Determining the environmental impacts of conventional and alternatively fuelled vehicles through Life Cycle Assessment

Summary of the Delphi Survey Round 2 Responses

1 Introduction

On behalf of the European Commission's DG CLIMA, Ricardo Energy & Environment and their partners ifeu and E4tech are carrying out a study on "Determining the environmental impacts of conventional and alternatively fuelled vehicles through Life Cycle Assessment".

Following the first round of the Delphi Survey which ran from 14th December 2018 until 18th January 2019, the second round of the Delphi Survey was launched on 26th March 2019 and was open for responses until 9th April 2019 (2 weeks). The second-round questionnaire was built on the feedback received from the first round of the survey and the expert workshop as follows:

- Since a number of methodological elements achieved a sufficient level of support in the first-round consultation, a summary of those methodological was provided in the second round survey for review and further comments, if deemed necessary.
- The main focus of the second round of the survey was on methodological aspects which did not gather sufficient support or were still open (i.e. alternative methodological choices are possible). For these cases, a specific way forward was proposed, and new or more refined questions were included in the second-round questionnaire.

The Delphi Survey was sent to specifically targeted stakeholders with expertise in Life Cycle Assessments (LCAs) or in related areas of interest to the study.

This summary of the Delphi Survey is intended to provide an overall view of the responses received to the second round of the survey. Overall, 44 stakeholders responded to the survey.

Please note that the views presented can only be associated to respondents to this specific consultation and may not be representative of the views of all or specific groups of stakeholders.

2 Overview and profile of respondents

A total of 44 stakeholders responded to the survey.

The survey questionnaire was split into different sections, each focussing on a specific area of the study (overall approach, vehicle life cycle, fuel/electricity life cycle). Similar to the first round survey, respondents could select which of the following topic-specific sections they would provide answers to, but were requested to answer the questions on the section on the overall methodological approach. The number of responses received to each section is indicated in Table 2-1.

Table 2-1: Overview of number of responses to different sections of the survey

Area	Section	No. of responses	%
Overall methodological approach	1	42	95%
Vehicle specification, operation/use	2	34	77%
Vehicle production, maintenance and end-of-life	3	34	77%
Fuel production	4	32	73%
Electricity production	5	35	80%
Total Respondents	**-**	**44**	**100%**

Overall, there is a good balance of response rates between the different sections of the survey, with slightly fewer responses received on the fuel production section.

The responses were also provided by a wide range of stakeholder groups, presented in Table 2-2. Among the associations and individual companies that took part in the survey, these also represent a number of sectors/areas of relevance to the study (vehicle, energy, materials and components – see Table 2-3). It is noted that a set of near identical responses were received from six individual companies and an association. These are all included in the following analysis.

Table 2-2: Analysis of responses by type of stakeholder

Type	Respondents	%
Academics & research institutions	10	23%
Associations	8	18%
Individual Companies	15	34%
NGOs	2	5%
Other	9	20%
Total Respondents	**44**	**100%**

Table 2-3: Sector of associations and individual companies that took part in the survey

Type	Respondents	%
Vehicle	12	52%
Energy	5	22%
Materials	4	17%
Components	2	9%
Total Respondents (Associations, Individual Companies)	**23**	**100%**

Overall, respondents provided an answer to the majority of the questions in the survey sections they selected as well as provided insightful comments to explain the reasoning behind their views.

The following sections in this document describe the results of this second-round consultation.

3 Analysis of responses

The following analysis is broken down by question and contains a mix of quantitative and qualitative responses. Since round one provided a clear agreement on some of the topics covered, this round provided a summary of the decision made and gave respondents the opportunity to provide further comments. For topics where there was more debate, a summary of the new or more detailed proposal was given, and respondents were asked to indicate if they support the adjusted proposal via multiple answer questions and text questions.

3.1 Section 1: Overall methodological approach

In the first round of the survey, most respondents had largely validated the proposed overall methodological approach but areas such as the modelling of end-of-life stage and the proposed coverage of environmental impact categories had generated more discussion. In the second round, respondents that provided further comments reiterated their support but also made additional suggestions for refinements to the approach. Very few demonstrated complete opposition to the proposed methodology. Nevertheless, mixed views remain concerning the approach to model end-of-life.

*“**Q4: Overall approach - our proposal:** It is concluded from Round 1 of the survey that the hybrid approach, with attributional analyses as the default option, complemented by consequential analyses for specific aspects, is validated by the majority of stakeholders, despite some concerns regarding uncertainty and potential bias. A consequential approach will be pursued for the production of electricity and alternative fuels which have also been regarded as particularly important by the stakeholders (see respective sections for detailed discussion). Consequential elements (new cell chemistries, electricity split and decarbonisation of materials) will also be considered implicitly in the scenarios for modelling of battery and fuel cell production. A full consequential modelling of further aspects mentioned by some stakeholders is nevertheless ruled out as beyond the scope of the project.”*

Overall, most of the respondents that provided further comments reiterated their support for the proposed approach, although there is some disagreement around what should be covered by the consequential approach and whether it can or should be named consequential.

Further suggestions were made by some of those respondents that were in agreement with the proposal. One respondent explained combining the two approaches is not a problem but the focus should be on providing an appropriate characterisation of the relevant life cycle stages. One other respondent advised that consistency across different tools/databases needs to be checked to ensure alignment of the underlying assumptions. For another respondent, the elements covered by the consequential approach should be clearly listed.

It was also widely suggested that the language around the consequential modelling should change, and the term ‘scenario’ should be used instead. For one of the respondents, this would be more appropriate since some of the elements proposed to be modelled based on a consequential approach are not truly consequential (e.g. new cell chemistries) but represent alternative scenarios that could be part of the attributional approach. This respondent also argued that the scenario analysis should be kept separate from the study’s other results, explaining that combining the two approaches leads to an intrinsic inconsistency in the study and, by keeping the results from the consequential modelling separate, this helps avoid inconsistencies and errors in the interpretation of the results.

Another respondent explained that consequential modelling is based on economic relationships and not on technical rules. As such, they proposed a “*prospective attributional approach with scenarios”* which represents the variation of technical model parameters of the attributional model on the basis of an engineering approach; consequential modelling could be undertaken as an additional approach.

Similarly, eight other respondents also noted that technical developments could be considered in the attributional approach – for one, the consequential approach should thus be avoided, for the other seven, consequential modelling should only be used for scenario analysis in order to present a range of results, highlighting that the conclusions should indicate whether differences in the results have significant implications for decision-making. Two other respondents also supported the presentation of results in ranges – i.e. business-as-usual results together with consequential results.

Furthermore, one respondent argued that the attributional approach should be complemented by a sensitivity analysis, and two other respondents referred to the need to carry out a scenario analysis that should be well defined.

There was, however, some disagreement and discussion on the proposed application of the consequential approach. It was suggested that the consequential approach should also address different rebound effects among different vehicles (one response) and that there is a number of other fuel types not mentioned that would require a consequential approach (one response). Similarly, one other respondent argued that if batteries are assessed on the basis of a consequential approach then ICE vehicle parts should also be taken into consideration. For another, the consequential modelling is important to deal with uncertainties in the future decarbonisation of the electricity grid.

One respondent pointed out the relevance of different electricity mixes for material and parts production, where the emissions from e.g. batteries may vary considerably if they are produced with “green” or fossil electricity. Therefore, emissions from materials/components will also change in future scenarios.

Two respondents also argued that a consequential approach should be applied to the refining products. According to these respondents, the use of the marginal approach has been validated in other studies (e.g. the Well-to-Wheels Study for JEC from CONCAWE). Further explanation for the proposed final approach is provided in Box 1 below.

One respondent pointed out the relevance of different electricity mixes for material and parts production, where the emissions from e.g. batteries may vary considerably if they are produced with "green" or fossil electricity. Therefore, emissions from materials/ components will also change in future scenarios.

Box 1: Additional commentary on proposed final approach

The alternative refinery analysis used by CONCAWE was supported by several stakeholders during the consultation process. It differs from the allocation approach of ifeu, but is the method used by the oil industry since the 1950s to calculate the crude oil needed to produce different products. Starting with a model of EU refineries producing the existing mix of products, CONCAWE adjust the operating parameters (flows, temperatures, pressures…), in order to decrease the output of one product (at a time), whilst keeping the others constant. The resulting decrease in total refinery emissions is the refining-emission reduction caused by substituting that product. The method takes into account the effect of one product on the refining emissions of all the others. For example, heavy fuel oil is basically the bottom fraction of the primary distillation column. If its demand falls (e.g. because it is substituted by alternative fuel), then the throughput of the basic distillation column has to be reduced, so there is now insufficient lighter distillates to meet the demand for gasoline and diesel: instead more of these have to be made from surplus bottom fraction by cracking, which is much more emissions-intensive. So reducing heavy fuel oil production increases emissions from the refinery; and one can express this by saying heavy fuel oil has negative *refining* emissions (but not negative enough to negate its combustion emissions).

The following considerations were taken into account when making the decision to go with the ifeu method, rather than the CONCAWE method:

- The marginal approach is used by refiners to make decisions around economic optimization of the refinery – e.g. how the change in production of one product would increase the crude oil demand of the whole refinery and the resultant impact on refinery emissions. However, the marginal approach can lead to some products, such as heavy fuel oil or petroleum coke, having negative refining emissions, (even if their overall carbon footprint, which includes combustion emissions, is still positive). Some stakeholders have trouble understanding this. Furthermore, this is a long term study, wherein fundamental large scale shifts in the transport fuel mix are envisaged. To take this into account using CONCAWE's method, the refinery model and operating parameters would need to be updated to reflect the future mix of product demand. The consortium does not have a way to do this.
- A key objective of this study is to go beyond what has already been carried out in other well-to-wheel LCA studies and to look at non-GHG impacts. Given that the CONCAWE model does not have the ability to model non-GHG impacts, this was another key factor in deciding to use the ifeu model, which does have this capability. It can model impacts including air pollution, water emissions and catalyst production and waste.

*"**Q5 Scope and system boundaries - our proposal:** It is concluded from Round 1 of the survey to be mostly acceptable to neglect road as well as recharging and refuelling infrastructure due to the expected small overall contribution and potential further uncertainties. Both will not be included in the study. Since infrastructure (capital goods) for the production of renewable energy is expected to be relevant, this will be taken into account for the energy sector (see respective sections for further details)."*

Of those that provided further comments, respondents demonstrated their support for the proposal and/or voiced concerns over the exclusion of some elements and/or the reasoning provided for their exclusion.

Three respondents highlighted the importance of including the relevant infrastructure for the different vehicle technologies – otherwise, having different system boundaries for different transport options could lead to inconsistencies. One explained that the inclusion of roads is not needed as they are used by all road users in the same way but other infrastructure should be included - they gave the example of overhead catenaries for long haul electric trucks only which in their view should not be neglected or just distributed over the whole road transport. For the other respondents, the issue is with the inclusion of infrastructure for the production of renewable energy *only* as it does not cover all transport systems alike to ensure a fully consistent comparison. The third respondent suggested that, to minimise the inconsistencies, the study should present ranges of results to acknowledge the bias in the interpretation of the results.

Similarly, one respondent added that including the infrastructure for renewable energy will lead to inconsistencies in the analysis so results for this area should be presented separately, and seven respondents highlighted the uncertainty surrounding the results and advise the presentation of results in ranges.

Another respondent advised to include manufacture of farm machinery as it has a significant contribution to emissions from biofuels – they suggested to include order-of-magnitude estimates.

The comments provided also reflect the discussion on the justification for the inclusion or exclusion of certain elements. One respondent advised that, for excluding certain elements on the basis of their expected low impacts, their contributions need to first be known.

For three other respondents, it would be useful to report an order-of-magnitude estimate of the potential emissions for those elements that are out of scope of the analysis.

On the other hand, one respondent suggested that the reason for exclusion should not be based on the expected small impacts given the lack of evidence – instead, the reasoning for their exclusion should be based on the uncertainty and lack of data for those impacts or if they are out of scope according to the goals of the study.

Furthermore, two respondents questioned the reasoning for including/excluding elements based on their expected impacts: one claimed that contribution of the infrastructure for production of renewable energy might not be significant, and another noted that the infrastructure efficiency losses (fuel provision) can be significant and could be considered.

There were also three respondents that showed their disagreement with the proposal. One indicated that fuelling and charging infrastructure must be considered in their view. Another argued that further information on recharging infrastructures is needed since these are novel infrastructures and to ensure consistency given that the infrastructure of renewable energy is also taken into account.

*“**Q6: Reference flows and functional units – our proposal:** It is concluded from Round 1 of the survey that the majority of stakeholders supports the proposed reference flows (i.e. intermediate units, e.g. impact per MJ energy consumed) which will therefore be used in the study. It further must be stated that the functional unit is defined along the lines of vehicle size/utility. The study will therefore carry out a technical comparison of similar vehicles (size/utility). Further differences between drive concepts (e.g. driving range, maximum speed and driving dynamics) are accepted in this context, assuming that chosen vehicles are always suited to the specific usage despite differences in driving range and driving characteristics. Mobility based approaches (sharing, multimodality) will be acknowledged in a qualitative discussion.*
Additional reference flows as proposed will be used for subsystems and also published to ensure transparency of results”

Among the respondents that provided further comments, many responded to demonstrate their support for the proposal but some also suggested caution regarding the comparison of similar vehicles.

A group of eight OEM respondents (with nearly identical responses) highlighted the importance of ensuring a fair comparison on the basis of the same use cases. For them, if there is a difference in the utility/function of the vehicle, this needs to be taken into account via system extension. The importance of comparing vehicles with the same use cases has also been noted by another respondent.

The group of eight OEM respondents recommended to using one vehicle during the whole life cycle (total vehicle life) as the functional unit. Alternatively, if vehicle/km is used, they suggest it would be important to fix the lifetime of 200.000km as a total driving range. In the case of Heavy Commercial Vehicles, total vehicle life should be the reference flow instead of pkm/tkm.

One respondent suggested also comparing vehicles with comparable driving ranges (at least in the form of a scenario). Another respondent pointed out the difference between a vehicle’s designed use and the user preference when actually using this vehicle. Therefore, burden shifting may occur when another vehicle or transport mode is used due to limitations in range or speed making aggregations to fleet or sector level a challenge.

One respondent also suggested that full/partial loads and empty trips for freight transport should be considered in the analysis.

It was also suggested by one respondent that the results should provide the adequate level of detail to allow the conversion to other units.

*“**Q7: Guidelines - our approach:** It is concluded that ISO 14040/14044 are the most important guidelines considering the goal of the study. Even though methodological aspects from other mentioned guidelines (e.g. ILCD/PEF) may be incorporated where available, it is concluded that a full compliance with further guidelines is not feasible due to the large number of analysed variations (scope of the project). This is regarded to be acceptable since the focus of the study is on general policy advice rather than monitoring of specific products. Internal methodological consistency will be ensured and is regarded to be of higher importance in respect to the goal of the study”*

The respondents had very few additional comments about this proposal. Ten respondents highlighted the importance of ensuring consistency, two of which were satisfied with the proposed approach to achieve this. However, one noted that it is not clear how the consistency of the results will be ensured if the analysis is based on a variety of sources. They also questioned whether the third-party review process will be organised as recommended by ISO. The remaining seven respondents adverted about the risk of compromising consistency by incorporating aspects from other guidelines, noting that even the ILCD handbook shows some inconsistencies regarding attributional/consequential and average/marginal.

One other respondent noted that complying with the guidelines should not compromise the development of a robust analysis – they explained that the risks associated with LCA for policy analysis can be different than the ones identified by the standards for LCAs used in a commercial context. For another respondent, PEF is not appropriate given that its focus is on product footprinting.

One respondent also questioned whether the study will fully comply with the ISO standard, and one other suggested writing a goal and scope definition according to the ISO standard.

