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# From Kyoto to Paris and Glasgow: overview of international climate agreements and regimes, their limitations, and the role of energy efficiency and sufficiency

Paolo Bertoldi[1]
European Commission, Joint Research Centre
Ispra
Italy
paolo.bertoldi@ec.europa.eu

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## Abstract

In 1988 the UN General Assembly defined climate change a "common concern of mankind". In 1990, the IPCC's first Assessment Report (AR) highlighted the impact of climate change and the need to have an international coordinated response. The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 established the United Nations Framework Convention on Climate Change UNFCC), and the subsequent regular Conferences of the Parties (COP). A major step forward in international climate agreements was the Kyoto Protocol in 1997. The Protocol was based on the principle of "Common but Differentiated Responsibilities", with obligations only for developed countries. A rapid increase in emissions by fast developing countries, showed the limitations of the Kyoto Protocol. The Paris Agreement reached at COP 21 in 2015 was a major step forward in climate change negotiations with global engagement to limit global warming to well below 2 °C. The Paris Agreement departs from the top-down approach of the Kyoto Protocol by adopting a bottom-up approach in which each country determines its contribution to reach the global target, through National Determined Contributions (NDCs). Other important elements of the Paris Agreement are the increased role of climate finance for developing countries, the role of non-state actors, and the "rule book" for GHG monitoring. Despite the Paris Agreement, the global emissions have continued to increase until 2019 and the current set of NDCs are not compatible with a 2 °C pathway. An important step in the implementation of the Paris Agreement was reached with the Glasgow Climate Pact, agreed at COP in November 2021.

The paper presents the key elements of the international climate agreements and their limitations, the current lack of ambition of NDCs and the latest agreement reached in Glasgow in 2021. Particular focus is on the EU climate and energy policies and targets and the role of energy efficiency and energy demand options including sufficiency in the global effort for GHG reduction and temperature stabilisation at 1.5 °C increase.

## Introduction

### THE UNFCC AND THE IPCC

Climate change has been recognized as one of the major challenges mankind is facing as early as the eighties lifting a scientific issue, correlating increased atmospheric concentrations of GHG with increased air and sea temperatures, into a political issue. In 1988, the UN General Assembly defined climate change a "common concern of mankind". In the following years industrialized countries started to discuss on how to stabilize greenhouse concentration in the atmosphere. At the time, several developed countries supported the stabilization of emissions by year 2000. The scientific community formally established the Intergovernmental Panel on Climate Change (IPCC) in 1988 (Seo, 2017). In 1990, the IPCC's first Assessment Report (AR) highlighted the impact of climate change and the need to have an international coordinated response. The IPCC AR 1 indicated that

1. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

global mean temperature was likely to increase by about 0.3 C per decade, under the business-as-usual emissions scenario. The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992 gathered several countries and, among other resolutions, established the United Nations Framework Convention on Climate Change (UNFCC) (Kuyper et al., 2018), and the subsequent regular Conferences of the Parties (COP). Article 2 of the Convention states its ultimate objective, which is to stabilize the concentration of GHG in the atmosphere "at a level that would prevent dangerous anthropogenic (i.e., human) interference with the climate system." The UNFCCC entered into force in 1994. It has been observed that climate legally binding international agreements would not only ensure implementation by the contracting parties, but also ensure that other parties will act too, enhancing fairness of multilateralism (Winkler and Beaumont, 2010).

#### THE KYOTO PROTOCOL

The next major step in international climate policy was the Kyoto Protocol (KP) (UNFCC 1988), which was an international treaty in the frame of the UNFCCC adopted in December 1997 and entered into force in February 2005, when a large number of countries ratified it (Maamoun, 2019). The KP objective was to reduce GHG in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC Kyoto Protocol Art. 2). The Protocol was based on UNFCCC the principle of "Common but Differentiated Responsibilities" (Rosencranz and Jamwal, 2020). It established the obligation to reduce current emissions in developed countries (Annex I) on the basis of their historical emissions. Under the KP Annex I. 38 industrialised countries) committed to binding GHG emissions targets to be achieved between 2008 and 2012 (in the first commitment period) compared to a base year (for most of the countries set at 1990). It is important to notice that: 1) the US never ratified the KP and 2) developing countries including large emitters such as China, India, Brazil, Korea did not have binding reduction commitments. This created a lot of tension with some industrialised countries. The emissions targets of Annex I countries for the first commitment period varied between different parties ranging from -8 % in the EU to a +8 % emission increase in Australia and + 10 % Iceland (Aichele and Felbermayr, 2013). Annex I Parties could use the so called "flexibility" mechanisms to meet their targets. The KP flexibility mechanisms included the International Emissions Trading (IET) (Grubb, 1998; Boom, 2001; the Clean Development Mechanism (CDM) (Matsuo, 2003), and Joint Implementation (JI) (Schmitz and Michaelowa, 2005). The role of emission trading schemes was recognised in in Article 17 both among counties and internally in countries by setting emission caps on economic operators (Grubb, 1998). The CDMs mechanism was designed to foster clean energy projects in developing countries, including energy efficiency. The CDM and JI were "project-based mechanisms," as they generate emission reductions from projects[2] (Woerdman, 2000). The production of emission reductions generated by the CDM and JI could be used by Annex I Parties in meeting their emission limitation commitments (Rosencranz and Jamwal, 2020). The emission reductions produced by the CDM and JI were both measured against a baseline of emissions that would have occurred in the absence of the project. CDM projects were implemented for end-use energy efficiency projects, mainly in industry (Olsthoorn et al, 2016) and in a reduced number on buildings and efficient appliances and lighting (Gómez-Paredes et al., 2013). The main problem linked to CDM was the complex methodology to identify the avoided emissions resulting from energy efficiency (Arquit Niederberger and Spalding-Fecher, 2006) and the low value in recent years in the international markets of the $CO_2$. It is important to notice that the KP highlighted the role of energy efficiency in Article 2:

> Each Party included in Annex I, in achieving its quantified emission limitation and reduction commitments under Article 3, in order to promote sustainable development, shall: (a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as: (i) Enhancement of energy efficiency in relevant sectors of the national economy. (UNFCCC, 1997).

