
Value Chain Actors	Fair competition	Corruption	Promoting social responsibility	

SOCIAL LIFE CYCLE ASSESSMENT

Social indicators – 5 stakeholder groups, divided into subcategories:

- Workers
  - Child labour
  - Discrimination
  - Forced labour
  - Health and Safety
  - Social benefits, legal issues
  - Fair Salary
  - Working time
  - Worker's right
- Consumers
- Local community
- Society
- Value Chain Actors

Health and Safety:

Fatal accidents
Non-fatal accidents
Presence of sufficient safety measures
Indoor and outdoor pollution
Workers affected by natural disasters

SOCIAL LIFE CYCLE ASSESSMENT

Selection of most important social indicators

Based on materiality assessment and sustainability reports of three main European wind turbine manufacturers and PSILCA (very) high risk levels.

Materiality assessments:

All three manufacturers had identified **'Health and Safety'** as a material aspects.

Other aspects mentioned were Business performance, Innovation, Environmental performance, Local community development, human rights…. -> but none of them mentioned by all three manufacturers

SOCIAL LIFE CYCLE ASSESSMENT

Selection of most important social indicators

Sustainability reports:

The S-LCA impact subcategories linked to the 17 SGDs (figure 3 as published in Benoît-Norris et al, 2020).

SOCIAL LIFE CYCLE ASSESSMENT

Selection of most important social indicators

Cross check with PSILCA (very) high risk levels for sectors relevant to the project

-> focus on Health & Safety (workers) + Fair salary

SOCIAL LIFE CYCLE ASSESSMENT

Results

SOCIAL LIFE CYCLE ASSESSMENT

Results for RS1:

Stakeholder group/Subcategory/Indicator	Impact result	Unit
Consumers		
Transparancy		
Bus. practices deceptive to consumers	7,24E-04	CONS med risk hours
Local Community		
Access to material resources		
Industrial water depletion	9,39E-02	WU med risk hours
Biomass consumption	4,77E-02	BM med risk hours
Certified envir. management systems	7,64E-02	CMS med risk hours
Minerals consumption	6,16E-03	MC med risk hours
Fossil fuel consumption	1,16E-03	FF med risk hours
Local employment		
Unemployment	3,84E-02	U med risk hours
Migration		
International migrant stock	1,20E-02	IMS med risk hours
Internat. migrant workers in the sector	7,63E-03	IMW med risk hours
Net migration	5,04E-04	NM med risk hours
Respect of indigenous rights		
Indigenous rights	3,36E-03	IR med risk hours
Safe and healthy living conditions		
Contribution to environmental load	2,11E-01	CS med risk hours
Sanitation coverage	2,53E-02	SC med risk hours
Pollution	9,91E-03	P med risk hours
Drinking water coverage	6,87E-03	DW med risk hours
Society		
Contribution to economic development		
Education	1,07E-02	E med risk hours
Illiteracy, female	7,00E-03	I med risk hours
Illiteracy, total	5,92E-03	I med risk hours
Illiteracy, male	5,51E-03	I med risk hours
Youth illiteracy, female	9,02E-04	YI med risk hours
Youth illiteracy, total	9,01E-04	YI med risk hours
Youth illiteracy, male	8,82E-04	YI med risk hours
Contribution to economic development	-2,70E-03	CE med risk hours
Health and Safety (Society)		
Health expenditure	9,28E-03	HE med risk hours
Life expectancy at birth	7,69E-04	LE med risk hours
Value Chain Actors		
Corruption		
Active involv. in corruption and bribery	1,80E-02	AI med risk hours
Public sector corruption	3,42E-02	C med risk hours
Fair competition		
Anti-competitive business pratices	9,87E-04	AC med risk hours
Promoting social responsibility		
Social responsibility along supply chain	7,40E-02	SR med risk hours

SOCIAL LIFE CYCLE ASSESSMENT

Results for RS1:

