Dynamic Baseline Study for a Solar PV Policy in Vietnam: Attracting carbon finance for NDC ambition raising

ICAT
Initiative for Climate Action Transparency

Initiative for Climate Action Transparency – ICAT
DYNAMIC BASELINE STUDY FOR A SOLAR PV POLICY IN VIETNAM:
TO ATTRACT CARBON FINANCE FOR NDC AMBITION RAISING

Deliverable 3.1

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1. Introduction

Viet Nam's response to climate change and its contribution to the global mitigation goal of limiting global warming to below 1.5-2°C was first communicated to the UNFCCC in its Intended Nationally Determined Contribution (INDC) 2015. Viet Nam signed the Paris Agreement (PA) on Climate Change April 22nd, 2016. From that time, Viet Nam's INDC has officially become its NDC. According to Viet Nam's updated NDC in 2020, Viet Nam will reduce GHG emissions with domestic resources (unconditional) by 9% in 2030 compared to the Business as Usual (BAU) scenario (estimated at 83.9 $MtCO_2e$). This 9% contribution could be increased to 27% (approximately 250.8 $MtCO_2e$) if international support is received (conditional). In addition to this, at the COP 26 in Glasgow, Viet Nam committed to achieve Net-Zero by 2050.

In order to facilitate the fulfilment of Viet Nam's commitments, Plan for Implementation of the Paris Agreement was issued by the Prime Minister in 2016 (Decision No. 2053/QD-TTg). It identifies five groups of tasks: (1) Mitigation of GHG emissions; (2) Adaptation to climate change; (3) Preparation and mobilization of resources; (4) Establishment of MRV system for transparency; (5) Institutional and policy development and strengthening. The development and operation of the national MRV system is one of the primary missions indicated in the Plan for Implementation of the PA (Mission 51 of the Plan).

Ministry of Natural Resources and Environment (MONRE) is the focal point for the National GHG Inventory System and is responsible for carrying out the GHG inventory and for developing a GHG inventory technical report. Measurement, reporting and verification (MRV) at sectoral level is currently under development by line ministries. In the Implementation Plan of the PA, line ministries have been assigned to develop the sectoral MRV systems.

At present, the establishment of the MRV system at local level is being studied by local authorities. For each type of mitigation project, an MRV system at project level will be developed by project stakeholders in accordance with the guideline of the mechanism. In parallel to the implementation of the Paris Agreement the Government of Viet Nam has developed a National Action Plan to implement the 2030 Agenda for Sustainable Development (Decision No. 622/QD-TTg, May 10th, 2017). The action plan identifies 17 sustainable development goals of Viet Nam by 2030, of which goal No. 13 is to take timely and efficient actions to respond to climate change and natural disasters. Viet Nam's response to climate change is viewed in context of sustainable development to promote socio-economic benefits and to avoid or mitigate negative impacts of policies and actions. Though a national GHG inventory system is established by Prime Minister decision, it is not yet working properly. For instance, GHG impact assessments have been carried by some experts, but methodologies, models and tools are not used consistently across 8 groups of experts in various ministries. Communication and sharing of data across sectors and between sub-sectors in agriculture energy can be improved. No other support partners such as CBIT and GIZ cover tracking progress of NDC implementation under the Enhanced Transparency Framework (ETF) of the PA. GIZ has developed 'Indicators for monitoring the implementation of 68 tasks of the Plan for Implementation of the Paris Agreement' under the SIPA programme, however, this is not designed to meet the requirements of the ETF.

Finally, in July 2022, the National Climate Change Strategy of Viet Nam was issued which aims to actively and effectively adapt to climate change, reduce vulnerability, loss and damage due to climate change; reduce greenhouse gas emissions according to the net-zero emissions goal by 2050, actively and responsibly contribute to the international community in protecting the earth's climate system; take advantage of opportunities from climate change response to transform growth models, improve resilience and competitiveness of the economy.

On this background the Initiative for Climate Action Transparency (ICAT) seeks to support Viet Nam's efforts to establish a domestic Measurement, Reporting and Verifiable (MRV)/transparency system for implementation of the ETF of the PA with a focus on tracking progress of NDC implementation in the energy and agriculture sectors.

ICAT also aims to support Vietnam it the development of institutional arrangements and capacity building to manage GHG and SD data for NDC implementation tracking but also for other actions such as those related with cooperative approaches under the Paris Agreement Article 6. In relation with the latter, the development of carbon crediting baselines that is more stringent over time and are consistent with the emissions paths leading towards net zero emissions in the second half of the century is the purpose of this report. We will call it 'dynamic' baseline in opposition to the traditional approaches to crediting baseline setting under CDM and JI. Within this scope, the report aims to develop ambition coefficients and dynamic baselines for Viet Nam and solar power development sector.

2. Background

2.1. The global emissions gap to achieve the Paris Agreement 1.5-2°C goal

According to the IPCC Sixth Assessment cycle Summary for Policymakers, it is estimated human activities have already caused a global warming of 0.8-1.2°C above pre-industrial levels and that, at the current rate of GHG emissions, global warming is likely to reach 1.5°C between 2030 and 2050 unless GHG emissions are immediately reduced at large scale. But, even if countries would drastically stop emitting, global warming would still increase by more than 0.5°C over the next two or three decades and the warming caused so far will persist for centuries and continue to cause changes in the climate system similar to those we are already experiencing, and which effects have been continuously appearing in the news.

Climate action taken so far to counteract this trend has been characterized by weak promises which, in some cases, have not even been delivered yet. As of September 2021, the pledges made so far by countries in their Nationally Determined Contributions under the Paris Agreement (NDCs) would result in an increase of 16.3% of the total global GHG emission level by 2030 (UNFCCC September 2021 NDC Synthesis Report) and would only achieve a reduction of 7.5% in the projected 2030 emissions compared to the previous round of commitments. Whereas, if we are to stay on the least-cost path for 1.5°C and 2°C, emissions reductions up to 30% and 55% respectively would be needed according to the 2021 Emissions Gap Report. As they are now, if only the unconditional goals of the updated NDCs are implemented, global warming could reach 2.7°C by the end of the century. Even if net-zero commitments, which in many cases are not aligned with the NDCs, are fulfilled, global warming could increase up to 2.2°C.

If these scenarios are to be avoided immediate action by all nations is needed. NDCs´ ambition must be raised, plans must be made, policies must be put in place and implemented and ultimately emissions cuts must be achieved. There is still time to do this, and the available tools to do so are many.

2.2. Transformational change and the role of Article 6 to close the gap

The Article 6 of the Paris Agreement foresees cooperation among countries as a strategy to contribute to the implementation of the NDCs. Carbon markets mechanisms in particular are considered useful approaches to achieve emissions reduction goals in a cost-effective manner, especially in regard to those emissions which are harder to abate. Besides, carbon markets may also contribute to promote ambition raising in both mitigation and adaptation, increase private sector engagement and pursue sustainable development. This has been acknowledged and interest on carbon markets has grown in the last years as a result, to the extent that, as of July 2021, 87% of the new and updated NDCs already mention voluntary cooperation under Article 6 as a mean to achieve their goals and 5 out of the 50 countries that announced net-zero targets have explicitly indicated their intent to use international trading to achieve it (UNFCCC, 2021).

However, the wide diversity of targets in the NDCs makes it difficult to assess the actual maximum mitigation potential of carbon markets. Still, some studies estimate that the use of market mechanisms could reduce mitigation costs by 2030 by 40-60% with an annual market volume of around USD 60-100 billion (Aldy et. al., 2016; Edmonds et. al., 2019; Edmonds et. al., 2021; Fujimori et. al., 2016; Hof et. al., 2017). It is also estimated that, if these savings were redeployed towards increased ambition, global emissions reductions could be roughly doubled over the next decade compared to parties acting on their own, and thus provide two thirds of the emissions reductions required to get on the 2°C pathway through 2035 (Edmonds et. al., 2021; Piris-Caberas et. al., 2019). In addition to this, carbon markets could also have an impact on several sustainable development categories and would also produce a flow of mitigation-focused capital from buyer to seller countries which could contribute to capacity building on emissions reduction among other things.

Provided carbon markets promote sustainable development, their activities rely on a robust baseline and fulfil environmental integrity, additionality and double counting avoidance, they might as well contribute to raise the ambition of the parts involved, to mitigate overall global emissions and, ultimately, to produce a system-wise sustained change towards the ending of high-carbon practices and the pursuing of a zero-carbon society, i.e., a transformational change.

The Article 6 rulebook agreed at the COP26 in Glasgow includes several provisions that may help to unlock carbon markets transformative potential such as the safeguards regarding environmental integrity or the requirement for the market mechanism to increase ambition over time. The provisions related to baseline setting (conservative, compatible with NDCs and PA goals etc.) would also contribute to make carbon markets a relevant vector for transformational change. In addition to this, several options that may contribute to unleash carbon markets transformative potential have been identified at market design level. For instance, the promotion of technologies with high costs and scaling needs, the development of tools to assess sustainable development co-benefits, the linking of crediting with payback periods, the establishment of long-term contracts to guarantee more investment security or the implementation of a fossil fuel subsidy reform. All these options would also benefit from the active participation and support of governments, non-state actors and the international community. This support may take the shape of incentives at national and international level, which could affect regulation (e.g., generation of positive list of activities, exclusion global GHG emissions budget non-compliant carbon credits etc), be oriented to monetarily reward specific projects characteristics (e.g., a sustainable development premium, monetarisation of positive effects on planet boundaries beyond climate etc) or focus on behavioural aspects, such as the promotion of good practices beyond the established standards.

2.3. The requirement for updating baselines and mitigation targets after COP26 in Viet Nam

a. Key results and issues of COP26

The decisions taken at COP26 confirmed the importance of international cooperation in tackling climate change and pursue sustainable development. COP26 counted with the participation of Heads of State and World Leaders who announced increased targets and committed to accelerating action towards 2030. They also recognized the important role of local communities and civil society organizations to respond to climate change. Some of the key results of COP26 can be summarized as follows:

Scientific research: The contribution of Working Group I to the 6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was appreciated, as well as the global and regional reports on the state of the climate by the World Meteorology Organization (WMO).

Adaptation to climate change: Launch of a two-year work program to define a global goal for climate change adaptation equivalent to the mitigation goal. This has been, a long-standing requirement from developing countries.

The Conference called on developed countries to urgently scale up financial provision for climate change adaptation by 2025 to at least the double compared to 2019. This shall be accompanied by technology transfers and capacity building to adapt to climate change and meet the needs of developing countries as part of a global effort, which includes the development and implementation of National Adaptation Plans (NAP).

Reducing GHG emissions: The need for stronger action in the current decade to achieve the goal of keeping the average global temperature by 2100 from a rise of 1.5°C above pre-industrial levels and thus avoid the adverse effects of climate change was emphasized. The targets, adopted by 197 countries, requires rapid and sustainable reductions in CO_2 emissions, including a 45% reduction in CO_2 emissions by 2030 compared to 2010 and achieving net zero around 2050, while drastically reducing emissions of other GHGs at the same time.

By the end of 2022, countries must review and consolidate their emissions reduction targets for 2030, a step forward instead of revising and submitting NDCs in 2025. They shall also establish a work program to urgently reduce emissions and call for an annual ministerial meeting to promote climate action. It was agreed to ask the Secretary-General of the United Nations to call for a meeting of world leaders in 2023 to scale up climate action.

The Glasgow Climate Compact calls on countries to "*accelerate efforts towards phasing down unabated coal power and reducing inefficient fossil fuel subsidies*". This is the first-time coal and fossil fuels have been explicitly mentioned in a COP decision. Countries also recognize the need to assist workers in this sector in finding other employment.

Finance, technology transfer and capacity building: COP26 highlights the importance of developed countries in fulfilling their financial commitments; urge regulatory agencies, multilateral development banks and financial institutions to scale up investments in climate-related actions, including grants and other sources of financing.

Loss and damage: developing countries demand more support from developed countries to respond to climate change, and to address the losses and damages caused by climate extremes and sea level rise, with priority given to the provision of technical assistance to developing countries.

Carbon markets: One of the main outcomes of COP26 was the finalization of the Article 6 rulebook (with some stubborn points still to be worked on), which set a framework for countries to cooperate to achieve their national goals and increase their ambition.

Other outcomes:

- Already 147 countries (accounting for almost 90% of global GHG emissions and over 90% of global GDP) have committed to net zero emissions by 2050. 103 countries (accounting for 40% of total global methane emissions) participate in the commitment to reduce global methane emissions by 30% by 2030 compared to 2020 levels.
- 141 countries (with more than 90% of the world's forests) joined the Leaders' Glasgow Declaration on Forests and Land Use.
- Nearly 50 countries joined the Global Declaration on the transition of power generation from coal to cleaner electricity. Major economies pledged to achieve a transition away from coal power generation by the 2030s. The rest of the countries committed to achieve this transition by the 2040s.
- There are 25 countries and international financial institutions committed to stop supporting fossil energy by the end of 2022 and support the transition to clean energy. An additional 28 countries have joined the Coal Discontinuation Coalition initiated by the UK and Canada, bringing the total number of members participating in this Alliance to 48. In particular, the United States and China issued a joint statement on climate change, comprehending cooperation to develop long-term strategies to achieve net zero emissions, solve problems of methane emissions, convert to clean energy and reduce GHG emissions.

b. Vietnam's contribution to global goals

At the Conference, Prime Minister Pham Minh Chinh stated: "*...even though it is a developing country that has only just begun the process of industrialization over the past three decades, Vietnam is a country with advantages in energy renewable energy and will develop and implement strong GHG* *emission reduction measures with its own resources but also with the cooperation and support of the international community, especially developed countries, through both financially and technology transfer, including implementing mechanisms under the Paris Agreement, to achieve net zero emissions by 2050."*

At COP26, Vietnam has joined the Leaders' Glasgow Declaration on Forests and Land Use, committed to reducing global methane emissions, adhere to the Global declaration on transition from coal to clean energy and endorse the Letter of Intent with Emergent Organization within the framework of The Lowering Emissions by Accelerating Forest finance (LEAF).

Vietnam's strong commitments and responsible contributions have been highly appreciated by the international community, opening many opportunities for international cooperation in low-emission growth, circular economy development and adaptation to climate change. To fulfill commitments and take advantage of opportunities, the following work lines will be pursued:

- Research and develop a number of financial mechanisms and policies for the conversion of projects under CDM to projects under Article 6.4 in accordance with the provisions of the Code of Conduct guiding the implementation of the Paris Agreement.
- Research and develop renewable energy technologies such as hydrogen, ocean waves or geothermal. Develop national technical standards and regulations, mechanisms and policies to promote and transfer technology to respond to climate change.
- Review and adjust relevant strategies and plans in line with the goal of net zero emissions by 2050. Take advantage of opportunities to transform growth models, meet sustainable development goals and respond to climate change. Anticipate the shift of investment, crediting and financial flows in the world. Strengthen international cooperation to take advantage of financial resources and knowledge, low-emission technologies transfer, renewable energy development, natural ecosystems protection and restoration, and natural and social systems resilience increasing.
- Raising awareness and capacity for organizations, businesses and individuals on Article 6 of the Paris Agreement market and non-market mechanisms in order to successfully implement the carbon market and carbon tax.
- Develop a national plan to reduce methane emissions by 2030.
- Implementation plan of the Glasgow Declaration on forests and land use.
- Promote the development of renewable energy sources along with energy storage solutions and study offsetting measures such as carbon landfilling.
- Update NAP in line with COP26's new commitment on climate change adaptation and develop a National Report on Climate Change Adaptation to confirm adaptation efforts, adaptation priorities and support needs.

Finance to fight climate change remains one of the most pressing issues Vietnam is facing. To achieve Vietnam´s emission reduction target, it will take billions of dollars of investment between now and 2050, to apply emission reduction and carbon offsetting technologies. These are new technologies with large costs that can only be widely applied when Vietnam has enough financial potential.

c. The need for enhancing Vietnam's mitigation target and updating baseline emissions

At COP 26, Vietnam committed to achieve net-zero emissions by 2050, to reach a 30% methane emission reduction by 2030, adhered to the Global declaration on the transition away from coal in 2030 – 2040 and joined the Lowering Emissions by Accelerating Forest (LEAF) coalition. The commitments of Vietnam at COP26 were recognized by the international community. This also opens many cooperation opportunities in the fields of low-emissions and green growth in response to climate change.

With the new commitments at COP26, the NDC needs to be updated in 2022 to meet the target of net-zero emissions by 2050. As mentioned in the National Strategy on Climate Change (MONRE, 2022), the cooperation with other countries could play a relevant role in the implementation of the updated

NDC. The Article 6 of the Paris Agreement rulebook agreed at COP26 in Glasgow sets the guardrails and guidelines for this cooperation. Among others, the Article 6.4 sets the requirements for the establishment of the baseline on which the mitigation outcomes Parties can exchange or trade with will be calculated. According to Article 6.4, these have to be conservative and below BAU, progressively ambitious, aligned with the country´s NDC and long-term strategy, as well as with the PA goals. These requirements are hardly compatible with static baselines and thus open the way for baselines that change over time, i.e., dynamic baselines (DBL).

3. Methodology for a dynamic baseline approach

3.1. Rationale for the dynamic baseline approach

In Paris Agreement Article 6.4, a mechanism is established to "contribute to the mitigation of greenhouse gas emissions and supporting sustainable development" (UNFCCC, 2016). One topic of discussion during the negotiations that led to the finalization of Article 6 rulebook at COP 26 was the setting of the baselines against which emissions reductions will be calculated. The determination of an emissions baseline can be done by means of different approaches, methodologies and assumptions which will eventually determine the maximum number of credits that can be generated under Article 6.4 mechanism. The methodologies will therefore affect the impact of the Article 6.4 mechanism on mitigation, the attractiveness of participating in the mechanism, as well as its role in assisting Parties to achieve their National Determined Contributions (NDCs).

