Supplementary material

Contents

[Supplementary material 1](#_Toc84443078)

[S1 Data sources 2](#_Toc84443079)

[S2 Policy matrix definition and policy categorisation 3](#_Toc84443080)

[S3 Distribution of policy instruments 13](#_Toc84443081)

[S4 Cluster description 14](#_Toc84443082)

[References 15](#_Toc84443083)

List of Tables

[Table 2 Policy options classified under the sector ‘general’ 2](#_Toc76122083)

[Table 3 Policy options classified under the sector ‘electricity and heat’ 3](#_Toc76122084)

[Table 4 Policy options classified under the sector ‘industry’ 3](#_Toc76122085)

[Table 5 Policy options classified under the sector ‘buildings’ 4](#_Toc76122086)

[Table 6 Policy options classified under the sector ‘land transport’ 4](#_Toc76122087)

[Table 7 Policy options classified under the sector ‘agriculture and forestry’ 5](#_Toc76122088)

[Table 1 Policy instruments in the database 6](#_Toc76122089)

[Table 8 Mapping of policy documents to policy options 8](#_Toc76122090)

List of Figures

[Figure 1 Structure of the matrix of policy options 3](#_Toc84446280)

[Figure 2 Policy instrument types (identified by colours) in the G20 13](#_Toc84446281)

[Figure 3 Distribution of policy instruments per sector and country 13](#_Toc84446282)

[Figure 4 Cluster results, each circle represents one policy option 14](#_Toc84446283)

# S1 Data sources

Overview of data sources. For some policies, the databases were complemented with peer reviewed articles or specific reports. Details on individual policies can be found at climatepolicydatabase.org. The general structure of the database is one entry per policy. Rollbacks are included by changing the policy status to ‘ended’ or ‘superseded’.

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Coverage** | **Country coverage** | **Reference** |
| Asia Pacific Energy Portal | Economy-wide | Asia-Pacific | [link](https://newclimate.org/wp-content/uploads/2018/12/PBL-CLIMA-2018_final_rev.pdf#main/lang/en/time/[1990,2018]/geo/[THA]/scope/[National]/cat/[]/timeline) |
| Brown to Green report | Economy-wide | G20 | [link](https://icapcarbonaction.com/ets-map#1531904804037-423d5c88-a7a7) |
| CAIT INDC | Economy-wide | Worldwide | [link](https://climate-laws.org/) |
| Climate Action Tracker | Economy-wide | A few countries | [link](http://climateactiontracker.org/countries.html) |
| Columbia Law School Database | Economy-wide | Worldwide | [link](http://www.res-legal.eu/) |
| COMMIT | Economy-wide | A few countries | [link](https://themasites.pbl.nl/commit/wp-content/uploads/COMMIT-Long-term-Low-emission-pathways-in-Australia-Brazil-Canada-China-EU-India-Indonesia-Japan-Republic-of-Korea-Russia-USA-2.pdf) |
| Deutsche Bank Global Climate Policy Tracker | Economy-wide | Worldwide | [link](https://newclimate.org/2019/12/11/greenhouse-gas-mitigation-scenarios-for-major-emitting-countries-analysis-of-current-climate-policies-and-mitigation-commitments-2019-update/) |
| Dieselnet | Emissions standards | A few countries | [link](https://edb.wto.org/) |
| ECOLEX | Economy-wide | Worldwide | [link](https://www.ecolex.org/) |
| EU Climate Change Mitigation Policies and Measures | Economy-wide | EU | [link](https://www.transportpolicy.net/) |
| GBPN - Building Policies for a Better World | Buildings | A few countries | [link](http://www.gbpn.org/databases-tools) |
| ICAP Emissions Trading Schemes | Economy-wide | Worldwide | [link](http://cait.wri.org/indc/) |
| IEA Clean Coal Database | Emissions standards | Worldwide | [link](https://newclimate.org/wp-content/uploads/2019/06/Mitigation_Scenarios_2019_June_Update.pdf) |
| IEA Policy Database | Energy-related | Worldwide | [link](https://www.iea.org/policies) |
| INDCs - UNFCCC | NDCs | Worldwide | [link](https://unfccc.int/national-communications-and-biennial-reports) |
| Climate Change Laws of the World | Economy-wide | Worldwide | [link](https://www.iea-coal.org/library/emission-standards/) |
| OECD Energy taxes | Economy-wide | OECD + others | [link](https://www.oecd-ilibrary.org/taxation/taxing-energy-use-2019_058ca239-en) |
| OECD Stat | Economy-wide (indicators) | OECD + others | [[link](https://stats.oecd.org/Index.aspx?DataSetCode=EPS)](https://asiapacificenergy.org/?DataSetCode=EPS) |
| OECD Policy Instruments for the environment | Economy-wide | OECD + others | [link](https://www.climate-transparency.org/g20-climate-performance/g20report2019) |
| PBL COP update 2016 | Economy-wide | A few countries | [link](http://database.aceee.org/) |
| PBL COP update 2017 | Economy-wide | A few countries | [link](https://newclimate.org/wp-content/uploads/2018/04/ec-pbl_fact-sheet_currentpolicies_2017_final3b.pdf) |
| PBL COP update 2018 | Economy-wide | A few countries | [link](https://www.db.com/cr/en/docs/Global_Policy_Tracker_20120424.pdf) |
| PBL COP update 2019 | Economy-wide | A few countries | [link](https://newclimate.org/wp-content/uploads/2016/11/161103_marrakech-policy-brief_main.pdf) |
| PBL Spring update 2018 | Economy-wide | A few countries | [link](https://newclimate.org/wp-content/uploads/2018/05/PBL-CLIMA_April2018Update.pdf) |
| PBL Spring update 2019 | Economy-wide | A few countries | [link](https://climate.law.columbia.edu/content/resources) |
| REN21 | Renewables/Efficiency | Worldwide | [link](https://www.ren21.net/reports/global-status-report/) |
| RES Legal | Renewables | EU | [link](http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx) |
| Scaling up Argentina | Economy-wide | Argentina | [link](https://www.dieselnet.com/standards/) |
| Scaling up EU | Economy-wide | EU | [link](https://climateactiontracker.org/documents/505/CAT_2018-12-06_ScalingUp_EU_FullReport.pdf) |
| Scaling up Indonesia | Economy-wide | Indonesia | [link](http://www.eea.europa.eu/data-and-maps/data/climate-change-mitigation-policies-and-measures-1) |
| Scaling up South Africa | Economy-wide | South Africa | [link](https://climateactiontracker.org/documents/398/CAT_2018-11-27_ScalingUp_SouthAfrica_FullReport.pdf) |
| Scaling up Turkey | Economy-wide | Turkey | [link](https://climateactiontracker.org/documents/672/CAT_2019-11-29_ScalingUp_TURKEY_FullReport_ENG.pdf) |
| State Energy Efficiency Policy | Efficiency | US | [link](https://climateactiontracker.org/documents/658/CAT_2019-10-10_ScalingUp_INDONESIA_FullReport_ENG.pdf) |
| State incentives of RE & EE | Renewables/Efficiency | US | [link](http://www.dsireusa.org/) |
| Transport policy | Transport | A few countries | [link](http://www2.oecd.org/ecoinst/queries/Default.aspx) |
| UNFCCC NatComs and BURs | Economy-wide | Worldwide | [link](https://climateactiontracker.org/documents/540/CAT_2019-09-05_ScalingUp_ARGENTINA_FullReport_ENG.pdf) |
| World Bank INDC data | NDCs | Worldwide | [link](http://spappssecext.worldbank.org/sites/indc/Pages/mitigation.aspx) |
| WTO Environmental Database | Economy-wide | Worldwide | [link](https://stats.oecd.org/Index.aspx) |

