ARTICLE 6.4 MECHANISM

A6.4-SB006-AA-A07

Concept Note

Proposals and options to operationalize baseline contraction factor, avoid ‘lock-in levels of emissions’ and address leakage in the draft recommendation on requirements for the development and assessment of mechanism methodologies

Version 01.1

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The Supervisory Body, at its fifth meeting (SB 005), requested the secretariat to further work on the draft elements for the recommendation on requirements for the development and assessment of mechanism methodologies taking into account guidance from the Supervisory Body at that meeting. In particular, the Supervisory Body requested the secretariat to prepare a draft recommendation for consideration at its next meeting, including:

   (a) Proposals to frame, implement or operationalise the elements discussed at the meeting, taking into account the inputs of members; '

   (b) Options to reflect different views expressed by members of the Supervisory Body at SB 005 as options to address the requirements;

   (c) Proposals for potential consolidation or grouping of options to implement the different elements through a common option.

2. The Supervisory Body requested the secretariat, in conducting the above tasks, to prepare and present a concept note on proposals and options to implement or operationalize elements in line with guidance and questions elaborated by the Supervisory Body at its fifth meeting, as contained in annex 1 to the meeting report i.e. information note "A6.4-SB005-A01: Guidance and questions for further work on methodology requirements". drawing on previous work, reflecting concerns expressed by members and alternate members, and taking into account previous public input.

2. Purpose

3. The purpose of this concept note is to address the mandate from the Supervisory Body included in A6.4-SB005-A01 on:

   (a) Baseline contraction factor (BCF);

   (b) Lock-in levels of emissions; and

   (c) Leakage.

4. The mandate to prepare draft recommendation as detailed under paragraph 1 above is addressed in a separate document A6.4-SB006-AA-A08 – Draft recommendation: Requirements for the development and assessment of mechanism methodologies".

3. Key issues and proposed solutions

5. The concept note provides a review and analysis of public inputs received and relevant literature and includes options for the consideration of the the Supervisory Body.

6. Proposals and options in this document are neither the recommendations of the secretariat nor that of the informal working group on methodologies, but are rather

options prepared to facilitate structured discussion and consideration by the Supervisory Body.

4. Subsequent work and timelines

7. Based on the guidance from the Supervisory Body, further work will be carried out as needed.

5. Recommendation

8. The Supervisory Body may wish to consider this document and provide guidance for any further work.

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1. Introduction

1. The Supervisory Body, at its fifth meeting, requested the secretariat to prepare and present a concept note, at SB 006 meeting, on proposals and options to implement or operationalize elements in line with guidance and questions elaborated by the Supervisory Body, as contained in annex 1 to the report of SB 005,[1] drawing on previous work, reflecting concerns expressed by members and alternate members, and taking into account previous public input. The questions asked by the Supervisory Body, and responses to those questions, are laid out in the following chapters.

2. General questions

2. What are the potential ways the different elements of paragraph 33 of the rules, modalities and procedures (hereinafter referred to as the RMP)[2] can be potentially consolidated or grouped to implement a common approach? And, what are those approaches that would be applicable to the groupings? Responses are detailed in paragraph 8 below.

3. Questions on baseline contraction factors

3. Which of the elements in paragraphs 33 to 39 of the RMP may be addressed by baseline contraction factors (BCFs)? And how could BCFs, including the top-down and/or bottom-up options, be operationalized?

4. What alternative measures, instead of BCFs, could be implemented to address the elements in paragraphs 33 to 39 of the RMP? And, how could these alternative measuresbe operationalized?

5. What are the pros, cons and risks, and/or advantages, of applying BCFs and alternative measures to implement the elements in paragraphs 33 to 39 of the RMP?

6. Subject to the above, should BCFs or alternative measures be a requirement or optional to apply?

3.1. Summary responses to questions on BCFs

7. Application and operationalisation of Baseline Contraction Factors (BCFs) is not a requirement under the RMPs. Nevertheless BCFs can potentially be an effective measure to support implementing multiple elements in paragraphs 33 to 39 of the RMPs. Under some circumstances however, BCFs may not be conducive or even hinder the

[1] A6.4-SB005-A01 Information note: Guidance and questions for further work on methodology requirements, available at https://unfccc.int/event/Supervisornder y-Body-5.

[2] FCCC/PA/CMA/2021/10/Add.1 Rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement, available at https://unfccc.int/documents/460950.

implementation of other elements in paragraphs 33 to 39 of the RMPs[3], depending on how they are defined and operationalised.

8. The following elements and approaches of the paragraphs 33 and 36 of the RMPs can be potentially addressed by BCFs:

(a) encourage ambition over time;

(b) be ……….below 'business as usual';

(c) align with the long-term temperature goal of the Paris Agreement;

(d) contribute to the equitable sharing of mitigation benefits between the participating Parties;

(e) align with nationally determined contributions of each participating Party, if applicable, its long-term low GHG emission development strategy, if it has submitted one;

(f) the long-term goals of the Paris Agreement;

(g) an approach based on existing actual or historical emissions, adjusted downwards to ensure alignment with paragraph 33 [of the RMP].

9. It is foreseen that there may be at least four potential options, as below, to operationalise BCFs, not all of which are mutually exclusive and the options may be futher considered:

Option 1: Where BCFs serve to update the methodologies and project parameters at the renewal of the crediting period, they can be operationalized through methodology procedures and principles and rules applicable to registered activities;

Option 2: The BCFs can also be operationalised as a qualitative requirement for mechanism methodolgoies;

Option 3: Top-down development of BCFs by the Supervisorby Body using IPCC Integrated Mitigation Pathways (IMPs) or other means, to create coefficients applicable to a sector or activity type on a global level, covering all potential global conditions. There will be a need to assess if there is a practical and inclusive way to accommodate different circumstances of the host Parties;

Option 4: Bottom-up development of BCFs at the national level where necessary differentiated by sector or region, as was done with the the CDM Standardized Baselines, or even at the activity level by activity participants, following rules that will be set by the Supervisory Body.

10. The above option(s) need further analysis should the Supervisory Body wish to pursue any of them. Included in Appendix 7 is a preliminary impact assessment of the above options subject to futher revisions based on the inputs received by the Supervisory Body.

[3] For example the element related to "…….relevant circumstances, including national, regional or local, social, economic, environmental and technological circumstances…."

Also Appendix 7 and paragraph 24 on page 11 discuss alterantives to BCFs and the pros/cons of the alternatives.

11. When considering each of these elements described in paragraph 8, different considerations may apply in the case of emission reductions and removals. The applicability of BCFs to removals requires further and separate consideration.

3.2. BCFs and alternatives to BCFs in the stakeholder submissions and literature

12. In order to address the above questions, a common understanding of the definition of a BCF would be essential.

13. Different interpretations of BCFs have been proposed by several sources under a variety of names. Hermwille (2020) proposed the "situation-ambition approach" capturing a transition between the IS-margin (current situation) and the OUGHT-margin (ambition). Michaelowa et al. (2021) proposed an "ambition coefficient", and Michaelowa et al. (2022) detailed how it could operate (see Appendix 3 for details).

14. Among the sumbissions made to the structured public consultation on requirements for the development and assessment of mechanism methodologies held between 16 March 2023 and 11 April 2023,[4] Carbon Market Watch referred to BCFs and International Emissions Trading Association (IETA) recommended "options for downward adjustment" and World Bank referred to "country-specific discounting of baseline emissions linked to a country's NDC and associated targets". Perspectives Climate Research (PCR) proposed a "Paris goal coefficient" set by the Supervisory Body and by the host country for Article 6.2, which ensures that baseline emissions fall linearly over time, reaching net zero at the time of the host country's net-zero target. PCR also suggested that the Supervisory Body could specify a net zero date for countries that have not announced such a date (see Appendix 1 for details).

15. In comparison, "Information Note: Status of current work on the application of the requirements referred to in chapter V B (Methodologies) of the rules, modalities and procedures"[5] (hereinafter referred as the Sharm text) included a broader definition. The purpose of BCFs was stated as to "periodically adjust the baseline downwards".

16. Thus, the alternatives to BCFs depend on the definition of BCF itself.

3.3. Proposals on BCFs and alternatives to BCFs in the stakeholder submissions to the Supervisory Body

17. Stakeholder submissions on this aspect can be grouped into two areas: methodology-level measures and measures that take into account country/regional/sectoral level pathways.

[4] The background for this structured consultation and the submissions received can be accessed at https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism/calls-for-input/sb004-requirements-methodologies.

[5] A6.4-SB003-A04, available at https://unfccc.int/event/Supervisory-Body-3.

18. In one group, proposed measures relate to the approval and update of methodologies applied to new projects and existing projects at the renewal of the crediting period. They include:

    (a) Applying a default technology improvement factor over time;

    (b) Continual improvement of methodologies through update of input parameters of the baselines every 5 to 10 years based on latest science and data, to apply to new projects, ensuring transparent public availability of the process and information;

    (c) Reassessing baselines at renewal of crediting period;

    (d) Supporting transformational projects as opposed to incremental benefits against BAU by focusing on improvements that can transform an entire sector and excluding continued use of fossil fuel infrastructure;

    (e) Applying qualitative requirement for mechanism methodolgoies to avoid increase in baseline emissions;

    (f) Taking into account all registered carbon market project activities in the baselines;

    (g) Digitization of some methodology elements, as part of monitoring to avoid human error through automation.

19. In the other group, proposed measures take into account country/regional/sectoral level pathways in applying a downward adjustment factor to the baselines of the existing projects on a periodic basis, presumably on an annual basis. They include:

    (a) Country-specific downward adjustment of baseline emissions linked to a country's NDC and associated targets from the host country;

    (b) Achieving (near) absolute zero emissions by 2050 or earlier through robust BCFs, depending on the sector, geographical location and level of uncertainty of the activity.

3.4. Using the approaches based on NDC alignment

20. Caution is advocated by IETA and World Bank in relation to NDC aligned baselines as follows:

    (a) Deriving NDC aligned baselines requires flexibility as cases where unconditional NDC targets would be directly translatable in crediting baselines are uncommon. Therefore, it seems preferable to encourage Parties to use the existing flexibility under Article 6.4 to come up with tailor-made solutions according to their respective circumstances. This is not meant to discourage the offering of default solutions but to caution against aiming for prescribing a pre-defined set of exclusive options;

(b) When applying an approach based on existing actual or historical emissions adjusted downwards, it would be important to have multiple options for downward adjustment depending on activity type and local circumstances.

21. Also, submitters refer to the NDC "ratcheting up" cycle that plays a part in encouraging ambition over time, implying alignment will have to be dynamic for this option.

22. Similar sentiments are expressed in the literature. Greiner et al. (2020) state that in practice, defining the optimal use of Article 6 for both facilitating national targets and incentivizing mitigation and development co-benefits beyond a country's target proves challenging. It requires a profound understanding of the policies and measures that have to be implemented to achieve the NDC targets. But, many countries do not yet have detailed NDC implementation plans.

3.5. Proposals on BCFs and alternatives to BCFs in literature

23. Luca, Lo Re et al. (2019), based on 'deep dives' on grid-connected power plants and blending-type activities in the cement sector, assessed existing methodologies and tools under the clean development mechanism (CDM) and highlighted the implications of setting baselines in these sectors under Article 6.4. Their analysis showed that a single approach—and even a single methodological tool—can lead to wide variations in baseline levels, depending on the input parameters in the methodologies. This is consistent with the findings of the "Draft recommendation: Requirements for the development and assessment of mechanism methodologies",[6] which showed that default parameters, assumptions made and primary and secondary data sources and vintage used could have significant impact on emission reduction estimates of an activity.

24. The authors of the above cited literature observed that "the Article 6.4 mechanism is not in itself the driver of ambition, since that comes from the progression in NDC ambition over time". Nonetheless, the framework for Article 6.4 could be set up in a variety of ways to increase the ambition of future pledges, for example encouraging the development of transformational activities (rather than incremental improvements in existing activities), discouraging specific types of activities, and limiting credits and/or crediting periods. They also listed the pros/cons of these options:

(a) Transformative projects would have the advantages of satisfying a demand in a least-emitting pathway rather than focusing on improving a specific method of producing a specific output; however, the boundaries of analysis tend to be large (international rather than national) requiring extensive data on demand and supply;

(b) Discouraging specific activities (so-called negative list) could prevent 'lock-in' with GHG intensive technologies with long lifetime; however, developing such a list of activities would be challenging considering different national circumstances in relation to those technologies;

[6] A6.4-SB004-AA-A10, available at https://unfccc.int/event/Supervisory-Body-4.

(c) Encouraging specific activities (so-called positive list) through simplified regulatory requirements and fast-track processes could reduce barriers for certain technologies and regions. However, it could skew market incentives, and establishing criteria to determine such a list of activities may be challenging;

(d) Limiting the number of credits (e.g. through conservative baselines, shorter crediting periods, discounting) may increase the cost of generating credits, which in turn could encourage buyer countries to enhance their efforts to reduce emissions domestically. However, some countries have stated that their current/future ambition is contingent on access to international offsets;

(e) Capping the total levels of credits generated by the Article 6.4 mechanism would limit the extent to which buying countries could limit/delay the introduction of measures to reduce domestic emission levels. However, it would skew market incentives that Article 6.4 sets up, would have many policy-related and operational challenges, e.g. ex ante rules on what the total cap is in a given sector, how it relates to crediting in specific Article 6.4 activities, stopping approval of proposed activities after a certain date/after a certain threshold of activities and/or expected emission reductions have been approved internationally.

25. Table 1 in Appendix 2 includes more details.

3.6. Paris alignment under multilateral development bank (MDB) financing

26. Joint MDB Methodological Principles for Assessment of Paris Agreement Alignment of New Operations: Direct Investment Lending Operations (2023)[7] includes lists of "Activities Considered Universally Aligned with the Paris Agreement's Mitigation Goals" and "Activities Not Aligned with the Mitigation Goals". The former includes energy generation from greenfield/retrofitted renewable energy, clean cooking, district heating/cooling, selected activities in manufacturing and agriculture, forestry and other land use (AFOLU), use of electric vehicles for transport, waste management, water supply and waste water, buildings, services and others and specifies conditions and provides guidance. It also states that operation types included on this list will have to go through the specific criteria assessment if they fall under any of the following:

(a) Operations whose economic feasibility depends on external fossil fuel exploitation, processing, and transport activities;

(b) Operations whose economic feasibility depends on existing fossil fuel subsidies;

(c) Operations that rely significantly on the direct utilization of fossil fuels.

[7] https://www.worldbank.org/en/publication/paris-alignment/joint-mdb-paris-alignment-approach.

27. Under the activities considered universally not aligned with the mitigation goals, it is stated “[A]t this time, the MDBs consider four activity types to be universally not aligned with the Paris Agreement’s mitigation goals:

    (a) Mining of thermal coal.

    (b) Electricity generation from coal.

    (c) Extraction of peat; and

    (d) Electricity generation from peat”.