The Article 6.4 mechanism will operate in circumstances different to those of the Clean Development

Mechanism under the Kyoto Protocol (KP). For once, all host Parties participating in the mechanism will have submitted a NDC indicating their commitments in terms of mitigation which was not the case under the KP. This may make Parties more conservative when it comes to authorizing mitigation outcomes transfers. In addition to this, the mechanism of Article 6.4 is to provide “overall reductions in global emissions” (OMGE) and Article 6 generally aims to explicitly encourage greater ambition in mitigation actions by the Parties. Regarding baselines, both mechanisms share however one common principle: they are to be conservative.

There is no one-size-fits-all approach for setting baselines in the new mechanism, given the diversity of possible mitigation activities. In its current form, the Article 6 rulebook agreed at COP 26 in Glasgow allows for a wide range of baseline setting approaches: for instance: (i) a “performance-based” approach (it estimates the GHG emission reductions of an activity against peers by providing an emission reference level), (ii) a “best available” approach (potentially a variant of the “performance-based” approach, considering the “best available technology” or process), (iii) a “business as usual” (BAU) approach (it creates a forward-looking scenario describing how GHG emissions may progress in the absence of the mitigation activity) and (iv) an approach based on “historic emissions” (it extrapolates future emissions based on historical performance).

The “performance-based” approach to establish a baseline is relatively simple to apply, although it can be based on subjective choices. The approach based on “historic emissions” is also relatively simple to set up but is unlikely to lead to a path that is consistent with the goals of the Paris Agreement. The development of BAU scenarios may be more conservative than baselines based on past emissions, but can be subjective, since they will be based on assumptions and may therefore include significantly uncertain.

The establishment of baselines could also be important for Parties hosting Article 6.4 activities, particularly with regard to how the delivery of Article 6.4 emissions reductions affects the achievement of NDC. For example, an inflated emissions baseline could generate credits with no associated emission reductions. Such a baseline could also mean that the host Party would need to make further mitigation efforts to achieve their own NDC, if it applies "corresponding adjustments" for to all the International Transferred Mitigation Outcomes (ITMOs). Host Parties may need to consider which short-, medium- and long-term mitigation outcomes they will keep for domestic use, and which can be used to generate credits under Article 6.4 mechanism

Finally, the conditionality of many Parties’ NDCs means that the level of a conservative emissions baseline can potentially be affected by the receipt of international climate finance. Potential updates to baseline levels following provision of support (by ensuring, for instance, that baseline levels are dynamic, i.e., that they can change during the crediting period) is another important consideration for the Article 6 rules.

In order to accommodate the Article 6 rulebook new requirements a BL that can change over time, i.e., a dynamic baseline could be a solution. A dynamic BL, could contribute to:

- Stringency, which will better guarantee environmental integrity in carbon markets i.e., GHG emissions do not increase as a result of any baseline-and-crediting mechanism or linking of emissions trading schemes.
- Increase consistency with PA long-term mitigation goals, NDCs and the emissions paths leading to net zero emissions by 2050. Consistency with national NDCs is a still disputed issue. Since NDCs are nationally determined and not to be assessed by another international body, a BL tied to an NDC cannot be reviewed by the Supervisory Body.
- Encourage ambition.
- Below BAU emissions trajectory.
- Increase conservativeness and transparency and thus decrease uncertainty among potential investors. However, the continue updates introduce also some uncertainty.
- Guarantee that emissions credits will only be traded if countries have actually made a contribution to the overall PA goal.

- Offer a solution to address the revision of CDM methodologies that are not aligned with PA principles of reference levels below BAU while preserving the body of knowledge on quantifying and calculating emissions and associated reductions.
- Smaller volume of ITMOs transferred and thus keep a larger share of the mitigation within the host countries.
- Ambition raising in NDCs: conservative BLs may lead to less mitigation credited but does not lead automatically to higher ambition in mitigation action of the host country. The latter depends on the political choices of the host or buyer party. If a conservative BL leads to more mitigation in one country, the corresponding government can choose whether to increase the NDC ambition by the mitigated amount or reduce others´ sectors ambitions by that same amount leaving ambition unchanged.
- The locking-in of emissions.

3.2. The concept and elements of a dynamic baseline

a. A conceptual approach towards dynamic baselines

Michealowa et.al (2021) developed an approach to set baselines consistent with long-term emissions pathways aligned with Paris Agreement Temperature goals. It consists in applying a decreasing multiplier or "ambition factor" to the BAU emission intensity calculated in the basic CDM methodologies until it reaches a reference value. The conceptual application of the ambition factor is shown in Figure 1.

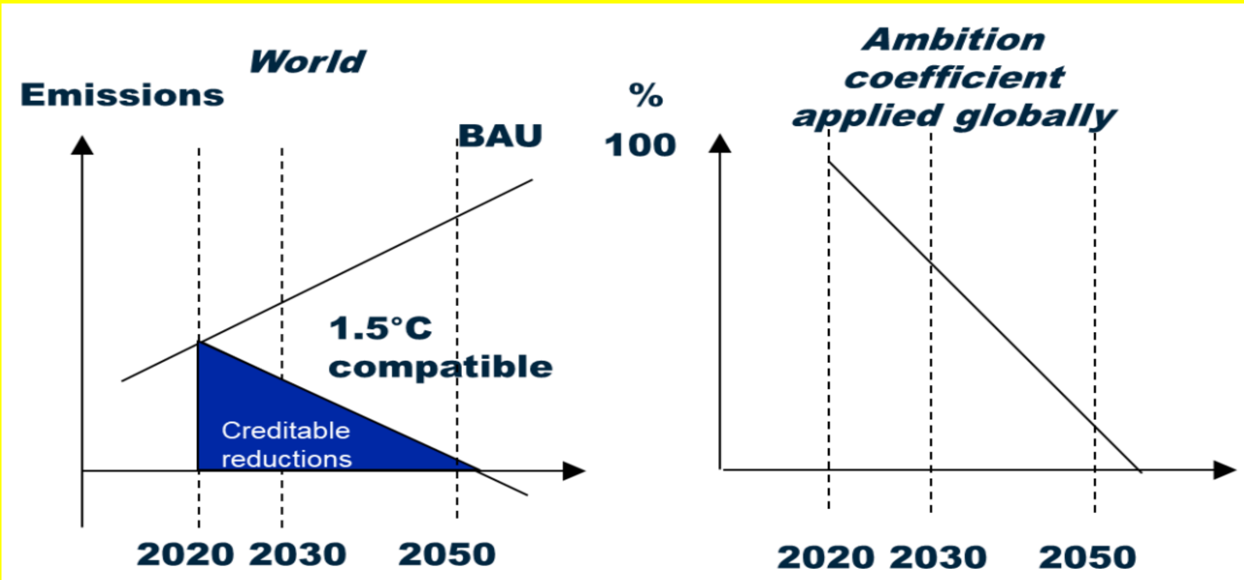

Figure 1. The ambition coefficient declining from 100% today to 0% when the long-term emission goal is reached (Michaelowa et al. 2021)

How the ambition coefficient evolves and therefore how long it will take for the baseline to achieve the final reference level, i.e., the transition period, is likely to be a highly contested issue where Common but Differentiated Responsibilities (CBDR) will be important. In this regard, it is expected that, since the level of mitigation costs that can be borne by poor countries is lower than for rich countries, this will be reflected in different transition periods of different lengths (Figure 2).

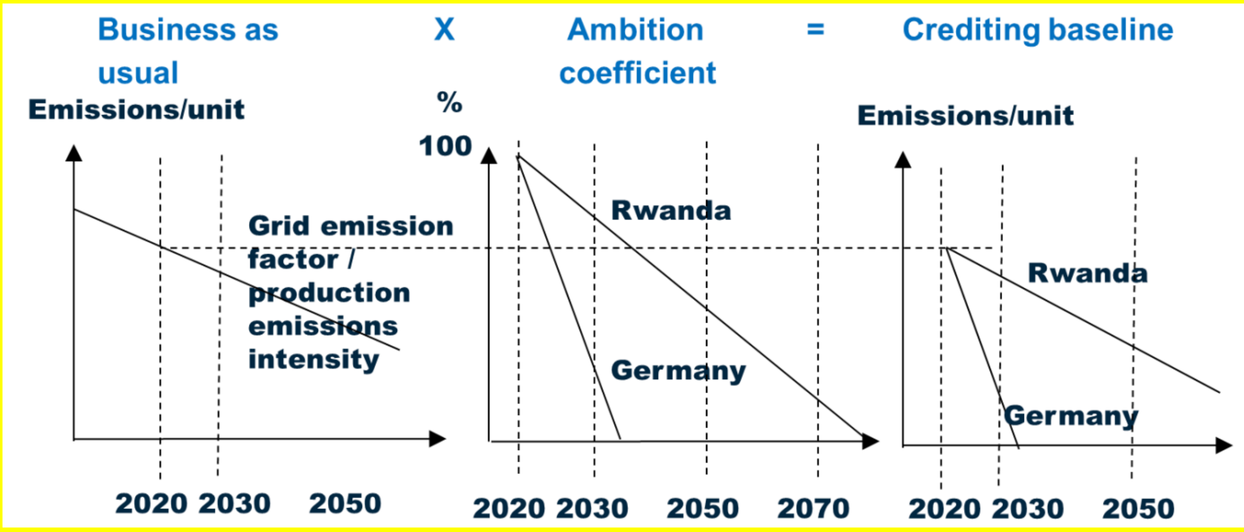

Figure 2. Application of the ambition coefficient to the BAU to derive a dynamic crediting baseline (Michaelowa et al. 2021)

In general, the ambition coefficient will decrease faster for rich countries than for poor countries and therefore the decline of the baseline of the former will also be steeper. This means, as it can be seen in Figure 3 that, the credits availability will be lower for rich countries than for poor countries. This is aligned with the responsibility of reducing emissions being higher for rich countries than for poor countries.

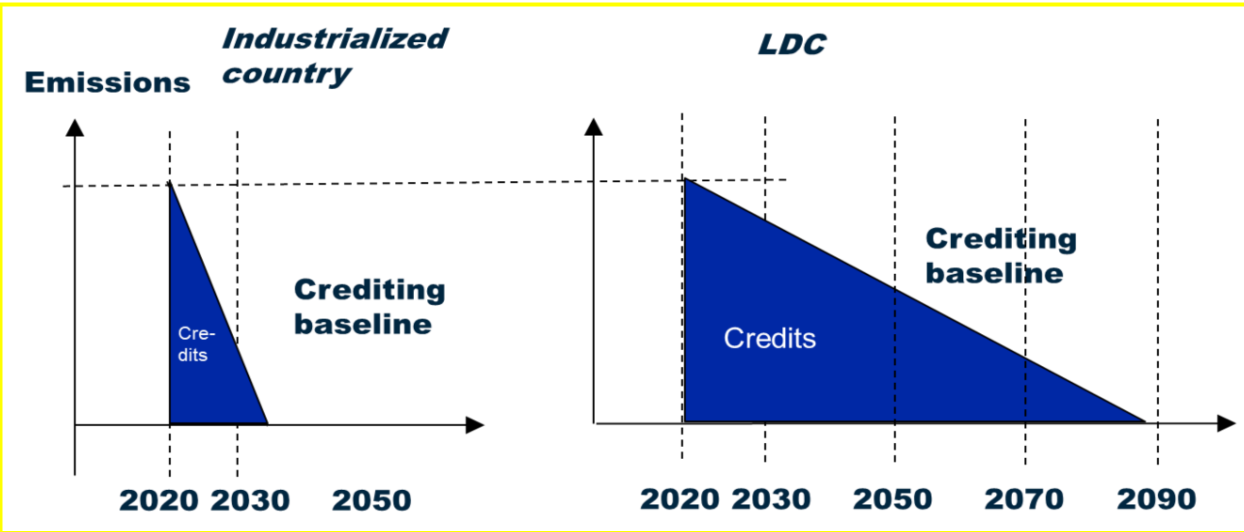

Figure 3. Reduction of baseline for rich and poor countries (Michaelowa et al. 2021)

To provide investment certainty, a pre-fixation of the ambition coefficient that is valid over the relevant credit period of the activity could be foreseen. An ideal approach would be to update the ambition coefficient with each NDC cycle (5 years) and based on the results of the most recent global stocktake see whether countries are actually in line with their net zero pathways or not.

b. Elements of a dynamic baseline

The calculation of a Party´s ambition coefficient may be based on several parameters, starting with the Party´s NDC and its low-emissions long-term development strategy (LT-LEDS). However, it must be acknowledged that Parties´ ambitions may not be commensurate with the national status quo, as presented by the Climate Action Tracker (2021). Michaelowa et al. (2021) recommends building on exercises like as van der Berg et al. (2020) where large groups of researchers from around the world attempted to calculate plausible emission pathways. Appropriate parameters for such calculations should take into account both the country's capacity and its responsibility for current emissions. Some of these parameters could be:

- GNI/capita.
- Cumulated historical emissions.
- Mitigation potential o Geographic criteria.

The identified parameters can be assigned weights and based on them the values for the ambition coefficient can be calculated. Another option could be to estimate an ambition coefficient and calculate a baseline for each parameter and then identify which are the most stringent of all of them. Regardless of the option chosen, the ambition coefficient and baseline are in any case, constrained by the sum of emissions reaching zero in line with the 1.5- or 2°C target.

Country-specific ideal paths could look like the ones shown in Figures 2 and 3. Emissions in countries with high responsibility and financial resources will fall rapidly to zero in the next years. As a matter of fact, for most industrialized countries, even zero emissions may not be aligned with PA's long-term goals and will have to go further done using Negative Emissions Technologies (NET). If that is not possible, these countries should finance an equivalent amount of mitigation in other countries. Whereas countries with low responsibility could gradually reduce their emissions through domestic efforts and contribute to climate finance until reaching zero around 2070 (Figure 4).

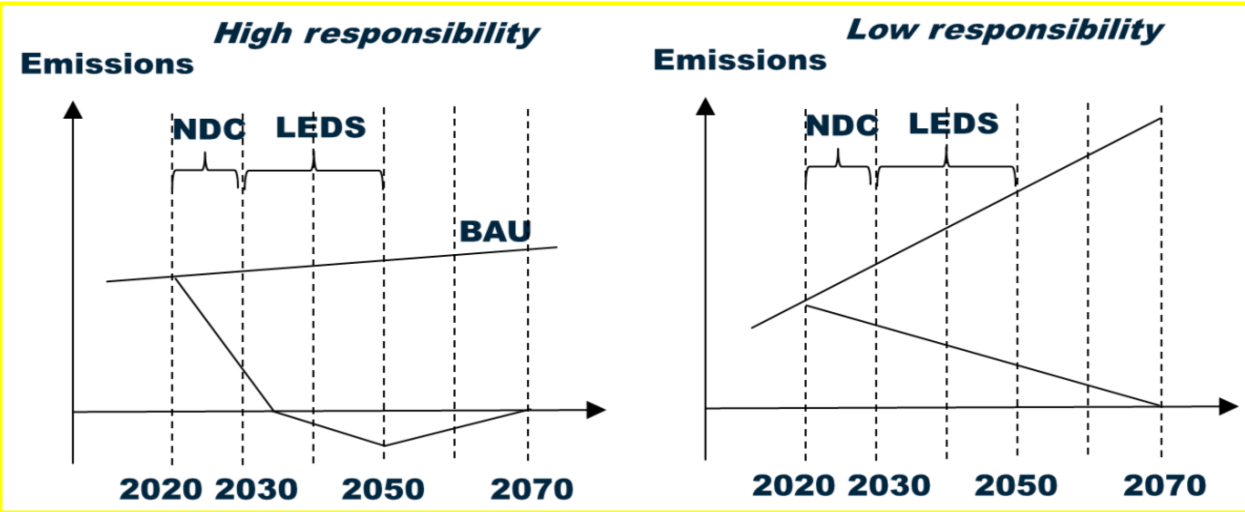

Figure 4. Ideal emissions pathways for countries with high and low responsibility (Michaelowa et al. 2021)

To avoid uncertainty for investors, it is not advisable to conduct a post-test to see if a country is indeed on the path indicated by the baseline. Finally, it may be worth it to mention, that the ambition coefficient baseline is not linked to the NDC decarbonization pathways. Therefore, the host country targets do not affect the crediting baseline as long as they are less stringent. This eliminates the gaming potential for the host country, i.e., adopting less stringent targets to maximize carbon credit revenue.

3.3. Dynamic Baseline Setting steps

What follows is a proposal of the steps to follow to set up a dynamic baseline according to the guidelines provided by Michealowa et.al (2021):

Step 1: Calculate BAU emissions: For this purpose, several methodologies can be used, including the CDM baseline setting methodologies.

Step 2: Setting a goal and a date to achieve it. Some examples:

- *Net zero.*
- *NDC*: Specific NDC sectorial targets can be directly translated into goals. For the sectors for which

there are not such targets, it would be required to break down the aggregated NDC into sectorial targets and/or develop the sectorial goals based on the possible implications NDC may have on these sectors. Breaking down aggregate long-term objectives may prove difficult though. However, if the NDCs are not ambitious enough or include "hot air", their goal may not be aligned with PA long-term goals. In case of doubt, it is recommended to choose the most stringent of both. Besides, if the DBL is linked to the NDC, there is a perverse incentive to adopt less ambitious targets in order to produce more tradable credits (Hermwille, 2020).

- *Best Available Technologies (BAT)*: The goal value will be given by the capacity of the most advance technology commercially available anywhere in the globe although other slightly different definitions have been proposed (Michaelowa et al., 2021). Applying sector-wide BAT may prove difficult, especially when the sector is not homogeneous and produces many different products. Besides, BAT-based goals may be too stringent and disincentivize investment (Hermwille, 2020).
- *Long-term low emissions development strategies (LEDS).*
- *Least-cost future investment plans* (Thioyé et al., 2018).

