Horizon 2020 Societal challenge 5:
Climate action, environment, resource efficiency and raw materials

COP21 RIPPLES

COP21: Results and Implications for Pathways and Policies for Low Emissions European Societies

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1. Changes with respect to the DoA

(with justification if applicable)

N.a.

2. Dissemination and uptake

(who will/could use this deliverable, within the project or outside the project)

This work is disseminated in a targeted way to specific audiences: the main conclusions on adequacy assessment is translated into a dedicated Policy Brief to maximise accessibility among EU policy-makers (Getting on to the right (emissions) path: An adequacy assessment framework and its application within the EU) and the focus of the last Policy Dialogue (EUCALC-COP21RIPPLES joint event, January 2020). Bilateral meetings with EC representatives and EU think tanks are planned to share and discuss our research findings in the context of the upcoming regulatory development of the European Green Deal (particularly Climate Law, Climate Pact, NECP Final Review under Governance Regulation). Knowledge gaps are to be shared with representatives from DG RTD through our H2020 Project Officer. The South African specific discussion led by Andrew Marquard will be separately published and circulated A specific mailing will also be prepared to share Key Findings section to the stakeholders of the COP21 RIPPLES Database, as well as other public channels (Climate-L, newsletters from Consortium partners). An academic publication is under discussion.

3. Short Summary of results (<250 words)

We are not on track to meet the Paris Agreement mitigation goals: the challenge is to better understand the nature of this gap and to feed political discussions at all relevant levels and across these different levels on how to address it. Studies on general abatement potentials or theoretical economic assessments have played a role but have limited capacity in moving us further. The successful implementation of the PA inevitably requires addressing different inter-connected dimensions: governance, economic and social, political, sectoral & physical transformations and GHG emissions. COP21 RIPPLES humbly contributes to the understanding of the significance of these dimensions, as well as establishing practice and developing methods for these analyses. An array of research papers covering all these dimensions provide insights for specific policy discussions in specific geographies. For each of the areas of study, EU-specific recommendations have been derived. The overarching take-aways that are relevant to current EU policy-making -and which should be regarded as complementary to specific findings- are as follows:

1. Take a sectoral approach
2. Benefit from early action and investments
3. Tackle the financial system to support its transformation
4. Make industrial & innovation policy central to the challenge
5. Adopt a country-driven approach to EU 2030 climate commitment enhancement
6. Use adequacy assessments to inform policy debates and track progress
7. Strengthen ‘guidance and signal’ function of international governance to accelerate ambition in emerging economies

4. Evidence of accomplishment

(report, manuscript, web-link, other)

A report is submitted and uploaded in the COP21 RIPPLES website.

Table of contents

1 Introduction

The COP21 outcome represents an important new strategic context for EU climate policy, both at the international but also at the EU level. Analysing the implications of this new context requires an interdisciplinary approach. It requires a capacity to combine analysis of the adequacy of the outcome of COP21 and the evolution of the international climate regime complex; to analyse NDCs and deeper mitigation pathways; and to assess their socio-economic implications at multiple levels: Member State, EU, and globally. COP21 RIPPLES research has contributed to this analysis.

In this report, we build on the results of the global and country-scale assessments, case studies and cross-cutting analyses conducted within COP21 RIPPLES to reveal the main dimensions on which targeted effort and action will be required to increase the ambition of national emission reductions in line with the Paris Agreement goals. It is not meant to be a summary of all the research findings, but rather an exercise to build a common outcome based on the diverse inputs and explicit and implicit learnings from this three-year multidisciplinary research effort.

Section 2 provides conclusions on the assessment of the adequacy of the global response to COP21, from analytical and empirical evidence to normative forward-looking perspectives. It defines an adequacy framework and deliberates on its potential application at EU and international levels. Section 3 adds strategic considerations for the application of such adequacy assessments ('when', 'how', 'who', in addition to the 'what'). Overarching conclusions are presented in Section 4. This reports also includes three all-important Annexes: two thought-pieces that elaborate further on the learnings of COP21 RIPPLES from two very different perspectives, the induced innovation and path dependency by Michael Grubb and Ali Poncia (Annex I) and considerations for the NDC enhancement and the next NDC in South Africa by Andrew Marquard (Annex II). Annex III puts forward a compilation of research and innovation gaps identified across the research undertaken under COP21 RIPPLES.

2 Assessment of the adequacy of the COP21 outcomes[1]

There is a generalised acknowledgment that the world is not on track to meet the Paris Agreement (PA) long-term goal of holding the increase in the global average temperature to well below 2C, let alone to 1.5C. In its final decision, the recent COP25 *re-emphasizes with serious concern the urgent need to address the significant gap between the aggregate effect of Parties' mitigation efforts (…) and aggregate emission pathways consistent with* the goal.

If current efforts were to remain unchanged, i.e. at current NDCs level, the necessary transformation of the energy systems to reach carbon neutrality would be abrupt from 2030 with evident transition acceptability consequences and we would have missed the opportunity to reduce the overall cost of the transition through 'learning by doing' and avoiding locked-in investments (COP21 RIPPLESa). The current

[1] Large part of this section can be found in a separate COP21 RIPPLES Policy Brief (COP21 RIPPLES, 2020. Getting on the right (emissions) path. Available on: www.cop21ripples.eu)

ambition level becomes a fundamental matter of feasibility to meet the PA mitigation goals, within and beyond the energy systems.

As Marquard (2020)[2] explains, most Parties' NDCs, were developed *and communicated before the Paris Agreement was adopted, and before the "Paris Rule Book" was adopted at COP 24 in Katowice in 2018*. Along with the evolution of the international climate regime, significant changes have taken place across the world and in the international political and economic realm. COP21 RIPPLES captured some of these in the analysis of the potential strength for certain key technologies, the speed of innovation and dynamics of diffusion (COP21 RIPPLES D3.3, COP21 RIPPLES D4.3; Grubb 2020). Looking into the socio-economic aspects of the transition, our research found an echo in actual political debates (for instance, with the EU proposed Carbon Border Adjustment measures), rising discourses (Just Transition) and movements driven by social and economic concerns, such as the yellow-vest in France or the protests in Chile. The study of the political economy of climate policy in emerging economies further contributed to understand the often poorly understood links between climate mitigation ambition and the realities of the countries and of the people.

In 2020 countries have the first opportunity to revise NDCs, following a 5-yearly successive review process defined in the PA. An adequate enhancement (from a GHG emissions perspective) would at least imply the necessary adjustments to consider the new parameters of the Agreement in Article 2, *today quantified by the IPCC SR15, which provide a set of constraints which are more stringent than before*. *The key distinction, since IPCC SR15, and since it is now 2020, is the emphasis on mapping a pathway to zero emissions* […] which generates the key questions at country-level about *which year one expects emissions to peak, and in what year emissions will reach zero* (Marquard, 2020).

Beyond GHG emission targets, COP21 RIPPLES argues that the ambition enhancement should only be considered adequate if it helps transform our societies so as to meet the global mitigation goal. Understanding adequacy becomes key. To contribute to this discussion, we provide a framework to think about the 'adequacy' of the global response based on the evidence found through the COP21 RIPPLES multidisciplinary research.

2.1 Objectives of an Adequacy Assessment framework

The first objective for establishing such a framework is the possibility to bring the political discussions underlying the transformation to public attention and disclose its diverse and inter-connected dimensions for coherent policies and approaches. The framework can help shaping actual discussions with views to unblock action and ambition which are largely driven by higher visibility of climate risks and impacts, and the civil society mobilisations stirred up by the youth.

The assessment of adequacy has a second objective: to track progress. The shift towards a dynamic, iterative regime of climate governance, based on learning and innovation and hopefully rapid strengthening of institutions, cooperation and policy commitments of the PA (Spencer *et al*., 2015) implies

[2] Marquard, A (2020) can be found in Annex II of this report.

a thorough and continuous monitoring of progress and prospective analysis against normative deep decarbonization pathways and its underlying drivers, as well as metrics that help us understand the pace of the transition (willingness, consensus, confidence).

With these two objectives in mind, adequacy assessments should play a prominent role at two levels: first with sectoral approaches, which are more likely to deliver ambition and can make transformation happen on the ground (COP21 RIPPLESa); second, with multi-level approaches that are needed to coordinate across levels of governance and action. For the EU as an example, this would entail the need to consider the specificities of subsidiarity and sovereignty principles of Member States (MS)—in particular their sovereignty over their own energy mix guaranteed by EU Treaty—as well as embracing heterogeneity as starting point.

2.2 Pillars of an Adequacy Assessment framework

According to IPCC 1.5SR reaching the 1.5C target requires a gigantic transformation of our economies and societies. Studies on general abatement potentials or theoretical economic assessments have played a role but have limited capacity in moving us further. The analysis of concrete changes that should drive pathways towards the 1.5C and its socio-economic implications must be focused on overcoming the technological, financial, policy, cultural and governance-related barriers that enables an acceleration of climate action and considerations of increased ambition in the context of new NDCs. As illustrated in Figure 1, an adequate response to this challenge should, at the very least:

1. Not be assessed (just) in terms of GHG emissions, but its underlying drivers. This ensures a response that tackles the structural transformative changes that are required, and avoids unrealistic nor desirable sequential approach to sectorial changes or insufficiently consideration of the links between solutions
2. Take into account the socio-economic reality, rather than define approaches based on oversimplified views of the world. For example, when discussing how technology is diffused in the real world, or understanding barriers to change (political, societal preference, behavioural, etc..)
3. Use the potential of sectoral global approaches and international cooperation to support the transformation.

However, if we look at current NDCs, as main planning instrument to bridge the ambition gap at international level, the focus is on economy-wide emissions, with few or no details on sectoral transformations and without factoring in the potential of international cooperation.

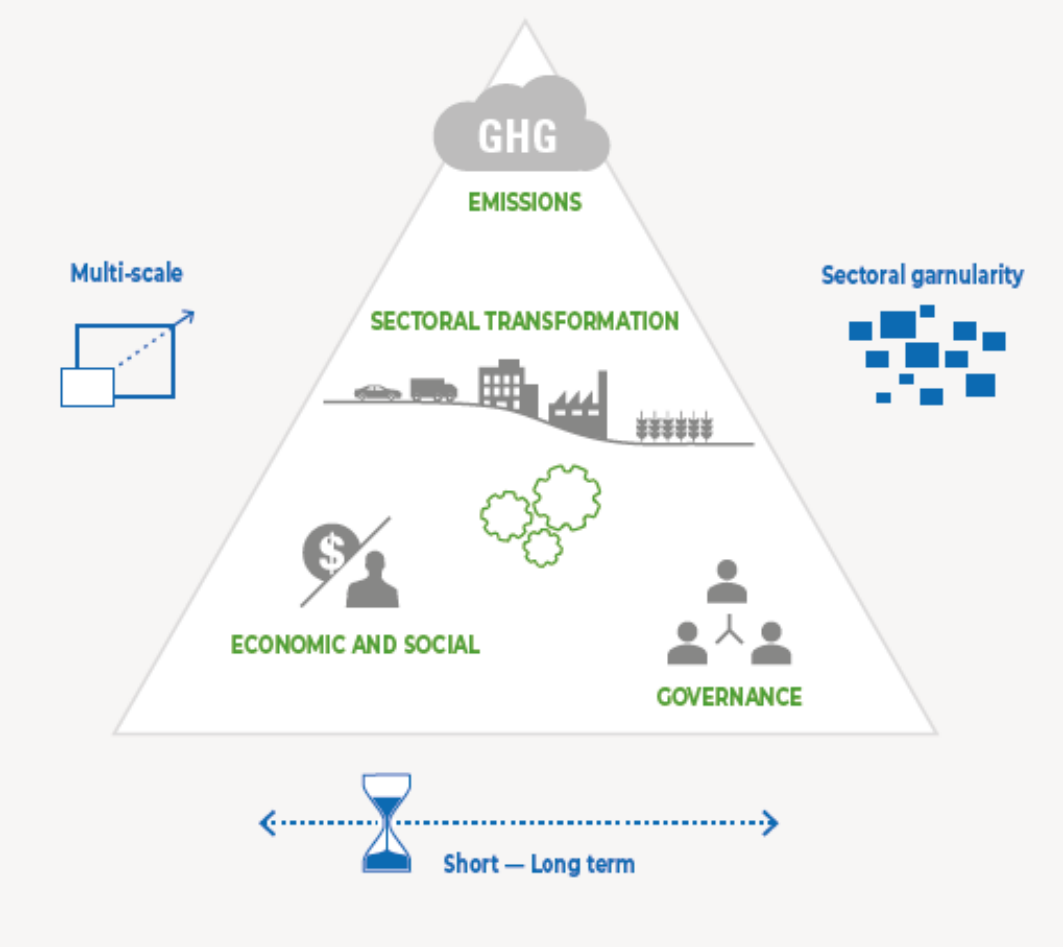

Figure 1 COP21 RIPPLES Assessment Framework features

COP21 RIPPLES research shows that gaps and opportunities exist for different dimensions—economic and social, governance—but often the focus is solely on emissions. From an environmental viewpoint, the gap on emissions is not the only effective marker of the insufficiency of climate policies. When looking at emissions, the alignment between the short and the long-term desired outcomes are not always enforced (COP21 RIPPLESb) and the debate on temporal aspects is poorly associated to the transformation requirements. For a given volume of emission reductions over time, different emissions profiles allude to different transition stories and associated risks. In the EU for example, freezing ambition to current NDC level by 2030 would imply that the relative reduction effort between 2030-50 would need to be almost twice as high compared to a scenario of enhanced ambition by 2030 in the energy system (COP21 RIPPLES D2.4). The analysis of socio-economic consequences in COP21 RIPPLES, for energy security (COP21 RIPPLES D3.2), industrial competitiveness (COP21 RIPPLES D3.4) or inequalities (COP21 RIPPLES D3.6) illustrates the need to manage the transition in the short term for effective transformations. Results on energy affordability in Bulgaria (COP21 RIPPLES D3.2) or upfront costs in developing countries (COP21 RIPPLES D3.5) require attention, to name few. COP21 RIPPLES D3.5 argues for the need of early investments to

foster learning and countries specialization to certain low-carbon technologies, often blind to ambition assessments. This report finds that an existing strong sector can fail to develop new technologies (electric vehicles in Italy), but also massive industrial expansions do not automatically yield the latest technology (PV in China) or same policy frameworks result in different outcomes from country to country (local content requirements for wind energy in Brazil and South Africa), which emphasises the importance of the context. On governance, COP21 RIPPLES D4.2 identifies opportunities to strengthen governance for most sectoral systems, and interestingly different across them, and COP21 RIPPLES D4.4 highlights the potential of international governance to tackle political economy barriers in emerging economies. International cooperation in the format of decarbonization clubs within the industrial sector can precipitate the transformation of specific sub-sectors, such as iron and steel, at the global level in a way that an in-country industrial and/or climate policy could not achieve.

These findings illustrate the importance of the different dimensions and the need to connect dots among them. We argue that only comprehensive approaches that address all of them, taking into account their interrelationships, are likely to keep 1.5C within reach. Rather than overcomplicating things, a more textured response, embedded in the realities of the different geographies and for each of the sectors, while making the best of international cooperation, will facilitate the design of possible new avenues to make a more rapid and effective transition (from an environmental perspective) possible.

