CLIMATE CHANGE

Scientific Assessment and Policy Analysis

WAB 500102 033

Monitoring emissions and actions in the post-2012 climate regime

CLIMATE CHANGE

SCIENTIFIC ASSESSMENT AND POLICY ANALYSIS

Monitoring emissions and actions in the post-2012 climate regime

Report
500102 033

Author
S.J.A. Bakker
A. De Vita
J.G.J Olivier

August 2010

ECN
Energy research Centre of the Netherlands

Netherlands Environmental Assessment Agency

This study has been performed within the framework of the Netherlands Research Programme on Scientific Assessment and Policy Analysis for Climate Change (WAB), Measurement, Reporting and Verification (MRV) under the Copenhagen Agreement.

Wetenschappelijke Assessment en Beleidsanalyse (WAB) Klimaatverandering

Het programma Wetenschappelijke Assessment en Beleidsanalyse Klimaatverandering in opdracht van het ministerie van VROM heeft tot doel:

- Het bijeenbrengen en evalueren van relevante wetenschappelijke informatie ten behoeve van beleidsontwikkeling en besluitvorming op het terrein van klimaatverandering;
- Het analyseren van voornemens en besluiten in het kader van de internationale klimaatonderhandelingen op hun consequenties.

De analyses en assessments beogen een gebalanceerde beoordeling te geven van de stand van de kennis ten behoeve van de onderbouwing van beleidsmatige keuzes. De activiteiten hebben een looptijd van enkele maanden tot maximaal ca. een jaar, afhankelijk van de complexiteit en de urgentie van de beleidsvraag. Per onderwerp wordt een assessment team samengesteld bestaande uit de beste Nederlandse en zonodig buitenlandse experts. Het gaat om incidenteel en additioneel gefinancierde werkzaamheden, te onderscheiden van de reguliere, structureel gefinancierde activiteiten van de deelnemers van het consortium op het gebied van klimaatonderzoek. Er dient steeds te worden uitgegaan van de actuele stand der wetenschap. Doelgroepen zijn de NMP-departementen, met VROM in een coördinerende rol, maar tevens maatschappelijke groeperingen die een belangrijke rol spelen bij de besluitvorming over en uitvoering van het klimaatbeleid. De verantwoordelijkheid voor de uitvoering berust bij een consortium bestaande uit PBL, KNMI, CCB Wageningen-UR, ECN, Vrije Universiteit/CCVUA, UM/ICIS en UU/Copernicus Instituut. Het MNP is hoofdaannemer en fungeert als voorzitter van de Stuurgroep.

Scientific Assessment and Policy Analysis (WAB) Climate Change

The Netherlands Programme on Scientific Assessment and Policy Analysis Climate Change (WAB) has the following objectives:

- Collection and evaluation of relevant scientific information for policy development and decisionmaking in the field of climate change;
- Analysis of resolutions and decisions in the framework of international climate negotiations and their implications.

WAB conducts analyses and assessments intended for a balanced evaluation of the state-of-the-art for underpinning policy choices. These analyses and assessment activities are carried out in periods of several months to a maximum of one year, depending on the complexity and the urgency of the policy issue. Assessment teams organised to handle the various topics consist of the best Dutch experts in their fields. Teams work on incidental and additionally financed activities, as opposed to the regular, structurally financed activities of the climate research consortium. The work should reflect the current state of science on the relevant topic.

The main commissioning bodies are the National Environmental Policy Plan departments, with the Ministry of Housing, Spatial Planning and the Environment assuming a coordinating role. Work is also commissioned by organisations in society playing an important role in the decision-making process concerned with and the implementation of the climate policy. A consortium consisting of the Netherlands Environmental Assessment Agency (PBL), the Royal Dutch Meteorological Institute, the Climate Change and Biosphere Research Centre (CCB) of Wageningen University and Research Centre (WUR), the Energy research Centre of the Netherlands (ECN), the Netherlands Research Programme on Climate Change Centre at the VU University of Amsterdam (CCVUA), the International Centre for Integrative Studies of the University of Maastricht (UM/ICIS) and the Copernicus Institute at Utrecht University (UU) is responsible for the implementation. The Netherlands Environmental Assessment Agency (PBL), as the main contracting body, is chairing the Steering Committee.

For further information:

Netherlands Environmental Assessment Agency PBL, WAB Secretariat (ipc 90), P.O. Box 303, 3720 AH Bilthoven, the Netherlands, tel. +31 30 274 3728 or email: wab-info@pbl.nl.
This report in pdf-format is available at www.pbl.nl

Preface

This report has been commissioned by the Netherlands Programme on Scientific Assessment and Policy Analysis (WAB) Climate Change. This report has been written by the Energy research Centre of the Netherlands (ECN) and the Netherlands Environmental Assessment Agency (PBL).

We would like to thank the Steering Committee of this research project, consisting of Ronald Flipphi (Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM), Peter Paul Ekker (VROM), Harry Vreuls (SenterNovem), Lucy Naydenova (VROM), Gerie Jonk (VROM), Marcel Berk (VROM), Maas Goote (VROM), Herman Sips (VROM), Ronald Schillemans (Ministry of Economic Affairs), Remco van der Molen (Ministry of Finance), Bas Clabbers (Ministry of Agriculture) and Aart van der Horst (Ministry of Foreign Affairs) for their useful guidance and comments throughout the research period. Jane Ellis and Gonçalo Cavalheiro reviewed draft versions of this report. Their helpful comments are greatly appreciated, as well as the input from Anke Herold, Andrew Higham, Heleen de Coninck, Marc Londo, Paul Vethman and Karina Veum. However, the sole responsibility for the contents is with the authors.

This report has been produced by:

Stefan Bakker, Alessia De Vita
Energy research Centre of the Netherlands (ECN)

Jos Olivier
Netherlands Environmental Assessment Agency (PBL)

Name, address of corresponding author:
Stefan Bakker
Energy research Centre of the Netherlands (ECN)
Unit Policy Studies
P.O. Box 56890
1040 AW Amsterdam, The Netherlands
http://www.ecn.nl
E-mail: bakker@ecn.nl

Disclaimer

Statements of views, facts and opinions as described in this report are the responsibility of the author(s).

Contents

List of Tables

List of Figures

Executive Summary

Introduction

Climate change is a collective action problem; only if all major emitting countries take sufficient mitigating actions, dangerous human interference with the climate system can be averted. In order to create and maintain a stable global climate coalition, trust needs to be established that all countries will contribute in accordance with the agreement, and that there will be no free riders. Therefore, for a successful global climate regime, it is essential that information is available, internationally, on actions taken per country.

In the current climate negotiations, the availability and reliability of such information is commonly termed 'MRV' (Measurable, Reportable and Verifiable). MRV can increase trust between developed and developing countries and give meaning to common but differentiated responsibilities of countries. This report aims to advance the debate on MRV and focuses on 1) gaining insight into whether and how national greenhouse gas inventories for developing countries can be established, and 2) the balance between transparency and efforts of MRV by defining MRV ability and evaluating it for a number of mitigation actions.

Background and status of MRV in the climate negotiations

MRV of climate policies and measures may focus on different aspects[1], namely:

- input, for example, the financial resources used to implement a policy;
- the process of developing a policy, for example, development of a low-emissions development plan;
- output that is a direct result of a policy, for example, increased production of renewable energy;
- outcome, relating to policy objectives, for example, greenhouse gas emission reductions.

The Bali Action Plan commits developing country Parties to Nationally Appropriate Mitigation Actions (NAMAs) that are measurable, reportable and verifiable, but does not specify how this can be done or what type of MRV is to be applied. For developed country Parties, quantified emission limitation and reduction objectives, commitments and actions that focus on outcome, that is, on greenhouse gas (GHG) emissions and emission reductions, should be measurable, reportable and verifiable. For these countries, the MRV requirement also extends to commitments to technology, financing and capacity building support for developing countries, thus focusing on inputs.

As of August 2010, many questions related to MRV remain unanswered. First of all, this includes the question of which functions of MRV are to be fulfilled. Such functions may include building trust between Parties, assessing progress towards the United Nations Framework Convention on Climate Change (UNFCCC) overall objective, providing incentives for mitigation actions, enabling the matching of support and actions, and tracking support and actions. Another question relates to the level at which MRV is established: international, national or subnational. More specifically, MRV requirements for NAMAs need to be clarified, as well as the extent to which GHG inventories for developing countries can be established, given limitations in data availability. It is important to the post-2012 negotiations, both in the run-up to and following Conference of Parties (COP16) in November-December 2010, to advance the discussions on these issues of informing decisions and creating trust between Parties.

Two important negotiation texts with respect to MRV are the report by the Ad Hoc Working Group on Long-term Cooperative Action (AWG-LCA) at COP15, and the Copenhagen Accord, which the COP took note of. Both acknowledge MRV. The AWG-LCA report includes references to MRV for actions and commitments by developed countries, and MRV for NAMAs and support relating to developing countries, for which the guidelines are to be agreed on by the COP. The Copenhagen Accord includes similar language, as well as several other relevant and specific

[1] In this report policies and measures are often referred to as 'actions'.

provisions with respect to MRV. This includes national inventory reports for developing countries, to be included in national communications every two years, domestic MRV of actions by developing countries, and international MRV of NAMAs that are funded by international support. The Copenhagen Accord also states that the guidelines for inventories and international MRV are to be adopted by the COP. It seems that, no matter what happens to the Copenhagen Accord and the AWG-LCA, national inventory reports for developing countries will become a central issue in the international climate regime.

Greenhouse gas inventories

Currently, developed countries have to submit annually a national inventory of greenhouse gas emissions to the UNFCCC based on IPCC guidelines for estimating these inventories and IPCC good practice guidance. For developing countries no such obligation exists, but a summary of their emissions are reported in the so-called national communications when these are provided. For this report, we analysed international data sources that may be used in estimating the various IPCC emission source categories. Based on this, we found that activity data and default emission factors are available for all significant emission sources and sinks. This demonstrates that national inventories in developing countries can be compiled at a Tier 1 level, which is the easiest and least demanding way of estimating and reporting emissions. Therefore, from the perspective of data availability, MRV can be applied to developing countries' emissions, in accordance with IPCC good practice guidance, given national circumstances of limited resources. However, moving towards higher tiers may be helpful for estimating greenhouse gas emissions with less uncertainty, especially for key emission categories, such as in the sectors energy, land-use change and forestry, agriculture, and industrial processes. The extent to which country-specific data can be used for estimating emissions for key categories will depend on data availability and the human resources available to compile the inventory. Following IPCC good practice guidance helps to ensure that the best possible emissions inventory is compiled with the available resources. This needs to be demonstrated by the team compiling the inventory, by *reporting* how the available resources have been used for emission inventory compilation, reporting, documenting and improvement. An essential element of MRV is the use of adequate resources for reporting the inventory, so that it can be reviewed and verified.

However, depending on national circumstances, a certain minimum number of sectoral experts is required to guarantee the maintenance and improvement over time of the national emission inventory, and to evaluate the needs for emission monitoring in the environmental policy-making process. The size and structure of a country will determine how this activity could be defined most efficiently, also taking into account other national circumstances and policy priorities. This could require additional resources for participating in the UNFCCC inventory review process, also for capacity building, and additional staff at the agency compiling the emission inventory. In case GHG emission inventories by many non-Annex I countries are also to be included in the UNFCCC review process, a modification of the present system of annual reviews of all Annex I Parties (about 40) to a more optimised and focused system would be indispensable, for an efficient use of resources (e.g. review frequency and depth depending on national and sectoral emission levels).

With regard to the estimation of net carbon storage in non-degraded (i.e. undisturbed) forests, degraded forests, forest plantations and other wooded lands, it is concluded that the difficulty in application of the simple Tier 1 method is transferred to the determination of the so-called *fraction of biomass lost in disturbance.* This accounts for all carbon losses in degraded forests, other than from wood and firewood extraction. Although the IPCC GHG inventory guidelines provide an analysis of the calculation scheme, no default values are mentioned and Tier 1 guidance is missing for estimating the degree of forest degradation.

Measuring of mitigation actions

In addition to the need for monitoring GHG emissions on a national (or sectoral) level, it is clear that actions by developing (and possibly developed) countries are subject to MRV. When MRV has been established, a matching of support and actions within the framework of NAMAs could be facilitated. Measuring policies and measures both need appropriate metrics or indicators that can focus on different policy stages, such as indicators of input, process, output and outcome.

For the objective of climate change mitigation, reduction in greenhouse gas emissions would be the most obvious choice for the outcome indicator. However, it may not always be possible to estimate this emission reduction with reasonable certainty against acceptable cost. Therefore, establishing MRV for other indicators that focus on the input, process or the output of an action can be considered. These might be attractive for several reasons: 1) they would provide information on whether an action is being taken (e.g. the implementation of policy, awareness campaigns or capacity building), thereby creating trust between Parties; and 2) MRV may be easier to monitor than GHG emissions reductions, as for the latter baselines and the extent to which they are attributable to a particular policy would be difficult and potentially costly issues to address.

In order to indicate the extent to which GHG reductions could be measured to be attributable to individual actions (i.e. the outcome indicator), we carried out an MRV ability analysis. This was based on six criteria, including the availability of data to construct a baseline and to monitor implementation. In the analysis,types of actions (such as a renewable energy subsidy)were categorised as high, medium or low GHG MRV ability. The actions were taken from existing energy and climate action plans from developing countries, and although they therefore do not cover the full range of possible actions, they do include all major sectors.

It appears that actions in the electricity sector are likely to have the highest MRV ability, while the transport and buildings sectors are in the ‘medium’ range. The most important determining factors are data availability, degree of difficulty in establishing a credible baseline, and emission factors. In addition, we found that there are many actions that do not directly translate to emission reductions, such as forest monitoring programmes, energy efficiency training programmes and audits. These actions, however, play a vital role in achieving emission reductions, and could be ‘MRV-ed’ by input and process indicators.

From three case study actions – biofuel blend, lighting efficiency and renewable energy subsidies – it appeared that, in developed countries, calculating GHG reductions resulting from certain policies is carried out to a limited extent. The monitoring of individual policies is done in most countries, but baselines and the extent to which effects could be attributed to a policy are often not explicitly considered. As only national emission totals have to be reported, to date this has not been an issue of international importance For developing countries, for the Clean Development Mechanism (CDM) projects, an elaborate system for the MRV of emission reductions has been developed. Important lessons can be learnt from this system development, for example related to emission factors, determining baselines and attributing impacts to policies. However, CDM experience, to date, has also shown that calculating GHG reductions can be a data- and cost-intensive process, and that establishing a baseline and demonstrating additionality (proving that the action would not be taken without the CDM) for a project or programme is counterfactual and therefore inherently dependent on uncertain assumptions.

Moving forward on MRV of mitigation actions

We show that, for many policies and measures, establishing the MRV of related greenhouse gas reductions is possible. However, assessing the extent to which impacts could be attributable to policies and measures, is likely to be even more difficult than for projects, as these policies and measures generally contribute to multiple objectives and the impact of one can ultimately not be distinguished from that of another. For unilateral and supported NAMAs that are not going to be used as offsets, stringent criteria for attributing impacts to policies and baselines may not be necessary. As only the action matters, MRV of emission reductions for individual NAMAs may be unnecessary. However, in order to create trust with the Parties that provide support, some indication of the *impact* of the action will be necessary; an Annex I Party may wonder ‘Why should we provide support for a biofuel policy that will be implemented anyway?’ In other words, some certainty is necessary regarding the question of whether support is being used for the ultimate goal of the UNFCCC.

If national inventory reports are going to be prepared on a regular basis, this could reduce the need for detailed estimates of the impact of individual policies. As the impacts of measures would become visible in emission trends on a national scale, they would indicate the national contribution toward global emission reduction.

The importance of ‘early action’ taken by developing countries has been emphasised, and in the Copenhagen Accord 30 billion USD have been pledged for mitigation and adaptation in developing countries, up to 2012. Therefore, it is key that a quick start is made with designing and implementing NAMAs, and their MRV. To ensure that this is possible, a progressive approach could be beneficial; in the coming years, MRV requirements could be flexible, particularly in countries with low data availability. In the meanwhile, international efforts could be made towards capacity building and data gathering programmes to establish the historical data and capacity necessary to enable MRV of mitigation actions according to the guidelines yet to be adopted by the COP.

Samenvatting

Inleiding

Klimaatverandering is een probleem van collectief handelen: alleen wanneer alle belangrijke landen bijdragen aan reductie van broeikasgasemissies kan gevaarlijke invloed van de mens op het klimaat worden voorkomen. Om een stabiele wereldwijde coalitie te houden is het nodig dat er voldoende vertrouwen tussen landen is dat iedereen bijdraagt aan de oplossingen, en dat er geen free-riders zijn. Om deze reden is international informatie over ieders bijdrage essentieel voor een succesvolle wereldwijde aanpak van het klimaatprobleem.

In de huidige klimaatonderhandelingen wordt de beschikbaarheid en betrouwbaarheid van zulke informatie ‘MRV’ genoemd: Meetbaar, Rapporteerbaar en Verifieerbaar. MRV kan het vertrouwen tussen geïndustrialiseerde en ontwikkelingslanden vergroten, en het principe van *common but differentiated responsibilities* van landen beter tot uiting brengen. Dit rapport heeft als doel de discussie rondom MRV verder te brengen en richt zich op 1) inzicht krijgen of en hoe nationale emissie-inventarissen voor ontwikkelingslanden kunnen worden opgezet en 2) de balans tussen transparantie en kosten van MRV door MRV-baarheid te definiëren en deze te evalueren voor een aantal emissiereductiemaatregelen.

Achtergrond en status van MRV in de klimaatonderhandelingen

MRV van klimaatbeleid en klimaatmaatregelen kan zich richten op verschillende delen van de beleidscyclus:

- Input, bijvoorbeeld de financiële middelen gebruikt voor het uitvoeren van beleid;
- Het proces van het ontwikkelen van beleid, bijvoorbeeld een *Low Carbon Growth Plan*;
- Outputs die een direct resultaat van het beleid zijn, zoals vergrote productie van hernieuwbare energie;
- Uitkomsten gerelateerd aan beleidsdoelen, zoals CO_2-emissiereducties.

Het Bali Actie Plan schrijft voor dat ontwikkelingslanden *nationally appropriate mitigation actions* (NAMA’s) die meetbaar, rapporteerbaar en verifieerbaar zijn zullen uitvoeren, maar geeft geen duidelijkheid over hoe de MRV gedaan dient te worden. De klimaatdoelstellingen en maatregelen waarin geïndustrialiseerde landen zich committeren moeten ook MRV zijn, en deze richt zich op uitkomsten, oftewel broeikasgasemissies. Voor deze landen moeten ook de ondersteuning voor financiering, technologie en capaciteitsopbouw voor ontwikkelingslanden MRV zijn - dus gericht op inputs.

Begin 2010 zijn nog vele vragen rondom MRV onbeantwoord. Ten eerste is dit de vraag welke functies MRV moet gaan vervullen. Deze functies zouden kunnen zijn: het vertrouwen tussen landen vergroten, de wereldwijde vooruitgang tot het ultieme doel van de UNFCCC beoordelen, prikkels voor reductiemaatregelen geven, het afstemmen van maatregelen met de gegeven steun, en het bijhouden van maatregelen en ondersteuning daarvoor. Een andere vraag gaat over het bestuursniveau op welke MRV gedaan zou moeten worden: internationaal, nationaal of subnationaal. Verder is het belangrijk dat er meer duidelijkheid komt over de vereisten van MRV voor NAMA’s, en in hoeverre emissie-inventarissen voor ontwikkelingslanden kunnen worden opgezet, gegeven beperkte databeschikbaarheid. Het is belangrijk voor de onderhandelingen over post-2012 klimaatbeleid voor en na COP16 in november 2010 om de discussies op deze punten verder te brengen, zodat er geïnformeerde beslissingen kunnen worden genomen en het vertrouwen tussen landen wordt vergroot.

Twee belangrijke onderhandelingsteksten voor MRV zijn het rapport van de *Ad hoc Working Group on Long-term Cooperative Action* (AWG-LCA) van COP15 en het Kopenhagen Akkoord. Beiden bevestigen het belang van MRV. Het AWG-LCA-rapport refereert aan MRV voor klimaatdoelstellingen en maatregelen voor geïndustrialiseerde landen, en MRV van NAMA’s voor ontwikkelingslanden en steun, voor welke de COP de richtlijnen dient vast te stellen. Het Kopenhagen Akkoord gebruikt soortgelijke bewoordingen, maar daarnaast komen nog een paar andere specifieke en relevante passages voor: nationale emissie-inventarissen voor ontwikkelingslanden, als onderdeel van *national communications* eens per twee jaar, nationale MRV van maatregelen van ontwikkelingslanden, en internationale MRV van NAMA's die internationale steun krijgen. Ook hierin staat dat de richtlijnen voor inventarissen en internationale MRV door de COP vastgesteld dient te worden. Wat er verder ook moge gebeuren met het AWG-LCA-rapport en het Kopenhagen Akkoord, het lijkt erop dat nationale emissierapportages voor ontwikkelingslanden een belangrijk onderdeel wordt van het internationale klimaatbeleid.

Broeikasgasemissierapportages
Op dit moment moeten geïndustrialiseerde landen jaarlijks een emissierapportage gebaseerd op IPCC-richtlijnen indienen bij de UNFCCC. Voor ontwikkelingslanden geldt deze verplichting niet, maar de rapportage dient een onderdeel te zijn van national communications wanneer deze worden ingediend. In dit rapport analyseerden we internationale databronnen die gebruikt kunnen worden voor de schattingen van de verschillende IPCC-emissiecategorieën. Hieruit concluderen we dat voor alle significante emissiebronnen en -sinks activiteitsgegevens en *default* emissiefactoren beschikbaar zijn, waardoor duidelijk wordt dat nationale emissie-inventarissen voor ontwikkelingslanden kunnen worden samengesteld op een Tier 1 niveau: de eenvoudingste en de minste capaciteit vragende wijze om emissieschattingen te maken. Vanuit het perspectief van databeschikbaarheid zijn broeikasgasemissies van ontwikkelingslanden zijn dus 'MRV-baar', in overeenstemming met *good practice guidance* gelet op de natjonale omstandigheden en bij de beperkte beschikbare capaciteit. Dat neemt niet weg dat voor de toekomst schattingen op een hogere Tier-niveau, dus met een grotere nauwkeurigheid, nuttig kan zijn voor de belangrijke broncategorieën, zoals in de sectoren energie, landgebruiksverandering en bosbouw, landbouw en industriële processen.

