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Guidance to assist developing country Parties to assess the impact of the implementation of response measures, including guidance on modelling tools

Technical paper by the secretariat

Summary

This technical paper first provides an overview of the work under the Convention in relation to assessing the impact of the implementation of response measures. The elements of and approaches to assessment of this impact are then discussed, and relevant assessment approaches, including modelling tools, are compiled with a view to providing guidance to developing country Parties. The discussion draws on relevant information in: (1) reports on the work of the forum on the impact of the implementation of response measures as well as submissions, presentations and statements made by Parties and observer organizations during previous sessions of the Conference of the Parties and the subsidiary bodies; (2) national communications, biennial reports and biennial update reports submitted by Parties; and (3) independent sources published by international organizations and research institutions. The paper concludes by presenting possible items for the work programme of the improved forum on the impact of the implementation of response measures to be undertaken by the subsidiary bodies.

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Contents

I. Introduction

A. Mandate

1. The Conference of Parties (COP), at its twenty-first session, requested the secretariat to prepare a guidance document to assist developing country Parties in assessing the impact of the implementation of response measures, including in using modelling tools for such an assessment, for consideration at the forty-fourth sessions of the subsidiary bodies.[1]

2. By the same decision, the secretariat was also requested to prepare technical materials to assist developing country Parties in their economic diversification initiatives. This mandate is addressed in a separate technical paper.[2]

B. Scope and approach used

3. This paper provides an overview of the work under the Convention in relation to assessing the impact of the implementation of response measures and identifies implications for consideration by Parties. The paper explores the approaches, including modelling tools, available for assessing the impact of the implementation of response measures, with a view to assisting developing country Parties with such an assessment.

4. The paper considers relevant information in reports on the work of the forum on the impact of the implementation of response measures as well as submissions, presentations and statements made by Parties and observer organizations during past sessions of the COP and the subsidiary bodies.

5. The paper synthesizes relevant information in national communications, biennial reports, national inventory reports (NIRs) and biennial update reports submitted by Parties. Some of the information used in the paper is drawn from independent sources, such as assessment reports of the Intergovernmental Panel on Climate Change (IPCC) and research papers published by international organizations and research institutions.

C. Possible action by the subsidiary bodies

6. The subsidiary bodies may wish to consider using the information in this technical paper as the basis for providing guidance to developing country Parties on assessing the impact of the implementation of response measures.

7. The subsidiary bodies, at their forty-fourth sessions, may wish to draw on the analysis and action points in this paper for their consideration of the work programme of the improved forum on the impact of the implementation of response measures with a view to commencing implementation of the work programme of the improved forum at their forty-fifth sessions.

[1] Decision 11/CP.21, paragraph 9.
[2] FCCC/TP/2016/3.

II. Overview of work under the Convention

A. Synthesis of work under the subsidiary bodies

8. Technical discussion on the assessment of the impact of the implementation of response measures and the use of modelling tools for such an assessment has taken place under the subsidiary bodies in the format of expert meetings mandated by the COP.

9. An expert meeting mandated by decision 5/CP.7 was held from 16 to 18 May 2002 in Bonn, Germany. It covered the status of modelling activities to assess the adverse effects of climate change and the impact of response measures already implemented on individual developing country Parties, as well as how to enhance the participation of experts from developing country Parties in such assessments.

10. Another expert meeting, mandated by decision 1/CP.10, was held on 23 and 24 November 2005 in Montreal, Canada. In this meeting, the outcomes of the workshops held in response to decision 5/CP.7, paragraphs 33 and 35, were considered, and information was exchanged on the tools and methodologies for achieving resilience to the possible impacts of the implementation of response measures, on the role of financial risk management strategies and on modelling socioeconomic impacts.

11. One of the results of implementing decision 1/CP.10 was the creation of a portal on the UNFCCC website for modelling tools for assessing the impact of the implementation of response measures.[3] The portal contains information on 38 models that have been, or could be, useful in assessing the impact of the implementation of response measures. However, some of the information on the portal does not reflect the latest developments in this subject area, and links to some of the model providers are no longer working. Moreover, the portal does not include pertinent information such as data requirements, estimated cost and examples of successful application of the model, particularly in developing countries. Therefore, there is a need to improve the portal so as to make it more user-friendly.

12. The COP, by decision 8/CP.17, established a forum on the impact of the implementation of response measures. Of eight total areas of work in the work programme of the forum, two had the objective of improving understanding of the impact of the implementation of response measures:[4]

(a) Assessment and analysis of impacts;

(b) Economic modelling and socioeconomic trends.

13. Given the close link between these two areas, two back-to-back in-forum workshops covering them were held on 6 and 7 June 2013, during the thirty-eighth sessions of the subsidiary bodies. The workshops provided an opportunity for Parties and relevant international organizations to exchange information, experiences, best practices and views on these two areas.

14. During the two workshops, developing country Parties noted that assessment of impacts is at the core of discussion on response measures, and that assessment should be conducted in the context of sustainable development in developing countries and provide information on social, economic and environmental impacts of mitigation policies. The outputs of the assessment should be quantitative and qualitative. The assessment should encompass:

[3] <http://unfccc.int/cooperation_support/response_measures/items/5112.php>.

[4] Decision 8/CP.17, paragraph 1.

(a) Ex ante assessment of proposed response measures by developed country Parties that seeks to quantify social, economic and environmental costs and benefits, thus identifying less harmful options;

(b) Ex post assessment of current response measures that analyses the social, economic and environmental consequences for developing country Parties.

15. Developed country Parties highlighted the importance of assessing the positive effects and co-benefits of climate policies and measures; for example, improvements in air quality, sustainable agriculture, job creation and health. One country-specific case study showed the possibility of decoupling economic growth from emissions: a total of 15,000 new jobs were created in the country and inflation was contained while emissions in the electricity sector decreased by 7.4 per cent and renewable energy generation increased by 30 per cent.

16. Modelling activities should produce quantitative outputs of the assessment, which are complemented by qualitative outputs for elements such as gross domestic product (GDP), employment, investment and trade, considering that all of these elements are important for promoting sustainable development.

17. There is a need for guidance to assist developing countries based on a comprehensive and structured assessment framework, for which they should be provided with resources and technical assistance in order to undertake national assessments of the impact of response measures. The guidance is particularly necessary if a measure or set of measures is being coordinated by a group of developed country Parties. Guidance should cover modelling expertise, with a focus on building the capacity of developing country Parties.

18. The difficulty of obtaining data for modelling in developing country Parties was raised and it was suggested that the governments of developing country Parties should cooperate in data collection.

19. Case studies on model-based assessments of the impact of the implementation of response measures were presented at the in-forum workshops, including:

(a) Using the GTAP-E model[5] to examine the effect of policy reforms on the renewable energy sector, including reforming fossil fuel subsidies and carbon taxes, lowering import tariffs on renewable energy products, removing feed-in tariffs, and removing local content requirements in the clean energy sector;

(b) Using the E3MG model[6] to assess the economic impact of decarbonizing the global economy;

(c) Using the GINFORS model[7] to assess the economic impacts of post-Kyoto Protocol carbon-pricing regimes.

20. IPCC assessment reports have been noted by Parties, particularly developing country Parties, to be an important technical source for informing the outcome of

[5] An extended computable general equilibrium model that uses the Global Trade Analysis Project (GTAP) database with energy substitution.

