CLIMATE CHANGE
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Final report

The Challenges of Assessing "Collective Progress": Design Options for an effective Global Stocktake process under the UNFCCC

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Kurzbeschreibung

Mit dem Übereinkommen von Paris (ÜvP) wurde ein Prozess der globalen Bestandsaufnahme („Global Stocktake", GST) als wichtiger Schutzmechanismus eingeführt, der die Anschärfung der NDCs im Hinblick auf die Erreichung der kollektiven Ziele des Abkommens erleichtern soll. Dieses Papier untersucht die Fragen, wie ein wirksamer GST-Prozess aussehen könnte, und welche Informationen und Daten zu seiner Unterstützung benötigt werden. Wir identifizieren vier Funktionen, die ein wirksamer GST erfüllen sollte: Er sollte als Schrittmacher der politischen Prozesse fungieren, die Rechenschaftspflicht der Länder gewährleisten, verstärkte Ambitionen von zukünftigen NDCs vorantreiben und Leitlinien und Signale für ein erneuertes Engagement für die Ziele des Pariser Abkommens geben.

Der GST sollte sich dabei auf umfassende Informationen stützen, die in direktem Bezug zu Politiken und Maßnahmen stehen. Der Transparenzrahmen des ÜvP soll dazu qualitativ hochwertige und umfassende Informationen liefern. Sein Beitrag ist jedoch begrenzt, da er erst ab 2024 in Kraft tritt und auch weiterhin mit lückenhafter Berichterstattung zu rechnen ist. Somit sollten zusätzliche Informationsquellen für den GST genutzt werden. Der IPCC könnte dazu beitragen, diese Informationen zu legitimieren und zusammenzutragen.

Zu den wichtigsten Herausforderungen bei der Bewertung des kollektiven Fortschritts durch den GST gehören Datenlücken bei der Quantifizierung und Aggregation der Emissionen und das eingeschränkte Mandat des GST zur Beurteilung des kollektiven Fortschritts. Vor diesem Hintergrund bewerten wir das Potenzial und die Grenzen des GST zur Erfüllung der vier oben beschriebenen Funktionen. Der UNFCCC-Prozess könnte seine Wirksamkeit maximieren, indem er (1) eine öffentliche Bewertung der Inputs vorsieht, (2) den in diesem Projekt entwickelten Ansatz zur Darstellung des Fortschritts zur Minderung von Emissionen anwendet, (3) in den strukturierten Expertendialogen eine detaillierte Erörterung von sektor-spezifischen Problemen vorsieht und (4) den IPCC auffordert, sich zum Stand der Forschung im Hinblick auf die Festlegung von Benchmarks für Emissionsminderung zu äußern. Die offizielle GST sollte durch unabhängige Aktivitäten der Zivilgesellschaft und der akademischen Gemeinschaft ergänzt und unterstützt werden.

Abstract

The Paris Agreement established a Global Stocktake process as a key safeguard mechanism to facilitate enhancement of the NDCs toward meeting the collective goals of the Agreement. This paper examines the questions of what an effective Global Stocktake process would look like, and what information and data are needed to support it. We identify four functions that an effective Global Stocktake should fulfil; acting as a pacemaker of policy processes, ensuring accountability of countries actions, driving enhanced ambition in subsequent NDC cycles, and providing guidance and signal of a renewed commitment to the Paris Agreement goals.

The Global Stocktake should be based on comprehensive information that can easily be related to policies and actions. The Enhanced Transparency Framework should provide good quality and extensive information but is limited due to its timing and scope. Other sources of information that could provide additional details should be utilised as far as possible and the IPCC could play a role in synthesising and legitimising some information sources.

Key challenges in assessing collective progress by the GST include data gaps in the quantification and aggregation of emissions under the NDCs and the limited mandate to assess collective progress only. Against this background we assess the potential and limits for the Global Stocktake to deliver on fulfilling the four functions outlined above. The UNFCCC process could maximise its effectiveness by (1) including an explicit public appraisal of the inputs, (2) applying the performance distributions approach as a tool to perform collective assessments developed in this project, (3) including detailed discussion of key sectoral systems in the structured expert dialogues, and (4) calling upon the IPCC to assess the available research specifically with a view to identifying benchmarks. The official GST should be complemented and supported by independent activities from civil society and the academic community.

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List of Abbreviations

AFOFI	CO2 emissions from fuel combustion in agriculture, forestry, fishing
AFOLU	Agriculture, Forestry and Land Use
APA	Ad Hoc Working Group on the Paris Agreement
AR	Assessment Report
BAU	Business-As-Usual
BP	British Petroleum
BR	Biennial Report
BUR	Biennial Update Report
CAT	Climate Action Tracker
CBDR	Common but Differentiated Responsibilities
CCPI	Climate Change Performance Index
CCS	Carbon Capture and Storage
CDIAC	Carbon Dioxide Information Analysis Center
CDR	Carbon Dioxide Removal
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CMA	Conference of the Parties serving as the meeting of the Parties to this Agreement
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSP	Concentrated Solar Power
EC	European Commission
EDGAR	Emissions Database for Global Atmospheric Research
EEA	European Economic Area
EJ	Exajoule
ETC/ACM	European Topic Centre on Air pollution and Climate change mitigation
ETS/ESD	Emissions Trading Scheme / Effort Sharing Decision
EU	European Union
FAO	Food and Agriculture Organisation
FAOSTAT	Statistics of the Organisation for Food and Agriculture
GCA	Global Climate Action
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GDP PPP	Gross Domestic Product, Purchasing Power Parity
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNI	Gross National Income
GST	Global Stocktake
GVA	Gross Value Added
GW	Gigawatt
HFC	Hydrofluorocarbons
HLPF	High-Level Political Forum
IAM	Integrated Assessment Model
ICAO	International Civil Aviation Organisation
ICAT	Initiative for Climate Action Transparency

ICTU	Information to enhance clarity, transparency and understanding
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRENA	International Renewable Energy Agency
ITMOs	Internationally Traded Mitigation Outcomes
LULUCF	Land Use, Land Use Change, and Forestry
MRV	Monitoring, Reporting and Verification
MW	Megawatt
NAZCA	Non-State Actor Zone for Climate Action
NDC	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
PA	Paris Agreement
PIK	Potsdam Institut für Klimafolgenforschung
PJ	Petajoule
PRIMAP-hist	Potsdam Real-time Integrated Model for probabilistic Assessment of emissions Paths
PV	Photovoltaic
QA/QC	Quality Assurance / Quality Control
RD&D	Research Development and Demonstration
RES-E	Renewable energy sources electricity
RES-HC	Renewable energy sources heating / cooling
RES-T	Renewable energy sources transport
RES-total	Total renewable energy sources
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SDG	Sustainable Development Goal
SED	Structured Expert Dialogue
SR1.5	IPCC 1.5 Special Report
SSP	Shared Socioeconomic Pathways
TACCC	Transparency Accuracy Completeness Consistency Comparability
TEAP	Technology and Economic Assessment Panel
TEP	Technical Examination Process
UBA	Umweltbundesamt
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WAM	With Additional Measures (scenario)
WEM	With Existing Measures (scenario)
WG Climate	Working Group on Climate
WGIII	Working Group three of the IPCC
WMO	World Meteorological Organisation
WRI	World Resources Institute

Zusammenfassung

Das Übereinkommen von Paris (ÜvP) bietet einen unbefristeten Rahmen für den globalen Klimaschutz. Es kombiniert global formulierte kollektive Ziele mit den Beiträgen der einzelnen Länder (National Determined Contributions (NDCs)). Eine zentrale Herausforderung dieses hybriden Ansatzes besteht darin, dass es keine Garantie dafür gibt, dass die individuellen Beiträge in der Summe ausreichen, um die kollektiven Ziele zu erreichen.

Um dieses Problem zu lösen, wurde mit dem ÜvP der Mechanismus der sogenannten Globalen Bestandsaufnahmen, in Englisch “Global Stocktake” (GST), eingeführt. Im Rahmen dieser globalen Bestandsaufnahme wird ab 2023 und danach alle fünf Jahre öffentlich Bilanz gezogen über die "kollektiven Fortschritte" bei der Erreichung der langfristigen Ziele des ÜvP. Dies geschieht auf der Grundlage von Informationen, die über den Transparenzrahmen des Abkommens, das “Enhanced Transparency Framework” an die UNFCCC berichtet werden. Der GST verbindet so die Umsetzung der NDCs auf nationaler Ebene mit den übergreifenden Zielen des ÜvP. Das Feedback, das der GST im Hinblick auf das Ambitionsniveau nationaler Beiträge generiert, soll die nationalen klimapolitischen Agenden in Richtung ehrgeizigerer NDCs beeinflussen und inspirieren. Vor diesem Hintergrund befasst sich diese Studie mit drei Fragen:

- **Wie sollte ein effektiver Global Stocktake aussehen?**
- **Welche Informationen und Daten werden für einen effektiven Global Stocktake benötigt?**
- **Ist es möglich, im Rahmen des Mandats des Übereinkommens von Paris einen wirksamen Global Stocktake durchzuführen?**

Um diese Fragen zu beantworten, wurde ein umfangreiches zweijähriges Forschungsprojekt vom Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit finanziert und vom Umweltbundesamt durchgeführt. Diese Kurzzusammenfassung liefert einen deutschsprachigen Überblick über die Ergebnisse des Forschungsprojekts. Konkret werden zunächst Hintergrundinformationen vorgestellt und definiert, was "effektiv" im Kontext des GST bedeutet. Dabei konzentrieren wir uns auf den Aspekt der Minderung von Treibhausgasen (*mitigation*). Klimaanpassung sowie Klimafinanzierung und nachhaltige Ausrichtung globaler Finanzströme werden dabei nicht oder nur am Rande thematisiert. Anschließend untersuchen wir Indikatoren und Benchmarks, die beim GST zur Beurteilung des kollektiven Fortschritts verwendet werden könnten, und bewerten, ob die erforderlichen Informationen überhaupt verfügbar und von ausreichender Qualität sind, um eine aussagekräftige Analyse der Fortschritte beim Klimaschutz durchzuführen. Anschließend werden Chancen und Herausforderungen bei der Aggregation der Informationen erörtert. Dazu entwickeln wir einen Ansatz für eine im Rahmen des GST zweckdienliche Darstellung aggregierter Informationen. Abschließend wird diskutiert, ob und inwieweit die vorgeschlagenen Ansätze die Bedingungen eines erfolgreichen GST erfüllen. Auf dieser Grundlage werden Empfehlungen für die Gestaltung des GST-Prozesses formuliert.

Hintergrund und Rahmen für die Analyse

Der Global Stocktake im Kontext

Der GST wird in Artikel 14 des ÜvP definiert. Sein Mandat umfasst drei "Themenbereiche": Minderung von Treibhausgasen, Klimaanpassung, sowie Mittel zur Umsetzung und Unterstützung (*means of implementation and support*). Maßnahmen zur Begrenzung unerwünschter Nebeneffekte von Klimaschutzmaßnahmen (*response measures*) und der Umgang mit unvermeidbaren klimabedingten Schäden und Verlusten (*loss and damage*) können ebenfalls in Betracht gezogen werden. Diese Studie fokussiert jedoch vorranging auf den ersten der gennanten Bereiche. Die Verhandlungen auf der 24. Vertragsstaatenkonferenz der Klimarahmenkonvention (*Conference of the Parties* – COP) in Kattowitz

bestätigten, dass der GST aus drei Komponenten bestehen wird: (1) Sammlung und Aufbereitung von Informationen, (2) technische Bewertung und (3) die (politische) Bewertung der Ergebnisse.

Die Ergebnisse des GST sollen "Chancen und Herausforderungen für die Verbesserung von Maßnahmen und Unterstützung im Lichte von Gerechtigkeit und der besten verfügbaren Wissenschaft sowie der gewonnenen Erkenntnisse und bewährten Praktiken zusammenfassen". Es sei darauf hingewiesen, dass die Ergebnisse des GST keinen Fokus auf individuelle Vertragsstaaten legen, ausschließlich den kollektiven Fortschritt betrachten und insbesondere keine präskriptiven Empfehlungen für konkrete Politikmaßnahmen enthalten (Beschluss 19/CMA.1 Kapitel I Absatz 14).

Informationen, die als Input für den GST dienen, sollten mindestens 3 Monate vor ihrer Berücksichtigung bei der technischen Bewertung und spätestens sechs Monate vor der politischen Bewertung der Outputs eingereicht werden. Berücksichtigt werden sollen Informationen über den Stand der Treibhausgasemissionen, die von den Vertragsparteien unternommenen Minderungsmaßnahmen, die Gesamtwirkung der NDCs, der Stand der Anpassungsbemühungen, die Finanzströme, spezifische Hindernisse und Herausforderungen für Entwicklungsländer, Möglichkeiten zur Verstärkung der internationalen Zusammenarbeit, Möglichkeiten zur Stärkung der internationalen (finanziellen) Unterstützung sowie Gerechtigkeitsaspekte.

Als Quellen für Beiträge werden Berichte und Mitteilungen der Vertragsstaaten, Berichte des Weltklimarats (IPCC), der Nebenorgane der UNFCCC (SBSTA und SBI), anderer relevanter Gremien im Rahmen der UNFCCC oder des ÜvP, des UNFCCC-Sekretariats, ander UN-Organisationen, regionaler Gruppen und Institutionen sowie Eingaben von Vertragstaaten und Stakeholdern genannt. Das UN-Klimasekretariat wird beauftragt, im Rahmen der Informationssammlung und -aufbereitung vier Syntheseberichte zu erstellen, die (1) den Stand der THG-Emissionen und der Maßnahmen zur Minderung von Treibhausgasen, (2) den Stand der Anpassungsbemühungen, Erfahrungen und Prioritäten, (3) die Gesamtwirkung der NDCs und (4) die Finanzströme abdecken sollten (UNFCCC, 2018, Abs. 6c).

Ein effektiver Global Stocktake: Funktionen und Erfolgsbedingungen

Wir identifizieren vier Funktionen eines effektiven Global Stocktakes: er sollte als Schrittmacher politischer Prozesse fungieren, die Rechenschaftspflicht der Länder gewährleisten, in den nachfolgenden NDC-Zyklen eine verstärkte Ambition im Klimaschutz fördern und Signal und Orientierung für ein erneuertes Bekenntnis zu den Zielen des ÜvP geben.

Der GST wird vielfach als der zentrale Mechanismus zur schrittweisen Erhöhung des Ambitionsniveaus wahrgenommen. Dennoch besteht eine große Diskrepanz zwischen dem hohen Anspruch, der in dem langfristigen Temperaturziel zum Ausdruck kommt, und dem derzeitigen Ambitionsniveau der NDCs (UNFCCC, 2016). Es ist daher notwendig, dass dieses Niveau in den folgenden Iterationen des NDC-Zyklus erheblich gesteigert wird. Verschiedene Theorien des Wandels können Anhaltspunkte dafür geben, wie der GST dazu beitragen könnte. Wir haben diese Theorien in die folgenden vier Governance-Funktionen für den GST "übersetzt". Um das Potential des GST voll auszunutzen, müssen alle diese Funktionen bestmöglich ausgenutzt werden (siehe auch Hermwille *et al.* , 2019). Damit der GST diese Funktionen erfüllen kann, müssen bestimmte prozess- und informationsbezogenen Bedingungen erfüllt werden:

- **Herzschrittmacherfunktion**: Das ÜvP schafft einen "Schrittmacher", der politische Prozesse über die verschiedenen Regierungsebenen hinweg stimuliert und synchronisiert. Nach dieser Perspektive verstärkt der GST den periodischen 5-jährigen NDC-Zyklus oder Rhythmus des ÜvP, der einem prototypischen Politikzyklus (Agenda-Setting, Politikformulierung, Entscheidungsfindung, Umsetzung, Evaluierung) ähnelt (Jann *et al.*, 2007). Der GST selbst kann dabei als Instrument zum Agenda-Setting betrachtet werden, der die anschließende Formulierung und Verabschiedung von nachfolgenden NDCs auf nationaler Ebene beeinflussen soll. Um diese

Funktion zu erfüllen, müssen rechtzeitig aussagekräftige Informationen zur Verfügung stehen. Darüber hinaus sollten die Ergebnisse des GST so formuliert werden, dass sie in den politischen Diskursen möglichst vieler Länder anschlussfähig sind.

- **Gewährleistung der Verantwortlichkeit**: Die erste Phase des GST-Prozesses erfordert länderspezifische Inputs (Informationen aus dem Enhanced Transparency Framework sowie andere "beste verfügbare Wissenschaft"). Diese Informationen könnten dazu beitragen, Länder zur Verantwortung zu ziehen. Sie ermöglichen es, Länder bei unzureichender Umsetzung ihrer NDCs öffentlich an den Pranger stellen. Dazu sind genaue und ausreichend detaillierte Daten erforderlich, um die Fortschritte in Richtung NDCs zu beurteilen. Der GST könnte dazu beitragen, die öffentliche Aufmerksamkeit hierfür zu erhöhen, indem einzelne Länderberichte öffentlich entgegengenommen, überprüft und bewertet werden. Damit könnte der Prozess der multilateralen Betrachtung der Fortschritte (*multilateral consideration of progress*) im Rahmen des Enhanced Transparency Framework ergänzt werden. Dies könnte beispielsweise umgesetzt werden, indem die entsprechenden Berichte von einem *high-level* Segment der Verhandlungen offiziell zur Kenntnis genommen und gebilligt würden. Der GST hat jedoch hierfür nur ein sehr enges Mandat, da nur der *kollektive* Fortschritt bewerten soll. Wenn man den GST als einen Prozess versteht, wäre es jedoch gegebenenfalls möglich, die länderspezifischen Inputs in der Informationsbeschaffungs- und -bewertungsphase des GST formal und öffentlichkeitswirksam zu erfassen, und zu überprüfen.
- **Steigerung der NDC-Ambition:** Wenn die Ziele des Abkommens erreicht werden sollen, ist eine Steigerung des Ambitionsniveaus in nachfolgenden NDCs unumgänglich. Das ÜvP beinhaltet einen sogenannten "Ambitionsmechanismus". Er verpflichtet die Staaten dazu, dass jedes neue NDC einen “Fortschritt” gegenüber dem vorherigen NDC und das höchste mögliche Ambitionsniveau darstellen muss. (Müller und Ngwadla, 2016; van Asselt, 2016). Um dies zu unterstützen, könnte der GST internationale Benchmarks festlegen, die helfen zu bestimmen, was ein “Fortschritt” und was das “höchste mögliche Ambitionsniveau” ausmacht. Es gehört nicht zum Mandat des GST, diese Bewertung auf Länderebene vorzunehmen, aber er könnte anderen, einschließlich nationalen politischen Entscheidungsträgerinne und Entscheidungsträgern und Organisationen der Zivilgesellschaft die Mittel hierfür zur Verfügung stellen. Der IPCC wird bei der Festlegung dieser Benchmarks eine zentrale Rolle spielen. Darüber hinaus könnte der GST besonders ehrgeizige NDCs oder Aspekte von NDCs positiv hervorheben. Darüber hinaus könnte der GST zu einer Peer-Learning-Plattform zur Frage werden, wie transformativer Wandel gelingen kann. (Milkoreit und Haapala, 2017). Dies könnte beispielsweise im Rahmen der technischen Dialoge geschehen, die während des GST-Prozesses stattfinden werden.
- **Signal und Orientierung:** Der GST bietet eine Gelegenheit, das bereits in Paris gegebene Signal zur globalen klimafreundlichen Transformation zu wiederholen und zu verstärken. Die Vertragsstaaten können und sollten im Rahmen des GST die Gelegenheit nutzen, sich erneut zu den Zielen des ÜvP zu bekennen. Mindestens ebenso wichtig ist, dass der GST das bestehende Signal weiterentwickeln und verfeinern kann. Zunächst muss dafür beurteilt werden, ob die langfristige Vision im Lichte der verfügbaren Wissenschaft noch angemessen und/oder erreichbar ist. Für den Bereich Minderung von Treibhausgasemissionen wäre es besonders hilfreich, wenn der GST sich mit sektoralen Visionen befassen würde, die die sektorspezifischen Transformationsherausforderungen deutlicher herausstellen. Er müsste solche Visionen nicht notwendigerweise selbst erarbeiten, sondern könnte bestehende Sektorvisionen oder -roadmaps zusammenfassen und formal anerkennen. Dies würde nicht nur Anhaltspunkte die nächste Runde der NDCs liefern, sondern könnte auch als aktualisierter Bezugspunkt für alle Arten von Governance-Initiativen (einschließlich nichtstaatlicher und subnationaler Akteure) dienen. Dies würde transnationalen Governance-Initiativen Legitimation und Orientierung geben und so dazu beitragen, die Vielzahl solcher Klimaschutzinitiativen zu "orchestrieren".

Bestandsaufnahme: Verfügbare Informationen zur Bewertung des kollektiven Fortschritts

Indikatoren für einen effektiven Global Stocktake

Der GST sollte ein breites Spektrum von Informationen berücksichtigen. Diese Informationen sollten sich bestenfalls direkt mit Politiken und Maßnahmen in Verbindung bringen lassen. Dabei könnte die Berücksichtigung detaillierter, sektorspezifischer Informationen ein besseres Verständnis der Treiber von Emissionen sowie spezifischer Barrieren auf dem Weg zur Dekarbonisierung ermöglichen und so die Entwicklung einer Vision einer 1,5 °C kompatiblen Welt erleichtern.

Um die oben beschriebenen Funktionen auszufüllen, werden beim GST Indikatoren und Benchmarks zur Bewertung des kollektiven Fortschritts benötigt. Dabei reicht es nicht aus, nur die Emissionen zu betrachten. Darüber hinaus sind auch Indikatoren gefragt, die die Treiber von THG-Emissionen betreffen. Außerdem sollten strukturelle und institutionelle Praktiken erfasst werden, die den Übergang zu einer kohlenstoffarmen Welt erleichtern (oder behindern). Die Indikatoren können quantitativer oder qualitativer Natur sein.

Ein guter Indikator ist relevant, zuverlässig, genau und handhabbar. **Im Rahmen des GST steht ein relevanter oder aussagekräftiger Indikator eindeutig mit nationalen und internationalen klimapolitischen Maßnahmen und Strukturen in Verbindung, und zwar zeitlich unmittelbar, auf die nahe Zukunft ausgerichtet und mit einem Detailgrad, der direkten Einfluss auf politisches Handeln hat.** Wenn der GST ambitioniertere klimapolitische Maßnahmen unterstützen soll, sollten die abgedeckten Themen und Indikatoren leicht in Politiken übersetzt werden können und nicht zu abstrakt sein. Um relevant zu sein, müssen die Indikatoren auch so formuliert werden, dass sie Daten verschiedener Länder vergleichbar machen, beispielsweise in Form von Pro-Kopf-Emissionen oder Emissionsintensität der Wertschöpfung.

Um zuverlässig und genau zu sein, muss ein Indikator robust formuliert sein und auf qualitativ hochwertigen Daten basieren, denen alle Nutzer vertrauen. Darüber hinaus ist es häufig ratsam, Daten im Mittelwert über mehrere Jahre zu betrachten. Damit lassen sich fehlerhafte Datenpunkte korrigieren und Schwankungen und besondere Ereignisse mit emissionsrelevanter Wirkung berücksichtigen, beispielsweise unerwartete wirtschaftliche Einbrüche oder wetterbedingte Schwankungen. Schließlich sind solche Indikatoren handhabbar, für die ausreichende Informationen zur Verfügung stehen, sei es für eine ausreichende Anzahl von Ländern, für genügend Jahre und hinreichend regelmäßig und zeitnah aktualisiert. Nur so ist eine robuste und akkurate Einschätzung der Situation möglich.

Der GST muss mehrere zeitliche Perspektiven berücksichtigen. Was ist der gegenwärtige Stand der Emissionen und der wesentlichen Emissionstreiber? In welche Richtung entwickeln sie sich? Und auf welchem Stand erwarten wir sie in der Zukunft? Dazu müssten alle Indikatoren idealerweise auf der Grundlage von Datenzeitreihen kontinuierlicher Jahre verfügbar sein, sowohl in die Vergangenheit (bis mindestens 1990) als auch in die Zukunft gerichtet (bis zum Zeitrahmen der aktuellen NDCs oder gar langfristigen Klimaschutzstrategien (long-term low greenhouse gas emission development strategies)) erstrecken. Insbesondere die hierfür notwendigen Projektionen stellen den GST vor große Herausforderungen. So kann es sein, dass einige Indikatoren nur zur Messung des bisherigen Fortschritts oder zur Bewertung künftiger Richtungen nur innerhalb eines begrenzten Zeitrahmens verwendet werden können (z.B. für NDCs, nicht aber für Langfriststrategien).

Ebenso wichtig ist der Detailgrad der Indikatoren. Der Detailgrad kann sich etwa auf die Disaggregierung nach Sektoren, nach Treibhausgasen, nach Regionen, nach Brennstoffen oder nach Technologien beziehen. Je spezifischer der Indikator, desto spezifischer müssen die Informationen sein, um den Indikator quantifizieren zu können. Einerseits lässt sich ein spezifischerer Indikator oft leichter direkt mit der Politik in Verbindung bringen (z.B. die Renovierungsrate von Gebäuden) und erfüllt somit die

Anforderung der politischen Relevanz. Auf der anderen Seite ist es weniger wahrscheinlich, dass vergleichbare Informationen für alle Länder und Jahre verfügbar sind.

Um die oben beschriebene Relevanzanforderung eines guten Indikators zu erfüllen, ist ein gewisses Maß an sektoraler Detaillierung erforderlich. Eine Herausforderung für den GST besteht darin, dass verschiedene Institutionen und Informationsquellen die Sektoren unterschiedlich definieren. Eine weitere Anforderung des GST ist, dass der Fortschritt auf kollektiver Ebene bewertet wird. Um relevant zu sein, könnte hingegen eine geographische Auflösung (entweder national oder regional) informativer sein.

In Bezug auf qualitative Indikatoren sollte der GST einen Überblick über die klimapolitischen Maßnahmen der Länder geben. Dabei wird es kaum möglich sein, die Stringenz, die Ambition oder die Wirksamkeit einer einzelnen Politik zu beurteilen. Eine Übersicht darüber, welche Länder umfassende Rahmengesetze eingeführt haben, welche Sektoren / Bereiche von Minderungsaktivitäten abgedeckt sind und ob die erwarteten Minderungsauswirkungen quantifiziert wurden, könnte dennoch relevante Informationen liefern. Eine zweite Art von qualitativen Informationen, die im Rahmen eines effektiven GST gesammelt werden sollten, betrifft bestehende Transformationsherausforderungen und -Hindernisse auf dem Weg zu einer dekarbonisierten Wirtschaft und Gesellschaft.

Im Rahmen des Projektes wurde ein **umfassender** Satz potentieller Indikatoren für den GST untersucht. Bewertetet wurde die Relevanz der Indikatoren sowie die Anforderungen und Datenverfügbarkeit für eine Auswertung der Indikatoren im Rahmen des GST. Die Auswahl umfasst **sowohl zentrale übergeordnete Parameter, die direkt mit den Zielen des ÜvP in Zusammenhang stehen,** als auch **sehr detaillierte Aspekte**, die, wie oben beschrieben, sektorale Details und politische Relevanz umfassen. Außerdem haben wir Indikatoren priorisiert, die für den Übergang zu einer kohlenstoffarmen Wirtschaft von grundlegender Bedeutung sind. Als quantitativer Indikator wäre hier zum Beispiel der Anteil erneuerbarer Energien am Endenergieverbrauch zu nennen. Ein zentraler qualitativer Indikator wäre das Vorhandensein von langfristigen Klimaschutz- und Entwicklungsstrategien.

Die energieintensive Industrie wurde exemplarisch für eine tiefergehende Analyse ausgewählt. Einerseits trägt der Sektor wesentlich zu den globalen Emissionen bei. Andererseits steht der Sektor weniger im Fokus von Analysen als etwa der Energiesektor. Die Emissionen der Industrie sind zusätzlich interessant, weil sie sowohl energiebedingte Emissionen als auch Prozessemissionen umfassen. Hierbei treten besondere Herausforderungen zu Tage, denn Sektordefinitionen wie sie bei der Erstellung von Treibhausgasinventaren genutzt werden, decken sich vielfach nicht mit den Sektorkategorien, wie sie in Politik und allgemeiner Öffentlichkeit genutzt werden. Für den Industriesektor haben wir Indikatoren ausgewählt, die auf dem 5. Sachstandsbericht des IPCC basieren, insbesondere auf Kapitel 10 der WGIII (IPCC, 2014). Als Treiber der Emissionen in der Industrie werden Energieeffizienz, Emissionseffizienz der Energie, Emissionseffizienz der Prozesse (CO_2 und nicht-CO_2), Materialeffizienz sowie die Produktnachfrage untersucht.

Festlegung von Benchmarks für die Bewertung von Fortschritt

Wir schlagen vor, dass der GST eine Reihe von Indikatoren in Betracht ziehen sollte. Hier skizzieren wir, wie diese Indikatoren anhand von Benchmarks bewertet werden können. Diese Benchmarks können aus makroökonomischen Modellbewertungen, Best-Practice-Beispielen oder der Berücksichtigung des technischen Potenzials abgeleitet werden. Bei der Anwendung von Benchmarks auf einzelne Länder oder Ländergruppen sollten nationale Gegebenheiten und Gerechtigkeitsüberlegungen berücksichtigt werden.

Ein Indikator ist nur dann aussagekräftig, wenn ein Kontext und ein Maßstab gegeben ist – auf welchem Niveau sollte der Indikator stehen, wenn ein bestimmtes Ziel erreicht wird? Im Falle des GST leiten sich die Benchmarks aus dem Kontext der Ziele des ÜvP ab: Was ist nötig, um die Erderwärmung

auf 1,5 °C zu begrenzen? Wie gelingt die schnellstmögliche Kehrtwende bei den globalen Emissionen, sodass diese nicht weiter steigen? Und was ist nötig, um eine ausgeglichene Bilanz zwischen menschgemachten Emissionen und der Aufnahme durch Treibhausgassenken zu erreichen? Eine der Herausforderungen bei der Festlegung von Benchmarks besteht darin, dass es viele verschiedene Möglichkeiten gibt, die übergeordneten Temperatur- und Emissionsziele zu erreichen.

Benchmarks können sowohl in qualitativer als auch in quantitativer Hinsicht festgelegt werden; beides kann nützlich sein. Insbesondere bei Indikatoren auf der obersten Ebene kann ein klarer beschriebener qualitativer Bezugspunkt besser, das heißt klarer und vermittelbarer, sein als ein numerisches Ziel. Eine Mischung aus deskriptiven und quantitativen Benchmarks ist am besten geeignet, um die Erkenntnisse aus der Analyse der gewählten Indikatoren robust und effektiv in wirksame politische Maßnahmen zu übersetzen.

Für die im ÜvP explizit enthaltenen Benchmarks (Begrenzung des globalen Temperaturanstiegs, Kehrtwende bei den globalen Emissionen und ausgeglichene Bilanz von Emissionsquellen und Senken) stellen die IPCC-Berichte eine sachdienliche Informationsquelle dar. Es lassen sich drei verschiedene Arten von Benchmarks für quantitative Indikatoren unterscheiden: makroökonomische Indikatoren, Indikatoren, die auf *best practice* Analysen basieren, sowie die Analyse technischer Potenziale. Die Benchmarks müssen möglicherweise in späteren Runden des GST aktualisiert werden, um verpassten Zielen Rechnung zu tragen oder ein verbessertes wissenschaftliches Verständnis berücksichtigen zu können.

Schließlich spielen bei der Definition und Festlegung von Benchmarks noch mehr als bei der Auswahl von Indikatoren Gerechtigkeitsaspekte eine Rolle. Sollten alle Länder mit demselben Maßstab gemessen werden? Oder sollten sie die Ziele der Länder auf der Grundlage ihrer Kapazitäten und ihrer historischen Verantwortung unterschiedlich bewerten? Anstatt diese Gerechtigkeitsaspekte bei der Formulierung der Benchmarks zu berücksichtigen, schlagen wir vor, dass (1) der GST einige spezifische Indikatoren für (Entwicklungs-)Gerechtigkeit enthalten sollte, beispielsweise Pro-Kopf-Emissionen, kumulative Pro-Kopf-Emissionen und finanzielle und technologische Kapazität zum Klimaschutz. Und (2) sollten Fragen der internationalen Entwicklungsgerechtigkeit dadurch operationalisiert werden, wie die ausgewählten Indikatoren verwendet und bewertet werden. Bei einigen Indikatoren, insbesondere bei denjenigen, die sich auf die *best practice* oder technische Potenziale beziehen, könnten Gerechtigkeitsaspekte operationalisiert werden, indem man von höher entwickelten und einkommensstärkeren Ländern eine schneller Umsetzung bzw. Ausschöpfung der Potenziale erwartet als von weniger entwickelten Ländern. Aus Perspektive der internationalen Gerechtigkeit wird darüber hinaus von entscheidender Bedeutung sein, in welchem Umfang die Entwicklungsländer finanzielle und technische Unterstützung erhalten (siehe auch Winkler, 2019).

Qualität und Verfügbarkeit von Informationen für die Global Stocktake

Das Enhanced Transparency Framework soll qualitativ hochwertige und umfassende Informationen liefern, die der Global Stocktake nutzen kann. Dieses Berichtswesen wird jedoch erst 2024 vollständig umgesetzt werden und selbst dann nicht alle Informationen bereitstellen, die für eine bestmögliche Umsetzung des GST idealerweise verfügbar wären. Andere Informationsquellen, die vor und nach 2024 zusätzliche Details oder Indikatoren liefern könnten, sind im Rahmen der UNFCCC möglicherweise nicht akzeptabel. Die Vertragsstaaten sollten dennoch prüfen, inwieweit diese Quellen genutzt werden können. Bei der Synthese und Legitimierung solcher Informationsquellen könnte der IPCC eine wichtige Rolle spielen.

Es existiert eine Vielzahl von Informationsquellen, die im Prinzip einen wertvollen Beitrag zum GST leisten und Daten zu ausgewählten Indikatoren und Benchmarks liefern könnten. Die Bedingungen für einen voll wirksamen GST werden jedoch schwer zu erfüllen sein, und es bleiben spezifische Datenlücken und Herausforderungen bestehen.

Die Informationen über die Fortschritte bei der Erreichung der Minderungsziele und die Höhe der THG-Emissionen werden hauptsächlich auf den Länderberichten beruhen, die der UNFCCC vorgelegt werden müssen. Diese Berichte weisen jedoch bisher für eine große Zahl von Ländern erhebliche Datenlücken auf. Die Aggregierung der Emissionen wäre auf der Grundlage nationaler Berichte in Kombination mit zusätzlichen Berechnungen zur Füllung von Datenlücken für Länder mit fehlenden Informationen möglich. Zusätzlich ergeben sich noch immer Herausforderungen aus der mangelnden Transparenz bei der Definition der NDCs der Länder. Beispielsweise fehlen bei einigen Ländern, die ihre Klimaschutzziele als Abweichung von einem Referenzszenario (*business as usual*) formuliert haben, häufig Informationen dazu, wie das zugrundeliegende Referenzszenario definiert wurde. Solche Aspekte werden durch die verfügbaren Daten nicht vollständig abgedeckt.

Einige der betrachteten Indikatoren, z.B. die Emissionen pro Tariftonnenkilometer (*revenue tonne km* – eine Kennzahl für die Transportleistung), sind derzeit für eine Bewertung im Rahmen des GST nicht durchführbar, da es keine einzelnen Datenquellen gibt, die diese Informationen für eine ausreichende Anzahl von Ländern liefern. Um eine solche Bewertung durchzuführen, müssten Informationen aus nationalen oder subnationalen Quellen gesammelt und aufbereitet werden.

Mangelnde Datenverfügbarkeit schränkt die potentielle Nutzung von Indikatoren für den GST stark ein. In einigen Fällen könnte der IPCC dabei helfen, fehlende Daten zu generieren, beispielsweise indem er ansonsten nicht öffentlich zugängliche Informationen im Rahmen der AR6-Berichte zusammenstellt. Über diesen Umweg könnten solche Datenquellen auch für die Nutzung im Rahmen der UNFCCC legitimiert werden. Dies wäre besonders nützlich bei Energiedaten der IEA und IRENA. Einige dieser Daten wurden in der Vergangenheit vom IPCC verwendet, jedoch nur auf global oder regional aggregierter Ebene.

In anderen Fällen liegen die Daten jedoch schlicht nicht in einer ausreichenden zeitlichen Auflösung für eine hinreichende Zahl von Ländern vor, sodass sie für den GST nutzbar wären. Dies ist insbesondere für Indikatoren relevant, die detaillierte Informationen für einzelne (Sub-)Sektoren bieten, wie z.B. die Materialintensität verschiedener Industriesektoren. Der Anspruch, möglichst politikrelevante Indikatoren zu berücksichtigen, stößt hier an Grenzen. Für einige Bereiche gibt es jedoch Daten, die hinreichend detailliert verfügbar und unmittelbar politisch anschlussfähig sind. Dies ist beispielsweise der Fall im Energiesektor beim Anteil von erneuerbaren Energien.

Eine pragmatische Option für die Verbreiterung der Datenbasis des GST wäre es, Schwellenwerte festzulegen. Dazu könnte eine Quote von Ländern festgelegt werden, für die Daten verfügbar sein müssen, um eine Auswertung im Rahmen des GST vornehmen zu können, ohne alle Länder abdecken zu müssen. Für Aktivitäten, die von einer relativ geringen Anzahl von weiter entwickelten Ländern dominiert werden, könnte eine solche Regelung besonders interessant sein und einen Kompromiss zwischen dem Anspruch universeller Abdeckung und der Relevanz des GST darstellen.

Darüber hinaus gibt es einige für den GST potentiell relevante Datenquellen, die nur auf kommerzieller Basis zur Verfügung stehen (z.B. die globale Datenbank für Kraftwerke des Informationsdienstes Platts (S&P Global Platts, 2018) oder der Bloomberg New Energy Finance Informationsdienst (Bloomberg New Energy Finance, 2018)). Der GST sollte jedoch idealerweise auf öffentlich zugänglichen Datenquellen basieren. Wenn dem GST Datenquellen wie IEA World Energy Outlook, SE4ALL, Enerdata oder Bloomberg New Energy Finance zur Verfügung gestellt würden, könnte die Zahl der Indikatoren, insbesondere im Energiesektor, zu denen der GST Aussagen treffen könnte, deutlich erhöht werden. Möglicherweise lassen sich für die Besitzer solcher nicht frei verfügbaren Daten (nicht-monetäre) Anreize schaffen, ihre Daten für den GST zur Verfügung zu stellen. Der GST könnte eine globale Plattform bieten, um ihre Produkte öffentlich bekannt zu machen und ihre Nützlichkeit für einen wichtigen internationalen Prozess zu unterstreichen. Wenn dies nicht gelingt, müssten einige Aspekte eines idealen GST von anderen unabhängigen Akteuren außerhalb des offiziellen UNFCCC-Prozesses umgesetzt werden.

Für **qualitative Indikatoren** gibt es verschiedene Informationsquellen. An erster Stelle stehen offizielle UNFCCC-Dokumente, die von den Staaten selbst erstellt und vorgelegt werden. Um die Qualität und Verfügbarkeit einschlägiger Informationen aus diesen Quellen zu überprüfen, haben wir im Rahmen unserer Studie für fünf ausgewählte Länder (EU, Indien, Mexiko, Vietnam und Äthiopien) Länderdossiers erstellt. Einerseits konnten wir so die Verfügbarkeit von Daten beispielhaft bewerten. Andererseits haben wir auf der Basis dieser Dossiers Optionen zur Aggregation qualitativer Informationen entwickelt.

In Bezug auf die nationalen Klimapolitikmaßnahmen war die Datenverfügbarkeit mit den vorhandenen offiziellen UNFCCC-Dokumenten im Allgemeinen ausreichend, jedoch nicht in allen Fällen sehr aktuell. Mit den verbesserten Berichtspflichten im Rahmen des Enhanced Transparency Framework wird sich dies vermutlich ab 2024 verbessern. Zwar konnte aus den offiziellen Quellen eine Liste relevanter Politiken zusammengestellt werden, aber eine Kategorisierung/Klassifizierung der Politiken war nicht unmittelbar möglich. Qualitative Informationen zu den NDCs werden von den Ländern sehr unterschiedlich berichtet.

Informationen über die Herausforderungen und Barrieren der Transformation waren in den offiziellen Dokumenten der UNFCCC jedoch weitgehend nicht verfügbar. Die Richtlinien für die Erstellung der zweijährlichen Aktualisierungsberichte für Entwicklungsländer (*biennial update reports*) sehen einen Abschnitt vor, in dem die Vertragsparteien "aktualisierte Informationen über Einschränkungen und Lücken bei der Umsetzung von Klimaschutzmaßnahmen und dem damit verbundenen finanziellen Bedarf an technischer Unterstützung und Capacity-Building" (UNFCCC, 2012, S. 41) bereitstellen sollen. Für entwickelte Länder gibt es keine solche Anforderung. Daher ist eine systematische Bewertung aktueller und erwarteter Transformationshemmnisse und Herausforderungen mit den vorhandenen offiziell bereitgestellten Informationen nicht möglich.

Informationen für die Festlegung von Benchmarks für den notwendigen Minderungsfortschritt sind vielfach leichter verfügbar als Informationen für die Indikatoren selbst. Sie werden in erster Linie durch den IPCC bereitgestellt, entweder in Form von Bewertungen auf der Basis verschiedener Modelle oder durch eine systematische Auswertung der bestehenden Forschungsliteratur. Der IPCC stellt die legitimste und umfassendste Informationsquelle für die GST dar. Modelle zur integrierten Folgenabschätzung (*integrated assessment models* – IAMs) bieten sowohl eine umfangreiche Breite als auch Tiefe an Informationen, die sowohl in den kommenden AR6-Berichten des IPCC als auch im GST verwendet werden können. Allerdings hat die Nutzung solcher Modelle auch Grenzen. Beispielsweise sind nicht alle Minderungsoptionen in den IAMs enthalten oder werden detailliert genug gelöst und möglicherweise werden Klimaschutzpfade beschritten, die sich in den Modellen nicht darstellen lassen. Insbesondere die Einbeziehung detaillierter Energiedaten, die derzeit nur kostenpflichtig verfügbar sind, eine klare Definition des technischen Potenzials für Emissionsminderungen und die Einbindung von Best-Practice-Beispielen aus der Industrie würden den GST erheblich bereichern. Jedoch ist die Festlegung von Benchmarks für sehr detaillierte Indikatoren besonders schwierig; insbesondere die Festlegung, dass ein bestimmter Grenzwert mit den Zielen des ÜvP kompatibel ist. Je spezifischer ein Indikator ist, desto mehr Verflechtungen bestehen mit anderen Prozessen/Indikatoren über die gesamte Wertschöpfungskette hinweg. Dies macht eine eindeutige Bewertung besonders schwierig. Die Definition von Benchmarks impliziert daher notwendigerweise Annahmen, die auf anderen, voneinander abhängigen Indikatoren beruhen. Hier besteht weiterer Forschungsbedarf bei der Frage, wie verschiedene Arten von Benchmarks integriert werden können und insbesondere wie Gerechtigkeitsaspekte bei der Definition von Benchmarks operationalisiert werden können.

Darüber hinaus könnten von unabhängigen Forschungsinstituten erstellte Analysen (z.B. der Climate Action Tracker oder Daten von Climate Watch) einen Mehrwert für den GST-Prozess liefern oder von der Zivilgesellschaft genutzt werden, um die Ergebnisse des GST unabhängig vom offiziellen Prozess zu interpretieren.

Beurteilung des kollektiven Fortschritts: Ansätze und neue Werkzeuge

Wir betrachten die sich aus dem Mandat des GST ergebenden Herausforderungen, insbesondere die exklusive Bewertung kollektiven Fortschritts. Und wir untersuchen die Möglichkeiten der wissenschaftlichen Forschungsgemeinschaft diese Herausforderungen zu meistern. Zu den wichtigsten Herausforderungen gehören die Quantifizierung und Aggregation der Emissionen im Rahmen der NDCs aufgrund der mangelnden Klarheit in den NDCs, der eingeschränkten Erfassung der Emissionen innerhalb eines Landes, Unsicherheiten über den Beitrag des Landnutzungssektors und der Auswirkungen der Nutzung von internationalen Kohlenstoffmärkten.

Herausforderungen bei der Aggregierung nationaler Informationen

Der GST wird notwendigerweise die Fortschritte bei den globalen Emissionen bewerten müssen. Eine solche Aggregation birgt jedoch eine Reihe von Herausforderungen.

Art. 4.4 des ÜvP legt fest, dass langfristig alle Länder ihre NDCs in Form von umfassenden (das heißt alle Sektoren abdeckende) und absoluten Emissionsreduktionsziele formulieren sollen. Angesichts dieser Tatsache sollte der GST prüfen, ob diesbezüglich Fortschritte erzielt werden. Als Ergebnis sollte der Anteil der Länder sowie der Anteil der globalen Emissionen bestimmt werden, die bereits solchen wirtschaftsweiten absoluten Emissionsreduktionszielen unterliegen. **Die Quantifizierung von NDCs ist immer dann besonders schwierig, wenn im Rahmen der UNFCCC in NDCs und anderen Dokumenten nur begrenzte oder widersprüchliche Informationen zur Verfügung gestellt werden.** Aufgrund des Fehlens allgemein anerkannter Normen und Informationsanforderungen weisen die von den Vertragsparteien im Vorfeld von Paris vorbereiteten und in vielen Fällen danach bestätigten (i)NDCs eine große Vielfalt hinsichtlich der Art der Verpflichtungen sowie der abgedeckten Sektoren und Gase auf. Darüber hinaus fehlen oft spezifische Informationen, um die Auswirkungen von NDCs genau bewerten und den aktuellen Fortschritt bei der Umsetzung und Erreichung von NDCs verfolgen zu können (wie z.B. Informationen über die genutzten Metriken oder IPCC-Richtlinien zur Berechnung des NDC, über Methoden zur Festlegung und Berechnung von BAU-Zielen, über den Beitrag des Landnutzungssektors oder die Nutzung von internationalen Marktmechanismen).

