INDONESIA'S GREENHOUSE GAS ABATEMENT COST CURVE

Dewan Nasional Perubahan Iklim, Indonesia

August 2010

Contents

FOREWORD

Man-made climate change is one of the major challenges we face as a global community. Success in tackling this highly complex problem will require strong will, great policy skills and above all, a global commitment to fairness and justice, according to the principle of common but differentiated responsibility among nations.

These principles underlie Indonesia's strong commitment to this struggle. We have committed to make a 26 percent cut in our greenhouse gas (GHG) emissions by 2020 (as against projections of our business as usual emissions). President Soesilo Bambang Yudhoyono has stated that – with the right level of international support – Indonesia can cut 41 percent of its emissions, which would in turn deliver nearly 7 percent of the cuts called for by the Intergovernmental Panel on Climate Change.

The REDD+ Partnership signed by Indonesia and Norway in May, 2010 is among the developments which should encourage us that a system of viable international support is evolving. Equitable partnerships between developing and developed world are central to a global climate change solution.

The analysis underlying this document is an important tool in Indonesia's efforts to deliver GHG emissions cuts while protecting, even enhancing, long-term economic growth and development. With this document, the Dewan Nasional Perubahan Iklim aims to provide a common analytical basis to which different stakeholders can refer in thinking through different options. What measures will deliver the biggest impact in terms of emissions reduced? Which are likely to be more expensive, which less so? Using this knowledge, how should we prioritize our policy moves? How can we sequence our moves? What can we do now, and what should wait? The Indonesia GHG Abatement Cost Curve will remain useful as the policy environment continues to evolve.

This analysis has been carried out in close consultation with many stakeholders and experts, inside and outside of government. While they may or may not agree will our conclusions, they have all certainly contributed to improve the quality of the analysis. A policy process now continues within and between central and provincial government, and the different national Ministries and relevant agencies. There is still a long way to go to establishing a rich consensus and a mutually-shared understanding among all experts, particularly in having a detailed understanding and database of the state of our forests and peat swamps, as well as our land use across the archipelago.

Part of the uncertainty resides in the science. Our understanding of emissions from peat soils, to pick one example, is still evolving, as research is done in different settings and with constantly improving methodologies and instruments. In some cases, we have had no choice but to use estimates for emissions. But the point of the exercise has not been to try to come up with the most nearly perfect estimates, of emissions or abatement potential. Rather the goal has been to create a framework for analysis that can guide us with genuine insights now, but which can be extended and improved as our knowledge grows.

Among the most important achievements of the report is to clarify and quantify the central importance of land use, and land use change in Indonesia's current emissions picture. The report has also measured the impact of the different efforts which could mitigate these land-use based emissions. Slowing deforestation is an important measure here, but it is by no means the only one.

And as the report calls for a greater focus on land and spatial planning, the analysis also highlights how emissions from energy generation and transportation will become increasingly important as Indonesia continues to grow. The impact of a carbon-inefficient energy and transport infrastructure may not be so important today, in the overall scheme of things. However, the forward-looking elements of this analysis provides a profound view of the importance of today's infrastructure decisions. Especially when the energy infrastructure accounts for a much higher percentage of total emissions in our future.

Thank you for your interest in this report, and for your efforts to enable Indonesia to work towards a future based on long-term, sustainable, development.

Prof. (Hon) Rachmat Witoelar
Executive Chair
National Council on Climate Change

PREFACE

Under the leadership of President Susilo Bambang Yudhoyono, Indonesia has made several important contributions to the global climate change debate. After hosting the United Nations Framework Climate Change Convention Conference of Parties (COP-13) in Bali in 2007, Indonesia has organized or participated in a series of high-level gatherings to address the issue of reducing greenhouse gas (GHG) emissions from the forestry sector. These include the Forestry-11 grouping convened by Indonesia, the Informal Working Group on Interim Financing for REDD, and the April 2009 meeting of Heads of State convened by the Prince's Rainforest Project.

At the September 2009 G-20 summit in Pittsburgh, President Yudhoyono voluntarily committed Indonesia to an ambitious roadmap for reducing carbon emissions by 26 percent against a business-as-usual estimate of emissions in 2020, the first large developing country to do so. Indonesia reaffirmed its commitment to the reduction target at the COP-15 round of UN climate change negotiations in Copenhagen in December 2009 and subsequently associated itself with the Copenhagen Accord in January 2010. The government is currently preparing a National Action Plan on Climate Change, which will describe in detail how Indonesia will meet its 26 percent commitment. Another major milestone was reached on 28 May 2010 with the announcement of a REDD+ Partnership between Indonesia and Norway, in which Norway pledged USD 1 billion towards REDD+ readiness programs and as contributions in return for verified emissions reductions. At the same time, Indonesia committed to a two-year suspension of new concessions or forested land and peatland.[1] These steps position Indonesia well to benefit from the USD 30 billion of fast-start funds committed at COP-15.

To coordinate climate change-related activities within Indonesia, in July 2008 President Yudhoyono established the Dewan Nasional Perubahan Iklim (DNPI) or National Council on Climate Change. The Council is specifically tasked with the role of convening different stakeholders in Indonesia to create consensus around the opportunities and challenges related to climate change. To that effect, the DNPI has commissioned this GHG Abatement Cost Curve analysis to provide a quantitative basis for a national discussion on the opportunities for reducing GHG emissions in Indonesia consistent with national development goals.

This report evaluates the potential reduction in emissions coming from different abatement initiatives, as well as estimating the costs involved for each of those initiatives. Through this paper the DNPI intends to provide an objective and uniform set of data that will support Indonesia's decision-making process, as we work together with relevant ministries, regional governments, and others to reduce Indonesia's GHG emissions. We are committed to ensure such reductions in carbon emissions support rather than undermine our national development goals and our long-term efforts to improve the standard of living for all Indonesians. The DNPI is currently extending the analysis and data contained in the GHG Abatement Cost Curve through its support in developing low-carbon growth strategies in several Indonesian provinces with high emissions levels.

This study builds on the proprietary global GHG abatement database created by the global consultancy McKinsey & Company and developed in partnership with governments, businesses, and non-governmental organizations around the world. The DNPI would like to acknowledge the technical support of McKinsey in extending and further developing its methodology for the Indonesian context. The DNPI would also like to thank the more than 150 government, private-sector, and NGO personnel who made important contributions to the sectoral working teams. While the GHG abatement methodology belongs to McKinsey, the conclusions and results set forth in this report are exclusively those of the DNPI.

1 The GHG abatement scenarios discussed in this report do not take into account emissions reductions stemming from the two-year suspension of new forest and peat concessions announced in May 2010

We would also like to express our appreciation to the ClimateWorks Foundation, the Agence Française de Développement (AFD), the Norwegian Government, and the Packard Foundation for partially funding this work.

Much work remains to further develop the scientific understanding that underlies this study, particularly in the Land Use, Land-Use Change, and Forestry (LULUCF) and peat sectors. Estimates and extrapolations have been made for some emissions categories where data is incomplete or missing.

This report highlights that while Indonesia's emissions are significant and expected to grow by more than 60 percent between today and 2030, many opportunities exist to mitigate these emissions. With the support of the global community, Indonesia has a window of opportunity to shift to a less carbon-intensive development model. Without early action, Indonesia may become locked into a growth model (particularly through long-term infrastructure choices) that is unsustainable for our, and the world's, environment.

This report focuses on the potential for GHG mitigation. It does not address the challenge Indonesia faces in adapting to climate change that has or will occur, although we recognize that the costs of adaptation will be both significant and additive to mitigation costs. This report also intentionally avoids any assessment of policies and regulatory choices. Its purpose is to provide an objective and uniform set of data that can serve to underlie policy discussions.

ACKNOWLEDGEMENTS

In the process of this study, the project team met with a large number of experts and stakeholders. The DNPI would like to thank the following individuals for their assistance and their time. While we have received input, advice and feedback from the following individuals, the conclusions here are those of the DNPI.