Step 3: Setting a start date:

Different criteria can be applied to decide the moment the baseline will start to be applied. These are a few examples:

- Readiness of the country to start emitting below the DBL. It may not be advisable to set the implementation start date if the country still requires some time to be in the position to go below the baseline.
- On the other hand, the later a country begins to implement the DBL and emit below it, the steeper the pathway will be and the more difficult it will be to reach the goal set.

Step 4: Calculate the ambition coefficient:

- Should be compatible with the goal value and the way in which it has been determined. For instance, if a BAT-based goal has been set, the AC shall reflect how quickly the best available technology becomes common practice.
- It will depend on the country and the sector. Provided a BAT-based goal for a certain sector is set, how long will it take for a sector to reach that goal may vary a lot. There are technologies with long technical lifetimes (few variations incorporated over time) for which the transition period shall be longer.
- It does not have to exactly match the project crediting period (Hermwille, 2020). Uncertainty increases as one goes further into the future; therefore, relatively short crediting periods may be a better option.
- It will be calculated ex-ante at country level and will decrease over time to reflect increasing ambition.
- Its updating should be done at regular intervals which could match or not NDC 5-years cycles.
- It will decrease faster for rich countries than for poor countries to reflect the principle of *Common but Differentiated Responsibilities (CBDR).*
- It will be calculated so that the resulting BL is aligned with the country´s NDC, long-term emissions goals and the PA goals.
- The resulting BL will move downwards from the BAU towards the value given by the long-term goal, which will mark the end of the DBL trajectory.

To calculate more concrete values for the ambition coefficient between the start and end dates (also called "*ought to margin*" or "*normative reference*") factors such as the country´s GDP, GNI/capita, accumulated emissions, mitigation potential, technological development etc. could be used.

In general, DBLs should at least ensure there is no "hot air", which can be guaranteed to some extent, by setting it below BAU and take into account relevant national, regional or local circumstances.

Ideally, they should also be based on the best available technologies or performance benchmarks, without being so stringent as to discourage the mitigation action and investment.

4. Development of Vietnam's dynamic baseline

4.1. Article 6 strategy and readiness in Vietnam

Vietnam has been promulgating legal documents related to the formation of a domestic carbon market:

- The Law on Environmental Protection 2020 includes regulations on the organization and development of the carbon market (Article 139, Law on Environmental Protection 2020), according to which the future domestic carbon market will include activities to exchange carbon credits (MONRE, 2020). These mechanisms comply with the provisions of law and international treaties to which the Socialist Republic of Vietnam is a signatory. According to this law, GHG-emitting establishments must inventory greenhouse gases and will be allocated GHG emission quotas which they have the right to exchange, buy and sell in the domestic carbon market.
- The ddecree on GHG emission reduction and ozone layer protection, recently issued by the Government of Vietnam, stipulates the roadmap for the development of the domestic carbon market and the implementation of credit exchange projects at national and international level including Article 6 projects.
- According to Vietnam's 2020 NDC, the country commits to reduce its total greenhouse gas emissions by 9% compared to BAU by 2030 using exclusively domestic resources. This level of commitment can be increased to 27% if it receives international support through bilateral, multilateral cooperation and market mechanisms under the Paris Agreement.
- At the COP26 Conference in November 2021 in Glasgow, UK, the Prime Minister made a strong statement about reaching net zero emissions by 2050, demonstrating the nation's determination and commitment to push forward economic transformation to tackle the climate crisis. Vietnam's commitment was highly appreciated by COP26 Presidents and countries around the world for its strong but practical determination.
- Vietnam's carbon market needs to be built and formed based on the set criteria. In particular, the scope, scale, objects and market tools need to be strictly guaranteed according to the criteria developed by Vietnam.

Vietnam has long experience on carbon crediting. As of June 2020, Vietnam has 257 CDM projects registered by the CDM Executive Board (EB), ranking fourth in the world in number of projects, accounting for a total amount of about 140 million tons of CO_2e reduction potential during the last crediting period. Out of these 257 projects, projects on energy accounted for 87.6%. Waste treatment accounted for 10.2%, and afforestation and reforestation accounted for 0.4%. However, most projects on energy, waste treatment, afforestation and forest regeneration were registered quite late after the price on the CER market plummeted. This is reflected in the announcements that Vietnam has only had over 18 million CERs issued by the EB so far, ranking sixth in the world[1].

Vietnam also has 10 CDM Programs of Activities (PoA), 14 registered Verified Carbon Standard (VCS) projects, and four Gold Standard registered projects. Regarding the fields covered by the Partnership for Market Readiness (PMR), Vietnam has six registered projects in the waste sector. However, no CDM/VCS projects have been registered in the construction and steel sectors.

Vietnam also has the potential to participate through mechanisms such as the Bilateral Clearing Credit Mechanism (BOCM) (later on called JCM) and the Program on Reducing Emissions Through Reducing Deforestation and Degradation (REDD).

Vietnam joined the JCM mechanism in July 2013 through a memorandum of understanding on "Low-carbon growth and building JCM joint credit mechanism."

The purposes of the JCM Mechanism include (1) disseminating Japanese low-carbon technologies, products, systems, services, and infrastructure, contributing to sustainable development in developing countries; (2) quantitative greenhouse gas emission reduction contribution through mitigation action in developing countries and achievement of emission reduction targets of developed countries (Japan); and (3) contributing to the UNFCCC's goal of reducing global emissions.

According to this mechanism, when Japanese enterprises consult and transfer energy-saving and emission-reducing technologies to Vietnamese enterprises, they will enjoy preferential credits from Japan. The maximum credit limit is 50 percent of the total project cost. At the same time, the amount of CO_2 reductions will be calculated for the Japanese side.

The total potential emissions reductions of the 28 JCM projects is undergoing a feasibility study (proposed by the Ministry of Environment and Ministry of Economy, Trade and Industry of Japan) but is estimated at 10 million tonnes CO2e/year. There are 18 projects in the energy sector, 4 transportation projects, 3 waste management projects, and 3 forestry projects.

Since 2012, Vietnam has participated in the Partnership for Market Readiness (PMR) program within which, since 2015, with the support of the World Bank, Vietnam has implemented the project "*Getting ready for a carbon market in Vietnam*" (VNPMR). After five years of preparing and implementing, the project has achieved some results, laying the foundation for Vietnam to form and develop a domestic carbon market towards joining the carbon market world.

From 2021-2030, Vietnam will continue to participate in the initiative "Partners for the Implementation of Carbon Markets" (PMI) initiated by the World Bank to form and develop a carbon market in the future. This is the next phase of PMR to deploy market tools in the participating countries. The focus is on the specific implementation of carbon pricing activities, contributing to the development of policies, tools for managing carbon credits, and carbon pricing in Vietnam in the next decade.

All experiences in setting cap and trade and trading mechanisms in PMR, in implementing carbon trading in CDM and in researching MRV for mitigation actions would contribute to Viet Nam´s readiness to tackle Article 6 projects in the upcoming period.

4.2. Links between the NDC and preparations for Article 6 readiness

Vietnam's updated NDC includes two commitments on emission reduction targets: (i) With domestic resources, by 2030, Vietnam will reduce its total greenhouse gas emissions by 9% compared to the national BAU, equivalent to 83.9 million tons of CO2e.; (ii) This reduction could be increased up to 27% compared to the national BAU (equivalent to 250.8 million tons of CO2e.) with international assistance via bilateral and multilateral agreements, and the implementation of the mechanisms of the Paris Agreement on climate change.

The 9% target builds on economically viable mitigation measures. Meanwhile, the 27% target is built on

[1] Nguyen Thi Lieu et al (2021). Research on the scientific and practical basis for the construction of a carbon market in Vietnam. Code TNMT.2018.05.01. Science and Technology Project at the Ministry of Natural Resources and Environment

both economically viable solutions and other potential mitigation measures. That implies, there will be about 167 million tons of CO_2e (equivalent to 18% i.e. the difference between the unconditional and conditional mitigation targets) added to that can be reduced by credit generating mitigation projects and participating in the carbon market by 2030.

The NDC implementation plan includes the tracking of mitigation results. Mitigation activities would be categorized according to whether they depend on domestic resources or on international supports. This would be the first step to prepare for Article 6.

4.3. Adapting the dynamic baseline approach to Vietnam

4.3.1. Approaches and methodologies to develop dynamic baselines for Viet Nam

Based on the general approach developed by Michaelowa et al. (2021) described above, this report will present the approach to develop a dynamic baseline (DBL) for Vietnam.

The first step to develop a DBL is setting a goal. In the present case, and in order for the DBL to be aligned with PA and the country long term objectives, the chosen goal was net zero emissions by 2050, which is the goal Vietnam committed to at COP26.

Once the goal has been set, the next step is estimating Vietnam´s business as usual (BAU) GHG emissions for the period in which the DBL will be applied, i.e., 2022-2050. This estimation will be mainly based on the updated NDC. For the period 2021 – 2030 GHG emissions will be forecasted for the 5 main economy sectors namely energy, agriculture, LULUCF, waste and industrial processes. Then, each sector´s mitigation potential will be identified.

a. Energy sector:

- Approach, methodologies and assumptions:

The BAU for the energy sector is calculated according to IPCC GL 1996 revised, GPG 2000 and IPCC GL 2006.

Activity data used for the development of the BAU of the energy sector for the period 2014-2030 are published data, including: statistics of the General Statistics Office; development plans of the energy sector up to 2030, such as the Adjustment of the National Power Development Plan for the period 2011-2020 with a vision to 2030 (Adjusted Power Master Plan VII), Adjustment of the Coal Industry Development Plan up to 2020 with a view to 2030, the data summarizing the operation of EVN, Vietnam Coal and Mineral Group. The results of the latest studies are also taken into account, including those of the Ministry of Industry and Trade (WB Project) and the Ministry of Transport (GIZ and WB Project). Accordingly, the final energy demand is forecasted by fuel and energy types for 5 energy-using sectors, including: Industry, agriculture, transportation, commercial services and household.

Electricity demand in the period of 2021-2030: Electricity demand is calculated based on forecast data of the revised Power Master Plan VII and updated NDC report 2020.

Energy/electricity demand in the period 2031-2050: The electricity demand is calculated based on forecast data of the Draft *Power Master Plan VIII* (MOIT 2021a) and the Draft "*National Energy Master Plan for the 2021-2030 period, with a vision to 2050*" (MOIT 2021b), which is currently being finalized for submission to the Government.

Emissions under the normal development scenario (BAU) for the period 2014 - 2030 are taken according to the updated NDC Report 2020. In the period 2031-2050, BAU is calculated according to the "0" option of the energy planning, in which: Function target is "Minimum cost of energy system"; primary energy sources are selected and developed to achieve optimal cost goals, regardless of fossil fuel, renewable energy or imported.

In transportation activities BAU emissions are determined by the bottom-up approach. In it, micro-level activities are considered to assess the ownership and use of energy consuming vehicles, considering scenarios from a technical perspective. As in the road transport section, factors to be considered include: vehicle ownership, technology, usage, transition to other modes of transport. For the bottom-up approach, GHG emissions will be calculated in more detail, more specifically for each transport sector and each different type of vehicle. On this average, it is also possible to separate vehicle types in other sectors such as construction machinery, agricultural machinery, which may be included in the top-down approach.

- BAU for energy sector:

On the basis of the above assumptions, the emission projections of the energy sector by sectors are illustrated in Table 1.

Table 1. BAU scenario of energy sector

Unit: mil tCO_2e

Emission sources	Year							
	2014	2020	2025	2030	2035	2040	2045	2050
Manufacturing and construction industry	49.4	66.9	114.2	257.5	301.4	359.9	407.4	455.8
Transportation	33.2	47.7	65.1	89.1	118.4	152.7	192.5	241.4
Household, agricultural and commercial services	13.6	18.1	25.1	41.2	56.1	73.3	89.5	109.3
Energy industry	75.4	214.8	296.3	290.6	355.2	386.8	413.0	403.8
Total	**171.6**	**347.5**	**500.7**	**678.4**	**833.8**	**972.7**	**1102.4**	**1210.3**

b. Agriculture sector:

GHG emissions from agriculture under the BAU scenario for the period 2021 – 2030 are referenced from the updated NDC of Vietnam. Agriculture sector GHG emissions under the BAU scenario for the period 2031 – 2050 are estimated by linear extrapolation until 2050 of the targets of current policies. Accordingly, livestock production, mainly dairy cows, beef cattle, and pigs will develop rapidly, while poultry will not.

Table 2. BAU scenario of agriculture sector

Unit: mil tCO_2e

Emission sources	2010	2014	2020	2030	2040	2050
4A. Digestion (livestock)	9.468	10.201	14.543	22.213	31.165	41.826
4B. Manure management	8.560	8.863	10.100	14.094	19.038	24.052
4C. Rice cultivation	44.614	44.295	39.891	41.536	41.891	41.659
4D. Agricultural land	23.812	23.956	23.282	32.195	37.608	43.549
4E. Burning savanna	0.0017	0.001	0.001	0.001	0.001	0.001
4F. Burning agricultural by-products in the field	1.899	2.437	2.392	2.128	2.361	1.786
Total	**88.355**	**89.752**	**90.108**	**112.165**	**132.065**	**152.874**

Emissions in agriculture still tend to increase and will increase sharply in the years 2040 and 2050. The reason for the sharp increase in emissions during this period is due to the rapid development of livestock, mainly dairy cows, beef cattle and pigs., while poultry did not increase.

c. LULUCF:

- Approach, methodologies and assumptions:

The forestry development strategy for the period 2021-2030 with vision to 2050 was issued in Decision No. 523/QD-TTg dated April 1, 2021. For instance, the goals by 2030 include:

  - Development targets:

  - o Growth rate of forestry production value: 5.0% to 5.5%/year.
  - o Afforestation of production forests: about 340,000 ha/year by 2030.
  - o Afforestation of protection forests and special-use forests with indigenous and rare species: 4,000 - 6,000 ha/year on average.
  - o Restoration of protection forests and special-use forests: 15,000 ha/year on average.
- Social targets:
  - o The rate of laborers working in forestry with vocational training will reach 45% by 2025 and 50% by 2030; ensure gender equality.
- Environmental targets:
  - o The national forest cover rate is stable at 42% to 43%, effectively contributing to the implementation of the national commitment to reduce GHG emissions.

LULUCF's BAU is built on the basis of applying GL 2006, GPG 2000 method of IPCC and combined with historical approach assumptions. The emission scenario projections according to the BAU are based on two main bases: (1) changes in forest area, emission reduction and increase in carbon sequestration in the period 2010-2020. During this period, the forest cover rate increased from 39.5% to 42%, the average increase in this period was 1%/year. In which, the area of natural forest decreased by 0.02%/year and the area of planted forest increased by 4.3%/year; average annual emission reduction is 49% and absorption increased by 46%; (2) Orientation, forestry development plan to 2030, vision to 2050.

Assumptions for LULUCF sector are based on the Technical report of National Climate Change Strategy (MONRE, 2022), in particular:

- The rate of change of forest area:
  - o In 2030-2040 the expected rate of change of the total forest area will be 0.2%/year; with natural forests and planted forests change rates being -0.2%/year and 0.6%/year respectively.
  - o In 2040-2045 the expected rate of change of total forest area will be s 0.02%/year; with natural forests and planted forests change rates being -0.01%/year and 0.2%/year respectively.
  - o After 2045 it is expected the forest area to remain stable around 42.5-43.0%, with negligible fluctuations.
- Logging:
  - o No natural forests will be exploited, only planted forests.
  - o The base year for calculating growth in timber harvesting is 2020 (20.5 million m3) and the goal is to reach 50 million m3 by 2030.
  - o The growth rate of timber harvested from planted forests is based on 2017-2020 data and this rate applies to the period 2021-2030, increasing by 6.5%/year until reaching 50 million m3/year and stabilizing in the following years.
- Annual rate of carbon sequestration:
  - o In 2030-2050, the annual average rate of carbon sequestration in natural forests is -5.3 tCO2/ha/year
  - o In 2030-2050, the annual average rate of carbon sequestration in planted forests is -28.1 tCO2/ha/year (equivalent to 16 m^3/ha/year).
- Natural forest carbon stocks:
  - o Average carbon sequestration rate for all types of natural forest is 117.4 tCO2/ha).

- BAU scenario of land use, land use change and forestry

The assessment of LULUCF sector shows that the area of natural forest will continue to shrink and to achieve the set coverage rate target, it is necessary to control forest conversion and increase the area of planted forest. With the above-mentioned assumptions, by 2050, the forest cover rate can reach 42.3%, equivalent to 14.8 million hectares of forest. Compared to the target of achieving by 2030, a maximum of 43% is difficult to achieve.

Table 3. BAU scenario of LULUCF sector

Unit: mil tCO_2e

Year	Natural forest (mil ha)	Planted forest (mil ha)	Total forest area (mil ha)	Emissions (mil. tCO_2e)	Absorption (mil. tCO_2e)	Net emissions/absorption (mil. tCO_2e)
2035	9.02	5.59	14.61	159.56	-213.9	-52.2
2040	8.93	5.83	14.76	162.86	-220.5	-55.5
2045	8.84	5.93	14.77	162.86	-223.1	-58.1
2050	8.84	5.93	14.77	162.86	-223.1	-60.2

With the target of increasing the source of timber harvested from planted forests (the amount of timber harvested peaks in 2035, reaching 50 million m^3 as the target with an increase of 2.44 times compared to 2020), the total net emissions will increase. not much after 2030. Net emissions in 2035 will be -52.2 million tCO_2e, -55.5 million tCO_2e in 2040, -58.1 million tCO_2e in 2045 and then stabilize at -62.0 million tCO_2e by 2050. Thus, the LULUCF sector will continue to be a GHG sink under the normal development scenario (Table 3).

d. Waste:

- Approach, methodologies and assumptions:

The BAU scenario of the waste sector is calculated on the basis of applying the IPCC 2006 Guidelines and GPG 2000 methods for national GHG inventory.