Der GST könnte abschätzen, mit welcher Wahrscheinlichkeit die NDCs erreicht werden, indem er bereits vorhandene Arbeiten einbezieht und zusammenfasst. Die Zusammenfassung könnte auf globaler Ebene durchgeführt werden – z.B. "mit den derzeitig umgesetzten Politikmaßnahmen werden die NDC-Ziele aller Voraussicht nach um X% übertroffen/unterschritten" –oder sie könnte die nationalen Klimaschutzanstrengung mit Aussagen zusammenfassen wie "X von Y Ländern sind auf dem Weg, ihre NDC-Ziele zu erreichen".

Einige Ungewissheiten werden jedoch nicht im Rahmen der UNFCCC gelöst werden können. Einige der Informationen, die im Rahmen des Enhanced Transparency Framework bereitgestellt werden sollen, werden für den ersten GST voraussichtlich noch nicht verfügbar sein, da die erste vollständige Berichterstattung erst 2024 fällig ist. Entweder das Klimasekretariat oder unabhängige Analysten müssen daher diese Informations- und Analyselücke schließen.

Die wissenschaftliche Forschungsgemeinschaft ist dafür gut gerüstet, da sie bereits seit 2015 ähnliche Analysen zur Aggregierung der NDCs durchgeführt hat. Einige dieser Methoden und Daten müssen für den GST aktualisiert werden; vorzugsweise rechtzeitig für die Aufnahme in den AR6 des IPCC. Dies könnte eine solide Überprüfung sicherstellen und die Legitimation wissenschaftlicher Bewertungen einzelner Akteure für die Nutzung im GST ermöglichen.

Für die **Bewertung des kollektiven Fortschritts in Richtung des 1.5°C-Ziels des ÜvP muss der den Fortschritt bei der Begrenzung der globalen Treibhausgasemissionen bewertet werden,**

die zur globalen Erwärmung führen. Allerdings ist die Verknüpfung der globalen Emissionen mit dem erwarteten zukünftigen Temperaturanstieg nicht trivial.

Unter der Annahme, dass die NDC-Minderungsziele erreicht werden, können die Emissionen im Jahr 2030 mit einiger Sicherheit bestimmt werden. Die langfristige Temperaturentwicklung wird jedoch auch von den Emissionen nach 2030 abhängen. Die global aggregierten Emissionen im Jahr 2030 können daher nur einen Hinweis darauf geben, ob die globalen Anstrengungen auf dem richtigen Weg sind, um die Ziele zu erreichen (Jeffery *et al.*, 2018). Die Gesamtemissionen im Jahr 2030 können dennoch als Barometer zur Bewertung der Klimaschutzanstrengungen verwendet werden. Dafür wurde eine Reihe von Methoden entwickelt. Sie unterscheiden sich in dem Maße, wie sie das Emissionsniveau in 2030 interpretieren und in den Annahmen darüber, was nach 2030 geschehen wird. Einige Ansätze stützen sich in erster Linie auf die Gesamtemissionen, während modellgestützte Ansätze auch tiefergehende strukturelle Veränderungen in den Energiesystemen berücksichtigen.

Drittens **kann es im Hinblick auf qualitative Informationen auch informativ sein, übergreifende Klimagesetze und Rahmenstrategien oder indikative Planungsdokumente von Ländern sowie die sektorale Abdeckung von Politiken zu beurteilen**. Aufbauend auf bestehenden UNFCCC-Dokumenten wie den *National Communications* und den *Biennial Reports* bzw. *Biennial Update* Reports sollte es möglich sein, eine aussagekräftige Übersicht über die Abdeckung der Politiken zu erstellen. Die neuen Berichtsanforderungen des Enhanced Transparency Framework werden die Grundlage dafür noch verbessern. Eine zentrale Herausforderung ist jedoch der Mangel an Struktur und einer sinnvollen Klassifizierung der Politiken. Die Aufnahme eines Rahmens, der Politiken und Maßnahmen in verschiedene Arten von Instrumenten in den Berichtsvorlagen des Transparenzrahmens klassifiziert, würde die Bewertung im GST deutlich vereinfachen.

Neue Instrumente und Methoden zur Bewertung des kollektiven Fortschritts

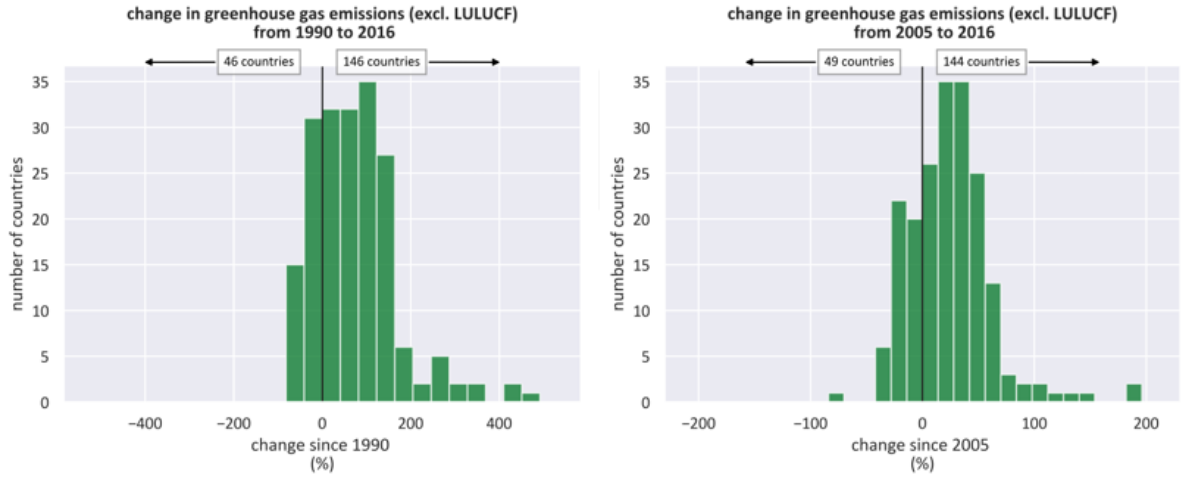
Um sowohl dem Auftrag zur Bewertung des kollektiven Fortschritts im Rahmen des GST als auch der Notwendigkeit gerecht zu werden, dass der GST politisch relevante, detaillierte Informationen berücksichtigt, haben wir eine neue Reihe von Instrumenten zur Durchführung kollektiver Bewertungen einer Reihe von Indikatoren vorgeschlagen und entwickelt.

Um den kombinierten Herausforderungen der Bewertung des kollektiven Fortschritts und der Bereitstellung relevanter Informationen gerecht zu werden, schlagen wir vor, dass der GST einen "*Performance-Distribution*"-Ansatz verwendet. Bei diesem Ansatz werden Informationen aus den einzelnen Ländern verwendet, allerdings in anonymisierter Form. Die Informationen zu den einzelnen Ländern werden in Histogrammen angezeigt, so dass kein einzelnes Land hervorgehoben wird, aber dennoch erkennbar ist, ob einige Länder entweder führend sind oder hinter anderen zurückliegen. Die Diagramme enthalten auch Informationen über globale Durchschnittswerte, und entweder die Durchschnittswerte oder die Verteilung können mit globalen (oder regionalen) Benchmarks verglichen werden, um den Fortschritt zu bewerten.

Im Rahmen dieses Projekts wurde ein Instrumentarium entwickelt, um diesen Ansatz zur Darstellung der Verteilung der Performanz zu testen und seine Nützlichkeit und Eignung für den GST zu bewerten.[1] Ein Beispiel für die Veränderung der Emissionen im Vergleich zu 1990 und 2005 ist in Figure 2 dargestellt.

[1] Das Python-basierte Toolset, das zur Erstellung dieser Auswertung verwendet wurde, steht unter https://github.com/mljeffery/performance-distribution-tools zum Download zur Verfügung.

Abbildung 1 Veränderung der Emissionen im Vergleich zu 1990 und 2005



Quelle: Eigene Darstellung basierend auf PRIMAP-hist v2.0-Daten (Gütschow *et al.* , 2016; Gütschow, Jeffery und Gieseke, 2019). Beachten Sie die Veränderung des Maßstabs zwischen den beiden Plots. Drei Ausreißer sind in der linken und zwei in der rechten Darstellung nicht dargestellt.

Viele NDCs werden als eine Reduzierung unter ein Basisjahr dargestellt, basieren aber auf unterschiedlichen Basisjahren. Diese Art der Berechnung und Abbildung ermöglicht es, den aktuellen Status oder möglicherweise auch NDC-Ziele selbst in Bezug auf mehrere verschiedene Basisjahren darzustellen. Bei der Bewertung des aktuellen Status oder der historischen Veränderungen würde der GST wirklich eine Bestandsaufnahme vornehmen und die bisher erzielten Fortschritte hervorheben.

Der erste GST könnte eine ähnliche Zahl präsentieren, um die Veränderung der Emissionen seit der Verabschiedung des ÜvP darzustellen. Wäre diese Zahl ähnlich wie die oben für den historischen Trend gezeigte, würde sie als klarer Hinweis darauf dienen, dass das ÜvP noch nicht in die Tat umgesetzt wurde. Wenn sich die Verteilung deutlich nach links verschoben hat, würde dies zeigen, dass die Mehrheit der Länder Fortschritte macht und etwaige Ausreißer entweder Spitzenreiter (links) oder Nachzügler (rechts) sind.

Auf der Grundlage der so präsentierten Informationen könnten unabhängige Akteure, einschließlich der Zivilgesellschaft und der politischen Entscheidungsträger, ihr Land innerhalb der Verteilung verorten und einschätzen, inwiefern ihre Performanz im internationalen Vergleich eher über- oder unterdurchschnittlich war. Auf diese Weise würde der GST den Wettbewerb zwischen den Staaten, aber auch eine öffentliche Kontrolle auf nationaler Ebene ermöglichen, und letztlich die Ambition der NDCs steigern.

Der Ansatz ermöglicht auch eine kollektive Beurteilung, ob alle Länder gemeinsam Bestrebungen zur globalen Emissionsminderung unternehmen, oder ob es einzelne führende Länder gibt, die substanzielle Fortschritte gemacht haben. Der Ansatz umgeht damit einerseits ein Naming and Shaming, ohne dass sich einzelne Länder innerhalb einer global aggregierten Zahl verstecken können, und ermöglicht es andererseits, ambitionierte Länder hervorzuheben.

Darüber hinaus ist der Ansatz so konzipiert, dass er für viele Indikatoren konsistent angewendet werden kann und somit einer breiten Öffentlichkeit leichter zugänglich sein sollte. Ein Verständnis einzelner Indikatoren lässt sich leicht auf andere Indikatoren und Werte übertragen.

Schlussfolgerungen und Empfehlungen

Wir bewerten die Potentiale und Grenzen des Global Stocktake, die oben beschriebenen Funktionen zu erfüllen. Dabei werden einerseits die Verfügbarkeit von Informationen und andererseits die politischen und diplomatischen Abhängigkeiten und Zwänge berücksichtigt. Die Wirksamkeit des GST-Prozess des UNFCCC lässt sich maximieren, indem (1) eine explizite und öffentliche Bewertung der Inputs vorgenommen wird, (2) der in diesem Projekt entwickelte Performance-Distribution-Ansatz angewendet wird, (3) die wichtigsten sektoralen Systeme in den strukturierten Expertendialogen ausführlich diskutiert werden und (4) der IPCC aufgefordert wird, die verfügbare Forschung speziell im Hinblick auf die Ermittlung von Benchmarks zu bewerten. Der offizielle GST sollte durch unabhängige Aktivitäten der Zivilgesellschaft und der internationalen Forschungsgemeinschaft ergänzt und unterstützt werden.

Können die notwendigen Bedingungen für einen effektiven Global Stocktake erfüllt werden?

Um diese Frage zu beantworten, setzen wir die Ergebnisse unserer Analyse in Bezug zu den entwickelten Funktionen eines effektiven GST. Der erste GST wird insbesondere in Hinblick auf die **Schrittmacherfunktion** deutliche Lücken aufweisen. Dies gilt in Bezug auf die verfügbaren Informationen, insbesondere für die von den Vertragsstaaten selbst berichteten und somit offiziellen, von der UNFCCC anerkannten Informationen. Ab 2024 ist es jedoch für alle Länder obligatorisch, alle zwei Jahre Transparenzberichte nach gemeinsamen Richtlinien für die Berichterstattung vorzulegen. Ab spätestens 2024 werden die Anstrengungen und auch die internationale Unterstützung für die rechtzeitige Übermittlung von Informationen erwartbar verstärkt werden. Neben diesen offiziellen Quellen haben wir eine Fülle alternativer Datenquellen außerhalb der UNFCCC identifiziert. Jedoch ist fraglich, ob diese im UNFCCC-Prozess Akzeptanz finden werden, da die herausgebenden Institutionen nicht Teil des UN-Systems sind oder die Daten aus privaten Initiativen usw. stammen (z.B. IEA World Energy Outlook oder Bloomberg New Energy Finance). Darüber hinaus sind viele dieser Datenquellen nicht umfassend in Bezug auf die erfassten Länder und/oder die verfügbaren Zeitreihen. Schließlich sind einige der umfassendsten und potenziell nützlichsten Datensätze nur kommerziell erhältlich. Dies sollte wohl kein Hindernis für den GST als solchen darstellen, könnte aber die Transparenz des Prozesses und die weitere Nutzung der Analyse z.B. durch zivilgesellschaftliche Akteure auf nationaler Ebene behindern.

Ob die öffentliche Aufmerksamkeit während der politischen Phase des GST bestmöglich genutzt werden kann, wird nicht zuletzt dadurch bestimmt, in welcher Weise die Vertragsstaaten die Ergebnisse des GST festhalten. Das Spektrum reicht von nicht verbindlichen politischen Erklärungen bis hin zu verbindlichen COP-Entscheidung mit einigen präskriptiven Formulierungen dafür, wie ein Land die Ergebnisse des GST bei der Ausarbeitung der nachfolgenden NDCs berücksichtigen soll.

Zugegebenermaßen wurde der GST nicht dafür entwickelt, einzelne Länder für die Umsetzung ihrer Klimaschutzziele zur Verantwortung zu ziehen, dies ist die Rolle des Enhanced Transparency Framework. Der GST könnte diese Funktion zwar theoretisch unterstützen; dies ist jedoch praktisch schwierig umzusetzen. Erstens ist die Verfügbarkeit von Informationen, wie oben beschrieben, zumindest für die erste Iteration des GST begrenzt. Ab 2024 ist mit einer Verbesserung zu rechnen, aber es bleibt abzuwarten, inwieweit die Vertragsparteien die in den Berichterstattungsrichtlinien des Enhanced Transparency Framework enthaltenen Flexibilitäten nutzen werden (insbesondere im Hinblick auf die Vorlage von Projektionen und die Quantifizierung von Politiken und Maßnahmen). Es besteht die Gefahr, dass erhebliche Lücken in den gemeldeten Informationen auch über 2024 hinaus bestehen bleiben. Darüber hinaus kann in der Praxis ein Mangel an Kapazitäten, Ressourcen oder Fachwissen weiterhin ein Hindernis für eine umfassende Berichterstattung darstellen. Die Einrichtung robuster Berichtssysteme nimmt viel Zeit in Anspruch, und wo solche Systeme noch nicht vorhanden sind, werden erweiterte Berichtsanforderungen allein nicht ausreichen. Die Initiative für den Aufbau von Kapazitä-

ten für Transparenz ist deshalb ein wichtiges Instrument, um diesen Mangel an Kapazitäten zu beheben.

Zweitens ist es fraglich, ob der GST genügend öffentliche Aufmerksamkeit schaffen kann, um politische Entscheidungsträger ins Rampenlicht zu stellen, insbesondere diejenigen, die ihre NDCs nicht umgesetzt haben. Wie oben erörtert, wird es im Rahmen des GST nicht möglich sein, einzelne Länder an den Pranger zu stellen. Die in Kattowitz beschlossenen Modalitäten des GST sehen lediglich ein Mandat für das UNFCCC-Sekretariat vor, einen Synthesebericht zu erstellen. Offen ist, wie weit das Sekretariat gehen kann, um Defizite einzelner Länder bei der Umsetzung der NDCs hervorzuheben. Ein aus unserer Sicht effektiver Ansatz zur Stärkung der Rechenschaftsfunktion könnte ein anonymisierter "Notenspiegel" sein, der in den Bericht aufgenommen wird. Dies könnte etwa mit folgender Formulierung umgesetzt werden: "X Länder, die Y Prozent der globalen Emissionen repräsentieren, weisen erhebliche Umsetzungsdefizite auf und werden ihre Ziele wahrscheinlich nicht erreichen, wenn die Umsetzung nicht verbessert wird". Es ist zwar unwahrscheinlich, dass das Sekretariat seine eigene Bewertung des Fortschritts bei der Umsetzung der NDCs entwickeln wird, aber es kann durchaus die von den Parteien zur Verfügung gestellte Selbstbewertung zusammenstellen. Der Synthesebericht kann dann als Grundlage für weitere Diskussionen dienen, in denen Länder implizit oder explizit zur Rechenschaft gezogen werden. Er wäre für verschiedene Interessensgruppen und Stakeholder zugänglich und könnte dazu genutzt werden, politischen Druck auf nationaler Ebene zu erzeugen. In welcher Wiese die Berichte des Sekretariats bei der technischen Phase des GST berücksichtigt werden, ist derzeit jedoch nicht in den Modalitäten festgelegt.

Maßnahmen zur Maximierung der öffentlichen Aufmerksamkeit sind der Schlüssel für einen effektiven GST. Nur dann können die Zivilgesellschaft und die globale wissenschaftliche Gemeinschaft den offiziellen Prozess unterstützen und ergänzende Bewertungen erstellen, die explizit Länder benennen und sowohl Versäumnisse als auch Mittel zur Verbesserung der Umsetzung aufzeigen.

In Bezug auf die Ambitionssteigerung nachfolgender NDCs sollte es mit den verfügbaren Informationen und im Rahmen des Mandats des GST trotz aller technischen Herausforderungen möglich sein, glaubwürdige übergreifende Benchmarks zu definieren. Mit zunehmendem Detailgrad wird es jedoch immer schwieriger, allgemein akzeptierte Benchmarks festzulegen. Im Idealfall würde der GST auch sektorale Benchmarks setzen, z.B. für Energie, industrielle Prozesse und Produktnutzung, Land- und Forstwirtschaft und andere Landnutzung (AFOLU) oder die Abfallwirtschaft. Solche Benchmarks würden es den politischen Entscheidungsträgern auf nationaler Ebene ermöglichen, eine ihre eigenen Minderungsaktivitäten umfassender zu bewerten.

Bei der Festlegung globaler und spezifischer Benchmarks spielt der IPCC eine wichtige Rolle. Er ist dafür das maßgebliche wissenschaftliche Gremium. Nach dem Beispiel des jüngsten 1,5 °C-Sonderberichts, zu dem der IPCC von den Vertragsstaaten durch einen entsprechenden COP-Beschluss "eingeladen" wurde (1/CP.21 §21), könnten die Staaten einen Aufruf an den IPCC senden, um gezielt für den GST Benchmarks zu bestimmen. Um die Wirksamkeit zu maximieren, müssten die vom IPCC formulierten und vorgeschlagenen Benchmarks dann im Rahmen der politischen Phase des GST offiziell zur Kenntnis genommen und gebilligt werden.

Die Integration von Gerechtigkeitsüberlegungen bleibt jedoch eine ungelöste Frage. Sollten alle Länder an denselben Benchmarks gemessen werden? Wie und wer wird entscheiden, welche Benchmarks für welche Ländergruppe gelten, usw. (siehe auch Winkler, 2019).

Der oben vorgestellte Performance-Distribution-Ansatz hat aus unserer Sicht das Potenzial, die Wirkung glaubwürdiger Benchmarks zu stärken. Die Einbeziehung globaler Benchmarks in die Visualisierung der Bewertung des kollektiven Fortschritts ermöglicht es Beobachtern und Vertragsstaaten selbst, ihre eigene Leistung anhand der Benchmarks zu bewerten. Eine solche Evaluierung explizit zu machen, würde zwar das Mandat des GST überschreiten, aber die Bereitstellung der Instrumente zur Durchführung einer solchen Evaluierung ist eine wesentliche Aufgabe für den GST.

Im Hinblick auf die Erleichterung des Peer-Learnings und des Erfahrungsaustauschs sind bereits wichtige Grundlagen erfüllt. Viele Länder führen bereits relevante Informationen über Politiken und Maßnahmen und deren Klimaschutzwirkungen in ihren nationalen Berichten auf. Informationen über Hindernisse und zentrale Transformationsherausforderungen, mit denen die Länder in allen relevanten Sektoren konfrontiert sind, werden allerdings nicht oder wenigstens nicht systematisch erfasst. Ob es gelingt, Informationsaustausch und Lernprozesse in Bezug auf erfolgreiche Klimaschutzaktivitäten im Rahmen des GST zu etablieren, hängt mehr von der Ausgestaltung des GST-Prozesses ab als von weiteren Informationsinputs. Bei der Gestaltung der politischen Phase des GST wird eine wesentliche Herausforderung sein, Wege zu finden, wie Best-Practice Beispiele nicht nur effektiv gesammelt, sondern auch so aufgearbeitet werden können, dass sie von anderen Ländern und Akteuren auch umgesetzt werden. Bei der Gestaltung eines solchen Prozesses würde der GST besonders von einer strukturierteren Klassifizierung der verschiedenen Arten von Politiken, der angesprochenen Sektoren und der wichtigsten von diesen Politiken behandelten Klimaschutzoptionen profitieren.

Die Modalitäten des GST sehen vor, dass technische Dialoge in Form von "Runden Tischen, Workshops oder anderen Aktivitäten innerhalb der Sitzung" (UNFCCC, 2018, Abs. 6) durchgeführt werden können. Dies schafft einen großen Spielraum für die Vorsitzenden der Nebenorgane und die zugeteilten Ko-Vorsitzenden der jeweiligen Kontaktgruppe, um eine sinnvolle Struktur für die technische Bewertung zu schaffen. Im Idealfall würde dies in Form von strukturierten Expertendialogen geschehen, die sich auf relativ konkrete (sektorale) Transformationsherausforderungen konzentrieren sollten, um deren Potenzial voll auszuschöpfen. Der Input von nicht-staatlichen und subnationalen Initiativen könnte hier besonders wertvoll sein, und die Modalitäten der GST ermöglichen eine solche Einbeziehung von Stakeholdern. Dabei kann auf Erfahrungen verschiedener internationaler Prozesse zurückgegriffen werden. Hervorzuheben sind etwa die freiwillige nationale Überprüfungen im Rahmen der Agenda 2030 für nachhaltige Entwicklung und der Ziele der nachhaltigen Entwicklung, der strukturierte Expertendialog (SED), der im Rahmen der ersten periodischen Überprüfung (2013-2015) stattfand, die unter der gemeinsamen Schirmherrschaft der Nebenorgane der UNFCCC bestehenden *Technical Examination Processes* (TEP), oder das technische und wirtschaftliche Bewertungsgremium (TEAP) im Rahmen des Montrealer Protokolls über Stoffe, die zu einem Abbau der Ozonschicht führen.

Die Frage, ob der GST in der Lage sein wird, die **Signal- und Orientierungsfunktion** zu erfüllen, hängt schließlich in hohem Maße von der Prozessgestaltung und weniger von den verfügbaren Informationen ab. Dies gilt insbesondere im Hinblick auf die Stärkung der im ÜvP vorgesehenen kollektiven Ziele. Inwieweit die COP in der Lage sein wird, das Signal für eine erneute Demonstration des Engagements auszusenden, wird maßgeblich von der COP-Präsidentschaft sowie von den Moderatoren der politischen Bewertung der Ergebnisse des GST bestimmt werden. Außerdem wird die Art und Weise, in welcher (rechtlich verbindlichen) Form die Ergebnisse des GST festgehalten werden, entscheidend für eine Bekräftigung des gemeinsamen Engagements sein. Um das bestehende Signal aus Paris weiter zu entwickeln und zu verfeinern, ist der GST entscheidend von externen Inputs abhängig, insbesondere vom IPCC und anderen wissenschaftlichen Quellen, die die übergeordneten Ziele des ÜvP in sektorale Ziele und Transformationspfade übersetzen. Solange es solche sektoralen Klimaschutzroadmaps noch nicht gibt, könnte der GST über die Einrichtung entsprechender (sektoraler) Expertendialoge die benötigten Informationen zusammentragen. Ein gemeinsames Verständnis über sektorale Pfade könnte als Grundlage für weitere politische Schlussfolgerungen dienen. Auch hier ermöglichen es die Modalitäten des GST den Vorsitzenden des GST, den Expertendialog entsprechend zu organisieren.

Mit den verfügbaren Informationen wird es voraussichtlich möglich sein, die Frage **"Wo stehen wir?"** zu beantworten. Die offiziellen UNFCCC-Berichte über Treibhausgasemissionen weisen zwar noch immer Informationslücken auf, aber die Verfügbarkeit von Informationen wird sich voraussichtlich deutlich verbessern, wenn die Berichtsanforderungen des Enhanced Transparency Framework ab 2024 in Kraft treten. Außerdem sind zusätzlich verfügbare Informationen von Dritten zuverlässig und

detailliert genug, um die bestehenden Lücken zu füllen und die Entwicklung eines genauen Bildes der Treibhausgasemissionen auf aggregierter Ebene zu ermöglichen.

Wohin wollen (müssen) wir gehen? Unsere Diskussion zu Benchmarks hat gezeigt, dass es auf der Grundlage der vorhandenen Forschung und Informationen möglich scheint, globale Benchmarks zumindest für die übergeordneten Metriken zu bestimmen, etwa für aggregierte Emissionen, Stabilisierung/Spitzenwerte der Emissionen, ausgeglichene Bilanz zwischen THG-Quellen und Senken. Dabei wird der GST jedoch entscheidend vom IPCC als der maßgeblichen Quelle der "besten verfügbaren Wissenschaft" abhängen.

Wie kommen wir dorthin? Die oben genannten übergreifenden Maßstäbe können nur eine allgemeine Orientierung geben – wie ein Kompass. Sie liefern nicht – wie ein Satellitennavigationssystem – die potenziellen Routen und spezifischen (Zwischen-)Ziele für die erforderliche Transformation. Dazu wären detailliertere sektorale Pfade und Fahrpläne erforderlich, die in spezifische Benchmarks umgesetzt werden. Der IPCC kann mit seinem Sechsten Sachstandsbericht einen maßgeblichen Beitrag zu solchen Roadmaps leisten. Große Herausforderungen bestehen nach wie vor in Bezug auf die fehlende Struktur und Klassifizierung von Politiken/Sektoren/Klimaschutzmaßnahmen im Rahmen der derzeitigen Berichterstattung. Während sich diese Situation mit dem Rahmen für verstärkte Transparenz nach 2024 verbessern könnte, besteht ein weiteres großes Manko darin, dass bestehende Hindernisse und Transformationsherausforderungen von den Vertragsstaaten nicht systematisch berichtet und reflektiert werden. Und schließlich erlaubt es das Mandat der GST nicht, länderspezifische Empfehlungen auszusprechen und diejenigen Länder zu ächten, die sich in die falsche Richtung bewegen.

Spezifische Empfehlungen für den offiziellen Global Stocktake und ergänzende Aktivitäten

Auf der Grundlage unserer Einschätzung der Informationsbedarfe und Prozessbedingungen für die Wirksamkeit des GST und einer Bewertung der für den offiziellen Prozess verfügbaren Informationen formulieren wir die folgenden Empfehlungen zur Maximierung der Wirksamkeit des GST:

- Der GST sollte eine explizite **öffentliche Bewertung der Inputs**, insbesondere der Transparenzberichte und deren technischer Überprüfung, beinhalten. Dies würde dazu beitragen, die öffentliche Aufmerksamkeit für den gesamten Prozess zu erhöhen und das Auge der Öffentlichkeit auf Informationsquellen zu lenken, die auch Daten auf Länderebene umfassen. Insbesondere sollte der GST die Ergebnisse der sogenannten “facilitative multilateral considerations of progress” innerhalb des Enhanced Transparency Framework berücksichtigen. Um die Fortschritte bei der Umsetzung der NDCs zusammenzufassen, schlagen wir vor, dass das UNFCCC-Sekretariat einen **anonymisierten "Notenspiegel"** in der folgenden Form erstellt: "X Länder, die Y Prozent der globalen Emissionen repräsentieren, weisen erhebliche Umsetzungsdefizite auf und werden ihre Ziele wahrscheinlich nicht erreichen, wenn die Umsetzung nicht verbessert wird."
- Für eine grafische Darstellung des kollektiven Fortschritts und der eigentlichen Zielmarke schlagen wir vor, dass das UNFCCC-Sekretariat den in diesem Projekt entwickelten ***Performance-Distribution*-Ansatz** anwendet. Innerhalb des engen Mandats des GST ermöglicht dieser Ansatz eine differenzierte Analyse des "kollektiven Fortschritts". Einerseits sind die so bereitgestellten Informationen auch für die nationale Ebene relevant. Andererseits ist bei dem Ansatz die Anonymität der einzelnen Länder gewährleistet.
- Um Informationen über die Herausforderungen und Hindernisse der sektoralen Transformation auszutauschen, sollten die Expertendialoge, die in den Modalitäten des GST für die technische Bewertung vorgesehen sind, den strukturierten Austausch über wichtige sektorale Systeme wie Energie, emissionsintensive Industrie, Verkehr, Land- und Forstwirtschaft und andere Landnutzung sowie Abfallwirtschaft umfassen. Diese Expertendialoge sollten sich auf den Austausch von positiven und praktisch umsetzbaren Erfahrungen konzentrieren. Sie dürfen

nicht zu einer endlosen Wiederholung der vorher kommunizierten (Selbst-)Verpflichtungen führen. Insbesondere dürfen sie auch nicht zu einem Forum werden, bei dem Vertragsstaaten ihrem mangelnden Ehrgeiz einen grünen Anstrich verpassen (*greenwashing*) oder gar Strategien präsentieren, sich der Verantwortung zu entziehen und ehrgeizigen Klimaschutz vorzutäuschen. Die Dialoge sollten sich insbesondere auf Folgendes konzentrieren:

1. Ermittlung der wichtigsten sektoralen Transformationsherausforderungen und -hindernisse, die viele Industrie- und Entwicklungsländer gemeinsam haben. Dabei sollten wirtschaftliche, politische und institutionelle, und technologische Hindernisse sowie mangelnde Sensibilisierung, Information und Kapazitätsengpässe berücksichtigt werden;
2. das Zusammenstellen von Politiken und Maßnahmen zur Überwindung dieser Herausforderungen und Hindernisse;
3. die Vereinbarung von Meilensteinen für sektorale Dekarbonisierungspfade/Roadmaps, die als Benchmarks für nachfolgende NDCs dienen können.

- Der IPCC wird eine wichtige Informationsquelle für die GST sein, insbesondere im Hinblick auf die Festlegung von Benchmarks. Daher schlagen wir vor, dass **die COP den IPCC auffordert, die verfügbare Forschung speziell im Hinblick auf die Ermittlung von Benchmarks** (auch für Schlüsselsektoren) für das, was zur Erreichung der Ziele des ÜvP erforderlich ist, zu bewerten. Diese Benchmarks können dann zur Information und Bewertung nachfolgender NDCs verwendet werden, und zwar nicht nur in übergeordneter Weise, sondern auch in Bezug auf die jeweiligen sektoralen Ziele und Politiken.
- Die politische Bewertung der Ergebnisse des GST sollte

1. **das fortgesetzte Engagement der Parteien für die Ziele des ÜvP überzeugend bekräftigen;**
2. **die vorhandenen Signale durch spezifischere Botschaften auf Sektorebene weiterentwickeln und verfeinern**, indem sektorspezifische Herausforderungen und Benchmarks hervorgehoben werden, so dass sie öffentliche Aufmerksamkeit erhalten und entsprechende Konsequenzen gezogen werden können;
3. die in der technischen Phase des GST identifizierten **Benchmarks politisch bestätigen;**
4. und **die Vertragsstaaten** durch einen COP/CMA-Beschluss **explizit auffordern, ihre nachfolgenden NDCs an diesen Benchmarks auszurichten**.

Angesichts des relativ engen Mandats des GST sowie den Limitierungen durch die politische Realität der UNFCCC-Verhandlungen argumentieren wir, dass die Wirksamkeit des GST, ob er "das größtmögliche Ambitionsniveau" in den nachfolgenden NDCs katalysieren kann, nicht allein von der Gestaltung und Durchführung des offiziellen GST-Prozesses abhängt. Vielmehr ist mindestens ebenso entscheidend, dass der GST von den Vertragsstaaten, von BeobachterInnen und der breiteren Öffentlichkeit aufgenommen, kommuniziert und (politisch) genutzt wird.

Im Geiste des ÜvP, das die Rolle aller Arten von nicht-staatlichen Akteuren und Stakeholdern ausdrücklich anerkennt, argumentieren wir daher, dass die katalytische Wirkung des offiziellen GST durch begleitende Aktivitäten der Zivilgesellschaft und der globalen Forschungsgemeinschaft unterstützt werden kann und sollte.

Um die **Schrittmacherfunktion** des GST zu unterstützen, ist es notwendig, zunächst die zentralen Botschaften zu verstärken und sie in den jeweiligen nationalen Diskursen zu kontextualisieren. Dies erfordert, dass die Forschungsgemeinschaft global aggregierte Informationen in national spezifische

Anforderungen und Empfehlungen übersetzt und globale Benchmarks auf die nationale Ebene herunterbricht. Im Anschluss an diese Forschungsaktivitäten sollte die Zivilgesellschaft versuchen, ihre Kommunikations- und Medienstrategien so zu orchestrieren und zu koordinieren, dass diese Empfehlungen Eingang in nationale Entscheidungen finden, und so die Agenda-Setting-Funktion des GST maximiert werden kann.

In Bezug auf die Funktion, Länder für den gemachten Fortschritt in der Emissionsminderung verantwortlich zu machen, kommen wir zu dem Schluss, dass der offizielle GST nur eine befähigende Rolle spielen kann. Er kann nur die Vergleichbarkeit von Ambitionen und Umsetzungsfortschritten ermöglichen, aber nicht den eigentlichen Vergleich anstellen. Dieser offensichtliche nächste Schritt muss außerhalb des offiziellen UNFCCC-Prozesses erfolgen. Unter Bezugnahme auf die Ergebnisse des GST sollte die internationale Forschungsgemeinschaft eine Bewertung der Fortschritte auf nationaler Ebene vornehmen, die aggregierten Ergebnisse aufschlüsseln, angeben, wo jedes Land stehen sollte, und die Performanz der Länder vergleichen, damit nationale Stakeholder ihre jeweiligen Regierungen zur Rechenschaft ziehen können.

Zur **Steigerung der NDC-Ambitionen** sollte die internationale Forschungsgemeinschaft globale Benchmarks auf die nationale Ebene herunterbrechen, sektorspezifische Transformationsherausforderungen/Hindernisse diskutieren und *best-practice*-Beispiele zu deren Überwindung hervorheben. Auch hier gilt, dass der offizielle GST keine länderspezifischen Empfehlungen entwickeln darf, so dass es für Forscher und zivilgesellschaftliche Organisationen großen Spielraum gibt, wissenschaftsbasierte länderspezifische Empfehlungen zu entwickeln und zu kommunizieren, die mit den offiziellen GST-Benchmarks übereinstimmen.

Eine ergänzende zivilgesellschaftliche Strategie zur Stärkung der **Signal- und Orientierungsfunktion** des GST könnte es sein, von politischen Entscheidungsträgern klare Bekenntnisse zu den Zielen des ÜvP und den daraus resultierenden notwendigen sozio-ökonomischen Veränderungen zu verlangen. Dies könnte zum Beispiel als "Treueschwur" zu den Zielen des ÜvP organisiert werden. Darüber hinaus könnten zivilgesellschaftliche Organisationen mit Unterstützung der Forschungsgemeinschaft den GST nutzen, um eine gemeinsame Vision zu entwickeln, wie die nationalen Gesellschaften im Jahr 2050 in einer 1,5 °C-Welt aussehen sollten.

Summary

The Paris Agreement provides an open-ended framework for global climate action. It combines top-down collective goals with individual countries' contributions (Nationally Determined Contributions (NDCs)). A key challenge of this hybrid approach is that there is no guarantee that the individual contributions add up to what is required to meet the collective goals.

To address this issue, the Paris Agreement established the Global Stocktake (GST). The GST will "assess collective progress" towards achieving the long-term goals of the agreement as of 2023 and every five years thereafter, on the basis of information reported through the Enhanced Transparency Framework. It thus provides feedback and connects the national-level implementation of NDCs with the overarching objectives of the Paris Agreement with a view to influencing and inspiring national agendas towards more ambitious subsequent NDCs. Corresponding to this role, this paper addresses three questions:

- **What should an effective Global Stocktake look like?**
- **What information and data are needed for an effective Global Stocktake?**
- **Is it possible to execute an effective Global Stocktake within the mandate of the Paris Agreement?**

To address these questions, a comprehensive two-year research project was financed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and conducted by the German Environment Agency.[2] This executive summary provides a condensation of the underlying study and the comprehensive final report. Specifically, we first present background information and determine what "effective" means when it comes to the GST, focussing on the mitigation aspects (chapter 2). We then examine indicators and benchmarks that could be used in the GST to assess collective progress and evaluate whether the required information is at all available and of sufficient quality to conduct a meaningful analysis on mitigation progress (chapter 3). Subsequently, we develop and present opportunities and challenges in aggregating the information and describe an approach to present the information in a way that serves the purposes of the GST (chapter 4). We conclude with a review whether and to what extent the proposed approaches meet the conditions of a successful GST and formulate recommendations for the design of the GST process (chapter 5).

Background and Framework for Analysis

The Global Stocktake in Context

The GST is established by Article 14 of the Paris Agreement. Its mandate comprises three 'thematic areas'; mitigation, adaptation, and means of implementation and support, while loss and damage and response measures will also be considered in the process. In our study we solely focus on the area of mitigation. Negotiations at COP24 in Katowice confirmed that the GST will consist of three components – (1) information collection and preparation, (2) a technical assessment, and (3) consideration of outputs (for a detailed assessment of the Katowice Rulebook in view of the Global Stocktake see Jeffery, Hermwille and Siemons, forthcoming).

The outputs of the GST should "summarize opportunities and challenges for enhancing action and support in the light of equity and the best available science, as well as lessons learned and good practices". It is worth noting that the outputs of the GST shall "have no individual Party focus, and include non-policy prescriptive consideration of collective progress" (Decision 19/CMA.1 chapter I paragraph 14).

[2] The project was funded under grant number FKZ 3717181030. The final report of the project is expected to be published in February 2020 at www.umweltbundesamt.de.

Information that is to serve as an input to the GST should be submitted at least 3 months before their consideration in the technical assessment and no later than six months before the consideration of outputs. It should include information on the state of greenhouse gas emissions and mitigation efforts undertaken by Parties, the overall effect of NDCs, the state of adaptation efforts, finance flows, barriers and challenges for developing countries, opportunities to enhance international cooperation and to increase support and fairness considerations.

Sources of input will comprise reports and communications by parties, reports of the IPCC, the subsidiary bodies (SBSTA and SBI), other relevant bodies under the UNFCCC or the Paris Agreement, the UNFCCC secretariat, UN agencies, regional groups and institutions as well as submissions from Parties and non-Party stakeholders. The Secretariat is asked to prepare four synthesis reports as part of the information collection and preparation stage that should cover (1) the state of GHG emissions and removals and mitigation efforts, (2) the state of adaptation efforts, experience, and priorities, (3) the overall effect of NDCs, and (4) financial flows (UNFCCC, 2018, para. 6c).

An Effective Global Stocktake: Functions of the Global Stocktake and Conditions to Fulfil Them

We identify four functions that an effective Global Stocktake should fulfil; acting as a pacemaker of policy processes, ensuring accountability of countries actions, driving enhanced ambition in subsequent NDC cycles, and providing guidance and signal of a renewed commitment to the Paris Agreement goals.

The GST is perceived as THE mechanism to increase the level of ambition over time. Still, a huge discrepancy exists between the high ambition expressed in the long-term temperature goal and the current level of ambition of NDCs (UNFCCC, 2016). It is therefore necessary that the level of ambition of NDCs is ramped up considerably in subsequent iterations of the NDC cycle. There are various theories of change that can help to explain how the GST could contribute to ramp up ambition over time. We have "translated" them into the following four governance functions for the GST that need to be fulfilled for the GST to be effective, i.e. to foster transformational change (also see Hermwille *et al.*, 2019). Specific process- and information-related conditions need to be fulfilled in order for the GST to meet those functions:

- **Pacemaker function**: The Paris Agreement establishes a "pacemaker" that stimulates and synchronizes policy processes across governance levels. According to this perspective, the GST reinforces the periodic 5-yearly NDC cycle or rhythm of the Paris Agreement which resembles a prototypical policy cycle (agenda setting, policy formulation, decision-making, implementation, evaluation) (Jann *et al.*, 2007). The process itself can be seen to function as an agenda setting mechanism, designed to influence decision-making at the national level. In order to fulfil this function, meaningful information needs to be available in time. Furthermore, the outputs of the GST should be formulated in a way that resonates with the national discourse of as many countries as possible.
- **Ensuring accountability**: The initial phase of the GST process requires country-specific input (information from the Enhanced Transparency Framework as well as other "best available science"). This information could contribute to hold countries accountable by "naming and shaming" countries with regard to the implementation of their NDCs. To do that, accurate and sufficiently granular data to track progress towards NDCs is necessary. Additionally, the GST could increase the level of public attention for progress made by publicly receiving, reviewing and appraising individual country reports, to complement the multilateral consideration of progress under the Enhanced Transparency Framework. This could be done if the corresponding reports of the process were officially endorsed by a high-level segment in the negotiations. However, the GST has a very narrow mandate as it is supposed to assess *collective* progress only. When one conceptualizes the GST as a process, it might be possible to receive and review the input during the initial phase of that process, possibly in public.

- **Driving NDC ambition:** It is necessary that the level of ambition of NDCs is ramped up considerably in subsequent iterations of the NDC cycle. To support the in-built "ambition mechanism" of the Paris Agreement that each NDC needs to represent a progression beyond the Party's previous NDC (Müller and Ngwadla, 2016; van Asselt, 2016), the GST could try to determine benchmarks that may help to determine what constitutes a progression as well as the highest level of ambition. It is not within the mandate of the GST to do this assessment, but it could provide the means for others including national policymakers and civil society organizations to carry out the work. The IPCC will play a prominent role in setting those benchmarks. Additionally, the GST could showcase particularly ambitious NDCs or aspects of NDCs. It could provide a peer-learning platform for 'how to do transformational change'" (Milkoreit and Haapala, 2017, p. 2). This could be done within the technical dialogues to be held during the GST process.
- **Guidance and signal:** The GST can be seen as an opportunity to reiterate and reinforce the signal already provided in Paris. The GST is an occasion to provide testament of whether or not Parties are still committed to the purposes of the Paris Agreement. More importantly, the GST could further develop and refine the existing signal. First, it needs to assess whether the long-term vision is still adequate and/or feasible in the light of available science. For mitigation, it would be particularly helpful if it collated and institutionalized sectoral visions that spell out more clearly sector-specific transformation challenges. Refining the signal provided from the Paris Agreement would not only help guide the next round of NDCs but could also serve as an updated reference point for all kinds of governance initiatives (incl. non-state and subnational actors). It would provide legitimation and orientation for transnational governance initiatives and thus help "orchestrate" the groundswell of climate action.

Taking Stock: Available Information for Assessing Progress

Indicators for an Effective GST

The GST should be based on a broad spectrum of information that can easily be related to policies and actions. Including consideration of detailed, sector specific information could facilitate a better understanding of emissions drivers and their barriers, and the development of a vision of a 1.5 °C compatible world.

To meet the functions described above, indicators and benchmarks will be necessary in the GST as a means to assess collective progress. Appropriate indicators for measuring progress against the Paris Agreement mitigation goal include not only emissions but also their drivers and the structural and institutional practices in place to facilitate the transition to a low carbon world. Indicators may be quantitative or qualitative in nature.

A good indicator is relevant, reliable, accurate, and tractable. **Under the GST, a relevant, or meaningful, indicator is clearly relatable to national and international climate policy frameworks, on a recent and near-future timescale and at a level of granularity that informs action.** If the GST is to inform enhanced ambition policies, the issues and indicators being tracked should be easily translatable into policies and not be too abstract. To be relevant, indicators also need to be formulated in a manner that is comparable between countries, such as per capita emissions or emissions intensity of economies.

To be reliable and accurate, an indicator must be robust in its formulation and based on good quality data that is trusted by all participants. Furthermore, averaging of data over multiple years is important to remove spurious data and account for fluctuations and events, such as those due to economic crises or year-to-year variations in temperature. Finally, a tractable indicator is one for which sufficient in-

formation is available, be that for a sufficient amount of countries, enough years, and updated regularly with the most up to date developments so that a good understanding of the situation is possible.

The GST needs to take multiple timeframes into account. We want to know the current state of emissions and their drivers, the direction in which changes are occurring, and where we expect emissions and their drivers to be in the future. To fulfil these purposes, all indicators would ideally be available based on data time series of continuous years extending both backward (until at least 1990) and forward (to the timeframe of current NDCs or long-term low emissions development strategies). Data and information for the latter require projections and are therefore particularly challenging. Thus, it may be that some indicators can only be used to measure progress to date, or to evaluate future directions only within a restricted timeframe (e.g. under NDCs but not long-term strategies).

