German Environment Agency

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Submission by the

German Environment Agency (Umweltbundesamt, UBA) regarding the

Strategy for long-term EU greenhouse gas emissions reductions

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High Level Messages

A new long-term climate strategy delivering the European Union's contribution to achieving the Paris Agreement objectives should consider the following issues:

1. - **Greenhouse gas-neutrality by 2050 at the latest while rapidly minimizing cumulative emissions is key to adequately contribute to achieving the objectives of the Paris Agreement.** The European Union must reduce GHG emissions on its own territory by at least 95% compared to 1990 paving the road down to net zero or even net negative emissions in the 2nd half of the century. All this requires that energy related emissions are reduced to zero, other emissions (e.g. process emissions of industry or agriculture) are reduced to the minimum technically feasible and environmentally compatible.

2. - **Cumulative emissions until 2050 and beyond must be minimized in order to keep temperature rise as low as possible.** Linear emission reduction pathways - even if leading to GHG neutrality – may lead to cumulative emissions that are not compatible with the pursued temperature limits. **Therefore**, **rapid action until 2030 is required.** A reduction of emissions by at least 45% as proposed by Commissioner Cañete (in August 2018) and later withdrawn is the absolute minimum and can only be the door opener for further deliberation on more ambitious 2030 commitments. The European Commission should analyse all technically and economically feasible and environmentally compatible options to reduce emissions in the next decade as much and as fast as possible.

3. - **The fast switch from fossil to renewable and sustainable energy is the key to minimizing cumulative emissions and avoiding lock-in effects. The transformation of the energy system including improvement of energy efficiency is of utmost importance to achieving the Paris Agreement objectives.** A fully decarbonized energy system needs 100% energy supply based on renewable energies. This requires a sustainable system without nuclear energy, carbon capture and storage as well as crop-based bioenergy. The decarbonization of the entire energy system requires further an integrated, cross-sectoral approach to supply all sectors and fields of application with renewable energy, i.e. a coupling of sectors. To comply with this requirement the electricity production needs to be fully based on renewables well before 2050 in order to contribute to the decarbonization through sector coupling. Key are also ambitious reduction activities in other sectors.

4. - **The European Union has to reduce GHG emissions domestically until 2050 by at least 95% compared to 1990. Hence, achieving GHG-neutrality may require removal of CO_2 from the atmosphere or additional reduction measures outside the EU, thus compensating a small amount of residual emissions.** The long-term strategy should establish an approach to this issue. There should be a separate target for CO_2 removals at EU level, which should be distributed amongst member states based on capacity and potential, in order to avoid Carbon dioxide removal being used to compensate delays in mitigation.

5. - **As intermediate and long-term reduction goals are to be achieved domestically**, the EU should use market mechanisms that may be developed under Article 6 of the Paris Agreement only to contribute to additional climate ambition abroad.

6. - **A high-level engagement by and political ownership of the European Council is needed**. The implementation of the strategy will have far-reaching implications for the transition of European societies and economies to become GHG neutral by mid-century. Provided this, the new long-term climate strategy should also exploit synergies and address possible trade-offs with the respective Sustainable Development Goals.

1 Introduction

With the Paris Agreement (PA; UNFCCC, 2016a), related parties including the European Union (EU) and its member states agreed to a significant shift towards long-term climate action aiming at keeping average global temperature rise *well below* 2°C and at pursuing efforts to limit it to 1.5°C. This goal shall be achieved by a global peaking of greenhouse gas emissions as soon as possible, and subsequent rapid emission reductions. In the second half of this century, anthropogenic carbon emissions and carbon sequestration are to be brought into balance. Therefore, parties were invited to provide "long-term, low greenhouse gas emission development strategies" by 2020[1]. Recent analysis and projections show, that global the mean temperature already increased by about 1°C compared to pre-industrial levels and could reach - based on current contributions of parties to the PA (nationally determined contributions, NDC) - temperature levels beyond 3°C by 2100 compared to the respective reference (UNEP, 2017).

With the Low-Carbon-2050 Roadmap (EU-COM 2011), the EU launched its first long-term decarbonization strategy in 2011. However, this roadmap, built on assumptions and expectations reflecting the consensus at that time: It was focused on a "*two-degree-world*"[2] and mid-century emission pathways were considered which reached rather the lower end of the 80 to 95% emissions reduction corridor. Today, with the PA representing a "*new normal*"[3] for climate policy aspirations, these assumptions have turned out to be insufficient (Marcu, et al. 2018). With the European Council (EUCO) requesting the Commission (EU-COM) to lay out a strategy proposal in line with the PA until early 2019 (EUCO, 2018), Europe's Heads of State and Government kick-started an overdue discussion on EU's current mid- and long-term climate commitments and signalled its willingness to engage into a long-term strategy (CAN Europe, 2018). The European Parliament made a similar request[4].

