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Two Sides of the Same Coin?

A Preliminary Analysis of Sustainable Development Opportunities Identified in National Communications of Non-Annex I Parties

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This thesis is dedicated in loving memory to my late grandmother, Carrie Fisk.

Abstract

The aim of this paper is to study the extent to which non-Annex I countries are implementing or exploring select actions that support both climate change mitigation and sustainable development objectives in the energy sector. The research is based on a survey of the national communications of 100 non-Annex I Parties to the UNFCCC. Although national communications are intended to provide information on national programs and measures implemented or planned which contribute to mitigating climate change, it is important to note that these communications do not always capture all relevant efforts and initiatives. In recognition of this limitation, it is concluded that most sustainable development practices that also support climate change mitigation assessed here are neither implemented nor considered to any great extent in the developing world, despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries. Furthermore, of the actions assessed in this study, measures to improve transport infrastructure and management, CHP and biomass to electricity applications, currently represent the greatest opportunities for sustainable development that addresses climate change mitigation, in the developing world. It is concluded that these three opportunities for sustainable development are technically and economically feasible, yet are neither implemented nor considered in up to 72%, 50% and 30-50% of the developing world, respectively. As a first exploratory investigation into the potential of select sustainable development actions that support climate change mitigation in the developing world, it is recommended that follow up research investigate the factors and mechanisms preventing these opportunities from reaching their full potential. Such an inquiry is critical, as measures that support both sustainable development and climate change mitigation may well represent the only type of measures that would stand a chance of being adopted on a large enough scale to achieve significant emissions reductions and limitations globally.

Executive Summary

Continued economic growth and the alleviation of poverty, fuelled by increasing energy use, are essential to the sustainable development of lower income nations. However, meeting the energy needs of today's two billion inhabitants that lack access to adequate, affordable, clean and convenient energy services, and providing up to another 8 billion people likely to be added to the global population over the next century, may also entail major implications for climate change if adequate consideration is not directed towards the limitation and reduction of greenhouse gas emissions associated with global energy use. As estimated by the IPPC, about three-quarters of global anthropogenic carbon dioxide emissions, the main contributor to the human-induced greenhouse effect, have resulted from the combustion of fossil fuel for energy over the past twenty years. Therefore, if significant greenhouse gas emission reductions and limitations are to be achieved on a global scale, the wide-spread exploration and implementation of climate change mitigation measures in the energy sector that simultaneously support economic development and growth, poverty alleviation and social equity in the developing world, is critical.

Increasing evidence from the developing world indicates that significant steps are already being taken to reduce rates of growth in carbon emissions. These achievements have resulted primarily from the pursuit of "development only" policies that have simultaneously achieved greenhouse gas emission reductions. These types of policies include national initiatives emphasizing the deregulation and privatisation of the energy sector, reductions in energy subsidies and the development of indigenous hydroelectric and other alternative energy sources. Although policies like these are often not motivated primarily out of concern for climate protection, but for other pressing social and economic goals, they continue to illustrate the potential for policies and actions to simultaneously drive development and address climate change concerns. However, international research and understanding of the potential sustainable development benefits of practices and policies normally implemented for their greenhouse gas reduction potential is limited, and developing countries are, in general, very wary of climate change mitigation labelled policies and actions lest they undermine other important development goals. In acknowledgement of this situation, it is suggested that perhaps not all potential development policies and actions are being identified and explored in the decision-making processes within developing countries. Therefore, the aim of this paper is to study the extent to which non-Annex I countries are implementing or exploring select actions that support both climate change mitigation and sustainable development objectives in the energy sector, and to explore the hypothesis that these actions are neither implemented nor considered to any great extent in the developing world, despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries.

This hypothesis is tested by conducting an initial investigation of the potential sustainable development impacts of select climate change mitigation measures in the following energy sectors: decentralised power generation, centralised power generation, residential, commercial, industrial and transport sectors. Using an assessment tool designed to quantify the potential sustainable development benefits of these practices, where possible, and a variety of literature sources, the following nine measures are assessed as offering the greatest benefits: small hydropower applications, centralised biomass to electricity applications, energy efficient lighting and building envelopes, alternative cooking fuels, energy efficient motor systems and industrial CHP, and improved transport infrastructure and alternative fuels for transport. Using the national communications of non-Annex I countries as a point of departure, the extent to which each action is implemented or is under consideration in the developing world

is quantified. In order to better understand the "potential" of these practices in the developing world, a further analysis of the technical and economic feasibility of these practices in those countries identified as neither implementing nor considering them is also undertaken. The main outcome of this analysis is the identification of those select actions representing the greatest opportunities for sustainable development and climate change mitigation in the developing world.

The overall conclusion of the analysis is that most of the sustainable development actions assessed here are neither implemented nor considered to any great extent in the developing world, despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries. In addition, of the nine actions assessed in this study, measures to improve transport infrastructure and management, biomass to electricity applications and industrial CHP applications, currently represent the greatest opportunities for sustainable development and climate change mitigation in the developing world.

The analysis indicates that measures to improve the energy efficiency of lighting, motor systems and building envelopes, although implemented or considered in no more than half of all non-Annex I countries, are most probably implemented or at least considered in those countries likely to gain the greatest sustainable development benefits from them.

The analysis also indicates that SHP, energy efficient cooking techniques and alternative fuels for transport may be highly feasible, but are neither implemented nor considered, in at least one-third of all non-Annex I Parties, thereby suggesting that these opportunities for sustainable development may be greatly under exploited in the developing world. Furthermore, measures to improve transport infrastructure and management, biomass to electricity applications, and CHP applications in industry are assessed as being the least exploited in non-Annex I countries. Measures to improve transport infrastructure and management are assessed as highly feasible in all 72% of non-Annex I Parties not currently implementing or considering such practices. With regards to the biomass to electricity option, 65.2% of sugar producing non-Annex I nations are not implementing this measure nor has it been identified as a measure for consideration. As these sugar-producing nations represent 30% of non-Annex I countries, it is estimated that between 30-50% of non-Annex I nations may find this opportunity for sustainable development technically and economically feasible, yet are currently neither implementing nor considering this option. And lastly, it is estimated that measures to promote industrial CHP may be technically and economically feasible, yet are neither implemented nor considered, in up to 50% of all non-Annex I Parties. These latter three sustainable development options, including measures to improve transport infrastructure and management, biomass to electricity applications and industrial CHP applications, are assessed as economically and technically feasible in a significant number of non-Annex I nations not currently implementing or considering them, and of the nine actions assessed in this study, represent the greatest opportunities for sustainable development that addresses climate change mitigation, at this time in the developing world.

It is also concluded that decision makers in the developing world may not be adequately considering future expected trends in economic growth and personal incomes and the potential implications of these in the pursuit of sustainable development pathways. This is particularly relevant for the energy efficient lighting, building envelope and motor system options as all of these involve the efficient use of electricity. Electrification rates are only expected to increase in the developing world and in all sectors of the economy, with major implications for development and climate change if measures to ensure the efficient use of energy are not implemented. Therefore, in consideration of future expected trends in economic development and growth, it is concluded that the "potential" for these options in the developing world is greater than the survey results imply, and that the significance of the sustainable development benefits they offer will only increase as economies and personal incomes continue to expand.

The survey results also reveal that 95 of the 100 countries surveyed are either implementing or considering at least one of the select climate change measures assessed here, thereby demonstrating the serious commitment of the developing world to the climate change agenda.

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1. Introduction

1.1 The United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is the first legally binding international instrument that deals directly with climate change. Presented for signature at the United Nations Conference on Environment and Development in Rio de Janeiro (Earth Summit) in 1992, the Convention immediately drew the signatures of 155 Heads of State and other senior representatives, and after its 50th ratification, took effect on March 21 1994. As of February 17 2003, 194 nations have ratified or acceded the Convention, thus binding themselves to its terms.

1.2 Objective

As stated in Article 2, the ultimate objective of the UNFCCC and all of its related legal instruments is as follows: *to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*

1.3 Principles

The three basic principles to be considered in working towards the objective of the UNFCCC are the precautionary principle, the common but differentiated responsibility of Parties, and contributions to sustainable development. As provided in Article 3, these are:

Precautionary principle: *The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.*

Common but differentiated responsibility: *The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.*

Contributions to sustainable development: *The Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change.*

1.4 Commitments of All Parties

The general commitments of both developing and developed parties are contained within Article 4.1 of the Convention. The most important of these include the development and publishing of national inventories of anthropogenic GHG emissions by sources and removals by sinks, and the formulation and implementation of national programmes containing measures to mitigate and adapt to climate change.

Other commitments outlined in Article 4.1 are related to the transfer of technology, practices and processes, the sustainable management and conservation of sinks, adaptation to impacts, promotion and cooperation in scientific and technological research, the exchange of information, and education, training and public awareness.

However, this is where the common commitments, between developing and developed countries, end. Article 4.2 of the Convention goes on to identify further commitments for developed country Parties and other Parties included in Annex 1. These countries are expected to take the lead in adopting measures to mitigate climate change and reduce greenhouse gas emissions. Thus, it was agreed that these countries should take actions to limit greenhouse gas emissions with the aim of returning individually or jointly to their 1990 levels by the year 2000.

The countries listed in Annex 1 of the Convention should also facilitate technology transfer and provide financial assistance to the developing countries so that they too may successfully implement the convention. In accordance with the principle of common but differentiated responsibility, the Convention fully recognizes that compliance by developing countries will be subject to this assistance. In addition, special attention is provided to the least developed nations and those that are most vulnerable to climate change impacts.

1.5 Commitments of Developing Countries (non-Annex I Parties)

All non-Annex I parties[1] to the convention are required to submit a national communication to the secretariat of the convention within 3 years of the entry into force of the Convention for that Party[2], or within 3 years of receiving funding for its development. The main purpose of these communications is to allow the assessment of the overall aggregated effects of the steps taken by Parties in the light of the latest scientific assessments concerning climate change, and the implementation of the convention, by the Conference of the Parties (COP) (COP2, Decision 10 1996). In accordance with Article 12.1 of the convention, national communications should include:

a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the COP;

b) A general description of steps taken or envisaged by the Party to implement the Convention; and

[1] Non-Annex I parties are mainly developing countries.

[2] Least developed countries may make their initial communication at their discretion (Article 12, UNFCCC).

c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

Concerning the second requirement listed above, non-Annex I Parties are encouraged to provide, to the extent their capacities allow and based upon national circumstances, information on programs and measures implemented or planned which contribute to mitigating climate change by addressing anthropogenic emissions by sources and removals by sinks of GHGs, including, as appropriate, relevant information by key sectors on methodologies, scenarios, results, measures and institutional arrangements (COP 8, Decision 17). It is this provision that the thesis research is founded upon.

The following study is based on a survey of the national communications of 100 non-Annex I Parties to the UNFCCC. Although national communications are intended to provide the information on national programs and measures detailed above, it is important to note that these communications do not always capture all relevant efforts and initiatives. In part, this is due to the relative young age of the convention and evolving guidelines for the development of national communications by non-Annex I Parties. Not all Parties have yet submitted their initial communication, and Mexico is the only party to have submitted a second communication. As a result, the development of first round national communications by non-Annex I nations has and continues to be very much a learning process, and as such, may not completely represent the national situation.

1.6 Problem Statement

Up until recently, climate change mitigation and development policy objectives have, for the most part, been pursued as separate policy objectives by governments. With the emergence and implementation of the UNFCCC, however, although not explicitly explored in the convention text, the integration of climate change objectives within national development programmes is acknowledged as an important sustainable development outcome. By implying that climate change policies have a role in the sustainable economic and social development of countries, particularly developing countries, the convention makes an important first attempt, in international law, to bridge the gap between the traditionally separate discussions of "development" and "climate change". Since the general acceptance of the greenhouse effect and global warming by the international community, tensions between industrialized Parties and developing Parties have often run high due to this division, with some in the industrialised world pushing the concept of Kyoto-like GHG reduction commitments upon developing countries, and the developing world strongly advocating their need for unhindered economic growth and social development.

Divided discussions of climate change and the development of nations have traditionally resulted from limited international research and understanding of the linkages between the two, and the potential sustainable development benefits of climate change mitigation policies and actions. This type of research is only just emerging and is mainly conceptual. Most of the emerging research is currently evolving out of the Clean Development Mechanism of the Kyoto Protocol, one of three mechanisms created to allow industrialised Parties to acquire GHG emission reduction units beyond national borders. Taking into consideration both the climate change mitigation and development discussions, the CDM aims to assist developing countries in achieving sustainable development and in contributing to the ultimate objective of the Convention, and at assisting the OECD countries and Economies in Transition in achieving compliance with their quantified emission limitation and reduction commitments (Article 12, Kyoto Protocol).

Yet, in recent years we have seen growing evidence of significant GHG reduction achievement in developing countries, resulting from the pursuit of "development only" policies. For example, the well-known and documented Ethanol Program in Brazil was originally developed to stabilize the sugar cane economy in light of wide fluctuations in the global sugar market, to reduce dependence on imported fossil fuels, diversify the fuel supply, and to address urban air pollution and the issue of massive unemployment in rural areas (Lebre la Rovere, 2000). As an ancillary benefit of this policy, significant reductions of carbon emissions have been achieved. In combination with Brazil's policy to use sugar cane bagasse as a fuel to generate electricity, Brazil's carbon dioxide emissions were reduced by 7 percent in 2000 (Chandler et. al., 2002). Another impressive example is that of China. Between 1996 and 2000, China reduced its GHG emissions by 15% and simultaneously achieved a 35% growth in its economy, without any explicit consideration for climate change mitigation impacts. Rather, measures were taken for their economic and environmental benefits. Although these policies, and others like it, may not be motivated primarily out of concern for climate protection, but for other pressing social and economic goals, they continue to illustrate the potential for policies and actions to simultaneously drive development and address climate change concerns.

However, despite an increasing interest in the development and climate change nexus, and mounting case studies and examples from the developing world demonstrating the achievement of significant GHG emission reductions as ancillary benefits of development policies, the implementation of development policies that consciously recognize climate change mitigation as an additional and important policy objective is minimal. As climate change mitigation and development policy objectives remain widely viewed as separate, climate change mitigation policies and programs in the developing world are often met with great scepticism, even if the pursuit of sustainable development objectives is equally advocated. As stated in the IPPC TAR (2001), " Given that developing countries have a large suite of pressing social and economic concerns besides emissions control, they tend to be wary of mitigation policies lest they undermine other policy goals"(Banuri et. al., 2001). As a result, and very understandably, climate change mitigation is simply not a priority in developing countries. This implies, however, that perhaps as a result of this wariness, further enhanced by our limited understanding of the potential sustainable development benefits of practices and policies normally implemented for their GHG reduction potential, not all potential development policies and actions are being identified and explored in the decision-making processes within developing countries. Yet it is these types of practices and programs, which simultaneously address a variety of sustainable development priorities, that may well represent the only chance of being adopted on a large enough scale to achieve significant emissions reductions and limitations globally, and that may thereby ensure the avoidance of dangerous anthropogenic interference with the climate system. It is for this reason that the wide spread exploration and implementation of these types of sustainable development measures is critical.

Therefore, the aim of this paper is to add to the discussion surrounding the linkages between sustainable development and climate change mitigation by studying the extent to which non-Annex I countries are implementing or exploring select actions that support both climate change mitigation and sustainable development objectives in the energy sector. An investigation of the potential sustainable development impacts of select climate change mitigation measures is carried out. Those practices offering the greatest sustainable development benefits are identified, and using the National Communications of non-Annex I countries as a point of departure, the extent of their implementation, and consideration, in non-Annex I countries is quantified. A further analysis of the technical and economic feasibility of these practices in those countries identified as neither implementing nor considering them is also undertaken. The main outcome of this analysis is the identification of those select actions representing the greatest opportunities for sustainable development that also supports climate change mitigation in the developing world.

1.7 Research Objectives

In accordance with the problem statement identified above, the main objective of this research is to determine to what extent non-Annex I countries are implementing or exploring select actions that support both climate change mitigation and sustainable development objectives, in the energy sector. The assumption is that a small representation of non-Annex I countries implementing a select action supporting both climate change mitigation and sustainable development may mean that not all potential development policies and actions are being identified or explored in the developing world and that this category of options supporting a range of sustainable development objectives is receiving too little attention.

The hypothesis of this research is that select actions supporting both sustainable development and climate change mitigation objectives in the energy sector are neither implemented nor considered to any great extent in the developing world, despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries.

The second objective of this study is to identify those select actions representing the greatest opportunities for sustainable development that also mitigates climate change, in the developing world.

2. Research Methodology

The research was undertaken following the general methodology detailed here. However, it is important to note that small adjustments in this methodology were carried out over the course of the research and are mentioned in detail where they are applicable in the following chapters.

Firstly, an initial review of 36 national communications was carried out to identify common practices that mitigate climate change in the following general energy sectors: energy generation and distribution, residential, commercial, industrial, transport. No more than four or five practices were identified for each sector. This step was based on the assumption that climate change mitigation practices implemented in developing countries, or that are being seriously considered in these countries, must already offer some degree of sustainable development benefits.

The next step was to assess these practices for their ability to support sustainable development objectives of developing countries. However, before the assessment could take place, an assessment tool was developed based upon GHG reduction and sustainable development indicators judged to be most relevant to non-Annex I countries. Each practice was then assessed by reviewing the development and climate change mitigation literature in an attempt to quantify the potential benefits these practices might achieve in ideal circumstances. The assessment tool and its indicators are described in later chapters.

Once the data was compiled, the practices within each sector were compared and scored against each other. The top one or two practices from each sector were then selected, resulting in nine preferred sustainable development actions that also support climate change mitigation.

The next step was to review all of the non-Annex I national communications for these practices to determine the extent of their implementation and/or consideration in these countries. Based on the results of this survey, a further general analysis of the technical and economic feasibility of these select actions in the developing world, and in particular, those countries not currently implementing or considering them, was carried out. Those actions found to be economically and technically feasible in the greatest number of countries not currently implementing or considering them are identified as those representing the greatest opportunities for sustainable development in the developing world. See Figure 1 for a descriptive flow chart of the methodology described here.

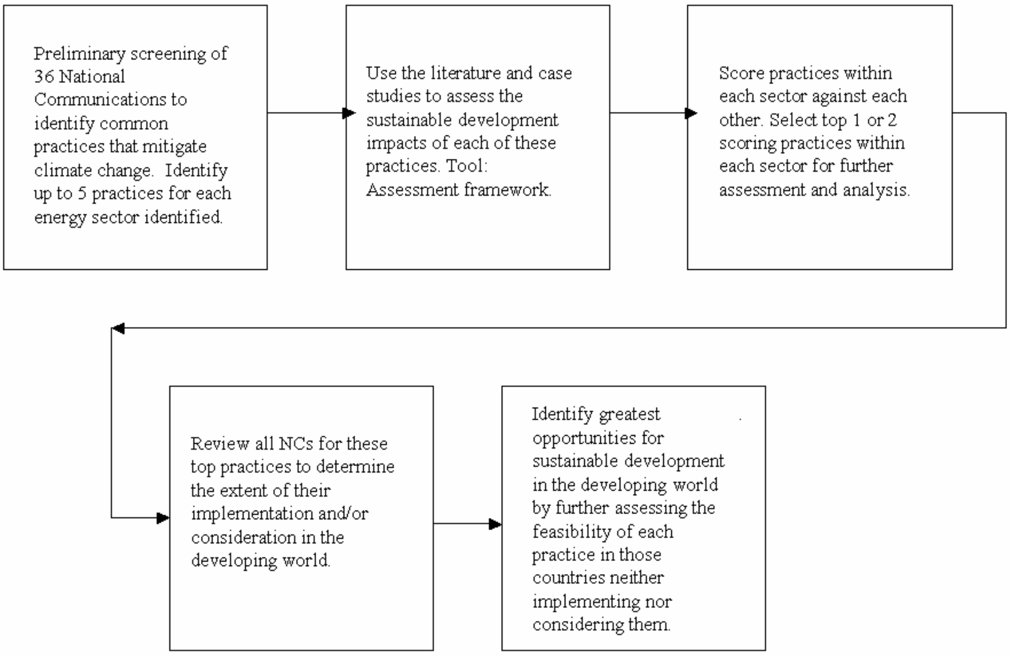

Figure 1- Research Methodology

2.1 Report Layout

The layout of this report closely follows the steps in the research methodology illustrated above. Chapter three describes how the first step in the methodology is carried out and how the 18 select actions are chosen. Chapter four outlines the assessment framework used to evaluate the actions identified in the previous step, in addition to further methodological details. The following chapter assesses the sustainable development impacts of each of the 18 actions, while chapter six outlines the results of the evaluation of the actions. Chapter 7 is dedicated to the review of all non-Annex I communications for the final nine select actions. This is followed by an analysis and discussion of the survey results. A conclusion section, followed by the appendices, wrap up the entire report.

3. Identifying "Good" Practices in non-Annex I Countries

3.1 The Inventory

This chapter describes the methodology and results of the first step in the research methodology previously detailed. The main objective of this step is the development of an inventory listing all of the mitigation practices implemented or considered by sector, in thirty-six[3] of the one hundred and three national communications. The purpose of the inventory is to give an indication of the most common climate change mitigation practices in the developing world. It is reasoned that those practices that are most common across countries, may be so because of their ability to simultaneously support sustainable development objectives. These types of measures are identified as "good practices" throughout the remaining report. Please see Appendix 2 for the inventory.

Steps taken to mitigate climate change in non-Annex I countries were identified using the National Communications as a point of departure. However, to better represent the non-Annex I community, other literature was used to identify actions in those countries that have not yet submitted National Communications (e.g. China, India, Brazil), and for those countries whose National Communication is published in a language other than English. Actions are categorized into two groups: namely, implemented and recommended. This latter category includes any activities identified in the Communication, or other literature, as planned, recommended, or identified in a mitigation option analysis. The inclusion of these actions in the inventory is considered important, as in most cases, their identification is the result of a formal assessment process in which mitigation options are generated based upon the specific criteria of the nation in question. These options are therefore generated with the development priorities, cost, and other important criteria in consideration. These options are considered the "best options" for mitigation in these countries, and by these countries. It is for this reason they are included in the inventory.

Specific mitigation projects and research studies sponsored by international or other foreign funding agencies were not included in the inventory, as there are so many going on in these countries and it would have been too time consuming to evaluate the relevant impact of these initiatives in further promoting mitigatory actions in these countries. It should also be noted that the inventory is not exhaustive and that the activities identified are solely based on reporting in National Communications and other limited literature.

For the energy supply sector, practices and measures are divided into the following categories: stand-alone energy applications, centralised energy applications, financial measures and other. Small hydropower, biomass to energy and solar applications are most common in the surveyed countries, for applications specifically identified as stand-alone. This includes the generation of heat and/or power and includes such applications as rural electrification applications, biogas applications in rural areas (for heating, lighting, cooking, electricity), and also includes in-house industrial applications of biomass to heat and power. However, if the literature noted that such an application exports power to the central grid, then this is considered a Centralised option, and is categorized separately.

[3] These thirty-six countries include: Maldives, Lao PDR, Lesotho, Kenya, Ethiopia, Uganda, Niue Island, Ghana, Egypt, Malaysia, Indonesia, Georgia, Macedonia, Albania, Bolivia, Chile, Argentina, Brazil, China, India, the Republic of Korea, Senegal, South Africa, Mexico, El Salvador, Colombia, Thailand, Philippines, Israel, Jordan, Lebanon, Sudan, Mongolia, Guyana, Dominica, and Ecuador.

For Centralised, large-scale applications of heat and/or power, switching fuel sources to natural gas is the most common practice, implemented in six countries and identified as an option for further consideration in seven more. This is followed by large-scale hydropower development with twelve countries, and by up grading of power generation infrastructure with ten countries. Financial policies promoting the development and penetration of renewable energy sources are also represented well in the countries surveyed. Ten countries have implemented or are considering implementing policies to remove market distortions surrounding renewables, like subsidized oil and gas industries, and eight countries have implemented or are considering implementing various subsidy programs and other fiscal incentive measures promoting the development and penetration of renewables.

For the residential sector, practices and measures are divided into six categories. These are as follows: cooking, heating, lighting, appliances, buildings, and other. In the cooking category, improved cook stoves and cooking with cleaner fossil fuels both are represented in eight countries each. In the heating category, the use of solar water heaters in homes is most common, with six countries implementing or considering implementing such a measure. For lighting, the replacement of lighting with more efficient types (e.g. substitution of incandescent bulbs with compact fluorescent bulbs) is of interest to at least twelve of the surveyed countries. With regards to the appliance category, seven countries have implemented or are considering implementing an energy efficiency labelling program for electric appliances, and five are implementing or considering implementing energy efficiency standards for appliances. However, in total, seventeen countries have implemented or are considering implementing initiatives related to the improved energy efficiency of appliances. In the buildings category, three countries indicated that they have implemented or are considering implementing a regulation requiring the mandatory installation of insulation in new buildings, in compliance with a thermal insulation standard. Two other countries indicate interest in the development of energy efficient building codes. In total, for the entire buildings category, seven countries have implemented or are considering implementing initiatives related to the improved energy efficiency of building envelopes. And finally, in the other category, the promotion of energy conservation through public information campaigns is most common, currently existing, or for consideration, in eleven countries.

For the commercial sector, practices and measures are divided into six categories. These include a cooking category, heating, lighting, appliance, building and other categories. Practices and measures for improved cooking and heating are not that common in the surveyed countries, however, twelve countries indicate that they have implemented or are considering implementing programs to improve the energy efficiency of commercial lighting. In the appliance category, nine countries in total have implemented or are considering implementing initiatives related to the improved energy efficiency of appliances. Equipment and appliance labelling is most common, with four countries at least interested in such a measure. In the building category, nine countries have implemented or are considering implementing energy efficient building codes that include provisions for improved building design and/or thermal integrity of buildings. Eight countries have implemented or are considering implementing energy efficient standards for commercial buildings. In total, twenty-six of the thirty-five countries surveyed identified some measure aimed at improving the energy efficiency of commercial buildings. Lastly, in the "other" category, six countries indicated that they are implementing or are considering implementing auditing programs in the commercial sector, and six countries are implementing or considering implementing fiscal incentive measures to promote energy efficiency and conservation in the sector.

For the industrial sector, practices and measures are divided into four categories. These are as follows: general measures for all industries and industrial equipment, measures for improved efficiency of buildings and lighting, measures for specific equipment and industries, and other. In the first category, three measures in particular are most common in the surveyed countries. The most common is an energy auditing and consultation service, implemented or considered for implementation in eight countries. Seven countries indicate they are providing or are considering providing financial support for energy efficiency improvements in industry, and six countries indicate a general overall policy for the replacement or upgrading of old technologies in the industrial sector. In the second category, a total of four countries overall indicate that they are implementing or considering implementing measures for the improved energy efficiency of industrial buildings and lighting. In the third category, the two most common measures are aimed at the improvement of motor and boiler efficiency. Measures to improve the efficiency of boilers are being considered for implementation in six countries, whereas measures to improve the efficiency of motors are being considered for implementation in five countries. In the other category, co-generation of heat and power is of most interest, currently implemented or considered for implementation in six of the countries surveyed.

Finally, for the transport sector, practices and measure are divided into four categories. These are as follows: measures related to transportation infrastructure, public transport, private vehicles, and other. In the first category, measures to reduce traffic congestion by improved traffic management are implemented or considered for implementation in five countries, as are measures to improve transportation infrastructure (roads). In the public transport category, the promotion of public transport, in general, is the most common practice identified in the countries surveyed. Alternative fuels for buses are next, identified in a total of 6 countries if measures promoting both NG/CNG/LPG and fuel cells are combined. In the third category, 11 countries combined have adopted or considered the adoption of alternative cleaner fossil fuels (NG/CNG/LPG) and biofuels, seven countries have implemented or are considering implementing measures to ensure vehicle maintenance and a total of eight countries have implemented or are considering implementing import restrictions or high import duties on vehicles. In the final category, the most common practices are the implementation or planned implementation of information campaigns on fuel conservation, and the introduction of catalytic converters (both represented by four countries each).

3.2 Final Selection

The preliminary screening of approximately one third of non-Annex I National Communications resulted in the identification of the following eighteen practices that are assumed to simultaneously mitigate greenhouse gas emissions and support sustainable development objectives in the energy sector of these countries. Where deemed necessary, an explanation for the selection is provided. It should be noted that the most common practices across countries are not always selected. In addition, it is also important to note that the energy sector categories adopted in the inventory stage, change somewhat in this process to better enable the comparison of options within the same sector in the next stages of the research.

In accordance with the inventory results for stand-alone, decentralised applications of heat and/or power, biomass to energy, small hydropower and solar applications are selected for further assessment and analysis. However, to ensure the comparability of these options in the following assessments and evaluations, these options shall be limited to electricity generation applications.

For large scale, centralised applications of heat and/or power generation, the following three measures are selected: large-scale hydropower development, improved efficiency of power generation by up grading of infrastructure, and biomass to energy applications. This differs somewhat from the results obtained in the inventory. For example, the substitution of conventional fuels with cleaner, natural gas is the most common practice identified in the countries surveyed. However, as there is particular interest in biomass to energy applications by the international community as a whole, and as its poorer representation in the countries surveyed is not considered a true indication of its ability to support development priorities, it is substituted for the natural gas option, for further assessment and analysis. However, to ensure the comparability of these options in the following assessments and evaluations, these options shall also be limited to electricity generation applications.

Measures and practices identified in the residential and commercial sectors have been combined to some extent. In both of these sectors, measures related to the improved energy efficiency of lighting, appliances and buildings are most common, therefore, the following measures are selected for further assessment in the residential/commercial sector: energy efficient lighting, energy efficient appliances and energy efficient building envelopes. However, measures to reduce GHG emissions caused by cooking are also very common in the surveyed countries. Therefore, the following measures related to improved cooking in the residential sector are selected for further assessment: improved cook stoves (identified in 8 countries) and cooking with alternative cleaner fuels, including both fossil fuels and biofuels (identified in a total of 10 countries).

With regards to the industrial sector, none of the measures detailed in the first category of "general measures for all industries and industrial equipment," are selected, as they are considered too general, all aiming to improve the energy efficiency of non-specific industrial equipment and operations. Therefore, more attention is focused upon the category of specific industrial measures. From this category, the two most common measures are selected, relating to improved motor efficiency and improved boiler efficiency. In addition, co-generation of heat and power is also selected as an option for further assessment and analysis.

The following measures and practices are selected in the transport sector: alternative fuels for transport, improved transport infrastructure, vehicle maintenance and vehicle import restrictions (demand management). These are in accordance with the inventory results, however, several measures are combined. For example, alternative fuels for transport include measures related to both public transport and private vehicles and also include biofuels, fuel cells and cleaner fossil fuels (total of 17 countries). Measures for improved transport infrastructure also include measures to reduce congestion, like the building of fly-overs and ring roads, and the implementation of traffic management measures (total of 12 countries). As for vehicle import restriction measures, these include both import restriction and high import duties on vehicles (total of 8 countries). Measures to ensure vehicle maintenance, common in seven of the countries surveyed is also selected for further study. See summary table below for a complete listing of the eighteen practices selected here.

Table 1- Summary Table of Selection Results

Energy Sector	Selected Measures
Stand-alone, decentralised applications of heat and/or power	Small hydropower Biomass to electricity Solar
Large-scale, centralised applications of heat and/or power	Hydropower Biomass to electricity Improved efficiency of power generation by up-grading of infrastructure
Residential/Commercial sector	Energy efficient lighting Energy efficient appliance Energy efficient building envelopes
Residential sector	Improved, energy efficient cook stoves Alternative cooking fuels
Industrial sector	Energy efficient motor systems Energy efficient boilers Co-generation of heat and power
Transport sector	Improved transport infrastructure Alternative transport fuels Vehicle maintenance Vehicle import restrictions (vehicle demand management)

The next section describes how these eighteen options are further narrowed down.

4. Climate Change Mitigation Option Assessment Tool and Methodology

This section of the report details how the eighteen "good" practices identified in the preliminary screening of the National Communications are further assessed to identify those practices offering the greatest sustainable development and climate change mitigation benefits.

4.1 Assessment Framework

To further narrow these eighteen practices down, an assessment tool is developed here to evaluate and score each of these on the basis of their climate change mitigation and sustainable development potential.

4.1.1 General Assessment Criteria

Both the Convention and the Kyoto Protocol indicate that initiatives to mitigate climate change should conform to the three principles listed below.

1. They should reduce GHG emissions and thus contribute to the Convention's overall goals.

2. They should promote sustainable development

3. They should correspond to national circumstances of the country taking action

The assessment framework presented in this section is designed primarily to reflect the first two principles, in the context of non-Annex I countries to the Convention. The third principle was not independently considered in this assessment, as the identification of "good practices" in this exercise is not intended to be country specific, but to be more generic in nature.

The criteria and indicators included in the framework were chosen upon careful review of several bodies of literature, the most important of these being ancillary benefit studies of climate change mitigation practices, and the relatively new and evolving literature surrounding project selection criteria for CDM projects[4]. In particular, indicators for assessing the consistency of climate change mitigation initiatives with objectives for sustainable development in the context of developing countries are developed based upon this CDM literature. Additional resources included materials devoted to the identification of good practices in policies and measures for climate change mitigation, climate change mitigation project selection criteria, environmental policy evaluation criteria, sustainable development indicators, sustainable energy development indicators and more.

The indicators developed to measure/assess the principles identified above are as follows:

[4] See literature review for an overview of the evolution of studies focused on the assessment of ancillary and co-benefits associated with climate change mitigation programs and policies. (Appendix 1).