The level of detail that the indicators should explore also needs to be taken into consideration, which we will refer to as granularity. This granularity could be in terms of sector, gas, region, fuel type, or technology. The more specific the indicator, the more specific information required to estimate the indicator. On the one hand, a more specific indicator is often easier to relate directly to policies (e.g. building renovation rates) and thus fulfilling the relevance requirement. On the other hand, it's less likely to be able to find comparable information for all countries and years.

To fulfil the relevance requirement of a good indicator outlined above, some level of sectoral detail is necessary. One challenge for the GST is that different institutions and information sources define sectors in a different way. Another requirement of the GST is that progress is assessed at the collective level but, to be relevant, some geographic resolution (either national or regional) could be more informative.

With regard to qualitative indicators, the GST should provide an overview about the domestic policies and measures that countries use. It will not be possible to assess the stringency, ambition or effectiveness of any individual policy. However, providing an overview of which countries have introduced comprehensive framework legislation, which sectors / areas of mitigation activity are covered and whether or not the expected mitigation impacts have been quantified could provide relevant information. A second type of qualitative information to be collated under an effective GST would relate to barriers and challenges regarding the transformation towards decarbonized economies and societies.

For the analysis underlying this paper, we examined a **comprehensive** set of possible indicators that could be used in the GST and assessed their relevance, data requirements, and the data availability for performing assessments. The selection includes **both key top-level parameters directly related to the Paris Agreement's objectives** as well as **highly-detailed aspects** of mitigation, incorporating sectoral level detail and policy relevance as described above. We further prioritised indicators that are fundamental to a transition to a low carbon economy, such as the share of renewable energy in final energy consumption, and key qualitative indicators of progress, such as the existence of a long-term low carbon development strategy.

Industry was selected as an exemplary sector to assess in greater detail because it is a substantial contributor to global emissions but less explored than the energy sector. Industry emissions are additionally interesting because their scope encompasses both energy emissions and process emissions and issues of sectoral definitions must be addressed. For the industry sector we selected indicators based on the IPCC's 5th Assessment Report, particularly WGIII Chapter 10 (IPCC, 2014). The drivers of emissions in industry are then considered in terms of energy efficiency, emissions efficiency of energy, emissions efficiency of processes (CO_2 and non-CO_2), materials efficiency and product demand.

Establishing Benchmarks for Evaluating Progress

We propose that the GST considers a series of indicators and here outline how those indicators can be evaluated using benchmarks. Benchmarks may be derived from macroeconomic modelling assessments, best practice examples, or consideration of technical potential. The application of benchmarks to individual or groups of countries should take national circumstances and equity considerations into account.

An indicator is only meaningful if a context and benchmark is given – what level should the indicator be at if a specific goal is to be met? In the case of the GST, the benchmarks derive from the context of the goals of the Paris Agreement: what is needed to be consistent with limiting warming to 1.5 °C, to peak emissions as soon as possible, and to achieve a balance of anthropogenic sources and sinks?

One of the challenges of setting benchmarks is that there are many different ways to achieve the overall temperature and emissions goals.

Benchmarks can be set in both qualitative and quantitative terms, and both can be useful. Particularly for top-level indicators, a clear descriptive benchmark can be more relatable than a numeric target. We propose that a mixture of descriptive and quantitative benchmarks is needed to robustly and effectively translate indicator assessment into effective policy action.

For the benchmarks explicitly included in the Paris Agreement (limiting global temperature increase, peaking emissions and balancing sources and sinks), the IPCC reports provide a pertinent source of information. We distinguish three different types of benchmarks for quantitative indicators that can be set; macroeconomic, best practice, and technical potential. Benchmarks may need to be updated in subsequent stocktakes to account for any missed targets in previous years or improved scientific understanding.

Finally, even more so than in defining indicators, defining and setting benchmarks is an aspect of equity. Should all countries be held to the same benchmark, or should countries be given different targets based on capacities and historical responsibility? Rather than formulating benchmarks for indicators based on equity, we propose that (1) the GST should include some specific indicators of equity such as per capita emissions, cumulative per capita emissions and capability, and (2) that equity can be operationalized through the manner in which indicators are used and assessed. For some indicators, particularly those derived on best practice or technical potential, equity could be operationalized with the expectation that developed countries are setting the best practice examples and are quicker in making improvements than less developed countries. Additionally, the level of support provided to developing countries will be crucial as will the overall adequacy of collective efforts (also see Winkler, 2019).

Quality and Availability of Information for the Global Stocktake

The Enhanced Transparency Framework should provide good quality and extensive information that the Global Stocktake can use. However, the framework will not be fully implemented until 2024 and, even then, will not include all information that would be ideal. Other sources of information that could provide additional details or indicators, before and after 2024, may lack legitimacy under the UNFCCC. These sources should be utilised as far as possible and the IPCC could play a role in synthesising and legitimising some information sources.

A rich variety of information sources is available which could, in principle, provide valuable input to the GST and provide data on selected indicators and benchmarks. However, the conditions for a fully effective GST will be difficult to fulfil and specific data gaps and challenges remain.

Information on progress towards mitigation targets and levels of GHG emissions will mostly be based on country reports submitted to the UNFCCC. However, these reports hitherto have included significant data gaps for a large number of countries. The aggregation of emissions would be possible on the basis of national reports combined with gap-filling approaches for countries with missing information, Additionally, challenges still arise from the lack of transparency in the definition of countries' NDCs. Additional information requirements in order to track progress towards these NDCs, such as BAU targets, are not entirely covered by available data.

Some of the indicators considered, e.g. emissions per revenue tonne km, are currently not feasible for assessment under the GST as there are no individual data sources that provide this information for a sufficient number of countries. To perform such an assessment, information would need to be gathered from national or sub-national sources.

Data availability poses a strong restriction on the number of indicators that could be considered under the GST. In some cases, these restrictions may be reduced if the IPCC, or other bodies, are able to use data that is otherwise not publicly available and collate and include the information as part of the AR6 reports, giving the sources legitimacy under the UNFCCC. This would be particularly useful with energy data from the IEA and IRENA. Some of this data has been used by the IPCC in the past, but generally at a global or regional aggregate level.

In other cases, the data simply does not exist at sufficient temporal resolution for enough countries to be usable under a GST that truly includes all countries. This issue is particularly relevant for those indicators that are more detailed in terms of sub-sectors, such as the material intensity of industrial subsectors. This is where efforts to ensure that the GST addresses policy relevant indicators run into limitations, although there is a level of detail at which both data is available and the indicator can directly inform policy, such as the share of renewables in the energy sector.

One option for the GST to consider for increasing the number of indicators that could be used, is to establish a cut-off number of countries for which data is available and an assessment could still be performed. This could be particularly relevant for activities that are dominated by more developed countries and where the countries for which data is available represent a major share of the global total for that indicator.

Additionally, there may be data sources available which hold data that could prove useful for a GST but which are compiled by entities which make them available on a commercial basis (e.g. the Platts database on world electrical power plants (S&P Global Platts, 2018), Bloomberg New Energy Finance (Bloomberg New Energy Finance, 2018)). However, the stocktake should ideally be based on data sources which are publicly available. If data sources such as IEA World Energy Outlook, SE4ALL, Enerdata or Bloomberg New Energy Finance were made available to the GST, the number of indicators, particularly in the energy sector, could be significantly increased. It may prove useful to consider whether there are (non-financial) incentives that could motivate such data-owners to contribute to the cause of a GST in the design of this process. The GST could provide a global platform for making their products publicly known and advertising their usefulness to an important international process. Otherwise, some of the features of an effective GST will need to be performed by independent organisations and activities.

For **qualitative indicators**, there are several different sources of information. First and foremost are official UNFCCC documents prepared and submitted by the Parties themselves. To review the quality and availability of pertinent information from these sources, we prepared country dossiers for five selected countries (the EU, India, Mexico, Vietnam and Ethiopia) with the dual purpose of assessing the data availability as well as providing input for attempts to aggregate qualitative information.

In terms of domestic policies, data availability with existing official UNFCCC documents was generally sufficient, however, not in all cases very recent. With the revised reporting obligations under the En-

hanced Transparency Framework, this will supposedly improve. While a list of relevant policies could be compiled from these sources, a categorisation/classification of those policies was not as straight forward and required significant additional research and deliberation. Meanwhile, information on the NDCs differs strongly.

Information on transformation challenges and barriers, however, was largely unavailable from official UNFCCC documents. The guidelines for the preparation of Biennial Update Reports for developing countries foresee a section where Parties are supposed to "provide updated information on constraints and gaps, and related financial, technical and capacity-building needs" (UNFCCC, 2012, p. 41), however only in the context of international support. For developed countries there is no such requirement. Hence a systematic assessment of experienced and anticipated transformation barriers and challenges is not possible with existing official documentation.

The **information for setting benchmarks** is more readily available than that for the indicators themselves and will primarily come through the IPCC, either in the form of multi-model assessments or literature review. The IPCC provides the most legitimate and comprehensive source of information for the GST. Integrated assessment models provide both an extensive breadth and depth of information that will undoubtedly be used in both the upcoming IPCC AR6 reports and the GST. However, there are limits to the information they can provide in terms of detail and in terms of the flexibility of assumptions used to set up the model. Not all options for mitigation are included in IAMs, or are resolved in enough detail, and some mitigation paths may be taken that are not possible in the models. In particular, including detailed energy data that is currently behind a paywall and clearly defining technical potential and best practice examples from industry would substantially boost the scope of the GST. Moreover, defining benchmarks for more detailed/granular indicators is really difficult, particularly in having confidence about what is Paris compatible. A key challenge here is that the more granular an indicator is, the more interlinkages with other processes/indicators exist e.g. across the value chain. Defining benchmarks therefore necessarily implies assumptions based on other interdependent indicators. Overall, some testing and development of how to integrate different types of benchmarks and particularly how to operationalize equity in the definition of benchmarks is still needed.

In addition, analyses prepared by research institutes (e.g. the Climate Action Tracker or data by Climate Watch) could provide additional value to the GST process or be used by civil society to interpret the results of the GST independently of the official process.

Assessing Collective Progress: Approaches and New Tools

We assessed the challenges of addressing the GST's mandate to assess collective progress and the ability of the analytical community to address those challenges. Key challenges include the quantification and aggregation of emissions under the NDCs due to lack of clarity in the NDCs, only partial coverage of emissions within a country, contribution of the land-use sector, and the impact of market mechanisms.

Challenges in Aggregating National Information

The GST will necessarily need to assess progress on global emissions. However, such an aggregation implies a number of challenges.

Given that Art. 4.4 of the Paris Agreement stipulates that all countries should move towards economy-wide absolute emission reduction targets over time, the GST should assess whether or not progress is being made in that regard. The analysis should be expressed as the share of countries that have committed to economy-wide absolute emission reduction targets as well as the share of global emissions

that is subjected to those kinds of targets. However, **quantifying NDCs is challenging, where limited or contradictory information is provided under the UNFCCC in NDCs and other documents.** Due to a lack of commonly accepted standards and information requirements, the (i)NDCs prepared by Parties in the run-up to Paris and in many cases confirmed thereafter display a huge variety in terms of types of commitments as well as sectors and gases covered. Additionally, a number of specific pieces of information are often missing in order to precisely assess the mitigation impact of NDCs and to track current progress with the implementation and achievement of NDCs (such as metrics or IPCC guidelines used for the calculation of emissions/removals; methodologies for establishing and accounting BAU targets or the contribution of the land-use sector or market mechanisms).

The GST could contribute to assessing the likelihood of overall implementation of the NDCs by incorporating existing work and summarising it. The summary could be performed at the global level – e.g. "current policies are set to exceed the NDC targets by X%" – or could summarise national efforts with statements such as "X of Y countries are on track to meet their NDC targets".

However, some uncertainties will not be resolved by or under the UNFCCC, and some of the information that will eventually be provided under the transparency framework will not be available for the first GST because the first reporting is not due until 2024. Either the Secretariat or independent analysts will therefore need to fill this informational and analytical gap.

Fortunately, the analytical community is well-poised to do so, having performed similar NDC aggregation efforts in 2015. Some of those methods and data will need to be updated for the GST and, preferably, in time for incorporation in the IPCC's AR6 which could give both robust review and legitimacy to individual assessments.

Secondly, to **evaluate collective progress toward the Paris Agreement goals, it is important to track global progress in the total emissions levels that are leading to that temperature change**. Unfortunately, the translation between global emissions and expected future temperature increase is non-trivial.

To estimate future temperatures, we first need to estimate future global emissions. If we assume that the NDC mitigation targets will be met, we have some constraint on emissions until 2030 but long-term temperatures will also strongly depend on post-2030 emissions. Globally aggregated emissions in 2030 can therefore only give an indication of whether global efforts are on track to meet the goals (Jeffery *et al.*, 2018). However, total emissions in 2030 can be used as a barometer to measure the level of effort and a number of methods have been developed for doing so. The methods vary in the extent to which they interpret the emissions level and the assumptions made about what will happen after 2030. Some approaches rely primarily on emissions totals whereas more model-based approaches also take more structural changes in energy systems into account.

Thirdly**, regarding qualitative information, it may also be informative to assess overarching policy frameworks, laws or indicative planning documents of countries as well as the sectoral coverage of policies in terms of dedicated sectoral policies**. Building on existing UNFCCC documents such as national communications and biennial reports / biennial update reports, it should be possible to establish a meaningful survey of the coverage of policies – even more so, when the new reporting requirements of the Enhanced Transparency Framework take effect. A main challenge, though, is a lack of structure and a meaningful classification of policies. Including a framework that classifies policies and measures in different types of instruments in the reporting templates of the transparency framework would make the assessment in the GST much more straight-forward.

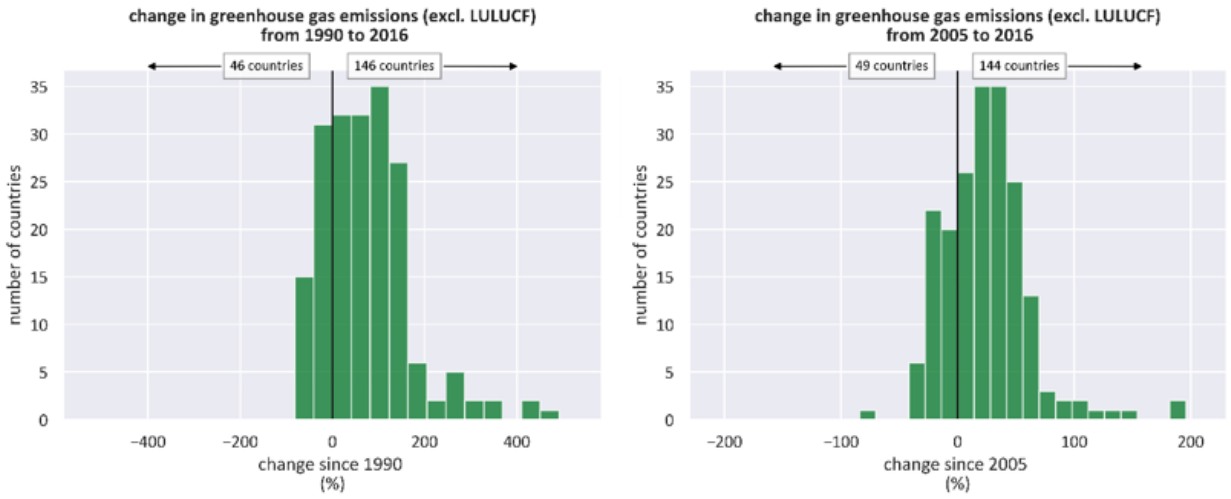
New Tools and Methods for Assessing Collective Progress

To meet both the mandate of assessing collective progress under the GST and the need for the GST to consider policy relevant, detailed information, we proposed and developed a new suite of tools to perform collective assessments of a range of indicators.

To meet the combined challenges of assessing collective progress and providing relevant information, we propose that the GST use a 'performance distribution' approach. In this approach, information from individual countries is used, but in an anonymised manner. Individual country information is displayed in histograms so that no individual country is highlighted but it is nevertheless possible to see if some countries are either leading or lagging behind others. The plots also contain information about global averages and either the averages or the distribution can be compared with global (or regional) benchmarks to evaluate progress.

Under this project, a toolset has been developed to test this performance distribution approach and evaluate its usefulness and suitability for the GST.[3] An example of change in emissions compared to 1990 and 2005 is shown in Figure 2.

Figure 2 Change in emissions compared to 1990 and 2005



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data (Gütschow *et al.*, 2016; Gütschow, Jeffery and Gieseke, 2019). Note the change in scale between the two plots. Three outliers are not shown in the left-hand side plot and two in the right-hand side plot.

Many NDCs are framed as a reduction below a base year but with different base years. This type of calculation and figure allows the current status, or potentially also NDC targets, to be framed according to multiple different base years. In assessing the current status, or historic changes, the GST would really be taking stock and highlighting the progress made to date.

The first GST could present a figure similar to this one to examine the change in emissions since the Paris Agreement was adopted. If that figure were similar to those shown above for the historic trend, it would serve as a clear indication that the Paris Agreement has not yet translated into action. Alter-

[3] The Python based toolset used to make these figures is available for download from https://github.com/mljeffery/performance-distribution-tools.

nately, if the distribution has shifted clearly to the left, it would show that the majority of countries were making progress and any outliers are either frontrunners (to the left) or laggards (to the right).

On the basis of information presented in this way, independent actors, including civil society and policymakers, would be able to locate their country within the distribution and know if their performance were rather as a leader or a laggard. That way, the GST would enable peer pressure among Parties, but also public scrutiny at the national level that could contribute to the enhancing ambition function of the GST.

The approach also allows for a collective assessment of whether all countries are moving together or whether there are clear leaders that have made substantial progress. The approach thereby circumnavigates on the one hand a naming-and-shaming while not letting individual countries hide within a global number and on the other hand a pride-and-fame illustration of high ambitious groups.

Furthermore, the approach is designed in such a way that it can be applied consistently for many indicators and so should be more accessible to a wide community. Once one figure is explained and understood it's easy to translate that understanding to other indicators and figures.

Conclusions and Recommendations

Considering the availability of information and procedural constraints we assess the potential and limits for the GST to deliver on fulfilling the four functions of an effective global stocktake outlined above. The UNFCCC GST process could maximise its effectiveness by (1) including an explicit public appraisal of the inputs, (2) applying the performance distributions approach developed in this project, (3) including detailed discussion of key sectoral systems in the structured expert dialogues, and (4) calling upon the IPCC to assess the available research specifically with a view to identifying benchmarks. The official GST should be complemented and supported by independent activities from civil society and the academic community.

Will the Necessary Conditions Be Met to Fulfil the Four Functions of an Effective Global Stocktake?

To answer this question, we relate the findings of our analysis back to the functions of an effective GST as outlined in chapter 0. For the **pacemaker function**, the first GST will face severe shortcomings with respect to the information available, particularly with respect to self-reported and hence official UNFCCC approved information. However, from 2024 it is obligatory for all countries to submit transparency reports every two years following common reporting guidelines. It can be expected that efforts and support to submit information in time will be significantly enhanced from 2024 onwards. We have identified a plethora of alternative data sources outside of the UNFCCC, but the majority of these is likely not to be acceptable in the UNFCCC process if institutions are not part of the UN system, or data stems from private initiatives etc. (e.g. IEA world energy outlook or Bloomberg New Energy Finance). Moreover, many of these data sources are not comprehensive in terms of countries covered and/or time series being available. Finally, some of the most comprehensive and potentially useful datasets are only commercially available. Arguably, this should not pose an impediment to the GST as such but could hamper transparency of the process and the further exploitation of the analysis e.g. by civil society actors on the national level.

Regarding public attention during the political phase of the GST, it will be up to Parties to decide whether the outcomes of the GST should be recorded e.g. in the form of a non-binding political declaration, or a COP decision with some prescriptive formulations for how a country shall take the findings of

the GST into consideration in the preparation of their subsequent NDCs. Whether the GST will be able to function as a pacemaker will thus depend on the decision by Parties on the outcomes of the GST and on the extent to which countries thoroughly implement the Enhanced Transparency Framework

Admittedly, the GST was not designed to **ensure accountability** at the level of individual countries, this is the role of the Enhanced Transparency Framework. The GST could, in theory, support this function, yet the ability of the GST to effectively do so is severely limited. Firstly, as outlined above, the availability of information is limited, at least for the first iteration of the GST. As of 2024, this can be expected to improve, but it remains to be seen, to what extent Parties will take advantage of the flexibilities implied in the reporting guidelines of the Enhanced Transparency Framework (particularly with regard to the submission of projections and the quantification of policies and measures). This might lead to important gaps in reported information. Moreover, in practice, a lack of capacities, resources or expertise may continue to pose obstacles to comprehensive reporting. It takes a significant amount of time to establish robust reporting systems and where such systems are not in place yet, enhanced reporting requirements alone will not suffice. The Capacity Building Initiative for Transparency, among others, will be an important instrument to address such lack of capacities.

Secondly, it is questionable whether the GST can create sufficient public attention to put policy makers into the spotlight, particularly those who have failed to implement their NDCs. As discussed above, singling out individual countries will not be possible under the GST. The modalities of the GST adopted in Katowice only provide a mandate for the UNFCCC Secretariat to prepare a synthesis report. It is not clear how far the Secretariat can go in highlighting failure of countries to implement NDCs. To be most effective regarding the accountability function an anonymised 'transcript of grades' could be included in the report. This could include statements like 'X countries representing Y per cent of global emissions show significant implementation deficits and are unlikely to meet their targets unless implementation is improved.' While it is unlikely, that the Secretariat will develop its own judgements on the progress of implementation, it may well collate the self-assessment provided by parties in this way. The report could be the basis of discussions and serve as a means to hold countries accountable. It would be accessible to various stakeholders and could be used to create political pressure on the national level. How these reports will be considered in the technical assessment is currently not specified in the modalities for the GST though.

Measures to maximize public attention are indeed key for an effective GST. Only then can civil society and the global scientific community support the official process and create complementary assessments that are explicitly naming countries and highlighting both failures as well as means to improve the implementation.

In order for the GST to **drive NDC ambition**, it should be feasible with available information and within the mandate of the GST to define credible overarching benchmarks despite significant challenges. However, with increasing levels of granularity it becomes more and more difficult to establish commonly acceptable benchmarks. Ideally, the GST would also set sectoral benchmarks e.g. for energy, industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU), or waste. Such benchmarks would allow policy makers on the national level to develop a more holistic perspective on their own mitigation activities.

The IPCC would have to play a major role in setting global and more specific benchmarks as it is the most authoritative scientific body to do so. Following the example of the recent 1.5 °C Special Report which was also "invited" by Parties through a corresponding COP decision (1/CP.21 §21), Parties could send a call to the IPCC to determine those benchmarks to feed into the GST. To maximize the effectiveness, the benchmarks formulated and proposed by the IPCC would then have to be officially endorsed also as part of the political consideration of outputs.

The integration of equity considerations, however, remains an unsolved question. Should all countries be measured against the same benchmarks? How and who is going to decide which benchmarks apply for which group of countries? etc. (also see Winkler, 2019).

Finally, we propose that the performance distribution tool as presented in chapter 0 has the potential to further facilitate the effect of credible benchmarks. Including global benchmarks in the visualization of the assessment of collective progress enables observers and parties themselves to evaluate their own performance against the benchmarks. While making such an evaluation explicit would exceed its mandate, providing the tools to perform such an evaluation is in our view an essential task for the GST.

With regard to facilitation of peer learning and sharing of experiences that might trigger enhancement of ambition in other countries, relevant information on policies and measures and their mitigation effects is already included by many countries in their national reports. However, there is no information being collected (systematically) on the obstacles or the main transformation challenges that countries face across all relevant sectors. Overall, providing information on successful mitigation policies to the negotiations to fulfil this function will be more a question of how to design the process of the GST than to generate new types of information input. A main task for the design of the political phase of the GST will be to identify ways of how to most effectively share best practice examples of mitigation options. In designing such a process, the GST would particularly benefit from a more structured classification of different types of policies, sectors addressed, and main mitigation options being addressed by those policies.

The modalities of the GST provide for technical dialogues to be held by means of "in-session round tables, workshops or other activities" (UNFCCC, 2018, para. 6). This creates ample leeway for the Chairs of the subsidiary bodies and the assigned co-facilitators of that contact group to provide a meaningful structure for the technical assessment. Ideally, this would take the form of structured dialogues of experts, which should focus on relatively concrete (sectoral) transformation challenges in order to fully exploit their potential. Input from non-state and subnational initiatives could be particularly valuable here and the modalities of the GST enable this stakeholder engagement. Voluntary national reviews under the Agenda 2030 for Sustainable Development and the Sustainable Development Goals, the Structured Expert Dialogue (SED) conducted under the first periodic review (2013-2015) as well as the existing Technical Examination Processes (TEPs) held under the joint auspices of the UNFCCC's Subsidiary Bodies or the Technical and Economic Assessment Panel (TEAP) under the Montreal Protocol on Substances that Deplete the Ozone Layer can provide useful lessons learnt to that end.

Lastly, whether the GST will be able to meet the **guidance and signal function** to a large extent depends on the process design and less on the information available. This is particularly true with respect to the reinforcement of the collective goals provided in the Paris Agreement. To what extent the COP will be able to send the signal of renewed demonstration of commitment will depend on the COP Presidency as well as on the facilitators of the political consideration of outputs and the way in which they chose to adopt the conclusions of the GST. To further develop and refine the existing signal, the GST crucially depends on external inputs, particularly from the IPCC and other sources of "best available science". In the meantime, as long as such roadmaps do not exist, the GST could try to gather such information through establishing corresponding in-session expert dialogues that may be able to establish a consensus on which to base further political conclusions in a discursive manner. Again, the modalities of the GST leave it at the discretion of the chairs of the GST to organize the expert dialogue in a way corresponding to this function, or not.

Thus, even with existing information, it will be possible to answer the question **"where are we?"** The official UNFCCC reported GHG emission data is still riddled with information gaps but the availability of information is bound to improve significantly when the reporting requirements of the Enhanced Transparency Framework take effect as of 2024. Also, additionally available information from third

parties is reliable and detailed enough to fill those gaps and to enable the development of an accurate picture of GHG emissions on the aggregate level.

Where do we want (need) to go? Our discussion of benchmarking has shown that building on existing research and information, it seems possible to determine global benchmarks at least for the most overarching metrics such as aggregate emissions, stabilization/peaking of emissions, net zero balance between GHG sources and sinks. However, for this the GST will crucially depend on the IPCC as the most authoritative source of "best available science".

How do we get there? The overarching benchmarks mentioned above can only provide a general sense of direction – like a compass. They do not provide – like a satellite navigation system – the potential routes and specific destinations for the required transformation. For that, more detailed sectoral pathways and roadmaps translated into specific benchmarks would be required. The IPCC with its Sixth Assessment Report may contribute such roadmaps authoritatively. Major challenges persist with regard to the lack of structure and classification of policies/sectors/mitigation actions under the current reporting framework. While this situation might improve with the Enhanced Transparency Framework after 2024, another major shortcoming is that the obstacles and transformation challenges that lie in the way are not being systematically reported nor reflected upon by Parties. And finally, the mandate of the GST does not allow it to make country-specific recommendations and call out those who are moving in the wrong direction.

Specific Recommendations for the Official Global Stocktake and Complementary Activities

Based on our assessment of the informational and procedural needs for the GST to be effective, and an assessment of the information available to the official process, we establish the following set of recommendations for the GST to maximise its effectiveness.

- The GST should include an explicit **public appraisal of the inputs**, especially the transparency reports and technical reviews thereof. This would help to increase public attention for the whole process as well as to generate interest in specific sources of input to the GST which also includes country-level data. Particularly the GST should take into account the proceedings of the facilitative multilateral considerations of progress under the transparency framework. To summarize the progress regarding implementation of NDCs we propose that the UNFCCC Secretariat could create an **anonymised "transcript of grades"** of the form "X countries representing Y per cent of global emissions show significant implementation deficits and are unlikely to meet their targets unless implementation is improved."
- For a graphic representation of collective progress and relating it to a global benchmark of where progress should be, we propose that the UNFCCC Secretariat may apply the **performance distributions approach** developed in this project. We suggest that within the narrow mandate of the GST the performance distribution presents the most differentiated analysis of "collective progress", providing information that is relevant at the national level while maintaining anonymity of individual countries.
- To exchange information on sectoral transformation challenges and barriers, the expert dialogues mandated in the modalities of the GST for the technical assessment should include structured expert dialogues on key sectoral systems including energy, emission intensive industry, transport, agriculture, forestry and other land use as well as waste. These expert dialogues should focus on actual positive learning. They must not result in an endless repetition of previously stated commitments nor must it become a forum for greenwashing lack of ambition, demonstrating effective shirking of responsibility, or pretence of ambition. In particular the dialogues should focus on:

    1. identifying key sectoral transformation challenges and barriers commonly shared by many developed and developing countries taking into account economic, political and

institutional, technological barriers as well as lack of awareness, information and capacity constraints;
2. collating good practice policies and measures to overcome those challenges and barriers;
3. agreeing on milestones for sectoral decarbonization pathways/roadmaps that may serve as benchmarks for subsequent NDCs.

- The IPCC will be a key source of information for the GST particularly with respect to the determination of benchmarks. Hence, we propose that **the COP should call upon the IPCC to assess the available research specifically with a view to identifying benchmarks** (including for key sectors) for what is required to meet the objectives of the Paris Agreement. Those benchmarks can then be used to inform and assess subsequent NDCs, not only overall but also their respective sectoral targets and policies.
- The political consideration of outputs of the GST should

1. **convincingly reinforce Parties' continued commitment to the goals of the Paris Agreement;**
2. **develop and refine existing signals through more specific messages at sector level** by highlighting sector-specific challenges and benchmarks so that they receive public attention and appropriate consequences can be taken;
3. **politically endorse the benchmarks** identified in the technical assessment of the GST
4. and **call upon Parties to align their subsequent NDCs with those benchmarks** by means of a COP/CMA decision.

Given the relatively narrow mandate for the GST provided in the Paris Agreement as well as the limitations of the political realities of UNFCCC negotiations, we argue that whether or not the GST is effective, whether it can catalyze "the highest possible level of ambition" in subsequent NDCs, not only depends on the design and execution of the official process, but also how it is received, communicated and utilized by Parties, Observers and the wider public.

In the spirit of the Paris Agreement which explicitly acknowledges the role of all kinds of stakeholders, we therefore argue that the catalytic effect of the official GST could be supported by accompanying activities from civil society and the global research community.

To support the **Pacemaker Function** it is necessary to first of all amplify the messages from the GST and contextualize them in respective national discourses. This requires the research community to translate global aggregates into nationally specific requirements and recommendations and break down global benchmarks to the national level. Following up on these research activities, civil society should seek to coordinate their storylines and orchestrated media strategy to maximize the agenda setting effect of the GST.

With respect to the **Ensuring Accountability** function we have concluded that the official GST can only have an enabling role. It can only enable comparability of ambition and progress of implementation; it cannot do the actual comparison. This is, of course, the natural next step for actors outside the official UNFCCC process. Referring to the results of the GST, the research community should come up with assessments of progress at the national level, disaggregate the aggregate findings, indicating where each country should be, and comparing country performance, thus enabling stakeholders to hold their respective national governments accountable.

For **Driving NDC Ambition** the global research community should break down international benchmarks to the national level, discuss sector specific transformation challenges/barriers and highlight good practices to overcome them. Again, given that the official GST must not develop country-specific

recommendations, there is ample scope for researchers and civil society organizations to develop and communicate science-based country-specific recommendations that are consistent with official GST benchmarks.

Finally, to amplify the **Guidance and Signal** provided by the GST, a complementary strategy for civil society actors would be to get policy makers on the record that they are still on board and buy in to the implications of the objectives of the Paris Agreement. This could be organized for instance as a “pledge of allegiance“ to the objectives of the Paris Agreement. Furthermore, civil society organizations with support from the research community could use the GST to build and communicate a commonly shared vision of what each country should look like in 2050 in a 1.5 °C world.

1 Introduction

This report is the final report of the UFOPLAN project FKZ 3717 18 103 0 funded by UBA and carried out by Potsdam Institut für Klimafolgenforschung, Wuppertal Institut, Öko-Institut and NewClimate Institute. It summarizes the results of the project, provides recommendations for carrying out the first Global Stocktake process in 2023 and highlights challenges of the process.

The Paris Agreement has brought a sea change to global climate governance. It provides a new international framework which extends beyond its predecessors – the Kyoto Protocol and the Cancún Agreements – in important ways. The first key feature of the Paris Agreement is its transformative ambition (Hermwille, 2016; Kinley, 2017). Unlike the Kyoto Protocol, the Paris Agreement signals a paradigm shift in the sense that it institutionalizes a new collective understanding of the nature of the climate change problem. In recent years, it has become more and more apparent that climate change should not be treated exclusively as an isolated environmental problem of a collective action nature (Harris, 2007). Instead it is now widely accepted that climate change will fundamentally transform our economies and societies, it has become a transformation challenge (Hermwille, 2016). If climate change remains unabated, this transformation will come in the form of significant temperature increase, natural disasters, disintegration of societies and unimaginable hardship across the globe.

Just how transformative the changes need to be if we want to safe a chance of meeting the Paris Agreements long-term goals – limiting global warming to well below 2°C (Art. 2.1a) and achieving greenhouse gas neutrality in the second half of the century (Art. 4.1). The recent IPCC Special Report on the impacts of global warming of 1.5 °C finds that to meet the 1.5°C target, global net CO_2 emissions need to decline by about 45% from 2010 levels by 2030 and reach zero by 2050 (IPCC, 2018). The implications are further illustrated in a recent paper by Kuramochi et al. (2018). The authors list ten short-term benchmarks including that

- growth rates of 25-30% per annum for renewables and other zero and low-carbon power generation need to be sustained until 2025 and a share of 100% needs to be attained by 2050;
- no new coal power plants must be built and emissions from the existing coal fleet must be reduced by 30% by 2025;
- no later than 2035-2050 the entire production of fossil fuelled cars needs to cease;
- as of 2020 every new building needs to be built to the highest efficiency standards (near-zero energy consumption) and be supplied by non-fossil energy only;
- emission-intensive sectors such as cement, steel, aluminium and chemical basic materials need to realize all new installations in low-carbon ways and maximize resource efficiency;
- net deforestation needs to be halted as soon as 2025;

The question is, how the Paris Agreement can actually contribute to facilitating this transformation beyond providing its terms of reference (Hermwille, 2017). The Paris Agreement finally provides an open-ended framework for global climate action. It combines top-down collective goals with individual countries' contributions (Nationally Determined Contributions (NDCs)). As the name suggests, the NDCs are developed and defined in a bottom-up manner according to the priorities of and in line with the intended development pathways of each individual country. For the first time the Paris Agreement demands ambitious mitigation efforts from all countries, however without specifying what ambitious means. Parties to the Paris Agreement have an obligation to formulate NDCs and to implement corresponding policies. Meeting the targets of the NDCs itself is not obligatory.

A key challenge of this hybrid approach is that there is no guarantee that the individual contributions add up to what is required to meet the collective goals. This is where two other elements of the Paris Agreement come into play. The Enhanced Transparency Framework obligates Parties to periodically report on their emissions and the progress towards implementing their NDCs. This is the foundation

on which the Global Stocktake (GST) will then "assess collective progress" towards achieving the long-term goals of the Agreement. As of 2023 and every five years thereafter, the GST will aggregate the individual country-level progress evaluation in order to formulate conclusions at the global level in order to inform subsequent NDCs. In that sense the GST is a central cog in the ambition cycle of the Paris Agreement. It provides a feedback and connects the national-level implementation of NDCs with the overarching objectives of the Paris Agreement with a view to influencing and inspiring national agendas towards more ambitious subsequent NDCs. Corresponding to this role, this report investigates two overarching research question:

- **What should an effective Global Stocktake look like?**
- **And is it at all possible to execute an effective Global Stocktake within the mandate of the Paris Agreement?**

To address these questions, we have broken them down in more manageable pieces. First and foremost, we need to determine what "effective" means when it comes to the GST, focussing on the mitigation part of the GST. To this end, chapter 2 analyses in more detail the role of the GST within the architecture of the Paris Agreement, derives four key functions and discusses process-related and information-related conditions for the GST to meet those functions.

Chapter 3 asks: what should we look at when assessing collective progress with regard to mitigation? It presents information sources and indicators that could be used in the GST to assess progress and discusses potential benchmarks against which to assess collective progress. While including sectoral-level information seems desirable to support an effective Global Stocktake, an analysis of a comprehensive set of sectors is beyond the scope of this project. We therefore highlight the industry sector as an example to showcase the limitations and potential benefits of a sectoral Global Stocktake.

We address the question of possible information sources and indicators for the Global Stocktake both quantitatively and qualitatively. We assess a wide range of quantitative indicators available from official UNFCCC reports as well as from third parties. Availability of qualitative information on policies and measures as well as transformation challenges is assessed by means of five country case studies covering a wide range of different circumstances (European Union, Mexico, India, Vietnam and Ethiopia).

In chapter 4, we do the reality check. We assess whether the required information is at all available and of sufficient quality to conduct a meaningful analysis on mitigation progress.

Chapter 0 develops and presents approaches to aggregate and present the information in a way that serves the purposes of the GST. Specifically, we propose to assess key indicators by means of distribution plots which reveal a broader range of information and may enable comparability of performance of individual countries without doing a direct comparison which would be clearly out of the mandate of the GST. The chapter also includes a test-run and specific applications of the proposed performance distribution approach.

Finally, chapter 6 concludes by reviewing whether and to what extent the proposed approaches meet the process and information-related conditions of a successful GST outlined in chapter 2 with a focus on mitigation. It also presents recommendations for the design of the official Global Stocktake process and for activities by civil society that complement the official process.

2 What is an effective GST?

2.1 The GST in Context

This section discusses the GST (UNFCCC, 2016b, Art. 14) within the legal context by highlighting cross-references between the GST and other elements of the Paris Agreement.

> *Art. 14.1 The Conference of the Parties serving as the meeting of the Parties to this Agreement shall periodically take stock of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals (referred to as the "Global Stocktake"). It shall do so in a comprehensive and facilitative manner, considering mitigation, adaptation and the means of implementation and support, and in the light of equity and the best available science.* (UNFCCC, 2016b, Art. 14)

Art. 14.1 provides the mandate for the GST. Although there are no explicit linkages to other elements of the Paris Agreement, there are clear connections. First, Art. 14.1 refers to the "purpose of this Agreement and its long-term goals". This clearly refers to the three specific objectives outlined in Art. 2 of the Paris Agreement:

- Mitigation target (Art. 2.1a): to limit global warming to well below 2°C and to make efforts to limit global warming to 1.5°C above pre-industrial levels.
- Adaptation target (Art. 2.1b): to increase the capacity for climate change adaptation and to promote climate resilience and low-GHG development.
- Finance target (Art. 2.1c): to make (global) financial flows consistent with the other two objectives.

The last sentence of Art. 14.1 also refers to numerous other elements of the Paris Agreement. The Paris Agreement has dedicated Articles for mitigation (Art. 4), adaptation (Art. 7) and support (Art. 9 on finance, Art. 10 on technological support, and Art. 11 on capacity building). Finally, the term "equity" mentioned in Article 14.1 can only be interpreted to refer to the principle outlined in Art. 2.2 of the Paris Agreement and indirectly to Art. 3.1 of the original United Nations Framework Convention on Climate Change that first established the principle of common but differentiated responsibilities (CBDR) (United Nations, 1992).

While Art. 14.2 specifies the timeline and institutional setup for the GST – every 5 years as of 2023 and under the auspices of the Conference of the Parties serving as the meeting of the Parties to this Agreement (CMA) – Art. 14.3 again contains a number of references to other elements.

> *Art. 14.3 The outcome of the Global Stocktake shall inform Parties in updating and enhancing, in a nationally determined manner, their actions and support in accordance with the relevant provisions of this Agreement, as well as in enhancing international cooperation for climate action.* (UNFCCC, 2016b)

The first part of the Article clearly refers to the NDCs established in Art. 3 of the Paris Agreement as a vehicle for promulgating national mitigation and adaptation policies and measures. It further refers again to action (i.e. Mitigation action, Art. 4, and Adaptation action, Art. 7) and support (Art. 9-11). Not explicitly mentioned but perhaps still relevant are the long-term low greenhouse gas emission development strategies that Parties have been "invited" to prepare as per Art. 4.19. The GST provides an opportunity to highlight the (dis-)connection between NDCs, these long-term mitigation strategies, and the temperature goals.

The last sub clause is a bit peculiar. The reference to "international cooperation for climate action" was introduced in the very last iteration of the negotiation text in Paris. It is unclear what the basis for inclusion was (Friedrich, 2017). Within the Paris Agreement the term "international cooperation" is only used at this very occasion and not elsewhere. However, it resembles to some extent the provisions of Art. 6 specifying that countries may voluntarily *cooperate* in implementing their NDCs (Art. 6.1) by means of "*cooperative approaches*" (Art. 6.2). A narrow interpretation would be, that the last bit of Art. 14.3 refers to any type of cooperation pursuant to Art. 6. This interpretation is plausible as also Art. 6 was completed at the last minute in Paris (Wolfgang Obergassel et al., 2015, 2016) and hence coincides with the late insertion of the respective sub clause in Art. 14.3.

However, a more widely shared interpretation is that the section refers much wider to all kinds of international cooperation beyond the UNFCCC (cf. Friedrich, 2017). This would relate for example to the International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO), but

could also extend to, for example, the World Trade Organisations. Given the acknowledged role of non-state and subnational actors and the increasing number of transnational governance initiatives, it is also reasonably plausible that the authors of the sub clause intended the GST to be a means to orchestrate the wider inter- and transnational climate governance landscape (Milkoreit & Haapala, 2017).

There are also a number of passages in the text that refer to Art. 14 implicitly or explicitly. These include:

- Art. 4.9 which mandates Parties to communicate and/or update NDCs every 5 years that shall be *informed by GST*.
- Art. 7.14 makes specific provisions for how adaptation shall be considered within the GST.
- Likewise, Art. 9.6 spells out how climate finance shall be reflected in the GST.
- Art. 10.6 outlines how the GST shall account for technology support and technology transfer.
- Art. 13.5 and 13.6 are particularly important as they state that the *purpose* of the transparency framework is to inform the GST about implementation of action (Art. 13.5) and support (Art. 13.6).

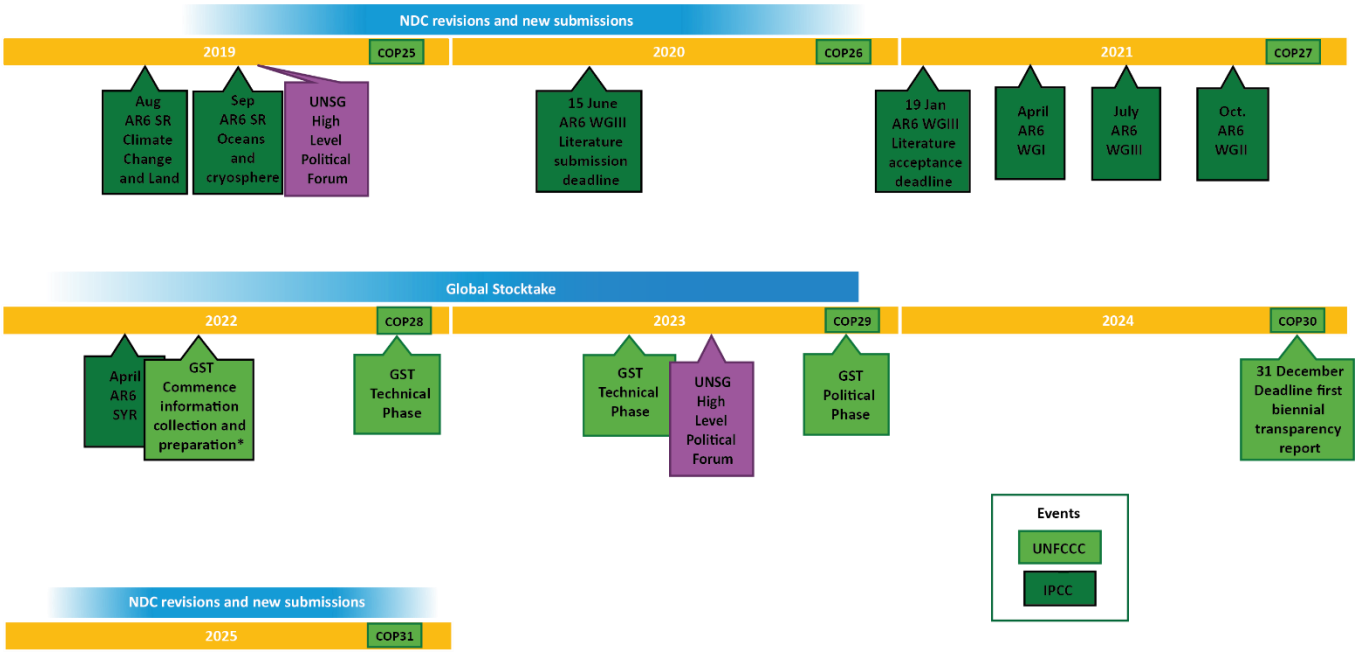
2.1.1 Process modalities of the Global Stocktake

What is clear from this analysis is that the GST is supposed to cover a wide range of issues. The scope is so wide, that it is commonly accepted that some structure is required within the GST in order to allow it to meet its mandate. But how can the enormous scope of the GST be broken down?

At COP24 in Katowice, Parties adopted the modalities of the GST (UNFCCC, 2018b). The work will focus on three 'thematic areas' – mitigation, adaptation, and means of implementation and support. Notably and after substantial controversies, Parties agreed to open the process to also consider loss and damage associated with the adverse effects of climate change.

