DISCUSSION PAPER – LIFECYCLE ASSESSMENTS IN WIND ENERGY AUCTIONS

EXECUTIVE SUMMARY

Lifecycle assessments (LCAs) are an effective tool to demonstrate that wind energy is environmentally sustainable. In comparative LCA research wind energy is always one of the most sustainable energy technologies (IPCC 2014; UNECE 2022).

This explains why the European Union's Green Deal sees wind energy becoming the core of a home-grown, resilient, and climate neutral energy system by 2050. In 2022 the EU had 204 GW of installed wind power capacity, providing 17% of total electricity demand and preventing 138 tonnes of CO_2 emissions (ETIPWind 2023). By 2050 the EU will need 1,300 GW providing for 50% of its increased electricity demand.

Wind energy deployment is mostly driven by Government-run auctions. These auctions can now include non-price criteria to evaluate the bids and award Government support. Policymakers are now exploring whether they could use LCAs, and related metrics such as carbon footprints, to evaluate and rank bids in renewable energy auctions.

This discussion paper outlines what LCAs are and why they are not (yet) suitable evaluation criteria for both onshore and offshore wind auctions. This is due to the principles such criteria should adhere to, as well as practical concerns for how auctions are run.

The following challenges will be treated in more details:

- LCAs remain at best a simulation of expected impacts.
- LCAs are sensitive to the assumptions and data used.
- LCAs are a time-bound exercise and time is limited by auction design.
- LCAs standards and methodologies are too flexible for true comparison.

The wind industry will help develop a common methodology through initiatives such as the Carbon Trust' Sustainability Joint Industry Programme and the IEA wind energy Technology Collaboration Platform to further standardise wind energy LCAs. This could lead to the use of LCAs as an evaluative award criteria in wind auctions in the medium-to-long term.

Notwithstanding these challenges, LCAs are still very useful as a way to communicate the environmental impacts and benefits of wind energy. Governments may therefore request that LCAs be performed and made public as part of prequalification criteria in wind energy auctions.

WHAT ARE LIFECYCLE ASSESSMENTS (LCAs)?

A Lifecyle Assessment or LCA is a method to assess the environmental impacts of a product or activity throughout its lifetime. LCAs are typically conducted upfront (*ex ante*) or during the assessed product's first years of commercialisation. It is a highly specialised activity that requires large-scale data collection, processing, and interpretation.

There are several internationally recognised standards to guide the LCA process. ISO 14040 describes the overall principles and framework. ISO 14044 provides specific requirements and guidelines. According to these ISO standards there are at least four steps to generate a robust and meaningful LCA. These are explained in more detail in Annex I.

Companies can also submit their LCAs to a certification process. These generate environmental declarations based on more prescriptive LCA guidelines known as Product Category Rules. The most well-known are Environmental Footprint Declarations (or EPDs) and the Product and Organisation Environmental Footprint (PEF/OEF). EPDs are compliant with ISO standard 14025. The verification of PEF/OEFs is addressed by European Commission guidelines[1].

Conducting an LCA provides companies with a clearer and more in-depth picture of the expected environmental impact of their products, services, and activities. This allows them to take targeted measures to address any adverse impact. At the same time, the LCA also provides them with easy-to-understand metrics and concepts, such as carbon footprint, to clarify that environmental footprints to clients and consumers alike.

However, it is important to stress that all LCAs are a simulation of expected impacts. They are not a calculation of actual impacts. This means that LCAs are always indicative and incomplete. The outcome is also dependent on the pre-determined set of conditions (or methodology) and the input material. This indicative nature and methodological dependency are key barriers to the use of LCAs as part of an evaluative criteria in a renewable energy auction.

Box 1: Terminology

Lifecycle assessment (LCA): This is a method to assess upfront the expected environmental impact of a product, service, or activity. LCAs can be used to get additional certifications for the assessed products, services, and activities.

Environmental Product Declaration (EPD): This declaration uses LCA methodologies and principles specified in specific Product Category Rules to better assess and evaluate the LCA results of products performing the same (or similar) function. To get a certified EPD, the underlying LCA must also comply with ISO standards.

Product and Organisation Environmental Footprint (PEF/OEF): This a methodology developed by the European Commission's Joint Research Centre to communicate the potential environmental impacts of products (and organisations) to EU consumers. The LCA requirements to get a certified PEF build on the relevant ISO standards, but they are more prescriptive in comparison.

[1] Commission recommendation of 16.12.2021 on the use of the Environmental Footprint methods to measure and communicate the lifecycle environmental performance of products and organisations (LINK).