Climate change mitigation potential

a. GHG emission reduction potential: Measured as a function of the % reduction in GHG emission from the baseline technology or scenario, and for some sectoral assessments, also includes an evaluation of the overall theoretical potential of the measure to reduce GHG emissions in the developing world. Fuel or energy saving, measured in percent reduction from the baseline, is often used as a proxy.

b. Marginal Abatement Cost: CO_2 abatement cost (USD/tonne CO_2 emissions avoided)

Consistency with sustainable development objectives

c. Employment generation: measured by the number of new jobs created

d. Improved balance of payments: measured in net foreign currency savings in USD

e. Health benefits: in reduction of health damaging pollutants like lead, CO, particulate matter, SOx, NOx, ozone, by tonne

f. Environmental benefits: in reduction of other environment damaging pollutants by tonne

g. Improved sustainable use of natural resources: measured by the reduced depletion of non-renewable natural resources, by tonne

h. Poverty reduction: measured by any direct increases in personal wealth or through the provision of opportunities for other income generating opportunities, education

i. Benefits to important or disadvantaged groups: measured by any economic or other benefits accruing to important or disadvantaged groups in society to reduce wealth disparities and improve social equity

j. Improved availability and access to energy: measured as a function of any increase in the fraction of households with access to electricity

k. Improved energy security: measured as a function of any diversification of the energy supply mix to reduce reliance upon energy imports, or through energy conservation and efficiency.

l. Achievement of OTHER development objectives/benefits (list other benefits not identified above)

Table 2- Assessment Framework for the Evaluation and Identification of "Good Practices"

Criterion	Measured/Assessed by	Details	Evaluation
Climate Change Mitigation	GHG reduction		
	Marginal Abatement Cost		
Achievement of sustainable development objectives	Employment generation		
	Improved balance of payments		
	Health benefits		
	Environmental benefits		
	Improved sustainable use of natural resources		
	Poverty reduction		
	Benefits to important or disadvantaged groups		
	Improved availability/access to energy services		
	Improved energy security		
	Achievement of other development objectives or benefits		

Traditionally, studies and evaluations of climate change mitigation policies and programs have focused on the determination of the net financial costs of these per tonne of carbon dioxide avoided, and the identification and prioritisation of the lowest cost options (see literature review, Appendix 1). However, in the framework presented above, this indicator is only one of twelve. The remaining 11 indicators may be considered to represent potential non-financial costs and benefits of the policy or program in question. Non-financial costs or benefits may be considered as those that are not traditionally associated with the financial viability of a climate change project or program (investment costs, operation and maintenance costs, fuel saving benefits etc.), and that in some way indicate progress towards sustainable development (Kolominskas, 2003 personal communication). In terms of climate change projects in the energy sector of developing countries, non-financial benefits may include labour saving, the empowerment of women, job creation, health benefits, time saving, an increase in disposable income for households etc., all of which are captured in the indicators presented above. Although financial returns may actually accrue from these benefits, these do not feed directly back into the project or program itself, and instead may feed into other sectors of the economy, and society as a whole. Valuing these benefits and costs, however, is often extremely difficult or impossible, and often results in heavily biased decision-making procedures that prioritise low cost options that may not offer the greatest economic benefit to society. As this research focuses on the assessment of policies and programs that address climate change from a national perspective, rather than the perspective of a development agency or foreign investor, those options offering the greatest benefits to society are preferred. Therefore, although the marginal abatement cost (MAC) of each option is determined in the following assessments, each of the 11 remaining indicators attempts to capture the potential non-financial benefits so as to improve the comprehensiveness of the evaluation.

4.2 Option Evaluation by Sector

All eighteen practices were evaluated against the framework developed above. Although quantitative data was preferred, in most cases this type of data was extremely difficult to locate. As a result, most of the data collected to satisfy the indicators provided in the assessment framework, is qualitative in nature.

In order to estimate the potential climate change mitigation and sustainable development benefits of each practice, the development of a baseline technology or scenario is necessary. Furthermore, in order to enhance comparability of the options within a sector, a baseline scenario for each sector must also be developed. The standardization of a baseline scenario for each sector is extremely important. Without this standardization, the results of the assessment may not be comparable, and could severely compromise the results of the entire research effort.

Each of these baseline technologies and scenarios, and their relevance, are discussed below.

4.2.1 Baseline Scenarios

For the large scale, centralised power supply options, coal and oil based thermal power generation was assumed in the baseline scenario. The main reasoning for this is that as of 2000, oil and coal together made up 58.9% of the primary energy source in developing countries (IEA, 2002). Estimates of GHG reduction potential were calculated based on the dirtiest of these fuels, which is coal. Conventional coal is assumed to have a life cycle GHG emission intensity of 960-1300 g CO_2-eq/kWh (Holdren & Smith, 2000). To estimate the potential climate change mitigation and sustainable development benefits of each of the three power generation options selected for this sector, each is compared against this baseline, and what would otherwise occur in such a scenario.

For the small scale, decentralised power supply options for off-grid rural communities, a diesel generator was assumed to produce electricity in the baseline scenario. However, some expansion of energy services is also assumed, resulting in an increased fraction of households gaining access to electricity as a result of the implementation of the new power supply option. To calculate the GHG reduction potential, the diesel generator baseline technology is assumed to emit 700 g CO_2 eq/kWh (Climate Change Solutions, 2001), however, it is important to note that this is not a life cycle GHG emission intensity value. As a result, some uncertainty is introduced into the estimations of the GHG reduction of each option from the baseline as life cycle emission estimates of these were used.

The baseline technology used to assess cooking options in the residential sector is a traditional biomass-fuelled stove with an assumed efficiency of 12-18%.

The baseline scenario used to assess residential/commercial options involves coal and oil based electricity and heat generation. A baseline technology for each option is also assumed. For the efficient lighting option, this baseline is incandescent lighting, and for the efficient appliance and building options, it is the average existing efficiency of appliances and buildings in the developing world (where data was available).

For the industrial sector, coal and oil fuels are also assumed to provide the electricity and heat required by industrial processes. For each option a baseline technology is also assumed. For the CHP option, the baseline scenario involves the separate production of heat and power, where electricity is consumed from the national grid. For the efficient motor system option and the efficient boiler option, the baseline technology is the average existing efficiency of these technologies in the developing world.

Finally, the baseline scenario considered for the transport sector as a whole involves the use of conventional gasoline to fuel vehicles. Like the other sectors discussed above, baseline technologies for each of the four options were developed. For the alternative fuel option, the baseline for comparison is conventional gasoline fuel and vehicles. The baseline scenario developed for the improved transport infrastructure option is the average fuel consumption of existing vehicles on dirt roads in developing countries. As for the vehicle demand management option, the developed baseline considers a complete lack of import restrictions on second-hand cars and therefore, a high and inefficient average fuel consumption of vehicles in the developing world. Lastly, for the vehicle maintenance option, the baseline for comparison is a poorly maintained vehicle.

Additional assumptions were also made. However, these are described where relevant, in the following chapter.

4.2.2 Scoring System and Methodology

The potential climate change mitigation and sustainable development impacts of each option are determined by comparing the potential impact of the option with the potential impact of the baseline scenario for each of the indicators detailed in the assessment framework above.

Once the impact against the baseline scenario for each of the criteria, and for each of the options within the sector is determined, each option is scored in relation to the others within the sector to identify the practices offering the greatest climate change and sustainable development benefits. The scoring system used is as follows:

Table 3- Scoring System

	Negative Impact	Positive Impact
High Impact Expected	-3	+3
Medium Impact Expected	-2	+2
Low Impact Expected	-1	+1
No Impact Expected	0	0

The scoring system illustrated in Table 3 is used to score for all criteria, however, scoring for GHG reduction potential and the marginal abatement cost is scored only positively. This is understandable for the GHG reduction potential, as all measures offer some level of climate change mitigation. As for the MAC criteria, the elimination of negative scoring was facilitated to simplify the scoring procedure.

As suggested above, the actual scoring process involves direct comparisons between options, of the estimated impacts for each criterion. At all times, scoring in relation to the estimated impacts of the other option is attempted. For example, the practice offering the largest positive impact on job creation is scored with a three, the practice offering the next largest impact is scored with a 2, and so on. In many cases, the exact same score for a criterion may be assigned to two or more practices. This suggests a high level of uncertainty as to which practice offers the greatest positive benefit. In cases where a negative score is assigned, judgement is passed to determine the significance, and scoring, of the negative impact.

It is also important to note that all criteria are weighted equally. As a decision-maker choosing between potential national programs for sustainable development, such a scenario is however, unlikely. National circumstances and priorities should play an important part in determining how each of these criteria is weighted. However, as the purpose of this exercise is not to favour any one set of national circumstances with potential climate change and sustainable development options, all criteria are weighted equally.

Upon completion of the scoring procedure for each option, the score is tallied to determine the most preferred options in each sector. The presence of the top one or two practices in each of these sectors, in non-Annex I countries, shall be determined in a later stage.

4.2.3 Assessment Criteria Limitations

Before reviewing the following section, it is perhaps important to note beforehand the limitations associated with the marginal abatement cost criterion of the assessment framework presented above. It is very important that the marginal abatement cost criteria for this assessment be considered carefully as some of the figures identified are estimated based on predictions of GHG mitigation potential of the option in question, in a specified time horizon, while others are calculated from actual program costs and results. The ranges of costs identified in the following assessment are pulled from a variety of literature including the UNEP Greenhouse Gas Abatement Costing Studies, National Communications, the Asia Least Cost Greenhouse Gas Abatement Studies (ALGAS), and private studies carried out by experts. However, the calculation of the marginal abatement cost of a mitigation practice is a function of many variables that can differ significantly between studies, even within the same country and for the exact same assessment. The calculation of this number, in most of the studies, required the generation of a future and baseline scenario. This future scenario involves estimates of the penetration rate of the technology, based on the predicted economic situation, the expected costs of the technology, market conditions, population growth etc. This is used to estimate the potential GHG reduction that may be achieved through the implementation of the technology, by subtracting the predicated cumulative amount of GHG emission in the future mitigation scenario, from what is expected in the baseline situation. The cost value is generated in consideration of all costs and savings that are expected to result in the specified time horizon, which also varies widely between studies. However, a discount rate must also be applied in order to discount future expected costs to today's (the studies baseline year, which also varies widely) values. Therefore, already several variables have been identified that undoubtedly vary significantly between studies. In combination, these make comparisons of MACs for the same practice very difficult. However, this information should certainly not be considered useless, as it can be used to generate an interesting general picture of the relative costs of practices being compared for cost-effectiveness. A decision-maker choosing between several climate change mitigation options can use the ranges generated here to gain an improved understanding of which options are within budget limitations, and which would most likely lie outside of these.

The next section in this report describes each of the eighteen climate change mitigation options and estimates the potential sustainable development impacts for each of them. Summary information tables are provided in Appendix 3 of this report. The score for each option is provided in the end of each sectoral description, along with any comments regarding the actual scoring procedure.

5. Climate Change Mitigation Option Assessment

5.1 Centralised Climate Change Mitigation Options for Electricity Generation

As noted in the previous section, the baseline scenario assumed here is that of electricity generation by conventional coal steam turbine technology. The life cycle GHG emission intensity of conventional coal is assumed to be 960-1300 g CO_2-eq/kWh (Holdren & Smith, 2000).

5.1.1 Biomass to Electricity

There are many ways in which biomass can be converted to energy in the form of electricity. Combustion of biomass to produce electricity on commercial scales is prevalent in many countries, and is often set up in cogeneration schemes in industry. Biomass can be combusted directly in boilers to produce steam for electricity, or it can be transformed into a combustible gas to generate electricity, either by gasification or anaerobic digestion. However, to simplify the assessment undertaken here, and as gasification of biomass is of increasing interest in the developing world, only the gasification option is evaluated. Gasification of biomass involves the conversion of solid biomass fuel (wood and agricultural residues, energy crops etc.) into a gaseous fuel. At a high temperature, biomass is gasified by burning it without sufficient air for complete combustion but with enough air to convert the solid biomass into a gaseous fuel (UNDP, 1994). Before combustion, the gaseous fuel produced in the gasifier is cleaned, resulting in lower emissions of sulphur dioxide, nitrogen dioxide and particulate matter than electricity generation from fossil fuels (Turkenburg, 2000). As for GHG emissions, it is estimated that biomass gasifier technology can reduce these by between 82-97% from the baseline technology[5].

One of the most promising technologies for biomass gasification is biomass integrated gasification/combined cycle (BIG/CC) technology, which has flexible fuel characteristics and a high electrical conversion efficiency. With the implementation of the BIG/CC technology, electrical efficiencies of 40-55% are possible at a scale of 30-100 MWe. This is greater than what can be achieved in the direct burning of biomass in stand-alone applications. In this type of application, an electrical efficiency of 20-40% can be achieved at a scale of 20-100 MWe (Turkenburg, 2000).

Biomass gasification can occur both at the small and large scale. At the large scale, biomass gasifiers can be arranged in co-generation configurations and provide electricity to the grid. These facilities can produce 10-100 MW of electricity (UNDP, 1994). As identified above, the generation of electricity by the burning and/or gasification of biomass residues often occur within industry. Industries for which this is most common are the sugar cane and pulp and paper industries, which both use process residues to generate heat and power for internal processes.

[5] Life cycle GHG emission intensity of biomass fuel 37-166 gCO2-eq/kWh (Holdren & Smith, 2000).

BOX 1: Biomass to Electricity in the Sugar Cane Industry

In developing countries, the sugar cane industry is a particularly favourable target for gasification technology. It is suggested that the amount of electricity that could be produced in such an application could be up to 44 times the on-site power needs of the sugar factory (Gabra, 1996). Currently in most developing countries, sugar manufacturers produce their own in-house electricity and heating needs by burning the leftover sugar cane residues in large boilers. This residue is called bagasse and is the left over fibre of the sugar cane after the sugar has been removed. Most of the energy produced from the burning of bagasse, in the form of low-pressure steam, is used to evaporate water from the juice to concentrate it to the point where sugar crystallization occurs. However, many sugar manufacturers operate inefficiently and have little incentive to optimise their energy production in order to sell excess power to other consumers, due to centralized decision-making in the electrical sector, low supply tariffs and other factors discouraging investment (UNDP, 1994). See figure below for characteristic conversion efficiencies for a range of technical options for electricity generation by sugar manufacturers.

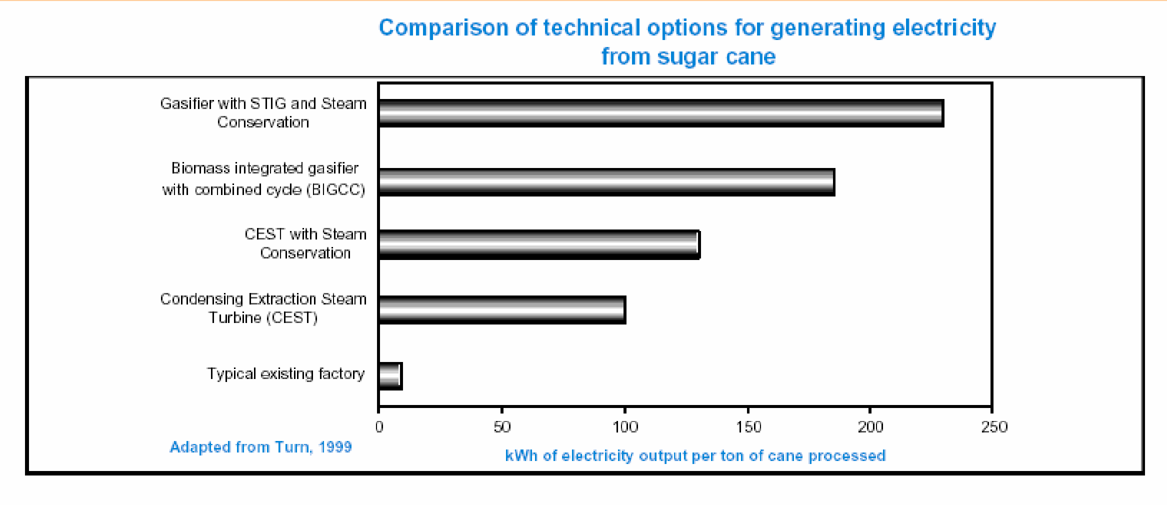

Figure 2- Conversion Efficiencies of Technical Options for Electricity Generation From Sugar Cane

Source: UNDP, 1994 page 16

As illustrated in the figure, the efficiency of electricity generation using sugar cane residues can be improved significantly through the use of gasification technology.

In Brazil, cogeneration of electricity and process heat in sugar refineries and alcohol plants using cane bagasse has been common for many years. However, the upgrade of systems and the production of electricity surpluses have only recently become attractive due to tariff reforms encouraging investment by the sugar cane industry in the export of electricity (Winrock International Brazil, 2002). Between 1999-2001, 40% of the almost 1, 000 MW of bagasse-fired cogeneration capacity in Brazil was created. The PROINFA program, a recent incentive program for alternative energy sources launched in 2002, aims to expand this capacity by another 1, 100 MW by 2006 (Chandler et. al., 2002).

Estimates of the marginal abatement cost of biomass to electricity applications in general range from 25-38 USD/ton CO_2 abated according to Energy Resources International (1999) and from –17 to 32.7 USD/t CO_2 abated specifically for biofuel applications of BIG/CC technology according to the IPPC (Moomaw & Moreira, 2001, pg. 256). In Brazil, the MAC of fuelwood gasification with pulp residues has been estimated at 0.65 USD/t CO_2 abated (Seroa da Motta et. al., 2000). As barriers to the export of electricity to the grid by industry and other producers continue to be removed in the developing world, an increasing interest in biomass for electricity generation by industry will most probably result. This could lead to additional employment opportunities in the collection and transport of waste residues, and in the operation of the electricity generation plant. If independent electricity generation plants are developed, this could lead to potential opportunities in the development, operation, maintenance and harvesting of commercial energy plantations (wood fuel, maize etc), thereby generating significant income in rural areas.

Large-scale biomass to energy projects would most likely address poverty issues through the creation of additional job opportunities in rural areas, and rural development. Financial benefits in the form of additional income to farmers and manufacturers would also result.

Biomass to generate electricity, if implemented on a large enough scale, can also positively impact upon the balance of payments of a country through reduced fossil fuel imports. However, depending on the technology selected to facilitate the conversion of biomass to energy, negative impacts may be experienced if the technology must be imported (e.g. gasification technology). Such a measure also enhances energy security through the diversification of supply.

The overall potential for biomass as an energy source to replace fossil fuel energy sources is significant, particularly in densely populated regions where much of the land is used for food production and large amounts of agricultural by-products or wastes are generated. A powerful example of this is provided in the UNDP paper, "Clean Energy Biomass," (1994). In 1996, China generated a combined total of 790 million tons of agricultural residue from the field (mainly corn stover, rice straw and wheat straw) and from agricultural processing (rice husks, corn cobs and bagasse). If half of this resource were to be used for generating electricity at an efficiency of 25%, the resulting electricity generation would be about half of the total electricity generated from coal in China in 1996.

5.1.2 Hydropower Development and/or Expansion

Large-scale hydropower involves the construction of a high dam over a large river to create a reservoir. Electricity is generated by allowing the stored water to flow, at controlled rates, through turbines attached to an electrical generator.

In some regions of the developing world, like Sub-Saharan Africa, centrally planned Asia and India, less than 18 percent of the economically feasible hydropower potential is in use (Turkenburg, 2000). In Latin America and the Caribbean nearly 44 percent of the potential is in use. This suggests that there is great potential for hydropower to replace fossil fuel as an energy source in developing countries.

Although the actual generation of electricity from hydropower does not result in the emission of greenhouse gases, bacterial decomposition of biomass in flooded reservoirs may result in the emission of CH4 and CO_2. The magnitude of this effect can only be determined on a case-by-case basis (Ishitani & Johansson, 1996). Therefore, it is estimated that this option can reduce GHG emissions by between 57-99.8% from the baseline technology[6]. Other significant ecological and social impacts may result from hydropower generation. Some of the most important impacts are changes in fish quantity and biodiversity, increased sedimentation, loss of species habitat and biodiversity, reduced water quality, proliferation of water-related human diseases and downstream social impacts in the form of increased competition for water resources, decreasing agricultural yields by reduced flow of natural fertilizer (silt) to land etc. (Turkenburg, 2000). Perhaps the greatest social impact is that of forced displacement of inhabitants from flooded areas. As a result of these significant impacts, the overall cost of producing hydropower is increasing, making it increasingly uneconomical in developing countries.

In terms of the marginal abatement cost of this option, this has been estimated at between 25-38 USD/ton net CO_2 avoided, by Energy Resources Internationals (1999), and between –2.7 to 35 USD/ton CO_2 avoided, by the IPPC (Moomaw & Moreira, 2001).

In terms of employment, the construction of a large hydroelectric dam will undoubtedly create a significant number of jobs in the short term, in both dam construction and in the creation of an infrastructure, including an improved transport infrastructure, for the large workforce (Ishitani & Johansson, 1996). In fact, such infrastructure development has often been viewed as a tool to stimulate regional economic and industrial development, with the notion that jobs will most likely be created indirectly in the long-term. However, flooding of significant land area in rural regions may also lead to a significant loss of employment for people working in the agricultural sector and in local businesses. Evidence from several hydropower projects shows that the "employment boom" created by new construction temporarily absorbs some resettlers, but severely drops by the end of the project. As reported in a World Bank study, unemployment or underemployment among resettlers often endures long after physical relocation has been completed (World Bank, 1997).

Like the potential employment effect of hydropower development, its impact on poverty in the region is also difficult to assess. As suggested above, the increased infrastructure in the region may stimulate economic and industrial development in the long term, thereby increasing income generation in the area. However, displaced peoples could experience a significant reduction in personal wealth, leading to further impoverishment.

However, regardless of its many environmental and social drawbacks, hydropower generation can significantly reduce the need for fossil fuel imports, positively influencing the balance of payments of a country and resulting in enhanced energy security. This is particularly important for many developing countries that spend large amounts of their national income on fossil fuel imports.

5.1.3 Improved Efficiency of Conventional Power Generation by Upgrading of Infrastructure

The efficiency of energy conversion is dependant on its design and on its condition relative to design specifications. When the condition of the equipment deteriorates, the efficiency of the system deteriorates as well, which leads to increased emissions of GHGs. Therefore, efficiency improvements can significantly reduce GHG emissions. Actions that fit into this category include improved firing equipment, boiler improvements, turbine maintenance and

[6] Life cycle GHG emission intensity of hydroelectric 2-410 gCO2-eq/kWh (Holdren & Smith, 2000).

improvements, proper selection and maintenance of auxiliary equipment, and use of modern plant instrumentation and control systems (Energy Resources International, 1999). Installing co-generation, or adopting new, more efficient power generation technologies can also improve efficiency. It is this latter action that shall be discussed here.

Both China and India, two of the fastest developing non-Annex I countries, rely heavily on domestic coal stocks for energy and both will continue to do so in the future, with major implications for global climate change. For this reason, Integrated Gasification Combined Cycle (IGCC) technology for improved efficient electricity generation is being considered and/or adopted in these regions, and is therefore the technology of choice evaluated here.

IGCC technology converts coal into a combustible and purified gas, which is passed to a gas turbine to produce electricity. The gases of this process generate steam for further electricity production. The efficiency of IGCC can be up to 50-55%, whereas the efficiency of a conventional steam turbine to produce electricity is only about 30-40% (Energy Resources International, 1999).

Due to a wide variety of potential gas cleaning treatments, IGCC technology offers great potential to meet strict air pollutant emission limits (Ishitani & Johansson, 1996). The emission of particulate matter can be all but eliminated, SO2 emission can be reduced by 90-99% and emission of NOx can be reduced by 60-90%. On top of this, CO_2 emission can be reduced up to 38% compared to conventional steam coal plants[7]. These reductions in emissions bring significant health and environmental benefits in the form of reduced air pollution and acidification.

The marginal abatement cost of this option has been estimated as part of two studies assessing the potential for this technology as a CDM project in India (Pathak, Srivastava & Sharma, 2000) and China (Ji & Junfeng, 2000). The Indian study estimated that it would cost approximately 26 USD to abate one tonne of CO_2, while the Chinese study determined that it would cost 18 USD. In addition, the IPPC estimates that the MAC of this option ranges from between –2.7 to 54 USD/tonne CO_2 abated (Moomaw & Moreira, 2001).

Job creation through the improvement of conventional power generation is not expected to be significant. Savings of fuel in the long term could lead to job creation in other sectors through increased spending.

No significant poverty alleviation or equity benefits are expected from the upgrading of coal-based electricity generation.

As coal is typically a domestic energy source (international trade in coal amounts to only 13% of production, a smaller share than for gas [Rogner, 2000]), impacts on the balance of payments are not expected to be significant. Minor negative impacts may be experienced if gasification technology must be imported from abroad. However, energy security benefits are achieved by the continued and more efficient use of domestic coal resources, rather than dependence upon foreign oil and/or gas imports.

[7] Life cycle GHG emission intensity for advanced coal: 800 – 860 g CO2/kWh (Holdren & Smith, 2000).

5.1.4 Option Evaluation

Table 4- Centralised Power Sector Option Evaluation

Power Generation Options / Criteria	Biomass Gasification	Hydropower	IGCC
GHG reduction from baseline	3	2	1
Potential to replace conventional energy sources overall	3	2	1
Marginal abatement cost effectiveness (USD/t CO_2)	3	2	1
Employment generation	2	2	1
Improved balance of payments	1	3	-1
Health benefits	1	2	2
Environmental benefits	1	0	2
Improved sustainable use of natural resources	3	3	1
Poverty reduction	2	1	0
Benefits to important or disadvantaged groups	2	-2	0
Improved availability/access to energy services	0	0	0
Improved energy security	2	3	1
Achievement of other development objectives or benefits			
Total Score	23	18	9

As apparent from the evaluation matrix above, biomass gasification is expected to have the greatest climate change and sustainable development benefits of the three power sector options. Biomass gasification is estimated to offer the greatest potential to replace conventional energy sources in the future due to the abundance of biomass in the developing world. The potential for hydropower is also considered high, however, it was not scored as highly because of the often severe environmental and social consequences associated with its development.

For both the employment generation criteria and the poverty reduction criteria, a range in score from 1 to 3 (low to high impact) is considered more accurate for the biomass gasification option, as the impact here is highly dependant upon the situation (e.g. job creation as a result of energy plantations would be much greater than would arise if gasification technology was combined with already existing sugar cane ethanol production facilities and electricity was sold to the grid). The middle score of two was therefore assigned to these criteria. Both biomass gasification and hydropower were assigned the highest scores for improved sustainable use of natural resources, as both of these options are renewable energy sources. As a result of its potential for causing massive disruptions to the lives and livelihoods of rural inhabitants in the long term, hydropower is assigned a score of –2 for its impact upon important or disadvantaged groups. All three options are assigned a score of 0 for their contribution to improved energy services, as all of them are assumed to simply replace conventional energy sources, rather than expand services.

5.2 Decentralised Climate Change Mitigation Options for Electricity Generation in Rural Communities

As noted previously, the baseline scenario for this category involves the generation of electricity by diesel generator in remote, off-grid locations. However, some expansion of electricity services is assumed for all options, over the diesel generator baseline. The GHG emission intensity (not life cycle) of the baseline technology is assumed to be 700 g CO_2 eq/kWh (Climate Change Solutions, 2001).

5.2.1 Solar

Solar energy can be captured and converted into electricity by several means, including central stand-alone solar generating units that can supply geographically grouped populations and individual photovoltaic systems for isolated households. Household units are specifically assessed here.

A household photovoltaic system includes a solar panel, a regulator, a battery and a distribution box. The solar panel is usually installed on the roof and converts sunlight into electrical power. From the solar panel, electricity is passed along a wire to the regulator, which keeps the battery from overcharging or draining and converts the electricity to the proper voltage (if necessary) before it is delivered through the distribution box to the end-use devices (UNDP, 2001). End-uses may include lighting, water pumping, refrigeration and educational purposes.

Although PV devices emit no GHGs or other pollutants while in operation, some systems involve the use of toxic materials, which may pose risks in manufacture, use and disposal of the devices. Toxic materials are also present in the batteries associated with household systems, and could lead to soil and water contamination, thus adversely affecting local health conditions. Lead acid batteries in particular can cause heavy metal poisoning if not disposed of properly (UNDP, 2001). In addition, the energy invested into the manufacturing of PV devices is significant, resulting in the indirect emission of GHG. As stated in the IPPC manual, " Climate Change 1995," the energy payback time (the ratio of primary energy required to manufacture 1 m2 of module plus the supporting structure, wiring etc., to the rate of primary fossil energy avoided by the electricity production with 1 m2 of module) for silicon devices used in power plants, is up to 10 years (Ishitani & Johansson). Taking this into account, GHG emissions are therefore reduced by approximately 79-96% from the baseline option[8].

As for the approximate MAC of this option, the IPPC estimates a range between 44 – 370 USD/ tonne CO_2 abated (Moomaw & Moreira, 2001) (for PV and thermal solar applications).

At the initial outset of a program for the implementation of household PV systems for rural electrification, employment impacts are not expected to be great. PV devices would most likely be imported, and any employment opportunities would be in the form of distribution,

[8] Life cycle GHG emission intensity of PV: 30-150 g CO2-eq/kWh (Holdren & Smith, 2000).

installation and training of users on how to use and maintain the technology. However, in the long term, commercialisation of the technology could create additional jobs in manufacturing, distribution, retail, installation and maintenance.

In most developing countries, rural electrification strategies in general aim at reducing inequities in access to electricity and associated limits on opportunities for increased social well-being, education, health and income generation (UNDP, 2001). Solar PV addresses these limits by providing energy for equipment that could improve the quality and effectiveness of work done for purposes of income generation (e.g. refrigeration and battery charging), reduced drudgery while performing daily tasks and providing greater opportunity for income generation. Although these benefits improve the lives of men and women, the benefits to women are particularly significant as they are often the ones to shoulder the majority of the domestic responsibility.

As noted above, PV devices would most likely adversely affect the balance of payments at the initial outset of a PV rural electrification program. However, savings in diesel and other fossil fuel import would be achieved in the long term. Energy security is also improved through a reduced dependence on fossil fuel for rural electrification.

5.2.2 Small Scale Hydropower

Small-scale hydropower involves the construction of a low dam across a small river. No reservoir is created and the stream's natural flow is used to rotate turbines to generate electricity (Miller, 2002). Small hydro units can take advantages of small discharges from perennial streams.

Small hydro has a huge and as yet untapped potential in most places of the world, and can make a significant contribution to future energy needs. Small hydropower is best suited to regions with hilly terrain, scattered settlements and many streams. In particular, there is significant potential for small hydropower in Asia, including China, Vietnam, Indonesia, and the Philippines (International Network on Small Hydropower, 2003).

Small-scale hydropower technology is typically divided into three categories that differ from each other on the basis of size. Micro hydro technology has a capacity less than 100 kW, mini hydro is 100-1,000 kW and small hydro is 1-30 MW (Goldemberg, 2000). Hydropower plants of 50 kW and greater can be used to electrify communities by establishing mini grids.

Small hydro does not pose the same significant environmental risks as large-scale hydroelectric technology as it is almost always operated "run-of-the-river" without the construction of reservoir capacity to store water. However, this increases the vulnerability of the system to seasonal variations in flow. In addition, small-scale hydropower projects can disturb aquatic life, disrupt the flow of natural rivers and destroy wetlands. Concerning climate change impacts, this option reduces GHG emissions by almost 100% from the baseline diesel generator case[9].

As for the marginal abatement cost of this option, an Indian study has estimated this for a CDM project, at approximately 29 USD/t CO_2 abated (Pathak, M. et. al., 2000), whereas the National Communication of Mongolia notes that this has been estimated in an ALGAS study,

[9] Life cycle GHG emission intensity 2-410 gCO2-eq/kWh for hydroelectric (Holdren & Smith, 2000).

at 10.3 USD/t CO_2 abated for Mongolia (Ministry of Nature and the Environment of Mongolia, 2001).

Small plants have a large potential to contribute to socio-economic development in rural areas through the stimulation of economic and industrial development (Ishitani & Johansson, 1996). Job creation benefits will most likely accrue as a result of the development that is stimulated by the electrification project, and the construction, operation and maintenance of the plant itself. Regional poverty alleviation may also be associated with such development. At a household level, and as suggested above for the case of PV, electrification can also open up opportunities for additional income generation and/or education through timesavings.

As for any impacts upon the national balance of payments, rural electrification by small-hydro is expected to have a positive impact as materials for construction and operation can be relatively simple (wooden water wheels etc.) and can be manufactured domestically, and as significant savings of fossil fuel imports may be achieved (International Network on Small Hydro Power, 2003). Energy security is also enhanced by reduced dependence on fossil fuel imports.

5.2.3 Small Scale Biomass to Electricity

At the small scale, perhaps the two most common methods of converting biomass to electricity is through the combustion of biogas, produced from the anaerobic digestion of organic wastes, and the combustion of producer gas, the gas resulting from the gasification of biomass. However, to simplify the assessment, only the gasification of biomass is considered here.

Fixed bed gasifiers (typically for systems of 100-200 kWe with an approximate electrical efficiency of 15-25%) may be coupled with modified internal combustion diesel or Otto engines to produce electricity. Producer gas can replace 70-80% of the diesel required by the generator engine, or 100% of the gasoline required (UNDP, 1994). Biomass gasification at this scale provides yet another option for decentralised electrification in rural areas in developing countries. However, the operational success of these small-scale gasification systems has been limited due to gas cleaning requirements, high costs, the need for careful operation and difficulties in ensuring a stable supply of appropriate fuel in remote rural areas (UNDP, 1994). As a result, large-scale application of these decentralised systems has been significantly hindered.