*“**Q8: Impact categories - our proposal:** It is concluded from Round 1 of the survey that the majority of respondents have agreed with the proposed coverage of environmental midpoint impacts categories. Since there are polarised views concerning some impacts, all suggested impacts will be quantified as part of the study. To accommodate for concerns regarding data transparency and controversial methodologies, a qualitative discussion about significance and uncertainties will be undertaken at the end of the study. The scope of impacts will be applied to all life-cycle stages of the study, including fuel production and electricity generation.”*

In general, respondents’ comments denote their agreement with the selected impact categories and the proposal to include a qualitative discussion to address uncertainties and ensure transparency. One respondent, however, suggested that a qualitative discussion is not sufficient and that it would be more appropriate to address the uncertainty by reporting the range of results obtained via sensitivity analysis.

Ten respondents (of which eight provided the same response) advised that methods to calculate certain impacts (especially toxicity) are still under development and/or are not sufficiently robust. In addition, there is fewer data for these impact categories that create further uncertainty. The eight respondents added that the LCA is not the appropriate tool to assess impacts where the dose including background concentrations are crucial (e.g. toxicity). As such, uncertainty surrounding these methods and data should be acknowledged, and the quality of the characterisation models should be assessed.

Three respondents proposed refinements. One advised the use the ILCD midpoint categories, and the other alerted for the risk of double counting energy sources in the "energy consumption” and "resource consumption" and suggested considering the consumption of EU critical raw materials. The third respondent also recommended including a metric of rare metals, platinum, cobalt, lithium.

One respondent also recommended calculating the impact categories with more than one method when possible.

“Q9. Which of the proposed approaches for end-of-life modelling are most suitable to complement a default cut-off approach?”

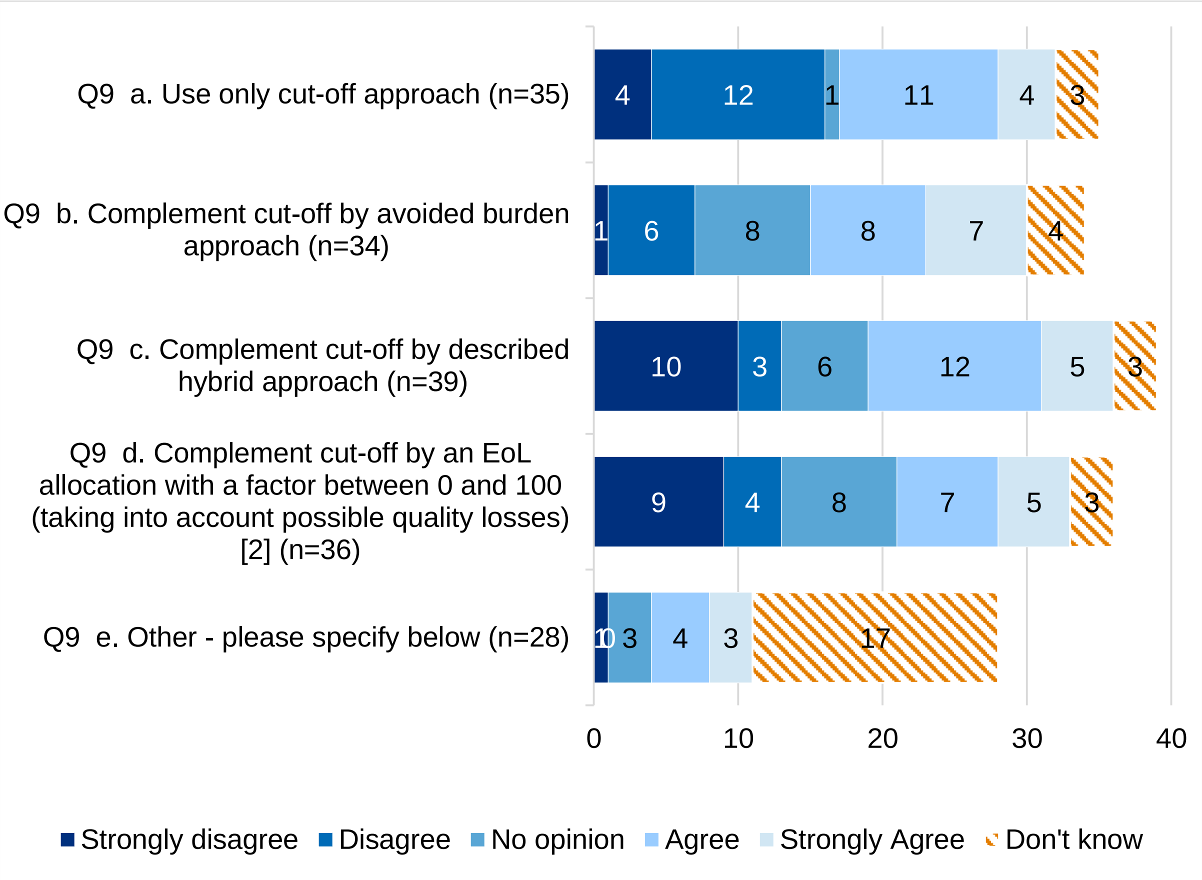
Following the first round of consultation (survey and workshop), it was concluded that the cut-off approach may be used as a conservative and robust default option but a second approach should be applied for certain materials. Respondents were therefore asked for their views regarding the most appropriate second approach to complement the default approach - Figure 3-1 provides a summary of the results.

The second round of consultation still shows mixed views regarding the most suitable approach to complement a default cut-off approach, as illustrated in Figure 3-1:

- 15 out of the 35 respondents providing a response “strongly agree” or “agree” with the use of the cut-off approach only compared to 16 that “strongly disagree” or “disagree”.
- 15 out of the 34 respondents providing a response “strongly agree” or “agree” with the complementing the cut-off approach with the avoided burden approach compared to seven that “strongly disagree” or “disagree”.
- 17 out of the 39 respondents providing a response “strongly agree” or “agree” with complementing the cut-off approach with a hybrid approach compared to 13 that (“strongly disagree” or “disagree”.
- 12 out of the 36 respondents providing a response “strongly agree” or “agree” with complementing the cut-off approach with an EoL allocation factor (between 0 and 100 - taking into account possible quality losses) compared to 13 that “strongly disagree” or “disagree”.

A specific pattern is also observed in the results: a group of seven OEM respondents that have provided nearly identical responses throughout the survey were particularly in favour of using a cut-off approach only and complementing the cut-off approach with the avoided burden approach, but strongly disagreed with the other approaches. On the other hand, the other respondents were more in favour of complementing the cut-off approach with a hybrid approach (17 strongly agreed and agreed vs six strongly disagreed and disagreed of the other 32 respondents responding to this question), followed by the use of the EoL allocation factor (12 strongly agreed and agreed vs six strongly disagreed and disagreed of the other 29 respondents responding to this question).

Figure 3-1: Views on approach to end-of-life modelling



A number of respondents responding to this question also provided additional comments.

Among those that agreed with the use of a cut-off approach only, one respondent commented to suggest that this approach should be complemented with the EoL allocation factor approach.

One respondent that favoured the complementary EoL allocation factor approach explained that it reflects the supply/demand situation of different recycled materials which makes it more relevant from a policy perspective to understand whether recycling is limited by availability of materials at EoL or on the demand for recycled/secondary materials.

Two respondents demonstrated strong support for the hybrid approach – for one, the hybrid approach is important when the system produces more recycled materials than the recycle material used in the input, for the other, this is the best approach to take into account technology improvements in battery technology and recycling.

Two other respondents agreed both with the use of a cut-off approach only but also complementing it with the hybrid approach; one explained that the study should follow the industry-specific approaches, and the other argued that more than one approach should be followed to demonstrate their impact on the results.

In addition, eight respondents (with nearly identical responses) preferred both the cut-off approach only but also the use of the avoided burden approach as the secondary approach – they explained that the cut-off approach should be used as the default approach and a complementary avoided burden approach could be applied as a sensitivity analysis only to present a range of results between different options. For another respondent, regardless of the choice of approach it should be consistent for all transport modes.

There were also three respondents that made other suggestions: undertake all approaches to show the range of results between options and/or add system expansion. One further comment was provided by one respondent that suggested that the use the cut-off as default approach, and the 0:100 or mixed approaches for dedicated scenarios (e.g. design for recyclability scenarios) which depends on the study’s goals.

One respondent pointed out that even though electric batteries and light-weighting result in higher impacts from production, the effects of these may be partially balanced in future by better recycling and higher recycling rates. Current legislation calls for a mandatory recycling of these.

Respondents were subsequently asked for which materials/situations the complementary approach should be used. Figure 3-2 shows that all the proposed materials should be assessed based on the complementary approach according to the majority of the respondents (i.e. more positive responses than negative responses) – although this is less consensual for plastics, carbon fibre and steel.

In the comments provided, two respondents recommended that all materials should be treated equally unless there is a good reason to treat them differently, whilst another six advised that the allocation rules should be chosen consistently for all materials, explaining that the level of impact from a particular material on the production phase is always case specific and needs to be analysed individually. For another, all raw materials are important.

For another group of respondents, the materials whose EoL should be modelled by the complementary approach depends on how widely recyclable they are. One respondent explained recycling processes for steel, aluminium and plastic are mature and, given that a significant difference is not expected between ICEs vs. EVs, a cut-off method would be sufficient. For another, the complementary approach is particularly relevant for those materials that are currently not largely recycled, or that are largely downcycled. On the other hand, one other respondent is of the opinion that those materials that are not recycled or their amount in vehicles are small do not need to follow the complementary approach. A third respondent specified that the complementary approach is more important for those materials whose recycling process is expected to become available in the future although they are currently not widely recycled.

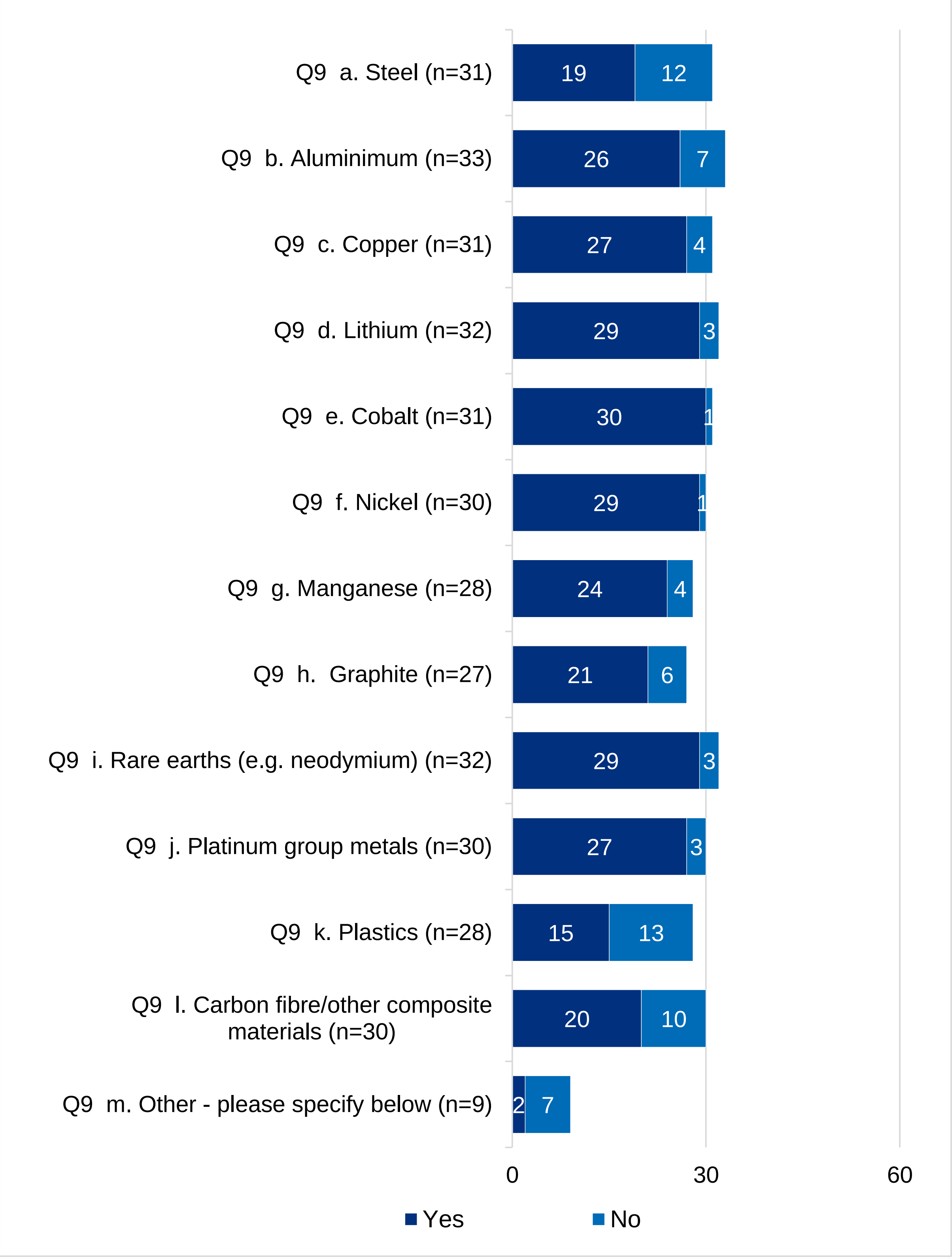
For one other respondent, the decision should be based on whether relevant effects from those materials are expected. One other noted that all the materials listed have a high impact on the production phase. For another, the information on the material itself is not sufficient and advised to model end of life on the basis of sensitivity analysis – for those materials that generate the most impacts they should be modelled more carefully.

In addition, one respondent argued that the focus should on when the system produces more recycled materials than the recycle material used in the input.

One respondent also advised care when assigning EoL credit so that it reflects actual burden avoidance. Another voiced doubts over the recyclability of carbon fibre and graphite.

A further comment provided more detail on the particularities of recycling aluminium.

Figure 3-2: Materials for which a complementary approach is necessary



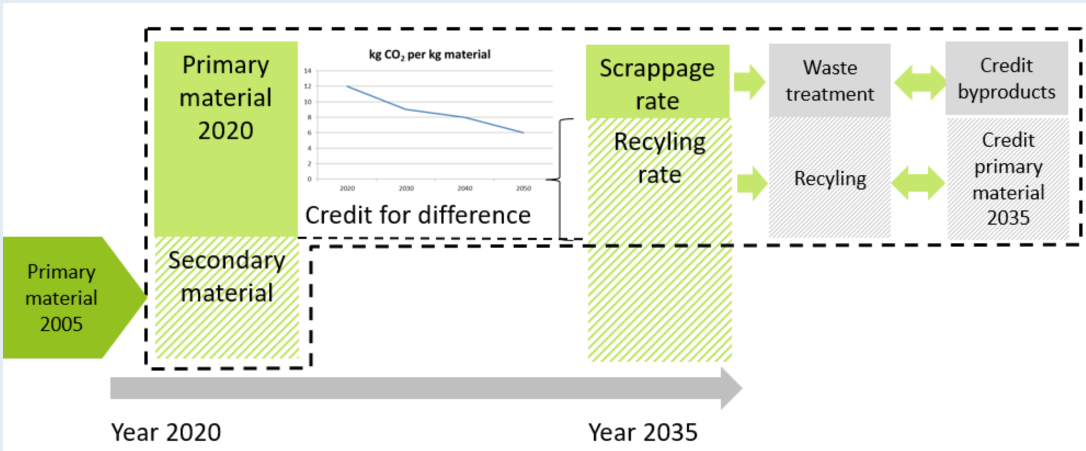
Box 2: Additional commentary on proposed final approach

The results of the second round of consultation demonstrate that there are still mixed views regarding the most suitable approach to complement a default cut-off approach. Considering the comments provided, the hybrid approach appears to be the most appropriate for the following reasons:

- This approach accounts for the very different situations in respect to recycled content and recycling rate. While up to 90% of metals may be recycled at the end-of-life, the amount of secondary material in the market is much lower. In addition, for materials like carbon fibre, that are not currently recyclable, new recycling processes are being investigated that could be applied in the longer-term timeframe considered in this study (i.e. to 2050). Additionally, the approach does justice to materials for which the automotive sector is a net recycling contributor.
- This is also consistent with the circular footprint formula proposed in the battery PEFCR (Product Environmental Footprint Category Rules), where an allocation factor between the first and the second user of a certain material is introduced.
- This approach basically covers the cut-off and avoided burden approach as marginal cases. It can therefore be seen as a consistent methodological reference point in the project.
- This largely ensures a robust and conservative approach which suits the policymaker's viewpoint, since environmental burdens are accounted for when they actually occur.