THE WIND INDUSTRY'S EXPERIENCE WITH LCAs

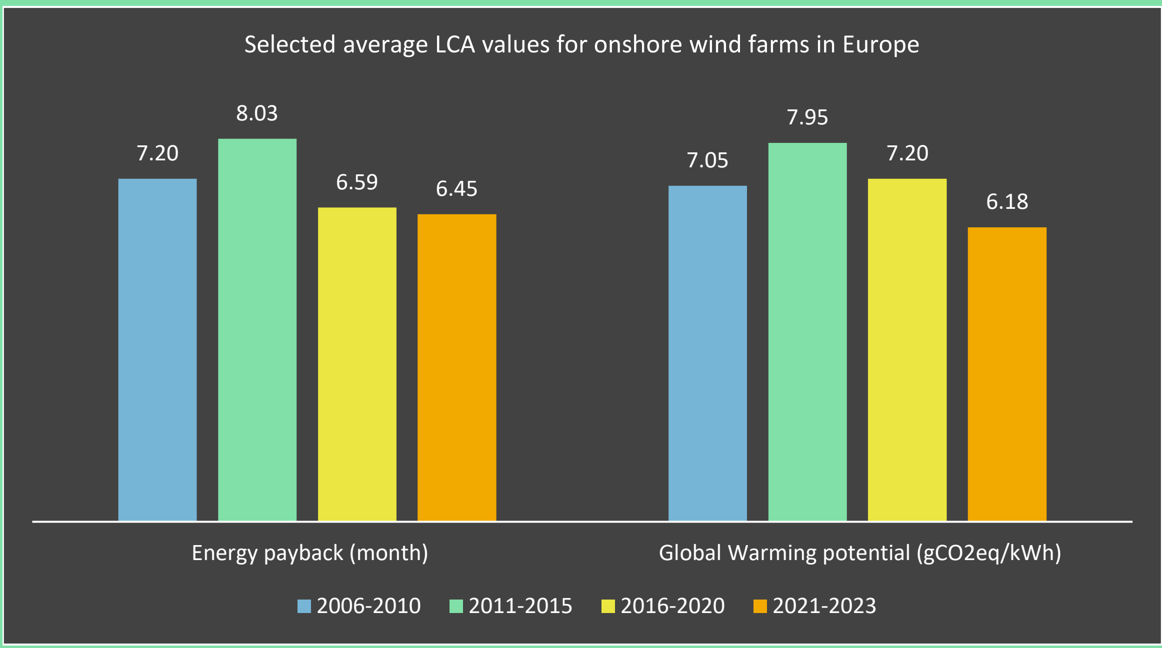
The wind industry has made use of LCAs and related products such as EPDs for many years. A survey conducted by WindEurope showed the primary use of LCAs is to engage and educate internal stakeholders on the environmental footprint of the company's products or services. But increasingly LCAs help to inform external stakeholders (potential clients, national authorities, and NGOs).

The very first wind energy LCAs published were academic studies. But as of 2005, the wind turbine manufacturers have delivered most of the more than 60 publicly available LCAs of wind energy. As LCAs are still primarily used for internal stakeholders, we can expect that many more LCAs have been conducted but have not been made public. Almost all public LCAs have been conducted for onshore wind farms. There may be two reasons for this. First, the onshore wind sector is more mature and better established. Second, onshore wind farms are less complex and can be more easily assessed in an LCA.

In any case the long history of wind energy LCAs can also offer insights into some macro-trends in the overall sustainability of the wind industry. In 2014 the IPCC estimated the global carbon footprint of wind energy to be between 7 and 56 g CO_2eq/kWh, with the higher range for wind turbines of 100 kW or less.[i] In 2022 UNECE estimated it between 12.4 and 14.2 g CO_2eq/kWh for Europe.[ii] LCAs by the European wind industry itself provide even lower numbers. See box 2 for more.

Box 2: Decreasing environmental impacts of wind energy LCAs

We can discover some large and positive trends emerging from the historic LCA records. Since 2011 the average energy payback time and carbon footprint for onshore wind farms in Europe as calculated in the various LCAs and EPDs have been steadily reducing. The average carbon footprint assessed since 2011 is almost 25% lower and the average energy payback time is 20% less. Whilst similar trends are visible in the other impact categories, we must be mindful that the underlying methodologies for calculating those impacts have undergone significant changes that make comparisons less reliable.



NON-PRICE CRITERIA IN RENEWABLE ENERGY AUCTIONS

In view of increasing public and political demand to demonstrate green credentials, several Governments and national authorities are implementing sustainability-related criteria when providing support to wind energy and/or other renewable energy sources.

The allocation of such support is determined by State-run auctions. This is a requirement under the EU Renewable Energy Directive (Article 4) and the EU State Aid policy. It had been long-standing practice under EU and national regulation that auction winners are selected solely on the basis of the price they offer for procuring electricity – the so-called 'price-only', rule where the cheapest bid wins.

But as wind is now the cheapest form of newly installed energy capacity in most of Europe, the relative cost differences between wind projects have become less relevant. Since 2022 new EU State Aid rules therefore also allow Member States to evaluate bids in an auction with non-price criteria for up to 30% of the total score. And the Net-Zero Industry Act tabled in 2023 could even make a non-price criteria weight of at least 30% and up to 50% mandatory.

Non-price criteria are a tool to reward and incentivise the positive benefits that wind energy projects can bring on top of the low-cost electricity they produce. These positive benefits manifest themselves in the environmental (pollution free), socio-economic (job creation), and political (energy independence) spheres.