Environmental benefits of this technology include reduced diesel use leading to reductions in particulate and CO emissions. Reductions in SO2 depend on the quality of the fuel used, while reductions in NOx depend on the combustion temperature. However, both of these emissions can be controlled to substantially reduce environmental and health hazards associated with diesel use. One negative aspect is the production of solid ash waste that must be disposed of. Solid waste can be significantly reduced through briquetting for a more complete combustion. As for GHG emissions, small scale biomass gasifier technology can reduce GHG emissions by up to 76% from the baseline technology, assuming that the producer gas can replace up to 80% of the diesel requirement[10].

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[10] Life cycle GHG emission intensity for biomass power generation 37-166 gCO2-eq/kWh (Holdren & Smith, 2000).

The marginal abatement cost of this technology is estimated in a study of India, for both agro-waste gasifiers and wood-waste gasifiers. The MAC of the former option is estimated at 177 USD/t CO_2 abated, whereas the MAC of the latter option is estimated at 169 USD/t CO_2 abated (Pathak et. al., 2000).

Regarding the generation of employment as a result of implementing such a system, minor but positive impacts are expected in terms of both job creation and economic development for the community affected by the project. Employment may be generated in both the collection and transport of agricultural and/or wood residues to the gasifier, and in the operation and maintenance of the gasifier itself. Increased electrification of the community may also stimulate the economy, attracting agricultural and other businesses that provide job opportunities into the long term.

Like the other decentralised energy options mentioned above, poverty reduction benefits are associated with the provision of electricity to rural households and any economic development of the region that may result from the project. Financial benefits in the form of additional income to farmers could also result.

It is uncertain how small-scale gasification of biomass would impact upon the balance of payments. Benefits would accrue through reduced diesel import, however, until there was a demand for gasification units leading to domestic manufacture, this technology would most likely have to be imported in the initial implementation stages (Pathak et. al., 2000). Energy security is also expected to be slightly enhanced through reduced fossil fuel imports.

5.2.4 Option Evaluation

Table 5- Decentralised Power Sector Option Evaluation

Power Generation Options / Criteria	Small scale Biomass Gasification	Small scale Hydropower	Household Photovoltaic
GHG reduction from baseline	1	3	2
Potential to replace conventional energy sources	3	2	1
Marginal abatement cost effectiveness (USD/t CO_2)	2	3	1
Employment generation	2	2	1
Improved balance of payments	1	2	0
Health benefits	1	3	2
Environmental benefits	1	2	2
Improved sustainable use of natural resources	1	3	3
Poverty reduction	3	3	1
Benefits to important or disadvantaged groups	3	2	1
Improved availability/access to energy services	3	3	1
Improved energy security	2	3	3
Achievement of other development objectives or benefits			
Total Score	23	31	18

For small-scale power supply, the small hydropower option is considered the most promising in terms of greenhouse gas reduction and sustainable development potential, with a total score of 31. Due to the abundance of biomass in the developing world, small-scale biomass gasification for off-grid applications receives the highest score for its potential to replace conventional fuel sources. Small hydropower places second because of its dependence upon a suitable location and topography. Household PV places third with regards to this criteria, due to its limited economic potential. Due to a continued, although much more limited, dependence on diesel fuel, biomass gasification receives lower scores for improved sustainable use of natural resources, and improved energy security, than the other options. PV does not score as highly as hydropower and biomass gasification in the category of poverty reduction as its rural development benefits are not considered as great. It also does not score as highly as the others in the categories of, benefits to important or disadvantaged groups and improved availability/access to energy services. For both of these criteria, the high initial costs of PV technology are assumed to limit its applicability in rural communities. Concerning energy security, the PV and hydro options are scored higher than the biomass option as both use 100% renewable fuels.

5.3 Climate Change Mitigation Options for Industry

As specified earlier, the baseline scenario assumed for the industrial assessment involves the use of coal and oil fuels to provide the electricity and heat required by industrial processes. In particular, for the CHP option, the baseline technology involves the separate production of heat and power, where electricity is consumed from the national grid. For the efficient motor system option and the efficient boiler option, the baseline technology is the average existing efficiency of these technologies in the developing world.

5.3.1 Co-generation of Heat and Power

Co-generation involves the simultaneous generation of heat and power in a single plant, and usually from a single heat source by recycling exhaust energy from the primary power generation process into a secondary process (Johansson et. al., 2001). In most applications, the power produced is used to drive an electric generator while the produced heat is typically used in some industrial process like drying, canning and heating (Roy-Aikens, 1995).

Up to 80% of the heat content of the fuel can be captured in a cogeneration configuration, significantly reducing the amount of CO_2 and other air pollutants that would have been produced in facilities where electricity and heat are produced separately. Cogeneration produces a given amount of electric power and process heat with 10% to 30% less fuel than it takes to produce the electricity and process heat separately (Energy Resources International, 1999).

In industries requiring process steam or heat and electricity, cogeneration can offer significant energy and cost savings, and can even provide an additional source of income. The potential is particularly great in as the pulp and paper, chemical, and the alcohol-sugar industries, as the industrial residues produced by these industries can be used to generate a surplus of energy that may then potentially be sold to the common grid (Jochem, 2000). In some developing countries, like Kenya, industries with large electrical and heating needs may still get most of their electricity from the national grid (Roy-Aikens, 1995).

In several developing countries, the potential for industrial cogeneration is estimated at 20-25% of industrial and commercial electricity demand (Jochem, 2000 pg. 205). However, the full potential of industrial cogeneration in these countries is yet to be realised. Monopolistic electricity sector structures offering low buy-back rates, costly technical standards for grid connection and other institutional barriers may deter industries from producing more than their minimal in-house electricity and heat needs.

Concerning any environmental and health benefits that may result from this option, these are expected to be in accordance with the fuel saving associated with the implementation of co-generation. If such is the case, 10-30% of the particulate matter, sulphur dioxide and nitrogen dioxide that would have been emitted otherwise, can be avoided.

As for the marginal abatement cost of CHP, no figures were identified for this option. However, it is expected that this option is cost-effective and that the benefits outweigh the costs (Moomaw & Moreira, 2001 pg. 209).

Significant job opportunities are not expected to result from the implementation of a program to promote CHP. However, jobs in other sectors may be indirectly created in the long run. Savings in fuel costs will free up more money for investment in other areas by these industries.

Industrial co-generation itself will most likely not lead to a direct alleviation of poverty. However, increased spending in impoverished regions where industries operate due to savings in energy expenditures as a result of CHP implementation, may lead to increased stimulation of economic development in the region. In addition, industrial CHP, if implemented in regions where residential electrification is lacking, could provide an important source of electricity to the community.

Industrial co-generation could affect the balance of payments positively, through a reduced need for fossil fuel imports, or negatively, if there is limited capacity to manufacture the high-pressure boilers and/or turbines that may be required to implement industrial cogeneration systems. However, industrial cogeneration can enhance national energy security through improved energy efficiency.

5.3.2 Improvement in Motor System Energy Efficiency

Electrical motor systems are major consumers of industrial electricity globally. For example, in China, industrial motors account for more than 60% of total industrial electricity (Ji & Junfeng, 2000). In Brazil, electrical motors consume 51 % of industrial electricity and in Argentina and Chile, it is up to 75% and 85% respectively (Jochem, 2000). Motors are primarily used to drive fans, pumps and compressors in industry, and together with the connecting shafts and belts that link them, make up the motor system. Major opportunities exist to improve the efficiency of the motor system.

Most electric motors operate with efficiency between 85 to 95% (Johansson et. al., 2001). This figure can be higher with larger motors. Although motors themselves are usually energy efficient, the systems they drive, if not designed properly, can cause large losses of this energy before it is converted into useful work. In fact, optimising system design, rather than simply choosing components can lead to improvements of 60% using existing technology (Baldwin, as cited in Kashiwagi, 1996 pg 664). Optimisation of motor systems might entail the adoption of improved drive belts, adjustable-speed electronic drives to better match mechanical load, improved motor rewinding, use of high efficiency motors, power conditioning and use of more efficient associated equipment (pumps, fans, compressors). Many motors work with varying loads and require some form of output regulation. Traditional flow control relies on dampers and valves that alter the flow, resulting in considerable energy waste. Adjusting the motor speed to load variation is more efficient. Adopting adjustable speed motors can save 10 to 25 % of electricity (Ji & Junfeng, 2000).

Environmental benefit in the form of reduced emission of air pollutants are in proportion to improvement in motor system performance. Therefore, in proportion with the potential fuel saving identified above, emission of greenhouse gases, sulphur dioxide, particulate matter and nitrogen dioxide may be reduced by up to 60%.

With regards to the MAC of this option, this varies with the type of improvement implemented. For example, the MAC of replacing motors of 86% efficiency with motors of 91% efficiency in Thailand is estimated at – 95.7 USD/t CO_2 abated (Halsnaes et. al., 2002)(based on an ALGAS study). UNEP GHG costing studies estimate the improved energy efficiency of motor systems in Venezuela at 17 USD/ton CO_2 abated, and at –2 USD/ton CO_2 abated in Zimbabwe (Hourcade, 1996). A Mongolian ALGAS study estimates this at –1.4 USD/t CO_2 (as cited in Ministry of Nature and the Environment of Mongolia, 2001).

Similar to the cogeneration option, a program to promote motor system efficiency is not expected to generate significant employment. However, employment may be generated indirectly in other sectors in the long run as a result of cost savings to industries adopting improved motor systems, and the subsequent investment of these savings in other sectors.

Improved motor system efficiency itself will not lead to a direct alleviation of poverty. However, increased spending in impoverished regions where industries operate, due to savings in energy expenditures, may lead to increased stimulation of economic development in the region.

The impact of a program to promote the implementation of efficient motor systems in industry upon the national balance of payments is not clear. An improvement in the balance could be achieved through reduced fossil fuel imports, whereas a negative impact may occur if significant import of efficient motors and other system equipment is required. On the other hand, national energy security will be positively impacted through a reduced need for fossil fuel imports to supply the industrial sector of the economy.

5.3.3 Improvement in Boiler Efficiency

The energy efficiency of industrial boilers can be improved in many ways. Improvements can include the optimisation of conditions for combustion (adjustment of fuel/air ratio), operational improvements (improved insulation, keeping the flue gas temperature in stack as low as effectively possible, sealing valves for reduced leakage, ensuring no blockage of convective passes with unburned fuel or ash etc.), or the adoption of high efficiency boilers (including superheaters and economisers, which can achieve over 90% fuel efficiency in modern boilers)(Johansson et al., 2001).

In China, the average efficiency of industrial boilers is about 10 % lower than in more developed countries (Ji & Junfeng, 2000). Most conventional boilers have efficiencies in the range of 80-90%. However, in some developing countries, boiler efficiency can be extremely low. For example, in Zimbabwe, some existing industrial coal-fired boilers have efficiencies as low as 50% (Halsnaes et. al., 2002).

Environmental and human health benefits in the form of reduced emission of air pollutants are achieved in proportion to the improvement in boiler performance. Therefore, in proportion with the potential fuel saving identified above, emission of greenhouse gases, sulphur dioxide, particulate matter and nitrogen dioxide may be reduced by up to 40% in some cases.

As for the MAC of this option, this will vary with the improvements employed, however, many improvements can be made at very little cost. Based on a UNEP national abatement costing study for Zimbabwe, the MAC associated with the replacement of existing coal-fired boilers of 50% efficiency with boilers of 79% efficiency, is calculated at –3.1 USD/ton CO_2 abated (Halsnaes et. al., 2002). The actual UNEP study itself estimated an MAC for improved boiler efficiency of –9 USD/ton CO_2 abated (Hourcade, 1996). In another UNEP national greenhouse gas abatement costing study for Venezuela, the MAC for improved boiler efficiency was estimated at 10 USD/ton CO_2 abated (Hourcade, 1996). Furthermore, a study on improved boiler efficiency in China has estimated MACs for different boiler improvement options. The MAC of improvements in the prefuel process, operation and combustion in the boiler are all estimated at less than 1 USD/t CO_2 abated. However, the MAC of replacing inefficient boilers with high efficiency boilers is estimated at 2.7-6.76 USD/t CO_2 abated (Ji & Junfeng, 2000).

Similar to the other industrial climate change mitigation options discussed above, a program to promote improved boiler performance is not expected to generate significant employment. However, employment may be generated indirectly in other sectors in the long run as a result of cost savings to industries adopting improved boilers systems, and that subsequently invest these savings in other sectors.

Improved boiler performance itself will not lead to a direct alleviation of poverty. However, increased spending in impoverished regions where industries operate, due to savings in energy expenditures, may lead to increased stimulation of economic development in the region.

The impact of a program to promote efficient boiler systems in industry upon the national balance of payments is not clear. Although an improvement in the balance could be achieved through reduced fossil fuel imports, a negative impact may occur if significant import of high efficiency boilers and/or system parts is required. However, it is important to note that some improvements in boiler efficiency can be achieved with relatively low cost and low capital (e.g. optimisation of fuel/air ration for improved combustion efficiency). Therefore, the potential for an improved balance of payments is considered greater than a negative impact. In addition, it is likely that national energy security will be positively impacted through a reduced need for fossil fuel imports to supply inefficient boilers in the industrial sector of the economy.

5.3.4 Option Evaluation

Table 6- Industrial Sector Option Evaluation

Industry Options / Criteria	Co-generation	Motor System Efficiency Improvement	Boiler Efficiency Improvement
GHG reduction from baseline	2	3	2
GHG reduction in terms of estimated theoretical potential for improved efficiency in the developing world	1	3	2
Marginal abatement cost effectiveness (USD/t CO_2)	3	3	2
Employment generation	1	1	1
Improved balance of payments	0	0	1
Health benefits	2	3	2
Environmental benefits	2	3	2
Improved sustainable use of natural resources	1	1	1
Poverty reduction	2	1	1
Benefits to important or disadvantaged groups	1	1	1
Improved availability/access to energy services	1	0	0
Improved energy security	1	1	1
Achievement of other development objectives or benefits			
Total Score	17	20	16

Of the three industrial options presented here, motor system efficiency is considered to offer the greatest greenhouse gas reduction and sustainable development benefits, followed by CHP and boiler efficiency improvements, respectively. Improvement in motor system efficiency is expected to offer the greatest GHG reduction potential in developing countries, as it is the number one industrial electricity end use in many of these countries, and because it offers the greatest technical (60% improvement) and overall theoretical efficiency potential of the other options discussed here. Boiler efficiency improvements are expected to offer greater GHG reduction potential in the developing world over CHP, as many industries use boilers and many improvements to boilers can be made economically. The CHP option is perhaps best suited to industries with large heat and/or electricity demand, in which it is most likely to be economically attractive. None of the options here are expected to generate a significant number of new jobs. The health and environmental benefits of these options are in proportion to the potential technical energy saving that can be achieved by each. All options involve the more efficient use of energy and are therefore expected to result in a slight improvement in the sustainable use of natural resources. Co-generation is assigned a higher score than the other options with regards to poverty reduction, as a result of its potential to be used as a local source of energy in areas with limited access to heat and electricity services.

5.4 Climate Change Mitigation Options for Cooking

The baseline technology used to assess cooking options in the residential sector is a traditional biomass-fuelled stove with an assumed efficiency of 12-18%.

5.4.1 Improved Energy Efficient Cook Stoves

Traditional biomass- based cooking is predominant in most developing countries, particularly in rural areas, and is the largest home energy use in most of these countries (Levine, 1996). The efficiency of biomass based cooking stoves is typically very low, ranging from between 12 to 18%. Such low efficiencies derive from the incomplete combustion of the biomass, which results in a number of health damaging pollutants, including suspended particulates and carbon monoxide (Reddy, 2000 page 53). Sometimes as much as 1/5 of the fuel carbon is diverted to products of incomplete combustion. Exposure to these pollutants can be extremely dangerous to human health, and is particularly dangerous to women and their small children, as women are usually the ones responsible for cooking and child rearing in the household.

The global warming commitment of cooking with inefficient wood fuel stoves is dependant on whether or not the fuel is produced sustainably, and on the efficiency of its combustion. If the fuel is produced in a sustainable manner, the CO_2 released during combustion will be assimilated back into the replacement biomass. If it is not, a net increase of CO_2 to the atmosphere results. However, of more concern is the emission of non carbon-dioxide greenhouse gases from the incomplete combustion of biomass, which have more global warming potential than CO_2 and are damaging to human health.

However, improved wood fuel cook stoves can help to reduce these health hazards somewhat, by reducing the amount of fuel required to cook a meal by 40-60%[11]. Improved cook stoves will achieve at least a reduction in GHG, particulate matter, carbon monoxide, nitrogen dioxide and other pollutant emissions in proportion to the amount of fuel savings achieved. Emission, and therefore, exposure to health and environmental damaging pollutants can be reduced by up to 60% by an improved cook stove. However, even the best biomass stoves currently available today do not improve combustion efficiency significantly, and do not, therefore, greatly reduce emissions of health-damaging pollution any further than is achieved by the fuel saving (Goldemberg, 2000). It should also be noted that the procurement of local materials for stove production (e.g. clay), could have adverse environmental impacts on soils and riparian systems (UNDP, 2001). In addition, chimneys directing smoke outside can lead to heavy neighbourhood pollution.

Concerning the MAC of this option, this has been estimated in many studies. Several Indian studies have estimated this between 0.03 and 3.24 USD/ton CO_2 abated (Hulsher, Luo & Koopmans, 1999 as cited in Kauppi & Sedjo, 2001) (Luo & Hulscher, 1999 as cited in Kauppi & Sedjo, 2001) (Ravindranath & Somashekhar, 1995). An ALGAS study concerning the dissemination of stoves saving 60% of fuelwood consumption in Thailand, estimated the MAC of this option at 2.8 USD/ton CO_2 (Halsnaes et. al., 2002). Another study for Thailand estimates the MAC for this option at 0.22 USD/ton CO_2 abated (Hulsher, Luo & Koopmans, 1999 as cited in Kauppi & Sedjo, 2001). In addition, a UNEP study for Senegal estimates the

[11] UNDP program in Kenya disseminated improved stoves in Kenya that achieved a 40% fuel saving (UNDP, 2001). 60% fuel saving achieved by improved stoves in Thailand (Halsnaes et. Al., 2002).

MAC of this option at 0 USD/t CO_2 abated (Hourcade, 1996), and a study for Ethiopia has estimated this at 0.57-2.2 USD/t CO_2 (as cited in Tadage, 2001).

With regards to employment generation, improved cook stoves are often produced domestically, using local materials and creating jobs for local manufacturers and artisans. Jobs are also created in stove distribution and retail. For example, the Kenya Upesi Rural Stoves Programme created 50 jobs for rural women producing, selling and installing stoves (UNDP, 2001).

In addition to the potential for creating jobs, improved cook stoves offer poverty alleviation benefits in the form of timesaving. In particular, women in developing countries can spend many hours a week collecting fuelwood for cooking purposes. Improved energy efficient cook stoves therefore address poverty by freeing up time for other income-generating or educational activities.

As neither fuel wood nor materials for improved wood stoves are imported, no impact upon the national balance of payments is expected. National energy security is also not affected.

5.4.2 Alternative Cooking Fuels

The switch from solid biomass cooking fuels to alternative fossil fuels (natural gas, LPG, propane etc.) or biomass derived fuels, involves a movement up the "energy ladder," to a higher quality, more efficient and cleaner fuel source. However, for the purpose of this assessment, only the substitution of traditional sources with cleaner fossil fuels is evaluated here.

History has demonstrated that when alternative fuels are affordable and available, populations tend to move up this energy ladder, from simple biomass fuels (dung, crop residues, wood) through fossil fuels (kerosene and gas) to electricity (Holdren & Smith, 2000). However, a movement up this ladder is unlikely to occur if access to the alternative energy source is not reliable and if capital and/or fuel costs are not affordable. For example, a switch to LPG can involve significant up front capital costs, as the gas must be distributed in pressurised canisters and a special stove is required to use the fuel (Goldemberg, 2000). In addition, a reliable distribution system operating between the refinery and neighbourhood distributor must also exist, something that is difficult to come by in the developing world (Goldemberg, 2000). Unfortunately, even though many households may be able to afford the daily cost of the fuel, these two factors together often prevent gaseous fuels from being used by households.

However, the switch to gaseous fossil fuels for cooking has been very successful in some developing countries, especially Brazil, where the use of fuelwood for cooking has all but been eliminated. In 1999, 97.4% of all households were equipped with LPG stoves (UNDP, 2002).

In addition, the switch to gaseous fuels from biomass can, surprisingly, result in a reduced contribution of greenhouse gases. Even though solid biomass fuels are renewable and can be harvested so there is no net contribution of carbon dioxide to the atmosphere when combusted, because of significant emissions of non-carbon dioxide greenhouse gases, these fuels can have a larger greenhouse gas commitment per meal than fossil fuels, kerosene and LPG (Holdren & Smith, 2000). In a study by Smith et. al, (2000), it is estimated that the full greenhouse warming commitment (GWC) (full GWC includes CO_2, CH4, N2O, CO, NMHC) of LPG is 37 gC/MJ delivered (CO_2-eq), of wood harvested renewably is 85 gC/MJ delivered and of wood harvested non-renewably is 236 gC/MJ delivered. This suggests that the use of LPG can reduce the GWC of wood fuels by up to 84% per MJ of energy delivered.

The switch to gaseous fossil fuels also presents certain environmental and health related benefits. The use of petroleum based gaseous fuels allows much better pre-mixing with air, thereby achieving much higher combustion efficiencies and much lower emissions of environmental and health damaging pollutants than would otherwise be achieved with traditional biomass fuels (Holdren & Smith, 2000). In fact, emissions of health-damaging pollutants per meal from these fuels are at least an order of magnitude less than those produced from solid fuels (Holdren & Smith, 2000). However, although the switch to gaseous fuels may result in enhanced conservation of local biomass resources, the pressure upon fossil fuel stocks is increased.

Concerning the MAC of this option, only two estimates are identified. An UNEP national greenhouse gas abatement costing study for Senegal estimated the substitution of charcoal fuels with LPG at 2 USD/t CO_2 abated (Hourcade, 1996). In addition, a similar type of study for Egypt estimated the MAC of fuel switching in households at –21 USD/t CO_2 abated.

With regards to the potential for this option to generate employment, in comparison with the common alternative, which is the individual household collection of biomass fuels, the production, distribution and retail of gaseous fuels and stoves could generate a significant number of jobs.

In addition, the use of LPG and other gaseous fuels may indirectly lead to a reduction in poverty by allowing for additional income-generating or educational opportunities in the time previously dedicated to collecting wood and cooking. As for any potential benefits to important or disadvantaged groups, like in the case of the improved wood fuel stove, significant health impacts accrue to rural women and children. However, the requirement of continual pay for a fuel supply may be considered a disadvantage over the wood fuel stove case. Although the purchase of a stove is required in both cases, the supply of alternative fuel makes the additional requirement of continued purchase.

Increased import of fossil fuels, or refined fuel gases, could adversely impact upon the national balance of payments. As for energy security, increased dependence upon imported fossil fuels will not enhance energy security.

5.4.3 Option Evaluation

Table 7- Residential Cooking Option Evaluation

Residential Cooking Options / Criteria	Improved Wood Stoves	Alternative cooking fuels
GHG reduction from baseline	1	3
Marginal abatement cost effectiveness (USD/t CO_2*)*	2	3
Employment generation	1	2
Improved balance of payments	0	-1
Health benefits	1	3
Environmental benefits	0	2
Improved sustainable use of natural resources	1	0
Poverty reduction	2	2
Benefits to important or disadvantaged groups	2	1
Improved availability/access to energy services	0	0
Improved energy security	0	-1
Achievement of other development objectives or benefits		
Total Score	10	14

Of the two options presented here, alternative cooking fuels are expected to offer the greatest greenhouse gas reduction and sustainable development benefits. Even though cooking with biomass fuels can result in no net contribution of CO_2 to the atmosphere, inefficient combustion leads to significant emission of non carbon dioxide GHGs with higher global warming potentials. Alternative fossil cooking fuels can significantly reduce this emission of GHGs. For this same reason, the health and environmental benefits of alternative cooking fuels scored higher than for the improved wood fuel stove. Due to an expected decrease of pressure on forest resources, and in consideration of the fact that wood fuel can be produced in a sustainable manner, the improved stove option scored higher than the alternative for an improvement in the sustainable use of natural resources. The improved wood stove option also scored higher than the alternative for its potential benefit to important or disadvantaged groups. The main reason for this is that a continued supply of alternative fuel requires a stable income, which many rural and/or disadvantaged groups may find difficult to provide. With regards to poverty reduction, both options are awarded the same score. Although the alternative fuel option may actually increase poverty by requiring regular payment for the fuel supply, the potential timesavings, are expected to be greater for this option. Neither option is expected to result in an improvement in the availability or access to energy services, as cooking is a very basic requirement of all households and will be carried out with or without improved, or more efficient technologies.

5.5 Climate Change Options for the Residential and Commercial Sectors

The baseline scenario used to assess residential/commercial options involves coal and oil based electricity and heat generation. The baseline technology for the efficient lighting option is incandescent lighting, and for the efficient appliance and building options, it is the average existing efficiency of appliances and buildings in the developing world (where data was available).

5.5.1 Energy Efficient Lighting

Lighting sources in developing countries include fire, paraffin candles, liquid fuelled lamps such as kerosene, gas lanterns and electricity. Kerosene is used predominantly in rural areas (Goldemberg, 2000). However, to simplify the forthcoming assessment, only electricity shall be considered here. Electricity occupies the highest rung of the energy ladder for lighting and is the most preferred, modern and efficient lighting source.

In most developing countries, lighting is one of the most important electrical end-uses in the residential and commercial sectors. For example, about 40% and 50% of the electricity used by the residential and commercial sectors respectively, in India, goes to meet lighting needs. Most electric lighting in these countries is provided by extremely energy inefficient incandescent light bulbs. Significant energy could be saved through expanded replacement of incandescent lighting with compact fluorescent lamps (CFLs), which require 20 to 25% of the electricity of these standard lamps to produce the same light output (Levine, 1996).

The achievement of greenhouse gas reductions through expanded use of energy efficient lighting is a function of the potential energy saving. In this case, energy savings of 75-80% can be achieved using CFLs. In combination with the high demand for lighting as an electrical end-use in developing countries, the overall potential for GHG reduction from improved lighting is significant.

Environmental and health benefits associated with improved lighting is in accordance with the achieved energy saving. Sulphur dioxide, nitrogen dioxide and particulate matter emissions (depending on the energy source generating electricity) could all be reduced by 75-80% from the baseline lighting scenario.

With regards to estimated MACs for this option, many studies have estimated these. According to Martinot (1998), the estimated MACs of programs that have been implemented in Mexico, Brazil, Jamaica and Peru range from 25-40 USD/ton CO_2 abated. Several different MACs have been estimated for programs in Thailand. Martinot (1998) calculates a MAC of 5-10 USD/ton CO_2 abated for an operating program in Thailand, whereas a UNEP GHG abatement costing study estimates a potential MAC of –9 USD/ton CO_2 abated in the residential sector and –14 USD/t CO_2 abated in the service sector (Hourcade, 1996) and the Thailand Initial National Communication (2000) reports an MAC of –323.1 USD/ton CO_2 estimated in the ALGAS study for Thailand. Both of these latter estimates were part of mitigation option costing studies. In addition, studies for Zimbabwe and Botswana based on UNEP national greenhouse gas abatement costing studies (Halsaes et. al., 2002) and the ALGAS study for Mongolia (as cited in Ministry of Nature and the Environment of Mongolia, 2001) estimate a MAC of –6.3 USD/ton CO_2 abated, -113.7 USD/ton CO_2 abated and –2.48 USD/ton CO_2 abated, respectively.

In the initial start-up period of an efficient lighting program, a significant number of jobs are not likely to be created. However, as the program expands over time, the domestic manufacture of CFLs could become a reality, resulting in additional work opportunities. Although this could also lead to possible job losses in any domestic incandescent lighting production, with continued expansion of the program, transformation of the lighting market could lead to the export of CFLs, like is the case for China, where in 1997 there were 1000 CFL manufacturers (up from 500 in 1995)(Martinot, 1998). Jobs can also be created indirectly, through increased investment of energy cost savings that accrue to users of the efficient technology, in other sectors of the economy.

The potential for poverty reduction in this case is a function of the number of new jobs created and the amount of household/commercial income that is saved through the implementation of the new technology. Savings that are invested in other sectors also indirectly address poverty issues through economic development.

The balance of payments could be improved through reductions in fossil fuel import for electricity generation and the export of CFL technology. However, small-scale programs may import all CFLs, thereby adversely impacting upon the balance (e.g. the national utility in Ireland imported CFLs from China for a pilot rebate programme) (Min et. al., 1997). Energy security is expected to be enhanced through fuel saving.

5.5.2 Energy Efficient Building Envelope

There are many ways in which the energy efficiency of building shells can be improved to reduce heating or cooling requirements. At the design stage, building orientation, insulation levels, and window quality can all be optimised for energy efficiency. At the construction stage, proper sealing and adequate, well-distributed insulation will reduce losses of energy, and for the block of existing buildings, the addition of insulation, storm window and doors, the improvement of sealing and many other conservation retrofits can greatly reduce heating or cooling losses. In China, studies have indicated that just through increases in wall and ceiling insulation and in the thermal characteristics of windows, energy losses can be cut by 40% relative to mid-1980s levels (Huang, 1990).

Like all of the climate change mitigation options described here, the achievement of greenhouse gas reductions through improved building shell performance is a function of the potential energy saving. In this case, heating and insulation standards in developed countries have achieved energy savings of up to 70% (Germany, since the 1970s)(Jochem, 2000). Although space heating in developing countries is not extremely common due to the generally warmer climates in this region, (with the exception of northern China, Korea, Argentina and a few other South American countries), the demand for cooling services in the developing world is on the increase. For example, the number of air conditioners in Malaysia has increased from 13 251 in 1970 to 253 399 in 1991 and is expected to be 1 511 276 in 2020 (Masjuki, 2001). A similar trend is expected in other hot and humid developing countries, with major implications for climate change.

Environmental and health benefits resulting from the improved energy efficiency of building envelopes are also related to the quantity of energy saved. Emissions of sulphur dioxide, particulate matter and nitrogen dioxide produced from the burning of fossil fuels for energy (electricity and/or heat) can therefore by reduced by up to 70% from the baseline scenario.

Regarding the potential MAC of such an option, this varies according to the type of improvements considered. However, most reductions are available at negative net direct abatement costs (Moomaw & Moreira, 2001). The IPPC estimates the MAC of energy efficient building improvements at –54 to 13 USD/ton CO_2 abated (Moomaw & Moreira, 2001). In addition, a greenhouse gas abatement costing study for Mongolia, done as part of the ALGAS studies, estimates this to be –1.73 USD/t CO_2 abated (as cited in Ministry of Nature and the Environment of Mongolia, 2001).

With regards to employment generation, the implementation of a thermal building code or standards could create additional jobs for skilled workers in building design and engineering, as well as in the retrofitting industry. Jobs may also be created indirectly through the financial savings that will accrue to residents of efficient buildings, and that may be invested in other sectors of the economy.

Improved building design and performance in the residential sector can contribute to poverty alleviation through decreased energy costs to poor consumers that spend a significant portion of their disposable income on heating services. However, it should also be noted that in many developing countries, the very poor do not live in buildings that would be traditionally targeted by government initiatives to conserve energy (e.g. sometimes as much as 75% of an urban population can live in shanty towns or urban slums)(Mathews et. al., 1995). Therefore, it is important that these areas are also targeted with extremely low-cost options. Poverty reduction through improved performance of commercial and residential building envelopes may also result indirectly through any economic development stimulated by increased investment in other sectors.

The national balance of payments is likely to be impacted positively through reduced fossil fuel imports. Energy security is also likely to be enhanced through reduced reliance upon energy imports.

5.5.3 Energy Efficient Electrical Appliances

As personal incomes continue to grow in the developing world, so too does the demand for electrical appliances (TVs, refrigerators, small appliances.). In the commercial sector, the use of electrical office equipment in the form of photocopiers, fax machines, computers, printers, etc., is also on the rise. As a result, electricity consumption is on the increase. Finding more energy efficient ways of satisfying this increase in demand for electricity end uses is an important component of a global climate change strategy.

Several policy options to improve appliance energy efficiency exist, including efficiency standards that specify the maximum electricity consumption limit for an appliance, price incentives to manufacturers, energy efficiency labels, or rebates to consumers buying energy efficient products (Millock, 1994). However, all involve technical changes in product design to conserve energy.

Many developed countries have had great success with appliance energy standards. For example, in the USA, standards for refrigerators, applied in 1993, reduced electricity use by 28% relative to the 1989 model (Levine, 1996 pg. 724). Other studies in the US have shown that huge energy savings can be achieved (over 70%), although the larger savings may not be cost effective. In Brazil, a voluntary energy standard for refrigerators achieved a 15% reduction in energy use between 1985-1993 (Geller et. al., 1998). An Indonesian study has estimated that the use of best-available cost-effective technologies for a variety of appliances could result in a reduction in energy use of 20 to 30% relative to the 1998 stock average

(Levine, 1996 pg. 724). Most cost-effective improvements in appliance energy efficiency most likely achieve energy savings around this range.