Moreover, negotiations in Katowice confirmed that the GST will consist of three components – (1) information collection and preparation, (2) a technical assessment, and (3) consideration of outputs. The information stage will begin at the inter-sessional in 2022, with the technical phase to proceed during the following two sessions (COP28 and the 2023 inter-sessional), and the final phase concluding at COP29 at the end of 2023 (Figure 1).

Figure 1 Timeline of the IPCC and UNFCCC processes leading up to the first GST in 2023 and the first submissions under the Enhanced Transparency Framework at the end of 2024.



Source: Potsdam Institute of Climate Impact Research based on official IPCC and UNFCCC timelines and documents

2.1.2 Information outputs and inputs

Decisions on outputs of the GST process and information inputs were also taken in Katowice. The final outputs are not clearly defined, but the decision states that the outputs should "summarize opportunities and challenges for enhancing action and support in the light of equity and the best available science, as well as lessons learned and good practices with a view to achieving the outcome identified in Article 14 para 3." It is worth noting that the outputs of the GST shall "have no individual Party focus, and include non-policy prescriptive consideration of collective progress" (Decision 19/CMA.1 chapter I paragraph 14).

Information that is to serve as an input to the GST should be submitted at least 3 months before their consideration in the technical assessment and no later than six months before the consideration of outputs. Although the information collection should conclude prior to the technical assessment, the technical assessment could overlap with the information collection and preparation to ensure effective use of time.

The Secretariat is asked to prepare four synthesis reports as part of the information and collection stage that should cover (1) the state of GHG emissions and removals and mitigation efforts, (2) the state of adaptation efforts, experience, and priorities, (3) the overall effect of NDCs, and (4) financial flows (UNFCCC, 2018b, para. 6c). Notably, the synthesis report on the overall effect of NDCs is explicitly linked to the latest reports of the IPCC[4], suggesting that the IPCC is seen as a key body for performing such assessments.

The type of information that will be considered as input to the GST was also defined[5]. On mitigation, the thematic areas to be covered by the sources of input include:

[4] ibid., paras 23 and 37

[5] ibid., para. 36

- (a) the state of greenhouse gas emissions be sources and removals by sinks and mitigation efforts undertaken by Parties,
- (b) the overall effect of their nationally determined contributions and overall progress made by Parties towards the implementation of their nationally determined contributions,
- (c) the state of adaptation efforts, support, experience and priorities,
- (d) finance flows and means of implementation and support and mobilization and provision of support; including information from the latest biennial assessment and overview of climate finance flows of the Standing Committee on Finance,
- (e) efforts to enhance understanding, action and support related to addressing loss and damage associated with the adverse effects of climate change,
- (f) barriers and challenges, including finance technology and capacity building gaps faced by developing countries,
- (g) good practice, experience, and potential opportunities to enhance international cooperation on mitigation and adaptation and to increase support under Article 13.5 of the Paris Agreement,
- (h) fairness considerations, including equity as communicated by Parties in their nationally determined contribution.

The following section[6] goes on to define the sources of input that will be considered to acquire that information.

- reports and communications by Parties,
- latest reports of the IPCC,
- reports of subsidiary bodies,
- reported from relevant constituted bodies and constituted forums under the Paris Agreement or the Convention,
- synthesis reports prepared by the Secretariat,
- relevant reports from UN agencies and other international organizations, that should be supportive of the UNFCCC process,
- voluntary submissions from Parties, including on inputs to inform equity consideration under the GST,
- relevant reports from regional groups and institutions,
- submissions from non-Party stakeholders and UNFCCC observer organizations.

The above lists are both considered non-exhaustive and will be reconsidered for each GST.

2.1.3 Other important issues in the negotiations the Global Stocktake modalities

Critically discussed was furthermore the question of how equity considerations are to be reflected in the GST. However, even though references to equity feature prominently at various paragraphs of the guidance for the GST, a concrete idea of how a consideration of equity could be operationalized in practice is still missing.

Another major bone of contention was whether and to what degree the GST is open to non-party stakeholders, observers and the public. On that matter, Parties decided that the GST will be "conducted in a transparent manner and with the participation of non-Party stakeholders". Opportunities for participation include to provide written submissions as input to the GST and to participate in the technical dialogue mentioned above. Yet, the extent to which non-Party stakeholders can actively participate will be dependent on how the two co-facilitators choose to organize the technical dialogue. Additionally, observers were concerned that Parties might not make their inputs publicly available as the deci-

[6] ibid., para. 37

sion only stipulates that the inputs will be made "fully accessible *by Parties*" (emphasis added)[7]. Obviously, such lack of transparency would contradict the purpose of the GST: to foster a constructive debate on ambitious climate action and to (re)align national political agendas for the subsequent NDCs with the goals of the Paris Agreement. To this end, inclusive and extensive stakeholder engagement is essential.

2.2 Functions of the Global Stocktake

The GST is particularly important because many hope and believe that the GST is THE mechanism that enables the dynamic increase of the level of ambition over time. It is supposed to foster a virtuous cycle of climate action[8] that leads current insufficient levels of ambition onto a self-reinforcing transformation pathway towards a sustainable and carbon emission free future. Still, a huge discrepancy exists between the high ambition expressed in the long-term temperature goal and the current level of ambition of NDCs (UNFCCC, 2016a). It is therefore necessary that the level of ambition of NDCs is ramped up considerably in subsequent iterations of the NDC cycle. There are, however, various theories of change for how the GST can contribute help ramp up ambition, how it could set in motion the required transformational change. There are different "schools of transformation" (Schneidewind & Augenstein, 2016) which adhere to very different theories of change, all of which can also be portrayed on the GST:

- a **rationalist perspective** that emphasizes climate change as a collective action problem. Change is incremental and market-driven. Prices (whether they are monetary, political, or any other kind) are the drivers of change.
- an **idealist perspective** that focuses on ideas and meaning as drivers of change. Ideas and values shape the way we see the future and therefore transformational change requires a fundamental "mindshift" (Göpel, 2016).
- an **institutionalist perspective** that is based on the understanding that human behaviour is fundamentally structured by institutions that "facilitate the diffusion of new ideas and shape processes of technological innovation" (Schneidewind & Augenstein, 2016, p. 89).
- and a **technology optimist perspective** that highlights the role of technological innovation and diffusion.

There is not one "correct" theory of change, we would like to argue. We consider all of these mechanisms of change to be at play at the same time. The GST can and should serve to promote each of them. Correspondingly, we have identified four governance functions for the GST. In order to fully leverage its potential, the GST should serve all four of them to the greatest extent possible.

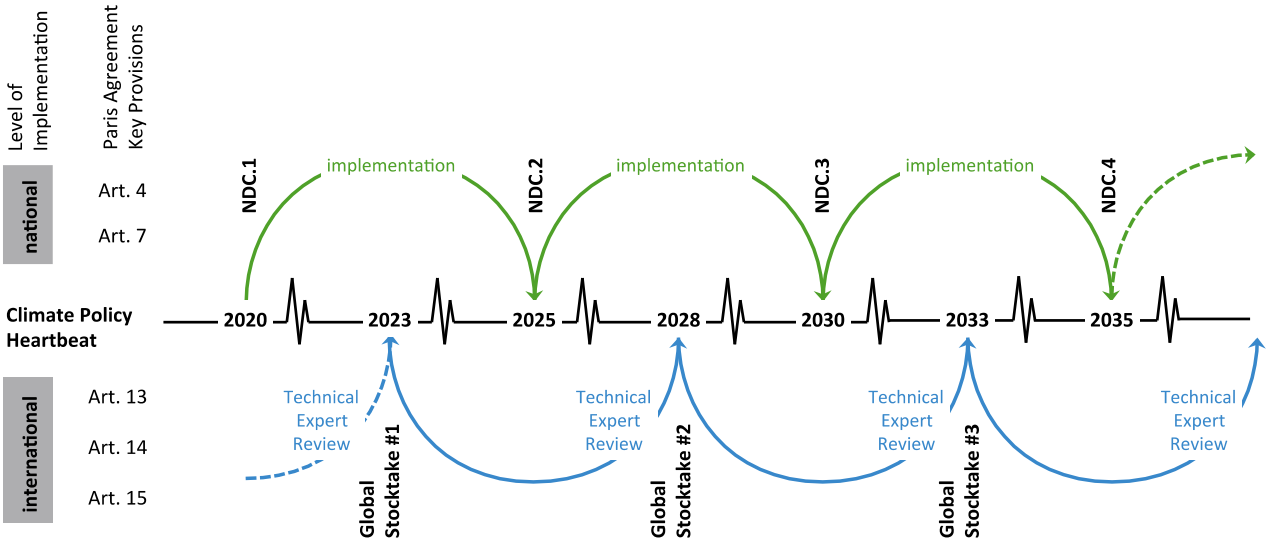
2.2.1 Pacemaker Function

The first function highlights the role of the GST from an institutionalist perspective. As outlined above, the Paris Agreement establishes a "pacemaker" that stimulates and synchronizes policy processes across governance levels. But what is the specific role of the GST within this pacemaker? A first and obvious contribution is that the GST reinforces the periodic 5-yearly cycle or rhythm of the Paris Agreement.

[7] ibid., paras 10 and 21.

[8] While the Global Stocktake is supposed to cover mitigation and adaptation as well as support, the subsequent analysis focuses on the mitigation perspective. The described functions may be perceived differently or with different nuances for adaptation.

Figure 2-1 Schematic illustration of the pacemaker function of the Paris Agreement and its elements.



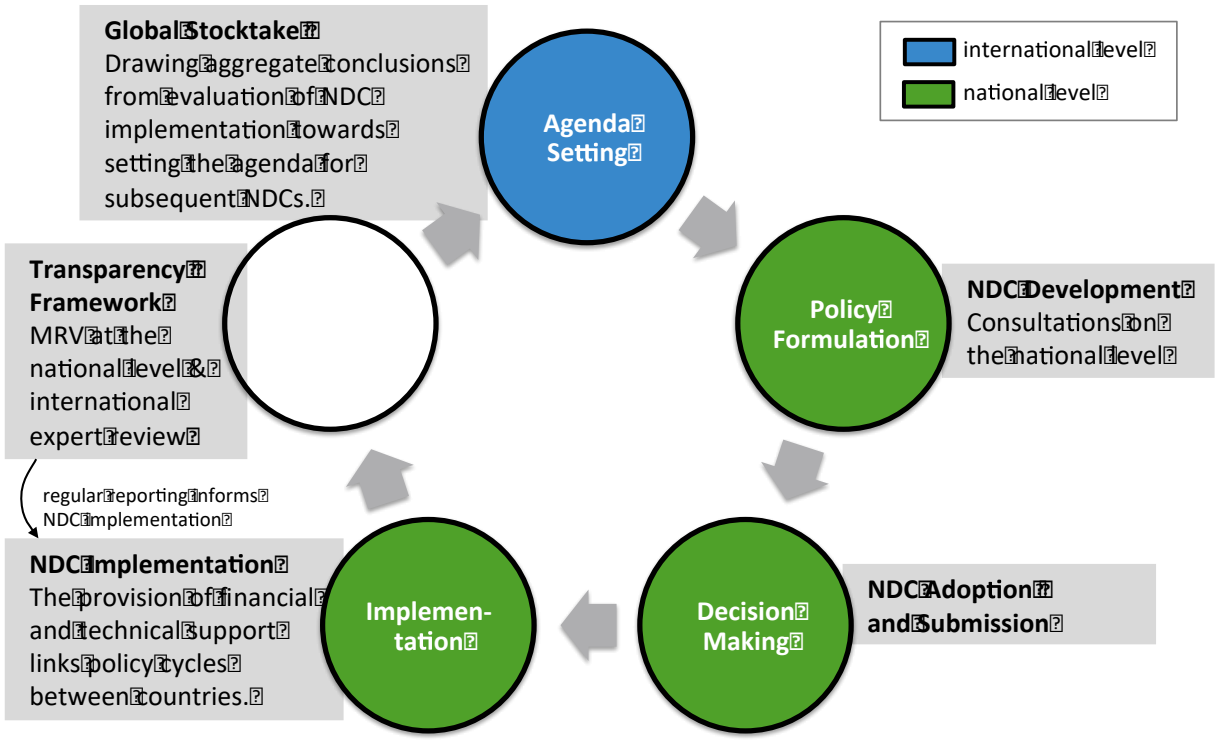
Source: Hermwille & Siemons (2018).

Essentially, the NDC cycle resembles a prototypical policy cycle (Jann et al., 2007)(see Figure 2-2 below). The agenda setting stage of the policy cycle for the initial NDC cycle was essentially accomplished with Decision 1/CP.20 adopted at COP20 in Lima that invited Parties to submit their (intended) NDCs before COP21 (Ott et al., 2014). The development of the NDCs, often with support of national and international consultants, represents the policy formulation stage. The decision-making stage is the final adoption and communication of the NDCs. The implementation of the NDCs obviously corresponds to the implementation phase of the policy cycle. It is important to note that in the implementation there is again an important interlinkage between the respective policy cycles of different countries. For developing countries who have specified needs for financial and technical support in their NDCs the implementation of the NDCs or parts thereof may be contingent on the required support actually being delivered. However, this support, particularly the financial support, critically hinges on the previous stages (policy formulation and decision making) in potential donor countries that determine the supply of climate finance and other means of implementation.

The evaluation stage of the policy cycle is essentially covered by the Paris Agreement's transparency framework which partly is implemented at the national level in the form of national MRV and accounting systems. The international part of the transparency framework entails the regular technical expert review pursuant to Art. 13.11 and 13.12 (UNFCCC, 2016b).

Finally, the GST bridges the evaluation stage and the agenda setting stage for subsequent NDC cycles. It aggregates the individual country-level evaluations in order to formulate conclusions at the global level. These conclusions in turn will co-determine (together with many other factors at the national and international level) the agenda for the next round of NDCs.

Figure 2-2 The NDC Cycle as a policy cycle..



Source: Hermwille et al. (2019).

So, what is required to enable the GST to effectively function as an agenda setting mechanism? First and foremost, this is a question of sequencing. The GST can only effectively aggregate and conclude on the individual country evaluations when they are available as an input in time.

The second important point regards to the output of the GST. If the GST is supposed to impact saliently on the national climate policy agendas, the outputs should be formulated in a way that resonates with the national discourse of as many countries as possible. Very general statements and mere calls for urgency will most likely not have a strong impact. It may be necessary to differentiate and formulate specific challenges that correspond to for example different stages of development. Ultimately, this problem is to be resolved in the political phase of the GST. However, the technical phase needs to supply data and analyses that allow formulating differentiated policy narratives.[9]

2.2.2 Ensuring Accountability

From a rationalist perspective, one of the key points of criticism of the Paris Agreement is its lack of legal compulsion (see analysis above) which has to some extent been substituted by a focus on transparency in the hopes that a threat of "naming and shaming" can discipline policy makers to adequately implement their NDCs. But what is required in order to make naming and shaming effective and what can the GST contribute in this regard?

For the "naming" part a key requirement is actual transparency. Without accurate and sufficiently granular data it is simply impossible to determine whether or not and to what extent countries have attained their NDCs. For the "shaming" part, a critical level of public attention is required. The transparency framework will most likely not be sufficient in this regard. It is unlikely that the technical ex-

9 We would like to highlight that climate change is intricately linked to other global challenges such as sustainable development and rapid urbanization for which dedicated international bodies and processes exist. To maximize political relevance, it would be beneficial to align as much as possible the Global Stocktake with the review processes of other agendas such as the Sustainable Development Goals and the New Urban Agenda.

pert reviews will receive a lot of public attention unless they are somehow highlighted in an international event.[10] Also, the review reports may not be written in a format that is easily accessible for media and the wider public.

This is where the GST could make a contribution. By publicly receiving, reviewing and appraising individual country reports, the GST could create an echo chamber for the transparency framework that helps to attract the necessary public attention. Synthesizing the country reports in an accessible manner could further facilitate this.

Unfortunately, the GST has a very narrow mandate (if at all) in this regard. Art. 14.1 postulates that the GST is supposed to assess *collective* progress only. Hence, Milkoreit and Haapala (2017) argue that there is really no scope for "naming and shaming" within the GST. This is right in the sense that the ultimate outcome(s) of the GST need to aggregate the individual country data. Yet, when one conceptualizes the GST as a process, the initial phase of that process would require to receive and review the input (information from the Enhanced Transparency Framework as well as other "best available science"). The question is, to what extent this can be done publicly. While this kind of public appraisal of country-specific information would arguably strengthen the efficacy of the Paris Agreement, it is also likely to receive strong political contestation.

2.2.3 Driving NDC Ambition

Even if accountability is ensured and Parties effectively implement their current NDCs, the next challenge is to provide a leg-up for ambition for the subsequent NDC. This is the third function of the GST which combines aspects of the aforementioned rationalist perspective and the technology optimist perspective.

A huge discrepancy still exists between the high ambition expressed in the long-term temperature goal and the current level of ambition of NDCs (UNFCCC, 2016a). This shortfall has even been acknowledged explicitly by Parties in the accompanying decisions at COP21 (UNFCCC, 2016c, para. 17). It is therefore necessary that the level of ambition of NDCs is ramped up considerably in subsequent iterations of the NDC cycle. The Paris Agreement has an in-built "ambition mechanism" or "ratchet mechanism" (van Asselt, 2016; Müller & Ngwadla, 2016). A key provision of this mechanism is outlined in Art. 4.3 of the Paris Agreement:

> *Each Party's successive nationally determined contribution will 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.* (UNFCCC, 2016c, Art. 4.3)

There are two ways in which the GST could support this provision. The first follows the logic of climate change as a collective action problem. This logic requires the identification and denunciation of free riders. But with respect to the provisions of Art. 4.3 this is challenging to do. After all, who is going to define what constitutes a progression beyond the current NDC and, even more importantly, how can we determine the "highest possible ambition"? This is where the GST could come in. The GST could determine benchmarks that may help to achieve this. One benchmark would be to determine what kind of level of ambition is required in the upcoming NDC period taking into account the achievements and shortfalls of the current NDC period. This could then serve as a yardstick against which to assess the new proposed NDCs. It is not within the mandate of the GST to do this assessment, but it could provide the means for others including national policymakers and civil society organizations to carry out the work.

[10] In the past, for example the Multilateral Assessment Process under the Assessment and Review procedure for Annex I countries under the SBI (review process for Biennial Reports submitted by Annex I countries) has received rather little public engagement or attention and no higher-level event or measures to enhance publicity have been undertaken.

Another useful benchmark would be to identify and showcase particularly ambitious NDCs or aspects of NDCs. This would arguably help to raise the bar of what is commonly perceived as "the highest level of ambition". Covering a diverse portfolio of countries with different states of development and a wide range of specific national circumstances would help to account for the latter part of Art. 4.3, the reference to the CBDR principle and national circumstances.

This kind of benchmark leads us to the second important contribution the GST could make in order to enhance the ambition of NDCs. Milkoreit and Haapala have proposed to "use the GST as a peer-learning platform for 'how to do transformational change'" (Milkoreit & Haapala, 2017, p. 2). This could be achieved if the GST was to identify synergies and transformative potentials to facilitate sustainable development in broader terms than just focussing on mitigation potentials. Parties may be motivated much more by positive development potentials and synergetic opportunities than by "yet another call for urgency".

Milkoreit and Haapala further highlight that enhancing ambition could be achieved by creating a mechanism that relies on "pride and fame" over "fear and shame" to motivate Parties to implement their NDCs (Milkoreit & Haapala, 2017, p. 9). To this end, they suggest that Parties be invited to voluntarily subject themselves to international review, mirroring the modalities of the voluntary review of the UN High-Level Political Forum (HLPF) for Sustainable Development that assesses progress towards the Sustainable Development Goals.

2.2.4 Guidance and Signal

Finally, the GST can also play a facilitating role in an idealist theory of change. The international relations literature increasingly recognizes that many international institutions including the Paris Agreement assume a guidance and signal function that extends beyond the international level (Bodansky, 2017; Falkner, 2016; Hermwille et al., 2017; Morseletto et al., 2016). The adoption of strong collective goals and pathways to achieve those goals signals the commitment of governments. In the words of Oberthür et al. it "signals the resolve of governments (or other members of international institutions) to pursue a certain course of action and hence indicates likely policy trajectories to business, investors and other actors operating at all levels of governance. As such, the signal and direction provided has the potential to help synchronise and align developments across levels of governance and across the boundaries of different countries" (Oberthür et al., 2017, p. 16).

The guidance and signal function of the Paris Agreement mainly derives from the purpose of the Paris Agreement (Art. 2) and in particularly the long-term temperature goal (Art. 2.1a) which is further operationalized in the goal to achieve climate neutrality in the second half of the century (Art. 4.1). This provides a collectively agreed vision for the global transformation at the aggregate level. Not only is the temperature limit enshrined for the first time in international law, but it is also strengthened compared to the previous formulation. Furthermore, the agreement contains the aim "to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels". Recent climate science has more and more underlined that the 2 °C limit cannot be taken to be a secure 'guardrail' but would in all likelihood mean severe damages from climate change. Reflecting this new understanding, the Paris Agreement changed the notion of the 2°C "goal" expressed already in Copenhagen and adopted in Cancún one year later a hard 2°C "limit"; the new "goal" is 1.5°C (Hermwille, 2016).

Obergassel et al. (2015, 2016) argue that the signal provided by the Paris Agreement can offer strong legitimation for the growing civil society movements for example against coal power plants, mines, pipelines and other carbon-intensive infrastructure. "Comparable to the Final Act of Helsinki that provided dissidents in the former Soviet Bloc with a crucial reference for their work, opponents of fossil infrastructures can now point to the goals of the Paris Agreement to justify their activities" (Wolfgang Obergassel et al., 2016, p. 7).

Yet, for some sectors the signal provided is much clearer than for others. For many sectors a great deal of ambiguity remains of what the 1.5°C goal actually means. This is also reflected in the short-term benchmarks identified by Kuramochi et al. (2018) who have identified clear thresholds for example for the power sector and the electrification of passenger transport but remain relatively vague for example on emission intensive industries, agriculture and land-use including forestry.

However, the 1.5/2°C target may also be a double-edged sword. While the target provides a strong mandate for climate change mitigation, the implications for adaptation may be challenging, because all optimism notwithstanding, the collective climate action seen to date is far from sufficient to deliver the set goal. The promise of the 1.5/2°C target may send an insufficient signal for adaptation (Sharma, 2017). Specifically, Article 7.1 of the Paris Agreement states that Parties agree to "strengthening resilience and reducing vulnerability to climate change, with a view to [...] ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2" (UNFCCC, 2016b, Art. 7.1).[11]

In the light of this discussion, what is the role of the GST? First of all, the GST is an opportunity to reiterate and reinforce the signal already provided in Paris. The GST is an occasion to provide testament whether or not Parties are still committed to the purposes of the Paris Agreement.

More importantly, though, the GST could further develop and refine the existing signal. First, it needs to assess whether the long-term vision is still adequate and/or feasible in the light of available science. This is particularly important in relation to the adaptation dilemma outlined above.

For mitigation, it would be particularly helpful, if it collated and institutionalized sectoral visions that spell out more clearly sector-specific transformation challenges. It could assess and/or endorse sectoral visions e.g. developed by sectoral transnational governance initiatives and assess barriers and facilitators (e.g. financial and technological support) towards the realization of these visions. In doing so, the GST could make a contribution to what Milkoreit and Haapala refer to as "collective meaning-making" (Milkoreit & Haapala, 2017, p. 7f).

Refining the signal provided from the Paris Agreement would not only help guide the next round of NDCs but could also serve as an updated reference point for all kinds of governance initiatives (incl. non-state and subnational actors). It would provide legitimation and orientation for transnational governance initiatives and thus help "orchestrate" the groundswell of climate action.

In that sense, the GST could even be understood to provide an implicit mandate to the UNFCCC Secretariat that has begun to play a more active role as an orchestrator recently through inter alia the Non-State Actor Zone for Climate Action (NAZCA), a platform on which all sorts of non-state and subnational actors can register their climate change mitigation and adaptation commitments, and through the "Marrakech Partnership for Global Climate Action" (Chan et al., 2018; Kuyper et al., 2018).

2.3 An effective Global Stocktake Process: Ideal vs. accomplishable

2.3.1 Operationalizing the Functions: What is Needed to Exercise Functions

The design of the GST will crucially impact the extent to which the GST as a new process under the UNFCCC negotiations will be able to fulfil the functions outlined above. In the following, the functions described in chapter 2.2 are "translated" into assessment criteria. These criteria shall help to assess to what extent the functions can be considered to be fulfilled when looking at different options regarding the process and design for implementing the GST.

[11] Only in Art. 7.4 do Parties recognize "that the current need for adaptation is significant and that greater levels of mitigation can reduce the need for additional adaptation efforts, and that greater adaptation needs can involve greater adaptation costs".

Table 2-1 lists the four functions of the GST (first column) and ascribes assessment criteria to each of these functions (second column). It then defines procedural (third column) as well as informational conditions (fourth column) as benchmarks for an effective GST case for each of the criteria.

The process-related conditions are described in chapter 2.3.1.1. The information that would ideally be necessary as inputs for the GST as well as the outputs of the process are described in chapter 2.3.1.2. In a next step, we summarise these conditions to define how an “ideal”, i.e. effective GST would look like (chapter 2.3.2). In the conclusion (chapter 6) we evaluate, to what extent it is possible to fulfil the formulated conditions in the implementation of the GST against the background of our analysis of available indicators, benchmarks and information sources and options for assessing collective progress (chapters 3, 0 and 0).

Table 2-1 Assessment criteria and conditions for an effective GST

Function of the Global Stocktake	Assessment Criteria	Conditions for an effective Global Stocktake	
		Process	Information
Pacemaker function	Availability of inputs to GST	► Timing of transparency reports	► Meaningful information needs to be included in transparency reports
	Outputs useful to serve national discourses/planning purposes	► Timing of GST: needs to happen with sufficient time ahead of setting the next NDCs	Outputs need to ► Align with national discourses ► Contain concrete recommendations ► Be public ► Be differentiated/detailed
	Authority/legitimacy of outputs	► Need high-level endorsement as well as public attention during the political phase of the GST	► Outputs should contain a concise summary by/for/of policymakers
Ensuring accountability	Availability of accurate and sufficiently granular data to track progress towards NDCs	► Public appraisal of (national) inputs e.g. in form of synthesis report of national technical reports under Art. 13 by Secretariat	► TACCC principles: transparency, accuracy, completeness, consistency, comparability of data and information submitted by countries
	Public attention on progress towards meeting NDCs	► Public consultation round on inputs to GST	Summary of national inputs, e.g. in form of synthesis report including: ► summary of reaching progress for each country in context of available means of implementation ► recommendations for closing potential gaps towards reaching NDCs
Enhancing ambition	Definition of benchmarks for ambition	► Benchmarks need to be commonly accepted	► Benchmarks set by "best available science"/IPCC (e.g. defining emission budgets for individual countries according to equity considerations) ► Transparency of NDCs ► Benchmarks enabling comparability of ambition between subsequent NDCs
	Promotion of peer-learning among Parties and highlighting positive developments and synergetic opportunities	► "Workstream" that enables information sharing at sectoral level ► Decision on thematic focus areas for sharing lessons learnt ► Voluntary in-depth review for countries that have made good progress	► Best available science on decarbonisation pathways, transformation strategies… ► Information on best practice regarding implementation ► Solution-oriented outcomes instead of focus on insufficiency of action
Guidance and signal	Reinforcement of the collective goals agreed in Paris	► Political endorsement of IPCC reports, restatement of commitment ("creed") to collective targets	► Best available science defining and adapting collective goals and pathways to reach them
	Further development and refinement of existing signal	► Processing and endorsement of sectoral transformation pathways ► Relating to other international Agendas (SDGs, New Urban Agenda) ► Providing a forum for exchange including stakeholders such as transnational governance initiatives (e.g. GCA)	► More clearly spell out sector-specific transformation challenges (input through best available science, TEPs…)

Source: Compilation by the authors

2.3.1.1 Process-related Considerations

In order to fulfil its governance functions, the GST needs to be understood as a process rather than an event or a specific outcome (also see Milkoreit & Haapala, 2018). This is also reflected in the Paris "rulebook", specifying three phases for the GST: information collection and preparation, technical assessment and a political phase of the "consideration of outputs" (UNFCCC, 2018b). The GST will commence 1.5 – 2 years (depending on the timing of the publication of the 6th Assessment Report of the IPCC) before the final consideration of outputs that will take place during COP29 in 2023. In this section we discuss key process-related conditions for the latter two phases, namely, the technical assessment and the consideration of outputs (see column 3 Table 2-1) for both the technical as well as the political phase of the GST. In the concluding section 6, we pick-up on these considerations and develop recommendations on how some of the identified limitations with regard to information availability can be remedied at least partially with an apt process design.

Technical Assessment

The first step of the GST as a process is to gather and process relevant data and information, particularly information provided from the transparency framework. Ideally, this would happen in the form of a **public appraisal of inputs, particularly the transparency reports and communications from Parties, and including the possibility for public consultations/feedback on those inputs.** This process could further be facilitated by a technical synthesis report by the Secretariat that systematically collates the results of the technical expert reviews by country, focussing on the progress in implementing and achieving the NDC. It may also include the identified deficits and proposed "areas of improvement" as well as insights from the facilitative, multilateral consideration of progress which is supposed to conclude the review process (UNFCCC, 2016b, Art. 13.11-12). The modalities of the GST as adopted in Katowice provide such a mandate. In fact, they request the Secretariat to prepare four synthesis reports on the state of emissions, the progress of NDC implementation, the state of adaptation efforts, and the state of financial flows.

Complementary to this suggested public appraisal of inputs, a more facilitative and issue specific workstream would be required **to enable information sharing and 'transformational learning'** (Milkoreit & Haapala, 2017). The GST modalities structure its work according to three "thematic areas" – mitigation, adaptation, and means of implementation and support. Notably and after substantial controversy, Parties agreed to open the process to also consider loss and damage associated with the adverse effects of climate change. On each of these themes, technical dialogues will be held by means of "in-session round tables, workshops or other activities" (UNFCCC, 2018b, para. 6).

To ensure engagement and support of all Parties, **the technical dialogues will need to consider equity issues, both in their design and in the content considered**. In terms of process, the dialogues should be scheduled in a manner that is inclusive, accessible, and manageable to all Parties, and broad in the scope of issues considered. At the same time, the technical assessment should also more directly address equity and the extent to which Parties, or groups of Parties, are falling short on their equitable contributions (Robiou du Pont, Jeffery, Gütschow, Rogelj, et al., 2016; Pan et al., 2017; Holz et al., 2018; Climate Action Tracker, 2019).

The GST should also **take into account, and relate itself to, other relevant international agendas endorsing sectoral transformation pathways**, particularly the Agenda 2030 for Sustainable Development with its Sustainable Development Goals (SDGs) as well as UN Habitat's New Urban Agenda. The goals of any single Agenda can only be achieved in accordance with the other Agendas (Wolfgang Obergassel et al., 2017; von Stechow et al., 2016). Looking at context beyond climate change mitigation will not only help to create more consistent narratives, it also increases the likelihood that the results of the GST are taken up on national political agendas. The modalities of the GST provide at least one inroad to do so: "Relevant reports from United Nations agencies and other international organizations,

that should be supportive of the UNFCCC process" are explicitly listed as one of the information sources to be considered (UNFCCC, 2018b, para. 37f)

Finally, a key procedural requirement for the technical phase of the GST is **adequate timing**. The inputs from the Enhanced Transparency Framework, such as the data and information from the technical reviews, need to be prepared and published at an appropriate time. Likewise, the results of the technical phase need to duly feed into the political phase of the GST and the political phase must be concluded in a timely manner to have an effect on national political agendas regarding the development of subsequent NDCs.

Political phase: Consideration of Outputs

Apart from adequate timing, two other procedural aspects are particularly important for the GST to succeed. The first aspect relates to the pacemaker function. Metaphorically speaking, the impulses from the GST process as a pacemaker must be strong enough to effectively stimulate national and subnational governance levels. The political weight of the suggested "public appraisal of inputs" could be maximised if the corresponding reports and stakeholder comments were formally 'acknowledged' or 'taken note of' through a high-level endorsement as part of the political phase. This could generate the level of public attention required to impact on national political agendas. The modalities foresee high-level events for the conclusion of the GST, which would identify good practices and opportunities for enhancing action. The modalities also state that the events could provide a summary of key political messages and recommendations. However, they leave open the question of whether these events would result in a formal COP decision or a political declaration with a lesser legal footing (UNFCCC, 2018b, para. 34).

Finally, the political phase of the GST needs to include **a renewed political commitment**. Parties need to reaffirm that they still honour the PA and its goals and demonstrate their continued resolve to act upon them. Doing so will not only raise the stakes in terms of the reputational repercussions of non-compliance at the international level (Simmons, 1998). It will also enable stakeholders to hold their respective governments accountable at the national level, in the event that they do not fully implement or achieve their NDC. Periodically expressing collective allegiance to the Paris Agreement may help to maintain support for it and make it more costly for policymakers to (silently[12]) abandon climate ambition.

2.3.1.2 Information-related Conditions for an effective Global Stocktake

Besides process-related considerations, the GST needs to fulfil a number of requirements related to the information that is used as a basis for the stocktake. Essentially, information inputs used in the GST need to fulfil three criteria: they need to

1. set benchmarks for collective mitigation action informed by sound and reliable scientific information ("best available science", see Box 1 below);
2. provide transparent information on the state of emissions/removals and the level of transformation towards a low-carbon economy achieved at country as well as global level;
3. be politically relevant and be specific enough to trigger national enhancement of ambition.

The following sections describe what this means in detail for specific information sources that could be considered as inputs to the GST.

Information that is Setting Benchmarks

[12] Since achieving NDC targets is not legally binding, Parties do not need to formally withdraw if they no longer wish to implement those targets. Instead, they may simply disregard the Paris Agreement, at least until the next NDC cycle.

Firstly, information inputs to the GST need to set **benchmarks for the globally necessary mitigation progress** in order to reach the target of the Paris Agreement to keep global warming to well below 2°C or to 1.5°C. These benchmarks are essential in order to break down the necessary level of ambition to the country level. Thus, they set collective goals on the one hand, but also describe pathways to reach them and provide guidance and signal to individual countries, as well as subnational and non-state actors as a necessary precondition in order to enhance ambition. These benchmarks should also enable **comparability of ambition between subsequent NDCs of individual countries**. The IPCC plays a crucial role in this regard as it is the globally most prominent and legitimate institution to generate such knowledge.

Box 2-1 What is “best available science” and how can it inform the Global Stocktake?

The Paris Agreement identifies the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge. Several paragraphs of the Agreement refer to *best available science* including Article 14 on the GST which stipulates that the process shall be carried out “in the light of equity and best available science”. What does this mean and what implications does it have for the information sources that are considered as inputs to the GST?

Firstly, systematic observation of the climate system is an important prerequisite for advancing scientific knowledge on climate change and advising informed policy-making. Implementation of systematic observation is supported through the World Meteorological Organisation (WMO), Global Climate Observing System (GCOS), the Joint Working Group on Climate (WG Climate) of the Committee on Earth Observation Satellites (CEOS) and Coordination Group for Meteorological Satellites (CGMS). Additionally, Parties provide information on the status of their national systematic observation in their National Communications (UNFCCC, 2018e).

Secondly, the Convention calls on Parties to promote and cooperate in climate change research to scientifically support the negotiations. Such research focuses on earth sciences, climate processes and variability, climate modelling and prediction, climate change impacts, vulnerabilities, risks and extreme events as well as on mitigation and adaptation concepts, policies and impacts. The SBSTA research dialogue, mandated by the COP, is a key modality for sharing up-to-date scientific information and Parties’ needs to support the science/policy interface under the Convention (UNFCCC, 2018d).

Thirdly, the IPCC plays a prominent role as a scientific body in the negotiations. It assesses the scientific, technical and socioeconomic information relevant for understanding the risk of human-induced climate change. It produces assessment reports which are “widely recognised as the most credible sources of scientific information on climate change” (UNFCCC, 2018a) as well as special reports and technical papers on specific issues, often upon the request of the COP or the SBSTA, which then find entrance into COP decisions. Also, the IPCC has developed guidelines for GHG reporting which are used by all Parties to prepare national reports such as GHG inventories (UNFCCC, 2018d). The COP has repeatedly expressed its appreciation for the IPCC’s work and has called on the Convention bodies, particularly SBSTA, to continue its cooperation with the IPCC and to seek its advice. The IPCC’s work covers physical scientific aspects of the climate system and climate change, the vulnerability of socio-economic and natural systems to climate change as well as options for mitigating climate change. **Therefore, it not only provides benchmarks with regard to the level of GHG emissions that needs to be achieved but also regarding e.g. sectoral decarbonisation pathways and transformation strategies**.

Fourthly, experiences made during the Structured Expert Dialogue (SED) on the 2013-2015 review[13] can provide relevant insights for the understanding of “best available scientific knowledge” in the negotiations. The conclusions of this process state that it has generated such knowledge (UNFCCC, 2015b). The SED was mandated to take into account the best available scientific knowledge (Decision 2/CP.17). This translated into substantial inputs from the IPCC, particularly the Fifth Assessment Report, but also included contribu-

[13] See https://unfccc.int/sites/default/files/resource/docs/2015/sb/eng/inf01.pdf.

tions from other UN organisations, such as UNEP, FAO, and the World Bank, and some independent, regional organisations. The SED experience suggests that 'best available scientific knowledge' can be applied to institutions in addition to the IPCC but may be restricted to larger UN and regional bodies.

Overall, no clear definition exists for what can be understood as best available science and the interpretation of the term in the negotiations will be evolving. The IPCC seems to be acknowledged as a scientific and politically "neutral" source of information through its long-standing cooperation with the COP processes. For other institutions, it will also depend on political sensitivities to what extent the knowledge generated by them will be considered as a legitimate input into the negotiations and thus be accepted as "best available science".

Thus, information that is setting benchmarks is a precondition for the GST as such information is essential in order to operationalize the goals that are laid down in the Paris Agreement at the country level. Without such information, it would be impossible to measure the ambition of countries' NDCs against the scientifically necessary level of mitigation action to achieve the 1.5°C target. Benchmarks are thus an instrument for enhancing the ambition of future NDCs and for providing orientation and guidance to countries regarding pathways to reach collective goals and implement transformation strategies. To fulfil that purpose, also sector-specific information needs to be included in such pathways that provide benchmarks.

Transparent, high-quality information on the state of emissions and the level of transformation achieved at country/global level

Information on GHG emissions

Secondly, information sources that are used as input to the GST need to be able to **transparently quantify the emission reductions implied in countries' NDCs** as well as clearly indicate the current progress made by countries in reducing their emissions and current progress towards their mitigation targets. For measuring current progress, the information reported in countries' GHG inventories are particularly important. In order to fulfil this condition, the TACCC principles defined in the IPCC inventory guidelines which are also laid down in the reporting guidelines for Annex I countries' inventories provide useful guidance for the quality of the data needed (IPCC, 2006). Accordingly, the information on GHG emissions reported needs to be

- **Transparent**: documentation is sufficient and clear so that other people than the information compilers can understand how data was compiled and assure themselves that the good practice requirements for national GHG inventories are met.
- **Complete**: GHG data needs to be provided for all relevant categories of sources and sinks and gases for multiple, preferably continuous years (missing elements should be clearly documented and their absence needs to be justified).
- **Consistent**: the same methodologies and data sources should be used for estimating GHG emissions over different years.
- **Comparable**: GHG emissions included in countries' inventories are presented in a way that allows comparison with GHG emissions for other countries (by using the classifications and definitions of categories of emissions and removals according to the inventory guidelines).
- **Accurate**: GHG inventories contain neither over- nor under-estimates of emissions as far as this can be judged.

Thus, GHG inventories that fulfil these principles need to be reported by all countries as information sources for an effective GST. The Paris Agreement explicitly refers to the TACCC principles by requiring Parties to "promote environmental integrity, **transparency, accuracy, completeness, comparability and consistency**, and ensure the avoidance of double counting, in accordance with guidance

adopted by the Conference of the Parties serving as the meeting of the Parties to this Agreement" (Article 4.13) in accounting for emissions and removals corresponding to their NDCs. To make this possible, Parties shall provide the information necessary for clarity, transparency and understanding of their NDCs in communicating these NDCs (Article 4.8).

Information requirements for different types of NDCs

The information necessary for increasing the transparency of NDCs includes:

- information on the target value to be achieved,
- definition of the target year(s) or target period of the NDC,
- the reference year/period or baseline,
- definition of gases and sectors, categories, pools covered, where they differ from inventory coverage and definitions,
- metrics and other emission methodologies used for the calculation of the NDC (e.g. Global Warming Potential),
- information on whether cooperative approaches under Article 6 of the Paris Agreement are used to achieve the target,[14]
- information on the contribution of the land sector and methods for accounting of the land use sector, if included in the NDC,
- information related to methodological consistency between the baseline and the implementation in each reporting year,
- information on how accounting approaches, assumptions and definitions used to track progress toward the achievement of the NDC under Article 4 are consistent with those used in communicating the NDC,
- an explanation of how double counting has been avoided in tracking progress towards the implementation and achievement of the Party's NDC under Article 4,
- information on any changes from the previous NDC to coverage, and approach(es), assumptions and definitions used,
- Information on how conditionality of possible multiple targets is defined (cf. also Herold et al., 2018).

The diverse nature of bottom-up defined NDCs creates the need for additional, different information requirements for different types of NDCs, e.g. for NDCs that define targets compared to a BAU scenario, methods underlying the establishment of this BAU scenario, the assumptions used for key input parameters such as future levels of GDP and population and whether the BAU baseline is fixed or understood as dynamic should be made transparent (Briner & Moarif, 2016a); or for NDCs that are based on the implementation of specific policies and measures, these measures and their mitigation impact should be described in detail. NDCs that include emission intensity targets require information on data sources and projections of the reference that emissions are measured against as well as methodological assumptions (e.g. GDP or population). For quantified sectoral targets in non-GHG units such as renewable energy targets, energy efficiency targets or forest-related targets, no methodological guidance exists under the UNFCCC, and the country would have to define methodologies for tracking progress as well as ideally provide mitigation impacts in GHG terms as well.[15] Table 2-2 provides an overview of the information requirements for different types of NDCs.

[14] However, it is not clear yet how such transfers could be accounted for at the global level (see for example Kreibich & Hermwille, 2016; Kreibich & Obergassel, 2016; Schneider et al., 2016).

[15] Considerations on the transparency requirements for NDCs have been elaborated in existing studies, see (Briner & Moarif, 2016b; Herold et al., 2018; Schneider et al., 2017).

Table 2-2 Overview of information requirements for different types of NDCs

NDC type	Information required
Absolute emission reduction targets relative to base year/ period	GHG emissions/removals from GHG inventories Base year emissions Indication which inventory was used to determine base year emissions. Information related to methodological consistency between base year inventory and inventory in implementation period (para 31(b) of decision 1/CP.21)
Relative targets for reducing emissions below BAU level	GHG emissions/removals from GHG inventories Quantified BAU level Information related to methodological consistency between BAU scenario and GHG inventory (para 31(b) of decision 1/CP.21)
Emission intensity targets with reductions in GHG emissions per unit of GDP or per capita	GHG emissions/ removals from GHG inventories Information on emission intensity indicator chosen GDP source and unit used (e.g. PPP or currency exchange rates; current prices or constant prices referring to a historic year) Information related to methodological consistency between base year inventory and inventory in implementation period (para 31(b) of decision 1/CP.21)
Targets which specified a time frame for peaking emissions	GHG emissions/ removals from GHG inventories Can only be assessed retrospectively after the peaking year/ period (but GHG inventories can be used to assess changes in growth rates that indicate progress towards peaking of emissions) Continues to be an element of tracking progress after the peaking year/ period
Achieve carbon / emission neutrality	GHG emissions/ removals from GHG inventories Additional information dependent on how carbon neutrality is defined
Quantified mitigation actions	Information related to any quantified indicators chosen by the Party as part of the NDC (e.g. share of renewables in electricity generation, forest area, reforestation area) GHG inventories relevant to track aggregate effects of actions
Non-quantified mitigation actions	Information on progress with implementation of actions GHG inventories relevant to track aggregate effects of actions

Source: Compilation by Öko-Institut

To assess the state of emissions at global level, national inputs will need to be summarized in the GST process and result in e.g. a **public synthesis report for policy makers including a summary of current progress for each country in the context of available means of implementation of countries' NDCs**. If the information outlined above were comprehensively provided in a standardised format by all Parties, aggregation of national emission reductions currently achieved would be relatively straightforward. If such information is available only for a few countries and includes gaps and different formats, additional gap-filling and aggregation methods for adding up achievements on the national level would be necessary. The experiences made with previous aggregation of national mitigation efforts will provide important insights in this regard (e.g. challenges in summarising NDCs in the UNFCCC synthesis reports).

Furthermore, information related to the progress made in transforming an economy into a low-carbon economy should be shared among countries in an effective GST.[16] Such information includes

- What are the priorities/visions of the country with respect to progressing towards a low-carbon economy?
- What are perceived key challenges/barriers for progress?
- Which approach should be used to track progress per challenge/priority (see methodologies included in Initiative for Climate Action Transparency (ICAT), 2017)?
- What are (successful) strategies to address the identified barriers and/or to accelerate progress?
- What are the political framework conditions of a country (MRV capacities, financial resources, etc.) in order to better be able to gauge the ambition of the NDC of a country?

In summary, information on the state of current emissions and the level of progress achieved are crucial in order to fulfil several functions of the GST. Such information is necessary to assess progress made on the country level and thus to compare overall progress to the necessary mitigation benchmarks in order to achieve the targets of the Paris Agreement. Furthermore, such information is necessary to ensure accountability of countries, build trust among Parties and shed light on areas where ambition needs to be enhanced. Experiences made with the current reporting framework under the UNFCCC has shown that this information is only available to a limited extent from countries' national reports. It will crucially depend on the implementation of the Enhanced Transparency Framework which has been adopted in Katowice in 2018 to what extent more comprehensive information will be available after the application of the new reporting guidelines becomes mandatory in 2024. Countries' use of the flexibilities implied in the guidelines as well as the implementation of capacity building to enhance reporting will be of crucial importance in that regard.