In 2024 the European Commission will give guidance on non-price criteria. But Member States reserve the right to choose which criteria they wish to apply in their auctions. And some are considering whether to include criteria related to LCAs or LCA-based metrics such as carbon footprint.

ARE LCAs SUITABLE NON-PRICE CRITERIA IN PRINCIPLE ?

WindEurope recommends that sustainability and other non-price criteria used to evaluate bids should be objective, easy to assess, and comparable. [iii] In the following section we will first see whether LCAs meet these three core principles.

Principle 1 – objectivity

Proper application of the relevant ISO standards or Product Category Rules for EPDs will ensure that LCAs can deliver outcomes that are consistent each time the LCA is carried out. This replicability and consistency of the results within a given framework gives LCAs an aura of objectivity.

However, anyone conducting an LCA enjoys a high level of agency. The standards are broadly defined and there are only minimum requirements for underlying data. Both make it so that the LCA results are highly dependent on the assumptions and data selected.

These underlying assumptions are allowed to vary greatly. And lead to significantly different results. See Box 3 for more detail. In this regard LCA results are not consistent and therefore not objective.

Principle 2 – ease of assessment

As mentioned, LCAs are a way to compile detailed and complex assumptions on environmental impact into singular, clear, and easy-to-understand metrics such as carbon footprint or eutrophication potential. As such the assessment of different LCAs should be relatively easy. We expect those products or services with lower environmental footprint values to be better than those with higher values.

But those environmental values are the end results of complex processes with a lot of assumptions and intricate methodologies. And the choices made have a lot of impact on the result. This means LCAs are in practice not easy to assess. To properly understand the end results (i.e. the environmental footprint values) one must understand and assess the many methodological choices that have been made and assumptions that have been used in the LCA process, as well as their impact on the end result.

Principle 3 – comparability

This requirement is the most important in terms of the potential application of LCAs or LCA-based metrics in auction criteria. From the first two requirements we can already deduce that LCAs are not very comparable. This because the outcomes of an LCA are highly dependent on the selection of conditions and input material. We can identify three main challenges to LCA comparability.

First, the existing standards and methodology guidelines allow for a lot of flexibility, or level of agency, in the LCA process. LCAs with a different scope and different system boundaries will have different end results. We can distinguish the effect of methodological choices on the scope and boundaries on the one hand, and the effect of key assumptions on for instance lifetime and electricity production on the other. See the examples in box 3 and box 4.

Box 3: The effect of boundaries on LCA results

For wind farms the most relevant choice in system boundaries (see Annex I) is whether to include the 'benefits and loads from beyond the system boundary'. This mainly concerns whether or not (and if so how) to allocate the benefits from sustainable waste management routes such as recycling or reuse of decommissioned wind turbines.

Including these benefits can help reduce the LCA carbon footprint measured in gCO_2eq/kWh of a wind farm with 20% to 33%. In addition, the benefits can be assessed as 'impacts avoided' or as 'recycled content'.

Second, LCAs rely heavily on secondary data as primary data – that is data directly provided by suppliers – is scarcely available. An industry survey shows wind energy companies typically rely between 50% and 75% on secondary data for their LCAs. This means that the secondary data used, most often compiled in specialised databases, has a big impact on the final results. And there are significant differences between, and sometimes even within, secondary data sources. See box 5 for more.

Third, the capacity to perform high quality assessments of environmental impacts is unevenly distributed across the wind energy supply chain. While some companies have a lot of experience with conducting LCAs and EPDs, many others are only starting out. In addition, many companies in the supply chain – often SMEs – lack the capacity to perform detailed assessments. As LCA methodologies prescribe the use of primary data where possible, a supplier's (in)ability to collect and provide high-quality data has a big effect on the final outcomes.

Box 4: The effect of lifetime assumptions on LCA results

For wind farms the most impactful performance metrics are the lifetime and the capacity factor of the wind turbines assessed. Adding just 5 years to the expected lifetime reduces the carbon footprint of the wind farm between 15% and 25%. Adding 10 years gives a reduction between 25% and 33%.

Most LCAs use an expected lifetime of 20 years. However, market data shows that half the operational wind energy capacity from 2003 is still operational today (14 GW out of 28 GW). This means that the real operational lifetime of wind turbines is much closer to at least 25 if not 30 or 35 years.

Box 5: The effect of secondary databases on LCA results

A comparative analysis of LCAs of several packaging systems using only secondary data from the GaBi and EcoInvent databases showed significant differences in the end results. Typically, the impacts calculated using GaBi data were lower than those using Ecoinvent. The authors suggest this could be due to Ecoinvent having wider system boundaries, but call for a more in-depth analysis before making any strong claims. (Source: Pauer, E et al., 2020).