#### THE PARIS AGREEMENT

It was soon evident that the KP was not delivering the required global emission reductions due to lack of target for fast developing economies, which become major emitters, in particular, China and India. In addition, the idea of binding targets, although decided by the individual countries, was not positively accepted by all nations, could favour short-term solutions, as opposed to long-terms goals, and not stimulate policy innovation (Rosen, 2015). The discussions on climate regimes centred on whether this coordination of countries relied upon binding targets allocated by principles of historical responsibility and equity, or carbon prices and emissions quotas or pledges and review of policies and measures (de Coninck et al, 2018). The failure of the KP approach resulted two important messages for future climate regimes: the inability to agree on rules to allocate emissions quotas under the UNFCCC principle of Common but Differentiated Responsibility and the limits of a climate-centric vision of climate regimes separated from development issues, which created resistance among developing nations (Shukla 2005; Winkler et al. 2013). The factors that limited the impact of the KP resulted in a completely different approach of not binding commitments started with the Copenhagen Accord (Hare et al., 2010) further developed in the Cancun Agreements, and finally adopted by the Paris Agreement.

In 2007, the Bali process, and in particular the Bali Action Plan (Ott et al., 2008), initiated a more cooperative process between Annex I and other countries based on a bottom-up approach, social justice and inclusion of development pathways. As part of the Bali Action Plan, developing countries were requested to prepare and submit **Nationally Appropriate Mitigation Actions (NAMAs)** in the context of sustainable development (Cheng 2010).

The Cancun Agreement in 2010 (Hourcade et al., 2015) laid the foundation for the Paris Agreement (PA) (UNFCCC 2005). It recognised the importance of setting global targets for a maximum temperature increase (e.g. 2 °C), engaging all coun-

2. The difference between IET and the project-based mechanisms is that IET is based on the setting of a quantitative restriction of emissions, while the CDM and JI are based on the idea of "production" of emission reductions. The CDM is designed to encourage production of emission reductions in non-Annex I Parties, while JI encourages production of emission reductions in Annex I Parties.

tries, including developing countries, in order to contribute to the common target based on differentiated responsibilities and establishing transparent mechanisms for accounting and monitoring emission reductions.

The new "bottom-up approach" started in Bali at COP 13 and re-affirmed at COP 17 in Durban, (Bäckstrand and Lövbrand, 2019) was fully reflected in the decision to ask countries to prepare Intended National Determined Contribution (INDC) and submit them to the UNFCC before the COP 21 in Paris. The INDC contained the national determined targets, plans and measures.

The PA reached at COP 21 in December 2015 was a major step forwards in climate change negotiation and global engagement to limit global warming. The PA aimed at reinforcing the global response to climate change, by limiting the increase of 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", with the "aim to reach global peaking of greenhouse gas emissions as soon as possible" and "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" (UNFCCC Paris Agreement 2015).

The PA departed from the top-down approach of the KP (Hare et al., 2010); instead of establishing mandatory GHG reduction limits to Annex I countries, it adopted a bottom-up approach in line with the Cancun Agreement in which each country determines its contribution to reach the global target (Criqui and Mathy, 2016). Under the PA, the countries' NDCs[3] shall be revised with the view of increasing the ambition every 5 years following a global stocktaking mechanism established by the UNFCCC. The global stocktaking mechanism was supported by a facilitative dialogue in 2018, the submission of the second NDC in 2020, and a formal review in 2023, before third round of NDCs should be submitted. According to Article 4.2 of the PA, each party is obliged to "prepare, communicate and maintain successive NDCs' as well as to pursue domestic mitigation measures to achieve the NDC's objective" (Savaresi, 2016, Rogelj et al., 2017). Revised NDCs must be more ambitious than the previous one and be based on the principles of 'highest possible ambition' as well 'common but differentiated responsibilities and respective capabilities, in the light of different national circumstances (Raiser et al., 2022). The targets set by the individual countries are not binding and there is no way to "force" a country to set any target. 194 NDCs, representing all 193 Parties to the Paris Agreement have been submitted. In May 2022, the 132 new or updated NDCs have been submitted.

One of the key questions is whether under the PA framework, countries will make their best efforts in domestically reducing their emissions and contribute to the global emissions targets, or whether countries will adopt a wait and see approach, hoping that other parties increase their efforts (Oberthür and Groen, 2020; Raiser et al. 2020). This is similar to the prisoner dilemma. Although the PA is a new approach, the KP's discussions and tensions between developed and developing countries, which led to its ultimate failure, are still there, with the developed countries responsible for historical emissions and the developing countries claiming their right to economic development leading to increased emissions. In recent IPCC reports, SDG compatible pathways have been identified to overcome this dilemma.

3. The 2015 country INDCs become NDCs when a country ratifies the PA.

#### THE GLASGOW CLIMATE PACT

Another important milestone was reached at COP 26 in December 2021 in Glasgow whereby the 197 participating countries agreed on the Glasgow Climate Pact.

The Glasgow Climate Pact consists of a range of agreed items, including strengthened efforts to build resilience to climate change, to reduce global greenhouse gas emissions and to increase the necessary finance for both adaptation and mitigation. As commented by various sources the Glasgow Climate Pact was a last call to keep the option to keep 1.5 °C alive, with temperature increase already above 1.1 °C. The Glasgow Climate Pact clearly indicates that;

> limiting global warming to 1.5 °C requires rapid, deep and sustained reductions in global greenhouse gas emissions, including global carbon dioxide by 45 per cent by 2030 relative to the 2010 level and to net zero around mid-century, as well as deep reductions in other greenhouse gases.

In order to reduce the emission gap, countries collectively agreed to continue their best efforts with urgency in order to reduce the gap between existing emission reduction plans as in the current NDCs, leading to a temperature increase by the end of the century well above 2 °C, and what 1.5 °C compatible pathways would require in terms of emission reductions. This translated in a call to submit the next round of more ambitious NDCs in 2022, instead of 2025. For the first time the discussions and negotiations on phasing out coal fired power took place, with the final agreement on "phasing down" coal use and to "phase out inefficient subsidies" for fossil fuels.

As part of the COP 26 package of decisions, the PA's rulebook was finalised. This covers the rules for market mechanisms and non-market approaches, fostering more investments in clean technologies in particular in developing countries. In addition, the Enhanced Transparency Framework was adopted allowing agreed formats for reporting of climate actions and progresses and ultimately creating better confidence of country contributions. A new common timeframe for intermediate targets, e.g., 2030 allowing for better comparison of efforts.

Decisions on climate adaptation (not in the focus of the current paper) included a call for doubling the finance for adaptation in developing countries and adopted the Glasgow-Sharm el-Sheik work programme on a Global Goal on Adaptation. Loss and Damage is enshrined in the PA (article 8), at COP26 the Glasgow dialogue on Loss and Damages funding was created. Developed countries confirmed their commitment to honour their pledge of providing US$100 billion annually to developing countries by 2023, this should have been in place since 2020.