The EU does not start from scratch, since European bodies and institutions, including member states, already dispose of broad know-how in developing strategies to drive climate action and encouraging practice in setting sectoral climate targets. The EU can also benefit from efforts and know-how of regions, states and cities across the world[5] with public sector bodies being in a phase of long-term planning, as well as from (major) businesses worldwide[6] (Mabey and Gaventa, 2018). Based on this broad foundation, the EU can now provide climate leadership and pave the ground for Europe's transition to a net-zero GHG-emission society by delivering a robust and ambitious new strategy in accordance with latest scientific analysis and forecasts.

We welcome the possibility to submit our considerations at this early stage. Our contribution is based on a long lasting and broad expertise regarding technical, socio-economic, legal and political issues of environmental strategies and their development. From today's perspective, we understand the overarching process of developing the EU long-term Climate Strategy as work in process. In doing so, we look forward to the various contributions in the upcoming public debate in order to reflect, to specify and when indicated revise our current position. Thus, we hereby submit our recommendations on the key framework elements of a new European Strategy for long-term greenhouse gas emissions reductions in a summarized format.

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[1] cf. UNFCCC (2016b), Document FCCC/CP/2015/10/Add.1, para 35 in accordance with Article 4, para 19, - of the Paris Agreement (UNFCCC, 2016a). -

[2] in accordance with UNFCCC Article 2 -

[3] Mabey und Gaventa (2018) -

[4] cf. para 18 EuP (2017). EuP Resolution European Parliament resolution of 4 October 2017 on the 2017 - UN Climate Change Conference in Bonn, Germany (COP23) (2017/2620(RSP)). -

[5] i.e. Carbon Neutrality Coalition, Declaration signed by sixteen countries, www.2050pathways.org, incl. - major cities, i.e. Barcelona; Berlin; Copenhagen; London; Milan; Oslo; Paris; and Stockholm. -

[6] i.e. www.wemeanbusinesscoalition.org -

2 Key priorities of a new EU long-term climate strategy

2.1 Greenhouse gas-neutrality by mid-century while minimizing cumulative emissions to contribute to achieving the objectives of the Paris Agreement

The EU's current 80-95% emissions reduction objective for 2050 laid down in the Low-Carbon-2050 Roadmap is an outdated target range and even more problematic, the EU's legally binding 2030 climate policy framework is rated to be far from being sufficient to bring the EU on track with the long-term temperature targets of the Paris Agreement (PA) (CAN Europe, 2018; CAT, 2018). Now, with the 1.5C-special report of IPCC (IPCC, 2018), the global community has a profound and up-to-date scientific basis for progressive in-depth deliberations on future climate policies at hand. And so does the EU.

Box 1: Concepts of climate objectives

UBA's concept of Greenhouse gas neutrality

Greenhouse Gas (GHG) neutrality requires at least a 95% domestic emission reduction in the EU compared to 1990, while any remaining GHG emission may require removal of CO_2 from the atmosphere or additional reduction measures outside the EU, thus compensating a small amount of residual emissions. This concept includes solely emissions recorded in the National Emissions Inventory.

Climate objective concepts according to IPCC

Carbon neutrality/net zero CO_2 emissions: Achieving net zero carbon dioxide emissions at a particular spatial level through the balance of residual carbon dioxide emissions with the same amount of carbon dioxide removal (cf. IPCC, 2018).

Net-zero GHG-emissions: Net-zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals. Where multiple greenhouse gases are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases, based on Global warming potential (GWP) and a 100-year time horizon (cf. IPCC, 2018).

Net negative emissions: A situation of net negative emissions is achieved when, as result of human activities, more GHG are removed from the atmosphere than emitted into it. Where multiple GHG are involved, the quantification of negative emissions depends on the climate metric chosen to compare emissions of different gases based on Global warming potential (GWP) and a 100-year time horizon (cf. IPCC, 2018).