In addition, the DACOMAT project found that one kg of glass fibre assembled roving has a carbon footprint of 2.16 kgCO2eq / kg in one database and 1.86 kgCO2eq / kg in another database. Sometimes even within the same database the values for the same product could differ. This is true for glass fibre mats in the Ecoinvent dataset with values of either 1.3 or 2.6 kgCO2eq / kg. (Source: Dacomat, D6.1)

CAN LCAs BE IMPLEMENTED AS EVALUATIVE CRITERIA IN AUCTIONS ?

In addition to the core principles that LCAs should but do not adhere, there are additional challenges related to the implementation of LCAs in auctions. First, an LCA is a time-bound process meaning the capacity of conducting meaningful LCAs is different depending on the phase within the auction process. Second, the comparative benefits of one wind project versus another are relatively small compared to the benefits of wind energy compared to other technologies. And last, not all wind auctions are structured the same way.

Challenge 1 – timing

First, early in the auction process applicants rarely have a lot of information available on the actual components and services they will actually use to build, develop, and operate the wind farm. Rather they rely on market intelligence and confidential information from potential suppliers to estimate which components they feel would be best for the project.

This information can be based on known commercially available products, but often it is not. For example the winning bid of the 2023 Centre Manche auction in France made assumptions that 24 MW wind turbines would be available by 2028.[iv] Those turbines are not yet commercially available.

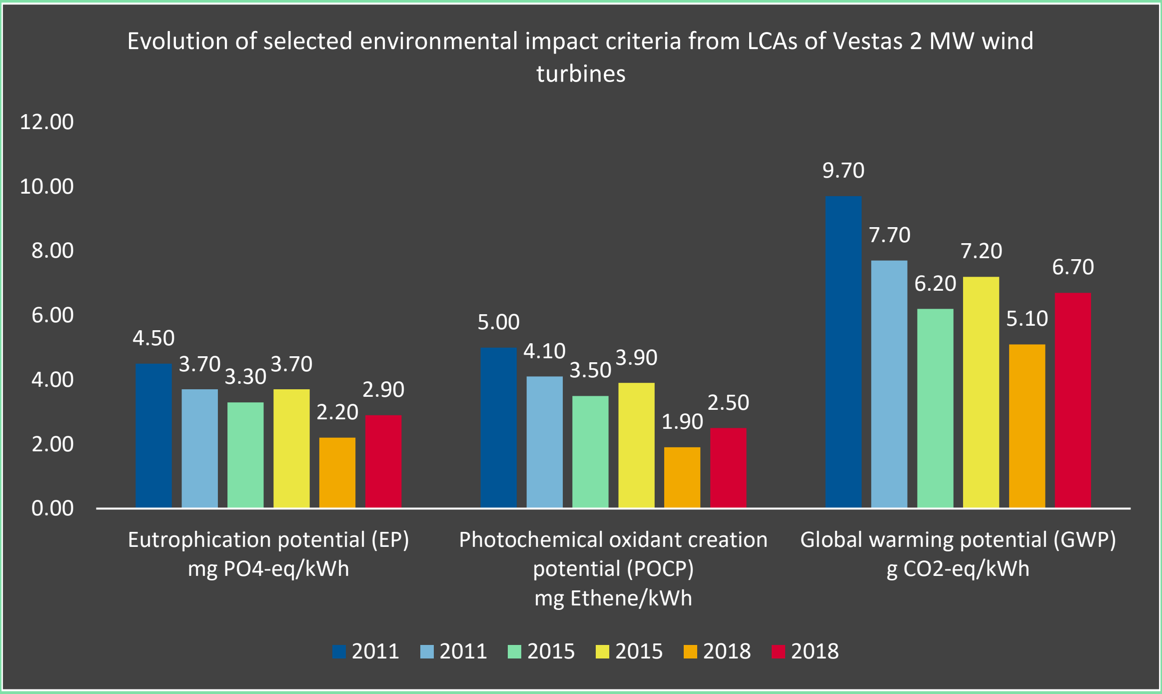
The lack of critical information and primary data renders most LCAs delivered early on in the auction redundant. We have seen that LCAs are over-reliant on assumptions and secondary data and that they are highly sensitive to assumptions on performance and lifetime. This could incentivise applicants to be more optimistic in their early-stage assumptions and skew the results in their favour.

Box 6: LCA comparison of the same turbine platform (Vestas 2.0 MW)

In addition to the above, we must recognise that LCAs are also a time-bound exercise. This means that the underlying data, methodology, and at times even the impact criteria themselves may significantly change over time. For this reason EPDs typically come with an 'valid until' date.

These underlying changes are significant as it decreases the comparability of LCAs of the same product over time. Should a Government request an *ex ante* LCA from a wind farm during the auction phase and one after a couple of years of operation, the two results may differ greatly (for better or for worse) just because of the changes in the underlying assumptions.

We can see this for example in a comparison of the various iterations of the LCA of the Vestas 2.0 MW wind turbine. Here we can see that depending on the selected wind class and expected operational performance, the environmental impacts of the assessed models have different values.



<u>Challenge 2 – relative and absolute benefits</u>

Second, we must keep in mind that wind energy is consistently ranked as one of the energy technologies with the lowest carbon footprint. Just like how the average cost of wind energy production is lower than that of most other generation technologies in Europe, so too is the average environmental impact.