The achievement of greenhouse gas reductions through expanded use of energy efficient appliances is a function of the potential energy saving. In this case, energy savings of more than 70% can be technically achieved in some appliances. However, as the use of electric appliances in lower income countries is considerably less than in the industrialized countries, and as electricity for lighting is still the dominant electricity end-use in both the residential and commercial sectors of the developing world, the overall GHG reduction potential of this option is not considered as high as the other options.

Environmental and health benefits associated with improved appliance performance is in accordance with the achieved energy saving. Sulphur dioxide, nitrogen dioxide and particulate matter emissions (depending on the energy source generating electricity) could all be reduced by 70% from the baseline appliance scenario.

Concerning the estimated MAC for this option, a UNEP climate change mitigation costing study for Egypt estimated the MAC of a program to improve the energy efficiency of appliances at –3 USD/ton CO_2 abated (Hourcade, 1996). No additional figures were identified.

In the initial start-up phase of a policy/programme to promote energy efficient appliances, a significant number of jobs are not likely to be created. However, as the program expands over time, the domestic manufacture of efficient appliances could become a reality, resulting in additional work opportunities. Although this could also lead to some initial job losses in any domestic appliance industry, with continued expansion of the program, transformation of the appliance market could lead to the increased competitiveness of domestic manufacturers, leading to an increased export potential. Jobs can also be created indirectly, through increased investment of energy cost savings that accrue to users of the efficient technology, in other sectors of the economy.

The potential for poverty reduction in this case is a function of the number of new jobs created and the amount of household income that is saved through the implementation of the new technology. Savings that are invested in other sectors also indirectly address poverty issues through economic development. However, it should also be noted that many households in developing countries are without electricity, and are therefore not directly affected by such an improvement.

There is some uncertainty as to how the balance of payments will be affected. In the short term, the balance may be negatively affected by increased import of energy efficient appliances and/or parts. However, in the long term, reduced need for fossil fuel imports could positively affect the balance, as could the eventual export of efficient appliances.

Energy Security is enhanced through decreased reliance upon fossil fuel imports.

5.5.4 Option Evaluation

Table 8- Residential/Commercial Sector Option Evaluation

Residential/Commercial Sectors Criteria	Energy Efficient Lighting	Energy Efficient Building Envelope	Energy Efficient Appliances
GHG reduction from baseline	3	3	3
GHG reduction potential in terms of estimated theoretical potential for improved efficiency in the developing world	3	2	1
Marginal abatement cost effectiveness (USD/t CO_2*)*	3	2	1
Employment generation	1	2	1
Improved balance of payments	1	1	1
Health benefits	3	3	1
Environmental benefits	3	3	1
Improved sustainable use of natural resources	1	1	1
Poverty reduction	1	2	1
Benefits to important or disadvantaged groups	1	2	1
Improved availability/access to energy services	0	0	0
Improved energy security	1	1	1
Achievement of other development objectives or benefits			
Total Score	21	22	13

For the residential/commercial sector, the option expected to offer the greatest potential GHG reduction and sustainable development benefits is energy efficient building envelopes, followed narrowly by efficient lighting and efficient appliances, respectively. Although all three options offer a similar technical potential for energy saving, and therefore GHG reduction, efficient lighting is expected to offer the greatest potential for reduction in developing countries as it is currently one of the largest energy end-uses in the developing world, after cooking and water heating (Metz et. al., 2001 pg. 188). The health and environmental benefits associated with these options does not follow exactly from this order of preference. Both the building and lighting options are assigned the highest scores despite the overall higher score attributed to the lighting option for its potential to reduce GHG emissions in the developing world. This is mainly in consideration of the potential for direct and local health and environmental benefits resulting from reductions in fossil fuels combusted directly in the home or building for space heating purposes (rather than the case for energy efficient lighting, which involves more indirect health and environmental benefits resulting from the reduced burning of fossil fuels for the production of electricity). In addition, the construction of energy efficient buildings and/or retrofitting of existing buildings is expected to generate more job opportunities than would result from efficient lighting and appliance initiatives. The logic behind this is that these initiatives are more likely to result in a shift of employment from any existing domestic manufacturing industry to the new technology industry over time, whereas an efficient building initiative is more likely to result in the creation of new employment opportunities. Energy efficient building envelope initiatives may also offer more poverty reduction potential than the other alternatives as improvements made to low-income households, including slum housing, can greatly reduce the percentage of income that must be spent by these households on fuel for heating. This suggests that efficient building initiatives can offer particular benefits to the poor, over efficient lighting and appliance initiatives.

5.6 Climate Change Mitigation Options for the Transport Sector

The baseline scenario for the following assessment, as identified earlier, is based on the use of conventional gasoline to power vehicles. Like the other sectors discussed above, baseline technologies for each of the four options are developed. For the alternative fuel option, the baseline for comparison is conventional gasoline fuel and vehicles. The baseline scenario developed for the improved transport infrastructure option is the average fuel consumption of existing vehicles on dirt roads in developing countries. As for the vehicle demand management option, the developed baseline considers a complete lack of import restrictions on second-hand cars and therefore, a high and inefficient average fuel consumption of vehicles in the developing world. Lastly, for the vehicle maintenance option, the baseline for comparison is a poorly maintained vehicle.

5.6.1 Alternative Fuels

Alternative fuels for vehicles include natural gas, CNG, LPG, and alcohols (methanol and ethanol from various sources). Methanol is typically produced from coal, natural gas and wood, whereas ethanol is typically produced from sugar cane, corn and wood (Turkenburg, 2000). Although the substitution of conventional fuels with alternative fuels has been implemented on a large scale in several countries (like Brazil), some of the main applications of these fuels are currently in situations where they substitute for conventional gasoline additives (Michaelis, 1996).

In considering the impacts of alternative fuels for transport on the emission of GHGs, it is important that the entire life cycle of the fuel is considered as emissions from feedstock and fuel production can vary significantly (Moomaw & Moreira, 2001). Principal greenhouse gas emissions in a vehicle life cycle are CO_2 in the vehicle exhaust, during vehicle manufacture, and in the process of fuel supply; CFCs, primarily as a result of leakage from air conditioning and refrigeration systems; CH4 emitted during oil extraction and from vehicle disposal where organic wastes are placed in landfills; and N2O produced during fuel combustion and in the catalytic converters currently used for gasoline engines in many countries (Michaelis, 1996). Life cycle greenhouse gas emission studies indicate that alternative fuels like Compressed Natural Gas can reduce GHG emission by up to 40% from conventional gasoline fuel[12]. This reduction can increase up to 75% for ethanol produced from sugar cane[13].

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[12] Total life cycle GHG emission from CNG estimated at 164-253 g/km CO2-eq. Total life cycle GHG emission from gasoline estimated at 222-282 g/km CO2-eq (Michaelis, 1996 pg. 696).

[13] Total life cycle GHG emission from ethanol produced from sugar cane estimated at 70-123 g/km CO2-eq.

Concerning the environmental/health impacts of this option, engine emissions of carbon monoxide are generally lower for gaseous fuels and alcohols than with gasoline. Particulate emissions are much lower and NOx emissions are generally similar to or lower than those from conventional fuels. However, emissions of unburned fuel and other pollutants like formaldehyde may be higher than for conventional fuels.

Regarding the potential MAC of such a climate change mitigation option, the only data identified comes from a study in Ethiopia that estimates the MAC of a climate change mitigation initiative to blend ethanol with gasoline, at –1.9 USD/ton CO_2 (Tadege, 2001).

Substitution of conventional fuels used for transportation with alternative fuels like the ones mentioned here could generate a significant number of additional employment opportunities. A famous example of this is Brazil's National Alcohol Fuel Program (PRO-ALCOOL), which has demonstrated the technical feasibility of large-scale production of ethanol from sugar cane to fuel car engines. Since its official launch in 1975, this program remains the largest commercial application of biomass for energy production and use in the world (Lebre la Rovere, 2000). Over the years, the program has been responsible for the creation of 720, 000 direct jobs and more than 200,000 indirect jobs in rural areas (Lebre la Rovere, 2000). However, the significance of employment generation will depend on the type of alternative fuel being considered. For example, if LPG is the preferred fuel, a shift of workers from petrol manufacturing, distribution and retail to this new sector could be expected. In such a case, new job opportunities would mainly exist in vehicle conversion and filling-station development.

The domestic production of alternative fuels can lead to significant poverty alleviation achievements, particularly in disadvantaged rural areas. This would mainly be the result of job creation and any regional development that may occur as a result of the alternative fuel industry.

Continuing to use Brazil's PRO-ALCOOL program as an example, foreign exchange savings of 18 billion USD from 1978 to 1990 (in 1990 dollars) have been estimated (Lebre la Rovere, 2000). This suggests that the domestic production and use of alternative fuels can significantly benefit the national balance of payments. However, this too will depend on the type of alternative fuel that is to substitute for gasoline. If it too is produced from fossil fuels (e.g. natural gas, CNG, LPG etc.) such a significant positive impact may not result.

The enhancement of national energy security will depend on where the alternative fuel is produced and whether or not any import of feedstock fuels is required. However, as evident in the case of Brazil, alternative fuels can offer significant energy security benefits through diversification of the national energy supply.

5.6.2 Improved Transport Infrastructure

Energy use in transport can be significantly reduced by the development and maintenance of transport infrastructure. Improvements that reduce fuel consumption include the paving of roads, infrastructure design to minimize congestion and unnecessary stops (e.g. construction of fly-over, ring and by-pass roads), and the installation of traffic lighting systems to name only a few. For this option, the focus is on the improvement of road quality by paving. A study for Botswana has estimated that the paving of a section of the road network can attain a 50% improvement in energy efficiency (UNEP, 1999). However, it is also important to note that any energy savings achieved by an improvement in infrastructure may be rapidly reversed by an increase in traffic.

Concerning the estimated GHG reduction potential of this option, if no increase in traffic volume is assumed, the emission of GHGs from transport is reduced in proportion to the fuel saving achieved. In this case, GHG emissions are reduced by 50% from the baseline scenario. The emission of pollutants from the combustion of petrol, that are damaging to human health and the environment are also reduced by 50%.

With regards to the expected MAC of a program to improve transport infrastructure, a further assessment of the Botswana study estimates the MAC of a program to pave a specific stretch of road at – 101.2 USD/ton CO_2 (Halsnaes et. al., 2002). No other figures were located.

The development and/or maintenance of transport infrastructure can generate a lot of jobs. Jobs in other sectors may also be created indirectly if the improved infrastructure leads to a stimulation of economic and industrial development in the region.

Some alleviation of poverty may occur as a result of enhanced economic and industrial development of the region affected. An improved transport network will often attract businesses and industry, as well as tourists, which could lead to additional income-generating opportunities for the unskilled and/or poor.

Under the same assumption as above, a reduced need for fossil fuel imports would positively affect the balance of payments. Energy security is also enhanced by the resulting reduced fuel consumption.

5.6.3 Vehicle Demand Management through Import Restrictions

High import taxes on second hand vehicles or the banning of import of vehicles older than a specific number of years restrains the ownership and usage of personal vehicles, thereby reducing energy consumption and GHG emissions (Pretorius Prozzi et. al, 2002). In effect, these measures act to gradually improve the fuel efficiency of the national vehicle fleet over time.

As hard data on the potential for GHG reduction by means of import restrictions on old vehicles could not be found, a rough estimate for this potential was generated using known fuel economy standards of several countries. Many countries ban the import of cars older than a certain age. This age ranges from 3 years, in India, to 5 years in Nigeria (Indiacar, 2003)(Reuters New Service, 2001). Most of these imports are of cars originally produced in OECD countries or from designs originating in OECD countries (Michaelis, 1996). Therefore, it was assumed that a developing country with a vehicle import ban in place, would not import any OECD vehicle over the age of 8 years old (1995). The estimated gasoline-equivalent fuel consumption per vehicle-km for the national car fleet in Western Europe around 1995 was 8-11 L/100 km (Michaelis, 1996). In 1985, the average fuel efficiency of vehicles in South Africa was estimated at 20-24 L/100 km. These vehicles in South Africa are most likely being replaced, or needing replacement at this time. If we assume these old vehicles are replaced with second-hand vehicles from the OECD produced around 1995, with the average fuel economy listed above, the resulting fuel economy improves approximately 60 % (using best fuel economy data for both countries). As the old vehicles in South Africa are replaced with newer, more fuel-efficient vehicles, the fuel consumption per vehicle-km for the national car fleet will continue to decrease over time, leading to a more fuel-efficient fleet.

GHG emissions are even further reduced through import restrictions as a result of the intended effect of reducing the number of cars on the road.

A potential fuel saving of up to 60% for each 100 km driven will also result in a 60% saving of environment and health damaging pollutant emissions of CO, NOx, HCs, benzene and lead (leaded gasoline). Emissions are even further reduced as a result of fewer cars on the road.

Unfortunately, no data concerning the estimated MAC of this type of climate change mitigation option was identified.

No significant job creation benefits are expected with this option. However, some job losses in the energy supply sector may result in response to reduced demand for petrol.

A reduction in the number of cars on the road is not expected to offer significant direct poverty alleviation impacts. However, high import taxes on vehicles can serve to reduce poverty by channelling revenues to poverty alleviation programs. Although its intended effect is to restrain ownership and personal use of vehicles, vehicle demand management practices like import restrictions may be considered somewhat unfair as they specifically target middle income households, making the purchase price of personal transport too high for some and thereby limiting vehicle access to the wealthy.

Reduced imports of vehicle fuel to satisfy a more efficient, and smaller national vehicle fleet, will most likely positively affect the balance of payments, as will the expected reduction in car imports. This will also most likely lead to an enhancement of national energy security.

In addition, vehicle demand management practices can also lead to the achievement of other development objectives, like the promotion of public transport and the reduction of traffic congestion.

5.6.4 Vehicle Maintenance

Changes in the maintenance practice of vehicles, vehicle-body design, engines, drive-trains and in the operating practices of drivers can achieve significant reductions in energy use per vehicle-kilometre (Michaelis, 1996). For this climate change mitigation option, focus is given to vehicle maintenance in the form of engine tuning.

Studies have shown that immediately after an engine tuning, vehicles can experience a 2 to 10 % fuel saving (Michaelis, 1996 pg. 691). However, vehicle maintenance is often inadequate in many countries, either because it is given a low priority by drivers, or because maintenance services and spare parts are too expensive or unavailable (Michaelis, 1996 pg. 691). Regular vehicle inspection and emission testing are one way of addressing this inefficiency.

The reduction of GHG emission from cars as a result of vehicle maintenance is in proportion to the efficiency improvement attained. Therefore, regular vehicle maintenance can achieve up to a 10% reduction in GHG emission from the baseline.

Such a fuel saving also reduces other environmental and health hazards. In addition, to being a primary source of GHG emission, transportation activities are also responsible for health and environment damaging emissions of CO, NOx, HCs, benzene and lead (leaded gasoline). Health and environmental benefits associated with improved vehicle efficiency are therefore also in proportion to the potential 10% fuel saving that may be achieved.

The marginal abatement cost of a potential vehicle maintenance and inspection program in Botswana is estimated at 1.6 USD/ton CO_2 (Halsnaes et. al., 2002). Unfortunately, no other figures were located.

No significant job creation impacts are expected with this option, although some expansion of any inspectorate office and vehicle maintenance providers is likely.

Poverty alleviation impacts are also not expected with this option. Some financial savings may accrue to car owners through reduced consumption of petrol; however, this is unlikely, as any savings will likely be put towards payment for any required vehicle maintenance. However, it is expected that the balance of payments would be positively impacted by reduced import of vehicle petrol, as would national energy security.

5.6.5 Option Evaluation

Table 9- Transport Sector Option Evaluation

Transport Sector Criteria	Alternative Fuels	Improved Infrastructure	Vehicle Demand Management (Import Restrictions)	Vehicle Inspection and Maintenance
GHG reduction from baseline	3	2	2	1
Marginal abatement cost effectiveness (USD/t CO_2)	2	3	2	2
Employment generation	2	2	0	1
Improved balance of payments	2	1	1	1
Health benefits	1	2	2	1
Environmental benefits	1	2	2	1
Improved sustainable use of natural resources	2	1	1	1
Poverty reduction	2	2	1	0
Benefits to important or disadvantaged groups	2	1	0	0
Improved availability/access to energy services	0	0	-1	0
Improved energy security	2	1	1	1
Achievement of other development objectives or benefits			1	
Total Score	19	17	12	9

As indicated in the matrix above, alternative fuels are expected to offer the greatest climate change mitigation and sustainable development benefits of the transport options discussed here, followed by improvements in transport infrastructure, vehicle demand management by import restrictions and vehicle maintenance, respectively. In the scoring of the alternative fuel option, a range from 1 to 3 is considered most appropriate for the following criteria, employment generation, improved balance of payments, improved sustainable use of natural resources, poverty reduction, benefits to important or disadvantaged groups and improved energy security, as the significance of these benefits is highly dependant upon the type of alternative fuel under consideration. The adoption of alternative biofuels like ethanol from sugar cane is expected to generate significant positive benefits and high scores against all of these criteria, whereas the adoption of fossil fuel based alternative fuels is not expected to generate such high positive benefits. To simplify the scoring for this option, the middle score of two was assigned to all of these criteria.

The improved infrastructure and import restriction options were assigned higher scores for their health and environmental benefits than the other two options, as a result of their high fuel saving potentials. If not combined with fuel efficiency and conservation measures, the substitution of conventional gasoline fuel with alternative fuels does not offer significant improvements in air quality (much lower emission of PM, about the same emission of NOx). For this reason, the fuel saving options of improved infrastructure and import restriction are scored more generously. Both the alternative fuel option and the improved infrastructure option are expected to offer the greatest poverty alleviation benefit as both have the potential to generate a significant number of direct job opportunities as well as indirect job opportunities from the stimulation of regional economic development.

6. Option Evaluation Results

To summarize, the highest scoring and therefore most preferred climate change mitigation options, by sector, are as follows:

Power Supply (large scale, centralised): biomass to electricity

Power Supply (small scale, decentralised): small hydropower

Residential (cooking): alternative fuel

Residential/Commercial: energy efficient lighting, energy efficient building envelope

Industry: co-generation, efficient motor systems

Transport: alternative fuel, improved transport infrastructure

6.1 Scoring Limitations

During the assessment process, several problems were experienced that introduce some further subjectivity into the result achieved. These include the following issues: the occasional compounding of scores, and the subjectivity of the scoring procedure in general.

With regards to the first issue, for many of the energy efficiency measures assessed here, the health and environmental benefits of these were scored in accordance with the fuel saving predicted for the GHG reduction potential indicator. However, for consistency sake, this should have meant that the same procedure be applied for the "improved energy security" and "sustainable use of natural resources" indicators, and in some cases, possibly the "improved balance of payments" indicator. This was not undertaken, though, as then the scoring procedure would have been extremely biased, with the resulting score completely based upon the estimated fuel saving potential of the practice. Therefore, in these instances, all practices being compared were assigned identical scores for these two indicators, usually a 1.

And finally, it is also important to express the overall subjectivity of the comparison and scoring procedure here. Although quantifiable data was desired at all times, major problems were experienced in locating studies quantifying the sustainable development impacts of practices that also reduce GHG emissions. Interest and research in this area is so recent that the data required for this study was very difficult to locate, and in many cases, could not be found. Therefore, the information gathered is very qualitative in nature, and required that a lot of judgement calls be made in the scoring procedure.

7. National Communication Survey

This section of the report is dedicated to the survey of National Communications submitted to the UNFCCC secretariat by non-Annex I Parties, for the nine "good practices" identified in the previous chapter.

Each country communication was reviewed for each of the nine good practices, and information was compiled on the basis of whether or not these practices are implemented in the country or are being considered in the country. This latter case also includes the identification of the practice as a mitigation option in a mitigation option analysis by the country in question. See the tables below for a checklist account of the implemented or planned practices in non-Annex I countries. Please note red highlighting in the Energy Efficient Motor System column signifies the presence of an industrial DSM program that may or may not address motor efficiency issues, however, the description of the program did not specifically mention the implemented or planned improvement of industrial motor systems. Black filled boxes indicate the countries in which practices are being implemented, or have been identified as a mitigation option, respectively. Three of the one hundred and three national communications could not be reviewed in time for the submission of this research, due to translation problems (they are all in Spanish). These countries, of Nicaragua, Panama and Paraguay, are highlighted in orange in the following tables.

With regards to the Alternative Cooking Fuel option, it is important to note that this practice is only represented in the tables for countries that have explicitly acknowledged the presence, or planned promotion of efforts to facilitate a transition from inefficient solid fuels to more efficient fuels. The dominant use of "cleaner" energy sources for cooking in the residential sector is not represented in the tables if it is not detailed in the Communication as a specific effort of the government. The same is applicable to the CHP option. This practice is only represented in the tables for countries that specifically identified a program to promote CHP in industry. More detailed information regarding the definition of each of these practices, and the sorts of programs and measures that qualify under each, are detailed below:

Biomass to electricity (large scale): including any conversion of biomass to electricity in centralised applications. Small scale, decentralised applications are not included.

Small hydropower: including any decentralised, hydropower development under 30 MW.

Promotion of alternative cooking fuels: including any programs or measures promoting the switch from inefficient solid fuels to cleaner and more efficient alternative fuels like kerosene, LPG, natural gas and biomass-derived fuels.

Energy Efficient Building Envelope: including any programs or measures to improve the energy efficiency of building envelopes (shells), including improved insulation requirements or standards, improved building design standards or guidelines, improved thermal integrity through building codes etc. However, this option does not include isolated efforts to improve the energy efficiency of electrical end uses in buildings like lighting, air conditioners and other appliances.

Energy Efficient Lighting: including any programs or measure to improve the energy efficiency of lighting in residential and/or commercial establishments. Efficiency improvements include the replacement of incandescent light bulbs with compact fluorescent ones, and/or the substitution of inefficient sources of lighting, like paraffin and candles, with more efficient sources like electricity

CHP: including any programs or measures to promote co-generation of heat and power in industrial facilities.

Energy efficient motor systems: any programs or measures to promote the improved efficiency of motor systems in industry, including replacement of inefficient motors and improvements in drive system design and function. As mentioned in the paragraph above, industrial demand side management programs are also included here regardless of whether or not the improvement of motor systems is identified as an objective.

Alternative Fuels for transport: including any programs or measures to promote the use of alternative cleaner fuels over conventional petrol fuels for transport. This includes conversion to LPG, CNG, NG, methanol, and ethanol fuels (biofuels).

Improved transportation infrastructure: including any programs or measures for improved road quality and traffic management. For example, this includes the upgrading of road surfaces, improved road maintenance, installation of traffic management systems, construction of by pass roads etc.

7.1 Implemented Practices in non-Annex I Countries

Table 10- Summary Table of Implemented Practices in non-Annex I Countries

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Albania									
Algeria (fr)			■					■	
Antigua and Barbuda									
Argentina					■			■	
Armenia		■							
Azerbaijan									
Bahamas									
Bangladesh					■			■	
Barbados									
Belize		■							
Benin (fr + eng exec)									
Bhutan		■							
Bolivia									
Botswana					■				
Burkina Faso (fr + eng exec)									
Burundi (fr)		■							
Cambodia		■							■
Cape Verde (fr)									
Central African Republic (fr)		■							
Chad (fr)									
Chile	■	■		■	■				
Colombia (sp + e exec)			■	■	■	■		■	■
Comoros fr + e exec)		■							
Congo (fr)									
Cook Islands									
Costa Rica (sp)									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Cote d'Ivoire (fr)									
Cuba (sp)									
Democratic Republic of the Congo (fr)									
Dijbouti (fr)									
Dominica									
Ecuador									
Egypt									
El Salvador									
Eritrea									
Ethiopia									
Georgia									
Ghana									
Grenada									
Guatemala (sp)									
Guinea (fr)									
Guyana									
Haiti (fr)									
Honduras (sp)									
Indonesia									
Iran									
Israel									
Jamaica									
Jordan									
Kazakhstan									
Kenya									
Kiribati									
Kyrgyz Republic									
Lao People's Democratic Republic									
Lebanon									
Lesotho									
Malaysia									
Maldives									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Mali (fr)									
Marshall Islands									
Mauritania (fr)									
Mauritius									
Mexico									
Micronesia									
Mongolia									
Morocco (fr + e exec)									
Namibia									
Nauru									
Nicaragua (sp)									
Niger (fr)									
Niue									
Palau									
Panama (sp)									
Papua New Guinea									
Paraguay (sp)									
Peru (sp)									
Philippines									
Republic of Korea									
Republic of Moldova									
Saint Kitts and Nevis									
Saint Lucia									
Saint Vincent and the Grenadines									
Samoa									
Senegal (fr)									
Seychelles									
Singapore									
Sri Lanka									
Sudan									
Swaziland									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Tajikistan									
Thailand									
The Former Yugoslav Republic of Macedonia									
Togo (fr)									
Trinidad and Tobago									
Tunisia (fr + e exec)									
Turkmenistan									
Tuvalu									
Uganda									
Uruguay									
Uzbekistan									
Vanuatu									
Yemen									
Zimbabwe									
Total (103)									
100 surveyed	7/100	27/100	14/100	13/100	14/100	5/100	9/100	15/100	9/100
%	7	27	14	13	14	5	9	15	9

7.2 Identified Abatement Options in non-Annex I Countries

Table 11- Summary Table of Identified Abatement Options in non-Annex I Countries

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transport-ation Infrastructure**
Albania		■		■	■	■	■		■
Algeria (fr)					■	■		■	■
Antigua and Barbuda									
Argentina						■			
Armenia		■							
Azerbaijan		■			■				■
Bahamas				■	■			■	
Bangladesh	■	■	■		■	■	■	■	
Barbados	■				■		■	■	
Belize									■
Benin (fr + eng exec)			■						■
Bhutan		■		■					
Bolivia	■		■		■			■	
Botswana					■		■		■
Burkina Faso (fr + eng exec)	■		■		■				
Burundi (fr)		■							■
Cambodia		■		■	■				
Cape Verde (fr)			■		■				
Central African Republic (fr)	■	■						■	
Chad (fr)		■	■						
Chile									
Colombia (sp + eng exec)	■	■						■	
Comoros (fr + eng exec)		■							
Congo (fr)		■							
Cook Islands									
Costa Rica (sp)					■			■	■

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transport-ation Infrastructure**
Cote d'Ivoire (fr)									
Cuba (sp)									
Democratic Republic of the Congo (fr)									
Dijbouti (fr)									
Dominica									
Ecuador									
Egypt									
El Salvador									
Eritrea									
Ethiopia									
Georgia									
Ghana									
Grenada									
Guatemala (sp)									
Guinea (fr)									
Guyana									
Haiti (fr)									
Honduras (sp)									
Indonesia									
Iran									
Israel									
Jamaica									
Jordan									
Kazakhstan									
Kenya									
Kiribati									
Kyrgyz Republic									
Lao People's Democratic Republic									
Lebanon									
Lesotho									
Malaysia									
Maldives									

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transport-ation Infrastructure**
Mali (fr)									
Marshall Islands									
Mauritania (fr)									
Mauritius									
Mexico									
Micronesia									
Mongolia									
Morocco (fr + eng exec)									
Namibia									
Nauru									
Nicaragua (sp)									
Niger (fr)									
Niue									
Palau									
Panama (sp)									
Papua New Guinea									
Paraguay (sp)									
Peru (sp)									
Philippines									
Republic of Korea									
Republic of Moldova									
Saint Kitts and Nevis									
Saint Lucia									
Saint Vincent and the Grenadines									
Samoa									
Senegal (fr)									
Seychelles									
Singapore									
Sri Lanka									
Sudan									
Swaziland									

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (large-scale)**	**Small hydro power**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transport-ation Infrastructure**
Tajikistan									
Thailand									
The Former Yugoslav Republic of Macedonia									
Togo (fr)									
Trinidad and Tobago									
Tunisia (fr + eng exec)									
Turkmenistan									
Tuvalu									
Uganda									
Uruguay									
Uzbekistan									
Vanuatu									
Yemen									
Zimbabwe									
Total (103)									
100 surveyed	18/100	37/100	29/100	31/100	40/100	11/100	22/100	39/100	20/100
%	18	37	29	31	40	11	22	39	20

7.3 Results

As provided in the summary tables above, 7% of the countries surveyed have implemented large scale biomass to energy applications, 27% have implemented small hydropower installations, 14% promote the use of alternative cooking fuels, 13% have programs or measures in place to improve the energy efficiency of building envelopes, 14% have undergone efforts to improve the efficiency of lighting in the residential and/or commercial sectors, 5% promote CHP in industry, 9% promote improved energy efficiency of motor systems in industry, 15% promote alternative fuels in the transport sector, and finally, 9% of the countries surveyed have implemented measures to improve transport infrastructure and/or management. In ranked order from most to least common, SHP is the most common option identified, followed by alternative fuels for transport, energy efficient lighting and alternative cooking fuels tie for the third most common option, followed by energy efficient building envelopes, improved transportation infrastructure and energy efficient motor systems tie for fifth, in sixth place is the large-scale application of biomass to electricity, and finally, the promotion of industrial co-generation is the least common option implemented in non-Annex I countries.

With regards to table 11 above, which represents all countries that indicated consideration of any of the select nine options assessed for here, including countries already implementing measures in these areas and interested in furthering their efforts, 18% of the surveyed countries have identified large scale biomass to electricity applications as a mitigation option of interest, 37% are interested in the development, or continued development of SHP applications to provide electricity to off-grid locations, 29% are interested in the promotion of alternative cooking fuels, 31% are interested in programs or measures to improve the energy efficiency of building shells, 40% are interested in programs or measures to improve the efficiency of lighting in the residential and/or commercial sectors, 11% are interested in the promotion of CHP applications in industry, 22% are interested in programs or measures to improve motor system efficiency in industry, 39% are interested in the promotion of alternative fuels in the transport sector, and finally, 20% of the countries surveyed are interested in the improvement of transport infrastructure. In ranked order from most to least common, energy efficient lighting is the most common option identified, followed by alternative fuels for transport, small hydropower, energy efficient building envelopes, alternative cooking fuels, energy efficient motor systems, improved transportation infrastructure, biomass to electricity installations, and finally, CHP is the least considered option. See table below for a summary of these results.

Table 12- Summary Table of Survey Results

Mitigation Programs or Measures	**Implemented**		**Options Identified**	
	%	**Rank**	**%**	**Rank**
Biomass to Electricity	7	6	18	8
Small Hydropower	27	1	37	3
Alternative Cooking Fuels	14	3	29	5
Energy Efficient Building Envelope	13	4	31	4
Energy Efficient Lighting	14	3	40	1
CHP	5	7	11	9
Energy Efficient Motor Systems	9	5	22	6
Alternative Fuels for Transport	15	2	39	2
Improved Transport Infrastructure	9	5	20	7

As evident from the table, the percentage of countries having indicated interest in pursuing any of the nine preferred "good practices", is greater than the percentage of countries actually implementing these practices in all cases. This is, however, not surprising as most countries, including Annex 1 countries, have many plans for programs that could be implemented when other factors like the economy, institutional capacity and funding, improves or becomes available.

It is also important to note that several countries are neither implementing nor considering any of the sustainable development options presented here. These include the following countries: Antigua and Barbuda, Cook Islands, the Democratic Republic of the Congo, Djibouti, Maldives, Micronesia, Tuvalu and Uruguay. This is discussed in the following section.

8. Analysis and Discussion

8.1 Introduction

This section is dedicated to an analysis of the results attained and presented in the previous section, in relation to the hypothesis of this study. As evident from table 10, small hydropower applications for rural electrification are most common in the surveyed countries (27%). Centralised biomass to electricity applications and CHP applications in industry are the least common at 7% and 5% respectively. The remaining practices were identified in at least 9-15% of the communications surveyed. There are several potential reasons for SHP's larger presence in these countries. For instance, in almost all countries surveyed, rural electrification and improved access to reliable energy sources for the entire population are very important development priorities, along with poverty eradication and food security. Therefore, what limited resources there are, likely go into these highly prioritised development goals. In addition, small hydropower applications in rural settings are often much cheaper to install than the conventional alternative, which is the expansion and extension of the central grid to these often remote areas.

However, if SHP is removed from the results, the remaining practices are present in no more than 15% of the countries surveyed, what could be considered a fairly low representation considering the potential sustainable development benefits that could result from their implementation. But is it really correct to imply that opportunities for economic and social development have not been fully explored in these non-Annex I countries? Although the primary aim of this research is to investigate the hypothesis that the actions studied here are neither implemented nor considered to any great extent in non-Annex I nations, it is extremely important to recognize that these nine "good practices" will NOT make sense in all non-Annex I nations. Although nations may share common political ideals, religions, development priorities, and climate, to name only a few potential commonalities, no two countries share an identical set of national circumstances. Using an example to explain further, it is likely that not all non-Annex I nations identified as neither implementing nor considering biomass to electricity applications have large enough agricultural industries that would make the export of electricity to the grid from these installations economically attractive, or even possible (e.g. this is the case for many small island states). Therefore, a deeper analysis of the results achieved in the survey is attempted to identify those nations with strong agricultural industries in which a biomass to electricity application may be technically and economically feasible. It is those countries that offer a large agricultural potential, but have not reported any consideration for the technology, where a potentially significant opportunity for sustainable development may exist and in which decision makers may not be fully aware of the sustainable development benefits of the option. Therefore, this section is dedicated to a deeper analysis of the technical and economic feasibility of each of the nine "good practices" in those countries identified as neither implementing nor considering each of the respective actions. This can only be achieved in general terms, however, as very specific information is required to determine the true technical and economic feasibility of these practices in each nation and in consideration of each nation's circumstances. The intended outcome of this analysis is the identification of those actions representing the greatest opportunities for sustainable development that also mitigates climate change in the developing world. Those actions found to be economically and technically feasible in a great number of nations that are neither implementing nor considering them, may represent significant opportunities for sustainable development and climate change mitigation in the developing world, and should serve as an important focal point for both local and international decision makers on questions of sustainable development and climate change mitigation.