# S2 Policy matrix definition and policy categorisation

This section is structured according to sectors in the policy matrix. It provides an overview of the policy options and the reasoning behind adding them to the policy matrix, together with some examples. The matrix supports the identification of policy gaps across sectors and policy areas, it includes policy options which are recognized as leading to direct or indirect emissions reductions. The developed matrix contains 50 policy options distributed across six sectors and five mitigation areas. Information and education policies are excluded, as their contribution to emissions reductions is often mediated by the identified policy options.

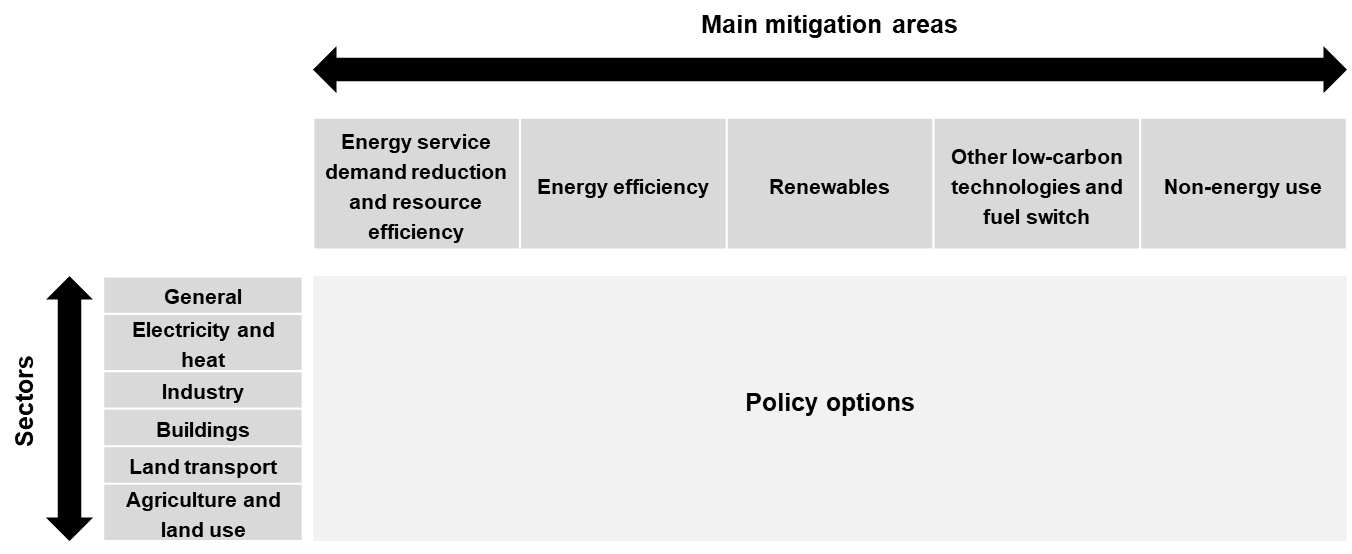


Figure 1 Structure of the matrix of policy options

Policy options

This section describes the policy options presented in the policy matrix in more detail. Please note that the selection of policy options is based on policies that are generally agreed to contribute to greenhouse gas emissions reductions, consist sector-level example policies which have been successful in specific contexts, or are expected to result in sufficient sectoral transformation to achieve greenhouse gas emissions reductions. This section is structured along the sectors in the policy matrix.

Table 1 Policy options classified under the sector ‘general’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Climate strategy | Overarching national plans for the implementation of measures related to climate change. National strategies must have been approved or adopted by a government body. | (Dubash *et al.*, 2013; Iacobuta *et al.*, 2018) |
| GHG reduction target | Targets related to GHG emissions reductions. Applies to absolute emissions targets as well as reduction below business as usual trajectories and intensity targets. More uncertain mid-century targets were not considered. | (IEA, 2015; Iacobuta *et al.*, 2018) |
| Coordinating body for climate strategy | Institutions with the main purpose of coordinating the implementation of climate strategies as well as overseeing activities related to climate change. | (IPCC, 2014; Iacobuta *et al.*, 2018) |
| Support for low-emission or negative emissions RD&D | Support for research and development of low- or negative-emissions technologies that help the transition to a low-carbon economy. | (UNFCCC, 2014a; IEA, 2017; IPCC, 2018) |
| No fossil fuel subsidies | Removal of all fossil fuel subsidies enabling the achievement of development goals and paving the way to a transition to green technologies. | (Jakob *et al.*, 2015; Rentschler and Bazilian, 2017) |
| Economy-wide energy efficiency target | Targets resulting in energy consumption below a business as usual trajectory. Usually presented as a reduction in energy intensity over GDP or as a total energy consumption target. | (IEA, 2015; Grubler *et al.*, 2018) |
| Renewable target for primary energy | Renewable target associated to primary energy demand. Targets related to electricity alone are included in the electricity and heat sector. Setting short- to mid-term targets for renewable electricity generation or capacity provides certainty for investors. | (IEA, 2015; REN21, 2018) |