One can see one project with an estimated carbon footprint of 9.0 gCO2eq/kWh and another with one of 9.2 gCO2eq/kWh. Intuitively the first would be better than the second. But selecting one over the other based on their relative environmental footprints may be less relevant to society. Both are multiple times better than the expected carbon footprint of other electricity generation technologies, both from conventional and even renewable energy sources.

Challenge 3 – auction processes

Third, not all auctions assess the same thing. Some auctions are technology neutral and can see bids from very different technologies, each with their specific environmental impact profile. Assessing, comparing, and weighting those impacts would be an extremely challenging task.

But also in technology-specific auctions dedicated exclusively to wind energy, there are big differences. Offshore wind auctions are typically site-specific and compare the various bids for one pre-defined location. Onshore wind auctions are more open-ended and see a large number of smaller wind energy projects at various locations applying for support.

Applying LCA-based non-price criteria in onshore auctions would be very difficult. It would mean comparing the environmental impact of projects in locations with very different environmental, social, and economic parameters. This could lead to certain onshore locations being systematically disadvantaged for wind energy development.

In offshore wind auctions, sites are often pre-defined and the comparability of the LCAs received should be slightly higher, due to the expected wind conditions, distance to shore and water depth being the same for all bids. But even so the challenges discussed above still make it difficult to use LCAs as an evaluative criterion in offshore wind auctions.

THE POSSIBLE ROLE OF LCAs IN OFFSHORE RENEWABLE ENERGY AUCTIONS

The requirements and challenges highlighted above do not negate the value of LCAs. But they signal that LCAs may not be suited to assess and evaluate the various wind energy projects within a competitive bidding process.

However, some countries (France, the Netherlands and Norway) have recently included LCA-related criteria in their offshore wind tender requirements. Each Government has formulated the requirements very differently with regard to methodology and how the metric is defined. And none of the criteria properly addresses or solves the issues highlighted above. As of the end of 2023, no auction with an LCA-based metric has been successfully carried out. See Annex III for details.

This scattered approach to LCAs is not helpful and puts an unnecessary burden on companies in the supply chain to collect, analyse, and conduct their LCAs in different ways. Governments and industry should work together to develop a harmonised and detailed methodology for wind energy LCAs.

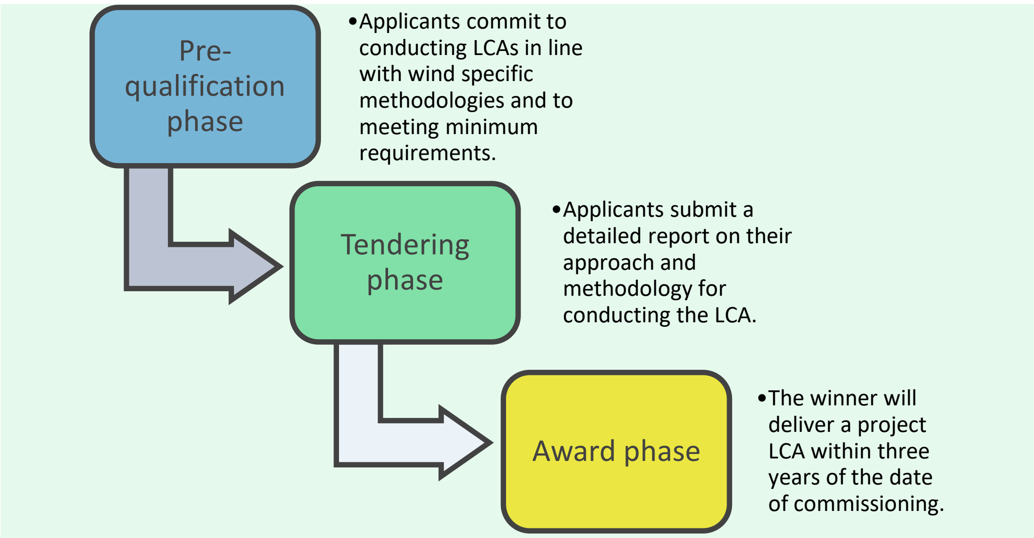
But there still may be a place for LCAs in an offshore wind auction. It’s all about setting the right expectations for the LCA. If done properly, these auctions could be a driver in developing a common methodology for LCAs.