For information and input on the LULUCF and peatland sectors, Dr. Boen Purnama, Dr. Wandojo Siswanto, Dr. Hadi Daryanto, Dr. Bambang Sukmananto, Ibu Lystia, Saiphul Rahman, Dyah Puspasari, Puja Utama, Magdalena Gultom, Dr. Wardojo, Dr. Syaiful Anwar, Dr. Ibu Yetti Rusli, and Pak Agus Sarsito, **Ministry of Forestry**. Others consulted include Joseph Leitmann, Timothy Brown, Eri Indrawan and Virza Susmitawidjaja, **World Bank**; Frances Seymour, Daniel Murdiyarso, and Louis Verchot **CIFOR**; Dieter Brulez, Heiner von Luebcke, and Anja Rosenberg, **GTZ**; Joel Daligault, Patrick Abbes, Dimitri Kanounnikoff, Philippe Guizol, Morgane Leterrier, Thierry Liabastre, **AFD**; Grahame Applegate, Dan Heldon, and Timothy Jessup, **AusAid**; Andrew Wardell, **Clinton Foundation**; Alfred Nakatsuma, **USAID**; Alex Heikens, **UNDP**; Marcel Silvius, Pak Nyoman, and Yus Rusila Noor, **Wetlands International**; Dr. Suyanto, Meine van Noorwijk, and Ujjwal Pradhan, **ICRAF**; Aljosja Hooijer, **Delft Hydraulics**; Fitrian Ardiansyah, Anna von Paddenburg, Katie Stafford, Adam Tomasek, Michael Steuwe, Iwan Wibisono, and Zulfira Warta, **WWF**; Lex Hovani, Wahjudi Wardojo, **TNC**; Fred Stolle, Beth Gingold, **WRI**; Aulia Aruan, Neil Franklin, and Jouko Virta, **APRIL**; Dharsono Hartono, PT Rimba Makmur Utama, Timotheus Lesmana and Canecio Munoz, **Sinarmas**; Taufiq Alimi, **Indonesian Biodiversity Foundation**; Adrian Suharto, **AsianAgri**; Sapto Sakti and Yosafat Erie, **Sampoerna Foundation**; Mahawira Singh Dillon, **PT Sumalindo Lestari Jaya T**; Michael Black, **Teknix Capital**; Aris Adhianto, **Asosiasi Pengusaha Hutan**; Nanang Roffandi Ahmad, **APH**; Rezal Kusumaatmadja, **Starling Resources**; Rizaldi Boer **Center for Climate Risk & Operation Management**; Ibu Moekti Soejachmoen, Pelangi; Dr. Agus Justianto, **MFP**; Dewi Rizki, **GRM International**; Emmy Hafild, Arief Wicaksono, Hanafi Guciano, **Kemitraan**; and A. M Velinda, **Ditjen Baplan**.

For information and input on the power, petroleum, and gas sectors, Lisa Ambarsari, Marwan Lobo Balia, Ellydar Bahar, I Made Agus, Ratna Ariati, and Sutijastoto, **DS ESDM**; Nunung Ajiwihanto, Bambang Praptono, Bambang Prasetoyo, Harris, Edy Iskanto, Assistia Semiawan, and Putu Wirasangka, **PLN**; Ami Indriyanto, **IIEE**; Agus Sari, **Ecosecurities**; Mohammad Boedoyo and Muhammad Wahid, **BPPT**; Saleh, **PUSPATIN and ESDM**; Anton Wahjosoedibjo, **MKI**; Ris Wahyudi, LITBANG, **ESDM**; Fathurrahman, Martha Maulidia, and Mauayat Ali Muhsi, **PEACE**; Bobby Watimena and Moekti Soejachmoen, **Pelangi**; Fabby Tumiwa, **IESR**; Firdaus Akmal, **Indonesia Coal Society**; Sri Endah Agustina, **METI**; Anna Reani, **Indonesia Power**; Ade Hermaka and Darman Mappangara, **PT. LEN Industri**; Widhyawan Prawiraatmadja, Timbul Silitonga, and Adi Pramono, **Pertamina**.

For information and input on the transportation sector, Arif, Arisman Harefa, Wendy Aritenang, Djarot, Pudji Kinanti, Siti Nur, Farida M, Edhy Sudjiono, and Gatot S, **Ministry of Transportation**; Bambang Susantono, **Transportation Association**; Moekti Soejachmoen, **Pelangi**; John Kwant, **Ford Asia Pacific**; Freddy Sutrisno, Noegardjito, Budi Susilo, and Juwono Andrianto, **Gaikindo**; Harya Dillon and Restiti, **ITDP**; Dadang Parikesit, **Pustral**; Mesra Eza, **Ministry of Finance**; Martha Maulidia, **PEACE**; and Bambang S and Heru Sutanto, **AISI**; Waty Suhadi, **Swisscontact**.

For information and input on the cement industry, Agus Wahyudi, Endang Supraptini, Sangapan, Denny Noviansyah, Emmy Suryandari and Tony Tanduk, **Ministry of Industry**; Urip Timuryono, Sudaryanto and Risatantin, **ASI**; Raju Goyal, Eamon Ginley, Faisal Nur, and Oepoyo Prakoso, Urip Timuryono, Sudaryanto, and Risatantin, **PT Holcim**; Enggun Puwoko, Rudi Hermanwan, and Gatot Mardiana, **Semen Gresik**; Agus Erfien, **Indocement**; Moekti Soejahmaoen and Martha Maulidia, **Pelangi**; and Gary Kleiman and Virza Sasmitawidjaja, **World Bank**.

For information and input on the agriculture sector, Gatot Irianto and Kaman Nainggolan, **Ministry of Agriculture**; H.S. Dillon, **Centre for Agricultural & Policy Institutes**; Rizaldi Boer, **Center for Climate Risk & Operation Management**; Dr. Shobha Shetty, **World Bank**; Taco Bottema, Peter Timmer, **Centre for Global Development**; Pete Smith, **University of Aberdeen (IPCC Report)**; and Dennis Vonboril, **US Embassy.**

For information and input on buildings, Jesper Vauvert, **Danish International Development Agency (DANIDA)**; Jonathan I Levy, **Harvard School of Public Health**; Francis Rubinstein, **Lawrence Berkeley National Laboratory**; Jean Su & Aleksandra Barnes, **Clinton Climate Initiative.**

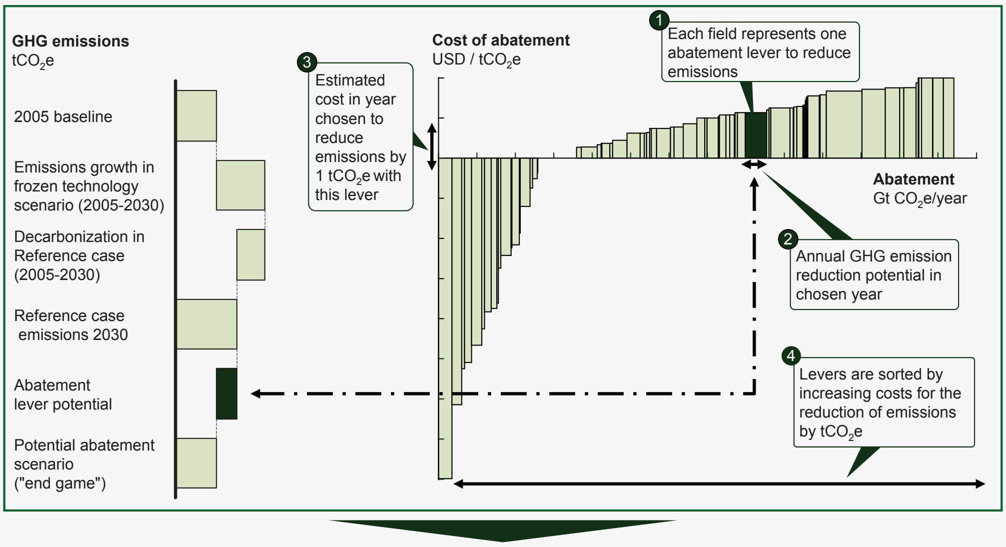
HOW TO READ THE GREENHOUSE GAS ABATEMENT COST CURVE

The global greenhouse gas abatement "cost curve" developed by global consultancy McKinsey & Company[2] summarizes the technical potential to reduce emissions of greenhouse gases at a cost of up to 80 USD per ton CO_2e[3] of avoided emissions. The cost curve shows the range of emission reduction actions that are possible with technologies that either are available today or are highly likely to be available by 2030.