De mate waarin land-specifieke data kan worden gebruikt voor de belangrijkste broncategorieën hangt af van de beschikbaarheid van de benodigde informatie en de beschikbare menskracht bij het inventarisatie-team. Toepassing van de *good practice* aanbevelingen van de IPCC zorgt ervoor dat de best mogelijke inventaris wordt gemaakt bij de beschikbare mogelijkheden. Dat wordt aangetoond met een rapportage die aangeeft hoe de beschikbare capaciteit is ingezet voor de emissie-inventarisatie zelf, rapportage, documentatie en verbeteringen. Een essentieel onderdeel van MRV is dat voldoende menskracht van beschikbare capaciteit wordt gebruikt voor de rapportage van de emissieinventaris, zodat die gereviewd en geverifieerd kan worden.

Afhankelijk van de nationale omstandigheden is een bepaald minimum aantal personen noodzakelijk die die kern vormen van het inventarisatieteam, zoals sectorale experts, om onderhoud en verbetering van de nationale emissie-inventarisatie te kunnen garanderen en om de behoefte van emissiemonitoring te bepalen die nodig is voor het nationale milieubeleid. Het is afhankelijk van de grootte en de structuur van een land hoe deze activiteiten het meest efficient kunnen worden uitgevoerd, maar ook afhankelijk van andere nationale omstandigheden en beleidsprioriteiten. Daarvoor kan additionele menskracht nodig zijn, ook voor *capacity building* en voor deelname van teamleden aan reviews van de UNFCCC van inventarisaties. Als de broeikasgas-emissieinventarissen van veel ontwikkelingslanden ook in het reviewproces van de UNFCCC worden opgenomen, zal een aanpassing van het huidige system van jaarlijkse reviews van alle 40 Annex I landen naar een meer effectief en gefocust system onontbeerlijk zijn voor een efficient gebruik van de berschikbare capaciteit (bijv. de frequentie en mate van diepgang van de reviews afhankelijk maken van de grootte van nationale en sectorale emissieniveaus.

Voor de schatting van netto koolstofopslag in niet-verstoorde bossen, gedegradeerde bossen, bosplantages en ander bebost land concluderen we dat de moeilijkheid in de toepassing van de Tier 1 methode ligt in het bepalen van de zogenaamde '*fractie biomassa verloren door verstoring'*, die alle koolstofverliezen uit gedegradeerd bos (anders dan door houtwinning) meeneemt. Hoewel de IPCC-richtlijnen voor broeikasgasemissie-inventarissen een toeliching op de berekeningswijze geven, worden er geen standaardwaarden gegeven voor deze fractie en ontbreekt een Tier 1 methodiek om de mate van degradatie van bossen te kunnen schatten.

Meten van reductiemaatregelen

Naast het nut van het bijhouden van emissies op een nationaal (of sectoraal) niveau is het duidelijk dat klimaatmaatregelen van ontwikkelingslanden (en mogelijk geïndustrialiseerde) MRV moeten zijn. Dit maakt het mogelijk om de maatregel te koppelen aan steun. Het monitoren van maatregelen dient te gebeuren met geschikte indicatoren, die kunnen worden gekoppeld aan verschillende beleidsstadia: input, proces, output en uitkomst. Voor het voorkomen van klimaatverandering de meest voor de hand liggende uitkomst-indicator is emissiereductie. Maar het vaak niet mogelijk om deze te schatten met voldoende nauwkeurigheid, tegen beperkte kosten. Daarom kan het nuttig zijn om ook input-, proces- en output-indicatoren te schatten. Deze kunnen belangrijke voordelen hebben: 1) ze geven informatie over de mate waarin een maatregel uitgevoerd wordt (bijvoorbeeld implementatie van beleid, bewustwordingscampagnes of capaciteitsopbouw) waardoor vertrouwen tussen landen wordt vergroot, en 2) ze zijn waarschijnlijk makkelijker te meten dan emissiereducties, voor welke referentiewaarden en de toeschrijfbaarheid aan beleid moeilijk en alleen tegen relatief hoge kosten zijn te bepalen.

Om een indicatie te geven in hoeverre van individuele maatregelen de emissiereducties geschat kunnen worden hebben we een ‘MRV-baarheid’-analyse uitgevoerd. Deze is gebaseerd op zes criteria, waaronder beschikbaarheid van data en referentiewaarden. De analyse plaatst verschillende soorten maatregelen (zoals subsidies voor hernieuwbare energie) in hoog, medium of lage MRV-baarheid. De verschillende maatregelen komen uit bestaande energie- en klimaatplannen van ontwikkelingslanden en omvatten niet alle mogelijke maatregelen, maar wel alle belangrijke sectoren.

Uit onze analyse blijkt dat maatregelen in de elektriciteitssector de hoogste MRV-baarheid hebben, en de transport- en gebouwensector zitten in het ‘medium’-gebied. De belangrijkste factoren die dit bepalen zijn databeschikbaarheid, problemen in het bepalen van betrouwbare referentiewaarden en emissiefactoren. Daarnaast blijkt dat er veel maatregelen zijn die niet direct in emissiereducties kunnen worden vertaald, zoals bosmonitoringsprogramma’s, trainingen voor energiebesparing en audits. Deze maatregelen zijn wel essentieel voor het behalen van emissiereducties, en zouden MRV-baar kunnen zijn via input-, proces-, en outputindicatoren.

Uit drie case study maatregelen - biobrandstoffen, verlichtingsefficiëntie en subsidies voor hernieuwbare energie - blijkt dat het meten van emissiereducties van beleidsmaatregelen in geïndustrialiseerde landen in beperkte en verschillende mate plaatsvindt. Het monitoren van individuele maatregelen wordt in de meeste landen wel gedaan, maar via verschillende methodes, en meestal worden referentiewaarden en toeschrijfbaarheid aan beleid niet expliciet meegenomen. Omdat de nationale emissies gerapporteerd moeten worden is dit tot nu toe geen internationaal probleem geworden. Voor ontwikkelingslanden heeft het Clean Development Mechanism als effect gehad dat er een uitgebreid systeem voor MRV-bare maatregelen is ontwikkeld. Hieruit kunnen belangrijke lessen worden meegenomen voor NAMA’s, bijvoorbeeld voor emissiefactoren en het bepalen van referentiewaarden en additionaliteit. Aan de andere kan leert de ervaring met CDM ons ook dat het meten van emissiereducties een data-intensief en kostbaar proces kan zijn, en ook dat het aantonen van toeschrijfbaarheid voor een project of programma altijd afhangt van onzekere aannamen.

MRV van reductiemaatregelen: hoe verder?

Hoewel onze analyse aangeeft dat MRV van emissiereductiemaatregelen mogelijk is, is het ook duidelijk dat het toeschrijven van effecten aan beleid nog moeilijker is dan voor projecten, omdat beleidsmaatregelen voor klimaat ook bijdragen aan verschillende andere beleidsdoelen, en het effect van een maatregel op het ene doel kan uiteindelijk niet worden onderscheiden van het effect op de andere. Aangezien unilaterale en ondersteunde NAMA’s niet gebruikt gaan worden voor emissiecompensatie zijn strenge richtlijnen voor toeschrijfbaarheid en referentiewaarden wellicht niet nodig. Maar om vertrouwen te wekken bij de landen die de maatregelen ondersteunen is er wel enige indicatie nodig van het effect dat de maatregel heeft. Een Annex-I-land zou zich bijvoorbeeld af kunnen vragen waarom er financiële steun aan een biobrandstofbeleid gegeven zou moeten worden als die ook zonder steun uitgevoerd zou worden. Met andere woorden, er is enige zekerheid nodig dat de steun ook werkelijk gebruikt wordt voor het uiteindelijke doel van de UNFCCC.

Mochten nationale emissierapportages met regelmaat en nauwkeurigheid gemaakt gaan worden dat kan dit de noodzaak voor MRV van individuele maatregelen verminderen. Omdat de effecten van reductiemaatregelen in de emissietrends op nationaal niveau zichtbaar worden, kan op deze manier de nationale bijdrage aan de wereldwijde emissietrend ook worden bijgehouden.

Het belang van *early action* van ontwikkelingslanden wordt door velen onderkend, en in het Kopenhagen Akkoord is $30 miljard toegezegd voor mitigatie en adaptatie tot aan 2012. Daarom is het essentieel dat er een snelle start wordt gemaakt met het ontwikkelen en implementeren van NAMA's, en hun MRV. Om dit mogelijk te maken kan een progressieve aanpak nuttig zijn: in de komende jaren zouden de richtlijnen voor MRV flexibel kunnen zijn, vooral in landen met lage databeschikbaarheid. In deze tijd kan er dan via internationale samenwerkingsverbanden capaciteitsopbouw en dataverzamelingsprogramma's de nodige gegevens en capaciteit worden verzameld om MRV van maatregelen te bereiken.

Abbreviations

NIR	National Inventory Report
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
QA/QC	Quality Assurance / Quality Control
ERT	Expert review team
GDP	Gross Domestic Product
GFED	Global Fire Emissions Database
GHG	Greenhouse Gas
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
MRV	Measurement, reporting and verification
NAMA	Nationally appropriate mitigation action
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land-Use Change and Forestry
LULUCF	Land-Use, Land-Use, Change and Forestry
PFC	Perfluorocarbon
EDGAR	Emissions Database for Global Atmospheric Research
LDC	Least developed country
EIT	Economies in transition
NAI	Non-Annex I
COP	Conference of the Parties to the UNFCCC
QELRO	Quantified emission limitation or reduction objective
AWG-LCA	Ad hoc working group on long-term cooperative action
REDD	Reduced emissions from deforestation and degradation
IEA	International Energy Agency
PAM	Policies and measures
CRF	Common reporting format
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
WSS	Water Supply and Sanitation
FAO	Food and agricultural organisation
EIA	Energy information administration
CDIAC	Carbon dioxide information analysis center
JI	Joint Implementation
HCFC	Hydrochlorofluorocarbon
OECD	Organisation for economic cooperation and development
MSW	Municipal solid waste
FOD	First order decay
GDP	Gross domestic product
DOC	Degradable organic carbon
WWTP	Wastewater treatment plant
AFOLU	Agriculture, forestry and land-use
SD	Standard deviation
LHV	Lower heating value
GIS	Geological information systems
WRI	World Resources Institute
ERT	Expert review team
CFL	Compact fluorescent lamp
AM	Approved methodology
NM	New methodology
PDD	Project design document
BAU	Business as usual
PoA	Programme of Activities

MW	Megawatt
BSG	Baseline sampling group
PSG	Project sampling group
INR	Indian Rupee
RE	Renewable energy
BE	Baseline emissions
EG	Electricity generated

1 Introduction

The Bali Action Plan (BAP - Decision 1/CP.13 paragraph 1 (i) and (ii), UNFCCC (2007)) committed developing country Parties to negotiate nationally appropriate mitigation actions (NAMAs) that are measurable reportable and verifiable (MRV) and developed country Parties to quantified emission limitation and reduction objectives, commitments and actions that are measurable, reportable and verifiable. For developed countries the MRV requirement also includes commitments to technology, financing and capacity building support for developing countries. Similar provisions, and in addition national inventory reports for non-Annex I countries, are included in the Copenhagen Accord (UNFCCC, 2009b), which the Conference of the Parties took note of at its 15th session.

As of early 2010 however, it is not clear what MRV requirements for NAMAs might look like, and to what extent inventories for developing countries can be established given limitations in data availability and personnel and financial resources for inventory construction. The Copenhagen Accord includes specific provisions with respect to MRV, including national inventory reports for developing countries, to be included in national communications every two years. It is important for the post-2012 negotiations in the run up to and after COP16 in November 2010 have more clarity on these issues in order to make informed decisions and create trust between Parties. This report therefore aims 1) to gain insight into whether and how inventories for non-Annex I countries can be established and 2) to clarify the balance between transparency and effort of MRV[2] by defining MRV-ability[3] and evaluating it for a number of mitigation actions.

There are existing arrangements for MRV under the Convention (particularly in relation to Article 4), and also within the framework of the Kyoto Protocol, where Annex I Parties are obliged to prepare national communications to report on commitments and inventories of greenhouse gas emissions and removals. Articles 5, 7 and 8 of the Kyoto Protocol address reporting and review of information by Annex I Parties under the Protocol, as well as national systems and methodologies for the preparation of greenhouse gas inventories. Annex 1 Parties are obliged to adopt accounting procedures to track and record holdings and transactions of units traded under the Kyoto Protocol flexible mechanisms. Specific commitments (policies and measures) of Annex I Parties to mitigate climate change are laid down in Article 4.2 of the Convention and Article 2 of the Kyoto Protocol, which must also be reported in national communications. All Annex I Parties are subject to independent in-depth reviews of national communications, which effectively functions as a third party verification procedure.

Non-Annex I Parties are also encouraged and supported to prepare national communications. The arrangement of provision of technical and financial support to non-Annex I Parties in preparing their national communications is embedded in Article 12.7 of the Convention. In accordance with the provisions of this Article, the Conference of Parties (COP) at its fifth session, established the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE) with the objective of improving national communications from non-Annex I Parties.

An MRV system can serve different purposes, and its design depends on these. Parties have expressed different views on what the functions of MRV are (McMahon, 2009). Functions include tracking mitigation/adaptation spending, enhancing accountability, evaluate mitigation actions, recognise actions, provide incentives for actions, enhance information about effective mitigation options, enabling matching of action and support and tracking progress towards the goal of the UNFCCC (McMahon, 2009; Ellis and Moarif, 2009). Thereby ‘credible MRV can strengthen mutual confidence in countries’ actions and in the regime, enabling a stronger collective effort’ (Ellis and Moarif, 2009).

[2] Although this report focuses on measurement, we often use the term MRV, as is commonly done in post-2012 climate policy analysis.
[3] MRV-ability is used in this document meaning: the possibility to measure, report and verify.

Another important issue related to mitigation is whether MRV should apply to individual actions or a country's overall progress. As noted by Ellis et al. (2009),"it may make more sense to focus international M, R and V efforts on quantifying the effects of a country's low-emission development strategy, rather than on the individual mitigation actions making up this strategy. Quantifying effects at a more aggregate level is also likely to reduce risks of double-counting."

Quantifying GHG impacts of mitigation actions can be challenging, particularly for actions whose effects - even if potentially significant - can be indirect and/or long-term, such as R&D expenditure or urban planning. This means that if a reporting/recording mechanism for GHG mitigation actions is established whereby the effects of GHG mitigation actions have to be quantified in GHG (rather than non-GHG) terms, it could skew activities in favour of actions that can be thus quantified, and/or could result in an incomplete listing of actions. On the other hand, MRV of actions could be useful for matching with support (Ellis et al., 2009)

Chapter 2 briefly discusses the methodology followed in this report. Chapter 3 gives an overview of the current status with regard to MRV. In Chapter 4 presents the main results of this study: MRV-ability of emission inventories and mitigation actions in non-Annex I countries. Chapter 5 reflects on these results in the light of the negotiations and the trade-offs between costs and accuracy, after which the conclusions are presented in Chapter 6.

In the appendices more details are provided on MRV aspects of national GHG inventories (Annex A), methods to determine the level of MRV-ability of mitigation actions (Annex B), MRV-ability analysis of selected GHG mitigation policies (Annex C) and the specific NAMA case studies on biofuel blends in the transport sector, lighting efficiency and subsidies for renewable energy (Annex D).

2 Methodology

In this study we mainly focus on the MRV-ability of mitigation actions and particularly on the issue of measurability. Issues related to reporting are often on a more technical side, as to how the metrics should be reported in a common and comparable way. The level of verification needs to be a political decision. It can take place on a national and on an international level, and depending on the method chosen it may implicate high costs. The main questions regarding reporting and verification can be summarised as (Fransen, 2008):

- who should do it and
- who should pay for it.

2.1 Action database

To assess the proposed and existing types of actions in the field of mitigation in developing countries, we took the actions from official policy documents published by the countries themselves or from the databases of the IEA[4] and the WRI[5]. Through this bottom up approach we obtained an overview of actions being undertaken and proposed in policy documents. We established a database containing the following information for each proposed action:

- regional/geographic location,
- description,
- sector[6],
- type[7],
- baselines, and
- quantifications.

If a reference year or time period is mentioned in the original document the information is used as the baseline information. Quantifications include the quantitative information that is available in the action document. This includes information such as e.g. the amount of MW of solar power to be installed or the percentage of biofuel in the fuel blend.

Whereas information is generally available in the original documents about the first four sets, often information is not available regarding action baselines (e.g. reference years) or exact quantification (e.g. amount of solar heating, to be put in place in solar heating programmes). The database only includes information included in the original documents.

As of June 2009 the database contained approximately 80 actions from 11 different countries [8] in Asia, Latin America and Africa, from six sectors and of six types. We used the action database to identify common actions that are taken by several developing countries, assuming that these may qualify as NAMAs as well in the future. In Chapter 4 these common actions are included in the MRV-ability analysis.

4 http://www.iea.org/textbase/pm/index_clim.html
5 http://projects.wri.org/sd-pams-database
6 The sectors are: electricity, energy production (other than electricity) and transmission, industry, transport, buildings, agriculture, forestry and LULUCF, and waste (as also used in the IPCC Fourth Assessment Report).
7 The types are: cross cutting, financial, information/education, legislative/normative, R&D, voluntary agreement. This classification is based on the MURE database. This database “provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union and enables the simulation and comparison at a national level of the potential impact of such measures” (http://www.isisrome.com/mure/)
8 Brazil, India, Indonesia, Israel, Republic of Korea, Maldives, Mexico, Morocco, Nigeria, Republic of South Africa, United Arab Emirates.

2.2 Approach

Mitigation actions are expected contribute to the overall aim of the Convention, therefore to the "stabilization, of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, Art. 2). Thus, one of the possible indicators that could be used to assess the effectiveness of mitigations actions could be the amount of GHG emissions reduced or avoided. But, this is not the only indicator and is it refers to the possible end-result of an action; there are other indicators that can be used both to assess the end-result and to assess an action in other moments of its implementation process.

Indicators, which can be used to assess and MRV an action, can be divided into input, process/intermediate and output/outcome indicators (Cust, 2008). Throughout a policy process different metrics can be used as indicators in the different stages (see Figure 2.1). Following this scheme GHG emissions are an outcome indicator, whereas for example megawatt hours of electricity produced by renewable energy technologies are an output indicator.

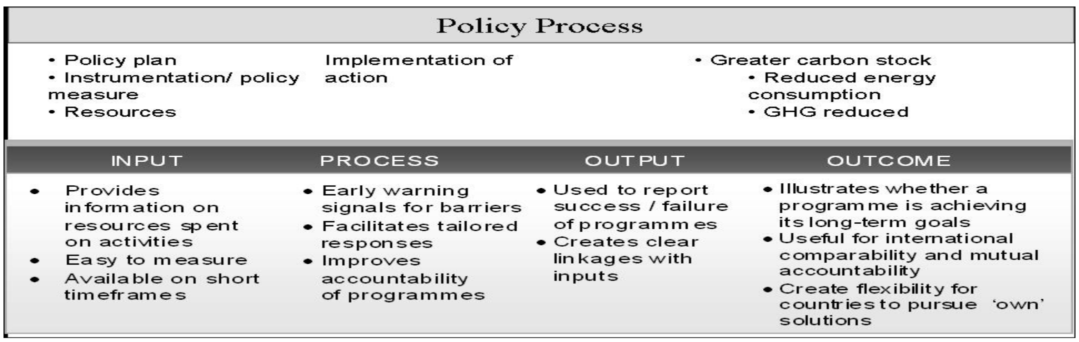

Figure 2.1 What can be MRV-ed and by which indicators? Source: Neuhoff, 2009.

For most mitigation actions GHG emission reductions can only be calculated using baseline to convert the output of the action into GHG emission reductions. Further, for certain actions, such as ones related to education, a direct correlation between the output (e.g. educated people) and GHG emissions might not be possible. There are also actions that might establish processes, the outcomes of which cannot be brought back to a specific indicator, but where an indicator could be the number of projects approved under a certain policy (e.g. the existence of a national or sectoral climate change mitigation plan). In this case the existence of for example projects may already be a sign of the action being successful. However, in most cases where the outcome of the process has an indicator, it may not be necessary to also use an indicator for the process itself, e.g. if the amount of MW hours installed renewable energy capacity is known it may not be necessary to know how many projects this refers to. Where neither the output nor the process of the action have specific metrics (e.g. establishment of a fund for deforestation), the input to the action may be considered a useful indicator. Whereas the process can be considered a black box if an outcome indicator exists, input indicators may nonetheless be of practical use when linking an action to support or when establishing the effectiveness of an action.

It can thus be stated that MRV of an action can be performed at several stages of the process, but the outcome in terms of GHG emissions is the most explicit to determine how an action contributes to achieving the goal of the Convention. Other indicators - output, process and input - can be used to support the emissions indicators. In the framework of Figure 2.1 our approach is to go 'from right to left'.

Considering the previous considerations possible inputs, outputs (e.g. MWh) and outcomes (GHG emissions) of the actions in our database were determined and a table was compiled which will be discussed in section 4.3. Processes were only determined when the output could not be established or the process is in itself the main outcome of the action. In theory the only necessary indicator for an action, is the change in emissions it has caused, if this can be determined. Nonetheless in practice knowing the indicators from which the change in emissions was calculated adds to the transparency of the system. For this reason intermediate outputs can be found in the table even where GHG emissions can be determined. The indicators that are chosen need to be MRV-able. To determine the MRV-ability of indicators, criteria were established that will be explained in Chapter 4.

3 MRV and indicators: state of play

At present, Annex I parties to the UNFCCC report their national inventories in great detail: for all 6 greenhouse gases, a full time series for all years from 1990 onwards, for all sources and sinks defined in the 1996 IPCC guidelines (IPCC, 1996). These are reported at the level of detail defined in the so-called Common Reporting Format - a set of Excel tables, in which at main and subcategory level emissions and activity data are provided, and automatically, the so-called 'implied emission factors' (i.e. the emission rate defined as emissions divided by the activity data provide for that source category). These emissions tables are provided annually, with a new year's emissions added and possible improvements (recalculations) in the old dataset (UNFCCC, 2009c). In addition to the data, a National Inventory Report (NIR) is provided documenting methods, data sources, selection of emission factors used, and QA/QC activities, which is required to assess compliance of methods, data and inventory compilation with IPCC guidelines (Good Practice and Inventory guidelines) (IPCC, 1996, 2000, 2001, 2006). The annual inventory submission is reviewed by *Expert Review Teams* (ERT) composed of independent exports from Annex I and non-Annex I countries, mostly centralised (in Bonn) and about every 5 years by in-country visits of the ERTs.