Strengthening the global response to the threat of climate change requires a long-term transition to a worldwide climate friendly economy. Considering the EU's historic responsibility, its capabilities[7] and its reputation, it is to the EU to adequately contribute to the objectives of the PA[8] including the long term ambition of achieving a balance between emissions and removals of greenhouse gases in the second half of this century. This ambition requires GHG neutrality by mid-century in the EU, while rapidly minimizing its domestic cumulative emissions. The latter objective can only be achieved by rapid below linear emission reductions from now on (see below). Hence, the EU must now reduce GHG emissions on its own territory by at least 95%

[7] see *Greenhouse Development Rights* project. www.gdrights.org -
[8] cf. Article 2, para 2 and Article 4, para 4 of the Paris Agreement (UNFCCC, 2016a). -

compared to 1990 by mid-century[9]: i.e. energy related emissions must be reduced to zero, other emissions (e.g. process emissions of industry or agriculture) must be reduced to the minimum feasible, given the economic and technological options. Translated into an ambitious EU long-term objective, a full decarbonization of the economy is necessary by mid-century including fossil fuel phase out, and far reaching efforts to minimize GHG emissions, i.e. methane and nitrous dioxide, from other sources. Achieving GHG-neutrality may require removal of CO_2 from the atmosphere or additional reduction measures outside the EU, thus compensating a small amount of residual emissions.

In this light, the analytical and modelling efforts, which form the basis for further deliberation within the EU, must include pathways with rapid non-linear emission reductions to reach GHG neutrality in the EU around mid-century, followed by further emission reductions to net zero and possibly below in the second half of this century. In doing so, the new long-term strategy needs to clarify climate objectives, i.e. carbon neutrality, net zero emissions etc., which would facilitate public debates and effective future policy making (see Box 1).

However, as latest findings, i.e. the IPCC-1.5C special report (IPCC, 2018), disclosed, achieving GHG neutrality by mid-century alone might not be enough to be in line with the long-term objectives of the PA, e.g. limiting global temperature rise to well below 2°C, preferably 1.5°C. Linear emission reduction pathways to GHG neutrality by 2050 imply cumulative emissions that are not compatible with the pursued temperature limits. The relationship between the total amount of cumulative emissions and temperature goals is, however, subject to strong uncertainties. In order to reduce the risk of overshooting the temperature limit, cumulative emissions must be minimized.

2.2 Transformation Pathways - How to divide the target over time and among sectors?

The new low-carbon emissions strategy shall outline pathways to achieve the long-term emission reduction targets of the European Union in line with the objectives of the PA. The strategy should therefore set clear and appropriate interim targets that lead to GHG neutrality by mid-century while minimizing cumulative emissions in Europe followed by further emission reductions to net zero and possibly below in the second half of this century. Safeguarding these Paris objectives requires rapid decarbonization action within the EU, thus, a linear reduction pathway seems to be not adequate. Early abatement action helps minimizing cumulative emissions and increases certainty that the EU will reach its long-term goals. As a low-carbon strategy with ambitious short-term targets is a strong (self-)commitment of the EU and its member states, companies and consumers get the signal to invest in CO_2 neutral innovations and business models. Thus, lock-in effects in fossil intense long-lived assets and infrastructures can be avoided which otherwise would make future abatement more costly.

Therefore, rapid action is already required within the next decade. The current European target to reduce emissions by at least 40% until 2030 is clearly not compatible with the PA as it leads only to emission reductions of 80% by 2050 if extrapolated and does not minimize cumulative emissions. However, the EU-COM is currently preparing negotiations on more ambitious targets for renewable energy (Council, 2018a) and energy efficiency (32% resp. 32.5%; Council, 2018b) by 2030 than was envisaged in autumn 2014, when the European Council adopted targets for emission reductions, renewable energy and energy efficiency (EUCO, 2014). Implementing these targets would lead to a reduction of emissions by "slightly over 45%" according to recent

[9] This represents the upper bound of the former emission reduction corridor (80-95% in 2050) for industrialized countries, derived by IPCC in its Forth Assessment Report (2007).

modelling by the European Commission (EU-COM 2018). However, this is not yet reflected in the binding European emission budgets, i.e. the cap of the EU Emissions Trading System (EU ETS) and the annual budgets for non-ETS sectors regulated by the Effort Sharing Regulation (ESR).

An EU emission reduction target of at least 45% by 2030 is therefore the absolute minimum that the EU should commit itself to during the ambition raising process within current the "Talanoa Dialogue". However, even a 45% reduction of emissions by 2030 will not be sufficient for a Paris-compatible transformation pathway without abrupt drops and interruptions. In this respect, the new long-term strategy should elaborate on all technically, economically and socially feasible and environmentally compatible options to enable deliberation on deeper emission reductions in the next decade as much and as fast as possible.

