# Net Present $CO_2$ Reductions – A Measure for an Adequate Evaluation of Green Initiatives

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## ABSTRACT

When assessing a green initiative, the standard approach is an application of the classical discounting of future gains converted into monetary terms. In doing so, significant uncertainties about the future value of $CO_2$ reductions are introduced. The current alternative is to measure the $CO_2$ reductions in a single reference year, e.g. 2030 or 2050. This does not take into account the $CO_2$ reduction trajectory process during the years up to, and after, the reference year. In this paper, a new basis for decision making is presented, in which discounting of the $CO_2$ reductions is measured in tonnes. In this approach, the discount factor takes into account the impatience implied from the tipping point theory. Furthermore, such a measure would adequately reflect the entire $CO_2$ reduction profile of the initiative in question, rather than being restricted to focusing on the impact in a (single) selected reference year.

**KEYWORDS:** $CO_2$ Emissions, $CO_2$ Reductions, Tipping Point Theory, Discounting, Intertemporal Choice

## 1. INTRODUCTION

In 2015, 196 countries signed the Paris Agreement and agreed to cut emissions aiming to limit global warming to an increase of between 1.5 and 2 degrees Celsius above pre-industrial levels. Each country set out their own individual Nationally Determined Contributions (NDC), and the European Union (EU) has pledged to reach climate neutrality (i.e. a net-zero $CO_2$ emission balance) by 2050, with an interim target in 2030. However, there is still no commitment plan specifically outlining the steps required to complete the goals for 2030 and 2050. As such, the trajectory of achieving climate neutrality remains unclear.

In the global warming debate, one of the main concerns is that global warming may reach a tipping point where the development is irreversible (e.g. Lenton et al., 2019). This concern implies an urgency for efforts across the planet to achieve lower emissions levels faster than the current efforts. It also emphasizes that emission reductions completed in 2050 may occur too late. Hence, emission reductions reached in earlier years are more valuable than emission reductions reached in later years.

Nevertheless, most assessments of emission reductions present no proper discounting methods that take into account this urgency.

Currently, every country and their associated decision makers are considering possible solutions to achieving their committed climate targets. The main focus is on annual emissions in the reference years, and not on the trajectory for reaching those goals. When choosing the appropriate green initiatives, it is imperative that the analytical framework applied takes proper account of the time preference for rapid $CO_2$ reductions. Furthermore, it is important that it considers the entire process of committing to $CO_2$ reductions from the initiatives, rather than a snapshot of reductions in a given reference year, such as 2050. Pollitt (2008) argues that international schemes (such as the EU Emission Trading Scheme) may not provide sufficient incentives to meet national objectives. Hence, measures are needed that directly create incentives for initiatives that generate $CO_2$ reductions in the years leading up to the reference year – and an adequate yardstick for comparing such initiatives is called for.

Hence, the adopted analyses contain three major shortcomings: i) the lack of urgency of $CO_2$ emission reductions, ii) failure to include the trajectory towards reaching the goals of 2030 and 2050, and iii) the lack of proper aggregation of $CO_2$ reductions. This creates the unfortunate incentive of postponing investments and decisions, which prioritize uncertain initiatives with $CO_2$ reductions in the far future (e.g. 2050), minimizing the incentives for initiatives with certain $CO_2$ reductions in the coming years (e.g. between 2020 and 2025). Such a strategy, often referred to as a 'hockey stick', does not reflect the urgency that the tipping point theory presents.

In this paper, the aspects of intertemporal $CO_2$ calculations will be elaborated on and a potential solution to adequately account for those problems will be discussed and presented.

## 2. INTERTEMPORAL DECISIONS

Dilemmas involving intertemporal choice are well known to economists. Man has faced decisions which have distributed gains or costs over time, for centuries. The notion of discounting future cash flows has been used since the 18th century, and was first formally explained by John Burr Williams (1938). In modern economics, discounting is considered a basic tool for evaluating gains and costs over time.