Non-Annex I countries do not have to submit their GHG inventory annually, but only as part of their National Communication, which is generally prepared once per ten years or so. To date 125 of the 150 non-Annex I parties have submitted their first National Communication and 10 have submitted a second (Argentina, Kazakhstan, Kyrgyzstan, Mauritania, Tajikistan, Macedonia, South Korea, Uruguay and Uzbekistan) or third (Mexico) (Breidenich and Bodansky, 2009; UNFCCC, 2009c). The minimum requirements for their GHG inventory are for 3 gases (CO_2, CH_4 and N_2O) for one year (1990 or 1994), for which IPCC inventory guidelines should be used, and use of *IPCC good practice guidance* is only encouraged not required. No documentation of the inventory is required, and it less extensively reviewed as Annex I inventories. As of September, 2009, 18 non-Annex I Parties have not yet submitted a National Communication (eight of which are oil producing countries): Afghanistan, Angola, Bosnia and Herzegovina, Brunei Darussalam, Cyprus, Equatorial Guinea, Kuwait, Liberia, Libya, Marshall Islands, Montenegro, Myanmar, Oman, Qatar, San Marino, Serbia, Syria and Timor-Leste.

The submission of inventory data by non-Annex I countries is subject to capacity and funds available for the inventory compilation. Of the 136 countries, 95 of them submitted data for one year, in most cases for 1994 (see Figure 3.1).

3.1 Coverage of submitted non-Annex I inventories

As of 2009, all Parties reporting their National Communication estimated, at least for one year, emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), with the exception of four Parties which did not report on one or more GHG:

- 12 Parties (10%) reported for 1990;
- 94 Parties (77%) for 1994;
- the remaining Parties (13%) reported for various years.

A total of 107 Parties (88%) provided emission estimates for some or all GHG precursors (CO, NOx, NMVOC) and SO_2. Fifteen Parties (12%) did not provide estimates of these gases. Eighteen Parties (15%) provided estimates of F-gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCc) or sulphur hexafluoride (SF6) (UN, 2005). According to the data provided, the energy sector was the largest source of GHG emissions for 70 Parties, whereas for 45 Parties the agriculture sector was the largest and for six the waste sector was the largest. Agriculture was the second largest emitter for most Parties, followed by the industrial processes sector, and then the waste sector. Removals by the Land Use Change and Forestry sector (LUCF) in most non-Annex I Parties offset GHG emissions from this same sector (UNFCCC, 2005).

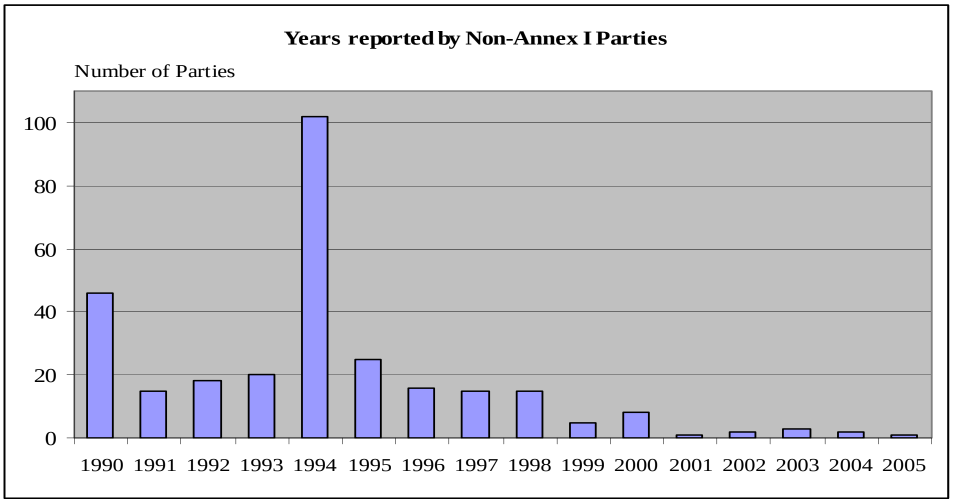

Figure 3.1 Years for which non-Annex I countries have submitted a GHG inventory in their National Communication(s)

Many of the non-Annex I GHG inventories were made several years ago, e.g. in the framework of projects carried out under the U.S. Country Studies Programme. Several may have used methodologies and emission factors that do not correspond to the *Revised 1996 IPCC guidelines*, in case they were prepared before these guidelines were released.

3.2 Characteristics of inventories for non-Annex I countries

To estimate how important specific sectors are for the total national emissions inventory of different groups of countries we summarised in Table 3.1 the shares of gases and main sectors for the whole group of Annex I, non-Annex I and all countries as reported in the EDGAR 4.0 database of national GHG emissions estimates (JRC/PBL, 2009). Here the IPCC sectors 1 (energy, combustion and fugitive emissions), 5 (LUCF, in the table referred to as 'Forest emissions'), 4 (Agriculture, including savannah burning and agricultural waste burning in the field), and the remaining 'Other' comprises IPCC sectors 2 (industrial production, non-combustion processes), 3 (solvents and other product use) and 6 (waste: landfills, wastewater and incineration).

Table 3.1 Number of countries with shares in total emissions in 2005 of Energy less than 50% or Forest, Agriculture or Other more than 50% (source: EDGAR 4.0)

Group	Number in group	Energy	Forest	Agriculture	Other
		< 50%	> 50%	> 50%	> 50%
Global total	219	91	24	33	9
Annex I + other EIT	53	2	0	0	0
Non-Annex I countries	166	89	24	33	9
Largest NAI (>100 MtCO_2eq.)	33	14	10	2	0
Medium NAI (1-100 Mton CO_2eq.)	123	62	24	23	1
Smallest NAI (<1 Mton CO_2eq.)	41	26	0	10	7

Table 3.2 Average of percentages of all countries of shares in total emissions in 2005 of Energy, Forest, Agriculture or Other sectors (%) (source: EDGAR 4.0)

Grouping	Energy [%]	Forest [%]	Agriculture [%]	Other [%]
Global share	66	14	11	9
Average of all national percentages	51	10	23	16
Annex I + other EIT	79	0	12	9
Non-Annex I countries	44	12	26	18
Largest NAI (>100 MtCO_2eq.)	49	27	18	7
Medium NAI (1-100 MtCO_2eq.)	47	17	26	10
Smallest NAI (<1 MtCO_2eq.)	33	0	26	40

Table 3.3 Average of percentages of all countries of shares of emissions per GHG in 2005 (%) (source: EDGAR 4.0)

Grouping	CO_2 [%]	CH_4 [%]	N_2O [%]	F-gas [%]
Global share	76	16	7	1.6
Average of all national percentages	57	31	11	0.7
Annex I + other EIT	76	17	7	
Non-Annex I countries	52	35	13	
Largest NAI (>100 MtCO_2eq.)	67	23	9	
Medium NAI (1-100 MtCO_2eq.)	58	29	13	
Smallest NAI (<1 MtCO_2eq.)	36	51	12	

There are two countries within the 53 Annex I or other EIT countries for which the Energy sector has a much lower share than about 80% on average: New Zealand with 47% and Georgia with 49%. In both cases this is due to the high share of Agriculture of about 33% (versus a group average of 12%).

However, of all 166 non-Annex I countries, more than half have a share of the Energy sector in national total GHG emissions of less than 50% (

Table 3.2). Since this group comprises also very many small countries (41 emitting less than 1 $MtCO_2$-eq in 2005), the table also shows the fractions for the 33 largest non-Annex I emitters, which emissions are higher than 100 $MtCO_2$-eq/yr and collectively account for 90% of total non-Annex I emissions. Of these larger countries, about 40% of them have an Energy sector share of less than 50%, whereas in 30% of the countries (i.e. in ten countries) the Forest sector contributes more than 50% to the national total in 2005. Of all 166 LDC countries in 30 of them does the Forest sector contribute more than 30% to the national total (i.e. including CO_2 emissions due to post-burn decay of remaining biomass but excluding sinks).

Thus, it can be concluded that for non-Annex I countries in general Energy sector emissions are less important than for Annex I countries, but instead Agriculture and Forest (i.e. LULUCF) emissions are more important. For the largest non-Annex I countries as opposed to the smaller ones, forest-related emissions (excluding carbon sinks) are more important than agricultural emissions.

3.3 MRV of actions

The Bali Action Plan (BAP (UNFCCC, 2007)) asks for “enhanced national/international action on mitigation of climate change, including, inter alia, consideration of:

(i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, by all developed country Parties, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances;

(ii) Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner;”

Discussions on an international climate agreement post-2012 leading up to COP16 in 2010 and beyond therefore need to take into account the MRV of mitigation commitments, actions and support. The design of a climate regime based on MRV could allow smoother negotiations (Fransen et al., 2008; Winkler, 2008) and serve various other functions, as mentioned in Chapter 1.

Whereas almost all Parties agree that commitments by developed countries need to be MRV-ed on other issues there are divergences. These issues include whether MRV of actions should be done both by developed and developing countries, how to MRV of support of technology transfer, finance and capacity building (McMahon and Moncel, 2009). When one moves away from commitments that are expressed in reductions of GHG emissions (quantified emission limitation or reduction objectives, QELROs) to more general actions, such as policies and measures, quantification problems may arise. For the system to be based on MRV it is necessary to determine what is measurable (Winkler, 2008), and determine a unit with which the actions can be quantified (Fransen, 2008). Theoretically it is also possible to use qualitative information about the actions, but comparability issues may arise (Ellis and Moarif, 2009).

Until now there are experiences with quantified emission reduction or limitation commitments of Annex I countries, which are reported to the UNFCCC in national GHG inventories. Annex I countries also report their mitigation policies and measures in their national communications, however with regard to estimation of the impact of these policies UNFCCC (2007b) notes that ‘(q)uantitative estimates of the mitigation effects of policies and measures are rarely reported in the NC4. Even when they are reported, estimates are not necessarily consistent among Parties, in terms of categorization, baseline assumptions, modelling procedures and methodological approaches to account for policy synergies and interactions.’

The term ‘mitigation actions’ may cover a very broad range of activities including policies and measures. In the BAP mitigation actions for Parties are referred to as Nationally Appropriate Mitigation Actions (NAMAs). The terminology used in the BAP is rather vague and does not give a precise explanation of what can be included under this name. In the draft negotiation text for

the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA) of May 19th 2009, paragraph 73 notes that NAMAs may include[9]: "
(a) Sustainable development policies and measures;
(b) Low-emission development strategies and plans;
(c) Programmatic CDM, technology deployment programmes or standards, energy efficiency programmes and energy pricing measures;
(d) Cap-and-trade schemes and carbon taxes;
(e) Sectoral targets, national sector-based mitigation actions and standards, and no-lose sectoral crediting baselines;
(f) REDD-plus activities[10] and other mitigation actions implemented in different areas andsectors, including agriculture."

In this report the word 'action' is used to cover mitigation actions. Whether these actions will in future be a NAMA or not, is not discussed here. A first list of possible types of NAMAs and the metrics used to quantify them can be found in Fransen (2008). This indicates that possible NAMAs can be taken from governmental plans and include both current and proposed actions. The plans also include metrics such as GWh renewable energy generated and in some cases the author suggested potential metrics. The metric 'CO_2-eq reduced' was not mentioned in the plans but was proposed by the author.

The use of different metrics that are not transformed into GHG emissions raises issues of comparability between actions. This could be solved by creating a robust MRV system with agreed metrics for different actions and common standards (Ellis et al., 2008). Fransen (2008) stated that actions should be analysed with quantitative metrics and consistent standards. When deciding how to MRV actions the following points should be kept in mind:
1. which actions should be MRVed?
2. how should indirect actions qualify?
3. how should technology, financing, and capacity building support be related to the actions?

Several proposals have been made in country submissions to the AWG-LCA in 2009, regarding the first point. As of November 2009 however there is no agreement about the scope of NAMAs and which actions should be MRV-ed (UNFCCC, 2009a). A distinction is made between three types of actions: (i) unilateral actions, (ii) actions taken through with support and (iii) actions that produce carbon credits for the carbon market. The first category comprises actions that a country takes through without support from external parties, and may be subject to MRV and/or international recognition. For actions from category two, there is general agreement that these should be subject to MRV, both in terms of support and outcome. For the third category of actions similar rules as for CDM projects should apply according some Parties, which would mean enlarging the CDM mechanism to include actions. For further views of Parties on this topic, see Moncel et al. (2009).

3.4 Indicators for mitigation activities

Considering that MRV of mitigation actions totally or partially is expected to take place at least for some actions or support by developed or developing Parties, it is important to see what indicators or metrics[11] are available to do this. An indicator can be defined as a "measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time" (EEA, 2005).

[9] In a later text, the AGW-LCA non-paper 51 (6 November 2009) on BAP 1 (b) (ii), these options related to NAMAs were not included in the negotiation text anymore

[10] In this document, actions under paragraph 1 (b) (iii) of the Bali Action Plan (issues related to policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries) are referred to collectively as 'REDD-plus'

[11] In this report 'indicator' is used rather than 'metric', as the former covers both quantitative and qualitative information.

An important question is to determine what should be MRV-ed: the actions (e.g. feed-in tariff) themselves, the output or outcome (e.g. MW capacity or GHG reductions) of the actions or both (Breidenich, 2009). A distinction of indicator types between outcome and intermediate indicators has been suggested (Cust, 2008, Ellis and Moarif 2009). Outcome indicators are used to monitor the target of a policy, which in the case of climate related policies is generally emission reductions. This type of indicator is important to determine the success of a policy, but often it is necessary to establish the effectiveness of a policy intermediately to facilitate policy design and to update policies, for this, intermediate indicators are used (see also Figure 2.1).

Further, indicators can be distinguished between quantitative and qualitative indicators. Qualitative provisions for policies and measures (PAMs) in an MRV system could be made on the lines of the IEA's database of PAMs regarding climate change mitigation (Ellis et al., 2009). Measuring and verifying qualitative actions is challenging (Ellis and Larsen, 2008). If only a database along the lines of the IEA database is created the focus would be on whether the action has been implemented, rather than on the effects of the PAM (Ellis et al., 2009). The effectiveness of the measure can therefore not be assessed and improvements cannot take place. To ensure comparability and objectivity the use of quantitative indicators is to be encouraged where possible.

4 MRV-ability of emissions and actions in developing countries

Section 4.1 looks at how GHG inventories for developing countries can be established. In the remaining part of this chapter we make an effort to determine to what extent actions are measurable, reportable and verifiable. We will define this as the *MRV-ability* of an action. To determine the MRV-ability criteria were established. The criteria were tested on the actions collected in the database of mitigation actions and through the information gathered in the database, possible metrics that can be used to MRV the actions could be established. Further it is possible to see whether there are actions that are difficult to MRV and what sectors they fall into.

4.1 MRV-ability of GHG inventories

This section builds on the analysis performed in Annex A, which includes a discussion on the data readily available to compile a national GHG emissions inventory, and the activities required to establish GHG inventories, in particular for non-Annex I countries. However, also for Annex I countries some MRV elements of the inventories could be improved in some areas. As it turns out, for most of the larger sources (energy production and use, many industrial processes, agriculture, landfills, wastewater) international statistics are available as activity data and the 2006 IPCC guidelines provide default emission factors enabling estimation of national emissions. Only for the use of F-gases (HFCs, PFCs and SF_6) national statistics are mostly missing in developing countries and are often incomplete in Annex I countries, thereby prohibiting to make accurate emission estimates (e.g. consumption per application).

Although there are very few officially submitted non-Annex I inventories for 2005, as the new EDGAR version 4 datasets for national GHG emissions for all countries show, it is quite well possible to make a complete estimate of all GHG sources of a country for the whole time series from 1990 onwards using IPCC tier 1 methodology or higher (JRC/PBL, 2009).

From the analysis of data availability described in Annex A we can conclude that all significant sources can be *measured* (i.e. calculated) and can also *reported* per detailed source category at the level of detail of present CRF reporting by Annex I countries for a time series from 1990 onwards. When using all international statistics and default emission factors, these emissions are by definition *verifiable* with international statistics and IPCC guidelines. And when using country-specific activity data and country-specific or plant-specific emission factors, these values can be compared to other data sources, default emission factors and reporting by other countries. The extent to which country-specific data can be used for key categories will depend on data availability and the resources that are available to the inventory agency. However, a certain minimum number of core staff of sectoral experts is required to guarantee the maintenance and improvement over time of the national emission inventory.

However irrespective of the uncertainty estimates made for the GHG emissions, the inventories are *consistent with good practice* if they contain neither over- nor under-estimates so far as can be judged, and if the uncertainties are reduced *as far as practicable*. These requirements are to ensure that emissions estimates, even when rather uncertain, are bona fide estimates, in the sense of not containing any biases that could have been identified and eliminated, and that uncertainties have been minimised as far as practical *given national circumstances*. Estimates of this type would presumably be the best attainable, given current scientific knowledge and *available resources* (text cited from IPCC good practice guidance (IPCC, 2000)).

Thus, in cases where inventory compilers may be unable to adopt a higher Tier[12] method *due to lack of resources* they will be able to use Tier 1 methods which can still be in accordance with good practice guidance. This may mean that they are unable to collect the required data for a higher tier or are unable to determine country specific emission factors and other data needed for higher methods. However, *determining the key categories* helps the inventory compiler to focus effort and resources on the sectors that contribute most to the overall inventory or inventory uncertainty and so helps to ensure that the best possible inventory is compiled *for the available resources*. This is being demonstrated by the inventory agency by *reporting* how the available resources are being used for inventory compilation, reporting, documenting and improvement. So an essential element of MRV is that an adequate part of the resources are used for reporting the inventory, so that it can be reviewed and verified.

However, a certain minimum number of core staff of sectoral experts is required to guarantee the maintenance and improvement over time of the national emission inventory (including reporting). This could require additional resources, also for capacity building and for inventory agency staff for participating in UNFCCC inventory review process. If GHG inventories by many non-Annex I countries are also to included in the UNFCCC review process, a modification of the present system of annual reviews of all Parties to a more optimised and focussed system will be indispensable, also for Annex I Parties, in order to have an efficient use of resources (e.g. review frequency and depth depending on national and sectoral emissions levels).

The estimation of net carbon storage in non-degraded (i.e. undisturbed) forests, degraded forests, forest plantations, and in other wooded lands is part of the LULUCF reporting. The 2006 IPCC guidelines provide a Tier1 method for natural forests and forest plantations using readily available activity data (areas from FAO statistics) and default factors for aboveground biomass growth per ha). For degraded forests, IPCC (2003b) has identified options to identify them in a measurable and quantifiable way and the 2006 IPCC guidelines provide an accounting scheme for including carbon losses due to wood and fuelwood extraction and due to other disturbances. However, for degraded forests, default values and practical tier 1 guidance for estimating the degree of degradation is missing in the 2006 IPCC guidelines (IPCC, 2006). For estimating the carbon storage in forests (i.e. the sink), developing countries may utilise the analysis and estimates made by national teams that participate in the FAO's Forest Resources Assessments (FRA), that are published periodically (FAO, 1993, 1005, 1998, 2006).

For most Annex I countries LUCF probably is a small non-key category, but for most non-Annex I countries it may be a key category, for which resources for using a higher Tier method may be lacking. However, future REDD policies may provide the additional means for using, reporting and documenting a higher tier method for this category as part of the national GHG *emissions* and *sinks* inventory, in particular since there is a need for identifying in a transparent way the impact of REDD activities.

4.2 Evaluating MRV-ability of actions: approach

This section discusses criteria to determine how readily the outcomes of an action can be MRV-ed. We have established the MRV-ability regarding GHG and non-GHG outcome indicators, such as electricity produced. With this method we try to establish whether the outcome of an action is measurable in terms of GHG emissions reduced or avoided, if other quantitative measures are applicable, or if no quantitative measures can be applied. Knowing whether the output of an action is MRV-able allows us to assess whether it is necessary to resort to previous elements of the policy process to MRV the action.
The criteria chosen are the following:

[12] IPCC 2006 Guidelines include 3 tiers for estimating GHG emissions: Tier 1 and Tier 2 methodologies do not depend on measurements on-site but are calculated with factors. Tier 1 uses average emission factors, whereas Tier 2 uses more country or regional specific factors. For Tier 3 local activity data and country-specific emission factors are required.

1. Is the outcome of the action measurable in a quantified manner? In what metric? This establishes whether quantification of the action can take place. If this is not the case, maybe qualitative indicators can be applied, but for the aim of this analysis the action would result as not MRV-able.
2. Can the outcome be expressed in GHG emissions reduced or avoided? This determines whether a transformation from the established metric to GHG emissions can take place. This implies the existence of a baseline. Nonetheless at this stage a more theoretical approach was taken, to determine whether the metric is transformable. Some (output) metrics, as number of people educated cannot be transformed into GHG emissions[13], whereas the amount of GWh produced by wind farms can if a baseline is available.
3. Can a baseline be established from existing data? The possibility to establish a baseline, i.e. the existence of a data to calculate a baseline needs to be determined. We decided to concentrate on the existence of data rather than on the existence of a baseline, because in some cases the data for a baseline might be collected for other reasons than baseline calculation.
4. Can quantified data be collected “easily”? In some cases quantified data to estimate the impact of an action might currently not be available, but the collection of the needed data is a well known process and structures are available in most countries to collect this data. If this is the case then this criterion will be positive
5. Is quantified data available in the absence of an MRV system? Data might be collected for national accountability purposes and will thus be collected without an international MRV system being in place
6. Is quantified data available if an MRV system is in place?

This methodology, based on these criteria, used to determine the MRV-ability of action outcomes can be found in **Annex B**. The approach allows the classification of actions into three categories ‘high’, ‘medium’ and ‘low’, for GHG and non-GHG MRV-ability, depending on whether the outcome of the action is MRV-able or not.

The criteria analysis was first carried out for all actions in the database. During the compilation of the database it became evident that actions in the different countries are often similar. Therefore, in a second step, actions that relate to the same policy aspects were united to allow a more concise overview of the existing types of actions.

Having united similar actions taking place in different countries, the indicators for the actions were analysed independently from the country where the action is taking place. Relatively high data availability was assumed.

4.3 Metrics for actions and their MRV-ability

As described above we united the individual actions from the database into a limited number of actions that generalise the individual actions on a more aggregated level, for example feed-in tariffs and incentives for renewable energy in different countries were united to a generalised action called renewable energy incentives. This synthesis allows to create an overview of the policy process related to the actions and to determine the MRV-ability of the aggregated actions through the criteria mentioned above.

Following the approach described in Chapter 2, we divided the action framework into three parts: input, process and output[14]. The input includes two parts, the action in itself, i.e. the introduction of a renewable energy feed-in tariff, and a concrete input if it is explicitly stated in the document (e.g. money). Secondly there is the process that transforms the input into the desired output, for example projects that take the money through feed-in tariffs to make a wind turbine economically feasible. This creates the output, the production of electricity (MWh)

[13] In this case these may be retained as output indicators
[14] Output can be further divided into output and outcome, the latter in this case being GHG emissions reduced.

through renewable energy source and avoids CO_2 emissions (outcome or impact of the action), which is the goal of the action from a climate perspective.