28. Further, The World Bank (2023) states that “Paris Alignment means, with respect to WBG (The World Bank Group) financial support for any country, public or private sector entity, as applicable, that new financing flows and guarantees provided by the WBG will be consistent with the objectives of the Paris Agreement and a country’s pathway towards low greenhouse gas (GHG) emissions and climate-resilient development. For these purposes, Paris Alignment is considered and assessed in the broader context of the WBG’s Twin Goals, taking into account, among other things, equity concerns and the principle of common but differentiated responsibilities and respective capabilities, in light of countries’ different national circumstances”.

3.7. BCFs as a default adjustment factor under top-down approach versus bottom-up approach

29. This section further assesses BCFs as a default prescriptive quantitative option for downward adjustment implemented as a top-down approach by the Supervisory Body. In Appendix 3, two approaches found in literature in this regard are summarized, ranging from a relatively simple approach of linear pathway towards net zero to a more complex approach of the baseline calculated as a weighted average of the BAU (the current situation) and the ‘ought margin’ (the ambition), with the weights shifting over time from 100% BAU and 0% ‘ought margin’ to 0% BAU and 100% ‘ought margin’.

30. For such approaches, it will be essential to determine a date for net zero and a mitigation pathway to reach net zero differentiated by sector and country, or differentiated by country. Appendix 4 includes extracts from Chapter 3: Mitigation pathways compatible with long-term goals from IPCC ARWG III (Riahi et al, 2022) which highlights the conditions required to apply the IPCC defined pathways. ‘illustrative mitigation pathways’ (IMPs), are characterised by heavy reliance on renewables (IMPRen), strong emphasis on energy demand reductions (IMP-LD), extensive use of carbon dioxide removal (CDR) in the energy and the industry sectors to achieve net negative emissions (IMP-Neg), mitigation in the context of broader sustainable development (IMP-SD), and the implications of a less rapid and gradual strengthening of near-term mitigation actions (IMP-GS). Marginal abatement costs of carbon are (in USD2015) about USD 90 (USD 60–120) per tCO_2 in 2030 and about USD 210 (USD 140–340) per tCO_2 in 2050; in pathways that limit warming to 1.5°C (>50 per cent) with no or limited overshoot, they are about USD 220 (USD 170–290) per tCO_2 in 2030 and about USD 630 (USD 430–990) per tCO_2 in 2050. As most of

the mitigation pathways follow cost-effectiveness approach, they do not make any additional equity assumptions.

31. Appendix 5 and Appendix 6 include information on corporate efforts towards net zero following the Science Based Targets Iinitative (SBTi) approach and key information from the ISO Net zero guidelines. While SBTi is praised for engaging the corporate sector in this regard, critics have said SBTi is giving companies too much latitude in how they set their targets; that it is allowing them to rely on certain dubious tools to address emissions; and that it is holding emerging companies in poor nations to the same standards as huge historic polluters.

32. All of the above highlights the complexities of top-down approaches to BCFs.

33. Furthermore, practices to date, including under the CDM to set methodological parameters for baseline or additionality, that are applicable at a national or sub-national level, have always been in consultation with the national authorities, as in the case of the CDM standardized baselines.

34. Therefore, a bottom-up approach for BCFs, where country authorities engage with the Supervisory Body, appears more feasible than a top-down approach, where the Supervisory Body assumes the entire responsibility for the development and update of BCFs.

3.8. Conclusions

35. The rules for Article 6.4 mechanism baselines must contribute to fulfilling the requirements in paragraph 33 of the RMP. Furthermore, they also must be suitable for developing and developed country contexts, apply to both reduction and removal activities (RMP para. 31), and still provide enough incentive to leverage the implementation of activities that would not have occurred in the absence of the incentives from the mechanism (RMP para. 38).

36. Broadly speaking, BCFs serve to adjust the baseline downward, year-by-year, from the historical or actual levels, being directly or indirectly aligned with the long-term temperature goal of the Paris Agreement and the pathways towards net-zero emissions. BCFs as discussed so far in the literature are applicable to emission reductions only, and not emission removals.

3.9. Elements in paragraphs 33 to 39 of the RMPs addressed by BCFs

37. The following elements in paragraphs 33 to 39 of the RMP may be addressed by BCFs.

38. In paragraph 33, mechanism methodologies shall:

(a) "encourage ambition over time"—applying BCFs to discount baselines can lead to precipitous reductions in the baseline emissions against which an activity can credit. This means that only the activities with transformational low emission levels would be able to generate Article 6.4 emission reductions, which, over time, would incentivize the most ambitious activities to be implemented. This is subject to corresponding price levels being realised for the units and in the absence of optimum price levels, BCFs could also affect financial viability of transformational actions thereby discouraging implementation of ambitious activities;

(b) "below 'business as usual'"—BCFs could generate below-BAU baselines, since they are used to discount baseline emission levels or baseline emission factors from the historical or current level. A cross-check of evolving conditions could demonstrate whether the baseline applied to a project continues to be lower than the conditions found in the evolving performance of the relevant sector during the crediting period;

(c) "align with the long-term temperature goal of the Paris Agreement"—BCFs can be defined to reduce baselines along a pathway aligned with emissions pathways consistent with the temperature goals of the PA. It is unclear whether BCFs can be used to operationalise this requirement as pathways aligned with emissions pathways consistent with the temperature goals of the PA can differ on host-country level;

(d) "contribute to the equitable sharing of mitigation benefits between the participating Parties"—BCFs are expected to set the baseline at a lower level than the real pace of evolving performance of the relevant sector, such that fewer Article 6.4 emission reductions would be generated than the true emission reductions achieved by the activity; It may be worthwhile to note that, depending on the country circumstances, by designating a portion of emission reductions as mitigation contrbution units, it may also be possible to achieve similar outcomes;

(e) "align with [the host Party's] NDC, if applicable, its long-term low GHG emission development strategy [LEDS], if it has submitted one"—BCFs can be defined to reduce baselines along a pathway aligned with the host Party's NDC and/or long-term LEDS, in accordance with the sectoral contributions outlines in NDC/LEDS implementation plans.

39. Paragraph 34 of the RMP states that "mechanism methodologies shall include relevant assumptions…and key factors…relevant circumstances, including national, regional or local, social, economic, environmental and technological circumstances…". With respect to BCFs:

(a) It may be a challenge for mechanism methodologies to include sufficient detail across all their potential geographical locations of application to include top-down BCFs in the methodologies;

(b) Mechanism methodologies may be able to include the conditions required to define the BCF on a country, sector, or technology basis, and then host Parties or other stakeholders could develop the BCF for approval by the Supervisory Body.

40. Paragraph 36 of the RMP states "each mechanism methodology shall require the application of one of the approach(es) below [in a list of (i)(ii)(iii) in the RMP] to setting the

baseline, while taking into account any guidance by the Supervisory Board, and with justification for the appropriateness of the choices…”. With respect to BCFs:

(a) The only baseline approach that explicitly refers to downward adjustment, which is what a BCF would provide, is “(iii) [a]n approach based on existing actual or historical emissions, adjusted downwards to ensure alignment with paragraph 33 above [in the RMP]”. This could mean that BCFs could apply only to baselines developed using approach (iii);

(b) The other two approaches would need a different method to increase ambition over time, such as a periodic update of the definition of ‘best available technology’ for option (i) or a periodic update of the ambitious benchmark for option (ii).

3.10. How BCFs could be operationalized

41. Operationalization of BCFs depends on how they are defined. Where they serve to update the methodologies and project parameters at the renewal of the crediting period, they can be operationalized through methodology procedures and principles and rules applicable to registered activities.

42. If the Supervisory Body were to choose top-down development of BCFs using IPCC IMPs to create coefficients applicable to a sector or activity type on a global level these would need to be very conservative to cover all potential global conditions. There will be a need to assess if there is a practical and inclusive way to accommodate different circumstances of the host Parties.

43. The BCF can also be operationalised as a qualitative requirement for mechanism methodolgoies (e.g. to avoid increase in baseline emissions, to implement scalable projects with impact).

44. Whereas, bottom-up options could be developed at the national level, like CDM standardized baselines were, or even at the activity level by activity participants, following rules set by the Supervisory Body.

3.11. References reviewed for addressing questions related to BCF

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4. Question on lock-in levels of emissions

53. How could 'taking a conservative approach that avoids locking in levels of emissions, technologies or carbon intensive practices incompatible with paragraph 33 of the RMP [rules, modalities and procedures]' be defined and operationalized?[8]

[8] See the Rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement, the annex to 3/CMA.3, contained in document FCCC/PA/CMA/2021/10/Add.1, available at: https://unfccc.int/documents/460950.

4.1. Summary or responses to the above questions

54. Carbon lock-in occurs when, due to technical, economic, or institutional factors associated with a given activity/investment, an emissions-intensive asset is expected to continue to operate even after there are feasible—and economically preferable— lower-carbon options that could replace it.

55. The following options may be considered by the Supervisory Body to address lock-in.

Table 1. Pros/cons of measures to address lock-in

Measure	Advantages	Challenges
• Develop a dedicated tool to assess the risk of lock-in (see Appendix 8 for illustration from literature) that takes into account the asset lifetime relative to 2030 and 2050 goals, the carbon intensity and the current and emerging landscape of climate policies (e.g. carbon pricing, potentially border carbon adjustments in the future).	• The development of a tool will allow a systematic assessment of different dimensions of the issue allowing to apply to a number of different situations.	• The tool should cover variety of circumstances for variety of technologies in different geographical locations. • Collecting sufficient information to develop such a tool for an effective assessment by the activity developer may be challenging. • Requirement to develop a tool may postpone operationalisation of the mechanism until after the tool as been developed and agreed by the SB, which may impact the relevance and effectiveness of Article 6.4 .
• Include requirements for 'best available measurement technologies' in the methodologies, based on public and expert consultation (e.g. including requirements for direct metering and/or uncertainty adjustment factors particularly for distributed technologies), and the periodic update to account for the continuous development in measurement methods and metering.	• Better measurement as part of holistic approach to the activity will allow identification of better performing technologies which will avoid lock-in with low performing technology.	• Follow through at the field level would be required to ensure the effectiveness which may require significant efforts and coordination with many actors.

Measure	Advantages	Challenges
• Indicate a negative list of activities that pose high risk of lock-in levels of emissions. These could include, subject to further discussion, proposed activities prolonging the lifetime or the operation of unabated coal-fired and peat-fired power plants, coal and peat mining.	• A concrete list of activities not compatible with the climate goals will give a clear signal to the activity developers regarding areas they could engage in project development with high certainty for investment security.	• It will be challenging to develop such a negative list if the scope of its coverage is too broad as it would require taking into account different circumstances in which activities are developed and implemented.
• Undertake further work on modalities for policy crediting and results based finance.	• Measure may expand the reach of the mechanism to results based finance which may be beneficial for the Host Parties.	• There is limited but growing experience with policy crediting, developing requirements including monitoring of impacts may require significant resources.

4.2. "Locking-in levels of emissions" in the RMP

56. The concept of locking-in levels of emissions (hereinafter referred to as "lock-in") is reflected in paragraph 38 of the rules modalities and procedures (hereinafter referred to as RMPs) where "taking a conservative approach that avoids locking in levels of emissions, technologies or carbon-intensive practices incompatible with paragraph 33 above [in the RMP]" is mentioned as the third element of the additionality test, together with incentive from the mechanism ("the activity would not have occurred in the absence of the incentives from the mechanism") and regulatory surplus.

57. Therefore, lock-in needs to be understood in relation to elements of paragraph 33 of the RMPs, i.e. encourage ambition over time; encourage broad participation; be real, transparent, conservative, credible, below 'business as usual'; avoid leakage, where applicable; recognize suppressed demand; align to the long-term temperature goal of the Paris Agreement; contribute to the equitable sharing of mitigation benefits between the participating Parties; and, in respect of each participating Party, contribute to reducing emission levels in the host Party; and align with its nationally determined contributions, if applicable, its long- term low GHG emission development strategy, if it has submitted one, and the long-term goals of the Paris Agreement.

4.3. 'Lock-in' from public submissions

58. The concept of lock-in was understood generally by the participants in the public consultation[9] as introducing, or prolonging the lifetime of, emissions, technologies or practices that are not aligned with the 1.5ºC long-term goal of the Paris Agreement (Information note: Compilation of public inputs in response to the "public consultation: Requirements for the development and assessment of mechanism methodologies,[10] see Appendix 7 forextracts of inputs from stakeholders). Some of the inputs explicitly referred to the following causes of lock-in:

(a) Activities that generate residual emissions;

(b) Activities that are deemed to have a low likelihood of additionality, as well as activities that are fundamentally incompatible with reaching the long-term goal of the Paris Agreement;

(c) Evolution of common practice over time (emission reductive to emission intensive);

(d) Current interpretation of performance-based approaches perpetuates lock-in, as the most favorable outcome and not the most precise one is sought for the baseline, by the activity developer;

(e) Applying outdated methodologies, producing inaccurate results;

(f) Applying a technology with a lifetime that goes beyond 2030 but does not allow net zero.

59. Stakeholders proposed the following solutions:

(a) Developing a negative list of activity types based on robust science, such as Intergovernmental Panel on Climate Change (IPCC) reports, in order to exclude technologies and practices that are incompatible with the temperature goals of the Paris Agreement;

(b) Performing a pre-mandatory eligibility test on proposed activities (e.g., to ensure the activity is not included on any negative lists, that the activity is in line with the host country's climate policies, that the activity's GHG emissions intensity per unit of production/consumption is lower than the intensity of the lowest emitting, technically feasible and commercially available production pathway for the product, service, or output delivered);

(c) Requiring common practice and technological additionality tests;

(d) Applying dynamic baselines that become more stringent over time;

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[9] Structured public consultation: Requirements for the development and assessment of mechanism methodologies, 16 March to 6 April 2023 (Extended to 11 April), available at https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism/calls-for-input/sb004-requirements-methodologies.

[10] Annex 8 of the annotated agenda to the SB 005 meeting (referred as A6.4-SB005-AA-A08), available at https://unfccc.int/sites/default/files/resource/a64-sb005-aa-a08.pdf

(e) Setting a minimum crediting period between 5 and 10 years to ensure 'investment return lock-in' after which a reassessment of the technology and actions for the "remaining eligible projects" is undertaken;

(f) Shorter crediting periods for some classes of activities (e.g., non-biological projects, except for those that remove and sequester carbon, projects that have high upfront costs but low mitigation);

(g) Application of a best available technology approach to methodologies as a whole (not only for the baseline), specifically covering measurement and verification through the application of 'best available measurement technology';

(h) Building off established scientific methods and avoiding complacency with levels of emissions, technologies, or practices;

(i) Establishing a positive list that favours projects fulfilling the core requirements of additionality while utilizing innovative technologies in a transparent manner; and

(j) Requiring that an eligible 6.4 activity reduces the emission/intensity by 50 per cent compared to the baseline if its crediting year ends before 2030, and by 99% compared to baseline if the activity extends beyond 2030.