Information that is relevant for national policy-making and able to trigger national enhancement of ambition

Lastly, an effective GST requires information that is able to inform national policy-making and to trigger national enhancement of ambition, which is one of the ultimate goals of the process. Again, this is challenging in the light of the mandate of the GST to assess collective progress only. Such information requirements are fulfilled under the following conditions:

- **Information is provided that aligns with national discourses,** lessons learned can be transferred from one country to the other,
- Information used stems from a source with credibility/legitimacy,
- **Sector-specific information regarding challenges and mitigation opportunities** is provided on a country-level as well as in global/aggregate reports that summarize experiences made and formulate concrete recommendations,
- Information is provided on **visible mitigation effects** which are quantitatively relevant (relative to size of country),
- **Best practice examples can be identified** (e.g. during the technical phase, in a similar way as best practice examples for pre-2020 action have been identified during the "Technical Examination Process" (TEP) or by the Technical and Economic Assessment Panel (TEAP) under the Montreal Protocol on Substances that Deplete the Ozone Layer),
- Co-benefits of mitigation actions for adaptation or vice versa are identified.

16 Measuring transformation is inherently difficult, particularly because it would need to be defined first what "transformation" is and when it would be supposed to be complete (Boodoo et al., 2018; cf. e.g. Mersmann & Wehnert, 2014). Going into the details of this question goes beyond the scope of this project; therefore we define more generic information requirements related to progressing towards a low-carbon economy rather than measuring transformation.

- All of the above information is **reflective of the specific national context and circumstances** for which recommendations are being developed.

Finally, in order to be able to trigger national action, the outcomes of the GST process should contain a concise summary for policy-makers with **specific policy recommendations for closing gaps towards reaching countries' NDCs**.

Information that is relevant for national policy-making and that is able to trigger national enhancement of ambition is thus necessary in order to provide guidance and orientation to countries. Also, it fulfils a **motivating function since it shows solution-oriented outcomes and opportunities and best practices** instead of focusing on gaps of mitigation action.

2.3.2 Summary of conditions for an effective Global Stocktake

What makes an effective GST? An effective GST is one that facilitates transformational change. The key conditions identified for the GST to fully exploit its potential as a motor of transformation can serve as a benchmark against which one can assess the emerging modalities and procedures and which can help to identify gaps and blind spots.

Based on our analysis, an effective GST is thus a process, not an isolated event, and this process needs to meet certain conditions:

- it needs to be scheduled in a timely manner, so that the informational input is ready when needed and the political output comes in time to be most effective;
- it needs to publicly appraise the input, particularly the national reports from the Transparency Framework in order to maximise a disciplining effect on Parties;
- complementarily, it requires a facilitative format in which good practice can be shared, highlighted and processed into relevant country-specific recommendations;
- and it needs to feature a choreographed high-level political event in order to amplify the messages towards influencing national policy agendas and as a renewed "creed" that Parties are still committed to the Agreement and its goals.

To serve this process, information and data is required. Essentially, information inputs used in the GST need to fulfil three criteria: they need to

- set benchmarks for collective mitigation action based on best available science;
- provide transparent information on the state of emissions and the level of transformation towards a low-carbon economy achieved at country as well as global level;
- be politically relevant and specific enough to trigger national enhancement of ambition.

The following chapter describes possible indicators and benchmarks for assessing progress towards collective targets and assesses and explains opportunities and challenges related to those indicators that are available.

3 Taking Stock: Available indicators and benchmarks for assessing progress

3.1 Introduction

In the previous chapter, we have identified the general information and process related conditions for an effective GST. In this chapter we elaborate on these conditions by identifying the relevant infor-

mation in more concrete terms, identifying specific indicators and benchmarks that could be used in the GST.

We begin by exploring the information and indicators that would be used to fulfil the four functions in an effective GST and reflect on the availability of information and any procedural constraints in subsequent chapters. By taking this approach, we can identify the potential and limitations of the GST.

Information included in the GST could encompass a wide-range of concepts but here we focus on information that can be gathered for most countries and compared against a reference, or benchmark, to evaluate progress toward the Paris Agreement mitigation goals.

Appropriate indicators for measuring progress against the Paris Agreement mitigation goal include not only emissions but also their drivers and the structural and institutional practices in place to facilitate the transition to a low carbon world. Indicators may be quantitative or qualitative in nature.

In the following sections, we examine the characteristics of a good indicator (Section 3.2) and explain our approach for identifying and selecting a wide range of possible indicators that could be used (Section 3.3) to measure collective progress. We then select those that best fulfil the functions of an effective stocktake (Section 3.4) and identify possible benchmarks against which those indicators can be measured (Section 3.5). According to the scope of the project, we focus on mitigation-related indicators and benchmarks.

3.2 What makes for a good indicator?

A good indicator is relevant, reliable, accurate, and tractable. **Under the GST, a relevant, or meaningful, indicator is clearly relatable to national and international climate policy frameworks, on a recent and near-future timescale and at a level of granularity that informs action.** If the GST is to inform enhanced ambition policies, the issues and indicators being tracked should be easily translatable into policies and not be too abstract. Most current tracking under the UNFCCC is in terms of emissions, possibly by sector, but policies tend to be more specific, such as increasing shares of electric vehicles or improving the efficiency of appliances. If the GST could help to bridge this conceptual gap by assessing and producing policy-relevant information, it may also help in the real increase of ambition. To be relevant, indicators also need to be formulated in a manner that is comparable between countries, such as per capita emissions or emissions intensity of economies. The absolute value of a given indicator (e.g. emissions intensity of cement) is important, but so are recent trends (e.g. average % change over the last 5 years). Using both of these perspectives can link the questions of 'where are we?' and 'where are we going?'. Recent trends are also particularly useful where projection data is not available and the only way to assess future expectations is to assess current trajectories.

To be reliable and accurate, an indicator must be robust in its formulation and based on good quality data that is trusted by all participants. Furthermore, averaging of data over multiple years is important to remove spurious data and account for fluctuations and events, such as those due to economic crises or extreme weather events.

Finally, a tractable indicator is one for which sufficient information is available, be that for a sufficient amount of countries, enough years, and updated regularly with the most up to date developments so that a good understanding of the situation is possible. Ideally, such information should be available in the same format to avoid confusion.

We use these concepts of relevant, reliable, accurate, and tractable to further explore indicators for an effective GST. We also elaborate on limitations we face and explain how this affects the range of indicators considered.

3.2.1 Timeframes

The GST needs to take multiple timeframes into account. The first two questions addressed by the Talanoa Dialogue in 2018 (formerly "facilitative dialogue") will continue to be relevant in the GSTs: "Where are we (today)?" and "Where are we going?" We want to know the current state of emissions and their drivers, the direction in which changes are occurring, and where we expect them to be in the future. Those expectations could be based on current trends in economy and infrastructure, or on the commitments made by countries to change those trends. All of these timeframe and scenario perspectives are relevant to a GST that should inform on progress made to date and the (in)sufficiency of future plans to limit global warming.

To fulfil these purposes, all indicators would ideally be available based on data time series of continuous years extending both backward (until at least 1990) and forward (to the timeframe of current NDCs or long-term low emissions development strategies). Where time series are available, it becomes possible to monitor current progress and trajectories in addition to the current state itself. However, it can be expected that such continuous data are not available for all countries, particularly if information reported under the UNFCCC is the sole data source that can be applied. Data and information regarding projections are particularly challenging, and it may be that some indicators can only be used to measure progress to date, and or to evaluate future directions only within a restricted timeframe (e.g. under NDCs but not long-term strategies).

3.2.2 Granularity

The level of detail that the indicators should explore also needs to be taken into consideration, which we will refer to as granularity. This granularity could be in terms of sector, gas, region, fuel type, or technology. The more specific the indicator, the more specific information required to estimate the indicator. On one hand, a more specific indicator is often easier to relate directly to policies (e.g. building renovation rates). On the other hand, it is less likely to be able to find comparable information for all countries and years.

To fulfil the relevance requirement of a good indicator outlined above, some level of sectoral detail is necessary. One challenge for the GST is that different institutions and information sources define sectors in a different way (Box 3-1). Another requirement of the GST is that progress is assessed at the collective level but, to be relevant, some geographic resolution (either national or regional) could be more informative. Even if information is only assessed at the global level, that information will commonly need to be derived from national or regional sources and extensive coverage is therefore necessary.

To assess the level of granularity that is helpful and feasible, we will therefore select some more detailed indicators for one sector to test the level of sectoral granularity that makes sense. In other sectors we restrict the analysis to less granular indicators.

Box 3-1 Sectoral definitions

Assessing progress on a sectoral level is a vital step toward providing policy relevant insights. One challenge to doing so is that different organisations and frameworks use different sectoral definitions. Reasons for the different definitions include whether the framework is more focussed on where the emissions come from or what the underlying economic activity is. Industry, for example, has emissions associated with energy production and with the actual industrial processes. Some frameworks group these emissions together under an 'industry' category whereas others separate them, preferring to keep all energy emissions together.

The IPCC reporting guidelines (2006) identify five major categories – Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), Waste, and Other. Fur-

ther breakdown of these five sectors is advantageous; as the energy sector alone covers around 75 % of global emissions (excl. LULUCF). See https://www.pik-potsdam.de/primap-live/primap-crf/ for an interactive diagram of the IPCC 2006 guideline categories, and the PRIMAP-hist dataset for an overview of national emissions in this categorisation.

It is especially common to separate, and sometimes exclude, emissions from Land-Use, Land-Use Change and Forestry (LULUCF) from emissions from Agriculture in many greenhouse gas inventories, as was the case for the IPCC reporting guidelines established in 1996. Reasons for this separation include the fact that LULUCF emissions include sources as well as sinks, whereas agricultural emissions are positive only, and that LULUCF is dominated by carbon dioxide emissions whereas agricultural emissions are dominated by methane and nitrous oxide. However, economic drivers and mitigation policies commonly affect land-use and agriculture in tandem, so a fully independent treatment of the two also has limitations.

The IPCC reporting guidelines were designed for reporting emissions and a somewhat different categorisation may be more useful when understanding emissions drivers or identifying effective policies (Oberthür et al., 2017). The IPCC itself uses a different emissions categorisation when assessing mitigation options in its reports. WGIII of the AR5 assesses mitigation in the following sectors: Energy systems, transport, buildings, industry, AFOLU, and human settlements, infrastructure, and spatial planning (cross-sectoral).

With different purposes and perspectives, the two categorisation schemes can provide complementary information. The differences can, however, also present challenges for a process such as the GST. If countries report data in a different structure to that in which policies are made or to the information used for benchmarking progress, that data will require some pre-processing to make it comparable. Such conversions are possible but may not be acceptable in the bounds of the UNFCCC. The IPCC could support the GST process by taking these different definitions into account when presenting their analyses.

It can be expected that data reported under the Enhanced Transparency Framework by all UNFCCC Parties will be based on sector definitions as included in the 2006 IPCC reporting guidelines as it was agreed in Katowice that Parties should follow these guidelines when preparing their National Inventory Reports (included in biennial transparency reports or submitted individually in years between) (UNFCCC, 2019c). However, Parties are free to choose their own sector definitions for metrics, data sources etc. when reporting progress on their NDC. The Katowice outcome only requires them to explain what these definitions are, particularly when they diverge from the NIRs, which will assist in the conversion of data to comparable metrics where possible.

3.2.3 Intensity and activities

Emissions result from specific human activities and depend on the intensity, or degree of efficiency, of those activities (amount of energy used, or emissions generated, per unit of outcome of the activity). Indicators for the GST thus need to take both the intensity and activity underlying emissions into account.

Emissions can be considered (and are usually calculated) at an activity level (e.g. tonnes of cement produced) multiplied by the emission factor of that activity (e.g. emissions per tonne of cement). The emission factor depends, for example, on the fuel (mix) used by the activity. An overall decrease in emissions will result from an improvement in the emission factor and/or activity indicator, but only if improvements in one are not offset by deterioration in the other. If efficiency improves but the activity increases, any improvements in efficiency may be partially offset (Gillingham et al., 2016). For these

reasons the indicator overview contains both an efficiency or intensity metric and the relevant activity metric for each indicator.

3.2.4 Single metrics and composite indicators

One challenge for the GST will be to distil the wealth of information to a manageable amount. Part of this can be done through process, for example through organisation of work under different workstreams on specific topics. Another option to consider is the use of composite indicators that combine multiple strands of information into one indicator.

Two examples of composite indicators used by independent climate tracking initiatives are the equity ratings of the Climate Action Tracker (CAT)[17], and the Climate Change Performance Index (CCPI, 2019) that integrates information on national and international climate policy, energy use, and renewable energy. Each of these indicators integrates multiple strands of information to give an overall rating of a country's performance with a single number or description.

Combined indicators are fairly easy to communicate, and the information is much more digestible as a single rating rather than several ratings with individual indicators for each strand of information included. The combined indicators also lend themselves to easy, broad comparisons between countries. However, some of the signals in the underlying data strands are then somewhat lost, and relevance to specific policy areas is reduced. The CCPI for example uses relative rankings between countries, which makes it difficult to evaluate how good the "best" and "worst" countries are in absolute terms of limiting warming according to the Paris Agreement (Burck et al., 2012).

For the GST, a key consideration is that the information needs to be assessed at the collective level and making comparisons between individual countries is therefore not the priority. The indicator overview considered here therefore includes composite indicators, but we suggest that simple indicators are generally more useful in the context of the GST, particularly in terms of providing information that is actionable by policy makers.

3.2.5 Qualitative and Quantitative information

The GST needs to be informed by both quantitative and qualitative information. By quantitative information we mean measurable quantities, such as emissions levels, share of renewables in energy production, or the emissions intensity of cement production for example. Relevant qualitative information includes a description or evaluation of policies in a given sector, or a characterisation of barriers to mitigation that have been identified by a country.

Aggregating qualitative information and complying with the mandate of the GST presents significant challenges. Some of these qualitative indicators may also be presented in quantitative terms, such as the share of countries with policies in a sector, but they are ultimately derived from qualitative information. Other qualitative information cannot be so easily summarised as barriers to mitigation may be country specific and closely related to national circumstances for example. In this latter case, a collective assessment can identify patterns and common occurrences but may need to retain some basic qualitative information to explain those barriers, why they exist, and any attempts to overcome them.

3.3 Selection criteria for possible indicators

In selecting indicators to prioritise in our assessment, and to propose for an effective GST, the following approach was used.

- Step 1: An overview of available information sources was generated by the project team. For that purpose, research was undertaken to identify a diverse range of relevant qualitative and quantitative data sources (see section 4.3).

[17] www.climateactiontracker.org

- Step 2: An overview of as many indicators (see Annex IV) as possible was generated based on a literature review and the authors' own assessments. The broad overview is categorised according to general type of indicator and the sector to which it applies (e.g. drivers of emissions in the industry sector).
- Step 3: Basic information about each of the indicators was gathered, including why the indicator is useful, what data would be needed, and possible sources of data. This step builds on the screening of information sources (step 1) described in section 4.3 of this report.
- Step 4: A selection of indicators was made to identify those indicators that should be assessed in more detail (Table 3-1). That detail includes data availability, building on the information sources identified in section 2.3.2, and identification of appropriate types of benchmark for the indicator.

All information sources identified in step 1 were collated in an excel table (see Annex I for a list of categories that were used to sort the information sources). The indicators identified in step 2 were also collated in an excel table (see Annex III) and the information needed for steps 3 and 4 collated for each indicator in separate columns.

The criteria and information captured as columns in the annexed excel table are as follows:

- **Indicator group and subgroup:** What is the general type of information contained? The breakdown includes whether the indicator is emissions based or captures other aspects of mitigation policy, such as equity, finance and investment, non-UNFCCC policies, and the NDCs, or qualitative information.
- **Unit:** The unit in which the indicator is commonly measured, e.g. tonnes of CO_2 per person, percent, or megajoule per tonne of product.
- **Sector:** Many indicators (e.g. total emissions) could be applied at several sectoral levels. Although the indicator group also encapsulates sectors, we use this column to indicate where, and which, additional sectors should be considered. For example, within the industry sector it is relevant to consider subsectors such as iron and steel, or cement.
- **Primary purpose:** Here we describe why the indicator is useful and what aspect of the socio-economic system and drivers it provides information about. Examples include different drivers of emissions, rates of change, investment lock-in, emissions intensity of activities, activities as a driver, or co-benefits.
- **Secondary purpose:** In some cases, an indicator fulfils multiple needs and additional functions are listed here. In addition to those purposes listed under the primary purpose, indicators that address societal norms or behavioural patterns, are needed for assessing overall progress and temperature projections, or are clearly connected to the over-arching goals of the Paris Agreement are also identified.
- **Data needs:** A simple description of the data required to generate the indicator. For detailed indicators, that data is often the indicator itself, e.g. forest area. For higher level indicators, such as total emissions, the multiple data sources (e.g. national emissions, bunker emissions, land-use emissions) required are specified.
- **Data sources:** Possible sources of data for each indicator are provided, with multiple options where possible. Data sources that are for historic data only are separated from those that (also) provide projections.

For those indicators that are selected for a more detailed analysis (see section 3.4.1), we consider the following additional aspects:

- **Data availability** (see section 4.2)
  To what extent is data available for this indicator in terms of
  - Spatial coverage – how many countries are included?

- Temporal coverage – what's the time period covered by available datasets?
- Access – are the identified datasets available to the public or only behind a paywall?

► **UNFCCC acceptability**
Could the data be acceptable under the UNFCCC and therefore used in the GST? In some cases, this is not always clear because the list of acceptable sources (UNFCCC, 2019e) is not exhaustive or exclusive. We therefore consider each source individually and consider whether there is precedent for the source being used, the type of body generating the data, and the Katowice outcomes on the GST to state whether we consider the data likely, plausibly, possibly, or unlikely to be available to the GST process.

► **Benchmark sources**
Evaluating progress for each indicator requires a benchmark against which to evaluate progress. Here, possible sources of benchmark information are identified for each indicator according to the framework described below in section 3.5.

► **Additional comments**
Any additional, relevant considerations and an explanation of why an indicator was included in the more detailed analysis, or not.

3.4 Which indicators of progress should the Global Stocktake assess?

It is not feasible or helpful, either for this project or for the GST, to fully assess all possible indicators identified in step 2 of the above indicator overview. A selection must therefore be made for the more detailed analysis. We outline criteria for making such a selection and define a sub-set of indicators that are explored in more detail here and in subsequent chapters.[18]

In assessing the indicators, we take into account two specific aspects of the GST. First, the limitations from the UNFCCC process regarding the requirement to assess collective progress only and limitations on the data that is available to the UNFCCC (see section 4.2). Second, the nature of the UNFCCC process which is mandated to be more facilitative than the aforementioned analyses are required to be.

We also considered it useful to explore the advantages and limitations of using indicators that give very specific, detailed information. Rather than testing the level of detail on all sectors, we instead pick just one – industry. Industry was selected because it is a substantial contributor to global emissions but less explored than the energy sector. Industry emissions are additionally interesting because their scope encompasses both energy emissions and process emissions and the sectoral issues outlined above must be addressed.

The final indicator set should also consider at least three different time frames: the current status, an NDC scenario (2030), and the long-term low emission development strategies (~2050). It will not be possible to consider all indicators for all three timeframes with more detailed information being available for the current status, some NDC specific indicators only useable for the 2030 timeframe and currently limited information for the long-term strategies. However, where possible, the three separate timeframes are helpful to inform different types of policies and to ensure that the long-term perspective is considered.

[18] Selection of key indicators or benchmarks has already been performed by multiple organisations, such as the ten benchmarks for mitigation identified by Kuramochi et al. (2018), the 2020: Climate Turning Point milestones (Revill & Harris, 2017) assessed by Ge et al. (Ge et al., 2019), the UNEP Emissions Gap Report (UNEP, 2018), and the Brown to Green report (Climate Transparency, 2018), among others. Some of the indicators identified in these studies should also be considered by the GST and there is considerable overlap between the indicators evaluated here and in these reports. However, some of these reports focus on reduced country groups, e.g. the Brown to Green Report assesses only the G20 countries, whereas the GST will need to assess all countries and others rely on information that may not be available to the UNFCCC.

3.4.1 Indicators selected for detailed analysis

Indicators selected for a more detailed analysis were identified from the broad overview such that the remaining subset **is comprehensive** in terms of sectoral coverage and types of indicator and at the same time includes **both key Paris Agreement, top-level indicators and highly detailed** aspects of mitigation. We further prioritised indicators that are fundamental to a transition to a low carbon economy, such as the share of renewable energy in final energy consumption, and key qualitative indicators of process, such as the existence of a long-term low carbon development strategy. The final list selected is not exhaustive and our evaluation may find that some of the indicators assessed are not appropriate for the (official) GST or that some indicators are missing.

Those indicators selected are listed in Table 3-1 and grouped according to the broad categories of the Excel table described in section 3.3. Below we also further justify and explain the selection of some of these specific indicators.

Table 3-1 Indicators selected for more detailed analysis

Indicator group	Indicator subgroup	Indicator	Unit
Emissions	Explicit Paris Agreement Goals	total GHG emissions (production based)	GtCO2e
		total CO2 emissions (production based)	GtCO2
		anticipated warming based on current pledges (or policies)	°C
		balance of sources and sinks	GtCO2e
		peaking emissions	yes / no / maybe, year
Emissions	economy wide drivers: socioeconomic and energy demand	CO_2 / capita	tCO2 / person
		GDP PPP / capita	USD / person
		GHG / capita	tCO2e / person
		primary Energy / GDP	PJ / billion USD
		final Energy / GDP	PJ / billion USD
		CO2 or GHG / GDP	tCO2e / USD
		CO2 or GHG / final Energy	tCO2e / USD
		consumption based emissions	GtCO2e
Sectoral	Energy	final energy / GDP	toe / million USD
		final energy / capita	toe / capita
		GHG (or CO2) emissions / final energy	tCO2e / ktoe
		share of renewable energy in gross final energy consumption	%
		installed capacity of renewables	MW
		coal plants – planned, permitted, under construction, operational,	GW of installed capacity
Sectoral	Power	electricity demand / capita	kWh / capita
		emissions intensity of power sector	gCO2/kWh
Sectoral	Transport	emissions / revenue tonne km	tCO2e / km
		passenger transport emissions / capita	tCO2e / person
		International shipping emissions	tCO2e / year
		International aviation emissions	tCO2e / year
Sectoral	Industry	emissions intensity	tCO2e / tonne product
		emissions intensity of processes	tCO2e / tonne product (excl. energy use)

		emissions intensity of energy use	tCO2e / MJ
		non-CO2 process emissions	tCO2e
		Energy intensity	EJ (total) or MJ / tonne of product
		material intensity	varies by sector, e.g. share of recycled steel in production
		product produced / demand	tonnes (or similar)
		total energy emissions of industry	MtCO2e
		total industry emissions	MtCO2e
		share of energy emissions produced by industry	%
		industry GHG emissions / GVA	tCO2e / USD
		food waste during production	tonnes
		per capita industry emissions	tCO2e / person
Sectoral	Buildings	total direct emissions	MtCO2e
Sectoral	Agriculture	Food waste / capita	kg / person *or* % food produced / person
		agriculture (and forestry) emissions / GVA	MtCO2e / million USD
Sectoral	Waste	emissions from solid waste disposal	tCO2e / year
		wastewater handling emissions	tCO2e / year
		total waste emissions	tCO2e / year
Emissions	F-gases	F-gas basket emissions	ktCO2e / year
Equity		per capita emissions	tCO2e / person
		cumulative (per capita) emissions	tCO2e / person
Drivers and Policies	Finance and Investment	fossil-fuel subsidies	USD
		renewable subsidies	USD
Policy	Domestic policy	(number of) policies in place by sector and type of policy (see table 1)	n/a
		sectors for which estimation of mitigation impacts is available	n/a
		barriers identified	n/a
		measures to overcome barriers	n/a
		development of long-term strategy	number or % of countries
Policy	NDCs	quantifiability of NDC	yes / no
		coverage of NDC (gases, sectors)	can be calculated as %
		Type of NDC	% of each type
		(intention toward) participation in international market mechanisms	n/a

3.4.1.1 Economy wide emissions and Paris Agreement Goals

The GST is mandated to track progress toward the over-arching objectives of the Paris Agreement goals. It's therefore necessary that the specific goals outlined in Articles 2 and 4 of the Paris Agreement are directly addressed in the GST. We therefore include indicators that directly measure these goals in our selection (temperature goal, peaking emissions and balance between sources and sinks) but note that defining and evaluating progress toward these goals is non-trivial. In the following section (3.5.2)

we further examine the Paris Agreement goals in more detail, outline how progress may be measured and describe some of the methodological considerations that need to be accounted for.

Temperature goal

> *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, recognising that this would significantly reduce the risks and impacts of climate change.*
> *[Paris Agreement, Article 2.1 (a)]*

Assessing progress toward meeting the Paris Agreement's temperature goal is technically difficult because future warming depends on many factors. However, it is possible to track progress using a range of proxy indicators and projections in a manner that is meaningful.

A first indicator to take stock of the current status is to track observations of global average temperatures and the warming we have already observed relative to a pre-industrial baseline. Secondly, current and projected emissions under NDC and current policy scenarios can be used to assess current trajectories in emissions growth. Such emissions trajectories can further be used to estimate a third indicator, anticipated warming under these scenarios.

Estimating warming under different scenarios requires multiple tools, including methods to estimate the contribution of different gas species and simple climate models to estimate warming levels. The Climate Action Tracker[19] provides one example of how such warming estimates can be made.

Many technical and political challenges are associated with evaluating these indicators which we discuss further in chapter 0.

Peaking emissions

> *In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse emissions as soon as possible, recognising that peaking will take longer for developing country parties, and to undertake rapid reductions thereafter in accordance with the best available science, ...*
> *[Paris Agreement, Article 4.1]*

The 'peaking emissions' goal in Article 4.1 of the Paris Agreement is a clear and necessary step for meeting the temperature limit set out in Article 2 and an obvious aspect for the GST to address. But how? There are two challenges here; first, how can we know if emissions have peaked or not? Second, how do we measure progress towards peaking emissions?

In 2016, the Global Carbon Budget (Quéré et al., 2016) reported that global carbon emissions growth had been stalling for 3 years in a row and optimism grew that we may be reaching, or have reached, a peak in global CO2 emissions. Two years later, and the 2018 update of the budget (Quéré et al., 2018) reported an estimated increase of 2.7% (1.8 to 3.7%) in 2018; clearly a peak has not yet been reached. To be sure that emissions have peaked, it would be necessary to (1) observe a sustained decrease in emissions over several years, and (2) understand the underlying drivers behind changing emissions

[19] www.climateactiontracker.org

rates. If, for example, another global financial crisis occurred and stalled emissions growth it would be premature to announce that global emissions had peaked.

Quere et al. (2018) examine the peak-and-decline emissions pathways of 18 countries using 5 different drivers – energy use, fossil share, fossil utilisation rate, fossil CO2 intensity, and trade. They found that the dominant factor in emissions decrease is a decreasing fossil share in final energy, followed by a decrease in energy use. However, the decreasing energy use is associated with slower GDP growth and if GDP growth were to accelerate, energy use could also increase accordingly (Quéré et al., 2018). The GST should therefore also take indicators such as GDP and energy demand trends into consideration.

The GST should not only guide countries on whether emissions have peaked or not, but also on what level at which emissions should peak and by when, noting that emissions peaking at a higher level and later date will require steeper reductions thereafter to comply with the temperature limit.

Balance between sources and sinks

> *… so as to achieve a balance between anthropogenic 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.*
> *[Paris Agreement, Article 4.1]*

The final explicit mitigation goal of the Paris Agreement is achieving a balance between anthropogenic sources and removals by sinks. During the earlier GSTs it will be difficult to measure progress toward this goal, but it will become increasingly important and some indicators and benchmarks can still be used in the near term.

Achieving a balance between sources and sinks depends on both decreasing absolute emissions as much as possible, and increasing sinks sufficiently to compensate any residual emissions (Luderer et al., 2018). The debate is still open as to what the extent and nature of the sinks should be, particularly whether the focus should be on “natural solutions”, such as afforestation and reforestation, or more technological approaches, such as bioenergy with CCS or Direct Air Capture. Part of that debate rests on uncertainties in the mitigation potential of various Carbon Dioxide Removal (CDR) options and potential negative consequences, such as land-use requirements for bioenergy. In the near term, the GST could track progress toward this goal through indicators of investment, research, and development going into understanding, improving and scaling the different options. At the same time, the GST could highlight the trade-offs between delays in mitigation and the need to rely on CDR in the future if the global goals are to be met (Strefler et al., 2018).

At present, the means of reporting and accounting for removals by (natural) sinks is complex and differing definitions used by different research and analytical communities lead to some confusion. Research in the years leading up to the first GST should improve the comparability between scenarios that lead to a balance between sources and sinks, and the inventories reported by countries to the UNFCCC (Grassi et al., 2018).

3.4.1.2 Case study: Industry

Indicators for industry were selected based on the IPCC’s 5th Assessment Report, particularly WGIII Chapter 10 (IPCC, 2014). Under WGIII sector definitions (see box 4-1), industry emissions encompass both those from energy production and those directly from industrial processes themselves. Energy

emissions are further separated into direct (energy produced on site) and indirect (emissions from electricity generated elsewhere) emissions.

The drivers of emissions in industry are then considered in terms of energy efficiency, emissions efficiency of energy, emissions efficiency of processes (CO_2 and non-CO_2), materials efficiency and product demand. Each of these aspects is more or less important depending on the specific industry considered. Steel production has a high energy intensity whereas cement production produces a larger share of process-based emissions.

Monitoring progress in the industrial sector would benefit from examining each industry separately so that it is easier to identify policies that are more, or less, effective. The consequent challenge is that such an approach is more data and labour intensive. However, industry emissions are dominated by a few sectors (steel, iron, cement, aluminium, pulp and paper, textiles), and for the purposes of the GST it would be reasonable to consider including a few of these.

3.4.1.3 Equity

For the specific equity indicators, we use per capita emissions and cumulative per capita emissions (see e.g. Meinshausen et al., 2015; Robiou du Pont, Jeffery, Gütschow, Rogelj, et al., 2016). Although many proposals exist for different ways to measure equity, these two concepts are both the most commonly used and the easiest to calculate. Both metrics also lend themselves well to the collective assessment approaches described and demonstrated in section 5.5 of this report.

3.4.1.4 Tracking Progress on Policies, Measures and Transformation Challenges with Qualitative Indicators

First and foremost, the GST should provide an overview about the domestic policies and measures that countries use. It will not be possible to assess the stringency, ambition or effectiveness of any individual policy. However, providing an overview which countries have introduced comprehensive framework legislation, which sectors / areas of mitigation activity are covered and whether or not the expected mitigation impacts have been quantified could provide relevant information. Particularly as it would also help to identify gaps in terms of areas of the economy that are thus far not targeted through dedicated legislation or regulation with equivalent status. Beyond the mere existence of corresponding policies, it would be helpful to classify those policies by type of instrument. The recent IPCC report provides a useful classification (see box below).

Box 3-2 Classification of policy instruments and packages

Classification of policy instruments and packages

Economic instruments include market-based instruments like emissions trading but also include taxes (including charges and border adjustments), subsidies as well as policies aiming at the removal of unsustainable subsidies.

Regulatory instruments include rules and standards that must be adhered to by polluters or otherwise a penalty is applied. The category includes emission standards, technology standards that mandate specific pollution abatement technologies or production methods and standards that define the characteristics of products.

Information policies include policies that aim at remedying market failure based on incomplete or asymmetric information. Examples include product or labelling mandates and information disclosure requirements for polluters.

Government provision of public goods and services and procurement include provision of physical infrastructure including for example district heating or public transport. Funding for research activities and removal of institutional barriers also fall into this category. Public forest management activities also fall into this category.

Voluntary actions refer to voluntary commitments and self-regulation by private actors beyond existing legally binding obligations and requirements.

Source: synthesized from IPCC (2014).

A second type of qualitative information to be collated under an effective GST would relate to barriers and challenges regarding the transformation towards decarbonized economies and societies. The GST should collate and assess those barriers and challenges with a view to identifying common problems which may be addressed through enhanced international cooperation. Moreover, by combining the previous analysis of existing policies with the analysis of barriers and challenges may help reveal good practices which can be replicated and adapted to address the same challenges elsewhere.

In order to, provide a more meaningful structure, it would be helpful to categorize the identified barriers and challenges:

- In many sectoral systems, **economic barriers** such as higher marginal costs of climate-friendly technologies and practices are key. Where sectors are exposed to international trade, concerns over competitiveness can limit ambition. Access to large amounts of capital for large-scale investments would also fall into this category.
- **Political and institutional barriers** are particularly pronounced in sectoral systems that are dominated by large incumbent corporations, often fiercely protective of their established business models. Unclear division of labour among relevant national agencies and/or lack of enforcement of regulations may also be a barrier to decarbonization.
- **Technological barriers** may also be of concern. In some sectoral systems full decarbonisation will require substantial further technological research and development.
- **Awareness, information and capacity** are key barriers in many sectoral systems. This includes awareness of problems, information about mitigation options and effective policies, and technical skills of the work force.

Article 4.19 of the Paris Agreement invites Parties to prepare long-term low GHG development strategies. In spelling out their visions and pathways towards achieving those, Parties implicitly need to address the barriers and challenges. While an assessment of the quality, stringency and ambition of those long-term strategies is beyond the scope of the GST, providing an overview about those parties which have prepared such integrated strategies may prove useful and help incentivise countries which have yet to engage on the process of developing their long-term strategy.

Finally, an effective GST would keep track of the level of ambition as well as remaining untapped mitigation potentials. However, as we will discuss below, an assessment of the level of ambition beyond a mere summary of Parties' own explanation how their contribution is fair and ambitious, will most likely be beyond the mandate of the official GST.

3.5 Establishing Benchmarks for Evaluating Progress

3.5.1 Concepts to consider when defining benchmarks

An indicator is only meaningful if a context and benchmark is given – what level should the indicator be at if a specific goal is to be met? In this case, the benchmarks derive from the context of the goals of the Paris Agreement: what is needed to be consistent with limiting warming to 1.5°C, to peak emissions as soon as possible, and to achieve a balance of anthropogenic sources and sinks? For the indicators assessed in this report, we therefore need to define means to set benchmarks against which those indicators can be measured.

Defining concrete benchmarks for these goals can be difficult but translating the overarching goals into more concrete targets is a necessary step in outlining how those goals can be achieved. In defining the framework for setting benchmarks, an additional layer of assumptions is added with regard to the priorities that are set for the way in which a specific goal is to be achieved. For example, a benchmark may be defined based on the assumption that the globally most cost-effective approach to mitigation should be taken. On that assumption, integrated assessment models can be used to determine the most efficient way to distribute effort across regions and economic activities thereby providing benchmarks

for sectors and regions. Alternatively, a more bottom-up perspective can be taken, such as identifying the maximum technical potential for improvements in efficiency or best practices in agricultural activities. Different types of benchmarks may be more useful in different situations and for different indicators. Technical potential is a more meaningful benchmark for measuring progress in specific industries whereas economic potential may be more helpful in setting bounds on mitigation goals that are consistent across sectors and ensure overall achievement of the global mitigation goals. In our benchmark analysis we consider which of these perspectives is most feasible and appropriate for each indicator.

One of the challenges of setting benchmarks is that there are many different ways to achieve the overall temperature and emissions goals. It is possible to reach 1.5°C along different pathways and any assessment needs to take account of these different options. For example, it may not be necessary to rely on substantial nuclear power, or bioenergy with CCS to meet future energy demands, but excluding all those options may severely limit the manoeuvring space in other sectors. Another example concerns electrification; electrifying end-use infrastructure is only effective if the electricity supply becomes carbon neutral at the same time. Any benchmarks given for sectoral or technology targets will therefore have to be ranges but with a clear understanding that to meet the long-term goals, we cannot meet the lower ambition end of all of these but should instead be aiming for the middle or ambitious part of these ranges.

In addition to including ranges, a benchmark could also contain more complex information – do we simply want to know a binary result of whether the indicator has reached the benchmark or not, or is some indication of how far off from meeting that benchmark we are also useful?

Benchmarks can be set in both qualitative and quantitative terms, and both can be useful. Particularly for top-level indicators, a clear descriptive benchmark can be more relatable than a numeric target. Kuramochi et al. (2018) suggest two different benchmarks for coal-fired power generation; 'no new coal power plants' and reducing emissions from coal-fired power generation from existing plants by 30% by 2025. The former is a clear, actionable target. The latter is more abstract at the policy level and could be achieved either by closing some plants early or reducing their output but is necessary as the first target would be insufficient for 1.5°C on its own. We propose that a mixture of descriptive and quantitative benchmarks is needed to robustly and effectively translate indicator assessment into effective policy action.

The concept of delaying action highlights one technical issue that the GST will need to address in its formulation – the longer action is delayed the more ambitious future action must be in order to meet the overarching goals. Benchmarks may, therefore, need to be updated in subsequent stocktakes to account for any missed targets in previous years. Updates to benchmarks may also be needed to reflect technological and scientific advances.

Finally, even more so than in defining indicators, defining and setting benchmarks is an aspect of equity. Should all countries be held to the same benchmark, or should countries be given different targets based on capacities and historical responsibility? Does this apply to all indicators, or just a subset? Benchmarks could be set at a global level, or at a regional level that incorporates some measure of regional circumstances; including UNFCCC principles of earlier and stronger mitigation by developed countries but still guiding less developed countries toward lower emissions pathways (see section 3.5.4).

Taking the above considerations into account, we explore the types of benchmarks that would best suit the different indicators outlined in section 3.4 and that would help to fulfil the functions of an effective GST. We then further identify the sources of information that could be used to identify appropriate levels for those benchmarks and identify any information gaps. We start with the indicators and benchmarks that address the major, explicit, mitigation related goals of the Paris Agreement; the temperature goal, peaking emissions, and achieving a balance between sources and sinks (section 3.5.2). The benchmarks needed for more detailed, supporting indicators are then explored in section 3.5.3 in

terms of the types of benchmarks available and the possible source of information for these benchmarks.

3.5.2 Benchmarks for explicit Paris Agreement Goals

3.5.2.1 Limiting global average temperature increase

The 1.5°C Special Report (SR1.5, Cross-Chapter Box 11, de Coninck et al., 2018) cites the UNEP Gap Report (UNEP, 2017) and a study by Rogelj et al. (Rogelj et al., 2016) that found the current NDCs to be consistent with a 66% chance of warming remaining below 2.9-3.4°C. The report also compares cumulative emissions anticipated under NDCs with carbon budgets for 1.5°C and states the ranges of total 2030 emissions that could be compatible with different warming levels. The SR1.5 report is unequivocal that continued action in line with current NDCs is not compatible with pathways consistent with limiting warming to 1.5°C. The upcoming sixth assessment report should contain similar information in a clear manner that can easily be picked up by the GST. As the IPCC is already listed as a key input to the GST, the IPCC is an obvious channel for this information and also provides an expert team that can review and distil any contradictory or inconsistent analyses.

Table 3-2 Indicators and benchmarks for the Paris temperature goal

Indicator	Benchmark
Emissions trajectories under current NDCs	Emissions trajectories consistent with 1.5°C according to integrated assessment modelling scenarios and assessed by the IPCC.
Progress made toward implementation of NDCs	Emissions trajectories expected if NDCs are met.
Anticipated warming based on current pledges (as projected by various assessment and modelling groups)	At least a 50% chance of limiting warming to 1.5°C

3.5.2.2 Peaking emissions

The SR1.5 report (de Coninck et al., 2018) provides some information on benchmarking of peaking emissions; that to be consistent with 1.5°C global greenhouse gas emissions should peak before 2030 (Ch 2.3.3 SR1.5) and that "all available 1.5°C pathways that explore consistent mitigation action from 2020 onwards peak global Kyoto-GHG emissions in the next decade and already decline Kyoto-GHG emissions to below 2010 levels by 2030." (Ch 2.3.5, SR1.5). This latter statement is stronger than the first and not only implies that global emissions should have peaked by 2030 but need to peak much earlier than that so that the required drop in emissions can occur. The scenarios on which these statements are based were developed by models with only 10 yearly timesteps, so more detailed peak years and amounts are not possible without modifications to the approach.

We suggest that the GST tracks global emissions growth with the latest available data (currently the Global Carbon Project for CO_2 and various sources for non-CO_2, e.g. FAO) and provides technical analysis on the implications of that growth for future targets. Peaking emissions is a key first milestone in achieving the Paris Agreement goals and the GST could help to raise the profile of this milestone and garner ambition around it. The GST could also take note of the share of countries in which national emissions have peaked. Tracking the number of countries whose emissions have peaked provides a guide to progress, but without taking into consideration the absolute emissions of those countries, it is only a weak indicator of global progress. One addition could be to aggregate the emissions in the countries that have (not) peaked with statements such as "emissions in X countries have peaked, accounting for Y% of current global emissions".

Nevertheless, for global emissions to peak and decline, individual countries' emissions also need to peak. We explore methods to define peaking of national emissions in section 5.5.2.5 below. Setting a

benchmark for the number of countries to have peaked by a certain year is much more difficult and, in this case, we suggest that the GST simply pushes toward peaking emissions of all countries.

Table 3-3 Indicators and benchmarks for peaking emissions

Indicator	Benchmark
Global emissions	2023 Stocktake – Global emissions not increasing 2028 Stocktake – Global emissions peaked and declining
Number of countries with peaked emissions and their share of global emissions.	All countries peaked covering 100% of global emissions.

3.5.2.3 Balance between sources and sinks

The Paris Agreement itself sets a broad benchmark for achieving a balance between emissions sources and sinks: that it must occur in the second half of the century. The IPCC reports provide more precise benchmarks for achieving this balance, both in terms of timing and separately for CO2 and the Kyoto-GHG basket.

The extent of carbon dioxide removal (CDR) required in the latter part of the century will depend on the pace of emissions reductions in the coming decade and the magnitude of non-CO2 emissions that are not completely reduced. Setting quantitative benchmarks for the magnitude of carbon dioxide removal, separately from remaining emissions, is therefore currently challenging. However, various IPCC scenarios can give a guide to the order of magnitude.

In coming years, the need for development and upscaling of different approaches, either natural or technical, will be a priority and the GST could, in qualitative terms, assess the world's preparedness to remove CO_2 to the extent that it will be required.

Table 3-4 Indicators and benchmarks for reaching a balance between sources and sinks

Indicator	Benchmark
Net global anthropogenic greenhouse gas emissions / Balance between source and sinks	Reaches zero in second half of century.
Net anthropogenic CO2 emissions	Reaches zero around 2050.
Research and investment into negative emissions technologies	Consistently increasing investment in the development of negative emissions technology over the coming decade.

3.5.3 Benchmarks for additional indicators supporting the Paris Agreement Goals

We have already concluded that to fulfil all four functions, the GST will need to consider information and indicators in addition to the top-level Paris Agreement goals. In Table 3-1 we therefore identified some additional indicators that better describe changes in emissions and their drivers in a manner that is also more directly relevant to policy makers.

For each indicator, we want to know what would be required to be consistent with limiting warming to 1.5°C. As stated above, defining such benchmarks can be challenging because of trade-offs between efforts in different sectors and the different ways in which benchmarks can be defined. We distinguish three different types of benchmarks for quantitative indicators that can be set; macroeconomic, best practice, and technical potential

In defining necessary mitigation pathways for 1.5 and 2°C, the IPCC relies strongly on the output of integrated assessment models (IAMs). These models take a **macroeconomic perspective** to distrib-

ute efforts in a global least-cost manner. Different scenarios of international co-operation, population, and GDP growth can be specified along with constraints on policy and technology options available. Some information about the technological potential of different sectors and industries is also taken into account, with different IAMs taking different levels of detail into account (see, for example, the IAM documentation wiki[20]). In general, however, benchmarks derived from these IAMs can be considered as taking a top-down, macroeconomic perspective. They may not identify the maximum mitigation potential in all sectors. Additional sources of information, such as best practice examples and technical potential, are therefore needed as an additional reference and to define benchmarks for more detailed indicators.

A more bottom-up approach to defining benchmarks relies on the identification of current **best practice examples**. Advantages of this approach is that it can more rapidly account for technological changes and improvements and is a tangible, real-world example. On the other hand, what is feasible in one situation may not be so readily transferable to another situation and the emphasis here is on the current situation and is therefore limited in providing benchmarks for future progress. Best practice examples can therefore provide a benchmark for near-term progress on an indicator but not, for example, for long-term low emissions development strategies.

A complement to best-practice examples that provides a longer-term, future benchmark is to assess **technical potential** for improvements. For many industrial processes and systems, a theoretical limit to technical improvements exists. Technical potential benchmarks are particularly useful for material, emissions, or energy intensity indicators as an aspirational goal toward which the indicators should tend.

It is usually easier to explicitly relate benchmarks derived from macroeconomic modelling to the Paris temperature goal as these models explicitly compare global emissions and socioeconomic development throughout the century to the temperature goals through the use of simple climate models. However, even these models find a range of options and any derived benchmarks tend to be ranges for a given warming limit.

Sectoral models and empirical analyses are less explicitly linked to the temperature goal as emissions from any one sector are only one part of the whole. It can be difficult to be sure that, for example, reaching the technical potential of an improvement would be sufficient to be compatible with the Paris Agreement goals. One option is to combine information for emissions limits for different sectors from macroeconomic models with bottom-up, sector specific analyses to constrain 1.5°C consistent benchmarks for sub-sectoral indicators. However, it may be that these sub-sectoral models could even reach more ambitious mitigation than the macroeconomic models (de Coninck et al., 2018) and thereby Paris compatible benchmarks from bottom-up methods could be more stringent. In either case, this consistency check is a necessary part of the benchmark definition process.