[6] The Energy-Environment-Economy (E3) Model at the Global Level (MG) is an econometric model that was used for macroeconomic assessment of environmental policy and oil price shocks until early 2014. Its capabilities are now encompassed in the global version of the E3ME (Energy-Environment-Economy macroeconometric) model.

[7] The Global Inter-industry Forecasting System (GINFORS) is a model for analysing international and global economic issues. The effects of policies and measures can be extensively analysed assuming alternative global conditions; indirect international spillover effects are modelled automatically.

assessment of the impact of the implementation of response measures, including of assessment using modelling tools.

21. In the Third Assessment Report of the IPCC, it was suggested that there may be adverse effects of response measures on some developing countries, but further work is needed in order to build a comprehensive understanding of these effects. The report highlighted the following limits of using economic models, among others: (1) the way models generally treat policy affects the assessment outcome differently, depending on whether they are top-down, bottom-up,[8] computable general equilibrium (CGE), input–output or macroeconomic models; (2) market imperfections are not well represented; and (3) most models are not able to reflect technology advances or accurately estimate the geographic diffusion of existing technologies.

22. The Fifth Assessment Report of the IPCC highlighted the wide range of possible adverse side effects as well as co-benefits and spillovers from climate policy that have not been well quantified (with high confidence). Whether or not side effects materialize, and to what extent they materialize, will be case- and site-specific, as side effects will depend on local circumstances and the scale, scope and pace of implementation of response measures. The side effects could take place in areas such as biodiversity conservation, water availability, food security, income distribution, efficiency of the taxation system, labour supply and employment, urban sprawl, and the sustainability of the growth of developing countries.

B. Synthesis of information communicated by Parties

1. Communications from Annex I Parties

23. Information related to assessing the impact of the implementation of response measures is identified in national communications, NIRs and biennial reports communicated by Parties included in Annex I to the Convention (Annex I Parties). The information reported varies from the policy assessment process to specific actions taken for the assessment of the policy impact.

24. The European Union (EU), in its NIR for 2014 and its sixth national communication, reported that a wide-ranging impact assessment system accompanying all new policy initiatives has been established in the EU. Impact analysis is required for all legislative proposals. Impacts on developing country Parties, including an analysis of consequences (or spillovers) in the longer term in areas such as economic, environmental, social or security policies, is one of the areas to be covered by the impact assessment when it comes to third countries or international relations. The European Commission should take the impact assessment report into account when making its decisions.

25. As an example, the EU reported in its NIR for 2014 that an impact assessment was conducted before a communication on a policy framework for climate and energy in the period 2020–2030 was published in January 2014. The assessment shows that all scenarios have reduced fuel consumption compared with the reference scenario. Specifically, solid fuel consumption declines substantially in all scenarios; oil consumption also declines, and

[8] Bottom-up modelling means that individual technologies are considered, and are summed to give aggregate results. Top-down modelling starts at a more aggregate position, usually using an economic equation to assess the sector, rather than a technological analysis. According to the Second Assessment Report of the IPCC, the macroeconomic and computable general equilibrium approaches can be further classified as "top-down" methodologies, while the technology-rich dynamic optimization/partial equilibrium simulation, and partial forecasting approaches can be considered "bottom-up" approaches. Recently, the two approaches have been linked to provide a detailed representation of the energy system within a whole-economy context.

much faster in scenarios with policies that promote electrification of transportation; and natural gas absolute consumption declines in general less sharply than oil, and slightly more in scenarios that include renewable targets. Net energy import decreases significantly, by about 50 per cent in most scenarios by 2050. The impact assessment therefore concluded that future fuel consumption in the EU will have an economic impact on fuel prices as well as trade effects for fuel-exporting countries.

26. Spain, in its NIR for 2015, provided a qualitative assessment of the impacts of mitigation actions in tabular format. The reported mitigation actions included international measures (EU Emissions Trading System, and clean development mechanism) and national measures implemented in sectors such as renewable energy, energy efficiency, biofuels, transportation, agriculture and waste. For each measure, the assessment looked into the potential social, economic and environmental impacts, both positive and negative, on third countries. For instance, for measures to increase the use of renewable energy, Spain reported that positive environmental effects result by incentivizing technology transfer in third countries. These measures also help to create new jobs in countries that supply machinery or materials to renewable energy projects. As for economic effects, the assessment highlighted revenue loss by fossil fuel exporting countries as a result of reduced demand; however, economic diversification may be incentivized in those countries. The assessment also pointed out the potential economic effects arising from interconnection of the power grid between Northern Africa and the EU.

27. Australia, in its NIR for 2015, reported that the Government of Australia undertakes impact assessments, including consultation processes that enable potentially affected stakeholders to raise concerns, as a matter of course in the development of policy. The Party also noted that by engaging in the forum on the impact of the implementation of response measures its understanding of positive and negative impacts was improved.

28. New Zealand, in its NIR for 2015, reported that there is no prescribed process for the analysis of impacts across all policies. The Ministry of Foreign Affairs and Trade is involved in advising the Government of New Zealand on international aspects of proposed policies, and public consultations are an opportunity for stakeholders to raise their concerns.

29. The United Kingdom of Great Britain and Northern Ireland, in its NIR for 2015, reported that it continues to undertake assessment, review and analysis to better understand the impacts its policies have on developing country Parties and how such impacts could be addressed. Recent examples of the latter include: (1) supporting developing country Parties to develop their own calculator (2050 Energy Calculator[9]) to explore options to reduce greenhouse gas (GHG) emissions and help tackle energy challenges; (2) leading work into understanding indirect land-use change impacts from biofuel; and (3) continuing to fund research that monitors GHG emissions associated with energy consumption in the United Kingdom, including products that the United Kingdom imports and exports.

2. Communications from non-Annex I Parties

30. A few Parties not included in Annex I to the Convention (non-Annex I Parties) have provided information on assessing the impact of the implementation of response measures in their national communications. Some of them applied a quantitative approach based on economic modelling tools, while some conducted a simple quantitative estimation. The results of the assessment reflected either the overall impact on the national economy or the impact on the fossil fuel production sector.

[9] <http://2050-calculator-tool.decc.gov.uk/#/home>.

31. In its initial national communication, the Islamic Republic of Iran predicted revenue losses from oil sales under a number of scenarios based on a study conducted through a general equilibrium model called MS-MRT.[10] Under a scenario that includes the application of Kyoto Protocol flexibility mechanisms, world crude oil prices are estimated to drop by 3.54 per cent from the baseline, entailing a loss of revenue of USD 900 million in 2010.

32. In its second national communication, Saudi Arabia presented modelling results estimating that the impact of the response measures of Parties to the Convention that are also Parties to the Kyoto Protocol with commitments inscribed in Annex B to the Kyoto Protocol up to 2030 would result in damages to its economy of USD 100–200 billion.

33. In its initial national communication, South Africa predicted a drop in coal exports to Annex I Parties, which would have a significant effect on the country considering that in 2000 it was the world's second largest exporter of coal.

III. Elements of guidance on and approaches to assessing impacts

A. Elements of guidance on assessing impacts

34. This chapter introduces the elements of guidance to assist developing country Parties in undertaking a national assessment of the impacts of the implementation of response measures. It discusses what is to be assessed, when the assessment should occur, who should be involved in the assessment and how to deal with the assessment results. This chapter also briefly looks at options for assessment approaches, but more details on this aspect are included in chapter III.B.

