# IEA WIND 2023 ANNUAL REPORT Guidelines for Task Chapters

**Overview**

The IEA Wind Annual Report is a key source of information for the world community on wind energy progress in our countries. We rely on our members to provide a balanced, nationwide picture of wind energy activities for the year. The report has one chapter from each Task, Member Country, and Sponsor Member.

The IEA Wind Annual Report is sent to Members, Alternate Members, Operating Agents and Task Managers for distribution within their countries to key stakeholders. It is also available for free download at [www.iea-wind.org](http://www.iea-wind.org/). We urge you to distribute the report to key decision-makers and to promote it on national websites and in newsletters.

|  |
| --- |
| **Instructions:**  Write the task chapter using the **chapter outline** (following pages).   * *Final text* must be submitted to [ieawind@dtu.dk](mailto:ieawind@dtu.dk) by **April 26, 2024**. * For your reference, the final printed version of last year’s task chapter is attached to this email. * After the editing and layout of your chapter is complete (approximately first week of June), *you will need to review* it carefully and mark any corrections prior to publishing.   **Submission Checklist:**  Text:   * Executive summary of Task report for Annual Report - 250-word limit * Chapter text adheres to the 1,200-word limit * Table 1 lists 2023 Task participants * Numbered references are placed manually at the end of the sentence in brackets [1]. For example, “…The Ministry of Economic Affairs finalized the Connect 6,000 report in May 2023 [1]." * Citations follow this format: [1] Author (year). Title of report or document. Download from (provide website link). * No automatic footnotes, formatting, or automatic numbering are used (they become lost during the text translation process for layout). * Full name and organizational affiliation of each author is included at the end of your chapter.   Photos/Graphics:   * **Two** high-quality (large file) photos or graphicsare sent with your chapter. Include the Task number and name on all files submitted. * Captions describing each photo/graphic and include the **source** (Source: ) or **photo credit** (Photo credit: ) are included in the chapter. * Chapter authors have checked to make sure we have been granted permission to print the photos and other graphics in the Annual Report and to post them on the public website. * Tables are inserted into the text as MSWord Tables, not as photos.   Review:   * Chapter text has been reviewed and approved by Task participants and your organization as appropriate. * ‘Terminology and Definitions’ have been consulted during drafting and/or review of the chapter. |

We appreciate your effort in creating a quality report and please let us know if you have any questions.

IEA Wind TCP Secretariat, Email: [ieawind@dtu.dk](mailto:ieawind@dtu.dk)

Executive Summary of Task Chapter for Annual Report

**Task XX Summary [250 words for Annual Report]**

*Briefly* describe each of the following:

* Task objectives
* Results from 2023
* Industry participation, other end-user organizations (e.g. NGOs)

TASK CHAPTER OUTLINE   
IEA Wind 2023 Annual Report

Please write your task chapter using the following outline. **Task Chapters are limited to two pages [1,200 words total]**; estimated word counts are included in the outline below.

The Annual Report 2022, including your Task’s chapter from last year, was attached to the email for reference. Place estimated numbers in brackets [ ].

**Introduction [250 words]**

*Briefly describe each of the following (avoid using references in the introduction if possible):*

* *The problem that inspired the creation of the task*
* *Task objectives*
* *Expected results*
* *Industry participation, other end-user organizations (e.g. NGOs)*

*List countries observing in the Task within the text of the chapter, if applicable.*

Airborne Wind Energy Systems allow capturing wind resources at altitudes up to 800m while significantly reducing the amount of material input. Through its scalability, the Airborne Wind Energy (AWE) technology opens up new markets and locations for wind energy which allows AWE to play a significant part of the future energy system.

The objective of Task 48 on AWE is to tackle technological, regulatory and policy challenges on a global level, addressing and including stakeholders such as AWE developers, suppliers, policy makers, authorities, regulators and other wind energy and technology experts.