As such, a cut-off application will be used in practice for the majority of the materials with an even balance between use of secondary material and recycling rate. An additional credit is given only for selected materials used in vehicles and key powertrain components (e.g. batteries, fuel cells, etc) where the recycling rate (current or projected future rate) significantly exceeds the content of secondary material, corresponding to an avoided burden approach for the difference (Figure 3.3).

Figure 3.3: Schematic explanation of the hybrid approach



This approach may be applied to following materials:

- Selected mass materials like steel, copper or aluminium.
- Selected battery materials like lithium, cobalt, nickel, manganese or graphite.
- Potentially also other materials like rare earths, platinum group materials and possibly certain types of plastics as well as carbon fibre.

3.2 Section 2: Methodological considerations for vehicle specifications and operational emissions

Following the first round consultation when most respondents supported the methodological proposals for characterising vehicles and their operational emissions, they reiterated their agreement in the second round but also made further recommendations and voiced words of caution regarding particular approaches. The further refinements proposed in the second round survey (i.e. on segmentation of baseline vehicles and calculation of battery replacements) were generally welcomed by respondents. The approach for defining vehicle energy consumption, which did not gather a sufficient level of agreement in the first round, received more support.

*"**Q11 General vehicle specification – our proposal:** It is concluded from Round 1 of the survey that the majority of experts have agreed with the proposed approach to define equivalent baseline ICE vehicle for vehicle type/segment, based on current market norms and characterise other powertrains relative to these. Alternative powertrains would then be defined by the use scaling factors to define sizing of key components for (e.g. motor, battery) based on market and engineering analysis, and performance criteria. As a refinement, to address the comments on additional segmentation, it is proposed to break passenger cars into at least two sub-segments, potentially up to four (e.g. aligning with the segments previously analysed in reports for the Commission). For the other vehicle body types (i.e. commercial vehicles, mainly heavy-duty), it is believed that sensitivities on duty-cycle/activity will be sufficient to capture the major differences in lifecycle impacts for these vehicles (due to the predominance of the operational use phase). Do you agree the proposed refined approach for splitting the passenger car body type into two to four sub-segments is sufficient to address the identified variation in this area?"*

Comments provided in the previous round of the survey suggested the need for additional segmentation, and so a refinement to the approach was proposed and open for consultation in round two of the survey. Figure 3-4 shows that a clear majority of respondents are in favour of the approach.

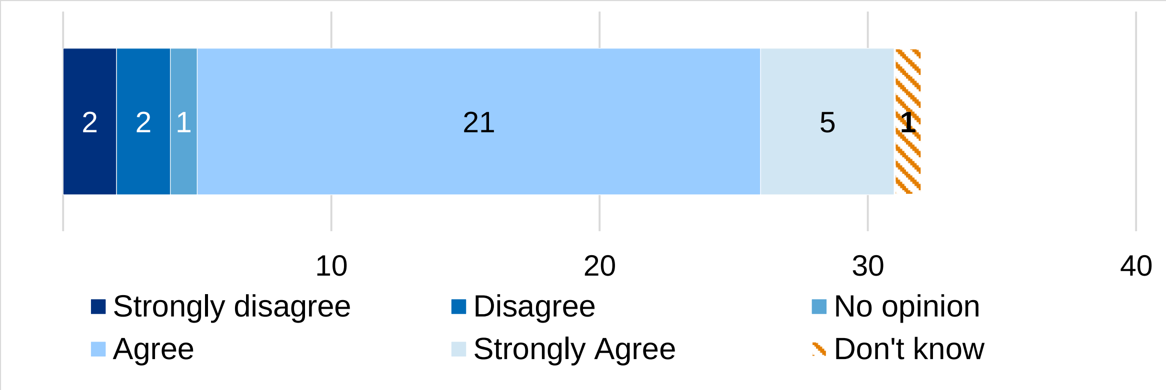
In comments, seven respondents reiterated support for a segmented approach. One respondent expanded to say two to four segments seemed appropriate and that more would be an overcomplication. Another added that the segments should be 'Segments A (city cars), C (medium class), D (upper class) and J (SUV)' in order to be representative of the European light duty market. Three indicated that this should be applied to the HDV market as well, however the suggested vehicle segmentation varied: one suggested regional and long-haul segments whereas the other respondent suggested a split between urban buses and lorries, along with mission profiles. A comment from a separate respondent suggested that the accurate comparison between HDVs and passenger modes would be enabled by expressing emissions in g/t-km (as well as /MJ and /km).

Another two respondents highlighted that the segments may change in the future, as the fleet composition and user behaviour changes, particularly considering the increase of BEVs.

Six other comments indicated more information on the definitions of the body type segments would be needed to provide transparency, plus also on the basis of any scaling factors/parameters used to define generic alternative powertrains relative to baseline ICEV equivalents. They also suggested that alternative powertrain should be defined to have identical range / performance to ICEV equivalents for full comparability.

Of the remaining three respondents who disagreed with the proposed approach, two included details of their preferred approach in the comments. One indicated that Regulation (EU) 2017/2400 for determination of HDV CO_2 emissions and fuel consumption should be used, as its vehicle classification considers vehicle groups, mission profiles and vehicle configurations. The other also suggested that user profiles should be applied to an average car.

Figure 3-4: Views on refined approach for splitting the passenger car body type into two to four sub-segments (n=32)



Box 3: Additional commentary on proposed final approach

In light of the suggestions to consider additional segmentation, passenger cars will be broken down into at least two sub-segments, and potentially up to four (e.g. aligning with the segments previously analysed in reports for the Commission).

"***Q12 Vehicle composition and unladen mass - our proposal**: It is concluded from Round 1 of the survey that the majority of experts have agreed with the proposed approach to define EU average mass and material composition for baseline ICE representative vehicle body types based on pre-existing sources/analyses, normalised to current market averages, where appropriate. For different powertrain types, variations would be characterised based on defined sizing /composition of key components. For clarification, we will also benchmark/cross-check results from the adopted approach with real-world models where feasible / appropriate, and revise assumptions where necessary*."

Further comments on the proposal to define vehicle composition and unladen mass were largely positive about the proposed approach. Around a quarter of respondents added brief comments highlighting the importance of considering future changes in mass of key components, in particular, some of these pointed specifically to BEV's battery composition. Another suggested running a short analysis of the differences between individual EU countries and a non-EU vehicle, to ensure this approach is sound.

Seven other responses warned that a screening approach may lead to high uncertainties.

"***Q13 Characterising vehicle energy consumption* – our proposal:** The feedback received from Round 1 of the survey and further discussion at the Expert Workshop with stakeholders suggested that further clarifications on the proposed methodology were needed, and that once this was provided the level of consensus improved. Further information has been provided on this in the Round 1 Summary document, together with our responses to specific elements raised by stakeholders."

Respondents were asked to review the additional information provided and asked if they support the proposed approaches for characterising vehicle energy consumption. The results of these questions are shown in

Figure 3-5. Overall, each question received a majority of positive over negative responses.

For question 13.a, on the definition of the baseline vehicles, over two thirds of respondents support the proposal. Seven respondents, who indicated they agree with the proposal, added in comments that they felt the base scenario should be based on actual legislative requirements/type approval values. One respondent who disagreed suggested that it would be better to work with ranges rather than averages. Another who indicated 'no opinion' added that it would depend on the details of the systematic approach. They went on to suggest that a vehicle longitudinal dynamics approach would be appropriate and should include characteristic maps or curves providing energy losses over power output in order to avoid overlooking differences in vehicle weight and powertrain characteristics.

The feedback on to question 13.b on cycle values and real-world performance shows less consensus between respondents. Given relatively close split shown in Figure 3-5, it is important to point out that seven nearly identical responses all selected 'disagree' on this question. The explanation provided explained that it is unclear how to derive 'real-world' performance. The respondents indicated that working with ranges it is fine but felt it was important to understand that the real world is different for each customer. Another respondent highlighted that the driver behaviour impact on emissions could be also included by applying a factor (with a default value of '1').

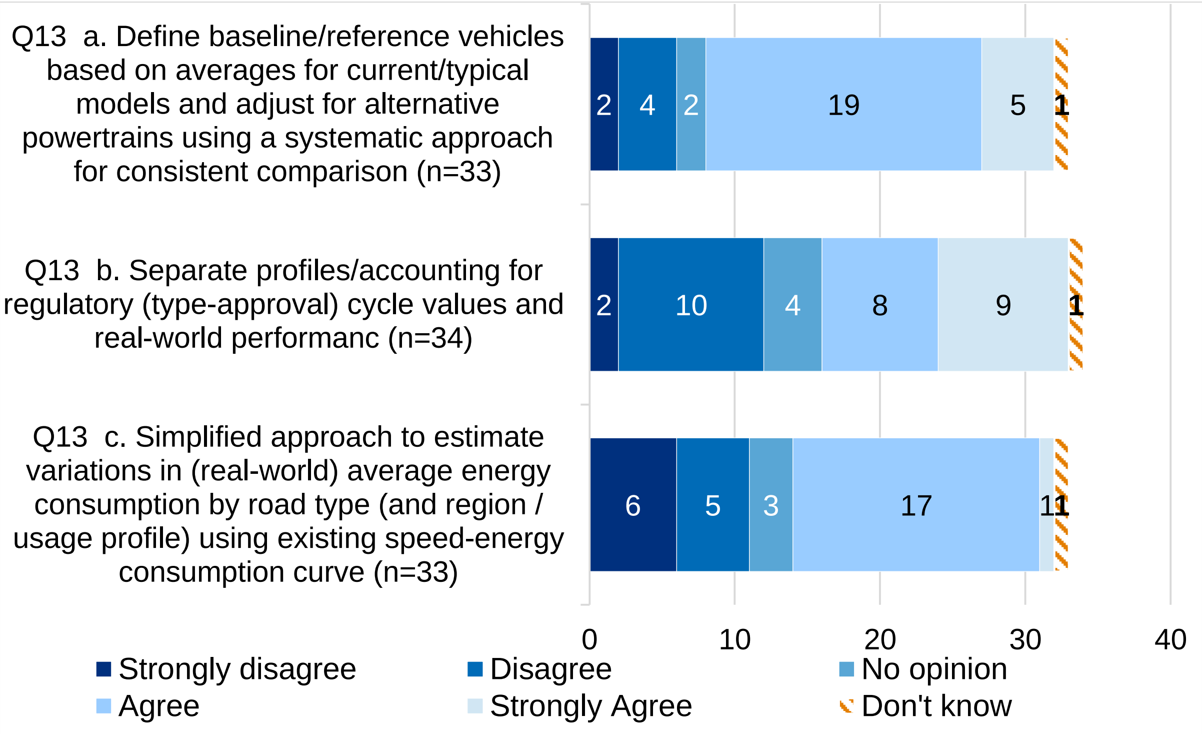
Finally, respondents largely expressed support regarding the simplified approach to estimate variations in (real-world) average energy consumption by road type (question 13c). However, it is, again, important to note that the seven identical responses selected 'agree'. A separate respondent, who also agreed, used suggested that energy demand should be split into energy for driving, heating, cooling and auxiliary services.

Of those who disagreed with this proposal, one indicated that energy consumption should be based on regulation for HDV (VECTO), as it is felt this should be close to real-world performance, including shares between long haul, urban and region. They also stated that additional road differentiation is not useful. Another indicated that they felt the speed-energy consumption curves may be too crude to use.

Concerns previously raised by one commenter in Round 1 were also repeated here, relating to a preference for a hybrid approach, indicating that variability between different countries was important to be covered (at least as a sensitivity), and that variations due to hot and cold climates should also be included, as well as charging inefficiencies for plug-in vehicles.

Another suggested the approaches were all valid and that the final choice should be determined in consideration of the time required for the analysis and the precision requested by the policy DGs. They also indicated a sensitivity analyses on these aspects were also appropriate given these considerations were some of the most influential.

Figure 3-5: Views on characterising vehicle energy consumption



The next part of the question asked respondents if they considered a sensitivity on the impact of particularly hot/cold climates to be important. As shown in Figure 3-6 below, respondents were largely in favour of including this sensitivity. In comments, two respondents highlighted the importance of considering the effect of temperature on BEV. Others provided information on how this sensitivity could achieved in modelling:

- Three suggested modelling 3-4 temperature climate scenarios.

- One suggested seasonal daily temperature curves were required for the model temperature variation, and its impact on vehicle cooling and heating requirements, accurately.

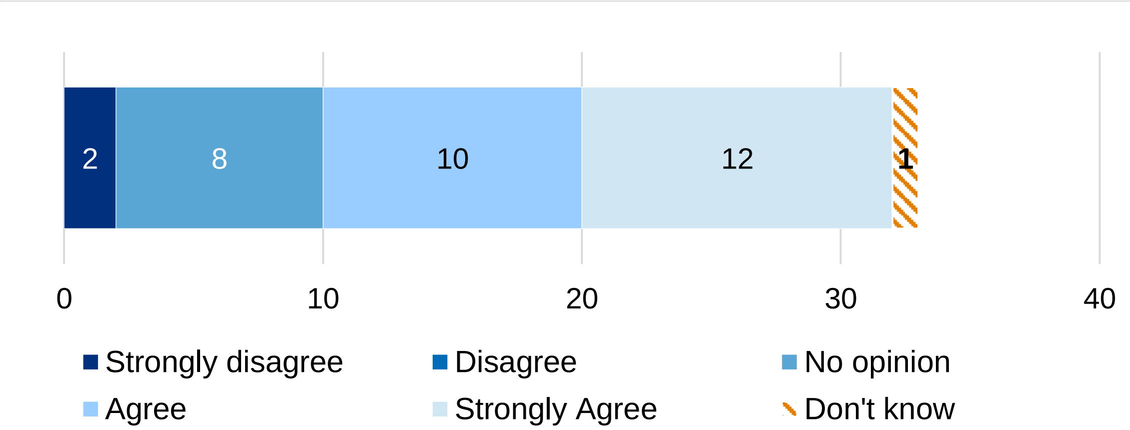
Five respondents also suggested data resources to assist with the definitions of this consideration:

- OEMs RDE databases.
- Documents on EU CIRCABC for the UNECE WLTP Low Temp Task Force.
- Driving data or climate chamber tests.
- Sourcing data for cold sensitivity from Norway and warmer climate sensitivity data from California.
- Use literature values.

Of the two respondents who disagreed with the proposal, one explained that this approach would be too complex, whereas the other pointed to the CO_2 regulation for HDVs should be applied, and that hot/cold conditions interact far more with vehicle application than with heating/air conditioning.

One suggested consideration beyond temperature for consideration, a specific accounting should be made for the real-world auxiliary power loads for BEV and fuel economy for ICE vehicles (i.e. for on-road versus test conditions) and that this should be also factored into battery sizing for BEVs.

Figure 3-6: Views on the sensitivity on the impact of particularly hot/cold climates on the energy consumption performance of different powertrain types is appropriate / proportional / necessary (n=33)



Box 4: Additional commentary on proposed final approach

It is concluded that stakeholders largely support the proposed approach to characterise vehicle energy consumption, which will be taken forward.

We also recognise that a number of stakeholders consulted indicated a preference for only using regulatory-based energy consumption (and tailpipe emissions) data in the LCA, however this would not be consistent with the goal of the study which is to inform policy understanding on real-world impacts.

