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ORIGINAL PAPER

# Can we provide appropriate tools to measure the effectiveness of climate agreements? The Paris agreement and the role of the European External Action Service

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**Abstract**
Can we provide appropriate tools to measure the effectiveness of climate agreements? How effective will, for example, the Paris Agreement be? Global emissions levels can be applied as a sole measure of performance. Current emission trends predict 2.7 degrees of temperature increase in the year 2100. The challenge rests in both the unavailability or difficulty of compiling proper data and information and the dynamic aspect which demands estimates of future developments. Furthermore, we argue that regime performance should be evaluated against a non-regime benchmark and compared to the objectives that the regime is created to achieve. In the case of the Paris Agreement, our measurement tools find that the agreement is likely to make a difference but far from sufficient to reach the 1.5-degree target. Reaching the 1.5-degree target is only possible if new negative emission technologies are developed and implemented unrealistically fast. To make the Paris Agreement successful, swift political action is, therefore, necessary from central institutional actors such as the European Union. In particular, climate diplomacy through the European External Action Service may channel the knowledge about measurement tools to partners worldwide.

**Keywords** Measurement tools · Effectiveness · Paris agreement · EU · Climate diplomacy · EEAS

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## Introduction

The United Nations Environment Programme (UNEP) concludes in its annual emissions report that despite a brief dip in carbon dioxide emissions caused by the COVID-19 pandemic, the world is still heading for a temperature rise of over 3 °C this century (UNEP 2020). Thus, the report states this is far beyond the Paris Agreement goals of limiting global warming to below 2 °C and pursuing 1.5 °C. The World Economic Forum (WEF) identifies in a global risk evaluation such lack of climate action as the main global challenge (WEF 2020). That notwithstanding, the climate change issue constitutes an ongoing struggle between countries and sectors after about 30 years of history, as the first international climate negotiations occurred in 1992 in Rio (Brandt and Svendsen 2011; 2013).

Estimates based on current emissions trends and current official policies indicate that global emissions are likely to increase rather than decrease in near future. For example, the rise in global $CO_2$ emissions in 2017 resulted in the highest yearly global emission ever measured (Jackson et al. 2018). The trend has continued, and in 2019, a new record-high global $CO_2$ emission is measured (UNEP 2020).[1]

On the other hand, several papers optimistically argue that the current and future climate policies will deliver a huge impact (Höhne et al. 2016; Figueres et al. 2018; Fuhr et al. 2018). Several countries have recently implemented or planned to implement ambitious climate policies, including Denmark's 70% $CO_2$ emissions reduction target in 2030 relative to 1990, the recent US re-entry into the Paris Agreement, and the EU's climate leadership (EU 2019; Skjærseth 2017). Recently, the EU has agreed on the "Green European Deal" requiring a 55% reduction of CO2e EU-wide in 2030 compared to 1990 (EU 2019). Finally, there still exists a significant "ambitious gap" between pledges and actual policies (IEA 2021). At the "Conference of the Parties" (COP21) in December 2015, 195 countries agreed on the long-term goal of limiting global warming to well below 2 °C relative to the pre-industrial level (EU 2015a; CEU 2018).

The evaluation of the actual performance of the climate agreement is complicated. Not only might proper data and information be unavailable or difficult to compile, but the longer the time horizon, the more uncertainty. So how can the effectiveness of a regime be measured over time?[2]

Overall, a missing link in the literature is to identify such an authoritative measurement method. Thus, we aim to answer the following research question: C*an we provide appropriate tools to measure the effectiveness of climate agreements?*

In the following, we will focus on these measurement tools relevant to measuring the success of international agreements in a dynamic setting. First, Sect. "Literature review" gives a literature review. Next, Sect. "A theoretical measure of effectiveness:

[1] In 2020 and 2021 (due to the unforeseen Covid-19 pandemic), a reduction in the global $${\mathrm{C}\mathrm{O}}_{2}$$ emission is observed due to temporary lower economic activities. In the following, we assume that in the beginning of the post-covid situation, the world's economy will recover, and emissions will return to the post-covid levels (IEA 2020, 2021).

[2] A regime is here defined as the parties that have signed the treaty.

The Oslo-Potsdam solution" gives a theoretical measure of success, namely the so-called "Oslo-Potsdam solution". Sect. "Analysing the expected effectiveness of the international climate regime" analyses the expected effectiveness of the international climate regime. Then, Sect. "Evaluating the Paris Agreement" evaluates the Paris Agreement before Sect. "Conclusion and policy implications" concludes.

## Literature review

The contribution of this paper is to set up an effective measurement framework that includes the three following issues, which are relevant for evaluating climate treaties. First, we wish to evaluate the performance of a given ongoing treaty where the targets are to be met in the future. Hence, we need to evaluate the expected development of the optimal, non-treaty, and actual emission over time to calculate the probability that it will be successful. Second, we also wish to express explicitly the uncertainty of the expected effectiveness. Such insights make it possible to reflect even better on an ex-ante evaluation of a treaty that specifies climate targets to be met in a future period. Finally, it allows a discussion about absolute versus relative effectiveness measures.

Methodologically, we establish a model framework to evaluate the effectiveness of climate regimes. We then populate the model with ample information gathered from a comprehensive literature review, allowing us to make near-future predictions regarding the development of the Paris agreement. Our methodology not only permits prediction but also encompasses uncertainties about progress, utilizing confidence intervals derived from statistical analysis. Despite not conducting a rigorous statistical analysis, our approach enables the identification of best and worst-case scenarios based on literature studies.

International regimes stretch over several dimensions, and the multi-dimensional nature needs to be addressed when evaluating their performance. Andersen and Hey (2005) argue that effectiveness ultimately deals with the ability of international regimes to solve the problems that prompted their establishment, while Young (2001) argues that the effectiveness of regimes can be analyzed by the contributions that institutions make to solve the problems they were created for.

One major issue when trying to measure the effectiveness of the Paris Agreement is not only to understand how the agreement will affect emissions shortly but also how the non-treaty emission path and the optimal path will develop over time. It is much easier to calculate the success of the Kyoto protocol. It only took a small step towards efficiently controlling the climate issue. This treaty, however, did encourage some reduction efforts and paved the way for the Paris Agreement (Brandt and Svendsen 2005).

We follow this line of thought when evaluating success based on policy outcomes. One such is the so-called Oslo-Potsdam solution (OPS).[3] The OPS defines a policy space for international regimes with two reference points. These reference

[3] See Underdal (1992), Helm and Sprinz (2000), and Hovi et al. (2003).

points are a lower and an upper bound that defines the policy space that could be covered by the international regime.[4]

The institutional causality, the ability of the regime to make a difference, signifies that the regime must be benchmarked against a non-observable non-treaty emission path. Barrett (2003) identifies the importance and complexity of this task rather than just seeing one thing, namely the world in which the treaty exists. To know whether the treaty has succeeded, we would have to see more. We would need to know what would have happened if the treaty had never existed. These benchmarks cannot be observed. They must instead be inferred.

Young (2001) and Hovi et al. (2003) discuss the appropriateness of using the non-cooperative Nash equilibrium as a benchmark to evaluate whether a regime makes a difference and helps solve the collective action problem: "interaction between self-interested states leads us to focus only on policy games themselves and to neglect several other driving forces—demographic, economic and technological—that interact to produce important (environmental) impacts" (Hovi et al. 2003, p. 78).