The width of each bar represents the potential of that opportunity to reduce GHG emissions in a specific year compared to business-as-usual development (BAU). The potential of each opportunity assumes aggressive global action starting in 2010 to capture that specific opportunity and so does not represent a forecast of how each opportunity will develop. The height of each bar represents the average cost of avoiding 1 ton of CO_2e by 2030 through that opportunity. The cost is a weighted average across sub-opportunities and years. All costs are in 2005 real USD. From left to right, the graph presents the lowest-cost abatement opportunities to the highest-cost.[4] The uncertainty of volume and cost estimates can be significant for individual opportunities, in particular for LULUCF and peat and for emerging technologies (Exhibit 1).

Exhibit 1

The cost curve is developed in a four step process…



- The cost curve displays abatement potential, and corresponding cost, for each abatement lever relative to a "business-as-usual" scenario
- The merit order is applied based on the cheapest measures in 2030 in USD/tCO_2e

Source: McKinsey & Company Global GHG Abatement Cost Curve v2.0

2 McKinsey & Company (2009) Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve

3 Following IPCC definitions, the abatement cost curve shows technical measures with economic potential under USD 80 per tCO2e

4 A negative cost lever on the cost curve implies that while an upfront capital investment may be required, the lever will more than pay for itself over its lifetime through energy savings when the investment is evaluated at a societal cost of capital (i.e., for the purposes of this study, this has been taken at 4 percent).

McKinsey's global greenhouse gas cost curve aims to look at global emission reduction opportunities with one consistent methodology, rather than to analyze in detail any individual emission reduction opportunity. Therefore the curve should be used for overall comparisons of the size and cost of different opportunities, the relative importance of different sectors, and the overall size of the emission reduction opportunity, rather than for predictions of the development of individual technologies. It can also be used as a simulation tool for testing different implementation scenarios, energy prices, interest rates, and technological developments.

The cost of abatement is calculated from a societal perspective (i.e., excluding taxes, subsidies, and with a capital cost similar to government bond rates), which is useful to allow comparisons of opportunities and costs across countries, sectors, and individual opportunities. However it also means that the costs calculated are different from the costs a company or consumer would see, as taxes, subsidies, and different interest rates in their calculations would then also be included. Therefore the curve cannot be used for determining switching economics between investments, nor for forecasting CO_2 prices. The cost of each opportunity also excludes transaction and program costs to implement the opportunity on a large scale, as these are highly dependent on how policy makers choose to implement each opportunity. The costs to fully implement specific reduction opportunities, therefore, will in most cases be higher than those shown in the cost curve.

SUMMARY OF FINDINGS

Indonesia's annual greenhouse gas (GHG) emissions amounted to approximately 2.1[5] Giga tons (Gt)[6] in 2005. As Indonesia continues to develop, its total GHG emissions are expected to rise to 3.2 Gt by 2030. In both 2005 and 2030, Indonesia's emissions account for approximately 4.5 percent of global GHG emissions in a business-as-usual scenario. Indonesia's share of global emissions is significantly higher than its share of real global GDP, which was 0.6 percent in 2005. A comparison of the DNPI's emission estimates and those in the Ministry of Environment's Second National Communication (revised on December 5, 2009) shows a broad consistency in the overall emission levels, albeit with significant differences in the sectoral composition of these emissions.[7]

Analysis of the potential benefits and indicative costs of various GHG emissions abatement measures suggests that by 2030, Indonesia has the potential to reduce its GHG emissions by 2.3 Gt, representing a reduction of approximately 72 percent compared to the current trend. Thus, emissions in 2030 would be 67 percent lower than emissions in 2005. Such a reduction would be an important contribution to global efforts, amounting to some 7 percent of the total global reduction required by 2030 to reach the levels recommended by the Intergovernmental Panel on Climate Change (IPCC).[8]

Furthermore, the average cost of Indonesia's potential emissions reductions is relatively low, compared to some of the abatement options available in most developed countries. The known technical cost[9] and the cost of currently available abatement technologies show that Indonesia's estimated average abatement cost is in the order of 2 USD per tCO_2e by 2030.[10]

Peat and LULUCF comprise Indonesia's largest opportunity

Peat and LULUCF-related emissions are by far the largest contributors to Indonesia's current and expected future emissions (Exhibit 2) under a business-as-usual scenario (BAU). They also represent the largest opportunities to abate emissions. High growth rates in power and transport-related emissions mean that, although opportunities in these sectors become progressively more important in the years ahead, strategic choices on the development pathway must begin today.

Emissions from carbon-rich peatlands amount to 772 $MtCO_2e$, roughly 38 percent of Indonesia's total emissions in 2005.[11] Peatlands have acidic water-logged soils, which in a dry state contain as much as 60 percent carbon in the form of organic matter that has accumulated over thousands of years. When peat soils are drained for cultivation, timber extraction or other land uses, they are aerated and begin to oxidize and decompose. The slow oxidation of drained peatlands or their more rapid oxidation through peat fires are the main sources of peatland emissions.

5 Total emissions here refers to emissions from eight sectors including LULUCF, peat, agriculture, power, petroleum and refining, transportation, cement and buildings, which together account for the majority of Indonesia's emissions

6 One Giga ton (Gt) is equivalent to one billion tons

7 The Second National Communication (SNC) provides emission estimates for the year 2000. The overall estimates of CO2 net emissions in 2000 from the DNPI and the SNC are very similar, differing by less than 8 percent.

8 The IPCC is a scientific intergovernmental body established in 1988 under the auspices of the United Nations and tasked to evaluate the risk of climate change caused by human activity. It has stated that global greenhouse gas concentrations will reach 650 ppm by 2030 on current global trends. This would far exceed the 450 ppm level – the level at which scientists have deemed we can avoid catastrophic climate changes as global temperatures would not rise more than 2 degrees Celsius. According to Project Catalyst, to limit greenhouse gas concentrations to this safer level, greenhouse gas emissions must be cut globally by at least 32 GtCO2e in 2030 compared to current trends.

9 This paper considers various costs in evaluating abatement options. Technical costs are defined as the incremental cost of a low emission technology compared to the reference case, measured as USD per tCO2e abated emissions. Technical costs include annualized repayments for capital expenditure and operating expenditure, and thus represent the pure "project cost" to install and operate the low-emission technology. They include neither implementation costs nor social costs (e.g. the loss of biosystem services such as clean, fresh water supply from forests). Full abatement costs include both technical costs as defined above and implementation costs., but not social costs. Finally, opportunity costs refer to the full foregone revenue an agent gives up to switch to a lower emission technology, behaviour or alternative.