#### PROJECTED GHG EMISSIONS IN 2030 AND THE EMISSION GAP

The 2022 IPCC AR6 WG III (Figure 1) estimated GHG emissions in 2019 were around 56 $GtCO_2eq$, i.e., about 12 % higher than in 2010.

NDC emission reductions pledges are not aligned with the PA targets nor are equitable (Robiou du Pont, and Meinshaus-

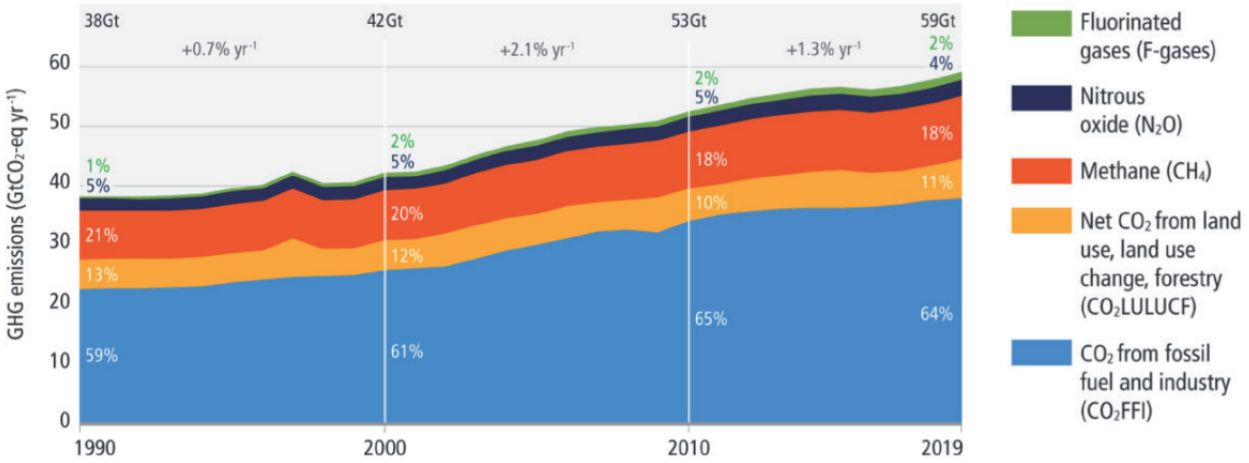


*Figure 1. Global net anthropogenic GHG emissions (source: IPCC AR 6 WG III).*

en, 2018). According to the 2021 UNFCC NDC Synthesis report (UNFCC, 2021), the total GHG emissions resulting from implementation of the unconditional elements of the submitted NDCs are projected to be 7.8 % (4.2 %–11.4 %) higher in 2030 than in 2019; whereas the total GHG emission level resulting from implementation of the NDCs including conditional elements would be to be only 2.3 % higher in 2030 than in 2019 (-1.4 %–5.9 %). This indicates that, in the case all NDCs (including their conditional elements) would be fully implemented, the possibility of peaking of global emissions before 2030, with the lower bound of the 2030 emission level (51.7 Gt $CO_2$ eq) estimated to be up to 1.4 % below the 2019 level (52.4 Gt $CO_2$ eq) and 2.1 % below the lower bound of the estimated 2025 level (52.8 Gt $CO_2$ eq) (Figure 2). The IPCC AR6 WG III confirmed that emissions resulting from the implementation of NDCs "would make it likely that warming will exceed 1.5 °C during the 21st century."

According to the IPCC SR1.5 (IPCC 2018), the total net anthropogenic $CO_2$ emissions need to decline by about 45 % from the 2010 level by 2030 (40–60 % interquartile range), reaching net zero around 2050 (2045–2055 interquartile range), in order to be consistent with global emission pathways that feature no or limited temporary overshoot of the 1.5 °C warming level in the present century. The 2021 IPCC AR6 WG I shares a similar finding, i.e., the "very low GHG emissions" scenario is the only scenario in which warming is limited to around 1.5 °C and reach net zero global $CO_2$ emissions around 2050. For limiting global warming to below 2 °C, $CO_2$ emissions need to decline by about 25 per cent from the 2010 level by 2030 on most pathways (10–30 per cent interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).

## The role of energy efficiency

Following the oil embargo both in the US and in Europe in the 1980s, EE started to be considered as an important option to promote energy security. At the time, scientists identified that a large untapped energy saving potential available and showed that with the implementation of energy the same useful service could be obtained with less energy input. Researchers also identified the energy efficiency gap (Jaffe and Stavins 1994) and barriers to investments and proposed adoption of energy efficiency and proposed policies and policy packages to overcome these barriers (Hirsh and Brown 1990). The first policies were adopted in the eighties in the US and in the EU related to buildings (e.g., building codes) (Economidou et al, 2020), appliances (e.g., efficiency standards) and vehicles, as well as horizontal measures such as energy taxes (Bertoldi 2022). Policy makers in the 1990s boosted up the adoption of energy efficiency policies, often tightening previous policies and expanding the policy coverage to new sectors. Additional policy instruments were introduced, such as utilities energy efficiency obligations (mainly in the US, but also in the UK and gradually in other European countries (Fawcett at al., 2018)), voluntary programs, financing instruments for investments in energy efficiency (Bertoldi et al. 2021), and energy performance contracting (Bertoldi and Boza, 2017).

The Third IPCC Assessment Report (AR 3), published in 2001, included energy efficiency in the mitigation chapter and included energy efficiency in buildings and end-use equipment alongside other mitigation options. Energy efficiency policies instruments were presented and discussed in the AR 3 policy chapter. In the subsequent AR 4 and AR 5, end-use energy efficiency was analysed in more details with specific chapters for buildings, industry and transport. The need to transition to low or zero emission buildings was highlighted, for both existing buildings and new construction. For the deep reduction of the buildings stock energy demand, in addition to technical energy efficiency improvements (such as insulation, efficient appliances), also consumer behaviour (Bertoldi, 2022) and sufficiency (Thomas 2019) shall be implemented. Finally, the decarbonisation of the energy used in can be achieved with the adoption of on-site renewable energy and purchase of green electricity.