Table 2 Policy options classified under the sector ‘electricity and heat’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Support for highly efficient power plant stock | Policies addressing energy efficiency for the electricity and heat sector, ensuring the phase-out of inefficient power plants. | (Somanathan *et al.*, 2014; IEA, 2015, 2019; UNEP, 2019) |
| Energy reduction obligation schemes | Schemes where electricity producers must ensure energy savings internally or support energy use reduction of end-users. | (UNFCCC, 2014b, 2015) |
| Renewable energy target for electricity sector | Renewable electricity targets that support policy making, i.e. formulation, implementation, as well as monitoring and evaluation of renewable uptake. | (IRENA, 2015; REN21, 2018) |
| Support scheme for renewables | Incentives to increase the share of renewables in the grid via increasing cost-effectiveness, allowing or facilitating grid integration as well as direct government investments. | (IPCC, 2014; IEA, 2015, 2019; Carley *et al.*, 2017; UNFCCC, 2018) |
| Grid infrastructure development and electricity storage | Measures for the development of the electricity grid and storage, allowing installation of high shares of variable renewable electricity, such as solar PV and wind, in the system. | (Lund *et al.*, 2015; IRENA, 2016; IRENA, IEA and REN21, 2018). |
| Emission-intensive phase-out policies | Policies setting a strategic plan for the phase out of emissions-intensive technologies, primarily coal- and oil-fired technologies. | (Kriegler *et al.*, 2018; Kuramochi *et al.*, 2018; Jakob *et al.*, 2020) |
| Support scheme for CCS | Support schemes for the development and uptake of Carbon Capture and Storage (CCS) in the electricity sector. | (IPCC, 2018) |
| Support scheme for non-renewable low-carbon alternatives | Support for options, besides renewable electricity and heat, such as nuclear and hydrogen-based technologies. | (Deetman, Hof and van Vuuren, 2015; IPCC, 2018) |

Table 3 Policy options classified under the sector ‘industry’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Strategy for material efficiency | Policies that aim to introduce resource-efficient processes or changes in materials used, and designs or enhance recycling and re-use of products. | (Fischedick *et al.*, 2014; IPCC, 2014; Kuramochi *et al.*, 2018; UNEP, 2019) |
| Support for energy efficiency in industrial production | Policies that support energy efficiency improvements. It often taken the form of voluntary agreements, which can play a major role of facilitating cooperation among firms, industrial associations, and governments to identify and realise low-cost emissions reduction measures. | (Somanathan *et al.*, 2014; UNEP, 2016; UNFCCC, 2018; IEA, 2019) |
| Energy reporting and audits | Policies that foster the implementation of energy management systems, e.g. energy monitoring and auditing, and energy data collection. | (Somanathan *et al.*, 2014; UNEP, 2016) |
| Performance and equipment standards | Mandatory energy efficiency requirements for equipment used in industrial production and for overall energy use. | (UNEP, 2019; IEA, 2020) |
| Support schemes for renewables | Policies that encourage or impose the uptake of renewables to address own energy consumption. | (BigEE, 2016; IEA, 2020) |
| Support scheme for CCS | Support schemes for the development and uptake of Carbon Capture and Storage (CCS) in the industry sector. | (Åhman, Nilsson and Johansson, 2017; Kuramochi *et al.*, 2018; IEA, 2020) |
| Support scheme for fuel switch | Policies supporting fuel and feedstock switching away from fossil fuels, such as the use of biofuels, electrification or hydrogen. | (Fischedick *et al.*, 2014; Agora Energiewende and Wuppertal Institut, 2019; UNEP, 2019) |
| Carbon dioxide removal technology development | Policies that aim to develop options for carbon dioxide removal such as Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Capture with Carbon Storage (DACCS), enhanced weathering and mineral carbonation as well as develop stable, predictable, efficient and large support mechanism for mature CDR technologies. | (IPCC, 2018; Kuramochi *et al.*, 2018; Luderer *et al.*, 2018; van Vuuren *et al.*, 2018; Cox and Edwards, 2019) |
| Landfill methane reduction | Policies that aim to address emissions associated with landfill waste and provide a clear mandate or strategies to reduce methane emissions. | (Powell, Townsend and Zimmerman, 2016) |
| Incentives to reduce CH4 from fuel exploration and production | Policies that regulate fossil fuel extraction, aiming at the reduction of fugitive emissions, particularly those associated with coal and gas exploration. | (Erickson, Lazarus and Piggot, 2018; Roelfsema *et al.*, 2018) |
| Incentives to reduce N2O from industrial processes | Policies addressing non-energy related industry emissions, especially those related to chemical processes. | (Somanathan *et al.*, 2014; IEA, 2015) |
| Incentives to reduce fluorinated gases | Regulations to accelerate the phase out of F-gases, originally introduced to replace ozone-harming chemicals. | (IPCC, 2014; IEA, 2015; Roelfsema *et al.*, 2018) |

Table 4 Policy options classified under the sector ‘buildings’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Urban planning strategies | Policies that address the overall future directions for the retrofit of old buildings, promotion of compact cities, improving infrastructure that promotes energy efficiency and use of renewable energy. | (Dulal, Brodnig and Onoriose, 2011; Somanathan *et al.*, 2014; UNFCCC, 2015; BigEE, 2016) |
| Building codes and standards as well as support for highly efficient construction | Policy instruments aiming at reducing energy consumption in buildings such as building codes and standards (including individual building components), and incentives to support energy efficiency in both existing and planned buildings. | (UNEP, 2016; OECD/IEA and IRENA, 2017; Kuramochi *et al.*, 2018; UNFCCC, 2018). |
| Performance and equipment standards as well as support for highly efficient appliances | Policies to reduce energy use in buildings by improving the energy use of appliances, including heating/cooling and cooking devices. As there are few policies addressing electrification of end use, policies aiming to increase the use of heat pumps and/or induction cookstoves were included as support for ‘efficient appliances.’ | (Climate Action Tracker, 2016, 2018; Roelfsema *et al.*, 2018; Knobloch *et al.*, 2020) |
| Support scheme for heating and cooling | Policies such as support schemes for the use of renewable energy in heating and cooling (e.g. biomass, geothermal, and solar thermal). | (Mitchell *et al.*, 2011) |
| Support scheme for hot water and cooking | Policies supporting the use of renewable technologies to heat water such as solar heaters and cooking, e.g. biogas. | (UNFCCC, 2014a; UNEP, 2015) |

Table 5 Policy options classified under the sector ‘land transport’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Urban planning and infrastructure investment | Urban planning strategies that support the reduction of land transport emissions. Strategies that ensure investment in well-connected and frequent public transport options, or invest in infrastructure for better connectivity and traffic fluidisation. | (Somanathan *et al.*, 2014; UNFCCC, 2015, 2017) |
| Energy/emissions performance standards or support for energy efficient for LDVs | Vehicle fuel efficiency and emissions standards or fiscal/financial incentives for light vehicles. | (IEA/IRENA, 2017; Roelfsema *et al.*, 2018; IEA, 2019; UNEP, 2019; Axsen, Plötz and Wolinetz, 2020) |
| Energy/emissions performance standards or support for energy efficient for HDVs | Vehicle fuel efficiency and emissions standards or fiscal/financial incentives for heavy-duty vehicles. |
| Support for biofuels | Targets and specific support policies (e.g. tax relief, mandatory blending) to support the uptake of biofuels. | (Daioglou *et al.*, 2017) |
| Support for modal share switch | Policies that encourage modal shift programmes, such as investments in public transport or subsidies for two- and three-wheelers. | (Wright and Fulton, 2005; UNEP, 2019; Axsen, Plötz and Wolinetz, 2020) |
| Support for low-emissions land transportation | Policies that support low-emissions land transport via, for example, the use of electric vehicles for light-duty transportation or hydrogen. | (IEA/IRENA, 2017; Kuramochi *et al.*, 2018; Roelfsema *et al.*, 2018; UNFCCC, 2018; Knobloch *et al.*, 2020) |