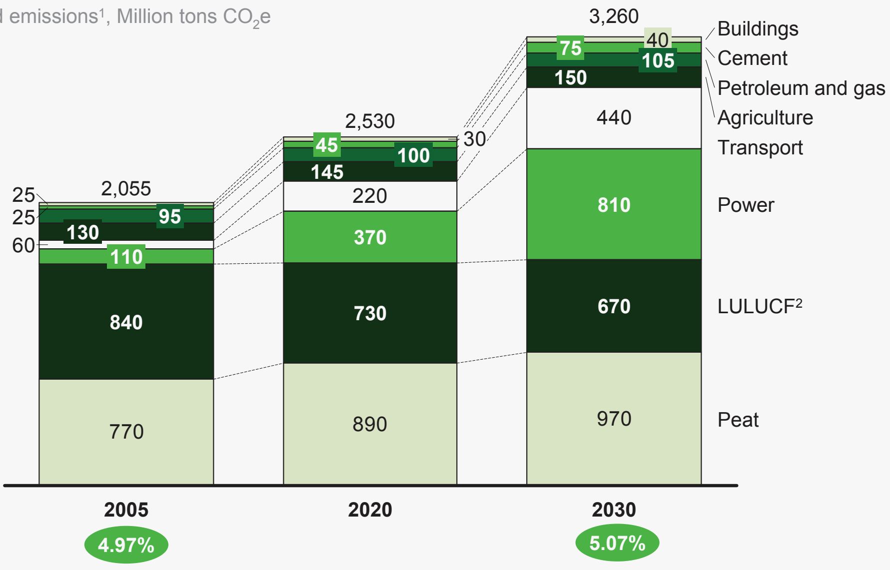
10 This estimate does not include transaction or other implementation costs, which can be significant for some abatement measures

11 The Ministry of Forestry data suggests that Indonesia has 22 million ha of peatland

Exhibit 2

Indonesian emissions are estimated to grow from 2.1 to 3.3 $GtCO_2e$ between 2005 and 2030

Projected emissions[1], Million tons CO_2e



1 Includes only direct emissions from each sector

2 Emissions from LULUCF are based on a net emission approach i.e., including absorption

SOURCE: Indonesia GHG Abatement Cost Curve

These two emission sources are globally significant, accounting for almost 0.77 Gt in current annual emissions, an amount close to that of Germany. Peatland-related emissions are also a unique and predominantly Indonesian challenge, as Indonesia accounts for almost 60 percent of global emissions from peat decomposition (Exhibit 3). A further 0.25 Gt is caused by deforestation and degradation (through timber extraction) of peatland forests, however we account for this loss of aboveground carbon in the LULUCF sector.

While a great deal of research into peat emissions and measurement is ongoing in Indonesia, the scientific world's understanding of peat-related emissions is still developing. Consequently, there is a relatively wide range in the estimates of Indonesia's emissions from peat decomposition and fires. We have adopted relatively conservative estimates for the two categories of peat-related emissions (decomposition, fires) to reach our total peat-related emissions 2005 estimate of 0.77 $GtCO_2e$. Most analyses of Indonesia's emissions related to peat decomposition and fire fall within the range of 0.75 to 1.5 $GtCO_2e$.

Deforestation, forest degradation and forest fire is the second largest source of GHG emissions in Indonesia and is expected to remain a significant contributor to Indonesia's emission profile, with approximately 1.1 million hectares of high carbon value (HCV) forests cleared per year, with slightly more than 25 percent occurring in peatland forests and the remainder occurring in dry-land forests. Deforestation, forest degradation and forest fire is resulting in gross emissions of approximately 1.1 $GtCO_2e$. Indonesia's natural secondary and "man-made" forests (timber and estate crop plantations) absorb at the same time significant amounts of CO_2e, which reduced Indonesia's gross emissions from LULUCF by more than 250 $MtCO_2e$ in 2005. This results in net emissions of approximately 838 $MtCO_2e$, representing 41 percent of Indonesia's current total emissions.

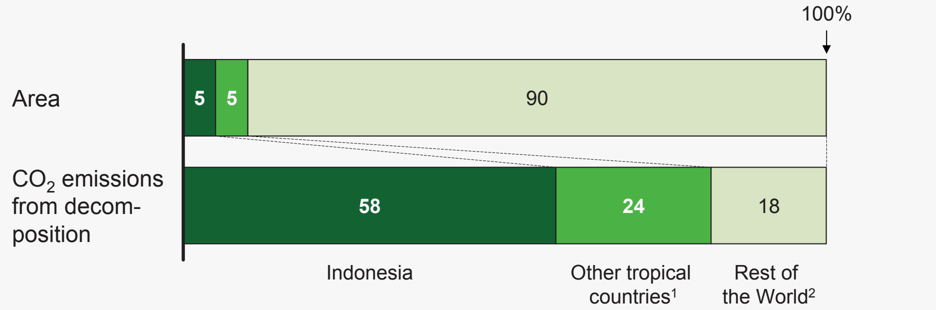
Broadly accepted estimates indicate that around 15–23 percent[12] of the world's GHG emission reduction potential needed by 2020 will come from the LULUCF and peat sectors. Unsurprisingly, given the size of Indonesia's forests, many of these opportunities are located within Indonesia.

12 Van der Werf et al. 2009

Exhibit 3

Emissions from peatland are a unique challenge for Indonesia as they account for 58% of global emissions from peat decomposition

Breakdown of global peatland area by surface and corresponding CO_2 emissions
Percent



- 5% of global and 50% of tropical peatlands are located in Indonesia
- Tropical peat has a share of more than 80% of emissions from peat decomposition
- Indonesia's share of total emissions from peat decomposition is 60% or 12 times more than share of area

1 Papua New Guinea, Brazil, Peru, Sudan, Malaysia
2 Canada, Russia, Scandinavia, USA

SOURCE: Hooijer et al 2006; Wetlands International

Additionally, the power and transportation sectors are likely to gain increasing significance in the future if current trends continue. These sectors contribute relatively low emissions today, but emissions are expected to rise sharply by 2030. Our estimates put Indonesia's power and transportation emissions at 110 and 70 $MtCO_2e$, respectively in 2005, but these are each expected to rise seven-fold over the 25-year period leading up to 2030. If approaches to low-carbon infrastructure development are not identified quickly, there is an added challenge of a lock-in effect, leaving little opportunity for implementing low-carbon alternative solutions for the next 30 to 40 years.

Large emission reductions possible with investment

Indonesia could potentially provide up to 2.3 $GtCO_2e$ of greenhouse gas abatement by 2030 (that is, 7 percent of required global emission reductions)[13] through implementing over 90 abatement opportunities[14] across eight major sectors: LULUCF, peatland, cement, power, petroleum and gas, agriculture, transportation, and buildings (Exhibit 4).

Unlike most countries and reflecting Indonesia's unique emissions profile, over 75 percent of the opportunity lies in LULUCF and peat (Exhibit 5).

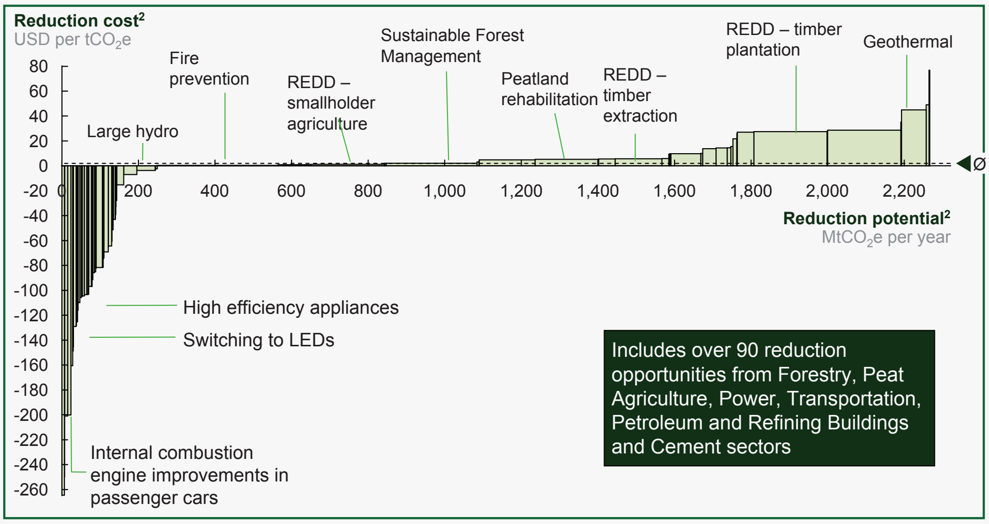
As noted, the average cost of emission reductions in Indonesia is relatively low compared to most developed country options, at around 2 USD per tCO_2e in 2030. (This cost estimate reflects a technical assessment only; it does not include implementation and transaction costs, which for some abatement opportunities are likely to be significant.) This means that underwriting abatement opportunities in Indonesia may be economically appealing to developed countries.