4.4. "Lock-in" in literature

60. Locking in emissions, as used in paragraph 33 of the RMPs, relates closely to the concept of 'carbon lock-in' introduced by Prof. Gregory Unruh a little over twenty years ago (Unruh 2000, Unruh 2002).

61. Carbon lock-in means that technical and institutional inertia formed around the dominant technologies, to generate "self-reinforcing barriers to change" primarily due to the co-evolution of large interdependent technological networks and the social institutions and cultural practices that support and benefit from system growth.

62. These barriers to change prevent policy action from prioritizing new technologies, even if they mitigate global climate risk and are cost-neutral or even cost effective (Unruh 2002). Carbon lock-in leads to the tendency to prioritize incremental changes to the status quo, rather than a swift transition to low- and zero-emissions solutions (Unruh 2002). The growth of the system is fostered by increasing returns to scale.

63. Economic Consulting Associate (2015), through its Carbon lock-in tool kit, emphasized that carbon lock-in occurs when it is costly to change course at some future date, and the costliness of changing course depends on a range of factors. It proposed a systematic check of these factors related to asset lock-in, institutional lock-in and technology lock-in to assess the risk of lock-in (see Appendix 8).

64. Recent research has demonstrated that carbon lock-in jeopardizes the chances of reaching the 1.5ºC goal of the Paris Agreement. Research found that the projected emissions from existing power plants in 2018 was more than the entire carbon budget available to limit warming to 1.5ºC. Furthermore, when also including the planned new power plants in 2018, the projected emissions are as much as double the available carbon budget (Tong et al. 2019).

65. The World Resources Institute (WRI) summarized the typical lifetime of different infrastructure and equipment and how this relates to locking in emissions. They describe that buildings have a typical lifetime of 80 years, while for residential cooking equipment the typical lifetime is 14 years. All infrastructure and equipment considered had a median typical lifetime of 27.5 years (WRI 2021). Using this median lifetime, the infrastructure and equipment installed in 2023 will still be operating in 2050, when the world needs to reach net zero to avoid overshooting 1.5ºC of warming (Rogelj et al. 2018).

66. Rosenbloom (2020), quoted examples from the recent shift from coal to natural gas-fired power, representing an unfolding form of carbon lock-in taking place across many jurisdictions. Based on current research, the following policy options were proposed to confront lock-in:

(a) Disincentivizing or banning incumbent technologies (from phaseouts to carbon pricing);

(b) Reforming institutions and market rules (to support broader societal goals);

(c) Eroding the financial resources of carbon-intensive interests (by removing subsidies);

(d) Weakening actor networks and access to decision makers (by rebalancing advisory boards to limit incumbent involvement).

67. Policy action can also include interventions to foster low-carbon behavior, research and development investment in alternative technologies, and transition supports for those who will be most affected by shifts away from high-carbon industries (e.g. workers).

68. Erickson et al. (2015) assessed, based on literature, how conventional technologies might be retired early, or 'unlocked' in the future.

4.5. The concept of 'carbon intensive'

69. In the reviewed literature, the label 'carbon intensive' is based on a comparison between alternatives, where technologies or practices that have a higher emissions intensity than others are considered carbon intensive. Examples were found for the oil and gas sector (Masnadi et al. 2018) and agriculture sector (Gan et al. 2014). The literature search did not turn up any examples defining carbon intensity based on a specific value of emissions intensity.

70. Submissions for the structured public consultation on requirements for the development and assessment of mechanism methodologies between 16 March 2023 and 11 April 2023 addressed the concept of carbon intensity similarly to the way it was addressed in the publications mentioned above, i.e. the practice or technology must be compared to an alternative that is less carbon intensive to be carbon intensive. Along these lines, a specific definition was proposed: that carbon intensive means a technology or practice that has a GHG emissions intensity per unit of production or consumption that exceeds the intensity of the lowest emitting, technically feasible and commercially available production pathway for the product, service or output delivered.

71. Another observation from the structured public consultation process was that a technology or practice that is not carbon intensive today may become carbon intensive after a number of years, as technologies develop and practices change. Therefore, the definition of carbon intensive needs to be regularly updated.

72. Another interpretation of carbon intensive from the public consultation was to consider the emissions of a technology or practice versus the pathway required to achieve the 1.5ºC long-term goal of the Paris Agreement. Since modeled pathways with no or limited overshoot of 1.5°C show global net anthropogenic CO_2 emissions decline by about 45 per cent from 2010 levels by 2030 and reach net zero around 2050 (Rogelj et al. 2018), the proposal was to define as carbon intensive those technologies or practices that does not reduce emissions by 45 per cent by 2030 and to net zero around 2050.

4.6. How to operationalize the concept of 'lock-in'

73. Based on the observsations and findings above, the Supervisory Body may consider the following measures to operationalize the concept of avoidance of lock-in, in addition to the proposals presented at SB 005:

(a) Publish a negative list of activities that pose a high risk of lock-in levels of emissions based on literature review, and expert and stakeholder consultation. The list could include, subject to further discussion, proposed activities prolonging the lifetime or the operation of unabated coal-fired and peat-fired power plants, coal and peat mining (see section 'Paris Alignment under MDB financing');

(b) Develop a dedicated tool to assess the risk of lock-in (see Appendix 8 for illustration from literature) that takes into account the asset lifetime relative to 2030 and 2050 goals, the carbon intensity and the current and emerging landscape of climate policies (e.g. carbon pricing, potentially border carbon adjustments in the future);

(c) Include requirements for 'best available measurement technologies' in the methodologies based on public and expert consultation (e.g. including requirements for direct metering and/or uncertainty adjustment factors particularly for distributed technologies), and requirements for periodic update to account for the continuous development in measurement methods and metering;

(d) Undertake further work on modalities for policy crediting and results based finance (e.g. although not in the specific context of lock-in, paras 10[11] and 11[12] of the A6.4-SB005-AA-A08 and the submission from the World Bank referred to accelerated phase out of coal plants and fossil fuel subsidies).

4.7. References reviewed to address questions related to lock-in levels of emissions

74. A6.4-SB005-AA-A08. Information note. Compilation of inputs received in response to the “public consultation: Requirements for the development and assessment of mechanism methodologies” and related literature. Version 01.0. https://unfccc.int/sites/default/files/resource/a64-sb005-aa-a08.pdf.

75. Economic Consulting Associates. Carbon Lock-In Toolkit. Economic Consulting Associates, London, UK (2015) 101 pp. Available at https://www.gov.uk/research-for-development-outputs/carbon-lock-in-toolkit.

76. Erickson P, Kartha S, Lazarus M, and Tempest K. (2015). *Assessing carbon lock-in*. Environmental Research Letters, 10(8),084023. https://iopscience.iop.org/article/10.1088/1748-9326/10/8/084023.

77. Gan, Y., Liang, C., Chai, Q. et al. *Improving farming practices reduces the carbon footprint of spring wheat production*. Nat Commun 5, 5012 (2014). https://doi.org/10.1038/ncomms6012.

78. Individual submissions. Call for input 2023 - Structured public consultation: Requirements for the development and assessment of mechanism methodologies. Submissions. https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism/calls-for-input/sb004-requirements-methodologies.

79. Masnadi, M S. et al. (2018). *Global carbon intensity of crude oil production*. Science361,851-853 (2018). DOI: https://doi.org/10.1126/science.aar6859. Summarized at https://news.stanford.edu/2018/08/30/measuring-crude-oils-carbon-footprint/.

80. Rogelj J, Shindell D, Jiang K, Fifita S, Forster P, Ginzburg V, Handa C, Kheshgi H, Kobayashi S, Kriegler E, Mundaca L, Séférian R, and Vilariño M V. (2018). *Mitigation*

[11] A key strength of using aspects of carbon market mechanisms for results-based climate finance is their ability, when properly implemented, to provide a unit that is quantified, monitored, reported, and verified in a relatively standard comparable metric – CO_2e. Further advantages include provision of the infrastructure to “crowdfund” mitigation or removals projects by connecting multiple small donors with projects on the ground with some measure of transparency.

[12] The World Bank has identified three areas that are particularly well-suited to RBCF (Resul-based climate finance): (a) Natural climate solutions focused on agriculture, forestry, land-use, oceans, and other sectors; (b) Sustainable infrastructure in energy, water, transport, urban, and other sectors. This could also include for example accelerated phase-out of coal-fired power plants by monetizing, in the carbon markets, the Emission Reductions Credits generated by the transition away from coal. This monetization would help crowd in private finance, support additional clean energy capacity; (c) Fiscal and financial solutions that directly or indirectly provide or mobilize resources for climate action. Examples include carbon taxes, the removal of harmful subsidies, like fossil fuel subsidies.

Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 93-174, doi:10.1017/9781009157940.004.

81. Rosenbloom, Daniel. (2020). *Breaking carbon lock-in through innovation and decline*.

82. Tong, D., Zhang, Q., Zheng, Y. et al. *Committed emissions from existing energy infrastructure jeopardize 1.5 °C climate target*. Nature 572, 373–377 (2019). https://doi.org/10.1038/s41586-019-1364-3.

83. Unruh, G C. (2020). *Understanding carbon lock-in*. Energy Policy 28(12): 817-830. https://doi.org/10.1016/S0301-4215(00)00070-7.

84. Unruh, G C. (2002). *Escaping Carbon Lock-In*. Energy Policy 30(4):317-325. https://doi.org/10.1016/S0301-4215(01)00098-2.

85. WRI. *What Is Carbon Lock-in and How Can We Avoid It?* May 25, 2021 By Ichiro Sato, Beth Elliott and Clea Schumer. https://www.wri.org/insights/carbon-lock-in-definition#.

5. Questions on risk assessment of leakage

86. What are the pros, cons, risks and/or advantages of the new proposals presented to SB 5 for leakage risk assessment and responses to identified leakage risk, including taking into account options for the scope of their application and role of the host Party?

87. What is their effectiveness at mitigating leakage risk and excluding any remaining leakage emissions from credited volumes?

5.1. Summary responses to questions on leakage

88. The RMP requires that Article 6.4 mechanism activities 'minimize the risk of leakage and adjust for any remaining leakage in the calculation of emission reductions or removals' (paragraph 31). It reiterates this in requiring mechanism methodologies "…avoid leakage, where applicable…" (paragraph 33) and to 'include relevant assumptions, parameters, data sources and key factors and take into account uncertainty, leakage,…" (paragraph 34).

89. Paragraph 27 of the SB 003 text[13] defined leakage as the net change of anthropogenic emissions by sources of GHGs which occurs outside the project boundary, and which is measurable and attributable to the Article 6.4 activity, as applicable. This is aligned with submissions from stakeholders.

[13] A6.4-SB003-A04, available at https://unfccc.int/event/Supervisory-Body-3.

90. By conducting a review of the different carbon crediting mechanisms, the following sources of leakage were presented to SB 005:[14]

(a) **Equipment transfer** transferred outside of the project boundary leading to continued use and GHG emissions outside the project boundary;

(b) **Diversion of resources** from other activities;

(c) **Activity leakage within national boundaries** through diversion of production or service provision, i.e. relocation of emission-intensive activities outside the project boundary, including, e.g., from jurisdictions with a higher cost to emit CO_2 to jurisdictions with a lower cost to emit;

(d) **Upstream/downstream emissions** owing to the production of products or services (upstream emissions) and use and disposal of products and services (downstream emissions). Emissions associated with the fuel/electricity consumed due to production, processing, transmission, storage and distribution are covered.

91. Stakeholders also proposed approaches to identify and address or minimize leakage from the potential leakage sources:

(a) Identifying through the application of robust monitoring, reporting and verification (MRV) systems (which may include life-cycle analysis), different climate policies among jurisdictions;

(b) Addressing through nesting of activities and jurisdiction-level crediting, application of discount factors to different leakage risks, creation of a 'leakage belt'.

92. Mechanism methodologies may require an assessment of the sources of leakage described in paragraphs 93 and 94 below and of potential solutions to those sources, described below:

(a) **Discounting:** deductions from credited volumes possibly taking into account equipment lifetime;

(b) **Scrapping:** evidence of destruction/decommissioning/disposal of a baseline technology;

(c) **Abundancy of resources:** demonstration of surplus availability of resources in the region;

(d) **LCA:** lifecycle assessment

(e) **Nesting:** may involve integration in a higher-level monitoring system and/or use of a standardized higher-level baseline that is regularly updated;

(f) **Larger-scale implementation:** sectoral, sub-national or national level implementation;

[14] See Appendix of the 'Info Note: Compilation of inputs received in response to the "public consultation: Requirements for the development and assessment of mechanism methodologies" and related literature' (A6.4-SB005-AA-A08), available at https://unfccc.int/sites/default/files/resource/a64-sb005-aa-a08.pdf.

(g) **Harmonized policies:** harmonized cross-national policies, may include matching commitment agreements.

93. Table 2 below combines the potential leakage sources and solutions for the different sectors.

Table 2. Approaches that may be considered to address leakage per sector

Leakage Type	Energy sector (RE+EE)	Industrial processes and product use	AFOLU	Transport
Baseline equipment transfer	• Discounting; • Scrapping	• Discounting; • Scrapping		• Discounting; • Scrapping
Diversion of Resources	• Discounting; • Abundancy of resources	• Discounting; • Abundancy of resources		
Diversion of non-renewable biomass saved	• Discounting; • Survey		• Discounting; • Survey	
Upstream/ Downstream emissions	• LCA	• LCA		• LCA
Activity leakage within national boundaries	• Sectoral/national standardized baseline and/or MRV; • Leakage belt	• Sectoral/national standardized baseline and/or MRV; • Leakage belt	• Sectoral/national standardized baseline and/or MRV; • Leakage belt	• Sectoral/national standardized baseline and/or MRV; • Leakage belt
Market leakage			• Discounting; • Apply default values	

94. The Supervisory Body may develop specific tools to address the above leakages (see the list of tools under the CDM in paragraph 115 below for illustration).

5.1.1. Pros, cons, risks and/or advantages, effectiveness of the above proposals

95. Available literature in this regard is scarce except for the case of market leakage. Measures based on equipment destruction have generally worked well where consistently applied, for example in the case of lighting technologies (e.g., evidenced destruction of incandescent lights).

96. However, in some cases involving larger equipment with considerable residual value (e.g. vehicles, boilers, chillers) the leakage impacts are difficult to determine. In such cases, the baseline equipment presumably remained in use and emissions were not reduced in respect of the baseline [unless those equipment displaced even more GHG intensive equipment]. Such methodological requirements were maintained in some cases when additional resources made available through other means can complement efforts (e.g. a programme of activity under the CDM enabled destruction of old taxis in Egypt based on

additional incentives to the taxi drivers to submit their old vehicles for desctruction) or where the equipment's re-use (so, resale) was no longer practical due to policy change.