Table 6 Policy options classified under the sector ‘agriculture and forestry’

|  |  |  |
| --- | --- | --- |
| Policy option | Description | Further information |
| Standards and support for sustainable agricultural practices and use of agricultural products | Standards and support for sustainable agricultural practices and agricultural products that incentivise emissions reductions in the agriculture sector. | (IPCC, 2014; Kuramochi *et al.*, 2018; UNFCCC, 2018; Roe *et al.*, 2020) |
| Incentives to reduce CO2 emissions from agriculture | Incentives to reduce emissions in subsectors, including CO2 emissions from agricultural soils. Emissions related to energy-CO2 are covered in the Electricity and heat sector. | (Ray *et al.*, 2020) |
| Incentives to reduce CH4 emissions from agriculture | Incentives to reduce emissions in subsectors, including CH4 emissions from animals, such as incentives for improved livestock production management. | (Herrero *et al.*, 2016; Frank *et al.*, 2018, 2019) |
| Incentives to reduce N2O emissions from agriculture | Incentives to reduce emissions in subsectors, including N2O emissions from animals and soils, such as those addressing the inefficient use of nitrogen fertilizers. | (Herrero *et al.*, 2016; Frank *et al.*, 2018, 2019; Thompson *et al.*, 2019) |
| Incentives to reduce deforestation and support for afforestation /reforestation | Incentives to reduce deforestation and encourage good forestry management via regulatory measures (command-and-control instruments), protection of areas of forests, or economic instruments (e.g. grants or subsidies to protect forests). | (Kuramochi *et al.*, 2018; Roe *et al.*, 2020) |
| Sustainability standards for biomass use | Standards for biomass production and use, ensuring that the biomass use leads to overall GHG emissions reductions. | (Johnson, 2009; Daioglou *et al.*, 2017; Booth, 2018) |

Considering the nature of climate policies, the options in each coded category are not mutually exclusive.

Mitigation Area

Energy service demand reduction and resource efficiency

Policies that indirectly reduce energy demand by supporting activity changes (e.g. reducing material use in manufacturing industries or developing urban planning strategies to minimize transport needs).

Energy efficiency

Policies that reduce energy consumption in the different sectors. It includes both framing policies which a goal to reduce energy consumption, such as energy efficiency targets, as well as policy options that support energy reductions.

Renewables

Policies that support the development of renewable technologies. This support might take a direct form, via subsidies or loans, or indirect e.g. by developing grid infrastructure technology, that support the integration of high share of variable electricity generation technologies.

Other low-carbon technologies and fuel switch

Policies that tackle the uptake of non-renewable low-carbon technologies and options that impose limitations on the use of emissions-intensive technologies, e.g. coal- and oil-fuelled technologies.

Non-energy

Policies that reduce non-energy related emissions. For example, policies to reduce fugitive emissions in fossil fuel production or process-related industrial emissions.

Cross-area policy options

Some economic policy instruments target broad energy prices and are applicable across all sectors (Somanathan *et al.*, 2014). Some examples of such instruments include energy and carbon taxes, cap-and-trade emission trading schemes, tradable energy saving certificates, and removal of fossil fuel subsidies.

Policy instruments

The policy instruments typology was developed based on the [IEA policies database](https://www.iea.org/policies/about), to which a set of new categories were added. The database includes all policy instruments in Table 7. The definition of subsides and taxes, and the information available per country, varies. Others have estimated subsidies and taxes using consistent methodologies without always providing policy details (Climate Transparency, 2019; IMF, 2019; OECD, 2019; OECD/IEA, 2019; World Bank Group, 2020). We rely on their data to analyse these instruments.

The main policy instrument types in our analysis are summarized below:

* **Economic instruments**: Support certain technologies, activities, behaviours or investments using financial supports and price signals to influence the market. Due to the diversity of economic instruments we further divide this category into:
  + *Direct investments*
  + *Fiscal or financial incentives*
  + *Market-based instruments*
* **Regulatory instruments:** Cover a wide range of instruments which impose targets, obligations and standards on actors or technologies. These include, for example, performance standards for appliances, equipment, and buildings.
* **Other approaches**: Include several policy instruments that support policy adoption, such as RD&D support and overarching target and strategies. Voluntary approaches refer to measures undertaken voluntarily or negotiated among actors. These commitments can also be initiatted by public actors who invite private actors to submit commitments. Negotiated agreements may require reporting and be subject to audits.

Table 7 Policy instruments in the database

| Category | Sub-category | Policy instrument |
| --- | --- | --- |
| Economic instruments | **Direct investment** | **Funds to sub-national governments** |
| **Infrastructure investments** |
| **Procurement rules** |
| **RD&D funding** |
| **Fiscal or financial incentives** | **CO2 taxes** |
| **Energy and other taxes** |
| **Feed-in tariffs or premiums** |
| **Grants and subsidies** |
| **Loans** |
| **Tax relief** |
| **User changes** |
| **Tendering schemes** |
| **Retirement premium** |
| **User charges** |
| **Market-based instruments** | **GHG emissions allowances** |
| **GHG emission reduction crediting and offsetting mechanism** |
| **Green certificates** |
| **White certificates** |
| Regulatory instruments | **Codes and standards** | **Building codes and standards** |
| **Product Standards** |
| **Sectoral Standards** |
|  | **Vehicle fuel-economy and emissions standards** |
|  | **Auditing** |
|  | **Monitoring** |
|  | **Obligation schemes** |
|  | **Other mandatory requirements** |
| Information and education | **Performance label** | **Comparison label** |
| **Endorsement label** |
|  | **Advice and aid in implementation** |
|  | **Information provision** |
|  | **Professional training and qualification** |
| Policy support |  | **Institutional creation** |
|  | **Strategic planning** |
| RD&D | **Research programme** | **Technology deployment and diffusion** |
| **Technology development** |
|  | **Demonstration project** |
| Voluntary approaches |  | **Negotiated agreements (public/private sector)** |
|  | **Public voluntary schemes** |
|  | **Unilateral commitments (private sector)** |
| Barrier removal |  | **Net metering** |
|  | **Removal of fossil-fuel subsidies** |
|  | **Removal of split incentives** |
|  | **Grid access and priority for renewables** |
| Climate strategy |  | **Formal & legally binding climate strategy** |
|  | **Political & non-binding climate strategy** |
|  | **Coordinating body for climate strategy** |
| Target |  | **Energy efficiency target** |
|  | **GHG reduction target** |
|  | **Renewable energy target** |

Mapping of policy documents to the policy matrix

Policies, once coded, are mapped to the policy options presented above. Table 8 presents an overview of the coding per policy option.