The new low-carbon emissions strategy will also outline how emission reduction efforts will be shared among sectors. The strategy should pay special attention to analyzing the efficient ratio between EU ETS and Non-ETS as there are legally binding emission budgets implemented by these two cross-sectoral instruments. The sharing of emission reduction efforts between ETS/Non-ETS and the setting of interim targets should be based on cost-effectiveness and abatement potentials. Because of the special role of the energy sector in terms of abatement potentials and its important role for decarbonization in other key sectors (see below), ETS sectors should reduce emissions more rapidly compared to the Non-ETS sectors.

Setting interim targets and dividing emission reduction efforts between sectors is challenging and facing many uncertainties. The new strategy therefore requires transparent modelling based on latest scientific knowledge. Assumptions on future developments, e.g. assumptions on future fuel cost, abatement costs, economic and demographic development and available technologies have a large influence on modelling results. Therefore, the EU-COM should grant full access to all input assumptions and details behind the underlying data to the public. Apart from technological and cost assumptions, discount rates play a key role when it comes to comparing today's investments in abatement technologies and processes with long-term benefits. The higher the discount rate, the higher the costs will seem compared to the benefits of a certain investment, making more ambitious emission reduction targets look uneconomic (CAN, 2018). The EU-COM should therefore not only give transparent justification for the discount rate used in the modelling, but also use different rates in form of sensitivity analyses in order to show the influence of varying discount rates on the results.

Sensitivity analyses are needed for other important assumptions as well, in our view at least for fuel costs and costs for renewable technologies. Moreover, the impact of varying industry production levels, innovation and technological progress and life style changes on emission reductions should be analyzed in different scenarios.

2.3 Reduction of GHG Emissions in Sectors

Energy related emissions account for the biggest share of GHG emissions, but can be fully avoided if fossil fuels are replaced by renewable energies. In contrast, the reduction potential of process- or land-use related GHG emissions (e.g. in industry, agriculture) is limited.

The **energy system** including the use of energy has therefore particular importance for the transformation towards an environmentally friendly, sustainable, greenhouse gas-neutral society. Its transformation should follow three central principles:

1. - Efficiency: exploiting energy and resource efficiency potentials across all sectors, and thereby reducing the absolute energy consumption;

2. - Renewable energies: expanding renewable energies and their use in all fields of application, and especially in electricity generation;
3. - Sector coupling: direct or indirect use of regenerative electricity across all fields of application towards the complete substitution of fossil fuels and raw materials. In addition a conversion and development of industrial processes, of propulsion technologies in transport and of heating processes to renewable energy sources is key.

In contrast, a sustainable and ambitious transformation of the energy system should be realized without:

1. - nuclear energy: Due to the high risks for humans and the environment as well as the possible high damage potential during the use, handling and nuclear fuel reprocessing, the use of nuclear energy should be phased out.
2. - crop-based bioenergy: Due to the growing competition for fertile cultivation areas, the disproportionately high area usage for crop-based bioenergy compared with other renewable energy sources and the problematic socioeconomic connection with food prices on the world market (UBA, 2014; UBA, 2013), the cultivation of biomass for fuel should be phased out.
3. - energy from forests: The use of wood energy should be gradually restricted to the final step of a cascading wood use where only waste wood after a maximized phase of non-energetic wood use would be eligible.
4. - CCS: Carbon dioxide capture and storage (CCS) is, at best, a time-limited technique. In case of leakage harmful effects on groundwater and soil can occur. Therefore, this technique should not be a component of sustainable development.