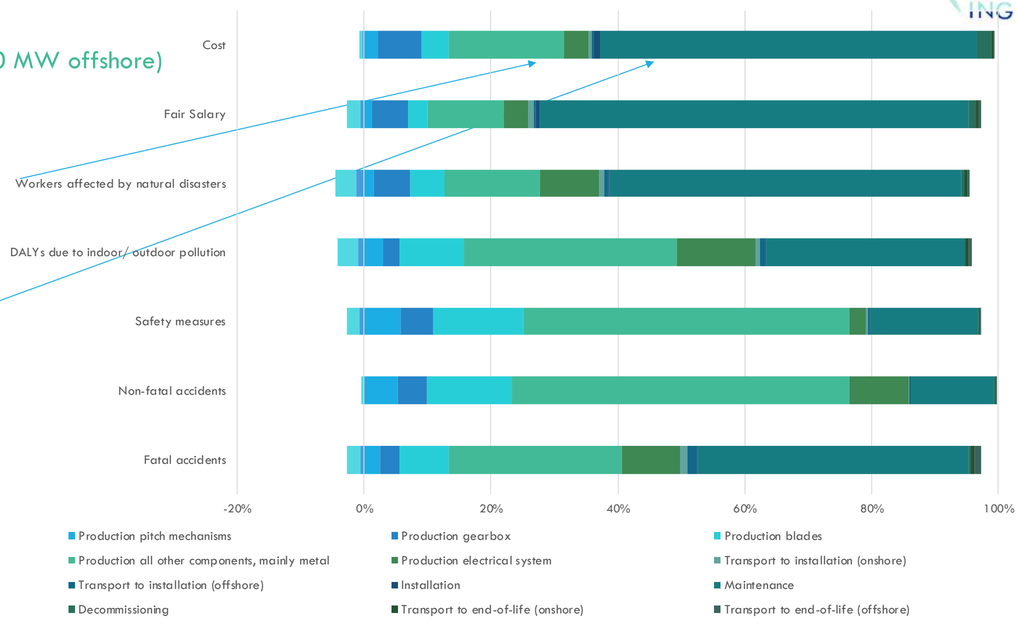
Stakeholder group/Subcategory/Indicator	Impact result	Unit
Workers		
Child labour		
Child Labour, male	1,76E-03	CL med risk hours
Child Labour, total	1,74E-03	CL med risk hours
Child Labour, female	1,59E-03	CL med risk hours
Discrimination		
Women in the sectoral labour force	1,13E-02	W med risk hours
Gender wage gap	1,54E-02	GW med risk hours
Men in the sectoral labour force	9,96E-05	M med risk hours
Fair Salary		
Fair Salary	7,69E-02	FS med risk hours
Forced labour		
Trafficking in persons	6,82E-03	TP med risk hours
Goods produced by forced labour	5,79E-04	GFL med risk hours
Frequency of forced labour	5,06E-04	FL med risk hours
Freedom of association and collective bargaining		
Trade unionism	9,81E-02	TU med risk hours
Association and bargaining rights	8,35E-03	ACB med risk hours
Health and Safety (Workers)		
Non-fatal accidents	4,58E-02	NFA med risk hours
Fatal accidents	8,22E-04	FA med risk hours
Safety measures	2,20E-02	SM med risk hours
DALYs due to indoor/ outdoor pollution	2,51E-04	DALY med risk hours
Workers affected by natural disasters	1,69E-03	ND med risk hours
Social benefits, legal issues		
Violations of empl. laws and regulations	4,42E-03	VL med risk hours
Social security expenditures	8,06E-03	SS med risk hours
Working time		
Weekly hours of work per employee	1,07E-03	WH med risk hours

SOCIAL LIFE CYCLE ASSESSMENT

Results for RS1 (20 MW offshore)