Sceptics about energy efficiency claimed that there is a large rebound effect, i.e., that the efficiency gains and the economics gains generated additional consumption either in the same sector/service or in other sectors of the economy (Brown and Wang 2017). In addition, claims were made that if energy efficiency is cost effective, it should be picked up by the market (basically denying the existence of market and other soft barriers), the difficulties to monitor and verify energy savings (and associated $CO_2$ emission reductions), and the high transaction

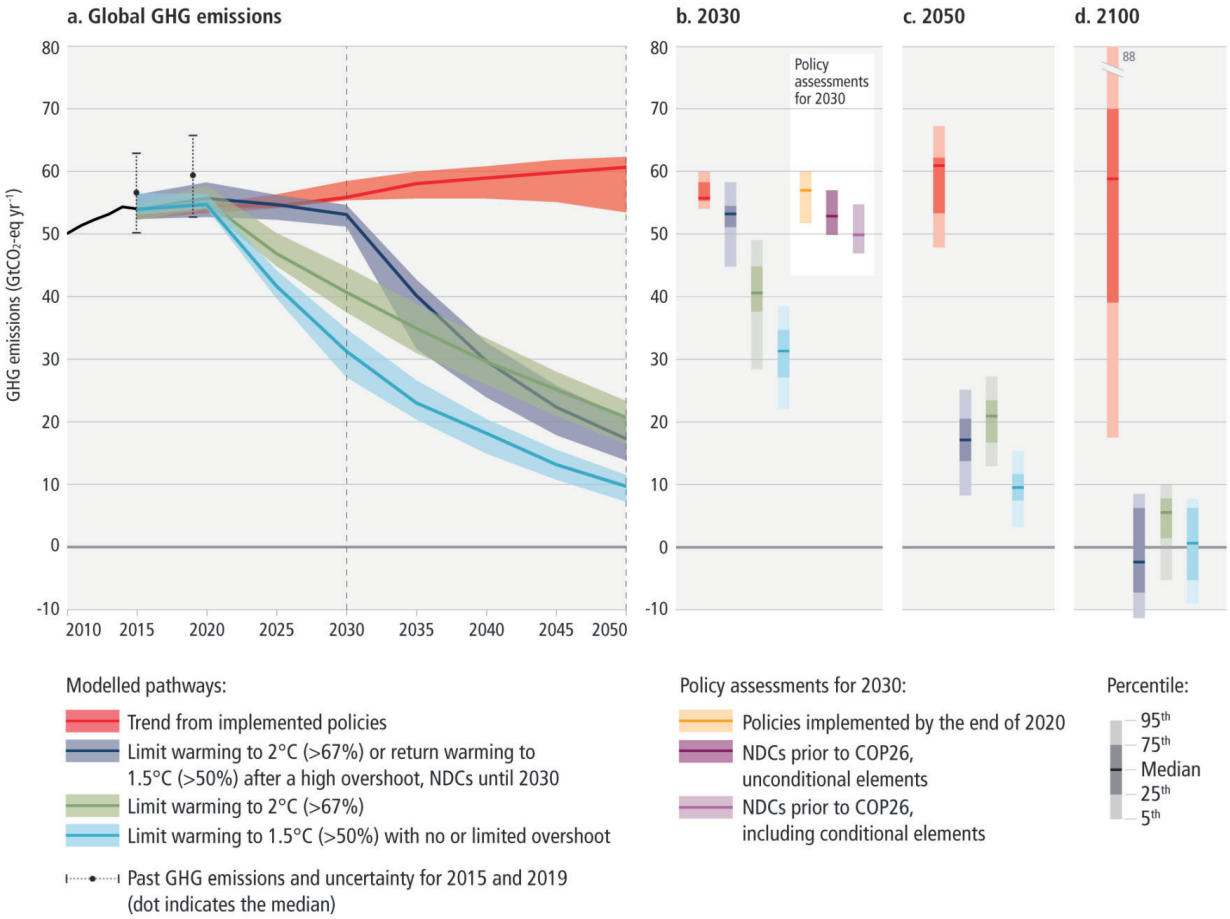


*Figure 2. Comparison of global emissions under scenarios assessed in the IPCC AR 6 WG III with total global emissions according to nationally determined contributions (source: IPCC AR 6 WG III).*

costs in energy efficiency projects due to their small size. It is important also to notice that many of these barriers also hampered the uptake of CDMs.

The debate on the rebound effect is still on-going. While the effect is recognized, the impact is low compared to the energy and $CO_2$ savings; and new and improved policies are overcoming specific barriers. In addition, more effective financing and de-risking instruments are used to support energy efficiency projects. Such non-energy benefits and co-benefits on energy efficiency investments should be included in the economic calculations.

Policies and packages of policies have proven to be effective in fostering the adoption of energy efficiency. In particular, there is no single policy, but different policies shall be adopted in the different sectors, ranging from regulation, financial incentives, information, voluntary programmes and market-based instruments.

Energy Efficiency policies and measures are part of the national climate strategies and are included in many countries NDCs. The 2021 Synthesis Report prepared by the UNFCCC Secretariat in September 2021 indicated that energy efficiency measures were second after renewable energy measures, with energy efficiency seen as the key area of action to reduce energy demand in the different sectors (Figure 3) and in particular in buildings, where energy efficiency is the first decarbonisation option (Figure 4).

In the NDCs several countries provided information on measures for raising public awareness, such as developing communication strategies, disseminating knowledge through traditional and new media, and implementing awareness-raising campaigns for specific sectors including energy efficiency. NDC reports on measures for improving energy efficiency, in particular through regulatory measures, pricing signals and technology deployment in the industry and buildings sectors.

## European Union climate and energy policies in the frame of international agreements

Since 1990, the European Union (EU) has been at the forefront of the global response to climate change and a pro-active partner in the international action to mitigate climate change impacts. The EU was among the first signatories of the Kyoto Protocol (1998) and ratified it in 2002. Mainly due to the EU efforts to convince other countries to ratify the Protocol, the Protocol finally entered in force in 2005.

The EU committed itself to a reduction of 8 % in the period 2008 to 2012 compared to 1990. The EU strategy for reaching the Kyoto commitment included energy efficiency, renewable energy and the de-carbonisation of the power generation sector (initially shifting from coal to natural gas and renewable energies).