Task 48 consists of five Work Packages: i) Resource potential and markets; ii) reference models, tools and metrics; iii) safety and regulation; iv) Social Acceptance and Environmental Impacts; v) AWES Architectures. Various tools, papers and studies have been developed throughout 2023 within Task 48 and in collaboration with other projects.

Task 48 has become a key platform for knowledge exchange about AWE, helping increase awareness and expertise on the technology.

The Task is supported by eleven countries and dozens of organizations.

**Table 1. Countries Participating in Task 48**

|  |  |  |
| --- | --- | --- |
|  | **Country/Sponsor** | **Institution(s)** |
| 1 | BE | Airborne Wind Europe, University of Ghent, KU Louvain |
| 2 | CH | EPFL, ETH Zürich, PSI, Swiss Federal Office of Energy, Swiss FOCA, Twingtec AG, UASolutions |
| 3 | DE | Enerkite GmbH, FGW, Fraunhofer ISI, kiteKRAFT, Leibniz University of Hannover, RWE, RWTH Aachen, Skysails GmbH, Uni Bonn, University of Applied Sciences Munich, University of Bonn, University of Freiburg, University of Halle, University of Stuttgart |
| 4 | DK | DTU |
| 5 | ES | CT Ingenieros, someAWE, UC3M |
| 6 | IE | MaREI Research Centre, BlueWise Marine, University College Cork, Mayo County Council , RWE Ireland, University of Limerick, SEAI, University College Cork |
| 7 | IT | Kitenergy, Politecnico di Milano, Politecnico di Torino |
| 8 | NL | Kitepower/ enevate , TNO Wind Energy, TU Delft |
| 9 | NO | Kitemill AS, NTNU Trondheim, University of Bergen |
| 10 | UK | ORE Catapult , University of Strathclyde, Windswept |
| 11 | US | Colorado State University, FAA, North Carolina State University, NREL, SNL, UCSB, University of Dayton, University of Michigan, University of Washington, Windlift, Worcester Polytechnic Institute |

**Progress and Achievements [400 words]**

*Describe highlights of the technical work carried out (research activities). Present concrete results as permitted by intellectual property restrictions. Briefly describe recent publications and deliverables (bullet points might be useful here). Briefly describe other recent communication activities to reach out to key clients and stakeholders.*

*[Possible Figure: graph of data collected, output of models, flow chart of process, map, photo of test site]*

In **WP1 on Resource potential and markets,** in collaboration with the Horizon Europe project MERIDIONAL**,** the impact on the inflow on the performance of AWE systems is simulated.

Various studies have focused on the AWE deployment potential. For instance TU Delft has used the Calliope energy system model to predict the deployment of AWE in the European renewable energy system until 2050 [Vos, 22; Launer, 11]. Other studies analysed the potential locations where AWE could be deployed, e.g. in Germany [Coca 5], or in offgrid systems [Reuchlin, 14]

The joint project of TU Delft and Polimi on the reference economic model for AWE systems has been continued in 2023, the study will be available in Q2-2024 *[Joshi, 23; forthcoming in 2024].*

Within **WP2 on Reference models, tools and metrics** examples of TU Delft’s work are the simulation models for soft-wing kites [Poland, 12; Cayon, 4, Thedens, 18], fixed-wing kites [Eijkelhof, 9; Porta Ko, 13] and hybrid kites [Candade, 3] the Sensor Fusion Technique which is a combination of multiple sensors to overcome individual inaccuracies and limitations​ and allows prediction of wind and aerodynamic characteristics and the state of the kite at the same time. A notable contribution to the understanding of wake effects of AWES was published by Polimi [Trevisi, 20].

**In WP3** **on safety and Airspace Integration,** the White Paper on AWE Airspace Integration [AWEurope, 1] was further enhanced in collaboration with TwingTec in a project co-funded by Swiss FOCA. The development of AWE-specific standards as part of IEC-61400 and/or unmanned aircraft systems has been started, among others with ORE Catapult [forthcoming]. The SORA process for AWES was detailed in [Salma, 15]

**In WP4 on Social Acceptance and Environmental Impacts**, the results of the survey conducted with local residents around the SkySails site in Klixbüll (Germany) has been published in 2023 [Schmidt, 16]. The work benefits from collaboration with the Horizon project JustWind4All.