2.3 Application of an Adequacy Assessment framework at EU level

The European Union is facing internally similar coordination challenges as elsewhere: finding a balance between Member States (MS)/regional *versus* pan-European approaches, sectoral *versus* national policies and short- *versus* long-term objectives. Applying "at home" the principles above mentioned will both help the EU and MS political processes and represents an opportunity to become a role model in ensuring an efficient implementation of its environmental objectives. A first priority should be to ensure existing tools of the Governance Regulation -the integrated National Climate and Energy Plans (NECPs) for 2030 and the national long-term strategies (LTSs) for 2050 - produce the necessary level of detail to reveal how they intend to fulfil their part of the EU climate mitigation effort. Both the NECPs and LTSs should give sufficient details on sectoral transformations, integrate socio-economic realities and identify areas of cooperation both with neighbouring countries, within the EU and at the international level. Importantly, NECPs should be assessed against the capacity to deliver the long-term ambition defined at national and EU-level. This should facilitate the needed political conversations at EU level and may be regulated in the context of the Climate Law.

The high-level political priority given to the European Green Deal will help drive changes in many existing policy levers and drive the creation of new ones at the EU and MS levels. However, ensuring that changes in existing policy packages happen in a coherent manner to deliver on all priorities will be of crucial importance to increase their efficiency and, in the end, the ability of the EU to deliver on its promises. The recent endorsement of the climate neutrality objective for 2050 and update of EU's GHG emission objective from -40% to -50% or -55% in 2030[3] announced as part of an overarching Green Deal policy initiative implies overall targets more aligned with the PA goals but also an even more intensive

[3] GHG emissions compared to 1990.

coordination across dimensions and sectors and a higher value in identifying synergies among them. To have a brief overview of the challenge, consider the 11 priorities (see Figure 2) set by the European Commission. All of these priorities and policy areas are strongly interlinked and require mobilising a variety of policy levers (regulation, standards, investments and innovation) at both the EU and MS levels. In addition, most identified priorities will have important impacts on other dimensions: energy policy will increasingly crossover with land-use and ecosystems protection as energy systems become more renewable-based while urban and space developments will impact the ability to shift to a more sustainable mobility.

Figure 2 Representation of the European Green Deal

NECPs, LTSs, and the application of the adequacy framework principles can help refocus the political discussion on identifying the areas where strategic alignments at the EU level or for a group of MS through regional cooperation are necessary such as finance regulation and macroeconomics policies, trade, industrial policy or energy infrastructure. In particular, an increased role should be given to monitoring and reporting on progress and implementation in the EU policy process as it allows to: (1) collect information that can inform the revision of policies by drawing lessons from experience; (2) present this information in an accessible format that ensure a transparent public debate regarding the achievement of objectives; and (3) understand the drivers and barriers to implementation by providing invaluable evidence to ground foresight work (Rudinger, 2018).[4]

Based on this diagnosis and the learnings emerging from COP21 RIPPLES, next we focus on three actions that the EU could engage today regarding the recently adopted EU energy and climate governance process,

[4] Rudinger (2018), Creating a dashboard to monitor progress for the low-carbon transition, IDDRI *study* n°11/2018

the European Climate law to be presented in March, and its announced Climate Pact as part of the Green Deal.

1. Use the NECPs final review process to structure a political discussion on ambition and sector-level priorities by linking them to the European Semester

A first assessment of draft NECPs in 2019 produced by the European Commission[5] identified significant ambition gaps, in particular in aligning with renewable and energy efficiency targets defined at the EU level and in integrating industry, innovation, financing opportunities and social dimensions. Therefore, the EU should give a high political priority to ensuring final NECPs do respond to the identified gaps and communicate its assessment at the highest political level. Then, the information included in the NECPs should serve as a basis to evaluate progress of MS regularly in the European Semester, including progress at sectoral level. The EU should also make sure that all MS produce their long-term strategy in 2020 with the appropriate amount of detail. The EU should review MS assessments on the alignment of NECPs with national long-term strategies; it should also compare the combination of these national strategies with the EU long-term vision for a climate neutral economy in 2050 in order to foster a country-driven policy debate on how to achieve carbon neutrality in the EU in the context of the sectoral policies work scheduled for 2021.

2. Invite MS to consider the establishment of independent advisory bodies in the Climate Law to be presented by March and ensure existing EU institutions support their collaborations at EU level

Independent advisory bodies can be very effective climate governance tools to inject the long-term nature of climate action into current policy processes. The UK has been a pioneer in putting in place the Climate Change Committee in 2008 which now has a central role in evaluating the impact of climate mitigation and adaptation policy and defining UK carbon budgets.[6]Today, a growing number of EU countries—and some EU subnational authorities—have recently put in place such entities (France, Sweden) to measure progress and advise on climate policy (both mitigation and adaptation) with a right to propose measures or targets. In developing these activities, these advisory bodies beneficiate greatly from cooperation with their counterparts and the use of similar adequacy assessment frameworks. The UK, German and the former French advisory bodies[7] already developed common reflections in workshops[8] and some of its members recently advocated for establishing an Expert Advisory Commission to assist the G20's Energy

[5] European Commission (2019). Communication "United in delivering the Energy Union and Climate Action - Setting the foundations for a successful clean energy transition https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1565713062913&uri=CELEX:52019DC0285"

[6] Rudinger, A. and Vallejo, L. (2018). Le comité pour le changement climatique au Royaume-Uni, quel retour d'expérience et quels enseignements pour la France?, IDDRI *Study* n°06/18

[7] Before the current Haut Conseil pour le Climat was established, the comité d'expert pour la transition énergétique existed since 2015 with a more limited mandate.

[8] "Monitoring and managing energy transitions: Experiences in the UK, Germany and France" workshop in Paris the 27th of March 2017 and "Seminar of the German and French Expert Commissions for the energy transition", Mannheim 26th of September 2018.

Transformation Processes.[9] EU institutions have a role to play to support this type of cooperation. At the EU level, the European Environmental agency (EEA) already produces indicators on climate and energy policy and Sustainable Development Goals.[10] Its current role is limited to producing data and analysis on a regular basis or on demand but it could support a collective work on applying a common adequacy framework and develop a large set of 'adequacy indicators' and should be made up of experts.

As part of the Climate Law, the EU should mandate the EEA to support cooperation among climate advisory bodies for the production of analysis and data recollection and invite MS that do not have such advisory bodies to consider putting one in place. The EU should offer the support of its existing institutions and a common framework laying down the terms of reference on their function (independence, monitoring of the transition, policy and target recommendations, and publicity of their work) leaving the introduction of such advisory bodies in the different institutional contexts in the hands of national governments. In the future, national advisory bodies' cooperation could develop in a similar way than what the ACER[11] did for National Regulation Agencies on energy regulation. Broader cooperation to include subnational advisory bodies could be explored, following the example of the EEAC Network.[12]

3. A European stocktake to prepare EU contribution under the Paris Agreement as part of its Climate Pact

The Climate Pact announced for March 2020 rightfully emphasises the need to engage with the public on climate action by multiplying information sharing and citizen's dialogues and providing opportunities to civil society and grassroots initiatives to express ideas and work on how to achieve climate objectives. To do so, it is essential that the EU takes a proactive role in exposing the priorities and socio-economic consequences of the ecological transition. However, it is equally important that the views of citizens', subnational authorities, local authorities and civil society resonate into the climate governance process across all dimensions and to the top. Building on the learnings on adequacy laid above, this stock take should be designed in a way that provides a systematic assessment of transformation challenges and barriers. In addition, the EU is an example of multi-level governance and the way it builds its consensus could contribute to smooth a consensus at the global level. Therefore, the EU could inform its internal policy process by organizing a regular process where governments and all actors of the EU society build a common understanding in the progress made in the low-carbon transition, present and discuss their way forward and potential readjustment of long-term strategies and accordingly short term public policies. This could take the form of a European stocktake among all EU MS governments and open to all actors of EU societies. Though focus and features may not fully coincide with the Global Stocktake laid down in the PA, implementing an European one will also contribute to the design and the credibility of the Global, supporting the EU leadership in the international sphere. To be able to inform the update of the EU contribution to the global effort, this EU stocktake should ideally take place at least every five years ahead the PA's Global Stocktake.

[9] https://www.g20-insights.org/policy_briefs/establishing-expert-advisory-commission-assist-g20s-energy-transformation-processes/

[10] The European Environment - State and Outlook 2020: Knowledge for Transition to a Sustainable Europe (European Environment Agency).

[11] The Agency for the cooperation of Energy regulators https://www.acer.europa.eu/fr

[12] The European Environment and Sustainable Advisory Councils (EEAC) https://www.eeac.eu

2.4 Application of an Adequacy Assessment framework at international level

The PA's Global Stocktake is a critical opportunity to assess adequacy, and therefore establish a political discussion beyond emissions, including sectoral assessments (Hermwille 2019, Jeffery 2019). Developing the global framework will make it possible to "sum up" these visions and discuss the global image that is progressively emerging, compared with more normative top-down vision. For this to happen, new or enhanced NDCs and LTSs expected in 2020 should enable such discussions. The EU needs to take leadership in framing NDCs in a way that will invite others to reveal these sectoral dimensions, their multidimensional framing, and the policy assumptions (beyond domestic level) and in promoting the development of LTSs that empower domestic thinking and policy exploration within the global long-term Paris vision of neutrality.

3 Strategic considerations

Based on the application of an adequacy framework at a specific level of governance, political discussion, policy design and implementation can be effectively shaped in that particular jurisdiction. Most decisions will have to respond to considerations of timing, structural transformation and leadership. The **timing** matters, not only from a physical transformation perspective but from a social and economic perspective. For instance, Grubb (2020)[13] argues that where *clean technologies become cheaper than traditional technologies, then not only will the speed of decarbonization be increased, but also the economic and political sphere will be easier to navigate*, and explains the risks of model-based analysis that ignore the impact of inertia, induced innovation (including learning-by-doing and scale economies), and path dependence as they are likely *to suggest erroneously to defer abatement, while greater dynamic realism implies it is optimal to make bigger efforts initially, and that significant benefits may flow from this*. The importance of this finding is underlined when looking at the evolution of country-level techno-economic scenario analysis results over time. In South Africa, Marquard (2020) finds that the biggest factor affecting long-term emissions scenarios is the drop in the cost of renewable energy technologies and the projected cost of battery electric vehicles, which in studies from 2018 onwards become least-cost technologies (renewable energy technologies in the present, and BEVs in the 2020s). In short, delaying action implies a triple burden: doing more later, being less prepared for it and paying more, besides a fundamental matter of feasibility to meet the PA mitigation goals (COP21 RIPPLESb). Accordingly, countries should start early to deploy and develop low-carbon technologies, concentrate on promising technologies, exploit individual regional strengths and bear in mind the opportunities and constraints of the national innovation systems (COP21 RIPPLESa).

When addressing **the question of transformation**, policy responses will need to explain how their contribution is aligned with the long-term objectives. Only strategies that are robust and normative to reach net zero emissions around 2050 can meaningfully inform the short term. The discussion of the current state of NDC and NDC enhancement discussions in South Africa by Marquard (2020), which may

[13] See Annex I of this report. Extract based on:

be illustrative for a large number of countries, makes this point central, *further work post the 2020 enhancement, anticipating the next NDC, should focus on long-term sectoral decarbonization strategies for South Africa, and on associated policies and measures to achieve this in the short, medium and longer term associated with the multi-faceted problems of the transition and its associated development challenges*. Robust strategies are found to be those that put at the centre the social and economic dimensions of a given context. Even for a central issue such as distributional and inequality impacts, D3.6 argues there is not enough research done on and data available for sound analysis, and points out the weaknesses of current economy wide modelling exercises that may underestimate the challenges of just transition, such as the assumption of the perfect labor mobility.

Making the case for country-driven approach (national and local levels) to effectively engage affected communities and produce economic and societal transformations with clearly identifiable benefits, is not meant to undermine the service of international governance and cooperation. To the opposite, it will help informing its design and the underlying political discussions. Climate policy has always been characterised by different levels of ambition among Parties, sectors or organisations (Grubb, 2018). Where action is taken first and by whom (which countries, regions, or subnational authorities, which sectors, or which constituencies) has obviously an effect on the evolution of the physical transformations, the socio and economic consequences, and notably how international cooperation is understood and orchestrated. For example, based on country pathways transformation needs and systematic assessment of sector-level governance needs and opportunities, COP21 RIPPLES found that a transnational steel sector decarbonization club can advance domestic & global decarbonization of this sector (COP21 RIPPLES D4.3), and in fact, it could be an ideal testbed to pilot the introduction of border carbon adjustments as discussed within the European Green Deal and provide an enabling policy environment that allows for conventional CO2-emitting primary steel production to be phased out altogether by 2050 in Europe, and soon thereafter in emerging countries (COP21 RIPPLESd). Within the EU, exploring heterogeneity across Member States implies the identification of identify of cooperation opportunities and intra-EU solidarity measures as illustrates the Italian discussion on its positioning towards the world of e-mobility[14] (COP21 RIPPLES D3.3), the Polish deliberation on different ways to seek for a robust and balanced solution in the long term[15] (COP21 RIPPLES D3.2) or the Bulgarian discussion on household-level affordability concerns resulting from a multi-dimension energy security analysis across EU countries (COP21 RIPPLES D3.2).

[14] Video on this topic available at www.cop21ripples.eu by Maria Rosa Virdis (ENEA)
[15] Video on this topic available at www.cop21ripples/eu by Aleksander Sniegocki (Wise Europa)

4 Key findings

We are not on track to meet the Paris Agreement mitigation goals: the challenge is to better understand the nature of this gap and to feed political discussions at all relevant levels and across these different levels on how to address it. Studies on general abatement potentials or theoretical economic assessments have played a role but have limited capacity in moving us further. The successful implementation of the PA inevitably requires addressing different inter-connected dimensions: governance, economic and social, political, sectoral & physical transformations and GHG emissions. COP21 RIPPLES humbly contributes to the understanding of the significance of these dimensions, as well as establishing practice and developing methods for these analyses. An array of research papers covering all these dimensions provide insights for specific policy discussions in specific geographies. For each of the areas of study, EU-specific recommendations have been derived. The overarching take-aways that are relevant to current EU policy-making -and which should be regarded as complementary to specific findings- are as follows:

1. **Take a sectoral approach**

   Sectoral approaches facilitate the understanding of the drivers of transformation and the appraisal of policy options, open the door for discussions framed in terms of economic and social progress and are a pre-requisite for strengthening international governance.

2. **Benefit from early action and investments**

   Early investment to foster learning reduces decarbonisation costs in the long term and offers economic opportunities for countries to develop new low carbon technologies and sectors. Countries should concentrate on promising technologies, exploit individual regional strengths and consider the opportunities and constraints of the national innovation system.

3. **Tackle the financial system to support its transformation**

   Current policy approaches to accelerate the pace and increase the ambition of the transformation of the financial system should be challenged as to fix its incapacity to deal with common goods and embrace long-termism. Finance cannot limit itself to growing green niches and must stop investing in carbon intensive assets.

4. **Make industrial & innovation policy central to the challenge**

   Industrial transformation is at the heart of the decarbonization challenge, and must be addressed with a coherent and ambitious industrial policy and innovation strategy. A transnational steel sector decarbonisation club could help advance domestic decarbonization and be an ideal testbed to pilot the introduction of border carbon adjustments.

5. **Adopt a country-driven approach to EU 2030 climate commitment enhancement**

   Improve 2030 commitment to ensure politically resilient decarbonisation pathways. Increasing pre-2030 ambition leads to a smoother and more realistic transition, avoiding asking for more from a specific sector, which may increase acceptability problems. For this Member States need to be equipped to define their own role in the EU long-term transformation towards neutrality to inform

coherent EU-level investments, cooperation strategies and solidarity mechanisms. Similar conclusions can be drawn at international level in anticipation of the next NDC, which should focus on long-term sectoral decarbonization strategies, and on associated policies and measures to achieve this in the short, medium and longer term associated with the multi-faceted problems of the transition and its associated development challenges.