35. Under Article 4, paragraph 8(h), of the Convention, Parties shall give full consideration to the impact of the implementation of response measures, including for "...countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products...". Under Article 2, paragraph 3, of the Kyoto Protocol, "Parties included in Annex I shall strive to implement policies and measures...in such a way as to minimize adverse effects...on other Parties, especially developing country Parties". In this context, response measures are mitigation actions taken or initiated by developed country Parties but with the impacts flowing to developing country Parties, in particular fossil fuel dependent developing countries.

36. Examples of policy initiatives that are the most likely to have an impact on developing country Parties include:[11]

(a) Carbon taxes;

(b) Subsidies, including those granted for the production and consumption of low-carbon technologies or goods, and removal of existing subsidies to GHG-intensive technologies or goods;

(c) Energy policy reform and green public investment;

(d) Cap-and-trade schemes and international offsets;

(e) Trade-related measures, including trade tariffs and border carbon adjustment;

(f) Standards and labelling requirements;

[10] Multi-sector Multi-region Trade.
[11] See document FCCC/KP/AWG/2009/INF.3.

(g) Technology cooperation.

37. These policy initiatives may lead to impacts on economic growth, income distribution, employment, the environment (e.g. biodiversity, water availability), health and food security in developing country Parties. Some of these response measures and their impacts can be quantitatively assessed using sophisticated methods (e.g. models), while others are unlikely to be assessed accurately by attributing a numeric value. A comprehensive assessment, in most cases, should include both positive and negative outcomes.

38. The assessment of impacts is usually undertaken ex ante; that is, before formulation and adoption of the policy initiative. Such assessment serves two purposes. First, policymakers can be informed by the outcome of the assessment before making their political decision. Second, stakeholders are given a chance to state their views on the outcome of the assessment. The ex post assessment is undertaken after the implementation of the policy initiative with the purpose of checking and evaluating its real impacts.

39. An impact assessment may be requested by the negotiators of a global climate change deal with an ambitious mitigation target. The outcome of the assessment helps to inform the negotiators and assist them in making a political decision that best serves their own country. Nevertheless, an assessment is sometimes requested at a later stage, when the already negotiated deal brings more certainty and clarity to Parties.

40. Most impact assessments of mitigation policies focus on impacts within developed country Parties. At the international level, many assessments that do cover developing country Parties tend to do so only at the regional level, omitting analysis of the sectoral, national and subnational impacts. For developing country Parties, carrying out their own assessment is particularly needed when the cross-border impacts of response measures have not been adequately assessed by the implementing country.

41. Stakeholders should be engaged during impact assessment as their views, practical experience and data will help deliver higher-quality and more credible assessment results. Stakeholder engagement also gives greater transparency to the policy development process. In general, the following stakeholders should be involved in the assessment:

(a) Government and its branches, which could lead the assessment, provide data and/or make policy and laws based on what the assessment results are found to be. Enduring political support and, where necessary, collaboration across related government branches are critical for carrying out impact assessment in developing country Parties;

(b) Sectors, firms and individuals that are directly or indirectly affected by the response measures to be assessed;

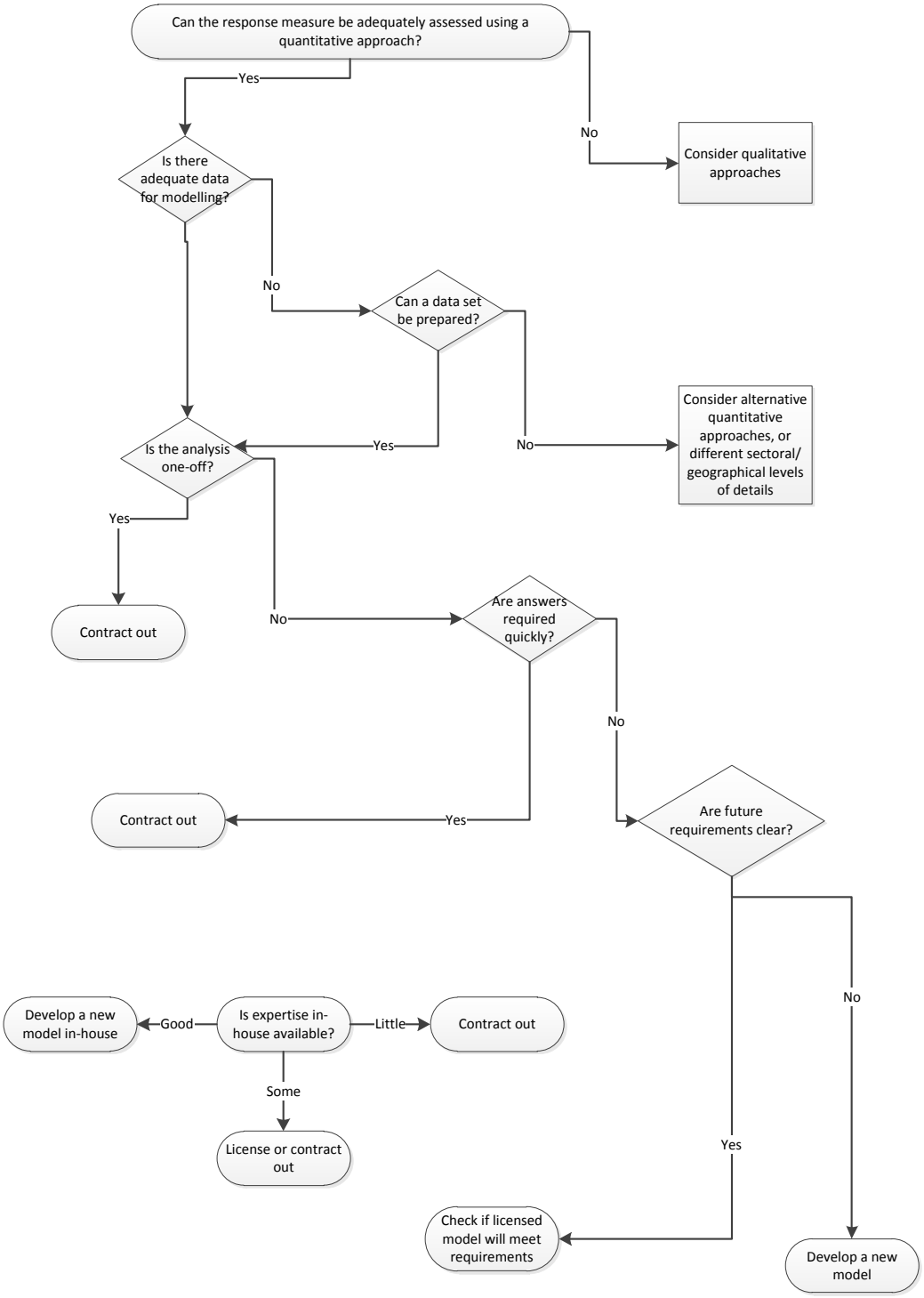
(c) Academics and researchers who are assigned to undertake the assessment or provide technical inputs to it.

42. When undertaking the assessment, expertise from energy, environment, economics, climate change, finance, trade and other relevant areas is crucial. If a modelling tool is used, relevant expertise (e.g. in the software) should also be involved. Expertise can come from an in-house source or be outsourced to an experienced institution.