WindEurope calls on Governments that want to use LCAs as part of their non-price criteria in auctions to take the following staged and qualitative approach.

a) **Pre-qualification phase**: Governments should insist that applicants commit to conducting an LCA of the project and that they would be willing to make the results publicly available. To safeguard low environmental impacts, Governments can call for commitments to meet certain minimum requirements (e.g., a project LCA carbon footprint equal to or lower than the those calculated by the UN)[v] or to follow industry-specific methodologies that the industry is preparing together with the Carbon Trust and the IEA TCP wind. Applicants that don't commit should either receive a negative grading or should be prevented from participating in the next phase.

b) **Tendering phase**: Governments should call on applicants to submit a detailed plan on how they will approach the LCA of their project. Applicants should be rewarded on the thoroughness and quality of the plan (e.g., approach to collect primary data) rather than on the actual results of the future LCA. Especially as minimum requirements have already set in the previous phase.

c) **Award phase**: Governments should insist that the winning applicant provide a full LCA of the project in the first three years following the date of commissioning. The report should also include a comparative analysis between the project LCA and the minimum requirements set and agreed upon in the pre-qualification phase. Governments should apply safeguard measures to ensure the LCA is made publicly available. And that specific data remains available for future operator of the wind farms in case of a change of ownership.

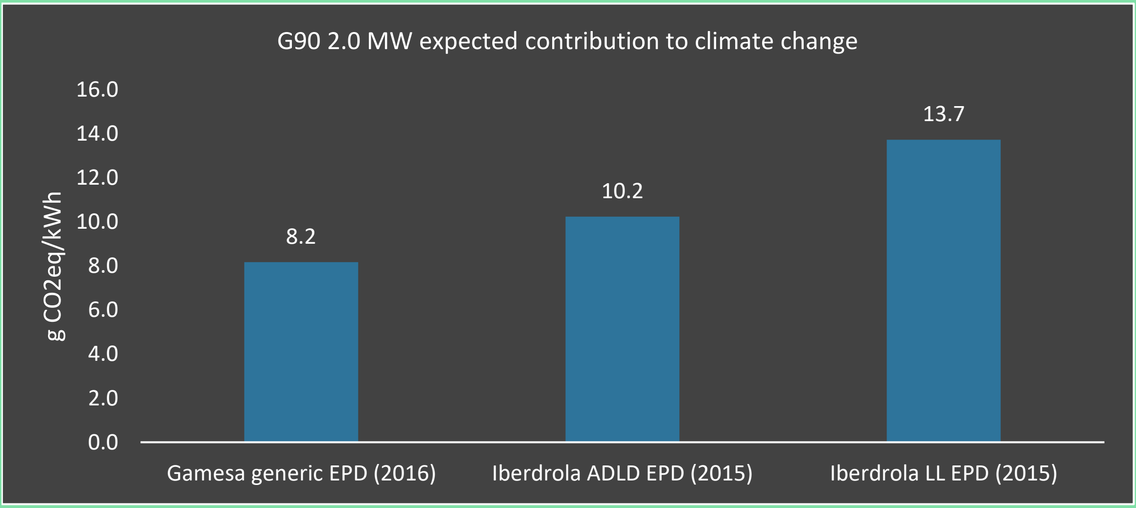


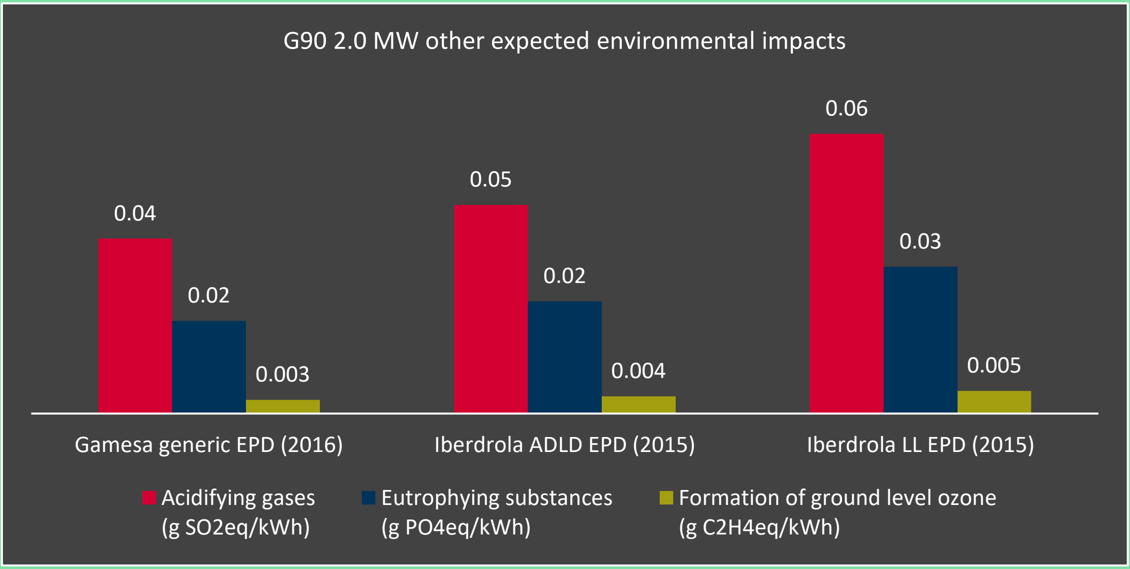
Box 7: Comparison of the EPDs of the same turbine (Gamesa G90 2.0 MW)

To demonstrate the effect of underlying assumptions and the data put into an LCA model, we can look at the three publicly available EPDs for the Gamesa G90 2.0 MW wind turbine. The first two were delivered by Iberdrola in 2015 for two of their wind farms built in 2010: Alto de la Degollada (ADLD) and Los Lirios (LL). In 2016, Gamesa developed an EPD to extrapolate the results of such site-specific EPDs to an 'average European wind farm' built with G90 2.0MW wind turbines.