6. Use adequacy assessments to inform policy debates and track progress

As explained in the previous, a multidimensional framework to assess the adequacy of global and country-level responses can play a key role in tracking progress and identifying avenues for international cooperation, given the dynamic and interactive nature of the ambition ratchet-up mechanism of the Paris Agreement. The EU should apply this framework in its policy process to accelerate climate action in context of the EU Green Deal and strengthen coherence across policy areas.

7. Strengthen 'guidance and signal' function of international governance to accelerate ambition in emerging economies

There is potential for NDC policy processes to be positively influenced by supporting actors operating according to the transparent, open communities that are explicitly orientated to general welfare, as well as demonstrating effectiveness of country-driven sectoral approaches to feed political discussions and constructive cooperative strategies. The signal function of global climate governance had significant influence on creating momentum to initiate policy processes and implementation within the constraints of national network competition. This power of international norms should not be underestimated and can potentially make a big difference in high emissions intensive economies, including India and China (D4.4).

5 References

COP21 RIPPLES[16]

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6 Annex I: Reflections on induced innovation and path dependence in modelling

By Michael Grubb with Ali Poncia, UCL

An important aspect of the decarbonization-innovation nexus is not only the potential strength in a technology, but also the speed of innovation and dynamics of diffusion. If clean technologies become cheaper than traditional technologies, then not only will the speed of decarbonization be increased, but also the economic and political sphere will be easier to navigate. Therefore, understanding the rate (and direction) of technological progress in clean (and dirty) energy is of first order importance, as is understanding how we can accelerate the cost reductions.

The models typically used for integrated assessment modeling, including many of those used in the course of the COP21 RIPPLES project and the model-comparison projects on which the IPCC typically draws, are based on some form of multi-period equilibrium. These include partial (eg. TIAM-UCL), general (eg. ENGAGE), or Stochastic (eg. MEWA). These models are very useful for exploring consistency across energy and economic systems, but are more limited with respect to representing the dimensions of transition and innovation.

Other work in COP21 RIPPLES estimated experience curves of low-carbon technologies to make probabilistic forecasts of future costs. When expanded to a suite of technologies, the analysis establishes a theoretical link between technology portfolios and financial portfolios. More broadly, work led by the UCL PI Prof Grubb has both explored the empirical evidence around induced innovation, and the wider implications of including this in modeling.

Empirical evidence

The empirical evidence from wide-ranging literature survey led by Ali Poncia at UCL is that: there is clear and unambiguous evidence that broad market conditions affect innovation, primarily as measured by patents. Specifically, rising energy prices and the introduction of carbon (and other) environmental pricing has generally, but not in all respects, enhanced 'green patenting' (ie. for cleaner energy-related technologies); more limited studies of impact on private R&D tend to reinforce the findings. Results are now extensive enough to build up multi-study estimates of the elasticity of patent generation with respect to energy prices. However, the range of estimates remain wide and the links from patenting to cost reduction, little documented.

Tentative evidence from the across the range of market-wide studies suggests that the 'market-wide' innovation induced tends to be more incremental, associated with incumbent industries seeking to improve their established technologies, rather than radical. As with market-wide influences, the statistical literature on the impact of technology-pull policies focuses mainly on patent generation. Feed-in tariffs, the most widely studied, tend to generate the strongest patent response especially for PV though even in this case, not all studies find positive impacts. Technology standards appear to have been a principal driver of patenting in the buildings sector (though potentially eclipsed by other drivers including labeling and subsidies for many appliances), and to have accelerated 'green patenting' for vehicles in Europe. The case study literature supports many of the findings, and in particular,

emphasizes that the co-evolutionary dynamics between innovation and policy can be very important, as innovation allows and can encourage the strengthening of environmental and clean-energy policy.

The major energy-related literatures on energy technologies demonstrate clear and unambiguous correlation of technology cost reductions with increased deployment for all technologies studied except nuclear power (the experience curve literature). Cost reductions associated with a doubling of market size ('experience rates') vary mostly in the range 5-20% across different technologies and studies. Smaller scale modular technologies, like PV, tend to be at the higher end of cost reductions, reflecting huge continuing cost reductions even as dominant designs emerged and move from initially concentrated deployment to wider global diffusion. However, of this sizeable literature, direct testing for a causal link from deployment to cost reduction is limited to a very few papers (though the results of these suggest clearly positive causality). Major components of causality are demonstrated by cost component analyses, particularly regarding economies of scale at the level of installed units, factory size, and industry (eg. larger efficient supply-chains) level. Case studies also provide insight into the plausible mechanisms underpinning observed cost reductions: economies of scale and learning-by-doing, but also increased private R&D (a result of both growing revenues for technology-producing firms, and increased market expectations about future revenues).

Emerging evidence also points to economies of financing (lower cost of capital) as technologies and industries mature, as financial communities become more familiar with, and more confident about, technology performance and surrounding regulatory regimes. Thus, while a causal link between deployment scale and cost reductions is extensively supported in the case study literature, the degree to which such conclusions can be extrapolated or generalized to any arbitrary technology inherently involves judgement based on a preponderance of evidence, rather than being a rigorous "law of nature".

Implications in Modeling

Such data is useful because it can helps explain when and why investments in dynamic, new technologies can be justified, and stimulated in part by mitigation incentives, particularly as an ageing competitor technology's capacity for learning diminishes. More broadly, work led by the UCL PI Prof Grubb has noted three interrelated features of "dynamic realism" – inertia, induced innovation (including learning-by-doing and scale economies), and path dependence. Representing such dynamic realism in models is potentially important.

Many **o**ptimizing Integrated Assessment Models, including the widely-used DICE model, assume temporal independence –abatement costs in one period are not affected by prior abatement. Explorations by Grubb and Weiners (2020) show that including dynamic realism in abatement systems can fundamentally alter results, and the understanding of policy implications. Key findings from this work suggest at least three major implications, to the extent that energy-related systems in reality have considerable inertia, induced innovation and path dependence:

(a) 'optimal' emissions diverge from baseline sharply but steadily and, after a few years, proceed on an almost linear reduction to net zero within about 40-70 years, in contrast to the traditional DICE optimal result of global emissions readjusting in the first period, but then rising for a few decades before declining towards zero some time next century;
(b) the abatement effort / investment / cost is substantially greater for some decades – initially by a factor of around 5 for full pliability compared to the traditional case – but then declines; this is the

opposite of the pattern in traditional treatments, in which the cost rises steadily as damage accumulates (at least until zero emissions are reached)

(c) Global temperature is stabilised at about 1 deg.C lower than in the traditional case of exogenous technology assumption with no path-dependence

Grubb and Weiners characterise this in terms of the *pliability* of the sytem and conclude that higher pliability logically leads to lower carbon concentrations and temperatures, and climate-inflicted damage, because it pays to make greater effort up front which lowers subsequent abatement and transitional costs. Models which ignore the impact of inertia, induced innovation and path dependence suggest erroneously to defer abatement, while greater dynamic realism implies it is optimal to make bigger efforts initially, and that significant benefits may flow from this.

Conclusion

In short, ignoring the dynamic characteristics of abatement, as typical in *most* models at present, produces misleading insights for policy, potentially encouraging a postponement of transitions that should be initiated urgently because they need time and up-front investment, and would unleash self-reinforcing innovations. If we understand induced innovation, robust policies can become driving pacemakers of the decarbonisation path. To understand better the potential and dynamics of early investments as an accelerator of progress the integration of experience curve forecasting method into modeling tools would be a useful contribution. This might also help to clarify financial implications of the decarbonization of the global economy and the design of funding architectures (addressed in COP21 RIPPLES, Deliverable D3.5).

Reference: M. Grubb and C. Weiners (2020), Modelling Myths: On the need for dynamic realism in DICE and other equilibrium models of global climate mitigation, Published as Working Paper of Institute of New Economic Thinking (https://www.ineteconomics.org), and in review with Wiley Interdisciplinary Reviews (WIRES) – Climate Change.

7 Annex II: Considerations for enhancement of South Africa's current NDC and framing the next

By Andrew Marquard, Energy Systems Research Group, University of Cape Town

Introduction

South Africa communicated its Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015, and ratified the Paris Agreement in December 2016. Since the Agreement had come into force by then, its INDC became its Nationally Determined Contribution (NDC)[17] in terms of the Agreement, in the absence of any further submissions from South Africa in this regard[18]. South Africa is due to communicate its next NDC by 2025[19], and in common with some other countries, will likely "enhance" its current NDC before the end of 2020 – in a recent communication to the UN Secretary General in the context of the UN Climate Action Summit, President Ramaphosa made such a public commitment[20], which was reaffirmed by South Africa's Minister of Environmental Affairs, Forests and Fisheries in a statement to the COP plenary during COP 25 in Madrid[21].

The South African NDC currently consists of three components – mitigation, adaptation and support. This paper will focus mostly on mitigation, with a brief note on the adaptation component. The support component expressed the required international support necessary for the implementation of the other two components. It will be argued that the NDC also consists of two "layers" – one a contextual layer, which describes the international policy context within which the NDC exists from South Africa's point of view, and the other is a substantive layer which contains the contributions themselves. We will argue that the contextual layer is critical to understanding the context for the ambition of climate action contemplated in the substantive layer.

The goal of this paper is explore the legal requirements, and the technical and policy potential and limitations for both the 2020 "enhancement" and also the next NDC communicated in 2025. The analysis will mainly focus on mitigation, although we will argue that the context within which the mitigation component exists is very significant. The approach is to situate the mitigation component of the NDC in the context of the Paris Agreement's temperature goal, re-examine the technical mitigation potential of the South African economy in relation to this, examine briefly the political

[17] South Africa's first NDC can be found here, in the UNFCCC's temporary NDC registry - https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/South%20Africa%20First/South%20Africa.pdf

[18] From here on, for ease of reference, INDC and NDC (the text of which is identical) will be referred to as the NDC, unless there is a specific reason to identify the INDC as such.

[19] South Africa's first NDC contains mitigation contributions for 2025 and 2030, and will therefore not be submitting an additional NDC in 2020 to cover the period from 2026 to 2030. However, South Africa's President has committed to enhance the current NDC.

[20] The statement can be found here: http://www.dirco.gov.za/docs/speeches/2019/cram0923.htm - retrieved November 2019.

[21] https://www.environment.gov.za/speech/creecy_cop25highlevelsegment_unfccc - Retrieved December 2019.

dynamics of both the national and international aspects of South Africa's mitigation ambition, and consider some likely outcomes which South Africa may consider in this regard. This paper will NOT explore the underlying political economy of South Africa's mitigation policy landscape in any detail, or consider national mitigation policy in any detail, other than its relationship to the NDC.

Since the original INDC was communicated in 2015, several key factors have changed in terms of the international and domestic climate policy landscapes in both mitigation and adaptation. The global temperature goal within the international climate change regime has evolved from Cancun's two degree goal to a far more ambitious "well below 2 degrees" goal with an aspiration to limiting anthropogenic warming to 1.5 degrees (Article 2, Paris Agreement). The release of the IPCC's "Special report on global warming of 1.5° C" (IPCC 2018) in 2018 (hereafter referred to as SR15), and the adoption of its key recommendations by the UN Secretary General's Climate Action Summit in 2019[22], has resulted in the 1.5 degree global temperature goal gaining significant traction in the last year as the de facto yardstick for global mitigation ambition, and associated goals of a 45% reduction of global emissions by 2030 from 2010 levels, and net zero global CO_2 emissions by 2050. The result is that much more, and more immediate, ambitious mitigation action will be expected from all countries.

The Paris Agreement also established a new regime for adaptation, via the establishment of a new global goal on adaptation[23]. The overwhelming majority of Parties chose to include adaptation in their NDCs in advance of the Paris Agreement, and will likely to continue doing so. Many Parties understand NDCs in terms of the Paris Agreement's Article 3 (so-called "full scope" NDCs), but the way in which the adaptation component of NDCs is now treated in terms of the Paris Agreement and its subsequent work programme is complex, and actual practice will likely determine how adaptation is included in NDCs over the next decade. President Ramaphosa has also made a commitment in his statement to the UN SG to update the adaptation component of South Africa's NDC in 2020.

At the same time the international political environment in which ambitious climate change commitments will have to be made is subject to a high degree of uncertainty, given the Trump Presidency's repudiation of the Unites States' commitment in terms of the Paris Agreement to mitigation and to the provision of support, and the recently-delivered notice of intention to withdraw from the Paris Agreement in late 2020. While the Trump Administration has been relatively

[22] https://www.un.org/en/climatechange/un-climate-summit-2019.shtml - "With global emissions are reaching record levels and showing no sign of peaking, UN Secretary-General António Guterres called on all leaders to come to New York on 23 September for the Climate Action Summit with concrete, realistic plans to enhance their nationally determined contributions by 2020, in line with reducing greenhouse gas emissions by 45 per cent over the next decade, and to net zero emissions by 2050." – retrieved December 2019.

[23] A global goal on adaptation (GGA) "of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2" (Paris Agreement, Article 7.1). The global goal on adaptation is a critical innovation in the Paris Agreement in that it recognizes explicitly the role of the international climate regime in ensuring an adequate collective adaptation response in the context of global mitigation efforts (more mitigation = less adaptation), and in terms of the required international support. The GGA has not been elaborated further, which will be required for its operationalization in NDCs and/or adaptation communications, reporting on adaptation and impacts in terms of Article 13 of the Paris Agreement, and assessing collective progress in the 5-yearly global stocktake. The controversy on how the process for further elaboration of the GGA should be conducted caused a delay in the start of COP 25 in November 2019.

unsuccessful in derailing the global momentum stemming from Paris, the symmetry of the US/China commitment which underpinned Paris has been undermined.

In terms of national South African climate policy, on the one hand, renewable energy costs have fallen dramatically over the last decade (and especially since South Africa's climate policy was finalised in 2011 and South Africa's NDC was communicated in 2015), leading to solar PV and wind energy being the cheapest form of new electricity generation investment (replacing coal power as the cheapest option) in South Africa. This has dramatically reduced South Africa's "with existing measures" GHG emissions baseline (which is explored further below). On the other hand, a complex and unfolding political situation has led to strong resistance to further investment in renewable energy, and a stalemate regarding further energy infrastructure investment in the short term, despite the country experiencing a severe electricity supply crisis.

This paper will focus on the techno-economic and policy dimensions concerning both South Africa's next NDC, as well as the "enhancement" of South Africa's existing NDC in 2020. The latter analysis will mostly limit itself to the enhancement of the mitigation component of South Africa's NDC, mindful that South Africa's existing NDC, in common with most other Parties to the Paris Agreement, also contains an adaptation and a support component. The latter two will be briefly touched on, but the bulk of the focus of this paper will be on the mitigation component of SA's NDC.

Lastly I am indebted to my co-authors of McCall (2019), which I have drawn on heavily for this study, and to the team at CAT, including Hanna Fekete and Michiel Schaeffer, who have very helpfully provided us with answers to many questions. None of the work below should be taken in any way to suggest that CAT supports the proposed approach or the analysis in this paper.