43. Various approaches are available for assessing the impacts of the implementation of response measures. Modelling tools provide quantitative assessment results with a high degree of accuracy, but they usually require a large data set and expertise and are associated with a high cost. Other quantitative approaches for which the data requirement is lower, such as cost–benefit analysis, econometric analysis and input–output analysis, may also be applied. A qualitative approach can be used when a response measure and its impacts cannot be adequately assessed using a quantitative approach.

44. When choosing an assessment approach, balance between accuracy and effort (time and cost) should be sought. For modelling tools, the options are to: (1) contract out modelling; (2) license an existing model to use in-house; or (3) develop a new model to use in-house. Detailed information on these three options can be found in paragraph 65 below. The following figure illustrates factors to be taken into account in the selection of an impact assessment approach.

Decision tree for the selection of an impact assessment approach



45. There are several ways to monitor and validate the results of an assessment:

(a) Undertake an ex post assessment after a period of time for implementation;

(b) Undertake a qualitative assessment by consulting with stakeholders;

(c) Compare the results with estimated impacts in other countries, especially countries with similar characteristics. The academic literature and regional and international conferences provide opportunities that allow for such comparisons.

46. The assessment report should include as a minimum: the mitigation policy being assessed; the impacts (positive, negative, direct, indirect); the stakeholders who will be affected, and how they will be affected; the assessment approach used (quantitative, qualitative); data sources; and details of stakeholder consultations.

47. To make the assessment meaningful for decision makers, the assessment report may include not only positive and negative impacts, but more importantly the magnitude of the negative impacts and the degree to which they can be balanced by positive impacts. Moreover, the report may provide proposals on how to address the negative impacts identified.

B. Approaches to assessing impacts

48. This chapter explores macroeconomic models and other quantitative assessment approaches that are available to assess the impact of response measures. It looks into the challenges developing country Parties may face in using these approaches, and provides solutions on how to address these challenges. This chapter also briefly looks at qualitative approaches that can be used as an alternative when developing countries, for one reason or another, cannot use a quantitative approach for assessment.

49. This chapter draws on information from sources in the academic literature and in research reports. The information about modelling tools has been contributed by an organization[12] that specializes in model development and application.

1. Quantitative assessment: macroeconomic models

50. A macroeconomic model is used widely to assess policies and measures that have economy-wide effects. It captures the linkage between markets across the entire economy, thus reflecting not only the direct impact of a policy but also indirect impacts on other linked markets. One of the main functions of macroeconomic modelling in policy analysis is to quantify impacts. Models can increase the understanding of response measures because they can attribute a numerical value to interacting costs and benefits, including environmental and energy costs and benefits. A list of modelling tools available for assessing the impact of the implementation of response measures is presented in annex I.

51. Macroeconomic models can address many issues of impact assessment:

(a) Attribute a numerical value to the indicators of interest in the expected outcome;

(b) Gauge the influence of opposing effects to derive an aggregate impact;

(c) Provide information on who the ‘winners’ and ‘losers’ of a policy might be;

(d) Determine what a potential least-cost scenario could look like.

[12] Cambridge Econometrics. See <http://www.camecon.com/Home.aspx>.

52. It is difficult to provide a comprehensive list of indicators common to all modelling approaches. The indicators will vary by the type of model used for the assessment and the particular assessment to be made. The most common economic measure adopted is GDP, usually used in terms of growth rate; moreover, models can produce many economic outputs of interest from a policy perspective, including tax revenues, sectoral impacts, and impacts on trade, competitiveness and prices.

53. Labour market dynamics can be an output of some macroeconomic models. Other labour market factors, such as the unemployment rate or employment within particular age and skill groups, can also sometimes be assessed.

54. Macroeconomic models have strong functionality in assessing the impacts of price-based response measures; for example, carbon taxes, levies, tariffs and subsidies.

55. However, modellers are beginning to incorporate non-price-based response measures into their models. In some cases, these can be modelled as if they are price-based. For example, emissions trading schemes or cap-and-trade schemes can be modelled as a price-based instrument that achieves a specific carbon emission reduction level. The emissions trade component can be modelled as an explicit market for permits.

56. **CGE models** are by far the most widely used approach for analysing climate policy at the whole economy level. These models provide assessments of feedback effects across all economic sectors. Economic activities are linked to energy demand and emission levels. The models can go into a high level of sectoral detail, with national or global coverage.

57. The core structure of CGE models relies on a set of optimization equations; CGE models conventionally calculate socially optimal (least-cost) outcomes rather than predictions based on observed behaviour. The CGE framework is fully internally consistent because all parts of the economy are in ‘equilibrium’, which makes these models appropriate for use in scenario analysis of long-term impacts. The models are highly complex, and require specialist software and expertise to use.

58. Data for CGE models need to be collected and processed for one year. The Global Trade Analysis Project (GTAP) database may provide the required data but it does not provide data to a sufficient level of detail for all countries. In particular, there are limited data provisions for 30 of the 48 least developed countries.

59. Annex II provides an example of the application of the CGE-based GTAP-E model to assessing the impacts of the implementation of response measures in South Africa. The case study shows the scope of the typical outputs that can be expected from a macroeconomic modelling exercise, as well as some of the processes involved in undertaking the modelling procedure. Overall, the model in this case showed how several key sectors in the South African economy would be affected by mitigation actions taken by other countries. It also estimated macro-level impacts on GDP.

60. **Macroeconometric models** are the main alternative to CGE models for assessing environmental policy at the whole economy level. These models use past behaviour to derive relationships between variables using econometric equations. Using historical relationships, the results are subsequently determined by observed data rather than theoretical assumptions. Consequently, the models can estimate a likely future path for each indicator. They can be applied to short- and medium-term forecasting and scenario analysis, as well as long-term outcomes. Macroeconometric models conventionally have larger data requirements than CGE models because they need time series data for each indicator rather than a single base year of data.

61. There are limitations to what a model can be used to assess. First, modelling exercises cannot quantify all types of impacts, and the outputs of any model are limited by its scope of coverage. For example, within current modelling frameworks, it is not usually

possible to assess directly the health impacts of changes in emission levels even though academic studies have found this to be a key impact that should be assessed.

62. Second, model assumptions may not always fit the requirements of the assessor. If the focus of the assessment is not specifically on economic outcomes, the usual strengths of these modelling efforts may not be applicable, and in those cases it may be better to use a different approach to answer the questions of interest.

63. Third, data limitations may restrict the types of modelling exercises that can be carried out. The limitations of economic data can be problematic, particularly when splitting national economies into sectors or looking back 10 years or more. Annex III to this paper provides information on the data sources available to developing country Parties.

Example of data gathering for a macroeconometric model

The E3ME[a] model has three main modules – economy, energy and environment – that provide greenhouse gas emission results. The methods used to gather these three types of data are examined below.

Economic data

Macro-level information is available. Priority is given to international sources that offer data based on consistent definitions and using a consistent format, such as Eurostat for the European Union and the Organisation for Economic Co-operation and Development (OECD) structural analysis (STAN) database for OECD countries. For other countries, aggregate values are obtained from the World Bank and International Monetary Fund databases and then split into sectors using data from national statistical agencies. The United Nations Comtrade database is used to provide trade data.