Within the WP4 sub-group on Life Cycle Analysis, a number of LCA studies have been carried out, several publications are forthcoming. [Guillore, 10; Van Hagen, 21; more *studies forthcoming*]

**WP5 on AWES Architectures** has finalised the AWE classification within the design space, i.e. the different concepts of AWE systems, as well as the report on relevant Performance Assessment Criteria. Novel power coefficient were defined [Trevisi, 20]. WP5 works closely with University of Freiburg [Sommerfeld, 17; De Schutter, 6].

**Highlight(s) [250 words]**

* *Publication Snapshot (Highlight a new recommended practice of major publication) Make sure that this is not prohibited by copyright restrictions. Not all journals are open-access journals.*
* *Success Story (Describe key stakeholders’ adoptions of tools/recommendations, etc.)*
* *Cross-cutting Activities (Highlight activities between tasks, within IEA, or outside of IEA)*

The Task 48 continues to be an important platform which allows collaboration among experts and stakeholders and increasing knowledge on Airborne Wind Energy. The exchange with Task 41 (Distributed Wind), Task 50 (Hybrid Plants) and Task 28 (Social Acceptance) as well as other publicly funded projects (like MegaAWE, MERIDIONAL, JustWind4All, NEON, BORNE, etc.) is helping to create a global AWE community.

WP1 presents the open source tool chain AWERA (<https://github.com/awegroup/AWERA>) to compute the wind resource classification/representation and power harvesting estimation for AWES at specific sites or an entire area. In WP2, the open source tool chain MegAWES (<https://github.com/awegroup/MegAWES>) provides a model of a megawatt-class airborne wind energy system based on rigid wing technology.

The already available LCA case study results of rigid and soft wing AWE electricity show that environmental impacts are generally on a low level due to the low material use. Material intensity of AWE electricity lies between ca. 1-3 kg/MWh, compared to ca. 6-7 kg/MWh for a HAWT. Impacts on climate change are around or below 10 g CO2-eq/kWh.

AWE has potential to reduce energy system costs due to a high capacity factor, and that onshore AWE may in many locations be the preferred technology, even at higher cost. However, comparable spatial capacity density (MW/km2) needs to be proven.

The site assessment study for Germany revealed that there are several thousand suitable sites available with a potential of several dozen gigawatts.

For single offgrid hybrid systems, a significant reductions in the cost of electricity are possible by shifting from purely diesel-based electricity generation to an hybrid power system comprising AWE, solar PV, batteries and diesel.

**Outcomes and Significance [200 words]**

*Emphasize the benefits of the results and activities to participants. How will/are the results being used by industry or other key stakeholders? Where relevant, emphasize benefit to society as a whole.*

Benefits of the results include:

* The White Paper on AWE Airspace Integration has turned out to be the base document for all discussions around that topic. It thus helps to define new regulation for AWE systems.
* The first peer-review study on a survey on social acceptance for AWE represents cutting edge research on social acceptance for innovative renewable energy technologies such as AWE. In conjunction with Task 28 it provide solid evidence and expertise for future projects, showing also that this topic is taken serious by the AWE sector.
* The work on Prospective Life Cycle Assessment (pLCA) is a novel method which includes e.g. learning curves, scaling rates, changes in the supply chains and energy sector. Harmonised guidelines for such pLCA will ensure the creation of robust and comparable study results not only for AWE but also for other innovative technologies.
* As shown in the reference list, a large number of peer reviewed papers on AWE support its technological significance and impact.

**Next Steps [100 words]**

*Briefly comment on any planned activities to complete the approved work plan. As relevant, discuss conclusions or extensions of the work.*

WP1 will continue to interface with the Horizon Europe project [Meridional](https://meridional.eu/), expanding our understanding of using AWE systems for airborne wind energy harvesting. The country mapping will be updated and further information on entry markets will be developed with the Interreg North-West Europe project DEM-AWE.