97. Measures to address shift of pre-project activities and diversion of resources seems to have generally worked, except in cases where the waste biomass was sourced from a dedicated plantation that was raised on land that had forest before and the forest was destroyed for the plantation (e.g. biomass waste from palm oil plantation established following clearing of forests).

98. In the literature (Wiehl et al. 2023) and public submissions to the Supervisory Body, effectiveness of leakage consideration in CDM cookstove methodologies is raised. According to these sources, CDM and Gold Standard methodologies account for leakage either through household surveys or "an unjustified default value of 5%" of final emission reductions. It is stated that it is largely unknown whether the introduction of an improved stove programme increases the consumption of biomass in non-project households. When projects do track leakage, they rarely report a value larger than 5 per cent. As projects are incentivized to find low leakage, this is not empirical evidence that 5 per cent is conservative according the above authors. It is suggested by these sources that Cookstove projects should contribute to a buffer pool. However, considering that cookstove projects are only credited a portion of the biomass saved (i.e. a fraction of non-renewable biomass) and have little control over the land from which biomass is sourced, it is unclear how such a measure might work in practice. Moreover, wood use for cooking is considered to impact degradation of forest rather than deforestation, in that sense it may have a different context than REDD+ projects.

99. In the case of REDD+ activity types and categories, the International Civil Aviation Orgainzation's Carbon Offsetting and Reduction Scheme for International Aviation (ICAO CORSIA) requires that activity baselines must, at a minimum, utilize a sub-national or national forest emissions reference level and be integrated within a monitoring system at that same level. Crediting schemes have emerged to support this model, including under the ART TREES Standard (by exclusively crediting national or sub-national programs) and Verra's jurisdictional nested REDD+ Framework (specifically, Scenarios 2b and 3). National ART TREES programs have issued and transacted ERs.

100. The use of standardized baselines by proponents of standalone activities has primarily been implemented in the power sector and in those instances, only on a limited basis. This is anecdotally attributed to the fact that sectoral, sub-national, or national emissions baselines are typically lower than those of specific emissions-intensive sites or locations, so are less attractive from both crediting and marketing perspectives. This may also disincentivize the implementation of a higher-level crediting scheme, where intensive crediting to standalone sites rivals or exceeds the amount that would be issued in respect of a higher-level baseline that includes the activity area.

101. The sections below describe with more detail the situations where leakage sources should be identified and addressed, including examples of methodologies from carbon certification schemes such as the CDM and the Voluntary Carbon Standards.

5.2. Equipment transfer

102. Activity participants are required to consider leakge when a project activity leads to replacement of existing equipment (baseline equipment) by energy efficient equipment and the baseline equipment is transferred for further use outside of the project boundary.

103. For example, an activity that replaces an existing and low-efficient boiler (baseline equipment) with a new more energy efficient boiler may produce leakage if the baseline equipment is transferred to and used by a facility located outside of the project boundary.

104. Methodologies under carbon certification schemes, such as the CDM and ACR, have addressed this potential source of leakage by means of either:

(a) Accounting for the leakage and discounting emission reductions; or

(b) Requiring evidence that the baseline equipment has been scrapped/destroyed/decommissioned to avoid being used by other facilities. For example, leakage under CDM methodologies AMS-II.C. v15, AMS-II.J. v07, AM0046 v02 and AM0113 v02 can be neglected if there is evidence that the replaced baseline lamps have been scrapped. Similar is the case with ACR methodologies for advanced refrigerants

105. At least one observed scheme requires either paragraph 104 (a) or 104 (b) unless the baseline equipment is resold or otherwise transferred for use outside of the activity host country, in which case no requirements apply in respect of leakage emissions accounting.

5.3. Diversion of resources

106. Activity participants are required to address leakage due to diversion of resources for projects implementing use of renewable biomass and low emission products for construction (e.g. bricks), including the following:

(a) Shifts of pre-project activities: decreases of carbon stocks, for example as a result of deforestation, outside the land area where the biomass is grown, due to shifts of pre-project activities;

(b) Competing use of the biomass: the biomass may in the absence of the project activity be used elsewhere, for the same or a different purpose.

5.3.1. Shift of pre-project activities

107. The shift of pre-project activities could result in decreases of carbon stocks, as a result of deforestation or land conversion outside the project boundary. For example, in the case of an Article 6.4 activity that converts cropland to a dedicated forest plantation to produce wood for energy production, the pre-project activity (crop production) might be shifted to other land areas. In the worst case, this shift of the pre-project activity could result in deforestation on other land. Options to address this leakage source include, for example, (i) extending the project monitoring boundary (inclusion of the land in which the pre-project activities will take place in the project boundary) and (ii) applying a (default) discounting factor.

108. Under the CDM (e.g. methodological tools 'TOOL16: Project and leakage emissions from biomass' and 'TOOL22: Leakage in biomass small-scale project activities'), this source of leakage was either neglected (if the possibility of leakage from the displacement of activities or people is deemed low) or addressed by applying a default discount factor of 15 per cent to the difference between baseline and project emissions, depending on specific indicators (i.e. percentage of families/households displaced and percentage of total production of the main product displaced due to the activity).

109. Under the VCS, methodologies require that the criteria and procedures to assess and quantify the effects of "deforestation outside of the projet boundary on all carbon pools, unless determined to be insignificant or conservatively excluded" are addressed.

5.3.2. Competing use of biomass

110. Competing use of biomass may result in leakage when an activity consumes a source of biomass that was previously consumed by another facility outside of the project boundary to produce the same output/product, meaning this other facility may have to rely on other types of resources to produce the same output/product. For example, a renewable energy power plant might consume an amount of bagasse that was previously used by a sugar mill located outside of the activity boundary to generate on-site heat, and this sugar mill might as a result have to use another type of fuel (renewable or fossi-fuel) to generate the same amount of heat.

111. Methodologies under carbon certification schemes, such as the CDM, have addressed this potential source of leakage by means of either:

(a) Accounting for the leakage and discounting emission reductions, or

(b) Neglecting the effects of leakage if it is demonstrated that the resources consumed by the activity are abundant in an area around the activity boundary, i.e. there are no competing uses of the biomass. For example, abundance of biomass under the CDM methodological tool 'TOOL16: Project and leakage emissions from biomass' is demonstrated when the quantity of that type of biomass residue annually available in the project region (an area of 250 km radius around the CDM project site) is at least 25 per cent larger than the quantity of biomass residue that is used annually in the project region.

5.4. Activity leakage within national boundaries

112. The information note considers the activity leakage that occurs within the national boundaries when emission-intensive activities are relocated outside the project boundary or between sites within a jurisdiction, including, e.g., from jurisdictions with a higher cost to emit CO_2 to jurisdictions with a lower emitting cost due to different stringencies of emission policies between the jurisdictions.

113. Approaches in the voluntary carbon market to address this source of leakage include employing the concepts of 'nesting', an approach that seeks to prevent leakage of emissions within a broader jurisdictional context, beyond the activity site. This option requires projects to formally engage a national or sub-national agency that is implementing

a higher-level crediting standard in order to align with the jurisidction's higher-level baseline, monitoring, and crediting arrangements.

114. In national or subnational jurisidictions that are not implementing any higher-level crediting program, a similar outcome can be achieved by requiring projects to use a standardized baseline or combined margin method, in combination with a higher-level monitoring system, with comparable coverage of all emissions sources relevant to leakage mitigation.

115. Other proposals include defining and monitoring emissions within a 'leakage belt', i.e., the geographical area around the project area where leakage is expected to occur.

116. Decisions regarding activities that involve reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+)[15] specify that these must be undertaken in the context of national safeguards and systems, which, if appropriate and as an interim measure, may involve subnational forest reference emission levels and/or forest reference levels and monitoring systems.

117. Those decisions further specify that sub-national activities, defined as "activities carried out within the national boundary", should "constitute a step towards the development of national approaches, reference levels and estimates", and "be… assessed for associated displacement of emissions". This includes "reporting on how displacement of emissions is being addressed, and on the means to integrate subnational monitoring systems into a national monitoring system"[16].

118. Winrock International, which administers the ART TREES and the ACR standards, recently commenced work on a comparable standard for crediting emissions reductions in the power sector based on a sectoral, sub-national, or national baseline, in order to address systemic leakage risks.

5.5. Upstream/downstream emissions

119. Upstream emissions are owing to all emissions associated with production processes upstream of the activity, whereas downstream emissions are associated with their use and disposal. Emissions associated with the fuel/electricity consumed due to production, processing, transmission, storage and distribution are covered. Examples include upstream emissions associated with the production of methanol that is used in the esterification process to produce biodiesel for activities that replace the consumption of fossil-fuel-based diesel, and examples of downstream emissions include the emissions from the transportation and treatment of sludge produced by the activity in a facility located outside of the project boundary.

[15] REDD+ Decision Booklet

[16] Decision 1/CP.16, Chapter C, paragraphs 70-71

120. The CDM published specific methodological tools to calculate and monitor these emission sources as listed below, some of which include a life-cycle analysis (LCA) approach to address such sources. The tools include:

(a) TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion;

(b) TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation;

(c) TOOL12: Project and leakage emissions from transportation of freight;

(d) TOOL13: Project and leakage emissions from composting;

(e) TOOL14: Project and leakage emissions from anaerobic digesters;

(f) TOOL15: Upstream leakage emissions associated with fossil fuel use;

(g) TOOL16: Project and leakage emissions from biomasas;

(h) TOOL22: Leakage in biomass small-scale project activities;

(i) TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants.

5.6. Diversion of non-renewable biomass saved

121. Activity participants need to consider leakage due to diversion of non-renewable biomass saved. With a view to simplifying the approach to consider leakage in cookstove projects under the CDM, it was proposed to use a discount factor of 5 per cent of emission reduction in lieu of monitoring the sources of woody biomass for the cookstoves.

122. This type of leakage can happen in activities that replace use of non-renewable biomass in the baseline, either due to use of an efficient cookstove or due to use of other fuels or technologies, such as biogas and renewable energy-based cookstoves.

123. For example, leakage under CDM methodologies AMS-I.E. v13 and AMS-II.G. v13 is addressed by applying a discount factor of 5 per cent to the baseline emissions.

5.7. Market leakage

124. Market leakage may refer to emissions happening outside of the activity boundary due to the reduction in the production of a commodity that causes a change in the supply and market demand equilibrium, resulting in a shift of production elsewhere to make up for the lost supply. For example, market leakage may be an important leakage source for improved forest management activities where the part of the timber produced will need to be harvested in another forest area or replaced by another type of wood.

125. Under the VCS, market leakage may be addressed either by:

(a) Applying default discount factors to the net change in carbon stock associated with the activity that reduces timber harvest depending on the level of the leakage risk identified; or

(b) Accounting for market leakage directly at the country-scale applied to the same general forest type as the project (i.e. forests containing the same or substitutable commercial species as the forest in the project area) and shall be based on methods for quantifying leakage from scientific peer-reviewed journal sources.

Appendix 1. Extracts from public inputs related to BCF

1. 'Information note: Compilation of inputs received in response to the "public consultation: Requirements for the development and assessment of mechanism methodologies" and related literature' (A6.4-SB005-AA-A08)

1. The Article 6.4 mechanism should update any inputs for baselines using the latest science and data every 5 to 10 years, or other known interval (but not too often). New projects should be compared against a new landscape of action and options (CARB).

2. This element speaks to innovating more accurate, stringent methodologies to extend the reach of project-based mitigations. Achieving continual improvement of methodologies, in alignment with current research could be encouraged through revision of methodologies, assessing their stringency and accuracy in relation to alternatives on a regular basis. Ensuring methodologies are public, understandable, and reviewed regularly is at the core of creating a transparent, ever-improving framework for future offsets (44M).

3. Default discounting of baseline emissions by an appropriate factor in the existing methodologies and country-specific discounting of baseline emissions linked to a country's NDC and associated targets from the host country may be considered to encourage ambition (WB).

4. Article 6.4 activities can only increase ambition if they broaden the scope of what is considered "possible" today, i.e. support transformational projects as opposed to incremental benefits against BAU by focusing on improvements that can transform an entire sector and excluding continued use of fossil fuel infrastructure. Conservative baselines not only help mitigate the risk of over-crediting but also serve as an additional safeguard to allow host Parties to benefit from a share of the mitigation benefits from Article 6.4 activities. Baselines must evolve with time. For most activities, this means achieving (near) absolute zero emissions by 2050 or earlier. Robust baseline contraction factors, depending on the sector, geographical location and level of uncertainty should be developed and applied (CMW).

5. The NDC "ratcheting up" cycle plays a part in encouraging ambition over time. Additionally, progressively conservative science-based pathways that lead to the 1.5-degree target could be considered based on 2030 and 2050 goals. Additional measures, such as applying a technology improvement factor over time, limiting eligibility of a baseline technology/benchmark to a few years, taking into account registered carbon market project activities in the baselines, reassessing baselines at renewal of crediting period, digitization of some methodology elements, as part of monitoring to avoid human error through automation, could be considered (AA).

6. Baselines should be real, transparent, conservative, credible, below BAU by adopting robust, open, and user-friendly measurement, reporting and verification (MRV) systems (IETA) and by using performance standards that are data driven and made publicly available (CARB).

7. Significant heterogeneity of NDCs makes it challenging to derive broadly applicable approaches on how best to share mitigation benefits and ensure NDC alignment through selecting the most suitable mitigation activities for Article 6 carbon market transactions and through baseline setting. Early experiences so far have shown that flexibility in activity selection is needed to enable buyer-seller matches, and even more so in a piloting and early market phase. Deriving NDC aligned baselines requires a similar degree of flexibility, and cases are rare where unconditional NDC targets would be directly translatable in crediting baselines. It seems therefore preferable to encourage Parties to use the existing flexibility under Article 6.4 to come up with tailor-made solutions according to their respective circumstances. This is not meant to discourage offering of default solutions but to caution against aiming for prescribing a pre-defined set of exclusive options (WB).

8. Setting baselines that are well below business-as-usual, including via the application of a baseline contraction factor is an effective way to ensure that Article 6.4 contributes to the equitable sharing of benefits for host Parties and to the reduction of emission levels in the host Party. Such baseline setting, regardless of how stringent any hypothetical contraction factor might be, must be dynamic. In most sectors and for most activities, this means achieving (near) absolute zero by 2050 or earlier. Fewer credits also mean higher prices, which leads to higher revenues for both the developers taking action, and the Host countries selling their reductions More stringent methodologies should hence not be seen as a difficulty to be overcome for market actors and Host countries. On the contrary, it will benefit these actors and better reflect the principle of "equitable sharing of mitigation benefits" (CMW).

9. Align with the long-term temperature goals of the Paris Agreement by considering emission reductions and removals that deliver mitigation in this decade and avoid creating perverse incentives and/or reward low-ambition NDCs (IETA).

10. When assessing the economic feasibility of Best Available Technologies (BAT), the cost of ownership as a percentage of average household annual income may not be suitable to all activities. A penetration rate (in absolute terms or as a fraction to uptake of the technology in the most mature markets) or other metrics may be used in some cases. Furthermore, when applying an approach based on existing actual or historical emissions adjusted downwards, it would be important to have multiple options for downward adjustment depending on activity types and local circumstances (IETA).