The relevance of having access to such a measurement can be seen in the EU's commitment to the Paris Agreement: "… the Council calls on the High Representative, Commission, and member states to work jointly and urgently towards a strategic approach to Climate Diplomacy (…) that identifies concrete, operational ways forward." (European Council 2019). To achieve the Paris goal, climate diplomacy may be undertaken by the European External Action Service (EEAS). The adequate institutional setup in the EU has been present since 2003 when the Thessaloniki European Council launched an initiative to promote the integration of the environment into external relations.

Here, the informal network, known as the "Green Diplomacy Network", was created. It "…consists of officials dealing with international environment and sustainable development issues in the EU's Ministries of Foreign Affairs and their diplomatic missions including the European External Action Service (EEAS) and the EU Delegations. Since January 2012, the Network is chaired by the EEAS" (CEU 2019). In other words, the EEAS has the institutional infrastructure to channel knowledge about measurement tools to improve the management of future climate action. Building capacity in this way can support the efforts of partner countries, in particular developing countries (CEU 2020; Mathiasen and Svendsen 2020).

According to the IEA (2016), carbon sinks may also play an important potential role in complying with long-term climate targets. This Carbon Capture, Utilization, and Storage (CCUS) presents a technology with high potential but also high uncertainty, see Peres et al. (2022) for an overview. The potential for Carbon Capture, Utilization, and Storage (CCUS) technology to contribute to reaching the Paris target of limiting global temperature rise to 1.5 °C above pre-industrial levels is significant, as it can help to reduce carbon emissions from industrial processes and fossil fuel-based power generation, although its deployment and effectiveness are subject to

[4] Although being a one-dimensional performance index, it can be applied to a multi-dimensional performance scheme by weighing the various scores of each dimension into a single, overall score. A technique applied in multi-criteria decision-making (Clemen and Reilly 2014).

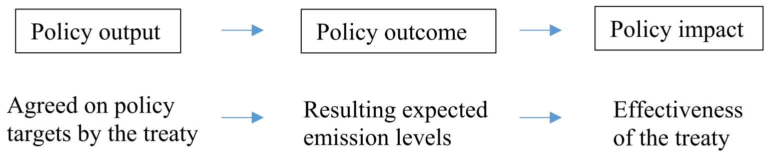



**Fig. 1** Policy outcome leads to policy outcome and policy impact

uncertainties. The high uncertainty surrounding CCUS technology relates to its economic viability, long-term effectiveness, potential environmental impacts, geological instability risks, and public perception and acceptance (Lane et al. 2021).

Currently, according to the International Energy Agency (IEA 2022), the annual capture capacity is almost 45 million tons of CO2. Additionally, the IEA reported that while CCUS deployment has been behind expectations in the past, momentum has grown substantially in recent years (ibid.). Some of these developments are the increasing demand for wood products leading to more carbon stored in harvested wood product's carbon pool (Johnston and Radeloff 2019), wildfires producing charcoal and expanding the pyrogenic carbon pool (Wei et al. 2018), and oceans sequestering atmospheric carbon and storing carbon for the long term (Lovenduski et al. 2019).

## A theoretical measure of effectiveness: The Oslo-Potsdam solution

To find out whether the regime is on track, we can distinguish between concepts measuring either policy output or policy outcome (Young 2011) and policy impact (Fig. 1).

Policy output is a necessary but not sufficient condition for actually achieving the stated target level. Thus, a regime can be successful in achieving policy output but not policy outcome.

At first sight, it would be tempting to attribute the reduced emissions levels to the treaty and label it a successful treaty. Evaluating a treaty by its outcome is done by comparing the resulting actual outcome to the stated target. If the difference diminishes, then the treaty is an improvement, for example when the observed emissions level over time approaches the targeted emissions level, then the treaty can be labeled successful. Does the treaty make a real impact? To find the effectiveness of a treaty, it has also to be benchmarked against a hypothetical situation, where the treaty does not exist. We will see that for the Paris Agreement, realistic future situations exist where these two measures point to opposite conclusions regarding the success of a treaty.

How to define the effectiveness of a regime more generally? Ultimately, the objectives of the regime define which performances that need to the measured. We will evaluate the environmental regime in terms of the observable consequences it is likely to have on the environmental performance comparing this to situations without the regime and what the regime ultimately should achieve in terms of policy outcome.

The lower bound is the non-treaty or non-regime emission path (NR), indicating the situation without any regime, while an upper bound or collective optimum (CO) represents the policy performance of a perfect regime. The distance between the two reference points (measured by the distance CO-NR) outlines the potential for improvement of a regime. Placing the actual performance (AP) of the regime in the same policy space, the effectiveness of international regimes can now be assessed by providing the measure for effectiveness (originally proposed by Helm and Sprinz 2000):

$$E = \frac{AP - NR}{CO - NR} \tag{1}$$

$E \in [0, 1]$ measures the effectiveness of the regime, with $E = 0$ implying an unsuccessful regime, while $E = 1$ implies a successful regime. $E$ gives a simple measure of the degree to which regime-induced policy performance has improved beyond the lower bound ($AP - NR$) compared to the potential for improvement ($CO - NR$).

While seeming intuitive and appealing, several complicating issues remains when using (1) to measure the effectiveness of the climate change regime. A climate change issue is in itself complex and intertwined with sustainability-related objectives (IPCC 2018). The huge complexity makes an effective evaluation of the Paris Agreement problematic. Instead, we will focus exclusively on emissions targets. After all, the fundamental objective of a climate treaty is to control global emissions levels.

By using global emissions levels as the sole measure for performance score, lower emissions establish a policy improvement, and the collective optimum, $E^{CO}$, yields a lower bound on emissions. The non-regime emissions level, $E^{NR}$, can be interpreted as the global emissions path that would emerge if the UN-led climate change regime were absent. Thereby, the non-treaty emission path constitutes an upper bound on global emissions. Finally, $E^{A}$ measures the actual emission level.

Using the OPS Eq. (1) yields the following expression for evaluating the effectiveness of a climate treaty:

$$E = \left( \frac{E^{NR} - E^{A}}{E^{NR} - E^{CO}} \right) \tag{2}$$

However, the OPS measure in (2) lacks some dynamic aspects. The expected development of the optimal non-treaty path compared to actual emissions needs to be evaluated over time thus calculating the probability that it will be successful. The effectiveness of an international climate treaty (ICT) at time $t$,$S_t^{ICT}$, can be calculated by how much the treaty enables total *observed* emissions ($E_t^{T}$) at time $t$ and how much it moves away from the non-treaty emission path ( $E_t^{NT}$) compared to the optimal emissions ($E_t^{O}$) at time $t$:

**Table 1** Classification of treaties concerning the progress

| | |
|---|---|
| Case 1: Real progress. Effectiveness progress and absolute progress | $\Delta S^{ICT} > 0, \Delta d < 0$ |
| Case 2: Partial failure. Effectiveness failure, but absolute progress | $\Delta S^{ICT} < 0, \Delta d < 0$ |
| Case 3: Partial progress. Effectiveness progress, but absolute failure | $\Delta S^{ICT} > 0, \Delta d > 0$ |
| Case 4: Real failure. Effectiveness failure and absolute failure | $\Delta S^{ICT} < 0, \Delta d > 0$ |

$$S_t^{ICT} = \left( \frac{E_t^{NT} - E_t^T}{E_t^{NT} - E_t^C} \right) \tag{3}$$

The effectiveness of the climate regime measured by (3) is between 0 and 1 at time $t$. What we are mostly interested in is whether an ICT achieves larger effectiveness over time measured by the difference in $S_t^{ICT}$ over time.