Emissions are possibly the easiest way to determine the effectiveness of an action when related to climate, but this may not be possible for all actions or may not be cost-effective. IN the following we will look at both the possibility to MRV actions in terms of GHG emissions and other indicators. As we focused on the implementation of the action, and are mainly interested in estimating the outcome of the action, we were only interested in the process if there was no possibility to calculate the outcome of the action. In this analysis we have added the input when it is explicitly mentioned in policy documents.

At the end of this analysis we thus obtained Table 4.1. In this table it is possible to see which actions can readily be MRV-ed in terms of GHG emissions. This does not imply that it is possible to do so in every country immediately, as this analysis does not describe the effective availability of data in a specific country. As mentioned previously the main difficulty is the determining the availability of data to create a baseline, both for GHG emissions and for other metrics, but particularly for the transformation of one into the other.

With this table it is also possible to link the outcome or impact of the measure to an input, as this might be requirement under a future agreement under the UNFCCC. This means for example that it is possible to link an amount of money to a certain amount of CO_2 reductions, although this criterion cannot always be used to judge the effectiveness of a measure.

Table 4.1 shows a synthesis of the analysis carried out for every single action. In Annex C the analysis of each action for GHG and non-GHG MRV-ability following the six criteria is carried out. Here we have added the metric used for the GHG MRV-ability and the non-GHG MRV-ability. If the action is MRV-able for either, we have not looked at the process. As the connection between the input and the output might be useful and add to transparency we have where possible added the input metric. In this way the analysis provides us a complete overview of possible metrics that can be used and their MRV-ability.

For the actions researched[15] the following picture can be observed (see also Annex C). In the energy related sectors, both for electricity and non-electricity, the MRV-ability tends toward 'high', as is the case for the industry sector, as we assume that in these sectors the outputs are easily measurable and the transformation into GHG is possible. The sectors that had the lowest MRV-ability in this analysis are the AFOLU and the buildings sector. The actions analysed for the AFOLU sector mainly relate to forestry, here monitoring, registration and funds play an important role, but these actions are difficult to MRV. In the AFOLU sector the difficulty lies in finding metrics suited to determine the effectiveness of the action. In the building sector there are a few actions related to appliances in the residential sector that are easy to MRV but the transformation to emissions is tricky; actions like building codes, building auditing and rating do not have direct output metrics as they initiate processes. The transport sector lies in-between and is classified as medium MRV-able, as there are difficulties related to creating credible baselines.

[15] It should be noted that these actions are based on proposed climate plans, and therefore are not likely to be representative of a comprehensive mitigation portfolio.

Table 4.1 Desk evaluation of chosen policies, their metrics and MRV-ability

INPUT Action	Input	PROCESS	OUTPUT other metric	GHG emissions reduced or avoided
Building sector				
Appliance switch (CFLs)	$	n/a	number of appliances exchanged	-GHG
Solar water heating programmes	norm/$	n/a	increase in m2 solar collectors sold incentives given	-GHG
financial incentives for energy efficient appliances	$	n/a	amount of incentives given increase in number of appliances sold	-GHG
Building codes	norm	n/a	reduced energy consumption in buildings	- GHG
Energy Audits in buildings/companies	n/a	auditing of buildings	classification of audited buildings	n/a
Rating of building	rating	n/a	share of buildings with certain characteristics	n/a
Labelling of appliances	rating	awareness of client	number of labeled appliances sold	-GHG
training of specialised technicians	$	n/a	number of trained specialists	n/a
Electricity sector				
RE targets	norm	n/a	MW installed capacity after norm MWh produced	-GHG
RE incentives	$	n/a	MW installed capacity with incentives MWh produced	-GHG
substitution of decentralised generation	$	n/a	Substituted generation capacity	- GHG
Reduction of non-technical losses in the electricity distribution	n/a	n/a	MWh saved	-GHG
non-electricity energy production				
Eliminate gas flaring	norm	n/a	power plants where flaring has been eliminated	-GHG
AFOLU				
Deforestation reduction	normS	n/a	km2 not deforested	-GHG
National public forestry register	n/a	catalogue of existing forests and area	n/a	n/a
Deforestation monitoring program	$ technical equipment	modification of forest extension	n/a	n/a
Funds against deforestation	$	actions against deforestation	n/a	n/a
Industry				
Energy Efficiency in Industry	n/a	n/a	MWh saved	-GHG
Limits to primary energy use per final product	norm	n/a	GJ primary energy savings	-GHG
Energy audits in industry	n/a	auditing of buildings	classification of audited buildings	n/a
Transport Sector				
Biofuel incentives	norm/$	n/a	increase in % of blend in fuel	-GHG
Emission standards	norm	n/a	minimum standard of mg/km	-GHG
Promotion of new vehicle types	$	research	number of new vehicles sold/substituted old vehicles	-GHG
Labelling of vehicles	norm	n/a	number of new vehicles sold/substituted old vehicles	-GHG
Fuel switch to CNG	n/a	n/a	increase in m3 gas used	-GHG
Urban transport campaigns	$	increase in awareness	increase in passenger numbers	-GHG

Legend
High (non-) GHG MRV-ability
Medium (non-) GHG MRV-ability
Low (non-) GHG MRV-ability

4.4 NAMA case studies

In order to gain more insight in how measuring actions could be done in practice we explore MRV issues (mostly related to measurement) in three case studies, which could be implemented as NAMAs. These are based on existing initiatives in non-Annex I countries, as shown in the action database (see 3.1), but are taken to a more general level so as to be applicable to all countries. They are in different sectors: electricity (feed-in tariff), buildings (lighting efficiency) and transport (biofuel blend). Here we briefly cover the most relevant outcomes, whereas Appendix D includes the full description of the case studies. These include examples of existing policies in non-Annex I countries, an overview of how MRV is currently done in Annex I and the Clean Development Mechanism, and possible ways forward. An overall discussion including the trade-off between certainty and transaction cost is provided in Chapter 5.

We note that the focus here is on MRV related to outcomes (GHG emissions reduced) or outputs, rather than inputs or process. Also we focus on policies rather than technology transfer or capacity building. We also note the difference in MRV requirements for countries with a GHG cap on the one hand, where the impact of individual policies is not of high importance for emissions accounting, and those without an emissions target, where a counterfactual ‘without policy’ baseline is of crucial importance to assess the GHG impact of an individual policy. This could be similar to what is done in the CDM, or any ‘baseline-and-credit’ system. However under the current CDM only projects and programmes are eligible and policies are not, so the lessons learnt may be of limited applicability.

4.5 Biofuel blends in the transport sector

Policies promoting the production and consumption of biofuels are common in both Annex and non-Annex I countries. Targets for biofuel blends over 10 or 20% can are in place or considered in many countries. Biofuel policies are pursued because they contribute to a multitude of policy objectives, including GHG reduction, employment, energy security and in some cases air quality improvement.

With regard to measuring the impact of biofuel policies and projects, it appears that from the current CDM projects and methodologies important experience has been created. With respect to life cycle emissions many issues have been covered in currently approved methodologies, or those under consideration. However for ethanol methodological issues need to be resolved. In the EU default emission factors have been developed for a large set of different biofuels, which could be used in non-Annex I countries if adapted to the local conditions, as the requirements for unilateral supported NAMAs may be less strict than in the case of CDM, where reductions are fully used as offsets.

With respect to determining the baseline scenarios and the extent to which the impacts can be attributed to the biofuel policy, great challenges remain. The approach taken in the EU does not seem sufficiently comprehensive and conservative to be adopted for developing country NAMAs, as this could easily lead to over or under estimation of emission reductions. The approach used in the currently only approved methodology (AM47) may be helpful for individual biofuel production project cases (though subjectivity remains), but for assessment of a policy on a country level more consideration may be needed. In some other transport CDM methodologies reference is made to modelling consumer behaviour to distinguish policy impacts from other influences. A key issue is that biofuel policies contribute to several important national policy objectives such as security of supply, employment and balance of payments.

An approach could be to base the determination of the extent to which the impacts can be attributed to policies on a combination of a thorough policy analysis where the different policy objectives are weighed, as well as an assessment of the biofuel production baseline in a country based on (a sample of) individual production plants as done in AM 47. In order to ‘validate’ the baseline, ex-post analysis could be done on a regular basis, e.g. by using key input parameters such as prices for oil and biofuel feedstock in the model and recalculate the baseline scenario, which can then be compared to the ex-ante baseline. In this fashion uncertainty with respect to the additionality question could be reduced greatly, but on the other hand involves larger data and modelling requirements, thereby increasing transaction cost.

4.6 Lighting efficiency

Two different types of actions can be carried out to replace inefficient lighting: (i) bans on inefficient lighting and (ii) substitution programmes, with free or reduced price distribution of efficient lighting (compact fluorescent lamps, CFLs) in exchange for inefficient lighting (incandescent light-bulbs). The former is currently being implemented or considered in several non-Annex I and Annex I countries, while the latter has been implemented in the 80s and 90s to some extent. In many non-Annex I countries substitution programmes are ongoing or being designed. Lighting efficiency measures are often cost effective from a social perspective and contribute to several policy goals beside climate change mitigation, including energy security and air quality.

The implications for MRV can be different for these measures due to the difference in the time horizon and means of implementation. Whereas a substitution programme has a predefined running time, the substitution of lighting with a ban takes place over a longer period that cannot be determined with certainty.

The experience to date with regard to MRV of replacing inefficient lighting can be called limited. The South African policy has been in place since 2004, the only evidence of MRV is the number of new distibuted lighting appliances which is published and updated. In India metering devices have been installed in some regions[16], but no conclusions from the monitoring are available as of February 2010.

To estimate the expected emission reductions of a ban on inefficient lighting, a business as usual scenario has to be estimated. In the EU surveys and household questioning were carried out to estimate the number of lighting appliances in households and through trend analysis a BAU scenario was developed. The emissions savings calculations is done mainly with estimates, derived from the lifetime of old light bulbs and their assumed time of substitution. As the estimates of emission reductions are thus done through factors (i.e. the lifetime of old appliances) and no direct household monitoring generally takes place, MRV related to this measure can be considered a Tier 1 or 2 case[12]. If the factors can be established with acceptable accuracy the main difficulties lie in the determination of the current situation and the baseline scenarios. The data requirements to determine the current situation are high.

Several CDM baseline and monitoring methodologies have been developed for substitution programmes, summarised together with non-CDM options in Table 4.2. All CDM methodologies can be considered Tier 3 methodologies as they require on-site monitoring. The Tier 3 methodology is the most data intensive and requires on-site monitoring and measuring. The difference between the methodologies for small and large scale projects is in the baseline; large scale projects have a dynamic baseline.

The question of attribution of impacts to policies is very relevant for substitution policies: would the substitution have taken place even without the free or subsidised distribution? In the CDM projects currently in the pipeline additionality is being demonstrated using the investment analysis. The main barrier considered is the higher cost of CFLs compared to the one of incandescent light bulbs. In methodology AM46, the baseline and additionality questions are solved by monitoring a baseline sampling group, which does not receive CFLs from the project. In this way changes in the energy use of the baseline group should be captured. Nonetheless a definitive answer to this inherently subjective question cannot be given.

[16] http://www.energymanagertraining.com/CDM/BLYconceptnoteandStatus_06Oct2008.doc http://www.energymanagertraining.com/CDM/cdm_main.htm, accessed 15th February 2010.

Table 4.2 Summary of main issues related to GHG emission reductions for the different policies and measures analysed.

	Substitution programmes			Bans
	CDM small scale	CDM large scale	Non-CDM	Non-CDM
Estimate of GHG reductions	(estimated consumption of old device-consumption of new device) * grid emission factor	Difference between consumption in baseline sampling group and project sampling group	No estimate (only estimate of reduction in electricity consumption)	Difference between BaU and Policy scenarios
Main effort needed for estimate	Sample surveys to verify correct functioning of substituted device Counting of exchanged devices	Extensive monitoring requirements for reading of installed metering devices	Counting of exchanged devices.	Surveys to determine starting situation and for trend developments to determine BaU scenario

Out of this brief analysis we can say that it is possible to determine the electricity reductions caused by substitution policies and calculate the emission reductions but that data requirements are generally high. CDM methodologies that relate to substitution programmes have a more comprehensive monitoring to verify whether the substitution is working, compared to policies regarding bans, as they have established standards for determining the baseline and the grid emission factor. This can be explained by the fact that CDM projects generate carbon credits and in order to maintain the environmental integrity of the system it is important to verify with high certainty that the emissions reductions are effectively taking place. In the case of a ban a substitution of lighting will take place but there is no certainty as to the time frame in which it will occur. If such a measure were to be allocated carbon credits timing of these and for how long they will be allocated might prove to be an issue. For bans a baseline needs to take into account substitutions that would have taken place anyway.

4.7 Renewable energy subsidies

The main challenge with GHG MRV-ing of renewable energy subsidy schemes is not related to measuring the electricity produced, which is state of the art in many countries, but determining a baseline against which to determine GHG emission reductions, i.e. the effect of the feed-in tariff in addition to business-as-usual. Renewable energy policies also contribute to policy goals other than climate change mitigation, e.g. security of supply. In addition establishing a CO_2 emission factor of the replaced electricity is challenging.

Measuring electricity production generally takes place through meters. The measurement is important for the generator, for the utility and for the agency responsible for the payments. As the amount of energy produced must be reported for the payments to occur, the measuring of the electricity produced under a feed-in tariff will occur independently from an international system being in place. In cases where measurements and subsequent payments take place it is expected that monitoring and reporting will take place independently from an international system. This means that countries that have or plan a subsidy scheme will already have the capacity to measure the electricity produced with such a policy. As the measuring occurs via metering the methodology could be considered a Tier 3 methodology.

However, the capacity to measure this policy in terms of electricity produced does not imply that the emission savings are known. The emission reduction depends highly on the baseline that is chosen. In Europe there is no standardised way to determine emission reductions from additional renewable energy. The CDM methodology ACM002 gives precise indications on how to calculate project and baseline emissions in a standardised way according to different cases. Determining which investments are additional to baseline and the baseline itself is a difficult issue.

In theory in the CDM the tendency is to underestimate the emission savings, so as to avoid giving credits for emissions reductions that have not taken place (i.e. the principle of conservativeness). For example when a renewable energy project is refitted or replaced, credits are only given until the time that the power plant would have had to be retrofitted or replaced due to end of lifetime. If the end of lifetime is a range, then the shortest time period will have to be considered.

Summarising it can be said that although measuring of the electricity produced with feed-in tariffs or other renewable energy subsidy schemes takes place in the countries that have implemented such a policy and possibly other countries have the capacity to monitor it, the MRV of subsidy schemes in terms of GHG emission reductions is based on a series of assumptions, concerning the baseline and may not be comparable. Many Annex I countries, such as the EU member states, have two targets: one for renewable energy and one for GHG emissions reduction and model estimates are used to determine the emission reductions that could occur due to the renewable energy target. In non-Annex I countries we found no evidence that emission reduction MRV of feed-in tariffs or other incentive mechanisms is taking place. For GHG emission reductions due to renewable energy projects in non-Annex I countries, there are CDM methodologies to calculate emission reductions. These may provide helpful insight for determining the extent to which impacts can be attributed to policy, as well as for grid emission factors.

5 Relevance for climate negotiations and cost-effectiveness

In this short chapter we look back at the results of the previous sections, in the context of the climate negotiations and the trade-off between cost and accuracy of MRV.

Two important negotiation texts with respect to MRV are the report of the AWG-LCA[17] at COP15 (UNFCCC, 2010b) and the Copenhagen Accord (UNFCCC, 2009b), which the COP took note of. Both have reaffirmed the importance of MRV. The AWG-LCA report includes references to MRV for developed county mitigation actions and commitments, and MRV of developing country NAMAs and support, for which the guidelines are to be agreed on by the COP.

The Copenhagen Accord includes similar language, but in addition several other relevant and specific provisions with respect to MRV: "Mitigation actions subsequently taken and envisaged by Non-Annex I Parties, including *national inventory reports*, shall be communicated through *national communications* consistent with Article 12.1(b) *every two years* on the basis of guidelines to be adopted by the Conference of the Parties. Those mitigation actions in national communications or otherwise communicated to the Secretariat will be added to the list in appendix II of the Copenhagen Accord. Mitigation actions taken by Non-Annex I Parties will be subject to their *domestic* measurement, reporting and verification the result of which will be reported through their national communications every two years. Non-Annex I Parties will communicate information on the implementation of their actions through National Communications, with provisions for international consultations and analysis under clearly defined guidelines that will ensure that national sovereignty is respected. Nationally appropriate mitigation actions seeking international support will be *recorded in a registry* along with relevant technology, finance and capacity building support. Those actions supported will be added to the list in appendix II. These supported nationally appropriate mitigation actions will be subject to *international* measurement, reporting and verification in accordance with guidelines adopted by the Conference of the Parties." (UNFCCC, 2009b; 3, italics added).

It is too early to say what the role of the Copenhagen Accord would be in the future negotiations, but the fact that it was agreed to by nearly all Parties indicates its significance. National inventory reports for the developing countries thereby may become important. The analysis in this report has shown that these inventories can generally be made, reported and verified, based on readily available data and default emission factors, of which the results may be not so accurate but may still comply with IPCC good practice, and may be improved over time based on targeted efforts. We note that an exception could be parts of the LUCF sector, in particular where default values and practical tier 1 guidance is missing for estimating the degree of degradation of forests, and possibly the estimation of forest sinks by growing forests.

It is clear that actions by developing (and possibly developed) countries are subject to MRV in one form or the other. No information on *how* this should be done is yet available from the negotiations. We have shown that there are several ways to do this, for example by focusing on the GHG emissions reduced or by MRV-ing other indicators that focus on the input, process or the output of an action. The latter option might be attractive for several reasons: 1) the indicators provide information on whether the action is being taken (e.g. the implementation of policy, awareness campaigns or capacity building) thereby creating trust between Parties, and 2) they may be easier to monitor than GHG emissions reduced, in which baselines and the extent to which impacts can be attributed to policies are difficult and potentially costly issues to address.

As exemplified in the experience with CDM projects to date, it is clear that measuring GHG reductions for a specific project can be a data intensive and cost intensive process, and that establishing a baseline and demonstrating additionality for a project or programme is difficult

[17] This text contains several (heavily bracketed) draft COP decisions, and is likely to be the basis for the AWG-LCA process in 2010.

and inherently subjective. Although we show that GHG MRV of many actions is possible, it is likely to be even more difficult for policies, as many policies contribute to several objectives and the impact of one can ultimately not be distinguished from the other. The current monitoring of single policies is also limited in Annex I countries. Fortunately, as unilateral and supported NAMAs are not going to be used as offsets for Annex I countries as in the case of CDM projects, the requirements for additionality and baselines may not be as stringent. One could even argue that MRV of GHG emissions reduced for single NAMAs is not necessary at all, as long as there is certainty that the action is being taken according to plan. However, in order to create trust with the Parties that provide support, some indication of the *impact* of the action will be necessary: an Annex I Party could wonder 'why should we fund a biofuel policy if it would have happened anyway'? In other words, some certainty is necessary regarding the question whether the support is being used and required to achieve the intended GHG mitigation.

If national inventory reports are going to be prepared on a regular basis (annually or biannulally), this could further reduce the need to make detailed estimates of the impact of individual policies, as the impacts of measures are going to be visible as the resulting trends in emissions on a national scale, and the progress toward global emission limitation can be seen. As discussed in Chapter 4, also for compilation of the national GHG inventory there is a trade-off between costs (resources required) and uncertainty in the overall emission estimate.

The importance of 'early action' has been emphasised, and in the Copenhagen Accord $ 30 billion for mitigation and adaptation in developing countries up to 2012 has been pledged (UNFCCC, 2009b). Therefore it is key that a quick start is made with designing and implementing NAMAs, and their MRV. To make sure this is possible a progressive approach can be beneficial: in the coming years the MRV requirements could be flexible, particularly in countries with low data availability. In the meanwhile international efforts can be made to carry out capacity building and data gathering programmes to establish the historical data and capacity necessary to MRV actions according to the guidelines to be adopted by the COP.

6 Conclusions

Measuring, reporting and verification of GHG mitigation actions are key issues for the success of a post-2012 climate agreement. The design of a system for MRV is therefore of high importance. As of February 2010, many questions related to MRV are unanswered. This first of all includes which functions MRV is to fulfil, which may include building trust between Parties, assess the progress to the UNFCCC overall objective, give incentives for mitigation actions, enable matching of support and actions, and track support and actions. Another question relates to the level at which MRV can be done: international level, national and subnational. The design of an MRV system will depend on the outcomes of these questions.

In this report we focussed on the MRV of mitigation actions and of national GHG emissions. Currently, developed countries have to submit annually a national inventory of greenhouse gas emissions to the UNFCCC based on IPCC guidelines, For developing countries no such obligation exists, but it should be included in their national communications when these are provided. The Copenhagen Accord also asks for inventory reports to be included in national communications on a biannual basis for developing countries after 2012. From the analysis of available data sources for estimating GHG emissions for national sources it is concluded that for all significant emission sources and sinks all activity data and default emission factors are available, from which it can be demonstrated that national inventories can be compiled at a Tier 1 level and thereby are “MRV-able” as these inventories can be in accordance with good practice guidance, given national circumstances of limited resources. Moving towards higher methodological tiers may be helpful to improve the quality of the emission estimates in the future though, especially for key emission categories.

With regard to the estimation of net carbon storage in non-degraded (i.e. undisturbed) forests, degraded forests, forest plantations and in other wooded lands, it is concluded that the difficulty in application of the simple tier 1 method is in the determination of the so-called *fraction of biomass lost in disturbance*, which accounts for all carbon losses in degraded forests other than wood and fuelwood extraction. that an exception could be parts of the LUCF sector, in particular where default values and practical tier 1 guidance is missing for estimating the degree of degradation of forests, and possibly the estimation of forest sinks by growing forests. For estimating the carbon storage in forests (i.e. the sink), developing countries may utilise the analysis and estimates made by national teams that participate in the FAO’s Forest Resources Assessments that are made periodically.