However, it should also be noted that the discussion presented here is not intended to answer questions relating to why opportunities have or have not been identified and/or explored in non-Annex I countries. It is out of the scope of this research to fully investigate the factors and mechanisms preventing the implementation or exploration of these actions, and therefore, to provide an in depth investigation of the "true" feasibility of the practice in question, within each individual nation. Such a full investigation, although very interesting and useful, is not possible here due to severe time restriction and is therefore suggested as an area of further research (please see Chapter 8.5). However, although a full investigation is not provided here, any reasoning for the non-implementation of these practices that is provided in the national communications, is presented, along with a very general discussion of common factors and mechanisms known to discourage the adoption of these practices in the developing world.

In the following analysis, the extent to which each action is implemented/considered in the developing world is quantified. This is followed by an assessment of the technical and economic feasibility of each action in those nations that are neither implementing nor considering it to identify those actions representing the greatest opportunities for sustainable development in the developing world. Please note that in calculating the extent to which each action is represented in the developing world, a country is only classified as either implementing the option, considering it, or neither of these. Therefore, those countries implementing the option are not added directly to those considering the option, as in some cases, countries report that they are both implementing an option and considering further measures to enhance the same option. Therefore, the calculations elaborated below represent those countries implementing measures, in addition to those "additional" countries that are considering it. This avoids double counting of countries in the calculations and provides a more accurate representation of the situation in the developing world.

The centralised biomass to electricity option is one of the least common climate change mitigation practices implemented in the developing world. In addition, it is also one of the least considered options. This is very interesting, as it is also the power sector option assessed as having the highest GHG mitigation and sustainable development impact score in chapter 5.1.1 of this thesis. Not only did this option score the highest score possible for its GHG mitigation potential, and its overall potential to replace conventional fossil fuels in the developing world, but if well designed such a practice can offer significant sustainable development benefits in the form of employment, poverty reduction, an improved balance of payments and enhanced energy security, to name only a few. Together with the results of this survey, this information can be interpreted as an indication of a potentially under exploited development opportunity in the developing world. A more detailed analysis of this presumption is provided in the following paragraphs.

8.1.1 Biomass to Electricity

As indicated in the results table, 7 countries, or 7% of the countries surveyed have implemented centralised biomass to electricity applications. These include Chile, Cote d'Ivoire, Honduras, Mauritius, Papua New Guinea, Senegal and Thailand. However, when the additional countries that indicate this practice as a potential option for consideration are combined with these implementing nations[14], a total of 24 nations results. This implies that 76% of all surveyed non-Annex I countries are neither implementing, nor considering the implementation of biomass to electricity applications.

Yet, if centralised biomass to electricity options can generate such significant development benefits, why is it that these installations are not more common in the developing world? Although this thesis does not presume to fully explore this question, due to severe time restrictions, some exploration of this issue is certainly warranted and is attempted here. From the literature, this small representation is attributed to several factors. Firstly, biomass to electricity installations are better suited to some industries than to others. As mentioned in chapter 5.1.1, biomass to electricity applications are perhaps most commonly applied in agricultural industries that can use agricultural waste residues from processing, as a fuel for heat and/or electricity generation. Interestingly enough, perhaps it is no coincidence that the industrial CHP option is the least represented in the countries surveyed (present in 5% of countries).

Of the biomass to electricity installations identified in non-Annex I countries, many are applied in the sugar industry. For instance, both Mauritius and Papua New Guinea specifically generate electricity from sugar cane bagasse. In fact, in 1995, bagasse accounted for 32.5% of primary energy supply in Mauritius (Sok Appadu & Nayamuth, 1999). Other non-Annex I countries that have not as of yet submitted national communications, but with installed biomass to electricity capacity in the sugar cane industry, include both Brazil and India. Although Brazil has traditionally used bagasse to produce in-house heat and power, the production of excess electricity for export to the grid has only recently been realized (see Box 1). In addition, Thailand promotes the generation of electricity from both bagasse and rice paddy husks. Cote d'Ivoire and Senegal report the use of agricultural wastes in general to produce electricity. In Honduras, electricity is generated from bamboo, wood residues and African palm, and in Chile it is generated from forest residues and the wastes from paper factories. However, as all of the countries identified are sugar cane producing nations, and as sugar cane bagasse may be included in the broader category of agricultural waste, it shall be assumed that Cote d'Ivoire and Senegal are also producing electricity from sugar cane residues. As the evidence provided here suggests that 5 of these 7 nations produce electricity from sugar cane bagasse, the following assessment of the economic and technical feasibility of this option in the developing world specifically addresses the sugar cane industry.

Of the 39 other non-Annex I countries with sugar cane industries (extracted from national communications)[15], Barbados, Colombia, Cuba, Guyana, Jamaica, and Swaziland express a further interest in pursuing the generation of surplus electricity in their respective sugar cane industries. In addition, the nations of Bolivia, Burkina Faso, Central African Republic, El Salvador and the Philippines express an interest in pursuing the generation of electricity from agricultural wastes in general. It shall therefore be assumed that these latter five countries are also specifically interested in the generation of electricity from sugar cane bagasse.

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[14] Nations considering this option include Bangladesh, Barbados, Bolivia, Burkina Faso, Central African Republic, Colombia, Cuba, El Salvador, Guyana, Jamaica, Malaysia, Marshall Islands, Philippines, Republic of Moldova, Sri Lanka, Swaziland, Yemen.

[15] Sugar producing nations include Argentina, Bangladesh, Barbados, Belize, Bolivia, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Colombia, Congo, Costa Rica, Cuba, Democratic Republic of the Congo, Ecuador, El Salvador, Ethiopia, Ghana, Guatemala, Guyana, Haiti, Indonesia, Jamaica, Kenya, Mali, Mexico, Niger, Peru, Philippines, Saint Kitts and Nevis, Saint Lucia, Sri Lanka, Sudan, Swaziland, Togo, Trinidad and Tobago, Uganda and Zimbabwe.

Therefore, 46 countries of the 100 non-Annex I countries surveyed produce sugar from sugar cane (46%). Of these 46 countries, 5 (or 10.9% of sugar producing nations) are currently generating electricity from bagasse and exporting it to the central grid. The remaining 41 of these countries are not currently doing so. However, of these 41 nations, 11 have identified this practice as a climate change mitigation option for consideration. This indicates that approximately 30 countries, or 65.2% of the sugar producing nations not currently exporting electricity to the grid has also not reported the identification of this option as an alternative of interest for consideration. As alluded to above, this suggests that perhaps a significant opportunity for economic and social development may be under exploited in the developing world.

In addition, it is interesting to note that of the 39 additional non-Annex I countries identified as having sugar cane industries, many factories in these countries do not generate all of the heat and/or electricity required by their operations through the burning of bagasse as a boiler fuel. For example, in Kenya, only one of seven sugar factories generates all of its in-house heat and electricity requirements. As indicated in the Kenyan national communication, it is common practice for sugar manufacturers to leave the bagasse to rot in the fields. Barbados, Colombia, Guyana, Jamaica, Sri Lanka, and Trinidad and Tobago all express their use of bagasse for the production of at least some in-house heat and electricity. Interestingly, Trinidad and Tobago is the only one of these countries that did not identify interest in the generation and export of surplus electricity to the grid. Bangladesh, Burundi, Peru, and Sudan express use of bagasse for the production of in-house heat only. Whereas Belize, Bolivia, Burkina Faso, Cuba, Guatemala, Haiti, Mexico, Philippines and Uganda simply state that bagasse is used as fuel in the sugar industry. No information is provided for Argentina, Cape Verde, Central African Republic, Chad, Costa Rica, Congo, Democratic Republic of the Congo, Ecuador, El Salvador, Ethiopia, Ghana, Indonesia, Mali, Niger, Saint Kitts and Nevis, Saint Lucia, Swaziland, Togo and Zimbabwe. Therefore, it is evident that at least 11 of the 46 nations producing sugar (23.9%) generate at least some in-house electricity by co-generation (not including Kenya). This is not clear for the remaining 35 countries.

Although most national communications do not provide any explanation as to why the generation of surplus electricity, and its export to the central grid, is not occurring in the sugar industry, the communication submitted by Barbados does provide some insight into this. The Barbados communication states that although the feasibility of cane bagasse in a separate co-generation plant to produce electricity has been explored, limitations on the amount of sugar cane available have prevented such ventures from being profitable or competitive. As the crop season is only 4 months, an alternative fuel would have to be used to supply the plant in the sugar cane off-season. In addition to concern for the cost of supplying alternative fuel to the plant, the government is also worried about the future market for sugar from Barbados, since the elimination of preferential rates paid for sugar to the former colonies of the European Union. And finally, the communication noted that Barbados' costs of production are much higher than the world market price of sugar, such that there is now a need to maximize the value derived from sugar cane (Wellington & Rawleston, 2001).

Another country of interest is that of Trinidad and Tobago. As identified above, this nation is the only one that employs CHP within its sugar industry, but does not identify the further optimisation of this set-up to generate surplus electricity. To explain this, the Trinidad and Tobago communication, like the Barbados communication, states that agricultural supplies to sustain large biomass energy installations are simply not available in the country. This is an important finding, as it suggests that opportunities for sustainable development resulting from the co-generation of heat and power in the sugar industry, do not exist in all of the 65.2% of sugar producing countries that have not indicated consideration for the generation and export of surplus electricity to the grid. Like Trinidad and Tobago and Barbados, some countries may not have large enough industries to produce surplus electricity economically.

In addition to this observation, and the other barriers to implementation identified by Barbados, there are many other potential reasons for the lack of implementation of this option in the developing world. In general, these may include the following: cheap oil prices that provide no incentive for the high initial capital costs of improved electricity generation efficiency in sugar industries, barriers to the grid in the form of poor rates from grid operators and difficult rules favouring the generating plants of these operators, and a lack of access to customers to name only a few.

Therefore, in conclusion, although 65.2% of sugar producing nations, which is 30% of non-Annex I countries in total, do not report the identification of this option for consideration, not all of these countries are likely to benefit significantly from the implementation of such a measure. However, in consideration of the importance of other agricultural production to most non-Annex I countries, it is likely that the number of countries with a strong potential for this measure in the agricultural industry overall, surpasses the number of countries with sugar industries in which the implementation of this option may not be attractive. Therefore, it is suggested that between 30-50% of non-Annex I nations may find biomass to electricity applications economically and technically feasible, yet are neither implementing nor exploring this option. However, it is out of the scope of this research to determine exactly which countries offer more potential than others. The purpose of this assessment is simply to provide a general indication of the potential for this option in the developing world. In accordance with the evidence provided here, it is suggested that significant opportunities for sustainable development resulting from the generation of surplus electricity from biomass, exist in the developing world and that a further assessment of this potential and/or the barriers hindering the adoption of this option in these countries, is required to determine the full potential of this practice.

8.1.2 Small Hydropower

As indicated in the results table, 27 countries, or 27% of the countries surveyed have implemented small hydropower installations as part of rural electrification schemes. However, when the additional countries that indicated this practice as a potential option for consideration, are combined with these implementing nations, a total of 50 nations results. This implies that 50% of all surveyed non-Annex I countries are implementing, or are considering the implementation of small hydropower applications. However, it should be noted that there is some uncertainty associated with this figure, as difficulties separating large hydro installations from small hydro applications were experienced in the survey process. In addition, many nations do not formally recognize the installation of small hydropower units as climate change mitigation practices, meaning that the information was either not contained in the communication, or it was more difficult to find. It is therefore suggested that the number of countries with small hydropower installations is somewhat greater, although it is difficult to determine by how much.

In addition to the uncertainty described above, further evidence suggests that the number of countries that are neither implementing nor considering small hydropower applications is again somewhat less than the 50 non-Annex I countries estimated here. In order to better understand the feasibility of this practice in the developing world, an understanding for the gross theoretical potential for SHP in these countries is required. Unfortunately, this information is not always available, and has not been estimated for many countries. However, using the WEC Survey of Energy Resources (1998, 2001) as a guideline, it is apparent that the economically exploitable capability for several non-Annex I countries, like the Middle Eastern countries of Iran, Israel and Jordan, is extremely low. This is not surprising considering the dry climate of this region. Therefore, it would not be fair to suggest that a significant opportunity for sustainable development exists in all countries that are neither implementing nor considering implementing SHP installations. In consideration of the limited water resources of several of these countries, it should therefore be noted that in reality, this percentage is certainly lower. Although it is out of the scope of this research to determine by exactly how much lower this figure is, it is likely that somewhere between 30-40% of surveyed countries, have an economically exploitable potential for SHP development, yet have not identified this as a development option for further consideration. However, further studies should be carried out in order to confirm this.

8.1.3 Alternative Cooking Fuels

As indicated in table 10 above, 14% of the countries surveyed have a program or measure in place to encourage the switch from solid cooking fuels like biomass and coal, to cleaner alternative fuels like Kerosene, LPG, NG and biogas. Including those countries that have identified this as a option for consideration, the total number of countries either implementing or considering this measure climbs to 33[16], thereby implying that 67 countries or 67% of non-Annex I countries are neither implementing nor considering this option.

However, this result may improve if we narrow the analysis down to only those countries that are reliant on biomass for cooking in the residential sector, as it is in those nations that alternative cooking fuels may be most feasible and in which the greatest sustainable development benefits are likely to accrue. Not surprisingly, most of the surveyed countries still use biomass for cooking to at least some extent in rural areas. However, for the purpose of this analysis, only those countries that specifically reported a heavy dependence upon traditional biomass energy sources for cooking are considered. According to the national communications surveyed, approximately 61 countries report being heavily reliant upon biomass for cooking, at least in rural areas, in the residential sector[17]. Of these 61 countries, 12 report having programs or measures in place to promote the use of alternative cleaner cooking fuels. From the table, these are Algeria, Colombia, Cote d'Ivoire, El Salvador, Eritrea, Ghana, Kenya, Mali, Mauritius, Senegal, Sri Lanka, and Sudan. This brings the percentage of countries with a program or measure in place to replace biomass fuels for cooking, to 19.7%.

In addition to these 12 reported programs, Bangladesh, Benin, Bolivia, Burkina Faso, Cape Verde, Chad, Guinea, Kiribati, Laos, Lesotho, Mauritania, Nauru, Niger, Swaziland, Tajikistan, Togo, Tunisia and Yemen identified the promotion of alternative cooking fuels as a climate change mitigation option for consideration (a total of 18 countries). In total, 30, or 49.2% of the 61 countries assessed as relying heavily on traditional biomass for cooking purposes, are implementing or considering implementing programs or measures promoting alternative

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[16] Implementing nations: Algeria, Colombia, Cote d'Ivoire, El Salvador, Eritrea, Ghana, Kenya, Mali, Mauritius, Korea, Senegal, Seychelles, Sri Lanka, Sudan. Considering: Bangladesh, Benin, Bolivia, Burkina Faso, Cape Verde, Chad, Cuba, Guinea, Kiribati, Lao, Lesotho, Mauritania, Nauru, Niger, Swaziland, Tajikistan, Togo, Tunisia, Yemen.

[17] These include the countries of Albania, Algeria, Bangladesh, Belize, Benin, Bolivia, Botswana, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Chile, Colombia, Comoros, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Dominica, Ecuador, Egypt, El Salvador, Eritrea, Ethiopia, Ghana, Guatemala, Guinea, Guyana, Haiti, Honduras, Indonesia, Jamaica, Kenya, Kiribati, Laos, Lesotho, Maldives, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Nauru, Namibia, Niger, Peru, Senegal, Sri Lanka, Sudan, Swaziland, Tajikistan, Thailand, Togo, Tunisia, Tuvalu, Uganda, Uruguay, Vanuatu, Yemen and Zimbabwe.

cleaner fuels. Therefore, the remaining 31 countries, or 50.8% of all countries surveyed that are heavily reliant on biomass as a cooking fuel, have not reported the identification of a fuel switching program as a climate change mitigation/sustainable development option of interest for consideration now or in the future.

In conclusion, the greatest sustainable development benefits are likely to accrue to those countries heavily reliant upon traditional biomass for cooking and that are not currently implementing or considering measures to substitute these inefficient fuels with cleaner alternatives. In consideration of the potential employment, health, environmental and timesaving benefits associated with a switch from solid fuels to cleaner and more efficient cooking fuel alternatives, it is suggested that a significant opportunity for sustainable development is currently under exploited in at least one-third of non-Annex I countries (31 countries). However, 12 of these 31 countries are implementing, or have at least identified the improved energy efficiency of wood/biomass fuelled cook stoves, as an option for further consideration[18]. If we include these 12 countries in the analysis, only 19 countries remain that have not reported any consideration for improved energy efficient cooking techniques. This reduces the percentage of countries that are reliant on biomass fuels, but have not reported the consideration of improved cooking techniques, from 50.8% to 31.1%

None of the national communications surveyed provide any information as to why this practice is not being implemented. However, experience from programs in India and Brazil indicates that low-interest loans towards initial costs for the stove and fuel, and a reliable distribution system from refinery to neighbourhood distributor can significantly improve the chances of success of fuel switching efforts (Goldemberg, 2000).

8.1.4 Energy Efficient Building Envelope

Concerning the implementation of measures to improve the energy efficiency of building envelopes in the residential/commercial sectors of non-Annex I nations, 13 countries currently have measures in place. These include Chile, Colombia, Iran, Israel, Lebanon, Lesotho, Malaysia, Mexico, Korea, Seychelles, Singapore, Sudan, and Tunisia. In combination with those countries in which this is a consideration, this number rises to 40[19]. This indicates that 60 countries, or 60% of non-Annex I countries surveyed did not identify this practice for further consideration.

Although building improvements that enhance energy efficiency are relevant in all climates, an assessment of the feasibility of this measure in the developing world requires both an understanding of the regional climate and heating/cooling methods currently practiced amongst different segments of society. For example, in regions that experience colder seasons space heating is an important requirement for all people, regardless of income level. In these regions, a great potential for energy efficiency improvements exist. Improvements to the building envelope can indirectly address issues of poverty by reducing energy costs and

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18 Of the 31 countries not implementing or considering measures to promote alternative cooking fuels, the following nations are implementing programs to disseminate improved cook stoves: Haiti. The following nations have identified this as a mitigation option: Burundi, Comoros, Ecuador, Ethiopia, Guatemala, Botswana, Mexico, Mongolia, Morocco, Namibia, and Zimbabwe.

19 Countries considering measures to improve the energy efficiency of buildings include: Albania, Bahamas, Bhutan, Cambodia, Cote d'Ivoire, Dominica, Egypt, El Salvador, Eritrea, Ghana, Grenada, Guyana, Haiti, Kazakhstan, Kyrgyz Republic, Mongolia, Nauru, Palau, Philippines, Saint Kitts and Nevis, Saint Lucia, Saint Vincent, Senegal, Tajikistan, Macedonia, Uzbekistan, Yemen.

thereby increasing disposable household income, and can provide other sustainable development benefits in the form of reduced GHG emission, health and environmental benefits. However, the same is not the case for regions that experience a predominantly hot and humid climate. In these regions, although demand for cooling services is on the rise, the use of fans and air conditioners is still rather limited and is accessible usually only to middle/high income groups and middle to large scale commercial enterprises. In these regions, therefore, efficiency improvements are particularly relevant to the more affluent sectors of society. Therefore, in order to estimate more accurately the feasibility of efficiency improvements to building envelopes in the developing world, and the degree to which these are currently exploited, all countries with colder seasons should be surveyed for efficiency measures, while countries that experience mainly warm temperatures should be surveyed for data related to the demand for energy by cooling end uses (a function of income and accessibility to electricity), in addition to the implementation of efficiency measures. Nations experiencing rapid growth in the economy and in personal incomes are likely to be experiencing an increasing demand for cooling services, with major implications for climate change if energy efficiency measures are not considered. All countries that experience cold seasons, and all countries that are predominantly characterised by warm temperatures and in which demand for cooling services is rapidly increasing, could benefit significantly from energy efficiency measures for building envelopes. Those that do not currently have measures in place, and that have not identified this for consideration, are the countries of interest and in which potentially significant opportunities for sustainable development may exist.

Although climate data and energy end use or welfare distribution data was not collected in the survey process and it is considered out of the scope of this research to accurately identify all nations exhibiting the characteristics identified above, general energy consumption trends for the developing world may be used to elaborate a very general analysis here. Energy consumption trends in developing countries indicate that most energy is consumed in cooking, followed by water heating, and then lighting (Moomaw & Moreira, 2001). Small appliances and refrigeration end uses follow these. As mentioned above, the need for space heating is limited due to the warmer climate of the developing world in general, thereby suggesting that of the 60 countries identified as not considering measures to improve the energy efficiency of buildings, very few are likely to experience cold seasons and therefore, to demand space heating services. This thereby implies that most of these 60 nations experience predominantly warm climates. In consideration of the general energy consumption trend detailed above, it is also likely that cooling services are not yet a major energy end-use in these countries. In conclusion, although 60% of the countries surveyed are neither implementing nor considering measures to improve the energy efficiency of building envelopes, it is likely that few of these countries exhibit energy consumption trends where cooling is a major energy end-use and where improvements to the building envelope would significantly reduce cooling losses. Therefore, although opportunities for sustainable development certainly exist in this sector, these opportunities are most likely not as significant as the survey data might suggest. However, it is also important to note that as income levels continue to rise in the developing world, and as developing nations become increasingly affluent, the incorporation of energy efficiency measures into building envelopes will become increasingly important. As populations and incomes increase, so too will the demand for housing, with significant consequences for global warming if measures are not introduced to reduce heating and cooling energy losses from these buildings. For this reason, although it is concluded above that opportunities for sustainable development in the buildings sector are, at this point in time, most likely not as great as the survey data implies, it also suggests that developing countries may not be adequately considering likely future growth trends in the design and construction of new building envelopes. To avoid major climate change implications and to enhance the sustainable development of nations, it is important that improvements to building envelopes are considered now and gradually built-in as new buildings are constructed and investment in the buildings sector continues to increase.

8.1.5 Energy Efficient Lighting

As provided in the summary table above, 14 countries, or 14% of all the countries surveyed are implementing programs or measures to improve the efficiency of lighting in the residential and commercial sectors. Efficiency improvements include the replacement of incandescent light bulbs with compact fluorescent ones, and/or the substitution of inefficient sources of lighting, like paraffin and candles, with more efficient sources like electricity. Furthermore, 36 additional countries have identified the improved efficiency of lighting as a mitigation option for consideration. In combination, these total to 50 countries, or 50% of all countries surveyed are implementing energy efficient lighting measures, or have identified the improved efficiency of lighting as an option for consideration. This indicates that 50% of non-Annex I countries are neither implementing nor considering this action.

However, in order to gain an improved understanding of the technical and economic feasibility of this practice in the developing world, an understanding for the type of energy efficient lighting measures that non-Annex I countries are implementing or are considering is required. For example, all of the countries currently implementing improved lighting practices are replacing incandescent light bulbs with compact fluorescent types (CFLs). Some are limiting this practice to certain sectors of society, or combinations of sectors, like hotels, government buildings, the residential and/or commercial sectors. For example, Kenya specifically promotes the use of CFLs in its commercial sector, and Botswana promotes CFLs in hotels and government buildings. This situation is somewhat different from that of countries only considering measures to improve the efficiency of lighting. For example, the country of Lesotho is interested in facilitating a switch from paraffin and candle lighting sources in the residential sector to electricity, as is Namibia. Access to electricity in these countries is limited, with only 3.5 % of households in Lesotho using electricity for lighting, and only 9% of rural households in Namibia with access to electricity. Another interesting case is that of Eritrea, that is interested in facilitating a switch from incandescent bulbs to CFLs. As only 2% of the rural population has access to electricity, it is assumed that this measure is directed towards the urban population. No mention is made of improving the efficiency of lighting in rural areas.

From this information we can perhaps draw some general conclusions as to the national circumstances in which this action may be most feasible, and in which the greatest sustainable development benefits may result. Although all countries can benefit from the efficient use of electricity, or from the use of cleaner lighting alternatives, some will undoubtedly reap more benefits than others from the implementation of this practice. In particular, countries with high levels of electrification, overall or within specific sectors of the economy, in which lighting is primarily provided by electricity may benefit significantly from improved energy efficient lighting, as may countries primarily reliant upon lighting sources like paraffin, kerosene, candles and other inefficient forms. The countries belonging to the former category, can experience significant benefits in the form of reduced electricity demand and peak loads, reduced need for new power supply, GHG emission and global/local environmental pollution. The countries belonging to the latter category can experience important benefits in the form of reduced GHG emission, reduced emission of health and environmental damaging pollutants, and improved convenience to name only a few. Therefore, in assessing the feasibility of improved lighting in the 50 non-Annex I countries in which improved lighting is neither implemented nor considered, it is important to take these circumstances into account. It is those countries with high levels of electrification (overall or at least within the residential or commercial sectors), or with very low levels of electrification, that are not considering improved measures for lighting, that are of interest and in which sustainable development benefits may be significantly under exploited.

Although data pertaining to the level of electrification of countries was not gathered in the survey process, a smaller inquiry into countries not considering improved lighting was facilitated in order to compile this information. Due to difficulties in locating the required information in the national communications, only 4 countries were reviewed: the Cook Islands, Dominican, Israel, and Kiribati. The Cook Islands' national communication reports that 98% of the population have access to electricity. The consideration of improved energy efficient lighting measures was not identified in the report, however, it should be noted that the report focuses on a discussion of the vulnerability of the islands to climate change rather than one related to the mitigation of climate change. As the report does not include a mitigation option analysis, the comparability of this data with information from other national communications is significantly reduced.

Another country with a high electrification level but that has not identified improved lighting, as an option for consideration, is that of the Dominica. As of 1991, 79% of Dominican households were electrified. Although no mention is made in the communication of specific measures to improve the energy efficiency of lighting, the adoption of energy-efficient products in the residential, commercial and institutional sectors is. A similar type of situation is identified for Israel. Although Israel has a high level of electrification, measures to specifically improve the energy efficiency of lighting are not identified in the communication. However, general measures to improve the energy efficiency of buildings are, through enhanced building codes and energy efficiency standards. Together with the Dominica case, this new information suggests that the survey result (50% of non-Annex I countries are not considering energy efficiency measures for lighting) is not fully representative of the situation in non-Annex I countries. Unfortunately, these types of circumstances were not considered in the original survey process. Further evidence to support this claim comes from the Kiribati communication. Kerosene is used primarily for lighting in Kiribati's rural atolls and islands. No mention is made in the report of any specific interest in replacing kerosene used for lighting with cleaner alternative lighting sources. However, the communication does identify the nation's interest in pursuing renewable energy sources for electricity in rural areas. This in fact is applicable to most nations in which the rural population has very limited access to electricity. Electrification of rural areas is usually a primary development goal of most developing countries.

Therefore, it is concluded that the results of the survey for this mitigation option are not fully representative of the situation in the developing world. It is most likely that somewhat more than 50% of non-Annex I countries are considering measures to improve the efficiency of lighting. The true number of countries not considering this option however, is too difficult to determine here, as a variety of interlinking variables must be researched for every country. Such a process would have considerably slowed the survey process. Furthermore, the very brief inquiry into several of the countries not considering implementing efficient lighting measures, provided above, did not reveal any cases in which the level of electrification was either very high, or very low and in which measures were not already being considered that could indirectly address lighting efficiency issues (other than the Cook Islands, for which it is suggested that it not be considered as no mitigation assessment was included in the report). Although it can not be concluded that all nations not considering improved lighting measures are those that would benefit the least from the implementation of such a practice, the evidence does appear to suggest that those countries likely to gain the most are in fact already implementing improved energy efficient lighting measures, or are at least considering to do so.

However, as in the case of energy efficient building envelopes, detailed above, it is important not to downplay the significance of the survey data by limiting its applicability to current trends. As populations and income levels continue to rise in those countries identified as not considering any measures to improve the energy efficiency of lighting, electrification rates will follow. As the largest energy consuming service demanded by the residential and commercial sectors of developing nations, increasing access to lighting services with little consideration for its efficient use, will have major implications for global warming. Therefore, to avoid these implications and to enhance the sustainable development of nations, it is important that efficiency measures are considered now and are gradually implemented as electrification rates increase.

Although information detailing why efficient lighting measures are not implemented or considered in non-Annex I countries was not prevalent in the national communications surveyed, general barriers/obstacles to the implementation of this practice in developing countries include: inappropriate energy pricing below the marginal opportunity costs, an overall lack of awareness of the potential benefits associated with implementation, high initial costs and a lack of life-cycle costing by households and the commercial sector (Jochem, 2000).

8.1.6 CHP

As detailed in the results section, co-generation of heat and power within industry is the least common climate change mitigation option reported in the national communications of the countries surveyed. Only 5% of non-Annex I countries report the promotion of this practice within the industrial sector, including the countries of Colombia, Kenya, Mexico, Korea, and Thailand. Even when combined with the additional eleven countries that identified this as a potential climate change mitigation option[20] only 16% (or 16 countries) of all non-Annex I countries are promoting, or have identified the promotion of CHP within the industrial sector, as a mitigation option of interest. However, it is important to note that this data only represents those countries that specifically reported or identified programs or measures to promote CHP in industry, and does not accurately represent those countries in which industrial CHP is already a common practice. For example, using the data compiled in the analysis above on biomass to electricity applications, 12 sugar producing non-Annex I nations currently employ CHP within their sugar industries (including Kenya). These include Barbados, Colombia, Guyana, Jamaica, Kenya, Sri Lanka, Trinidad and Tobago, Mauritius, Papua New Guinea, Thailand, Cote d'Ivoire and Senegal. In addition to these twelve countries, two more identified the generation of surplus electricity from bagasse in their sugar industries as a climate change mitigation option of interest (Cuba, Swaziland). This indirectly indicates that industrial co-generation of heat and power is also of interest in these countries. Of these 14 countries, only 4 report the promotion of CHP specifically, or the identification of CHP within the industrial sector, as an option for consideration (Colombia, Kenya, Thailand, Cote d'Ivoire). Therefore, of 14 sugar producing nations currently manufacturing or considering the manufacture of sugar in CHP configurations, only four report the implementation or consideration of measures or programs to promote CHP applications in industry. To conclude, if the remaining 10 sugar producing countries that are either

[20] Considering nations: Albania, Algeria, Argentina, Bangladesh, Cote d'Ivoire, Guatemala, Haiti, Honduras, Israel, Macedonia, Yemen.

implementing or considering CHP configurations in their sugar industries, are considered together with the sixteen that reported the promotion, or identification of industrial CHP as an option for consideration, the total number of countries implementing, or considering implementing CHP in the industrial sector increases to 26. This number is in fact assumed to be even higher considering the limitation of this analysis to sugar producing nations. Many nations also have rice, palm oil, forest, pulp and paper and other large industries in which the co-generation of heat and power is most likely already occurring.

The overall potential for this option in the developing world is considerable. Although the industrial sectors of many non-Annex I countries are not fully developed, with limited contributions to national GDP, the industries that are present in these countries are largely of the type best suited to CHP configurations. As mentioned above, these include large agro-industries, food and beverage manufacturing, distilleries, the forestry industry, pulp and paper industries and many others. Therefore, taking into consideration the evidence provided above suggesting that not all nations reported the implementation and/or consideration of CHP installations, and the notion that CHP is not likely to be feasible and to achieve significant sustainable development benefits in all 74 nations identified as neither implementing nor considering it, it is suggested that this action may be feasible in up to 50 of these nations.

According to the World Energy Assessment, several studies in the developing world have identified a potential for CHP in some countries of 20-25% the industrial and commercial electricity demand (Jochem, 2000). However, the full potential of this option has not been exploited in many of these countries due to various obstacles and barriers, including: inappropriate energy pricing below the marginal opportunity costs, an overall lack of awareness of the potential benefits associated with implementation, high initial costs and a lack of life-cycle costing by industry, slow progress on power buyback arrangements with grid operators, limited capacity to manufacture high pressure boilers and turbines and an overall lack of capital and financing, to name only a few (Jochem, 2000).

8.1.7 Energy Efficient Motor Systems

Practices and measures to specifically improve the efficiency of industrial motor systems are reported in the national communications of Korea and Singapore. However, several more countries reported the operation of more general demand side management programs (DSM) targeting energy inefficient equipment and processes. If we assume that these programs also indirectly target inefficient industrial motor systems, the total number of countries implementing measures to improve the efficiency of motor systems increases to nine[21]. In addition, thirteen more countries identified the improvement of energy efficiency in motor systems as an option for further consideration. These include Albania, Bangladesh, Barbados, Botswana, Cote d'Ivoire, Cuba, Lebanon, Mongolia, Philippines, Sudan, Swaziland, Tajikistan, and Zimbabwe. Nine more identified a need for a DSM program in general, targeting energy inefficient equipment and processes, including Egypt, Guyana, Haiti, Iran, Malaysia, Sri Lanka, Macedonia, Indonesia and Papua New Guinea. If we assume that these DSM programs would also address inefficient motor systems, a total of 22 additional countries identify improved industrial motor system efficiency as an option of interest. In total, 31 non-Annex I countries report implementing programs or measures to improve motor system efficiency, or have identified this as an important climate change mitigation option for exploration.