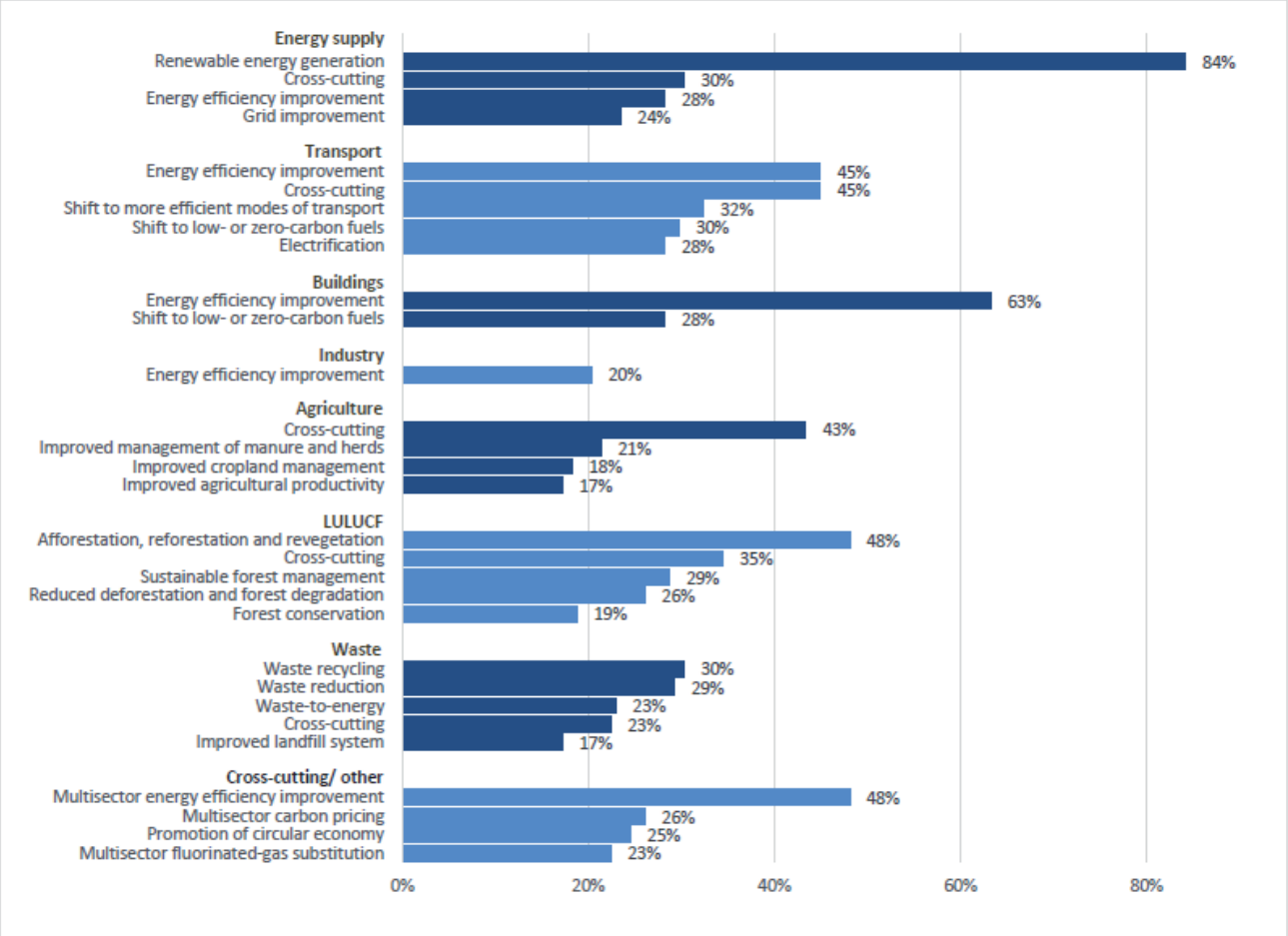


*Figure 3. Share of Parties referring to the frequently indicated mitigation options in nationally determined contributions (source: UNFCCC 2021).*

#### THE EU CLIMATE AND ENERGY TARGETS

In March 2007, EU leaders committed Europe to become a highly energy-efficient, low carbon economy and agreed on the targets, known as the "20-20-20" targets, by setting three key objectives for 2020 (Conclusions of the European Council of 8 and 9 March 2007):

- A 20 % reduction in EU greenhouse gas emissions from 1990 level;
- Raising the share of EU energy consumption produced from renewable resources to 20 %;
- Improving energy efficiency to achieve a 20 % savings on EU primary energy consumption.

The targets were set by, and were enacted through, the Climate and Energy Package in 2009. The Climate and Energy Package was a set of binding legislation which aimed at ensuring the EU met its ambitious climate and energy targets for 2020. The 20-20-20 targets represented an integrated approach to climate and energy policy that aims to combat climate change, increase the EU's energy security and strengthen its competitiveness. They were also headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth. This reflected the recognition that tackling the climate and energy challenge contributes to the creation of jobs, generating "green" growth and strengthening Europe's competitiveness.

In October 2014 the European Council endorsed a binding EU target of an at least 40 % domestic reduction in greenhouse gas emissions by 2030 compared to 1990. The target will be delivered collectively by the EU in the most cost-effective manner possible, with the reductions in the ETS and non-ETS sectors amounting to 43 % and 30 % by 2030 compared to 2005, respectively. Other targets include at least a 27 % share of renewable energy consumption and at least 27 % energy savings. In 2018, the energy saving target was increased to 32.5 % with the adoption of the revised Energy Efficiency Directive, while the renewable target was increased to 32 % with the adoption of the amended Renewable directive.

In 2018 the EU Governance Regulation (Regulation (EU) 2018/1999) was adopted regulating MSs climate and energy planning and reporting requiring MS to develop detailed and strategic National Energy and Climate Plans by December 2019 (Knodt et al., 2020).

In 2019, the European Commission, launched a new broad climate and environment initiative; the 'European Green Deal', implying the revision of many EU climate and energy polices. This roadmap developed a 'new growth strategy for the EU' aimed at reaching climate neutrality by 2050 and covered several sectors. In 2020, the European Commission introduced a proposal for a new climate law establishing the framework for achieving the climate neutrality by 2050 and upgrading the 2030 GHG emission reduction target to at least net 55 %;