13 the global community is to meet the 450-500 ppm target described above
14 See „How to read the greenhouse gas abatement cost curve“

Exhibit 4

Indonesia has the potential to reduce CO_2 emissions by up to 2.3 Gt per by 2030

Societal perspective[1], 2030



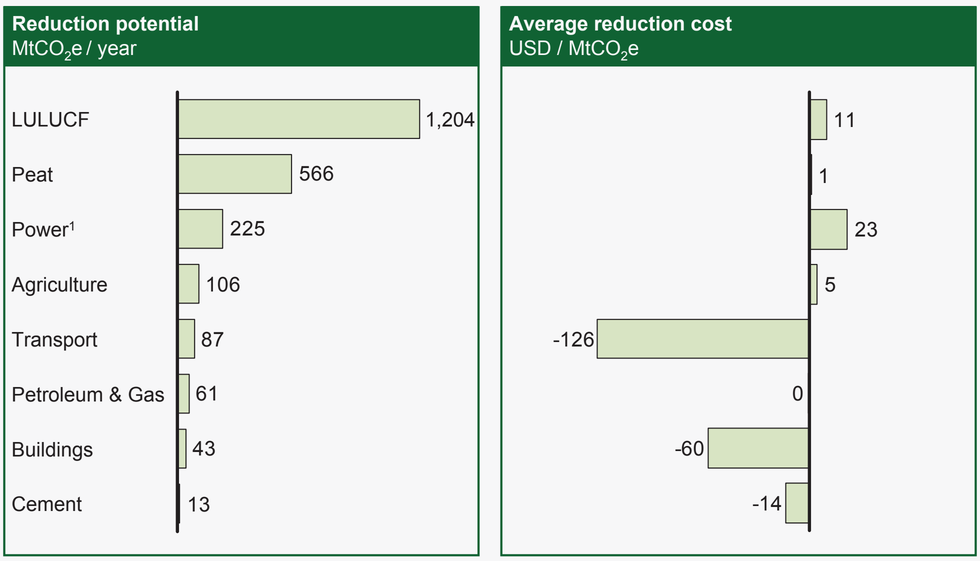
1 Societal perspective implies utilizing a 4% discount rate

2. The width of each bar represents the volume of potential reduction. The height of each bar represents the cost to capture each reduction initiative

SOURCE: Indonesia GHG Abatement Cost Curve

Exhibit 5

Indonesia's reduction potential is concentrated largely in the forestry and peat sectors



1 Exclusive of demand side reductions from other sectors

SOURCE: Indonesia GHG Abatement Cost Curve

EMISSIONS SCENARIOS AND ABATEMENT OPPORTUNITIES BY SECTOR

The DNPI's GHG abatement cost curve study for Indonesia involved in-depth research into eight sectors – LULUCF, peatland, agriculture, power, transportation, petroleum and gas, cement, and buildings – which currently represent the majority of Indonesia's total emissions. The findings described in this section are based on our ongoing analysis, which continues to be refined and updated.

Several challenges to the analysis persist. For example, access and availability to national-level data with regional breakdowns was limited in the LULUCF, peat, and agricultural sector analyses. Furthermore, the science and methodology behind peat emission calculations is still at a relatively early stage. Such challenges are further articulated within each sector description that follows.

For each of the sectors, we have developed both business-as-usual and abatement scenarios. These have taken into account, amongst others, government and industry perspectives on how the sector would develop (a) should no major policy or regulatory changes take place between now and 2030 and (b) should identified abatement opportunities within each sector be taken up fully.

This work has involved extensive stakeholder interactions and workshops.

PEAT

2030 – emissions: 972 $MtCO_2e$, abatement potential: 566 $MtCO_2e$

While in the past emissions from deforestation and forest degradation have received the vast proportion of climate-focused attention, both domestically and internationally, carbon emissions from Indonesian peat[15] reserves are even more significant.[16] Only very recently has there been a broad recognition of the importance of peatland emissions, and while the science is still at a relatively early stage it has improved significantly in recent years.[17] The importance of peat as a source of carbon emissions has gained greater acceptance globally. Exhibit 6 captures the difference between this DNPI report and various estimates published by other government agencies, multilateral organizations, and non-governmental organizations.

Sectoral emissions

Peatlands store a massive amount of carbon in the form of organic matter accumulated in waterlogged soils.

The release of carbon from tropical peatlands represents a unique and predominantly Indonesian challenge as Indonesia holds approximately 50 percent of the total tropical peat area. Emissions from peatland today represent 38 percent of Indonesia's total emissions and will continue to remain a dominant portion in 2030 (at 30 percent) if no major action is taken.

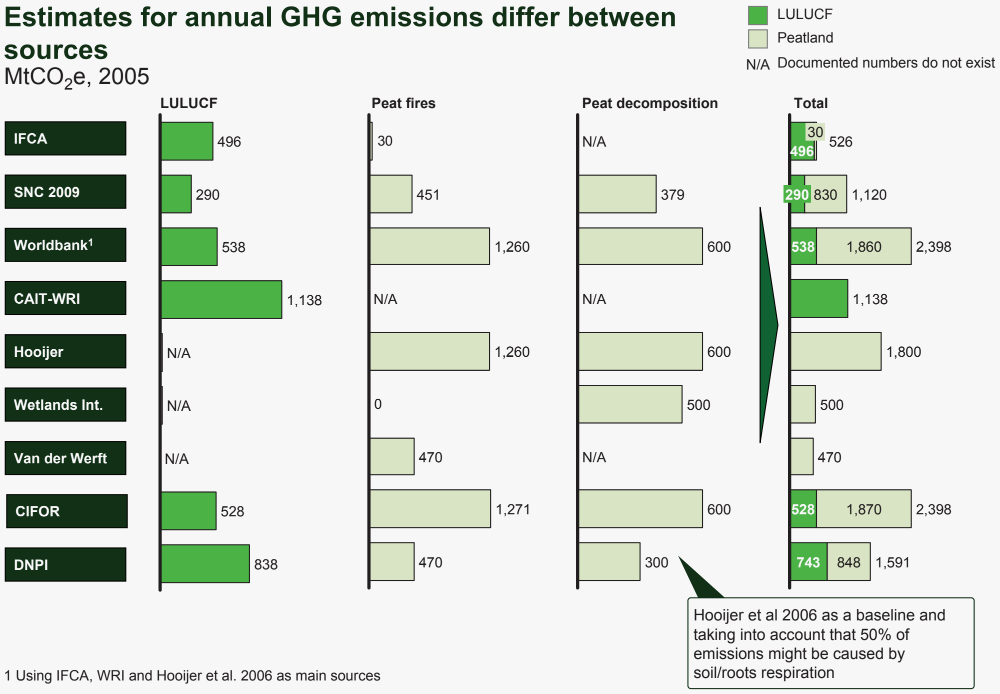
Under the business-as-usual scenario, emissions from peatland are expected to increase by 20 percent from 772 $MtCO_2e$ in 2005 to 972 $MtCO_2e$ in 2030 (Exhibit 7).