[21] Implementing nations: Korea, Singapore, Ghana, Kenya, Mexico, Peru, Philippines, Thailand and Tunisia.

Similar to the case of energy efficient lighting, it is probably not realistic to suggest that the 69 % of non-Annex I countries that have not identified energy efficient motor systems as an option for consideration, may be losing out on a significant opportunity for sustainable development. Due to significant differences in the size of the industrial sector between countries, it is suggested that this survey result does not fairly represent the potential for this option in the developing world. Significant contributions to sustainable development as a result of measures to improve industrial motor systems are most likely to occur in higher income developing countries with larger industrial sectors, and therefore, a larger consumption of energy. For example, in Tuvalu, 80% of the population is employed in subsistence agriculture and fishing, indicating the lack of industry on the island. For countries like this, therefore, the implementation of a program or other measures to improve the efficiency of motor systems may not be the most preferred option in a portfolio of development projects/programs. However, for higher income developing countries, with larger industrial sectors, the implementation of such a program could offer significant development benefits in the form of reduced industrial energy costs and energy import, reduced GHG emission, and other environmental/health benefits. In fact, all of the countries that indicated the implementation of industrial DSM programs (and that provided this data in their national communications), or specific measures to improve the efficiency of motor systems, have industrial sectors that contribute at least 20% to national GDP[22]. Therefore, it is those countries with large industrial sectors that have not identified the improvement of motor system efficiency for consideration, that are of interest and in which sustainable development benefits may not be fully realized.

Although data on the contribution of the industrial sector to national GDP was not gathered during the survey process, a smaller random inquiry in to the countries that do not identify this as a measure for consideration is presented here. The countries surveyed include Lesotho, Tuvalu (already mentioned above), Uganda, Vanuatu, Ethiopia, Georgia, Israel, Turkmenistan, Cambodia and Bolivia. The industrial sector of all of these countries contribute less than 26.1% to GDP[23], except for Lesotho and Turkmenistan, for which industry contributes 43.2% and 35.6% respectively. However, in the case of Turkmenistan, the communication includes some general statements expressing the need for improving the efficiency of energy use in industry. With regards to Lesotho, the focus of mitigation efforts is on the substitution of inefficient biomass energy sources with cleaner, alternative sources, rather than the improved efficient use of energy.

Therefore, in consideration of the evidence presented here, only one case was identified in which the contribution of industry to national GDP is large and measures to improve the efficiency of industrial motor systems, or industrial energy use in general are not identified in the national communication (Lesotho). Although it can not be concluded that all nations not considering the implementation of measures to improve the efficiency of industrial motor systems are those that would benefit the least from this, the evidence does appear to suggest that most non-Annex I countries likely to gain significantly from the implementation of this practice, are in fact already implementing measures to improve the energy efficiency of industrial motor systems, or are at least considering to do so.

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22 24.9% for Ghana, 28.8% for Mexico, 35.52% for the Philippines, just under 30% for Korea, about 32% for Singapore, 34% for Tunisia and about 20% for Kenya.

23 Industry contributes 19.9%, 13%, 11%, 18%, 26.1%, 18.3%and 22% to the GDPs of Uganda, Vanuatu, Ethiopia, Georgia, Israel, Cambodia and Bolivia respectively.

However, this analysis and conclusion is applicable only to the present. Although improved motor systems may not currently offer significant sustainable development benefits in the developing world, with the continued growth of economies and expansion of the industrial sectors of these nations, the efficient use of energy will become an increasingly important opportunity for GHG reduction and sustainable development. As concluded here, 69% of non-Annex I parties are neither implementing nor considering measures to improve the energy efficiency of industrial motor systems, indicating that governments in these countries may not be adequately considering or prioritising likely future growth and energy consumption trends in their respective industrial sectors. Therefore, to avoid major global warming implications and to realize a sustainable development pathway for developing nations, it is important that efficiency measures are considered now and are planned for accordingly in the future as industrial sectors continue to grow.

Although information detailing why measures to improve the efficiency of industrial motor systems are not implemented or considered in non-Annex I countries was not located in any of the national communications surveyed, general barriers/obstacles to the implementation of this practice in developing countries include: inappropriate energy pricing below the marginal opportunity costs, an overall lack of awareness of the potential benefits associated with implementation, high initial costs and a lack of financing, and a tendency in developing countries to favour investments in additional capacity rather than in energy efficiency (Jochem, 2000). This leads to a proliferation of the problem as this usually encourages an increase in the import of used and energy inefficient equipment. In addition, many industrial users in the developing world focus on the minimisation of initial costs, thus tending to opt for cheaper, inefficient equipment.

8.1.8 Alternative Fuels for Transport

The following fifteen countries are implementing programs promoting the substitution of conventional petroleum transportation fuels with alternative cleaner fuels like NG, LPG, CNG, and various biomass derived fuels: Algeria, Argentina, Bangladesh, Colombia, Cuba, Egypt, Indonesia, Iran, Mali, Korea, Sri Lanka, Thailand, Trinidad and Tobago, Uzbekistan and Zimbabwe. In particular, Mali and Zimbabwe are the only countries to report some penetration of biomass-derived fuels. The national communication of Mali reports the limited used of ethanol and jatropha, and Zimbabwe reports the blending of ethanol from sugar cane into conventional petroleum fuels up to 13%. Thirty-one additional countries identified the substitution of conventional petroleum transportation fuels with alternative cleaner fuels as a climate change mitigation option for consideration[24]. In total, 46 non-Annex I countries report implementing measures to substitute conventional fuels with cleaner alternatives, or identify such a fuel substitution as an option for consideration. This suggests that 54% of non-Annex I countries are not implementing, or considering implementing a fuel switching measure or program.

But does this fairly represent the potential for this option in the developing world? Is the implementation of such a fuel substitution policy realistic in these remaining 54 countries? With regards to the substitution of conventional fuels with cleaner fossil fuels for transportation, the answer is not obvious. Especially if such a substitution does not result in reduced fuel import dependence, which would be the situation for most non-Annex I

[24] Bahamas, Barbados, Bolivia, Central African Republic, Costa Rica, Cote d'Ivoire, Dominica, Ecuador, El Salvador, Ethiopia, Ghana, Guyana, Haiti, Israel, Lebanon, Mauritania, Mauritius, Namibia, Papua New Guinea, Peru, Moldova, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & Grenadines, Samoa, Seychelles, Swaziland, Tajikistan, Tunisia, Uganda, Yemen.

countries interested in substituting conventional fuels with cleaner fossil fuels, as many do not have indigenous fossil fuel resources. However, the same cannot be said of biomass-derived transportation fuels. In this case, the potential may be significant, considering the importance of agricultural production in most non-Annex I countries. It is these countries with large agricultural production, and/or large tracts of land that could be used to grow and harvest energy crops, that have not identified biomass-derived transportation fuels as a measure for consideration, that are of the greatest interest and in which sustainable development benefits may not be fully realized.

Therefore, if we return to the analysis of countries implementing or considering measure to promote biomass-derived fuels, of the 31 countries identified above as considering measures to promote cleaner alternative fuels in general, the Central African Republic, Cote d'Ivoire, Ethiopia, Guyana, Lebanon, Mauritius, Papua New Guinea, Saint Kitts and Nevis, Saint Lucia, Samoa, Swaziland and Uganda (a total of 12 countries) all indicate interest in the development of biomass-derived transportation fuels. In addition, the countries of Bangladesh, Cuba and Korea, already implementing measures to substitute conventional fuels with cleaner fossil fuel alternatives, also indicate consideration for biomass-derived fuels. Interestingly enough, all 17 nations that are either implementing or considering measures to replace conventional fuels with biomass derived fuels[25], with the exception of Lebanon, Korea and Samoa, produce sugar. This indicates that 14 sugar producing nations are either implementing or considering measures to promote biomass-derived fuels for transportation.

As implied above, only the two sugar producing nations of Mali and Zimbabwe, of a total of 46 sugar producing nations surveyed, or 4.34% of sugar production nations, are implementing measures to substitute conventional fossil fuels with biomass-derived transportation fuels. Even when this result is combined with the 12 additional sugar producing countries that identified biomass fuels as an option for further consideration, the total number of sugar producing nations that reported interest in or the implementation of this option only increases to a total of 14, or 30.4% of all non-Annex I sugar producing nations. This indicates that 69.6% of sugar producing nations are not implementing this measure, and have not identified this option for consideration. Of the 54 countries not exploring this option, at least 32[26] of these are sugar-producing nations. Although it is tempting to suggest that sustainable development benefits may not be fully exploited in these countries, which make up 32% of non-Annex I countries, it can not be assumed that these 32 countries all have large enough industries to produce biomass-derived fuels for transportation economically. As data that would give some clue as to the relative size of the sugar industry in each country was not collected in the survey process, it is thereby estimated that up to 32% of non-Annex I countries are not fully realizing the potential of this option (down from the 54% calculated above). This estimate takes into consideration all agricultural industries, and not just the sugar industry.

Perhaps even more interesting is that most of the countries implementing fuel substitution programs involving the replacement of conventional fuels with cleaner fossil fuels, or that have at least identified this as an option for consideration, are sugar producing nations. This is

[25] Implementing nations: Mali, Zimbabwe. Considering nations: Central African Republic, Cote d'Ivoire, Ethiopia, Guyana, Lebanon, Mauritius, Papua New Guinea, Saint Kitts & Nevis, Saint Lucia, Samoa, Swaziland, Uganda + Bangladesh, Cuba, Korea.

[26] Calculation: 46 sugar producing nations – 14 sugar production nations implementing or considering biomass transport fuels.

the case for 8[27] of the 10[28] sugar producing nations implementing transportation fuel substitution programs. However, this improves somewhat when the analysis turns to those sugar-producing countries that have identified the substitution of conventional fuels with cleaner fossil fuels as a mitigation option for consideration. In this case, only 8[29] of 20[30] sugar producing nations specifically identified interest in cleaner alternative fossil fuels for transport, rather than biomass-derived fuels (40%). This indicates that up to 60% of the sugar producing nations that identified the substitution of fossil fuels with cleaner alternatives as an option for consideration, specifically are interested in the exploration of biomass-derived fuels.

Therefore, although it is suggested here that the "potential" for the production of biomass-derived fuels for transport in the developing world is significant, it can be seen that interest in the option of biofuels for transport is undoubtedly increasing in the developing world. As the adoption and use of motorized transport, and therefore motor fuel, is only expected to grow in the developing world, the evidence presented here suggests that significant opportunities for addressing national development priorities, and simultaneously reducing GHG emissions, exist in at least one-third of non-Annex I countries. However, in order for this potential to be fully exploited, major obstacles, primarily in the form of high production costs, will need to be overcome (Turkenberg, 2000).

8.1.9 Improved Transport Infrastructure

The following nine countries reported implementing road improvement and/or traffic management programs or measures: Cambodia, Colombia, Eritrea, Jordan, Kenya, Kiribati, Peru, Seychelles and Swaziland. In addition to these nine countries, nineteen more identified road improvement, or traffic management measures as an option for consideration. In total, 28 countries, or 28% of non-Annex I parties report implementing road improvement and/or traffic management programs or measures, or identified such a program or measure as an option for consideration. This implies, therefore, that 72% of non-Annex I countries are not implementing this option, and have not identified this as an option of significance.

Ground transport is a primary means of transportation and distribution the world over, and is particularly important in developing countries with underdeveloped rail, sea and air transport options. In addition, almost all communications reported an increasing number of private and commercial vehicles in the national vehicle fleets. Many countries also reported that this is resulting in major traffic congestion in larger cities and significant urban air pollution. In consideration of this common trend, it is suggested here that the "potential" for road improvement and traffic management programs and measures in the developing world both now and in the future is great, represented fairly by the evidence provided above, and that significant opportunities for GHG reduction, employment, reduced urban air pollution and health benefits may exist in the 72% of non-Annex I countries not currently implementing or considering such types of programs or measures.

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[27] Argentina, Bangladesh, Colombia, Cuba, Indonesia, Sri Lanka, Thailand, Trinidad & Tobago.

[28] Same as footnote above plus Mali and Zimbabwe.

[29] Barbadoes, Bolivia, Costa Rica, Ecuador, El Salvador, Ghana, Haiti, Peru.

[30] Same as footnote above plus Bangladesh, CAR, Cote d'Ivoire, Cuba, Ethiopia, Guyana, Mauritius, Papua New Guinea, Saint Kitts & Nevis, Saint Lucia, Swaziland, Uganda.

8.2 Analysis Summary

To summarize, the survey results alone, before any analysis is attempted, indicate that 84% of non-Annex I countries are neither implementing nor considering measures to promote and install industrial CHP, 76% are neither implementing nor considering biomass to electricity applications, 72% are neither implementing nor considering measures to improve transportation infrastructure, 69% are neither implementing nor considering actions to improve industrial motor system efficiency, 67%, 60%, and 54% are neither implementing nor considering measures to promote alternative cooking fuels, energy efficient building envelopes and alternative fuels for transport, respectively, and 50% of non-Annex I countries are neither implementing nor considering energy efficient lighting practices and SHP applications. See summary table below.

Table 13- National Communication Survey Result Summary Table

Rank	Action	% NAI neither implementing nor considering action
1	CHP	84
2	Biomass to electricity	76
3	Improved transport infrastructure	72
4	Energy efficient motor systems	69
5	Alternative cooking fuels	67
6	Energy efficient building envelope	60
7	Alternative fuels for transport	54
8	Energy efficient lighting	50
8	Small hydropower	50

However, as indicated previously, these results do not take into account the technical and economic feasibility of each of these actions in those countries not currently implementing or considering them. To address this, criteria were developed with the aim of identifying the national circumstances in which each practice would most likely achieve the greatest sustainable development benefits. See summary table below for the overall results of the performed analyses.

Table 14- Analysis Results Summary Table

Rank	Action	General Criteria	Adjusted % of NAI for which action feasible but neither implemented nor considered
1	Improved transport infrastructure	NA	72
2	CHP	Industry type	50
3	Biomass to electricity	Industry type	30-50
4	Alternative fuels for transport	Industry type	30
4	Small hydropower	Gross theoretical potential	30
4	Alternative cooking fuels	Fuel type	30
5	Energy efficient building envelope	Climate, Energy end use demand	Insignificant*
5	Energy efficient lighting	Level of electrification	Insignificant*
5	Energy efficient motor systems	Industry contribution to GDP	Insignificant*

* Only applicable to the present, no consideration for future trends. See final paragraph in this section.

The overall conclusion of the analysis is that most of the sustainable development actions assessed here are neither implemented nor considered to any great extent in the developing world, despite their technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries.

The analysis indicates that measures to improve the energy efficiency of lighting, motor systems and building envelopes, although implemented or considered in no more than half of non-Annex I countries, are most probably implemented or at least considered in those countries likely to gain the greatest sustainable development benefits from them. For example, with regards to the building envelope option, although 60% of the countries surveyed are neither implementing nor considering measures to improve the energy efficiency of building envelopes, the analysis indicates that very few of these countries have space heating needs, or consume significant amounts of energy for space cooling. Therefore, it is suggested that sustainable development benefits resulting from the implementation of measures to improve the energy efficiency of building shells, would not be significant in the developing world, at this time.

The analysis above also indicates that SHP, energy efficient cooking techniques and alternative fuels for transport may be highly feasible, but are neither implemented nor considered, in at least one-third of non-Annex I Parties, thereby suggesting that these opportunities for sustainable development are greatly under exploited in the developing world. Furthermore, measures to improve transport infrastructure and management, biomass to electricity applications, and CHP applications in industry are assessed as the least exploited in non-Annex I countries. Measures to improve transport infrastructure and management are assessed as highly feasible in all 72% of non-Annex I Parties not currently implementing or considering such practices. With regards to the biomass to electricity option, 65.2% of sugar producing non-Annex I nations are not implementing this measure nor has it been identified as a measure for consideration. As these sugar-producing nations represent 30% of non-Annex I countries, it is suggested that between 30-50% of non-Annex I countries possess an economically and technically exploitable potential for this sustainable development opportunity, yet are currently neither implementing nor exploring this option. And lastly, although the readjusted survey results indicate that 74% of non-Annex I countries are neither implementing nor considering measures to promote CHP in industry, this number is reduced even further to 50% in consideration of the probability that several countries already implementing CHP did not detail this in their national communications and in acknowledgement of the likelihood that CHP is not technically and economically feasible in all nations currently not implementing or considering it. Therefore, it is estimated that measures to promote industrial CHP may be technically and economically feasible, yet are neither implemented nor considered, in up to 50% of non-Annex I countries. In conclusion, these latter three sustainable development options, including measures to improve transport infrastructure and management, biomass to electricity applications and industrial CHP applications, are assessed as highly feasible in a significant number of non-Annex I nations not currently implementing or considering them, and of the nine actions assessed in this study, represent the greatest opportunities for sustainable development and climate change mitigation in the developing world at this time.

However, this conclusion may not hold true if likely future growth and development trends are considered. This is particularly relevant for the energy efficient lighting, building envelope and motor system options. Electrification rates are only expected to increase in the developing world and in all sectors of the economy as economies and personal incomes continue to grow, with major implications for global climate change if decision makers in the developing world do not adequately consider these expected trends in the pursuit of sustainable development pathways. Therefore, although the sustainable development benefits of energy efficient lighting, building envelopes and motor systems in the developing world may not be significant at the present time due to limited availability and accessibility to electricity in many developing nations, the significance of these opportunities will increase in proportion to the rate of electrification in these countries. In consideration of future expected trends in economic development and growth, therefore, the potential and attractiveness of these options in the analysis increases, as does the significance of their sustainable development benefits in the developing world.

8.3 Countries Identified as not Implementing any of the Practices

As stated in the result section, several countries are neither implementing nor considering any of the sustainable development options presented here. Of the 43 countries[31] determined to not be implementing any of the nine preferred practices, only eight of these countries also did not identify any of the nine practices for further consideration. These eight countries include: Antigua and Barbuda, Cook Islands, the Democratic Republic of the Congo, Djibouti, Maldives, Micronesia, Tuvalu and Uruguay. In Antigua and Barbuda, Maldives, and Tuvalu, different mitigation/sustainable development options are being pursued from the ones assessed here. For example, the national communication of Antigua and Barbuda indicates that the government has been very successful in promoting solar water heaters, and that there is interest and consideration for the improved efficiency of electricity generation, the implementation of a DSM program for the residential, commercial and tourism sectors, the investigation of solar and wind energy sources, and a driver education program on engine maintenance and vehicle operation. Tuvalu is particularly interested in the installation of solar units for electricity, while the Maldives is particularly interested in the use of high efficiency generators in the production of electricity, increasing awareness of energy efficient appliances,

[31] Albania, Antigua & Barbuda, Azerbaijan, Bahamas, Barbados, Benin, Bolivia, Burkina Faso, Cape Verde, Chad, Congo, Cook Islands, Costa Rica, Democratic Republic of the Congo, Djibouti, Dominica, Ecuador, Grenada, Guatemala, Guinea, Haiti, Jamaica, Maldives, Marshall Islands, Mauritania, Micronesia, Mongolia, Morocco, Namibia, Nauru, Niger, Niue Island, Palau, Moldova, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & Grenadines, Samoa, Togo, Turkmenistan, Tuvalu, Uruguay, Yemen.

increasing the use of solar energy sources, using solar energy to desalinise water, banning the import of reconditioned vehicles, charging high import duties on vehicles, and finally, developing an integrated land, sea and air transport system.

As for the remaining five countries, a climate change mitigation option assessment is not included in the national communications of these countries. For Micronesia, an assessment of mitigation measures for the energy sector specifically, is not included. As for Uruguay, its communication indicates that a project is currently running to identify the priority areas for mitigation and the potential costs of mitigation options identified. Although the communication for Djibouti also does not contain a climate change mitigation option assessment, it does indicate an interest in the exploration of geothermal energy sources.

In conclusion, this survey demonstrates the commitment of the developing world to the cause of development that supports climate change mitigation. Of the 100 countries surveyed, only 5 did not report any implementation or consideration for climate change mitigation measures, and even this does not accurately represent the true situation, as these countries did not include a climate change mitigation option assessment in their national communications. However, despite this impressive result, it still remains that 43 countries are currently not implementing any of the 9 practices assessed as offering potentially significant sustainable development benefits, in this report. Of these 43, 35 identified at least one of the measures assessed here for consideration (81.4%). Such a result begs us to ask the question why. Why is it that these 35 countries have not implemented any of the practices that have been identified as measures that promote climate change mitigation and perhaps strongly support other policy objectives based on national priorities, in their own national studies? Many obstacles and barriers to the implementation of identified measures are discussed in national communications, and include limitations in the form of financial resources, institutional capacity, technical expertise, available technology and others. However, a more in depth inquiry into the obstacles and barriers preventing implementation of these practices is required and is of extreme importance if significant sustainable development achievements are to be realized in the developing world.

8.4 Survey Limitations

Like the previous assessments undertaken in this thesis, the full survey of non-Annex I national communications carried out here is not without its limitations. The most important of these has been stated several times throughout the text, and shall be repeated here. It is important that the survey result and analysis presented above is understood for what it truly is, a generalized first exploratory look into the existence and extent of under exploited opportunities for sustainable development, that also mitigate climate change, in the developing world. A deeper inquiry into the "real" potential for these practices in each country surveyed was not possible in the time allotted for the writing of the thesis, and would require extensive literature review and consultation with experts. Therefore, the results attained in the sections above should be considered carefully, and understood as maximum indications of under exploited opportunities in non-Annex I countries.

In addition, it is also important to note that climate change mitigation and sustainable development efforts in the developing world are not limited to the measures selected for inclusion in this survey. As suggested above in section 8.3, over 95% of non-Annex I countries are implementing measures that address climate change, or have at least identified measures for consideration, indicating that although the options presented here may not be pursued in all countries, other options are. The methodology of study carried out here was designed in consideration of time limitations, and is therefore only able to provide a snapshot of the extent of implementation, and potential for select climate change mitigation actions, in the developing world. There are many other climate change actions offering potentially significant sustainable development benefits that could have been selected for inclusion in this study, and it is suggested that additional studies target these to further enhance the snapshot of the situation in the developing world provided here.

Another important limitation to note is that the results presented above are based entirely on the information detailed in the national communications of the countries surveyed, and therefore, may not fully represent all climate change mitigation efforts, or options for consideration, in each country. In addition, during the survey process it was noted that many countries did not provide full descriptions of climate change mitigation measures currently undertaken. For example, as already suggested in the analyses of the relevant measures, in some cases it was very difficult to determine whether countries had SHP installations in place, or to what degree CHP already existed in the industrial sector of the nations surveyed. Therefore, just like in any other study based on only one information source, the potential for bias should be recognized. In addition, it should also be noted that there is a small chance that not all programs and measures were extracted from the communications and represented in these tables. Unfortunately, time did not permit for a full reading of each of the 100 communications surveyed. Although each was thoroughly searched and scanned for the required information, there is of course a small possibility that some information may have been overlooked. This is perhaps even more relevant for the communications written in the French language, as these could not be investigated as easily and thoroughly as desired.

Other limitations include the use of assumptions in the analyses above. For example, in the analysis of measures improving industrial motor system efficiency, it was assumed that any general measure to improve the energy efficiency of industrial equipment would also target inefficient motor systems. This was assumed to try and make the analysis a bit more representative of the actual situation in these countries; however, it is always possible that such a program would in fact not target motors. In the absence of this information, however, an assumption was made. Other assumptions were also made in the other analyses.

8.5 Areas for Further Research

Perhaps the most obvious and important area for further research identified in this study concerns the mechanisms and factors behind why these practices are under exploited in the developing world. This thesis research has served to fulfil the first step in the process, an assessment of the extent to which opportunities for sustainable development and climate change mitigation are realized in non-Annex I countries. The next step in the process might be to investigate why these opportunities are not reaching their full potential. Such an inquiry is critical, as these types of measures may well represent the only type of measures that would stand a chance of generating significant emissions reductions and limitations globally. The identification of barriers to their adoption and implementation, and the eventual removal of these, is therefore of utmost importance.

In addition it is suggested that additional studies of measures to address climate change, not considered here, be carried out to further enhance understanding of the sustainable development benefits of measures that mitigate climate change, the extent to which these measures are implemented or considered in the developing world and the overall potential for these measures in non-Annex I nations now and in the future. An option of particular interest might be that of biogas for lighting, cooking and electricity in rural areas, as this was noted as a common practice, at least at an experimental level, in many of the countries surveyed.

Another interesting area for further research concerns the quantification of sustainable development benefits of climate change mitigation programs or policies. This type of research is only just emerging and most of it is in relation to the CDM. However, as suggested previously, little is known about the sustainable development impacts of climate change mitigation efforts, leading to a lack of awareness and consideration for these types of measures amongst decision makers the world over. As noted earlier in the paper, it was very difficult to find quantifiable information detailing the number of new jobs created by a climate change/sustainable development initiative, or the potential cost savings that may result. Without solid, quantifiable evidence of the sustainable development co-benefits of climate change mitigation efforts, however, it is most likely that decision makers will continue to prioritise the types of development programs and initiatives they are familiar with, and that may not address climate change issues. Therefore, it is recommended that a handbook type of resource that details case studies of countries implementing these types of measures, and that quantifies the sustainable development benefits attained, be compiled as research in this area evolves. If updated regularly, such a resource would be a valuable tool for decision-makers in the developing world.

Another alternative may be to use the UNFCCC national communications of non-Annex I countries to communicate experiences with measures and practices that simultaneously address climate change and sustainable development objectives. As they are designed now, communications usually do not do more than list, and possibly briefly detail national measures and actions to address climate change. Although almost all communications listed the development priorities of the nation and noted that climate change efforts would only be undertaken in the context of sustainable development, most communications did not provide any specific details as to how current initiatives, or options identified in a mitigation option assessment, are/were expected to address these national development priorities. Perhaps by including this information, the National Communications could evolve into more of an educational and promotional tool for sustainable development that strongly supports climate change mitigation, rather than functioning simply as a reporting forum. In addition, the inclusion of such information, when available, would better represent the importance placed on the sustainable development of non-Annex I parties as stated in the Convention itself.

9. Conclusions

If significant GHG emission reductions and limitations are to be achieved on a global scale, the wide-spread exploration and implementation of climate change mitigation measures that simultaneously support economic development and growth, poverty alleviation and social equity in the developing world, is absolutely critical. Up until very recently, this category of options that addresses many sustainable development concerns, has attracted too little attention by decision makers, overshadowed by the call for strict emission targets on developing countries from part of the industrialised world and emphasis on the call for unhindered economic and social development from lower income nations.

Yet, in recent years, we have seen growing evidence of significant GHG reduction achievement in developing countries, resulting from the pursuit of "development only" policies. Although often not motivated primarily for climate concerns, but by other pressing social and economic issues, these examples continue to illustrate the potential for policies and actions to simultaneously drive development and address climate change concerns. However, in spite of these achievements, climate change mitigation remains out of the scope of important development policy objectives in developing countries, and discussions of climate change mitigation and economic/social development remain to a large extent, divided. This is largely attributed to our limited understanding of the potential sustainable development benefits of practices and policies normally implemented for their GHG emission reduction potential, and a general wariness of developing countries to climate change mitigation actions lest they undermine more important development goals. As a result, climate change mitigation has simply not been a priority in developing countries. This suggests, however, that perhaps not all potential development opportunities are being identified and explored in decision-making processes in the developing world, and that, in particular, this category of options that addresses many sustainable development concerns, is not receiving adequate attention. Therefore, the aim of this paper has been to study the extent to which non-Annex I countries are implementing or exploring select actions that support both climate change mitigation and sustainable development objectives in the energy sector and to investigate the hypothesis that these actions are not represented to any great extent in the developing world despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries.

This hypothesis was tested by conducting an initial investigation of the potential sustainable development impacts of select climate change mitigation measures in several different energy sector categories. These measures were selected from an initial survey of 36 non-Annex I national communications, and included: small hydropower, biomass to energy and solar applications for stand-alone applications of heat and/or power; hydropower, biomass to energy and improved efficiency of power generation by up-grading of infrastructure for centralised applications of heat and/or power; energy efficient lighting, appliances and building envelopes for the residential/commercial sectors; improved, energy efficient cook stoves and alternative cooking fuels for the residential sector; energy efficient motor systems, boilers and CHP for industry; and finally, improved transport infrastructure, alternative transport fuels, vehicle maintenance and vehicle import restrictions for the transport sector. Using an assessment tool designed to quantify the potential sustainable development benefits of these practices, and a variety of literature sources, the following nine measures were assessed as offering the greatest benefits: SHP, centralised biomass to electricity applications, energy efficient lighting and building envelopes, alternative cooking fuels, energy efficient motor systems and industrial CHP, and improved transport infrastructure and alternative fuels for transport. Using the national communications of non-Annex I countries as a point of departure, the extent to which each action is implemented or is under consideration in the developing world was quantified. A further analysis of the technical and economic feasibility of these practices in those countries identified as neither implementing nor considering them was also undertaken. The main outcome of this analysis was the identification of those select actions representing the greatest opportunities for sustainable development and climate change mitigation in the developing world.

The analysis results indicate that measures to improve the energy efficiency of lighting, motor systems and building envelopes, although implemented or considered in no more than half of non-Annex I countries, are most probably implemented or at least considered in those countries likely to gain the greatest sustainable development benefits from them. For example, with regards to the building envelope option, although 60% of the countries surveyed are neither implementing nor considering measures to improve the energy efficiency of building envelopes, the analysis indicates that very few of these countries have space heating needs, or consume significant amounts of energy for space cooling. Therefore, it is suggested that sustainable development benefits from the implementation of measures to improve the energy efficiency of building shells, would not be significant in the developing world, at this time.

The analysis results also indicate that SHP, energy efficient cooking techniques and alternative fuels for transport may be feasible, but are neither implemented nor under consideration in at least one-third of all surveyed non-Annex I Parties, thereby suggesting that these opportunities for sustainable development are greatly under exploited in the developing world. Furthermore, measures to improve transport infrastructure and management, biomass to electricity applications, and CHP applications in industry are assessed as the least exploited in non-Annex I countries. Measures to improve transport infrastructure and management are assessed as highly feasible in all 72% of non-Annex I Parties not currently implementing or considering such practices. With regards to the biomass to electricity option, 65.2% of sugar producing non-Annex I nations are not implementing this measure nor has it been identified as a measure for consideration. As these sugar-producing nations represent 30% of non-Annex I countries, it is estimated that between 30-50% of all non-Annex I nations are likely to find this opportunity for sustainable development technically and economically feasible, yet are currently neither implementing nor considering this option. And lastly, it is estimated that measures to promote industrial CHP may be technically and economically feasible, yet are neither implemented nor considered, in up to 50% of all non-Annex I Parties. In conclusion, these latter three sustainable development options, including measures to improve transport infrastructure and management, biomass to electricity applications and industrial CHP applications, are assessed as highly feasible in a significant number of non-Annex I nations not currently implementing or considering them, and of the actions assessed in this study, represent the greatest opportunities for sustainable development that also mitigates climate change in the developing world.

However, this conclusion may not necessarily hold true if likely future growth and development trends are incorporated into the analysis. This is particularly relevant for the energy efficient lighting, building envelope and motor system options. Electrification rates are only expected to increase in the developing world and in all sectors of the economy as economies and personal incomes continue to grow, with major implications for global climate change if decision makers in the developing world do not adequately consider these expected trends in the pursuit of sustainable development pathways. Therefore, although the sustainable development benefits of energy efficient lighting, building envelopes and motor systems in the developing world may not be significant at the present time due to limited availability and accessibility to electricity in many developing nations, the significance of these opportunities will increase in proportion to the rate of electrification in these countries. In consideration of future expected trends in economic development and growth, therefore, the potential and attractiveness of these options in the analysis increases, as does the significance of their sustainable development benefits in the developing world.

The survey results also revealed that 95 of the 100 countries surveyed are either implementing or considering at least one of the select climate change measures assessed here, thereby demonstrating the serious commitment of the developing world to the climate change agenda. Although it is concluded that a total of 42 countries are not implementing any of the nine practices, 34 of these do report consideration for at least one of the select options. This implies that about 80% of non-Annex I countries not currently implementing these select climate change mitigation measures may not be doing so as a result of some economic, social, or political barrier(s). Further research into the obstacles and barriers preventing implementation of these practices is recommended and is of extreme importance if significant sustainable development achievements are to be realized in the developing world.

The overall conclusion of the research is that most of the sustainable development actions assessed here are neither implemented nor considered to any great extent in the developing world, despite their high technical and economic feasibility and their potential to achieve significant sustainable development benefits in these countries. In addition, of the actions assessed in this study, measures to improve transport infrastructure and management, biomass to electricity applications and industrial CHP applications currently represent the greatest opportunities for sustainable development and climate change mitigation in the developing world. It is concluded that these actions may be feasible in a large number of nations that are neither implementing nor considering them at this time, and as a result, should be explored further by local decision makers in developing countries. In addition, such information may also be of interest to international funding agencies, including potential CDM partners, in the development of prioritisation schemes for the distribution of funds and for other investment purposes. However, if used for such purposes, parties must be careful not to misunderstand or misuse the results detailed here. These results do NOT mean that the three options identified actually achieve greater sustainable development benefits than other alternatives. Although this may in some instances be the case, the potential sustainable development impacts of each option in the context of the nation's circumstances, must be explored individually and thoroughly if the most appropriate solution offering the greatest sustainable development benefits is to be identified.