It is more difficult to obtain sectoral data and it is sometimes necessary to estimate sectoral-level data using a combination of sources, including:

1. Input–output tables that provide data for one year;

2. Sectoral information for other indicators that can be used as a proxy;

3. Data from other countries that can be used as a proxy.

Energy data

The E3ME model uses data from the International Energy Agency (IEA). There are two main sources of inconsistency in energy data: the first concerns energy balances, where there can be year-on-year inconsistencies, and the second concerns missing values in a set of energy prices and taxes. The developers of the model choose to fill these data using a specific set of assumptions:

1. If data are missing for all years, the tax is assumed to be zero;

2. If data are missing at the end of the series, taxes stay constant at the value of the final year the data are available;

3. If data are missing at the beginning of the series, taxes rise at 5 per cent per year up to the first year of observation.

Negative values are assumed to be errors (i.e. it is assumed that there are no subsidies: these data are treated as missing).

When collecting energy data, one of the challenges is to ensure consistency with economic data, otherwise the results of the modelling will be biased.

Emission data

The E3ME model uses emission data (for carbon dioxide and other greenhouse gases and for non-greenhouse gases) from the Eurostat and EDGAR[b] databases, which require some data adjustments to remove inconsistencies. These data sets are cross-referenced with the energy data from IEA as a consistency check.

[a] Energy-Environment-Economy macroeconometric.
[b] Emission Database for Global Atmospheric Research.

64. When a macroeconomic model-based assessment is being considered, two questions help define the scope of the exercise:

(a) Do the data available support modelling? If the data necessary for a model-based assessment are not available, a more basic approach will need to be followed;

(b) Could existing models, or slightly adjusted existing models, be used? A review of existing modelling options will provide insights into what is feasible for the assessment. The developers of existing modelling tools can provide advice on how best to assess the response measure.

65. Once it has been determined that a model-based assessment of the impact of response measures is appropriate, three options for the modelling tools may be considered:

(a) Develop a new model to use in-house, considering the following factors:

(i) Developing a new model is a significant undertaking and should be viewed from a long-term perspective. If the analysis of the impact of response measures is likely to be a one-off exercise, developing a new model for the purpose is unlikely to be a viable option;

(ii) A new model could be developed to be used either in-house or in a scientific support unit. The group in charge will be responsible for the long-term support and maintenance of the model. They need not necessarily be involved in the original development work (which could be contracted out), but it is best to involve them as closely as possible so that they are equipped to carry out future maintenance and development work;

(iii) It is crucial that the staff involved have the necessary skills in computer programming as well as expertise in economics. In practice, one person usually takes on responsibility for the model, but this can create problems if he or she becomes unavailable;

(iv) With an institutional framework in place, the benefits of developing a new, dedicated modelling tool are potentially considerable. The model will be available for future applications (at a relatively low cost) and it will be able to be further developed in line with future policy requirements. Training should be available to the staff involved so that they can understand the model's mechanisms;

(v) Developing a new model will in most cases take at least one year, and three years would not be unusual to allocate for the task. It is therefore necessary to plan ahead for future requirements for policy analysis;

(vi) The financial resources required for new model development vary widely depending on the model type but an estimate of USD 1 million is likely to be the minimum requirement. Organizations that offer support for model development, which are usually academic institutions or specialized research companies, should provide in-house staff with adequate training and ideally will offer support beyond the initial model development. Nevertheless, when budgeting for the development of a new model, provision must be made for the in-house staff who will take on support, maintenance and future development of the model;

(b) License an existing model to use in-house, considering the following factors:

(i) Using an existing model under licence is a lower cost option compared with developing a new model in-house. Licensing can be used to establish capacity, without committing the resources required for developing a new model. If the arrangement is successful, the staff who use the model could be involved in developing a new model in future;

(ii) The licensing process generally has two main steps. The first step is to provide training for the staff who will be using the model. Training should include not only practical aspects of how to run the model, but also underlying theory and details of the main assumptions. The second step is to arrange for the model to be used in-house but with external support from the model developers;

(iii) The main drawback to the licensing option is that the organization taking out the licence has little control over future development of the model and is reliant on external providers to keep the model up to date;

(iv) Low external cost is one of the main attractions of licensing. To license an existing model, the initial cost would be in the range of USD 30,000–40,000, which is at least an order of magnitude lower than for developing a new modelling tool. Although there are some further costs for renewing licence fees each year, these could be as low as USD 10,000;

(v) There are, however, internal costs to consider for the licensing option. The impact assessment will need to be carried out by in-house staff, who will need to be allocated a sufficient amount of time to design, run and check the model scenarios, in addition to the (potentially significant) time it takes to train them in use and theory of the model;

(c) Contract out the modelling exercise on a consultancy basis:

(i) Outsourcing the impact assessment to an external organization is in many ways the simplest option. This organization can use an existing model to carry out the assessment and will provide only the results. This option can provide results quickly, as no time is required in-house for model development or for training staff in model use. Contracting out is likely to be the most appropriate means of carrying out the assessment if it is a one-off exercise;

(ii) Aside from speed, the main advantage of this option is that no specific expertise is required in-house, although it is still very helpful if the staff interpreting the model results have a basic understanding of how they have been derived. The main disadvantage of the option is that no capacity is being developed in-house, so future analyses will again need to be outsourced;

(iii) Another advantage is that the results of the analysis will carry the weight and branding of the organization that was contracted to carry out the work;

(iv) Consultancy rates vary around the world and the amount of time devoted to an assessment of the impact of response measures will also vary, depending, for example, on the level of detail required. However, an estimate of the costs would be USD 50,000–100,000. Unlike the other two options, relatively few additional internal costs are associated with the outsourcing option.

66. A summary of the advantages and disadvantages of each of the three modelling options discussed in paragraph 65 above is presented in table 1.

Table 1
The advantages and disadvantages of options for carrying out model-based assessment of the impact of implementation of response measures

Option	*Advantages*	*Disadvantages*
Develop a new model to use in-house	• Suitable for long-term use • Model can be shaped by future policy requirements	• High time requirements • High level of programming skill and expertise in economics required • High cost
License an existing model to use in-house	• Lower cost than developing a model in-house • Scope to develop a new model without full	• Little control over future development of the model • Reliant on external providers to keep the model

Option	*Advantages*	*Disadvantages*
	commitment from the start	up to date • Internal costs for understanding and running the model
Contract out the modelling exercise on a consultancy basis	• Simplest and most straightforward approach • Low time requirements • No specific expertise required in-house • Analysis carries the weight and branding of the organization contracted	• No capacity developed in-house

2. Quantitative approach alternatives to macroeconomic models

67. Basic assessment approaches are relatively simple to implement and require much less expertise than modelling approaches. Basic assessment can provide a quick approximation of what the impact of a response measure may be and whether further, more detailed analysis is worthwhile. In general, the costs for undertaking basic assessment tend to be lower than for other alternatives because of the simplicity of the calculations involved. However, because of this simplicity, the quantitative results are limited in their accuracy and are not likely to include whole-economy impacts.

68. Basic assessment can take many forms and many response measures can be assessed in this way. For example, institutions may be able to assess the implications of labelling standards with this approach, while existing macroeconomic models would struggle. It would not be difficult to conduct a simple **cost–benefit analysis** using company-level data on the costs of implementing labelling standards, and aggregating the data to an economy-wide level to derive an overall cost for business.