1. The international context

The challenge which countries faced in negotiating the Paris Agreement was how to respond to the political challenge of addressing the failure, since the negotiation of the UNFCCC in 1992, to negotiate a top-down architecture for the international climate regime, which would allocate specific responsibilities (in mitigation, adaptation and the provision of support) to countries according to principles ("common but differentiated responsibilities and respective capabilities") contained in the UNFCCC[24]. The solution contained in the Paris Agreement is a bottom-up architecture consisting of a set of core long-term goals (Article 2), a process whereby countries communicate and implement "ambitious efforts" (Articles 3 and 4) in mitigation, adaptation and support, and a "global stocktake" of collective progress against the long-term goals (Article 14), which in turn informs a new round of national contributions. National climate action in the context of the Agreement is internationally verified through transparency provisions in Article 13, which provides for reporting on mitigation, adaptation and the provision and receipt of support. At the same time, while contributions to achieving the long-term goals are nationally-determined, the overall framework of the Agreement is

[24] Even the Kyoto Protocol, which only applied emissions targets to developed countries, did not succeed in establishing a process for the top-down allocation of emissions targets. In both the first and second commitment periods, targets were set by countries themselves, and not by a top-down process. The key legal distinction, in terms of emissions targets, between the Kyoto Protocol and the Paris Agreement, is that achieving targets is a legal obligation under the Kyoto Protocol, whereas it is not under the Paris Agreement. The only instance of a successful top-down allocation of GHG targets in an international context (but within the legal context of the EU) to date has been within the EU via their burden-sharing agreement.

legally-binding, although the extent to which different elements are binding varies. Compliance provisions apply to the regular submission of (the mitigation components of) NDCs, of information on the indicative provision of finance, and on the submission of biennial transparency reports[25] only.

The Paris Agreement's Article 2 sets out as its key aim "to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty" (Article 2, Paris Agreement), and establishes three key long-term goals, which include a global temperature goal of "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels", "increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development", and "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".

The way in which contributions towards achievement of these goals is communicated is somewhat uneven across different goals and their respective elements, and the different legal status of these is reflected in a long-standing political wrangle during the negotiations between developing and developed countries. The formal communication of "nationally determined contributions" is laid out in Article 4, which speaks primarily to mitigation and the global temperature goal. The language in Article 3, which applies to mitigation, adaptation, the provision of support and to transparency, is much vaguer as to the legal vehicle concerned, and the periodicity of communications. The references in Article 4 to the legally-binding and regular submission of NDCs are specifically to the mitigation component of NDCs. In relation to compliance, in decision 20/CMA.1, the CMA decision which fleshes out the compliance provisions in Article 15, compliance procedures may only be initiated by the compliance committee in respect of NDCs in terms of Article 4 (mitigation), and in terms of information communicated in terms of Article 9.5, which is arguably covered by Article 3 but not by Article 4.

In terms of adaptation, the Paris Agreement is very clear in Article 2 – a long-term goal is established for adaptation, against which progress is considered in the global stocktake, but in terms of adaptation action, the outcome is more opaque, and the opacity was not resolved subsequently. Article 3 provides for the communication of adaptation information, as do Articles 7 and 13. Article 7 provides for the periodic submission of an "adaptation communication", which may be submitted via a variety of vehicles, including a country's NDC. Some countries understand adaptation communications to be synonymous with the adaptation components of NDCs, whereas others do not. Regular, or any, submission of either an adaptation component of NDCs or adaptation communications is not a legal requirement of the Paris Agreement. However, many countries regard the inclusion of adaptation in the NDC/GST cycle as essential to the full implementation of the Agreement. South Africa has also committed to enhance the adaptation component of its NDC.

1.1 What is "Paris-compatible" mitigation?

It is necessary to preface this discussion on temperature outcomes by observing that the context in which the Paris Agreement places mitigation is sustainable development. Thus, collective mitigation effort is defined both by a long-term temperature goal, as well as the goal to "foster.. ..low greenhouse gas development", in Article 2. The global temperature goal of the Paris Agreement is specified as

[25] Parties are obliged to report according to the modalities, procedures and guidelines contained in the Annex to decision 18/CMP.1, as applicable.

"Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels". There has been much debate concerning the physical implications of "well below 2 °C above pre-industrial levels". Peters (2017) has argued persuasively that a global emissions trajectory which has a 66% chance of keeping global temperature increase below 2 °C is consistent with "well below 2 °C" since such trajectories would have a median temperature increase of 1.6-1.7 degrees, which in relation to 1.5 degrees is "well below" 2 degrees. This is significantly more stringent than a global goal based (as the Cancun goal was assumed to be) on a 2 degree median increase (50%)[26]. SR15 has assembled a range of global emissions pathways capable of limiting warming to 1.5 degrees, and its two key takeaway messages from its Summary for Policymakers – global net zero CO_2 emissions by 2050, and a global reduction in emissions of 45% by 2030 from 2010 levels, have cemented these as key benchmarks for global mitigation ambition. There is also in Article 4.1 of the Paris Agreement an additional qualification for the achievement of the global temperature goal, as follows:

> "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty." (Article 4.1, Paris Agreement)

The key innovation is that the Paris Agreement obliges every Party to achieve net zero emissions (for all gases) in the latter half of the century, which implies net zero CO_2 emissions before this point is reached. Article 4.1 does not mention the use of mechanisms defined under Article 6, and is clearly subject to equity considerations, and takes into account the development challenges of developing countries. The IPCC's SR15 reports in the SPM that to stay within 1.5 degrees, global emissions have to reach net zero CO_2 by around 2050, and for 2 degrees (66% probability), around 2070. Most countries do not extent their long-term mitigation scenarios beyond 2050, although an increasing number have adopted various forms of "net zero" targets for 2050[27]. The more pressing and relevant constraint introduced by SR15 was the constraining emissions level in 2030. Collective scenarios capable of staying within 1.5 degrees reduce global emissions by 45% from 2010 levels, and for 2 degrees, 25%. Current NDCs fall significantly short of this.

In addition, Article 4.3 requires NDCs to "represent a progression beyond the Party's then current nationally determined contribution" and "reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances". It is highly contextual as to what "highest possible ambition" means, but it is clear that this should go beyond "business as usual", and most definitions of emissions pathways "with existing measures".

[26] Many commentators have argued that setting out to reach a policy goal with only an even chance is not very sensible. Many others disagree as a result with Peters' interpretation of "well below", and would prefer a more stringent goal for "well below.

[27] If reaching net zero global CO_2 emissions by 2050 is "1.5 degree compatible", then from an equity point of view, developed countries should be reaching net zero CO_2 emissions before this.

The above summary provides some parameters for the "Paris compatibility" of the collective global mitigation effort, which is undoubtedly inadequate currently, but limited guidance to individual countries concerning the "Paris compatibility" of their NDCs per se. Clearly equity questions come into play, and are central to how the global mitigation burden is divided, within the overall framework above. There is a long history of considering different approaches to dividing the burden, based on the UNFCCC principles of responsibility and capability. The new parameters of the Paris Agreement, quantified by the SR15, provide a set of constraints which are more stringent than before, but do not avoid the previous dilemmas. The key distinction, since SR15, and since it is now 2020, is the emphasis on mapping a pathway to zero emissions. The key long-term questions, which have different answers for different countries, are in which year one expects emissions to peak, and in what year emissions will reach zero.

1.2 Legal context regarding the submission and content of NDCs

The scope of "national contributions" is arguably contained in Article 3, but the legal obligation to submit regular NDCs is contained in Article 4 of the Paris Agreement, and in the accompanying decision 1/CP.21. Elaboration of information to facilitate clarity, transparency and understanding is contained in an annex to decision 4/CMA.1, concluding post-Paris negotiations on this item at COP 24 in Katowice. The latter only applies to Parties' second NDC on, but Parties are "strongly encouraged" to provide this information for their first NDC, "..including when communicating or updating it by 2020". The relevant information contained the annex is explicitly related to mitigation. There are no legal requirements to include information on adaptation and support in NDCs, but many countries will interpret the guidance developed in Katowice for adaptation communications as applying to adaptation components of NDCs.

There are two temporal elements of NDCs – the frequency of submission of NDCs, and the length of their respective "periods of implementation"[28], usually referred to as "timeframes". There is currently a process to negotiate a "common timeframe" which was not agreed to in Paris, which has not yet reached a conclusion. Specifications on the timing of the submission of NDCs is contained in decision 1/CP.21 and in Article 4 of the Agreement. In Article 4.9, each Party shall communicate an NDC every five years.

There are two contexts, which are often confused, for communicating an "enhanced" or "new" NDC in 2020. The first context is paragraphs 23 and 24 of decision 1/CP.21, which was designed to ensure that there is in fact a five-year cycle of NDC submissions, and also that in the event of a decision on a 5-year common timeframe, a systematic approach to updating NDCs with timeframes stretching to 2030. The second context is the context of ambition in the wake of the Talanoa Dialogue, which was designed to address the current gap in NDC ambition as a proto-GST. Both paragraphs are framed as "requests".

1.3 Strategic considerations

[28] A "period of implementation" is analogous to a "commitment period" under the Kyoto Protocol, although since most NDCs contain only single year targets. The term has legal relevance in the MPGs applicable to Article 13, since Parties are obliged to report on implementation of their NDC during this period, and will possibly have relevance in the detailed guidance for the implementation of Article 6. The term "common timeframes" applies to the length of periods of implementation, but in reality, to the time between emissions targets.

Finally, there are a number of strategic considerations which countries potentially consider which formulating and communicating their NDCs in relation to the international regime. The first of these is narrowly-defined in terms of a strategic dilemma revolving around the concept of mitigation ambition – whether to put forward an ambitious mitigation NDC without the guarantee that other countries will follow suit? This is a particularly difficult question for developing countries, and specifically for developing countries of South Africa's size – whose emissions are significant (about 1% of global emissions), but not of a scale which is determinate of a global emissions outcome. On the other hand, South Africa and other middle-sized developing countries have a strong interest in a rule-based international system, since especially in the context of a global commons-type problem such as climate change, an international regime devoid of rules and determined only by geopolitical power is not going to protect smaller countries' interests. South Africa's progressive position in the international regime is based on this rationale.

In the context of the Paris Agreement, on the one hand there is the risk that powerful countries (such as the US) will defect, and both remove themselves and their contributions from the regime (mitigation and especially support), and thereby undermining its legitimacy and increasing the domestic political risk to governments in developing countries such as South Africa of making progressive international contributions, but on the other hand the Paris Architecture raises the opportunity to shape practice, for instance in adaptation, where the lack of clarity on the global goal on adaptation, and on adaptation communications/NDCs provides an opportunity to establish practice.

2. South Africa's current NDC

South Africa communicated an "Intended Nationally Determined Contribution" (INDC) in September 2015[29]. South Africa's INDC became its NDC after the country ratified the Paris Agreement in late November 2016. The NDC was therefore, in common with most other Parties, communicated before the Paris Agreement was adopted, and before the "Paris Rule Book" was adopted at COP 24 in Katowice in 2018. There are two layers to the South African NDC. The first layer consists of mitigation and adaptation "contributions", with associated support provisions. Often when commentators refer to NDCs, they refer only to the mitigation component of countries' NDCs, and usually only in a narrow sense related to a quantitative target. It is important to note a) the adaptation component of South Africa's NDC, and b) the second layer, which provides the context for both contributions, which has legal and policy significance from the perspective of the international climate change regime.

We will spend some time focused on the second layer, before returning to the specific mitigation and adaptation contributions in the NDC, and how these might evolve in either a 2020 "enhancement" or in future NDCs in 2025 or beyond. The reason for this is that the overall framing in the NDC represented by this layer effectively creates a bridge between South African climate policy (2011) and South Africa's international commitments under the Paris Agreement, further qualifies this policy in an international context, and thus provides further insights on how this may evolve in future.

[29] https://www4.unfccc.int/sites/submissions/indc/Submission%20Pages/submissions.aspx

This layer is typically misunderstood as a set of conditions, and/or a set of conditional/unconditional components (usually associated with the trajectory range – see below)[30]. The NDC does NOT frame any of its components in terms of conditionality, which South Africa was vocally opposed to in the negotiations in the run up to the Paris Agreement[31], but rather in terms of "assumptions" concerning a) the nature of the Paris Agreement itself (since the NDC was communicated before the conclusion of the Agreement), and the nature of other NDCs. The NDC anticipated that:

> "..the Paris Agreement will be binding, fair, effective and incorporate a 'no-backsliding' and a 'progressive' approach to enhance climate change mitigation and adaptation implementation and ambition. This implementation and ambition will be enabled by finance and technology and capacity building support."

In a specific section on assumptions, these were stated as "the adoption of a comprehensive, ambitious, fair, effective and binding multilateral rules-based agreement under the UNFCCC at the 21st Conference of the Parties (COP21) in Paris", which would "attract the full participation of all Parties to the Convention", and "consistent with scientific requirements in the short, medium and long term, deliver the necessary ambitious mitigation and adaptation commitments". These would be assumed to be "enabled and supported by significant climate finance and investment, accessible and affordable technology and substantial capacity building commitments". The Agreement should include "effective arrangements for transparency of action and support" and "give effect to the principles of equity and common but differentiated responsibilities and respective capabilities". Furthermore, in relation to mitigation specifically,

> "It is assumed that this agreement will provide the multilateral rule-based infrastructure, mechanisms and tools to enhance international and regional cooperation on mitigation. Further, that this cooperative effort enables and supports Parties' capability to transition to low carbon economies and societies in a manner that addresses the social, economic and environmental dimensions of their sustainable development."

There are a number of other relevant contextual specifications, which remain relevant to further iterations of South Africa's NDC, including its announced "enhancement" by 2020. The first of these is that South Africa is "committed to addressing climate change based on science and equity", noting that "The nature of the climate change challenge is one characterised by the overuse of a global commons in an unequal world". In terms of science, there is specific reference to the global temperature goal, which anticipated the formulation in the Paris Agreement:

> "South Africa is firmly committed to working with others to ensure temperature increases are kept well below 2°C above pre-industrial levels, which could include a further revision of the temperature goal to below 1.5°C in light of emerging science, noting that global average temperature increase of 2°C translates to up to 4°C for South Africa by the end of the century"

[30] See for instance http://climatecollege.unimelb.edu.au/files/site1/factsheets/SouthAfrica_INDCFactsheet_UoM-PRIMAP_GWPAR4.pdf

[31] Personal communication – South African senior mitigation negotiator.

In terms of equity, the NDC contains a section titled “equitable access to sustainable development”, which identifies the core principles of equity as “responsibility, capability and sustainable development”, which the NDC applies to mitigation, adaptation and support, in terms of the overall cost of addressing climate change. Both mitigation and adaptation are situated in terms of these principles.

These overall assumptions are further elaborations of several key principles contained in South Africa’s climate change policy, the 2011 National Climate Change Response White Paper (NCCRWP), and it is worth focusing on three elements in particular:

1. The vital role of multilateralism, which is emphasised in the White Paper and in the NDC;
2. The context of sustainable development, which involves a strong emphasis on situating South Africa’s NDC in the context of a long-term sustainable development trajectory;
3. Equity and common but differentiated responsibility, which places South Africa’s contribution in the context of making a “fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner” (NCCRWP p.11).

The two key additional observations from the NCCRWP which are of interest in positioning South Africa’s NDC are i) the fact that South Africa is “by any measure a significant emitter of GHGs” (NCCRWP p26) and ii) that South Africa is peculiarly vulnerable to the impacts of climate change, a vulnerability which is more acute due to the socio-economic challenges which the country faces.
The underlying assumptions stated in the NDC are now facing some challenges. On the one hand, the Paris Agreement was successfully concluded in 2015, and was widely regarded at the time as a balanced and ambitious outcome (in terms of developed and developing country interests). On the other hand, the architecture of the Paris Agreement depends critically on a process of action and reflection, since the legal architecture is based on obligation of conduct (regular submission of NDCs, regular reporting) combined with a collective assessment of progress (the global stocktake) rather than an obligation of outcome. The current environment has some contradictory features in this regard. On the one hand, the release of the IPCC’s 1.5 degree report, emphasizing the importance of the 1.5 degree global temperature goal and the climate impacts already being experienced by vulnerable developing countries, including South and southern Africa, has provided a new global impetus to ratchet up climate action. On the other hand, the imminent withdrawal of the USA from the Paris Agreement (scheduled for November 2020) and the implications for the provision of support (particularly financial support) to developing countries, has fundamentally upset the balance achieved in Paris. Progress towards the global temperature goal is starkly inadequate as highlighted by the UNFCCC Secretariat’s synthesis report on current NDCs; and at the same time, negotiations on the implementation of both adaptation and finance provisions in the Paris Agreement have been fraught, and have made little progress.