The additional adjustment proposed for ambient climate conditions will be investigated based on feedback from the Delphi survey and stakeholder workshop. However, their final inclusion in the methodology / application will be subject to confirmation of feasibility/complexity and the availability of suitable data.

*"**Q14**: **Dynamically adjusting energy consumption** – **our proposal**: It is concluded from Round 1 that there was good support from most experts for the specific vehicle energy consumption (e.g. in MJ/km) to be adjusted dynamically based on battery size/mass (or energy density) and vehicle loading*

(for freight vehicles). These will be taken forwards. Additional comments relating to heating/air conditioning have been addressed under the previous question."

In the further comments provided on the proposal to dynamically adjust energy consumption, several respondents appeared to agree with the proposal, and used the comments to highlight important details that should be included in the energy consumption adjustments. For example, it was suggested that:

- Passenger loading should be considered during the modelling of buses and payload impacts are of vital importance for freight.
- Energy use for BEVs has less variation due to regenerative braking.
- Road gradients need to be considered.
- Mass could be considered by longitudinal dynamics.

However, another comment explained that reasonable vehicle loadings are already considered in the CO_2 regulation for HDV (VECTO).

The seven respondents with collaborative responses, and one other respondent suggested instead that the type approval values should only be used.

"***Q15: Fuel/operation split for dual-fuel / PHEVs* – our proposal**: *It is concluded from Round 1 of the survey that there was good support from most experts for all three of the options proposed, with the strongest support for approaches where the share was based on the operation/duty cycle and consideration of how the distribution of different operational modes changed between different road types. The proposals will therefore be taken forward reflecting this. Sensitivities will also be considered to reflect concerns over extreme cases (e.g. owners not regularly plugging in PHEVs, or in contrast making more significant efforts to operate in electric mode).*

There was some agreement with the proposed approach to dealing with fuel/operation split for dual-fuel / PHEVs. Around a quarter of the comments provided highlighted the importance of certain factors on this analysis, the suggestions include:

- Importance of sensitivity analysis and not only assuming a fixed utility factor.
- Energy consumption.
- The duty-cycle.
- Road type (motorway vs urban road).
- Weight MPG.
- Driving patterns.

Seven other responses suggested referring to ECE 1995 (Revision 3)/WLTP and that all other modes may be investigated in in additional scenarios.

There were also some questions raised about this approach in relation to HDVs, as two questioned how it could be applied for these vehicles, with one suggesting 'factor determination'. Additionally, one respondent suggested only keeping the central scenarios.

"***Q16: Vehicle Emissions* - our proposal:** *It is concluded from Round 1 of the survey that most experts have agreed with the approach for estimating real-world tailpipe/non-tailpipe emissions, using existing inventory methods and accounting for variation in activity by road type. The proposals will therefore be taken forward unchanged. However, there is still considerable uncertainty as to how to handle potential future improvements in regulated tailpipe emissions (i.e. future Euro standards beyond Euro 6 / VI). Suggestions would be welcomed for how to approach this in the comments area below."*

Overall, most comments received supported the proposed approach to vehicle emissions, with some proposing some refinements. For instance, it was suggested that sensitivity analysis could reduce uncertainty. One respondent suggesting that these could be defined to cover scenarios by including both little changes compared to current situation, as well as others with a large improvement potential (e.g. based on interviews with policy DGs could be beneficial to help set these scenario definitions). Other recommendations from respondents include using "Euro 7 standards", or real driving emissions tests and Handbook Emission Factors for Road Transport (HBEFA) (two respondents).

However, seven OEM respondents disagreed with this proposed approach, instead suggesting that legislation e.g. WLTP (Euro 6 d) for LDVs, should be used. Additionally, they suggest all other emissions scenarios are incorporated in scenario analysis.

Box 5: Additional commentary on proposed approach

The majority of stakeholders agreed with the proposed approach to estimate direct vehicle emissions based on inventory approaches covering existing regulatory standards. However, no suitable method for accounting for potential future improvements has been found.

The best option appears to be leaving the option open to conduct a sensitivity on potential future improvements, but leaving impacts derived based on current regulatory requirements as the default. The appropriate sensitivity assumptions will be further discussed and agreed with the Commission.

"Q17: **Electrical energy storage - our proposal:** *It is concluded from Round 1 of the survey that most experts have agreed with the approach for characterising energy storage with a more detailed approach for batteries and fuel cells, taking into account potential future technical development (e.g. in Wh/kg or W/kg, vehicle electric range / energy consumption, with appropriate sensitivities). The proposals will therefore be taken forward unchanged; however, a limited data validation exercise for key assumptions with relevant stakeholders will also be considered."*

In general, comments regarding the proposal for electric energy storage were supportive, however there were some amendments and adjustments suggested. Three repeated earlier message that the future technical changes batteries/fuel cells should be included (included size, type and battery characteristics). Another added that future development of ICE technology should not be overlooked. Seven other respondents commented that Li-Ion technology must be the reference/base scenario and that battery producers should be consulted regarding battery technologies.

Others asked for further information, these respondents had not taken part in Round 1.

"Q18**: **Battery replacements **- our proposal:** *It is concluded from Round 1 of the survey that the majority of experts have agreed with the approach for accounting for the frequency of energy storage replacement based on [X] (to be defined) full charge/discharge cycles. This will enable a dynamic link to the assumptions on battery sizing/electric range and lifetime mileage (and potential sensitivities on these elements). The technical performance of batteries with regards to cycle life are likely to evolve (improve) over time; assumptions in this regard should also be tested/validated with relevant stakeholders."*

When asked '*do you agree with the proposed refined approach for defining the number/frequency of battery replacements required?*', around two thirds of respondents indicated they did. In comments, these respondents included a number of suggestions for sensitives/scenarios that should be applied:

- One suggested including depth of discharge (DoD) as a factor (i.e. where there are on average smaller DoD, the battery can perform more cycles in its lifetime), also to factor in that larger batteries usually degrade less as they tend to have fewer deep discharge events.
- One suggested future improvement in lifetime mileage of battery.
- One suggested including sensitivity analysis for different size and utilization of the battery.
- Four respondents suggested the method should include charging characteristics (different charger powers) in analysis/scenarios as this can also affect battery lifetime.

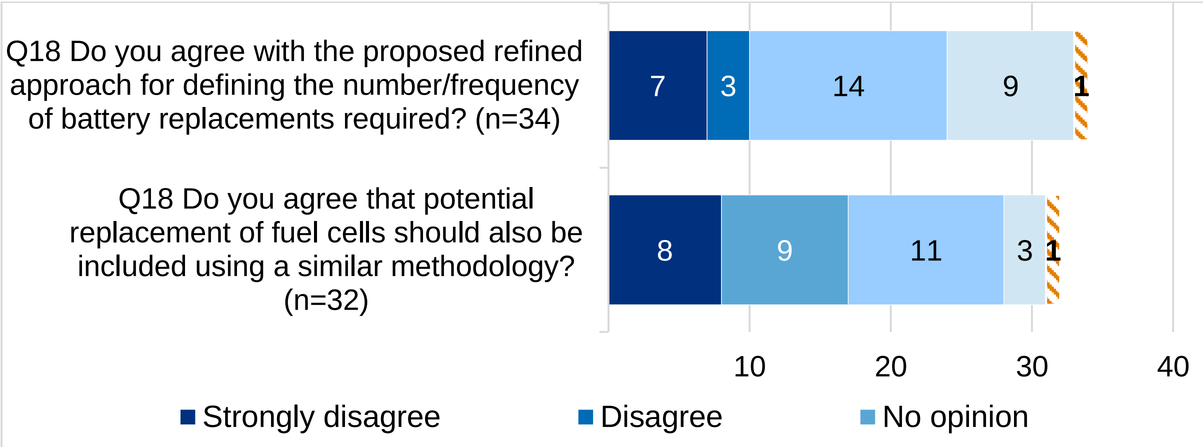
Next the survey asked *'Do you agree that potential replacement of fuel cells should also be included using a similar methodology?*'. There was an increase in respondents answering 'no opinion' compared to the previous question. Most of the remaining respondents indicated they agreed with the proposal.

Three respondents who agreed indicated that there should be no need to replace fuel cells over the life time of the vehicle, although another respondent indicated that fuel cells would need to be replaced only in larger (HDV) vehicles. Another felt that the technology was too new to be sure as to whether fuel cell stacks may need replacing, or not.

One respondent who disagreed stated that a directly similar methodology could not be applied given that it is stack degradation that mainly influences the lifetime of the Fuel Cell System, and not the number of cycles of the storage system, or total energy consumed. Instead it was suggested to use a maximum operating hours or current degradation/decay rate to model this.

The seven OEM responses who answered similarly throughout all selected ‘disagree’ or ‘strongly disagree’ and indicated that one battery and one fuel cell would be sufficient for the life time of a vehicle.

Figure 3-7: Views on battery replacements



Box 6: Additional commentary on proposed approach

The majority of stakeholders agreed with the proposed approach to estimate the number of battery replacements. Some stakeholders suggested adding even more complexity (e.g. accounting for depth-of-discharge, other impacts affecting lifetime), but these are not judged by us to be practical/proportionate for this study. Others also suggested a more simplified approach.

There was a less conclusive result on whether a similar methodology should be employed also for fuel cells; further research is needed to confirm whether this will be possible/appropriate or not.

*“**Q19: Activity and lifetime - our proposal**: It is concluded from Round 1 of the survey that the majority of experts have agreed with the approach for age-dependant activity (i.e. annual mileage) profile and EU average activity split by road type with sensitivities on this to account for variations in use (regional or otherwise). The proposals will therefore be taken forward unchanged.”*

Overall, the comments on the proposal to model vehicle activity and lifetime show both agreement and concerns over the approached proposed. Three respondents added some information on how it could be achieved: two indicated the ranges should be transparent, with one of these suggesting the method uses examples of extremes in the EU to define high and low range values.

However, there was also some disagreement. Three comments suggested the approach should be simplified, one specified that, in particular, the age-dependant activity seems too complicated and another that the distinctions between road types is not useful. Seven harmonised responses indicated they disagreed with this approach, and suggested using data from WLTP driving cycle with a lifetime mileage of 200,000 km.

*“**Q20: Temporal considerations - our proposal**: It is concluded from Round 1 of the survey that the majority of experts have agreed with the approach for accounting for future improvements/changes in mass of the vehicle/glider as a whole (linked also to changes in material composition) and of different components (e.g. via energy or power density), and projections for future vehicle energy consumption. The proposals will therefore be taken forward unchanged.”*

Most respondents used the opportunity to provide further comments to show their agreement with the approach to temporal considerations. One respondent noted this should be included as a sensitivity. Another two suggested the method should consider including improvement to mass of LDVs temporally. However, one comment expressed another view. They disagreed with the approach and said that new studies showed ‘different results’, but did not provide any examples.

*"**Q21: Spatial considerations - our proposal:** It is concluded from Round 1 of the survey that the majority of experts have agreed with the approach for accounting for EU level variability in vehicle efficiency, emissions and mileage by road type, plus sensitivities to investigate the degree of variability in these by country or duty cycle. As discussed above, we will also investigate the feasibility of a sensitivity on the impact of particularly hot/cold climates on the energy consumption performance of different powertrain types.*

Comments provided by respondents are mainly supportive of the methodological spatial considerations proposed. Some respondents went on to specify the sorts of considerations they thought were important to be included:

- Two indicated that the difference between hot/cold climate is important.
- Two indicated spatial considerations needed to include altitude changes.
- Two indicated the difference in urban and long-haul truck mileage.

Additionally, six stated that it was important to maintain a similar level of sophistication through the methodological approach, specifically they advocated that the study should ensure that the main considerations are based on a consistent baseline scenario (WLTP).

Three OEM respondents, however, voiced their disagreement. For two respondents, this related to the treatment HGVs, both highlighting the Regulation (EU) 2017/2400 for determination of HDV CO_2 emissions and fuel consumption. One went on to explain that it includes a vehicle classification which considers vehicle groups, mission profiles and vehicle configurations and that these factors have a major impact on life cycle impacts. One added that they did not believe that including accounting road type nor country simplification were appropriate. A further respondent disagreed stating that the method should concentrate on a central scenario.

3.3 Section 3: Methodological considerations for vehicle production, maintenance and disposal

Overall, responses received in the first round of the survey also conveyed a general level of support for the proposed methodology for vehicle production and end-of-life. Some questions were raised regarding the topic of recycling quotas, which are covered in Question 27 here.

Round 2 responses generally show respondents agree with the proposed methodologies for vehicle production and disposal. While some disagreement is voiced regarding the glider and factoring locations, respondents tended to offer suggestions for refinement rather than object to the proposals.

*"**Q23: Relevant components - our proposal:** It is concluded from Round 1 of the survey that the proposed level of differentiation of vehicle components [1] was largely regarded as appropriate for a detailed assessment of the average/overall vehicle market. A differentiated material inventory will be used to characterise each of the proposed components, with a more detailed approach to be adopted for characterising traction battery, the fuel cell system and the H2 storage."*

Comments received supported the proposed approach to using a differentiated material inventory for relevant components. One respondent, who was in support of the proposal, added that different technologies, (Type I to IV) for CNG tanks should also be included, as for hydrogen storage system.

However, there were also some disagreements voiced. Seven nearly identical OEM responses indicated that the approach was too complicated. Another respondent aired similar sentiments, and suggested fewer vehicle components could be considered for policy purposes.

*"**Q24: Scaling factors - our proposal:** It is concluded from Round 1 that scaling factors are appropriate for most components and will therefore be used in the study to define these components for each vehicle type relatively to the baseline vehicle. Further aspects beyond simple scaling will be considered for the traction battery, the aftertreatment system and the fuel cell.*

The majority of respondents provided further comments to reiterate their agreement with the proposed use of scaling factors. Additionally, one respondent suggested it could be simplified by reducing the number of vehicles. Seven responses all said that linear scaling factors can be applied to materials but not to production processes. Another respondent focused on the application to HGVs, stating that upscaling was not appropriate for the vehicle type meaning that the material composition should come from '*an actual HGV'*.

*“**Q25: Vehicle Manufacturing: assumptions regarding the ‘glider’ – our proposal:** It is concluded from Round 1 of the survey that using a standardised material composition by vehicle type for the glider enjoys slightly more agreement than disagreement among the stakeholders. Nevertheless, it is acknowledged that the diverse vehicle market in reality may lead to considerable differences in material composition for specific vehicle types. Since the study explores generic vehicle types and transport service rather than specific vehicles, the approach of using standardised material composition will still be pursued. Reasonable care will be taken to reflect the average market mix for vehicle bodies. Material with relevant differences in usage can be explored in sensitivities.”*

Overall, most of the respondents reinforced their support regarding the proposed use of the ‘glider’. There were some additional comment regarding future material compositions:

- Two added that outliers and assumptions need to be closely monitored, and their impact on results considered.
- One indicated that if a significant amount of OEMs plan to use light weighting materials, in particular on the EVs, this should be captured in a sensitivity.