Blue text – coding criteria

--------------------------------------------

* Any policy document can be categorized into more than one cell – ensure that its applicability to other cells is verified, and that the verification does not stop after one cell is found valid.

-------------------------------------

**PI** – policy instrument

**PT** – policy type

**S** – sector

**SS** – sub-sector

**;** - or (either of the given options)

-------------------------------------

Table 8 Mapping of policy documents to policy options

|  | Energy service demand reduction and resource efficiency | Energy efficiency | Renewables | Other low-carbon technologies and fuel switch | Non-energy |
| --- | --- | --- | --- | --- | --- |
| General | * Climate strategy (PI: Climate Strategy, PT: any, S: any) * GHG reduction target (PI: GHG reduction target, PT: any, S: any) * Coordinating body for climate strategy (PI: Coordinating body for the climate strategy, PT: any, S: Any) * No fossil fuel subsidies (PI: Removal of fossil-fuel subsidies, PT: Any, S: General, SS: Any * Support for low-emission or negative emissions R&D (PI: Research & Development and Deployment (RD&D); RD&D funding, PT: any, S: Any) | | | | |
|  | * Economy-wide energy efficiency target (PI: Energy efficiency target; PT: Energy efficiency, S: either “general” or more than 1 sector) | * Renewable target for primary energy (PI: Renewable energy target. PT: Renewables, S: either “general” or more than 1 sector) |  |  |
| Electricity and heat |  | * Support for highly efficient power plant stock (PI: Codes and standards; Fiscal/financial incentives, PT: Energy efficiency, S: Electricity and heat, SS: any) * Energy reduction obligation schemes (PI: Obligation schemes, PT: Energy efficiency, S: Electricity and heat, SS: any) | * Renewable energy target for electricity sector (PI: Renewable energy target. PT: any, S: electricity and heat) * Support scheme for renewables (PI: green certificates; fiscal/financial incentives; obligation schemes; net metering; direct investment, PT: Renewables, S: Electricity and heat, SS: any) * Grid infrastructure development and electricity storage (PI: Infrastructure investments, Grid access and priority for renewables, PT: Any, S: Electricity and heat, SS: any) | * Coal and oil phase-out policies (PI: Strategic planning, PT: Other low-carbon technologies and fuel switch, S: Electricity and heat, SS: Coal) * Support scheme for CCS (PI: Fiscal/financial incentives; Demonstration project, Infrastructure investments, PT: Other low-carbon technologies and fuel switch, S: Electricity and heat, SS: CCS) * Support for non-renewable low-carbon alternatives (PI: Fiscal/financial incentives; direct investment; Sectoral Standards, PT: Other low-carbon technologies and fuel switch, S: Electricity and heat, SS: Any) |  |
| * Overarching carbon pricing scheme (PI: GHG emissions allowances; GHG emission reduction crediting and offsetting mechanism; CO2 taxes, PT: Any, S: Electricity and heat, SS: Any) * Energy and other taxes (PI: Energy and other taxes, PT: Any, S: Electricity and heat, SS: Any) | | | |
| Industry | * Strategy for material efficiency (PI: Codes and standards; Other mandatory requirements, PT: Energy service demand reduction and resource efficiency, S: Industry, SS: any) | * Support for energy efficiency in industrial production (PI: Voluntary approaches; Fiscal/financial incentives; Obligation schemes; White certificates, PT: Energy efficiency, S: Industry, SS: any) * Energy reporting and audits (PI: Auditing; Monitoring, PT: Energy efficiency, S: Industry, SS: any) * Performance and equipment standards (PI: Codes and standards, PT: Energy efficiency, S: Industry, SS: any) | * Support scheme for renewables (PI: fiscal/Financial incentives; Green certificates; Obligation schemes, PT: Renewables, S: Industry, SS: any) | * Support scheme for CCS (PI: Fiscal/financial incentives; Infrastructure investments, PT: Other low-carbon technologies and fuel switch, S: Industry, SS: Industrial CO2) * Support scheme for fuel switch (PI: Fiscal/financial incentives; Infrastructure investments, PT: Other low-carbon technologies and fuel switch, S: Industry, SS: Industrial energy related) * Carbon dioxide removal technology development (PI: Fiscal/financial incentives; Infrastructure investments, PT: Other low-carbon technologies and fuel switch, S: Industry, SS: Negative emissions) | * Landfill methane reduction (PI: any, PT: Non-energy, S: Industry; SS: Waste CH4) * Incentives to reduce CH4 from fuel exploration and production (PI: any, PT: Non-energy, S: Industry; SS: Oil and gas production CH4) * Incentives to reduce N2O from industrial processes (PI: any, PT: Non-energy, S: Industry, SS: Industrial processes N2O) * Incentives to reduce fluorinated gases (PI: any, PT: Non-energy, S: Industry, SS: Fluorinated gases) |
| * Overarching carbon pricing (PI: GHG emissions allowances; GHG emission reduction crediting and offsetting mechanism; CO2 taxes, PT: Any, S: Industry, SS: Any) * Energy and other taxes (PI: Energy and other taxes, PT: Any, S: Industry, SS: Any) | | | | |
| Buildings | * Urban planning strategies (PI: Infrastructure investments; Strategic planning, PT: Energy service demand reduction and resource efficiency, S: Buildings, SS: any) | * Building codes and standards as well as support for highly efficient construction (PI: Codes and standards, Building codes and standards; Fiscal/financial incentives, PT: Energy efficiency, S: Buildings, SS: Any) * Performance and equipment standards as well as support for highly efficient appliances (PI: Product standards; Performance label; Fiscal/financial incentives, PT: Energy efficiency, S: Buildings, SS: Appliances) | * Support scheme for heating and cooling (PI: Fiscal/financial incentives; Obligation schemes, PT: Renewables, S: Buildings, SS: Heating and cooling) * Support scheme for hot water and cooking (PI: Fiscal/financial incentives; Obligation schemes PT: Renewables, S: Buildings, SS: Hot water and cooking) |  |  |
| * Energy and other taxes (PI: Energy and other taxes, PT: Any, S: Buildings, SS: Any) | | | |
|  |
| Land transport | * Urban planning and infrastructure investment (PI: Strategic planning; Infrastructure investments, PT: Energy service demand reduction and resource efficiency, S: Transport, SS: any) | * Energy/emissions performance standards or support for energy efficient for light duty vehicles (PI: Vehicle fuel-economy and emissions standards; Fiscal/financial incentives, PT: Energy efficiency, S: Transport, SS: Light duty) * Energy/emissions performance standards or support for energy efficient for heavy duty vehicles (PI: Vehicle fuel-economy and emissions standards; Fiscal/financial incentives, PT: Energy efficiency, S: Transport, SS: Heavy duty) | * Support for biofuels (PI: Renewable energy target; Fiscal/financial incentives; Obligation schemes, PT: Renewables, S: Transport, SS: any) | * Support for modal share switch (PI: Infrastructure investment; Strategic planning, PT: Other low-carbon technologies and fuel switch, S: Transport, SS: Any) * Support schemes for low-emissions land transportation (PI: Any, PT: Other low-carbon technologies and fuel switch, S: Transport, SS: Low-emission mobility) |  |
| * Tax on fuel and/or emissions (PI: CO2 taxes; Energy and other taxes, PT: Any, S: Transport, SS: Any) | | | |
| Agriculture and forestry | * Standards and support for sustainable agricultural practices and use of agricultural products (PI: Strategic planning; Product standards, PT: any, S: Agriculture and forestry, SS: none) * Incentives to reduce CO2 emissions from agriculture (PI: any, PT: any, S: Agriculture and forestry, SS: Agriculture CO2) * Incentives to reduce CH4 emissions from agriculture (PI: any, PT: any, S: Agriculture and forestry, SS: Agriculture CH4) * Incentives to reduce N2O emissions from agriculture (PI: any, PT: any, S: Agriculture and forestry, SS: Agriculture N2O) * Incentives to reduce deforestation (PI: any, PT: any, S: Agriculture and forestry, SS: Forestry) | | | | |
|  |  | * Sustainability standards for biomass use (PI: Product standards, PT: Renewables, S:Any, SS: any) |  |  |