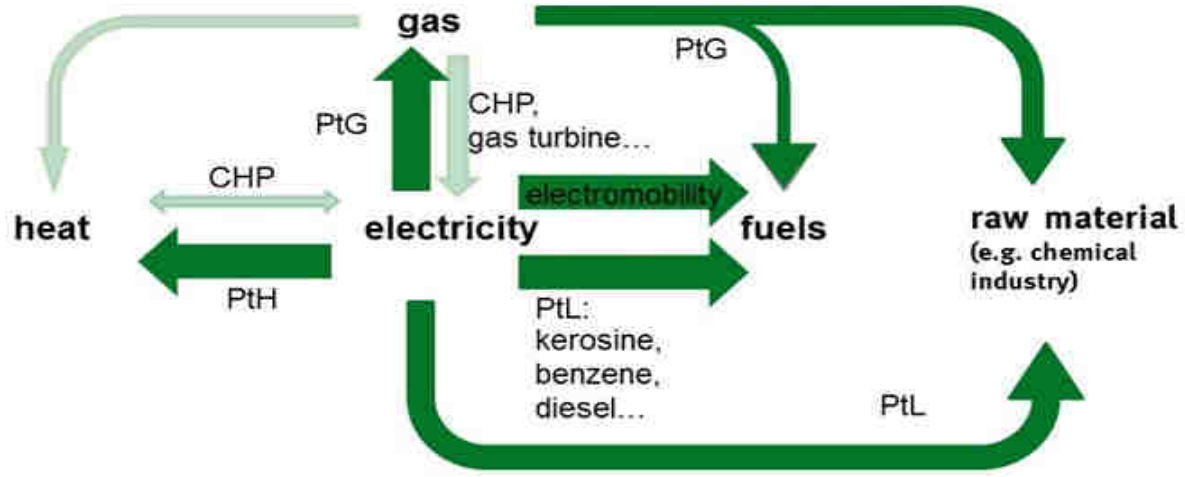
A fully decarbonized energy system needs 100% energy supply based on renewable energies. In this light, increasing energy efficiency and reducing energy demand will help achieving this objective significantly. The decarbonization of the whole energy system further requires an integrated, cross-sectoral approach that allows for supplying all sectors respectively all fields of application with renewable energy (UBA, 2014). Electricity is convertible into every other form of energy. The direct or indirect use of electricity-based energy in all fields of application is therefore a core component of a carbon neutral energy system. The variety in and importance of sector coupling in all sectors is explained in more detail in box 2.

Only the fast switch from fossil to renewable and sustainable energy is able to deliver a significant impact on GHG mitigation in the energy system (Greiner et al, 2018). Therefore, the renewable energy capacity in **energy supply** needs to be adjusted to accommodate the new additional electricity needs. Therefore, the European Union should create a consistent regulatory framework to address the key role of sector coupling and to account for energy flows and greenhouse gas emissions from the production and consumption of greenhouse gas neutral fuels from renewable energies.

The long term EU-strategy should outline approaches to an efficient energy use and a reduction of the absolute energy consumption. Tapping the energy efficiency potentials is vital, especially as the EU is currently loosing track of meeting its 2020 primary energy efficiency objective. Thus the framework of the EU Energy Efficiency Directive has to be fully implemented, both as a contribution to reach the 2020 energy efficiency target as well as to deliver in the 2030-perspective. If the implementation during the period after 2020 indicates a drift off course from the long term-perspective, the efficiency-targets of the directive have to be adjusted.

Box 2: Sector coupling with Power to X (PtX)

Power to X (PtX) technologies offer the opportunity to supply all fields of application with energy from renewable sources and thus to virtually eliminate energy-related and considerably reduce process-related GHG emissions. The initial point of this new approach of sector coupling is renewable electricity, offering a broad range of options (shown in the picture). These are namely Power to Heat (PtH), Power to Gas (PtG) as well as Power to Liquids (PtL). PtH includes all technologies for electricity-based heat supply, such as electric heaters (e.g. electric boilers in district heating networks, electric smelting furnaces, electric heating for process heat in manufacturing processes) or indirect heating with heat pumps (which provide a multifold heat output of electric heaters). PtG is the production of hydrogen and methane using renewable electricity, and PtL is the production of liquid fuels based on renewable electricity. PtG und PtL can be used in various sectors, can substitute fossil fuels vastly maintaining the traditional infrastructures (eg. gas pipes) and enable supplying renewable energy carriers and platform chemicals for all applications (such as in the chemical industry) (UBA, 2016a). For the renewable power-based provision of methane/methanol and higher hydrocarbons (PtG-CH4 and PtL) carbon sources are needed. It is assumed that this is also based on renewable and sustainable sources (e.g. atmosphere, waste biomass) or - to a lower extent - on the unavoidable process-related emissions from industries (e.g. from cement or lime production).



The most energy-efficient option for using renewable electricity in the transport sector is the direct use in electric vehicles. However, electrification is not feasible for all applications, i.e. for long range vehicles additional renewably based liquids or gaseous fuels (as plug-in hybrids) are necessary (UBA, 2016). Especially for aviation (UBA, 2016) and for shipping, PtL is needed as GHG-neutral energy supply in these subsectors. The renewable heat sector, both space and process heat, should shift towards electricity-based supply processes and especially focus on efficient technologies such as heat pumps wherever possible. In addition renewable gas as fuel should supply combustion processes, whenever a carbon source is required.