South Africa’s current NDC contains two claims relevant to the international context which are now outdated. The first is its equity claims which are based on a South Africa study, which itself is based on a) an outdated global temperature goal, and b) outdated baselines, including an outdated South

African baseline[32]. The second is the claim, based on the 2014 Mitigation Potential Analysis[33], that South Africa's NDC represents its "full migration potential". As can be seen from the national studies referred to below, this is now definitely not the case at all, and it seems as if South Africa will be able to achieve its NDC without additional measures.

3. What is a "fair contribution" for South Africa's current and second mitigation NDC from an international point of view?

As noted above, there are many different approaches to equity which have been put forth over the last two decades, including the approaches cited in South Africa's current NDC. Approaches to quantifying different equity principles are by nature normative, and reflect the complex array of different interests represented by different countries and country blocs in the international climate regime. The most comprehensive attempt to provide an up-to-date assessment of the full spectrum of these different approaches is the Climate Action Tracker[34] which provides assessments based on over fifty studies[35] to dividing the global mitigation burden amongst individual countries. The methodology employed by CAT assesses the outcome of these approaches for each assessed country in 2020, 2025, 2030 and 2050, for a 1.5 degree-compatible global emissions pathway (50% probability), and for a 2 degree-compatible global emissions pathway (66% probability), which, as discussed above, can be taken to represent the full range of "Paris compatible" emissions outcomes. The next step in the CAT methodology is to identify an "equity range" for 1.5 degrees and for 2 degrees, which is done on the basis of grouping the more than 50 equity approaches into six or seven different groups, excluding outliers, and identifying the range of the remaining approaches[36]. The overall "fair share range" combines these two ranges. The next step is somewhat more controversial, and involves the segmentation of this range into three subranges, corresponding to the global temperature implications of countries each choosing a specific point in the range. For instance, if all countries chose an emissions outcome at the top of their ranges, the resulting temperature rise would be around 3 degrees by the end of the century. If all countries choose an emissions level at the bottom of their ranges, then the outcome will be to limit global temperature rise to just below 1.5 degrees, as portrayed in the "CAT Thermometer" below.

[32] The study in question, Winkler et al (2013) uses a methodology based on the Greenhouse Development Rights framework, and uses a baseline approach. Outdated baselines would therefore have a very significant impact on the analysis. The NDC also draws on a short study by Climate Analytics (Rocha et al 2015).
[33] Department of Environmental Affairs (2014). It is arguable that full technical mitigation potential does not equate to full mitigation potential, if non-technical considerations come into play. However, evidence presented below suggests that it may be more costly in future for South Africa to follow an emissions trajectory near the top of the PPD than a lower one.
[34] www.climateactiontracker.org
[35] Detail on the CAT methodology and a complete list of studies which form the basis of the CAT assessment can be found here - https://climateactiontracker.org/methodology/comparability-of-effort/
[36] There are several reasons to object to this approach. The first is that "outliers" are frequently approaches which have distinctly different normative assumptions to the majority of the rest of the approaches. Given that the majority of approaches have been put forward by authors from developed countries, excluding outliers in this way is likely to prejudice approaches put forward by developing country authors. The second is that the concept of "outliers" is borrowed from statistics, and its applicability here, where the context is normative, and also characterized by a sometimes large divergence of views on key normative elements, is doubtful.

This shift from the "fair share" range to a temperature range is somewhat confusing, given the relationship between the underlying data (which are themselves based on specific temperature outcomes), which means that countries' mitigation targets can lie within their "equity ranges" for a 1.5 degree or 2 degree outcome and still be deemed "insufficient". The CAT rating therefore reflects two things: i) the extent to which countries will be prepared to make commitments which take into account that other countries may not share their equity preferences – in other words a reflection of countries' willingness to play a "leadership" role; and ii) a useful coherence on the global temperature outcome, which is a counterbalance to many of the pitfalls referred to here.

Figure 3 - CAT "thermometer". Source: https://climateactiontracker.org/methodology/comparability-of-effort/

We will use a different approach, which uses the underlying CAT data for 2025, 2030 and 2050 for each temperature range, and uses a "heat map" to indicate areas of convergence of different equity approaches. The approach still has the following shortcomings:

- The CAT equity analysis excludes LULUCF emissions. This is on account of the risk of their high level of uncertainty and variability drowning out the long-term decarbonization signal from the rest of the economy. For a country like South Africa, with a relatively small source/sink of emissions from the land sector, this is not a big problem, but for other countries (especially large developing countries such as DRC, Brazil and Indonesia) this is a very significant omission. This is particularly a problem in a world in which countries are reducing emissions to net zero

CO2, which only makes sense if sinks are taken into account. In terms of the results of an overall burden-sharing analysis, the effect of this probably be to slightly overestimate South Africa's "fair share". This overestimation is counterposed to the assumptions used here concerning the South African land sector baseline, which is assumed to be a net sink until 2050.

- There are inconsistencies in the juxtaposition of different burden-sharing approaches – especially for approaches which use baselines. Since baselines have changed so dramatically with new technology options (cheaper RE), the use of inconsistent baselines will tend to overestimate the top of the range of South Africa's "fair share". Since the underlying studies which make up the CAT analysis were done at different times, the overall analysis probably underestimates the economic impact of the decrease in the cost of low-carbon technologies.
- The extent and concentration of the approaches to equity which underpin the "fair share" range are determined by a range of contingent factors, one of which is the ability to conduct global analyses of this kind, which is weighted towards developed country researchers. The spread of approaches is not necessarily representative of different country interests and groupings. This is partly counteracted by using the classification method which CAT uses for different approaches, which effectively weights different approaches differently. The current range of CAT analyses rank developing countries slightly worse than developed countries.
- Some approaches allow for "negative" emissions, especially for baseline-based approaches in which countries are required to reduce emissions more than their baselines. Since others are based on dividing available emissions space, the timing of these approaches can be inconsistent.

The approach that has been taken here in the following analysis to develop a benchmark for South Africa is as follows:

- The underlying data from CAT's latest assessment for South Africa (November 2019) for each class of effort-sharing approach (6 classes for 1.5 degrees, 7 classes for 2 degrees) has been used as a basis[37].
- It has been assumed, contrary to CAT, that globally, "Paris compatible" lies in the range between the 66% 2 degree assessment (which CAT defines as "Copenhagen-compatible") and the 50% 1.5 degree assessment.
- We have, instead of the methodology CAT uses (based on an average of historical land use data from South Africa) used a baseline for LULUCF from Stevens et al (2016), and used this baseline projection to adjust South Africa's current NDC commitments, and the "peak, plateau, decline" value for 2050, for comparison with the CAT ranges, which exclude land use emissions.
- We have added to this the CAT "equity ranges" for 2 degrees and 1.5 degrees, the "CAT thermometer", and also a "heat map", for purposes of comparison. The goal of adding the heat map is to indicate the density of the 90% ranges for each category of equity approach over a specific range (per 100 Mt). This is a very crude measure of the "concentration" of different approaches, but helps to give some texture to the uncertainty in the overall range, subject to the overall shortcomings listed above.

It is also worth noting that the CAT analysis of South Africa's current NDC ranks it as "highly insufficient", and outside South Africa's fair share range. This ranking is based on the upper limit of the emissions range in the NDC, and not indicative of the range as a whole. In the figures below, the

[37] Downloaded from https://climateactiontracker.org/countries/south-africa/.

underlying CAT data for 2025, 2030 and 2050, as well as the CAT "fair share range" has been compared to the emissions values for the South African NDC and the emissions value for 2050 from South Africa's benchmark emissions range. All values exclude LULUCF. The NDC values have been adjusted as above.

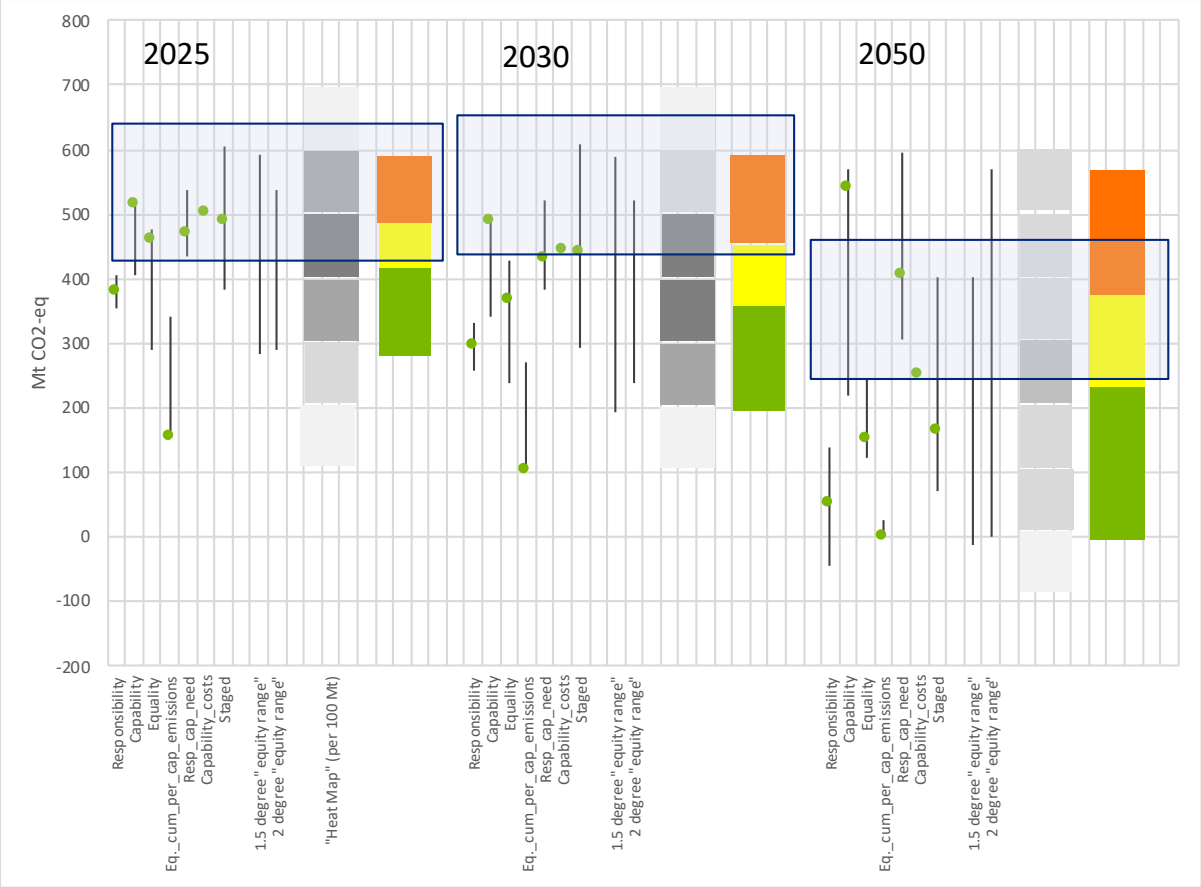

Figure 4 – CAT equity ranges for a 2 degree global temperature limit (66% probability), for 2025, 2030 and 2050, plotted from the underlying data available at https://climateactiontracker.org/countries/south-africa/. The ranges for each approach are 90% ranges (excluding outliers), and the green dots are medians for each approach. The "equity ranges" for 1.5 and 2 degrees range from the second lowest to the second highest 90% range. The "fair share range" ranges from the lowest point on the 1.5/2 degree equity ranges to the highest point. The temperature ranges, also shown here, are derived from these. The shaded blue boxes for each year represent the range of the South African NDC for 2025 and 2030, and of the long-term benchmark range for 2050. As in Figures 2 and 3, the difference in the NDC emissions ranges between 2025 and 2030 is due to the adjustment for LULUCF as described above (in the actual NDC these are identical).

There are several key points which are evident from Figure 4 (2 degrees) and Figure 5 (1.5 degrees). While the 2050 values are quite divergent, there are two key factors in the overall trend. The first is that equity analyses converge in terms of the timing of the peaking of South Africa's emissions. There is generally a decline in South Africa's allocated emissions from 2025 to 2030, which can be seen more

clearly in Figure 6, which consists of the averages of the median values for each approach for 1.5 and 2 degrees for each year only[38].

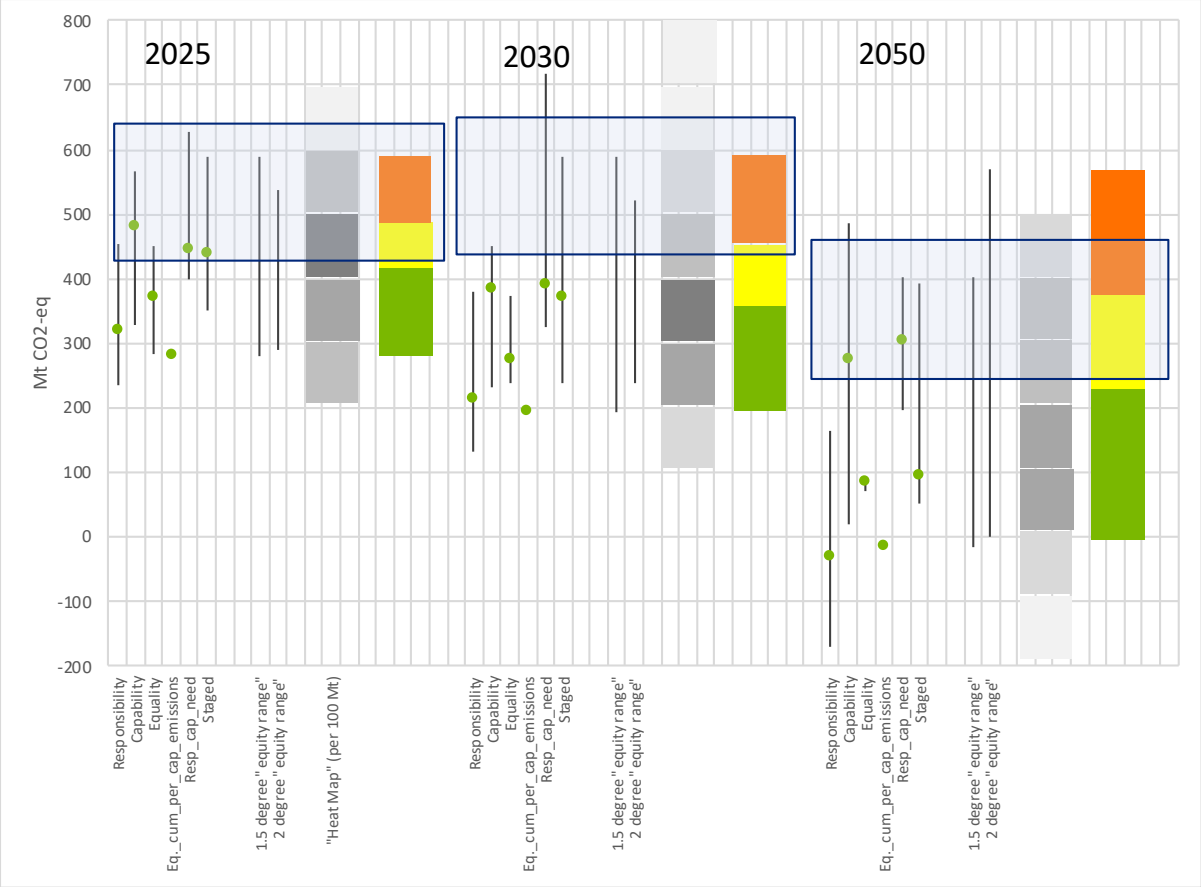

Figure 5 - CAT equity ranges for a 1.5 degree global temperature limit (50% probability), for 2025, 2030 and 2050, plotted from the underlying data available at https://climateactiontracker.org/countries/south-africa/. The ranges for each approach are 90% ranges (excluding outliers), and the green dots are medians for each approach. The "equity ranges" for 1.5 and 2 degrees range from the second lowest to the second highest 90% range. The "fair share range" ranges from the lowest point on the 1.5/2 degree equity ranges to the highest point. The temperature ranges, also shown here, are derived from these. The shaded blue boxes for each year represent the range of the South African NDC for 2025 and 2030, and of the long-term benchmark range for 2050.