In order to evaluate the gains and costs distributed over a long time horizon, economists discount the future payment streams to a net present value (NPV). In order to do so, the economist applies a discount factor. The discount factor captures the patience (or impatience) of the decision maker. If there is no impatience, that corresponds to a discount factor of 1. This means that a payment today has equal value to a similar payment in the future. The closer to 0 the discount factor gets, the more impatient a preference it represents.

Most economic decisions can be transferred into monetary terms, meaning a cash flow of expenses and income, and a discounting of this cash flow can be performed. Whether the analysis concerns the building of a factory, buying a piece of property or investing in a mutual fund, these analyses can be transferred into a cash flow that can be discounted. This is a standard tool in economics, and issues of intertemporal decision making are widely researched and discussed (e.g. Laibson 2003).

Hence, the discounting of cash flows is applied to a variety of economic assessments – from calculating the NPV of an investment to calculating the socioeconomic cost benefit analysis (CBA) of an investment. In the latter example, all costs and benefits are – using a set of assumptions – calculated in monetary terms, and discounted to a common reference year. However, investments made in order to reduce $CO_2$ emissions do not share the same property. Here, the 'revenue' from the investments is not cash dividends, but reductions in $CO_2$ emissions.

The link to the urgency of $CO_2$ reductions – which the tipping point theory suggests – is straightforward. When choosing between different initiatives, the impatience of obtaining $CO_2$ reductions should be reflected in the method applied to assess such initiatives.

## 3. DISCOUNTED CASH FLOWS AND $CO_2$ REDUCTIONS

To apply a discounting method to a green investment, future $CO_2$ reductions are translated into – and presented in – monetary terms. Thus, all future (financial) costs and gains (in the form of $CO_2$ reductions) of a green investment or project will be assessed and converted into monetary terms. While this is a straightforward exercise to do for the dividends of financial investments, it involves a set of assumptions for a green investment evaluating $CO_2$ emission reductions. Specifically, since it involves all future $CO_2$ reductions being converted into monetary terms, a complete profile of all future values of $CO_2$ emissions is needed.

Such a profile is an estimate of the future value of $CO_2$ emissions in any given year. When this is performed for a green investment or initiative, the profile typically originates from one of the following three approaches.

1. Future curves from the $CO_2$ quota markets are adopted as the best guess of the future value

2. Estimates from organizations or governmental bodies (i.e. International Energy Agency), often calculated from a model

3. A straight-up assumption, potentially justified by the level necessary to achieve the 2030/2050 target.

A forecast profile based on any of the three categories has various advantages and disadvantages. In any case, forecasts from each of the above three categories share the same inherent property: they are merely guesses as to what will happen in 10, 20, 30 or more years. Hence, they are inherently uncertain.

When calculating the discounted cash flow of future gains, the applied $CO_2$ price forecast profile is therefore of extreme importance to the final NPV result. Even small changes to the $CO_2$ price forecast profile can prove detrimental to the discounted value of the green project. The advantage of this approach is that the impatience of the decision maker is captured in the applied discount factor. However, the disadvantage is the introduced uncertainty from the $CO_2$ price forecast profile. The latter can be avoided by applying the tools of intertemporal decision making directly to $CO_2$ reductions, rather than to the monetary value of the $CO_2$ reductions. This would allow $CO_2$ reductions to be measured in tonnes of $CO_2$ rather than in monetary terms, based on imprecise assumptions of the future $CO_2$ price.

Issues related to the appropriate discount factor for climate change initiatives have been discussed in the literature (e.g. Pollitt (2008), Weitzmann (2007) and Evans (2008)). Nonetheless, these discussions deal with problems related to the classical discounting of the monetary values, and not specifically with the discounting of $CO_2$ reductions themselves. Poudineh and Penyalver (2020) share the concern of applying an NPV approach of discounting monetary values to green investments, yet their concern is concentrated on inter-generational equity rather than the impatience inferred by the tipping point theory.