One respondent suggested scenario analysis covering ‘carbon fibre, high strength steel and aluminium’ The effect of future material compositions was also highlighted by one respondent, who was less keen on the proposal, arguing that a standardised glider is not sufficient due to future changes in material compositions. Another respondent was opposed to including this analysis in sensitivities, stating that it should be included in the main methodology: ‘*It should not be worked with sensitivities separate to the main results but with ranges incorporated in the main results (in general and also for glider assumptions).*’

*“**Q26: Vehicle Manufacturing: production location - our proposal:** More respondents to Round 1 of the survey agreed than disagreed with the proposal of considering average European conditions (e.g. in respect to electricity) for vehicle assembly. Nevertheless, reasonable concern has been voiced also at the Expert Workshop which argued towards differentiation of vehicle producing countries within the EU as well as consideration of vehicles imported from outside the EU. It is therefore suggested to consider an electricity split reflecting the market mix of EU new registrations by country of origin (e.g. based on OICA vehicle production statistics and Eurostat data on imports). Likewise, the countries of origin will be considered for important components as initially proposed. Which countries/regions should be individually considered for vehicle production? Please provide your suggestions in the boxes below:’*

Overall, comments supported the proposed approach to dealing with vehicle manufacturing locations. Respondents suggested a number of countries that could be included in analysis, Table 3-1 includes a list of suggested EU countries and the number of respondents that suggested the country, Table 3-2 contains the same for non-EU countries. The most commonly suggested EU countries were France, Germany and Hungary with nine, eight and six respondents suggesting them, respectively. For countries outside of the EU, China, Japan, the USA and South Korea were most commonly mentioned, with 11, seven, six and six respondents suggesting them, respectively. Additionally, four comments suggested reviewing car production figures to determine which EU countries should be selected.

Table 3-1: Question 26 Which countries/regions should be individually considered for vehicle production? - EU countries

MS	No. Respondents
Czech Republic	1
France	9
Germany	8
Hungary	2
Italy	4
Poland	6
Romania	1

MS	No. Respondents
Slovakia	1
Spain	4
Sweden	2
UK	5

Table 3-2: Question 26 Which countries/regions should be individually considered for vehicle production? -Non- EU countries

Country	No. of respondents
Brazil	3
China	11
India	3
Japan	7
South Korea	6
Mexico	1
Morocco	1
Turkey	1
USA	6

Table 3-3 contains the reasons respondents gave when explaining which countries should be included in the analysis. Other comments from two respondents who didn't specify countries also highlighted the importance of gathering data from countries of different extremes regarding energy production.

Seven other responses suggested that regional mixes could be used to simplify this process.

Table 3-3: Question 26 - Justifications for suggesting countries

Reasoning	Countries
Substantial manufacturing industry	Czech Republic, France, Germany, Hungary, Italy, Poland, Romania Spain, Slovakia, Sweden, United Kingdom
Variability in electricity mix	Italy, France, Germany, Poland, Sweden, United Kingdom Specific contrasting examples provided by respondents: • Difference between Sweden, Poland and China, • France (Low-CO_2/nuclear) compared to Poland (high CO_2/ coal)

Box 7: Additional commentary on proposed approach

The proposal to factor in the location of vehicle production into the analysis was broadly supported by stakeholders in Round 2 of the Delphi Survey, also confirming the analysis to consider the EU mix as well as potentially other key regions including primarily China, Japan, the USA and South Korea. To manage complexity, it is not proposed to provide separate estimates for different countries, but rather estimates based on an appropriately weighted average of different regions (with the share fixed across the timeseries), possibly with some specific sensitivities for production in particular territories. A similar approach is proposed for xEV batteries, although a timeseries is proposed for the share of production of these, reflecting an anticipated change in this area from the current situation.

*“**Q27: Use of recycling quotas/rates - our proposal:** Recycling quotas remain of relevance as long as a cut-off approach is not solely performed for the End of Life (EoL). It is concluded from Round 1 of the survey that considering European recycling quotas/rates for the current situation is appropriate for vehicles remaining in the EU for the full vehicle life cycle. The relevance of vehicles with an EoL outside the EU needs to be further evaluated, also in light of a potential default cut-off approach. Do you think that vehicles leaving the EU should be treated differently (e.g. with different recycling quotas/rates) than vehicles remaining in the EU for the full vehicle life-cycle?”*

The previous round of the survey concluded that European recycling quotas/rates for the current situation is appropriate for vehicles remaining in the EU, round two therefore asked about the treatment of those leaving. As shown in Figure 3-8, just over half of respondents do not think that vehicles leaving the EU should be treated differently.

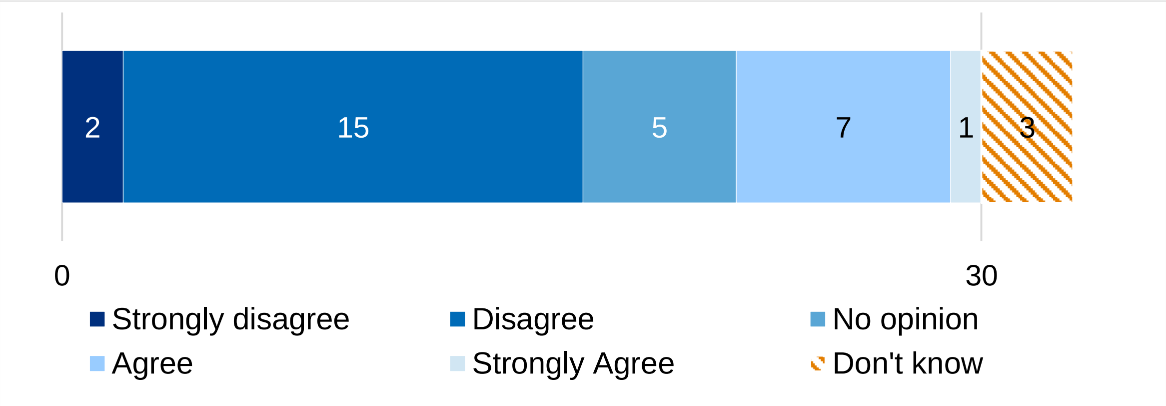
Comments from those who disagreed cite a number of reasons, focusing on European recycling quotas, the complexity this approach could add, and carbon leakage. For example, there was support for continuing to use European recycling quotas, from two respondents. Additionally, one of these respondents added that recycling quotas included in the ELV Directive refer only to specific type of vehicles, not to all the vehicles. Another respondent suggested that European recycling quotas were misleading, providing the example of ELV recovery rate in Germany which exceeds 100%.

Additionally, two suggested this would add unnecessary complexity to the project. Two also indicated that the data would be difficult to come by. In a similar vein, another respondent went further to explain that recycling rates do not vary significantly between countries, and the end of life method could be simplified by removing country specific calculations. Another respondent who disagreed indicated that vehicles should be treated the same way in order to prevent carbon leakage and selling polluting vehicles to EU's immediate neighbour countries to the East and South.

It is important to note that seven coordinated responses all disagreed, and said that ‘type approval recycling is not bound to geographical scope.’

Of those who ‘agree’ or ‘strongly agree’, two comments suggested that it was important due to different recycling rates and a further two added that the effect of the UK leaving the European Union should be included in the analysis.

Figure 3-8: Views on whether vehicles leaving the EU should be treated differently than vehicles remaining in the EU for the full vehicle life-cycle (n=33)



Box 8: Additional commentary on proposed approach

There were mixed views from stakeholders, with no clear majority view, on whether vehicles leaving the EU should be treated differently to those remaining in the EU for the full vehicle life cycle. Since this is highly uncertain, we believe it would be best addressed with a simple sensitivity. The default case would be to assume the average vehicle has a full lifetime in the EU and is also recycled/disposed of in the EU at the end of its life. The alternative case could be provided as a simple sensitivity – with the details to be confirmed with DG CLIMA.

*"**Q28: Second life batteries - our proposal:** It is concluded from Round 1 of the survey that second life of batteries should be considered due to their potential importance, but only as a sensitivity in this study and not as a default in the vehicle life cycle due to the high uncertainty. Applying a credit based on avoided use of an equivalent new storage appears to be the most feasible option and was also supported by the majority of the stakeholders."*

In general, respondents' comments denote their agreement that the second life of batteries should be considered in a sensitivity due to their potential importance. Two highlighted the importance of considering the loss of performance of 2nd life batteries. One went on to suggest definitions of the sensitivities: one wherein there is no 2nd life battery use.

One respondent pointed out the diverse range of battery chemistries and the differences in the ability to recycle or re-use certain materials. They proposed showing a range of impacts shown, especially from pyrometallurgical battery recycling; including a worst-case scenario that highlights possible negative impacts like toxic waste and poor material re-use. It was also suggested to show a recycling scenario without any credits from secondary materials. There were also two respondents who considered the proposed methodology to be methodologically sound but were unsure of its overall importance. One of these added that the process is unrealistic in today's market given the cost and warranty issues. There was also a question of how to 'allocate the impacts to 1st and 2nd life'.

On the other hand, one respondent thought that the second life of batteries should be included in the main methodology due to uncertainty in the 'share of batteries being re-used' which would best be dealt with using ranges, rather than sensitivities. Another respondent suggested returning to the suggestion from Round 1, in which 'credit applied based on comparison of LCIA of second-use battery versus an alternative reference case.' was proposed.

*"**Q29: Temporal considerations - our proposal:** The proposed temporal aspects have been largely supported by the stakeholders. It is therefore concluded from Round 1 of the survey that a temporal variation should be considered for the electricity splits for vehicle and component production as well as overall improvements in the production process (especially for battery production), shifts in the material composition of the vehicle body (vehicle weight, light-weight materials), policies on use of secondary material/ recycling quotas and new battery chemistries.*

Overall, respondents provided further comments to demonstrate their agreement with the proposed temporal considerations. Their comments highlight the importance of some of the topics mentioned in the question:

- Two highlighted the importance in changes in electricity mixes
- One highlighted the importance of end of life treatment. Adding that predations are often too optimistic regarding rates.
- One referred to the importance of changes the material composition.

Additionally, one respondent added a new topic for consideration in the temporal analysis, suggesting that future mobility trends (i.e. car sharing) were considered.

One respondent, however, disagreed with the proposal regarding the material composition, stating that it should not be included in temporal analysis.

3.4 Section 4: Methodological considerations for liquid and gaseous fuel lifecycles

A number of questions remained regarding liquid and gaseous fuel lifecycles from Round 1 of the survey. This section in Round 2 therefor included a number of multiple-choice questions seeking clarification on the proposed methodological considerations. While there was broad agreement on many of the topics discussed, there remained some debate around addressing multi-functionality, accounting for secondary fossil feedstocks, counterfactual uses of secondary fossil feedstocks, counterfactual uses of secondary fossil feedstocks, biogenic residue and fertiliser emissions.

"Q31: Reference flows – our proposal: Round 1 of the survey revealed that 83% of respondents agree with the proposed reference flow for this sub-section of the vehicle life cycle (i.e. 1 MJ of fuel delivered). Practically, this reference flow will enable the practitioners to calculate impacts generated by fuel production, which can then be added to and transformed into impacts in the 'vehicle in use stage'. Those will be expressed in the functional unit of the overall vehicle life cycle (vehicle km), which represent 'well to wheel' impacts – please see Question 7 for more information on reference flows and functional unit."

The majority of respondents agreed with this approach to reference flows. Six respondents suggestion regards the reference flows for the full vehicle LCA (e.g. additional FU in t.km or MJ/t.km). Two respondents had concern over the treatment of HDVs which may need additional functional units of tkm or MJ/tkm. One respondent highlighted the potential need for the inclusion of an occupancy rate as the reference flow is in MJ and the functional unit is then per km (which are taken into consideration in other sections).

"Q32: Environmental impacts/mid-points - our proposal: The issue of impact categories is addressed for the whole LCA methodology under "General Methodology" (Section 1) and is therefore no longer included in this section."

The response rate for this question was quite low, with some respondents expressing general agreement. One respondent recommended the use of ILCD midpoint categories for guidance, which is the case in this methodology.

"Q33: Emissions from capital goods - our proposal: Results from round 1 of the survey showed that respondents gave a moderately higher importance to the inclusion of capital goods in the LCA. Impacts associated with capital goods may be significant for low volume alternative fuels, electrolysis and renewable electricity production. Necessary data is likely to be available. We therefore propose to include emissions associated with capital goods in the fuel production chain."

There was reasonable support for this approach to emissions from capital goods. Some respondents added conditions for consideration: Seven responses suggested the approach requires reliable data is available, warning that there is low quality of data on this topic. Another respondent indicated data in this area was also a concern. Two respondents highlighted the importance of a consistent approach across the different fuels (e.g. infrastructure for oil extraction/refinery, hydrogen production, transport etc.).

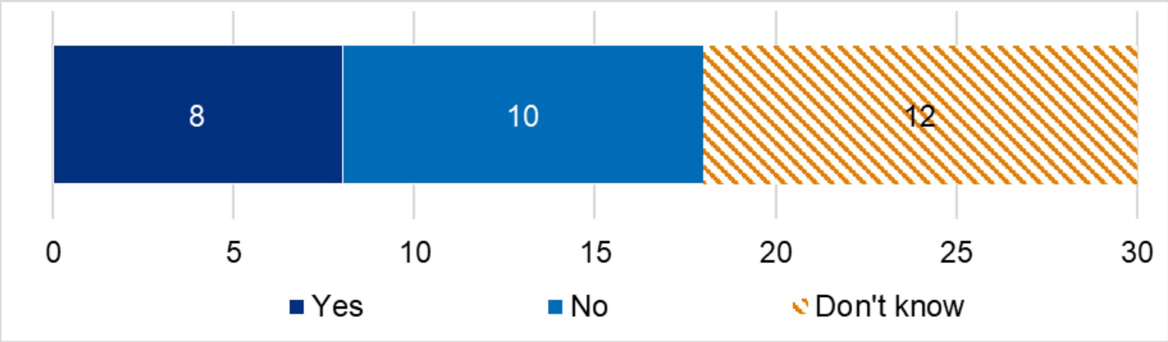
"Q34: Addressing multi-functionality at the refinery - our proposal: In light of the disagreement of round 1 survey respondents with the proposal of allocating burdens according to the economic value of all products of crude oil refining, we suggest consideration of an alternative modelling approach by Horst Fehrenbach and Axel Liebich (ifeu). This natural science based approach has the additional benefit of avoiding the need to project future prices of refinery products as the LCA is projected out towards 2050. Do you agree with this approach?"

Answers to this question on the approach to addressing multi-functionality at the refinery are evenly split between yes, no and don't know, with no major trend.

Of the comments received from respondents who answered 'no', one said that liquid fuels should not be unduly disadvantaged by the method, another suggested that care must be taken over unintended outcomes. Additionally, another respondent expressed concern and suggested that this method may not be suitable for products with non-energy purposes.

Alternative approaches were also suggested: one respondent suggesting that the Concawe methodology is preferable for the approach taken for refining products. Another respondent proposes the use of mass allocation for the refinery burdens, adding that step 3 of the proposed methodology is not reflective of the real world. Three comments discussed non-intended co-products, with one respondent suggesting that no burden should be allocated, and another suggesting their impact should be included.

Figure 3-9: Views on multi-functionality approach at refineries (n=30)



Box 9: Additional commentary on proposed approach

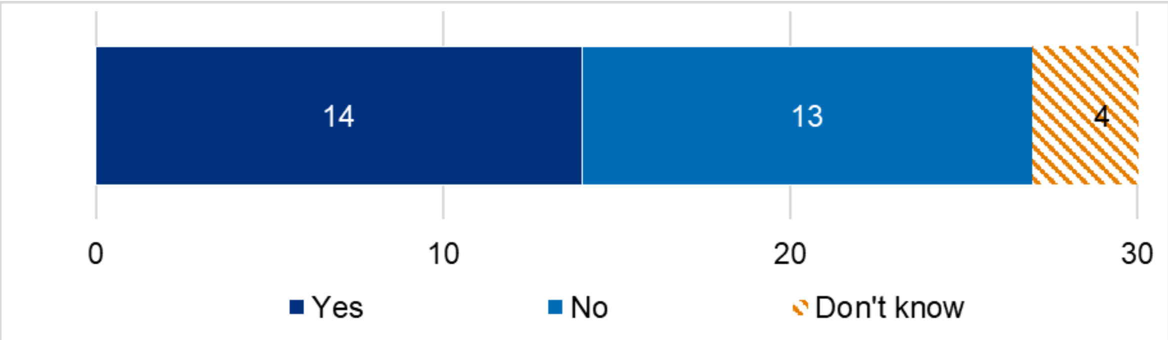
It was decided to use the ifeu model – please see Box 1 for a summary of the reasons that motivated this choice.