# S3 Distribution of policy instruments

Timeline

Description automatically generated

Figure 2 Policy instrument types (identified by colours) in the G20. Bar charts indicate country coverage weighted using G20 members’ share of total emissions in 2018.

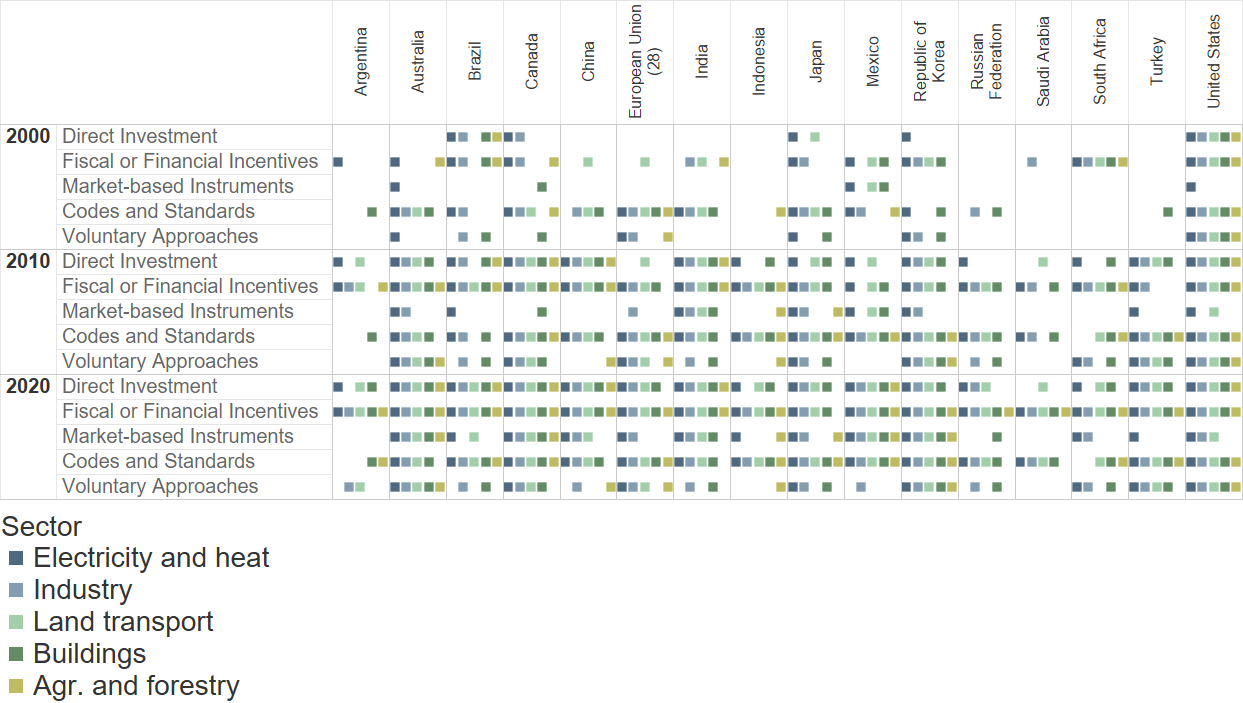


Figure 3 Distribution of policy instruments per sector and country.

S4 Cluster description

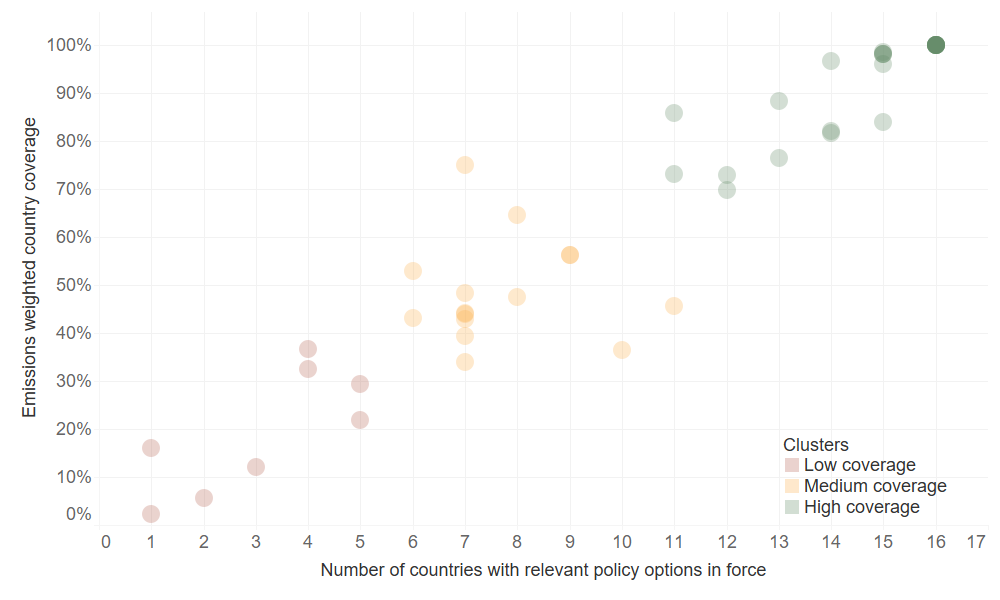


Figure 4 Cluster results, each circle represents one policy option. No G20 country has removed fossil fuel subsidies. This policy option is not used in the cluster analysis but would be categorised ‘low coverage’.