The benchmark range for South African emissions contained in the NCCRWP, the "peak, plateau and decline", peaks in 2025, plateaus until 2035, and then declines. This does not seem to be "Paris compatible", both for "well below 2 degrees" and for 1.5 degrees. "Progression" in this context for both the 2020 revision of the 2030 NDC target, and looking forward to the next NDC (applicable to 2035) means the anticipation of South African emissions peaking before 2030. This will be examined in more detail based on national emissions scenarios below.

[38] This figure is designed to show the trend and relative value of equity analyses in comparison to the South African NDC and long-term benchmark range. The values in themselves (averages of the medians of the various approaches reported by the CAT) have no validity in themselves and are not a guide to what South Africa's "fair share" should be.

The second key feature of these comparisons is that the level of South Africa's NDC commitment in 2025 and 2030 is clearly higher than most equity approaches would allow. While it is possible to choose an equity approach which is consistent with the PPD, very few of these are consistent with the upper range, and in the case of 1.5 degrees, most of these extend below the lower end of the range. These serve as a guide to the emissions outcome South Africa might consider when enhancing its current NDC or communicating a second NDC.

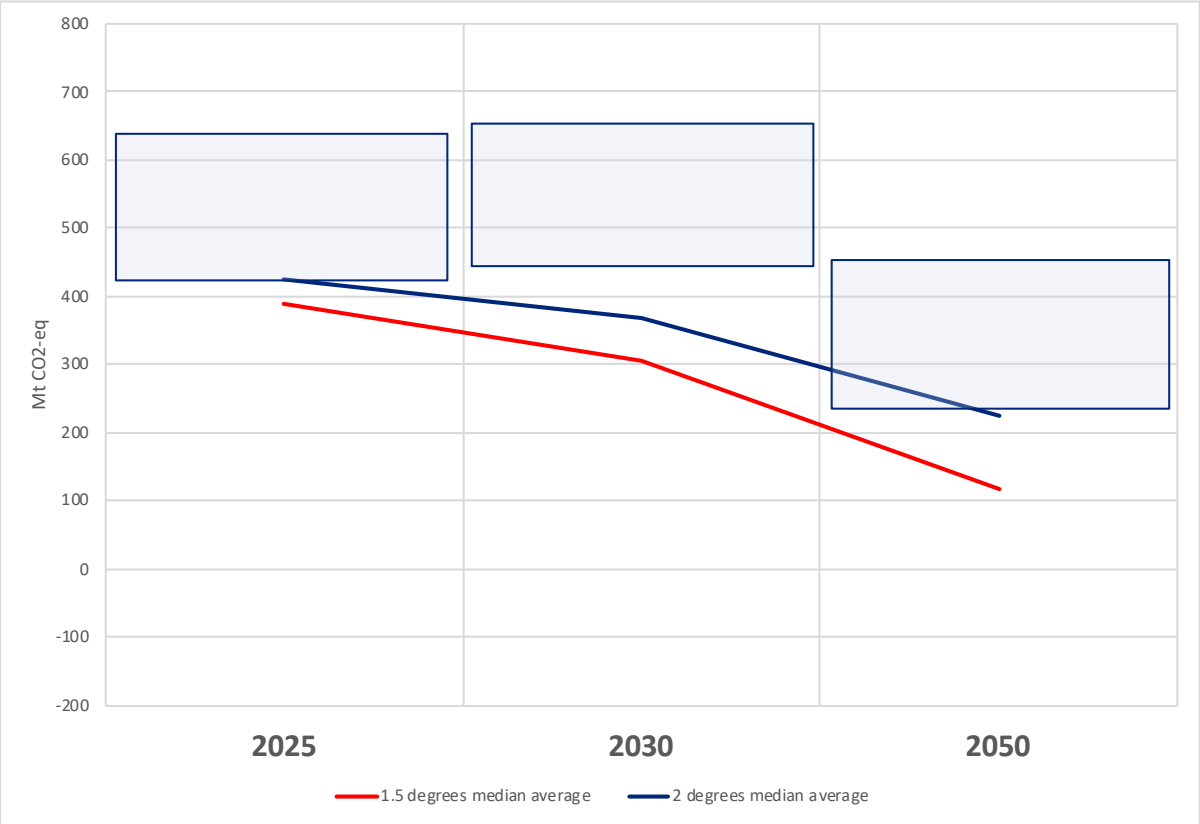

Figure 6 – averages of medians of different CAT equity approaches for 2025, 2030 and 2050 for South Africa, for 1.5 and 2 degrees. The shaded blue boxes for each year represent the range of the South African NDC for 2025 and 2030, and of the long-term benchmark range for 2050.

4. National questions concerning mitigation ambition

For South African decision-makers, future GHG emissions levels are an abstraction which imply a range of other key policy implications, themselves embedded in a number of existing policy and political contexts. The NDC development process is not formally established, and is currently viewed as part of the engagement process with the international climate regime. However, in the existing NDC, current mitigation policy as expressed in the NCCRWP, is a strong point of reference, as are the current national mitigation potential studies. Both of these were developed / undertaken in a national policy context, which generally has implications for who the key actors are and what processes are followed. The key question for both the NDC "enhancement" in 2020 and the next NDC in 2025 is whether these will follow from further developments in national policy, whether these will be accommodated within existing policy, or whether the NDC process itself will drive policy. It is possible to argue for instance that the 2009 commitment made by President Zuma to limit emissions in 2020 and 2025 drove climate policy in the electricity sector and elsewhere, and also contributed directly to South Africa's long-term

emissions benchmark range; however this was in the absence of a climate policy framework at the time.

Government is currently in the process of finalising the Climate Change Bill, which amongst other impacts, will have two in particular: 1) the Bill will establish Sectoral Emissions Targets, for which line departments are responsible; and 2) it will establish a process for updating South Africa's long-term emissions goal. At the same time the National Planning Commission is conducting a dialogue on the just transition away from fossil fuels which contains a proposal for South Africa reaching net zero emissions by 2050[39]. Both these processes are due to be finalised during 2020, but the setting of sectoral targets, and the revision of the currently national GHG emissions benchmark range, is unlikely to be completed in 2020. Moreover, there are a set of very difficult energy policy tradeoffs which are currently being faced by government, which suggest that a more comprehensive process will be delayed until after 2020. This sets the context for the 2020 "enhancement", which will most likely be framed within existing policy. There are three mitigation-related enhancements which will likely be undertaken:

1. The current emissions targets for 2025 and 2030 are expressed as a range, which is derived from national policy. Since national policy is unlikely to be amended during the relevant timeframe, a specific point within the range could be identified as part of the process of clarification and enhancement. The range for both 2025 and 2030 comprises around 1/3 of the overall absolute emissions level, so this provides some room for "clarification" and does not propose an emissions outcome outside of existing policy.
2. The NDC currently comprises information on arrangements for implementation, which include policies and measures, the costs of measures, and also other information in a technical background document, which would need to be updated; and
3. As mentioned above, 4/CMA.1 provides a list of information to be provided for "clarity, transparency and understanding", which Parties are required to provide for their second NDCs[40] on, but "strongly encouraged" to provide for their initial NDCs. It is likely that South Africa will provide such information, including potentially more detailed information on the role that land sector emissions and removals will play in the NDC and how these will be accounted for.

We will not consider points 2 and 3 in detail, except to note further down that sectoral policy enhancements may require more elaboration in terms of climate finance requirements.
For the next NDC to be submitted early 2025, it is anticipated that bar a collapse of the international climate regime, a step change will be needed which is focused on the long-term decarbonization of the economy, on a national level and on a sectoral level, which will require a different approach and an overhaul of existing climate policy.

[39] See https://oneworldgroup.co.za/wp-content/uploads/2019/10/NPC-JT-Vision-and-Pathways-draft-2-final.pdf . The NPC process is expected to conclude in the first half of 2020.
[40] As above, it is not clear what "second NDC" means, especially for South Africa which communicated two NDC mitigation targets, one for 2025 and one for 2030.

5. South African national techno-economic emissions scenarios

Since the mid 2000s, a number of comprehensive national studies have been undertaken on South Africa's mitigation potential[41], including scenarios developed under COP21 RIPPLES, and attempts have been made to map the costs and benefits of specific mitigation actions, and of long-term emissions pathways available to the country. All of these studies have been aimed at reducing emissions from a baseline, and none of these have reached beyond 2050. It is arguable, given the Paris goals and SR15, that long-term mitigation goals now have to be understood in terms of reducing emissions to net zero. There is currently no Government-led work which explores this in detail specifically for particular sectors, or for the economy as a whole. However, a significant step change is visible in the evolution of mitigation studies in South Africa over the last 12 years or so.

Figure 7 portrays the evolution of South African emissions baselines from 2007 to 2019 (Hartley et al 2020, forthcoming). These are "with existing measures"[42] modelled least-cost scenarios. The striking decline in the long-term emissions trajectory is the result of a number of factors. Economic growth rates and population growth varies (later studies assume lower economic growth rates, especially in the short term, and projected economic growth rates for the 2010-2019 period turned out to be far too optimistic) and advances in estimation of land use emissions resulted in an estimation of a sink of 20-30 Mt[43]; however the biggest factor affecting long-term emissions scenarios is the drop in the cost of renewable energy technologies and the projected cost of battery electric vehicles, which in studies from 2018 onwards become least-cost technologies (renewable energy technologies in the present, and BEVs in the 2020s). Whereas earlier studies assumed that least cost future emissions scenarios would continue to be dominated by emissions from coal combustion (primarily from electricity generation, but also from liquid fuels manufacture and process heat for industry), the dramatic drop in the cost of solar PV and wind generation technology has displaced coal in future "business as usual" emissions scenarios. Over a longer timeframe, electric vehicles have also displaced ICE vehicles in future energy/transport scenarios, further reducing emissions scenarios.

[41] Of particular significance are the Long Term Mitigation Scenarios (DEA 2007) and the Mitigation Potential Analysis (2014), which is in the process of being updated by government.
[42] "with existing measures" includes measures currently being implemented, but excludes planned measures which have not begun implementation.
[43] Considerable work on this was done in 2015-16 (See Stevens et al (2016); the Mitigation Potential Analysis, for example, completed in 2014, discounted land use emissions on account of lack of data.

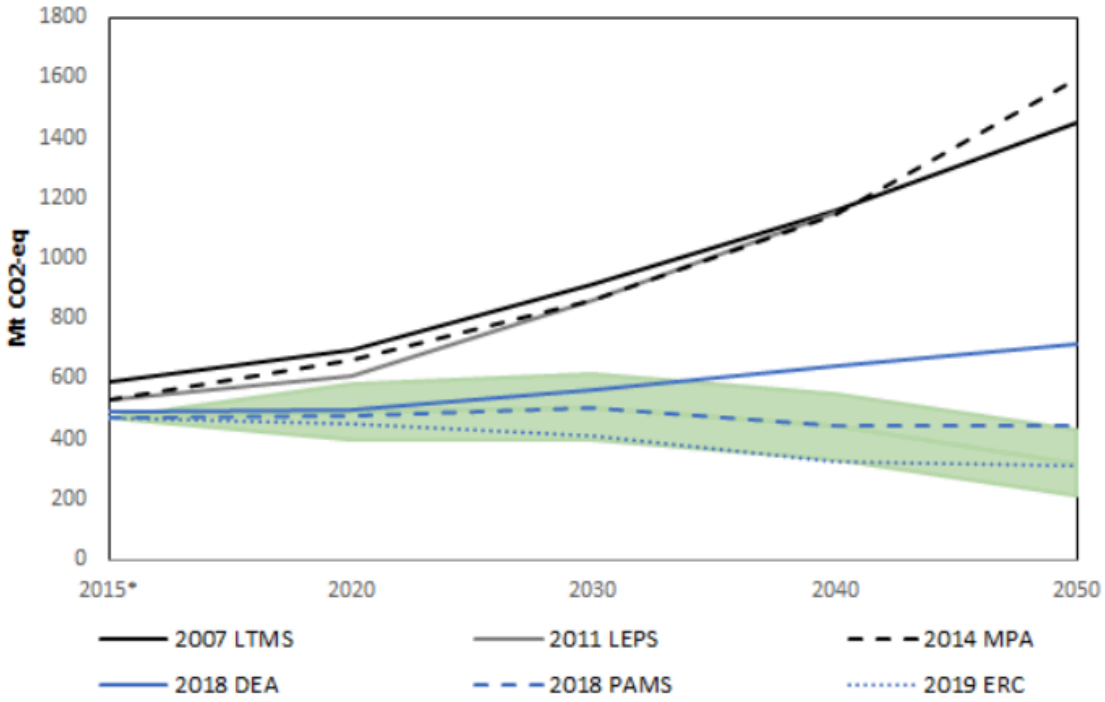

Figure 7 – The evolution of South African emissions baselines ("Business As Usual") over the last 12 years. Baselines here have been modelled considering existing policies in place, but not unimplemented programmes. "2007 LTMS" is the "current development plans" scenario from the Long-term Mitigation Scenarios process; "2011 LEPS" is an existing-policies scenario from an ERC study on long-term emissions pathways for South Africa; "2014 MPA" is the "with existing measures" scenario from the South African government's Mitigation Potential Analysis study, which is referenced in the NDC; "2018 DEA" is from a draft potential emissions pathways study (not yet finalised) undertaken by the Department of Environmental Affairs; "2018 PAMs" is a "with existing measures" baseline from a draft (not finalised) study of the emissions and economic impact of existing and planned policies and measures; "2019 ERC" is the "with existing measures" baseline from McCall et al. (2019) referenced extensively below. Source: Hartley et al (forthcoming).

In McCall et al (2019), an "alternative IRP" is explored in the context of the IRP process underway at the time[44]. While the study focuses on the power sector, the analysis is undertaken using a linked energy-economic model, SATIMGE[45], representing the whole economy. The study develops a least-cost reference case based on compliance with existing policy and regulation, including with air pollution regulations, which require retrofitting of the existing coal fleet. There are some key uncertainties in the study which require more exploration, including uncertainties in the base year

[44] The Integrated Resource Planning process in South Africa has since been finalized with a plan that is significantly less ambitious than the plan proposed in McCall et al. in emissions terms, since it included two new coal plants, and uses the existing coal fleet far more extensively.