In addition to monitoring GHG emissions on a national (or sectoral) level, MRV of individual actions could be helpful. In this fashion, matching of support and action in the framework of NAMAs could be facilitated by creating transparency and trust between donor and recipient. Measuring the impact of policies and measures needs appropriate metrics or indicators. We found that indicators focusing on different stages of the policy could be used: input, process, output and outcome indicators. For climate change mitigation, reduction in GHG emissions would be the most obvious choice for the outcome indicator. However, it may not always be possible to estimate this with reasonable certainty against acceptable cost. Therefore output indicators, e.g. kWh wind electricity produced, could be helpful. In addition inputs, such as financial resources or a norm, and process indicators that focus on whether the actual action is being taken, such as the auditing of buildings, can be used to MRV actions and track the progress towards implementation.

In order to provide an indication of the extent to which the GHG reduction of individual actions (i.e. the outcome indicator) can be estimated, we carried out an MRV-ability analysis for three case studies. This was based on six criteria including data and baseline availability and categorises types of actions (such as a renewable energy subsidy) into high, medium or low GHG MRV-ability. The actions have been taken from existing energy and climate action plans from developing countries, and therefore do not cover the full range of possible actions, but do cover all major sectors.

From the cases studies we conclude that the mitigation actions in the electricity sector are likely to have a 'high' MRV-ability, while the transport and buildings sector are more in the 'medium' range. The most important factors determining the quality level of MRV appear to be data availability, difficulty in establishing a credible baseline against which to determine the emission reductions, and emission factors. Also we find that there are many actions that may not be translatable into emission reductions, such as forest monitoring programmes, energy efficiency training programmes and audits. Those actions however may still be vital in achieving emission reductions, and could be MRV-ed by input and process indicators.

From three case study actions - biofuel blends in transport, lighting efficiency and feed-in tariffs for renewable energy - it appears that in developed countries measuring GHG reductions due to policies is carried out to a limited and varying extent. Monitoring of policies is done in most countries, however a baseline is often not explicitly considered. As total national emissions have to be reported this has not been an issue of international importance until now. For developing countries the CDM has developed an elaborate system of MRV of emission reductions of projects. Important lessons can be learnt from this, e.g. related to emission factors, determining baselines and attribution of impacts to policies. However this latter issue remains one of the key areas of uncertainty. NAMAs are likely to be more on the level of programmes or policies, and requirements for MRV might be different compared to CDM projects. An important question is the level of certainty with which we want to know the extent to which it is additional to business-as-usual.

References

Bouwman, A.F., Lee, D.S., Asman, W.A.H., Dentener, F.J., Van Der Hoek, K.W. and J.G.J. Olivier (1997). A Global High-Resolution Emission Inventory for Ammonia, *Global Biogeochemical Cycles*, 11:4, 561-587.

Breidenich, C., Bodansky, D. (2009) *Measurement, reporting and verification in a post 2012 climate agreement*, Pew Centre on Global Climate Change, April 2009

Neuhoff (ed., 2009). International support for domestic climate policies in developing countries. *Climate Policy* (9) 5, special issue October 2009, ISBN 9781844078721

CDIAC (2009) *Fossil-Fuel* CO_2 *Emissions*. Carbon Dioxide Information Analysis Center, internet: http://cdiac.ornl.gov/trends/emis/meth_reg.html

Cust, J. (2008) *Intermediate Indicators: Lessons for their Use in Measurement, Reporting and Effective Policy Implementation*, University of Cambridge, 2008

EEA (2005) *EEA Core set of indicators*, Guide, EEA Technical Report No 1/2005, ISSN 1725-2237

Ellis, J., Larsen, K. (2008) *Measurement, reporting and Verification of Actions and Commitments*, OECD, IEA 2008

Ellis, J., S. Moarif (2009) *GHG mitigation actions: MRV issues and options*, OECD, IEA 2009

Ellis, J., S. Moarif, J. Kim (2009). *Reporting and recording post-2012 GHG mitigation commitments, actions and support*. OECD/IEA, COM/ENV/EPOC/IEA/SLT(2009)4, Paris.

Energy Research Centre (2007) *Long Term Mitigation Scenarios: Technical Summary*, Department of Environment Affairs and Tourism, Pretoria, October 2007

FAO (1993, 1995, 1998, 2006). *Global forest resources assessment*. FAO, Rome. Report no. FP-112, 124, 147.

Fransen, T., McMahon, H., Nakhooda, S. (2008) *Measuring the way to a new global climate agreement*, WRI 2008

Geist, H.J. and E.F. Lambin (2002) Proximate Causes and Underlying Driving Forces of Tropical Deforestation. *Bioscience,* 52, 143-150.

Government of Brazil (2007) *Interministerial Committee on Climate Change, National Plan on Climate Change*, Executive Summary, Brasilia, December 2007

Governo Federal (2007) *Comite Interministerial sobre Mudanca do Clima, Plano Nacional sobre mudanca do clima*, Brasilia, December 2007

Hooijer, A., Silvius, M., Wösten, H. and Page, S. (2006). *PEAT-*CO_2*, Assessment of* CO_2 *emissions from drained peatlands in SE Asia.* Delft Hydraulics report Q3943. WL/Delft Hydraulics, Delft. Internet: http://www.wetlands.org/LinkClick.aspx?fileticket=NYQUDJl5zt8%3d&tabid=56

IPCC (1996). Revised 1996 *IPCC Guidelines for National Greenhouse Gas Inventories*. IPCC/OECD/ IEA, Paris.

IPCC (2000). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC-TSU NGGIP, Japan.

IPCC (2003). *Good Practice Guidance for Land Use, land-Use Change and Forestry*. Penman, J., Gytarsky, M., Hiraishi, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner, F. (Eds). Intergovernmental Panel on Climate Change (IPCC), IPCC/IGES, Hayama, Japan.

IPCC (2003b). *Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types*. Penman, J. et al. (Eds.) IPCC-TSU NGGIP, IGES, Japan.

IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Eggleston, S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (eds). IPCC-TSU NGGIP, IGES, Japan. Internet: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

JRC/PBL, 2009. Emission Database for Global Atmospheric Research (EDGAR), release version 4.0. European Commission, Joint Research Centre/Netherlands Environmental Assessment Agency. Internet: http://edgar.jrc.ec.europe.eu.

McMahon, 2009. *Enabling MRV in the post-2012 regime*. Presentation at UNFCCC parallel event, 29 September 2009.

McMahon, Hilary and Remi Moncel (2009). "*Keeping Track: National Positions and Design Elements of an MRV Framework*". WRI Working Paper, June 2009. http://www.wri.org/climate

Page, S.E., F. Siegert, J. O. Rieley et al. (2002). The amount of carbon released from peat and forest fires in Indonesia during 1997, *Nature*, 420, 61, doi:10.1038/nature01131

Schultz, M. G., A. Heil, J. J. Hoelzemann, A. Spessa, K. Thonicke, J. G. Goldammer, A. C. Held, J. M. C. Pereira, and M. van het Bolscher (2008). Global wildland fire emissions from 1960 to 2000, *Global Biogeochem. Cycles*, 22, GB2002, doi:10.1029/2007GB003031.

Smill, V. (1999). Nitrogen in crop production: an account of global flows. *Global Biochemical Cycles*, 13, 647-662.

UNEP/Risø, 2010. *UNEP Risoe CDM/JI Pipeline Analysis and Database*, February 1st 2010, available at www.cdmpipeline.org

UNFCCC (2008). *Developing performance indicators to monitor and evaluate the effectiveness of the implementation of the technology transfer framework*. Interim report by the Chair of the Expert Group on Technology Transfer. FCCC/SB/2008/INF.6, 14 November 2008.

UNFCCC (2009a) *Nationally appropriate mitigation actions by developing country Parties*. Non-paper by the facilitator. Non-paper No. 51. 6 November 2009.

UNFCCC (2009b), *Copenhagen Accord. Decision -/CP.15*. Advance unedited version, 18 December 2009.

UNFCCC, 2009c. *Sources and availability of GHG data for non-Annex I Parties*. Internet: http://unfccc.int/ghg_data/ghg_data_unfccc/data_sources/items/3816.php. Retrieved 31 July 2009

UNFCCC (2010a). *Clean development mechanism*, cdm.unfccc.int

UNFCCC (2010b) *Report of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention on its eighth session, held in Copenhagen from 7 to 15 December 2009*. Advance version. FCCC/AWGLCA/2009/17, 5 February 2010.

UNFCCC (2005). *Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention.* Note by the secretariat. FCCC/SBI/2005/18, 25 October 2005. Internet: http://unfccc.int/resource/docs/2005/sbi/eng/18.pdf

UNFCCC (2007a) *Bali Action Plan*, decision 1/CP.13, FCCC/CP/2007/6/Add.1.

UNFCCC (2007b) *Policies, measures, past and projected future greenhouse gas emission trends of Parties included in Annex I to the Convention. Compilation and synthesis of fourth national communications*. Note by the secretariat, Addendum. FCCC/SBI/2007/INF.6/Add.1, 23 November 2007. http://unfccc.int/resource/docs/2007/sbi/eng/inf06a01.pdf

UNFCCC (2003) *National communications of Parties included in Annex I to the Convention. Compilation and synthesis report on third national communications, Addendum. Policies and measures*. FCCC/SBI/2003/7/Add.2, 29 May 2003. http://unfccc.int/resource/docs/2003/sbi/07a02.pdf

Van der Werf, G. R., J. T. Randerson, L.Giglio, G. J. Collatz, P. S. Kasibhatla and A. F. Arellano, Jr. (2006). Interannual variability in global biomass burning emission from 1997 to 2004, *Atmos. Chem. Phys.,* 6, 3423–3441.

Van der Werf, G.R., J.T. Randerson, L. Giglio, G.J. Collatz, M. Mu, P.S. Kasibhatla, D.C. Morton, R.S. DeFries, Y. Yin and T.T. van Leeuwen (2010), Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997-2009). Internet: http://www.falw.vu/~gwerf/GFED/

Winkler, H. (2008) Measurable, reportable and verifiable: the keys to mitigation in the Copenhagen deal, *Climate Policy* (8) 2008, pp 534-547.

Yevich, R. and Logan, J. 2003. An assessment of biofuel use and burning of agricultural waste in the developing world. *Global biogeochemical cycles*, 17(4), 1095, doi:10.1029/2002GB001952.

Annex A. MRV aspects of GHG inventories

This annex examines how GHG inventories for developing countries can be developed. It starts with listing general issues, and then gives a more detailed analysis by sectors, with specific attention for forestry. Finally it gives recommendations for data collection in order to improve inventories.

A.1 General issues for developing countries

Developing countries can be characterised by the following aspects, which determine availability of statistics to be used as activity data, institutional capacity for developing, documenting, updating and improving the GHG inventory:

- Size (population, GDP, or area) - the relative complexity of industrial activities and climate regimes often increases with size, which could require a more detailed assessment of sector 2 sources (industrial processes) and a climate-weighted approach of emission factors such as CH_4 from animal waste and of landfills (k-values); their institutional capacity for inventory compilations will generally increase with increasing population or GDP.
- Very small countries may have difficulty getting required statistics or complete time series for major sources such as fuel combustion and agricultural activities. Also their institutional capacity for inventory compilation may be very limited.
- LULUCF emissions, which are difficult to monitor accurately, often are an important fraction of total national GHG emissions.
- Countries may consider existing statistics for their countries as being very uncertain. However, that does not prohibit using them for compiling their national GHG inventory. The result will show which the key sources are for which improvement will be most beneficial in enhancing the overall inventory quality. Moreover, uncertainties may be roughly estimated and used to prioritise resources for inventory improvement, if available or can be made available with additional funding.
- For countries with limited capacity it may be difficult to assess completeness of their inventory. This is particularly applicable to the Industrial Processes sector with its many sources that it potentially comprises. However, checking sources included in other existing global inventories, such as EDGAR 4.0, and other global mineral statistics, such as from the U.S. and British Geological Survey, may be an efficient way of checking the existence in a particular country.

Institutional and capacity limitations may affect the capability of non-Annex I countries to produce, document, update and improve a national GHG inventory. Institutional problems may relate to the existence and accessibility of national statistics required as activity data for emission calculations. However, in many cases production or consumption statistics may be available or estimated by international statistical organisations such as UN, IEA, FAO, UNEP, USGS, British Geological Survey. In addition, production capacity data is often available from (inter)national industry or trade organisations. It should be noted that this does not only apply to non-Annex I countries: also Annex I countries such as the USA or the Netherlands may use these data sources for parts of their inventories, in particular for industrial production processes.

A.2 Availability of international data sources

When using the 2006 IPCC guidelines for national emission inventories, in many cases national production or consumption statistics are required as activity data, and default emission factors are provided by the guidelines, in case country-specific factors are not available. When required national statistics are not available or incomplete, the guidelines often suggest to use international statistics collected from the countries (e.g. by UN, IEA or FAO) or international industry organisations that cover most or all countries. Below, we will review, by IPCC sector, the availability of international data sources and the quality of default emission factors when used for compiling emission estimates in cases where country-specific data are not available.

We will highlight for which of the likely key categories the use of more country-specific information is recommended, if possible. For this discussion we use the standard sector grouping of sources as recommended in the 1996 IPCC guidelines for national GHG inventories, each of which is comprised of several source categories, which often have some common characteristics.

A.2.1 Energy: 1A. Fuel combustion

IEA statistics for fuel consumption per economic sector are available for 138 of the 192 UN countries. However, when combining the three IEA “other” regional totals e.g. with energy statistics published by the EIA, for all UN countries sectoral energy statistics are available except for ten very small states. For six of these ten, UN energy consumption data are available (as are their CO_2 emissions per major fuel type (CDIAC, 2009): Marshall Islands, Nauru, Palau, Timor-Leste, Tonga and Tuvalu). This leaves four very small European states: Andorra, Liechtenstein, Monaco and San Marino without energy statistics available through international bodies. Since Liechtenstein and Monaco are Annex I countries, which are submitting inventories under the UNFCCC, this then leaves Andorra and San Marino as two very small UN states (468 and 612 km^2) for which no international sources of energy statistics are available. Thus it can be concluded that for almost all UN countries energy statistics are available though international agencies such as IEA and the UN. Most of these statistics originate from the countries themselves, but have been checked for consistency by these statistics collecting organisations. Although it can be questioned how accurate the data are, especially for biofuels, activity data are generally available for making estimates of GHG emissions. The fact that biofuel production and consumption data are rather uncertain does not directly affect the GHG emissions from the Energy sector, since the associated CO_2 emissions are not accounted for in that sector. Rather, the fraction of biofuels produced unsustainably will affect the net carbon losses in the LULUCF sector.

Emission factors for fuel combustion can be taken from the defaults provided by the IPCC guidelines. Only for the CO_2 emission factors it may be recommended to try to establish country-specific emission factors for the mostly used fuels (e.g. petrol, diesel, natural gas and coal), if resources are available. In particular the emission factor for coal and natural gas can differ substantially between countries. A limited number of fuel composition and heating value measurements of the key fuels could already provide country-specific emission factors.

A.2.2 Energy: 1B. Fugitive emissions from fuels

Statistics for fuel production are also available for the same countries as discussed above. For coal production a distinction is made between hard coal and brown coal and between underground and surface mining and the average depth of coal mined. Information on the latter is not available in international statistics, but need to be sought from specific publications or from the coal producers. Activity data for fuel transport and distribution statistics can also be extracted from the energy balances provided. A more difficult subject is the amount of natural gas vented and flared. Here international statistics provided by CDIAC or IEA are available. However, more accurate data - also on the shares of venting and flaring - may be available from the oil and gas companies that exploit production sites in the country. This also applies to oil refineries, which may provide data on unused refinery gas that is flared. Other sources are carbon losses from coke production, which can be calculated from the energy statistics.

Emission factors for CO_2 and CH_4 in this sector can be taken from default values in the IPCC guidelines. However, for CH_4 the uncertainties when using a tier 1 method for oil and gas transmission are very large. When this is a key category in a country, information from the oil and gas companies about e.g. length of pipelines and fraction of associated gas flared will improve the emission estimates. For underground coal production, one needs to know if methane is being recovered (and used or flared), as this is to be subtracted from the methane emissions calculated. This information should be checked and collected from the companies, if applicable. Detailed data on this may also be available if emission reductions are achieved through CDM or JI projects.

A.2.3 Industrial Processes (including Product Use)

This sector may consist of very many sources. However, often only a limited number of them are key categories such as cement and lime production and the production of chemicals such as ammonia, nitric acid, adipic acid or HCFC-22 (HFC-23), and aluminium production (PFCs). Urea production may include a process where CO_2 generated from ammonia production may be stored in the product. Also iron and steel production using metallurgical coke in a blast furnace as reductant, when applicable, is a major source of CO_2 emissions (for which fuel inputs and outputs from the energy statistics are the activity data). Major other sources of F-gas emissions are found in magnesium foundries (SF_6), manufacturers and users of electrical switchgear (SF6), manufacturers of semiconductor, flat panel displays and PV cells (PFCs, SF_6) and various HFC uses, of which HFC-134a is the mostly used one (for refrigeration and air conditioning, also in cars).

Activity data for most of the production processes mentioned above (except for F-gas usage) can be found in international statistics such as the UN Industrial Commodity Statistics, U.S. and British Geological Survey, FAO, and the UNEP Ozone Secretariat. However, some of them such as production of lime, nitric acid and HCFC-22 may not provide total production statistics including so-called captive production (i.e. amounts produced that are used by the company and not sold). So for completeness it is recommended to check that with the manufacturers.

The amounts of fuel used in iron and steel production as reductant in the blast furnace are usually included in the national energy statistics. However for estimating CO_2 emissions per ton crude steel produced from the non-fossil fuel carbon (e.g. limestone and dolomite) added in the blast furnace no default IPCC emission factors are available. However, from the technical literature or from data from reporting Annex I countries an estimate of these factors can be made (as was done for the EDGAR 4 dataset compilation).

For the industrial users of F-gases, often national industry associations exist, which may be able to provide the activity data required to estimate the emissions or to provide the F-gas emissions estimated by the companies themselves. Also for PFCs from aluminium production, additional information is required from the companies on the type of process used. If they take part in the International Aluminium Institute's international annual survey of PFC emissions, they will also be able to provide tier 2 PFC emissions calculations.

For other uses of F-gases country-specific data may be more difficult to find. However, in most cases these sources will often be only be a very small fraction of total national GHG emissions. A check of the order of magnitude of these emissions can be found by checking the EDGAR 4.0 estimates for emissions from F-gas uses (these were made using reports on regional emissions and a proxy to distribute these over individual countries within a region). This data source can also provide a completeness check of the existence of other production processes in this sector.

For all sources the IPCC guidelines provide default emissions factors. However, if a particular source is identified as a key source, it would be good practice to check for more plant-specific information if resources are available. This would be, firstly cement production, then ammonia production (using clinker production and gas consumption is suitable method to estimate CO_2 emissions), and next nitric and adipic acid production (plant-specific N_2O emission factors). This information should be checked and collected from the companies. Detailed data on this may also be available if emission reductions are achieved through CDM or JI projects.

Summarising, for this very diverse sector, for most production processes international statistics are available, although for some of them plant-specific information will further improve the emission estimates (using cement clinker production, inclusion of captive production, and some plant-specific emission factors for N_2O).

A.2.4 Agriculture (including savannah burning)

Most statistics required for this source sector are available from FAO (FAOSTAT). Livestock numbers are available from FAO. They can be used to calculate methane emissions from enteric fermentation and to calculate the total amount of animal waste generated. Also statistics for harvested rice areas, the consumption of nitrogen fertilisers and the amounts of various crops produced are available from FAO. The fractions of ecosystem types for rice cultivation are available from International Rice Research Institute and urea consumption statistics from the International Fertilizer Association.

The *total amount* of crop residues can be calculated from the amount of crops produced and IPCC default factors. However, for the *fraction* of crop residues burned in the field no IPCC default values are available. If country-specific data on the fraction burned are not available, fractions reported in the scientific literature may be used, such as Yevich and Logan (2003) or Smill (1999).

If no country-specific information is available on the feed-intake of the larges livestock types (e.g. cattle, buffalo, sheep), the fractions of manure management and crop residues, IPCC default values can be used to calculate the CH_4 and N_2O emissions. Where data on the climate zones per country are required for determining the emission factors, this may be obtained from auxiliary datasets e.g. provided with EDGAR datasets. For rice cultivation, depending of the level of information available more or less aggregated IPCC scaling factors for different water regimes and adjusted scaling factors for organic amendments can be applied. If rice cultivation is a key category, if resources allow, the inventory agency may assess the options for using a more detailed method for estimating CH_4 emissions from rice production.

FAO reports whether their international statistics are data reported by the country or estimated by FAO. For example, for cattle and sheep numbers for 2000-2005, FAO reports statistics for 2008 and 190 countries. In both cases, for about 60% of the countries reported data were used, about 23% of the countries only estimated data and the remainder was a mixture for different years. It should be stressed that even if the data has been estimated by FAO, it can be used for a first estimate of the source category. If it would appear to be a key category and resources allow, the inventory agency could try to collect more country-specific data.

Summarising, for this sector, for most activity data international statistics are available, although some of them may be estimates by the international statistical agency (FAO). For the fraction of crop residues burned in the field are no regional default data available. However, since this is in general only a small source of agricultural CH_4 and N_2O emissions, default fractions from the literature could be used when country-specific information is not readily available. For rice producing countries that may be one of the largest agricultural sources. Determining the best applicable emission factor will be key in improving the GHG emissions estimate of this sector. However, inventory agencies should be aware that some statistics may be underestimated in countries where incentives exist for farmers to report low areas used or low production figures. In addition, for key activity data such as areas of rice harvested the inventory compiler may check whether this effect is a significant amount and a correction is warranted.

A.2.5 Land Use Change and Forestry: large-scale biomass burning and decay of remaining biomass and REDD

Estimating emissions from this sector is a difficult task, in particular when an overall carbon balance calculation is made that requires the estimation of all changes in so-called carbon pools of biomass, including carbon storage in aboveground and underground biomass. The IPCC has produced more and more expanding guidelines on this sector (IPCC, 1996, 2001, 2006), which are even for OECD countries difficult to apply.

However, the estimation of actual emissions from burning of forests and other wooded lands and of post-burn emissions from decay of aboveground biomass that remains after burning or logging is less complex, albeit surrounded with rather large uncertainties. Therefore, in this

section we only explore the data sources for countries to estimate their GHG emissions from large-scale biomass burning and CO_2 and N_2O from post-burn decay. Estimating carbon *sinks* from afforestation and growing of existing stocks (i.e. biomass growth in maturing forests) is briefly discussed in section A.3 on REDD.
For estimating the amounts of biomass burned in large-scale fires the following key parameters have to be multiplied:

- area burned
- aboveground biomass density (kg/ha)
- fraction of aboveground biomass burned

The first can be estimated using either bottom-up statistics or top-down estimates from satellite observations. For the other two parameters, the values use should be not reflect the country-specific average per vegetation type but preferably also the actual areas burned. All three variables are subject to considerable uncertainty, so the resulting activity data - total amount of biomass burned - has also a high uncertainty (of the order of 50%).