|  |  |
| --- | --- |
| **Number of Clusters:** | 3 |
| **Number of Points:** | 49 |
| **Between-group Sum of Squares:** | 8.5516 |
| **Within-group Sum of Squares:** | 1.0859 |
| **Total Sum of Squares:** | 9.6375 |
|  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | Centres | |  |
| Clusters |  | **Number of items** |  | **Emissions share** | **Count of countries** |  |
| High |  | 26 |  | 0.92323 | 14.615 |  |
| Medium |  | 15 |  | 0.48722 | 7.7333 |  |
| Low |  | 8 |  | 0.19544 | 3.125 |  |

References

Agora Energiewende and Wuppertal Institut (2019) ‘Climate-Neutral Industry. Key technologies and policy options for steel, chemicals and cement. Executive Summary’.

Åhman, M., Nilsson, L. J. and Johansson, B. (2017) ‘Global climate policy and deep decarbonization of energy-intensive industries’, *Climate Policy*. Taylor & Francis, 17(5), pp. 634–649. doi: 10.1080/14693062.2016.1167009.

Axsen, J., Plötz, P. and Wolinetz, M. (2020) ‘Crafting strong, integrated policy mixes for deep CO2 mitigation in road transport’, *Nature Climate Change*, 10(9), pp. 809–818. doi: 10.1038/s41558-020-0877-y.

BigEE (2016) *Buildings: Package Elements*. bigEE initiative, Wuppertal Institute. Available at: http://www.bigee.net/en/policy/guide/buildings/package-elements/ (Accessed: 25 January 2016).

Booth, M. S. (2018) ‘Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy’, *Environmental Research Letters*. {IOP} Publishing, 13(3), p. 35001. doi: 10.1088/1748-9326/aaac88.

Carley, S. *et al.* (2017) ‘Global Expansion of Renewable Energy Generation: An Analysis of Policy Instruments’, *Environmental and Resource Economics*. Springer Netherlands, 68(2), pp. 397–440. doi: 10.1007/s10640-016-0025-3.

Climate Action Tracker (2016) *Constructing the future: Will the building sector use its decarbonisation tools? CAT Decarbonisation Series*. Available at: https://newclimate.org/2016/11/02/constructing-the-future/.

Climate Action Tracker (2018) *A Policy Spotlight on Energy Efficiency in Appliances & Lights Could See Big Climate Gains*. Available at: https://climateactiontracker.org/documents/70/CAT\_2018-03-23\_DecarbEnergy\_CATAnalysis.pdf.

Cox, E. and Edwards, N. R. (2019) ‘Beyond carbon pricing: policy levers for negative emissions technologies’, *Climate Policy*. Taylor & Francis, 19(9), pp. 1144–1156. doi: 10.1080/14693062.2019.1634509.

Daioglou, V. *et al.* (2017) ‘Greenhouse gas emission curves for advanced biofuel supply chains’, *Nature Climate Change*, 7(12), pp. 920–924. doi: 10.1038/s41558-017-0006-8.

Deetman, S., Hof, A. F. and van Vuuren, D. P. (2015) ‘Deep CO2 emission reductions in a global bottom-up model approach’, *Climate Policy*. Taylor & Francis, 15(2), pp. 253–271. doi: 10.1080/14693062.2014.912980.

Dubash, N. K. *et al.* (2013) *Developments in national climate change mitigation legislation and strategy*, *Climate Policy*. doi: 10.1080/14693062.2013.845409.

Dulal, H. B., Brodnig, G. and Onoriose, C. G. (2011) ‘Climate change mitigation in the transport sector through urban planning: A review’, *Habitat International*, 35(3), pp. 494–500. doi: https://doi.org/10.1016/j.habitatint.2011.02.001.

Erickson, P., Lazarus, M. and Piggot, G. (2018) ‘Limiting fossil fuel production as the next big step in climate policy’, *Nature Climate Change*, 8(12), pp. 1037–1043. doi: 10.1038/s41558-018-0337-0.

Fischedick, M. *et al.* (2014) *Industry*, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by O. Edenhofer et al. Cambridge, UK and New York, NY, USA: Cambridge University Press.

Frank, S. *et al.* (2018) ‘Structural change as a key component for agricultural non-CO2 mitigation efforts’, *Nature Communications*, 9(1), p. 1060. doi: 10.1038/s41467-018-03489-1.

Frank, S. *et al.* (2019) ‘Agricultural non-CO2 emission reduction potential in the context of the 1.5 °C target’, *Nature Climate Change*, 9(1), pp. 66–72. doi: 10.1038/s41558-018-0358-8.

Grubler, A. *et al.* (2018) ‘A low energy demand scenario for meeting the 1.5°C target and sustainable development goals without negative emission technologies’, *Nature Energy*. Springer US, 3(June), pp. 515–527. doi: 10.1038/s41560-018-0172-6.

Herrero, M. *et al.* (2016) ‘Greenhouse gas mitigation potentials in the livestock sector’, *Nature Climate Change*, 6(March), pp. 452–461. doi: 10.1038/nclimate2925.

Iacobuta, G. *et al.* (2018) ‘National climate change mitigation legislation, strategy and targets: a global update’, *Climate Policy*. Taylor & Francis, 18(9), pp. 1114–1132. doi: 10.1080/14693062.2018.1489772.

IEA/IRENA (2017) *Perspectives for the Energy Transition - Investment Needs for a Low-Carbon Energy System*. Available at: https://www.energiewende2017.com/wp-content/uploads/2017/03/Perspectives-for-the-Energy-Transition\_WEB.pdf.

IEA (2015) *Energy and climate change. World Energy Outlook Special Report.* Paris, France: International Energy Agency. Available at: https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf (Accessed: 8 September 2015).

IEA (2017) *Energy Technology Perspectives 2017. Catalysing Energy Technology Transformations*. Paris, France: International Energy Agency. Available at: http://www.iea.org/etp2017/.

IEA (2019) *World Energy Outlook*. Paris, France: International Energy Agency (IEA). doi: 10.1049/ep.1977.0180.

IEA (2020) *Tracking Industry 2020*. Paris. Available at: https://www.iea.org/reports/tracking-industry-2020.

IPCC (2014) *Summary for Policymakers*, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by O. Edenhofer et al. Cambridge, UK and New York, NY: Cambridge University Press. Available at: http://report.mitigation2014.org/spm/ipcc\_wg3\_ar5\_summary-for-policymakers\_approved.pdf.

IPCC (2018) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,*. Intergovernmental Panel on Climate Change.