The IPCC 2006 Guidelines are applied in the calculation of emissions for the waste sector. The methodologies of Clean Development Mechanism (CDM) projects published by CDM Executive Board (EB) are also applied. Consists of:

- ACM0001 on "Consolidated baseline and monitoring methodology for landfill gas project activities".
- AMS-III.F on "Avoidance of methane emissions through composting" has been simplified to account for the country (Version 12.0).
- AMS-III.AO on "Methane recovery through controlled anaerobic digestion" has been simplified to account for the national scope (Version 1.0).
- ACM0012 on "Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects" has been simplified to account for the country (Version 4.0.0).

Emissions from solid waste treatment are calculated based on the amount of domestic solid waste generated per capita annually in urban and rural areas, the rate of collection, burial and waste treatment methods. Other published in the National Environment Report 2019 and according to the scale of population growth in urban and rural areas from 1999 to 2049 (Report on Vietnam Population Forecast 2009 of the General Statistics Office).

Emissions from industrial solid waste treatment are based on World Bank data and forecasts on solid waste management in Vietnam 2018 and National Environmental Reports in 2015, 2017 and 2019.

Emissions from industrial wastewater treatment are calculated based on the National Environmental Report 2015, 2016, 2017 and the data in the Industrial Pollution Management Project in Vietnam supported by the World Bank.

Emissions from domestic wastewater treatment are also based on the data from the above report.

Emissions from human waste, nitrous oxide emitted by burning fossil fuels and solid wastes, as well as in wastewater treatment processes.

Input data for calculation are taken from national environmental reports and some other research reports of ADB and JICA. Compost production from domestic solid waste is calculated based on the data of the National Environmental Reports in 2015, 2017 and 2019.

The input data for the estimate of domestic solid waste burning are referenced from the National State of the Environment Report 2019 - thematic solid waste management; The input data for the estimated volume of hospital waste incinerated are referenced from the statistical yearbook (number of beds). Assumptions about medical waste generation are based on the assessment of solid waste generation in the 2019 National State of the Environment Report.

The input data for the estimate of domestic solid waste burning is referenced from the National State of the Environment Report 2019 - thematic on domestic solid waste management. The input data for the estimate of hospital waste incineration volume is referenced from the statistical yearbook (number of beds). Assumptions about medical waste generation are based on the assessment of solid waste generation in the 2019 National State of the Environment Report.

Total waste sector emissions the sum of emissions from the following processes: solid waste treatment (including composting, solid waste incineration, semi-aerobic landfilling, and collecting solid waste landfilling. gas recovery (LFG), production of fuel pellets from waste), industrial wastewater treatment and domestic wastewater treatment.

Table 4. Assumptions for waste sector

Parameters	Assumptions
Population	The population growth rate in urban areas is 2%/year for the period 2030-2040 and 1%/year for the period 2040-2050; The share of the population in rural areas will decrease by 1.1%/year for 2030-2040 and by 1.1%/year 2040-2050.
Amount of solid waste generated per capita (kg/person/day)	Urban areas: period 2030-2040: increase 3%/year; 2040-2050: increase only 2%/year; Rural areas: period 2030-2040: an increase of 8%/year; 2040-2050: increase only 6%/year.
Ordinary industrial solid waste	Generated about 25 million tons/year
Solid waste disposal rate	88% by 2030; 50% by 2050
Amount of domestic wastewater generated	Urban areas: 120 liters/person/day; Rural areas: 80 liters/person/day.
BOD index in domestic wastewater	BOD content in wastewater is taken as default value according to IPCC 1996
The amount of wastewater treated is concentrated in industrial zones	Period 2030-2040: 1.5 million m3/day and night; 2040-2050: 1.8 million m3/day and night
COD and BOD in industrial wastewater	Default COD and BOD indicators for major industries
Waste incineration	Daily-life solid waste is burned at an increasing rate in the period 2021-2050 in solid waste treatment zones; Medical solid waste is mainly burned and causes GHG emissions; Medical solid waste is generated about 450 tons/day and hazardous waste accounts for about 10%; The amount of medical solid waste increases by about 8%/year in the period 2030-2040; The amount of medical solid waste will increase by about 10% per year in the period 2040-2050.
Producing compost from domestic solid waste	Period 2030-2040: the proportion of composting from solid waste remains at 16% of the total volume of collected solid waste; Period 2040-2050: 18% of total solid waste collected.

- BAU of the waste sector

The development-as-usual scenario emissions are calculated based on the above parameters and assumptions.

- The forecast shows that GHG emissions in the waste sector will continue to increase in the period after 2030.
- In 2030: total emissions in the waste sector according to BAU are 46.3 million tons of CO_2e. The scenario under NDC 9% is 37.3 million tons of CO_2e (decreased by 9.1 million tons of CO_2e). In which, emission (methane) from solid waste landfill accounts for the highest proportion and is calculated based on the total amount of urban, rural and industrial waste based on the assumption of landfilling of collected domestic solid waste will reach 85% by 2030. The treatment of domestic and industrial wastewater, especially industrial wastewater with high organic matter content, is used by technology and measures. Treating water under anaerobic conditions produces methane. The calculation of this gas emission from domestic wastewater is based on the BOD of the on-site treated wastewater and is estimated using the IPCC method and default parameters.

Table 5. BAU scenario of waste sector

Unit: mil tCO_2e

Emission sources	Year							
	2014*	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Solid waste disposal	8	11.7	16.9	23.2	33.3	43.4	53.6	63.7
Industrial wastewater treatment	1.6	4.3	5.7	7	6.6	6.2	5.7	5.2
Domestic wastewater treatment	9.6	10.5	10.8	11	11.2	11.3	11.5	11.6
Emissions from human waste	2	2.3	2.8	3.1	3.1	3.2	3.3	3.3
Solid waste incineration	0.3	1.7	1.8	1.8	1.8	1.9	1.9	1.9
Composting	N/A	0.15	0.15	0.15	0.15	0.15	10.5	0.15
Total	**21.5**	**30.6**	**38.1**	**46.3**	**55.8**	**65.2**	**74.7**	**84.2**

Source (*): Vietnam's third National Communication to UNFCCC, MONRE, 2018; and update the research of experts in 2022.

In 2050: BAU is calculated based on the population growth rate at an annual rate of about 1.2% from 2030 onwards. The rate of increase of domestic solid waste generation per capita is about 10% per year in the period 2021-2050, and the rate of landfilling of collected domestic solid waste reaches 100% from 2030 onwards, the total emissions in waste sector according to the BAU is 84.2 million tons of CO_2e (Table 5).

e. Industrial process:

- Approach, methodologies and assumptions:

The year 2014 is selected as the base year to build the BAU. The emission baseline is built based on the current state of industrial development in 2020, the industry's plan to 2030 and a vision to 2050.

- Methods to get data:
  - The "top-down" approach: priority is to get data from the management agencies of the General Statistics Office, the Ministry of Industry and Trade, the Ministry of Construction, industry, industry associations, corporations.
  - Emission coefficient is taken according to the default coefficient of IPCC (1996 improved).
  - Industrial production output in the period 2020-2050 is calculated based on actual output data in 2019 (according to the 2019 Statistical Yearbook) and forecasted industrial output growth according to production value growth. annual output of industries.
- Methodologies:
  - The GHG emission calculation method is based on the IPCC 2006 Guidelines and updated version in 2019.

- o The BAU for the IP sector was developed in accordance with the IPCC National GHG Inventory Guidelines, revised 1996 (IPCC 1996 revised), 2006 edition (IPCC 2006) and GPG 2000.

Activity data for the period before 2020 are collected and aggregated from the General Statistics Office, research reports of ministries, statistics from associations and reports of corporations. Forecasted data for production output of all sectors are taken from the development planning of the sectors already approved by the line ministries or the Prime Minister.

In the period of 2021-2030, the assumption about the performance of the cement industry is determined according to the past trend; assumption about the growth rate of glass production is taken according to the average value of the growth rate of industrial production value of the building materials industry; Assumptions about the performance of the steel industry are determined by expert judgment. The BAU of the IP sector up to 2030 is shown in Table 4.

The year 2014 was chosen as the base year for BAU determination, the year with the most recent GHG inventory and reported in Vietnam's third National Communication to UNFCCC. The total GHG emissions in the year 2014 were 284 million tons CO_2e (compared to the total GHG emissions in the year 2010 of 246.8 million tons CO_2e in the NDC).

- Assumptions:
  - o Cement manufacturing industry:

By 2030, the average rate of using clinker in cement production in the whole industry will be at 65%; Additives for cement use at least 35%.

By 2050, the average rate of using clinker in cement production in the whole industry will be at 60%; Additives for cement use at least 40%.

By the end of 2025, 100% of cement production lines with a capacity of 2,500 tons of clinker/day or more must install and operate a power generation system that utilizes exhaust heat.

- o Iron and steel industry:

The total design capacity of the production units is 18,500,000 tons/year, of which the designed capacity of the oxygen blowing furnace (BOF), electric arc furnace (EAF) and induction furnace (IF) are 9,100,000 tons/year (accounting for 49.2%), 7,000,000 tons/year (accounting for 37.8%) and 2,400,000 tons/year (accounting for 13%).

The norm of energy consumption for the production of steel billets by transfer furnaces (blowers) in the steel industry by 2020 is 150 MJ/ton.

After applying all scientific and technical measures, by 2050, the emission factor from BOF technology will be 1.22, EAF technology will be 0.145.

- o Chemical manufacturing industry:

Modern technology in Europe (nitrogen gas): emission factor is: 1,694 (ton CO_2/ton NH_3).

Partial oxidation technology, emission factor is 2,772 (ton CO_2/ton NH_3).

Medium technology (both old and new technology) - Nitrogen - gas, emission factor is 2,104 (ton CO_2/ton NH_3).

The average technology, the emission factor is 3,273 (ton CO_2/ton NH_3).

Fertiliser production technology in Vietnam uses both nitrogen gas and coal nitrogen, the estimated average emission index EF= 2,558 tons CO_2/ton NH_3.

- BAU scenario of industrial processes sector

Table 6. BAU scenario of industrial processes sector

Unit: mil tCO_2e

Emission sources	2014*	2020	2025	2030	2035	2040	2045	2050
Mining industry - Building materials	35.2	53.1	61.1	64.8	73.4	77.14	81.08	83.11
Chemical industry	1.7	3.2	5.3	5.6	6.88	8.04	9.23	10.39
Metallurgical industry	1.7	24.2	49.7	69.9	58.9	52.8	44.8	38.6
Total	**38.6**	**80.5**	**116.1**	**140.3**	**139.2**	**138.0**	**135.1**	**132.1**

Source (*): Vietnam's third National Communication to UNFCCC, MONRE, 2018; and update the research of experts in 2021.

4.3.2. Estimating Vietnam´s ambition coefficient and dynamic baseline

a. GHG emissions under Vietnam's BAU scenario to 2050

Based on the assumptions and sources enumerated in the previous section the Vietnam GHG emissions under the BAU scenario for the 2021-2050 were estimated (see Table 7). GHG emissions under Vietnam's BAU scenario will approximately triplicate by 2050 compared with 2020. However, the increase in the period 2031 - 2050 is slower than in 2021-2030. This is completely consistent with the forecasted growth of the GDP for the period 2031 – 2050, which is expected to be lower than in the period 2021 - 2030 (MPI, 2021). The BAU emissions from 2014 until 2030 are taken from the latest NDC in 2020 which uses 2014 as base year to estimate the emissions in the subsequent years. This makes the figures less and less accurate as the distance from the base year increases. For the 2030-2050 period, the BAU values have been calculated differently depending on the sector as it was explained in 4.3.1. For instance, for the Energy sector, the 2021-2030 emissions were calculated based on the electricity demand according to the forecasted data of the Draft *Power Master Plan VIII* (MOIT 2021a) and the Draft "*National Energy Master Plan for the 2021-2030 period, with a vision to 2050*" (MOIT 2021b), which is currently being finalized for submission to the Government. The BAU values where correspond to the 0 option of the energy plan, where the cost of the energy system is minimized regardless of their origin or polluting capacity. On the other hand, for the Agriculture sector, the BAU values for the period 2031 – 2050 are estimated by linear extrapolation until 2050 of the targets of current policies.

Table 7. GHG inventory in 2014 and Vietnam's BAU to 2050

Unit: mil tCO_2e

Year	Energy	Agriculture	LULUCF	Waste	IP	Total
2014	171.6	89.8	-37.5	21.5	38.6	**284.0**
2020	347.5	90.1	-35.4	30.6	80.5	**513.3**
2025	500.7	99.4	-37.9	38.1	116.1	**715.7**
2030	678.4	112.2	-49.2	46.3	140.3	**927.9**
2035	833.8	119.6	-52.2	55.8	139.2	**1096.1**
2040	972.7	132.1	-55.5	65.2	138.0	**1252.5**
2045	1102.4	142.6	-58.1	74.7	135.1	**1396.7**
2050	1210.3	152.9	-60.2	84.2	132.1	**1519.3**

b. GHG emissions under Vietnam's Net-Zero scenario in 2050

Once the BAU GHG emissions for 2021-2050 have been estimated, the next step is to estimate which should be the emission pathway for that same period if the net zero goal by 2050 is to be achieved. This will be done considering the maximum emission reduction potentials of each sector.

GHG emission reduction targets of sectors/sectors for the period 2021 - 2030 are given by the updated NDC. For the 2031 - 2050 they are based on the assumptions in the National Strategy on

Climate Change (MONRE, 2022) which is in line with the Net-Zero target by 2050.

In Table 8, the energy sector has the greatest potential to reduce GHG emissions with more than 1.1 billion tons of CO_2e by 2050. This is consistent with the fact that, under the BAU scenario, energy sector GHG emissions account for the largest emissions share going from around 70% in 2021 up to almost 80% by 2050.

In Table 8, it can also be appreciated that in the foreseen emissions pathway to reach net-zero by 2050, emissions will still continue growing in the coming years, although at a lower rate than under the BAU, will peak by 2035 and decrease afterwards. This is related with the foreseen GDP growth until 2031 mentioned before. Besides, most of the measures in the National Strategy on Climate Change will be implemented significantly only after 2035, that is why the GHG emissions will only start decreasing after that date.

As it can be noticed, the Net-Zero scenario emissions in 2020 are much lower than the BAU emissions and the gap between both grows as years pass by. A reason for that is the BAU was forecasted departing from year 2014 and therefore, its accuracy decreases over time. At the same time, emissions in 2020 in NZ scenario are based on GHG inventory data. Therefore, emissions gap may be higher than the actual values achieved.

Table 8. GHG emissions under the Net-Zero scenario for the period 2014 – 2050

Unit: mil tCO_2e

Scenario	2014	2020	2025	2030	2035	2040	2045	2050
Net-Zero	284.0	387.3	518.6	530.5	539.1	419.3	233.8	0.0
- Energy	171.6	247.0	394.1	457.2	495.3	408.2	261.3	101.0
- Agriculture	89.8	88.3	75.3	63.9	62.2	63.8	61.5	56.4
- LULUCF	-37.5	-45.9	-65.6	-95.3	-112.4	-134.0	-149.6	-185.2
- Waste	21.5	30.6	22.91	18.2	15.9	13.3	10.64	7.8
- IP	38.6	67.3	91.9	86.5	78.1	68.0	50.0	20.0

To peak emissions by 2035 and reach net zero emissions by 2050, in the period 2036 - 2050, the rate of increase in the reduction of greenhouse gas emissions will increase and reach 100% by 2050. This will be reflected in a reduction of the emissions intensity which will reach zero by 2050 (Table 9 and Figure 5).

Table 9. Emission intensity in BAU and Net-Zero scenario

	2014	2020	2025	2030	2035	2040	2045	2050
Emission from BAU Scenario (mil. tCO_2e)	284.0	513.3	716.5	928.0	1096.0	1252.5	1396.7	1519.3
Emission from Net-Zero Scenario (mil. tCO_2e)	284.0	387.3	518.6	530.5	539.1	419.3	233.8	0.0
Projected GDP (bil. USD)	186.2	271.2	375.4	522.9	720.1	974.3	1288.9	1664.4
BAU Emission intensity (tCO_2e/1000USD)	1.53	1.89	1.91	1.77	1.52	1.29	1.08	0.91
NZ Emission intensity (tCO_2e/1000USD)	1.53	1.43	1.38	1.01	0.75	0.43	0.18	0.00

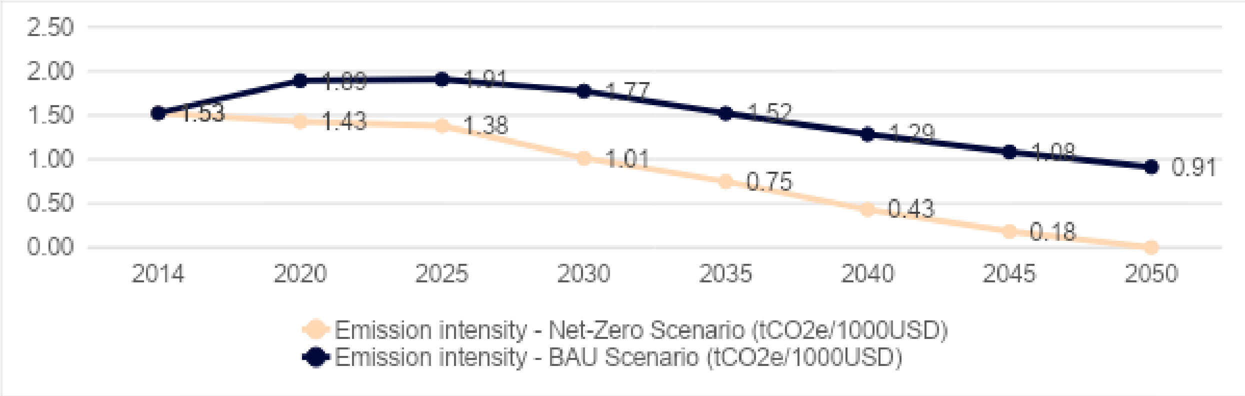

Figure 5. Vietnam´s GHG intensity under net-zero scenario

According to Michealowa (2021), the dynamic baseline would result from multiplying the BAU emissions by the Ambition Coefficient. Building on this definition, and assuming the Net-Zero by 2050 scenario described above could be an approximation to a dynamic baseline, it would be possible to get an idea of how the ambition coefficient at national level would look like by dividing BAU emissions (Table 7) by the 2050 Net-Zero emissions (Table 8):

$$AC_{national} = \frac{GHG_{2050\ Net-Zero}}{GHG_{BAU}}$$

However, baselines under CDM for instance, have been traditionally expressed as intensity factors. Since the GDP forecast for the 2021-2050 period remains the same in both scenarios BAU and 2050 Net-Zero, the national AC for emission intensity which could be calculated using Table 7 and Table 8 data, would be the same as for the absolute emissions. To obtain an Ambition Coefficient. The previous calculation can also be applied to the BAU and 2050 Net-Zero emission intensity scenarios.

