

Third party critical review of phase 1 of LCA on treatment of wood waste in the Nordics

Miljødirektoratet on behalf of Nordic Council of Ministers

Date: 14 January 2022

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1 Introduction

The Nordic Working Group for Circular Economy (NCE) under the Nordic Council of Ministers, with the Norwegian Environment Agency (Miljødirektoratet) as the administrative body, has funded a project consisting of a comparative Life Cycle Assessment (LCA) of treatment of wood waste in the Nordics. The aim of the project is to gain more knowledge about the environmental impact of different treatment scenarios of the wood waste. Incineration is currently the most common treatment option of wood waste, however the potential for increased reuse and recycling can be substantial. NCE has therefore engaged Gaia Consulting Ltd in cooperation with Sweco to conduct the LCA.

The LCA is performed in two phases. Phase 1 consists of the goal and scope definition, including a description of considered life cycle phases, wood waste types and treatment methods, as well as marginal energy and environmental categories to include in the LCA. Phase 2 consists of the execution of the full LCA. To make sure that the scope and boundaries of the LCA are good and trustworthy, NCE has hired NIRAS to perform a third party critical review of the Phase 1 report.

The review team is composed of four LCA experts; Alexandra Katkjær, Jesper Jakobsen, Yana Ramsheva and Julie Gade Gørbitz, and one expert in waste treatment, Håkon Jentoft. The review team has directly commented on the Phase 1 report (the commented report is part of the review deliverables), and the most important points are summarized in the following note.

2 Comments to the report

2.1 Section 1.1 to 1.3: Wood products and climate change mitigation, Study objectives and Wood waste in the Nordics

It is NIRAS' evaluation that sections 1.1 to 1.3 to a certain degree provide context of the study, discussing why wood is under focus today and looking at different treatment options for wood waste in the Nordics. Nevertheless, the relevance and coherency of the introduction as a background for the LCA study should be increased. The next paragraphs will discuss this topic in more detail, giving concrete suggestions for improvements.

First, it is suggested that **Section 1.1** focuses even more on wood *waste* and treatment options, for example by pointing at previous research in the field, describing characteristics of different treatment methods, explaining differences between the Nordic countries, and explaining how wood waste can contribute to solving climate change mitigation challenges. Section 1.1 also needs to clearly define what is meant by "wood as a resource". In some cases it is referred to raw wood materials or wooden products, and in other cases to wood as *waste*.

Section 1.2 explains the study objectives. Here, NIRAS proposes to include details also on the scope of the study in order to give a clear delimitation of the study. For example, it is unclear which kind of wood waste the study focuses on. Even though the project description states that non-hazardous waste is the focus of the study, there is a chance that the reader might not have read the project description. Thus, Section 1.2 should clearly state the focus of the study. It should also be explained which sources of the wood waste are considered - waste from industry, construction or households and whether garden waste is included. The geographical scope should also be explained this early in the report (see comments to Section 2.2.2 in this note's Section 2.4.2). Additionally, NIRAS suggests that the contents of the rest of the report is shortly explained at the beginning of Chapter 1 in order to prepare the reader. Furthermore, a comment is made regarding Figure 1 in section 1.2 – a visual description of the LCA process with the steps as described in ISO 14040/14044. Section 1.3 presents a desktop study conducted as part of the project, while Section 1.4 introduces a "screening". Figure 1 neither mentions a desktop study, nor a screening process. Thus, it is confusing to the reader what methods are applied in the study. In order to avoid such confusion, a figure illustrating the study process, and not only the LCA process, may be added.

Lastly, to make Section 1.2 more specific with respect to study objectives, it is suggested to move Figure 1 to a separate section (for example a new chapter) titled "Methodology" and to move the text below the figure (information on the working group contributors), to another (existing or new) section, preferably earlier in the report.

Section 1.3 consists of descriptions of waste statistics for the Nordic countries. It is NIRAS' view that this information must be reviewed and revised based on relevance. The data given in this section is taken from Eurostat and national statistical databases, but misses points and conclusions that can be deducted from the presented data. In general, it is NIRAS' opinion that it is necessary to provide more in-depth descriptions of the learnings that can be gained from the presented data. This point is further elaborated in the comments added to the report. A recurring issue that should be commented on, is the discrepancies between national statistics and Eurostat data. Also, the differences between the data input for Finland compared to the other countries regarding wood waste generation in the manufacturing industry should be investigated and commented.