In the table below (Table 3-5), we provide some examples from existing work. For many of the indicators that we consider useful for the GST, a benchmark has not yet been defined. One helpful bounding condition is the need to reach net zero CO_2 at the global level by 2050. A similar target can be applied at the sectoral level but the trajectory from now until 2050 must still be determined.

Table 3-5 Examples of benchmarks for more detailed indicators

Indicator	Global Benchmark	Source
Coal plants – planned, permitted, under construction, operational,	No new coal power plants; Reduce emissions by 30% by 2025	(Kuramochi et al., 2018); Macroeconomic modelling
Emissions intensity of power sector	Zero by 2050; ~50% reduction by 2030	(Climate Action Tracker, 2018); macroeconomic modelling studies

[20] https://www.iamcdocumentation.eu/index.php/IAMC_wiki

3.5.4 Incorporating equity into benchmark setting

To date, most equity analyses focus on fair-share distributions of total greenhouse gases emissions between countries based on principles of historical responsibility, per capita emissions and/or capabilities (Höhne et al., 2015; Robiou du Pont, Jeffery, Gütschow, Christoff, et al., 2016; Robiou du Pont, Jeffery, Gütschow, Rogelj, et al., 2016) with some also taking domestic inequality into account (e.g. Holz et al., 2018). Although extensively used by civil society and the independent analytic community, such equity analyses have so far only been used at a regional aggregate level in the IPCC and have failed to gain traction within the UNFCCC process itself. Assessment of countries' contributions in terms of total emissions under their NDCs is more likely to focus on Parties' own statements of how they see their contributions as fair. Winkler (2019) points out that the most important component of equity is adequacy – inadequacy is inherently unfair to those most vulnerable. Existing equity studies are therefore somewhat limited in terms of setting benchmarks for more specific indicators. We propose two ways in which benchmark setting can incorporate equity. First, the GST could include some specific indicators of equity (e.g. per capita emissions) and, second, that equity can be operationalized through the way indicators are used and assessed.

There are a range of options for operationalizing equity in the definition of benchmarks for other indicators, including accounting for national circumstances, ensuring discussion of equity issues is included in both the technical or political phases of the GST (Winkler, 2019), timing and pace of action, and presentation of data and information.

Although the global goals should set the overall pace and timing of phase out of emissions, national circumstances can be taken into account when setting interim targets at the national level. For example, the current structure of the power sector could place strong constraints on the mitigation potential. France's existing nuclear infrastructure allows it to have a much lower emissions intensity of the power sector than others where nuclear plants are either politically or economically not feasible.

Some aspects of equity may be further addressed in terms of timing. The Katowice outcomes set flexibilities for countries with different circumstances and those flexibilities could be applied in terms of the timing to reach specific benchmarks. Examples include reaching a peak in emissions earlier or decreasing emissions more quickly. However, given the urgency of mitigation needs to meet the 1.5°C goal, an equitable approach to mitigation thorough delaying action is now limited and could impinge on the need for adequate efforts. Equity, justice and fairness will therefore also need to be addressed through climate finance, technology transfer, and loss and damage.

Finally, the manner of assessment of indicators against benchmarks could be conducted in an equitable manner. In section 5.5 below, we propose a new methodology for assessing indicators that includes all countries. With this approach, progress can be assessed by showing the status of an indicator in all countries and how the distribution of that status changes through time. For many indicators, if that distribution is converging, we are moving toward a more equitable world. The range of indicators ultimately selected should therefore also be assessed in terms of whether they account for structural, global inequalities or potentially even exacerbate them.

4 Quality and availability of information for the Global Stocktake

4.1 Introduction

In this chapter we examine to what extent good quality data is available as an input to the GST. For that purpose, we firstly identified criteria for describing possible data sources (section 4.2). In a second step we assessed to what extent data and information sources are available for the qualitative and quantitative indicators outlined above (section 4.3). Similarly, we compared available data and information sources with the information requirements for the benchmarks outlined above (section 4.4.). Based on this analysis, we identify data and information gaps for the GST and summarise to what extent information is, or is not, available to the GST.

4.2 Data requirements and availability for selected indicators

A key constraint on which indicators can be included in the GST is the data availability for assessing progress on each indicator. There are a few different constraints on data availability;

- **Existence**: Is data available for the indicator at all?
- **Coverage**: Does the dataset cover most countries (spatial) and a sufficient number of consecutive years (temporal)?
- **Accessibility**: Many datasets are not open access and a fee must be paid for access. Even when paying a fee, there may be some restrictions on using the data. As the UNFCCC process is a multilateral, public process, any inputs to this process should also be publicly available.
- **Acceptability**: Is the data source likely to be acceptable under the UNFCCC? The Katowice outcomes provide some guidance as to what is, or is not, acceptable as an information source for the GST (UNFCCC, 2019e). Where data availability is only limited in this dimension, there are still opportunities for the extended global analytic community to include that data in sources that are considered acceptable, e.g. in the IPCC reports.
- **Quality**: Can the data be trusted?

In conjunction with the information analysis presented in section 2.3.2, we therefore identify indicators for which data is entirely unavailable, those for which it's only available with limitations, and those that should be usable for the official GST.

In the negotiations, it has generally been decided that only aggregate information sources will be used as input to the GST. However, to promote mutual learning and for countries to showcase best practice examples, the purpose of the initial phase of the GST could be seen as to receiving and analysing the information input, possibly as a process of public appraisal (see also chapter 2.2.2). Additionally, there may be processes whereby national information is aggregated by a legitimate body (e.g. NDC synthesis report, IPCC reports) so that such national information might become acceptable as an input to the GST as well. Thus, in order not to narrow the scope of potentially relevant sources too early and to better being able to identify data gaps in the information that is available, global/aggregate as well as national sources are taken into consideration in the following analysis of available information.

4.3 Overview of available information sources for selected indicators

As outlined in section 3.3, in a first step for assessing available indicators and benchmarks to assess progress, we generated an overview of available information sources. As a result of a screening, we identified and categorized 79 different types of information sources from publicly available documents and information sources (see Annex II). After selecting indicators for more detailed analysis and for carrying out a test run of assessing collective progress (chapter 0), we looked deeper into the identified information sources to assess, to what extent data is available for implementing an effective GST.

The source of information for each type of indicator varies; macroeconomic modelling for the macroeconomic indicators and sector, technology or industry specific studies for the best practice or technical potential benchmarks. There is precedence for the IPCC and other major reports (e.g. UNEP Gap Report, HLPF) to gather information from all these sources. As the IPCC has been identified as a source of information for the Stocktake, we draw heavily on the SR1.5 and AR5 reports for examples of what type of information the IPCC is likely to provide.

4.3.1 Key data sources and data availability for selected quantitative indicators

Potential data sources for many of the indicators is limited to a few sources from major organisations or data repositories. Most of the indicators in some way require energy, emissions, or socioeconomic data (including population, GDP, and trade). These major organisations and the availability of information provided are described in table Table 4-1. The indicators for which they may provide information is further outlined in the indicator table (Annex III).

Table 4-1 Overview of key data sources

Data source	General description of data type	Coverage		Accessibility	Acceptability in the UNFCCC process
		Spatial	Temporal		
IEA (multiple resources)	Energy Statistics; Emissions; Fuel type,	Comprehensive, all countries	Historic and projections under different scenarios, annual	Summary and top-level statistics publicly available in the Fuel Combustion Highlights, but most behind a paywall.	Possibly not directly, although IEA statistics support many other datasets and have been used by the IPCC.
World Bank – World Development Indicators	Many socioeconomic indicators, including population and activity data	Comprehensive; most countries included where data available	Historic only, annual	Freely available to all.	Unknown.
BP Statistical Review of World Energy	Energy Statistics and emissions by fuel.	80 individual countries, regions	Historic (1965-2018)	Freely available to all.	Unknown.
EDGAR	Historic emissions data.	Comprehensive, all countries	Historic only, annual, most recent years for fossil CO2 only.	Freely available to all.	Unknown.
PRIMAP-hist	Historic emissions data (all sectors except LULUCF)	Comprehensive, all countries	Historic (1850-2016), annual.	Freely available to all.	Unknown.
International Council on Clean Transportation	Transport emissions and activity	Limited	Historic	Some results freely accessible.	Unknown.
Enerdata	Energy statistics, costs, and GHG data	Comprehensive (186 countries)	Historic (1970-2018); cost and energy demand projections	Paid subscription required.	Unlikely to be useable directly.

Data source	General description of data type	Coverage		Accessibility	Acceptability in the UNFCCC process
		Spatial	Temporal		
UNFCCC (National Inventories, National Communications, Biennial Update Reports)	Emissions data; Policies; National Circumstances	Comprehensive, all countries	Historic and projections, (can be discontinuous timeseries and patchy sectoral coverage)	Freely available to all.	Yes.
FAO	Emissions and activity data for forestry and agriculture.	Comprehensive, all countries	Historic data, some time series are 5-yearly resolution.	Freely available to all.	Probably, as another UN organisation. Data is also used by the UNFCCC.
UN population	Historic population data and several projection scenarios	Comprehensive, all countries	Historic and projections, annual	Freely available to all.	Probably, as another UN organisation.
US EPA	Non-CO2 emission scenarios	Comprehensive, all countries	Historic and projections (multiple scenarios)	Freely available to all.	Unknown.

Countries' reports under the reporting framework of the UNFCCC will probably be the most important source for information on the state of emissions. Yet, the information reported includes significant data gaps which will make it difficult to assess progress towards emission reduction targets on the basis of information reported by countries in their national reports. Non-Annex I countries are requested to submit GHG inventories in the guidelines for non-Annex I national communications. However, these guidelines are outdated and have not been updated for many years. They fix specific dates for the national communications to be submitted (1994 for the initial report, 2000 for the second national communication, no later year specified). Only the introduction of biennial update reports for non-Annex I countries in 2011 implied the request for more recent GHG data. Thus, the availability of up-to-date information on emissions and removals from developing countries varies considerably. Roughly 30% of non-Annex I countries provided GHG emissions and removals for a year later than 2012 in their national communications or biennial update reports. On the one hand, the availability of such outdated information is due to a too strict interpretation of the reporting years indicated in the guidelines instead of a best practice approach. On the other hand, capacity constraints limit non-Annex I countries' possibilities to submit current data. Additional reasons could be that the countries selected a particular inventory year because this is also the base year for their NDCs or it took longer than expected to complete the BURs due to lack of staff capacities. Furthermore, more than 40% of those developing countries that submitted reports between 2014 and 2017 have not provided an emission time series. Also with regard to other aspects of reporting of data on GHG emissions, such as the amount of gases included in reporting, the IPCC guidelines used or the presentation of a key category assessment, the scope and quality of information included in non-Annex I reports varies considerably (analysis from 2017, Herold et al., 2017). It is questionable to what extent this situation will improve

under the Enhanced Transparency Framework because lack of capacity and political reasons seem to play a strong role in diminishing the quality of information.

Other data sources identified in our screening could provide complementary information on the state of emissions at national level to the information provided by the countries themselves and contain comprehensive data for all countries. The publishing institutions of these data sources are European authorities (EDGAR data), international organisations (FAOSTAT, State of Global Air Report, Global Carbon Project), research institutes (CDIAC and PRIMAPhist) and a commercial organisation (BP Statistical Review of World Energy). However, most data sources do not cover all greenhouse gases; only older versions of the EDGAR database and composite data sources (such as PRIMAPhist and CAIT) include all gases and sectors. Additionally, the State of Global Air Report or the BP Statistical Review of World Energy do not primarily focus on analysing trends in GHG emissions. It is also questionable, to what extent information sources from European sources or private organisations are acceptable as inputs to the negotiations (see Box 3 2).

4.3.2 Sources and availability of qualitative indicators on domestic policies, measures and transformation challenges

Like with quantitative indicators, there are several different sources of information. First and foremost are official UNFCCC documents prepared and submitted by the Parties themselves. These include National Communications, Biennial Reports / Update Reports (BR/BUR), NDCs, and official submissions such as for the recent Talanoa Dialogue. To review the quality and availability of pertinent information from these sources, we conduct five case studies. For five strategically selected[21] countries (the EU, India, Mexico, Vietnam and Ethiopia) we prepared country dossiers for the dual purpose of assessing the data availability as well as providing input for attempts to aggregate qualitative information as proposed in section 5.4 below. The dossiers are included in Annex VI.

In terms of domestic policies, data availability with existing official UNFCCC documents was generally sufficient, however, not in all cases very recent. With the revised reporting obligations under the Enhanced Transparency Framework, this will supposedly improve. While a list of relevant policies could be compiled from these sources, a categorisation/classification of those policies was not as straight forward and required significant additional research and deliberation. Meanwhile, information on the NDCs differs strongly. Some NDCs, such as for example the EU's NDC do not go into any details of policies and measures foreseen for the implementation of the NDC. With the adoption of implementation guidelines of the Paris Agreement at COP24 in Katowice, Parties agreed to a list of information requirements that will be applicable for the second round NDCs, but Parties are also 'strongly encouraged' to apply them for updates of the first NDCs that are taking effect as of 2020 (UNFCCC, 2019; also see Obergassel et al., 2019). The information requirements include:

- information on the reference point of the target;
- timeframe and implementation period;
- the scope (what gases and sectors are covered?);
- the planning process;
- assumptions and methodologies;
- considerations of how the NDC is fair and ambitious;
- and how the NDC contributes to the long-term goals of the Paris Agreement.

Information on transformation challenges and barriers, however, was largely unavailable from official UNFCCC documents. The guidelines for the preparation of Biennial Update Reports for developing

[21] The countries were sampled to cover a range of dimensions including different types of NDCs, state of development, size, membership in UNFCCC negotiation groups, as well as availability of official UNFCCC documents (national communications, BR/BURs).

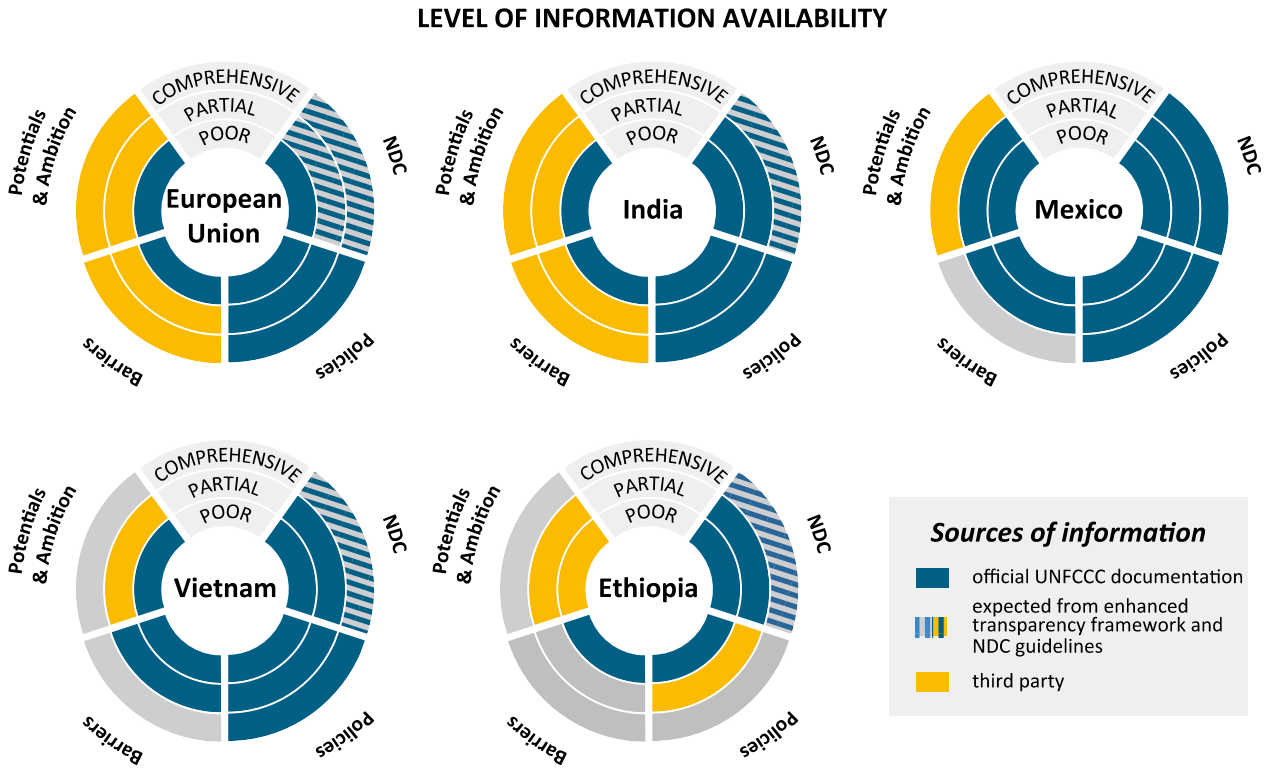
countries foresee a section where Parties are supposed to "provide updated information on constraints and gaps, and related financial, technical and capacity-building needs" (UNFCCC, 2012, p. 41), however only in the context of international support. For developed countries there is no such requirement. Hence a systematic assessment of experienced and anticipated transformation barriers and challenges is not possible with existing official documentation.

Additional to various the official UNFCCC documents, we identified a series of other sources of information, including domestic policy documents and strategies. Information is also available from third parties including inter alia the following sources:

- The IEA policies and measures database: https://www.iea.org/policiesandmeasures/
- The Climate Change Laws of the World database by the London School of Economics and Political Science's Grantham Research Institute on Climate Change and the Environment: http://www.lse.ac.uk/GranthamInstitute/climate-change-laws-of-the-world/
- The Climate Policy Database run by the NewClimate Institute: climatepolicydatabase.org/
- And numerous country specific reports and analyses both from peer-reviewed journals as well as grey literature.

The results of analysing the availability of information for each of the areas for which qualitative indicators could proof valuable for the GST (see section 3.4.1.4).

Figure 4-1 Level of availability of qualitative information on policies and measures and transformation barriers in five selected countries.



Source: Wuppertal Institut & Öko Institut.
Note: Inner most circle segments indicate a poor level of information availability, middle segment indicate partial availability and outermost segment indicates comprehensive information availability.

4.4 Information sources for defining benchmarks

In this analysis we look in more detail into the identified sources of information to identify the most appropriate type(s) of benchmark for each indicator identified in section 3.4. We describe, where information for that benchmark may be found, and identify where information is not currently available (Annex IV).

A number of information sources include benchmarks for the globally necessary mitigation progress. Such information sources have a global scope and comprise projections or emission scenarios until 2050/2100. Of the information sources covered in our collection, 10 sources fulfil these criteria and have a focus on mitigation. Of these information sources, one is/will be prepared/published by the UNFCCC Secretariat itself (long-term low GHG development strategies under Art. 4(19) of the Paris Agreement). Of the remaining information sources, four data sources are published by international organisations (IPCC, ICAO, IMO) which is likely to provide them with legitimacy in the UNFCCC context (see Box 4-2). Also, these reports should qualify as "best available science" as they go through international review processes and the publishing organisations have a strong reputation as providers of knowledge and a balanced representation of views. Additionally, future documentation of expert review under Paris transparency framework, synthesis report on NDCs and a database on Art. 6 accounting of ITMOs that will be prepared under the UNFCCC will make it possible to assess countries' contributions in the light of benchmarks.

The information needed to develop benchmarks varies according to what the benchmark is being applied to (e.g. energy efficiency, total emissions, sectoral emissions reductions) and to the type target the benchmark relates to (e.g. best-practice, cost-optimal, 1.5° or 2°C consistent).

4.4.1 Integrated Assessment Model scenarios

A particularly important source of benchmarks are the scenario databases developed for the AR5 and SR1.5 reports of the IPCC. They contain a comprehensive suite of scenarios that account for a range of socioeconomic scenarios and technical options (de Coninck et al., 2018; IPCC, 2015). The scenario suites focus on scenarios consistent with 1.5° or 2°C warming but also contain a range of business as usual and middle of the road scenarios. The SR1.5 database contains 598 different variables for 5 different global regions over the course of the 21st century. Of those 598 possible variables, around 18% are emissions, 17% climate diagnostic variables, 21% socioeconomic variables, 2% related to water, and the remaining 44% describe the energy, industry and AFOLU sectors. Not all variables are available for all model and scenario combinations, but there is a wealth of consistent pathway information contained within these scenario data.

What is of interest to this project is the general types of variables and the level of detail that is available so that we can assess for which of the indicators the scenario databases can be used to derive benchmarks (Annex IV). To get an overview of the variables available we disaggregate and organise the variables into the different levels of detail available for each main type of variable (level 1). The most detailed information is available for the energy sector with top line variables including (electricity) capacity, transportation energy services, carbon sequestration, and final, primary, and secondary energy. Each of these top line variables is further distinguished by energy source, e.g. coal, gas, oil, hydro, nuclear, solar, or wind (level 3). Some more aggregate variables, e.g. final energy from fossil fuel sources, are provided and others could fairly easily be calculated from the information available, e.g. non-fossil final energy per capita.

For the GST, a useful set of information is that final energy is also separated into Industry, Non-Energy Use, Residential and Commercial (Buildings), and Transportation, and the energy source is also provided for each of these. Such information was used as a basis for some of the AR5 WGIII report sec-

tions and could be built on for the AR6 report. However, to be useful for the GST, the IPCC will need to resolve differences between the sectoral definitions used by the UNFCCC and those used in IAMs (Box 3-1).

Emissions of all major greenhouse gases and many climate pollutants are also provided within the scenario databases (Table 4-2). Total emissions are given for all gases and for some gases emissions from specific sectors are also given. The major subdivisions are Energy, AFOLU, and Other. More detail is given for energy with total supply and subsectors for industry, buildings, and transportation available for energy demand for most major gases. Additional detail is given for CO_2 in both energy supply and demand, and an additional subcategory for Industrial Processes. Kyoto greenhouse gases are provided as totals across all sectors only, so aggregation for sub-sectors would need to be independently calculated. One aspect of mitigation not yet well addressed by IAMs is mitigation of F-gases and other sources of information may be needed for setting benchmarks for F-gas indicators (Box 4-1).

Additional variables not listed in Table 4-2 may be available from individual models or scenarios. However, one of the benefits of the scenarios suites with information from multiple studies is that some of the uncertainties and assumptions are accounted for in the range of results obtained across the different model-scenario combinations.

Table 4-2 Emissions information included in SR1.5 Scenario Database[22]

	Variables available	
Emitted species	Carbon dioxide, Methane, N_2O	
	Combined F-gas basket, SF_6, HFCs, PFCs, (includes some specific HFCs and PFCs)	
	Kyoto Gas basket (combined CO_2, CH_4, N_2O and F-gases)	
	Black Carbon, Ammonia (NH_3), Nitrous Oxides (NOx), Organic Carbon, Sulfur, Volatile Organic Compounds (VOC)	
Sectors	Total	
	Energy	
	AFOLU	
	Industrial Processes (CO_2 only)	
	Energy Demand	Total
		Other
		Industry
		Residential and Commercial
		Transportation
		AFOFI[23] (CO2 only)
	Energy Supply	Total
		Electricity
		Gases (CO2 only)
		Solids (CO2 only)
		Liquids (CO2 only)
		Heat (CO2 only)
		Other (CO2 only)

[22] According to the emissions variables listed in the documentation of the SR1.5 database repository (Huppmann et al., 2018).
[23] AFOFI - CO_2 emissions from fuel combustion in agriculture, forestry, fishing (IPCC category 1A4c)

Integrated assessment models therefore provide both an extensive breadth and depth of information that will undoubtedly be used in both the upcoming IPCC AR6 reports and the GST. However, there are limits to the information they can provide in terms of detail and in terms of the flexibility of assumptions used to set up the model. Not all options for mitigation are included in IAMs, or are resolved in enough detail, and some mitigation paths may be taken that are not possible in the models.

Box 4-1 Fluorinated Gases

Emissions of fluorinated gases (F-gases) are rapidly rising and in 2016 reached 954 MtCO2e (Gütschow et al., 2016, 2019) and are projected to grow substantially in the coming decades (Purohit & Höglund-Isaksson, 2017). Slowing the growth of, and subsequently reducing, F-gas emissions is a key component of reaching the Paris Agreement goals and use of an appropriate combination of indicators and benchmarks in the GST could help to promote mitigation action of these gases.

Scenarios for emissions of fluorinated gases are commonly exogenous to integrated assessment models and therefore these models do not provide the best source of benchmarks for F-gas emissions and other sources may be needed. The IPCC therefore also draws from individual studies that examine the technical potential and mitigation costs for estimating the total mitigation potential of f-gases. Purohit & Höglund-Isaksson (2017) found that under currently available technologies, F-gas emissions could be reduced by 97% below the baseline by 2050.

In addition, the Kigali amendment to the Montreal Protocol provides a framework for both setting benchmarks and monitoring progress toward HFC phaseout. Benchmarks set by the Kigali amendment include decreasing HFC emissions of non-article 5 members from 2020 and of all countries from 2028 at the latest. Substantial phase-out should be observed by 2036 and full phase-out by 2047. However, the IPCC notes that additional reductions of F-gases will be needed to meet the Paris temperature goal (Ch 2.3.3.2, de Coninck et al., 2018).

Given the timing of the Kigali amendment phases and time lags in data reporting, it's unlikely that the first GST will be able to observe any progress on these targets. However, the first GST could examine current status and trends of F-gas emissions. A simple benchmark could be that global F-gas emissions should have stalled by 2020. Indicators and benchmarks can still be used in the first GST to set clear goals, thereby setting the framing and orientation for future Stocktakes.

4.4.2 IPCC reports for technical potential and best practice

Additional sources of information are required to set different types of benchmarks, to fill information gaps that are not filled by IAM output, and to identify potential for stronger mitigation. In addition to assessing IAM model output, the IPCC 's WGIII also reviews and consolidates information on mitigation options in different sectors. The fifth assessment report includes extensive descriptions of the drivers of emissions in each sector, and how they may be reduced (IPCC, 2014). It is comprised of the results of multiple different modelling studies (e.g. LIMITS, AMPERE), and a similar database can be anticipated for the AR6 report based on more recent studies (e.g. CD-LINKS, ADVANCE). Also, the upcoming AR6 report could build on the approach to describe drivers of emissions in each sector and clearly set benchmarks for key indicators based on technical potential and best practice examples. Because it was used for the IPCC reports, we consider the AR5 database and any AR6 updates as likely to be acceptable for use in the GST. However, the model results need to be interpreted, either in individual scientific studies, as part of IPCC reports, or as part of independent assessments, to be used as benchmarks.

4.4.3 Additional information sources for defining benchmarks

In addition, information sources were collected which are prepared by research institutes (PIK, WRI, IIASA, Climate Analytics/NewClimate/Ecofys) which are national organisations that are fully or partly privately financed. As such, their status is different from information sources from international, publicly funded institutions. Nevertheless, their research could provide additional value to the GST process or be used by civil society to interpret the results of the GST independently of the official process.

As an example of such independent information sources, the Climate Action Tracker (CAT) quantifies the mitigation targets and current policies of 32 individual countries and assesses them against equity benchmarks. Under their data portal[24], the CAT also provides some sectoral benchmarks according to 'best-practice' and '2°C consistent' scenarios. The data is viewable online and available for download. Many of the benchmarks are derived from the AR5 scenario database or extracted from the IPCC Fifth Assessment Report. The CAT therefore adds to the scenario databases above by adding an interpretative step that is relevant at the national level. Running since 2009, the CAT has substantial recognition but no formal acceptance under the UNFCCC process.

As a second example, Climate Watch[25] is a data platform providing access to and visualisations of various data sources, including information about NDCs, historic GHG emissions, and various future scenarios. GHG emissions datasets presented include that of WRI (CAIT), PIK (PRIMAPhist), and UNFCCC data. The platform also includes some sector specific scenarios from multiple different models. Most data cannot be directly downloaded, but clear references are given to the original data. It's therefore a useful survey tool to identify and visualise some of the available information. The project has several partners with strong standing, including the UNFCCC, Climate Action Tracker, World Bank, and GIZ, but is still an independent organisation and therefore legitimacy of the information within the UNFCCC process is not guaranteed.

4.4.4 Spatial and temporal resolution of information for benchmarks

Ideally, we would like to know a precise level of 1.5 or 2°C compatibility for all countries at all points in time, and for all indicators. Clearly, this is not feasible. So, when defining benchmarks and sources of information we need to cover these dimensions as best as possible. Most IAMs are limited to 10 yearly resolution but do have the capacity to set benchmarks according to different future pathways until 2100. Best-practice based benchmarks are mostly only available and useful for recent history and near-term time frames although could set an upper bound for the longer-term. Benchmarks based on technical potential may be useful over a longer timeframe but may also be time limited if further technological developments allow for additional mitigation potential. On the other hand, best practice and technical based benchmarks may be more directly applicable at the national or sub-national level due to the limited regional resolution of IAMs.

Equity based targets have been defined at both the regional and national level, although mostly only for emissions and not for other indicators (

[24] See https://climateactiontracker.org/decarbonisation/emissions/countries/us+eu+in/variables/all.

[25] See https://www.climatewatchdata.org/.

Table 4-3) outlines the different resolutions of information available for each of the four types of benchmark.

Table 4-3 Types of benchmarks and their use cases.

Benchmark Type	Source	Time frame and temporal resolution	Spatial resolution	1.5 or 2°C compatibility clear?
Macroeconomic	IAMs[26]	10 yearly out to 2100	5 core regions reported in IPCC, most models have more regions (e.g REMIND has 11, IMAGE has 26) that are described in individual studies.	Yes, estimated warming is calculated for all scenarios.
Technical potential	Academic studies, Industry, Sectoral models	Useful in the medium-term (decades)	Generally global but could be assessed on a regional basis – what is the maximum potential given local constraints?	To some extent. Reaching the highest technical potential is the best option. However, demand reductions may additionally be needed.
Best practice	Independent studies and reports with sectoral focus	Current, near-term targets	National or regional	Not necessarily, simply gives an indicator of current status.

4.5 Summary: Information available and data gaps

Overall, it can be concluded that a rich variety of information sources is available which could, in principle, provide valuable input to the GST. However, the conditions for a fully effective GST will be difficult to fulfil, and specific data gaps and challenges remain.

A key challenge of the GST will be in examining progress in sufficient detail that it meets the criteria identified in chapter 2, being policy relevant with the data and information available, given the restrictions on availability under the UNFCCC system.

Information on progress towards mitigation targets and levels of GHG emissions will mostly be based on country reports submitted to the UNFCCC. However, these reports hitherto have included significant data gaps for a large number of countries. Additionally, while the aggregation of emissions would be possible on the basis of national reports and potentially gap-filling approaches for countries for which comprehensive information is missing, challenges arise from the lack of transparency in the definition of countries' NDCs. Additional information requirements in order to track progress towards these NDCs, such as BAU targets, are not entirely covered by available data.

Some of the indicators considered, e.g. emissions per revenue tonne km, are currently not feasible for assessment under the GST as there are no individual data sources that provide this information for a sufficient number of countries. To perform such an assessment, information would need to be gathered from national or sub-national sources.

Data availability poses a strong restriction on the number of indicators that could be considered under the GST. In some cases, these restrictions may be reduced if the IPCC, or other bodies, are able to use data that is otherwise not publicly available and collate and include the information as part of the AR6 reports, giving the sources legitimacy under the UNFCCC (see Box 4-2). This would be particularly

[26] For a detailed overview and comparison of different global integrated assessment models and their respective capabilities and limitations see Bingler et al (2019).

useful with energy data from the IEA and IRENA. Some of this data has been used by the IPCC in the past, but generally at a global or regional aggregate level.

In other cases, the data simply does not exist at sufficient temporal resolution for enough countries to be usable under a GST that truly includes all countries. This issue is particularly relevant for those indicators that are more detailed in terms of sub-sectors, such as the emissions intensity of freight transport. This is where efforts to ensure that the GST addresses policy relevant indicators run into limitations, although there is a level of detail at which both data is available and the indicator can directly inform policy, such as the share of renewables in the energy sector.

One option for the GST to consider for increasing the number of indicators that could be used, is to establish a cut-off number of countries for which data is available and an assessment still be performed. This could be particularly relevant for activities that are dominated by more developed countries and where the countries for which data is available represent a major share of the global total for that indicator.

Additionally, there may be data sources available which hold data that could prove useful for a GST but which are compiled by entities which make them available on a commercial basis (e.g. the Platts database on world electrical power plants (S&P Global Platts, 2018), Bloomberg New Energy Finance (Bloomberg New Energy Finance, 2018)). However, the stocktake should ideally be based on data sources which are publicly available. If data sources such as IEA World Energy Outlook, SE4ALL, Enerdata or Bloomberg New Energy Finance were made available to the GST then the number of indicators, particularly in the energy sector, could be significantly increased. It may prove useful to consider whether there are (non-financial) incentives that could motivate such data-owners to contribute to the cause of a GST in the design of this process. The GST could provide a global platform for making their products publicly known and advertising their usefulness to an important international process. Otherwise, some of the features of an effective GST will need to be performed by independent organisations and activities.

The information for setting benchmarks is more readily available than that for the indicators themselves and will primarily come through the IPCC, either in the form of multi-model assessments or literature review. The IPCC provides the most legitimate and comprehensive source of information for the GST. To assist further, the AR6 report could cater directly to the GST by being clear and explicit on indicators and benchmarks and collating the relevant data. In particular, including detailed energy data that is currently behind a paywall and clearly defining technical potential and best practice examples from industry would substantially boost the scope of the GST. However, some testing and development of how to integrate different types of benchmarks and particularly how to operationalize equity in the definition of benchmarks is still needed.

Box 4-2 Political Dimension: Factors influencing the legitimacy of an information source

A number of political aspects influence which information sources will be accepted by Parties in the negotiations. Most importantly, such information sources need to be considered as legitimate by negotiating Parties in order to be accepted. Under which conditions is an information source likely to be ascribed legitimacy in the context of the UNFCCC negotiations?

One important aspect of legitimacy is the authorship of a source. In the negotiations, national sovereignty is one of the highest-valued principles, so that information sources that are authorized or published by national governments have legitimacy as information sources about the respective countries. Additionally, UNFCCC bodies have legitimacy because by being Parties to the UNFCCC, countries generally accept the multilateral mode of producing outputs that are of importance to the negotiations. Institutions with limited membership might not be so readily accepted (e.g. OECD) (cf. e.g. Hurd, 1999).

Also, a source might become legitimate by being mandated by the UNFCCC: through the multilaterally legitimized working mode of the UNFCCC other external bodies may be tasked by the UNFCCC / the COP to provide certain inputs to the negotiations which are then used as references in the negotiations, such as reports by the IPCC, the GEF, IMO or ICAO.

Furthermore, it will be important whether research is publicly or privately financed. Generally, sources by public actors are more likely to be accepted in the negotiations as private actors are more likely to pursue political or business-related interests.

Lastly, it will play a role to what extent data and methods included in an information source are transparent and can be reproduced. Adhering to standards of good scientific practice will be necessary in order to be considered by negotiating Parties as “best available science” (see also Box 2-1).

The current informal note by the co-facilitators chairing the negotiations on the GST still include a large variety of options of information sources that might be considered as inputs to the GST. This indicates that beyond a basis of already agreed sources of input, including information of GHG emissions from countries’ reports under the Enhanced Transparency Framework, a synthesis of NDCs, the latest reports of the IPCC and reports of the subsidiary bodies, countries’ views on this issue diverge. As guidance for identifying additional sources of input, the informal note includes the following non-exhaustive list of criteria which shed light on the understanding of legitimacy of information shared by Parties: information from any source of input should be

- appropriate to assess collective implementation and or progress and address the information needs of the GST;
- directly relevant to the technical stream under discussion;
- presented in a concise, easily digestible and accessible format;
- openly accessible;
- of high standard of quality and integrity (current, drawing from relevant expertise, and peer reviewed where appropriate) and
- technical in nature (UNFCCC, 2018c).

Thus, which sources of input will ultimately be considered as ‘legitimate’ and will be accepted to be used in the GST process will depend on the outcome of negotiations.

5 Assessing collective progress: addressing challenges with new tools

Apart from availability of information and benchmarks, a major challenge of the GST is to fulfil the functions set out in chapter 2.2 and, at the same time, stick to the principle that only collective progress should be assessed. Statements regarding the 'collective' nature of the exercise are included in the Paris Agreement's original mandate for a GST (UNFCCC, 2015a) and further re-iterated in the Katowice Outcomes (UNFCCC, 2019e).

In this chapter, we elaborate on approaches for aggregating data at collective level. Examples of aggregation of national emissions data on the global level include:

- The NDC synthesis report which ensures a consistent aggregation of emissions on a 'gas by gas' basis by converting the different metrics used by the Parties to the Paris Agreement in their NDCs. The varied targets expressed in the NDCs (i.e. conditional and unconditional) are taken into account in the aggregation by calculating a range of global emission reductions (UNFCCC, 2016a).
- The IPCC aggregates a range of scientific studies to develop findings for a certain level of confidence for observed climatic changes. This is based on the author teams' evaluations of underlying scientific understanding and is expressed as a qualitative level of confidence (from very low to very high) and, when possible, probabilistically with a quantified likelihood (from exceptionally unlikely to virtually certain).

In this chapter we first describe challenges in aggregating emissions under the NDCs submitted by countries (section 5.1) and elaborate on approaches for dealing with those challenges (section 5.2). Subsequently, we explain possible ways of evaluating collective progress towards the Paris Agreement Goals (section 0) and of aggregating qualitative information (section 5.4). Finally, and building on experiences made with the aggregation of data at global level, we present two approaches to operationalise 'collective' progress (section 5.5):

- The first approach is to aggregate the progress of all Parties combined and compare that progress against global level goals (**full aggregate**). The most obvious example for this approach is total global greenhouse gas emissions, although other indicators are also useful at the global level, e.g. a time series of globally averaged per capita emissions.
- The second approach is to retain some level of information about individual Parties but to anonymise that information (**performance distribution**). Such an approach allows for more insights to be drawn on the heterogeneity across individual Parties' developments while complying with the requirements for collective progress. We propose that the information could be presented in figures that show the distribution of countries and related, descriptive summaries (see examples in section 5.5.2 below).

For the performance distribution approach, we describe and show a new set of tools developed under this project to perform such analyses.

5.1 Challenges in aggregating emissions under the NDCs

The GST will necessarily need to assess progress on global emissions. In particular, quantifying NDCs where limited or contradictory information is provided under the UNFCCC in NDCs and other documents is particularly challenging. Here we outline the issues that need to be taken into consideration when aggregating emissions, and particularly projected emissions under NDCs, to the global level.

5.1.1 Nationally Determined Contributions

Due to a lack of commonly accepted standards and information requirements, the (i)NDCs prepared by Parties in the run-up to Paris and in many cases confirmed thereafter display a huge variety in terms

of types of commitments as well as sectors and gases covered. Given that Art. 4.4 of the Paris Agreement stipulates that all countries should move towards economy-wide absolute emission reduction targets over time, the GST should assess whether or not progress is being made. The analysis should be expressed as the share of countries that have committed to economy-wide absolute emission reduction targets as well as the share of global emissions that is subjected to those kinds of targets. Conversely, the GST should keep track of the share of emissions that are not currently covered by any (quantified) target. A breakdown per sector would provide additional meaningful information. Table 5-1 below provides an example for how this kind of information could be summarized in a tabular format.

Table 5-1 Example Table for Aggregating Scope and Coverage of NDCs

Indicator	Share
Share of countries / global emissions with economy-wide absolute emission reduction targets	##% / ##%
Sectoral coverage of NDCs (share of global emissions per sector):	
Energy	##%
Transport	##%
Industrial Processes and Product Use	##%
Agriculture	##%
LULUCF	##%
Waste	##%

5.1.2 Further Quantifying NDCs

While most countries' NDCs seem to be roughly quantified at first glance, **a number of specific pieces of information are often missing in order to precisely assess the mitigation impact of NDCs and to track current progress with the implementation and achievement of NDCs**. Information on target value, coverage of sectors and gases often is available, while about 40% of the NDCs submitted do not include information on the metrics used for the calculation of the NDC and 32% do not indicate whether and which IPCC guidelines have been used for preparing the target. Particularly BAU targets which have been defined by 87 out of 190 countries that have submitted their NDCs until March 2018 imply methodological challenges that are currently not addressed by international guidance and that risk wrong estimation of emission reductions achieved. 20% of all BAU targets do not provide any specific figures on the target or only provide a graph indicating the target level and about half of all NDCs including BAU targets do not provide any information on the methodology applied for establishing the target. Also information is missing for a number of NDCs regarding the contribution of the land-use sector to achieving their NDCs (Forsell, Turkovska, Gusti, Obersteiner, den Elzen, et al., 2016; Grassi, House, Dentener, Federici, den Elzen, et al., 2017), and for most countries it remains unclear to what extent credits from carbon markets will be used to reaching their target (Herold et al., 2018). The list of information requirements for NDCs defined in chapter 2.3.1.2 thus remains a list of ideally available information which is not reflected in the documentation accompanying countries' submitted NDCs at the moment.

Additionally, methodologies for establishing and accounting for BAU targets currently remain absent at the international level and it is questionable to what extent it will be possible to agree on detailed methodologies that would be necessary in order to make BAU targets more transparent in the near future. Submissions by Parties have stressed the importance of respecting the nationally-determined nature of NDCs in the way that accounting guidance is developed, rather than arguing for converting the current range of diverse NDC targets (at least those defined in quantitative terms) into a common accounting format (Hood & Soo, 2017).

An additional factor contributing challenges to estimating emissions under the NDCs is that of the **political uncertainty in the extent to which the NDC is achieved.** The current NDCs have a varying level of ambition, ranging from very ambitious emissions reductions to those that could be overachieved with no additional effort. In the latter case, analysts must consider the likelihood of the country overachieving their NDC and decide how to include the 'hot-air' created by the inflated baselines in the emissions aggregation. Existing analyses (e.g. UNEP, 2018) do take these concepts into account, but tend to focus on major economies, such as the G20, and do not consider all countries.

5.1.3 LULUCF

The Land-Use sector is particularly challenging to assess and incorporate into a global aggregation. It is important to separate out the land-use emissions and sinks from emissions from other sources for several reasons;

- Uncertainties about emissions from land are much higher than other sectors
- Emissions reductions or sink development can be rapidly reversed.
- If incorporated into the same target, uncertainties in accounting and reporting for land-based mitigation can be propagated to the whole target, potentially weakening other efforts.
- To understand progress toward the Article 4 target of achieving a balance between sources and sinks, we need to be able to separately monitor and understand the land-based sinks.

However, assessing land-based mitigation measures under the NDCs has proven challenging. In part, this is because definitions of land-use vary greatly between different datasets and countries (see, e.g. Grassi et al., 2018; Roman-Cuesta et al., 2016). But it is also due to ambiguities in how countries intend to incorporate land-based mitigation into their NDCs. Forsell et al. (2016), Grassi et al. (2017)), and Fyson and Jeffery (Fyson & Jeffery, 2019) all outline these challenges and some options for how they may be addressed through clarification of targets and careful use of disparate datasets.

Even when individual NDCs are correctly evaluated, it is important to ensure that the definitions of emissions estimated under the NDCs are comparable with the definitions in the models and tools that set the benchmarks being used to assess them. The land-use emissions pathways in integrated assessment models and the carbon cycle representation in climate models used to evaluate the NDCs do not necessarily correspond to data used for the NDCs (Grassi et al., 2018).

For estimating global emissions in 2030, a number of methods are possible. A few countries dominate current land-based emissions and if a good estimate for these countries can be established then the uncertainties can be significantly reduced. According to FAOSTAT data[27], 80% of net emissions (excludes countries with net sinks) from forest land were from just 14 countries. However, an effective GST would include an estimate for all countries.

Alternatively, a completely independent land-based emissions pathway could be taken that is, in narrative terms, comparable with what is expected under the UNFCCC. The Climate Action Tracker applies planned emissions reductions from a few individual countries to a middle-of-the-road business as usual deforestation scenario.[28]

Here, again, the IPCC has an opportunity to collate and synthesise the different information sources and approaches and provide clear input to the GST on the progress of mitigation in the land-use sector.

5.1.4 Market mechanisms

When estimating the total global aggregate emissions, it's important to know whether any international mechanisms actually enhance or reduce total ambition calculated for the NDCs alone. Market

[27] http://www.fao.org/faostat/en/#data/GL

[28] https://climateactiontracker.org/methodology/global-pathways/

and non-market mechanism negotiations (Article 6) were not concluded in Katowice at the end of 2018, and the implications of these mechanisms for achieving the NDCs therefore remains open. Additionally, the CORSIA mechanism for offsetting emissions in the aviation sector has not yet been fully established and safeguards to ensure that any emissions reductions are additional to those in the NDCs are not yet in place.

Hermwille and Kreibich (2018) point out the interdependencies between Article 6 market mechanisms and the GST, highlighting that both are intended to increase ambition under the Paris Agreement. Not only will the GST need to take market mechanisms into account when aggregating global emissions, but the GST could also provide a platform for reviewing the market mechanisms themselves to examine how market mechanisms are, or are not, being used to raise ambition and where improvements could be made (Hermwille & Kreibich, 2018).

5.1.5 International bunkers

Emissions from international bunkers currently comprise around 3.5% of global fossil CO_2, or 2.7% total GHG emissions[29]. Currently emissions from shipping are slightly higher than those from aviation but more rapid growth is foreseen in the aviation sector.

Data for each of these sectors is provided by individual countries, the IEA, and the respective governing bodies; IMO for marine shipping and ICAO for aviation. Data reporting is currently poor for both international aviation and shipping, with the latest official shipping estimates from IMO being for 2012 and strong disagreement between different datasets. Uncertainties in total emissions are quite high for international shipping, with bottom-up and top-down estimates differing substantially (Olmer et al., 2017). Challenges in quantifying international bunker emissions arise due to the different approaches in allocation emissions to domestic and international use.