Based on the previous calculations, a series of values were chosen for the Ambition Coefficient which, multiplied by the BAU emissions intensity would provide a dynamic baseline aligned with the goal of Net-Zero by 2050. It was decided the AC would change every two years, so that the baseline will change every two years to match the national GHG inventory cycle (Table 10).

Table 10. Calculated Ambition Coefficient to achieve Net-Zero by 2050

	2020	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**
$AC_{national}$	0.75	0.74	0.73	0.69	0.63	0.57	0.54	0.51
	2036	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**
	0.46	0.40	0.33	0.27	0.20	0.13	0.07	0.00

The $AC_{national}$ is calculated based on Net-zero scenario. However, the Net-zero scenario includes a conditional target. Therefore, the $AC_{national}$ will be adjusted to be consistent with unconditional target and economic – social development factors and priorities (e.g., GDP expected growth). For instance, current socio-economic development targets will lead to the increase in energy demand by 2030. Meanwhile, solar and wind power in the BAU scenario will have a limited share. So, the GHG emissions of the energy industry in 2030 will still increase sharply. It is expected that peak emissions of this sector can be reached in the period after 2035 or 2040 when renewable energy is strongly developed, and alternative energy sources or nuclear power are considered for development. All this has to be taken into account when adjusting the AC (Table 11).

Table 11. Adjusted Ambition Coefficient to achieve Net-Zero by 2050

	2020	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**
$AC_{national}$	1.00	0.98	0.96	0.95	0.93	0.91	0.89	0.87
	2036	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**
	0.85	0.79	0.72	0.62	0.52	0.40	0.22	0.00

Figure 6 compares calculated $AC_{national}$ and adjusted $AC_{national}$.

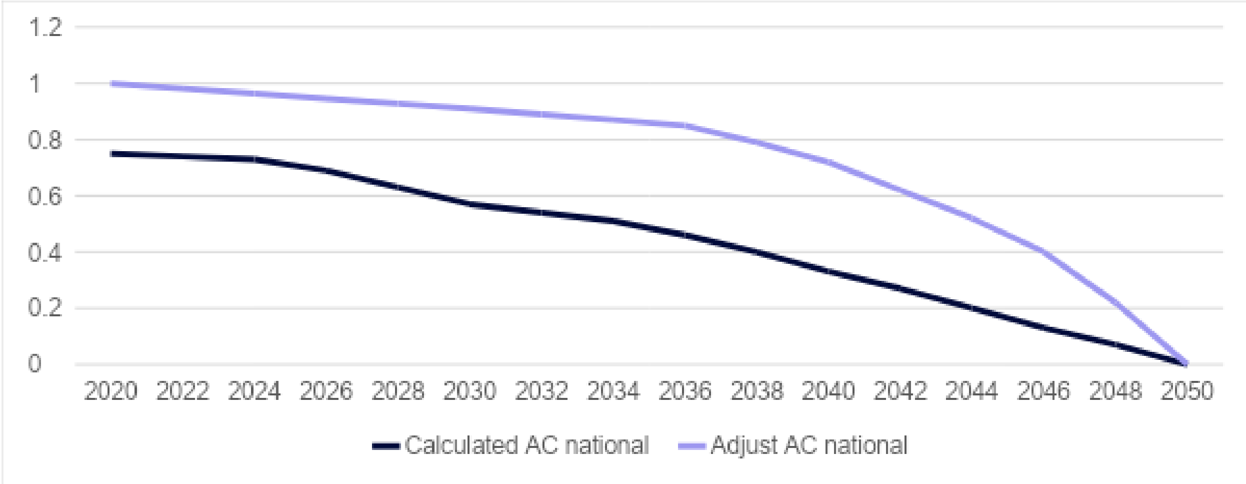

Figure 6. Calculated $AC_{national}$ and Adjusted $AC_{national}$

The application of these results to the BAU total emissions leads to a dynamic baseline (see Table 12 and Figure 7).

Table 12. Vietnam's dynamic baseline

Unit: mil tCO_2e

$Dynamic\ Baseline_{national}$	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**
	513.3	583.9	651.5	717.8	782.7	844.5	885.7	924.3
	2036	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**
	958.2	940.0	901.8	812.3	711.3	568.5	323.5	0.0

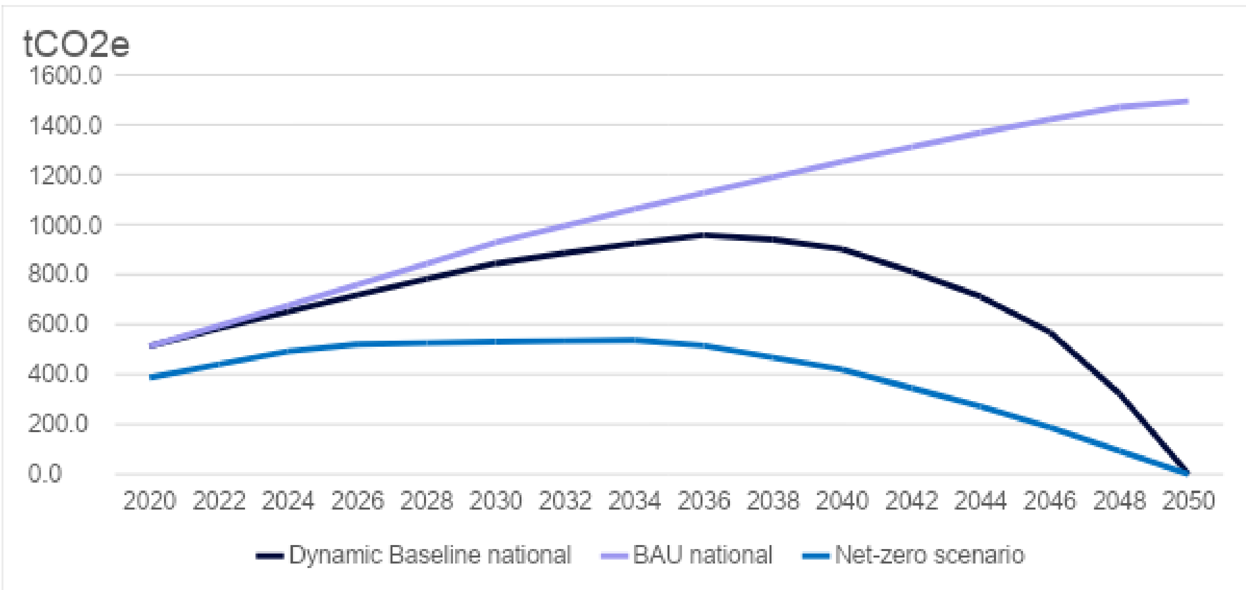

Figure 7. Vietnam´s dynamic baseline

c. Options to attract carbon finance for NDC ambition raising

At this moment, the Parties to the Paris Agreement NDCs fall short with regard to achieving the Paris Agreement long-term temperature goals. Collaboration and cooperation under Article 6 of the Paris Agreement is considered a mean to promote the much-needed NDC ambition raising, foster sustainable development and attract carbon finance. An increasing number of countries are mentioning voluntary cooperation under Article 6 in their NDCs as a mean to achieve their goals

(UNFCCC, 2021).

At the same time, some aspects of the CDM experience together with the slow pace and uncertainty of the Article 6 negotiations and a surge of projects claiming dubious carbon offsets have casted some doubts on carbon trading and carbon markets.

During CDM-times, most international banking institutions and investors were sceptical about the crediting system and therefore not especially willing to either lend against the sales contracts for credits (Emission Reduction Purchase Agreements, ERPAs) or invest in this kind of projects. The market was based on payment on delivery, i.e., just buying the credits once they have been created according to prior ERPAs. So far, there is nothing that indicates that the situation should be different for AR6 projects. This, together with the lack of clarity on the dynamics of the credits value, makes it hard for local investors to raise funds for carbon crediting projects. On the other hand, it cannot be expected from the potential credit sellers, developing countries in most of the cases, to take upon themselves the risk of developing carbon crediting projects. It is thus necessary to make international investors commit with the projects they expect to get carbon credits from. This could be done in different ways such as requiring upfront payment or finding a way for international investors to become shareholders/partners in the projects.

In addition to this, carbon finance should ideally not be directed to the easiest and lowest cost mitigation options. Seller countries may be able to implement the low-cost options without external support. Instead, international carbon finance should rather be directed to those projects that are less likely to be implemented in a particular host country without some degree of external support, but which still may lead to relevant emissions reductions.

Finally, there are also measures that seller countries could implement to increase their attractiveness before the investors. Firstly, the Article 13 of the Paris Agreement established the Enhance Transparency Framework (ETF) which, among other things, sets higher transparency reporting requirements, both in terms of depth and frequency. According to the ETF, all countries are expected to submit both National Inventory Reports (NIRs) and Biannual Transparency Reports (BTRs). The implementation of reforms to adapt to the ETF and in general the strengthening of information flows between countries and UNFCCC could therefore pose an effective pathway to increase investors' confidence and attract carbon finance. Secondly, the establishment of Long-term Low Emissions Development Strategies (LT-EDS) laying out the pathway for mitigation up to 2050 as the basis of countries´ successive NDCs which include information on the role of cooperative approaches under Article 6 are expected to have in the pathway towards decarbonization, could possibly provide the kind of long-term assurance that may attract investors. Finally, the myriad of carbon offsetting projects that have appeared in the last years have put the spotlight on the quality of the credits generated and whether they are actually additional, guarantee environmental integrity or contribute to SDGs. In this sense, setting safeguards and applying tools that could guarantee the quality of the carbon credits produced would reduce perceived risks and could contribute to increase investors willingness to support carbon crediting projects.

5. Development of Energy industry's dynamic baseline: Solar power case study

5.1. Overview of energy sector

The energy sector has always been an important sector in Vietnam, both in terms of socio-economic development and greenhouse gas emission reduction, response to climate change and green growth. Total energy use in Vietnam doubled between 2000 and 2013 (World Bank 2019). On a per capita basis, Vietnam's energy use increased by 80% in the same period and was only about a third of the world average in 2013 and slightly above energy use of lower middle-income countries (World Bank, 2019).

After increasing the energy intensity of the economy from 2000 to 2010, Vietnam managed to reduce it between 2010 and 2017. However, energy carbon intensity has increased from 2000 to 2014. Vietnam's share of fossil fuels in total energy consumption has increased from less than 46% in 2000 to 70% in 2010, then fell again to less than 70% in 2013.

Vietnam's per capita tCO_2e emissions have more than tripled between 2000 and 2016, from 0.68 to 2.18 tonnes, but are still below world´s average (4.8 tCO_2 per capita) (JRC, 2016).

From 2000 to 2014, electricity consumption per capita increased fivefold. The share of fossil fuels in power generation has increased significantly from nearly 45% to nearly 71% between 2000 and 2010, and then fell again to 63% in 2015. Coal's share in power production has increased from 11.8% (2000) to nearly 30% (2015). At the same time, the share of electricity produced from renewable sources (excluding hydroelectricity) has increased slightly from 0% in 2010 to 0.1% in 2015 and remains very low. If hydropower is taken into account, the share of renewable energy increased significantly to more than 36% in 2015 (World Bank, 2019). Hydroelectricity has so far played a dominant role in renewable energy production, despite recent increases in wind power capacity (both onshore and offshore), solar and also solid biomass. Hydropower capacity has nearly doubled between 2000 and 2017.

Between 2000 and 2014, Vietnam reduced the share of electricity lost due to transmission and distribution losses from more than 13% to about 9% (World Bank, 2019).

Vietnam has significant coal reserves and resources and was formerly a coal exporter. As a result, coal use is increasingly playing an important role in the energy mix, where power generation is expanding rapidly to meet growing energy demand. Under current planning, Vietnam will further increase its capacity with 44 GW of coal power plants, which is the largest planned expansion in Southeast Asia and accounts for 12% of the total global coal expansion. Despite having large coal reserves, due to rapidly increasing domestic use of coal, Vietnam has imported coal since 2005 and became a net importer of coal for the first time in 2015 (IEA, 2016). Against this backdrop, the government began to limit coal exports and increase production to ensure domestic demand. However, under current expansion plans, growing domestic coal demand will continue and coal imports could become a significant burden on the national account.

Vietnam plans to expand coal-fired power plants to nearly 183% of current capacity. At global level, this represents almost 12% of the global coal-fired generation expansion plans. Nearly all existing capacity is based on out-of-date technology, with high emission intensities. However, most of the coal plants under construction are either subcritical or supercritical, with low emission intensity.

The planned expansion of the coal fleet will lead to a significant increase in emissions. If all plants in the pipeline are built, committed emissions are likely to peak only in 2040, eventually being phased out in 2070, reflecting the large expansion relative to current capacity.

In terms of greenhouse gas emissions, from Vietnam´s first inventory in 2000 (inventory for 1994) until its latest inventory in 2020 (for 2016), the Energy sector has always been the largest source of greenhouse gas emissions in Vietnam. GHG emissions from the energy sector have increased from about 151.9 million tons CO_2e in 2010 to 175.5 million tons CO_2e in 2014 and up to 205.8 million tons CO_2e in 2016, accounting for 57.5%, 63% and 65% of the total national GHG emissions in 2010, 2014 and 2016 respectively.

In the face of pressures on energy demand for socio-economic development and commitments to reduce greenhouse gas emissions in the NDC and achieve net-zero emissions by 2050, the current Master Plan Power Development 8 is being reviewed and revised. When this Master Plan is finalized, the energy sector GHG emission scenarios and GHG emission reduction targets will also need to be reviewed and updated. In addition, the net-zero targets by 2050 also requires energy industry planners to have a longer vision and a plan to be ready to participate in the carbon market to take advantage of international finance to change the direction of industry development.

5.2. Identifying an ambitious target for solar power development

The goal of solar power development in the 2050 Net-Zero scenario will be one of the most important renewable energy sources which will contribute to NDC’s targets. Assumptions for solar energy development are shown in Table 13.

Table 13. The goal of solar power development to 2050 according to the Net-Zero scenario

Measures	Assumption – implementation period	
	2021-2030	2031-2050
Developing concentrated solar power	Increasing the capacity of concentrated solar power plants from 4,086 MW in 2019 to 8,736 MW in 2030	Reach 25,034 MW in 2035, 75,987 in 2045 and 94,760 MW in 2050
Developing rooftop solar power	Increasing the capacity of rooftop solar power plants from 1,607 MW in 2020 to 7,755 MW in 2030	Reach 20,679 MW in 2045 and 28020 MW in 2050

Source: Technical report on national climate change strategy - Net-Zero Option 2 (MONRE, 2022)

The GHG emissions reduction from solar power is calculated by multiplying the grid´s emission factor by the total electricity generated from solar power. It is estimated that the potential to reduce GHG emissions comes mainly from concentrated solar power development solutions and is about 81%. The potential for GHG emission reduction of the rooftop solar power solution is only about 19% (MONRE, 2022) (Table 14).

Table 14. Potential for mitigation of solar power under the Net-Zero scenario

Measures	2020	2025	2030	2035	2040	2045	2050
Concentrated solar power	5.55	10.14	10.44	31.62	60.30	97.50	113.33
Rooftop solar power	1.45	7.12	7.33	7.83	14.14	20.93	26.52
Total	7.00	17.26	17.77	39.45	74.44	118.43	139.85

Unit: mil tCO_2e

5.3. Solar power development BAU and NZ reference scenarios

GHG emissions under the BAU scenario of the energy sector are detailed by sub-sectors/sectors as follows (Based on Table 1).

Table 15. BAU scenario of energy sector 2014- 2050

Unit: mil tCO_2e

Emission Categories	**Year**							
	2014	2020	2025	2030	2035	2040	2045	2050
Manufacturing and construction industry	49.4	66.9	114.2	257.5.6	301.4	359.9	407.4	455.8
Transportation	33.2	47.7	65.1	89.1	118.4	152.7	192.5	241.4
Agriculture, Commercial and Household Services	13.6	18.1	25.1	41.2	56.1	73.3	89.5	109.3
Energy industry	75.4	214.8	296.3	290.6	355.2	386.8	413.0	403.8
Total	**171.6**	**347.5**	**500.7**	**678.4**	**833.8**	**972.7**	**1102.4**	**1210.3**

The national electricity demand in the period 2021 - 2030 is calculated based on the forecast data of the revised Power Master Plan VII and the updated NDC Report 2020. Electricity demand in the period 2031 - 2050 is calculated based on National Climate Change Strategy (MONRE, 2022). Forecast data of the Draft *Power Master Plan VIII* (MOIT 2021a) and the Draft "*National Energy Master Plan for the 2021-2030 period, with a vision to 2050*" (MOIT 2021b), are currently being finalized for submission to the Government.

Table 16. Forecast of national electricity demand to 2050

Unit: GWh

Year	2014	2020	2025	2030	2035	2040	2045	2050
National electricity demand (GWh)	128,627	214,300	391,338	595,356	822,513	1,040,784	1,213,053	1,413,836

As solar power development is a mitigation measure for energy industry, the BAU scenario for solar power developoment will be emissions from energy industry. Emission intensity for energy industry sector will be defined by dividing total GHG emissions by the total electricity demand. Emissions and emission intensity from BAU and Net-Zero scenario are presented in Table 17 below.