Consider two points in time, $t_1$ and $t_2$, $t_2 > t_1$. Define $\Delta S^{ICT} = S_{t_2}^{ICT} - S_{t_1}^{ICT}$.[5] If $\Delta S^{ICT} > 0$, then the treaty has increased its effectiveness.

A second measure of achievement is the observed progress, which simply is measured by changes in $d_t = E_t^T - E_t^O$ over time. If over time the emissions we observe when ICT is in place converge to the optimal emission, then absolute progress is observed. Note, however, that absolute progress defined in this way does not identify the treaty as the main cause for progress.

Consider two points in time, $t_1$ and $t_2$, $t_2 > t_1$. Define $\Delta d = d_{t_2} - d_{t_1}$ as the change in distance over time between observed and optimal emissions.[6] Combining these two measures leads to a total of four cases (see Table 1 below).

We use this setup to showcase the classification scheme in three situations, one where the observed treaty emissions fall over time, another where observed treaty emissions increase over time, and finally a situation where all three paths fall over time, which is most likely the case for the climate change issue.

Real progress is illustrated in Fig. 2. Here the actual emission level experiences a large reduction which can be solely attributed to the policy outcome of the treaty. The effectiveness of the treaty increases significantly over time (shown in the right-hand side of Fig. 2). Moreover, the observed emission path approaches the optimal emission path also achieving absolute progress.

Figure 3, on the contrary, depicts a situation where the effectiveness of the treaty has not increased, even though emissions are expected to fall. The non-cooperative emission path has fallen over time to fully outweigh the observed emission reductions—even though the treaty has implemented more stringent policies.

Therefore, the observed decline in the observed emissions cannot be attributed to the outcome of the treaty since external forces have pushed the non-cooperative

[5] Effectiveness (comparing $t_1$ with $t_2$, $t_2 >$) will increase (decrease) given: $\frac{E_{t_2}^{NT} - E_{t_2}^T}{E_{t_1}^{NT} - E_{t_1}^T} > (<) \frac{E_{t_2}^{NT} - E_{t_2}^O}{E_{t_1}^{NT} - E_{t_1}^O}$

Effectiveness will increase over time, if the relative distance between $E_t^{NT}$ and $E_t^T$ increases more than the relative distance between $E_t^{NT}$ and $E_t^0$ (See appendix for more).

[6] $\triangle d = \left(E_{t_2}^T - E_{t_2}^O\right) - \left(E_{t_1}^T - E_{t_1}^O\right)$

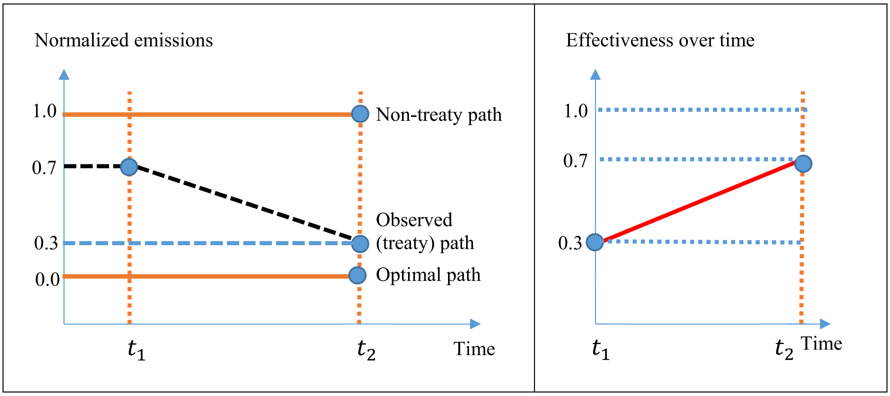



**Fig. 2** (Situation 1a): Reduced expected emission and higher effectiveness (Calculations for the Figure to the left: $S^{t_1}_{2020} = \left(\frac{E^{NC}_{2020} - E^{t1}_{2020}}{E^{NC}_{2020} - E^{C}_{2020}}\right) = \left(\frac{1-0.7}{1-0}\right) = 0.3,\ S^{t_2}_{2030} = \left(\frac{E^{NC}_{2030} - E^{t2}_{2030}}{E^{NC}_{2030} - E^{C}_{2030}}\right) = \left(\frac{1-0.3}{1-0}\right) = 0.7.$ )