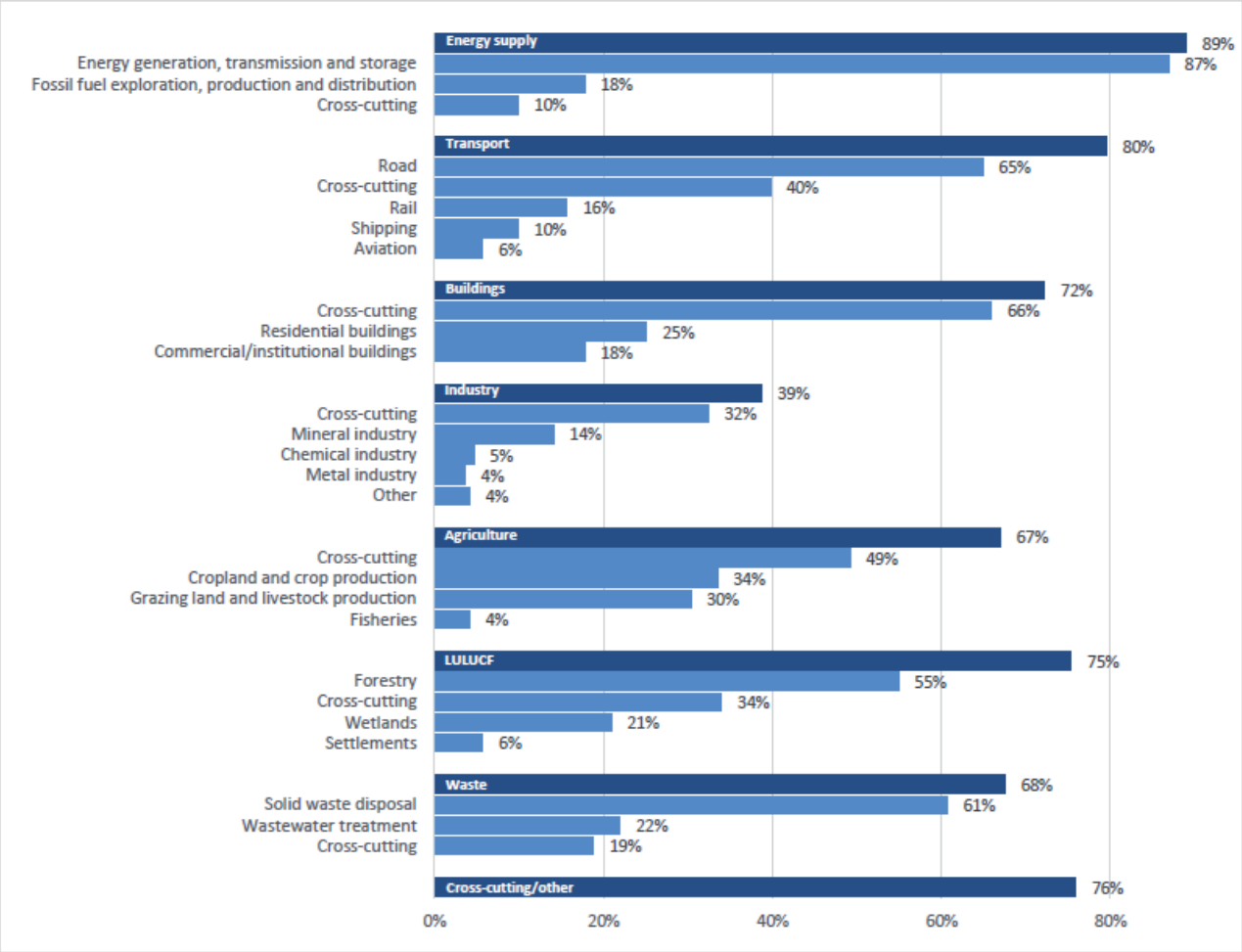


*Figure 4. Share of Parties referring to specific priority areas and sub-areas for domestic mitigation measures in nationally determined contributions (source: UNFCCC 2021).*

the Regulation was adopted in June 2021 (Regulation (EU) 2021/1119). An updated EU NDC was submitted to the UN FCCC in December 2020, with the new 55 % target (Gheuens and Oberthür, 2021).

In July 2021, the new policy package "Fit for 55" was adopted by the Commission. The packages included a proposal for the revision of the ETS, including its extension to shipping and a separate emission trading system for road transport and buildings, a revision of the effort sharing regulation, an amendment of the regulation setting $CO_2$ emission standards for cars and vans, a revision of the energy tax directive, a new carbon border adjustment mechanism, a revision of renewable energy and energy efficiency targets and directives, and a new social climate funds to make the transition to climate neutrality fair. In May 2022 these legislative proposals are in the institutional adoption process in the EU Council and in the European Parliament.

### THE EU ETS

The EU ETS has been a cornerstone climate policy conceived in the frame of the Kyoto Agreement the EU ETS Directive was adopted in 2003 and the system was launched in 2005. The EU ETS Phase 1 (2005–2007) was a 3-year pilot of 'learning by doing'. The cap on allowances was set at national level through national allocation plans (NAPs). Almost all allowances were given to businesses for free. The penalty for non-compliance was set at €40 per tonne.

The ETS initially covered only $CO_2$ emissions from power generators and energy-intensive industries. Although Phase 1 was a pilot it succeeded in establishing in the EU a common price for carbon; free trade in emission allowances across the EU; and the infrastructure needed to monitor, report and verify emissions from the businesses covered. The total amount of allowances issued exceeded emissions and as consequence, with supply significantly exceeding demand, in 2007 the price of allowances fell to almost to zero.

The EU ETS Phase 2 covered the period 2008–2012. In phase 2 a lower cap on allowances was introduced (around 6.5 % lower compared to 2005). The proportion of free allowances allocation fell slightly to around 90 %. Several Member States introduced auctions. The penalty for non-compliance was increased to €100 per tonne. The trading volumes increased considerably from 321 million allowances in 2005 to 7.9 billion allowances, in addition organisation were allowed to buy international credits. The aviation sector was brought into the EU ETS on 1 January 2012. However, the 2008 economic crisis led to emissions reductions that were greater than expected. This led to a large surplus of allowances and credits, which weighed heavily on the carbon price throughout Phase 2 (Hintermann et al., 2016).

During the Phase 3 (2013–2020), the EU ETS covered more than 11,000 installations (power stations and industrial plants) and intra EU airlines flights covers, i.e., around 40 % of the EU's greenhouse gas emissions. The main changes from the previous two phases were: a single, EU-wide cap on emissions in place of the previous system of national caps; auctioning become the default method for allocating allowances (instead of free allocation), and harmonised allocation rules apply to the allowances still given away for free; additional sectors and gases were added; 300 million allowances were set aside in the New Entrants Reserve to fund the deployment of innovative, renewable energy technologies and carbon capture and storage through the EU NER 300 programme. The Market Stability Reserve (was introduced in 2015 to reduce the surplus of emission allowances in the carbon market and to improve the EU ETS's resilience to future shocks (Kollenberg and Taschini2019).

The EU ETS was revised in early 2018 to enable it to contribute to the EU 2030 emission reduction targets. In Phase 4 (2021–2030) the EU ETS was further strengthened by increasing the pace of annual reductions in allowances to 2.2 %. The July 2021 proposal has increased the target.