Table 17. Energy industry emissions and emission intensity for the BAU and Net-Zero scenarios

Scenario	2014	2020	2025	2030	2035	2040	2045	2050
$BAU_{energy\ industry}$ (mil tCO_2e)	75.4	214.8	296.3	290.6	355.2	386.8	413.0	403.8
Net-Zero $_{energy\ industry}$ (mil tCO_2e)	75.4	207.8	279.1	272.8	315.8	312.4	294.6	264.0
Emission intensity – BAU (tCO_2e/MWh)	0.5862	1.0023	0.7571	0.4881	0.4318	0.3716	0.3405	0.2856
Emission intensity – NZ (tCO_2e/MWh)	0.5862	0.9697	0.7130	0.4583	0.3839	0.3001	0.2428	0.1867

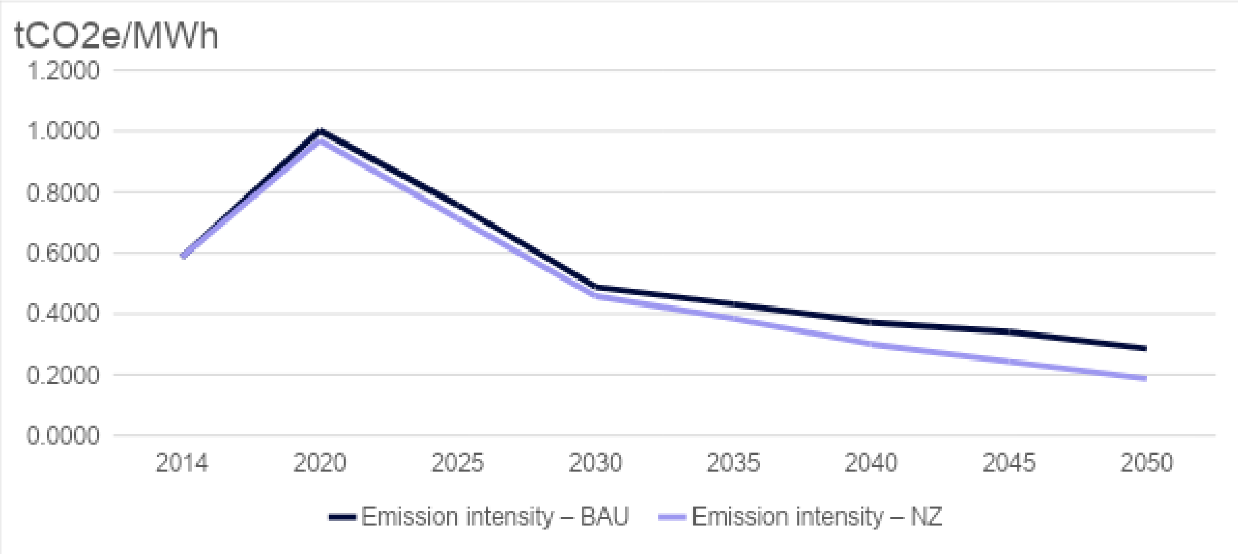

Figure 8. Energy industry emission intensity for the BAU and Net-Zero scenarios

5.4. Calculation of a dynamic baseline for the energy industry sector

As it was done in Chapter 3 at national level, here a dynamic baseline for the energy industry between 2020 and 2050 will be establish so that, it can be used to calculate the mitigation outcomes produced by the solar power developments which could potentially be subject of cooperative approaches under Article 6.

The first step to do so is to calculate an Ambition Coefficient departing as in Chapter 3 from the emissions and emissions intensity of the energy industry sector for the BAU and Net-Zero scenarios.

$$AC_{Energy\ Industry} = \frac{GHG_{Energy\ Industry\ NZ}}{GHG_{Energy\ Industry\ BAU}}$$

Based on the results of these calculations a series of values for the Energy Industry Ambition Coefficients for 2020-2050 will be selected (see Table 18). Again, the Ambition Coefficient will be updated every two years matching the national GHG inventory cycle. As it can be seen in Table 18, the ambition coefficient of solar power development will gradually decline from 0.967 in 2020 to 0.654 in 2050.

Table 18. Calculated Energy Industry Ambition Coefficient

Calculated $AC_{energy\ industry}$	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**
	0.967	0.955	0.946	0.941	0.940	0.939	0.916	0.897
	2036	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**
	0.872	0.838	0.808	0.768	0.731	0.702	0.678	0.654

The $AC_{energy\ industry}$ is calculated based on the Net-zero scenario for the energy industry sector. However, the Net-zero scenario for energy sector includes conditional target. In order to compatible with social – economic development targets, the $AC_{energy\ industry}$ will be adjusted to consistent with unconditional target and development priorities of energy sector (diversifying energy sources, encouraging the development of renewable energy and limiting the development of thermal power plant after 2035) (Table 19).

Table 19. Adjust Energy Industry Ambition Coefficient

Adjusted $AC_{energy\ industry}$	2020	2022	2024	2026	2028	2030	2032	2034
	1	0.99	0.985	0.98	0.975	0.970	0.960	0.955
	2036	2038	2040	2042	2044	2046	2048	2050
	0.950	0.945	0.930	0.890	0.850	0.800	0.750	0.654

Figure 9 compares calculated $AC_{energy\ industry}$ and adjusted $AC_{energy\ industry}$.

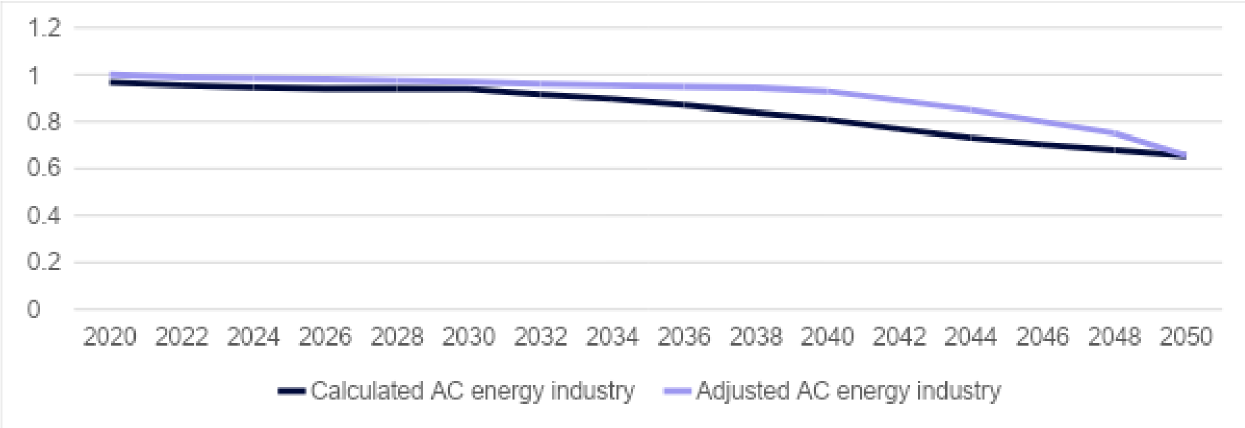

Figure 9. Calculated $AC_{energy\ industry}$ and adjusted $AC_{energy\ industry}$

This AC is calculated for energy industry sector. Therefore, it can be used for any project within the energy industry sector, not just the solar project. Using the selected Ambition Coefficients in Table 19, the dynamic baseline of the energy Industry sector for 2020-2050 can be easily calculated by multiplying them by the Energy Industry BAU emissions intensity (Table 20).

Table 20. Energy Industry dynamic baseline

Unit: mil tCO_2e

$Dynamic\ Baseline_{national}$	2020	2022	2024	2026	2028	2030	2032	2034
	214.9	245.0	275.7	289.3	285.6	281.8	303.9	327.0
	2036	2038	2040	2042	2044	2046	2048	2050
	343.3	353.8	359.5	353.7	346.7	328.7	305.5	264.0

The resulting dynamic baseline for the energy industry fulfils the requirements established in the Article 6.4 of the Paris Agreement for it is below BAU, conservative and aligned with Vietnam´s long-term goals, which in turn are aligned with Paris Agreement long-term targets.

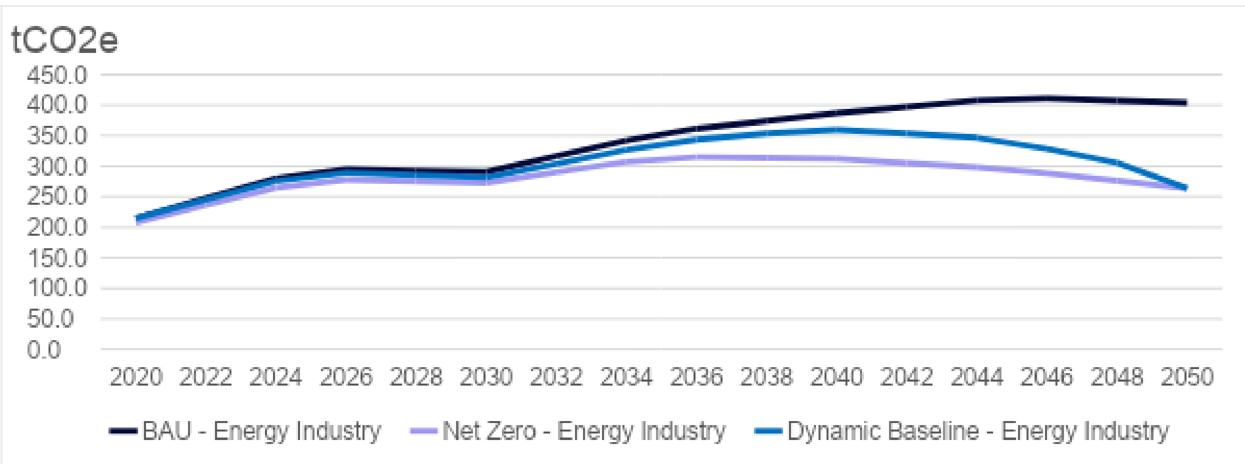

Figure 10. Energy industry dynamic baseline

This dynamic baseline can be now used to estimate the mitigation outcomes produced by solar power developments subject to be part of cooperation approaches under Article 6. To do so it would be necessary to calculate the amount of these mitigation outcomes below the dynamic baseline.

Figure 10 shows the dynamic baseline of solar development which implies that the mitigation above the dynamic baseline would be implemented by domestic efforts, and the mitigation below dynamic baseline would be achieved by international supports.

6. CONCLUSION

The present report introduced the concept of dynamic baseline an approach based on the application of an ambition coefficient to a baseline emissions scenario (BAU). Such an approach would allow to keep the accumulated knowledge of the mitigation projects with regard to activity-type specific baseline development while keeping baselines conservative, aligning them with countries long-term targets (i.e., the baseline will become zero when the country reaches the point where emissions need to be zero) and thus making them compliant with the requirements established in the Article 6 rulebook agreed in 2021 in Glasgow at the COP 26.. The dynamic baseline would also incorporate the common but differentiated responsibilities and capacities principle through the ambition coefficient which values would vary depending on the countries´ diverse circumstances. This would mean that, while developed countries could embark solely on generating removal credits and would need to finance emission reductions through other means, in line with their responsibility and capacity, developing countries would be able to generate emissions credits a bit longer. Such a transparent and long-term oriented approach could generate new trust in carbon markets and encourage new investments to reach the long-term goals of the Paris Agreement in an efficient way compatible with a fair distribution of costs and benefits.

This report applies the dynamic baseline concept to Vietnam at national level and also to the Solar PV developments included in Vietnam´s 2050 Net-Zero program. The dynamic baseline resulted from the combination of the BAU emissions projections in the technical report of National Climate Change Strategy (MONRE, 2022) and an AC calculated based on the 2050 Net-Zero emissions pathway. The calculated AC was then adjusted based on the NDC unconditional targets and the GDP expected growth and energy demand estimations.

Results show that while the ambition coefficient of Vietnam's net-zero target will gradually reduce to

0 by 2050 in line with the country´s Net-Zero goal, the ambition coefficient of solar power development is not necessarily to be 0 since the development of solar power is just one among the many potential mitigation measures for the energy sector. The development of solar power will be prioritised and balanced with other renewable energy sources.

A 2-years updating interval for the ambition coefficient was chosen, so that it coincides with the national GHG inventory cycle, and it would be feasible to MRV the implementation of mitigation measures as well as monitoring and evaluate the ambition coefficients.

The present study on the dynamic baseline for Viet Nam and for a set of Solar PV development points out some important factors for the calculation and adjustment of the AC. Some of them are the NDC conditional and unconditional targets, social – economic development priorities such as GDP expected growth rate and energy demand. The resulting dynamic baseline is expected to server to increase countries´ NDC ambition as well as to highlight the potential of carbon credits.

One of the main challenges to set up a dynamic baseline was the development of a net-zero scenario for this process for this process involves a several sectors, takes time and requires human and financial resources.

REFERENCES

Aldy, J., Pizer, W., Tavoni, M., Aleluia Reis, L., Akimoto, K., Blanford, G. *et al.* (2016). Economic tools to promote transparency and comparability in the Paris Agreement. *Nature Climate Change* 6, 1000–1004.

Axel Michaelowa et al. 2020, CDM method transformation: updating and transforming CDM methods for use in an Article 6 context, Zurich Open Repository and Archive, University of Zurich, Perspectives Climate Group;

Axel Michaelowa et al. 2021a, Setting crediting baselines under Article 6 of the Paris Agreement, Perspectives Climate Research gGmbH;

Axel Michaelowa et al. 2021b, Promoting Article 6 readiness in NDCs and NDC implementation plans, Perspectives Climate Group;

Axel Michaelowa et al. 2021c, Toward Net Zero: Dynamic baselines for international market mechanisms; University of Zurich, Perspectives Climate Research;

Axel Michaelowa et al. 2021d, Ambition Coefficients: Aligning baselines for international carbon markets with net zero pathways, University of Zurich and Perspectives;

Climate Action Tracker (2021): Climate action target update tracker, https://climateactiontracker.org/climate-target-update-tracker/ (accessed January 20, 2021);

Dezan Shira 2021, COP26 and Climate Change: Vietnam's Commitment to Reducing Emissions, Accessed via: https://www.vietnam-briefing.com/news/cop26-climate-change-vietnams-commitment-reducing-emissions.html/

Edmonds, J., Yu, S., McJeon, H., Forrister, D., Aldy, J., Hultman, N. *et al.* (2021). How much could article 6 enhance nationally determined contribution ambition toward Paris Agreement goals through economic efficiency? *Climate Change Economics* 12(2), 2150007.

Edmonds, J., Forrister, D., Clarke, L., de Clara, S. and Munnings, C. (2019). *The Economic Potential of Article 6 of the Paris Agreement and Implementation Challenges*. Washington, D.C.: International Emissions Trading Association, University of Maryland and Carbon Pricing Leadership Coalition.

Edmonds, J., Yu, S., McJeon, H., Forrister, D., Aldy, J., Hultman, N. *et al.* (2021). How much could article 6 enhance nationally determined contribution ambition toward Paris Agreement goals through economic efficiency? *Climate Change Economics* 12(2), 2150007.

Fujimori, S., Kubota, I., Dai, H., Takahashi, K., Hasegawa, T., Liu, J.-Y. *et al.* (2016). Will international emissions trading help achieve the objectives of the Paris Agreement? *Environmental Research Letters* 11(10), 104001.

Füssler, Juerg; Oberpriller, Quirin; Duscha, Vicky; Lehmann, Sascha; Arens, Marlene (2019): Benchmarks to determine baselines for mitigation action under the Article 6.4 mechanism, DEHSt, Berlin, https://www.infras.ch/media/filer_public/80/4f/804f890a-7bba-4485-8e5d96ed616220b8/discussion-paper_bonn-2019_2.pdf (accessed October 10, 2019);

Füssler, Jürg; Kohli, Anik; Lehmann, Sascha; Kreibich, Nicolas; Obergassel, Wolfgang (2019): Options for fostering increasing ambition levels under the Article 6.4 Mechanism, Discussion Papier, 14 https://www.dehst.de/SharedDocs/downloads/EN/project-mechanisms/discussionpapers/klimakonferenz-bonn-2019_3.pdf?__blob=publicationFile&v=1 (accessed October 10, 2019);

General Statistics Office of Vietnam 2009, Vietnam Population Forecast 2009;

Hof, A.F., den Elzen, M.G.J., Admiraal, A., Roelfsema, M., Gernaat, D.E.H.J. and van Vurren, D.P. (2017). Global and regional abatement costs of Nationally Determined Contributions (NDCs) and of enhanced action to levels well below 2 °C and 1.5 °C. *Environmental Science & Policy* 71, 30–40.

Lukas Hermwille 2020, Reconciling Pretensions and Reality The Situation-Ambition Approach for Dynamic Baselines under Article 6.4, Wuppertal Institute for Climate, Environment and Energy GmbH;

MOIT 2021a, The Draft "Power Development Plan VIII";

MOIT 2021b, the Draft "*National Energy Master Plan for the period 2021-2030, with a vision to 2050*";

MONRE 2019, National Environment Report in 2019;

MONRE 2015, National environmental reports in 2015;

MONRE 2017, National environmental reports in 2017;

MONRE 2022, Technical report on national climate change strategy;

Nguyen Thi Lieu et al (2021). Research on the scientific and practical basis for the construction of a carbon market in Vietnam. Code TNMT.2018.05.01. Science and Technology Project at the Ministry of Natural Resources and Environment;

Piris-Cabezas, P., Lubowski, R. and Leslie, G. (2019). Estimating the power of international carbon markets to increase global climate ambition. In *First International Research Conference on Carbon Pricing*. World Bank Working Paper Series. World Bank and Carbon Pricing Leadership Coalition.