15 A more detailed description of peat and its relevance to carbon emissions is included in the appendix
16 Indonesia's peatland represents 5 percent of global and 50 percent of tropical peat. It is storing 132 GtCO2e below ground and a further 4.2 GtC above ground, a value comparable to the Amazon rainforest, which is the single largest ecological carbon sink in the world, at 46 GtC (or 168 GtCO2e)
17 A description of the most important scientific uncertainties is included as an appendix

Exhibit 6

Estimates for annual GHG emissions differ between sources

$MtCO_2e$, 2005

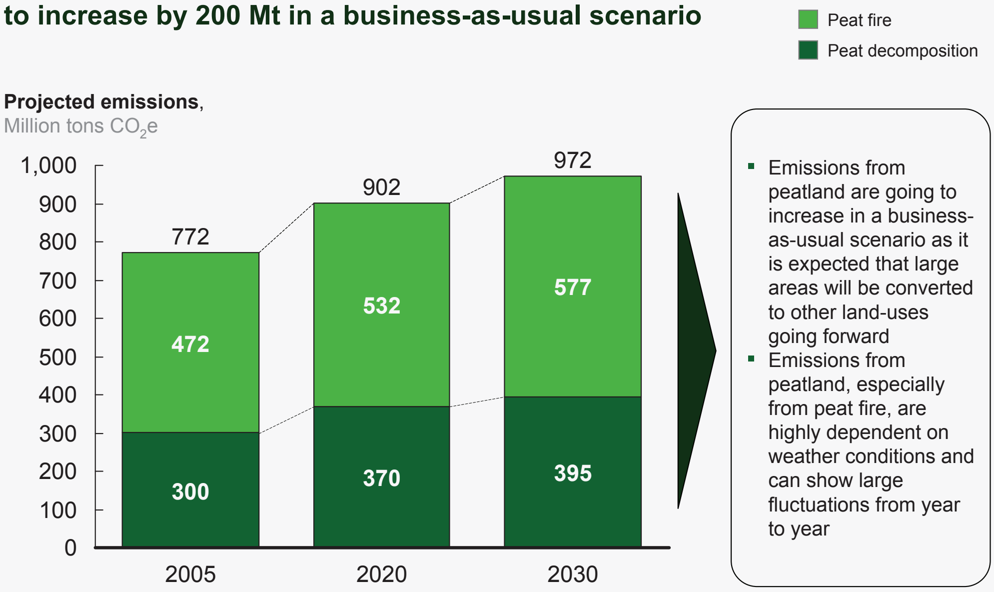


1 Using IFCA, WRI and Hooijer et al. 2006 as main sources

SOURCE: IFCA; Ministry of Forestry Indonesia; Houghton; Worldbank; CAIT – WRI; Hooijer 2006; SNC 2009, Indonesia GHG Emission Cost Curve

Exhibit 7

Emissions from peat fire and peat decomposition are expected to increase by 200 Mt in a business-as-usual scenario



SOURCE: Hooijer et al 2006- PEAT CO2e; Alterra; Wetlands International; Expert interviews; Couwenberg et al 2009; Van der Werft et al 2008

Fires are the main sources of peat related emissions. In 2005, fires accounted for 472 $MtCO_2e$, more than 60 percent of all peatland related emissions. Decomposition of peatland as a consequence of drainage is the second largest source of peat related emissions, accounting for another 300 $MtCO_2e$. As peatland forest are converted to another land use, the removal of the aboveground biomass during land clearing and timber extraction during logging of production forests (HPH) result in further CO_2e emissions; to avoid double counting, these emissions are accounted for in the LULUCF sector.

Peat fires

Emissions related to peat fires will increase from approximately 470 $MtCO_2e$ per year at present to nearly 580 $MtCO_2e$ in 2030, as the total share of degraded peatland at high risk to fire increases if peatland conversions are not stopped and if fire is continued to be used as the main tool for land preparation and fertilization by smallholders. It should be noted that the year-to-year emissions from peat fires tend to fluctuate significantly, as they are heavily correlated with annual rainfall, the groundwater table, and the extent of the dry season.

The estimates for peatland fires are based on an analysis of 2000–2006 emissions from peat fires by Van der Werf et al. (2008) as well as the future projected development of degraded land areas and the share of different land types as described by Hooijer et al. (2006). The estimates are based on the same publication from Van der Werf as used by Indonesia's Ministry of Environment in Indonesia's Second National Communication. When compared to estimates published by other scientists (e.g., Page et al. (2002)), estimates for peat fire based on the Van der Werf data can be considered to be conservative.

There should be no doubt that emissions from fires on degraded peatland will continue to be a major contributor to emissions, pending strong action. Indeed emissions from peat fires could easily range higher than the estimates used here.

Decomposition

Emissions from decomposition will continue to grow by 30 percent from 300 $MtCO_2e$ in 2005 to approximately 395 $MtCO_2e$ in 2030, due to the combination of emissions from already drained peatland and due to the fresh conversion and drainage of peatland for plantations (e.g., pulpwood and oil palm plantations) and smallholder agriculture. Drainage accelerates the rate of soil decomposition, as significantly larger volumes of peat soil are exposed to oxygen and hence made susceptible to further oxidation.

It is only in recent years, as more peatlands have been cleared, that land managers and scientists have come to understand how peat soils behave as they dry out. Peat soils subside dramatically due to compaction, shrinkage, and decomposition, and this can result in a loss of the fertile surface layers. At the same time, the drying out of the surface layers results in a growing vulnerability to hard-to-manage peat fires.

Our estimates of carbon emissions from peat decomposition are based on an analysis of historically drained peat areas and their expected future conversion into different land uses. Emissions from soil decomposition are assumed to depend on drainage depth. Estimates are derived from measures of decomposition for different levels of drainage (for different land uses) combined with the area of degraded land and the number of years of decomposition after the initial drainage. One key uncertainty is that soil and root respiration make up somewhere between 40 and 60 percent of measured carbon flux between soil and atmospheric carbon, as a result of soil and biomass respiration and carbon uptake during photosynthesis, as recently described in Couwenberg et al. (2009). Measurements of carbon flux from soil decomposition, using changes in soil mass and carbon composition, are not subject to this uncertainty, but few such studies with comparable measurement methods have been published.

The emission levels used here were calculated using Wösten's linear peat drainage emission model (which predicts emission patterns for different drainage depths) and average drainage depths of different land uses provided by Hooijer et al. 2006. Hooijer et al. 2006 synthesizes the direct observations of drained peatlands made by different scientists in different areas of Indonesia, Papua New Guinea, Malaysia, and Brunei. It includes estimates for decomposition of peat soils in secondary forests, palm oil plantations, and agricultural areas planted with other crops affected by drainage.

Estimates of emissions from peat decomposition remain subject to revision, as further scientific work is done. Many potentially useful research efforts to tackle open issues were started only recently. The results of these efforts, expected to be published in the coming two to three years, might change the current view of the extent of peat decomposition. Given this uncertainty, estimates used here are conservative relative to other widely cited estimates.

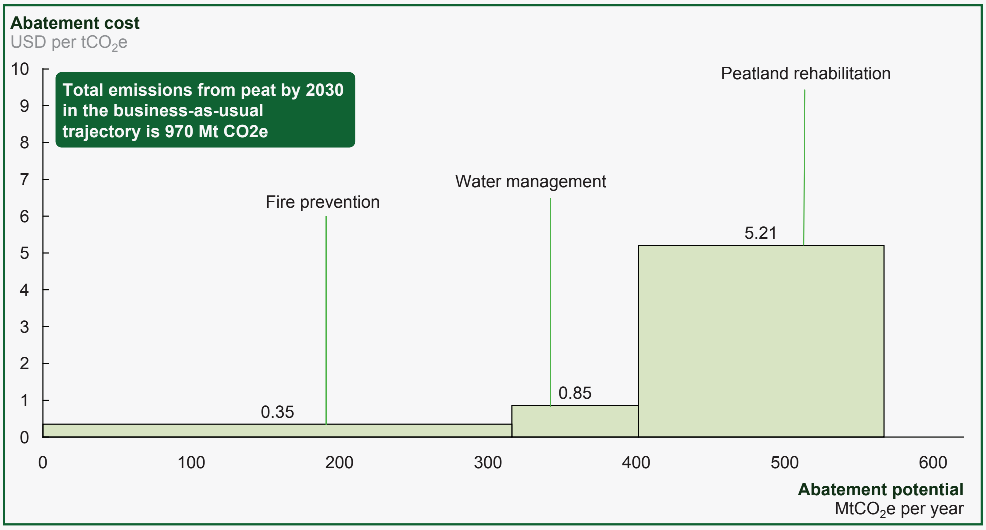
Abatement potential and cost

The Indonesian government has already begun to address peat emission through a decree that prohibits land conversion of peat which is more than three meters deep. In addition to this, several opportunities exist for reducing emissions at a relatively modest cost. A total of 566 $MtCO_2e$ of abatement opportunity exists in the peat sector across several levers, including fire prevention, peatland rehabilitation, but also water management in existing timber plantations and oil palm plantations or more generally in areas under agricultural use (Exhibit 8).