Although it was out of the scope of this research to determine the factors and mechanisms preventing the implementation or exploration of these actions in non-Annex I countries, it is likely that in addition to financial, institutional, social and/or political barriers to the implementation of these measures, the most important reason behind this may be an overall lack of research and knowledge of the potential sustainable development benefits of climate change mitigation programs and policies. As mentioned previously, research on the linkages between sustainable development and climate change is only just emerging and is mostly conceptual. However, perhaps the greatest tool to increase knowledge of these linkages and to improve our understanding for the potential and real sustainable development co-benefits of climate change mitigation programs and measures will be the Clean Development Mechanism. With its implementation, let us look forward to increasing consideration of measures that simultaneously address climate change, poverty, and economic and social development by decision-makers in the developing world.

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Abbreviations

BIG/CC	Biomass Integrated Gasification Combined Cycle
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Light
CHP	Combined heat and power
COP	Conference of the Parties
DSM	Demand Side Management
GHG	Greenhouse gas
MAC	Marginal Abatement Cost
SHP	Small hydropower
UNFCCC	United Nations Framework Convention on Climate Change

Appendices

Appendix 1 – Sustainable Development and Climate Change Backgrounder

Appendix 2 – Measures and Practices to Mitigate Climate Change Identified in the National Communications of 36 non-Annex I Parties

Appendix 3 – Comparison of Climate Change Mitigation Practices by Sector

Appendix 4 – Description of Programs Implemented and Considered or Planned in non-Annex I Countries

Appendix 1 - Sustainable Development and Climate Change Backgrounder

Climate change problems are rooted in core aspects of economic and social development processes. Anthropogenic GHG emissions result from the consumption of resources and the production processes that drive the global economy, and these emissions in turn influence the productive basis of the economy and living conditions. Furthermore, the capacity for climate change policy implementation including adaptation and mitigation policies is closely linked to general institutional issues such as market efficiency, information sharing and human and social capital. As indicated here, the linkages between development processes and outcomes, and climate change are complex, but an understanding of them is critical to the successful pursuit of integrated policies that adequately address multiple development and climate change related goals. This section is therefore dedicated to a review of the linkages between development and climate change, and how the concept of sustainable development evolved out of these as a potential framework enabling the assessment of synergies and trade-offs involved in the pursuit of multiple goals.

The first part of this paper is therefore dedicated to a brief outline of various alternative development paradigms and how each of these approaches offers a different framework for understanding the key linkages between development and climate change and the policy recommendations that follow from them. This section is based entirely on an excellent review of the development and climate change literature by Halsnaes, Verhagen, La Rovere, Klein and Huq (2003). This is followed by a brief overview of the evolution of the sustainable development and climate change discussion to its present form, and in particular, to detail how the concept of sustainable development has become integrated into a conceptual framework for assessing climate change mitigation policies. This section is based predominantly on the work of Working Group III to the TAR of the IPCC, summarised in the chapter titled, "Setting the stage: Climate Change and Sustainable Development," in Climate Change 2001: Mitigation. Other literature is cited where used.

Development and Climate Change Linkages

The following five development theories present different conceptual frameworks for understanding climate change and development linkages.

The term "development" is understood differently depending on the paradigm considered, however, economic growth is always understood as represented by aggregate measures of economic output like GDP.

Economic Growth Theories: Economic growth theories have evolved in parallel with economic theory, and consider how an economy uses available natural, human, and technological resources to produce goods and services. Changes in resource availability and imbalances between different economic sectors are studied to determine the impact on economic development. As climate change is a direct result of GHG emissions generated in the production of goods and services, climate change policies are therefore directly related to the core drivers of economic growth including capital accumulation, investments and technological change, and the productivity of labour. The identification of the conditions leading to optimal resource allocation is the basis for most economic development theories, and as a result, economic policy recommendations usually focus on promoting the market mechanism to achieve efficiency in resource allocation and the removal of all market distortions. From a climate change policy perspective, recommendations usually involve the internalisation of climate change externalities into the market mechanism and the use of various economic instruments in mitigation or adaptation policies (e.g. taxies, emission trading). In addition to internalising climate change, energy policies include market liberalization policies, subsidy removal and other measures.

The Structuralist Theory: Structuralist theory embodies a discussion about economic growth versus development, inspired by the observation that industrialised countries developed faster than other nations with underdeveloped economies due to their ability to flood the global market with goods not reflecting true production costs, thereby resulting in the deflation of prices of primary products in international trade. The most important structuralist argument is that the objective of development is the structural transformation of underdeveloped economies so as to permit a process of self-sustained economic growth. To enhance the capacity of underdeveloped countries to compete in the international market, key policy recommendations are to stimulate structural change and industrialisation, import substitution and the establishment of an effective domestic demand. From a climate change policy perspective, a number of key policy recommendations for the energy sector reflect structuralist arguments. These include energy security strategies promoting the use of domestic resources, technology transfer models, and leapfrogging strategies.

The Dualistic Theory of Development: The dualistic theory of development argues that in poorer nations, the modern sector develops alongside a traditional rural sector, resulting in a dual economy. This modern sector achieves relatively high profits, thereby attracting all the investment and leaving the traditional sector with little investment and low labour productivity. The main argument of this theory is that industrialisation should also be supported with policies ensuring the integration of the rural sector in the development process so as to enhance the living conditions of rural people. Specific policy recommendations typical of this theory include policies to introduce new technologies in the agricultural sector, and the establishment of links between the rural and modern sectors. From a climate change policy perspective, this school of thinking is reflected in policies that reduce the vulnerability of the poor in the land use sector and that promote low GHG emission intensity development of rural areas.

Institutional Economic Theory: Institutional economic theory suggests that institutions, here defined as the central structure in a society that allocates resources and organizes the market, play a critical role in determining an economy's capacity to use resources optimally. It is argued that a weak institutional structure may explain why an economy is not achieving the optimal level of resource allocation. Policy recommendations that follow from this include the enhancement of institutions like the financial sector, information and risk sharing, and the development of the market. Concerning climate change, weak institutions in developing countries can reduce the ability of countries to adapt or mitigate climate change. In particular, weak institutions can limit the success of GHG emission reduction options if they are unable to reduce the risk of participating, introduce new actors that may be required, or to strengthen the incentives for exchange. Climate change policy recommendations that reflect this school of thinking include general capacity building programmes, educational and training programmes, finance development and the development of local enterprises.

Basic Needs Theory: The final development theory to be discussed here is the basic needs theory that focuses on the relationship between development and human welfare. The main argument of this theory is that access to income and basic needs, including education, food, energy, health care and other factors, are pivotal to human well being and that these needs serve as a prerequisite to development. Basic needs theories have an important ethical dimension. In terms of climate change policy, this equity dimension has had major implications for how climate change impacts and mitigation actions are considered at both the international and national levels. At the global level, much of the discussion has focused on the unequal distribution of climate change impacts and how in particular, developing countries and low-income groups are most likely to experience the most significant negative impacts. Discussions of equity focus on the provision of an adequate climate resource for all. At the national level, the basic needs theory has been used to argue for the integration of climate change policies in more general development policies so as to ensure access to those resource that are critical to the development of the nation, but that are also the target of climate change adaptation and mitigation policies. Such policies in particular target the energy sector and land resource management.

Stemming from these development paradigms, some specific linkages between development and climate change are identified by the authors. Not all are listed here:

- Key drivers of economic growth, including capital accumulation, investment patterns and technological change have important implications for future GHG emissions and are key elements of national mitigative and adaptive capacity.
- Development policies often give high priority to investments in the major GHG emitting sectors of energy and industry.
- Inefficient economies in the developing world result in high GHG emission intensities. These reflect low production efficiencies in industrial sectors as well as the use of GHG emission intensive production processes or fuels. Reduction of GHG emission intensity can be achieved by structural change and efficiency improvements in resource consumption, which are difficult to implement due to market distortions and weak institutions.
- Foreign investment required to make structural change, efficiency improvements and to introduce clean technologies is considered “risky” in developing countries and is therefore severely limited.
- Developing countries with large agricultural sectors are particularly vulnerable to climate change impacts due to their dependence on the climate.
- Climate change is expected to affect poor people the most as they are heavily reliant upon the direct services provided by natural resources that are likely to be influenced negatively by climate change.

From these specific linkages and the more general ones identified previously, a number of development policies that support climate change objectives are identified by the authors. Not all are listed here:

- Market liberalisation, removal of subsidies and other market distortions, internalisation of externalities
- Support for the building of a good investment environment
- Energy efficiency policies (energy and carbon taxes etc.), leaping frogging and technology transfer strategies
- Prioritising the selection of mitigation or adaptation projects that emphasize development issues and equity
- Integration of climate change policy objectives in sectors with most implications for climate change like energy and food security

There are many examples of the successful pursuit of development policies that support climate change objectives in the developing world. Some are reported in the UNDP report, “Promoting Development While Limiting Greenhouse Gas Emissions: Trends and Baselines,” (1999), which outlines for example, how Argentinean policy has emphasised the development of hydroelectric and nuclear power, how Mexico has deregulated and privatised its energy sector and reduced energy subsidies, how China has dramatically reduced energy subsidies, as has Brazil, and how India has deregulated prices for certain grades of coal in addition to removing energy subsidies, all for development purposes.

This suggests that there are many policy options that can simultaneously address issues of development and climate change. Although each of these policies can individually lead to positive outcomes with respect to both development and climate change, in combination, significant achievements in both arenas are likely. For example, in the Energy Scenario chapter of the UNDP World Energy Assessment (2000), several scenarios are developed to illustrate potential future energy system outcomes under different assumptions of economic growth, technological development and global equity. Scenario C represents the ecologically driven case, and is based on fulfilling key sustainable development indicators including poverty eradication, universal access to energy, reduced adverse health impacts, limited GHG emissions, increased end-use efficiency and many others. These are achieved through emission standards and caps, incentives to encourage energy producers and consumers to use energy more efficiently, green taxes, international environmental and economic agreements and technology transfer. The predicted outcome of this scenario is one of substantial technological progress and significant global achievements in equity and environmental protection. Thus, it is this combination of policies that address development and the environment that is most likely to lead to global sustainable development.

The origins of these linkages, that derive from the various development paradigms discussed here, provides a strong background for the following discussion of sustainable development, which has been inspired largely by climate change researchers aiming to expand the scope for climate change policies through the development of alternative policy options that address multiple development and climate change objectives.

Climate Change and Sustainable Development

As detailed in the IPPC TAR, the thinking and discussion surrounding climate change mitigation policy options and design, has evolved from a cost-effectiveness and efficiency perspective, to include equity and sustainable development considerations. The objective of analyses of policies considered from the first perspective, have generally focused on the determination of the most cost-effective amount of mitigation for the global economy (or sector, project etc.), starting from a particular baseline GHG emission scenario and taking into account a particular set of socio-economic scenarios. Such cost-effectiveness analysis of policy options has been based on various analytical approaches such as global integrated assessment models, macroeconomic models, sectoral models, and technology and project assessment approaches (Halsnaes, 2002). The objective of such analysis is to identify the most optimal solutions addressing climate change mitigation and economic development, in some cases conditioned by consideration of equity and sustainability, but certainly not guided by them.

Over time, an expansion of this scope to include equity considerations and the effects of policies on existing inequalities among and within nations gradually occurred. Equity considerations originated from the basic needs paradigm outlined above and have become an important component in defining efficient emissions mitigation pathways. From a climate change mitigation perspective, this requires that neither the impact of climate change nor that of mitigation policies exacerbate existing inequities in income levels, opportunities, capacities and human welfare, both within and across nations.

Although the motivating concern of this perspective is global equity, concerns of efficiency and sustainability have also been incorporated by using equity considerations to argue for the protection of the prospects of sustainable development in developing countries. Sustainable development, as termed and popularised by the World Commission on Environment and Development report, entitled Our Common Future (1987) is defined as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Despite wide spread disagreement on the concept and on its operationalization, most researchers accept a concern for economic development, ecological integrity or sustainability and social justice or equity as its three pillars. Therefore, in addition to including economic and environmental dimensions, it also considers human development, poverty eradication and social equity by broadening conventional development theory from its narrow focus on economic growth and the expansion of the manmade stock of capital to include the expansion of human (educational level and professional skills), natural (energy sources, forestry, soil quality, ecological systems) and social capital (institutions, information sharing systems, government regulation, property rights, trust and enforcement).

It is argued that the pursuit of equity will help generate support for mitigation efforts and that this will in turn lead to more effective mitigation in the developing world. The sustainable development perspective enables the comparison of policy options that emanate from concerns of global equity, and thus, the development of a framework to enable these comparisons, has been the ultimate objective of the conceptual work on sustainable development. As stated, this framework has evolved to enable the assessment of the synergies and trade-offs involved in the pursuit of multiple goals, including environmental conservation, social equity, economic growth and poverty eradication. The goal of research on sustainable development has therefore been to show that under appropriate institutional and social conditions there is a synergy rather than a conflict between different goals.

As presented by Banuri and others, the assessment of climate policy for sustainability includes economic, environmental and social assessments, the drivers of which are efficiency, equity and sustainability as detailed above. The sustainability aspect is the only aspect not yet discussed here. Sustainability is introduced in the analysis through emphasis on alternative long-term development pathways, shifting the discussion away from the shorter-term impacts of climate policies towards a longer-term focus on sustainability and the alternative development pathways that could lead to it.

Integrating cost, equity and sustainability considerations into climate change mitigation policies

Mitigative Capacity

In recognition of the inevitable complexities of adding issues of cost-effectiveness, equity and sustainability to the climate change mitigation discussion, Banuri et. al. (2001) introduce a preliminary framework for the integration and assessment of these dimensions in climate change mitigation policies. Termed, "mitigative capacity", it is introduced as an organizing tool to aid policy makers and analysts in the integration of these dimensions. A nation's mitigative capacity reflects its ability to respond to the mitigation challenge. The mitigative capacity of a nation depends on:

- The range of viable technical options for reducing emissions
- The range of viable policy instruments with which it might effect the adoption of these countries

- The structure of critical institutions and the derivative allocation of decision-making authority
- The availability and distribution of resources required to underwrite their adoption and the associated, broadly defined opportunity cost of devoting those resources to mitigation
- The stock of human capital, including education and personal security
- The stock of social capital including the definition of property rights, the country's access to risk spreading processes
- The ability of decision-makers to manage information, the process by which these decision-makers determine which information is credible, and the credibility of decision makers themselves

(Yohe, 2001)

These factors will vary dramatically between nations, between sectors, between regions, between groups and between timeframes. The conclusion is, therefore, that policies designed to pursue development, equity and/or sustainability goals might be the most effective climate change mitigation policies, as these types of goals, as well as past and future development trajectories, play critical roles in determining the type of option that will be chosen and when it will be chosen (Halsnaes, 2002). This therefore broadens the range of potential policy options that address climate change, to include various general social and development policies. It is these types of policy instruments and strategies that draw on efficiency, equity and sustainability considerations that offer the potential for identifying new options and synergies and a broadened range of win-win options, that may make the pursuit of climate objectives less disruptive to societies and economies (Banuri et. al., 2001).

Ancillary and co-benefits

Another approach that aims at the integration of these three perspectives is the assessment of ancillary and co-benefits of climate change mitigation policies, to augment mitigation cost estimates generated in the efficiency approach. A number of studies assessing the potential sustainable development impacts of policies that also mitigate climate change have emerged. The scope of these approaches is to assess a number of side-impacts of climate change mitigation policies, and these have primarily focused on the assessment of local environment impacts on air and water quality, and are classified into two major groups: the ancillary benefits studies and the CDM studies.

Concerning the former group of studies, the IPPC summary report includes an assessment of a number of empirical studies that have estimated the costs of various policy options per unit of GHG emission reduction and the ancillary benefits associated with decreased local air pollution and improved health. Ancillary benefits are those indirect secondary or side effects of policies aimed exclusively at climate change mitigation (IPCC, 2001). These side effects feed into the economic system in the form of changes in other pollutants and non-environmental externalities like impacts on employment, transportation, agriculture, land use practices, and fuel security (Halsnaes, 2002). These studies focus on the short-term impacts of climate change mitigation and can be seen as an extension of traditional efficiency analysis of environmental policies.

With regards to the latter group of studies, as previously stated, one of the main objectives of the CDM mechanism of the Kyoto Protocol is to assist sustainable development in developing countries. In preparation for the implementation of the CDM, a number of international studies have been undertaken in an attempt to develop a framework and indicators for assessing sustainable development co-benefits of potential CDM projects. Co-benefits are defined as sustainable development impacts related to air and water pollution, other environmental impacts, biodiversity and social impacts, employment and income distribution (Austin et. al., 1999). The Bonn Agreement (July 2001), which sets out the guidelines, rules and mechanisms of the CDM, specifies that the host country of the project is responsible for developing the sustainable development criteria and indicators of the project. In particular, a WRI study reviews candidate CDM projects for Brazil, China and India, and assesses how these might advance both sustainable development and climate change mitigation objectives. Undertaken by national experts in each country, project sustainable development outcomes are assessed for their alignment with national development priorities. Although each project followed the same conceptual approach, inevitable differences resulted. In particular, each country assessed projects using different sustainable development criteria and indicators, and evaluated and compared projects differently. In addition, the types of projects themselves were different between countries as they reflected each country's own priorities and opportunities (Austin et. al., 1999). Although, many sustainable development indicators were common throughout all studies, these studies and others like it suggest that SD impact indicators should be based on national development priorities in project host countries and that impacts should be assessed in relation to the specific site and institutional context of the projects.

However, it is important to note that assessments so far are rather limited, focusing on specific mitigation policies and the financial and technical aspects of these (Halsnaes et. al., 2003). Work in this area has focused in particular on the potential synergies between local air pollution and climate change. A broader agenda of sustainable development policy objectives has not yet been reflected in climate change studies.

Appendix 2 – Measures and Practices to Mitigate Climate Change Identified in the National Communications of 36 non-Annex I Parties

Table 15- Measures and Practices to Mitigate Climate Change in the Energy Supply Sector

	Implemented Measures		Planned, Recommended or Identified as a Mitigation Option		
Energy Supply Practices	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Decentralised (specifically identified stand-alone applications of heat and/or power)					
Small hydro power	Lao, Lesotho, India	3	Ghana, Georgia, Albania, El Salvador, Mongolia, Ecuador	6	9
Biomass to energy	Lao, Kenya, Ghana, Chile, Thailand, Sudan	6	Ecuador, Lao, Lesotho	3	9
Solar	Kenya, Ghana, India, Korea, Senegal, Thailand	6	Malaysia, Ecuador	2	8
Geothermal for heating	Macedonia	1	NA	0	1
Improved efficiency of diesel generators	NA	0	Maldives, Niue,	2	2
Increase penetration of renewable in rural areas	NA	0	Lao, Bolivia	2	2
Centralised (large scale applications of heat and/or power)					
Hydro	Kenya, Brazil, China, India, Mexico, Thailand, Dominica	7	Georgia, Macedonia, Albania, Guyana, Dominica	5	12
Wind (in general)	India, Korea, Israel, Jordan	4	Egypt, Albania, Lebanon, Sudan, Mongolia	5	9
Geothermal	Kenya	1	Georgia	1	2
Solar	Egypt, India, Korea	3	Egypt, Israel, Lebanon, Sudan, Mongolia	5	8
Biomass to energy	Brazil, India	2	Malaysia, El Salvador, Bolivia	3	5
Co-generation	Mexico, Mongolia, Korea	3	Israel, Albania	2	5
Increase efficiency by up-grading of infrastructure- power production	Brazil, India, Senegal, Philippines	4	Egypt, Georgia, Israel, Mongolia, Guyana, Dominica	6	10

	Implemented Measures		Planned, Recommended or Identified as a Mitigation Option		
Energy Supply	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Practices					
Up-grading of infrastructure-transmission and distribution	Brazil, India, Philippines	3	Egypt, Georgia, Guyana, Ecuador	4	7
Tighten efficiency targets in power plants	NA	0	Philippines, Guyana	2	2
Construction of large-size coal fired plants	China	1	NA	0	1
Improved quality of fuel (coal, heavy oil)	China, India, Mexico, Israel	4	Mongolia	1	5
Switch to NG	China, India, Mexico, Thailand, Philippines, Israel	6	Egypt, Georgia, Macedonia, Albania, Philippines, Jordan, Dominica	7	13
Switch to liquid fuel from lignite, coal	NA	0	Macedonia	1	1
Waste to energy	Korea, Jordan	2	Lebanon	1	3
Nuclear	Korea, Argentina	2	NA	0	2
Renewable energy source pilot projects and research	Kenya, Ghana, Chile, Brazil, India, South Africa, Jordan	8	Indonesia, Philippines	2	10
Financial Measures					
Subsidies or financial incentives to promote renewable energy	Georgia, Argentina, Brazil, India, Korea, Senegal, Thailand	7	Dominica	1	8
Removal of market distortions surrounding renewables	Brazil, China, India, Korea, Senegal, Mexico	6	Indonesia, India, Israel, Dominica	4	10
Other					
Extension of oil pipeline	Kenya	1	NA	0	1
Development of NG pipeline	China, El Salvador, Lebanon	3	Macedonia	1	4
Enhanced importation of refined oil products	Kenya	1	NA	0	1
Rural electrification in general	Kenya	1	NA	0	1
Reduced flaring of NG in fields	Argentina	1	Bolivia	1	2
Reduced fugitive emissions from NG distribution network	Brazil	1	NA	0	1

	Implemented Measures		**Planned, Recommended or Identified as a Mitigation Option**		
Energy Supply Practices	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Economic structural reform towards less energy-intensive services	China	1	NA	0	1
Closing down of small-inefficient coal mines	China, Korea	2	NA	0	2
Exploration and development of NG fields	China, Philippines	2	Ecuador	1	3
Energy suppliers required to develop and submit DSM investment plans	Korea	1	NA	0	1
Local governments required to develop local energy plans	Korea	1	NA	0	1
Solar energy for desalinisation of drinking water	NA	0	Maldives	1	1
Promote use of renewable energy (for consideration only)	NA	0	Maldives, Indonesia, Macedonia, Georgia, Senegal, Guyana, Dominica	7	7
Reuse flared gas in petroleum industry	NA	0	Egypt	1	1

Table 16- Measures and Practices to Mitigate Climate Change in the Residential Sector

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Residential Sector / **Practices**	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Cooking					
Dissemination of efficient improved cook stoves	Kenya, India, Senegal, el Salvador,	4	Lao PDR, Lesotho, Bolivia, Ecuador	4	8
Promotion of solar cookers	Sudan	1	Lesotho	1	2
Cooking with biogas	Kenya	1	Lesotho	1	2
Cooking with cleaner fossil fuels (NG, propane, LPG, CNG etc.)	ghana, korea, sudan, senegal	4	bolivia, sudan, lesotho, ghana	4	8
Heating					
Heating with biogas	NA	0	Lesotho	1	1
Heating with solar heaters	NA	0	Lesotho	1	1
Improved energy efficient heaters	NA	0	Lesotho	1	1
Solar water heaters in homes	Israel, Kenya	2	Lesotho, Niue Island, Egypt, Ecuador	4	6
Lighting					
Replacement of lighting with more efficient types	Kenya, brazil, Argentina, Mexico, Thailand	5	Lao PDR, Niue Island, Egypt, Bolivia, India, Sudan, Ecuador, Lesotho	7	12
Solar lighting	Kenya	1	NA	0	1
Lighting biogas	Kenya	1	NA	0	1
Appliances					
Energy efficiency labelling of electric appliances	Argentina, Brazil, China, India, Philippines, Israel	6	Albania	1	7
Appliance efficiency standards	China, Korea, Philippines, Israel	4	Lebanon	1	5
Financial incentives for machines, equipment conserving energy	Thailand	1	NA	0	1
Efficient refrigeration	NA	0	Bolivia, India	2	2
Efficient air conditioning	NA	0	India	1	1
High efficiency evaporative coolers to replace air conditioners	NA	0	Sudan	1	1
Buildings					
Mandatory insulation in new buildings in compliance with thermal	korea, israel	2	macedonia	1	3

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Residential Sector	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Practices					
insulation standard					
Energy efficient building code	NA	0	Albania, Egypt	2	2
Financial support for insulation retrofits in old buildings	Korea	1	NA	0	1
Law on energy efficiency for existing buildings	NA	0	Albania	1	1
Other					
Energy conservation program in schools	Brazil	1	NA	0	1
Public information campaign for conservation of energy	Thailand, Philippines, Jordan, Senegal, Ghana	5	Maldives, Niue Island, Ghana, Egypt, Indonesia, Macedonia	6	11
Development and dissemination of heat conserving technologies	Lesotho	1	NA	0	1
Creation of DSM program	NA	0	Malaysia	1	1
Increased on-farm wood-fuel production	Kenya,	1	NA	0	1

Table 17- Measures and Practices to Mitigate Climate Change in the Commercial Sector

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Commercial Sector Practices	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Cooking					
Improved, efficient cook stoves	NA	0	lesotho, bolivia, guyana	3	3
Introduction of biodigesters for cooking	NA	0	Lesotho	1	1
Cooking with cleaner fossil fuels	NA	0	Lesotho	1	1
Heating					
CHP	NA	0	israel, albania	2	2
Solar water heaters	Maldives	1	Lesotho, Egypt	2	3
Energy efficient heaters	NA	0	Lesotho	1	1
Introduction of biodigesters for heating	NA	0	Lesotho	1	1
Lighting					
Efficient lighting (replacing lighting with more efficient types)	Kenya, India, Mexico	3	Lao, Egypt, Bolivia, India, Sudan, Mongolia, Guyana, Ecuador, Lesotho	9	12
Appliances					
Equipment and appliance labelling	Korea	1	Albania, Guyana, Dominica	3	4
Efficiency standards for equipment and appliances	Mexico	1	NA	0	1
Efficient air conditioning, cooling systems	NA	0	Sudan, Mongolia	2	2
Procurement programs	NA	0	Guyana	1	1
Efficient refrigeration	NA	0	Bolivia	1	1
Building					
Guidelines for energy efficient buildings	Lesotho, Israel, Lebanon	3	NA	0	3
Energy efficient building code that ensures improved design, thermal integrity of buildings	China, Senegal	2	Egypt, Macedonia, Albania, Israel, Philippines, Guyana, Dominica	7	9
Energy efficiency plans required in permitting process	Korea	1	NA	0	1
Energy efficiency	Korea, Mexico	2	Ghana, Senegal, Israel,	6	8

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Commercial Sector	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Practices					
Standards for specified building types			Guyana, Dominica, ecuador		
Improving building insulation	NA	0	Mongolia, Dominica	2	2
Law on energy efficiency for existing buildings	NA	0	Albania	1	1
Substitution of concrete with wood	NA	0	guyana, dominica	2	2
Other					
Building, appliance, lighting audits	Korea, Thailand	2	Ghana, Indonesia, Israel, Sudan	4	6
Restructuring of electricity tariff	Thailand	1	NA	0	1
Financial support for conservation projects and other financial incentives (tax incentives, reduced electricity pricing etc.)	Thailand, Korea	2	Israel, Sudan, Guyana, Dominica	4	6
Promotion, awareness raising of green buildings, energy efficiency, conservation	Israel, Jordan	2	Egypt	1	3
Creation of DSM program	NA	0	Malaysia	1	1
Encourage use of NG	NA	0	Indonesia	1	1
Installation of thermostat radiator valves	NA	0	Mongolia	1	1

Table 18- Measures and Practices to Mitigate Climate Change in the Industrial Sector

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Industrial Sector / **Practices**	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
General Measures for All Industries and Industrial Equipment					
Energy audit and consultation program	Kenya, Ghana, Korea, Senegal, Mexico, Philippines	6	Egypt, Sudan	2	8
CP, good housekeeping program, energy management (utilization of waste heat etc)	Macedonia	1	Egypt, Senegal, Mongolia	3	4
Upgrading or replacement of old technologies	Argentina, China,	2	Senegal, Guyana, Lao PDR, Jordan	4	6
Mandatory requirement to conduct energy audits and report to authorities	Thailand	1	Indonesia	1	2
Mandatory retirement of obsolete equipment	China	1	NA	0	1
Energy efficiency guidelines for industrial equipment and systems	China, Korea	2	NA	0	2
Standards for appliances and industrial equipment and certification program	China	1	Malaysia	1	2
Energy efficiency standards and labelling of industrial equipment	NA	0	Egypt	1	1
Financial support for replacement of inefficient equipment, efficiency improvements	Korea, Senegal, Mexico, Thailand, Philippines	5	Lebanon, Sudan	2	7
Measures for Improved Efficiency of Buildings and Lighting					
Solar hot water applications	NA	0	Egypt	1	1
Efficient lighting	NA	0	Albania	1	1
Energy efficiency guidelines for buildings	Lesotho	1	Israel	1	2
Measures for Specific Equipment, Industries					
Mandatory inspection of boilers	Kenya	1	NA	0	1

	Implemented Measures		Planned, Recommended or Identified as Mitigation Options		
Industrial Sector	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Practices					
Efficient kilns in brick production industry	India	1	NA	0	1
Improved motor efficiency through upgrading or replacement of inefficient electric motors with new ones	NA	0	Albania, Lebanon, Mongolia, India, Sudan	5	5
Improved boiler efficiency through upgrading or replacement with new technologies	NA	0	Albania, Lebanon, Lesotho, Egypt, Sudan, Ecuador	6	6
Improve efficiency of pumps	NA	0	India	1	1
Introduce steam saving devices	NA	0	Mongolia	1	1
Improved lime and cement production	NA	0	Israel, Lebanon, Mongolia	3	3
Improve quality of refined oil products produced by refinery	NA	0	Jordan	1	1
Other					
Education, information campaign	Kenya, Philippines, Jordan	3	Indonesia, Philippines	2	5
Training on energy conservation in vocational courses	Brazil, Mexico	2	NA	0	2
CHP	Brazil, Korea, Mexico	3	Albania, India, Israel	3	6
Closure of inefficient energy intensive plants	China	1	NA	0	1
Financial incentives for development of technology for use of renewables	Philippines	1	NA	0	1
Energy-intensity targets for products	Korea	1	NA	0	1
Restructuring of electricity tariff to regulate consumption	Thailand	1	Lesotho	1	2
Inclusion of env conditions in permitting procedure (air pollution)	Israel	1	NA	0	1
Voluntary air pollution emission standards	israel	1	NA	0	1

	Implemented Measures		**Planned, Recommended or Identified as Mitigation Options**		
Industrial Sector **Practices**	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
emission standards for industry	NA	0	jordan	1	1
Promotion and incentives to companies with ISO 14001	Israel	1	NA	0	1
Legal requirement for all large energy users to appoint energy conservation officers and conduct energy conservation surveys etc.	Israel	1	NA	0	1
Fuel switching to NG	NA	0	Indonesia, Israel, Lebanon	3	3
Use of non CO_2 emitting industrial processes	NA	0	Philippines	1	1

Table 19- Measures and Practices to Mitigate Climate Change in the Transport Sector

	Implemented Measures		Planned, Recommended, or Identified as Mitigation Options		
Transport Sector Practices	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Transportation Infrastructure					
Construction of fly-over, ring and by-pass road to reduce congestion	Kenya, Jordan	2	NA	0	2
Construction of bicycle paths, pedestrian zones, restricted traffic zones	China	1	NA	0	1
Restoration/maintenance/improvement of transportation network/infrastructure	Senegal, Kenya	2	Georgia, Senegal, Sudan	3	5
Traffic management	Jordan	1	Kenya, Macedonia, Mongolia, Lebanon	4	5
Provide for 2-way traffic	NA	0	Georgia	1	1
Public Transport					
Establishment of regular scheduled public transport	Maldives	1	NA	0	1
Extension of railway, subway,	Kenya, Korea	2	Jordan	1	3
Promotion of public transport	Kenya, Korea, Mexico	3	Lesotho, Kenya, Egypt, Indonesia, Macedonia, Sudan	6	9
Natural gas/CNG/LPG public transport	Brazil, India, Thailand	3	Ecuador, Israel	2	5
Fuel cells for public transport	India	1	NA	0	1
Removal of obstacles to introduction of LPG buses	Israel	1	NA	0	1
Improved public transport system	NA	0	Indonesia, Macedonia, Senegal, Israel	4	4
Introduce double decker buses	NA	0	Jordan	1	1
Subsidized public transport	NA	0	Lebanon	1	1
Intensified use of river transport	NA	0	Egypt	1	1
Tax exemptions on new taxis	Jordan	1	NA	0	1
Private Vehicle Measures					
Vehicle emission regulations	Kenya, brazil, Thailand, Israel	4	Philippines, Jordan	2	6
Measures to ensure vehicle maintenance	Kenya	1	Lesotho, Egypt, Indonesia, Senegal, Mongolia,	6	7

	Implemented Measures		**Planned, Recommended, or Identified as Mitigation Options**		
Transport Sector **Practices**	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
			Dominica		
Vehicle efficiency standards and testing program	Philippines	1	NA	0	1
Natural gas/CNG/LPG as vehicle fuel	Argentina, Korea	2	Egypt (commercial sector), Bolivia, India, Israel, Guyana, Ecuador, Dominica	7	9
Biofuel as vehicle fuel	Brazil	1	India	1	2
Fuel economy rating/labelling program for automobiles	Korea	1	NA	0	1
Fuel economy targets for vehicle manufacturers	Korea	1	NA	0	1
Fuel economy standards or improved fuel economy	NA	0	Sudan, Mongolia, Guyana, Dominica	4	4
Introduce vehicles with higher fuel economy in light duty vehicle fleets	NA	0	Sudan	1	1
tax reductions and licence fee reductions for smaller cars	Korea	1	NA	0	1
Tax exemptions for new cars	Jordan	1	NA	0	1
Vehicle import restrictions	Maldives, Kenya	2	Lesotho, Georgia, Guyana, Dominica	4	6
High import duty on vehicles	Maldives, Kenya	2	NA	0	2
Tax incentives for import of new cars	NA	0	Macedonia, Senegal	2	2
Automobile emissions tax	Korea	1	Israel	1	2
Vehicle improvement (shape, weight etc.)	NA	0	Israel	1	1
Compulsory fitting of speed limiters	NA	0	Sudan, Guyana, Dominica	3	3
Licensing fees to encourage purchase of energy eff vehicles	NA	0	Guyana	1	1
Improvement in tire performance	NA	0	Guyana, Dominica	2	2
Promote air-cleaning devices on vehicles	NA	0	Georgia	1	1
Incentives for owners to convert cars to cleaner fuels	NA	0	Indonesia	1	1
Other					
Promotion of non-motorized transport	NA	0	Senegal, Philippines, Israel	3	3

	Implemented Measures		Planned, Recommended, or Identified as Mitigation Options		
Transport Sector	**Countries**	**Tally**	**Countries**	**Tally**	**Total**
Practices					
Zero-rated duty on bicycles	Kenya	1	NA	0	1
Efficient street lighting	Argentina	1	Ecuador	1	2
Driver training for economical driving	Korea	1	Senegal	1	2
Oil pipeline construction to reduce trucker transport	Korea	1	NA	0	1
Carpooling program	Korea	1	Lebanon, Guyana	2	3
Information campaigns on fuel conservation	Mexico, Philippines, Jordan	3	Israel	1	4
Introduction of lead free gasoline	Israel	1	NA	0	1
Improvements in fuel quality (reduced sulphur etc.)	Israel	1	NA	0	1
Introduction of catalytic converters	Israel	1	Ghana, Guyana, Dominica	3	4
Inauguration of a car free day	Israel	1	NA	0	1
4-stroke replacing 2-stroke engine 2 wheelers	NA	0	Lao PDR, India	2	2
Increase fuel taxes	NA	0	Lesotho, Philippines, Israel	3	3
Improve telecommunications to reduce commuting	NA	0	Kenya, Israel	2	2
Road pricing	NA	0	Indonesia, Philippines, Jordan	3	3
Staggered commuting scheme	NA	0	Philippines	1	1

Appendix 3 – Comparison of Climate Change Mitigation Practices by Sector

Table 20- Comparison of Centralised Power Generation Options

Centralised Power Generation Options **Criteria**	**Biomass to electricity**	**Hydropower**	**IGCC**
GHG reduction from baseline	82-97%	57-99.8%	10-38%
Potential to replace conventional energy sources	High	High	High
Marginal abatement cost effectiveness (USD/t CO_2)	-17 to 38	-2.7 to 38	-2.7 to 200
Employment generation	Jobs may be directly created by activities related to collection, transport of wastes, and operation of gasifier, maintenance of any energy plantations, and may also be indirectly created through regional development of industry and economic sectors (WRI, 2000).	Short-term positions in construction of dam, transport and other related infrastructure. Development of region may result in job opportunities in the long term. However, resettlement of affected peoples can result in massive unemployment.	No significant impacts expected. Increased spending in other sectors due to fuel savings could indirectly generate jobs.
Improved balance of payments	Potential for improvement through reduced fossil fuel imports. Minor negative impacts may result if technology must be imported.	Potential for improvement through reduced fossil fuel imports.	No significant impacts expected since coal typically a domestic energy source. Minor negative impacts may result if technology must be imported.
Health benefits	Lower emission of sulphur, NOx and particulate matter.	100% reduction in air pollutants. Proliferation of water-related human disease.	Complete elimination of pm. SO2 reduction of 90 to 99%. NOx reduction of 60 to 90%.
Environmental benefits	Adverse environmental impacts may occur if proper measures not taken to control water and air emissions. Disposal of ash may be a problem. Producer gas has much lower sulphur content therefore lowering risk of soil and water acidification. Production of NOx and particulate matter is also reduced.	100% reduction in air pollutants. However, significant adverse effects may be caused by flooding of land including reduced water quality, loss of habitat and biodiversity, soil and land degradation etc. Waste is not generated.	Elimination of pm, and reduction of SO2, NOx leads to reduced acidification of environment. Bottom ash is still generated.