We can compare the EPDs because the 'generic' EPD by Gamesa relied heavily on the two Iberdrola EPDs. The ADLD and LL wind farms were two of the four reference wind farms for the Gamesa EPD. And because most of the underlying assumptions were very similar. The main differences are the more optimistic assumptions on turbine performance in the Gamesa EPD. See the selected assumptions in Annex II.

This should not come as a surprise as manufacturers have a natural interest in presenting their product as being highly performant. But kWh produced is the functional unit of the LCAs. So the more kWh is expected to be generated, the lower the expected environmental impacts will be. This means the outcomes of the Gamesa EPD are significantly lower compared to those from the Iberdrola EPDs. The expected carbon footprint of 1 kWh produced by the turbine for instance is between 20% and 40% lower.





INDUSTRY COMMITMENTS TO IMPROVE LCAs

The wind industry firmly commits to conducting LCAs to better identify environmental impacts, to make improvements, and to communicate clearly on the overall footprint of wind energy. In spite of the challenges highlighted in using LCAs as a comparative evaluation criterion in auctions, they are still a great tool in demonstrating wind energy's green and sustainable credentials.

As such, the wind industry has an invested interest in building up the sector's capacity to conduct and deliver high-quality LCAs in the short term. In the long term this may also increase the overall comparability of LCAs outcomes. To this end, the wind industry commits to:

1. **Promote correct use of LCAs**. LCAs have strengths and limitations and their use should be tailored to these. We want industry, academia, and national authorities across Europe to develop a common use case for LCAs based on a common understanding of what LCAs can and cannot do.
2. **Build up capacity to improve LCA capabilities within the value chain**. We want to enable industry and other stakeholders to better perform LCAs and to ensure there is a stable pool of talent skilled in conducting and assessing LCAs. The wind industry will engage in industry-academia partnerships and develop a common public repository for wind energy LCAs.
3. **Improve LCA data quality and collection across the value chain**. LCAs are dependent on the quality of the underlying data. Access to and quality assurance of LCA data is not always easy. We want to ease data collection practices and improve overall quality of LCAs. Quality is defined as being more or less representative of actual occurring impacts. To this end the industry could develop common 'requests of information' requirements to suppliers.
4. **Develop a common LCA methodology**. To increase comparability of LCAs and their eventual use in non-price criteria in auctions, the industry will need a common methodology to assess environmental impacts across the lifecycle. To develop such a methodology, industry will work with the Carbon Trust Joint Industry Programme on Sustainability and support the creation of a dedicated task under the IEA Wind Technology Collaboration Platform.

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[i] IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[ii] UNECE, 2022: Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources
[iii] WindEurope, 2022: WindEurope position on non-price criteria in auctions (link)
[iv] La presse de la Manche, 2023 (link)
[v] UNECE, 2022: Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources

Annex I – Four steps to conduct an LCA

1) Defining the goal and scope.

The first step is to define the system boundaries of the assessment. The most critical decisions are to define the functional unit and which stages of the product lifecycle will be assessed. These stages start from the production stage to the end-of-life stage.

LCAs can therefore be 'cradle-to-gate' (from material extraction to manufacturing), 'cradle-to-grave' (from material extraction to end-of-life), and 'cradle-to-cradle' (from material extraction to end-of-life and back).

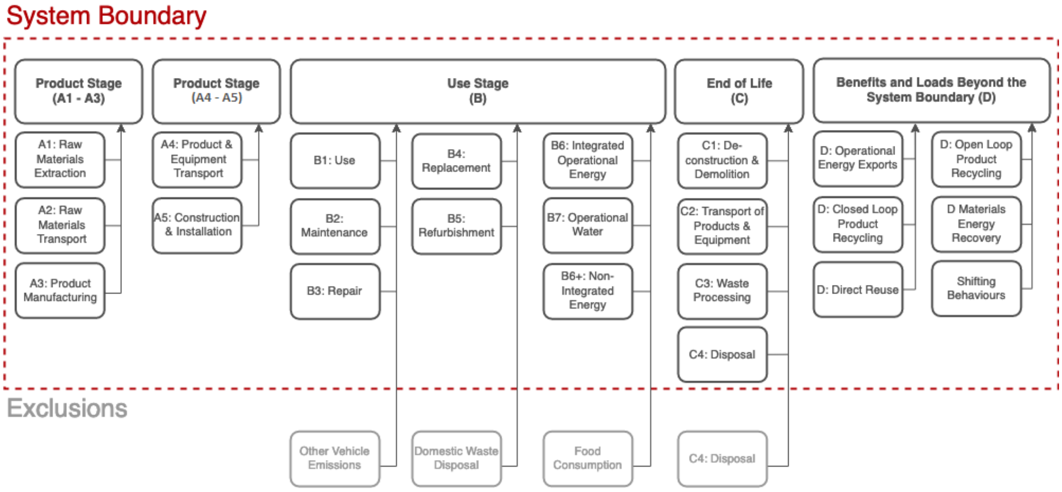

Figure 1 LCA system boundaries (© eTool LCD)

2) Creating a lifecycle inventory

The second step is all about data collection. This means firstly to identify all the relevant inputs and outputs related to the functional unit and within the scope defined in step one. And secondly to collect and quantify all relevant data on the environmental impacts of those steps.