Section 1.4 begins with a conclusion that the statistical data is not very reliable and that it will not be used in the selection of treatment methods to include in the LCA. This statement puts a question mark on the relevance of section 1.3

and the already presented information. NIRAS recommends to argue for the claimed unreliability of the statistics, e.g. by elaborating on discrepancies, and to better define the goal of Section 1.3. Although the statistics do not provide sufficient details with regards to the different recycling solutions, they can potentially be used to argue for the relevance of incineration (with or without energy recovery), recycling, and landfilling as waste treatment solutions in general.

In general, the description of the LCA methodology, analysis of statistical information and the selection of waste treatment scenarios go beyond the usual content of an introduction as NIRAS understands it. It is therefore suggested to divide Chapter 1 into more chapters (possibly with subsections). In addition to the "Methodology" section suggested above, this could for example include a separate chapter on the selection of waste treatment solutions to be analysed, with subsections on statistics and recycled products, respectively.

2.2 Section 1.4: Recycled products from wood waste

This last section of the introduction presents different recycled products from wood waste and the products that are chosen for further analysis in the LCA. As mentioned above, the report concludes on a lack of data on wood waste and wood waste streams. By limiting the sources of data to the national and Eurostat statistics and without any reflections around the differences in the statistics, this seems to be a reasonable conclusion. However, NIRAS questions the choice of statistics as the only input source for data. An alternative method could have been used to at least give some indications of both resource quality, amounts and treatment methods. For instance, by contacting larger actors such as municipalities, private waste management companies and larger receivers of wood waste for input to production, an insight in both waste streams, quality and treatment options should be possible to achieve. As a quick check, NIRAS contacted the City of Oslo, which has carried out a sorting analysis of their wood waste. That could give insights in the amount and qualities of wood waste from household and smaller enterprises. The City of Oslo has also gained knowledge of quality requirements in their public procurement of treatment of wood waste for material recycling. A check with one of the largest handlers of wood waste in Norway and Scandinavia confirms this approach.

NIRAS also questions the postulation "This is partly because historically it has been deemed unnecessary, as the wood waste is mainly incinerated, but also because economically feasible methods for recycling are still scarce, and thus more detailed data on waste streams and their quality is not needed." The use of wood waste and the market for wood waste as input to industrial processes are established and developing. Although the historical situation could be as described, this is not NIRAS' impression of the actual situation. Furthermore, data should be available from producers in Denmark where 50% of recyclable wood waste is recycled for chipboard production (page 13 in the report).

As the statistical data is discarded, NIRAS would expect the choice of waste treatment solutions to be well argued for based on other sources of information. However, more argumentation for the choices made in this section is requested. This could, for example, include insight into the maturity of the listed technologies, challenges related to them, and the demand for the recycled products. Furthermore, the treatment solutions included are solely based on possible recycled products resulting from the treatment, even though landfilling and incineration without energy recovery are relevant in Iceland (with 24-37% of non-hazardous wood being landfilled, according to European/national statistics). Composting of garden waste and other wood waste is also not mentioned, and even if deemed irrelevant, this choice should be argued for.

The section states that "Nine different products that can be produced from wood waste were screened". How this screening was performed is not sufficiently explained in the report. The same paragraph also states that "[...] the quality required for the input wood waste was looked at, but only little information was available". What was "looked at" to reach this conclusion is not clear. NIRAS would recommend including more on the methodology used, for example on which sources were consulted, if only online sources were used or if relevant actors were contacted. This could typically be part of a "Methodology" section as introduced in this note's section 2.1. For the data availability in Table 11 the

actual references for the LCI or LCA data would be useful, but NIRAS understands if these are maybe not fully identified yet as part of Phase 1. Furthermore, since NIRAS' reviewers are not experts on wood or wood waste, a third party verification of the selection of recycled products would help ensure relevance and completeness. This could possibly be done by a trade association or research institute within the wood industry.