Improved sustainable use of natural resources	Reduced dependence on fossil fuels.	Reduced dependence on fossil fuels.	Reduced pressure on coal stocks.
Poverty reduction	Through employment generation and economic development in rural areas.	Increased infrastructure could lead to economic development of region. However, displaced peoples could experience significant reductions in personal wealth/income.	No impact expected.
Benefits to important or disadvantaged groups	Job creation for unskilled labour and through rural development that may result. Additional income to farmers for agricultural residues.	Large projects can displace peoples. Downstream users may also be significantly disadvantaged by increased competition for water resources, reduced natural fertilization of agricultural lands etc.	No impact expected.
Improved availability/access to energy services	No impact expected.	No impact expected.	No impact expected.
Improved energy security	Through reduced fossil fuel imports and diversification of fuel supply.	Through reduced fossil fuel imports and diversification of fuel supply.	Through improved efficiency of power generation and potential for reduced fossil fuel imports.
Achievement of other development objectives or benefits			

Table 21- Comparison of Decentralised Power Generation Options

Decentralised Power Generation Options	**Small scale Biomass Gasification**	**Small hydropower**	**Household Photovoltaic**
Criteria			
GHG reduction from baseline	Up to 76 % reduction assuming gas can replace 80% of diesel use	Almost 100% reduction	79-96% reduction
Potential to replace conventional energy source	High	Medium	Low

Marginal abatement cost effectiveness (USD/t CO_2)	169-177	10-30	44-370
Employment generation	Associated with collection, transport of agricultural/fuelwood residues. Jobs may also be generated into the long term through rural development.	Associated with construction, operation and maintenance of station, as well as with rural development.	Rapid commercialisation could create jobs in manufacturing, distribution, retail, installation and maintenance activities. However, short-term job creation most likely limited to distribution, installation of systems.
Improved balance of payments	Potential to positively affect balance of payments through reduced diesel imports. Potential to negatively affect balance if significant import of technology required.	Potential to positively affect balance through reduced diesel imports.	Potential to negatively affect balance if significant import of equipment required. However, savings in diesel import could be achieved in long term.
Health benefits	Reduced diesel use leading to reductions in health hazards such as particulate matter and CO emissions.	Complete elimination of health hazards associated with particulate matter and CO emissions from diesel generators.	Complete elimination of air pollution during operation. However, lead-acid batteries associated with systems may pose health risks.
Environmental benefits	Same as above. Reductions in SO2 would depend on the quality of the fuel used, while reductions in NOx would depend on the combustion temperature. Solid waste generated that requires disposal.	Complete elimination of air pollution during operation. Complete avoidance of impacts associated with large-scale hydropower development. Some disturbance of aquatic life and natural flow can occur, wetlands may suffer.	Complete elimination of air pollution during operation. However, disposal of batteries associated with solar systems may contaminate soil and water sources (UNDP, 2001)
Improved sustainable use of natural resources	Reduced pressure on fossil fuel resources.	Reduced pressure on fossil fuel resources.	Reduced pressure on fossil fuel resources.
Poverty reduction	Poverty reduction through timesaving opportunities provided by electrification, for income-generation, education etc. Poverty reduction also associated with rural economic development.	Poverty reduction through timesaving opportunities provided by electrification, for income-generation, education etc. Poverty reduction also associated with rural economic development.	Poverty reduction through time-saving opportunities provided by electrification, for income-generation, education etc.
Benefits to important or disadvantaged groups	Directly benefits disadvantaged rural communities. Women in particular. Additional income to farmers providing residues for energy.	Directly benefits disadvantaged rural communities. Women in particular.	Directly benefits disadvantaged rural communities. Women in particular. However, poorest households may not be able to afford the technology.
Improved availability/access to energy services	Improved access to electricity.	Improved access to electricity.	Improved access to electricity for those who can afford it.

Improved energy security	Through reduced dependence on fossil fuel imports to achieve rural electrification and diversification of energy supply.	Through reduced dependence on fossil fuel imports to achieve rural electrification and diversification of energy supply.	Through reduced dependence on fossil fuel imports to achieve rural electrification and diversification of energy supply.
Achievement of other development objectives or benefits			

Table 22- Comparison of Industry Options

Industry Options / **Criteria**	**Co-generation**	**Motor System Efficiency Improvement**	**Boiler Efficiency Improvement**
GHG reduction potential	10-30% fuel saving	Up to 60% fuel saving	Up to 40% fuel saving
GHG reduction in terms of estimated theoretical potential for improved efficiency in the developing world	CHP best suited to certain industry types with large heat and/or electricity demand, therefore not realistically applicable to all industries producing in-house heat.	Motors consume 50-85% of industrial electricity in the developing world	Many industries require process steam. Many boiler efficiency improvements can be made at minimal cost. Applicable to all industries producing in-house heat.
Incremental cost effectiveness (USD/t CO_2)	Benefits greater than costs	-95.7 to 17	-9 to 10
Employment generation	Impact not expected. Indirect job creation through increased spending in region by industry in other sectors.	No significant impact expected. Indirect job creation through increased spending by industry in other sectors.	No significant impact expected. Indirect job creation through increased spending by industry in other sectors.
Improved balance of payments	Potential for improvement through reduced fossil fuel import. However, imports of efficient equipment could negatively affect balance.	Potential for improvement through reduced fossil fuel import. However, imports of efficient motors and other system equipment could negatively affect balance.	Potential for improvement through reduced fossil fuel import. Imports of efficient boilers and or parts/equipment could negatively affect balance. However, significant improvements can be achieved with out major retrofitting/replacement of equipment.
Health benefits	In accordance with fuel saving, up to 30% reduction in SO2, pm, N0x.	In accordance with fuel saving, up to 60% reduction in SO2, pm, N0x.	In accordance with fuel saving, up to 40% reduction in SO2, pm, NOx
Environmental benefits	In accordance with fuel saving, up to 30% reduction in SO2, pm. Reduced N0x. All leading to reduced	Same as above, leading to reduced acidification of environment, air	Same as above, leading to reduced acidification of

	acidification of environment.	pollution etc.	environment, air pollution etc.
Improved sustainable use of natural resources	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stocks.
Poverty reduction	Potential for poverty reduction caused by economic savings to industry that may lead to increased spending in local community. CHP may also contribute to poverty reduction if excess heat/electricity provided to local residents without these services.	Potential for poverty reduction caused by economic savings to industry that may lead to increased spending in local community.	Potential for poverty reduction caused by economic savings to industry that may lead to increased spending in local community.
Benefits to important or disadvantaged groups	Financial savings to industry	Financial savings to industry	Financial savings to industry
Improved availability/access to energy services	Only if excess electricity/heat supplied to neighbouring community.	NA	NA
Improved energy security	Through fuel saving.	Through fuel saving.	Through fuel saving
Achievement of other development objectives or benefits			

Table 23- Comparison of Residential Cooking Options

Residential Cooking Options	**Improved wood fuel cook stoves**	**Switching to gaseous fuel (LPG, NG, propane etc.)**
Criteria		
GHG reduction from baseline	40-60% fuel saving	Up to 84% reduction
Marginal abatement cost effectiveness (USD/t CO_2)	0-3.24	-21 to 2
Employment generation	Improved cook stoves often manufactured within country, rather than imported, using local materials and creating jobs for local manufacturers, artisan etc.	Biomass fuels typically gathered by individual households. Therefore, import and/or domestic production, distribution, retail of gas fuels could positively impact upon job creation. Manufacturing, distribution and retail of stoves could also create jobs.

Improved balance of payments	NA	Increased import of fuel gases will adversely impact upon balance.
Health benefits	Even the best biomass stoves available today do not greatly reduce the health damaging pollution from biomass.	Gas resources significantly improve indoor air pollution caused by burning of biomass fuels.
Environmental benefits	Some reduction of air pollution. Procurement of local materials for stove production (e.g. Clay) could have adverse environmental impacts on soils and riparian ecosystems (UNDP, 2001).	Reduced air pollution.
Improved sustainable use of natural resources	Reduces pressure on forest stocks.	Greatly reduces pressure on forest stocks. However, increased pressure on non-renewable fossil fuel stock.
Poverty reduction	The time saved collecting fuel may indirectly alleviate poverty by allowing for additional income generating, educational opportunities.	The time saved collecting fuel may indirectly alleviate poverty by allowing for additional income generating, educational opportunities.
Benefits to important or disadvantaged groups	Use of traditional biomass stoves typically by rural households, therefore, improved stoves directed here. Health benefits to women and children minorities.	Significant health benefits to women and children minorities. However, households will have to pay for continued supply of gas.
Improved availability/access to energy services	NA	NA
Improved energy security	NA	Increased reliance on fossil fuels could negatively impact upon energy security.
Achievement of other development objectives or benefits		

Table 24- Comparison of Residential/Commercial Options

Residential/Commercial Sectors	**Energy Efficient Lighting**	**Energy Efficient Building Envelope**	**Energy Efficient Appliances**
Criteria			
GHG reduction from baseline	75-80% energy saving	Up to 70% energy saving	Up to 70% energy saving
GHG reduction in terms of estimated theoretical potential for improved efficiency in the developing world	Highest electricity end-use in Brazil, India	Can apply to any building	Not as significant an electricity end use

Incremental cost effectiveness (USD/t CO_2)	-323.1 to 40	-54 to 13	-3
Employment generation	Possible job losses in any domestic incandescent lighting industry. Possible domestic employment in CFL manufacturing. Financial savings to consumers could generate employment in other sectors.	Implementation of an improved building code may create positions for skilled workers in building design, engineering plus retrofitting industry etc. Indirect jobs may also be created by increased spending of consumers due to energy saving.	Possible job losses in any domestic appliance industry. Possible increased employment in domestic efficient appliance industry in long term. Financial savings to consumers could generate employment in other sectors.
Improved balance of payments	Potential for improvement through reduced fossil fuel imports and exports of CFLs. However, may adversely affect balance if mass import of CFLs required.	Potential for improvement through reduced fossil fuel imports.	Potential for improvement through reduced fossil fuel imports. However, may adversely affect balance if significant import of appliances and/or parts required. Or, potential for increased competitiveness of domestic producer, leading to increased exports.
Health benefits	In accordance with fuel saving, 75-80% reduction in N0x, SO2, pm.	In accordance with fuel saving, up to 70% reduction in N0x, SO2, pm emission.	In accordance with fuel saving, up to 70% in N0x, SO2, pm.
Environmental benefits	Same as above.	Same as above.	Same as above.
Improved sustainable use of natural resources	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stock.
Poverty reduction	Potential for indirect poverty reduction caused by economic savings to consumers that may lead to increased spending in local community. Job creation.	Potential for indirect poverty alleviation caused by economic savings to consumers that may lead to increased spending in local community. Particular benefits to the poor who can spend large portion of income on provision of heat.	Potential for indirect poverty alleviation caused by economic savings to consumers that may lead to increased spending in local community.
Benefits to important or disadvantaged groups	Financial savings to consumers.	Financial savings to consumers. Benefits to poor.	Financial savings to consumers. However, improved appliances not likely to benefit the poor due to high initial costs.
Improved availability/access to energy services	NA	NA	NA
Improved energy security	Through fuel saving.	Through fuel saving.	Through fuel saving.
Achievement of other development objectives or benefits			

Table 25- Comparison of Transport Options

Transport Sector **Criteria**	**Alternative Fuels**	**Improved Infrastructure**	**Vehicle Demand Management (Import Restrictions)**	**Vehicle Inspection and Maintenance**
GHG reduction from baseline	Up to 40% reduction for gaseous fuels up to 75% reduction for biofuels	Up to 50% fuel saving	Up to 60% fuel saving	2-10% fuel saving
Marginal abatement cost effectiveness (USD/t CO_2)	- 1.9	- 101.2	NA	1.6
Employment generation	Transfer of workers from petrol manufacturing, distribution, retail to alternative fuel sector. Additional jobs created in vehicle conversion and filling station development.	Significant job creation in short term. Jobs may also be created indirectly through stimulation of regional development.	No significant impacts expected. Reduced petrol consumption could lead to potential job losses in the energy supply sector in the long term.	No significant impacts expected. However, inspectorate office may expand in number as may service providers.
Improved balance of payments	Potential for improvement through reduced fossil fuel imports (in the biofuel case).	Potential for improvement through reduced fossil fuel imports.	Improved balance due to reduced imports of vehicles and fossil fuels.	Potential for improvement through reduced fossil fuel import.
Health benefits	Particulate emissions from gaseous fuels much lower than from gasoline. NOx emissions generally similar to or lower than those of conventional fuels. CO generally lower (IPPC, 1996). Elimination of lead emission. Emission of unburned fuel and other pollutants like formaldehyde may be higher.	In accordance with fuel saving, 50% reduction in N0x, CO, HCs, lead, pm and other pollutants.	Reduced air pollution resulting from fewer and cleaner burning cars on road. 60% reduction in NOx, CO, HCs, lead, pm etc.	In accordance with fuel saving, 2-10% reduction in NOx, etc.
Environmental benefits	Same as above leading to reduce acidification of environment, air pollution etc.	Same as above.	Same as above.	Same as above.
Improved sustainable use of natural resources	Pressure on fossil fuel stocks reduced for biofuels.	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stocks.	Reduced pressure on fossil fuel stocks.
Poverty reduction	Indirect poverty alleviation through potential job opportunities and economic development of locations where fuel manufacturing occurs.	Indirect poverty alleviation as improved infrastructure may lead to enhanced economic development of region.	Import taxes on second hand vehicles could be used to fund poverty alleviation programmes.	No significant impacts expected.
Benefits to important or disadvantaged	Potential economic benefits to rural areas, and to unskilled workers.	Financial savings to consumers.	Banning of second hand vehicle import, or high import taxes target	No benefits expected.

groups			middle-income households, making the purchase price of supposedly "cheaper" imports too high for some.	
Improved availability/access to energy services	NA	NA	Exact opposite effect.	NA
Improved energy security	Through diversification of fuel supply.	Through reduced fuel imports.	Through reduced fuel imports.	Through reduced fuel imports.
Achievement of other development objectives or benefits			Promotion of public transport. Congestion relief.	

Appendix 4 – Description of Programs Implemented and Considered or Planned in non-Annex I Countries

Table 26- Description of Programs Implemented in non-Annex I Countries

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Albania									
Algeria (fr)			Promotion of natural gas for cooking, LPG in rural areas away from gas network					Conversion of 40 000 vehicle to LPG and 160 service stations, promotion of NG	
Antigua and Barbuda									
Argentina					pilot programs for res/comm			Natural Gas Vehicle Programme	
Armenia		x							
Azerbaijan									
Bahamas									
Bangladesh					current project to replace at least 50% of all incandescent bulbs with CFLs by 2020			conversion of 17 000 petrol driven cars to CNG	

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Barbados									
Belize		x							
Benin (fr + eng exec)									
Bhutan		x							
Bolivia									
Botswana					in some hotels and govt buildings				
Burkina Faso (fr + eng exec)									
Burundi (fr)		27 micro hydro power							
Cambodia		one small hydro plant exists							road improvement financed by foreign donors
Cape Verde (fr)									
Central African Republic (fr + e exec)		2 SHP							
Chad (fr)									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Chile	3 plants using forest wastes or wastes from paper plants to generate heat, electricity	some SHP in place		documents promoting energy efficient building design	program replacing lights in 60% of municipalities, municipal sector				
Colombia (sp + e exec)			policy for the substitution of biomass with alternative fuels, particularly NG, LPG	policy to improve energy efficiency of buildings	policy to improved efficiency of lighting	policy promoting CHP, particularly in the following sectors: sugar, food, beverage, tobacco, paper and printing, hotels and hospitals		gas-conversion programs	many programmes to improve traffic management currently in place
Comoros fr + e exec)		3 SHP in place							
Congo (fr)									
Cook Islands									
Costa Rica (sp + e exec)									
Cote d'Ivoire (fr + e exec)	some electricity produced by agro-industry and sawmill wastes		program promoting butane		program in 1986				
Cuba (sp)		x						some penetration of diesel	

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Democratic Republic of the Congo (fr)									
Dijbouti (fr)									
Dominica									
Ecuador									
Egypt		x						CNG	
El Salvador			promotion of LPG						
Eritrea			LPG outreach to rural areas						road improvment
Ethiopia		x							
Georgia		15							
Ghana			promotion of NG, propane, LPG to replace fuel wood National LPG Promotion Program						
Grenada									
Guatemala (sp)									
Guinea (fr)									
Guyana		x							
Haiti (fr)									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Honduras (sp)	Two projects currently running are mentioned. One is to get energy out of bamboo (50MW). The other project is the installation of two plants generating energy out of wood residues and african palm (30MW each plant).								
Indonesia		x						CNG, LPG used in some major cities	
Iran				building codes and standards specify insulation, window, building material requirements				CNG powered buses in some cities, LPG taxis	
Israel				new buildings must comply with standard mandating thermal insulation levels environmentally responsible building guidelines					
Jamaica									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Jordan									upgrading of roads, construction of bridges, installation of computerized traffic lights
Kazakhstan		some small hydo in place							
Kenya		4 in place	promotion of biogas as cooking fuel		comm & res	promotion of CHP in tea, sugar industry			maintenance of roads, construction of fly-over, ring and by-pass roads
Kiribati									has implemented several road-upgrading campaigns over years
Kyrgyz Republic		some small hydo in place							
Lao People's Democratic Republic		4 small hydro units under construction							
Lebanon				thermal building guideline					
Lesotho		4 mini hydro units		guidelines					

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Malaysia				Energy efficiency guideline					
Maldives									
Mali (fr)		some SHP in place	program promoting biogas for cooking in rural areas					limited use of ethanol and jatropha	
Marshall Islands									
Mauritania (fr)									
Mauritius	in 1995, bagasse accounted for 32.5% of primary energy supply		govt strongly promotes LPG for cooking						
Mexico				regulation of energy consumption of buildings	Illuminex project promotes CFLs	promote CHP			
Micronesia									
Mongolia									
Morocco (fr + e exec)									
Namibia									
Nauru									
Nicaragua (sp)									
Niger (fr)									
Niue									

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Palau									
Panama (sp)									
Papua New Guinea	some use of bagasse for electricity								
Paraguay (sp)									
Peru (sp)					x				project with support from WB
Philippines		continuing installation of SHP			setting of regulatory standard for efficiency of fluorescent lamps				
Republic of Korea		x	major LNG promotion, LNG in apartment complexes larger than a certain size, promotion of LPG in rural areas and smaller cities where LNG pipeline not yet available, CNG, electricity	insulation mandatory in new buildings, financial support available for insulation retrofits in existing buildings Comm: mandatory building audits for large buildings, permit applications for large buildings must be accompanied with an energy efficiency plan, minimum energy efficiency standards established for hotels, hospitals, public baths, indoor swimming pools	energy suppliers required to develop and implement DSM plans - rebates for efficient lighting one measure	promotion of CHP in industrial complexes	tax incentives and financial assistance to replace inefficient motor systems and other equipment min. Efficiency standards for motors plan to replace all motors with high-efficiency ones by 2006 research priority	programs to promote CNG for private vehicle, LPG for taxis and trucks	

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Republic of Moldova									
Saint Kitts and Nevis									
Saint Lucia									
Saint Vincent and the Grenadines									
Samoa									
Senegal (fr)	some large agro-industries use wastes to produce in-house electricity needs, can sell surplus to grid		tax policy making wood fuel less competitive, gradual penetration of butane						
Seychelles			LPG typically used in hotels, restaurants, rapidly replacing kerosene in domestic sector. Promoted by 0 tax on LPG stoves, low taxes on LPG etc.	energy efficient standards in building design recently introduced	no tax on CFLs				road improvement programme

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Singapore				energy conservation standards in building code Energy efficiency indices for comm buildings - post construction performance requirements	energy efficient lighting in apartment complexes		tax incentive program to promote investment in efficient technologies including variable speed motors		
Sri Lanka		continuing development of sites	promotion of LPG over biomass for cooking					fuel switching to LPG	
Sudan			promotion of LPG over biomass for cooking- price has been halved, fees and customs on stoves decreased substantially	all buildings designed with wind direction in mind + upper ventilation pore etc.					
Swaziland									major upgrading recently taken place, want to improve maintenance
Tajikistan		20 SHP plants in operation							

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Thailand	program promoting sale of electricity to grid from private sector, commercial and renewable sources like bagasse, paddy husk etc.				as part of DSM program	promote sale of commercial energy to grid by private sector		LPG, NG in buses and taxis	
The Former Yugoslav Republic of Macedonia		some small hydo in place							
Togo (fr)									
Trinidad and Tobago								fuel pricing policy to encourage use of CNG	
Tunisia (fr + e exec)				working on thermal regulation for buildings					
Turkmenistan									
Tuvalu									
Uganda		some SHP in place							
Uruguay									
Uzbekistan								some use of compressed, liquified gases	
Vanuatu		x							

	Implemented Practices in non-Annex I Countries								
Country	**Biomass to energy (large-scale)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Yemen									
Zimbabwe								ethanol blending up to 13%	

Table 27- Description of Abatement Options Considered or Planned in non-Annex I Countries

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Albania		x		law on energy efficiency for existing buildings new energy code for buildings to ensure adequate insulation	x	x	x		rehabilitate roads
Algeria (fr)					x	promote CHP in large institutions, hospitals, etc.		continue promoting LPG, NG	improved traffic management, flow
Antigua and Barbuda									
Argentina						x			
Armenia		x							
Azerbaijan		x			x				improve quality of roads
Bahamas				encourage use of insulation and tinting of windows	x			CNG	
Bangladesh	interest in energy plantations (wood) for energy	x	substitution of wood fuels in institutions like schools, hospitals etc.		x	promote use of bagasse and other industrial waste residues for in-house CHP	x	ethanol	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Barbados	bagasse for co-generation				x		x	electric vehicle strategy	
Belize									improve infrastructure and traffic control
Benin (fr + eng exec)			programme to promote butane LPG and kerosene in urban areas						improve infrastructure and traffic control
Bhutan		continued development and rural electrification		improve building designs to min heat losses					
Bolivia	achieve efficiency in commercial use of biomass		increase residential use of NG		x			NG	
Botswana					x		x		paved roads
Burkina Faso (fr + eng exec)	interest in use of industrial wastes for production of electricity		solar cookers, promote other alternative fuels		x				
Burundi (fr)		continue expansion							improved traffic management
Cambodia		x		efficiency improvements to existing and new building shells	x				

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Cape Verde (fr)			shift to use of butane for cooking		x				
Central African Republic (fr + e exec)	interest in use of agricultural residues for electricity	aim to develop this further						interest in agricultural residues for motor fuel	
Chad (fr)		x	substitute butane gas for fuel wood						
Chile									
Colombia (sp + eng exec)	interest in identifying, evaluating and prioritizing strategies to eliminate barriers to export of electricity produced by co-generation in sugar and other industries	x						continued expansion of CNG, LPG	
Comoros (fr + eng exec)		x							
Congo (fr)		SHP in rural areas							
Cook Islands									
Costa Rica (sp + e exec)					x			LPG	improve roads and traffic control, flow
Cote d'Ivoire (fr + e exec)		x	substitute butane for charcoal and wood in cities	interest in energy efficiency in buildings, had a pilot project		promotion of CHP from all energy sources including biomass wastes in agroindustry	x	bio fuels	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Cuba (sp)	increase use of bagasse to meet increasing demand for electricity	x	substitute gas stoves with electric stoves and kerosene		x		x	ethanol, gas and electric cars + biomass fuel for train	
Democratic Republic of the Congo (fr)									
Dijbouti (fr)									
Dominica		x		substitute wood for concrete update building code energy standards improve thermal integrity of buildings				NG	
Ecuador		x			res/comm			CNG, especially for buses and taxis	
Egypt				revise building energy code to ensure adequate insulation	res/comm			CNG in commercial sector	
El Salvador	x	x	continued expansion of LPG	new construction designs	x			NG, LPG	improve road network
Eritrea			continued expansion of LPG	maximization of ventilation in housing	x				
Ethiopia								ethanol blending	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Georgia		x			x				renewal of roads
Ghana		x	continued expansion of LPG	energy efficiency standards and audit	x			NG	
Grenada				improved building design	x				
Guatemala (sp)					x	x			improve transport planning and infrastructure
Guinea (fr)			promotion of butane LPG over biomass, biogas in rural areas						
Guyana	sugar cane bagasse and rice husk co-generation			updating building codes to improve thermal integrity substitute wood for concrete	x			NG, other alternative fuels like ethanol, methanol	
Haiti (fr)				substitute wood for concrete	x	x		LPG, NG	traffic control
Honduras (sp)					x	x			
Indonesia		implementing project for 3 units						promotion of switch to clean alternatives	
Iran									

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Israel				economic incentives for energy efficient retrofitting of existing builidings enhanced building codes energy standards for buildings		x		switch to gas operating and electric vehicles	
Jamaica	greater use of bagasse for electricity								
Jordan									
Kazakhstan		x		improved insulation of buildings and adoption of new construction standards					
Kenya			encourage use of alternative energy sources like kerosene, LPG, electricity, solar, wind						
Kiribati			continued expansion of alternative fuels						

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Kyrgyz Republic		x		improved construction standards					
Lao People's Democratic Republic			LPG, electric		res/comm				
Lebanon							x	biomass derived gases	
Lesotho			biogas, LPG, electric	improved building designs	res/comm, electric, solar				
Malaysia	biomass waste for power co-generation (rice husks, wood fuel, palm oil wastes)								
Maldives									
Mali (fr)		x	continue promoting biogas for replacement of biomass					continue investigating ethanol and jatropha	traffic control measures, improve quality of roads
Marshall Islands	interested in biomass to energy systems								
Mauritania (fr)			promote alternative fuels, particularly butane and kerosene					gas	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Mauritius	implementation of gasification technology		encourage use of LPG					gas from sugar cane ethanol	
Mexico					res/comm				
Micronesia									
Mongolia		x		improved building insulation	x		x		
Morocco (fr + eng exec)		x							
Namibia					x			considering using gas fuelled govt vehicles	
Nauru			LPG for cooking in res sector	energy building codes	x				
Nicaragua (sp)									
Niger (fr)		x	biogas and other alternative cooking fuels						
Niue					x				
Palau				energy building codes (however, focus on use of energy eff. Appliances)	efficient lighting in govt buildings				
Panama (sp)									
Papua New Guinea								ethanol from SC mixed with gasoline	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Paraguay (sp)									
Peru (sp)		x						LNG, CNG for vehicles, LPG for taxis, CNG for buses	
Philippines	interest in biomass to energy systems			energy efficient design for new buildings			x		rehabilitation of roads
Republic of Korea								research into ethanol	
Republic of Moldova	interested in biomass to energy systems							NG,	reconstruction of roads
Saint Kitts and Nevis		x		energy building code, minimum efficiency standards				NG, or bio-fuels	
Saint Lucia				energy efficient design of new govt buildings, retrofitting of existing buildings	govt buildings			electric, el/hybrid, CNG, bio-fuel demonstration fleet	
Saint Vincent and the Grenadines				energy efficient design of buildings				interest in hydrogen based fuels	
Samoa								methanol from biomass	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Senegal (fr)			promotion of butane LPG through price incentives	working on a project for improved energy efficiency in buildings					
Seychelles			continued promotion of LPG over kerosene and electricity		x			interested in LPG or CNG pilot study	construction of by pass roads, improved traffic management system
Singapore									
Sri Lanka	demonstration projects investigating feasibility of fuel wood based electricity generation, intend to promote fuel wood plantations				x				
Sudan		x	promotion of LPG, solar cookers	improve natural ventilation of buildings	res/comm		x		develop transport infrastructure
Swaziland	interested in adoption state of art technologies to produce electricity from bagasse (large resource)	x	switching from fuelwood to LPG, electricity		x		x	gasoline/ethanol blending	

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Tajikistan		x	switching from fuelwood to electricity mainly through SHP	improved thermal insulation of buildings enery efficient design of new buildings	x		x	switching to gaseous fuels in public transport	optimization of road network
Thailand									
The Former Yugoslav Republic of Macedonia				insulation of res buildings building energy code for comm sector		prepare regulations for sale of surplus electricity from CHP in industry to grid			improve traffic management and control systems
Togo (fr)		SHP potential	switching from biomass to gas and gas stove						
Trinidad and Tobago									
Tunisia (fr + eng exec)		x	biogas	development of thermal regulation	x			LPG	
Turkmenistan		x							
Tuvalu									
Uganda		continued expansion of SHP						ethanol blending	
Uruguay									

	Abatement Options Under Consideration								
Country	**Biomass to Electricity (centralised)**	**Small hydropower**	**Promotion of Alternative Cooking Fuels**	**Energy Efficient Building Envelope**	**Energy Efficient Lighting**	**CHP**	**Energy Efficient Motor Systems**	**Alternative Fuels for Transport**	**Improved Transportation Infrastructure**
Uzbekistan		x		introduce more strict efficiency standards for builidings	x				
Vanuatu									upgrading of roads
Yemen	identified potential for use of agricultural wastes for electricity generation by gasification		substitution of wood fuels with LPG	regulations for energy-efficient buildings		promote CHP for decentralized power supply in industry (and commercial, residential sectors)		natural gas and solar technology	
Zimbabwe		x					x		