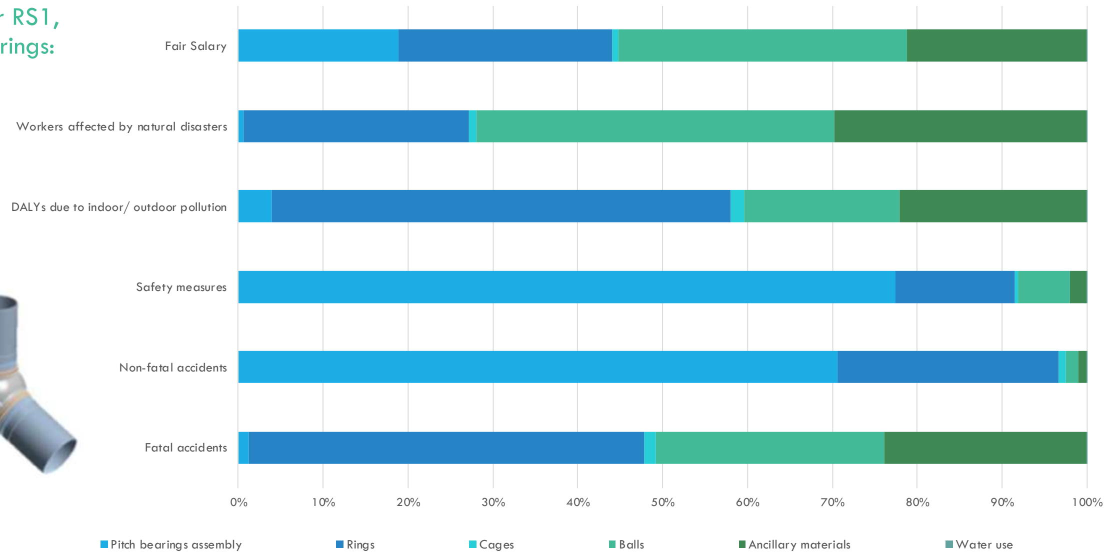
All metal components except gearbox, pitch mechn. and electrical system

Maintenance



SOCIAL LIFE CYCLE ASSESSMENT

Results for RS1, pitch bearings:



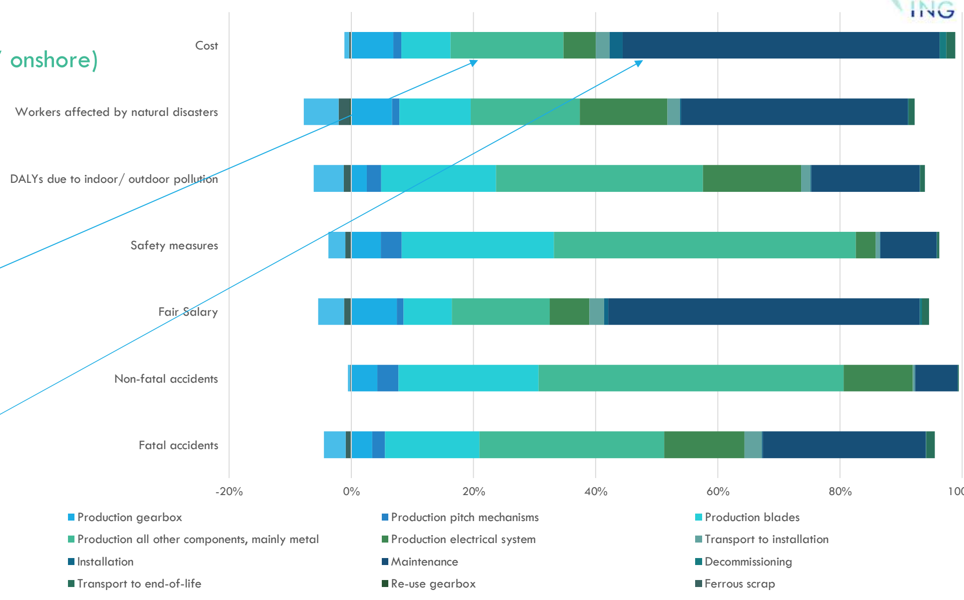
SOCIAL LIFE CYCLE ASSESSMENT

Results for RS2 (10 MW onshore)

Similar trends for the life cycle

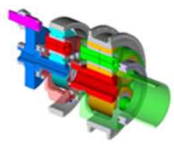
All metal components except gearbox, pitch mechn. and electrical system