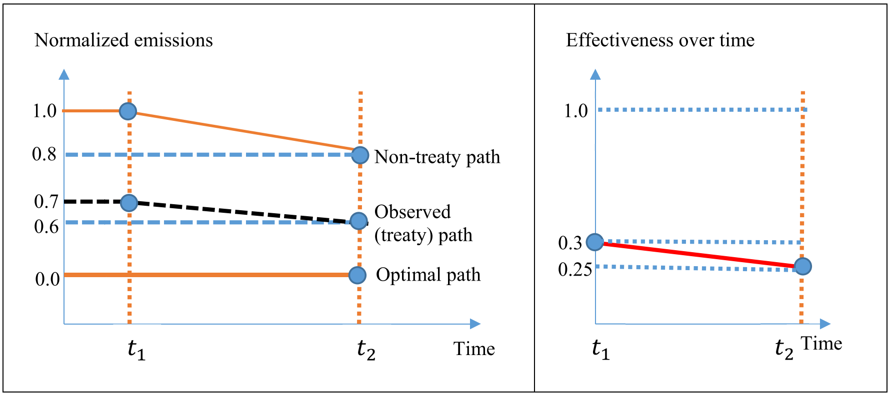



**Fig. 3** Situation 1b (version 1): Reduced expected emission, but reduced effectiveness

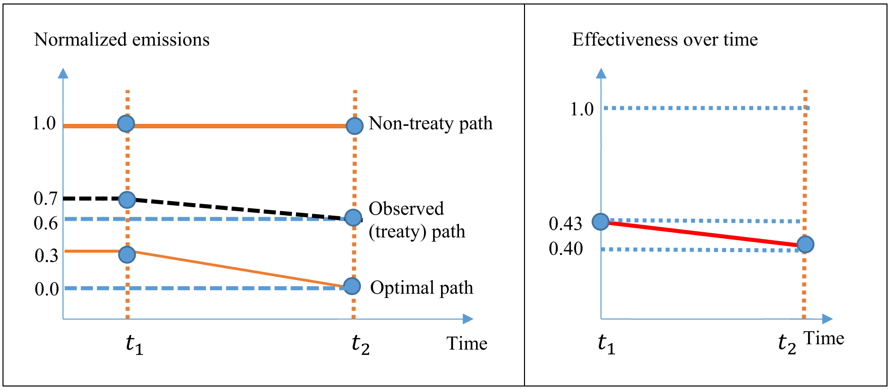



**Fig. 4** Situation 1b (version 2): Reduced expected emission, but reduced effectiveness

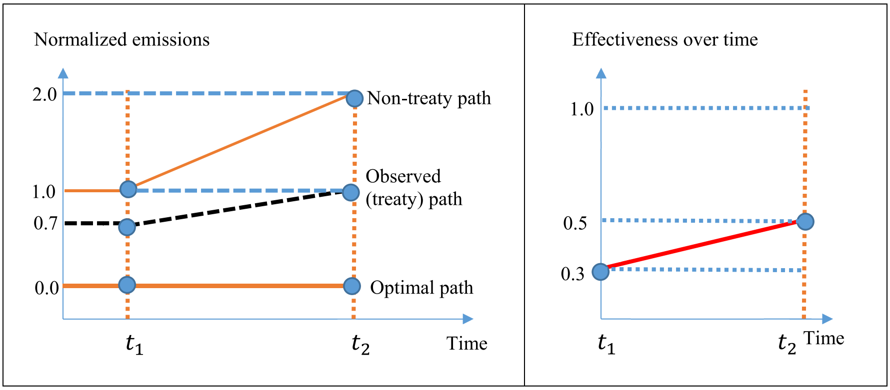



**Fig. 5** Situation 2a: Increased actual emissions but also increased effectiveness

emissions path downwards. This might be due to new technology developments or changing preferences for the environment. However, the observed emission still approaches the optimal path over time.

In Fig. 4, the optimal path falls over time. While the expected observed emissions are also over time and therefore imply progress compared to the NC-path, this reduction is not sufficient to reduce the absolute distance between observed emissions and the optimal emission path. Hence, the effectiveness also falls over time in this case. Hence, the observed emission still approaches the optimal path over time. An example of this is that the international community urged for the adoption of the 1.5-degree target based on the 2018 IPCC report (IPCC 2018).

The second situation is characterized by an increase in the expected emission level over time. In Fig. 5, the expected emissions will increase, but progress can still be attributed to the treaty, as the emission along the non-cooperative path increases significantly more. The effectiveness of the treaty increases. But not that in absolute terms, the treaty emission gets further away from the required optimal emission path A situation that could resemble the Kyoto Protocol, which was signed in 1997, requiring 37 industrialized countries and economies in transition and the European Union to collectively reduce their emissions by 7% in 2012 (average of 2008–2012) compared to 1990 levels. Global emissions kept increasing, but without the treaty, these countries would very likely have increased their emissions, such that global emissions would have increased even more (Brandt and Svendsen 2005).

In Figs. 6 and 7, expected observed emissions also increase, but in these instances leading to a reduction in the effectiveness of the treaty over time.

In Fig. 6, the reduced effectiveness is caused by the fact that actual emission increases more than the increase in the non-cooperative emissions level, while in Fig. 7, the reduction in effectiveness is caused by a drop in the emissions along the optimal emissions path over time. Version 1 portrays a less realistic situation, where the emission given the treaty approaches that in the case of no agreement, such that effectiveness falls.

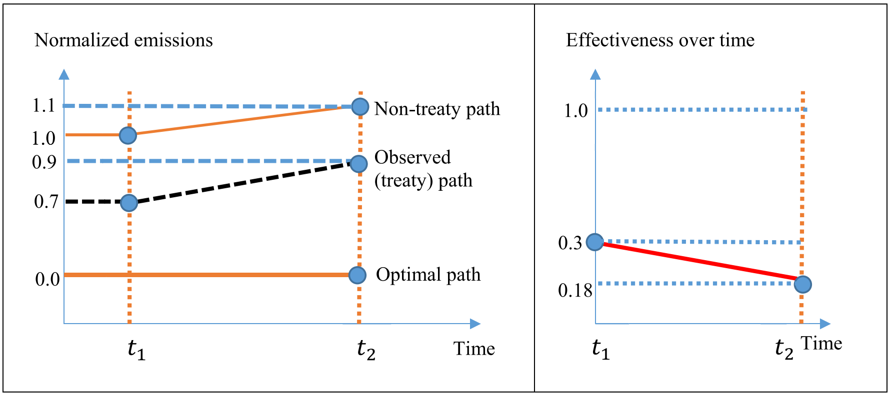



**Fig. 6** Situation 2b (version 1): Increased actual emissions and also reduced effectiveness

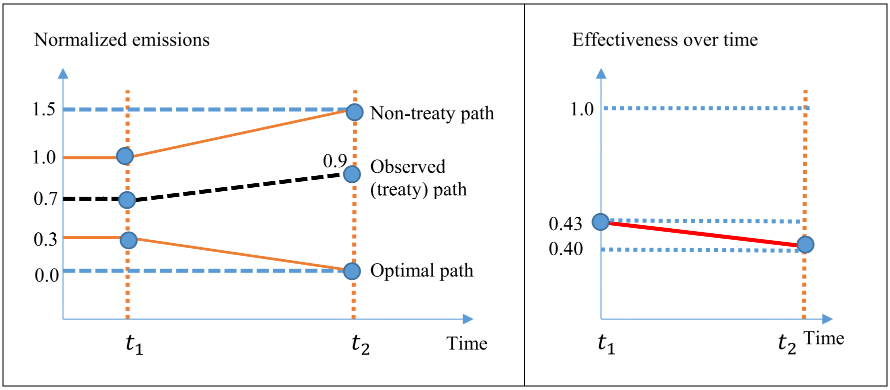



**Fig. 7** Situation 2b (version 2): Increased actual emissions and also reduced effectiveness

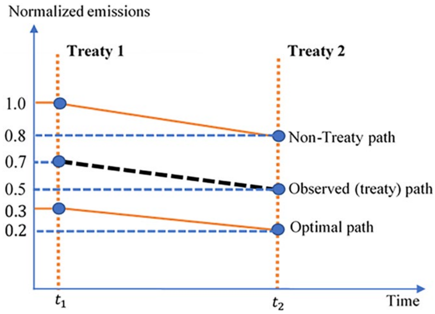
A third situation emerges where all three paths are falling over time: As Table 2 shows, in this situation, any result can emerge (a full characterization and examples are given in the appendix).

In the case where all three emissions paths are downward sloping, the relative reductions determine the effectiveness of the treaty and the outcome. Given the definition of real progress caused by a treaty, real progress is only observed in situation 1. Note, that in Case 4, the observed emission is falling and still the treaty is a real failure.

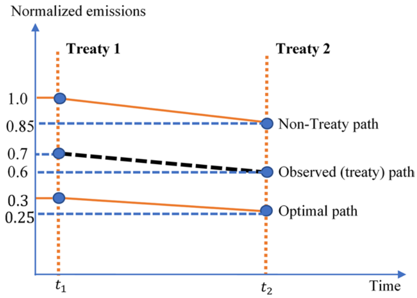
Given this arsenal of possible developments, we now analyze the possible emissions paths of the global $CO_2$ emission levels over the next decade.