[45] SATIMGE consists of a CGE model with detailed representation of the energy sector (ESAGE) linked to a TIMES model of the energy system, which includes process emissions. Waste and AFOLU emissions are not modelled, but are accounted for.

regarding South Africa's GHG emissions[46], assumptions regarding the costs of batteries vs natural gas (unlike other studies, the modelling in this study results in investment in large-scale utility-scale batteries rather than natural gas infrastructure).

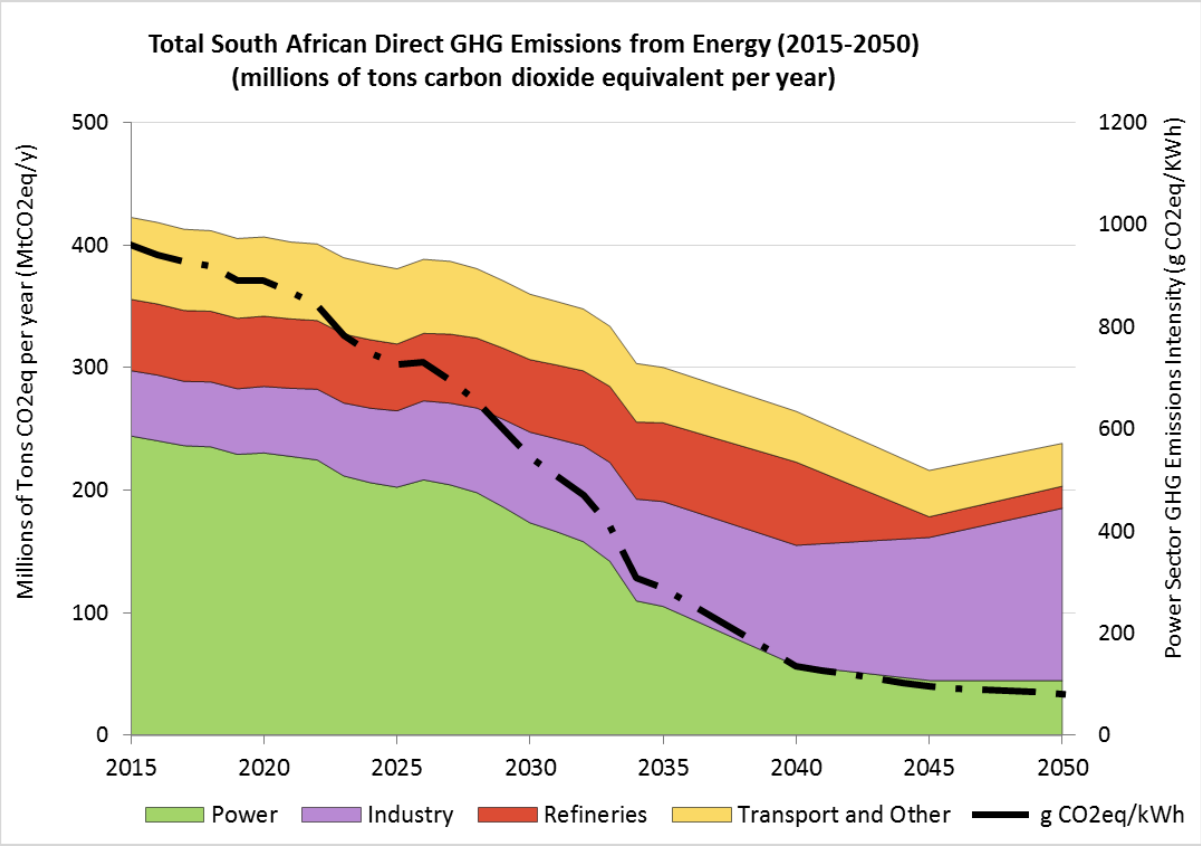

Figure 8 – reference case GHG emissions for energy and IPPU emissions, from McCall et al (2019), as well as GHG intensity of the power sector.

The reference case (without an emissions constraint) results for the electricity sector are significantly different from the IRP as finalised in 2019, in several respects, which result in less emissions: first, the assumed compliance with air pollution legislation leads to earlier retirement of existing coal capacity[47], and second, there are no new coal plants built (whereas the final IRP contains two). The result is that emissions from the electricity sector decline more rapidly in the 2020s. Energy and industry (including industrial process emissions) GHG emissions are portrayed in Figure 8.

[46] SATIM currently uses a modified energy balance for its base year, to address inconsistencies in the official energy balance. See McCall (2019).

[47] Curiously, the technical work underlying the IPR 2019 seems not to take the cost of compliance with current air pollution legislation into account. Many large coal plants in South Africa are not currently compliant, and are expected to comply by 2025, or retire shortly after that. Compliance would require significant additional investment to retrofit existing plants, and would therefore make existing coal plants less competitive.

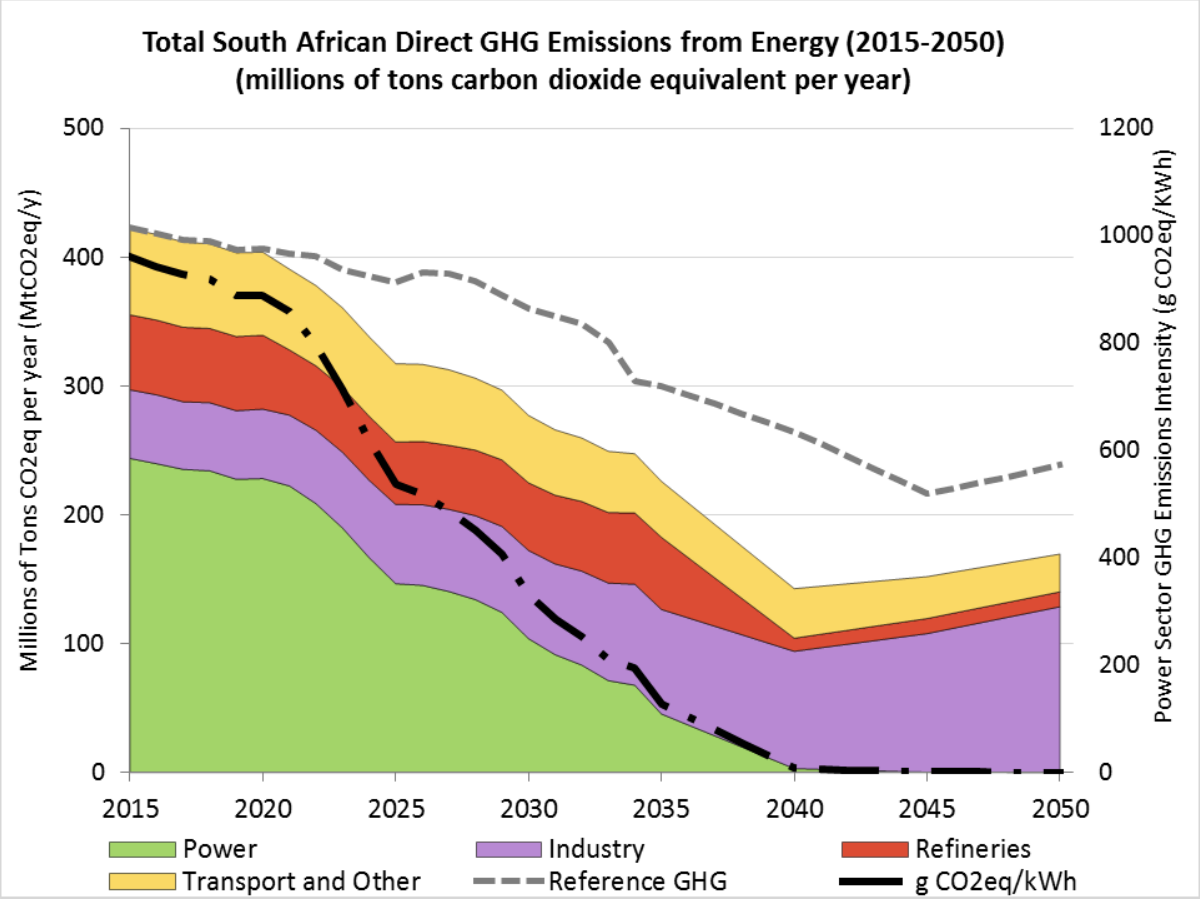

Figure 9 – mitigation case from McCall et al (2019) for energy and IPPU emissions, as well as GHG intensity of the power sector.

Without an emissions constraint, power sector emissions decline dramatically during the period, reaching less than 50% of their 2020 level by 2035. Transport and liquid fuel supply emissions do not grow significantly due to the electrification of transport, which also adds to electricity demand. The only major source of emissions still growing in the economy are emissions from industry, which is the last major sector in which coal is still used on a large scale in the economy at that point, in this analysis.

A number of incrementally lower cumulative GHG emissions budgets were modelled to test for the impact on the economy as a whole (via the CGE model) and to test the impact on the electricity price. Figure 10 indicates the source of the additional mitigation over the modelled period (2020-2050), which is identified on account of it being the least-cost option[48].

[48] Within the confines of the modelling framework used in this study, additional modal shifting is not modelled due to uncertainties in the cost of the required infrastructure. It would also be possible to include more aggressive energy efficiency policies, whose cost is not currently known, which may be cheaper options that additional RE investment in the power sector. Policy options for additional land use and waste emissions mitigation policies.

Increased mitigation almost all takes place in the power sector, which consists of more rapid investment (from 2025) in renewable energy from 2025 onwards, and declining utilization of the existing coal fleet.

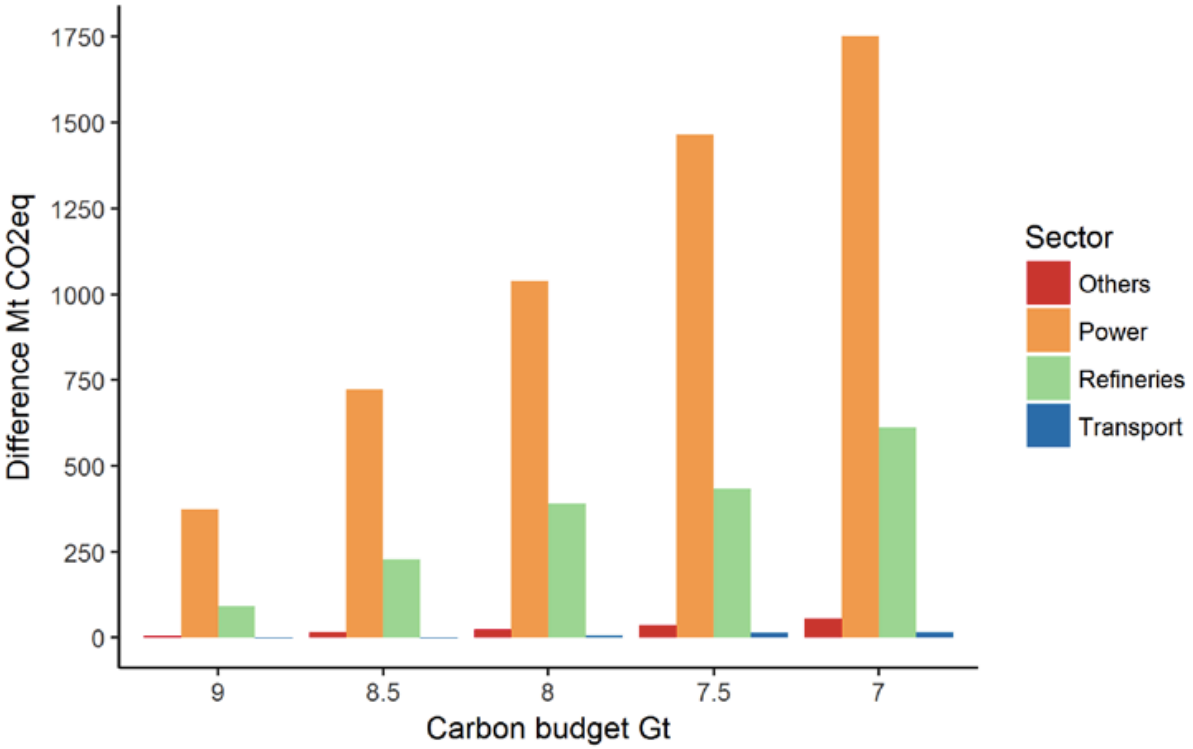

Figure 10 – progressive mitigation per sector as the overall GHG emissions budget is decreased for energy and IPPU emissions.

The other source of mitigation, as the GHG constraint is increased, is in the liquid fuels supply sector, in which synthetic fuels infrastructure retires earlier. Figure 9 portrays the emissions from the more aggressive mitigation scenario, which has some notable features. The first is that the power sector has effectively decarbonized by 2040, which requires very much more rapid investment in RE in the 2020s and 2030s, and the consideration of the early retirement of more existing coal plants. The economic impact of this is plotted in relation to the GDP in the reference case for different levels of mitigation in Figure 11. The effect for the more aggressive mitigation scenarios is more pronounced after 2030. This analysis does not consider the external effects of air pollution (other than through the regulatory costs of compliance), nor the potentially positive impact of a proactive industrialisation strategy, nor the impact of concessionary climate finance on these investments.

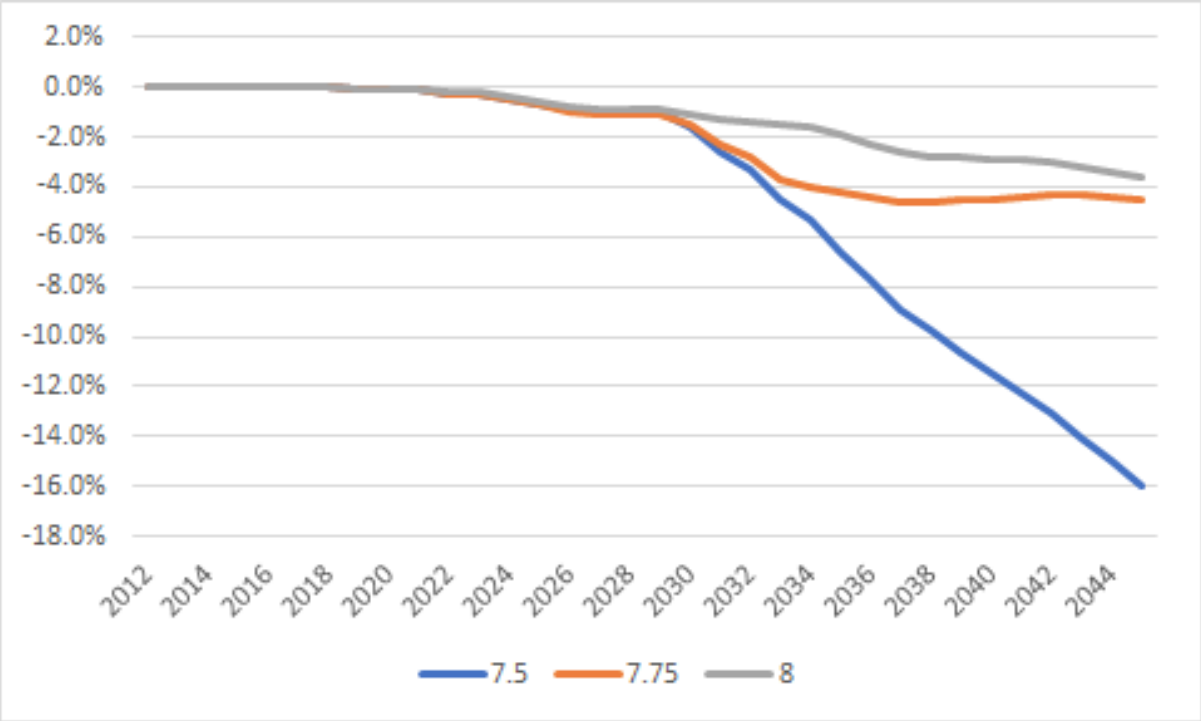

Figure 11 - impact on GDP (relative to the reference case) of imposing different GHG emissions on the economy

Implications for the 2020 "enhancement" are that for 2025 and 2030, the focus should be on careful quantification of existing and additional measures taken in the power sector, given the investment commitments currently contained in the IRP 2019, which have not been modelled from an economy-wide GHG perspective[49]. It should be feasible for South Africa to commit to an emissions outcome, particularly in 2030, which is lower than the top of the current NDC range, based on an integrated policy which considers the retirement or lower utilization of the existing coal fleet, accelerated investment in RE, and a just transition programme in affected areas of the country which addressed the socio-economic consequences to workers and communities of the retirement of existing coal assets and the creation of economic alternatives. For the NDC to be communicated in 2025 (aimed at 2035) a more extensive analysis which reconsiders long-term emissions outcomes in terms of the Paris Agreement, and which develops sectoral strategies to fully decarbonize sectors in the long term, will have to form the basis of mitigation policy following the finalization of the Climate Change Act, which will in turn form the basis for the next NDC. The above analysis indicates the potential pathways to be considered, and more detailed analysis will have to be conducted to inform this process. From a support point of view, instead of support being provided for the incremental costs of mitigation technologies, the focus needs to shift to systemic costs associated with a transition to low carbon technologies, including the costs of decommissioning and replacing existing fossil fuel infrastructure. This requires a reconceptualization of climate finance for mitigation.