Simon Evans et al. 2021, COP26: Key outcomes agreed at the UN climate talks in Glasgow, Accessed via: https://www.carbonbrief.org/cop26-key-outcomes-agreed-at-the-un-climate-talks-in-glasgow/

Thioye, M., Shrestha, J., Krieger, M., Burian, M., & Schnurr, J. (2018, July). Forward-looking Baselines for Results-based Financing: A new approach for measuring climate mitigation contributions in the power sector. Carbon Mechanisms Review, 2018(2), 14–20;

UNFCCC 2021, Decision -/CP.26: Glasgow Climate Pact;

United Nations Framework Convention on Climate Change (2021). *Nationally Determined Contributions under the Paris Agreement. Synthesis Report by the Secretariat*. 17 September. FCCC/PA/CMA/2021/8. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf. Accessed 13 October 2021.

van den Berg, Nicole; van Soest, Heleen; Hof, Andries; den Elzen, Michel; van Vuuren, Detlef; Chen Wenying; Drouet, Laurent; Emmerling, Johannes; Fujimori, Shinichiro; Höhne, Niklas; Kõberle, Alexandre; McCollum, David; Schaeffer, Roberto; Shekhar, Swapnil; Vishwanathan, Saritha; Vrontisi, Zoi; Blok, Kornelis (2020): Implications of various effort-sharing approaches for national carbon budgets and emission pathways, in: Climatic Change, 162, p. 1805–1822;

World Bank 2018, Solid waste management in Vietnam 2018;

Annex 1. Assumption for the BAU

1.1. Energy sector

The industry and trade sector has made many efforts, through policies on promoting activities on economical and efficient use of energy, reducing transmission and distribution losses, and promoting the development of renewable energy. and some positive results have been obtained.

In the past period, Vietnam's energy industry has had a strong and relatively synchronous development in all energy fields and sub-sectors, closely following the energy development orientation of the Party and State. However, traditional fossil energy (coal, oil, gas) still accounts for a large proportion of total supply and consumption. Meanwhile, these forms of energy are increasingly depleted and in all stages from exploitation, production and consumption, they cause air and water pollution.

Transforming the energy structure towards increasing the proportion of renewable energy in electricity production

The structure of primary energy supply has changed in a positive direction, non-commercial biomass energy has decreased rapidly, hydroelectricity has increased... The revised Power Plan VII has prioritized the development of power sources using energy. renewable energy sources, gradually increasing the proportion of electricity produced from renewable energy sources in order to reduce dependence on imported coal-fired power sources, contributing to ensuring energy security, reducing climate change, and ensuring energy security. environmental protection and sustainable socio-economic development.

Increasing the use of renewable energy in the final energy consuming sectors

In terms of energy consumption, the ratio of electricity consumption to total final energy consumption increases continuously representing the transition from other forms of fuel to electricity. The structure of coal in final consumption did not change much, approximately at 23-24%. Renewable energy also has a significant growth rate, 5.9%/year. However, the share of renewable energy in total final energy consumption decreased from 8.1% in 2015 to 8.0% in 2019. Oil products accounted for the largest share of total energy consumption. in the end and also without major fluctuations. Non-commercial energy has had a huge change, decreasing by more than 20% per year in the period 2011-2019.

With the above efforts, by 2014, energy consumption and especially electricity consumption has decreased a certain amount, equivalent to an estimated emission reduction of 7.3 million tons of CO2e compared to the previous BAU.

In 2019, the Prime Minister approved the National Program on Energy Efficiency and Saving, through Decision No. 280/QD-TTg dated March 13, 2019, in which the goal of saving the total energy consumption of the whole the country will reach 5-7% in the period from 2019 to 2025 and 8-10% in the whole period from 2019 to 2030.

The BAU for the energy sector is calculated according to the revised GL 1996, GPG 2000 and GL 2006.

Activity data used for the development of the BAU of the energy sector for the period 2014-2030 are published data, including: statistics of the General Statistics Office; development plans of the energy sector to 2030, such as the Adjustment of the National Power Development Plan for the period 2011-2020 with a vision to 2030 (Adjusted Power Master Plan VII), Adjustment of the Coal Industry Development Plan up to 2020 with a view to 2030, the data summarizing the operation of EVN, Vietnam Coal and Minerals Group. The results of the latest studies are also taken into account, including those of the Ministry of Information and Communications (WB Project) and the Ministry of Transport (GIZ and WB Project). Accordingly, the final energy demand is forecasted by fuel and energy types for 5 energy-using sectors, including: Industry, agriculture, transportation, commercial services and household.

Electricity demand in the period 2021-2030: Electricity demand is calculated based on forecast data of the revised Power Master Plan VII and updated NDC Report 2020.

Energy/electricity demand for the period 2031-2050: The electricity demand is calculated based on forecast data of the Draft *Power Master Plan VIII* (MOIT 2021a) and the Draft "*National Energy Master Plan for the 2021-2030 period, with a vision to 2050*" (MOIT 2021b), which is currently being finalized for submission to the Government.

The BAU for the period 2014 – 2030 is taken from the updated NDC Report 2020; for the period 2031-2050, BAU is calculated according to the "0" option of the energy planning, in which: The objective function is "Minimum cost of the energy system"; primary energy sources are selected for development to achieve optimal goals, regardless of fossil fuel, renewable energy or imported.

1.2. Transportation sector

Transport sector emissions under the normal scenario are expected to increase with increasing mobility and mechanization needs. Based on assumptions about population and economic growth, passenger-kilometer traffic (PKT) is expected to increase at an average annual growth rate of 5.9% during 2014-2030. The ratio between modes remains relatively stable throughout the forecast period: road transport accounts for 94% of PKT by 2030, although the share of commercial PKT has increased relative to individual PKT; Air transport PKT remained at about 4% of total PKT. Cargo-kilometers transported (FTKT) is expected to grow at an average annual growth rate of 6.9%. Coastal transport accounted for 55% of FTKT, while road and waterway accounted for 23% and 21% respectively.

Road transport: Road transport is one of the dominant modes of the market in Vietnam and also a very fast growing mode. Road infrastructure receives the largest share of public funding allocations and road lengths have quadrupled over the past 2 decades; The rate of mechanization in Vietnam is increasing rapidly, though still at a modest rate compared with higher income countries. Based on assumptions about population and economic growth, the number of kilometers traveled by road transport is forecast to increase from 212.7 billion kilometers per year from 2014 to 476.4 billion kilometers per year by 2020. 2030, with an average annual growth rate of 5.2%. Of the total number of kilometers traveled, motorbikes accounted for 60%, cars accounted for 23%, trucks and passenger cars accounted for 10%.

Inland and coastal water transport: Vietnam's inland waterway transport has grown significantly in recent years, becoming a vibrant and strategically important activity for the transportation system. Vietnam. This mode helps to transport nearly one-sixth of total goods transported domestically and nearly 80% of freight volume (ton-km) is transported by road. Inland waterway passenger traffic is expected to grow from 2.9 billion passenger-km in 2014 to 6.2 billion passenger-km in 2030, with an average annual growth rate of 1 percent. .7%. Most ships and barges (92%) are small, with less than 100 HP capacity. Cargo traffic is expected to grow at an average annual rate of 9.0% to 127.8 billion ton-km by 2030. Large vessels with a capacity of less than 1,500 tons account for 94% of the number of ships in service. on inland waterways. Cargo movement by coastal transport is expected to increase from 130 billion ton-km in 2014 to 338.4 billion ton-km in 2030; Vessels used in coastal transport are expected to be mostly large ships (64%) with a capacity of more than 1,000 tons.

Domestic Aviation: Aviation is a very fast-growing activity. The number of passenger-km carried by domestic civil aviation has increased exponentially from PKT 4.4 billion in 2000 to PKT 11.0 billion in 2014 and is expected to increase to PKT 36.5 billion by 2030. Although there is currently no dedicated air freight service, cargo movement on passenger aircraft is expected to increase from 0.1 billion ton-km in 2014 to zero. 7 billion ton-km by 2030.

Railway: Rail transport in Vietnam accounts for a small proportion of PKT and FTKT and is decreasing, largely due to the deterioration of old infrastructure, low speed service and low capacity. The number of passenger-km traveled by rail was 4.4 billion passenger-km in 2014 and is expected to increase to 7.1 billion passenger-km by 2030. Tons of freight kilometers transported by rail was 4.3 billion ton-km in 2014, decreasing gradually in 2015 and 2016 to 3.1 billion ton-km. However, the forecast shows that railway FTKT will reach 8.5 billion tons-km by 2030.

1.3. Agriculture sector

Vietnam's agriculture comes from a backward and poverty-stricken agriculture from the late 70's and early 80's of the last century. However, after more than 30 years of renovation, Vietnam's agriculture has grown continuously in both scale and technical level.

The output of agro-forestry-fishery products of the agricultural sector has increased continuously, not only to meet the needs of over 90 million people, but also to export for hard foreign currency, contributing to the country's economic growth. As a result, Vietnam is the world leader in cashew exports, second in rice, third in coffee, etc. give the country a large source of foreign currency.

Agriculture still affirms an important role in the development process and international economic integration of Vietnam. However, agricultural growth is also facing many challenges such as shrinking productive land due to industrialization, urbanization, population growth, degradation of water resources, degradation of land resources, agricultural market unstable production, especially the adverse impacts of climate change on agricultural production are increasing. Agriculture is not only an industry affected by climate change, but also an industry that causes large greenhouse gas (GHG) emissions, increasing global warming. Rice farming, rumen fermentation, agricultural land use, livestock waste management and agricultural by-products are major sources of GHG emissions. Therefore, calculating GHG emissions from agricultural production activities plays an important role in determining the emission structure and proposing measures to reduce GHG emissions.

1.4. LULUCF

The historical approach is used in the determination of the emissions under the normal scenario. The BAU emission scenario projections are based on two main bases: (1) The rate of deforestation, forest development, and carbon growth in the period 2000-2014. These are the results of observation and spatial analysis; and (2) Forestry Development Plan to 2030 and expert projections to 2050.

No.	Parameters	Assumptions
1	The rate of change of forest area	• In the period 2030-2040, the rate of change of total forest area is 0.2%/year; with natural forest is -0.2%/year and planted forest is 0.6%/year; • Period 2040-2045: the rate of change of total forest area is 0.02%/year; with natural forest is -0.01%/year and planted forest is 0.2%/year; • The period after 2045: stable, with negligible fluctuations, forest cover remains at 42.5-43.0%.
2	Wood gathering	• Harvest from planted forests and not from natural forests • The base year for calculating growth in timber harvesting is 2020 (20.5 million m3) and the goal is to reach 50 million m3 by 2030. • The growth rate of timber harvested from planted forests is based on 2017-2020 data and this rate applies to the period 2021-2030, increasing by 6.5%/year until reaching 50 million m3 and stable over the years. next.
3	Annual rate of carbon sequestration	• For natural forests, the annual average rate of carbon sequestration in the period 2030-2050 is -5.3 tCO2/ha/year • The rate of carbon sequestration in planted forests in the period 2030-2050 is -28.1 tCO2/ha/year (equivalent to MAI 16 m3/ha/year).
4	Carbon reserves of natural forests	• Average for all types of natural forest is 117.4 tCO2/ha)

1.5. Waste sector

Emissions from solid waste treatment are calculated based on the amount of domestic solid waste generated per capita annually in urban and rural areas, the rate of collection, burial and waste treatment methods. other emissions according to the National Environment Report 2019 and according to the scale of population growth in urban and rural areas from 1999 to 2049 (Report on Vietnam Population Forecast 2009 by the General Statistics Office).

Emissions from industrial solid waste treatment are based on World Bank data and forecasts on solid waste management in Vietnam 2018 and National Environmental Reports in 2015, 2017 and 2019.

Emissions from industrial wastewater treatment are calculated based on the National Environment Report 2015, 2016, 2017 and data in the World Bank's Project on Industrial Pollution Management in Vietnam.

Emissions from domestic wastewater treatment are also based on the data from the above report.

Emissions from human waste - nitrous oxide - are emitted by burning fossil fuels and solid wastes, as well as in wastewater treatment processes.

Compost production from domestic solid waste is calculated based on the data of the National Environmental Reports from 2015, 2017 and 2019.

Input data for calculation are taken from national environmental reports and some other research reports of ADB and JICA.

Parameters	Assumptions

Population	Population growth rate in urban areas is 2%/year for the period 2030-2040 and 1%/year for the period 2040-2050 The share of the population in rural areas will decrease by 1.1%/year for 2030-2040 and by 1.1%/year 2040-2050
Amount of solid waste generated per capita (kg/person/day)	Urban areas: period 2030-2040: increase 3%/year; 2040-2050: only 2%/year increase Rural and urban areas: period 2030-2040: an increase of 8%/year; 2040-2050: only increasing by 6%/year
Ordinary industrial solid waste	Generated about 25 million tons/year
Solid waste burial rate	88% by 2030; reach 50% by 2050
Amount of domestic wastewater generated	Urban area: 120 liters/person/day Rural areas: 80 liters/person/day
Only BOD in domestic wastewater	Default criteria according to IPCC 2006
The amount of wastewater is treated centrally in the Industrial Parks	Period 2030-2040: 1.5 million m3/day and night; 2040-2050: 1.8 million m3/day and night
Indicators of COD, BOD and BOD5 in wastewater in industrial zones	Default COD indicators for key industries
Burning waste	Domestic solid waste is burned at a low rate in domestic waste treatment zones Medical solid waste is mainly burned and causes greenhouse gas emissions Medical solid waste is generated about 450 tons/day and hazardous waste accounts for about 10%. The amount of medical solid waste will increase by about 8%/year in the period 2030-2040 The amount of medical solid waste will increase by about 10% per year in the period 2040-2050
Producing compost from domestic solid waste	Period 2030-2040: the ratio of composting from solid waste to be maintained at 16% of the total volume of collected solid waste Period 2040-2050: 18% of total solid waste collected

1.6. Industrial processes

Operational data for the period 2014 - 2020 is collected and aggregated from the General Statistics Office, research reports of ministries, statistics from associations and reports of corporations. Forecasted data for production output of industries by 2030, with a vision to 2050 are taken from the development planning of the sectors already approved by the line ministry or the Prime Minister.

In the period of 2021-2030, the assumption about the performance of the cement industry is determined according to the past trend; assumption about the growth rate of glass production is taken according to the average value of the growth rate of industrial production value of the building materials industry; Assumptions about the performance of the steel manufacturing industry are determined by expert judgment.

Annex 2. Assumptions for developing options to reduce greenhouse gas emissions

2.1. Energy sector

The high-net zero option is assumed to have 9 supply-side measures and 11 demand-side measures (excluding transport), with a higher scale, specifically:

Mitigation measures	Assumption - execution time	
	2021-2030	**2031-2050**
Energy supply side mitigation solutions		
ES1. Small hydropower development	Increase capacity of small hydroelectricity from 3.8 GW in 2020 to 6.1 GW in 2025 and 7.3 GW in 2030	Exploiting full potential by 2030
ES2a. Developing concentrated solar power (DMT)	Increasing the capacity of solar power plants from 9.1 GW in 2020 to 21 GW in 2030	Reach 193 GW by 2040 and 481.6 GW by 2050.
ES2b. Developing rooftop solar power	Capacity of rooftop solar power projects 7.7 GW in 2020; 6.4 GW in 2030	14.9 GW by 2050.
ES3a Developing wind power onshore	Increase onshore wind power capacity from 539 MW in 2020 to 14 GW in 2030	Increase to 217 GW by 2050.
ES3b Offshore wind power development	Offshore wind capacity by 2030 is 2.1 GW	Increase to 46.3 GW by 2040 and reach 122.7 GW by 2050.
ES4. Biomass thermal power development	Biomass power capacity is 2.5 GW	4.1 GW by 2040; and 8.78 GW by 2050.
ES5. Development of thermoelectric technology on supercritical	Supercritical thermal power capacity is 13 GW by 2025, 19.5 GW by 2030 (out of 36 GW of coal power)	Down to 7.06 GW. 2050: Apply CCS technology with all 17.6 GW of coal power
ES6. Development of a hybrid gas turbine using LNG	The capacity of the mixed gas turbine plant using LNG is 27.33 GW	Combined gas turbine plant capacity using LNG 40.3 GW by 2040; and 34.3 GW by 2050; 2050: 100% of gas power plants apply CCS
ES7. Development of gas-fired cogeneration plant (CHP)	~0.27 GW by 2030	~1.74 GW by 2050

Mitigation solutions on the energy use side- Civil & Commercial Services		
ED1. Using high-efficiency household appliances (air conditioners, water heaters, refrigerators, lighting equipment, cooking appliances, general electrical equipment and others)	Percentage of households using high-efficiency equipment is 40%	The percentage of households using high-efficiency equipment is 50%
ED2. Using high-efficiency electrical equipment in commercial services (Air conditioners, water heaters, lighting equipment, cooking equipment, office equipment, commercial building equipment	The percentage of commercial service households using high-efficiency equipment is 40%.	The percentage of commercial service households using high-efficiency equipment is 50%.
Mitigation measures on the agricultural energy use side		
ED3. Use high-performance agricultural equipment (pumps, harvesters, plows, tractors, etc.)	High performance equipment utilization rate is 50%	The utilization rate of high-performance equipment is 100%.
Mitigation measures on the energy use in Industries		
ED4. Optimized clinker burning cycle	Combustion cycle optimization will be applied to produce about 50% of clinker output. The solution saves 1% of heat consumption.	Combustion cycle optimization will be applied to produce approximately 100% of clinker output.
ED5. Use of vertical mill in cement production	Using vertical mill will be applied to produce about 50% of cement production. This solution can save up to 5.26% of power consumption.	Using vertical mill will be applied to produce about 100% of cement production.
ED6. Spray powdered anthracite coal into blast furnace	Spraying powdered anthracite coal into blast furnace is applied to produce about 50% of cast iron output.	Spraying powdered anthracite coal into blast furnace is applied to produce about 100% of cast iron output.
ED7. Preheating of scrap steel before putting it into an electric arc furnace (EAF)	Preheating of scrap steel before being put into electric arc furnace will be applied to produce about 50% of steel output. Potential savings of about 13% of power consumption.	Preheating of scrap steel before being put into electric arc furnace will be applied to produce about 100% of steel output.
ED8. Heating in steel mills	Heating in the steel mill will be applied to produce about 50% of the steel output.	Heating in the steel mill will be applied to produce about 100% of the steel output.
ED9. Gas heat recovery from a blower oxygen furnace (BOF)	Gas heat recovery from blast furnace (BOF) is applied to produce about 50% of steel output by blast furnace technology.	Gas heat recovery from blast furnace (BOF) is applied to produce about 100% of steel output by blast furnace technology.
ED10. Improve energy efficiency in sub-industries (except for 03 sub-sectors of brick, cement and	Improving energy efficiency across industries by improving the efficiency of boilers, electric motors and electrical equipment can save up to 6.5% of energy demand; applied to 50% of production	Improve energy efficiency in sub-industries by increasing the efficiency of boilers, electric motors and electrical equipment for 100% of production output.

iron and steel production)	output.	
ED11. Optimization of the clinker burning cycle	Optimization of the clinker burning cycle applies to 50% of businesses, which can save energy up to 30%	This measure applies to 100% of enterprises in the industry.