11. For an ambitious benchmark, determine a performance distribution curve using the most up-to-date data (not more than three years old) of all technologies providing similar outputs or services in similar social, economic, environmental and technological circumstances as the proposed activity in the host country. If host-country specific data are not available, data from the region to which the host country belongs are to be used. Determine an ambitious benchmark, at minimum at the 20th percentile of the performance distribution curve if the characteristics of the distribution curve show that these percentiles are conservative. Calculate the average emissions intensity of the benchmark group selected in the previous sub-step (the "benchmark emissions intensity"). Downwards adjust the benchmark emissions intensity over the years (i.e. after the first year) to ensure it is in line with the long-term target of the Paris Agreement. This is done through the application of a "Paris goal coefficient", set by the Supervisory Body and by the host country for Article

6.2, which ensures that baseline emissions fall linearly over time, reaching net zero at the time of the host country's net-zero target (PCR).

12. For existing actual or historic emissions adjusted downwards, determine an actual or historical emissions baseline based on existing methodologies used under the Kyoto Protocol mechanisms. Adjust baseline downwards through a discount factor ("Paris goal coefficient") to the actual or historical emissions intensity, declining over time. The historical emissions level of the first year needs to be adjusted downwards by at least 5 per cent. Historical data shall not be older than five years and represent at least a three-year historical time series (PCR).

13. The baseline setting (BAT, ambitious benchmark) should take into account region or country-specific circumstances. In addition, Adjustment factor (BCF/PAC) should take into account national factors (PCR).

Appendix 2. Possible options for Article 6.4 to support increased ambition of future pledges

1. Luca Ro Le et al (2019) summarized possible options for Article 6.4 to support increased ambition of future pledges as follows:

Figure 1. Extract from Luca, Ro Le et al (2019)

Table 1. Possible options for Article 6.4 to support increased ambition of future pledges

Options	Description	Advantages	Challenges
Promote transformational change	Use A6.4 to encourage "disruptive" technologies/ systems.	Would enable significant improvements in GHG emission reductions performance if A6.4 could be used to focus on how to satisfy demand for a particular service (e.g. food) more GHG-efficiently, rather than focusing on improving specific methods of producing a specific output (e.g. cattle).	May be more complex/data-intensive to set up and agree internationally, if baseline methods need international approval. Moreover it may be more complex to set up also if it involves establishing large boundaries around a particular activity, including both supply and demand-side information and data.
Discouraging specific activity types	Establish eligibility or other criterion at international level to discourage/ prohibit specific types of activity.	Ensuring that a GHG-intensive means of production for technologies with a long lifetime and/or for which there are proven alternatives (e.g. construction of new coal-fired power plants) are not eligible for crediting under A6.4, could discourage the construction of some GHG-intensive technologies or systems.	Setting rules at international level on the eligibility (or not) of specific technologies or processes may run counter to specific national circumstances and Parties' ability to determine what constitutes sustainable development.
Encouraging specific activity types	Reduce barriers for specific activity types; e.g. lower levels of international oversight, any share or proceeds, etc.	Could encourage specific types of activities which have a large total GHG mitigation potential (e.g. energy efficiency activities, certain small-scale activities) but where take-up has been relatively low in carbon markets to date.	Would need further discussion of how such barriers could be reduced, and who would make such decisions. It would also skew market incentives. The idea of a "positive list" was not politically palatable in the context of the CDM.
Limit crediting levels (1)	Lower the number of credits generated by a specific activity compared to calculated emission reductions.	Limiting the number of credits that could be generated (e.g. via conservative baselines, short crediting periods, and/or discounting of credits), could raise their cost, which could in turn encourage buyer countries to enhance their efforts to reduce emissions domestically.	Some countries have stated that their current/future ambition is contingent on access to international offsets.
Limit crediting levels (2)	Cap total levels of credits generated by the Article 6.4 mechanism	Would limit the extent to which buying countries could limit/delay the introduction of measures to reduce domestic emission levels.	Would skew market incentives that A6.4 sets up, would need *ex ante* rules e.g. on what the total cap is. How a cap would influence crediting from specific A6.4 activities such as discounting credits from all activities, stopping approval of proposed activities after a certain date/after a certain threshold of activities and/or expected emission reductions have been approved internationally.
Increase sectoral scope of non-economy-wide NDCs	If the issuance of A6.4ERs is allowed for sectors outside of current NDC scope, require that the sector is included	Would progressively increase the scope of the NDC, encouraging early mitigation also in those sectors that are currently not covered by the NDC.	Some countries might see this as a disincentive to start early mitigation in sectors outside the NDC scope if a corresponding adjustment is required for transactions of ITMOs from outside NDCs scope.

Appendix 3. Literature related to BCF

1. Michaelowa et al (2022)

1. To enable continued use of emissions intensity baselines in crediting mechanisms while being in line with the PA’s goal to pursue efforts to limit temperature rise to 1.5˚ C, we propose to apply an ‘ambition coefficient’ to emissions intensities of technologies when establishing the baseline. This coefficient would decrease to reflect increasing ambition over time, and reach zero when a country needs to reach net zero emissions. Due to the principle of common but differentiated responsibilities and respective capabilities, the coefficient would fall more quickly for developed than for developing countries. The latter would be able to generate emission reduction credits well beyond 2050, while for the former, crediting would stop around 2035 or before. The ambition coefficient is not directly applicable to removal activities as typically these do not feature an intensity baseline (or this baseline is zero). Still, we believe that the underlying principle of including a normative reference point could also be applied for removal activities. Yet, elaborating this would require future research.

2. Illustrative examples are included in Table 2 below

Table 2. Baseline and project emissions and credit volume differences between CDM and ambition coefficient approach (t CO_2) for waste-related activities in South Korea and Ethiopia.

Emissions	2020	2025	2030	2035
LFG power plant in Changwon, South Korea				
Baseline under CDM	15,560	11,707	8808	6627
Declining accountable share of BAU emissions as per ambition coefficient	100%	75%	50%	25%
Baseline including ambition coefficient	15,560	8780	4404	1657
Project emissions	–	–	–	–
Credit volume per CDM approach	15,560	11,707	8808	6627
Credit volume per ambition coefficient approach	15,560	8780	4404	1657
Difference in credit volume between CDM and ambition coefficient approach	*0%*	*−25%*	*−50%*	*−75%*
GHG emissions reduction through Modjo Common Effluent Treatment Plant, Ethiopia				
Baseline under CDM	151,230	151,230	151,230	151,230
Declining accountable share of BAU emissions as per ambition coefficient	100%	90%	80%	70%
Baseline including ambition coefficient	151,230	136,107	120,984	105,861
Project emissions	8627	8627	8627	8627
Credit volume per CDM approach	142,603	142,603	142,603	142,603
Credit volume per ambition coefficient approach	142,603	127,480	112,357	97,234
Difference in credit volume between CDM and ambition coefficient approach	*0%*	*−11%*	*−21%*	*−32%*

Note: Project emissions are zero for the LFG power plant in Changwon, South Korea.

2. Hermwille, Lukas. (2020)

3. Hermwille (2020) refer to the normative reference as an ‘ought margin’ which is defined as the normatively desirable endpoint of the emissions trajectory, i.e. zero GHG emissions if we follow the long-term objective of the PA. The baseline is calculated as a weighted average of the BAU (the situation) and the ‘ought margin’ (the ambition), with the weights shifting over time from 100% BAU and 0% ‘ought margin’ to 0% BAU and 100% ‘ought margin’.

4. They suggest to calculate the crediting baseline as a weighted average of the IS margin representing the status quo of current (insufficient) levels of climate performance in the relevant area and the OUGHT margin – representing the transformative ambition that is required to meet the Paris objectives. The IS-margin is defined by the average performance of the sector and can be developed using the same set of methodologies and tools developed for the CDM including the principle of conservative estimates. A dynamic element is introduced by shifting the relative weight from the IS margin towards the OUGHT margin in the course of the crediting period.

5. The OUGHT-margin represents the transformative ambition of the Paris Agreement. The first and most obvious point of departure would be to develop the OUGHT-margin based on NDCs. For example, countries that have specified a target for the power sector this target could be translated into an OUGHT-margin relatively easily. For many other sectors, though, it would be required to break down the aggregated NDC into sectoral targets…

6. One option is benchmarking on the basis of best available technologies for the ought-margin i.e. the most advanced technology commercially available anywhere on the globe. In particular, this option needs high quality performance data in the sector. The ought margin could also be developed on the basis of long-term deep decarbonization scenarios provided in the academic literature including the work of the IPCC i.e. Integrated assessment models (IAMs).

7. A technically straightforward yet politically charged approach would be to accept zero emissions as long-term benchmark for the Ought-margin. Transition factor and transition period can be understood to represent a normative commitment of how fast the host country should switch tracks onto a transformative low-GHG development pathway.

8. In terms of cons of the proposal, authors note that resulting decreasing revenue stream may also threaten projects that depend on a continuous revenue stream to maintain operation. If the revenue stream is not sufficient to cover operation and maintenance cost of the mitigation equipment used in the project, the actual mitigation activity may be stopped and the underlying economic activity continue unabated. … one could apply any other combination of weights for the IS and OUGHT margin, e.g. 50/50 throughout the crediting period, to more evenly distribute the revenue stream.

Appendix 4. Extracts from the Chapter Mitigation Pathways Compatible with Long-term Goals from IPCC AR6 WG III report (2022)

1. Scenario and emission pathways are used to explore possible long-term trajectories, the effectiveness of possible mitigation strategies, and to help understand key uncertainties about the future. A scenario is an integrated description of a possible future of the human–environment system and could be a qualitative narrative, quantitative projection, or both. Scenarios typically capture interactions and processes that change key driving forces such as population, GDP, technology, lifestyles, and policy, and the consequences on energy use, land use, and emissions. Scenarios are not predictions or forecasts. An emission pathway is a modelled trajectory of anthropogenic emissions and, therefore, a part of a scenario.

2. More than 2000 quantitative emissions pathways were submitted to the IPCC's Sixth Assessment Report AR6 scenarios database, out of which 1202 scenarios included sufficient information for assessing the associated warming consistent with WGI. Five Illustrative Mitigation Pathways (IMPs) were selected, each emphasising a different scenario element as its defining feature: heavy reliance on renewables (IMPRen), strong emphasis on energy demand reductions (IMP-LD), extensive use of carbon dioxide removal (CDR) in the energy and the industry sectors to achieve net negative emissions (IMP-Neg), mitigation in the context of broader sustainable development (IMPSP), and the implications of a less rapid and gradual strengthening of near-term mitigation actions (IMP-GS).

3. Pathways limiting warming to 2°C (>67%) or lower exhibit substantial reductions in emissions from all sectors (high confidence). Projected CO_2 emissions reductions between 2019 and 2050 in 1.5°C (>50%) pathways with no or limited overshoot are around 77% (31–96%) for energy demand, 115% (90–167%) for energy supply, and 148% (94-387%) for agriculture, forestry and other land use (AFOLU).

4. In mitigation pathways that limit warming to 2°C (>67%), marginal abatement costs of carbon are about 90 (60–120) USD 2015 tCO_2 in 2030 and about 210 (140–340) USD 2015 tCO_2 in 2050; in pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, they are about 220 (170–290) USD 2015 tCO_2 in 2030 and about 630 (430-990) USD 2015 tCO_2 in 2050.

5. As most IAM pathways follow the Mitigation Pathways follow cost-effectiveness approach, they do not make any additional equity assumptions.

6. Regional IAM results therefore need to be assessed with care, considering that emissions reductions are happening where it is most cost-effective, which needs to be separated from who is ultimately paying for the mitigation costs. Cost-effective pathways can provide a useful benchmark, but may not reflect real-world developments.

7. In addition to the constraints on change in global mean temperature, the Paris Agreement also calls for reaching a balance of sources and sinks of GHG emissions (Art. 4). Different interpretations of the concept related to balance have been published (Rogelj et al. 2015c; Fuglestvedt et al. 2018). Key concepts include that of net zero CO2 emissions (anthropogenic CO2 sources and sinks equal zero) and net zero greenhouse gas emissions……Moreover, it should be noted that while reaching net zero CO2 emissions typically coincides with the peak in temperature increase; net zero GHG emissions (based on GWP-100) imply a decrease in global temperature (Riahi et al. 2021) and net zero GHG emissions typically require negative CO2 emissions to compensate for the remaining emissions from other GHGs. Many countries have started to formulate climate policy in the year that net zero emissions (either CO2 or all greenhouse gases) are reached – although, at the moment, formulations are often still vague (Rogelj et al. 2021). There has been increased attention on the timing of net zero emissions in the scientific literature and ways to achieve it.

8. In cost-optimal scenarios, regions will mostly achieve net zero emissions as a function of options for emission reduction, CDR, and expected baseline emission growth (van Soest et al. 2021b). The timing of net zero CO2 or GHG emissions may differ across regions and sectors. Achieving net zero emissions globally implies that some sectors and regions must reach net zero CO2 or GHG ahead of the time of global net zero CO2 or GHG if others reach it later.

9. The adoption and implementation of net zero CO_2 or GHG emission targets by countries and regions also depends on equity and capacity criteria. The Paris Agreement recognises that peaking of emissions will occur later in developing countries.

10. (Art. 4.1). Just transitions to net zero CO2 or GHG could be expected to follow multiple pathways, in different contexts. Regions may decide about net zero pathways based on their consideration of potential for rapid transition to low-carbon development pathways, the capacity to design and implement those changes, and perceptions of equity within and across countries. Cost-effective pathways from global models have been shown to distribute the mitigation effort unevenly and inequitably in the absence of financial support mechanisms and capacity building (Budolfson et al. 2021), and hence would require additional measures to become aligned with equity considerations (Fyson et al. 2020; van Soest et al. 2021b).

Appendix 5. Target-setting methods used by the Science Based Targets initiative (SBTi)

1. SBTi (https://sciencebasedtargets.org/), designed to assess corporate emission reduction targets, includes ‘the Absolute Contraction Approach (ACA)’ and ‘the Sectoral Decarbonization Approach (SDA)’.

1. These are based on (i) Convergence, where all companies within a given sector reduce their emissions intensity to a common value by some future year as dictated by a global emissions pathway (e.g., the emissions intensity of all electric power companies converges to a maximum of 29 g CO2e per kWh of electricity in 2050) or (ii) Contraction, where all companies reduce their absolute emissions or economic emissions intensity (e.g., tonnes GHG per unit value-added) at the same rate, irrespective of initial emissions performance, and do not have to converge upon a common emissions value. The SDA method that allows carbon-intensity metrics and targets to be derived from global mitigation pathways are used for road transportation, aviation, the generation of electricity or the production of basic materials. These activity-specific metrics are meant to help reflect the different pace at which different sectors and economic activities decarbonize in Paris-aligned mitigation pathways, including those activities that decarbonise faster than the global average (e.g. power generation) or others that decarbonize at a slower pace (e.g. aviation, cement production, etc.).