IRENA (2015) *Renewable Energy Target Setting*. Abu Dhabi, United Arab Emirates: International Renewable Energy Agency.

IRENA (2016) *Scaling Up Variable Renewable Power: The Role of Grid Codes*. Available at: http://www.irena.org/publications/2016/May/Scaling-up-Variable-Renewable-Power-The-Role-of-Grid-Codes.

IRENA, IEA and REN21 (2018) *Renewable Energy Policies in a Time of Transition*. Available at: http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA\_IEA\_REN21\_Policies\_2018.pdf [accessed on 23 July 2018].

Jakob, M. *et al.* (2015) ‘Development incentives for fossil fuel subsidy reform’, *Nature Climate Change*, 5(8), pp. 709–712. doi: 10.1038/nclimate2679.

Jakob, M. *et al.* (2020) ‘The future of coal in a carbon-constrained climate’, *Nature Climate Change*, 10(8), pp. 704–707. doi: 10.1038/s41558-020-0866-1.

Johnson, E. (2009) ‘Goodbye to carbon neutral: Getting biomass footprints right’, *Environmental Impact Assessment Review*. Elsevier, 29(3), pp. 165–168. doi: 10.1016/J.EIAR.2008.11.002.

Knobloch, F. *et al.* (2020) ‘Net emission reductions from electric cars and heat pumps in 59 world regions over time’, *Nature Sustainability*, 3(6), pp. 437–447. doi: 10.1038/s41893-020-0488-7.

Kriegler, E. *et al.* (2018) ‘Short term policies to keep the door open for Paris climate goals’, *Environmental Research Letters*, 13(7). doi: https://doi.org/10.1088/1748-9326/aac4f1.

Kuramochi, T. *et al.* (2018) ‘Ten key short-term sectoral benchmarks to limit warming to 1.5°C’, *Climate Policy*, 18(3), pp. 287–305. doi: 10.1080/14693062.2017.1397495.

Luderer, G. *et al.* (2018) ‘Residual fossil CO2 emissions in 1.5–2 °C pathways’, *Nature Climate Change*, 8(7), pp. 626–633. doi: 10.1038/s41558-018-0198-6.

Lund, P. D. *et al.* (2015) ‘Review of energy system flexibility measures to enable high levels of variable renewable electricity’, *Renewable and Sustainable Energy Reviews*. Elsevier, 45, pp. 785–807. doi: 10.1016/j.rser.2015.01.057.

Mitchell, C. *et al.* (2011) *Policy, Financing and Implementation*, *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*. Edited by O. Edenhofer et al. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

OECD/IEA and IRENA (2017) *Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System*, *International Energy Agency*. International Energy Agency, International Renewable Energy Agency. Available at: http://www.irena.org/DocumentDownloads/Publications/Perspectives\_for\_the\_Energy\_Transition\_2017.pdf.

Powell, J. T., Townsend, T. G. and Zimmerman, J. B. (2016) ‘Estimates of solid waste disposal rates and reduction targets for landfill gas emissions’, *Nature Climate Change*, 6(2), pp. 162–165. doi: 10.1038/nclimate2804.

Ray, R. L. *et al.* (2020) ‘Soil CO2 emission in response to organic amendments, temperature, and rainfall’, *Scientific Reports*, 10(1), p. 5849. doi: 10.1038/s41598-020-62267-6.

REN21 (2018) *Renewables 2018 global status report*. Paris, France, France: REN21.

Rentschler, J. and Bazilian, M. (2017) ‘Reforming fossil fuel subsidies: drivers, barriers and the state of progress’, *Climate Policy*. Taylor & Francis, 17(7), pp. 891–914. doi: 10.1080/14693062.2016.1169393.

Roe, S. *et al.* (2020) ‘Contribution of the land sector to a 1.5°C world’, *Nat. Clim. Chang*, 9, pp. 817–828. doi: 10.1038/s41558-019-0591-9.

Roelfsema, M. *et al.* (2018) ‘Reducing global greenhouse gas emissions by replicating successful sector examples: the “good practice policies” scenario.’, *Climate Policy*, 18(9), pp. 1103–1113. doi: 10.1080/14693062.2018.1481356.

Somanathan, E. *et al.* (2014) *National and Sub-national Policies and Institutions*, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by O. Edenhofer et al. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Thompson, R. L. *et al.* (2019) ‘Acceleration of global N2O emissions seen from two decades of atmospheric inversion’, *Nature Climate Change*, 9(12), pp. 993–998. doi: 10.1038/s41558-019-0613-7.

UNEP (2015) *The Emissions Gap Report 2015: A UNEP Synthesis Report*. Nairobi, Kenya: United Nations Environment Programme (UNEP). Available at: https://newclimateinstitute.files.wordpress.com/2015/12/unep-emissions-gap-report-2015.pdf.

UNEP (2016) *The Emissions Gap Report 2016*. Nairobi, Kenya: United Nations Environment Programme (UNEP). doi: ISBN 978-92-9253-062-4.

UNEP (2019) *Emissions Gap Report 2019*. Nairobi, Kenya: United Nations Environment Programme. doi: 10.18356/ff6d1a84-en.

UNFCCC (2014a) *Non-market based approaches. Technical paper. FCCC/TP/2014/10*. Bonn, Germany: United Nations Framework Convention on Climate Change. Available at: http://unfccc.int/resource/docs/2014/tp/10.pdf (Accessed: 25 January 2016).

UNFCCC (2014b) *Updated compilation of information on mitigation benefits of actions, initiatives and options to enhance mitigation ambition. Technical paper FCCC/TP/2014/03*. Bonn,Germany: United Nations Framework Convention on Climate Change. Available at: http://unfccc.int/resource/docs/2014/tp/03.pdf (Accessed: 25 January 2016).

UNFCCC (2015) *Mitigation benefits of actions , initiatives and options to enhance mitigation ambition. Technical paper 2015*. Bonn, Germany: United Nations Framework Convention on Climate Change.

UNFCCC (2017) *Urban environment related mitigation benefits and co-benefits of policies, practices and actions for enhancing mitigation ambition and options for supporting their implementation. Technical paper by the secretariat*. Bonn, Germany: United Nations Framework Convention on Climate Change.

UNFCCC (2018) *Talanoa dialogue for climate ambition. Synthesis of the preparatory phase 19/11/2018*. Bonn, Germany: United Nations Framework Convention on Climate Change.

van Vuuren, D. P. *et al.* (2018) ‘Alternative pathways to the 1.5 °C target reduce the need for negative emission technologies’, *Nature Climate Change*, p. 1. doi: 10.1038/s41558-018-0119-8.

Wright, L. and Fulton, L. (2005) ‘Climate Change Mitigation and Transport in Developing Nations’, *Transport Reviews*, 25(6), pp. 691–717. doi: 10.1080/01441640500360951.