Exhibit 8

566 Mt of CO2e could be abated by fire prevention, water management and rehabilitation of degraded peatland

Societal perspective; 2030



SOURCE: Indonesia GHG Abatement Cost Curve

Fire prevention

Fire prevention is the largest abatement opportunity and could prevent nearly 320 $MtCO_2e$ in 2030. Necessary actions to reduce emissions from peat fires include prohibiting fire as a tool for land preparation, providing appropriate and practical technologies (and, if appropriate, financial incentives) for manual land clearing, developing appropriate early-warning systems based on fire risk status and field-based fire detection, strengthening fire brigades, ensuring strong enforcement and large penalties for rule violations, and building public awareness of the local economic and social costs of forest fires. Besides the reduction of emissions, fire prevention will have additional positive effects on the health of the local population as well as on the overall economy of Indonesia through, e.g., the avoidance of airport closures and haze-related transportation delays. Fire prevention can be done as discrete activities, however it will be more successful and sustainable if the main source of fires, the degraded peatlands, are rehabilitated in parallel.

Cost for fire prevention is relatively small, averaging at 0.35 USD per tCO_2e if the implemented actions focus primarily on the historical fire hotspots. If the prevention of fire-caused economic losses, e.g. haze-related transportation delays, loss of agricultural crops and loss of valuable timber, would be taken into account as well, societal cost for fire prevention could be negative, as these economic losses can be significant. The World Resource Institute estimated the direct economic loss of the 1997/98 fires at more than 5 billion USD.

It should be noted that the technical potential for emissions reductions due to peat fire prevention could be as high as 580 Mt CO_2e. However, it would require massive investments in infrastructure to be able to attack or suppress all fires across the breadth of Indonesia. As a result, we have assumed a more conservative figure in this analysis.

Peatland rehabilitation

The rehabilitation of Indonesia's degraded peatland, e.g., areas within the Ex-Mega Rice Project in Central Kalimantan, is the second largest abatement opportunity of peat emissions. Peatland rehabilitation combines the restoration of the hydrological functions of the peat and the replanting with native species.

While the restoration of the hydrological functions of the peat by blocking drainage channels is relatively cheap at a cost below 1 USD per abated tCO_2e, replanting degraded peatlands is relatively expensive with costs between 500 to 1,100 USD per ha or 3 to 5 USD per t of sequestred CO_2e. Fostering natural regeneration of existing tree cover could reduce the replanting costs significantly and should be applied wherever possible.

Water management

Installing a dam-based water management system in timber and estate crops plantations located on peatland is another powerful tool to reduce emissions. There is a technical abatement potential of 90 $MtCO_2$e by 2030.

Water management is relatively cheap, with an associated cost below 1 USD per abated tCO_2e. In addition, water management can help to reduce the risk of flooding in the wet season and prevent the risk of drought in the dry season.

LAND USE, LAND-USE CHANGE, AND FORESTRY (LULUCF)

2030 – Net emissions: 666 $MtCO_2$e, abatement potential: 1,204 $MtCO_2$e

With over 100 million hectares of tropical forest, Indonesia is home to the world's third largest tropical forest – rich in biodiversity and with total carbon storage of 15 Gt above ground, which is equivalent to 60 $GtCO_2$e if completely emitted.

Deforestation peaked in Indonesia in the late 1990s, at a rate of more than 1.8 million ha annually, and has significantly decreased since then, averaging roughly 1.1 million ha annually between 2000 and 2005. However, the increasing global demand for pulp and paper and palm oil together with a growing domestic demand for food crops is expected to result in the conversion of an additional 21–28 million ha of currently forested land by 2030 (Exhibit 9) in a business-as-usual scenario. Much of that additional land is likely to be made available through deforestation of conversion forest (Hutan produksi yang dapat di konversi, HPK); the shift of production forests (Hutan produks tetap, HPH) to conversion forests because of high rates of degradation (due to poor logging practices); and from conversion of forests located outside the forest estate (kawasan hutan).

Given that Java and Sumatra have already lost large parts of their original forest areas, it is expected that deforestation will shift to other, still largely forested islands such as parts of Kalimantan and especially Papua.

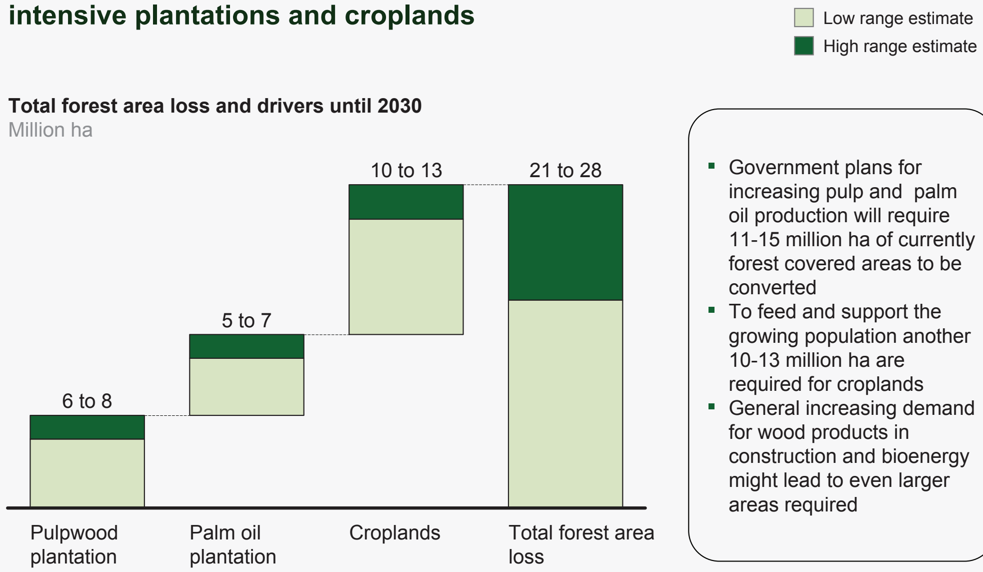
Sectoral emissions

Net emissions from LULUCF account for over 35 percent of total carbon emissions in Indonesia, at 745 $MtCO_2$e in 2005, and are expected to remain significant even if LULUCF-related net emissions decrease to 570 $MtCO_2$e; its relative share will sink to 18 percent in 2030 (Exhibit 10). However, annual gross emissions are likely to remain at a high level of more than 1,080 $MtCO_2$e.