2. As per SBTi website information, an analysis of 338 companies showed that companies with science-based targets have reduced their combined emissions by 25% in 5 years since 2015, contrasting with an increase of 3.4% in global emissions from energy and industrial processes over the same period.

3. However SBTi approach is criticized in the literature as below:
Ian Morse. May 16, 2023. *Inside the little-known group setting the corporate climate agenda. MIT Technology Review*.
https://www.technologyreview.com/2023/05/16/1073064/inside-the-little-known-group-setting-the-corporate-climate-agenda/#:~:text=Critics%20say%20SBTi%20is%20giving,standards%20as%20huge%20historic%20polluters

4. The group has earned praise for some of its strictest policies, and for reeling the private sector into a constructive conversation about climate emissions.

5. Critics however say SBTi is giving companies too much latitude in how they set their targets; that it is allowing them to rely on certain dubious tools to address emissions; and that it is holding emerging companies in poor nations to the same standards as huge historic polluters.

6. The starting point for SBTi’s approach is what’s known as the world’s “carbon budget.” The UN Intergovernmental Panel on Climate Change determined that collectively, nations can only afford to emit another 500 billion metric tons of carbon dioxide over roughly the next three decades and still have a 50-50 shot at holding warming to 1.5 ºC. SBTi allocates shares of that carbon budget to sectors and companies, which then have several choices in setting targets. Two-thirds of companies have selected the simplest method, committing to per-year emissions cuts through 2030. To be in line with 1.5 ºC targets, SBTi requires companies to plan to reduce emissions across their supply chains by at least 4.2% every year.

7. For that reason, scientists have said that SBTi's methods do not support a UN principle, established in 1992, that richer countries should bear a larger share of the responsibility for mitigating climate change.

8. **Anders Bjørn et al 2021 Environ. Res. Lett. 16 054019 'From the Paris Agreement to corporate climate commitments: evaluation of seven methods for setting "science-based" emission targets', DOI 10.1088/1748-9326/abe57b**
Authors note regarding SBTi, that the methods for setting such targets are not presented in a comparable way in target-setting guidelines and concerns that certain methods may lead to overshoot of the temperature goal have not been investigated. ……..The methods vary greatly with respect to emission allocation principles, required company variables and embedded global emission scenarios. Some methods treat companies largely the same, while others differentiate between company types based on geography, economic sector, projected growth rate or baseline emission intensity. The application of individual target-setting methods as well as different mixes of methods tend to result in an imbalance between time-integrated aggregated SBTs and global allowable emissions. The sign and size of this imbalance is in some cases sensitive to the shape of the global emission pathway and the distribution of variables between the company archetypes. We recommend that the SBT initiative (a) use our SBT method characterisation to present methods in a systematic way, (b) consider our emission imbalance analysis in its method recommendations, (c) disclose underlying reasons for its method recommendations, and (d) require transparency from companies on the calculation of established SBTs.

Appendix 6. ISO. Net Zero Guidelines – Accelerating the transition to net zero. IWA 42:2022(E). First edition 2022-11.

1. Pg vi.This document provides guiding principles and recommendations to enable a common approach with a high level of ambition, to drive organizations to achieve net zero GHGs as soon as possible and by 2050 at the latest.

2. Pg 2. net zero GHG: condition in which human-caused residual GHG emissions (3.2.9) are balanced by human-led removals (3.3.3) over a specified period and within specified boundaries

3. Note 1 to entry: Human-led removals include ecosystem restoration, direct air carbon capture and storage, reforestation and afforestation, enhanced weathering, biochar and other effective methods.

4. Pg. 3. science-based pathway: trajectory to achieve global net zero (3.1.1) greenhouse gas emissions (3.2.2) based on scientific evidence.

5. Note 1 to entry: Scientific evidence refers to evidence that has been confirmed through peer review.

6. Note 2 to entry: In this document, applicable science-based pathways are independent 1,5 °C aligned pathways.

7. Pg 9. 5.3 Urgency: Immediate and ongoing action is taken to effectively contribute to the global efforts to hold the increase in the average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1,5 °C, by organizations achieving net zero GHG emissions as soon as possible and by 2050 at the latest.

8. Organizations set long-term targets to meet net zero by or before 2050, and interim targets to achieve substantial emissions reductions of Scope 1, Scope 2 and Scope 3 emissions by 2030 or earlier. Subsequent targets are no more than five years from the preceding target and support long-term commitments for ongoing action towards and beyond 2050.

9. NOTE In order to make a fair contribution towards global net zero, some organizations, such as those with high current or historical GHG emissions and/or high capacity to act, will need to achieve net zero well before 2050.

10. Pg 9. 5.4 Ambition: Targets are set to achieve net zero GHG emissions as early as possible. Organizations with higher capacity, historical responsibility or high current emissions take additional and ambitious action to achieve net zero emissions well before the global average.

11. Specific interim targets are derived from long-term targets and take into account all GHG emissions to enable global achievement of net zero and to limit temperature rise to 1,5 °C above pre-industrial levels.

12. Pg 15. Target setting. The organization should set targets consistent with 50 % global GHG emissions reductions by 2030 (from a 2018 global baseline), achieving net zero by 2050 at the latest, and supporting global efforts to limit global warming to 1,5 °C above pre-industrial temperatures.

13. Pg 16. In addition to net zero targets, the organization should set additional, separate targets to have a neutral or positive impact on nature (e.g. a biodiversity net gain target, enhanced land regeneration).

14. Pg 31. To claim net zero, only residual emissions should remain, and these should be counterbalanced by removals. The organization should not make a net zero claim if it is on the path to net zero and still has GHG emissions that are not residual emissions, even if the emissions are counterbalanced.

15. Pg 33. Improvement. The organization should use iterative and adaptive approaches on a regular basis with an increasing level of ambition to achieve interim targets and long-term targets and to address wider impacts, where feasible. The organization should take into account emerging scientific evidence, best practice and external and internal lessons learned.

Appendix 7. Impact assessment of options for BCFs

1. In Table 1 and 2 below, a preliminary analysis of impacts of different options for BCFs and alternative/complimentary measures for BCFs are included. It is not an exhaustive analysis, nor is based on a systematic analysis of impacts based on a standard impact assessment methodology and is meant to serve as a starting point for assessing impacts.

Table 1. Impact Assessment of options 1 to 4 in relation to BCFs

Options for BCFs	Impacts	
	Advantages	**Challenges**
Option 1 (Meth. Update) and option 2 (qualitative)	• Activity participants, regulators, national authorities, auditors and other stakeholders are familiar with the proposed processes. • Buyers and activity participants and host Parties may perceive it as better for investment security with better visibility for risks. • If processes are implemented well, it may be possible to achieve similar results for emission reductions/removals as in option 3 and 4 considering that monitored and default parameters in a methodology and project reach greatly influence the emission reductions or removals achieved. • Works for both emission reductions and removals.	• Quantitative impacts on emission reductions/removals may be perceived to be less certain than option 3 or 4. • Needs greater coordination among regulators and different stakeholders to assemble information on up-to-date science and data, including on activities, in a timely manner to update parameters with more conservative values aligned with long-term climate goals. Similarly, significant capacity-building efforts to reflect changes in field-level implementation may be necessary to ensure changes are understood and implemented in an efficient and timely manner. • Scalability/impact reach their limits at some point.
Option 3 (top down)	• May be seen as a consistent approach to achieve ambitious emission reductions with greater certainty. • May facilitate speedier implementation. • Experience shows that in some jurisdictions (e.g. certain emission trading schemes) reduced supply of units has resulted in a greater price per unit. • Perception of better alignment with climate goals may attract more buyers and may reduce the reputational risk concerns of buyers.	• IPCC integrated mitigation pathways (IMPs) are based on cost optimization models and assume optimum carbon pricing and do not cover equity issues. • There are concerns related to practical ways to take into account different national circumstances. • Realization of higher prices corresponding to shrinking delivery of units is not guaranteed, beyond a threshold financial viability of an ambitious mitigation or removal activity is in question. • As observed in the literature, reduced supply of units will not necessarily

Options for BCFs	Impacts	
	Advantages	**Challenges**
		result in higher prices for the units. In some cases, host Partiess/buyers may choose to opt for other options, e.g. more domestic action by host Parties, buyers may look for alternative sources of supply. •
Option 4 (bottom up)	• May be seen as a consistent approach to achieve ambitious emission reductions with greater certainty • There is experience in relation to standardized baselines to develop country-specific parameters and factors which may be leveraged. • Experience shows that in some jurisdictions (e.g. certain emissions trading schemes) reduced supply of units has resulted in a greater price for units. • Perception of better alignment with climate goals may attract more buyers and may reduce the reputational risk concerns of buyers.	• Experience shows that internal consultation processes in the host Parties takes time. Given that the method to develop the factors is also complex and data intensive, the uptake of the option may be low. • Realization of higher prices corresponding to shrinking delivery of units is not guaranteed, beyond a threshold financial viability of an ambitious mitigation or removal activity is in question. • As observed in the literature, reduced supply of units will not necessarily result in higher prices for the units. In some cases, host Partiess/buyers may choose to opt for other options, e.g. more domestic action by host Parties, buyers may look for alternative sources of supply. • Market participants may perceive a higher level of risk that cannot be quantified up front.

Table 2. Alterantive/complementary measures to BCFs, advantages and challenges

Alternative measure	Advantages	Challenges
1. Supporting transformational projects as opposed to incremental benefits against BAU by focusing on improvements that can transform an entire sector.	• Transformative projects would have the advantages of satisfying a demand in a least emitting pathway rather than focusing on improving a specific method of producing a specific output.	• The boundaries of analysis tend to be large (international rather than national) requiring extensive data on demand and supply
2. Discouraging specific activities (so called negative list) could prevent lock-in	• Reduced supply of units can potentially lead to higher prices per unit.	• Developing such a list of activities would be challenging considering different national

Alternative measure	Advantages	Challenges
with GHG intensive technologies with long lifetime.	• May create a level playing field of upcoming technologies with better GHG performance compared to alternatives but facing barriers.	circumstances in relation to those technologies.
3. Capping the total levels of credits generated by the Article 6.4 mechanism per sector or technology.	• Reduced supply of units can potentially lead to higher prices per unit. • May create a level playing field of upcoming technologies with better GHG performance compared to alternatives but facing barriers.	• It would skew market incentives that A6.4 sets up, would have many policies related and operational challenges in relation to thresholds.

Appendix 8. Extracts from public inputs related to lock-in levels of emissions

1. 'Information note: Compilation of inputs received in response to the "public consultation: Requirements for the development and assessment of mechanism methodologies" and related literature' (A6.4-SB005-AA-A08)

1. Mechanism methodologies should require an assessment of how the activity promotes low-emission and sustainable development pathways aligned with the long-term goals of the Paris Agreement to ensure the activity is 'taking a conservative approach that avoids locking in levels of emissions, technologies, or carbon-intensive practices incompatible with paragraph 33 of the RMP' (IETA).

2. Projects that use outdated methodologies, producing inaccurate results, can deliver lock-in usually identifiable by large up-front costs but low mitigation. With forest-based projects the application of traditional carbon measurement leads to inaccurate data. Using more effective, accurate and cost-effective technology should be encouraged. This would eliminate barriers for project development and thus encourage broad participation (44M).

3. A practice/technology that has GHG emissions intensity per unit of production/consumption that exceeds the intensity of the lowest emitting, technically feasible and commercially available production pathway for the product, service or output is considered emission intensive practice/technology. An activity that leads to the prolongation of the lifetime, of an emissions-intensive practice/technology delivers lock-in of emissions levels (PCR).

4. Once a methodology is established, a minimum of 5-10 years crediting should be provided. That would ensure investment return lock-in, and after that time period a reassessment of the technology and actions for remaining eligible projects could be undertaken to ensure higher emissions technologies are not locked in for a long time (CARB).

5. When assessing "lock-in" levels, instead of promoting negative lists, a broader assessment should be conducted focused on how the activity promotes low-emission and sustainable development pathways aligned with the long-term goals of the Paris Agreement (IETA).

6. Technologies with lifetimes that go beyond 2030 but which do not allow for net zero emissions will result in emissions lock-in (AA).

2. Call for input 2023 - Structured public consultation: Requirements for the development and assessment of mechanism methodologies[17]

2.1. IETA Input to Article 6.4 Supervisory Body. Requirements for the Development and Assessment of Mechanism Methodologies April 2023

7. Finally, it is important to be pragmatic when assessing "lock-in" levels as, by definition, any project that generates residual emissions would lock-in some emissions. Instead of promoting negative lists, a broader assessment should be conducted – an assessment focused on how the activity promotes low-emission and sustainable development pathways aligned with long-term goals of the Paris Agreement.

2.2. Carbon Market Watch. Brussels, 6th April 2023

8. Overall, the framing of the document should better elaborate on key elements from the chapeau to paragraph 33 of the RMP. Article 6.4 should be aligned with 1.5°C, avoid lock-in of emissions and deliver on ambition increase over time.

9. When developing the next iteration of the recommendations in the form of an information note, the informal SB working group on methodologies, the SB, and the Secretariat must further elaborate on all the elements in paragraph 33 of the RMP. They should draw on relevant literature, and keep in mind the broader picture that the 6.4 mechanism must not inadvertently erode climate ambition by adopting weak methodological requirements that allow for over-crediting, non-additional credits, or lead to lock-in.

10. Are there classes of project, or levels and lifetimes of emissions that would deliver lock in? how might these be identified?

    (a) The 6.4SB should establish, and regularly update, a list of activities that are deemed to have a low likelihood of additionality, as well as activities that are fundamentally incompatible with reaching the long-term goal of the Paris Agreement. Activity types on this list should not be eligible under Article 6.4;

    (b) This could include for example, renewable energy projects in most regions of the world, as these are cost-competitive and highly unlikely to be additional. It would also include activity types that further the world's reliance on fossil fuels, such as increasing the efficiency of fossil fuel powered power plants, capturing leaks from fossil fuel transport infrastructure or from fossil fuel extraction sites, etc. The SB should request the Secretariat to prepare a list of activity types that are proposed for exclusion, on the basis of their low likelihood of additionality, and/or their incompatibility with reaching the long-term goals of the Paris Agreement due to lock-in risks;

    (c) Negative lists must also be developed by the SB (especially if positive lists are planned). Negative lists can be a critical way of excluding project types/activities that would lead to lock-in that is inconsistent with Paris Agreement aligned emission pathways.

[17] Submissions. https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism/calls-for-input/sb004-requirements-methodologies.

11. How might these elements or options to address them be informed by assessments such as in IPCC and IEA or Food and Agriculture Organization?