2.2. Transportation sector

Driving industry transformation with greater international support and strong private sector participation, the High Option in Transport provides a vision with additional policies and measures not currently outlined in Strategy and planning for transportation development. In the high scenario, it is assumed that by 2050 all road vehicles will use electricity.

Mitigation measures	Specific measures	Description
1. Energy efficiency	1.1. New fuel vehicles and new emission standards	Same Low and Medium Scenario
	1.2. Increase the load factor of the truck	Cargo load factor improved from 56% to 65%
2. Transition of private to public passenger transport	2.1. Expanding the bus system	Same Medium Scenario
	2.2. Expansion of the BRT system	Same Medium Scenario
	2.3. Deployment of metro system	Same Low and Medium Scenario
3. Transition of road freight	3.1. Conversion from road transport to inland waterways	Same Medium Scenario
	3.2. Converting from road transport to coastal transport	Same Medium Scenario
	3.3. Transition from road transport to railway	Same Medium Scenario
4. Fuel swithching	**4.1. Encourage the use of biofuel E5/E10**	***2018 - 2024*** ▪ **E5 gasoline gradually increases from 40% of total gasoline sold in 2018 to 100% in 2024** ***2025-2030:*** ▪ **E5 gasoline is gradually replaced by E10 gasoline with the rate of 50% in 2025 and 100% in 2030**
	4.2. Encourage the use of electric motorbikes	**Electric motorcycles account for 30% by 2030; 100% electric motorcycles by 2050**
	4.3. Encourage the use of electric cars	**Encouraging the use of electric cars (by 2030, reaching 33%, by 2050, reaching 100% of using electric cars)**
	4.4. Encourage the use of electric cars and buses	▪ **By 2030, to achieve 33% of annual sales of new cars; 100% electric cars by 2050** ▪ **All BRT lines after 2020 use electric buses** ▪ **Encourage the use of electric buses (10% in the period from 2020 to 2030; by 2050, reach 100% to use electric buses)**

2.3. Agriculture sector

The highest emission reduction plan, towards carbon neutrality, in which all 19 measures mentioned above are implemented on a large scale, adding:

i). Measures to create biogas (biogas) and;

ii). Very effective remedy - composting.

Some measures have increased scale: Withdrawal of water in the middle of the rice crop (A2) up to 2.5 million ha; increase the scale of application of recycling and reuse of crop and livestock by-products as organic fertilizer (A7 and A13) to 40 million tons; scale up integrated crop management (ICM) for rice (A8), integrated crop management (ICM) for annual terrestrial crops (A9) to 4 million hectares by 2050 and; using 1.5 million tons of waste as biogas (A14). Composting will increase from nearly 65 million tons in 2020 to 80 million tons in 2050.

The scale of application of emission reduction measures in the high case is shown in the following table

Mitigation measures	Applicable scale (1000 ha/animal/ton of waste)						
	2020	2025	2030	2035	2040	2045	2050
A1. Alternating Wet Dry Irrigation and SRI (Completed Infrastructure)	45.0	125.0	250.0	297.3	353.6	420.4	500.0
A2. Withdrawing water in the middle of the rice crop	200.0	625.0	1,250.0	1,486.5	1,767.8	2,102.2	2,500. 0
A3. Converting inefficient rice land into shrimp-rice land	50.0	150.0	300.0	356.8	424.3	504.5	600.0
A4. Converting inefficient rice land into dry cropland	45.0	250.0	500.0	594.6	707.1	840.9	1,000.0
A5.1 AWD Irrigated Organic Rice (about 50%)	100.0	62.5	125.0	148.7	176.8	210.2	250.0
A5.2. Organic upland crops	-	162.5	325.0	386.5	459.6	546.6	650.0
A5.3. Organic farming	-	133.5	267.0	317.5	377.6	449.0	534.0
A5.4. Organic aquaculture	-	146.0	292.0	347.2	413.0	491.1	584.0
A6.1. Improve the diet of dairy cows	100.0	200.0	400.0	475.7	565.7	672.7	800.0
A6.2. Improve cow's diet	500.0	1,000.0	2,000. 0	2,378.4	2,828.4	3,363.6	4,000. 0
A6.3. Improve the buffalo's diet	-	250.0	500.0	594.6	707.1	840.9	1,000.0
A7 Cycle of agricultural waste (cultivation by-products as compost)	100.0	10,000. 0	20,000 .0	23,784. 2	28,284. 3	33,635. 9	40,000 .1
A8. Integrated Crop Management (ICM) for rice	65.0	1,000.0	2,000. 0	2,378.4	2,828.4	3,363.6	4,000. 0
A9. Integrated Crop Management (ICM) for terrestrial annuals	-	1,000.0	2,000. 0	2,378.4	2,828.4	3,363.6	4,000. 0
A10. Replace Urea fertilizer with ammonium sulfate-$(NH_4)_2SO_4$	-	2,500. 0	5,000. 0	5,946.0	7,071.1	8,409. 0	10,000. 0
A11.1. Alternating Wet Dry Irrigation and SRI (half Infrastructure)	-	175.0	350.0	416.2	495.0	588.6	700.0
A11.2. Alternating Wet Dry Irrigation and SRI (Poor Infrastructure)	-	500.0	1,000.0	1,189.2	1,414.2	1,681.8	2,000. 0

A12. Modernizing watering and fertilizing long-term plants	-	160.0	320.0	380.5	452.5	538.2	640.0
A13. Recirculation of agricultural waste (livestock waste as organic fertilizer)	100.0	10,000.0	20,000.0	23,784.2	28,284.3	33,635.9	40,000.1
A14. Biogas	-	375.0	750.0	891.9	1,060.7	1,261.3	1,500.0
A15. Applying compost	64,980.3	67,271.8	69,644.1	72,100.1	74,642.7	77,275.0	80,000.1

2.4. LULUCF sector

The highest level of emission reduction and absorption increase was studied, considering the additional scale of application under the assumptions of 7 emission reduction measures, but especially expected to significantly reduce the amount of timber harvested (from 50 million m3 of timber in 2030 to 35 million m3 of timber in 2040 and then stabilized). Thus, in the period 2030-2035, about 3 million m3 of timber harvested annually will be reduced, as described in measure F5 below:

Mitigation measures	Description of intervention
F1: Protection of existing natural forest areas in mountainous areas F2: Protection of coastal protection and special-use forests	Promote cooperative forest management among forest managers, state forestry companies and local communities; land conflict management; control deforestation, forest conversion and forest degradation; forest fire control; control forest pests and diseases; development of livelihoods and non-timber forest products. The assumptions for the calculation include: ▪ Protect the entire area of natural forests and coastal protection and special-use forests ▪ Reduce forest loss by 60% compared to BAU in the period of 2021-2030 and by 90% for the period of 2031-2050 ▪ Average carbon stock of natural forest is 117.4 tCO2/ha The carbon sequestration rate of BAU is -4.3 tCO2/ha/year ▪ The rates of carbon sequestration when implementing forest protection options are: -5.3; -6.3 and -7.9 tCO2/ha/year for 2021-2025; 2026-2030 and 2030-2050
F3: Rehabilitation of protection forests and special-use forests	Is a new planting solution on land without forests. Activities include: identification of suitable planting areas; selection of plants suitable for the site; improve seedling quality, use native trees, improve technical measures and build capacity; investment in afforestation and forest management. Assumptions include: ▪ The average new planting area is 3,000 ha in the 2021-2030 period and about 1,000 ha/year in the 2031-2050 period. ▪ The rate of carbon sequestration is -11.2 tCO2e/ha/year ▪ Cycle is 20 years, no mining
F4: Improving the quality and carbon stock of poor natural forests	Combined with cooperative forest management between the forest owner being an organization and the local community; apply measures to promote natural regeneration and forest enrichment (additional planting of native trees); plant selection; assessment of plant suitability for plant species selection and application techniques; produce and improve seedling quality and develop forest management capacity. Computational assumptions include: ▪ Annual forest enrichment is 10,00000 ha in the period of 2021-2030 and 30,000 ha/year for the period 2031-2050 ▪ Towards the 2050 Net Zero target, the additional carbon sequestration rate is -7.9 tCO2e/ha/year (compared to the BAU of -4.3 tCO2/ha/year) for the period 2021-2030 and is -8.5 tCO2e/ha/year for the period 2031-2050
F5: Improve productivity and carbon stock of large timber plantations	This is a business model to convert short cycle acacia plantations (usually 5-6 years), to long cycle plantations (10 to 15 years) to provide high value lumber that meets demand. domestic wood processing. This includes capacity building for stakeholders, raising awareness and investing in forest management activities such as planning, thinning, pruning and logging. Assumptions include: ▪ Planting and converting 9,000 ha/year in the period 2021-2030, increasing productivity (additional absorption of -2.5 tons of CO2e/ha/year for 60% of the existing planted forest area (4.4 million ha) ▪ Planting and converting 15,000 ha/year in the period 2031-2040, productivity increase (additional absorption of -5.0 tons of CO2e/ha/year (compared to BAU) for 60% of the planted forest area (4). ,5-5.0 million ha); increase by -6.0 tons (compared to BAU) for

Mitigation measures	Description of intervention
	80% of planted forest area in the period 2040-2050 ▪ Minimum 10 year reforestation cycle ▪ Reduce logging from planted forests for woodchip processing from 50 million m3 in 2030 to 35 million m3 in 2040 and stabilize at 30 million m3 in 2040-2050.
F6: Scaling up agro-forestry models to improve carbon stocks and conserve soil	Planting trees on cultivated land, agricultural land of households and organizations. Depending on the ecoregion, successful agro-forestry models will be replicated to enhance carbon stocks and improve soil fertility. Agroforestry is encouraged to be applied in sloping land (Northwest, Central Highlands, etc.). The assumptions are as follows: ▪ The annual area of agro-forestry application is 1,000 ha in the period of 2021-2030; 3000 ha/year for the period 2031-2040; and 5,000 ha/year for the period 2041-2050 ▪ The increase in carbon stock due to forestry is -4.4 tCO2/ha/year).
F7: Sustainable forest management and forest certification	Capacity development in planning for sustainable forest management; provide technical support on forest trading; monitoring and surveillance; investment support for forest certification for natural forests and planted forests as production forests. Through sustainable forest management will reduce pressure on natural forests and reduce deforestation and forest degradation. Assumptions include: ▪ The annual impact area is 50,000 ha for 2021-2030 and about 150,000 ha/year for 2031-2050 ▪ Reduce forest loss by 10% when implementing sustainable forest management ▪ Average carbon stock of natural forest is 117.4 tCO2/ha ▪ Increase the amount of absorption by -1.0 tCO2/ha

2.5. Waste sector

Assuming that by 2050 all organic solid waste will be treated with alternatives, only a small amount of non-recyclable waste will be disposed of by landfilling. Waste treatment solutions will include both cost-effective solutions and potential solutions.

Mitigation measures	2021-2030	2031-2050
W1. Reduce waste	10%	30%
W2. Reuse and recycle waste	100% paper and cardboard, glass, metal	100% paper and cardboard, glass, metal
W3. Producing compost from solid waste	100% leftovers, wood and garden waste	100% leftovers, wood and garden waste
W4. Burning solid waste to generate electricity	70% textile waste, diapers; 70% plastic waste; leather	70% textile waste, diapers; 70% plastic waste; leather
W5. Production of RDF	30% textile waste, diapers; 30% plastic waste; leather	30% textile waste, diapers; 30% plastic waste; leather
W6. Semi-aerobic disposal	10% is used for semi-aerobic treatment	20% is used for semi-aerobic treatment
W7. Landfilling of solid waste with gas recovery (LFG) for power generation	20% is used for gas recovery for power generation	80% is used for gas recovery for power generation

2.6. Industrial processes

The proposed solutions to reduce GHG emissions from IP are based on: (i) Potential to reduce GHG emissions taking into account the elements of sector/sub-industry development planning for the period 2021-2030, with a vision to 2045, 2050 and (ii) The feasibility of both technology and finance in line with regional and global contexts to ensure emission reduction, fuel savings, and cost savings.

Calculation data is taken according to:

- Planning and orienting the development of industries and industrial processes with potential to reduce emissions as mentioned in the previous section, including cement production, steelmaking and fertilizer production.

- Current technologies and potential future technologies, when the cost is reasonable in reducing GHG emissions

a. Assumptions about mitigation measures in cement production

In the mining and building materials industries, the potential for emission reduction in the industrial process is mainly concentrated in the cement industry (accounting for 87.02%).

For the cement industry, measures to reduce CO2 emissions during industrial production are alternatives to clinker in the cement composition. This solution is relatively easy to implement, does not require changing technology, so it is assumed that by 2030, 100% of enterprises in the cement industry will apply emission reduction measures. In 2030, the total output of the cement industry is about 140.1 million tons of CO2, if the proportion of additives accounts for 40%, the amount of CO2 will be reduced by 25.6 million tons of CO2 (reducing the clinker ratio from 95% to 60%).

Mitigation measures	Implementation period	Assumption
I 1. Crushed fly ash to replace clinker in cement composition	2021-2050	By 2030: reduce the clinker content in cement by 35% (from 95% to 60%) with a scenario of cement production output of 140.1 million tons. In which, fly ash will contribute to replace 8.75% of clinker and maintain until 2050
I 2. Crushing Puzolan to replace clinker in cement composition	2021-2050	By 2030: 35% (from 95% to 60%) with the cement production scenario of 140.1 million tons. In which, fly ash will contribute to replace 8.75% of clinker and maintain until 2050
I 3. Crushing limestone to replace clinker in cement composition	2021-2050	By 2030: reduce the clinker content in cement by 35% (from 95% to 60%) with a scenario of cement production output of 140.1 million tons. In which, fly ash will contribute to replace 14% of clinker and maintain until 2050
I 4. Crushing blast furnace slag (GBFS) replaces clinker in cement composition	2021-2050	By 2030: reduce the clinker content in cement by 35% (from 95% to 60%) with a scenario of cement production output of 140.1 million tons. In particular, fly ash will contribute to replace 3.5% of clinker and maintain until 2050
I 4.1 Application of CCS technology in cement production	2035-2050	By 2035: apply CCS technology for 11% of output; In 2050: apply to 50% of production

b. Assumptions about mitigation measures in steel production

In Vietnam, the steel industry accounts for a large proportion of the metallurgical industry (accounting for 96.47%). In which, furnace technology (Basic Oxygen Furnace - BOF) accounted for 96%, electric arc furnace technology (Electric Arc Furnace - EAF) accounted for 4%. According to IPCC2006 guidelines, the emission factors of two types of technologies are as follows:

Technology	BOF	EAF
Emission factor - tons of CO2/ton of steel	1.46	0.08

In fact, for the current state of Vietnam's steel industry technology, the industrial process emissions of BOF technology are 1.56 tons of CO_2/ton of steel and EAF technology is 0.18 tons of CO_2/ton of steel. In the period from 2021-2030, the steel industry needs to improve production efficiency, in order to reach the emission level according to IPCC and 50% of enterprises achieve an emission level of 1.22 tons of CO_2/ton of steel.

In order to go green in the steel industry, besides energy saving solutions, using renewable energy, many studies have been carried out such as using hydrogen, electrolysis of molten oxygen to replace Coke in the steelmaking process. However, these solutions are costly and are currently being implemented on a small scale. The assumptions about the application of mitigation measures in the steel industry are as follows:

- 100% of steel enterprises apply and improve BOF technology
- Applying CCS to the steel industry with a scale of about 16% of the whole industry's output,

equivalent to a reduction of about 10 million tons of CO_2 annually

- Applying "green steel" technology with a scale of 30% of the whole industry's output is equivalent to reducing about 20 million tons of CO_2 by 2050

c. Assumptions about mitigation measures in the chemical industry

Vietnam's chemical industry includes the following industries: fertilizers, plant protection agents, paints, plastics, etc. In which, the fertilizer industry accounts for a large proportion of greenhouse gas emissions. According to IPCC (2006), to produce 1 ton of fertilizer requires 0.5622 tons of NH_3. To produce 1 ton of NH3 will emit 2,558 tons of CO_2. In the chemical industry, the solution to reducing process emissions is not much besides carbon storage (CCS). Therefore, the plan to apply CCS in the chemical industry will only be implemented from 2045.

For the ammonium nitrate production industry, applying the best technology at MICCO Thai Binh factory shows that it can reduce up to 98% of N_2O (of which, according to IPCC, 1 ton of N_2O emissions into the environment is equivalent to 298 tons of CO_2) at a cost of about 0.46-1.34 USD/ton CO_2. The assumptions about the application of mitigation measures for the chemical-fertilizer industry are as follows:

- 100% of enterprises apply N2O reduction technology in the production of chemicals and fertilizers
- Applying CCS to the chemical industry from 2045 will result in about 50% of the production level, which equates to an annual reduction of about 4 million tons of carbon.