## 4. THE NATURE OF GREEN INVESTMENTS AND UNCERTAINTY ABOUT FUTURE GAINS

Most green investments (e.g. conversion to electric vehicle infrastructure, R&D to develop P2X technologies, CCS solutions) involve large investments in the early years of the project, in order to reap the green dividends in the future. Such investments are characterized by a low level of uncertainty about current costs relative to a high level of uncertainty about future gains. The later in time that the future gains will be known, the greater the uncertainty that characterizes them. As risks and uncertainty increase over time, a careful approach would account for this by putting less emphasis on future (and hence uncertain) benefits, compared to the current benefits. In other words, the future benefits should be discounted in order to take into account the inherent uncertainty of the future. When applying a strong discounting to future $CO_2$ reductions, less weight is put on the future. As a result, the effects of future technological advances are given little weight in today's evaluation. This may lead to a reduction in R&D initiatives. However, such a result stems from the applied discount factor – not from the discounting itself. The discount factor applied can very well

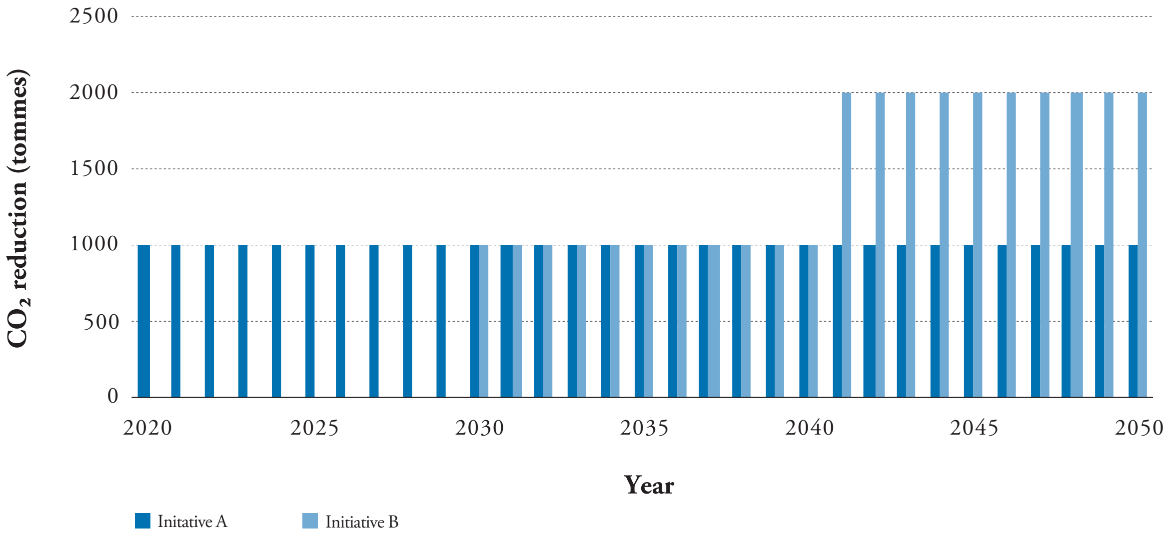


**FIGURE 1. EXAMPLE OF ANNUAL $CO_2$ REDUCTION PROFILES FOR TWO HYPOTHETICAL GREEN INITIATIVES.**

depend on the time horizon applied. This is the case in Denmark for all public cost-benefit analyses. These are required to apply a discount factor that is increasing during the time horizon of the initiative (Finansministeriet, 2018).

## 5. TIME HORIZON AND THE UNCERTAIN LIFETIME OF GREEN INITIATIVES

The economic and technical lifetime of any investment is subject to uncertainty. Recently, the lifetime of the Great Belt Bridge ('Storebaeltsbroen') in Denmark was prolonged from 100 to 200 years due to optimized AI calculations and new drone inspection routines.[1] Such a dramatic change in the lifetime of an asset obviously changes the discounted NPV of the asset. However, it does not merely double, as might be intuitively assumed. The reason for this is the discounting. Because of the impatience factor, the last 100 years of the lifetime of the asset matter less today than the first 100 years, and this is reflected in the discounted cash flow. This implies that the value to the discounted cash flow of an extra 10, 20 or even 30 years of lifetime is negligible. Hence, the annual incremental gains diminish over time. This is a significant strength as it eliminates the sensitivity to a key parameter of any green initiative: the long unknown tail of the duration of the initiative's effect on $CO_2$ reductions.