[49] The GHG emissions resulting from the investment plan contained in IRP 2019 were apparently quantified, but not publicly reported.

Conclusion and further work

The above analyses are an initial attempt to provide some context for the current and future consideration of South Africa's 2020 NDC "enhancement" and its next NDC to be communicated in 2025. The NDC "enhancement" for South Africa's current NDC, to be communicated to the UNFCCC in 2020, will in terms of mitigation most likely occur within existing policy constraints. Changes in technology and in the goals of the international climate change regime, as well as developments in national policy goals, will most likely result in a much more thorough reassessment of mitigation policy as a prelude to the next NDC, due to be finalized in 2024 and communicated in early 2025 to the UNFCCC. In terms of adaptation, it is likely that South Africa will formulate an "adaptation communications" in terms of the guidance decided on in Katowice (in the annex to decision 9/CMA.1) as the adaptation component of its enhanced NDC. Further work post the 2020 enhancement, anticipating the next NDC, should focus on long-term sectoral decarbonization strategies for South Africa, and on associated policies and measures to achieve this in the short, medium and longer term associated with the multi-faceted problems of the transition and its associated development challenges.

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8 Annex III: Research and innovation knowledge gaps

This compilation of research and innovation gaps was separately submitted as a contribution to the preparation of the new Horizon Europe.

Input 1: Research and innovation gap #1: A truly country driven approach of EU transformation that allows capturing the specificities of different country circumstances and recompose a EU perspective as a composite

Challenge: A truly country driven approach of EU transformation. To date, much decarbonisation has been achieved by policy instruments that operate in a largely invisible way. When their effects (for example in raising consumer prices) become apparent, they may lose legitimacy. To reduce this risk, policymakers (at EU, national and local levels) seeking to increase the rate of decarbonisation must do so more explicitly. Policies should be developed in a way that more effectively engages affected communities, and produces economic and societal transformations with clearly identifiable benefits. This requires a country driven approach that allows capturing the specificities of different country circumstances and recompose a EU perspective as a composite.

In order to achieve this, some common research gaps in national perspectives regarding policy engagement and scenario building were identified:
Making national LTS relevant for both high level policy-makers and broader stakeholders:

- The need to bridge the current disconnect between short-term national energy policy making and ambition and long-term climate mitigation analysis, notably “to manage the transition”
- Missing analysis on what net zero emissions means and how policy implications differ from -80% scenarios at national level
- The need for better communication tools and/or innovations in scenario design so that strategies that can speak to a broader range of stakeholders and policy makers, and allow a transparent discussion on their acceptability/desirability

The missing detail in existing scenarios on how to finance/reduce costs of key aspects of the transition (e.g. infrastructure, renewable energy support schemes, etc), given perceptions in several countries that costs are excessive and co-benefits limited.

Key issues needing alignment across the EU scenario-building community

- The desire for greater alignment between scenario builders in Europe on overarching narratives/storylines, as well as on key assumptions that underpin certain parts of those narratives (e.g. timing of innovations).
- The existence of gaps/uncertainties around how to tackle circularity, behavioural change, disruptive technologies, structural changes.
- The need to better unpack issues around biomass and socio-technical issues around it to better ground scenario assumptions. As well as the importance of more analysis on options to develop deep decarbonisation in agriculture and land-use to some MS where it’s a large share of emissions.

- The importance of cross border issues – especially for smaller MS – in determining what makes sense as a decarbonisation strategy for certain sectors (power, transport, industry). This can be important notably to inform issues of cooperation within the EU (for example, issues of grid integration)

***Targeted impacts**:* Addressing this gap will support MS to identify specific needs and strategies for deep decarbonisation, and by doing so, inform and encourage engagement in EU-MS cooperation strategies discussions to design effective policies at EU level to deliver its LTS. Rather than overcomplicating things, a more textured response, embedded in the realities of the different geographies and for each of the sectors, while making the best of international cooperation, will facilitate the design of possible new avenues to make a more rapid and effective transition (from an environmental perspective) possible.

Sources:

- COP21 RIPPLES Consortium (2018). A sectoral perspective to embark on transformative pathways.COP21 RIPPLES, Policy Brief.
- COP21 RIPPLES Consortium (2019). Some arguments for increasing the EU's 2030 climate ambition. COP21 RIPPLES, Policy Brief.
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Input 2: Research and innovation gap #2: Sectoral approaches to international governance

***Challenge*:** Increasing EU ambition requires sector-specific approaches. The COP21 RIPPLES analysis of governance gaps at sector level provided insights to strengthen the suite of functions that international governance can serve to sector-specific decarbonization efforts. The gaps significantly differ from sector to sector, and therefore, the need to act at this level. The sectoral approach to understanding international climate governance can be further developed, including by considering in further detail multi-level interactions across various levels (local, national, regional and international), and what expectations it is necessary and reasonable to have regarding the international (including transnational) contribution to the whole. Future research could further systematise the investigation of the factors and driving forces that determine or affect the performance and effectiveness of sectoral governance systems in making meaningful progress toward decarbonisation. What endogenous/design and exogenous factors help advance the effectiveness of sectoral governance, and how might these factors be shaped and furthered. This step of the analysis can further systematise the assessment of the political feasibility of different policy options (such as engaging in further efforts to advance orchestration of different governance arrangements, enhance certain particularly promising elements of the international governance landscape, or progress regional/national and bilateral efforts, possibly as a stepping stone to broader international change). COP21 RIPPLES research undertook deeper governance gaps analysis in three specific areas: financial, climate clubs

(particularly in industry), technology and innovation. Similar could be done for other areas and/or sectoral systems.

Impacts: Further deepened and systematized analysis would provide a firmer basis for identifying policy options for the EU and other actors interested in advancing effective climate governance. The political feasibility analysis would assist the EU (and other actors) in prioritising the different options (that may not necessarily be incompatible, but may not all be pursued concurrently given resource constraints). In turn, by highlighting projected sector-specific changes, these results can inform and facilitate the adoption of country-specific approaches.

***Sources*:**

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Input 3: Research and innovation gap #3: Critical research and data gaps with regards to the financial system as enabler of the transformation

Challenge: The financial system as a whole must be used to combat climate change, to guarantee that all the progress that could be achieved for climate are not offset by other non-compatible objectives. Thus far, finance has been mostly understood within the international climate community as a system in equilibrium that can efficiently allocate capital according to perfectly informed prices. Looking at finance as a sectoral system allows us to take a step back and try to understand why, for example, despite increased competitiveness in renewables and numberless pledges by financial actors since the signature of the Paris Agreement, most of the leading institutional managers in the world have expanded their equity stakes in the oil & gas majors between 2014-2017 (IEA, 2018).

COP21 RIPPLES research demonstrates a significant number of research gaps, that ongoing and future academic research should address for the sake of a better contribution of scholar work to the overwhelmingly important issue of climate change related to the financial sector. The list includes gaps in Regulation, Asset impairment, Adaptation (should be taken in the double sense of the necessity of climate change adaptation finance and the reciprocal imperative adaptation of the financial system to the climate change emergency and new economic conditions that the financial system will face), Managing increased volatility and Valuing opportunities according to the categories identified by Linnenluecke, et al. From a modelling perspective, there is a need for more exploration of paths for aligning investments with Paris Agreement targets, whilst having the challenge of covering different regions and markets without falling into a one-size-fits-all approach. For this, the availability

of greater corporate data on Environmental and Social Governance (ESG) to effectively mobilise climate friendly investment constitutes a main challenge.

Impact: Enhanced study of the financial system will make possible the identification of policy actions necessary to achieve Article 2.1c of the Paris Agreement. From a modelling perspective, developing more specialised and diverse tools to study climate finance will enhance the assessment of financial needs. It will also have impact in guiding the development of more platforms for collaboration on climate finance between economic policy makers, key financial actors and other stakeholders. Environmental and climate criteria and societal benefits grow in the priority lists for the financial sector, and greater disclosure of sustainable finance information can reduce the cost of climate action and broaden the scope of tools available.

Source:

- From transformational climate finance to transforming the financial system for climate by Hugues Chenet (UCL), Luis Zamarioli, Bianka Kretschmer, Rodrigo Narvaez (Climate Analytics). COP21 RIPPLES, 2019. Deliverable 4.3 Part A.
- Report on quantitative and qualitative analysis of the financial system implications of decarbonisation. COP21 RIPPLES, 2019, Deliverable D3.5
- Linnenluecke, Smith and McKnight. “Environmental finance: A research agenda for interdisciplinary finance research”. 2016.

Input 4: Research and innovation gap #4 Stronger need for transdisciplinary approaches

***Challenge*:** We are not on track: the challenge is to understand better the nature of this gap and to feed political discussions at all relevant levels and across these different levels on how to address it. Studies on general abatement potentials or theoretical economic assessments have played a role but have limited capacity in moving us further. There is a strong need for transdisciplinary approaches that have to transcend the usual limits between the academic fields of macroeconomic modelling, political economics, energy modelling, climate policy, climate modelling, financial regulation, financial mathematics and more. This needs to be undertaken in collaboration with practitioners in order for research to concretely help decision makers. The experience of COP21 RIPPLES as a multidisciplinary project in exploring how to cover the EU's gap between current climate action and the Paris Agreement targets show that model-based assessments yield more results when accompanied with information from other fields of expertise. However, building a type of dynamic where different disciplines work together on climate change research demands sufficient time and the expansion of stakeholder engagement activities to cover the set of relevant areas and communities of practice across EU. Strengthened support to transdisciplinary research is critical.

***Impacts*:** The successful implementation of the Paris Agreement inevitably requires addressing different inter-connected dimensions : governance, economic and social, sectoral & physical transformations and GHG emissions. Political discussions on ambition need to be confronted with adequacy assessments that allow for these different dimensions to be considered.

Source:

- COP21 RIPPLES Consortium (2020). Getting on to the right (emissions) path. An adequacy assessment framework and its application within the EU. COP21 RIPPLES, 2020. Policy brief
- First Policy Dialogue Report. COP21 RIPPLES, 2019. Deliverable D5.8
- Second Policy Dialogue Report. COP21 RIPPLES, 2019. Deliverable D5.9

Input 5: Research and innovation gap #5: Enhancing modelling capacities to assess decarbonisation impacts at the sectoral level

***Challenge*:** Integrated Top Down and Bottom Up Climate Modelling. Current research has relied on several types of models to assess climate policy impacts, inter alia, Integrated Assessment Models (IAMs), energy system models, computable general equilibrium models and system dynamic models While IAMs can picture an overall decarbonisation scenarios or pathways, there is the need to analyse those pathways with increased granularity. This is where bottom-up models can provide more detailed results at the sectoral level. On the other, bottom-up models provide only a partial assessment, which lack detail on the interaction with the rest of the economy. Therefore, bottom up models (such as Agent Based) should be complemented with the use of top-down and macroeconomic models

In order to achieve this integration whilst maintaining consistency, modelling approaches should either: 1) Establishing a linking protocol to take advantage of bottom-up and Top-down models following a harmonised set of assumptions, or 2) Increasing the detail of top-down models including specific bottom-up features in order to provide more detailed projections at the sectoral level of decarbonisation pathways.

Impacts: Addressing this gap will allow for the improvement of climate and decarbonisation policy assessment, by consistently bridging the gap between top-down and bottom-up models. This will allow for the improvement of policy analysis addressing potential competitiveness and redistributive effects. This could also help to improve the analysis of sectors that are more difficult to decarbonise because of their intrinsic features, such as the transport sector. This approach could also help to address the analysis of behavioural changes designed to support a more efficient use of energy and natural resources.

***Sources*:**

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Input 6: Research and innovation gap #6 Better understanding of the pace of change in alternative future scenarios

***Challenge*:** An important aspect of the decarbonization-innovation nexus is not only the potential strength in a technology, but also the speed of innovation. If clean technologies become cheaper than traditional technologies, then not only will the speed of decarbonization be increased, but also the

economic and political sphere will be easier to navigate. Therefore, understanding the rate of technological progress in clean (and dirty) energy is of first order importance, as is understanding how we can accelerate the cost reductions. COP21 RIPPLES research estimated experience curves of low-carbon technologies to make probabilistic forecasts of future costs. When expanded to a suite of technologies, the analysis establishes a theoretical link between technology portfolios and financial portfolios. This is useful because it helps explain precisely when and why investments in dynamic, new technologies can be justified, as an ageing competitor technology's capacity for learning diminishes. This work is yet to be embedded in modeling tools that are generally used to inform decarbonization policies. More research efforts have gone to improve the understanding of induced innovation to realise that there is plenty of scope for more research to pinpoint the contribution of induced technology innovation to resolve tensions of economy and environment at macro levels.Beyond innovation but related to this, many **o**ptimizing Integrated Assessment Models, and specifically the widely-used DICE model, represent abatement costs as a result of assuming temporal independence –abatement costs in one period are not affected by prior abatement. This is in contrast with three dimensions of dynamic realism in emitting systems: inertia, induced innovation, and path dependence. Representing dynamic realism in such models is as important. Far greater analytic and empirical attention should be given to ways of representing, and estimating, the dynamic realities of energy-emission systems in integrated assessments.

***Impacts*:** Ignoring the dynamic characteristics of abatement produces misleading insights for policy, potentially leading to a postponement of a transition that should be initiated early because it needs time and up-front investment. If we understand induced innovation, robust policies can become driving pacemakers of the decarbonisation path. To understand better the potential and dynamics of early investments as an accelerator of progress the integration of experience curve forecasting method into modeling tools would be a useful contribution. This would also allow to clarify financial implications of the decarbonization of the global economy and the design of funding architectures (addressed in COP21 RIPPLES, Deliverable D3.5).

Source:

- COP21 RIPPLES. Report on assessing the technology innovation implications of NDCs, technology portfolio choices, and international competitiveness in clean technologies. 2018. Deliverable D3.3
- Grubb, M., Wieners, C. Modelling Myths: On the need for dynamic realism in DICE and other 'equilibrium' models of global climate mitigation. January 2020. Working Paper submitted to the Institute of New Economic Thinking.
- COP21 RIPPLES. Report on quantitative and qualitative analysis of the financial system implications of decarbonization. 2019. Deliverable D3.5