Lastly, "reuse" is considered out of scope. This is a consequence of having only the recycled products as the starting point for the analysis. Nevertheless, scoping out reuse should be accompanied by more thorough reasoning, as reuse stands higher in the waste hierarchy compared to recycling (as correctly stated in the report). Since it is given in the project description that "The environmental impacts [...] shall be quantified for different relevant treatment methods, both preparing for reuse and recycling scenarios [...]", NIRAS suggests commenting on the reason why reuse is not under scope. Also there are several previous and ongoing research projects looking into benefits of reuse¹, suggesting that an LCA on reuse would also be useful. It is positive that the report states that Phase 2 will look into environmental benefits of reuse, however it is not clear how this fits into the rest of the study when reuse is actually considered out of scope. An explanation of this could fit into the previously suggested "Methodology" section.

2.3 Section 2.1: Goal of the study

The goal definition in section 2.1 is inadequate with respect to ISO 14044 requirements. The goal should include the intended application, reasons for carrying out the study and the intended audience, as well as whether it's a comparative LCA, cf. Section 4.2.2 in ISO 14044. Furthermore, the goal is stated to be "to analyse the environmental impacts of alternative scenarios for waste wood treatment." If the goal is also to compare, and maybe even rank, the treatment options based on environmental performance, as suggested by the last sentence in Section 2.2.1, this should be included in the goal definition.

2.4 Section 2.2: Scope of the study

Section 2.2 with subsections describe the scope of the comparative LCA. As with Section 1.2, the scope is missing a clear definition of the system to be studied, i.e. what types of wood waste are looked at. According to Section 4.2.3.1 in ISO 14044, the scope should also clearly describe the function of the systems that are studied (not only the functional unit (FU)), value choices and optional elements of the LCA as well as limitations. Furthermore, the scope shall define whether a critical review is necessary, the type of critical review that is to be performed, and who will conduct the review. Detailed comments to the subsections of Section 2.2 are given in the following subsections.

2.4.1 Section 2.2.1: Functional unit

The functional unit (FU) is not sufficiently defined. The FU is the "quantified performance of a product system for use as a reference unit" as defined by ISO 14044. Thus, the FU cannot not merely be "1 tonne of wood waste", but should as a minimum be "treatment of 1 tonne of wood waste." Furthermore, the FU should be more specific when it comes to location (for example include "In the Nordics" or "In Nordic countries") and technology assumption (like "Using current average/representative/best available technologies"). The FU could thus be defined as: Treatment of 1 tonne of non-hazardous wood waste in the Nordics using the following current treatment solutions: 1) incineration with energy recovery (baseline), 2) insulation, etc.

The last sentence in Section 2.2.1 states that "[The FU] measures what is the best use we can make of 1 tonne available wood waste." This is perceived as confusing for several reasons and seems to be based on a misconception of what the FU is. First, the FU does not measure anything, it functions as a reference in order to define inputs and outputs to the unit processes. Second, the sentence indicates a new goal of the study – "the best use of 1 tonne of wood waste",

¹ Examples include the large Norwegian research project [SirkTre, Indledende miljømæssig vurdering af disponeringen af træaffald i Danmark](#)

whilst the previously defined goal of the study is only to analyse the environmental impacts of the different scenarios. Reformulation or simply removal of this sentence is suggested.

2.4.2 Section 2.2.2: Type of LCA

Section 2.2.1 and 2.2.2. mention that two LCA methodologies will be applied – consequential LCA (CLCA) and attributional LCA (ALCA). An argument on what the benefits of applying both methods would be is recommended, even if it was given in the tender process.

2.4.3 Section 2.2.3: System boundaries and scenarios

This section describes the system boundaries and scenarios of the LCA. As mentioned in Section 2.2 of this note, the sources consulted in the desk study are unclear and should be further elaborated on. This is considered necessary because important assumptions are made based on the results of the desk study, especially with respect to the missing availability of information on quality requirements. According to actors in the market, industries that use wood waste have established different methods for sorting and pre-treatment of the wood waste before using the waste as input in industrial processes. NIRAS would therefore expect that at least a qualitative discussion on quality requirements should be possible, and if that is not possible, sources should be provided to support the argument.

As wood waste input sources, types and quality are not being specified in the study, one very important assumption is that sorting and processing of wood waste is the same for all recycling scenarios. This is in contrast to the differentiated quality assumptions in Table 11. This contradiction indicates that somehow 1 tonne of input waste is not the same in all the scenarios, and thus they cannot be directly compared. In general, this assumption means that the study does not count for handling of discarded material from high quality requirements (this may entail further transport and waste processing). It is stated that this will be further studied in Phase 2, and NIRAS strongly suggests this to be prioritised by the authors.