"Q35: Accounting for secondary fossil feedstocks – our proposals: Secondary fossil feedstocks are fossil feedstocks produced as a waste/residue of another primary process, including waste fossil CO2. We suggest that for secondary fossil feedstocks, carbon must be explicitly tracked in the LCA so that e.g. avoided emissions in upstream/primary processes are given a credit and emissions from fuel combustion are accounted for. For example, when CO2 is used as a feedstock it would be given a credit for avoided emissions (not only CO2, but also other substances) from the primary process, and then counted as a CO2 emission only when the fuel is combusted. Do you agree with this approach?"

This question received a comparable number of positive and negative responses. It should be noted, however, that the seven respondents with similar responses throughout all disagreed with the proposal.

Suggestions from those supporting the method include two comments that indicated there was a need to account for avoided CO_2 emissions (and allocate them to the fuel) and avoid double counting. One suggestion was to not to refer to CO_2 as feedstock since it does not carry energy. No alternative approach was suggested. The respondents that did not agree with the proposed approach were asked to provide an alternative approach. Most of the responses do not provide an alternative approach but rather, discuss the issues they associate with the proposed approach. The seven respondents which provided similar answers throughout suggested that 'credit needs to stay with the fuel, otherwise no e-fuels will be available'.

Figure 3-10: views on approach to accounting for secondary fossil feedstocks (n-31)

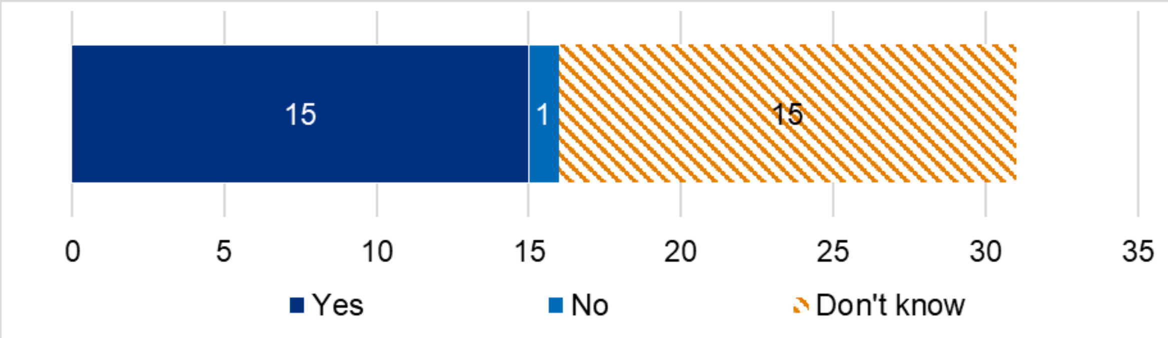


"Q35.2: We suggest that in cases where the secondary fossil feedstock was diverted from an existing productive use (e.g. waste plastic combusted to generate heat or power), the indirect emissions associated with replacing this useful product should be assigned to the secondary fossil feedstock. This represents a system expansion approach to include the previous use of the secondary fossil feedstock. Do you agree with this approach?"

This additional question sought greater consensus regarding the system expansion approach and the previous use of secondary fossil feedstocks. There was a significant amount of support for the proposal, as well as a large contingent of respondents indicating they 'don't know' The seven respondents that provide similar responses throughout indicated 'don't know' in response to this question and added that that system expansion was suitable as long as double counting was avoided.

No respondents provided a suggestion for an alternative methodology. However, one respondent raised concern regarding displaced emissions from diverting a low value feedstock from other uses. Several comments also suggest ensuring a high level of transparency over the calculations performed.

Figure 3-11: Accounting for secondary fossil feedstocks – system expansion approach (n=31)



Box 10: Additional commentary on proposed approach

Given very little opposition to this suggestion, and with no alternative approaches provided, the system expansion approach for secondary fossil feedstocks will be adopted. Whilst some LCA methodologies to-date do not burden waste feedstocks with any environmental impacts (e.g. RED methodology), this approach may underestimate the environmental impact of diverting waste feedstocks from an existing productive use. Therefore, in this study, in cases where the secondary fossil feedstock was diverted from an existing productive use (e.g. waste plastic combusted to generate heat or power), the indirect emissions associated with replacing this useful product will be assigned to the secondary fossil feedstock. This 'system expansion' approach brings within the system boundary of fuels produced from secondary fossil feedstocks the environmental impacts of diverting that feedstock from an existing productive use, and consequently replacing the heat or power or other utility that was produced. If through diverting a secondary fossil feedstock to liquid fuel production instead of an existing use, the release of that CO_2 is avoided, then this should be treated as a credit (i.e. negative GHG emission) in the GHG intensity of the feedstock. The CO_2 emissions should then be counted when the fuel is combusted. This approach aims to avoid either losing or double-counting GHG emissions.

Nevertheless, some of the comments provided by the consulted stakeholders reveal concern about using the system expansion approach when CO_2 is used to produce fuel (often called e-fuels, due to the requirement for an energy source such as electricity to transform CO_2 into a fuel).

- The proposed approach would essentially allow the fuel production process to use CO_2 as an input with net zero emissions from it (as the avoided CO_2 emissions credit cancels out with the combustion emissions from the fuel). Some respondents were concerned there could be confusion over the proposed approach and a risk of double-counting.
- Some respondents thought that there should be no 'credit' for avoided CO_2 emissions, so that the CO_2 released when the fuel is combusted is attributed to the fuel as a release of fossil CO_2.

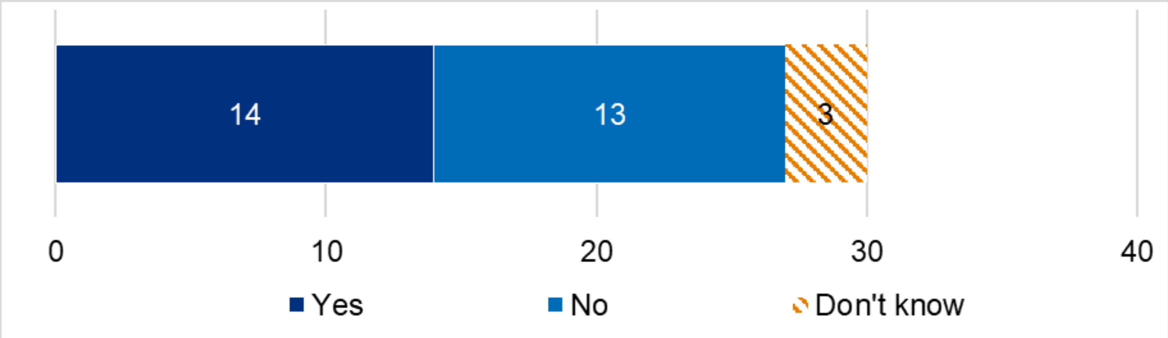
We think that being explicit about the avoided CO_2 emissions and then accounting for the CO_2 when the fuel is combusted makes the proposed approach more transparent and lowers the risk of double-counting. However we note that under the proposed approach there is an assumption that the original producer of that CO_2 accounts for its release under the appropriate regulations in the sector in which it was originally emitted, such as the ETS.

"Q36: Approach to counterfactual uses of secondary fossil feedstocks – our proposal: Throughout the LCA of fuel production chains we suggest taking into account average environmental impacts (as opposed to marginal impacts) owing to practicable feasibility. Do you agree that this approach is sufficient?"

A comparable number of respondents rejected or supported the proposed approach. Yet it is important to note that the seven respondents who supplied similar answers all answered 'no'.

Supporters acknowledged the feasibility and efficiency, with one commenter adding that it was to consider multiple future scenarios (e.g. 2030 and 2050). As for those who did not support the approach, two respondents raised concerns about ensuring that the proposed approach and alternative approaches had been properly tested and compared to validate the suggested approach (two respondents). Another respondent who answered no, suggested a comparison between an average and marginal approach.

Figure 3-12: views on Approach to counterfactual uses of secondary fossil feedstocks



Box 11: Additional commentary on proposed approach

For the purposes of this study, the 'average' impact will be used as a baseline, but in cases where a large variation between average and marginal emissions has a significant impact on results, marginal emissions will be used as an alternative.

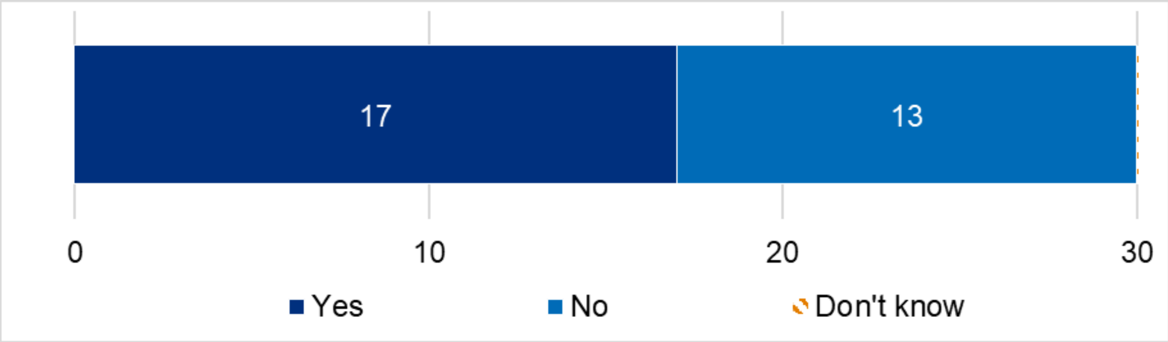
Comments from survey respondents generally requested that both the average and marginal approaches be used and compared, particularly in cases where this is expected to have a big impact on the overall results. Choosing a priori some emissions factors or impacts where the average and marginal are expected to have a big impact on results and investigating these in more detail obviously introduces a bias in favour of those areas where substantial work has been done and where this impact is already known. However, to assess the impact of average compared to marginal data for all inputs would require both average and marginal data sets being collected for all inputs, which is not an effective use of resources for this study.

"Q37: Inclusion of land use change – our proposal: Some respondents to round 1 of the survey "disagreed" with the inclusion of iLUC in a fuel LCA. The Expert Workshop held on February 25 revealed that this disagreement is rather related to the terminology of "direct" vs "indirect" land-use change. Some stakeholders disagree with the concept of "direct" land-use change and suggested evaluating any land-use change (direct or indirect) through "land-use scenarios" by using global economic models such as GLOBIOM or GTAP. However other stakeholders expressed a preference to evaluate direct LUC through an attributional LCA whereas iLUC would be addressed through a consequential approach. Do you agree that the fuel LCA methodology should aim to evaluate any land-use change [1] caused by fuel production (both fossil and biogenic)?"

This question aimed to establish greater agreement in regard to the approach to include land use change. The responses are slightly more in favour than against the proposal. It is noted, however, that the comments received from two of those who responded 'yes' suggest not considering iLUC. This is at odds with the proposed approach.

Beyond these comments, two clear positions can be identified: Some respondents suggest aligning with current policies (e.g. EU RED), which do not include iLUC. Whereas others suggest going beyond these, to ensure this methodology fills an important gap in how GHG emissions are accounted.

Figure 3-13: Inclusion of land use change (n=31)



"Q38: Characterising land use change – our proposal: As mentioned in the previous question, disagreements exist over the best approach to address different types of land-use change. In round 1 of the survey, the use of GLOBIOM comes out ahead of other models, which were picked by fewer respondents or not picked at all. It was confirmed at the Expert Workshop that GLOBIOM would likely be more adapted to the EU context.

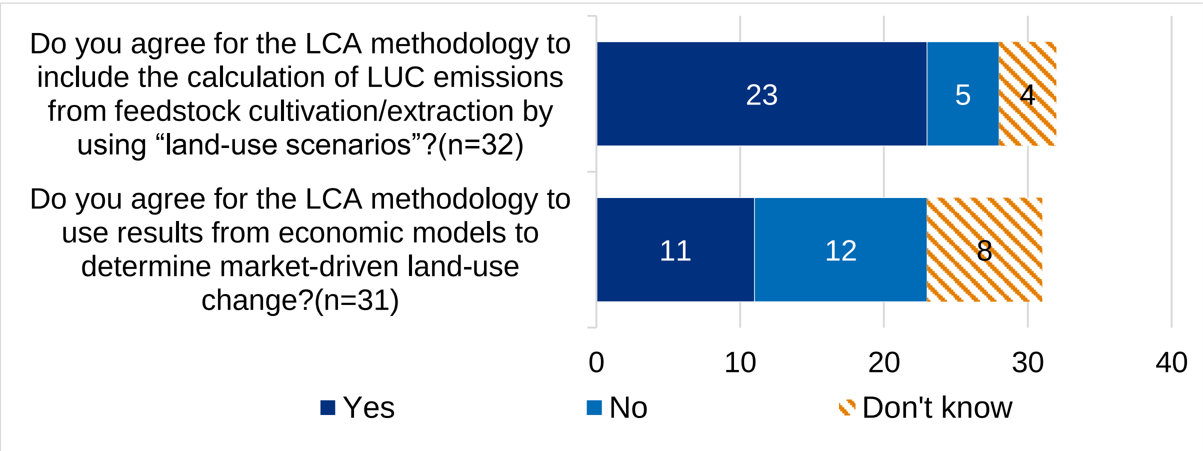
Do you agree for the LCA methodology to use results (expressed per functional unit) from economic models (e.g. global or partial equilibrium) to determine market-driven land-use change (i.e. due to the displacement of feedstock production/extraction for non-energy sectors due to an increased diversion of feedstock for fuels)?"

The survey asked three questions regarding the approach to characterising land use change. The majority of respondents agreed with the first proposal to use land-use scenarios. One respondent suggested that it needs to be made clear that land use change is outside of attributional LCA. Two respondents, who disagreed with the proposal, suggested that only direct LUC should be used.

The suggestion to use economic models did not meet as large as majority as the preceding question, with a similar pattern of answer as with the suggestion to address all types of LUC. One respondent suggested using both econometric and causal-descriptive, the latter being more appropriate to evaluate long-term effects.

All respondents who support the use of economic modelling agreed with the use of GLOBIOM as the model by default. Some of them suggest exploring the possibility to use Monte-Carlo analysis, MIRAGE, JRC's top down analysis (http://publications.jrc.ec.europa.eu/repository/handle/JRC83819) in addition to GLOBIOM. One respondent raised concerns regarding GLOBIUM, as it is not publicly available and suggested using the Global Trade Analysis Project (GTAP) instead.

Figure 3-14: Characterising land use change



Box 12: Additional commentary on proposed approach

As suggested by stakeholders, land-use change scenarios will be used to characterise related emissions, using default values such as those established by the IPCC and used in the Renewable Energy Directive.

In response to the challenge of distinguishing between direct and indirect LUC as highlighted by a few stakeholders, we will avoid using these terms to the extent possible by using a model which addresses both at once. As such, land-use change estimates and resulting GHG emissions will be obtained from the GLOBIOM model and added to the corresponding midpoint used at the LCIA stage (GWP). Alternative models such as GTAP or MIRAGE may be considered in certain circumstances.

"Q39: Biogenic residue – our proposal: For simplicity reasons, we suggest not making a distinction in the LCA methodology between waste and residues. Do you agree?" "Do you agree that the EU RED II definition of residues would be adapted to a consequential approach (e.g. straw and palm oil fatty effluents are residues from the production of cereals and crude palm oil respectively)?"