The development of a detailed tracking system for fuel use and emissions to be used by individual airlines as part of the CORSIA system could lead to substantial improvements in data accuracy and reliability as of 2019. Similarly, the IMO has also initiated a more regular data collection approach as part of its new roadmap (IMO, 2018) and total emissions from both sectors should be available on an annual basis from at least 2020 onwards. As well as providing a basis for action within each sector, this information will provide a valuable input to emissions aggregation for the GST and should be available in time for the first stocktake in 2023.

A more complex aspect of the role of international bunkers in global aggregation is that one of the mitigation efforts planned by the aviation sector is through market mechanisms, specifically the CORSIA scheme. What is not yet clear is how the CORSIA sector will interact with the NDCs and any market mechanisms established under Article 6 of the Paris Agreement.

5.1.6 Other considerations

Additional considerations in the aggregation of emissions under the NDCs and estimating their long-term evolution includes the following:

- The extent to which all sectors and gases are covered by the NDCs; where no target is present an assumption must be made about emissions growth in those areas.
- The long-term implications (e.g. lock-in effects) of varying levels of effort across sectors should be taken into account in long-term projections,
- The mix of gases in any aggregate level of emissions will impact the temperature development in the near-term and has implications for meeting the temperature goal.

[29] Percent shares of bunkers in global emissions calculated for the year 2015 based on IEA Fuel Combustion highlights (IEA, 2018) for aviation CO_2, ICCT for marine CO_2 and GHG (Olmer et al., 2017), FAOSTAT for LULUCF (FAO, 2019), and PRIMAPhist (Gütschow et al., 2016, 2019) for all remaining emissions.

- In the absence of common timeframes, some interpolation or extrapolation of NDC targets is required to estimate aggregate emissions in a given year.

Many of these considerations have been addressed in existing methodologies to some extent but there remain challenges and source of uncertainty (see, for example, Rogelj et al., 2017).

Although some agreement on common timeframes was reached in Katowice – that common timeframes should be used for NDCs covering the period from 2031 onwards (UNFCCC, 2019b) – further discussions are set to continue to establish what that common timeframe should be. The GST will therefore have to deal with such timeframe inconsistencies not only in the first Stocktake but also in later iterations.

5.2 Dealing with aggregation challenges under an NDC scenario

In 2015, most studies assessing the cumulative impacts of the first NDCs were in general agreement with each other (see, for example, UNEP, 2015). However, many of the challenges encountered then will also be valid for the first GST. **Key among these challenges are quantification of individual NDCs** (Benveniste et al., 2018; Rogelj et al., 2017)**, the role of market mechanisms, political uncertainty in the achievement of the NDCs, and the role of land-based mitigation**.

Some of these uncertainties may be reduced by Parties providing more information and clearer targets in their NDCs and through the newly agreed transparency arrangements (UNFCCC, 2019d). Further clarification of how market mechanisms will be incorporated under the UNFCCC will also reduce uncertainties further.

The GST could contribute to assessing the likelihood of overall implementation of the NDCs by incorporating existing work and summarising it. The summary could be performed at the global level – e.g. current policies are set to exceed the NDC targets by X% – or could summarise national efforts with statements such as X of Y countries are on track to meet their NDC targets.

However, some uncertainties will not be resolved by or under the UNFCCC, and some of the information that will eventually be provided under the transparency mechanism will not be available for the first GST because the first reporting is not due until 2024. Either the Secretariat or independent analysts will therefore need to fill this informational and analytical gap.

Fortunately, the analytical community is well-poised to do so, having performed similar NDC aggregation efforts in 2015. Some of those methods and data will need to be updated for the GST and, preferably, in time for incorporation in the IPCC's 6th Assessment report which could give both robust review and legitimacy to individual assessments.

Box 5-1 outlines two approaches used to fill informational gaps. First, for historic data and second for projections. Such approaches will be needed to complete aggregation of emissions under the GST where official information is lacking. Critically missing or under-developed at present are approaches for assessing how international market mechanisms will affect total emissions and up-to-date assessments of emissions from international aviation and shipping.

Box 5-1 Gap-filling

Although data reporting is increasing in coverage, and the new transparency mechanism agreed in Katowice will ensure that this continues, an ongoing challenge for the GST will be missing information. Similar challenges have been addressed by different institutions in different ways and here we provide two examples of such 'gap-filling' methods. The first explains how different data sources are used to complement country-reported data in EU greenhouse gas projections and the second describes how numerical and proxy data were used to complete the PRIMAP-hist historical emissions data set.

Example 1: EU Monitoring Mechanism Regulation

Under Regulation No 525/2013 (EU, 2013), European Member States need to submit greenhouse gas emission projections to the European Commission (Article 14) every two years. These national projections are subject to a Quality Assurance and Control (QA/QC) process undertaken by the European Environmental Agency (Article 24(g)). This process includes filling data gaps with appropriate information (Article 24(h)). This is done in order to allow for an aggregation of national data for the compilation of a Union greenhouse gas projection (which is to be reported under UNFCCC).

ETC/ACM (2017) outlines the QA/QC procedure in detail, including the gap-filling methods which are applied in consultation with the affected Member States. The following gap-filling methods are applied and described in ETC/ACM[30] (Schmid et al., 2017):

- Intermediate reporting years (those which do not end on 0 or 5) which are not provided are gap-filled by linear interpolation.
- If information for mandatory reporting years (those ending on 0 or 5) is not provided, a surrogate dataset (latest available projection from the European Commission) or extrapolation will be used to close the gaps.
- If data is not provided organised by sector and gas a surrogate dataset (latest available projection from European Commission) will be used. From it the relative shares of (sub)sectors will be drawn and applied for the respective year taking into account the reported total for that sector. There is no gap-filling if a split by gas is not provided.

If data on international bunkers and international aviation is not provided, this data will be gap-filled by the latest available greenhouse gas inventory year. The value will be applied to the entire time series. European Member States need to provide their projected emission data split (per sector) by those that fall under the Emissions Trading Scheme (Directive 2003/87/EC[31] and those falling under Effort Sharing (Decision No 406/2009/EC[32]) / Regulation (Regulation (EU) 2018/842[33]). If such a split is not reported, the dataset will be adjusted / gap-filled by using a relative ETS/ESD share of the total emissions of a surrogate dataset. If total emissions are not available a surrogate dataset will be used to extrapolate the MS' trend for ETS and ESD emissions. Gap-filling takes place also for a missing sectoral ETS/ESD split on key source level (ETC/ACM 2017 p. 29).

If a Member States does not report a 'with additional measures' (WAM) scenario, the corresponding 'with existing measures' (WEM) scenario reported by the Member State will be used for gap-filling. Complete-gap filling will occur (in consultation with the Member State) if a Member State fails to submit complete projections AND the gaps cannot be filled according to the above procedure. Complete gap-filling may occur when:

- No projection is provided;
- The same projection as previously was submitted;
- The reference year is outdated or the trend between the latest inventory year available and reference year deviates from the trend in the corresponding greenhouse gas inventory;
- The submission is substantially delayed and cannot undergo QA/QC.
- In such cases an alternative data set will be selected in close coordination of the experts from the European Commission, EEA and ETC/ACM.

[30] European Topic Centre on Air Pollution and Climate Change Mitigation
[31] https://eur-lex.europa.eu/eli/dir/2003/87/oj
[32] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2009.140.01.0136.01.ENG
[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32018R0842

Example 2: PRIMAP-hist national historic emissions dataset

The PRIMAP-hist dataset (Gütschow et al., 2016, 2019) combines multiple different information sources to build an emissions dataset that covers all UNFCCC countries from 1850 to present and for all major sectors (except LULUCF). As no single information source includes all the information required, the gaps in the data need to be filled. In PRIMAP-hist, gaps in emissions time series are filled using one of two different approaches, depending on data availability.

The first approach entails filling gaps in the primary dataset with data from other time series. To fill a gap, data from a different source (but the same country/region, sector, and gas) can either be used directly or it can be numerically scaled to match the primary data source that has a gap. If both data sources are reasonably consistent (ie. similar trend and absolute values), the additional data sources can be used directly. If the magnitude of the secondary data source is inconsistent with the primary data, the new data is numerically scaled to match the original data at the gap boundaries. In some cases, the only additionally available data for the gap has a lower sectoral, gas, or regional resolution. In this case, the secondary data may be downscaled to the required level of detail using data from the primary source.

The second approach is used where no alternative information sources are available. In this case, the gap is filled by numerical interpolation or extrapolation. In PRIMAP-hist, the interpolation is usually linear. Care must be taken in the interpretation of datasets that have been interpolated or extrapolated in this way. Because data for recent years is commonly missing, it's common for some datasets to extend the last years of data by extrapolation, either numerically, (e.g. by extending the trend of the data) or based on proxy data (e.g. GDP projections). For data with extrapolation in the final years, any interpretation of trends would then just be evaluating the method used to extrapolate the data. Non-extrapolated datasets should therefore be used wherever possible to avoid such errors.

Gap filling in the GST

As the UNFCCC reporting is currently sparse for many countries, we will use the PRIMAP-hist dataset for our test run of the GST and the performance distribution tools (section 5.5). The tests will make use of the PRIMAP-hist dataset version that does not include extrapolated data so that interpretation of trends are real and not based on numerically extrapolated data.

The real GST will also face similar challenges. To some extent the IPCC should provide some of the role of data collation and gap-filling, and datasets such as PRIMAP-hist could be used. A clear approach to the use of surrogate information sources, such as that used by the EU in the first example above, could encourage Parties to provide more comprehensive information of their own given the risks that alternate data sources may be incorrect or less favourable. One scenario that should be avoided is that of the Entry into Force data for the Paris Agreement whereby the latest available year in each country's reported emissions data was used to generate a global emissions dataset. While useful and acceptable for the purposes of Entry into Force criteria, the resulting dataset would be meaningless in tracking progress under the GST.

5.3 Evaluating collective progress toward the temperature limit set by the Paris Agreement

> *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, recognising that this would significantly reduce the risks and impacts of climate change.*
> *[Paris Agreement, Article 2.1 (a)]*

Progress toward the Paris Agreement temperature goal can be both directly and indirectly measured. A direct observation of current global temperatures is performed by multiple institutes and these observations can provide input to the GST in terms of how global temperature are responding to our actions (e.g. WMO, 2019). However, it is also important, and arguably more useful, to track global progress in the total emissions levels that are leading to that temperature change. Unfortunately, the translation between global emissions and expected future temperature increase is non-trivial.

To estimate future temperatures, we first need to estimate future global emissions. If we assume that the NDC mitigation targets will be met, we have some constraint on emissions until 2030 but long-term temperatures will also strongly depend on post-2030 emissions. Globally aggregated emissions in 2030 can therefore only give an indication of whether global efforts are on track to meet the goals. However, total emissions in 2030 can be used as a barometer to measure the level of effort and a number of methods have been developed for doing so. The methods vary in the extent to which they interpret the emissions level and the assumptions made about what will happen after 2030. Some approaches rely primarily on emissions totals whereas more model-based approaches also take more structural changes in energy systems into account.

Simpler approaches, that include fewer assumptions, include comparing aggregate emissions with either a carbon budget or emissions scenarios from integrated assessment models that are consistent with 1.5°C or 2°C (e.g. Rogelj et al., 2016; UNEP, 2015; UNFCCC, 2015c). Both of these approaches are relatively easy to calculate and communicate. They can give a clear indication of whether or not global efforts are on track. However, they are fairly limited in terms of evaluating how close or far away efforts are from being on track and are more appropriate for the yes / no question of 'are current efforts sufficient?' Furthermore, both of these methods do rely on assumptions common to all approaches – the IAM pathways and carbon budgets are generated from models containing assumptions about what is possible in the latter part of the century, particularly in terms of negative emissions technologies.

A more complex approach is to extend the near-term emissions pathway beyond 2030 and calculate either longer-term cumulative emissions or the warming anticipated over the full century (Climate Action Tracker, 2015; Gütschow et al., 2018). The latter is more directly comparable with the Paris Agreement goals and provides a gradational scale on which progress or regress can be measured. However, the assumptions made, and methods used to extend the pathway can have a significant impact on the resulting temperature. Jeffery et al. (2018) and Gütschow et al. (2018) examined the various methods used to-date and found that some were not capable of evaluating success at being on track to meet the Paris Goals whereas others give a broader range of results and are more consistent with economic modelling analyses. For example, Climate Interactive (2015) extended near-term emissions pathways by assuming constant emissions or a constant reduction below BAU until end of the century. Under these assumptions it's not possible to meet the Paris Agreement goals with 2030 emissions (except for the unlikely scenario that they go to zero by 2030). Alternatively, the method developed by (Gütschow et al., 2018) and used for the Climate Action Tracker uses information from a range

of modelled scenarios to extend pathways post-2030 and thereby obtains temperatures across a wider range in response to changing 2030 target emissions (Jeffery et al., 2018).

A final approach to evaluate emissions targets is to include NDCs directly into integrated assessment models (Fawcett et al., 2015; Kitous & Keramidas, n.d.; Spencer et al., 2015; Vandyck et al., 2016). By doing so, the economic and structural impacts of meeting the NDC targets can be assessed. Further advantages are that specific sectoral commitments, such as non-fossil energy share contributions, can be properly accounted for. These modelling exercises can give greater insights into the extent to which efforts required to meet the NDCs are truly transformational. These insights are particularly important in the current situation of some but limited action – although the NDCs promised reduced emissions, they are not currently stringent enough to prevent the establishment of new fossil fuel infrastructure that is incompatible with the Paris goals. However, when it comes to assessing progress against the temperature goals, these modelling exercises run into many of the same challenges as the simpler approaches described above in that assumptions about the development of emissions pathways after 2030 must be made that critically affect the results. Options in the model include increasing the carbon-price at the same rate as that required to meet the Paris Agreement goals or fixing the decarbonisation rate across the century.

From a political perspective, further constraints on the evolution of emissions pathways post-2030 may come from the long-term low emissions development strategies that Parties have been invited to submit under the UNFCCC by 2020. Those strategies that have been developed thus far are quite detailed in terms of plans for individual sectors and political processes which could be helpful in modelling exercises. However, only eleven strategies have been submitted as of May 2019[34] and given the timeframes of these strategies, there are some limitations to the confidence that can be placed in them being followed and achieved.

Some of the analyses described above are likely to be too complex for the UNFCCC secretariat to perform themselves and their assessment of global total emissions could be expected to be similar to that presented in the NDC synthesis reports (UNFCCC, 2015c, 2016d). In these reports, total global emissions in 2030 were compared with those in 1.5 and 2°C scenarios produced by integrated assessment models. The GST could, however, draw on other analysis performed or assessed by the IPCC to provide further insights.

5.4 Aggregating qualitative information on Policies, Measures and Transformation Challenges

In section 4.3.2 above we assessed the availability of qualitative information. This information may be particularly useful in informing subsequent NDCs e.g. by highlighting good practice policies. But can this information also be meaningfully aggregated? How could the GST assess collective progress, aggregate and present information on domestic policies and measures that countries have put in place to reach their NDCs? For that purpose, overarching policy frameworks or laws as well as indicative planning documents, visions, strategies or roadmaps are pertinent information sources. From the five country case studies assessed (see Annex VIII), three have **overarching policy frameworks or laws** in place, so it is questionable to what extent such information will be available on a large scale.

Beyond that, it may also be informative to assess the sectoral coverage in terms of dedicated sectoral policies. Building on existing UNFCCC documents such as national communications and bilateral reports / bilateral update reports, it should be possible to establish a meaningful survey of the coverage of policies – even more so, when the new reporting requirements of the Enhanced Transparency

[34] Communication of Long Term Strategies on the UNFCCC website - https://unfccc.int/process/the-paris-agreement/long-term-strategies

Framework take effect. A main challenge, though, is a lack of structure and a meaningful classification of policies. Including a framework that classifies policies and measures in different types of instruments in the reporting templates of the transparency framework would make the assessment in the GST much more straight-forward.

An example of how this kind of information can be meaningfully aggregated is provided by the New-Climate Policy Database. The authors categorize policies and measures according to different sectors and types of mitigation activities and assess the share of countries that have corresponding policies in place, albeit only for the top 30 largest emitters (including the EU as a single entity). The results of this analysis are presented Table 5-2 below.

Table 5-2 Coverage of selected good practice policies in top 30 largest greenhouse gas emitting countries

0% — *100%*

low coverage — *high coverage*

	Changing activity	Energy efficiency	Renewables	Nuclear or CCS or fuel switch	Non-energy
General	Climate strategy (53%)				
	GHG reduction target (87%)				
	Coordinating body for climate strategy (67%)				
	Support for low-emission RD&D (53%)				
		National energy efficiency target (57%)	Renewable energy target (67%)		
Electricity and heat		Support for highly efficiency power plants (including codes and standards and fiscal/financial incentives) (70%)	Renewable energy target for electricity sector (83%)	CCS support scheme, including fiscal/financial incentives and infrastructure investment (23%)	
		Reduction obligation schemes (10%)	Support scheme for renewables (including green certificates, fiscal/financial incentives, obligation schemes, net metering or direct investment) (87%)		
			Grid infrastructure development (60%)		
			Sustainability standards for biomass use (10%)		
	Overarching carbon pricing scheme or emissions limit (23%)				
	Energy and other taxes (10%)				
	No fossil fuel subsidies (33%)				
Industry	Strategy for material efficiency (including product standards and other requirements) (27%)	Support for energy efficiency in industrial production (including voluntary approaches, fiscal/financial incentives, obligation schemes or white certificates) (53%)	Support schemes for renewables (including fiscal/financial incentives, green certificates, obligation schemes) (27%)	CCS support scheme (including fiscal/financial incentives and infrastructure investment) (27%)	Landfill methane reduction (17%)
		Energy reporting and audits (57%)	Sustainability standards for biomass use (3%)		Incentives to reduce CH4 from oil and gas production (20%)
		Minimum energy performance and equipment standards (50%)			Incentives to reduce N2O from industrial processes (13%)
					Incentives to

0% — *100%*

low coverage — *high coverage*

	Changing activity	Energy efficiency	Renewables	Nuclear or CCS or fuel switch	Non-energy
					reduce fluorinated gases (20%)
	Overarching carbon pricing scheme or emissions limit (23%)				
	Energy and other taxes (30%)				
	No fossil fuel subsidies (3%)				
Buildings	Urban planning strategies (including infrastructure investments) (17%)	Building codes and standards and fiscal/financial incentives for low-emissions choices in heating, cooling, hot water, and cooking (60%)	Support scheme for heating and cooling (13%)		
		Minimum energy performance and equipment standards for appliances (60%)	Support scheme for hot water and cooking (10%)		
			Sustainability standards for biomass use		
	Energy and other taxes (10%)				
	No fossil fuel subsidies (10%)				
Transport	Urban planning and infrastructure investment to minimize transport needs (37%)	Minimum energy/emissions performance standards or support for energy efficient for light duty vehicles (40%)	Biofuel target (30%)	Support for modal share switch (30%)	
		Minimum energy/emissions performance standards or support for energy efficient for heavy duty vehicles (27%)	Support schemes for biofuels (including fiscal/financial incentives and obligation schemes) (53%)	E-mobility programme (17%)	
			Sustainability standards for biomass use (10%)		
	Tax on fuel and/or emissions (50%)				
	No fossil fuel subsidies (23%)				
Agriculture and forestry	Standards and support for sustainable agricultural practices and use of agricultural products (33%)				
	Incentives to reduce CO2 emissions from agriculture (23%)				
	Incentives to reduce CH4 emissions from agriculture (23%)				
	Incentives to reduce N2O emissions from agriculture (23%)				
	Incentives to reduce deforestation and support for afforestation/reforestation (63%)				

Source: NewClimate Institute (2019)

In terms of the types of policy instruments used, it is beyond the scope of this report to present a comprehensive overview of a larger set of countries.

The analysis carried out in the five case studies has revealed that a systematic reporting of transformation challenges and barriers is currently not being performed. Without such information, it is there-

fore impossible to assess collective progress towards addressing those barriers. Given this dearth of information, it may be useful to focus the discursive elements of the GST – expert dialogues, roundtables or other appropriate discussion formats – to identify common transformation challenge and highlight good practice examples off overcoming such challenges.

5.5 New tools and methods for assessing collective progress

5.5.1 General concept

To meet the combined challenges of assessing collective progress and providing relevant information, we propose that the GST use a 'performance distribution' approach. In this approach, information from individual countries is used, but in an anonymised manner. Individual country information is displayed in histograms so that no individual country is highlighted but it is nevertheless possible to see if some countries are either leading or lagging behind others. The plots also contain information about global averages and either the averages or the distribution can be compared with global (or regional) benchmarks to evaluate progress.

Under this project, a toolset has been developed to test this performance distribution approach and evaluate its usefulness and suitability for the GST. In developing the toolset, the following principles were followed:

- The tools should be usable by many and therefore built on open access tools on freely available software.
- The approach should be as simple as possible while still leaving some flexibility to the user(s).
- The analysis should work with multiple data sets and types so that it can be easily updated in the future and adapted to different assessments.

Accordingly, the toolset is written in the Python programming language (Python Software Foundation, https://www.python.org/) and uses Jupyter Notebooks as an interface. Python is freely available and runs on all operating systems. The notebooks are able to prepare data for analysis, including format and calculation of trends, and perform the analyses. All results are presented as summary statistics and plots that are easily exported. A detailed explanation of how the tools are designed and some user instructions are available in Annex V.

5.5.2 Example analyses and results

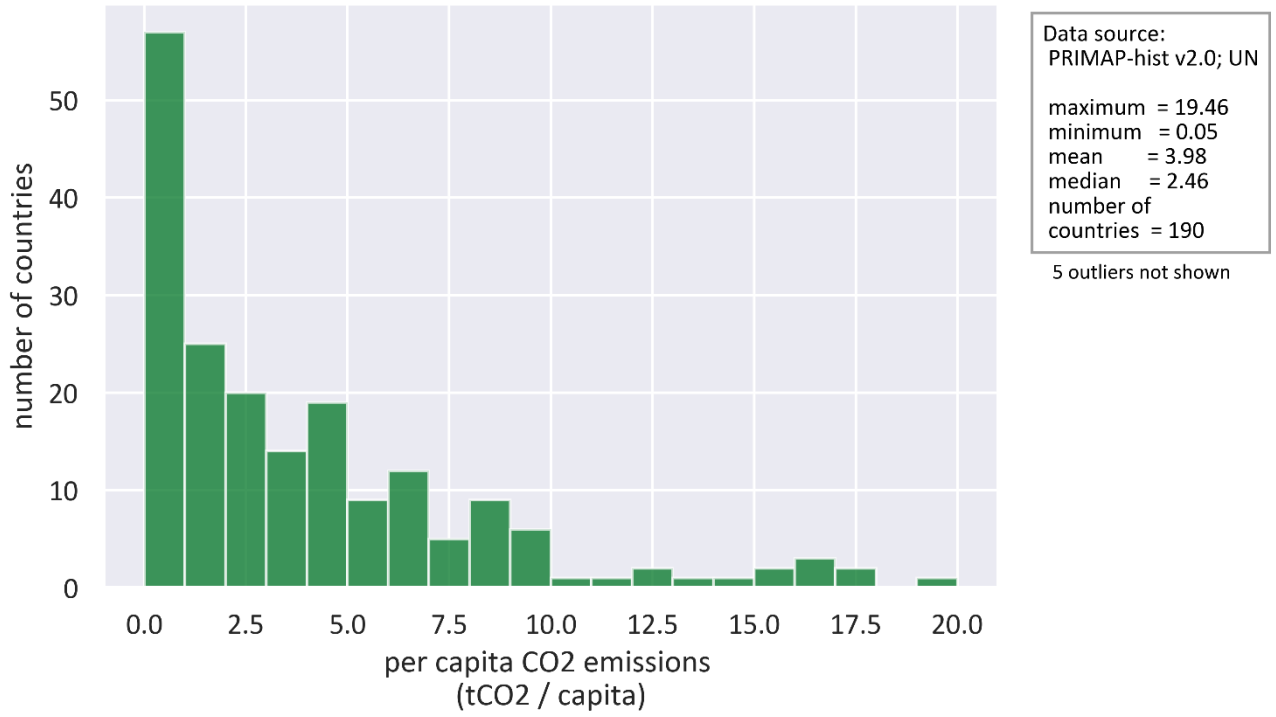
To illustrate the capabilities of the tools, we here provide five examples. Each example is appropriate for slightly different questions and types of data, but all follow a similar principle and collectively can be used for most of the indicators identified in section 3.4.

5.5.2.1 Example 1: Status quo / absolute values

The distributional approach of the collective progress tools allows us to develop an overview of how similar or different countries are and what the current status is. The first example here assesses the status quo using absolute values of indicators. Such an approach is more appropriate for normalised variables, such as intensities or per capita metrics, than national totals as the latter are highly dependent on the size of the country or economy and are not readily plotted together. In Figure 5-1 below we show the example of current per capita emissions.

For this type of analysis, we first average the variable over a few (5) years to avoid any spurious data and account for interannual fluctuations.

Figure 5-1 Absolute values of per capita CO2 emissions (national total excluding land-use)



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data Gütschow et al. (2016, 2019) and UN population data

From the per capita emissions distribution (Figure 5-1) we can easily see that a few countries have much higher per capita emissions than the majority. In more than 25% of countries, per capita emissions are less than 1t CO_2/ person.

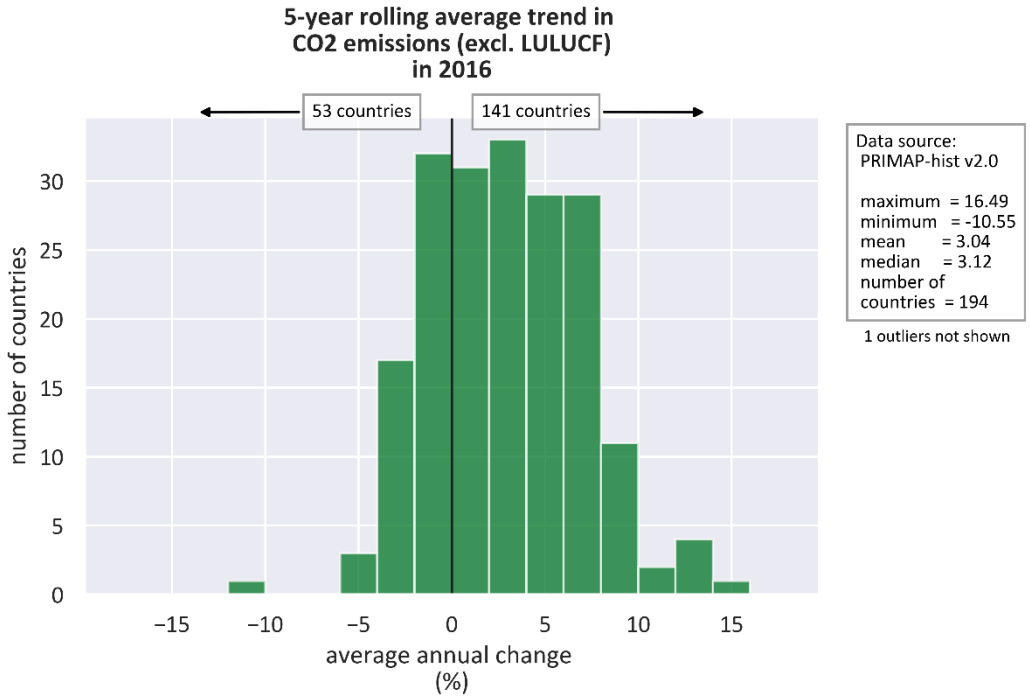
Per capita emissions is one measure of equity and if this distribution were to narrow through time it would indicate a shift toward a more equitable world. For meeting the Paris Agreement goals, the average global per capita emissions would have to decrease at the same time.

5.5.2.2 Example 2: 5-year rolling average trend in emissions

In addition to the status quo, it's also important to look at current trends; are most countries on a positive or negative trajectory? How do current trajectories compare with those required for 1.5°C or 2°C?

In Figure 5-2 we show the 5-year average of recent trends in total emissions. Unlike for absolute emissions, we do not need to normalise by population or GDP as the trends are more evenly distributed. In the majority of countries, recent emissions are still increasing with an average of 1.7% across all countries. This contrasts strongly with the need for strong reductions in emissions over the coming decades.

Figure 5-2 Monitoring trends in emissions



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data (Gütschow et al., 2016, 2019).

In chapter 0 we outlined that meeting the Paris Agreement goals means that all countries should peak as soon as possible, with developed countries peaking sooner. From Figure 5-2 we can see that in 141 out of 195 countries, CO_2 emissions have continued to increase over the last 5 years. Emissions have only decreased in 53 countries over the same time period. Note that 1 'outlier' country is not shown in this plot.

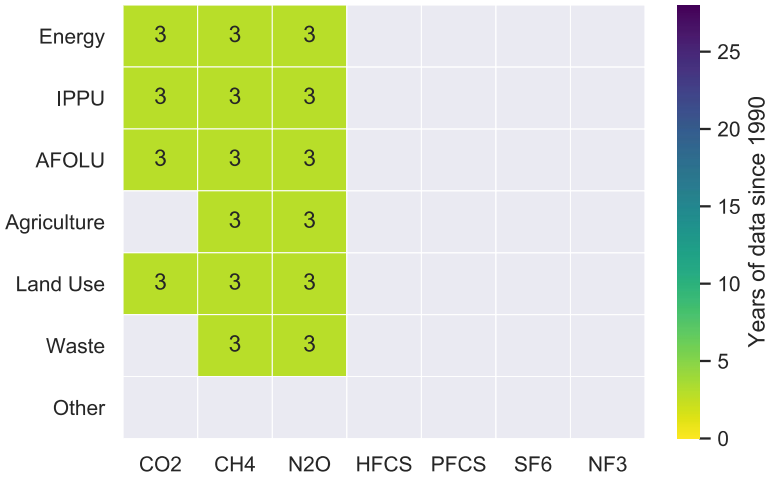
In subsequent GSTs we should see more countries with decreasing trends in emissions and a convergence toward the emissions reductions rates required by global modelling assessments. Macroeconomic models can give a guide (benchmark) to the annual emissions global and regional emissions reduction rates that are necessary for meeting the Paris Agreement goals. A challenge for these figures is how to implement any equity considerations for individual countries when comparing them to these reduction rates.

5.5.2.3 Example 3: Assessing completeness of times series data

The performance distribution toolset also contains tools to assess the coverage of dataset, in particular emissions reporting under the UNFCC. This tool assesses the temporal and sectoral coverage of individual countries' reporting.

In the first type of assessment, the number of years reported (within a specified time frame) for each individual gas and sector is counted. In the example below (Figure 5-3), India has reported information for most gases and sectors, but only for three years. Data for fluorinated gases (expected from the IPPU sector) are also missing.

Figure 5-3 Number of years of data reported by India to the UNFCCC, by sector and gas, between 1990 and 2016

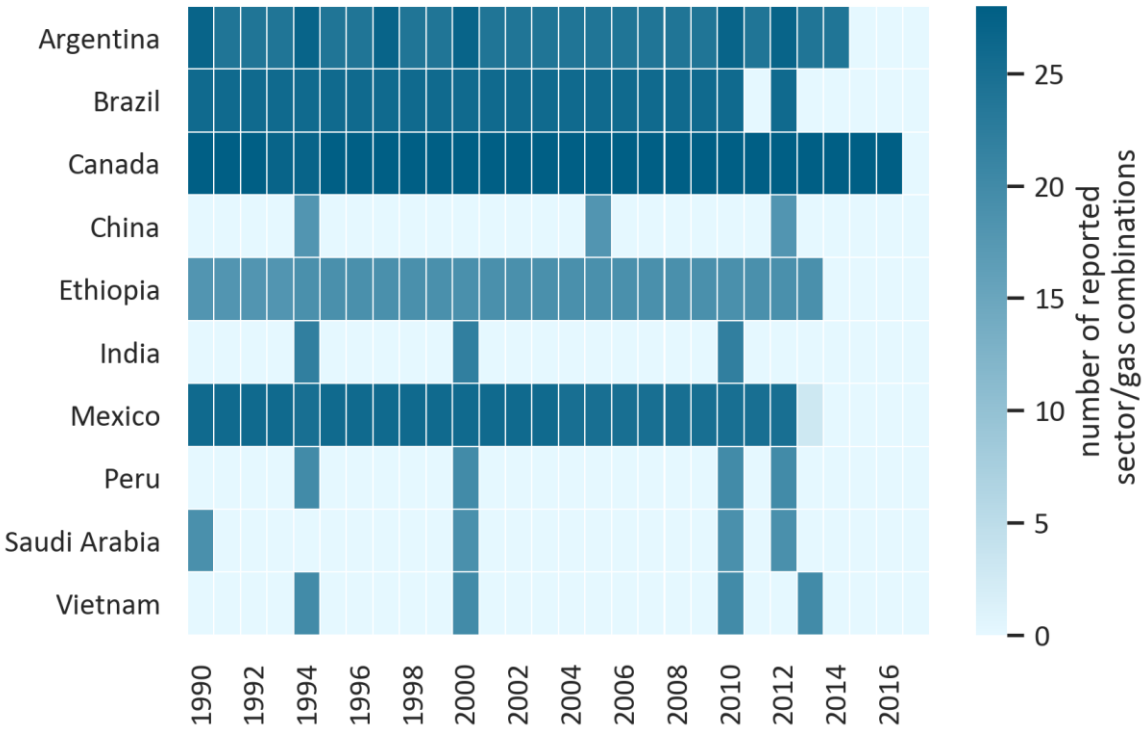


Source: Figure generated using Performance Distribution tools developed for this project and using data submitted to the UNFCCC as of November 2018 and collated in PIK's PRIMAP database.

As the continuity of data is important, it's also useful to know which years countries report data for; are the data points sparse or has a country begun to report more continuous information? The second type of plot allows this to be readily observed for a number of countries. Here we can see that India has reported data for the years 1994, 2000, and 2010. This figure additionally contains an overview of the number of gas / sector pairs that are included in the reporting; the darker the shade of blue the more comprehensive the reporting in terms of sector and gas coverage. This commonly remains consistent throughout the years for most countries but may change (e.g. Argentina).

These two plots allow for a quick assessment of how comprehensive data availability is, and for which years more data is available.

Figure 5-4 Number of years and sectors reported to the UNFCCC since 1990



Source: Figure generated using Performance Distribution tools developed for this project and using data submitted to the UNFCCC as of November 2018 and collated in PIK's PRIMAP database.

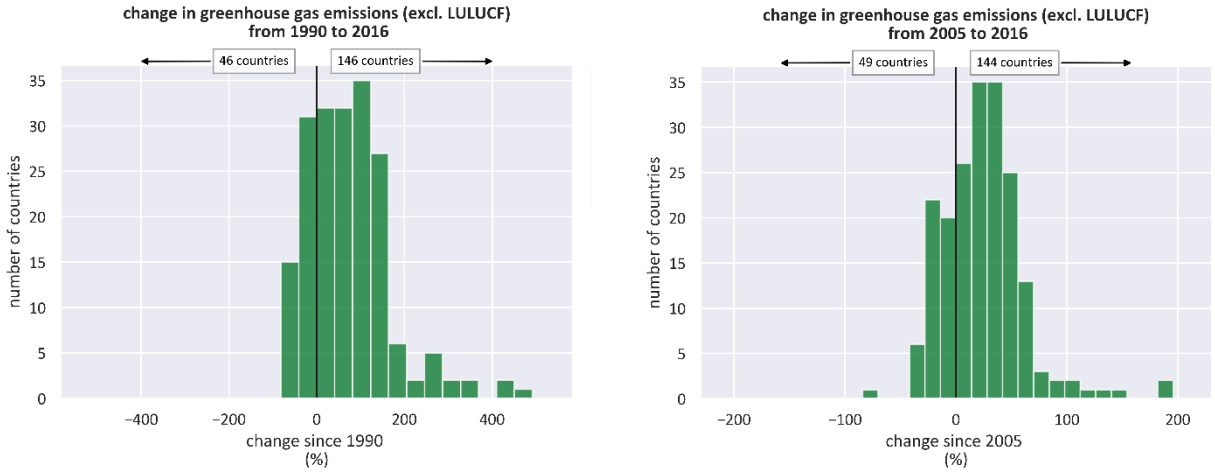
5.5.2.4 Example 4: Making progress comparable

One of the challenges of the NDCs is that their bottom up nature makes them difficult to compare. In an effective GST it would be possible to make progress more comparable between countries so that leaders and laggards could be identified. Without singling out individual countries, it's still possible to show if the majority of countries are performing well and/or similarly. The performance distribution approach therefore makes it possible to compare countries using different methods of evaluating ambition or progress.

In the example below (Figure 5-5) we use the commonly used metric of evaluating changes in emissions relative to an historic year. Many NDCs are framed as a reduction below a base year but with different base years. This type of calculation and figure allows the current status, or potentially also NDC targets, to be framed according to multiple different base years. In assessing the current status, or historic changes the GST would really be taking stock and highlighting the progress made to date.

In addition, these figures also outline a general measure of progress; only around one quarter of all countries have decreased emissions since either 1990 or 2005 with the rest having increased emissions since these base years. What is further striking from these figures is the magnitude of emissions increases – in the 11 years from 2005 to 2016, a significant number of countries emissions increased by 50% or more.

Figure 5-5 Change in emissions compared to 1990 and 2005



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data (Gütschow et al., 2016, 2019). Note the change in scale between the two plots. Three outliers are not shown in the left-hand side plot and two in the right-hand side plot. Please see appendix V for an explanation of how and why outliers are excluded.

The first GST could present a figure similar to this one to examine the change in emissions since the Paris Agreement was accepted. If that figure were similar to those shown above for the historic trend, it would serve as a clear indication that the Paris Agreement has not yet translated into action. Alternately, if the distribution has shifted clearly to the left, it would show that the majority of countries were making progress and any outliers are either frontrunners (to the left) or laggards (to the right). Any individual country would be able to place itself within the distribution and know how it was performing relative to others. Such peer pressure could contribute to the enhancing ambition function of the GST.

5.5.2.5 Example 5: Peaking emissions assessment

In chapter 0 we examined how peaking emissions is an important metric toward meeting the Paris Agreement goals, both at the global and national levels. At the global level, a peak in emissions is a necessary first step on the way to decreasing emissions and eventually reaching a balance of sources and sinks. As with all global metrics, global peaking of emissions relies on peaking of national emissions and some countries (notably China) have also specified peaking emissions as a part of their NDC target.

However, identifying a 'peak' in emissions can be quite challenging because emissions can 'peak' and then grow again later, emissions growth can stall but not decline, or can fluctuate significantly on an inter-annual basis, particularly if land-use emissions are included. It's therefore difficult to evaluate if emissions growth has really peaked or only temporarily stalled. For example, in 2016 the Global Carbon Budget (Quéré et al., 2016) identified a slow-down in global CO_2 emissions growth and a stabilisation or peak had been speculated, but the 2018 report (Quéré et al., 2018) identified further emissions growth.

Furthermore, when assessing the progress against the global goals, it's not only the peaking that matters but also the rate at which emissions decline after peaking (Levin & Rich, 2017) and therefore what the underlying driver of the emissions growth trends are.

We propose the following criteria for identifying countries whose emissions have 'peaked', 'stabilised', or are 'still growing'. For emissions to have **'peaked',** we require that:

- maximum emissions occurred at least 5 years ago (consistent with Levin and Rich (2017))
- maximum emissions occurred since the year 2000
- the trend in emissions, averaged over the last 5 years, is decreasing by at least 1.5% per year

The **'stabilised'** category includes countries that either meet the first two maximum emissions criteria and have an average emissions growth rate over the last 5 years of between -1.5 and 0.5% per year, or have peaked emissions more recently (within the last 5 years) but now have strongly decreasing average annual growth rates (more than 1.5% decrease per year).

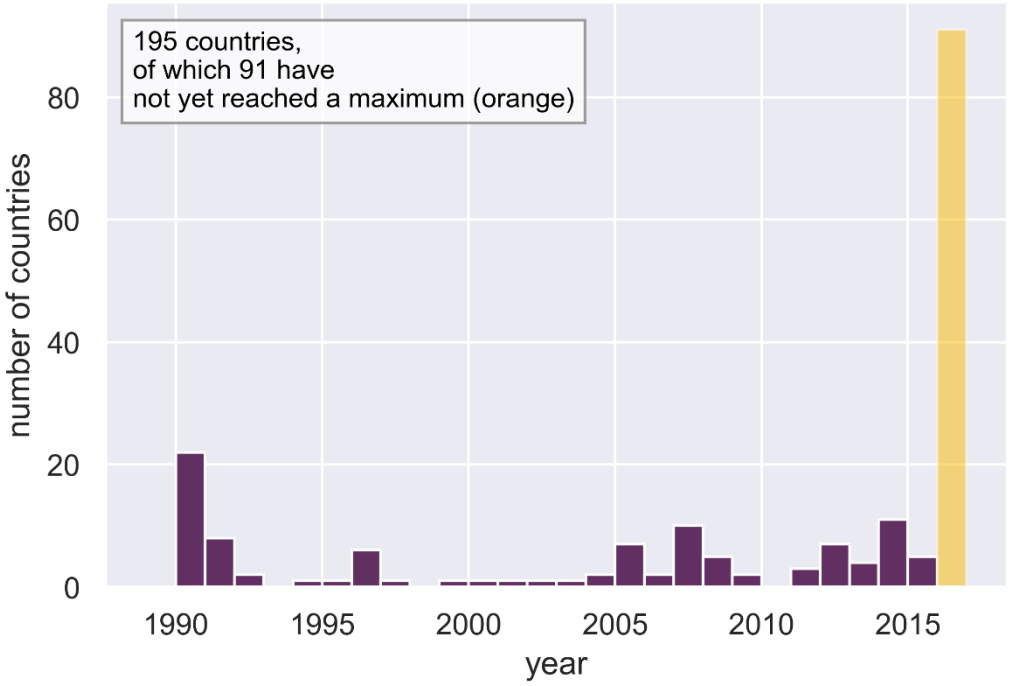
Finally, countries that do not fit in either of these two categories, that is countries whose emissions have not yet reached a maximum and/or are not decreasing sufficiently strongly, are considered to be **'still growing'**.

By including a criterion of current trends, the framework excludes those countries from the 'peaked' category whose emissions were higher in the distant past than they are today (e.g. former Soviet Union countries), unless recent emissions are still decreasing. Countries whose first peak has reversed are still contributing to growing global emissions and a second peak in emissions will be required to transition to a Paris consistent trajectory.

The collective assessment tools include a notebook to evaluate the above peaking criteria and to establish which countries belong to each of the three groups. Firstly, the year in which individual countries reached a maximum in emissions (or another variable) is calculated and plotted. Countries whose emissions (or other variable) have not yet reached a maximum are indicated separately in orange.

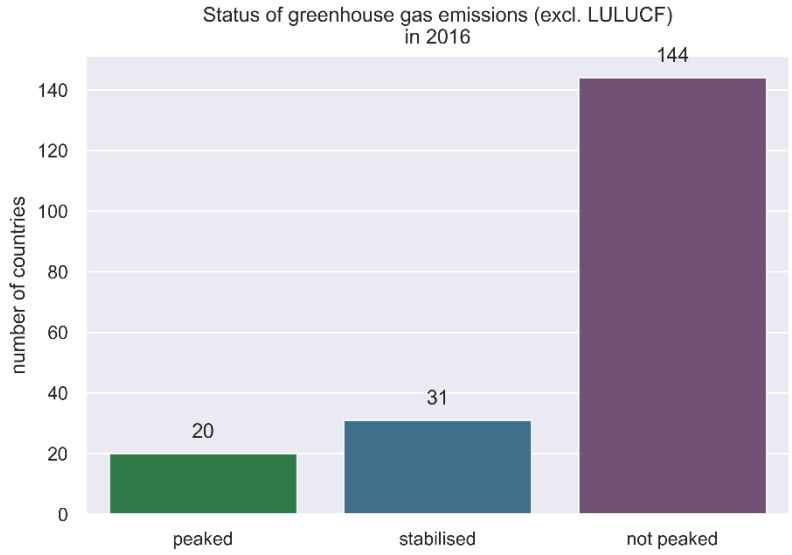
Secondly, the three groups described above are established and also plotted (Figure 5-7). Note that the additional criteria mean that although only 91 countries have not yet reached a maximum, 144 countries are classified as not yet peaking. This is because the recent trajectory for these countries is not yet decreasing sufficiently to give confidence that emissions have really peaked. The trajectories leading to the classification can also be visually checked for individual countries (see Appendix V).

Figure 5-6 Year in which individual countries' emissions reached a maximum



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data (Gütschow et al., 2016, 2019).

Figure 5-7 Number of countries in each category of 'peaking' emissions for total greenhouse gas emissions (excl. LULUCF)



Source: Figure generated using Performance Distribution tools developed for this project and based on PRIMAP-hist v2.0 data (Gütschow et al., 2016, 2019).

With the above two graphs we can see that more countries have reached a peak in emissions in recent years (between 2005 and 2015) but that very few countries have peaked (20) or stabilised (31) their emissions. In comparison, 144 countries fall in the 'not peaked' category. Such a graph can serve as a reminder that peaking is possible, and at the same time a push that many more countries need to peak or stabilise emissions as soon as possible.

Subsequent GSTs could compare progress, with many more countries expected to lie in the ‘peaked’ or ‘stabilised’ category by 2028 than in 2023.

5.5.3 Evaluation of “performance distribution” approach

The “performance distribution” approach developed and described here allows the anonymity and collective progress criteria of the GST process to be met while still enabling a more informative assessment than global averages alone.