## 6. EXAMPLE

Consider two green initiatives, Project A and Project B. Project A provides a $CO_2$ reduction of 1,000 tonnes per year from 2020 to 2050, whereas Project B provides a $CO_2$ reduction of 1000 tonnes (per year) from year 2030 to 2040, and 2,000 tonnes per year from 2040 to 2050. The $CO_2$ reduction profile of each of the initiatives is depicted in Figure 1.

Using the typical approaches, one of the following methods for evaluating the two projects against each other could be applied:

- By simply evaluating $CO_2$ reductions in a base year, the two years would look equally good in 2030 (both projects have a $CO_2$ reduction of 1000 tonnes in year 2030). However, if the base year was 2050, Project B would look better (as the 2000 tonnes $CO_2$ reduction of Project B is bigger than the 1000 tonnes $CO_2$ reduction of Project A in 2050).

- If the total $CO_2$ reductions were to be added without discounting, the two projects would each, over their lifetime, reduce $CO_2$ by 31,000 tonnes in total. Hence, they would appear equally good.

- If an assumption on the future $CO_2$ price were to be included, the assumed $CO_2$ price profile itself would determine which of the two projects would be favoured.

None of the three methods provide a solid basis for comparing the two projects. However, a calculation of the net present $CO_2$ reduction reveals a much more unambiguous answer as to which initiative is preferable. To illustrate this, a discount factor of .96 (corresponding to a

[1] https://www.Berlingske, 2020. Droner og kunstig intelligens.

discounting interest of 4%), reveals that the net present $CO_2$ reduction value of Project A (17,588 tonnes) is more appealing than the net present $CO_2$ reduction value of Project B (13,037 tonnes).

## 7. CONCLUSION

The solution presented in this paper is highly relevant for all evaluations and socioeconomic and net present value calculations for an initiative that leads to $CO_2$ reductions. Each such evaluation should assess the $CO_2$ reduction profile properly, rather than adopting an isolated focus on specific reference years or a spurious conversion of $CO_2$ reductions into monetary terms. This notion follows the principles of Pollitt (2008), where emphasis is on the process of $CO_2$ reductions, rather than just on the outcome.

Hence, such evaluations and calculations should be supplemented with a calculation of the discounted net present $CO_2$ reductions measured in tonnes. In doing so, well-developed methods and tools of intertemporal choice are applied to $CO_2$ reductions directly, rather than to a spurious and uncertain cash flow conversion. The resulting net present reductions are a measure of reductions in $CO_2$ tonnes in present terms. The proposed comparison and calculation would increase the accuracy of the basis for decision making, as it eliminates the uncertainty from the assumptions of the $CO_2$ price profile. This approach would enable a proper aggregation of all the annual benefits from a proposed initiative, rather than limiting the focus to a few selected reference years. Furthermore, it would reduce the impact of future (and hence more uncertain) $CO_2$ reductions and create a strong incentive to create more immediate (and more certain) $CO_2$ reductions.

If such discounting of $CO_2$ reductions were to be applied and used as a basis for decision-making, it would create a clearer and more comprehensive image of a green initiative in regards to the actual accumulated effect on $CO_2$ reductions. Ironically, the reductions would be lower (due to discounting) than a simple aggregation of the annual reductions. Hence, it could lead to the misperception that such an approach would not support the green transition and climate agenda. However, nothing could be further from the truth. The discounting emphasizes the need to promote initiatives which – with certain and rapid reductions – can lead to rapid $CO_2$ reductions, rather than initiatives with uncertain $CO_2$ reductions in the distant future. Hence, the discounting approach presented in this paper takes into account the urgency presented by the tipping point theory.

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