#### THE EFFORT SHARING LEGISLATION

As part of a set of policies and measures on climate change and energy for reaching the 2020 energy and climate targets the Effort Sharing Decision was adopted in 2009, establishing binding annual greenhouse gas emission targets for MSs for the period 2013–2020. These targets covered emissions from sectors not included in the EU Emissions Trading System (EU ETS), such as transport (except aviation), buildings, agriculture and waste. The national emission targets for 2020 were expressed as percentage changes from 2005 levels and have been set on the basis of MSs relative wealth (measured by GDP per capita). They range from a 20 % emissions reduction by 2020 (from 2005 levels) for the richest MSs, to a 20 % increase for the least wealthy MSs, which are allowed to increase emission because their relatively higher economic growth is likely to be accompanied by higher emissions. Nevertheless, their targets represent a limit on their emissions compared with projected business as usual growth rates. Emission reduction efforts are thus required by all MSs. By 2020, the ESD national targets should have collectively delivered a reduction of around 10 % in total EU emissions from the sectors covered compared with 2005 levels. Together with a 21 % cut in emissions covered by the EU ETS, this will accomplish the overall emission reduction goal of the climate and energy package, namely a 20 % cut below 1990 levels by 2020.

The Effort Sharing Regulation, adopted in 2018, establishes binding annual greenhouse gas emission targets for Member States for the periods 2021–2030 (Peeters and Athanasiadou, 2020). Under this Regulation, the national targets will collectively deliver a reduction of 30 % by 2030, compared with 2005 levels. Together with a 43 % by 2030, this will allow the EU to achieve the climate targets.

#### THE VEHICLES $CO_2$ EMISSION REGULATIONS.

The most significant policy action at the EU level for reducing road vehicle $CO_2$ emissions is the definition of fleet-wide, sales-weighted average $CO_2$ emissions targets. After voluntary agreements with the car industry did not show the desired effects, such targets were mandated for the first time in the EU by Regulation 2009/443/EU as part of the EU integrated approach to reduce $CO_2$ emissions from light-duty vehicles. The Regulation introduced a fleet target of 130 g/km for passenger cars and year 2015 while laying down a series of provisions and measures that would drive EU policy in the next decade. An additional 10 g/km reduction was foreseen to originate from technologies relevant in real world vehicle operation, such as tyre pressure monitoring systems and gear shifting indicators. In March 2014, the EU Regulation No 333/2014 amended the previous Regulation defining the modalities for reaching the 2020 target to reduce $CO_2$ emissions from new passenger cars. The Regulation No 333/2014 set a target of 95 g $CO_2$/km for the new car average emissions for the period after 2021. Additionally, in April 2019, the EU adopted Regulation (EU) 2019/631 which sets $CO_2$ emission standards for new passenger cars and new light commercial vehicles (vans) in the EU for 2025 and 2030 (Oki, 2021), while later that year regulation (EU) 2019/1242 set similar targets for heavy trucks. The new targets are as a percentage reduction from the 2021 starting points. For cars: 15 % reduction from 2025 onwards and 37.5 % reduction from 2030 onwards, while for vans: 15 % reduction from 2025 onwards and 31 % reduction from 2030 onwards. The July 2021 package has proposed a ban of sales on internal combustion engine starting from 2035, the proposal is under discussion in Parliament and Council.

#### THE RENEWABLE ENERGY DIRECTIVE

After the adoption of the EU 2020 targets in 2007, in the 2009 the EU adopted the Directive on Renewable Energies, 2009/28/EC, which mandated the level of renewable energies as share of total national energy consumption for year 2020 for each MSs in order to reach the 20 % share of renewable energy in the total energy consumed in the EU. The directive introduced a number of policies to foster the production and consumption of renewable energy such at the guarantee of origin, the preparation of regular national renewable action plans, rules for national support schemes, access to the grid and Sustainability criteria for biofuels and bioliquids. In 2018 the Renewable Energies was recast to introduce the new EU renewable target for 2030 of 32 %, however mandatory target for MSs were abolished (Schoenefeld and Knodt, 2021). After the adoption of the 55 % target for 2030 the Commission proposed in July 2021increasing the new EU renewable target for 2030 to 40 %.

## EU Energy Efficiency Policies

Since the nineties, energy efficiency has been a main component of the EU climate strategy. In the 1990s, improving energy efficiency and limiting energy demand was key to reach the EU climate goals, first the $CO_2$ emission stabilisation goal, then the Kyoto target.

#### THE ENERGY EFFICIENCY DIRECTIVE

In more recent year in order to provide a legal basis to the 2007 energy efficiency target, the Energy Efficiency Directive[4], (EED), was adopted in October 2012. The Directive quantifies

4. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2012/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ L 315, 14.11.2012, p.1.

the 20 % energy efficiency target defined in the Climate and Energy package, establishes a common framework of legally binding measures for the promotion of energy efficiency in the EU MSs in order to reach the 2020 target 2020, and paves the way for greater energy efficiency beyond that date.

The EED required EU MSs to set indicative national energy efficiency targets and legally binding measures to help the EU reach its 20 % energy efficiency target. In particular, all EU MSs were required to implement policy measures that improve energy efficiency at all stages of the energy chain from production to final consumption.

In compliance with the Directive's requirements, MSs had to present the progress and efforts made in the so-called National Energy Efficiency Action Plans (NEEAPs), which were due every three years starting from 2014 (Bertoldi and Economidou 2016). The NEEAPs were regarded as strategic national policy documents placing energy efficiency at the heart of energy policy. They outline national energy efficiency targets and detail actions put in place to ensure that energy savings are generated in all sectors of the economy. The previous experience gained through the submission of NEEAPs under the Energy Services Directive 2006/32/EC (ESD)[5,6] provided a strong foundation upon which Member States have continued to develop and strengthen their energy efficiency policy strategies.

The EED Article 7 required MSs to achieve 1.5 % annual energy savings by establishing Energy Saving Obligations (ESOs, or Energy Efficiency Obligation Schemes, EEOSs) for energy companies, giving however the option to MSs to use also alternative measures resulting in equal savings. Other measures introduced by the EED included: the requirement for the public sector to renovate annually 3 % of central government building stock, metering and billing measures, and long-term strategies for national building stock renovation, promotion of EPC in the public sector, removal of split incentives and opening up the energy markets to demand response.

The EED was amended in 2018 in order to introduce the legal obligation of the new EU energy efficiency (or more precisely) energy saving target of 32.5 % for 2030. Other key amendments included extending the EEOs till 2030, though with a reduce level of annual savings, and to strengthen the provisions of other specific articles.

In July 2021 the Commission presented a proposal for the recast of the EED, with an increased EEOs energy saving target and the possibility to adopt mandatory energy saving targets for MSs.

The EED is complemented by appliance and lighting efficiency standards established at EU level, mandatory energy labelling for appliances, fuel efficiency standards for light and heavy-duty vehicles (fleet target), and a framework for setting building energy performance standards (building codes) based on cost-optimality and building certificates under the Energy Performance of Buildings Directive[7].