The FAO has a long tradition of publishing decadal or 5-year average data on the change in forest area per country in their global forest resources assessments. Although these data are often criticized in the scientific literature for inconsistencies between definitions applied in different countries and between reports, they are often used as reference data on deforestation trends and associated CO2 emissions. These data can be used as proxy for the average area of forest fires in a particular country (neglecting the area deforested by logging without prior or subsequent fires).

Another option is to use products from satellite data that observed large-scale biomass burning. Various satellites observe biomass burning and many products of them have been published in scientific papers (for an overview e.g. see Van der Werf et al., 2006; Schulz et al., 2008). These two papers also provide datasets with longer time series: GFEDv2.1 (for 1998-2004; recently extended to 2009 using the GFED 3.1 model) (Van der Werf et al., 2010) and RETRO (for 1960-2000), respectively. Many of these datasets, however, do not produce readily available data at country level but produce gridded datasets, e.g. at 1x1 degree resolution. However, aggregated data with amounts burned at country level have been compiled by different organisations. For example the EDGAR 4.0 country-specific data for biomass burning are based on the gridded data of GFEDv2.1 and extrapolated before 1997 using the RETRO dataset; these data are available at country level for the years 1970-2005 (see Table A.1 for the ten non-Annex I countries with highest total GHG emissions which Forest emissions comprise more than 50% of the national total).

For estimating GHG emissions from these forest fires default IPCC emission factors for CO2, CH4 and N2O can be used (including default values of the carbon content of aboveground biomass per type).

Table A.1 Non-Annex I Parties for which the share of forests in total emissions is more than 50% (including peat soils) (source: EDGAR 4.0)

Party	Share of forests in 2005 [%]
Angola	93
Bolivia	87
Brazil	65
Central African Republic	78
Congo, Democratic Republic of	95
Cote d'Ivoire	90
Indonesia	58
Myanmar	82
Tanzania	60
Zambia	80

According to global budget studies, CO_2 from large-scale biomass burning is only one component of emissions from forests. Roughly about half of the aboveground biomass is not burned, but it decomposes over time, thus resulting in delayed decay emissions of approximately the same over of magnitude as the direct emissions from the fires but distributed over a period of 10 to 20 years. Having estimated direct burning emissions, from the same data, also the post-burn CO_2 emissions can be estimated. Moreover, it was shown that enhanced N_2O emissions exist after large-scale tropical biomass burning (Bouwman *et al.,* 1997) and these can be calculated from the same dataset too.

Another source of CO_2 emissions that has been quite recently identified as significant are peat fires and decomposition of organic carbon in drained peat soils (Page *et al*., 2002; Hooijer *et al*., 2006). Peat fire emissions are already included in satellite products such as the Global Fire Emission Database (GFED; Van der Werf *et al.,* 2006, 2010), which provide estimates of the extent of large-scale biomass burning based on satellite observation of areas burned by fires with a high spatial resolution and estimates of the local biomass density and fraction burned, but are generally not included in estimates using FAO deforestation data. In addition, a separate estimate needs to be made for CO_2 from decomposition from drained peatlands. Although this phenomena is highlighted in the literature for Indonesia, also in other non-Annex I as well as in a number of Annex I countries this occurs with associated CO_2 emissions that should be accounted for as anthropogenic emissions.

Summarising, for the forestry sector - that comprises roughly about a quarter of total national emissions for the largest non-Annex I countries and that is for about 24 non-Annex I countries the largest sector - it is possible to estimate direct and post-burn emissions at national scale using readily available data. However, bottom-up and top-down studies provide different types of data: multi-year averaged or single year data aggregated from grid cell values within a country. When country-specific data on the amounts burned per year are lacking, countries may choose on type and use the other for estimating the possible or apparent uncertainty in the activity data. When using bottom-up statistics, special attention is required for checking the occurrence of drained peat soils, for which CO_2 emissions should be estimated if applicable (in satellite products such as GFED, peat fires are included, which can be used as proxy for the drained peat soil area).

One element not yet discussed is the estimation of net carbon storage due to biomass growth in non-degraded (i.e. undisturbed) forests, forest plantations, in degraded forests and in other wooded lands, which should be part of the LULUCF (CRF sector 5) reporting. This is discussed separately in Section A.3.

A.2.6 Waste (including wastewater)

The amounts of Municipal Sold Waste (MSW) that are generated are the primary statistics for emissions from landfills. The 2006 IPCC guidelines provide for many but not all countries country-specific data for 2000 of the amount of MSW generated per year per capita (urban capita in case of non-Annex I countries) and the fraction landfilled and incinerated. For other countries regional defaults are provided. In addition, UN statistics on MSW treatment may provide country-specific data for some other years than 2000. If country-specific data for MSW generation/cap for other years are not available, they may be estimated using a fit of the data for 2000 to GDP/cap. Based on regional defaults for the composition of MSW, the IPCC guidelines provide regional defaults for the fraction Degradable Organic Carbon (DOC). In addition, regional defaults for the Methane Conversion Factor and the k-value used in the First Order Decay (FOD) model for calculation of methane emissions from landfills are provided. If country-specific MSW composition data are available, also country-specific a MSW weighted k-value can be calculated and used. The IPCC guidelines provide an Excel spreadsheet model for calculating emissions using the FOD model, including an estimation method for MSW landfilled up to 40 years ago.

For landfills, one needs to know if methane is being recovered (and used or flared), as this is to be subtracted from the gross methane emissions calculated. This information should be checked and collected from the landfill managing companies, if applicable. Detailed data on this may also be available if emission reductions are achieved through CDM or JI projects.

For domestic wastewater, total organics in wastewater (BOD_5) can be estimated using regional default or country-specific default values for BOD_5 generation per capita per day provided by the IPCC guidelines. For industrial wastewater, total organically degradable material in wastewater from industry can be calculated per type of industry from waste water generation per ton of product and COD values (chemical oxygen demand) of industrial degradable organics concentration in wastewater) in kg/m^3 wastewater, for which the IPCC guidelines provide defaults. Production statistics for industry types that produce most organics in wastewater are available from UN Industrial Commodity Statistics. Examples are meat and poultry, raw sugar, alcohol, pulp and organic chemicals. To estimate methane emissions from domestic wastewater, additional information is required on the waste water treatment systems, such as sewer (to wastewater treatment plants (WWTP) or to raw discharge), latrines by type, open pits and septic tanks. IPCC guidelines provide regional or country-specific default fractions for 2000. The inventory agency should use expert judgement on the fraction of WWTPs that are overloaded. Country-specific fractions of improved sanitation over time can be found for in the UN Water Supply and Sanitation (WSS) dataset. For industrial methane emissions, fractions on-site treatment in WWTP, sewer with and without city-WWTP, and raw discharge need to be estimated. Lacking country-specific information, regional values reported by Doorn *et al.* (1997) may be used.

To calculation methane emissions from wastewater, the IPCC guidelines provide default factors are provided per type of wastewater treatment, using default methane correction factors per type of treatment. In WWTPs part of the methane may be recovered (and either used as biogas or flared), as this is to be subtracted from the gross methane emissions calculated. This information should be checked and collected from the companies, if applicable. Detailed data on this may also be available if emission reductions are achieved through CDM or JI projects.

For estimating N_2O emissions from wastewater, the activity data required is total annual amount of nitrogen in the wastewater. This can be calculated from annual protein consumption per capita reported by FAO and correction factors for non-consumed protein and for the fraction of industrial and commercial protein that is co-discharged. For the correction factors and the N_2O emission factor defaults are provided in the IPCC guidelines.

A.3 Reduced Emissions from Deforestation and Degradation (REDD)

Until now, we have only discussed emissions related to large-scale biomass burning including post-burn emissions. This means that *net sinks* from *biomass growth* in existing *natural forests* and *forest plantations* and net *emissions* from forest *degradation*, were not considered. Including these activities in the national GHG inventory, however, is important for completeness and for the international discussions on '*Reduced Emissions from Deforestation and Degradation'* (REDD). Important factors contributing to degradation of forests include[18]

- Selective logging
- Fuelwood collection
- Road or railroad construction
- Settlement extension
- Soil disturbances
- Oil and gas exploration and exploitation
- Mining
- Fragmentation by anthropogenic disturbance mentioned above.

[18] See IPCC (2003b) for more examples of anthropogenic disturbances.

The 2006 IPCC guidelines provide a tier 1 method for estimating net emissions or sinks from *natural forests and forest plantations*, for which activity data are readily available from FAO statistics (forested areas and extraction of roundwood and fuelwood). Regional default factors for aboveground biomass growth per ha per ecological zone (type of forest) are provided in the IPCC guidelines. Although good practice guidance recommends using a higher tier method for key categories, estimations of this national source/sink strength ultimately will remain very uncertain regardless of the efforts put into reducing them. This conclusion may not be applicable at a very local scale, for which much more detailed assessment could be made resulting in more accurate net emission estimates. However, if REDD is to be effective, it should comprise monitoring emissions at country-level to avoid that mitigation efforts in one area that is monitored result in a shifting of activities to other, nearby areas that are not monitored.

Whether there is a need to include the "other wooded land" in these assessments will depend on the size of their net contribution compared to the net emissions from forests and the relevance for domestic policy on environmental, energy and social issues.
It is difficult to assess net emissions from non-pristine forests, because it is difficult to make a clear distinction between non-degraded (natural) and degraded forests, but also because not all wood extraction (roundwood and fuelwood) originates from forest trees but will in part also come from "other wooded land". Moreover, small scale fires in degraded forests will not be included neither in satellite datasets nor in FAO deforestation statistics. However, including estimates for these types of degradation - which do not occur only in tropical countries - would not only expand the LULUCF estimates to a more complete estimate of gross and net emissions. It also highlights that a larger reduction can be achieved than when only deforestation of non-degraded tropical forest is included in the estimates: not only by mitigating emissions from degraded forests, but also because reducing degradation may prevent net emissions in dryer open areas in or along borders of rainforests that are prone to fires. This also applies to drained peat soils, which are not only sources through decomposition but also are more prone to new fires.

A good operational definition to distinguish degraded from non-degraded forests and a simple and transparent accounting scheme for estimating all significant CO_2 emissions and carbon storage terms of these two forest types may be key to arrive at an successful agreement on REDD, which is "MRV proof" but focuses on mitigation activities rather than administrative accounting activities. Recognising the cause of the underlying uncertainties that are inherent to the activity data, that can never be reduced cost-effectively at country level, should provide clear guidance on the level of detail that is sufficient for estimating total net emissions or sinks from the LULUCF sector.

For degraded forests IPCC (2003b) has identified several options to define and identify them, but the report concludes that this is not easy to define them in a measurable and quantifiable way. In the 2006 IPCC guidelines for national GHG inventories this issue was "solved" by introducing a parameter *fd* (in Equation 2.14) called the *fraction of biomass lost in disturbance*, which is defined as the proportion of biomass that is lost from the biomass pool. For example a stand-replacing disturbance will kill all (*fd* = 1) biomass while an insect disturbance may only remove a portion (e.g. *fd* = 0.3) of the average biomass C density. However, this has only redefined the issue into the question how to determine this value. The guidelines say that it is good practice, if possible, to develop and use a disturbance matrix for each biomass, dead organic matter and soil carbon pool, even under tier 1, from which this factor could be deduced. However, default values and practical tier 1 guidance for estimating the degree of degradation is missing in the 2006 IPCC guidelines (IPCC, 2006).

For estimating the carbon storage in forests (i.e. the sink), developing countries may utilise the analyses and estimates made by national teams that participate in the FAO's Forest Resources Assessments (FRA), that are published periodically (FAO, 1993, 1005, 1998, 2006).

We note that both for Annex I countries for which this is a very small non-key category and for non-Annex I countries for which it may be a key category but that may lack resources for using, reporting and documenting a higher tier method, a simple though un-biased and transparent method for making the tier 1 calculations is warranted, in particular for inventory agencies with limited resources. In view of the present IPCC AFOLU guidelines that are very complex and lengthy, these guidelines should be summarised in a transparent accounting scheme for the main LULUCF categories, in particular for net CO_2 emissions or sinks from 'forests remaining forests', that should be covered in a tier 1 approach, which can applied by any inventory agency, also those with very limited resources. These concise summary guidelines should also provide guidance on the determination of the so-called *fraction of biomass lost in disturbance*, which accounts for all carbon losses in degraded forests other than wood and fuelwood extraction. At the same time such a scheme needs to be sensitive to observe that impact of mitigation actions that can be implemented as REDD policy.

Summarising, distinguishing non-degraded and degraded forests (including drained peat soils) and a simple and straightforward tier 1 scheme for making a non-biased estimate of net emissions or sinks from LULUCF that reflects the inherent uncertainty in the data is needed. This should include concrete guidance on the determination of the so-called *fraction of biomass lost in disturbance*, which accounts for all carbon losses in degraded forests other than wood and fuelwood extraction. For future REDD policies to be working, there is a need for estimating in a simple, transparent way also this part of the national GHG *emissions* and *sinks* inventory. This will be pivotal for engaging non Annex I countries, which have limited resources for monitoring activities and will need to focus on mitigation activities rather than meticulously accounting net LULUCF emissions.

A.4 Improving national inventories

When looking at the data sources required for estimating national GHG *emissions*, we can conclude that virtually all activity data (except for some small sources such as consumption of F-gases per application) - if needed from international data sources - and default emission factors are available to compile the emissions of all significant sources of a national inventory. This also applies to additional information that is required, which is accessible from specific data sources. Most activity data are available from international statistics, also for biomass burning and post-burn emissions. In addition default GHG emission factors are available from IPCC guidelines for GHG inventories (although these may be rather *uncertain* for some sources).

A limited number of sources and sinks require more detailed activity data to estimate the emissions or carbon storage, the most important being:

- hard coal production by average mining depth *(several countries)*
- cement clinker production (when clinker import or export is significant) (*several countries)*
- primary aluminium production by process type *(several countries)*
- rice cultivation by ecosystem type (*most countries)*
- fraction of crop residues that are burned in the field (*most countries)*
- area of deforestation, degraded forests (*most countries)* and drained peatlands *(several countries)*
- contribution of factors leading to the estimate of the degree of degradation of forests (*most countries)*
- fractions of municipal solid waste (MSW) generated that is landfilled and that is incinerated (*most countries)*
- fraction of urban and industrial wastewater that is treated in a wastewater treatment system (*most countries).*

Between brackets is indicated whether these sources exists in most (or all) countries or only in a limited number of them. In many cases international organisations also compiled this type of data for a number of years or the IPCC inventory guidelines provide default values.

Since all inventory agencies have limited resources, improvements should be prioritised to the largest sources with relatively uncertain emissions. An estimate of the uncertainty in emissions can be made using the default values for activity data and emission factors provided in the 2006 IPCC guidelines. In case some activity data available and used are highly uncertain, they may still be used to estimate the emissions of a particular source, albeit with a high uncertainty. The same holds for the use of default IPCC emission factors. But one needs to distinguish the fact that emissions *can* be calculated ('measured') from the *accuracy* of the measurement. The IPCC good practice guidance follows this principle and provides guidance on how the uncertainty of emission estimates could be reduced, when resources are available for the inventory agency.

Improvements in the emissions inventory can be made by:

- changing to a higher tier method, i.e. a more detailed method, as suggested by the methodological *decision trees* provided in the 2006 IPCC guidelines for all source categories. This often requires more detailed information on the sources and more time to evaluate, use and document them for the emission inventory;
- changing to more country-specific emission factors instead of using IPCC default values. This requires the results of studies to determine source-specific, country-specific values, for which knowledge on the homogeneity and variability of the national sources is required and/or on the comparability with sources of other, similar countries.

Areas where higher tier methods or country-specific emission factors instead of default IPCC factors will increase the inventory quality are:

(a) *CO_2 emission factors for fuel combustion (1A).* Natural gas, coal, petrol and diesel in road transport are often used and in large amounts and therefore cover a large fraction of national GHG emissions. It is known that carbon contents of gas and coal can vary significantly, depending on where it is produced. Also Annex I reporting of petrol emission factors shows a considerable spread in values and a tendency to depart from the IPCC default values (see examples provided in Table A.2). As we can see, determining a country-specific value for these fuels may improve the accuracy in this part of the inventory. In particular for natural gas and for diesel in road transport the IPCC defaults, although still within the estimated uncertainties, seem to be somewhat biased to the low side (by 4 and 2.5%). For coal this conclusion cannot be drawn from the table since the values reported by Annex I countries refer to total "solid fuel", which may include not only coal, but also coal-derived gases such as coke oven gas and blast furnace gas as well as brown coal.

(b) *CH_4 emission factors for animals (4A) and rice production (4C)* may be improved compared to (region-specific) default values by using higher tier methods to determine these values. This is particularly relevant if the productivity (e.g. meat or milk production per animal) changes significantly over time or when the national circumstances result in different values of parameters that have been used to calculate regional default IPCC emission factor values in the 2006 IPCC guidelines[19].

(c) *CH_4 from landfills and wastewater (6A and 6B).* More up-to-date country-specific information or estimates, such as of the amounts of MSW generated and the fraction landfilled, the waste composition and the Degradable Organic Carbon fraction, and their change over time, will improve the accuracy of the emission estimates.

(d) *CO_2 from large-scale biomass burning and deforestation and sinks from biomass growth (5)* The uncertainty of this category could be reduced by using more detailed information. However due to the limited accuracy of the key parameters for the emissions and sinks calculation due to the variability in biomass types, their spatial distribution and the inherently limited knowledge of the extent of logging, burning and other forest degradation, will in general prevent making a quite accurate estimate of emissions and sinks. However, in case this source category is one of the largest key categories, more capacity to perform a more detailed assessment of changes over time will improve the emissions/sink estimates, albeit still rather uncertain.

[19] Note that the uncertainty of indirect N_2O emissions from agriculture cannot be reduced due to the largely inherent uncertainty of this source category

Table A.2 Variability in CO_2 factors from fuel combustion reported by Annex I countries and comparison with IPCC default values in the 2006 guidelines. Unit: kg/GJ (LHV). Uncertainties expressed as 2 standard deviations (SD). (source: UNFCCC, 2009c)

Fuel type	Sector	IPCC default EF	Unc. [%]	Unc. (low)	Unc. (high)	Average EF reported	Stand. dev. reported	Unc. (low)	Unc. (high)	Dif-ference	Dif-ference
coal	residential sector	**98.3**	**3.3**	94.6	101.0	**96.6**	**6.6%**	83.9	109.3	**-1.7**	-1.7%
coal	power generation a) b)	**94.6**	**5.4**	89.5	99.7	**99.0**	**8.1%**	82.9	115.1	**4.4**	4.7%
coal	industry a) c)	**94.6**	**7.2**	87.3	101.0	**99.5**	**22.9%**	53.9	145.1	**4.9**	5.2%
natural gas	all sectors	**56.1**	**3.6**	54.3	58.3	**58.4**	**19.0%**	36.2	80.6	**2.3**	4.1%
petrol	road transport	**69.3**	**4.0**	67.5	73.0	**71.0**	**2.6%**	67.3	74.7	**1.7**	2.5%
diesel	road transport	**74.1**	**1.5**	72.6	74.8	**73.5**	**0.8%**	72.3	74.7	**-0.6**	-0.8%

a) Less reliable for hard coal, since coal-derived gases such as coke oven gas and blast furnace gas as well as brown coal can be included here (Annex I countries refer to "solid fuel"). This is much less so for the residential sector.
b) For IPCC default value for other bituminous coal was used.
c) For IPCC default value for coking coal was used.

In summary, for the following sources emission factors may require a more detailed assessment if they are a key category, if possible (applicable to most countries except where indicated otherwise):

- CO_2 from combustion of hard coal and natural gas (*most countries)* and of petrol and diesel in road transport *(many countries)*
- methane from gas transmission (pipeline) *(several countries)* and from gas distribution *(many countries)*
- methane from oil transmission (pipeline) *(several countries)*
- methane recovery from coal mining *(several countries)*, landfills *(most countries)* and wastewater treatment plants
- plant-specific data on abatement notably for HCFC-22 manufacture and N_2O from adipic acid and nitric acid production *(several countries)*
- HFC from HFC consumption and SF_6 from GIS equipment manufacture and use *(several countries)*
- fractions of three flooding subcategories of water regimes in rice cultivation *(several countries)*
- the fraction of biomass lost in disturbance of degraded forests *(most countries)*
- the biomass growth rate in existing forests *(most countries)*
- the DOC fraction of municipal solid waste (MSW) landfilled over time *(most countries)*
- methane from domestic and industrial wastewater treatment systems *(most countries)*

For the first two items CDM- or JI-projects may be defined that can provide this information; the latter activity may be included in future national REDD projects. For national inventory agencies to be able to produce, maintain and improve their national GHG inventory, requires a certain minimum capacity and knowledge of the main sources: fuel production and use, industrial processes, agriculture, deforestation and forest fires, and waste and waste water. A minimum of core staff is required to make these sectoral estimates, to report the inventory , to define how to overall prioritise improvements and to discuss the role and needs for monitoring of emissions for the environmental policy-making process. It will depend on the size and structure of a country how this activity could be defined most efficiently, taking into account national circumstances and policy priorities.

These activities could require additional resources, also for capacity building and for inventory agency staff for participating in UNFCCC inventory review process. If GHG inventories by many non-Annex I countries are also to included in the UNFCCC review process, a modification of the present system of annual reviews of all Parties to a more optimised and focussed system will be indispensable, also for Annex I Parties, in order to have an efficient use of resources (e.g. review frequency and depth depending on national and sectoral emissions levels).

Annex B. Methodology to determine the level of MRV-ability

For the MRV-ability of actions two types of MRV-ability were established:
- GHG MRV-ability
- Non-GHG MRV-ability, i.e. by other indicators than emission reduction

According to the criteria defined in section 4.2 the level of GHG and non-GHG MRV-ability (high, medium or low) can be established by following the methodology proposed in the schemes below.