WP2 will define the reference economic model and develop case studies. Of central importance for companies is a validated digital twin of their system, allowing them to accelerate the development.

In WP3 the various permitting procedures in different jurisdictions will be further investigated and joined conclusions and recommendations developed. The process to develop AWE standards within the IEC 61400 framework will be initiated.

In WP4 will continue to collaborate with the Horizon Europe project the Horizon Europe project [JustWind4All](https://justwind4all.eu/). A survey on AWE acceptance in county Mayo in Ireland is on the way and work on LCA and Prospective LCA will continue.

The next step of WP5 is to define and describe the various AWE archetypes in more detail.

**References**

*Include references used directly in the text of the chapter.*

* *DO NOT use automatic footnotes, formatting, or automatic numbering in MS Word. They become lost during the text translation process for layout; texts containing automatic numbering will be returned to the author for revision.*

*Place the numbered reference at the end of the sentence in brackets [1]. For example, “…The Ministry of Economic Affairs finalized the Connect 6,000 report in May 2023 [1]. “*

* *Use the following format for citation under the reference heading: [1] Author (year). Title of report or document. Download from (provide website link).*

[1] Airborne Wind Europe (2023), Safe Operation and Airspace Integration of Airborne Wind Energy Systems – White Paper of the AWE industry. Petrick, K., Houle, C. <https://airbornewindeurope.org/studies-papers/safe-operation-and-airspace-integration-of-airborne-wind-energy-systems/>

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[5] Coca-Tarrago (2023), Site Identification Analysis for AWE Devices. A case study in Germany. Deliverable Report. https://doi.org/10.5281/zenodo.10462306

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[15] Salma, V., Schmehl, R. (2003), Operation Approval for Commercial Airborne Wind Energy Systems. Energies 16(7), 3264. https://doi.org/10.3390/en16073264

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[17] Sommerfeld, M. D̈orenk̈amper, J. De Schutter, C. Crawford (2023), Impact of wind profiles on ground-generation airborne wind energy system performance. Wind Energy Science, 8(7), 1153–1178. https://doi.org/10.5194/wes-8-1153-2023

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**Author(s)**Include the full name and organizational affiliation of each author at the end of your chapter, e.g., [name] and [name], [organization], [country]  
  
**Photos & Graphics:**Use the GUIDELINES FOR PHOTOS, FIGURES, AND TABLES at the end of this document.

***Include two high-quality (large file) photos or graphic elements in your chapter:***

* One high-quality (large file) photo for the chapter opening
* Other photos, graphics, or tables corresponding to your chapter text.
* Include a caption describing each photo/graphic and include the **source** (Source: ) or **photo credit** (Photo credit: ). It is the chapter author’s responsibility to ensure that we have been granted permission to print the photos and other graphics in the Annual Report and to post them on the public website.

# TERMINOLOGY & DEFINITIONS

IEA Wind 2023 Annual Report

**Definitions:**

**Capacity**

The potential for generating power, measured in kilowatts or megawatts, of a power plant. Also the electric load, measured in watts or kilowatts, of a piece of electrical equipment.

**Capacity factor**

The annual capacity factor is the amount of energy a generating plant produces over the year divided by the amount of energy that would have been produced if the plant had been running at full capacity during that same time interval.

**Electric/electrical energy**

The flow of charged particles (electrons). Always in terms of hours.

**Electric/electrical** (adjective)

Of, relating to, or operated by electricity (synonymous with electrical; not the same as electricity).

**Electric power**

Measured in watts. Volts X amps = watts.

**Electricity (noun)**

The movement of electrons in a conductor from a negatively charged point to a positively charged point.

**Energy**

The capacity to do work; the use of power, measured in watt hours. Energy = power X time (watts in hours or seconds). Energy is the total amount of work done, measured in watt hours. Electricity is one form of energy, heat is another. (In physics terms, energy is converted from one form to another, not generated.)