#### EU POLICIES FOR ENERGY EFFICIENCY IN BUILDINGS

In 2002 the EU adopted the Energy Performance Buildings Directive (EPBD, 2002), requiring MSs to adopt minimum efficiency performance standards for buildings according to a common methodology both for new and existing buildings, when undergoing major renovation (Economidou, 2020). The 2002 EPBD has also introduce the obligation to show an energy performance certificate when a building is sold or rented (Economidou et al., 2021). In 2010, the EPBD was amended by introducing the requirements for MSs to set the national energy requirement for new and existing buildings at the cost-optimal level and providing a common methodology for calculating it. The 2010 EPBD introduced the requirement for all new buildings to be nearly zero energy (nZEBs) by 2021, (D'Agostino et al, 2021; Economidou et al. 2020). In 2018 the latest amendment of the EPBD introduced the requirements for MSs to prepare a Long-Term Renovation Strategies (LTRSs)[8] with an overarching decarbonisation target of the national building stock by 2050. In December 2021 the Commission will propose a new amendment to align it with the new -55 % GHG target for 2030 and the decarbonisation goal of 2050.

The 2020 Renovation Wave Communication addresses the key barriers to the renovation of existing buildings and aims at increasing the energy renovation rate to at least 2 % per year till 2030. The financing for the renovation of buildings is also supported by a number of EU initiatives.

## Discussion and Conclusions

Since 1989 scientists have indicated that climate change is one of the major challenges for mankind. The international scientific community, represented by the IPCC, has recently shown that GHG emissions must peak as soon as possible and well before 2030, and then rapidly decline reaching net zero emissions by around 2050 (IPPC, 2018; IPCC 2022). Global average temperature has already reached 1.1 °C. This is now an urgent imperative to limit the temperature increase by 2100 to 1.5 °C and avoid a dramatic impact on humans and the biosphere. The rate of the emission descent after peaking will determine the possible temperature overshoot and the possible needs for carbon removal options (e.g., CDRs, BECCs, etc.). As highlighted by the recent IPCC AR6 (IPCC, 2022) the remaining carbon budget from 2020 onwards for limiting warming to 1.5 °C with a probability of 50 % has been estimated to be 500 Gt $CO_2$, this means that at current emission levels it will depleted in 10 to 15 years.

This gives an idea of the urgency and size of the climate challenge and the need to adopt urgently new and effective policies and measures at the global level, leading to a reduction of the global energy demand, with the remaining demand to be met by zero carbon energies.

The PA is the major international framework to limit the global temperature increase and it is widely supported by most nations. It is based on a bottom-up approach where countries establish their own targets and their own strategies to reach their target as described in the NDCs. It is important to high-

5. European Union, 2006, Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

6. In compliance with the ESD, the first and second ESD NEEAP were due in 2007 (a year after the entry into force of the ESD) and 2011.

7. Directive 2010/31/EU approved on 19 May 2010 and entered into force on 18 June 2010.

8. Previously the LTRSs were part of the EED and were submitted by MSs in 2014 and 2017.

light that the PA calls for voluntary action, without any sanctions or obligations for contributing to the global efforts.

However, the sum of current and recently revised NDCs targets in 2030, net zero emissions pledges and current policies adopted are not enough to limit the temperature increase.

In 2018 the facilitative dialogue and the first stock taking helped in reinforcing the national pledges made in the NDCs, however not all NDCs have been revised, strengthened or resubmitted.

A new impetus to climate action and the rapid implementation of the PA, in particular in mitigation has been enshrined in the Glasgow Climate Pact. In preparation for COP 26, many countries confirmed or made new pledges or adopted targets to be climate neutral by mid-century or in the two subsequent decades. These are important developments. The Glasgow Climate Pact among other calls for the phase down of coal use and the removal of "inefficient" subsidies to fossil fuel. In addition, the mobilisation of the US$100 billion funding for developing countries, which should have been already in place since 2020, was re-affirmed during COP26 by starting in 2023. This would help in adoption of more ambitious climate targets in developing country and the implementation of effective policies and measures including energy efficiency, but it is not enough. This may not be enough, but still an important first step agreed in Paris and not yet implemented. Also, the adoption of the Paris Rule Book will increase the transparency of the PA reporting and assessment mechanisms, creating more trust among countries and it will trigger additional investments in developing countries, including those from the private sector.

The NDCs will be reviewed more frequently, starting from 2022 in Egypt and targets and dates will be harmonised among countries.

It is still too early to see any result from the Glasgow Climate Pack. An important milestone will be the 2023 global stocktaking, perhaps the last call for dramatically change the current emission trends and start reducing them.

Energy efficiency will continue to be an important component of the decarbonisation package as there is the need to decrease global energy consumption (IPCC, 2018) along with the decarbonisation of the energy supply. To this end it is necessary to reinforce current energy efficiency policies mainly focusing on efficient technology deployment and complement them with policies enabling an effective change in behaviour and lifestyle of energy end-users (both private consumers and organisations), by limiting the demand for energy services through energy conservation and sufficiency measures (IPCC, 2018; IPCC 2022; Bertoldi, 2022). The combination of efficiency, conservation and sufficiency would help in delivering energy savings, enabling citizens, organisations, communities, cities and economies at large to gradually reduce their energy consumption according to a trajectory compatibl5e with the Paris agreement target (Creutzig et al., 2021).

The EU has committed itself and its Member States to reducing GHG emissions since the establishment of the UNFCC and has ratified to KP. Recently the EU has increased its GHG emission reduction target for 2030 from 40 % to 55 % and has adopted the climate neutrality target for 2050. This has been reflected in the revised EU NDC submitted to the UNFCCC. A new set of reinforced and new policies has been proposed in the Fit for 55 Package of July 2021. The policy package includes policies for the different sectors, such as industry, building transport, as well as some cross sectoral policies, such as the extended ETS. The EU strategy has confirmed the role of energy efficiency in reaching its GHG targets. EU Member States have to prepared National Energy and Climate Plans and regularly report their progresses. The plans are subject to an independent assessment by the European Commission. The EU monitoring and assessment of national climate and energy action plans includes also national energy efficiency policies and reporting on the progresses towards the Member States 2030 energy saving targets. As a large part of the EU energy savings will be achieved in the building sector and in particular in existing buildings, Member States have also to adopt Long Terms Renovation Strategies under the EPBD. The EU climate and energy governance model could also in principle be exported to other regions and countries to support their NDC preparation and monitoring.

Additional research shall further develop methods to evaluate climate and energy efficiency policies, allowing more trust in energy efficiency project by investors and effective models for the global governance of climate change in order to overcome the limitations of the PA.

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