(a) External scientific reports and literature should be used to inform additionality assessments and baseline setting throughout the process, but are particularly relevant in the establishment of negative lists (and positive lists if these are used, though see answer to question 15 as positive lists should be considered with great caution). These external scientific resources should be used in particular to assess the risk of lock-in that some activity types represent, and the compatibility of activities with achieving the long-term goals of the Paris Agreement. A negative list of activity types should be based on robust science, such as IPCC reports, in order to exclude technologies and practices that are incompatible with a realistic and safe pathway towards meeting the temperature goals of the Paris Agreement.

2.3. Perspectives Climate Research. Input to questions raised by the Article 6.4 Supervisory Body (Axel Michaelowa, Juliana Keßler, Aayushi Singh, Ximena Samaniego,Olivia Wallis| Freiburg | 6 April 2023 / II-AMT)

12. (iv) ‘taking a conservative approach that avoids locking in levels of emissions, technologies or carbon intensive practices incompatible with paragraph 33 of the RMP’: the following two steps are proposed in the TOOL01 to fulfill this requirement:

(a) Perform a pre-mandatory eligibility test: The eligibility pre-check aims to prevent emissions lock-in by limiting the eligibility of activities under the Article 6.4 mechanism to activities that are not featured on any negative lists, that are in line with the host country’s long-term low-emissions development strategy (LT-LEDS) (if an LT-LEDS is available) and that do not lead to the continuation of emissions intensive technologies. The latter implies that an Article 6.4 activity should have GHG emis-sions intensity per unit of production/consumption that is lower than the intensity of the lowest emitting, technically feasible and commercially available production pathway for the product, service, or output delivered. In addition, the pre-check requires that, for proposed activities that lead to the replacement of technologies, the emissions intensity of the new technology is aligned with the generally accepted (IPCC/IEA) emissions scenario for reaching the long-term goal of the Paris Agreement.

13. Are there classes of project, or levels and lifetimes of emissions that would deliver lock in? how might these be identified?

(a) Answer: To identify classes of project or levels and lifetimes of emissions that would deliver lock in the TOOL01 (para. 12) propose the following definitions to consider:

(i) Lock-in of emission levels: The proposed activity leads to the adoption or the prolongation of the lifetime, of an emissions-intensive practice/technology;

(ii) Emissions-intensive practice/technology: A technology/technique that has a GHG emis-sions intensity per unit of production/consumption that exceeds the intensity of the lowest emitting, technically feasible and commercially available production pathway for the prod-uct, service, or output delivered. Note that this definition seeks to exclude the lock-in of incremental improvements in emissions intensity where an alternative technology or technique is available that provides the deep emission reductions required to meet the goals of the Paris Agreement.

2.4. Sylvera. Sylvera's responses to consultation: Requirements for the development and assessment of mechanism Methodologies

14. iv) taking a conservative approach that avoids locking in levels of emissions, technologies or carbon intensive practices incompatible with paragraph 33.

15. What is understood? The evolution of common practice over time, what is carbon-intensive (/carbon reductive) now may peter out.

16. How can it be operationalized?

    (a) Common practice/technological additionality tests;

    (b) Utilised dynamic baselines that automatically update to become more stringent over time.

2.5. California Air Resources Board (06/04/2023)

17. Once a methodology is established, a minimum of 5-10 years crediting should be provided. That ensures investment return lock-in and after that time period, a reassessment of the technology and actions for remaining eligible projects could be pursued to ensure higher emissions technologies are not locked in for a long time. The classes of projects best suited for shorter time periods would generally include non- biological projects, except for those that remove and sequester carbon.

2.6. 44.moles GmbH. Göttingen (05/04/2023)

18. Furthermore, we encourage applying the BAT approach to methodologies as a whole, specifically looking at measurement and verification. This would ensure project developers select the best available measurement technology, reducing the risks of overestimation.

19. In conclusion, with the current interpretation the performance-based approaches perpetuate lock-in, as project developers tend to choose baseline approaches that give them the most favourable outcome and not the most precise.

20. v. 'taking a conservative approach that avoids locking in levels of emissions, technologies of carbon intensive practices incompatible with paragraph 33 of the RMP':

    (a) This can be demonstrated by building off established scientific methods and avoiding complacency with levels of emissions, technologies, or practices. Our terrestrial laser scanners allow us to see the full capacity of a forest, preventing lock-in of emissions.

21. Are there classes of projects, or levels and lifetimes of emissions that would deliver lock in? How might these be identified?

    (a) Yes, projects that use outdated methodologies, producing inaccurate results, can deliver lock-in. Usually identifiable by large up-front costs, but low mitigations. With forest-based projects the application of traditional carbon measurement leads to inaccurate data. However, due to it being long- established it is still commonly used. Using more effective, accurate and cost-effective technology should be encouraged. This would eliminate barriers for project development and thus encourage broad participation. Ensuring that especially smaller stakeholders have feasible options to participate is crucial. Collective action is one of the main points of the Paris Agreement and the only way to achieve its goal.

22. Are there classes of project, or levels and lifetimes of emissions that might be favoured in a positive list?

(a) A positive list should favour projects fulfilling the core requirements of additionality while utilizing innovative technologies in a transparent manner. This will allow for a reduction in lock-in and a push for continuous optimization of methodologies. Transparency will allow for greater knowledge sharing among project developers and accordingly increase participation.

2.7. Ambachew F. Admassie, Public input:04/04/23

23. f) Align with the long-term temperature goal of the Paris Agreement: means:

(a) Science told us that halving emission by 2030 and achieving Net Zero by mid century will help us achieve the 1.5 ° C target. This should inform eligibility of A6.4 activity;

(b) In terms of project activity eligibility (or Additionality): one that graduates technologies such that the eligible project activity technology should be only those that allow decarbonizing at least half of the baseline emission/emission intensity for those seeking crediting years reaching until 2030 and that allow decarbonizing 99 per cent (net zero) decarbonization potential for crediting years extending after 2030;

(c) In terms of baseline: one that serves as baselines congruent to the above eligibility prescription;

(d) In terms of Activity formulation: where should an activity lie to ensure successful achievement of long- term ambition?

(i) An entire facility, product(s) or service(s) from a facility needs to determine the point of activity determination since human being consumes a product or a service (mobility, cement, food preservation, dwelling, energy/electricity etc) and not an interim activity in the process of availing these. Therefore an activity should be formulated around product, service or entire facility related to a product or service rather than a partial process. Proposal that restrict activity to a certain sub activity in a product or service delivery, may not give full picture regarding what happens in the other part of the related facility and hence may even assist emitting more than what is seen as reduction in partial activity.

Example 1: One may install a facility that exhibits significant emission and propose an emission reduction activity in a certain segment of a process using a better technology in that process referencing other scenarios or facilities in same sector utilizing inefficient technology in that partial process as baseline. However, the overall emission from this plant at the stage of final product may be much more higher than the other plants or the baseline benchmark for availing the final product or service. Therefore checking whether the A6.4 Activity allows the emission from the entire facility or the intensity of a final product or service has been at least halved (pre-2030 crediting years) or eliminated (post 2030 crediting years), compared to the baseline level, is paramount. Specific examples: cement blending, material, technology or fuel switch in partial industrial process etc.;

(ii) Even after determining an activity at a facility or final product level, what level of de-carbonization should be eligible? When should technology cease to be credited even if it was eligible once?

A brand new Audi 2023 ICE will not halve emissions from any baseline, by 2030 but may be better performing (in terms of emission) than an average vehicle in the same country. A Hybrid electric vehicle (HEV) may improve fuel consumption compared to the baseline but may not help halve emission by 2030. A plug in Hybrid Vehicle (PHEV) may help halve emission by 2030 depending on charging pattern/consistency but may not help achieve net zero. A Battery electric Vehicle (BEV) will help net zero if the source of electricity is renewable. This allows foreseeing whether technology locking happens or not that may or may not help achieve mitigation goals at different future times.

(e) iv. 'Taking a conservative approach that avoids locking in levels of emissions, technologies or carbon intensive practices incompatible with paragraph 33 of the RMP':

(i) Installing eligibility requirement to project activity technologies based on length of crediting period and emissions intensity of proposed project technology compared to the baseline. Any activity that has crediting year before 2030 should halve emission/intensity compared to baseline to be an eligible 6.4 activity, while that extends beyond 2030 should allow decarbonizing by 99 per cent (net Zero).

24. Are there classes of project, or levels and lifetimes of emissions that would deliver lock in? How might these be identified?

(a) Technology with lifetime that goes beyond 2030 but not allow net zero, results in emissions lock in. Such classes of project can be identified by weather (sic) and to what extent fossil fuel plays part compared to baseline and by whether CCS/CCU can help achieve net zero post 2030 in the specific circumstance.

Appendix 9. Ilustravive examples from Literature related to lock-in levels of emissions

1. Erickson et al (2015) assessed, based on literature, how conventional technologies might be retired early or 'unlocked' in the future, especially if the full costs of an alternative, low-carbon technology were to fall below the marginal (in this case, the ongoing operating) costs of the conventional technology, accounting for all climate policies (e.g., carbon pricing) and incentives. For each technology, they defined the financial barrier to unlocking as the break even carbon price needed for early retirement and replacement of a technology with its most promising low-carbon alternative, determined as the predominant substitute under the low-carbon pathway.

2. The price in a given year is driven primarily by the cost of the alternative technology, which in turn will depend on how rapidly its costs decline. For the analysis, they calculated the cost of unlocking as the carbon price at which the all-in levelized cost of the low-carbon technology is equal to the marginal cost – which is mostly fuel cost – of the existing (high carbon) technology, as is common in modeling and techno-economic analyses of energy technologies. Figure 1 presents the results of the assessment, where technologies are positioned according to their technical lifetimes (x-axis) and financial barrier to unlocking (y-axis). The area of each bubble is proportional to its over-committed CO_2 emissions from equipment installed over the next 15 years and the bubble's shading reflects the degree of the techno-institutional lock-in, from low (light gray) to high (black), based on an assessment of changes in market share. Key conclusions include:

   (a) Globally, coal-fired power plants are long-lived (averaging 45 years), and large numbers are expected over the next 15 years (over-committing 200 $GtCO_2$), creating further political and institutional entrenchment. Unlocking coal plants would, on average, require a carbon price of about USD 30 per tonne;

   (b) Two other technologies that lock in at least 5 per cent of the 270 $GtCO_2$ of over-committed CO_2 in the figure below are gas power plants (25 $GtCO_2$) and internal combustion engine (ICE) passenger vehicles (14 $GtCO_2$). Gas power may be overbuilt in the near term, that these plants may last decades, but with a lower carbon price (USD 20/tCO_2) required to unlock them, than for other technologies. Despite relatively short lifetimes, overinvestment in less efficient, more carbon-intensive ICE passenger vehicles is significant – yielding 14 $GtCO_2$ over-committed emissions due to vehicle purchases over the next 15 years, and where a carbon price of over USD 1,000 would be needed to retire them early. Continued investment in conventional ICE vehicles risks further entrenching these technologies at the expense of fostering alternatives, such as electric vehicles, and the systems that support them, such as recharging infrastructure.

Figure 1. Global assessment of carbon lock-in risks by fuel and sector.

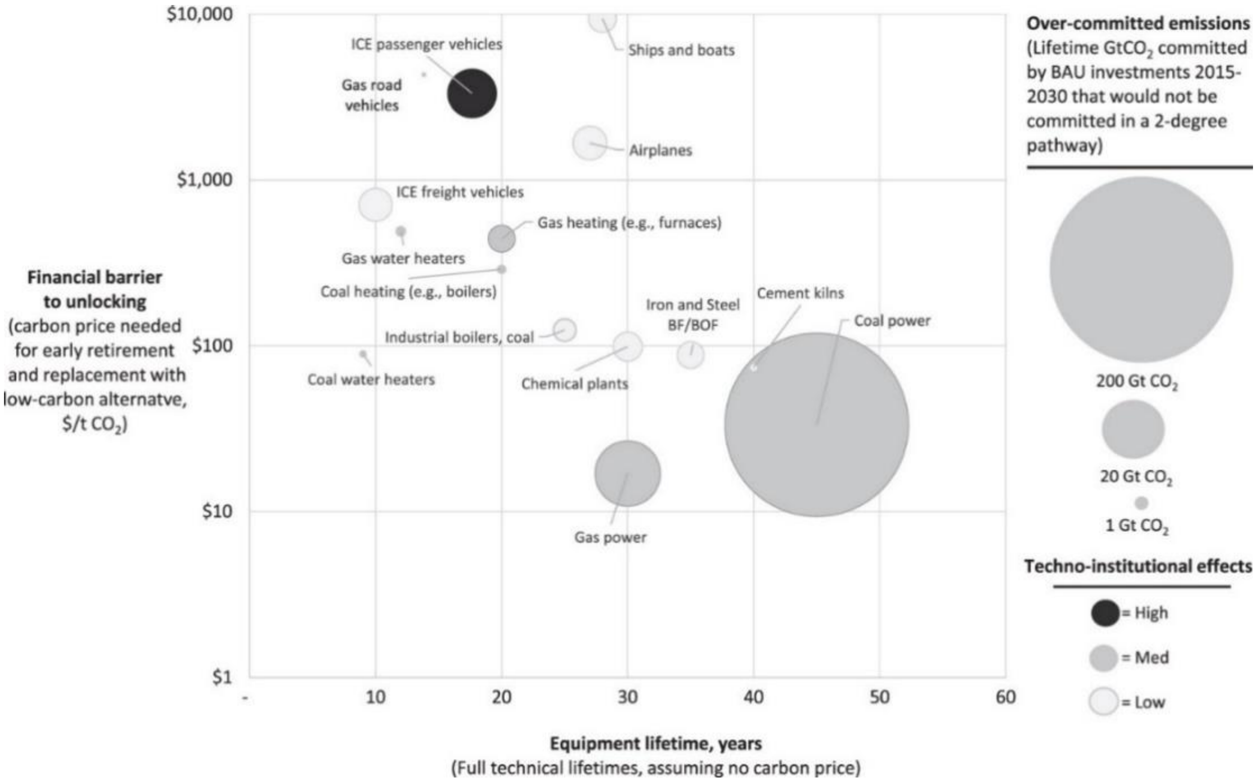
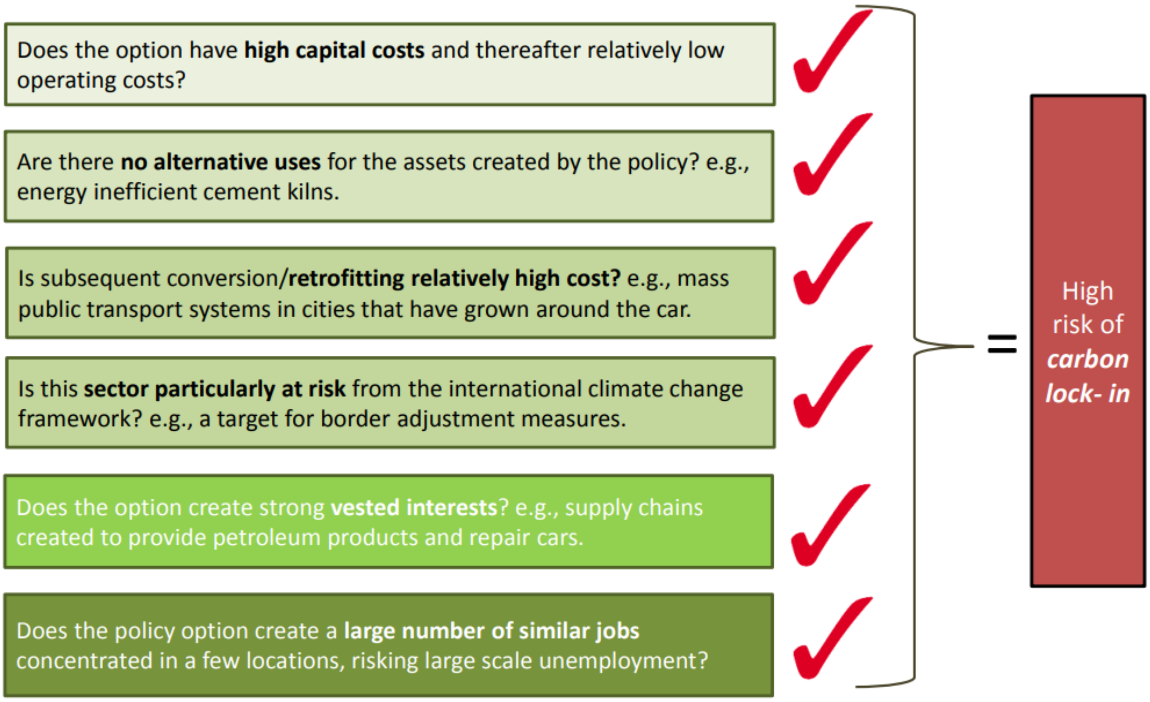


Figure 2. Quick-start guide to carbon lock-in assessments (Carbon lock-in toolkit, 2015, Submitted to the Department for International Development by Economic Consulting Associates)



Note: border adjustment measures have been discussed as a way to protect domestic firms that are subject to climate change regulation from competition from foreign firms that are not.