In order to achieve the overall emission objectives at the European level, a general transition in the **transport sector** is needed. Transportation and urban development concepts which include measures to avoid trips, to reduce distances, and to shift towards less environmentally harmful transport modes, to improve energy efficiency and to establish a complete renewable energy supply in transport have to be implemented. In order to transform the transport sector these core elements must go hand in hand, enabling lower energy consumption and lower demand for renewable energies in this sector. However, ambitious intermediate targets for 2030 on the European level and hence enormous efforts in the short term are vital aspects for the sectors

contribution. This is especially important due to long innovation lead-times for transformative emission reductions in transport. The attractiveness and choice of transport mode largely depend on the availability of infrastructure. Hence, adapting transport infrastructure in the short term is a prerequisite for a shift from the road to low-emission options and a coordinated effort for building a trans-European sustainable transport infrastructure.

The EU policy already addresses decarbonization in the **building stock** by 2050[10]. Hence, the new long-term strategy must ensure to significantly increase the quantity and quality of refurbishments in the next decade and a restriction to use only renewable energies for reaching the desired indoor comfort. The new long-term strategy should therefore consider particular policy measures such as quality assurance of the refurbishments, providing information (i.e. building performance certificates for owners) and educational (i.e. training of engineers) matters, which go far beyond technical and regulatory issues.

Direct energy-related GHG emissions in **industry** and commerce can be fully avoided if fossil fuels are replaced by renewable energies in combination with sector coupling (see box 2). In addition, energy and material efficiency in the industry, such as consistent use of waste heat, is required. Therefore, organizations need to be enabled to self-check their status-quo in energy efficiency and climate impact and thus to derive and implement appropriate measures (preferably through energy or environmental management systems or, for smaller organisations, through regular energy audits). The process-related emissions in industry, such as CO_2 originating from the calcination of limestone, non-energy use of carbon-containing energy carriers or the use of solvents and fluorinated gases, have to be minimized to their technical limit. This presents a particular challenge because they can only be mitigated, if at all, by fundamental procedural changes or by substituting raw materials. With regard to the steel industry, for example, this means that in the long-term the primary steel production should be carried out in hydrogen-based direct reduction systems and subsequent melting in the electric arc furnace. Last but not least PtG and PtL could play a major role in supplying renewable based raw materials and thus contribute to GHG reduction in the chemical industry. Nevertheless, in the cement, lime and glass industry the potential for reduction of process-related emissions is limited. Regarding fluorinated greenhouse gases, substances and processes are available to avoid these gases in most applications, e.g. natural refrigerants to replace hydrofluorocarbons (HFCs) in the refrigeration and air conditioning sector. Beyond the phase-down of HFCs to 21% by 2030 according to the F-gas Regulation (EU, 2014), a total phase-out is manageable in the EU by 2050.

A relevant GHG emissions' source is **agriculture**. The most important mitigation measures in this sector are increasing efficiency of nitrogen fertilizer use, limiting stocking rates in general as a significant factor influencing nutrient flows in agroecosystems and ruminant stocking rates in particular (reducing methane) as well as increasing fermentation of farm manure and residues. The long-term strategy must also include policy measures beyond agriculture to address the full agricultural mitigation potential. Such measures include incentives for behavioural changes, i.e. reducing consumption of animal products and food wastes.

Maintaining and enhancing **LULUCF** sinks must play a key role in the new strategy. Therefore, the new strategy must be in line with the EU target of no net land take by 2050 (EU-COM, 2012) in order to avoid loss of natural soil sequestration and locking in additional energy intensive infrastructures. Further, reducing the pressure on land resources can unlock the largest

[10] Energy Performance Building Standard Directive (EU, 2018).

mitigation and carbon sequestration potential, by making more land available for i.e. rewetting agricultural wetlands, maintaining permanent grassland, and afforestation/reforestation. Hence, the strategy should aim at incentivizing such approaches in parallel to the agricultural policy measures mentioned above. In addition, the new strategy should enable a redirection of biomass from energy to long lived products, including through incentivizing innovation and developing the market for long-lived paludicultural and hardwood products. Considering the currently large share of bioenergy in renewable energy sources, assumptions and parameters on resource potential and sustainable applicability of bioenergy require particular consideration. A clear and over time decreasing cap on the use of forest resources is necessary, similar to thresholds on crop based biofuels. In addition, as these measures primarily affect EU's sovereignty and territory, the indirect land use foot print of EU policies outside the EU must be considered. In order to maximize emission mitigation from agriculture and LULUCF, the long term strategy should set clear, quantified targets, with an additional target for CO2 removals, both at EU and MS level, and ensure harmonization with other EU Regulations and Instruments (e.g. Common Agriculture Policy, Nitrates Directive).