69. Another example of a basic assessment approach is the **marginal abatement cost (MAC) curve**. These graphs show the direct cost of reducing GHG emissions through a range of measures or technologies, starting with the lowest-cost options. The curve builds up these options sequentially, with any point on the curve depicting the marginal cost of the last abated unit of emissions. MAC curves[13] are useful for analysing data graphically and communicating the costs of a wide range of carbon mitigation measures.

70. **Econometric (or regression) analysis** is a common approach used by economists to estimate the behavioural response to a change in situation; for example, how much petrol consumption might fall in response to higher prices. The approach usually relies on having a large amount of data for the indicators covered. Several modern statistical software packages are able to undertake econometric analysis (e.g. Stata, eViews), although some expertise is needed to produce convincing results. In the context of response measures, econometric analysis may be a suitable approach for estimating community-level impact, or examining the impacts before and after the implementation of a policy.

71. Econometric analysis has several weaknesses. It often requires strong, and at times oversimple, assumptions. Furthermore, econometric analysis requires the policy impact to be isolated in order to draw the conclusion that the policy on its own leads to a certain

[13] An example of a MAC curve can be found in: McKinsey & Company. 2009. *Pathways to a Low-Carbon Economy – Version 2 of the Global Greenhouse Gas Abatement Cost Curve*. Available at <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/pathways-to-a-low-carbon-economy>.

output – economists often find it difficult to observe situations in which this condition is fulfilled. In the context of response measures, the effect of a specific policy would have to be separated from everything else going on in the economy to be able to carry out a proper analysis. Although the approach requires less data than macroeconomic modelling (and is more flexible about inputs), the results are entirely dependent on the quality of the input data.

72. **Input–output analysis** uses input–output tables to determine the flows between sectors, producers and consumers. One of the strengths of input–output analysis is that it can provide an assessment of feedback effects between sectors. The approach is commonly used to derive economic multipliers that estimate the effect of changing the output in one sector on the rest of the economy.

73. Emission levels can be linked to the input–output framework through environmentally extended input–output analysis. For example, as part of their study of trade-derived carbon dioxide (CO_2) emissions in China, Qi et al.[14] conducted an input–output assessment to determine the level of CO_2 emissions in various industries.

74. The underlying weakness of input–output analysis is that it assumes behaviour does not change. Supply chains, production structures and consumption patterns are expected to be the same for each industry, regardless of changes in the prices or volumes of goods produced. Therefore, the input–output approach tends to be regarded as having quite rigid assumptions.

75. **Energy system models** map the interactions within the energy sector to a high level of detail. Energy models have been used for various purposes, including forecasting and policy impact assessments. Energy models include a wide range of technologies, with a great deal of information on their costs and other characteristics. However, their partial coverage means that they cannot be used to assess impacts outside the energy sector, and they lack wider economy feedback on energy consumption. Energy models are also quite complex and usually require engineering expertise in the energy and electricity markets.

76. Sector-specific models may be used for assessing the impact of the implementation of response measures on particular sectors, going into more detail for a sector than the macroeconomic models can. Sector-specific models can also be combined with existing macroeconomic models for certain types of analyses. One example of a sector-specific model is GLOBIOM,[15] which is used to analyse the "competition for land use between agriculture, forestry, and bioenergy, which are the main land-based production sectors".[16] There are also highly specialized models for the transport sector that take into account factors such as vehicle fleet composition and stock turnover (e.g. the TREMOVE model[17]).

77. **Integrated assessment models (IAMs)** are models that link the economy with energy consumption and impacts on the climate – ideally with a representation of land-use patterns as well. The main advantage offered by IAMs over other types of models is that IAMs provide estimates of changes in climate factors such as surface temperature and precipitation rate. They may also incorporate economic damage incurred through changes in the climate. Subsequently, the environmental and economic outcomes would include additional feedback effects due to the consideration of climate factors. Because climate effects tend to be an important consideration only in the long term, IAMs also typically have a longer time horizon than other models.

[14] Qi T, Winchester N, Karplus VJ and Zhang X. 2014. Will economic restructuring in China reduce trade-embodied CO_2 emissions? *Energy Economics*. 42: pp.204–212.

[15] Global Biosphere Management Model.

[16] International Institute for Applied Systems Analysis. 2014. GLOBIOM. Available at <http://www.iiasa.ac.at/web/home/research/modelsData/GLOBIOM/GLOBIOM.en.html>.

[17] See <http://www.tmleuven.be/methode/tremove/home.htm>.

78. The main inputs and outputs of IAMs are model-dependent, as they can cross different disciplines. Table 2 outlines some of the most common inputs and outputs.

Table 2
Potential inputs and outputs of an integrated assessment model

Inputs	*Outputs*
Economic data	Aggregate economic indicators Economic welfare, including health effects
Energy supply and demand data	Energy consumption and supply
Emission data linked to the use of energy by producers and consumers	Emission projections
Climate data on carbon content in soils, water cycles, temperature effects, and linkages between the biosphere and human behaviour	Sea level rise, temperature effects, precipitation levels, and pollutants in the atmosphere

79. The data requirements of IAMs are model-dependent, as IAMs can cover many modules, all of which require different data. The data requirements for the economy, environment and emissions modules are broadly similar to those of CGE models or macroeconometric models. Climate data are the main additional requirement of IAMs. At a minimum, this includes a global database on precipitation and temperature levels. Detailed climate models have more stringent data requirements.

80. The links between climate change and agriculture through land-use modules might be of particular relevance for developing country Parties because of the importance of agriculture in their economies. A land-use module within the integrated assessment framework would require data on crop and livestock production by region or country, as well as the corresponding crop yields.

81. Table 3 provides an overview of all the quantitative approaches presented in this paper. Their contrasting requirements should be taken into account when choosing an approach for assessing the impact of the implementation of response measures.

Table 3
Summary of quantitative approaches to assessing the impact of the implementation of response measures

	Coverage	*Data requirements*	*Degree of complexity*	*Software required*	*Time and cost requirements*
Computable general equilibrium (CGE) model	Whole economy	High	High	Specialist software	High
Macroeconometric model	Whole economy	High	High	Specialist software	High
Cost–benefit analysis	Case-dependent	Low	Low	Spreadsheet or similar	Low
Marginal abatement cost (MAC) curve	Energy-generating technologies	Low	Low	Spreadsheet or similar	Low

	Coverage	*Data requirements*	*Degree of complexity*	*Software required*	*Time and cost requirements*
Econometric (or regression) analysis	Specific variables of interest	Medium	Medium to high	Econometrics package	Medium
Input–output analysis	Whole economy	Low	Medium	Spreadsheet	Low to medium
Energy system model	Sectoral	High	High	Specialist software	High
Integrated assessment model (IAM)	Whole economy	High	Very high	Specialist software	Very high

3. Qualitative assessment

82. Qualitative assessment produces as an output a description of the potential effects of policies and measures. This approach does not involve cost estimates based on data. Instead, it is designed to provide an estimate of the direction of change (positive, negative) and its relative size (small, medium, large). It can also provide an indication as to which area of technology or input factor may be affected the most. Qualitative assessment is usually conducted by individual expert judgement or through surveys (e.g. Delphi survey). The approach does not require a substantial amount of resources, but it may be time-intensive if undertaken via large survey. The interpretation of results is usually limited. In some circumstances, a comprehensive literature review can provide a sound assessment of the expected effects.