Moreover, the description of the system boundaries could be expanded with a more detailed description of the waste stream. This could include explanations on whether all wood waste collected for recycling arrives in similar sorting facilities, where the waste is sorted in sub-fractions by quality level, in which case an allocation by mass for emissions from sorting is possible (so sorting will indeed be assumed similar), or if the average wood waste collected arrive in distinct sorting facilities for different recycling methods, where there will be different loss of materials due to different quality requirements.

Further Section 2.2.3 shortly describes consideration of avoided emissions in the CLCA. NIRAS misses more explanations on how multifunctionality and allocation procedures are handled, especially in the ALCA. In a comparative LCA, the function of the compared systems must be the same. In this LCA, the function is “treatment of 1 tonne of wood waste”. Thus, the recycled products generated from the waste treatment (and the energy in the reference scenario) are to be considered co-products. Whether system expansion/substitution or allocation is used, should be explained and justified, cf. that according to ISO 14044, allocation should always be avoided if possible,

2.4.4 Section 2.2.4: Choice of marginal technologies

Section 2.2.4 describes the choice of marginal technologies assumed to be substituted by the recycled products and energy produced in the waste treatment scenarios. NIRAS suggests to expand this section with more thorough explanations of how the marginal technologies will be defined and used, as proposed in the comments to the report.

2.4.5 Section 2.2.5: Geographical system boundaries

The geographical system boundaries are good, nevertheless NIRAS suggests mentioning earlier in the report, which countries are studied – preferably in the description of study objectives, as well as in the goal description, and also in the FU section.

2.4.6 Section 2.2.6: Data sources and quality

It is very good that a section on data sources and quality is included in the report. Yet, it is still somewhat unclear why the cut-off system model is used for the CLCA, so a short discussion of the reasons and consequences of this choice is suggested.

2.4.7 Section 2.2.7: Impact categories to be assessed

It is explained that four impact categories will be included in the results of the study. The argumentation regarding the choice of impact categories is however somewhat missing and unclear. ISO 14044 Section 4.4.5 states that "An LCIA that is intended to be used in comparative assertions intended to be disclosed to the public shall employ a sufficiently comprehensive set of category indicators." Moreover, the project description states that: "We would like to analyse as many as possible of environmental impact categories to get a holistic picture where several impact categories are analysed together". It is NIRAS' opinion that it is not obvious that four indicators is sufficiently comprehensive, and an argumentation behind this choice should be included.

Additionally, NIRAS questions the inclusion of biogenic CO₂ as one of the four impact categories when sequestration is omitted from the study, given that sequestration, as described in the final paragraph of Section 2.2, is a very important aspect of the cumulative biogenic CO₂ emissions of wood products.

Furthermore, NIRAS recommends basing the choice of impact categories on the emissions that are expected from the various waste treatment processes and the impacts commonly associated with the substituted materials. Categories which are relevant for assessing wood-based products are not necessarily the same as the one relevant for assessing treatment of wood waste. For example, abiotic resource depletion may be a relevant impact category considering that wood incineration results in the substitution of energy, which in some cases might be fossil-based. According to the suggested reference by the authors, abiotic resource depletion is also often included as a relevant impact factor.

2.5 Formalities

Language and formalities have not been emphasised in the review, nevertheless some recurring issues have been noted:

- Exclude unused acronyms from the List of Acronyms and add a few additional (see comments in report)
- Footnotes to be placed after periods.
- Include extraction date for all website sources.
- Include sources for unreferenced statements.
- Consistency with respect to "-zation" and "-sation" word spelling (i.e. American vs. British spelling).
- Check for consistency with regard to the use of determiners, such as "the", "any", etc. (especially in introduction and summary).
- Percentages to be written without a space separating the number and "%" (i.e. 37% and not 37 %).
- Consistency on table layout (meaning of table symbols, capital letters and use of bold text).

In the commented report the comments on formalities are marked in green.

3 Concluding remarks

Overall, the review team considers that the Goal and Scope definition is missing some elements with regards to the requirements in ISO 14044 and suggests to further elaborate on the selection of the waste treatment solutions and the methodological aspects of the LCA modelling to increase the quality of the assessment. It is NIRAS recommendation that these comments are thoroughly dealt with before commencing Phase 2 of the project.