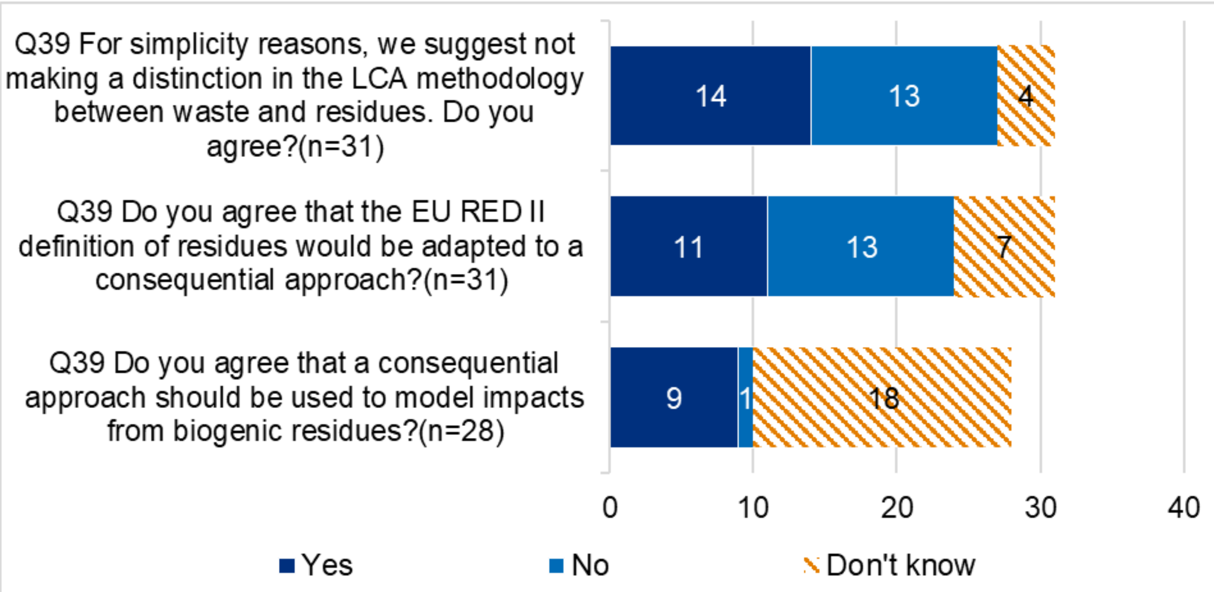
As shown in Figure 3-15, respondents were split evenly between 'yes' and 'no' regarding the proposal for dealing with biogenic residue in the methodology. The seven responses who provided identical answers all indicated 'no' on this question.

However, while almost half of the respondents disagreed with the approach, analysis of comments reveal that several were under the impression that the suggestion was to consider residues are waste. For instance, concerns were raised that if a waste product is used, this impacts the supply chain, it no longer can be defined as a waste, which is in line with the suggested approach to consider waste as residue (i.e. with an economic value).Since the suggested approach is more robust (i.e. not considering any feedstock as waste), one may consider that the degree of support would probably be larger.

The second question also received significant number of 'nos. In comments, two respondents highlighted concerns with RED II's definitions. It is also important to consider that some respondents who indicated 'no' understand the proposal suggested using the EU RED II **approach** to residues, whereas the intension was to use the EU RED II **definition** of residues. The suggested approach to evaluate the impact of residues is to use system expansion, which is not in line with EU RED II (energy allocation). Therefore, the level of support to the suggested approach could be higher.

Finally, regarding the consequential approach to model the impact of biogenic residues, a large proportion of respondents (18) indicated they 'don't know'. Those who did reply almost all supported the approach.

Figure 3-15: Views on biogenic residue proposal



Box 13: Additional commentary on proposed approach

It was decided not to use the term waste, since the characterisation of feedstock as waste is generally controversial, especially regarding the demonstration of conformity with the definition of waste as in the EU Waste Directive. Therefore, all secondary biogenic feedstocks shall be considered and treated as residues.

They are defined following the definition of EU RED II, i.e. a substance that is not the end product(s) that a production process directly seeks to produce; it is not a primary aim of the production process and the process has not been deliberately modified to produce it.

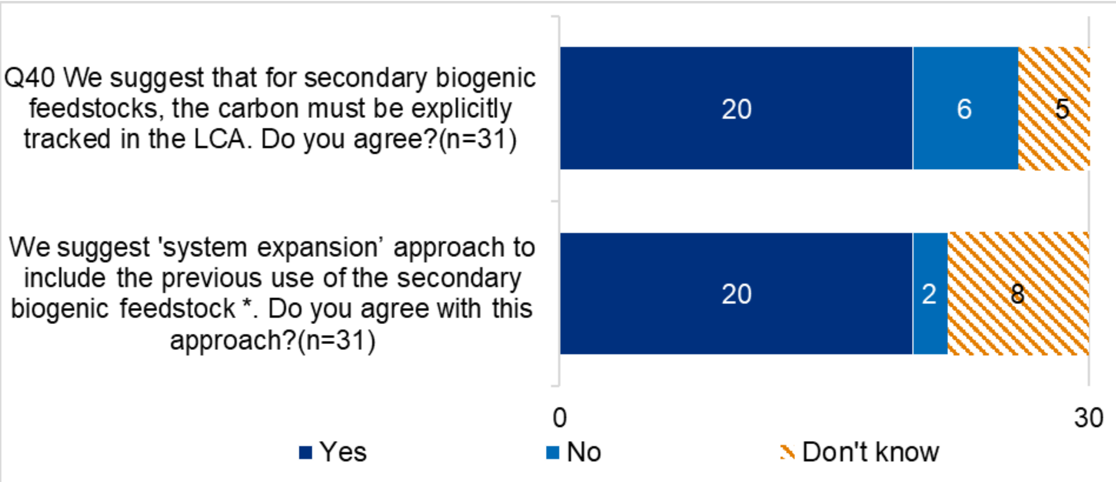
While few stakeholders disagreed with the consequential approach, a large majority expressed no opinion on the issue. As such, the upstream impacts related to secondary biogenic feedstocks will be accounted for through a consequential approach (system expansion), which accounts for the environmental impacts of diverting them from an existing use. This treatment is in line with the one proposed for secondary fossil fuels, therefore giving secondary feedstocks consistent treatment. For example, where the secondary biogenic feedstock was diverted from an existing productive use (e.g. straw combusted to generate heat or power), the indirect emissions associated with replacing this useful product should be assigned to the secondary biogenic feedstock.

"Q40: Secondary biogenic feedstocks – our proposal: Secondary biogenic feedstocks are biogenic feedstocks produced as a waste/residue of another primary process, including waste biogenic CO2. We suggest that for secondary biogenic feedstocks, the carbon must be explicitly tracked in the LCA so that e.g. avoided emissions in upstream/primary processes are given a credit and emissions from fuel combustion are accounted for. For example, when biogenic waste is used in liquid fuel production a credit is given for avoided methane and biogenic CO2 emissions from waste decomposition, and then counted as an emission of biogenic CO2 when the fuel is combusted."

"We suggest that in cases where the secondary biogenic feedstock was diverted from an existing productive use (e.g. straw combusted to generate heat or power), the indirect emissions associated with replacing this useful product should be assigned to the secondary biogenic feedstock. This represents a 'system expansion' approach to include the previous use of the secondary biogenic feedstock. Do you agree with this approach?"

A significant majority of respondents were in favour of the proposed approaches to secondary biogenic feedstocks. No comments were received from respondents who indicated 'yes'. Of the respondents who selected 'no', some suggested amendments to the approach to track carbon were received. This included the need to include temporal dynamics (esp. for credited emissions) (one respondent); that residues used for biofuel production has a higher economic value and should therefore carry a larger share of emissions (two respondents); and that both biotic and abiotic carbon should be considered (one respondent).

Figure 3-16: Question 40 Secondary biogenic feedstocks proposal



Box 14: Additional commentary on proposed approach

The majority of stakeholders supported the proposed approaches to secondary biogenic feedstocks. In general the methodology used to assess fuels produced from secondary biogenic feedstocks will be the same as that used for primary biogenic feedstocks. However, several issues exist for secondary biogenic feedstocks, which require a specific treatment:

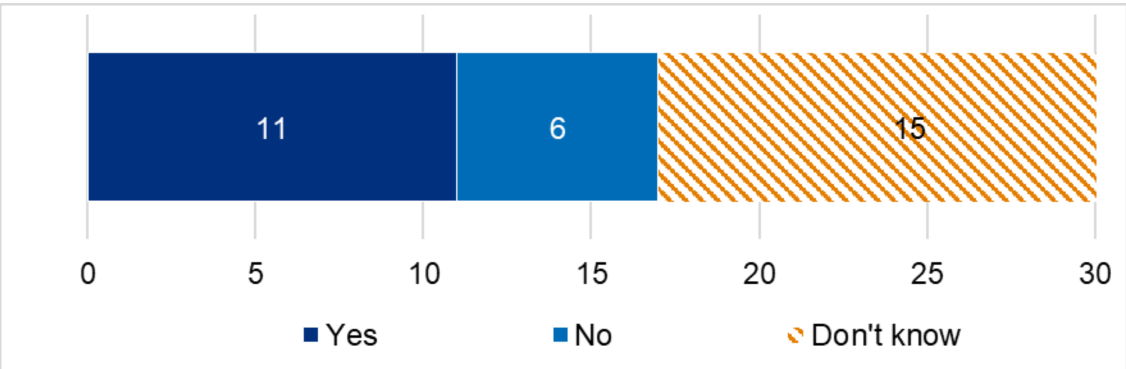
- The characterisation of feedstock as biogenic residues; and
- The upstream allocation of environmental impacts to biogenic residues through system expansion ('counterfactual uses'). Such approach will take both positive and negative effects from diverting biogenic residues from other uses (e.g. incineration for power production or landfilling) into account.

Biogenic CO_2 is included within the definition of 'secondary biogenic' feedstock, and will be treated using the same system expansion approach. As a result, no emissions burden will be associated with producing fuel from waste biogenic CO_2. However under this method, the production process in which the CO_2 was created shall not claim a negative emission from capturing or re-using the CO_2, as ultimately that CO_2 still gets released to the atmosphere.

*"**Q41: Soil organic carbon – our proposal:** The limited response on this topic observed during round 1 of the survey was confirmed during the Expert Workshop. Few stakeholders expressed any strong views on the topic; those who commented on the topic consider that changes in SOC would not significantly impact final results in most cases and that potential options would not adequately address changes in SOC. For case where SOC may significantly impact results, one suggestion was made to use GBEP indicators, but those require primarily in situ measurements of soil carbon, which appears impractical in the context of conducting an LCA. In absence of a concrete recommendation as to how to practically integrate SOC modelling results in LCA, we suggest not considering SOC losses in the methodology until options more adapted to use in a LCA are available. Do you agree?"*

The large number of respondents stating they "don't know" reflects the limited level of expertise regarding whether SOC losses should be included in the methodology. Among those who replied, a significant majority supported the proposed approach. Among those who rejected the approach, one detailed comment was left describing the magnitude of SOC losses in intensive agriculture and how SOC could be practically included in an LCA by using an EU-average value for SOC losses. Additionally, it was noted that by that there are sufficient SOC datasets available for use (one response) and SOC can have a significant impact on the LC outcome (one response).

Figure 3-17: Views on inclusion of SOC in the LCA (n=32)



Box 15: Additional commentary on proposed approach

Few stakeholders expressed a strong opinion about SOC. It was decided to test its inclusion in the methodology to allow evaluation of the practicality of the approach.

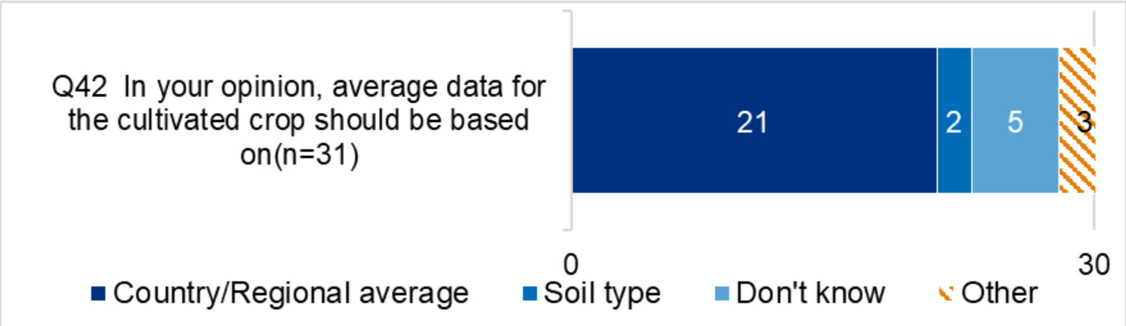
*"**Q42: Marginal emissions per tonne of crop - our proposal:** With 65% of the respondents not knowing or without an opinion, this question was not properly understood. It may have been understood as referring to multi-cropping systems, either through rotation or intercropping, in which several crops are cultivated on the same land. Multi-cropping systems pose the question of allocating agricultural inputs and associated impacts over the different crops. On the other hand, the initial question actually related to the use of average vs marginal data for the inputs required for crop cultivation. While the latter would capture the granularity of local situations (e.g. additional fertilisers required to compensate for less productive land), the practicality of such approach in an LCA context (e.g. availability of data) remains uncertain. Therefore, the use of average values remains the preferred option to date, with a preference for average values based on a specific type of soil for the cultivated crop(s). Do you agree with the use of average data (rather than marginal) for the inputs required to cultivate crops?*

As Figure 3-18 shows, a large majority of respondents supported the proposal to use average data for the inputs required for crop cultivation. Commenters that disagreed were asked to specify an alternative approach: Two suggested using a marginal approach in conjunction with averages, another pointed to the existence of real allocations for the multi-cropping scenario. Another further commenter suggested using the principle of additionality biomass use for energy production should either come from additional land or by increasing yield on existing land, both leading to more intensive cultivation practices. As a result, an average approach based on other uses of agricultural biomass would tend to underestimate the intensity of biomass cultivation for biofuels.

Figure 3-18: Views on the use of average vs marginal data for the inputs required for crop cultivation (n=31)

Those that agreed with the previous question also were asked what the average data for the cultivated crop should be based on. A clear majority of respondents favoured a country or regional approach.

Figure 3-19: Views on the data for the cultivated crop cultivation



Finally, a majority of respondents disagreed to allocate impacts from agricultural inputs to the different crops on a mass basis. However, associated comments revealed a relatively limited understanding of agricultural practices, for example by assuming that crop-specific inputs could be assigned separately to each crop. In practice, the next crop will still benefit from inputs used in the previous rotation, etc.

Furthermore, respondents were also consulted on whether the impacts from agricultural inputs should be allocated to the different crops cultivated on the same land on the basis of biomass outputs. Among those that disagreed, 14 respondents suggested different approaches. Eight respondents provided identical comments that recommended that in the case of crop rotation the agricultural input during the planting/growing/harvesting period should be allocated to the crops during this specific period; but in the case of a crop exhausting the land, there should be a system expansion, or allocation of input related to the needs of each crop/period.

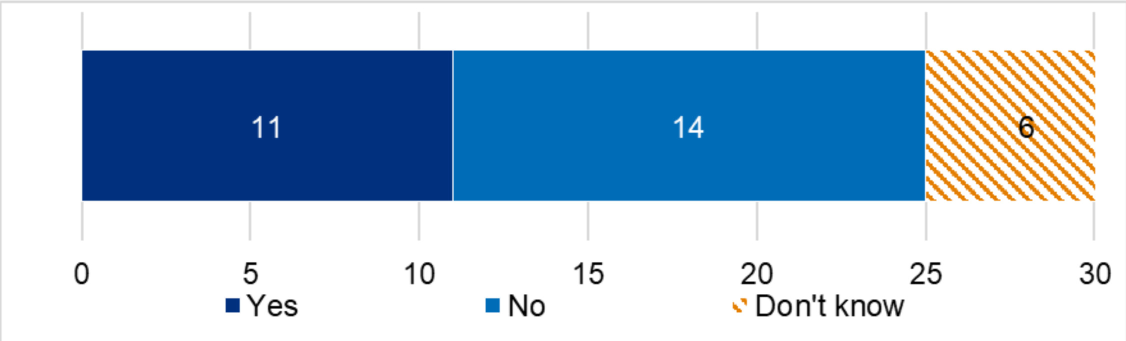
Some respondents also suggested allocating impacts through a system subdivision, an allocation based on economic value or based on energy content. One respondent's recommendation was to assign the value of a crop as part of a cropping system based on avoidance of costs, explaining that biomass weight is not necessarily an appropriate measure of biomass value as part of the overall system. Two others advised that allocation should be done on the basis of the value of the crop, one of which also stated that energy allocation could provide a better approximation to value. Similarly, one respondent suggest allocation based on energy content

In addition, one respondent also indicated that real allocation should be done based on multi-cropping scenarios, whereas another suggested that inter-cropping should not be included in the modelling.