83. A qualitative approach plays an important role when it is not possible to quantify the effect of a policy; for example, when data are unavailable or the cost incurred to collect data would not be justified in the light of the magnitude of the likely impacts. It may also serve as the first step in assessment, to be followed by quantitative assessment.

IV. The way forward

A. Key messages and remarks

84. Most impact assessments of mitigation policies have been undertaken by developed country Parties as part of their policymaking processes, and the assessments have primarily focused on domestic impacts. Quantitative approaches, in particular those using modelling tools, have been widely employed, which has led to the accumulation of experience and expertise.

85. Developed country Parties have increasingly been carrying out assessments on the cross-border impacts of response measures. However, as a result of many factors, these assessments are either limited to a qualitative approach, or, if a quantitative assessment is made, less comprehensive than an assessment of domestic impacts.

86. Although the importance of assessing the impact of response measures is widely recognized by developing county Parties, only a few have undertaken comprehensive assessments, and those that have been done are limited to an assessment of the overall impact on the economy (using GDP), with an emphasis on the fossil fuel sector. However, there are many other impacts that should be investigated through such assessment; for

example, impacts on employment and jobs, on competitiveness and other socioeconomic factors, and on the environment. In addition, these assessments do not reflect the continuing change in the climate change regime at the international level.

87. Developing country Parties have stressed their urgent need for capacity-building support for their policymakers, experts and practitioners in the assessment of response measures, including in the use of modelling tools. To address this need, guidance based on a comprehensive and structured assessment framework should be developed, under which developing country Parties should be provided with training, resources and technical assistance that will enable them to undertake national assessments of the impact of the implementation of response measures.

88. A platform for technical discussion of assessment methodologies and modelling tools may be needed to facilitate assessment by developing country Parties, and could potentially fulfil two purposes: (1) transfer expertise from experienced modellers to developing country Parties; and (2) facilitate collaboration among developing country Parties, which could join forces to conduct macroeconomic modelling, and share input data and modelling results.

89. As discussed in paragraph 11 above, the portal for modelling tools on the UNFCCC website does not reflect the latest developments in the area. Some models that were widely used have been integrated into larger-scale models (e.g. the Organisation for Economic Co-operation and Development GREEN[18] model has been developed into the ENV-Linkages model), while others are no longer used or have been replaced by new models built from scratch. Part of this change is motivated by the expansion of data availability, which ensures greater coverage of countries, greater sectoral detail and end-use disaggregation. There is an urgent need to update the portal so that current versions of models can be easily accessed. Moreover, the description of each model on the portal should emphasize its strengths, and application examples of each model should be provided to assist potential users in easily identifying the appropriate one. The subsidiary bodies may consider mandating the secretariat to update the information on the portal and to generally improve the portal to make it more user-friendly.

B. Possible elements of the work programme of the improved forum

90. The COP decided[19] that the implementation of the work programme of the improved forum on the impact of the implementation of response measure shall address the needs of all Parties, in particular developing country Parties, and shall be informed, inter alia, by the assessment and analysis of impacts, including the use and development of economic modelling, taking into account all relevant policy issues of concern.

91. The work programme could include the organization of technical workshops, which would allow the sharing of information, experience and best practices in the assessment of the impact of the implementation of response measures. Such workshops should involve a broad range of stakeholders, including Parties, observer organizations, research institutions and practitioners. The workshops would serve two purposes: (1) expertise transfer from developed country Parties to developing country Parties or among developing country Parties; and (2) encouragement of cooperation among Parties on data gathering and model development and improvement.

92. An ad hoc technical expert group could play an important role in supporting Parties in addressing the technical barriers in the assessment and analysis of the impacts of the

[18] GeneRal Equilibrium ENvironmental.
[19] Decision 11/CP.21, paragraph 6.

implementation of response measures. Expert group meetings could be organized to facilitate this support.

93. To address the capacity-building needs of developing country Parties, the work programme could include the development of training materials on assessment and modelling. Such training materials could be based on the information in chapter III above, and further enhanced by input from the ad hoc technical expert group.

94. A mandate could be given to the secretariat to improve the portal for modelling tools on the UNFCCC website.

Annex I

Modelling tools available for assessing the impact of the implementation of response measures

Model	*Coverage*	*Developer*	*Access*	*Features related to response measures*
Computable general equilibrium (CGE) models				
EPPA	Global	Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change	Available to the public	The model's greater disaggregation is useful for analysing existing policies that are sector-specific and for emission permit trading
ENV-Linkages	Global	Organisation for Economic Co-operation and Development	Information obtainable by contacting the developer	For assessing the extent of carbon leakage, impacts on competitiveness, border tax adjustments
G-cubed	Global	Warwick McKibbin and Peter Wilcoxen	Information obtainable by contacting the developer	For modelling the domestic, as well as the cross-border, economic impacts of mitigation pledges, (e.g. a new climate change agreement)
GEM-E3	Global	Energy-Economy-Environment Modelling Laboratory (E3M-Lab), European Commission	Information obtainable by contacting the developer	For assessing European Union-wide impacts of decarbonization strategies
GTAP	Global	Center for Global Trade Analysis, Purdue University Department of Agricultural Economics	Available to the public	The model's emphasis on trade (a central consideration in assessing cross-border impacts) is useful for analysing carbon emissions trading schemes
IMACLIM	Global	CIRED	Information obtainable by contacting the developer	For assessing macroeconomic impacts of energy use to a greater level of detail than conventional CGE models, and with a more realistic treatment of technologies
Worldscan	Global	CPB Netherlands Bureau for Economic Policy Analysis	Information obtainable by contacting the developer	For assessing environmental impacts (e.g. air pollutants); results may be compared with energy system models
Macroeconometric models				
E3ME	Global	Cambridge Econometrics	Available for licensing	For assessing employment effects of response measures; aggregate impacts of environmental policies can be broken down into specific effects on different sectors and regions
GINFORS	Global	GWS	Information obtainable by contacting the developer	For comprehensive outputs beyond 'headline' results such as export growth and gross domestic product
Integrated assessment models (IAMs)				
IGSM	Global	MIT Joint Program on the Science and Policy of Global Change	A data portal is available, but for research purposes only	For assessing health and agriculture effects of climate change in different environmental scenarios

Model	*Coverage*	*Developer*	*Access*	*Features related to response measures*
IMAGE	Global	PBL Netherlands Environmental Assessment Agency	Software not available for download, but data results for scenarios specific to previous projects are available	For forecasting the likely trajectory of economic, climate and energy variables given a set of driving forces
GCAM	Global	Joint Global Change Research Institute, Pacific Northwest National Laboratory	Open source software	For cap-and-trade schemes, carbon taxes, technological standards, terrestrial pricing strategies and bioenergy taxes, allowing climate or land-use feedback
MESSAGE	Global	International Institute for Applied Systems Analysis	Software not available for download	The model has been linked with other models for policy analysis; it provides flexibility when a wide group of stakeholders across different disciplines is involved
REMIND	Global	Potsdam Institute for Climate Impact Research	Information obtainable by contacting the developer	For linking a bottom-up energy systems module with a macroeconomic module, and for linking with climate and land-use modules
Energy system models				
LEAP	Unknown	Stockholm Environment Institute	Free licence for students, non-governmental organizations, not-for-profit governmental agencies, and academic organizations in developing countries	The model has a low data requirement and has been extensively used for assessment in developing countries
PRIMES	Europe	E3M Lab, National Technical University of Athens	Information obtainable by contacting the developer	For emission and renewables targets, price-based policies, emission standards and emissions trading schemes
TIMER	Global	PBL Netherlands Environmental Assessment Agency	Information obtainable by contacting the developer	For impacts of mitigation pathways, especially response measures that either affect pricing of certain electricity generation technologies or government investment strategies
World Energy Model	Global	International Energy Agency	Information obtainable by contacting the developer	The model considers three scenarios, all of which are helpful for response measure analysis; the latest version has further disaggregated Africa into six regions