The necessary steps in order to restructure the **waste sector** towards "climate-friendly" **waste management** are known and reliable techniques for recycling and waste treatment are available. Withdrawal from landfilling untreated waste, along with increased recycling rates and energy-efficient treatment of residual waste, will result in immediate and long-term GHG reduction. Crucial for GHG reduction within this sector is terminating the disposal of untreated municipal waste to landfills and a diversion of waste streams into recycling and energy recovery. Further, the separation of recyclable material as well as the mechanical/biological treatment or energetic treatment of domestic waste before landfilling reduces methane emissions from landfill sites considerably. The expansion of separate biowaste collection and treatment is necessary. Furthermore, the more efficient use of fermentation technologies instead of composting or cascade utilization of biowaste will lead to reduced emissions in spite of rising volumes treated. **Waste water treatment** in central waste water treatment plants leads to a decrease of methane emissions from septic tanks, thus the connection of households throughout the EU to the respective facilities is crucial in the long term strategy. Waste water and sewage sludge like waste contain energy and, therefore, may be used as a source for energy supply.

2.4 The role of negative emissions

The EU has to reduce GHG emissions on its own territory until 2050 by at least 95% compared to 1990. To achieve GHG neutrality, it may be necessary to remove CO_2 from the atmosphere (CDR[11]), thus compensating a small amount of residual emissions. If net negative emissions after 2050 are required, CDR will have to play an even larger role. The long-term strategy should address this issue and establish an approach to it. In order to avoid CDR being used as an excuse for and to compensate delaying mitigation efforts and risk effective reductions within the EU (as all sectors will need to get as close to zero emissions as possible), the new long-term climate strategy should include a separate target for CO_2 removals at EU level which should be distributed amongst member states based on capacity and potential (similar to effort sharing approaches in current legislation).

There are of course different levels of risk, potential and maturity in various CDR approaches or technologies. The most readily available, least cost and lowest risk measures are those that

[11] Carbon Dioxide Removal (CDR) methods refer to processes that remove CO2 from the atmosphere by either increasing biological sinks of CO_2 or using chemical processes to directly bind CO_2.

maintain and enhance carbon sinks from LULUCF. Therefore the new long-term climate strategy should consider such LULUCF measures, possibly in form of a specific chapter to the long-term strategy. Initially only these measures should be eligible for achieving the respective new EU CDR target. It is however not yet possible to reasonably rule out risks of other CDR approaches and technologies than the above-described LULUCF measures (such as for example carbon capture and storage). In accordance with the precautionary principle, different CDR approaches must be carefully analyzed with regards to their risks, benefits and efficacy before being decided if they can be adopted. Consensus amongst member states should be reached that associated risks needs to be reduced to an acceptable level before any further approach is considered for eligibility. It should be discussed whether a *risk assessment scheme* could provide support in this analysis. The regulatory concept agreed under the London Protocol for marine geo-engineering should be considered in this respect. For any approach or technology (including LULUCF measures) rules or safeguards should also be established to ensure that risks are actually minimized and that CDR measures harness synergies and avoid conflicts with the Sustainable Development Goals. Finally, ongoing debates on CDR reveal, that any consideration of CDR in the long term strategy will require scientific support from inter alia JRC, Horizon 2020 and possibly other research programmes.

2.5 Domestic and international action

The latest low-carbon economy roadmap from 2011 (EU-COM, 2011) suggested that, by 2050, the EU should cut its emissions to 80% below 1990 levels through domestic reductions alone (i.e. rather than relying on international credits). In the first and second compliance period of the Kyoto-Protocol (2008-2012; 2013-2020), however, European emission reduction targets were achieved with the help of using credits from the Kyoto flexible mechanisms, which led to an expansion of the emission budget available within the EU by approx. 1.5 Gt CO_2e.

In the current NDC for the period 2021-2030, the EU has committed to achieve a reduction of emissions by at least 40% domestically, without the use of international credits. It is necessary to raise the ambition of the European emission reduction target in order to ensure compatibility with the goals of the Paris agreement (see section above).

The new low-carbon climate strategy should therefore be very clear that the target to reduce emissions until 2050 by at least 95% and the intermediate targets are to be achieved through domestic reductions, i.e. not relying on the use of market mechanisms that may be developed under Article 6 of the Paris Agreement. The EU should not use these market mechanisms in order to ease the achievement of domestic targets, but in order to contribute to additional climate ambition abroad.