Appendix 10. Extracts from public inputs related to leakage

1. 'Information note: Compilation of inputs received in response to the "public consultation: Requirements for the development and assessment of mechanism methodologies" and related literature' (A6.4-SB005-AA-A08)

1. Carbon leakage has two definitions: (1) it can refer to the relocation of emission-intensive activities from jurisdictions with a higher cost to emit CO_2 to jurisdictions with a lower cost to emit, and (2) it can refer to an increase in fossil emissions outside the boundary of the project caused by the project activity itself. The Article 6.4 mechanism should be focused on minimizing any potential increase in fossil emissions outside the boundary of a project (with respect to the second definition of carbon leakage, above). In the case of removals, guidance on leakage can be specified as "Removal supplier shall assess all potential sources of leakage (i.e. increase of fossil emissions) outside of the project activity boundary but due to the activity as specified in the methodology. In the case where leakage potential is identified it shall be quantified and deducted from the CO_2 removals" (PE).

2. Leakage describes a situation where a project activity has impact outside of its boundary. This impact can be physical, economic, or social (44M).

3. The Article 6.4 mechanism should minimize the increase in emissions outside the activity boundary. Nesting of activities and jurisdiction-level crediting are proving to be effective approaches. A thorough lifecycle assessment of the impact of an activity should be the starting point to address the risk of leakage. Robust MRV systems and integrated registries are also key to identifying carbon leakage and reducing such risks across different types of activities and countries (IETA).

4. Leakage should be avoided where possible and discounts should apply when leakage risk exists. Methodologies can determine certain discount factors attached to different leakage risks. Jurisdictional approaches can help tackle leakage within the borders of a territory. Market leakage is seen by economists as inevitable for any genuinely additional project, suggesting issuing entities must seek to accurately quantify and account for (i.e. apply discounts for) this (SR).

5. Innovation is needed to improve estimation of leakage, to better avoid leakage, such as increased emissions elsewhere due to displacement of food or timber production to non-project areas. At present many leakage assessments focus on rough estimates of local-scale (or "direct") leakage and ignore or greatly underestimate longer-range ("market") displacement of forgone production (CCC).

6. For forestry-based solutions, the greatest risks of negative leakage occur when a nation's timber industry policies do not account for the industry's intersection with the carbon market. On the other hand, a strong benefit of positive leakage is a shift in sustainability trends of the timber market. With lower barriers to entry, carbon projects provide an alternative to low-grade timber harvesting (44M).

7. On the project level, leakage can be addressed by thorough inspection of the area surrounding a project. Some project developers create a "leakage belt" to assess this element of a project over time and account for it through discounting of offsets. Providing foresters with a cost-effective alternative to timber harvesting reduces leakage in the long run (44M).

8. Activity carbon leakages should be addressed in cases where the effect is negative to the jurisdiction with less stringent climate policies. This is often the case when project developers from Annex I countries create projects in Non-Annex I countries, of a lower quality than they otherwise would. Stricter national policies outlining the parameters for which carbon projects by foreign entities can exist could help with this. Another approach, on a larger scale, could be to increase cross-national policies or matching commitment agreements as proposed by the authors of "Combating climate change with matching-commitment agreements" (44M).

9. Leakage involves the risk of displacing activities that cause GHG emissions from the project site to another geographic location (including across international boundaries) for economic reasons. Economic leakage occurs when the market demand for an emitting activity is sustained despite the development of a carbon dioxide removal project. Note: these concepts are distinct from physical leakage (reversals), which occur when carbon that is stored throughout the course of a carbon offset project is re-released into the atmosphere through either avoidable (for example, a failure to maintain sequestration wells) or unavoidable (for example, extreme weather events) means (MS).

10. Leakage occurs when efforts to reduce GHG emissions in one country or sector lead to an increase in emissions in another country or sector. This can happen, for example, if a country imposes a tax on carbon emissions, which leads to the relocation of carbon-intensive industries to countries with less stringent regulations. In this case, the emission reductions achieved in the country that imposed the tax is offset by the emissions increase in the country where the industries have relocated. The greatest risks of leakage occur when mitigation policies are implemented in a way that is not globally coordinated or when there is a lack of global cooperation on climate change. For example, if a group of countries agree to reduce their emissions under the Paris Agreement, but other countries do not follow suit, the emission reductions achieved by the first group of countries could be offset by emission increases in the nonparticipating countries. Another risk of leakage occurs when mitigation policies are not comprehensive and do not cover all sectors of the economy or all types of emissions. For example, if a country imposes a tax on carbon emissions from electricity generation but does not regulate emissions from transportation or agriculture, emission reductions in the electricity sector may be offset by emissions increases in the other sectors (CP).

11. Emissions from the construction phase should be counted as project emissions (CCC).

12. The emissions from the construction phase should be considered part of the project emissions in the Life Cycle Assessment (PE).

Appendix 11. Current practices to address leakage

1. Included in Table 1 below is a granular information from specific CDM methodologies on how different leakage sources were addressed.

Table 1. Identification and addressing of leakage sources in CDM methodologies

Sector and key measures to address leakage	Extract from the methodology	Any revisions to the requirement and rationale	Implementation in projects
Energy efficient (lighting) Destruction/scrapping of baseline light bulbs	Leakage can be neglected if the lamps replaced are scrapped. The scrapping of replaced lamps should be documented and independently verified (destruction documented via witnessing by local environmental officials or time stamped video records). Scrapped lamps should be stored until such correspondence has been checked. (AMS-II.C. v15, AMS-II.J. v07 AM0046 v02, AM0113 v02)	Requirement holds.	PoA 3223: ICLs were collected by the PP and certificate of handing over/ taking over ("Certificate of Destruction") were issued by ICL destruction agencies. DOE verified the certificates and boxes where the lamps were stored. PA4056: the number of scrapped lightbulbs has been crosschecked against available records from a local recycling company contracted by the project participants to collect and recycle the metal sockets of the scrapped lightbulbs.
Energy efficiency (equipment in general) Destruction/scrapping of baseline equipment	Leakage can be neglected if the equipment replaced is scrapped. An independent monitoring of scrapping of replaced equipment needs to be implemented which includes a check on whether the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other (scrapped equipment should be stored until such correspondence has been checked). (AM0091 v04)	Requirement holds. AM0091 v04 is the latest version.	No project registered applying any version of the methodology.
Energy efficiency (chillers) Destruction/scrapping of baseline chillers	The existing chiller will be scrapped, and scraping will be monitored and certified according to an established monitoring and certification protocol.	Requirement holds. AM0060 v02 is the latest version.	No project registered applying any version of the methodology.

Sector and key measures to address leakage	Extract from the methodology	Any revisions to the requirement and rationale	Implementation in projects
	The destruction must be witnessed, photographed (still and video), and certified by an independent third party, using a standard form of certification that shall make provisions for the unique identification of the existing chiller destroyed. (AM0060 v02)		
Energy efficiency (transformers) Destruction/scrapping of baseline transformer	No leakage is accounted if it can be ensured that the replaced transformers are not used elsewhere through documentary evidence of scrapping. DOE should verify that the replaced transformers have not been distributed at other places. (AM0067 v02)	Requirement holds. AM0067 v02 is the latest version.	No project registered applying any version of the methodology.
Transport (cars) Destruction/scrapping of baseline vehicles	For PoAs only: leakage can be neglected if the equipment replaced is scrapped. An independent monitoring of scrapping of replaced equipment needs to be implemented which includes a check on whether the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other (scrapped equipment should be stored until such correspondence has been checked). The scrapping of replaced equipment should be documented and independently verified. (AMS-III.C. v11 and AMS-III.S. v03)	Requirement removed to keep the methodologies simple (from AMS-III.C. v12 and AMS-III.S. v04 onwards)	PoA 2897: A scrapping certificate is issued to owners that hand-over their vehicles to scrapping facilities. This certificate contains the details of the vehicle scrapped, such as the chassis number, and is used by the vehicle owner to get a loan to buy a new and more efficient vehicle.
Transport (buses) Destruction/scrapping of baseline vehicles	The methodology is applicable for the segregated BRT bus lanes or the rail-based MRTS replaces existing bus routes (e.g. through scrapping units or through closing or re-scheduling existing bus routes) operating under mixed traffic conditions.	For projects involving BRTs, the following specific provisions apply: (…) (b) The buses used in the routes that were replaced by the project MRTS can be retired or	No project registered applying version 05 of the methodology. (From ACM0016 v05 and AM0031 v07 onwards)

Sector and key measures to address leakage	Extract from the methodology	Any revisions to the requirement and rationale	Implementation in projects
	(ACM0016 v04, AM0031 v06)	relocated to another part of the network.	Requirement to scrap baseline buses removed to allow the use of baseline buses in other parts of the transport to meet a growing demand to avoid use of even more emission intensive technologies.
Type I methodologies (electricity and/or heat generation) Transfer of equipment	No need to include a requirement to the replaced energy-generating equipment is scrapped and that this scrapping should be independently monitored since the replaced equipment would most likely replace less efficient equipment outside the project boundary.	This is the latest version of the guidelines.	If the energy generating equipment currently being utilized is transferred from outside the boundary to the project activity, leakage is to be considered (AMS-I.C v22).
Biomass for power and/or heat generation Diversion of biomass	Demonstrate that the total quantity of biomass residues annually available in the project region is at least 25 per cent larger than the quantity of biomass residues which is utilized annually in the project region (e.g. for energy generation or as feedstock), including the project facility to conclude that there is an abundant surplus of the biomass residue in the project region which is not utilized. The project region is an area within a radius of 250km around the project activity, (TOOL16 v05)	This is the latest version of the methodological tool.	PA7575: demonstrated using statistics from local government.
Cookstoves Diversion of non-renewable biomass saved	- Leakage related to the non-renewable woody biomass saved by the project activity shall be assessed based on ex post surveys of users and the areas from which this woody biomass is sourced (using 90/30 precision for a selection of samples). The potential source of leakage due to the use/diversion of non-renewable woody biomass saved under the project activity by non-project households/users that previously used renewable energy sources shall be considered. If this leakage	This is the latest version of the methodology.	Most projects have used discounting (5% of baseline emissions).

Sector and key measures to address leakage	Extract from the methodology	Any revisions to the requirement and rationale	Implementation in projects
	assessment quantifies an increase in the use of non-renewable woody biomass by the non-project households/users, that is attributable to the project activity, then $Bold,i,j$ is adjusted to account for the quantified leakage. - Alternatively, $By,savings,i,j$ is multiplied by a net to gross adjustment factor of 0.95 to account for leakages, in which case surveys are not required. - Project activities switching from baseline device using firewood to efficient project device using charcoal or switching from firewood to efficient project device using processed biomass (briquette, pellets, and woodchips) shall take into account the leakage effects related to the charcoal or processed biomass production. A default value of 0.030 $t_{CH4}/t_{charcoal}$ may be used in accordance with AMS-III.BG. (AMS II.G v 13)		

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Document information

Version	*Date*	*Description*
01.1	29 June 2023	Editorial correction to table of contents to include appendix 11.
01.0	28 June 2023	Published as a late annex to the annotated agenda of SB 006.

Decision Class: Regulatory
Document Type: Information note
Business Function: Methodology
Keywords: A6.4 Mechanism, methodologies, regulatory framework

Related documents:

28 June 2023	A6.4-SB006-AA-A08 – Draft recommendation: Requirements for the development and assessment of mechanism methodologies (version 04.0)
17 May 2023	A6.4-SB005-AA-A07- Information note: Draft elements for the recommendation on requirements for the development and assessment of mechanism methodologies (version 01.0) A6.4-SB005-AA-A08 - Information note: Compilation of inputs in response to the “public consultation: Requirements for the development and assessment of mechanism methodologies” and related literature (version 01.0)
21 February 2023	A6.4-SB004-AA-A10 - Draft recommendation: Requirements for the development and assessment of mechanism methodologies (version 03.0) (Zip file: Appendices 1 - 4 to Annex 10)
07 November 2022	A6.4-SB003-A04 – Information note: Status of current work on the application of the requirements referred to in chapter V B (Methodologies) of the rules, modalities and procedures (version 01.0)
25 October 2022	A6.4-SB003-AA-A05 – Draft recommendation: Requirements for the development and assessment of mechanism methodologies (version 02.0) A6.4-SB003-AA-A06 - *Information note*: Requirements for the development and assessment of mechanism methodologies (version 02.0)
12 September 2022	A6.4-SB002-AA-A07 - Draft recommendation: Requirements for the development and assessment of mechanism methodologies (version 01.0) A6.4-SB002-AA-A08 - *Information note*: Requirements for the development and assessment of mechanism methodologies (version 01.0)
08 July 2022	A6.4-SB001-AA-A06 - *Concept note*: Guidelines for implementation of methodological principles, approaches, and methods for the establishment of baseline and additionality (version 01.0)