Lifecycle inventories can have tens of thousands of data entries. Data can relate to the foreground (e.g., impacts from a specific manufacturing process) or to the background (e.g., the impacts of a raw material extracted or of energy procured).

The data can be owned by the company directly, gathered bilaterally from suppliers, obtained from public resources, or procured from specialised LCA databases. For most LCAs, companies collect and combine data from all these sources.

3) Calculating the expected impacts

The third step is to calculate the overall environmental impacts. The calculation process itself also contains several steps. Classification and characterisation are mandated by ISO standards. Normalisation and weighting are additionally required by PEF/OEF, but remain optional under ISO standards.

Classification is to allocate the large number of data results into several ‘environmental impact categories’. These categories keep the overall assessment manageable and understandable. Known categories include, for instance, climate change impact, contribution to acidification, contribution to eutrophication, and water use.

Characterisation is to express the classified data in a common denominator. For instance, all impacts under climate change are expressed in units of CO_2eq.

4) Interpretation of the results

The last step of an LCA is to take a critical look at the results, understand what they mean, and explain how they were obtained. This step includes identifying issues faced in the previous steps, defining solutions to overcome these issues, and performing quality checks through sensitivity analyses.

Annex II – case study assumptions

Selected assumptions behind the LCA case studies included in box 6.

	V80 (2011)	V90 (2011)	V100 (2015)	V110 (2015)	V116 (2018)	V120 (2018)
Rated capacity (MW)	2.0	2.0	2.0	2.0	2.0	2.0
Wind class	IEC I	IEC III	IEC II	IEC III	IEC I	IEC S
Wind speed (m/s)	9.25	7.00	8.00	7.00	8.50	7.20
Rotor size (m)	80	90	100	110	116	120
Hub height (m)	80	80	100	110	116	120
Capacity Factor (%)	47%	36%	48%	43%	56%	50%
Lifetime (years)	20	20	20	20	20	20
Annual generation (MWh)		6257	8401	7567	9755	8787

Selected assumptions behind the LCA case studies included in box 7.

	Gamesa generic EPD (2016)	Iberdrola ADLD EPD (2015)	Iberdrola LL EPD (2015)
Model	G90 2.0 MW	G90 2.0 MW	G90 2.0 MW
Wind farm capacity (MW)	28.5	50	48
Annual generation (MWh)	8,119	4,219	3,471
Lifetime (years)	20 years	25 years	25 Years
Hub height (m)	78 m	78 m	78 m
Grid connection (kV)	132 kV	132 kV	66 kV
Grid losses (%)	2.2%	2.02%	2.65%
Recycling of materials	Yes	Yes	Yes
Database	Ecoinvent 2.2	Ecoinvent 2.2	Ecoinvent 2.2

Annex III – LCA-based non-price criteria in offshore wind auctions

	France	Netherlands	Norway
Technology	Floating	Bottom-fixed	Bottom-fixed and floating
Measure	Carbon footprint	Carbon footprint	Carbon footprint
Stage	Tendering phase	Tendering phase	Pre-qualification
Request	Carbon footprint of installation and operations and maintenance (O&M)	Provide within one year after licencing the carbon footprint of: - Manufacturing of main wind turbine components - Construction phase - Operation phase (incl. maintenance) - Decommissioning and recycling	- Minimise carbon footprint - Deliver carbon footprint report and climate action plan
Evaluation measure	Quantitative (minimum requirement) - Carbon footprint of installation should be less than 2 tCO2eq/kW - Carbon footprint of O&M should be less than 8,000 tCO2eq over a five-year period	Qualitative - Applicant provides or does not provide the requested carbon footprints	Qualitative - Proposed measures in climate plan - Description of past experiences in executing such measures
Rating	Minimum requirement	2 out of 200 (1%)	2.5% (1/4 of 10%)
Methodology	Either at least ISO 14044:2006 (or later) or using a dedicated French method based on	Greenhouse Gas Protocol or similar standards (e.g., based on ISO standards 14040 and 14044).	ISO standards 14040 and 14044 and mandatory use of Ecoinvent 3 database

	ISO 14064-1:2018 AND mandatory third party verification in line with ISO standard 14064 at least six months prior to the date of commissioning		
Links	AO5 (FR)	Ijmuiden Ver Alpha (NL) Ijmuiden Ver Beta (NL)	Sorlige Nordsjo II (EN) Utsira Nord (EN)