Independent actors, including civil society and policymakers, would be able to locate their country within the distribution and know if their performance were rather as a leader or a laggard. The approach also allows for a collective assessment of whether all countries are moving together or whether there are clear leaders that have made substantial progress. The approach thereby circumnavigates a naming-and-shaming while not letting individual countries hide within a global number.

Furthermore, the approach is designed in such a way that it can be applied consistently for many indicators and so should be more accessible to a wide community. Once one figure is explained and understood it’s easy to translate that understanding to other indicators and figures.

6 Results and conclusions

6.1 Discussion: Can the conditions for an effective Global Stocktake be met?

In section 2.3 we have elaborated on a range of different process and information-related conditions for a successful, i.e. most effective, GST (see Table 2-1). In this section we reflect back on these conditions in the light of the above analysis and discuss whether and to what extent these conditions can be met taking into account i) the modalities of the GST as adopted in Katowice, ii) the available information from official UN sources and third party sources, and iii) the aggregation methods provided in section 5.5 above.

6.1.1 Pacemaker Function

For the pacemaker function of the GST we highlighted 1) the need of relevant information being available on time to be reflected in the GST and 2) the need for high-level endorsement and public attention for the results of the GST. Given that the Enhanced Transparency Framework and the biennial transparency reports are only required after 2024, **the first GST will face severe shortcomings with respect to the information available**, particularly with respect to self-reported and hence official UNFCCC approved information. However, from 2024 it is obligatory for all countries to submit transparency reports every two years following common reporting guidelines. It can be expected that efforts and support to submit information in time will be significantly enhanced from 2024 onwards. We have identified a plethora of alternative data sources outside of the UNFCCC, but the majority of these are likely not to be acceptable in the UNFCCC process if institutions are not part of the UN system, or data stems from private initiatives etc. (e.g. IEA world energy outlook or Bloomberg New Energy Finance). Moreover, many of these data sources are not comprehensive in terms of countries covered and/or time series being available. Finally, some of the most comprehensive and potentially useful datasets are only commercially available. Arguably, this should not pose an impediment to the GST as such but could hamper transparency of the process and the further exploitation of the analysis e.g. by civil society actors on the national level.

A further condition outlined in section 2.3.1 above was that the outputs of the GST receive sufficient legitimacy/authority through high-level endorsement as well as public attention during the political phase of the GST. The modalities of the GST adopted in Katowice foresee a political consideration of outputs including a high-level segment with inclusion of the ministerial level, but it does not prescribe in what form the conclusions should be documented. It is up to Parties to decide whether the outcomes of the GST should be recorded e.g. in the form of a non-binding political declaration, or a COP decision with some prescriptive formulations for how a country shall take the findings of the GST into consideration in the preparation of their subsequent NDCs. W**hether the GST will be able to function as a pacemaker will thus depend on (1) the decision by Parties on the outcomes of the GST and (2) the extent to which countries thoroughly implement the Enhanced Transparency Framework.**

6.1.2 Ensuring Accountability

To ensure that the GST can effectively contribute to ensuring accountability (1) accurate and sufficiently granular information needs to be available to enable tracking of progress and (2) the GST needs to create a moment of public appraisal of national inputs to the process in order to put policy makers into the spotlight, particularly those who have failed to implement their NDCs .**The ability of the GST to effectively contribute to ensuring accountability is severely limited**. Firstly, as outlined above, the availability of information is limited, at least for the first iteration of the GST. As of 2024, this can be expected to improve, but it remains to be seen, to what extent Parties will take advantage of the flexibilities implied in the reporting guidelines of the Enhanced Transparency Framework (particularly with regard to the submission of projections and the quantification of policies and measures). This

might lead to important gaps in reported information. Moreover, in practice, a lack of capacities, resources or expertise may continue to pose obstacles to comprehensive reporting. It takes a significant amount of time to establish robust reporting systems and where such systems are not in place yet, enhanced reporting requirements alone will not suffice. The capacity building initiative for transparency will be an important instrument to address such lack of capacities.

What is more, the NDCs themselves are still in many cases not sufficiently clear and transparent to allow for robust assessment. Again, the Katowice rulebook specifies further information requirements for NDCs, the so-called "information to enhance clarity, transparency and understanding" (ICTU) of NDCs. Yet, these requirements are only mandatory for subsequent rounds of NDCs which will need to be defined more clearly and indicators for tracking progress towards NDCs need to be explained and methodologically specified (e.g. with regard to the reference or base year). Parties also adopted a decision in Katowice which "strongly encourages" Parties to apply those requirements already when revising or updating their first NDCs in 2020 (W. Obergassel et al., 2019).

Secondly, it is questionable whether the GST can create sufficient public attention to put policy makers into the spotlight, particularly those who have failed to implement their NDCs. As discussed above, singling out individual countries will not be possible under the GST. The modalities of the GST adopted in Katowice only provide a mandate for the UNFCCC Secretariat to prepare a synthesis report. It is not clear how far the Secretariat can go in highlighting failure of countries to implement NDCs. To be most effective regarding the accountability function **an anonymised 'transcript of grades'** could be included in the report. This could include statements like 'X countries representing Y per cent of global emissions show significant implementation deficits and are unlikely to meet their targets unless implementation is improved.' The report could be the basis of discussions and serve as a means to hold countries accountable. It would be accessible to various stakeholders and could be used to create political pressure on the national level. How these reports will be considered in the technical assessment is currently not specified in the modalities for the GST though.

Much better suited to ensure accountability – at least from a technical point of view – is the so-called "multilateral consideration of progress" mandated under Article 13.11 of the Paris Agreement. Under the multilateral assessment established under the International Assessment and Review process created as part of the Cancun Agreements progress of individual countries is publicly assessed and reviewed. Unfortunately, previous experience with this process does not suggest that it will be an effective tool to hold policy makers accountable. In practice, this process received very little public attention, nor have other countries used it to put particular pressure on their peers. Likewise, the Talanoa-Dialogue, despite its originally high profile and extensive participation from all kinds of stakeholders, ultimately did not receive a lot of public attention either.

This leads us to conclude that measures to maximize public attention are indeed key for an effective GST. Only then can civil society and the global scientific community support the official process and create complementary assessments that are explicitly naming countries and highlighting both failures as well as means to improve the implementation.

6.1.3 Driving NDC Ambition

For the driving NDC ambition function of the GST we again defined two overarching conditions namely (1) whether the GST can define benchmarks for ambition which can be used to assess the adequacy of subsequent NDCs and (2) whether it promotes peer-learning and highlights positive developments and synergetic opportunities.

We have discussed the potential for and challenges with the establishment of benchmarks at length in section 3.5 above. **Despite significant challenges, it should be feasible with available information and within the mandate of the GST to define credible overarching benchmarks** including:

- Expected aggregate emissions trajectories should be consistent with 1.5°C according to integrated assessment modelling scenarios and assessed by the IPCC.
- Current pledges (as projected by various assessment and modelling groups) should secure at least a 50% chance of limiting warming to 1.5°C above pre-industrial levels.
- Global emissions should have stabilized in time for the first GST in 2023 and have peaked and declined in 2028 globally.
- Eventually all countries will have to achieve a peaking of their emissions.
- The balance between anthropogenic GHG emissions from sinks and removals in sinks needs to reach zero as soon as possible after 2050.

However, with increasing levels of granularity it becomes more and more difficult to establish commonly acceptable benchmarks. Ideally, the GST would also set sectoral benchmarks e.g. for energy, industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU), or waste. Such benchmarks would allow policy makers on the national level to develop a more holistic perspective on their own mitigation activities.

From official UNFCCC sources, it seems impossible to create such sectoral benchmarks and it would certainly exceed the capacity (and authority) of the UNFCCC Secretariat. If anything, the IPCC would have to play a major role in setting global and more specific benchmarks as it is the most authoritative scientific body to do so. Following the example of the recent 1.5°C Special Report which was also "invited" by Parties through a corresponding COP decision (1/CP.21 §21), Parties could send a call to the IPCC to determine those benchmarks to feed into the GST. To maximize the effectiveness, the benchmarks formulated and proposed by the IPCC would then have to be officially endorsed also as part of the political consideration of outputs.

The integration of equity considerations, however, remains an unsolved question. Should all countries be measured against the same benchmarks? How and who is going to decide which benchmarks apply for which group of countries? etc. (also see Winkler, 2019).

Finally, we propose that the performance distribution tool presented in section 5.5 above has the potential to further facilitate the effect of credible benchmarks. Including global benchmarks in the visualization of the assessment of collective progress enables observers and parties themselves to evaluate their own performance against the benchmarks. While making such an evaluation explicit would exceed its mandate, providing the tools to perform such an evaluation is, in our view, an essential task for the GST.

With regard to facilitation of peer learning and sharing of experiences that might trigger enhancement of ambition in other countries, relevant information on policies and measures and their mitigation effects is already included by many countries in their national reports. As a new reporting element, it has been proposed in the negotiations to provide information on co-benefits of mitigation activities as well as on indicators and sources of data used to track progress on mitigation co-benefits from adaptation (UNFCCC, 2018c). However, there is no information being collected (systematically) on the obstacles, the main transformation challenges that countries face across all relevant sectors. Such information would be highly relevant though and make it much easier to relate findings of the GST to tangible problems at the national and subnational level. Neither the current nor the future transparency framework requires countries to reflect on the challenges they face in a systematic manner. For instance, by specifically considering economic barriers, political and institutional barriers, technological barriers as well as lack of awareness, information availability and capacity constraints it would be much easier to identify common challenges and use this information to systematically identify good practice policies and measures countries have successfully used to overcome similar challenges.

Overall, providing information on successful mitigation policies to the negotiations to fulfil this function will be more a question of how to design the process of the GST than to generate new

types of information input, though. A main task for the design of the political phase of the GST will be to identify ways of how to most effectively share best practice examples of mitigation options. In designing such a process, the GST would particularly benefit from a more structured classification of different types of policies, sectors addressed, and main mitigation options being addressed by those policies.

The good news is that the modalities of the GST provide for technical dialogues to be held by means of "in-session round tables, workshops or other activities" (UNFCCC, 2018b, para. 6). This creates ample leeway for the Chairs of the subsidiary bodies – the GST will be supported by a joint contact group of the Subsidiary Body for Implementation (SBI) and the Subsidiary Body for Scientific and Technological Advice (SBSTA) – and the assigned co-facilitators of that contact group to provide a meaningful structure for the technical assessment. The facilitators have the responsibility to make sure that the exchange is focused and oriented towards actual positive learning. It must not result in an endless repetition of previously stated commitments nor must it become a forum for greenwashing lack of ambition, demonstrating effective shirking of responsibility, or pretence of ambition.

Ideally, this would take the form of **structured dialogues of experts**, which should focus on relatively concrete (sectoral) transformation challenges in order to fully exploit their potential. Input from non-state and subnational initiatives could be particularly valuable here and the modalities of the GST enable this stakeholder engagement. How could these technical dialogues be structured? Huang (2018) draws parallels between the GST and the voluntary national reviews under the Agenda 2030 for Sustainable Development and the Sustainable Development Goals. Countries that have made good progress could volunteer to undergo an in-depth review including an independent assessment of ambition and implementation in order to promote their success stories even further. Milkoreit & Haapala (2018) suggest that the first periodic review (2013-2015) of the adequacy of, and overall progress toward, achieving the long-term global goal could serve as a valuable precedent, in particular the Structured Expert Dialogue (SED) that was conducted under this review. They particularly highlight the fact that the SED created a true science-policy dialogue with expert presentations followed by questions from parties and a subsequent dialogue. Moreover, they highlight that "the hybrid nature of the First Periodic Review – not being a negotiation space but taking place within the negotiation context rather than outside of it – was important for its ability to influence the negotiation dynamics." (Milkoreit & Haapala, 2018, p. 101)

Alternatively, the dialogues could be modelled, for example, after the existing Technical Examination Processes (TEPs) held under the joint auspices of the UNFCCC's Subsidiary Bodies for the topics of mitigation and adaptation, or the Technical and Economic Assessment Panel (TEAP) under the Montreal Protocol on Substances that Deplete the Ozone Layer (Hermwille, 2018). The latter has been particularly successful in translating technical work at the expert level into a gradual increase of ambition at the political level (Andersen & Sarma, 2002; Gonzalez et al., 2015). (Wolfgang Obergassel et al., forthcoming). A key lesson from the Technical Examination Process is that designing the interface between the technical phase and the political phase is particularly challenging. While the TEP worked well in identifying good practices, these insights never resulted in a meaningful political uptake of the identified policy options (Hermwille, 2018). This failure must be avoided in the GST (see also chapter 2.3.1.1).

6.1.4 Guidance and Signal

To meet the guidance and signal function, the GST needs to 1) reinforce the collective goals of the Paris Agreement as well as to 2) further develop and refine the existing signal, e.g. by spelling out sector-specific transformation challenges and pathways. **Whether this function can be met to a large extent depends on the process design and less on the information available.** This is particularly true with respect to the reinforcement of the collective goals provided in the Paris Agreement. To what extent the COP will be able to send the signal of renewed demonstration of commitment will de-

pend on the COP Presidency as well as on the facilitators of the political consideration of outputs and the way in which they chose to adopt the conclusions of the GST.

Box 6-1 A complement or competition? The "periodic review of the adequacy of the long-term global goal" under the Cancún Agreement.

Another process to watch in this regard is the periodic review of the adequacy of the long-term global goal in the light of the ultimate objective of the Convention, and overall progress toward achieving the long-term global goal, including a consideration of the implementation of the commitments under the Convention. This periodic review under the Convention, not the Paris Agreement, was adopted by Parties in 2010 as part of the Cancún Agreements. A first review carried out in the 2013-2015 period in the form of a structured expert dialogue was instrumental in that it stipulated that the 2°C target was insufficient to avoid dangerous climate change and therefore proposed the 1.5°C target instead. Arguably, without the conclusions of the structured expert dialogue, the 1.5°C target would not have found its way into the Paris Agreement. Deciding on the scope of the second periodic review is now on the agenda of the upcoming COP25 in Madrid and will expressly take into account the modalities of the GST in view of the close relationship of the two processes.

The second aspect of the guidance and signal function – to further develop and refine the existing signal – also crucially depends on process design. The idea is that the GST could for instance institutionalize credible sectoral pathways or roadmaps that are aligned with the overall objectives of the Paris Agreement. However, to date there are relatively few if any authoritative and commonly accepted pathways/roadmaps of that kind. Here again, the GST crucially depends on external inputs, particularly from the IPCC and other sources of "best available science". In the meantime, as long as such roadmaps do not exist, the GST could try to gather such information through establishing corresponding in-session expert dialogues that may be able to establish a consensus on which to base further political conclusions in a discursive manner. Again, the modalities of the GST leave it at the discretion of the chairs of the GST to organize the expert dialogue in a way corresponding to this function, or not.

6.2 Overall Conclusions

The 2018 Talanoa dialogue was structured according to three questions: Where are we? Where do we want (need) to go? And how do we get there? Although these three questions are not contained explicitly in the modalities for the GST, they are still likely to guide and structure the analysis building on the experiences of the Talanoa Dialogue. Building on our analysis we can get back to these questions and ask, to what extent the GST can be expected to address those very questions.

Where are we? Even with existing information, it is possible to answer this question. The official UNFCCC reported GHG emission data is still riddled with information gaps – countries not reporting accurately for all gases/sectors or only for specific years and not comprehensive time series. On the other hand, the availability of information is bound to improve significantly when the reporting requirements of the Enhanced Transparency Framework take effect as of 2024. Still substantive capacity building efforts will be required to enable countries to build reliable monitoring and reporting systems in due time. However, additionally available information from third parties is reliable and detailed enough to fill those gaps and to enable the development of an accurate picture of GHG emissions on the aggregate level. Unfortunately, that picture is not a pleasant one. Collectively, the world is far off a sustainable development pathway towards well below 2°C, let alone 1.5°C.

With respect to the progress of implementation, again the Enhanced Transparency Framework will improve the information basis. The challenge will be that the GST has no mandate to single out those countries that fail to fully implement their NDCs. Even on the aggregate level, it remains to be seen whether it will be politically feasible to expressly quantify the number of countries that are failing to implement their NDCs or whether they meet the previously identified benchmarks. The performance

distribution tool developed in this project could within the narrow mandate of the GST help to provide a relative differentiated picture of where we are without singling out individual countries. Additionally, progress as well as challenges of individual or groups of countries to implement their NDCs could be highlighted in a forum for sharing experiences and best practices along the proposals outlined above.

Where do we want (need) to go? Our discussion of benchmarking has shown that building on existing research and information, it seems possible to determine global benchmarks at least for the most overarching metrics such as aggregate emissions, stabilization/peaking of emissions, net zero balance between GHG sources and sinks. However, for this the GST will crucially depend on the IPCC as the most authoritative source of "best available science".

If corresponding benchmarks are included in the proposed performance distribution charts, again the proposed tool can meaningfully contribute to addressing this second question. At present, the availability of benchmarks is limited to overarching dimensions, so the relevance and instructiveness of the visualizations is also limited. A potentially valuable area of research in the coming years is to further elaborate on pathways to 1.5C at the (sub-)sectoral level. Doing so would both provide additional information to enhance the performance distribution visualisations and provide more concrete input to the political discussion of "where do we want to go?"

How do we get there? The overarching benchmarks mentioned above can only provide a general sense of direction – like a compass though. They do not provide – like a satellite navigation system – the potential routes and specific destinations for the required transformation. For that, more detailed sectoral pathways and roadmaps translated into specific benchmarks would be required. The IPCC with its sixth Assessment Report may contribute such roadmaps authoritatively. Major challenges persist regarding the lack of structure and classification of policies/sectors/mitigation actions under the current reporting framework. While this situation might improve with the Enhanced Transparency Framework after 2024, another major shortcoming is that the obstacles and transformation challenges that lie in the way are not being systematically reported nor reflected upon by Parties. And finally, the mandate of the GST does not allow it to make country-specific recommendations and call out those who are moving in the wrong direction.

6.3 Specific Recommendations

6.3.1 Recommendations for the official GST

As stated previously, the information base for the second and subsequent GSTs is bound to improve significantly with the Enhanced Transparency Framework taking effect after 2024. For the first GST, the UNFCCC Secretariat should make use of the extensive information available from third party sources to complement the limited information provided through official reporting mechanisms under the UNFCCC. The IPCC will play a crucial role in lending authority to all kinds of information including on required emissions pathways, sectoral roadmaps and most importantly benchmarks against which proposed new NDCs can be assessed. But besides these, we have identified a set of issues with regard to information being not available or not acceptable that cannot be remedied easily. For some of these issues, however, a proper process design of the GST may make up some of the deficits. In this section we list key recommendations for the GST process design and implementation thereof.

- The GST should include an explicit **public appraisal of the inputs**, especially the transparency reports and technical reviews thereof. This would help to increase public attention for the whole process as well as to generate interest in specific sources of input to the GST which also includes country-level data. Particularly the GST should take the proceedings of the multilateral considerations of progress into account. To summarize the progress regarding implementation of NDCs we propose that the UNFCCC Secretariat could create an **anonymised "transcript of grades"** of the form "X countries representing Y per cent of global emissions show

significant implementation deficits and are unlikely to meet their targets unless implementation is improved."

- For a graphic representation of collective progress and relating it to a global benchmark of where progress should be, we propose that the UNFCCC Secretariat may apply the **performance distributions approach** developed in this project. We suggest that within the narrow mandate of the GST the performance distribution presents the most differentiated analysis of "collective progress", providing information that is relevant at the national level while maintaining anonymity of individual countries.
- To exchange information on sectoral transformation challenges and barriers, **the expert dialogues mandated in the modalities of the GST for the technical assessment should include structured expert dialogues on key sectoral systems** including energy, emission intensive industry, transport, agriculture[35], forestry and other land use as well as waste. These expert dialogues should focus on actual positive learning. They must not result in an endless repetition of previously stated commitments nor must it become a forum for greenwashing lack of ambition, demonstrating effective shirking of responsibility, or pretence of ambition. In particular the dialogues should focus on:
    1. identifying key sectoral transformation challenges and barriers commonly shared by many developed and developing countries taking into account economic, political and institutional, technological barriers as well as lack of awareness, information and capacity constraints;
    2. collating good practice policies and measures to overcome those challenges and barriers;
    3. agreeing on milestones for sectoral decarbonization pathways/roadmaps that may serve as benchmarks for subsequent NDCs.
- The IPCC will be a key source of information for the GST particularly with respect to the determination of benchmarks. Hence, we propose that **the COP should call upon the IPCC to assess the available research specifically with a view to identifying benchmarks** (including for key sectors) for what is required to meet the objectives of the Paris Agreement. Those benchmarks can then be used to inform and assess subsequent NDCs, not only overall but also their respective sectoral targets and policies.
- The political consideration of outputs of the GST should
    1. **convincingly reinforce Parties' continued commitment to the goals of Paris Agreement;**
    2. **develop and refine existing signals through more specific messages at sector level** by highlighting sector-specific challenges and benchmarks so that they receive public attention and appropriate consequences can be taken;
    3. **politically endorse the benchmarks** identified in the technical assessment of the GST
    4. and **call upon Parties to align their subsequent NDCs with those benchmarks** by means of a COP decision.

6.3.2 Recommendations for complementary activities outside of UNFCCC

Given the relatively narrow mandate for the GST provided in the Paris Agreement as well as the limitations of the political realities of UNFCCC negotiations, we argue that whether or not the GST is effective, whether it can catalyse "the highest possible level of ambition" in subsequent NDCs, not only depends on the design and execution of the official process, but also how it is received, communicated and utilized by Parties, Observers and the wider public.

[35] The "Koronivia joint work on agriculture" mandated by COP decision 4/CP.23 is a rare example of sectorally focused technical work under the UNFCCC and could lend inspiration to the proposed sectoral structured expert dialogues.

In the spirit of the Paris Agreement which explicitly acknowledges the role of all kinds of stakeholders, we therefore argue that the catalytic effect of the official GST could be supported by accompanying activities from civil society and the global research community.

To support the **Pacemaker Function,** it is necessary to first of all amplify the messages from the GST and contextualize them in respective national discourses. This requires the research community to translate global aggregates into nationally specific requirements and recommendations and break down global benchmarks to the national level. Following up on these research activities, civil society should seek to coordinate their storylines and orchestrated media strategy to maximize the agenda setting effect of the GST.

With respect to the **Ensuring Accountability** function we have figured that the official GST can only have an enabling role. It can only enable comparability of ambition and progress of implementation; it cannot do the actual comparison. This is, of course, the natural next step for actors outside the official UNFCCC process. Referring to the results of the GST, the research community should come up with assessments of progress at the national level, disaggregate the aggregate findings, indicating where each country should be, and comparing country performance, thus enabling stakeholders to hold their respective national governments accountable.

For **Driving NDC Ambition** the global research community should break down international benchmarks to the national level, discuss sector specific transformation challenges/barriers and highlight good practices to overcome them. Again, given that the official GST must not develop country-specific recommendations, there is ample scope for researchers and civil society organizations to develop and communicate science-based country-specific recommendations that are consistent with official GST benchmarks.

Finally, to amplify the **Guidance and Signal** provided by the GST, a complementary strategy for civil society actors would be to get policy makers on the record that they are still on board and buy in to the implications of the objectives of the Paris Agreement. This could be organized for instance as a „pledge of allegiance“ to the objectives of the Paris Agreement. Furthermore, civil society organizations with support from the research community could use the GST to build and communicate a commonly shared vision of what each country should look like in 2050 in a well below 2°C world.

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Annexes

Annex I: Pre-defined Lists for Categorization of Information Sources

Type of information

- raw data
- composite data
- model or tool
- model results
- analysis of data
- report
- website/platform

General topic of the information source

- historical emission data
- projected emission data
- drivers of emissions
- methodology for aggregation
- methodology for gap-filling
- NDC information
- policies and measures
- progress in transformation
- co-benefits
- emission scenarios
- emission targets
- renewable energy
- emissions from aviation
- accounting methodologies
- investments (energy)
- air pollutants
- historical population data
- historical GNI data
- bunker fuels/maritime emissions
- n/a
- climate status and trends of the conditions of Arctic ecosystems
- climate change
- historical and projected population data
- GDP growth
- investment needs for mitigation
- global carbon budget
- Mitigation pre-2020
- climate finance

Indicators: Emissions data; projections; Policies and Measures (PaMs); renewable energy capacity/deployment; aggregation method; drivers of GHG emissions; accounting methodologies for tracking progress towards targets

- included
- not included
- partially included
- tbd

Quantitative/qualitative focus
- qualitative
- quantitative
- both
- tbd

Geographical scope
- global
- Annex I
- non-Annex I
- Europe
- EU
- OECD
- Arctic region
- top 30 emitting countries
- OECD countries and a selection of non-OECD countries such as China, Brazil and Russia
- European and OECD countries. In addition, the databases include some information on policies and measures in Brazil, China, the European Union, India, Mexico, Russia and South Africa.
- top 30 emitting countries

GHG included
- CO2
- according to IPCC GL
- all GHG
- unclear
- not applicable
- tbd
- country specific

Sectoral scope
- all sectors according to IPCC GL
- all relevant economic sectors
- energy
- agriculture
- land-use change and forestry
- waste
- Industrial processes
- international bunkers
- not applicable
- tbd
- country specific
- RES-E, RES-HC, RES-T, RES-total
- agriculture and LULUCF
- fossil fuel burning, flaring, cement, and international bunkers
- international aviation

Level of geographical granularity/disaggregation of data
- subnational
- national
- regional
- global

Start year
- 1990
- 2020
- country specific
- tbd
- not applicable
- 1850
- 2007
- t-1
- t-2
- 2008

End year
- 2030
- 2050
- country specific
- tbd
- not applicable
- current year -2
- 2035
- 2100
- 2012
- 2016
- t-1
- t-2
- 2015

Time step (between data points)
- annually
- biannually
- every 4 years
- country specific
- tbd
- not applicable
- every 5 years
- every 10 years
- varying

National/international data source
- national
- international
- not applicable
- European

Type of publishing institution
- international organisation
- national authority
- research institute
- commercial organisation
- UNFCCC

- European authority

Rhythm of publication
- annually
- biannually
- every 4 years
- every 5 years
- not applicable
- updates when new projection reporting incoming
- tbd
- website updated regularly
- no longer updated
- every few years
- one-time publication
- several papers per year

Data available/used under UNFCCC framework?
- Yes
- No

Annex II: Collection and categorization of information sources

See separate document

Annex III: Excel table with overview and evaluation of indicators

See separate document

Annex IV: Energy system variables available in the SR1.5 database

Energy system variables included in the SR1.5 scenario database[36]

Level 1	Level 2	Level 3	Level 4	Level 5
Agricultural Demand	Crops	Energy, Feed, Food, other		
	Livestock	Food, Other		
Agricultural Production	Energy	Crops, Residues		
	Non-Energy	Crops, Livestock		
Food Demand	Crops, livestock			
Food energy supply	Livestock			
Land Cover	Built-up area			
	Cropland	Cereals, energy crops, irrigated		
	Forest	Afforestation and reforestation, managed, natural forest		

[36] According to the emissions variables listed in the documentation of the SR1.5 database repository (Huppmann et al., 2018).

	Other land	Arable, natural, other		
	Pasture			
Capacity	Electricity	Biomass, Coal, Gas, Geothermal, Hydro, Nuclear, Ocean, Oil, Solar (CSP / PV), Wind (Offshore, Onshore), Other	With or without CCS (where appropriate)	
Cumulative Capacity	Electricity	Biomass, Coal, Gas, Geothermal, Hydro, Nuclear, Ocean, Oil, Solar (CSP / PV), Wind (Offshore, Onshore), Other	With or without CCS (where appropriate)	
Carbon Sequestration	CCS	Biomass	Energy	Supply: Electricity, Gases, Hydrogen, Liquids, Other Demand: Industry
			Industrial Processes	
		Fossil	Energy	Supply: Electricity, Gases, Hydrogen, Liquids, Other Demand: Industry
			Industrial Processes	
	Direct air capture			
	Enhanced Weathering			

	Land Use	Afforestation, Biochar, Soil Carbon Management		
Energy Service	Transportation	Freight	Aviation, navigation, railways, road	
		Passenger	Aviation, railways, road	
Final Energy	Electricity			
	Fossil			
	Gases			
	Geothermal			
	Heat			
	Hydrogen			
	Industry	Electricity, fossil, gases, geothermal, heat, hydrogen, liquids, other, solar, solids (biomass, coal)		
	Liquids			
	Non-energy Use	Biomass, coal, fossil, gas, oil		
	Residential and Commercial (buildings)	Electricity, fossil, gases, geothermal, heat, hydrogen, liquids, other, solar, solids (biomass, coal)		
	Solar			
	Solids	Biomass	Total, Traditional	
		Coal		
	Transportation	Electricity, fossil, freight, gases, geothermal, heat, hydrogen, liquids (biomass, oil), solar, solids (biomass, coal)		
Primary Energy	Biomass	Electricity, Modern, traditional	With or without CCS	
	Coal	Electricity, total	With or without CCS	
	Fossil	With or without CCS		
	Gas	Electricity, total	With or without CCS	
	Geothermal			
	Hydro			
	Non-biomass renewables	Geothermal, hydro, ocean, solar, wind		
	Nuclear			
	Ocean			
	Oil	With or without CCS		

	Other			
	Second energy trade			
	Solar			
	Wind			
Secondary Energy	Electricity	Biomass, coal, fossil, gas, geo-thermal, hydro, non-biomass renewables, nuclear, ocean, oil, other, solar (CSP / PV), wind (Off-shore, Onshore),	With or without CCS (where ap-propriate)	
	Gases	Biomass, coal, natural gas		
	Heat			
	Hydrogen	Biomass, electricity, fossil	With or without CCS	
	Liquids	Biomass, coal, gas, oil	With or without CCS	
	Solids			

Annex V: Technical documentation of Performance Distribution tools

The performance distribution toolset is designed to work with a variety of datasets, such as emissions, energy use, or steel production, so long as it concerns time series for a range of countries. The toolset is designed to help the user format the data appropriately with the correct information and labels, and then interrogate that data. There are three types of analysis that the tools can perform:

1. Data availability – for which countries and years, or sectors and gases is there data included in the dataset?
2. Distributions of absolute values and trends – actually plotting the data for a given year or trends over a time period
3. Peaking – specifically aimed at emissions but also available for other variables, this tool identifies the countries in which the variable has peaked, stalled or is continuing to grow.

Examples of all three of these are included in section 5.5.2 of the main report.

In this annex, we guide the user as to how they can perform their own calculations and describe the technical implementation of some of the features.

The toolset works with data in .csv files is written in python. The python code is split between a series of Jupyter Notebooks that the user can use to analyse different datasets and a package of python functions that primarily perform checks on the data and generate the plots. The idea behind this setup is that most users can use and modify the notebooks whereas the python package is for development only.

Accessing the tools

The toolset has been published on a git-hub repository[37] and can be downloaded and used by anyone simply by downloading it and installing the required tools. The README.md file in the repository includes instructions on how to do so. It's also possible for others to contribute their own updates and improvements to the code by checking out the repository through git and requesting developer status on the project.

The repository contains a limited amount of data that can be used with the tools and guidance of how to include additional datasets. The amount of data provided with the toolset is limited for two reasons, 1) to keep the toolset light and limited in size, and 2) because it's important that the use knows where the data has come from, that it's up to date, and that if used it is properly cited to its original source. However, in the main paper here we describe many data sources that could potentially be used with this toolset.

Using the tools

The Performance Distribution toolset contains Jupyter Notebooks[38] that are the main interface to the toolset. Jupyter Notebooks are python-based notebooks that run in an internet browser. They are user-friendly in their appearance, are easy to edit, can be run in sections and can easily display output to the screen, allowing the user to see what's going on. An additional advantage is that the notebooks can be saved to document how analysis was performed, and figures made.

The eight notebooks in this toolset can be considered in terms of four different tasks; data processing, , performance distribution assessment, peaking assessments, and data availability assessment.

[37] https://github.com/mljeffery/performance-distribution-tools

[38] https://jupyter.org/

Data processing

The notebooks and tools utilise the “pandas” data structure to organise the data. Before using the analysis tools, the data needs to be formatted in the right way so that the relevant information can be found. The data processing notebooks help the user to do this.

The data structure anticipated by the performance distribution tools is a dataframe for a single variable that has data for individual countries over several years. Each year is a separate column and additional information describing the data is stored in the following separate columns:

- variable (required): describes the thing that is measured by the data, e.g. greenhouse-gas-emissions
- unit (required): the unit of measurement of the data, e.g. MtCO2e
- country (required): an ISO 3-letter country code, e.g. DEU
- category (optional): can describe the sector that the data represents, e.g. LULUCF
- scenario (optional): indicates if the data is historic or a particular scenario, e.g. HISTORY
- source (optional): describes where the data has come from, e.g. PRIMAP-hist_v2.0

Figure Annex V-1 Example dataframe used in performance distribution toolset

```
In [4]: data
```

]:

	category	country	scenario	source	unit	variable	1990	1991	1992	1993	...	2007	2008
0	IPCM0EL	AFG	HISTCR	PRIMAP-hist_v2.0	GgCO2eq	KyotoGHG-AR4-total-excl-LU	12800.0	13000.0	12100.0	12200.0	...	18500.0	21700.0
1	IPCM0EL	AGO	HISTCR	PRIMAP-hist_v2.0	GgCO2eq	KyotoGHG-AR4-total-excl-LU	68800.0	71000.0	73300.0	72700.0	...	84900.0	84500.0
2	IPCM0EL	ALB	HISTCR	PRIMAP-hist_v2.0	GgCO2eq	KyotoGHG-AR4-total-excl-LU	6780.0	8090.0	5800.0	5890.0	...	8270.0	8180.0
3	IPCM0EL	AND	HISTCR	PRIMAP-hist_v2.0	GgCO2eq	KyotoGHG-AR4-total-excl-LU	476.0	484.0	494.0	504.0	...	630.0	627.0
4	IPCM0EL	ARE	HISTCR	PRIMAP-hist_v2.0	GgCO2eq	KyotoGHG-AR4-total-excl-LU	60200.0	66100.0	67600.0	74900.0	...	210000.0	238000.0

Data for the tools are stored in two folders; ‘input-data’ which is for raw data and where new data should be placed, and ‘proc-data’ which is where data in the correct format for the collective assessment tools is stored. Each of the different processing tools performs a different function, as follows:

prepare-PRIMAP-hist-data-for-collective-progress-plots.ipynb

The PRIMAP-hist[39] emissions dataset(Gütschow et al., 2016, 2019) is a comprehensive emissions dataset covering all UNFCCC countries, for the years 1850-2016, multiple gases and multiple sectors. It is open access and regularly updated and therefore provides a useful input to the performance distribution tools. This notebook provides the user with the tools to extract relevant data from the dataset that can be downloaded from the public repository.

The notebook guides the user in selecting the data to save and in setting appropriate names for the output. It then extracts the desired data and saves it to as a .csv file in the proc_data folder. The user is advised to refer directly to the PRIMAP-hist documentation to understand the codes used to describe the sectors and entities included in the dataset.

[39] https://www.pik-potsdam.de/paris-reality-check/primap-hist/

prepare-PRIMAP-data.ipynb

The performance distribution tools were originally developed in conjunction with the PRIMAP database, which is developed and maintained at the Potsdam Institute for Climate Impact Research. The PRIMAP database contains a wide range of data sources covering climate policy relevant variables. This notebook converts data exported from the PRIMAP database into a format that is usable by the performance distribution tools. It is intended primarily for users of the PRIMAP emissions module to make the PRIMAP data accessible for this tool.

However, it was used to generate some of the basic data provided with this tool and is therefore provided for documentation and completeness.

calculate-indicators.ipynb

In some cases, the raw data may not be complete or yet be the desired indicator. The performance distribution approach lends itself well to normalised indicators, that is variables that are evaluated per capita or per unit of GDP, as these indicators are generally more comparable across countries than absolute values.

The calculate-indicators notebook takes data that has already been prepared in the correct format and divides one by the other. It can therefore be used to calculate a normalised indicator, such as emissions per capita. The same set up could also be used to calculate variables such as the share of fossil energy in total energy.

In principle, all the user needs to do is to enter the names of the prepared .csv files and run the code. However, it's also possible to give the newly created source a sensible name and unit that is easier to read. Care should be taken in both these steps to ensure that the names and unit remain correct.

The resulting data will be saved as a .csv file in the proc-data folder and can be used in the collective assessment notebook.

Performance Distribution Assessment

The 'make-collective-progress-plots' notebooks allows the user to access the core aspects of the performance distribution toolset. For a given dataset, the user can step through a series of different plot types to assess the performance of countries for that variable.

Three types of plot can be generated from this notebook.

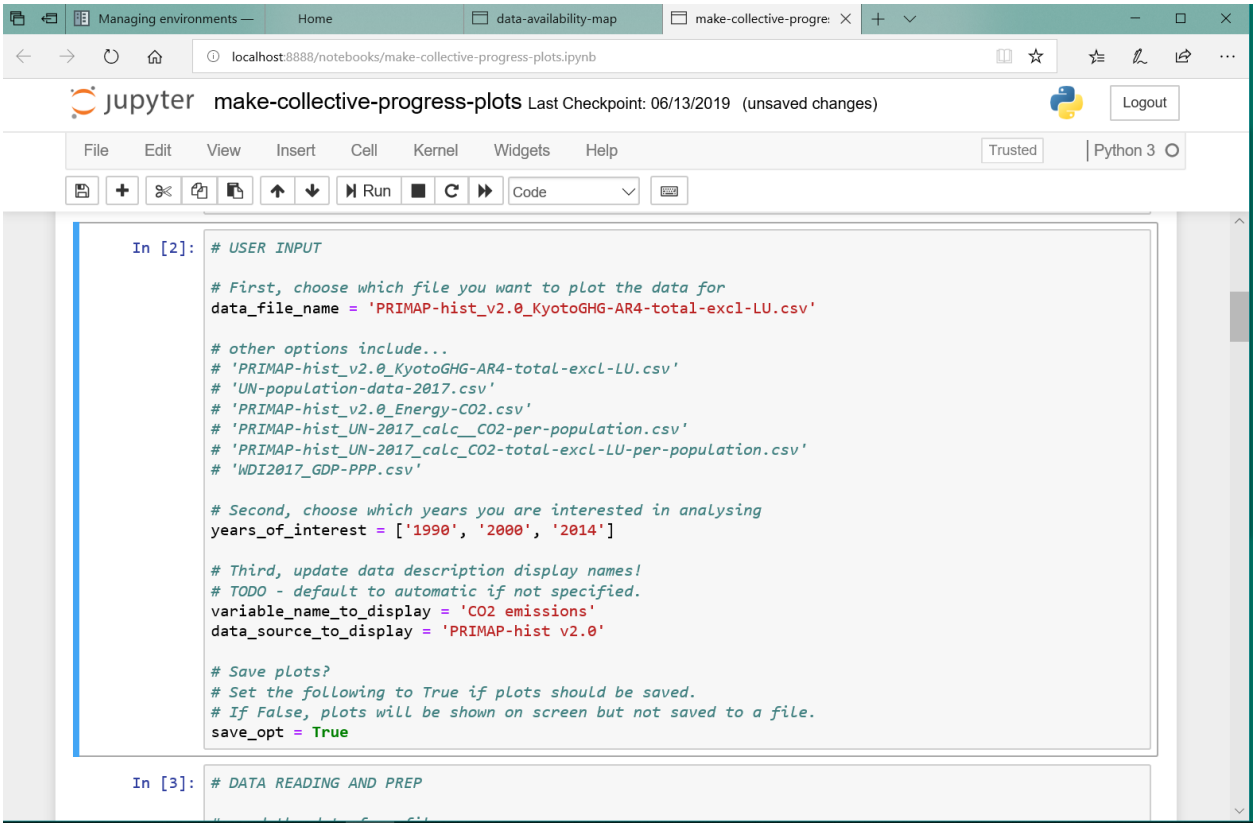
1. A histogram of absolute values of the data for selected years
2. A histogram of the 5-year rolling average trends in the data
3. A histogram of the change in the variable relative to selected reference years.

Each of these plots can be generated with fairly little modification to the scripts from the user (Figure Annex V-2), but some flexibility is available if desired. Calculations of trends and differences and plotting are performed by the python package embedded with the toolset.

The plots include information about the data source and some basic statistics describing the data, including information about any outliers that have been excluded. For more details on how the plots are generated, including how outliers are determined, please see the 'under the hood' section below.

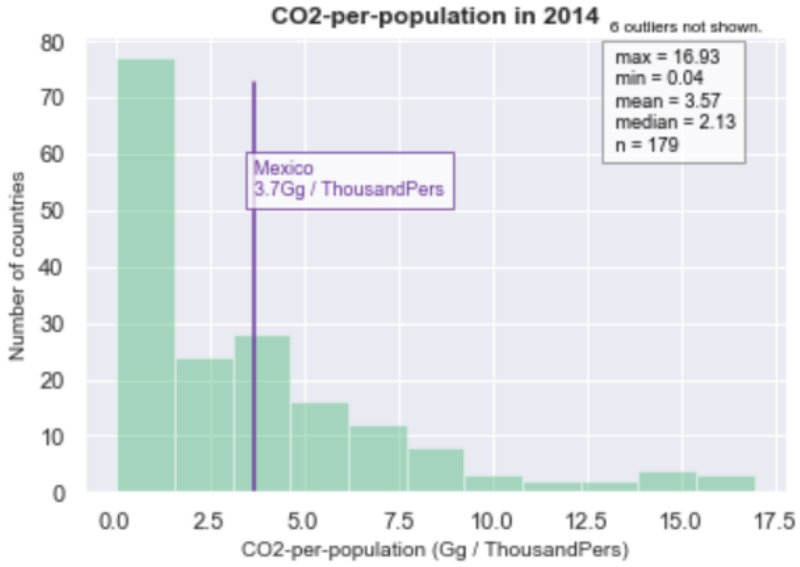
The plots generated can be shown directly to the screen or saved to a file in the output folder.

Figure Annex V-2 User input to the make-collective-progress-plots notebook



The highlight-country-collective-plots notebook is similar to the notebook described above but allows the user to highlight where a specific country lies within the distribution (Figure Annex V-3). Such an approach would not be acceptable under the official GST process but illustrates the potential of the approach for countries to situate themselves within the distribution.

Figure Annex V-3 Locating an individual country within a distribution



Peaking Assessment

The assess-peaking-emissions notebook both performs calculations and plots the output to determine if the emissions of a set of countries have peaked, stalled, or are continuing to grow. The criteria to establish peaking are described in the main text (section X). These criteria can be tested and modified in this notebook.

As with the collective assessment notebook, the user can select which dataset to examine. The notebook then first assesses in which year the maximum emissions (or other variable) is reached for each country since a user-specified start year.

The peaking criteria are then used to categorise the countries into three groups:

- **Peaked** – maximum reached at least 5 years ago, decreasing at least 1.5% / year on average over the last 5 years
- **Stabilised** – maximum reached at least 5 years ago and currently average trend over the last 5 years not increasing by more than 0.5% OR maximum not reached more than 5 years ago but decreasing by more than 1.5% /year on average over the last 5 years
- **Not peaked** – All other countries, so those that still have increasing emissions and/or have not reached a maximum more than 5 years ago.

The number of countries in each of these groups is then counted and plotted.

So that the user can check the suitability of the categorisation criteria, the function also makes plots for each individual country to show the absolute values and the trends over the full dataset. If desired, the number of years since the maximum was reached, and the rate of decrease required for the peaking criteria can be modified.

Data availability

The goal of this notebook is to provide an easy overview of how comprehensive data availability is for a given data source. The data-availability-map notebook can generate two types of 'heatmap' plots;

1. An overview of how many years of data are available for selected countries in a given dataset.
2. For a given year and country, an overview of which sectors and gases data is available.

The current approach is targeted at emissions data, and particularly data available under the UNFCCC. The approach could be adapted for alternative dataset and data types.

Under-the-hood – technical implementation of features

Dealing with outliers

In generating the histograms of the collective progress tools, it's important that the figures are readable and useful. In some cases, individual countries can be extreme outliers and including them in the plot can make the figure useless, except to show that there are extreme outliers. For example, Equatorial Guinea's emissions rose dramatically in the mid-90s due to the discovery of oil. So much so that the current emissions relative to 1990 are over 6000% higher.

The plotting routine therefore includes the option to automatically detect outliers, exclude them from the plot, and write the name and value of the excluded countries to the screen. A note on the figure will also be automatically written if any countries are not included.

The method for identifying outliers is based on the interquartile range following methods proposed by John Tukey. The interquartile range of all the data is calculated and any data that lies outside the interquartile range by more than a specified factor times the interquartile range is excluded.

That is, a data point x is an outlier if:

$$x > Q3 + kTuk * (Q3 - Q1)$$
or
$$x < Q1 - kTuk * (Q3 - Q1)$$

Where Q1 and Q3 are the lower and upper interquartile values respectively.

In the performance distribution tools, a kTuk factor of 1.5 indicates an outlier and a factor of 3 indicates an extreme outlier. A default of 3 is used but an alternate factor can be chosen instead.

Python packages used

The performance distribution tools make use of both some standard python data and plotting packages and some specialised ones. The standard packages are pandas, numpy, matplotlib, pyYAML, and seaborn. In addition, a couple of packages are used to make plots more readable and to handle country groups; shortcountrynames and countrygroups.

Formatting and annotating

The plotting functions include some conditions to automatically format and annotate the data based on the data itself. In terms of formatting, the most significant feature is that if the data contains both positive and negative values, a symmetrical plot around zero will be generated. The number of countries lying above and below zero are also counted and annotations added to the plot.

For all histogram plots, some basic statistics are also calculated and shown; the number of data points and the minimum, maximum, mean and median of the data. Axes labels are automatically taken from the data or from the function calling the plotting routine. In the latter case, some of the labels may be adjusted for readability.

Colours for the plots are all coded according to the UBA colour scheme.

Annex VI: Country dossiers to assess availability of qualitative information

See separate document.