Annex II

Example of using a computable general equilibrium model to assess the impact of the implementation of response measures

1. A study by Jooste et al. on the effects of response measures on the South African economy using the computable general equilibrium (CGE)-based GTAP-E model[1] focused on two questions related to the implementation of response measures: (1) how the demand of developed economies for exports of South African coal would change; and (2) how production of energy- or emission-intensive goods in South Africa would change.[2]

2. The authors used the Global Trade Analysis Project (GTAP) database (version 7), a widely used source of data for CGE models. The authors aggregated the 57 sectors within the GTAP database to 20 sectors. This was done partly to harmonize the GTAP database with export data from a national database in South Africa, and it ensured that different parts of the analysis within the paper were based on a consistent level of sectoral detail and were thus coherent. The authors compiled a list of energy-intensive and trade-exposed industries to isolate the sectors that may be affected the most by the implementation of response measures.

3. With regard to scenario design, the authors examined the implications of Parties included in Annex I to the Convention (Annex I Parties) meeting two emission targets:

(a) Annex I Parties reducing carbon emissions by 25 per cent below the 1990 level by 2020;

(b) Annex I Parties reducing carbon emissions by 40 per cent below the 1990 level by 2020.

4. In order to achieve these targets, response measures were incorporated into the model according to three scenarios:

(a) Scenario 1: carbon taxes and no emissions trading among Annex I Parties;

(b) Scenario 2: carbon taxes and emissions trading within a group of Annex I Parties;

(c) Scenario 3: carbon taxes and emissions trading within a group of Annex I Parties, and the possibility for developed country Parties to buy emission reduction credits from Parties not included in Annex I to the Convention (non-Annex I Parties).

5. The output of the simulation suggested ‘winners’ and ‘losers’, depending on the scenario. In scenarios 1 and 2, there is a fall in global energy prices and reduced demand for coal, both of which affect South African energy exports. While there is higher demand for exports of energy-intensive goods (from developed countries, as a result of competitiveness effects), South Africa does not benefit much because other countries (such as China) are in general better placed to produce these goods.

6. However, South Africa can gain in scenario 3 and losses from scenarios 1 and 2 can be offset. This is because emission abatement costs in South Africa are lower than in other

[1] An extended computable general equilibrium model that uses the Global Trade Analysis Project (GTAP) database with energy substitution.

[2] Jooste M, Winkler H, Van Seventer D and Truong PT. 2009. *The Effect of Response Measures to Climate Change on South Africa’s Economy and Trade. Final Report to the Department of Environmental Affairs.* Available at <http://www.erc.uct.ac.za/sites/default/files/image_tool/images/119/Papers-2009/09Joosteetal-Response_Measures.pdf>.

countries, so Annex I Parties would be expected to buy permits from South Africa, creating additional revenues.

7. Coal production declines across all three scenarios, while industries such as agriculture, chemicals and non-ferrous metals lose out in scenarios 1 and 2. In contrast, the main winners in scenarios 1 and 2 are non-energy mining and air transport, which can export to Annex I Parties. With the exception of coal mining, iron and steel, and non-energy mining, all the other energy-intensive, trade-exposed sectors gain in scenario 3.

8. The model results suggest that carbon leakage would occur. If developed countries met the 25 per cent reduction target, carbon dioxide (CO_2) emissions would be 14 per cent higher in South Africa in 2020. If the 40 per cent reduction target were met, CO_2 emissions would be 16 per cent higher. These figures, however, assume that no action is taken by non-Annex I Parties during the same period.

Annex III

Sources of data for use by developing country Parties in macroeconomic models

Asian Development Bank (ADB)
ADB collates data sets of many statistical agencies, both international and national. For the assessment of response measures, the data of interest are economic indicators, such as gross domestic product per person employed, carbon dioxide emission levels and health indicators. ADB focuses on developing countries.

Emission Database for Global Atmospheric Research (EDGAR)
EDGAR, developed by the European Commission and the Netherlands Environmental Assessment Agency, is a comprehensive global database of emission data. EDGAR covers all the greenhouse gases as well other emissions, such as ozone precursor gases, particulates and acidifying gases. The database distinguishes between emissions sources, and is global in scope, covering most of the small island developing States (SIDS) as well as the least developed countries.

Global Trade Analysis Project (GTAP)
The GTAP database is the main source of data for many computable general equilibrium models. The database has detailed data for many developing countries, including some of the least developed countries and SIDS. The economic data are arranged in a set of social accounting matrices. There are also data on energy use and supply and on emissions.

International Energy Agency (IEA)
The IEA statistics division focuses on energy data. Its statistics are classified into four main categories: energy balance flows, energy indicators, European gas trade flows and key world energy statistics. Energy balance flows detail the production and imports of energy-generating fuels from 1973 to 2012 for more than 100 countries that are not members of the Organisation for Economic Co-operation and Development (OECD).

International Monetary Fund (IMF)
The IMF database has data on many economic indicators for the government and for financial, trade and other sectors. IMF also provides a world economic outlook, which is an economic forecast by region. This may be used in models that require a future trajectory of economic indicators.

Organisation for Economic Co-operation and Development (OECD)
OECD provides a wide range of data, covering a wide range of issues. Its database includes economic data with a high level of detail for OECD countries. The data include sectoral output, prices and trade by commodity. In some cases, OECD harmonizes the data from national statistical agencies to ensure consistency of measurement.

United Nations Comtrade
United Nations Comtrade is a global bilateral trade database with highly detailed data on global commodity flows. It details the imports and exports of goods since 1962 for monthly and quarterly intervals. In total, there are 254 reporting institutions.

United Nations Statistics Division (UNSD)
UNSD has many databases that can be used for the assessment of response measures. UNSD manages the Comtrade database, and also has the National Accounts Main

Aggregates database, which covers 249 regions and countries, and the United Nations Service Trade Statistics database, which is a services counterpart to Comtrade. Geographical and temporal coverage are database-dependent.

World Input–Output Database (WIOD)

WIOD is a global database of national input–output tables that are generally consistent with national accounts. WIOD covers 40 countries and also has one table for the rest of the world, for the period 1995–2011. World input–output tables are also available, as are environmental input–output accounts at the industry level. The world input–output tables have the same dimensions as national tables (40 countries and the same time period), while the environmental accounts cover the period 2005– 2009.

World Bank

The World Bank database covers many developing countries and contains a wide range of aggregate social, economic, climate change and emission data. Because of its focus on low-income economies, the database can often be a good source for national aggregate data for the least developed countries and small island developing States.