Finally, respondents provided further comments to the whole question on marginal emissions per tonne of crop as follows:

- The eight respondents noted that this is comparable to the polluter-pays-principle.
- Three respondents all highlighted the uncertainty around assessing agricultural inputs.
- Two highlighted the limitations of an average approach. With one proposing the use of both average and marginal calculations.

Figure 3-20: Views on allocation of impacts from agricultural inputs concerning crops cultivated on the same land



Box 16: Additional commentary on proposed approach

In line with the views of the majority of stakeholders, we will use an industry average[1], such as IPCC tier 1 method (single global emission factor for the N_2O emissions from fertiliser and manure application to fields) or the GNOC tool (global nitrous oxide calculator) which provides more disaggregated data (Edwards, et al., 2017).

*"**Q43: Fertiliser emissions – our proposal:** Two modelling approaches to estimate emissions from fertiliser use were discussed at the Expert Workshop: JRC's Global Nitrous Oxide Calculator (GNOC) or IPCC methodology. No clear consensus emerged during the workshop regarding their use. It was acknowledged that neither one covers impact categories other than GWP (i.e. GHG), and while the former appears to provide more accurate results at local level, neither capture temporal aspects (e.g. seasonal changes), which were deemed important. Do you agree that the LCA methodology should allow for the use of GNOC (local level) and/or IPCC (national/EU average) to account for fertiliser emissions?"*

Respondents are divided over the most appropriate approaches to estimating emissions from fertiliser use A large number of respondents did not express any opinion on this topic. The response from the remaining respondents was supportive of the approach.

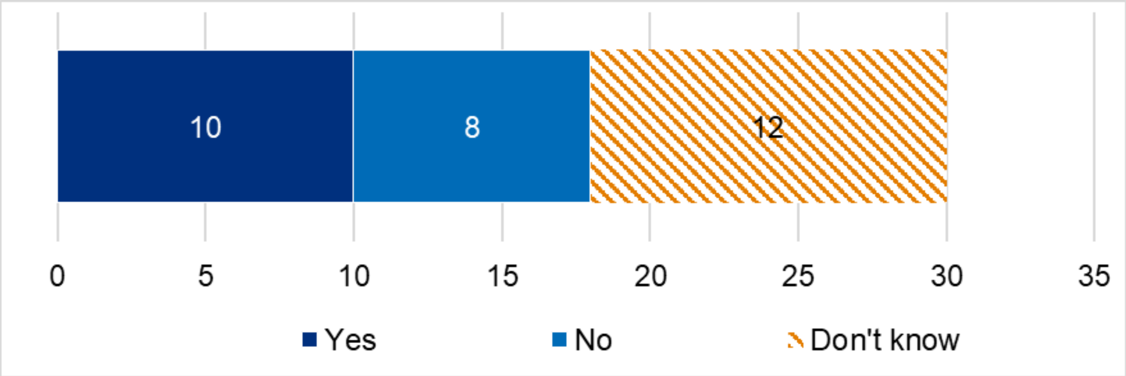
Additionally, it is worth noting that seven of the eight respondents that disagreed provided an identical response when asked for an alternative. These respondents recommended using the IPCC however,

[1] However, when considering policy, it should be noted though that this approach would remove any incentive to improve agricultural practices.

this is already part of the suggested approach (for national/regional evaluations). Therefore, the level of support might in reality be higher than would otherwise appear in the following chart.

Those that agreed were also asked to provide examples of models being used in an LCA context, suggestions included: EU legislation regarding biofuels (two respondents), their own organisations work (one respondent) and GREET model (one respondent), which also uses the IPCC methodology to determine N_2O emissions due to fertilizer application.

Figure 3-21: Views on modelling of fertiliser emissions (n=30)



3.5 Section 5: Methodological considerations for the electricity lifecycle

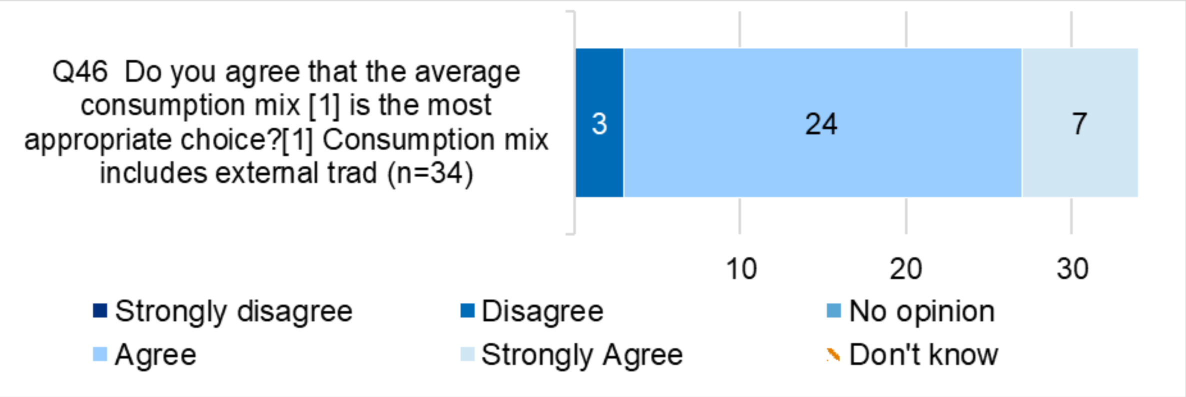
Respondents responding to the first round of the survey also generally supported the methodological proposals for the electricity life cycle. However, there were mixed views on certain proposals such as the cut-off criteria and data sources. In Round 2, clarity was provided on proposals dealing with differentiation of electricity generation, the modelling of generic generation types, with respondents largely agreeing with the new proposals.

Overall, there was continued agreement regarding other topics included here, that were considered to have reached a consensus in Round 1. Though in some cases, respondents used the survey to add clarifications and suggest changes.

"Q46: Differentiation of electricity generation – our proposal: A differentiation in terms of level of detail between countries inside and outside of the scope of this study is validated by the majority of stakeholders. For countries under scope, electricity generation will be modelled, while for countries outside of scope, datasets or emission factors from established data providers such as ecoinvent or other sources, e.g. IEA will be used. As a default, the yearly average (consumption) mix will be assessed. In order to account for the significant differences in power generation, bespoke mixes or results from individual electricity chains, e.g. wind power or lignite, could be explored as sensitivities using our methodological approach. A more detailed assessment of potentially influencing factors such as consumer (charging) behaviour not only is difficult to predict but also goes beyond the scope of the project. Do you agree that the average consumption mix [1] is the most appropriate choice?"

There was good agreement that the proposed method of using average electricity generation data is appropriate from the survey respondents (Figure 3-22).

Figure 3-22: Views on differentiation of electricity generation



In the comments provided, some of the respondents emphasised the likely difficulty in any further analysis, whilst others emphasised the value of the Ecoinvent and GaBi databases. There were a number of other suggestions raised by respondents:

1. Request for inclusion of sensitivities (three respondents).
2. Suggestion that separate country averages could be used (two respondents).
3. Suggestion that the boundaries of the data system should be carefully examined (one respondent).
4. Suggestion that "consequential analysis" should be used to examine what-if questions. (one respondent).

Box 17: Additional commentary on proposed approach

The majority of stakeholders supported the proposed approach. The scope of the electricity generation product system will therefore comprise all relevant generation technologies on the basis of their share on gross electricity consumption (consumption mix) within the spatial (countries under) scope. The mix is thus adjusted for external trade with third party countries (e.g. Switzerland or Norway). For countries outside of scope, data sets from well-established databases will be used. The following generation technologies are considered:

- Coal (lignite, hard coal)
- Oil-fired
- Nuclear
- Solar (photovoltaic)
- Hydro
- Natural gas (and derivatives)
- Waste incineration
- Wind (onshore and off-shore)
- Biomass (solid and biogas)

The above describes the current status-quo in the EU 28 as of 2019 and, dependent on the scenarios applied, could be subject to change over time, as new technologies emerge, or specific technologies are phased out due to political, economic or environmental reasons.

In addition, variation in electricity transmission and distribution losses will be accounted for based on different country conditions.

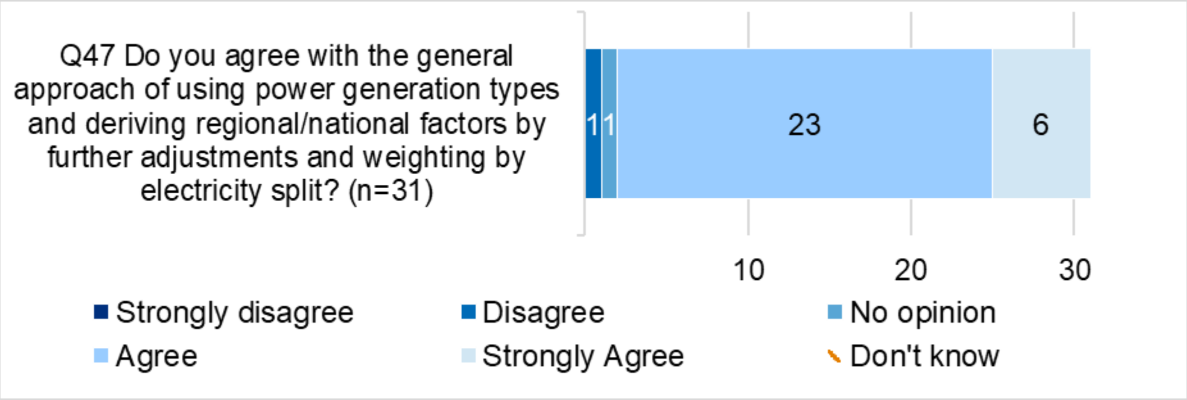
"**Q47: Modelling of generic generation types – our proposal:** Results from Round 1 of the survey indicated strong support for the proposed approach but more clarity and detail were requested by stakeholders. The proposed approach comprises three main steps: (1) Modelling individual electricity chains by power generation type (kWh_{el} generated by coal, hydro, gas, etc.) on a defined average baseline technology level, (2) (Potential) adjustment of baseline technology level to reflect regional/country-specific characteristics (e.g. efficiencies, fuel quality, level of emission control); (3) Weighting of different power generation types by regional/national share on power generation (i.e. electricity split). This approach will also provide the potential for exploration of bespoke generation mixes in sensitivities (e.g. specific marginal or residual mixes, etc.) Do you agree with the general approach of using power generation types (coal, hydro, gas, etc.) and deriving regional/national factors by further adjustments (e.g. efficiencies, fuel quality, level of emission control) and weighting by electricity split?”

There was a high level of agreement over the use of power generation types is an appropriate method for this work, as shown in Figure 3-23. In comments, one of those who agreed added comments regarding the method added that national emissions balances can be used for direct emissions from power sector. Additionally, seven respondents stated that the baselines should be based on the actual generation mix.

In terms of options for scenario considerations, there were multiple suggestions:

- 12 suggested exploring efficiencies in scenarios.
- Nine suggested considering age of power generation plants.
- Two technologies and fuels with significant future potential.
- Four suggested generation mix (including co-generation).
- One suggested upstream emissions.
- Two suggested regional differences.

Figure 3-23: Views on modelling of generic generation types (n=31)



Respondents were subsequently asked which regional/national factors should most importantly be accounted for in the context of this study. There was a relatively wide range of responses to this question. Many respondents stated that the consumption mix in terms of electricity generation was an important factor (five respondents). Equally, seven respondents said that factors such as efficiency and age of generation plan should only be changed in the sensitivities and a baseline should be only the generation mix. Of the factors which the respondents stated should be included, there was a wide range of views: age of generation plant (one respondent), emission factor for power plant (one respondent), CHP ratios (one respondent), foreign GHG factors (such as in China where cells are manufactured) (one respondent).

“Q48: Fuel / generation technologies - our proposal: *The majority of stakeholders confirmed the list of suggested fuels and power generation technologies. However, some stakeholders suggested including further technologies, e.g. geothermal and CSP (concentrating solar power) due to their potential future role. This, as well as the market shares of the other listed technologies, will be subject to change over time. The finite selection of technologies will be determined by the cut-off criteria depending on their underlying market shares. For technologies that produce both power and heat, allocation of emissions and impacts based on energy will be carried out.”*

Respondents responses to this question either reinforced their agreement with the proposal or indicated that this approach was too complex. Of the respondents who said that this was potentially too complex, nine urged for the approach to be based on data availability, and one stated that the difference between low carbon technologies is minimal in this analysis and efforts to distinguish between them are not worthwhile.

"**Q49: Cut-off criteria – our proposal:** *The majority of stakeholders (with an opinion) confirmed the proposed cut-off criteria. However, multiple stakeholder stated the lack of a sound justification as to why 5% as cut-off is chosen. Against the background of the project and the variety of different technologies and countries, the proposed cut-off criteria allow to focus on all significant technologies while limiting the overall complexity. Moreover, data availability especially with respect to potential future technologies with low market shares is very limited with a high level of uncertainties. Therefore and, in addition, considering the overall scope of the study, a 5% cut-off is reasonable.* "

Most of the additional comments provided were in agreement with this approach to defining cut-off criteria, with two respondents commenting that future market introductions should be supported by lower percentages, and querying whether 95% recyclability could actually be achieved. Nevertheless, eight respondents said that this justification was not specific enough to suggest that 5% was preferable to another figure (either 1% or 10% was suggested).

"Q50: Impact categories (electricity generation) - our proposal: *While the majority of stakeholders generally agreed with the suggested impact categories, consistent categories across all life cycle stages is of key importance. Therefore, the appropriate choice of impact categories was addressed for the project as a whole under question 9.* "

Although they generally agreed with the statement regarding impact categories, most respondents responding to this question added further input. Seven responses stated that impact categories should only be used subject to data availability and these should be globally accepted and not dependant on local specifics. Additionally, one respondent stated that ILCD midpoints should be used, and one stated that they should be kept the same as the vehicle.

"**Q51: Data sources - our proposal:** *A large part of the stakeholders confirmed the appropriateness of the suggested data sources. We will prioritise sources based on consistency and comparability to other sources, e.g. in terms of system boundaries and general methodology. In addition to the already mentioned data sources, data from governmental agencies (national and international), research institutions, industry publications and guidelines as well as commercial LCA databases will be utilised. For aspects of future developments and scenarios, data from the EC will be incorporated.*

There was good support for the approach discussed in this question, with all but one respondent reinforcing the desire for consistent data sources. The one respondent that criticised this approach did so by saying that it was generally right, but that correctness should be valued over consistency.

Some respondents gave additional information, for instance seven respondents suggested that transparency of data sources was also key and that ranges of data should be sought where uncertainties exist. Another respondent suggested that consistency was so important that only datasets with standardised documentation should be included (such as ecoinvent or GaBi). On the other hand, another respondent warned against using such datasets by saying that they may use different methodologies, and that they should only be used for minor inputs.

"**Q52: Energy storage options – our proposals:** The importance of storage options was validated by the stakeholders. As V2G concepts are highly uncertain both in terms of technical feasibility and consumer acceptance, only stationary storage options will be assessed by sensitivity analysis.

The further comments provided reflected the good agreement for this approach. Respondents suggested any uncertainties should be reflected in the overall results. However, two respondents queried whether this was too much detail, saying that this will have little impact on the results or suggesting that it should be left out entirely.