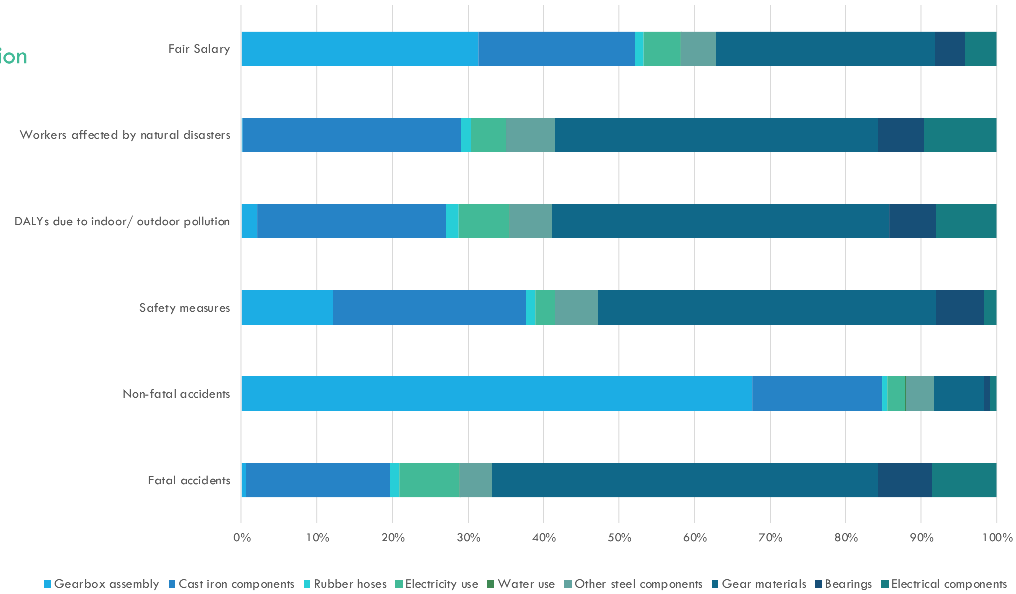
Maintenance



SOCIAL LIFE CYCLE ASSESSMENT

Results for RS2, gearbox production in Finland

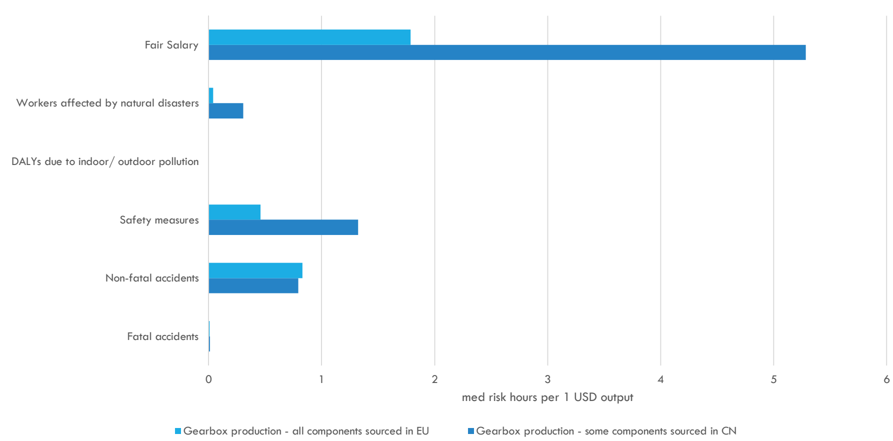




SOCIAL LIFE CYCLE ASSESSMENT

Results for RS2, gearbox production in Finland -> All components are sourced within Europe

If we would change this to outside Europe (for gear materials, bearing and electrical components), e.g. China, the comparative environmental profile looks as follows:



SOCIAL LIFE CYCLE ASSESSMENT

Risk along the entire supply chain, e.g. child labour

CLOSING OF THE MEETING

NEXT STEPS FOR LCSA

Jun 2022 — Report on sustainability assessment results of screening INNTERESTING solutions incl. revision of BAU with data on prototype testing

- Stakeholders are welcome to provide Life Cycle Inventory (LCI) data on prototype testing or improvements for applied LCI data

Dec 2022 — Final report on sustainability assessment results of INNTERESTING solutions

THANK YOU!

If you're interested in the bi-annual newsletter, please send us an e-mail and you will be added to the mailing list

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