**Generation**

The process of producing electric energy, or the amount of electric energy produced by transforming other forms of energy into electrical energy. Expressed in kilowatt-hours (kWh), megawatt-hours (MWh), gigawatt-hours (GWh) or terawatt-hours (TWh) as appropriate.

**Power**

Use the specific term *energy* or *capacity* whenever possible. Power is the rate of producing or consuming energy (power = energy / time) or how fast you can do the work. In the context of electricity, power is a general term usually means capacity (kW), but sometimes refers to energy (kWh), or both.

**Production**

Synonymous with generation

# GUIDELINES FOR PHOTOS, FIGURES AND TABLES

IEA Wind 2023 Annual Report

At least one ***high-quality (large file) photo is required*** for your chapter opening page. Submit at least one additional figure, graphic, or table following these guidelines. Send all files to [ieawind@dtu.dk](mailto:ieawind@dtu.dk) by April 26, 2024, and include task number on all files submitted.

**Photos**

* For every photo, please provide a description of the photo (e.g., location, turbine type, application).
* Include a **source** (Source: ) or **photo credits** (Photo credit: ) in the caption of the figure. Please be certain that we have permission to print the photos in the Annual Report and to post them on the public website.
* Choose photos with high resolution (300+ dpi) and no compression. *Large photo files (300 MB or larger) will print with the best resolution.*

**Image Quality**

* **Drawn Figures:** send as high-quality (large file) photo files along with the final text file.
* **Charts and graphs:** submit editable excel files so we can harmonize the style of the figures in the layout. If the excel file is not available – submit high-quality (large file) photo.
* **Tables:** place directly into the chapter text as MSWord tables (not photos or pdfs)

**Captions and Titles**

* Provide a **caption for figures** telling what they are and include the source or photo credit.
* Provide a **title for tables**. Refer to the printed version of your chapter in last year’s report for examples.

**Figure and Table Numbering**

* **Figures**: number all figures (Figure 1. through Figure n.). The opening photo is not numbered. Figures include graphs, drawings, and photos.
* **Tables**: number all tables (Table 1. through Table n.).
* Figure and table numbers MUST be mentioned in the text as well. Example: “The costs are increasing for small projects (Table 2).” This helps us know where to place the figures and tables in the layout.
* *DO NOT use automatic numbering in MS Word. They become lost during the text translation process for layout; texts containing automatic numbering will be returned to the author for revision.*

# CURRENCY CONVERSION RATES

IEA Wind 2023 Annual Report

For figures, tables, and written portions of your chapter, please use these conversion rates. Our standard is to use rates effective on December 31, 2023. This table will be used in Appendix C of the 2023 Annual Report**.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Currency Conversion Rates for the IEA Wind TCP 2023 Annual Report** | | | |
| **Country** | **Currency** | **EUR** | **USD** |
| Austria | EUR | 1 | 1.073 |
| Belgium | EUR | 1 | 1.073 |
| Canada | CAD | 0.688 | 0.739 |
| China | CNY | 0.135 | 0.145 |
| Denmark | DKK | 0.134 | 0.144 |
| Finland | EUR | 1 | 1.073 |
| France | EUR | 1 | 1.073 |
| Germany | EUR | 1 | 1.073 |
| Greece | EUR | 1 | 1.073 |
| India | INR | 0.011 | 0.012 |
| Ireland | EUR | 1 | 1.073 |
| Italy | EUR | 1 | 1.073 |
| Japan | JPY | 0.007 | 0.008 |
| Korea | KRW | 0.0007 | 0.0008 |
| Netherlands | EUR | 1 | 1.073 |
| Norway | NOK | 0.095 | 0.102 |
| Portugal | EUR | 1 | 1.073 |
| Spain | EUR | 1 | 1.073 |
| Sweden | SEK | 0.089 | 0.096 |
| Switzerland | CHF | 1.008 | 1.082 |
| United Kingdom | GBP | 1.128 | 1.210 |
| United States | USD | 0.932 | 1 |
| **Source: Federal Reserve Bank of New York (x-rates.com) 31-Dec-2023** | | | |