**Table 2** Situations where all three paths fall over time

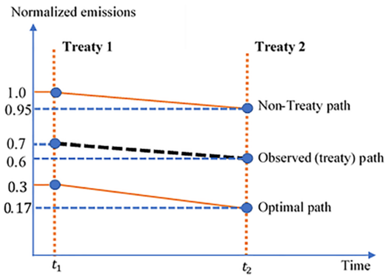
Case 1: Real progress. Effectiveness progress and absolute progress
$\Delta S^{ICT} > 0, \Delta d < 0$
$(\Delta S^{ICT} = 0.07, \Delta d = -0.1)$



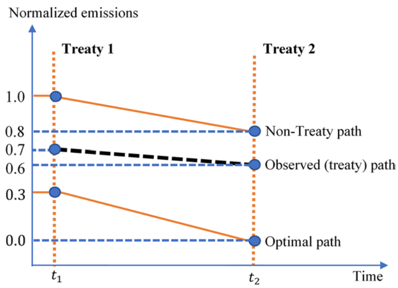

Case 2: Partial failure. Effectiveness failure, but absolute progress
$\Delta S^{ICT} < 0, \Delta d < 0$
$(\Delta S^{ICT} = -0.01, \Delta d = -0.05)$




Case 3: Partial progress. Effectiveness progress, but absolute failure
$\Delta S^{ICT} > 0, \Delta d > 0$
$(\Delta S^{ICT} = 0.02, \Delta d = 0.03)$




Case 4: Real failure. Effectiveness failure and absolute failure
$\Delta S^{ICT} < 0, \Delta d > 0$
$(\Delta S^{ICT} = -0.17, \Delta d = 0.20)$




## Analysing the expected effectiveness of the international climate regime

The theoretical setup in Sect. "A theoretical measure of effectiveness: The Oslo-Potsdam solution" allows us to evaluate the future of climate negotiations by

**Table 3** Projected and actual emissions 2018

| | Total emissions (Gt $CO_2$) | Change in 2018 (%) | Uncertainty range | Actual change (%) |
|---|---|---|---|---|
| ROW | 15.3 | + 1.8 | + 0.5 to + 3.0 | + 1,7 |
| China | 10.3 | + 4.7 | + 2.0 to + 7.4 | + 2.3 |
| USA | 5.4 | + 2.5 | + 0.5 to + 4.5 | + 2.8 |
| EU28 | 3.5 | − 0.7 | − 2.6 to + 1.3 | − 2.1 |
| India | 2.6 | + 6.3 | + 4.3 to + 8.3 | + 8.0 |

Source: Le Quéré et al. (2020)

*ROW* rest of world

developing a dynamic OPS-score calculation for the Paris Agreement. Compared to the stylized examples in Sect. "A theoretical measure of effectiveness: The Oslo-Potsdam solution", several issues need to be discussed. These issues concern the calculation of a proper non-regime (non-treaty) emission path, the determination of the expected progress that the climate treaty has on global emissions, and what establishes the optimal path. Therefore, the actual evaluation of the success must be expressed in probabilistic terms, given current emissions levels, projected trends, and the climate policy landscape. In the end, we will distill all the information into our estimation of the probability of success, which obviously will be an interval.

## Actual emissions path

Studies looking exclusively at actual emissions levels discover no sign of reductions in global emissions. Jackson et al. (2018) find that after a three-year pause with stable global emissions, fossil $CO_2$ emissions grew by 1.6% in 2017 to 36.2 Gt and are expected to grow a further 2.7% in 2018 to a record 37.2 Gt $CO_2$. These estimates have been verified by UNEP (2020) where the global 2019 $CO_2$ emissions from fossil fuel combustion is reported to be 38 Gt. Another dire development is the global primary energy intensity—a key indicator of how efficiently the world's economic activity uses energy—which is expected to improve by less than 1% this year, the weakest rate since 2010, according to IEA (2020).

In 2018, all regions (except for the EU) saw an increase in emissions as depicted in Table 3. The reasons for the renewed increase in global emissions levels are persistent global economic growth and insufficient emissions reductions in developing countries. Moreover, the table shows the uncertainty range and the actual emissions change. When projecting emissions into the future, the uncertainty will add up.

Two major sources of uncertainty exist when using the pledges made in the Paris Agreement for predicting the future path of emissions. First, even if fully implemented, the implied policies result in an overshooting of the temperature target by about 1 degree. This has been denoted the emissions gap.[7] However, these estimates assume that countries successfully implement the policy measures implied in the nationally determined contributions (NDCs) and that no further (and more demanding policies) are agreed upon. Will countries comply (implement their pledges)? There are no built-in enforcement mechanisms in the Paris Agreement. There are mechanisms intended to ensure compliance. In addition to reporting information on mitigation, adaptation, and support, the agreement requires that the information submitted by each party undergoes international review. The agreement also includes a mechanism that will facilitate implementation and promote compliance in a non-adversarial and non-punitive manner and will report annually to the CMA (i.e., the transparency article (Art. 13) and the implementation and compliance article, Art. 15).[8]. Even with this structure, it is not guaranteed that countries will implement their pledges or strengthen them sufficiently.

Second, uncertainty is caused by the Paris Agreement's built-in mechanism where the pledges of the countries will be revised every five years. Every five years (starting from 2022) there will be a global stocktake to assess the collective progress toward achieving the purpose of the agreement. To raise the level of ambition over time, parties must submit updated NDCs every five years. Each party's new NDC must be more ambitious than its previous NDC (UNFCCC 2021). How this mechanism works and whether it will imply mere stringent national emission targets is hard to say (EU 2016).[9]

Finally, Nordhaus (2018) argues that the international target for climate change with a limit of 2 °C appears to be infeasible with reasonably accessible technologies, even with very ambitious abatement strategies. This is so because of the inertia of the climate system, rapid projected economic growth in the near term, and revisions in several elements of the model. A target of 2.5 °C is technically feasible but would require extreme and virtually universal global policy measures shortly.

Other studies convey a much more optimistic view of the development of actual emissions. Iacobuta et al. (2018) find that climate negotiations and climate summits (Copenhagen, COP15, and Paris, COP21) have a significant impact on the countries' national commitment strategies. As an example, economy-wide GHG reduction targets witnessed a strong increase in the build-up to 2015 and are adopted by countries

[7] UNEP (2018) describes the emissions gap: "The difference between the greenhouse gas emission levels consistent with having a likely chance (> 66%) of limiting the mean global temperature rise to below 2 °C/1.5 °C in 2100 above pre-industrial levels and the GHG emission levels consistent with the global effect of the NDCs, assuming full implementation from 2020."

[8] CMA: Conference of the Parties serving as the meeting of the Parties to the Paris Agreement. For definition of CMA, see http://unfccc.int/bodies/body/9968.php. More on lack of enforcement (blog): https://www.forbes.com/sites/anderscorr/2016/12/01/expect-climate-catastrophe-paris-agreement-lacks-enforcement/#245964b53313. See also: https://www.iied.org/qa-steps-enforcing-paris-agreement

[9] According to the UNEP (2017, p. xix): "The assessment of the emissions gap and the mixed progress on implementation of both the Cancun Pledges and the NDCs show that there is a significant distance between the current collective ambitions and commitments and what is required to meet the temperature goals of the Paris Agreement. It is therefore absolutely crucial that the Facilitative Dialogue in 2018 addresses the need and the opportunities for significantly enhanced action pre-2030, including by assisting and informing countries in urgently strengthening their NDCs".