Other than in the period 2008-2020, the use of international market mechanisms shall not lead to an expansion of the emissions budget that is available within the EU. International market mechanisms should therefore preferably not be linked with the European binding, market-based emission reduction instruments ETS and ESR, except for a possible linking of the EU ETS with another, Paris compatible ETS in the future. If however, against this advice, the EU should decide to admit units from international market mechanisms in European carbon markets, then the lessons learnt from the past should be taken by adjusting the respective EU internal caps downwards equivalent to the maximally permitted inflow of units from international mechanisms. It goes without saying that only units from high quality mechanisms should be admitted, i.e. units from activities which are compatible with the long-term targets of the PA.

2.6 Overarching Policy Considerations beyond Technicalities

With its overarching climate and energy policy framework, including the Low-Carbon-2050-Roadmap (EU-COM, 2011) the EU was respected as progressive until the beginning of the outgoing decade. Since then, this momentum faded little by little not only due to economic and fiscal disruptions within the EU (i.e. financial crisis) but also because of developments outside the EU's sovereignty. Having pushed for the PA and its implementation while simultaneously establishing its mid-term climate and energy framework (EUCO, 2014), including Emission Trading System Directive (EU, 2018a), Effort Sharing Regulation (ESR; EU, 2018b), LULUCF Regulation (EU, 2018c), Renewable Energy Directive (Council, 2018a), Energy Efficiency Directive (Council, 2018b), Energy Union Governance Regulation (Council, 2018c), the EU struggles to regain back its reputation and trust among international partners.

During the negotiations of the PA in November 2015 at COP21 under UNFCCC[12] the EU was recognized as influential partner in the "High-Ambition-Coalition". Now, by announcing a holistic analysis of transformation options across all key sectors of the economy[13], the new long-term climate strategy as such is due to represent, besides immediate implications for the rather narrow scope of climate policy, a far broader impact on other policy domains, i.e. inclusive growth, structural change, (social) innovation, research and development and digitalization, respectively. Provided this, the new long-term climate strategy should also exploit synergies and address possible trade-offs with relevant Sustainable Development Goals (i.e. SDG 7, SDG 8, SDG 9, SDG 11 - SDG 15[14]) to help attaining the objectives of the PA (UBA 2016b).

As a consequence, the new long-term climate strategy of the EU should be developed as a multifunctional toolkit delivering a principle guideline on the EU's adequate share to the PA and a climate policy guidance for international (i.e. economic) cooperation. With respect to the Energy Union Governance Regulation, the new long-term climate strategy could also represent a guardrail for EU's member states in developing and implementing their own long-term national climate strategies. In addition, as transformation processes are not only enabled solely by technological progress, the EU's new climate strategy should tackle apart from rather techno-economic challenges lifestyle changes, in particular in domains, i.e. mobility, diets, where full decarbonization is challenging, including sustainable patterns of consumption and production.

From a rather political point of view, however, the EU must signal with the strategy both its seriousness on the Paris Agreement's objectives and its self-commitment to this strategy in future policy making including various related domains and fields of action, such as modernization and innovation; enhancing quality of life; and enabling a just transition respectively. Therefore a high-level engagement by and political ownership of the European Council is key to the strategy.

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[12] Speech of EU-Commissioner Cañete during COP21: "How we formed the High Ambition Coalition". - www.businessgreen.com/bg/opinion/ Download: March 2018. -

[13] i.e. Director General Petriccione (DG Climate) during the "EU LIFE MaxiMiseR Conference "Plan it right: - fighting climate change through 2050 strategies" on May 23rd 2018 in Brussels. -

[14] **SDG 7**: Ensure access to affordable, reliable, sustainable and modern energy for all; **SDG 8**: Promote - sustained, inclusive and sustainable economic growth, full and productive employment and decent work - for all; **SDG 9**: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster - innovation; **SDG 11**: Make cities and human settlements inclusive, safe, resilient and sustainable; **SDG 12**: - Ensure sustainable consumption and production patterns; **SDG 13**: Take urgent action to combat climate - change and its impacts; **SDG 14**: Conserve and sustainably use the oceans, seas and marine resources for - sustainable development; **SDG 15**: Protect, restore and promote sustainable use of terrestrial ecosystems, - sustainably manage forests, combat desertification, and halt and reverse land degradation and halt - biodiversity loss. -

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