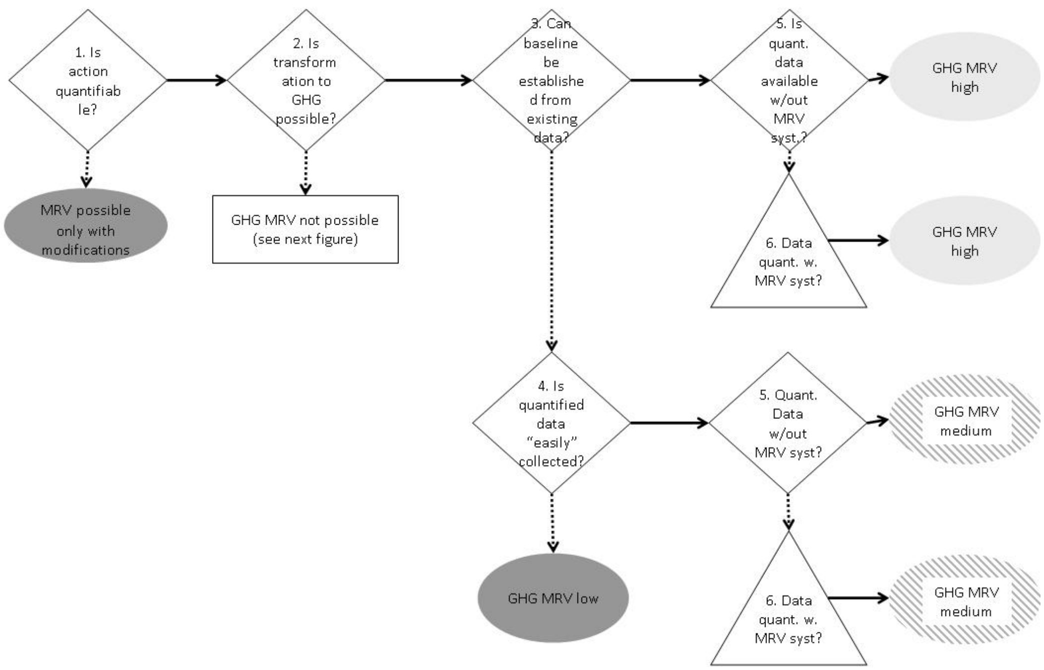

Figure B.1 Scheme to determine level of MRV-ability (line arrow=yes: dotted arrow=no)

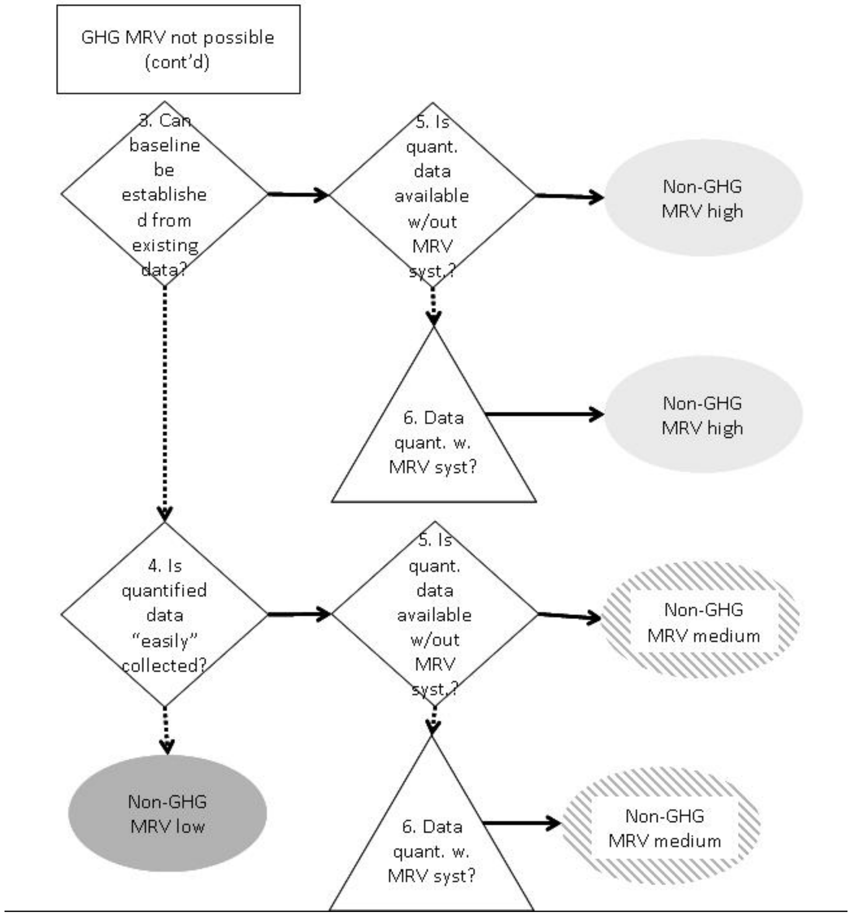

Figure B.2 Scheme to determine level of MRV-ability of actions not quantifiable with GHG emissions reduced or avoided (line arrow=yes: dotted arrow=no)

Following the schemes it can be established that an action has high (GHG and/or non-GHG) MRV-ability if:

- All criteria are positive
- All criteria are positive, but quantified data would not be collected if MRV system was not in place

An action has medium MRV-ability if:

- No baseline is available, but the information for the baseline is available, with or without an MRV system in place

An action has low MRV-ability if:

- No baseline information is available

Annex C. MRV-ability analysis of selected policies

Table C.1 Analysis of selected policies following the established criteria

	1. Metric	2. Transformation into GHG emis?	3. - Can a baseline be established from existing data?	4. - Is quantified data "easily" collected?	5. Quantified data without MRV system?	6. Quantified data with MRV system?	GHG MRV-ability	non-GHG MRV-ability
Building sector								
Building codes	n/a	no	no	no	no	yes	low	low
Energy Audits in buildings/companies	n/a	no	no	no	no	yes	low	low
Rating of building	classification of rated buildings	no	no	no	yes		low	low
financial incentives for energy efficient appliances	$	yes	yes	yes	yes		medium	high
Appliance switch (CFLs)	lamps changes	yes	no	yes	yes		medium	high
Labelling of appliances	n/a	no	n/a	n/a	no	yes	low	low
Electricity sector								
RE targets	MW installed MWh produced electricity	yes	yes	yes	yes		high	high
RE incentives	$/kW $/KWh	yes	yes	yes	yes		high	high
substitution of decentralised appliances	number of changed appliances	yes	no	yes	yes		medium	medium
Non-electricity energy production								
Solar water heating programmes	m2 of solar heating number of appliances sold	yes	no	yes	yes		medium	medium
Eliminate gas flaring	GHG reduced	yes	yes	yes	yes		high	high
Reduction of non-technical losses in the electricity distribution	MWh reduced demand	yes	yes	yes	yes		high	high
AFOLU								
Deforestation reduction	km2 deforested	yes	yes	yes	yes		high	medium
National public forestry register	number of protected areas	no	yes	yes	yes		low	high
Deforestation monitoring program	number of monitoring programs	no	no	yes	yes		low	medium
Funds against deforestation	$	no	yes	yes	yes		low	high
Industry								
Energy Efficiency in Industry	TWh savings PJ savings	yes	no	yes	yes		medium	medium
Energy audits in industry	n/a	no	no	no	no	yes	low	low
Limits to primary energy use per final product	MWH, tcce	yes	yes	yes	yes		high	high
Transport Sector								
Biofuel incentives	% in blend subsidy payments	yes	no	yes	yes		medium	high
Emission standards	mg/km	yes	no	yes	yes		medium	high
Promotion of new vehicle types	number of new vehicles	yes	yes	yes	yes		high	high
Labelling of vehicles	n/a	no	n/a	n/a	no	yes	low	low
Urban transport campaigns	n/a	no	no	no	no	yes	low	low
Fuel switch to CNG	m3 gas use	yes	no	yes	no	yes	medium	medium

Annex D. NAMA case studies

This annex gives a full description of the three case studies included in section 4.4. These are based on existing initiatives in non-Annex I countries, as shown in the Action database (see 3.1), but are taken to a more general level so as to be applicable to all countries. They are in different sectors: electricity (feed-in tariff), buildings (lighting efficiency) and transport (biofuel blend). Examples of existing policies in non-Annex I countries are briefly outlined for each case study. After this we explore, how MRV is currently done in Annex I and the Clean Development Mechanism, and propose possible ways forward.

D.1 Biofuel blends in the transport sector

There are several reasons to promote the production and use of biofuels in the transport sector, including reducing GHG emissions, energy supply security and providing local employment (e.g. REFUEL-team, 2008). The impact on air pollutants can be rather mixed, with reductions in sulphur and possible increases in NO_x (Anonymous, 2005). In this case study we look at policies that mandate a certain percentage of biofuel in the transportation fuel mix, and explore how these can be MRV-ed. We focus on the supply of biofuel from the viewpoint of a country government, and assume the consumers are not affected (or do not have a choice than to use the biofuel blend).

In 2002 the share of biofuels in the consumption of gasoline and diesel consumption varied greatly, from 22% in Brazil, 3% in India, 2% in South Africa, 1% in Saudi Arabia, 0.2% in South Korea to 0.02% in the UK (WWI, 2007). Since then policies have developed further. In follow-up of its successful ethanol policy, Brazil currently also has a 3% mandatory blend of biodiesel, and is planning to increase this to 4%[20] in 2009. It requires fuel suppliers to achieve this blend. In India a mandatory ethanol blend of 5% exists, while 10% is being studied and piloted[21]. It has set a target of 20% in 2017[22]. Thailand currently has a 2% biodiesel mandate (B2) and is planning to increase this to 5% in 2011[23]. In 2007, five Chinese provinces had a mandatory ethanol blend of 10% in place and are considering expanding this into a national statutory framework (WWI, 2007). It should be noted that biofuel targets and polices in many countries are subject to change and the figures stated here are only for illustration purposes[24].

We anticipate that key MRV issues related to biofuel blend NAMAs could be:

- How can a plausible baseline scenario be set up, i.e. what is the *additional*[25] effort of the NAMA?
  - What are current biofuel usage, trends and policies?
  - Should the baseline be updated after a certain period of time?
  - How can an acceptable method for cost calculations be designed?
- How should the indirect emissions associated with producing biofuels be taken into account?

In the following we will analyse current MRV practice in Annex I and non-Annex I countries, including CDM, focussing on these issues.

---

[20] http://www.anp.gov.br/biocombustiveis/biodiesel.asp; New Energy Finance, Weekly Briefing 15 February 2009.
[21] http://www.iea.org/Textbase/pm/?mode=cc&id=3840&action=detail.
[22] New Energy Finance, Weekly Briefing 7 July 2009.
[23] New Energy Finance, Weekly Briefing 3 July 2009.
[24] UNEP (2009) also includes updated estimates.
[25] The importance of the additionality question may depend on the wider climate policy context a NAMA is embedded in: e.g. in case of a country or sector-wide emissions target, additionality may of less importance as the calculated emission reductions are backed by a fixed number of AAUs and the contribution of a single policy instrument towards this goal is more of a national distribution issue rather than an international problem. This is also the reason why in many cases the accounting methods of the CDM are much more elaborate and well-established than those for policies in Annex I countries.

D.1.1 Measuring impact of biofuel use in Annex I

Most Annex I countries have or are considering policies promoting the use of biofuels in the transport sector. This includes the EU, US, while Japan and Australia are in the process of formulating their policies. We found that as of early 2010 the EU probably has the most specific policy related to biofuels, as laid down in the Renewables Directive (2009/28/EC) (European Commission, 2009). This directive requires Member States to ensure that by 2020 at least 10% of energy consumed in the transport sector is from renewable sources. This may cover both liquid and gaseous biofuels and (renewable) electricity, and can therefore not be seen as a mandatory biofuel target. However as electricity provides only a small share of energy in the transport sector, biofuel is likely to play a major role in achieving this target[26].

The Directive contains several provisions on the types of biofuels that can be used, including sustainability criteria. Only those fuels that save at least 35% GHG emissions compared to its fossil alternative are eligible, a threshold level that will increase over time. With regard to the emission savings the document includes a list of ‘typical’ and ‘default’ GHG emission reduction factors (in %) for a large set of biofuel types. Annex V of the Directive provides the methodology for calculating these emission factors, which includes emissions from the raw material production, land-use changes, processing, fuel transport and of the fuel in use; and emissions savings from soil carbon storage and cogeneration.

Detailed guidelines on how to calculate these different emission sources, as well as default emission factors for different parts of the biofuel chain are also given. Co-products, including e.g. electricity and glycerine, should be taken into account when calculating the GHG emissions. These methodologies may be adapted to scientific and technical progress. A critical issue in the GHG calculations is how to deal with indirect impact of biofuels, e.g. through indirect land use change. The directive calls for the commission to come up with a proposal on this issue by the end of 2010. UNEP (2009) also calls for unified rules with regard to life-cycle analysis for biofuels.

With regard to reporting the Directive requires biannual reports from Member States which should include the estimated GHG saving by the use of renewable energy, as well as developments and anticipated impacts of the production of different types of biofuels. It also gives broadly defined requirements for the template of the national renewable energy action plans. These include, by sector and total, expected final energy consumption, target shares for energy from renewables and its anticipated trajectory, the measures to achieves these targets, and an assessment of the contribution different technologies (renewables as well as energy efficiency) are likely to play. In the Eurobarometer[27] the progress of biofuel consumption (and production) is monitored on the Member State level and reported annually.

The Directive does not explicitly state how GHG savings are to be calculated: it only gives values for GHG emissions and savings compared to a fossil alternative, i.e. it does not mention the issue of what the baseline use of biofuels would have been in absence of the Directive (or it assumes this is equal to zero[28]). The overall impact of the biofuel policy therefore cannot be calculated.

For the EU the energy model PRIMES (Capros et al, 2008) has been used to estimate a baseline for the use of biofuels. This baseline is a simulation of the how the energy system would evolve based on historical trends, taking into account EU and Member State policies that

[26] Up to 2010 there is a target specifically for biofuels, which should provide at least 5.75% of liquid transport fuels.

[27] See www.eurobserver.org

[28] Constructing baselines for biofuels could a very difficult undertaking. The supply curve for biofuels are often quite flat, which means that with varying prices for feedstock and fossil fuels the cost-benefit ratio can change significantly. However at oil prices of approximately $60 per barrel the GHG abatement cost are estimated to be more than € 50-100/tCO_2-eq for most types of biofuels except for ethanol from sugar cane in Brazil (see e.g. Bakker et al., 2009; WWI, 2007), which could be an argument for considering all biofuels additional.

had been implemented up to 2006. The share of biofuels in this baseline is projected to be 4% in 2010, rising to 7 and 10% in 2020 and 2030 respectively. Assumptions that are reported include an oil price of $61 and $62 per barrel in 2020 and 2030 respectively, private discount rates of e.g. 17.5% for private passenger investments, and member state support policies that render biofuels competitive to competing fuels. Furthermore the baseline conditions presuppose investment and infrastructure development in sectors such as agriculture, forest, waste management and in sectors performing pretreatment, transport and processing of biomass and waste resources. Other assumptions, such as cost of biofuels, biofuel reference technologies and fuel prices were not found.

In the US, the Renewable Fuels Standard (2007[29]) mandates production of 8 billion gallons of renewable fuel in 2008, rising to 36 billion in 2020. Biofuels are required to reduce GHG emissions with at least 20% compared to gasoline. Non-corn starch feedstock biofuels are considered 'advanced' and are required to provide 3 billion gallons in 2016 and 21 billion gallons in 2022. The framework for measuring and reporting the use and impacts appears less elaborate than in the EU.

In Australia biodiesel and ethanol are already exempt from excise duty[30], while on the state level there are several mandatory blends for biofuels as of 2009, which will be increased in the coming years. Under one mandate 'each supplier of wholesale fuel for sale in New South Wales will be required to provide evidence on a quarterly basis from September that ethanol makes up at least 2 per cent of the total volume of petrol they sell in New South Wales' (GAIN, 2009).

D.1.2 Biofuel monitoring in non-Annex I

As mentioned above, several non-Annex I countries have implemented a policy mandating a biofuel blend. The monitoring requirements of these policies appear to be limited to measuring the blend provided at fuel stations, and at the national and regional level. It is unclear whether or not there is enforcement of the policy in case of non-compliance, and whether explicit account is taken of the upstream emissions. We have found no cases where GHG reductions due to the policies are reported. We note that we have not been able to fully investigate these issues in developing countries, so the afore-mentioned observations should be seen as preliminary.

As of February 2010, several biofuel CDM projects have reached the validation stage. There are three large scale biodiesel projects, all based on production from waste fats or oils from biogenic origin, using approved methodology AM47. For large scale project using biodiesel from other sources the methodology ACM17 has been approved, but is not used yet by any projects. For large scale projects on ethanol there is no approved methodology yet. For small scale projects (i.e. emission reductions up to 60 ktCO_2-eq/yr) there are two approved methodologies: 'plant oil production for use in transport applications' (AMS-III.T) and 'emission reductions by low-greenhouse emission vehicles' (AMS-III.C), both of which are used by one biofuel project (UNEP/Risø, 2010).

Developing baseline and approved methodologies for biofuel CDM projects has proven a large challenge. More than 5 years after submission of the first large scale methodology, the first large scale widely applicable biodiesel methodology has been approved. Approximately 10 methodologies have been rejected, of which some more than once (UNFCCC, 2010; cdm.unfccc.int)[31]. The most important reasons for rejection for biofuel-specific aspects include[32]:

- Insufficient consideration of upstream emissions of biofuels (either covered as project emissions or leakage).

---

29 http://www.ethanolrfa.org/resource/standard/

30 For imported biofuel an import tariff exists.

31 This number of rejections may indicate that biofuels under the CDM is problematic, and perhaps that NAMAs could be a more conducive framework, however these assertions are outside of the scope of this report.

32 Based on methodology reviews, http://cdm.unfccc.int/methodologies/PAmethodologies/publicview.html.

- 'Shift of pre-project emissions', i.e. the possibility that land used for biofuel production in the project scenarios was formerly used for other purposes such as agriculture and could thereby induce land clearance and associated GHG emissions.
- Treatment of by-products such as glycerol[33].
- Double counting of emission reductions - which has been clarified in guidance by the EB but several proposed methodology failed to address properly.
- Other issues such as baseline determination (NM129), baseline approach (NM223), unclarity as to the origin of the raw material (NM253), emission factors, lack of uncertainty assessment (NM142), and project boundaries.

Most of the methodologies only apply to projects where the baseline scenario is continuation of current practices, i.e. diesel utilisation for the approved methodologies. For AM 47 the baseline scenario should be separately determined for the following elements:

- Production of fuels (P): What would have happened at the production level in the absence of the CDM project activity?
- Consumption (C): Which fuel would have been consumed in the absence of the CDM project activity?
- Material (M): What would have happened to the material used as input for production of biofuel in the absence of the CDM project activity?

The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality". Additionality is assessed only for the project activity (i.e. the construction and operation of the biodiesel plant). Additionality is established ex-ante for the duration of the crediting period, i.e. the relevant parameters are not subject to monitoring, and only need to be revalidated at the renewal of the crediting period. In case the Investment Analysis is used, a sensitivity analysis of the biodiesel sales price, the feedstock costs and fuel costs should be carried out.

Baseline emissions are calculated based on the amount of biofuel consumed, using the relative net calorific value of the biofuel compared to the fossil fuel (both to be measured based on a representative sample). The emission reductions are obtained by subtracting leakage (e.g. from existing uses of waste fats/oils) and project emissions from the baseline emissions.

The methodology also includes elaborate procedures for monitoring the baseline, project and leakage emissions. This covers the biofuel itself and all by-products, which should be accounted for in a full mass balance, i.e. all inputs and outputs of the biofuel production plant need to be measured. In addition recording of amount of biofuel received by filling station or distributor, and the amount filled into end-user where combustion takes place must take place.

D.2 Lighting efficiency

In this section policies and measures that entail the substitution of inefficient lighting systems, often incandescent light bulbs, with more efficient lighting systems such as compact fluorescent lighting (CFL) will be discussed. The measure reduces electricity consumption in buildings and with it reduces overall electricity demand which reduces overall greenhouse gas emissions from the power sector, when power generation is based on fossil fuels. In many countries it is also carried out to reduce peak load demand. There are two main measures implemented to encourage the substitution of inefficient lighting: (i) bans on inefficient lighting and (ii) substitution programmes, with free or reduced price distribution of efficient lighting (CFLs) in exchange for inefficient lighting (incandescent light-bulbs). As we will show in the following

[33] AMS-III.T states that all project emissions should be attributed to the biofuel produced.

banning is a measure which is used both in Annex I and non-Annex I countries[34], whereas substitution programmes are now typical for non-Annex I countries.
Key MRV issues related to possible NAMAs regarding efficient lighting could include:

- How can a plausible baseline scenario be set up, i.e. what is the *additional* effort of the NAMA?
  - Should the baseline be updated after a certain period of time?
  - How should the baseline for new grid connected costumers be calculated?
- If a ban will become a NAMA for which carbon credits are given, when should these be given?
- Are the substituted lamps being used? To what extent?
- What lamps have been replaced?

D.2.1 Policies in non-Annex I countries

Several non-Annex I countries are carrying out substitution programmes with or without the use of CDM, among others South Africa, India, Ecuador and Rwanda. A brief description of the programmes in these countries follows.

South Africa[35]
South Africa has implemented a programme to substitute incandescent light bulbs through CFLs in several regions of the country. The programme is carried out by Eskom, the state owned utility company. The programme was started in 2004 and has since substituted more than 18 million incandescent light bulbs. Eskom has been calculated that if all light bulbs were substituted in South Africa the savings would be around 1350 MW. The practical implementation is carried out by contractors who exchange the incandescent light bulbs with CFLs in the individual households. A maximum of six light bulbs per household are distributed free of charge. The uninstalled incandescent light bulbs are taken away by the installer.

India
In India the Bachat Lamp Yojana was launched by the Ministry of Power on February 25th 2009[36] and will be developed by the Bureau of Energy Efficiency. The scheme requested validation as a CDM Programme of Activities (PoA) in July 2009. Under the PoA several projects in distinct areas with different stakeholders will take place. As of July 2009, 10 lighting energy efficiency projects are requesting validation, with the same methodology AMS-II-J "Demand-side activities for efficient lighting technologies", this methodology will be explained in section 0.

Ecuador
In Ecuador a CFL project is proposed by the Ecuadorian ministry of electricity and renewable energy, together with two Ecuadorian private entities, and is as of November 2009 the only large scale CDM project of this type that has reached validation stage. The project uses CDM methodology AM0046 "Distribution of efficient light bulbs to households", which will be further explained in section 0. It is a large scale project and it is projected to reduce 439,247 tCO_2-eq per annum. There are currently no projects using this methodology and no other project proposed with this methodology. The programme plans to distribute 6 million CFLs to people living in poverty, in 808 urban areas, 109 rural areas, distributed in 21 provinces. A maximum of four CFLs will be distributed in exchange for the current light-bulbs per household; the substituted light bulbs will be destroyed onsite. Currently 43% of energy consumption in the area is consumed by lighting.