**Table 4** Total expected installed power capacity by fuel and technology 2020–2025

| Source | 2020 (GW) | 2025 (GW) | Percentage change (%) |
|---|---|---|---|
| Wind + PV | 1398 | 2349 | + 68.0 |
| Hydro | 1324 | 1427 | + 7.8 |
| Natural Gas | 1822 | 1999 | + 9.7 |
| Coal | 2131 | 2079 | − 2.4 |

*Source* IEA: https://www.iea.org/reports/renewables-2020

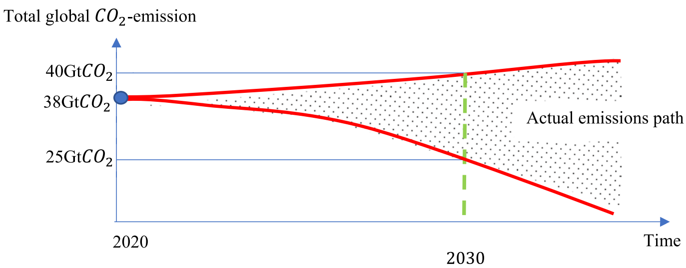



**Fig. 8** The range of uncertainty in the actual emissions path until 2030

covering 89% of global GHG emissions and 90% of the global population in 2017. Renewable energy targets also saw a steady increase throughout the last decade. As shown in Table 4, the estimates of future development are also encouraging with an expected growth of 68% in wind and solar PV.

In this same line, Höhne et al. (2016) provide several arguments that the Paris Agreement will have a large positive impact. Even though they acknowledge that the NDCs are not consistent with the $2^oC$ target ($1.5^oC$), there are reasons to expect that the Paris Agreement is moving the process in the right direction and the preparations of the NDCs have advanced national climate policymaking, notably in developing countries. The Paris Agreement contains a revision mechanism that updates and strengthens national actions. Furthermore, also according to Höhne et al. (2016), a significant number of non-state actions launched in recent years have not yet been adequately captured in the NDCs. Figueres et al. (2018) also provide an optimistic outlook, as their main conclusion finds that key technologies are on track and that subnational actions are booming, supporting the finding that subnational actions are not yet materialized in the data on global emission but are soon to have some larger impact. Fuhr et al. (2018) present an in-depth analysis of cities and local governments. They acknowledge the importance of climate action at a sub-governmental level, but they also stress that one should be tempted to overestimate its potential.

Finally, several countries have implemented more ambitious climate policies (e.g., Denmark's ambitious climate policy of a 70% reduction in $CO_2$ emissions in 2030 compared to 1990, and EU's European Green Deal pledging for carbon neutrality in 2050, EU 2019). Although Table 2 presents an optimistic view about the application of renewables, it does not portray a clear-cut positive development because the expected reduction in coal is very small. According to Carbon Brief

(2020), coal consumption needs to be reduced by four-fifth in this decade to reach the 1.5-degree target.

In Fig. 8, these findings are brought together. The upper path describes a world that follows the emissions path outlined by the current NDCs, assuming no further stringency in the targets and continued large economic growth (the 40 Gt $CO_2$ in 2030 might be a low estimate as we here assume that countries will implement their current pledges). The lower bound will be a case with more stringent policies, and due to the Paris Agreement induced technological developments (RES, energy effectiveness). Future COP meetings result in real progress and also large renewable technology diffusion. However, there are no signs that the global emissions in 2030 would be significantly lower today (e.g., below the 25 Gt $CO_2$).

## The optimal emissions path

Due to the immense uncertainty of costs and damages including the risk of tipping points and irreversible changes, the collective optimal emissions path is hard to determine. There are several attempts to develop meaningful goals based either on avoiding too large damages (based mostly on damage assessments and on a precautionary approach) or on attempts to stipulate an optimal emissions path that minimizes costs (damage costs and mitigation costs) using integrated assessment models.

The most prominent targets were set at the 21st Conference of the Parties (COP21) in December 2015. Here, 195 nations adopted the Paris Agreement and formulated the objectives of “holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels” (IPCC 2018). We consider this target-setting approach as belonging to the class of damage-avoidance approach. The main reason for using the damage avoidance approach for setting the long-term global goal has repeatedly been justified by pointing out that standard cost–benefit-analyses become difficult to justify and are not used as an assessment tool (IPCC 2018: 76).

The original long-run global goal set by the UN was formulated in 1992 in connection with the creation of the United Nation Framework Convention on Climate Change (UNFCCC). The objective of the UNFCCC was to fight global warming by reducing greenhouse gas concentrations in the atmosphere to “a level that would prevent dangerous anthropogenic interference with the climate system” (Art. 2).

The original wording has over time been translated into the 2-degree target and was finally formally adopted by the UN at COP21. The history of the 2-degree target is outlined by Randalls (2010). He argues that the target has its roots in the ways scientists and economists developed heuristics from the 1970s to guide understanding and policy decision-making about climate change (CarbonBrief 2020).

Being a long-term temperature goal, this target needs to be operationalized and related to emissions and emissions reduction targets. A prominent way to convert temperature targets into emissions targets is by using the carbon budget: It illustrates the $CO_2$ emissions left (if global emissions remain at present levels) to emit before

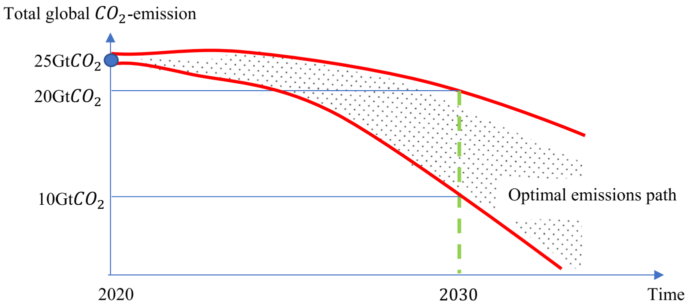



**Fig. 9** The range of uncertainty in the optimal emissions path until 2030

the temperature is likely to overshoot the target to set-up a carbon budget (IPCC 2018).[10]

By unchanged emission levels, 8–18 years remain before the entire budget is used, and no further net emissions are permissible. For the 2-degree target, more room for emissions is granted. Even for the world to remain on a non-overshoot path "*it's clear that many policymakers who argue that emissions must be curbed, and fast, don't seem to appreciate the scale of what's required*" (Nature 2018, page 404). The obvious conclusion is that the longer the global yearly emissions are not reduced, the larger the required yearly percentage mitigation to stay on target. As the climate policies (and the effect of those on emissions reductions) contain large inertia, the likelihood of being on a feasible emissions path will be reduced for each additional year global emissions remain non-decreasing.

Moreover, different pathways consistent with the 1.5 °C are described in IPCC (2018). All paths include net negative emissions in the future. Negative emissions in the second part of this century might therefore be unavertable. The required decarbonization compatible with the Paris Agreement target would, however, entail a worldwide reduction of carbon intensity by 6.2% every year from now until 2100—more than five times the rate currently achieved. While technically feasible, it is unrealistic due to social, economic, and political factors that hold back the speed of decarbonization (EU 2015b). Finally, not all agree with the "well below 2-degree target". Using the newest version of the integrated assessment model, DICE, Nordhaus (2018) finds that the optimal global temperature could increase up to 2.5 degrees in the year 2100 based on the cost and benefits of emissions reductions.

From the discussion in Sect. "Analysing the expected effectiveness of the international climate regime", we derive the uncertainty range for the optimal emissions path presented in Fig. 9. There is large uncertainty about the optimal path. However, for all cases, global $CO_2$ emissions need to fall as soon as possible and, depending on these technologies and the socio-economic development, approach a very low level of GHG emissions.

[10] Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 Gt $CO_2$ over the course of this century and more thereafter.

### The non-treaty emission path

The non-treaty emission path appears as the most complex part. Several papers and authors have proposed ways to identify potential scenarios and/or developments that the global emissions would follow without the treaty (Young 2003 and 2011; Barrett 2003; Hovi et al. 2003; Helm and Sprinz 2000).

The theoretical approaches underlying these analyses fall into four categories: Game theoretic frameworks, projections, econometric approaches, and elucidation process of expert opinions. The game theoretic approach asserts that without a treaty, all countries would simply act by the non-cooperative Nash equilibrium hypothesis (Helm and Sprinz 2000). Theoretically, it should be feasible to derive such an emissions path by using integrated assessment models (IAMs). The non-cooperative solution generally assumes that no cooperation of any kind will happen and is therefore the upper bound estimation of global emissions.

Such non-cooperative Nash equilibrium is a worst-case scenario, where only climate policies that give national benefits would occur (Young 2011). This might, however, not reflect reality. Even without the globally UN-led institution (COP), other types of cooperation might occur in technology development. This is likely to lead to a lowering of global emissions.

The econometric approach aims at deriving an econometric specification for the demand for emissions reductions tested empirically on pre-treaty data and then using these specifications as bases for estimating non-treaty emissions. This approach has been used in the European Acid Rain problem by Murdoch and Sandler (1997). For the climate change issue, this is problematic. The first climate treaty was signed already in 1997, and pre-regime data are, thus, outdated for the prediction of current non-treaty emissions.

A more pragmatic solution would be a Business-As-Usual (BAU) approach. However, establishing a BAU baseline is far from straightforward. Would that be a scenario where no future policy initiatives are implemented? According to CarbonBrief (2019), the 8.5 RCP is a worst-case (and very unlike) scenario where essentially no further reduction is undertaken, and some current policies are withdrawn.[11] IPCC (2013) also warns that the 8.5 RCP should not be interpreted as a no-climate-policy socioeconomic reference scenario.[12] Young (2011) argues that this scenario is unrealistic as it will result in a global annual emissions level of 100 Gt $CO_2$ and run counter to the fast-falling price of renewable energy sources (such as wind and solar) and energy storage. This point of view is supported by Hausfather and Peters (2020), who argue that the 8.5 RCP is mistaken for a BAU.

[11] In van Vuuren et al. (2011), the underlying science of Representative Concentration Pathways (RCP) is explained.

[12] While each single RCP is based on an internally consistent set of socioeconomic assumptions, the four RCPs together cannot be treated as a set with consistent internal socioeconomic logic. For example, RCP 8.5 cannot be used as a no-climate-policy socioeconomic reference scenario for the other RCPs because RCP 8.5's socioeconomic, technological, and biophysical assumptions differ from those of the other RCPs (http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html).

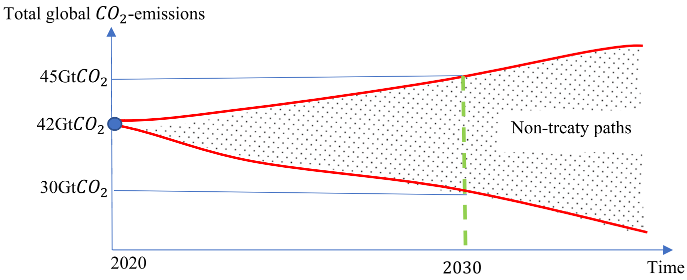



**Fig. 10** The range of uncertainty in the non-treaty emission path until 2030

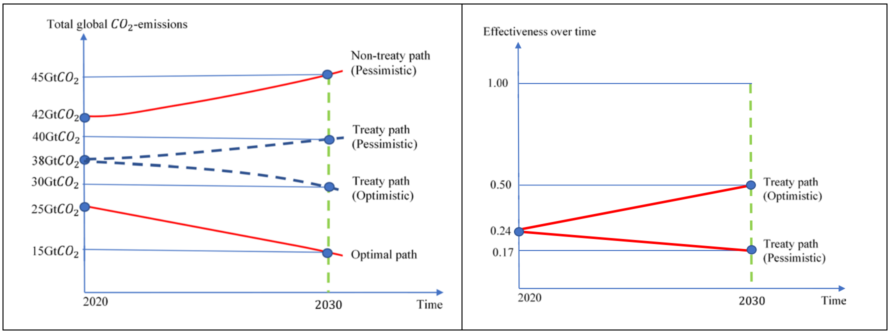



**Fig. 11** Pessimistic-NT-path situation

In the most optimistic scenario, there might still be room for some coordination where cleverly designed RES policies can have a large effect and be optimal in a non-cooperative Nash setting depending on, e.g., learning rates. This can trigger larger reductions through the spread of climate technologies. Moreover, countries may try to gain first-mover advantages in such a booming renewable energy market (Brandt and Svendsen 2006).

An approach could be to invite a group of experts to derive a consensus about the most likely non-treaty emission path (Landeta 2006). This approach has become a popular technique for forecasting and aid in decision-making based on the opinions of experts. However, to our knowledge, it has not been applied on the non-treaty global emission path.

Regarding the non-treaty emission path, our estimates of the uncertainty are shown in Fig. 10. The upper value is from both IEA (2016) and RCP 8.5, which is taken as an absolute maximum. The lower bound is based on a very optimistic non-treaty estimate of technology advances, large local co-benefits from partially switching away from coal and low-price electrical cars, energy effectiveness development that prove competitive, and other socioeconomic favorable conditions.

**Table 5** Key numbers of the pessimistic NT-case

| Pessimistic NT-case | Effectiveness | | | Absolut difference | | |
|---|---|---|---|---|---|---|
| | $S_{2020}^{PA}$ | $S_{2030}^{PA}$ | $\Delta S$ | $d_{2020}$ | $d_{2030}$ | $\Delta d$ |
| Upper bound (optimistic PA-path) | 0.24 | 0.50 | +0.24 | 13 | 15 | +2 |
| Lower bound (pessimistic PA-path) | 0.24 | 0.17 | −0.07 | 13 | 25 | +12 |

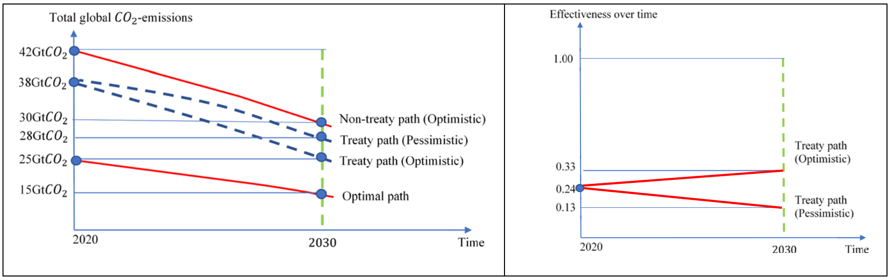



**Fig. 12** Optimistic-NC-path situation

## Evaluating the Paris Agreement

Now, we are finally in the position to evaluate the expected effectiveness of the Paris Agreement in 2030 by combining Figs. 8, 9, and 10. To add the uncertainty inherent in the use of estimates, the most pessimistic and the most optimistic paths to identify upper and lower limits to the range of the treaty and non-treaty emission paths, while letting the optimal path follow an average path. We compare the pictures to the findings in Sect. "A theoretical measure of effectiveness: The Oslo-Potsdam solution".