---

[34] Cuba, Venezuela and Brazil have implemented bans since 2005 (http://www.dailymail.co.uk/news/article-1107290/Revolt-Robbed-right-buy-traditional-light-bulbs-millions-clearing-shelves-supplies.html), Argentina plans to ban incandescent bulbs starting in January 2010 (Ley Argentina 26.473, 21st January 2009), as does the Philippines (http://en.wikipedia.org/wiki/Phase-out_of_incandescent_light_bulbs#cite_note-12).

[35] http://www.eskomdsm.co.za/?q=CFL_Exchange_Read_more, http://www.eskomdsm.co.za/?q=CFL_Exchange_Background_information.

[36] http://pib.nic.in/release/release.asp?relid=47970&kwd

Rwanda

Rwanda has requested validation for a CDM project for the distribution of CFLs. The project uses two CDM methodologies, for the four phases of the project. The project is divided into 4 phases: in the first phase (distribution of 50,000 CFLs) a maximum of two CFLs are provided in exchange for incandescent light bulbs; in the second phase (distribution of 150000 CFLs) up to 5 CFLs are distributed at a price of US$0.37 in exchange for incandescent light bulbs; in the third phase 200,000 CFLs will be distributed; and the fourth phase will concentrate on new costumers, that are currently not connected to the grid. The first methodology is AMS-II.J "Demand-side activities for efficient lighting technologies", which is used for the first three phases of the project that deal with the substitution of less efficient lighting techniques. Methodology AMS-II.C will be used for the last phase of the project, as methodology AMS-II.J has no provisions for new sites.

D.2.2 Lighting efficiency policies MRV in Annex I countries

In this section we concentrate on Annex I policies to reduce inefficient lighting from households. Bans are the most common lighting policy in Annex I countries[37], but also white or energy savings certificate systems are in place.

Among others the UK, Italy, France and Denmark have white certificate systems. Each certificate is issued for a determined amount of energy savings achieved. These are used by suppliers or distributors of energy to meet obligations that are generally set by the government or a regulator. To simplify the system in the above mentioned countries there are standardised methods to calculate savings. These provide with ex-ante calculations and are only partially, if at all, monitored ex-post. The methods take into account free-riders, based on historic trends, but the attribution of savings to the policies cannot be ensured. It is planned that the standards will be changed to take into account changes in the baseline, but it is still unclear how this will be done in the different countries.[38]

In the residential sector, so for example also for the exchange of incandescent light bulbs with CFLs, the establishment of average energy savings is often used. The Italian Authority for Electricity and Gas (Autorita' per l'energia elettrica e il gas) calculates energy savings by considering the difference between the power difference between an incandescent light bulb and a CFL, the room where the light is installed and the number of working hours.[39] This is similar to the CDM methodology AMS II-J (see below). Default factors are used to take into account free-riding. Similar methods to calculate ex-ante savings are used in all the countries mentioned above. Nonetheless the energy savings considered can vary significantly, as can be seen in Figure D.1. Similar to substitution programmes in non-Annex I countries CFLs in these systems are often provided with subsidies or for free by the supplier or distributor who has to comply with the obligation. Certificates are only given for energy savings no relationship to emission reductions is carried out.

---

[37] In the EU the ban should take effect from 2012, although some countries may anticipate the ban and it is stated that: "The annual electricity consumption related to products subject to this Regulation in the Community has been estimated to be 112 TWh in 2007, corresponding to 45 Mt CO2 emissions. Without taking specific measures, the consumption is predicted to increase to 135 TWh in 2020. The preparatory studies showed that electricity consumption of products subject to this Regulation can be significantly reduced." (Commission Regulation (EC) No 244/2009 [(8)). Australia will ban the sale of incandescent light bulbs from 2010. Also the US, Canada and other Annex I countries have bans in place.

[38] Ea Energy Analyses 2007, http://ea-energianalyse.dk/reports/710_White_certificates_report_19_Nov_07.pdf

[39] http://www.ewc.polimi.it/dl.php?file=ESD21SeptPavan.ppt

	First years savings (kWh/year)	Life time savings (kWh)
CFL		
France	(33)	230
Italy	66	330
UK	10	208
Denmark	18-77	(144-616)
Assumptions		
France	4% discount, 7.5 years life time	
Italy	5 years life time	
UK	3.5% discount, 16 years life time. Heat replacement corrected	
Denmark	5 sizes, 1,000 hours per year, 8 years life time	

Figure D.1 Standardised savings per CFL in four different European countries[40]

The substitution of incandescent light bulbs, through a ban, will not take place directly, but will be a gradual process, based on the lifetime of the incandescent light bulbs previously installed. In the EU estimates have been carried out about the amount of emission reductions expected to take place. In the following we describe how this was done.

In the EU, the current stock in households was estimated with information of the Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe project[41], which ended in 2008. This project collected data from existing studies, surveys and questionnaires in the countries and own measurements. The result is, among others, an average number of lighting equipment, efficient and non-efficient, per household. The business as usual (BAU) development for lighting electricity consumption is estimated by taking into account recent trends in lighting (i.e. shift from incandescent lamps to halogen lamps), a projection of the number of households in the EU and that central and eastern EU countries might expand their lighting to the same levels as the rest of the EU. In the BAU scenario the average number of bulbs per household is therefore projected to rise from 24.3 in 2006 (survey data) to 27.5 in 2011 and 31 in 2020. The types of lamps, in 2020, following known trends, are expected to be incandescent lamps (19%), halogen lamps (42%), linear fluorescent (6%) and compact fluorescent (33%)[42]. Potential savings due to policies and measures are compared to this business as usual scenario.

In the Netherlands[43] the scenario calculations are done in a similar manner. In the BAU scenario historic trends, derived from marketing surveys, are assumed to continue. For other scenarios such as the “ban scenario” it is assumed that the incandescent light bulbs will be banned and thus the diffusion rate of more efficient lighting will increase. The results of the different scenario calculations are different amounts of electricity use from lighting. The emission reductions from the different scenarios can be calculated by using an emission factor ($kgCO_2$/MWh).

D.2.3 Lighting efficiency MRV in non-Annex I countries

In this section we concentrate on substitution programmes in non-Annex I, where incandescent light bulbs are replaced for free or a small charge. The programmes have in some cases requested validation as CDM projects. In the following we focus on these CDM methodologies.

40 http://ea-energianalyse.dk/reports/710_White_certificates_report_19_Nov_07.pdf
41 http://web.ceu.hu/envsci/projects/REMODECE/index.htm
42 Preparatory Studies for Eco-design Requirements of EuPs, Lot 19: Domestic Lighting, Part 1: Non-directional lighting sources, Task 2: Economic and market analysis.
43 Basisdocument Elektrische apparatuur in Nederlandse huishoudens Overzicht 1980-2005 Scenario's 2010-2020, December 2008

There are three different CDM methodologies that can be applied to efficient lighting, of which two relate only to lighting (one small scale, one large scale methodology) and one more generic methodology applies to demand side energy efficiency activities for specific technologies (small scale).

*AM0046: "Distribution of efficient light bulbs to households***"** applies to projects in which the distribution of light bulbs takes place free of charge or for a small fee. It can take place through substitution at household level or upon presentation of an invitation issued by the project coordinator. For this methodology to be applicable the beneficiaries of the project need to be connected to the national or regional grid. The monitoring is carried out through two sampling groups, a baseline sample group (BSG) and a project sample group (PSG), who have metering devices installed at the start of the project. Metering of the hours of use of the new lighting equipment or the energy use of appliances can take place. In the proposed project the energy use is metered. Before the start of the project the technical characteristics of the substituting light bulbs have to be certified through laboratory measurements. The energy savings are determined through the difference between the energy use for lighting of the PSG and the BSG. Cross checks also take place by taking measurements in a sample of households that have not taken place in the project (baseline cross-check group, BCCG) and in sample households that have participated in the project (project cross-check group -PCCG). The BSG will have received the same amount of information, i.e. in local information campaigns, as the PSG but will not have received any light bulbs through the project. This does not exclude that they might buy new light bulbs outside the project. The emission savings will be determined through the difference in energy use and the grid emission factor, which is to be determined with the latest version of the "Tool to calculate emission factor for an electricity system"[44]. The reporting is done through databases, where the data from the meters and the data collected in on-site surveys are included. The substituted lamps need to be documented, so that the validator (Designated Operational Entity, DOE) can verify that they have been destroyed.

AMS-II.J: "Demand-side activities for efficient lighting technologies" can only be applied to an exchange of inefficient lighting systems with new CFLs that have not previously been used for other activities. The lumen output of the CFLs should be greater than or equal to the lumens of the previous lighting. It is encouraged that the CFLs be chosen with a long life and the lowest wattage. An independent test for the quality of the lamps has to be carried out. The Project Design Document (PDD) has to include the distribution method and a description of how the following activities will be documented and carried out: the return, storage and destruction of the baseline incandescent light bulbs. Ex ante calculations of emissions reduction will be conducted by: (1) estimating the consumption of the incandescent light bulbs; (2) determining the average operation hours through measurement or using the default value of 3.5 hours/day; (3) comparing the gross electricity savings that will take place through the substitution and multiplying this with the average annual operation hours; (4) calculation of the net electricity savings through a correction factor for transmission and distribution losses (5) multiplication with the emission factor, determined with the provisions in methodology AMS-I.D. A factor for the estimation of lamp failure is also included in the calculations. Ex-post corrections will be carried out through surveys checking the factor for lamp failure.

AMS-II.C: "Demand-side energy efficiency activities for specific technologies" This methodology covers all energy efficient equipment. The output of the device, in this case light output, in the project scenario should be comparable to that of the original device with a divergence in output of maximum -10% to +50%. Lighting counts as an electric device for which the following rules apply. The baseline emissions are calculated through the consumption of the equipment/appliance and the grid emission factor calculated with the latest version of the "Tool to calculate emission factor for an electricity system". The project emissions shall be calculated taking into account the number of appliances, the power of the appliance, the annual operating hours and the technical grid losses. "A representative sample of the replaced devices shall be recorded in a way to allow for a physical verification by DOE", for verification.

[44] Available from cdm.unfccc.int

In all projects the main method used to demonstrate additionality is the investment barrier. It is demonstrated that the higher upfront investment of the CFLs are a major impediment to the diffusion of CFLs and that without the project the substitution would not have occurred. In the project design document (PDD) for the project in Rwanda it is stated that the difference in price between 0.4US$ for an incandescent bulb and 7US$ for a good quality CFL is difficult to sustain for areas with a per capita income of 250US$/year. The utility is able to achieve better prices, if it buys the CFLs in large quantities (1.5US$) nonetheless to make the price comparable to incandescent light bulbs CFLs need to be subsidised. The price difference is covered by the utility. Also in the Indian proposals the investment analysis is used. The project proponent would incur in losses if it decides to sell the CFLS at the maximum retail price of the incandescent bulbs, so the price of carbon credits is necessary to cover this difference. For the Ecuadorian project an investment analysis and a barrier analysis is carried out. The first demonstrates from a distributor perspective that the project would not have occurred, because the distributor has no revenue a part from the CDM credit and the second demonstrates that the CFLs are too expensive for the population to consider buying them autonomously.

Table D.1 Summary of the main aspects of the three CDM methodologies described

Methodology	Devices included	Baseline determination	Ex-post monitoring	Additionality
AMS II J (Small scale)	Only lighting	Estimated consumption of incandescent light-bulb multiplied with the grid emission factor	Surveys at regular intervals	“Combined tool to identify the baseline scenario and demonstrate additionality”
AMS II C (Small scale)	All demand-side energy efficiency activities for specific technologies	Estimated consumption of inefficient device multiplied with the grid emission factor	Surveys at regular intervals	“Combined tool to identify the baseline scenario and demonstrate additionality”
AM 00046 (Large scale)	Only lighting	Dynamic baseline obtained through monitoring of baseline sample group (BSG)	Regular measuring and adjustment of baseline Cross checks with baseline cross check group	latest version of the “Tool for the demonstration and assessment of additionality”. Step 2, investment analysis.

D.3 Subsidies for Renewable Energy

There are several ways to give incentives for renewable energies among which: feed-in tariffs and premiums, renewable obligation certificates, tradable green certificates, tax incentives and investment subsidies. Many countries have a combination of support schemes for renewable energy. In the following we will present examples of feed-in tariffs and premiums, as examples of measures used to give incentives to renewable energy. These are often part of a wider scheme to promote renewable energy.

Feed-in tariffs and premiums are specific payments that are given for e.g. produced electricity. They are a commonly used incentive for renewable energy and technologies that have not yet reached market maturity. They are mainly used to give security to investors in the field of renewable energy as through this mechanism they will receive fixed revenue for the electricity they feed into the grid. The aim is to make the renewable energies competitive to non-renewable power plants producing for the electricity market, so as to provide incentives for a transformation towards a more sustainable energy system. In the following there are some examples of how feed-in tariffs have been applied in non-Annex I countries and an exploration how MRV is currently being done, focusing on:

- How is a plausible baseline scenario being established?
- How are increased amounts in renewable electricity converted to avoided emission and/or emissions savings?

D.3.1 Policies in non-Annex I countries

In the following some examples of renewable energy feed-in tariffs in premiums in developing countries are given.

South Korea[45]
Since 2001 the Electricity Business Law obliges the purchase of renewable energy connected to the grid by the Korea Electric Power Corporation and determines fixed prices for the electricity. The aim of the measure is to promote the installation of renewable energy. The feed-in tariffs are fixed for five years for small hydro, biomass and waste and for 15 years for wind and photovoltaics. The tariffs for the different energy sources are:

- photovoltaics : 716.4 KRW/kWh (0.70 USD/kWh)
- wind: 107.6 KRW/kWh (0.105 USD/kWh)
- small hydro: 73.7 KRW/kWh (0.072 USD/kWh)
- tidal/ocean: 62.81 KRW/kWh (0.061 USD/kWh)
- landfill gas: 61.80 KRW/kWh (0.06 USD/kWh)

The renewable energy providers sell their electricity at the Korea Power Exchange and the state compensates the difference between the received power and a predetermined tariff. In 2002 an upper limit to support was set at 250MW new installed capacity for wind and 20 MW for solar. In 2008 the cap was modified. The payments for PV will decrease, but the limit of support is increased 500MW. The tariffs will be paid for 15 or 20 years, depending on the choice of the electricity producer. The tariff shall be reduced by 4% p.a. for PV and 2% p.a. for wind shall be applied starting in 2009. A reduction of 3% p.a. shall apply for fuel cells starting in 2010.

India[46]
The Tariff Policy 2006 of India also includes provisions for the promotion of renewable energy. A minimum percentage of renewable energy and cogeneration have to be set. The State electricity regulatory commission has to establish how much of this purchase is made applicable for tariffs. The procurement of energy from non-conventional energy sources[47], which is done at predetermined preferential tariffs, is done through competitive bidding. In case it is done without competitive bidding then the pricing will be determined by the central commission. In January 2008 a subsidy for solar power plants that feed electricity to the grid was announced by the Indian government. The tariffs are:

- INR 12 (USD 0.30) per kWh for solar photovoltaic power and
- INR 10 (USD 0.25) per kWh for solar thermal power.

These tariffs will be in addition to any state funding, for ten years, but there are limitations to the amount paid per state and developer. A similar norm was passed in July 2008 for wind energy. The aim of the scheme is to achieve 10,500 MW installed wind capacity by 2012. Eligible for the incentive are wind power projects with an installed capacity of over 5MW, with a site validated by the Centre for Wind Energy Technology. These projects will receive INR 0.5/kWh (USD 0.0125) for ten years in addition to other tariffs determined by the authorities.

South Africa[48]
The Renewable Energy Feed-In Tariff was approved by the National Energy Regulator of South Africa (NERSA) on March 31st, 2009. Eskom, South Africa's public utility is obliged to buy the output of qualifying renewable energy generators at the following tariffs[49]:

- wind: ZAR 1.25/kWh (0.162 USD/kWh);
- small hydro (less than 10 MW): ZAR 0.94/kWh (0.122USD/kWh);

---

[45] IEA Climate Change Database: http://www.iea.org/Textbase/pm/?mode=cc&id=1686&action=detail
[46] IEA Climate Change Database: http://www.iea.org/Textbase/pm/?mode=cc&id=4227&action=detail; http://www.iea.org/Textbase/pm/?mode=cc&id=3839&action=detail; http://www.iea.org/Textbase/pm/?mode=cc&id=4164&action=detail
[47] Non-conventional power sources include renewable energy and co-generation.
[48] http://www.nersa.org.za/documents/Press%20Release/Media%20Statement%20Announcement%20of%20REFIT%20decision%2031%20March%202009.pdf
[49] Conversion 1st September 2009: 1ZAR= 0.12947 USD (http://markets.ft.com/markets/currencies.asp)

- landfill gas: ZAR 0.90/kWh (0.117USD/kWh);
- concentrating solar power (CSP): ZAR 2.10/kWh (0.272USD/kWh).

Other renewable energy sources will be considered within 6 months of the approval of the tariffs. The scheme will be reviewed yearly for the first five years and then every three years. The REFIT power purchase agreement is valid for 20 years. The Renewable Energy Purchase Power Agency will be housed in Eskom's Single Buyer Office. This office will be responsible for monitoring and verification. The aim of the tariff is to achieve the target of 10,000 GWh from renewable energy sources by 2013.

D.3.2 Renewable energy subsidy scheme MRV in Annex I countries

Feed-in tariffs are a very common subsidy for renewable energy and are applied in a number of Annex I countries. Most of these laws like the German law for renewable energy (Erneuerbaren Energien Gesetz 2009) contain a section dedicated to transparency and measuring provisions. Here the obligations of the different actors in the electricity market (among others generators, network regulators, utilities) are described, as well as mechanisms to avoid double counting[50]. The generators have to report production data to the Federal Network Agency on a yearly basis. Part of the information must also be available online for the general public. This data provides information about the amount of produced energy (MWh), the installed capacity (MW) and the amount of subsidies given.

Avoided and/or saved GHG emissions are a likely outcome of a renewable energy subsidy scheme, however, the avoided emissions are not directly measurable. In particular it is difficult to attribute the emissions savings or reductions one particular policy such as a feed-in tariff when more than one policy is in place. When changes to the electricity supply system occur compared to a baseline (i.e. no RE incentives), these can only be attributed to the entire bundle of renewable energy incentive mechanisms. There are two main issues concerning the baseline that need to be addressed: one regarding the question what would have happened if there were no incentive mechanisms (i.e. what would the electricity mix have looked like, e.g. more coal-fired power generation, and what emissions would have resulted?), the other regarding baseline emissions (i.e. what are the emissions compared to, business-as-usual scenario, one specific technology or the current emission factor?).

Whereas the German renewable energy law does not directly state anything about emission reductions, the Spanish renewable energy plan[51] determines the emissions savings from renewable energies by comparing them to those of a combined cycle gas turbine with an efficiency of 54%. Only for biomass co-firing they are compared to a conventional coal power plant. In EU's the Impact Assessment of the Renewable Energy Roadmap[52] there are several factors for avoided emissions that are determined from different model calculations, resulting in emission reductions between 600 and 900 $MtCO_2$ in 2020 for the EU renewable energy target of 20%.

The baseline is relevant when the measure needs to be quantified in greenhouse gas emissions. As can be deduced from the examples above, there is not one single method to calculate baseline emissions and emission reductions from a renewable energy subsidy scheme.

All actors participating in a feed-in tariff system are obliged to carry out measurements in the system: the government agency that pays the tariffs; the supplier for the amount of energy that it produces; and the utility that owns the grid. The measuring of the produced electricity in a

[50] Double counting occurs when multiple targets at different points in the supply change take credits or subsidies for having participated to achieving a target. In case a power plant receives credits for reducing emissions it is not eligible to also take advantage of the subsidized tariffs (para. 56).

[51] Plan de Energias Renovables (PER) 2005-2010.

[52] http://ec.europa.eu/energy/energy_policy/doc/05_renewable_energy_roadmap_full_impact_assessment_en.pdf (p. 51).

feed-in tariff will thus occur independently from an MRV system being in place. For other incentive mechanisms the situation may differ.

D.3.3 Renewable energy subsidy in the CDM

For the CDM, establishing a plausible baseline scenario and emissions assume particular importance. There is a CDM methodology that relates to the baseline issue, methodology ACM0002 “Consolidated baseline methodology for grid-connected electricity generation from renewable sources”, which has been used by over 1000 projects (UNEP/Risø, 2010). This methodology can apply to three different cases (i) greenfield power plants, (ii) retrofit or replacement power plants and (iii) capacity addition. To calculate the baseline emissions (BE) the net amount of electricity generation (EG) that is fed into the grid and the grid emission factor, (the combined margin CO_2 grid emission factor-EF), are needed. The EG is calculated differently according to the three cases mentioned above. For greenfield power plants the EG is equivalent to the electricity produced by the project; for a retrofit or replacement the EG is based on the historical electricity generation of the power plant; for capacity addition either of the two above can be used depending on the influence the new project has on existing power plants. The calculation for the grid emission factor is found in the “Tool to calculate the emission factor for an electricity system”. There are different ways to calculate the emission factor according to data availability, to the amount of off-grid power plants in the system and to type of resources in the electricity system. The methodologies are elaborate and took several years to establish.

Additionality for projects under this methodology needs to be demonstrated through the “Tool for the demonstration and assessment of additionality”. ACM0002 requires projects to demonstrate that there is “at least one credible and feasible alternative that would be more attractive than the proposed project activity.”[53] The following steps must be followed: 1) identification of an alternative project; 2) investment analysis and or 3) barrier analysis; 4) common practice analysis. If the CDM project is unlikely to be the one chosen for investments without additional funding and/or there are barriers impeding its development, then it must be checked that it is not common practice to carry out similar projects. If it is not then the project is additional. There are several additional sub-steps that need to be carried out to demonstrate the different steps of the additionality check. In some cases it can be assumed that renewable energy is the most economical power generating solution and thus would require no additional incentives. The tool of the CDM methodology mentioned above is used to demonstrate that the project would not have occurred without the CDM.

The project emissions are 0 in most cases, except in cases where there is fossil fuel combustion, for geothermal power plants and for hydro power plants with new or increased reservoirs. No leakage emissions are considered in this methodology. The emission reductions from the project are the difference between the baseline emissions and the project emissions. According to the CDM methodology metering has to occur to monitor the flow of electricity into the grid, further depending on the type of power plant other monitoring requirements are prescribed.

For additional crediting periods, the baseline might have to be recalculated depending on the changes that have occurred, in particular regarding policy changes. An example for a policy change would be if by the start of the second or third crediting period the project activity has become mandatory through local policy. Also the validity of the baseline needs to be reassessed.

[53] Methodological Tool: “Tool for the demonstration and assessment of additionality” version 05.2 (4).