The NT-emission paths outlined in Fig. 10 stipulate an upper (pessimistic) and lower (optimistic) bound on non-treaty emissions ($E_t^{NT}$), while Fig. 8 depicts the upper (pessimistic) and lower (optimistic) bound on the expected emissions observed in the presence of the Paris Agreement ($T$).[13]

In Fig. 11, the non-treaty emission path follows a pessimistic trend: No significant technological developments are expected (without a treaty), no unilateral climate policies initiated (by major emitters), and the underlying factors driving emissions keep pushing emissions upwards, which produces the upper path in Fig. 10. The expected emission path resulting from the Paris Agreement either also follows a pessimistic emission path, if the treaty does not in any significant way enables changes compared to the pessimistic non-treaty path or enables real changes compared to the pessimistic non-treaty situation, described as the upper and lower bounds of emissions in Fig. 8.

[13] We will here assume that $E_t^{NT} > E_t^{PA}$, at any time to avoid a negative effectiveness coefficient. As identified in Sect. "A theoretical measure of effectiveness: The Oslo-Potsdam solution", this assumption does not exclude that the effectiveness is reduced over time.

**Table 6** Key numbers of the Optimistic NT-case

| Optimistic NT-case | Effectiveness | | | Absolut difference | | |
|---|---|---|---|---|---|---|
| | $S^{PA}_{2020}$ | $S^{PA}_{2030}$ | $\Delta S$ | $d_{2020}$ | $d_{2030}$ | $\Delta d$ |
| Upper bound (optimistic PA-path) | 0.24 | 0.33 | +0.09 | 13 | 10 | −3 |
| Lower bound (pessimistic PA-path) | 0.24 | 0.13 | −0.11 | 13 | 13 | 0 |

The potential for effectiveness increases is high if the Paris Agreement can cause new global policy initiatives, foster breakthrough technologies, and/or improve energy efficiency including enabling widespread diffusion of renewable energy systems. If the agreement does not foster any such achievements (pessimistic observed emission path), then the effectiveness of the treaty will likely fall over time.

As shown in Table 5, depending on the ability of the Paris Agreement to fulfill the above-mentioned improvements, the effectiveness can increase up to about 0.5, but in the most pessimistic situation, where no improvements are achieved, the effectiveness will fall to 0.17. However, in any case, the absolute distance from the expected observed emission and the optimal emission increase over time.

Using the notation from Sect. "A theoretical measure of effectiveness: The Oslo-Potsdam solution", the pessimistic NT-path, and optimistic PA-path both have the characteristics of situation 1b (version 2), while the pessimistic PA-path follows situation 2b (version 2). Note, that we here are likely to face a situation where an increase in effectiveness over time does not translate into being any closer to "solving the climate problem" if the NT emissions follow a pessimistic path.

In the optimistic NC-case, portrayed in Fig. 12, emissions continue to fall even without a climate agreement, driven by the development and deployment of $CO_2$ reducing technologies that turn out competitive even without any formal agreement. This induces a declining reliance on fossil fuels, together with improved energy efficiency which effectively decouples emissions from economic growth. Here, the potential for effectiveness increases is less, unless the Paris Agreement can add significantly to technology development and deployment, stringent climate policy, etc. If not, then effectiveness will fall. In any case, since emissions are pushed downward in both cases, the absolute distance to the optimal path is reduced. The key performance in the case is summarized in Table 6.

The most general situation 3 is where all three emission paths are downward-sloping over time. Hence, all outcomes are possible, depending on the relative changes in the emission level on the three paths.

The optimistic PA situation follows the real progress case 1 from Table 1, entailing both effectiveness progress and absolute progress because $\Delta S > 0$ and $\Delta d < 0$. The pessimistic PA situation can be placed between case 2 and case 4 since $\Delta S \downarrow$ and $\Delta d = 0$. It is close to the real failure case with effectiveness failure but unchanged absolute distance.

It is worth noticing that in the worst case (under the optimistic NC), the distance is 13 ($d_{2030} = 13$), while in the best case (under the pessimistic NC), the distance is 15 ($d_{2030} = 13$). The implication is that even a low achieving treaty will – under the best (external) conditions – achieve a better outcome than a high performing treaty under the worst (external) conditions. This result emphasizes that to evaluate the achievements of a treaty, it is essential to estimate what the treaty can achieve compared to the situation without the treaty.

## Conclusion and policy implications

There is a strong need for a measurement method within climate policy. A gap in the literature exists concerning the aim of identifying such an authoritative measurement method. Thus, the research question addressed how we can develop a new tool to measure the effectiveness of climate agreements. Our suggested approach holds several advantages. Theoretically, it shows how to develop a performance measure that includes uncertainties and that is based on estimates. Functionally, we show its application by evaluating the Paris Agreement, identifying the large uncertainty inherent in the expected effects of this agreement and where this uncertainty stems from. Finally, it has practical implications since the above insight will help as an input to more effective policies, as exemplified by the EU external climate policies.

Overall, we found that while the Paris Agreement is likely to make a difference, this is not sufficient to reach the 1.5-degree target. While the 1.5-degree target in principle could be reached, it will only happen if negative emissions technologies are developed and implemented unrealistically fast. Almost all papers and studies identify a large discrepancy between observed emissions and potential outcomes of intended policy targets. Current emissions trends based on NDC indicate an expected 2.7 degrees of temperature increase in 2100. Therefore, further actions are needed. Here, previous studies vary significantly in the type of policy needed, and the likelihood that such policies will be put in place is often not quite feasible yet. The use of carbon sinks, for example, is projected to increase significantly in near future.

More specifically, the expected effectiveness (as evaluated in 2021) in 2030 will be between 13 to 50% and an absolute difference between 10 and 25 $GTCO_2$. However, high effectiveness does not translate to having the lowest absolute difference. A higher effectiveness of a treaty over time can still imply larger absolute distances (pushing actual emissions further away from the target emission), while a lower effectiveness measure over time might imply a lower absolute distance. Specifically, in the NC-pessimistic situation, where an increase in the effectiveness of the Paris Agreement up till 2030 is a realistic possibility, the distance (between the expected emission for the Paris Agreement in 2030 and the needed emission in the optimal path in 2030 will increase. For the optimistic NC situation, the results are more blurred. In any case, the distance between the expected observed emissions level and the needed optimal emission level will slightly approach 2030, while the effectiveness will slightly increase or decrease, depending on the causes of the emission reductions.

When we evaluate whether “institutions matter” for the climate change issue, an important issue is whether the Paris Agreement provides a push factor and thereby demands factors for decarbonization solutions, i.e., a development of the necessary technological development that would not have materialized without the treaty. Does the Paris Agreement mean progress toward the optimal target? Based purely on current developments of emissions and on the pledges of the parties, we found that the likelihood of achieving the stated goal is small. Only "radical technologies" like large-scale CCS are successfully implemented, which is also questionable. Thus, measurement tools must be taken into use and disseminated through adequate institutional channels, such as the EEAS and its "Green Diplomacy Network." With this new tool in the climate diplomacy toolbox, it is possible to focus on the actual effects of climate policy rather than just stating political goals that may never be achieved. In this way, political output about what to do can be turned into outcome and actual implementation. If the EEAS furthermore supports global action through support and cooperation with its numerous partner countries, in particular developing countries, the road to achieving the goal of the Paris Agreement is open.

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