Exhibit 9

Deforestation is expected to remain constant driven by conversion to intensive plantations and croplands

Total forest area loss and drivers until 2030
Million ha



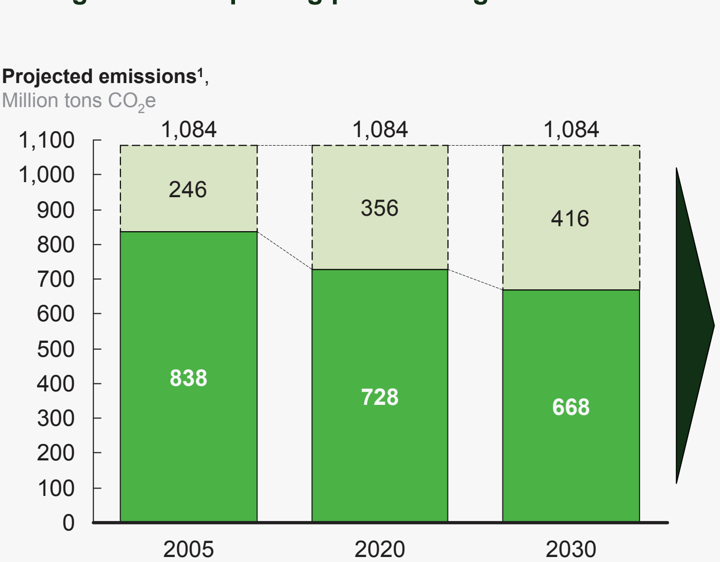
- Government plans for increasing pulp and palm oil production will require 11-15 million ha of currently forest covered areas to be converted
- To feed and support the growing population another 10-13 million ha are required for croplands
- General increasing demand for wood products in construction and bioenergy might lead to even larger areas required

SOURCE: RISI; EMGE; Government of Indonesia; A Rante Tondak DG Estate Crops , Min of Agri, Proceedings of the World Conference on Palm and Coconut Oils for the 21st Century, American Oil Chemist Society, Leonard Perkins and Cahn edts, 1999; Indonesia GHG Abatement Cost Curve

Exhibit 10

Net emissions from the forest sector are expected to constantly decrease throughout the reporting period but gross emissions will remain constant

Projected emissions[1],
Million tons CO_2e



- Gross emissions are expected to remain constant at nearly 1,100 $MtCO_2e$
- Net emissions are expected to decrease by approximately 170 $MtCO_2e$ by the increasing absorption potential of reforested areas but also through the expansion of timber and estate crops plantation

1 Net emissions include absorption in secondary forests, timber and estate crops plantations and initiated reforestation programs

SOURCE: DNPI - Indonesia GHG Abatement Cost Curve

Gross emissions from dry-land forests stem primarily from deforestation, forest degradation and forest fires. Deforestation is caused by land conversion for (smallholder) agriculture, oil palm cultivation and pulpwood plantation but also illegal logging. Deforestation is expected to remain constant at the current rate of 1.1 million ha annually resulting in around 750 MtCO_2e of gross emissions. Forest degradation caused by non-sustainable logging activities in Indonesia's production forests could on average account for another 250 MtCO_2e of gross emissions per year if current logging practices are not changed. Forest fires are expected to contribute in average another 78 Mt CO_2e annually going forward.

Abatement potential and cost

The LULUCF sector's potential to bring about emission reductions by 2030 is unique, in that the potential reductions significantly exceed business-as-usual emissions. This is due to the fact that conservation-dedicated afforestation and reforestation efforts could effectively create a net carbon sink, capturing more carbon (called sequestered carbon) than would otherwise be emitted. Indeed, the total annual abatement potential of the LULUCF sector is 1,204 MtCO_2e by 2030, of which halting deforestation and forest degradation would account for 811 MtCO_2e, afforestation and reforestation efforts could account for 280 MtCO_2e (Exhibit 11) and fire prevention for 43 Mt CO_2e.

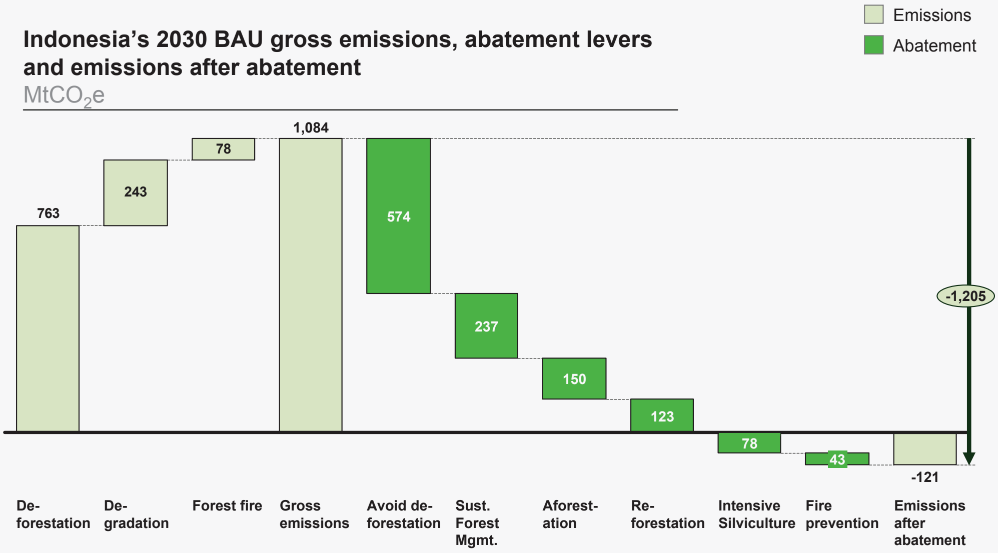
Reduced emissions from deforestation and degradation (REDD)

The abatement potential of REDD is by far the largest of the LULUCF levers. We use the term REDD as shorthand for the halting or prevention of emissions-causing activities in forested areas. REDD represents a combined abatement opportunity of more than 570 MtCO_2e, of which stopping forest conversion to smallholder agriculture is the single largest opportunity at slightly more than 190 MtCO_2e. As with the case of fire prevention, reduced emissions from so-called "REDD smallholder agriculture" could technically be as high as 300 MtCO_2e. Given the large number, fragmentation and remoteness of many smallholder farmers in Indonesia, it seems unrealistic that the full potential could be reached until 2030 and so a discount of 40 percent was applied to the maximum technical potential reduction.

Opportunity costs differ significantly between deforestation drivers, ranging from 1 USD to 29 USD per ton of avoided CO_2e (Exhibit 12). Avoided deforestation and degradation from smallholder agriculture has relatively

Exhibit 11

Avoiding deforestation,sustainable forest management, afforestation, and reforestation could turn the LULUCF sector into a net carbon sink by 2030

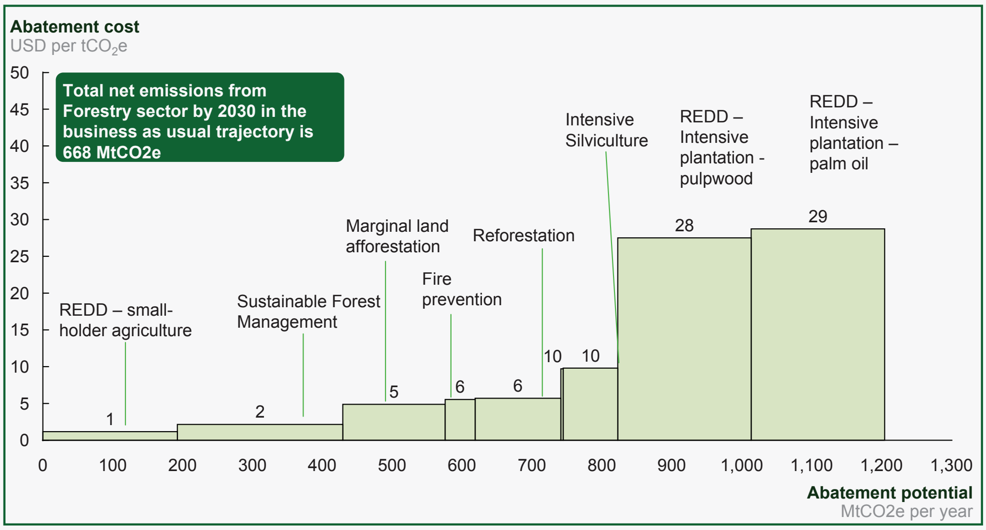


SOURCE: Indonesia GHG Abatement Cost Curve

1,200 $MtCO_2e$ could be abated in 2030 by implementation of 9 different abatement levers

Societal perspective; 2030

Exhibit 12



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below EUR 60 per tCO2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play. Assuming a 4% societal discount rate

SOURCE: Indonesia GHG Abatement Cost Curve

low opportunity costs, given the limited economic alternatives facing smallholder farmers in Indonesia. However, those costs could significantly increase if transaction costs are included due to the sheer size of Indonesia and the complexity of changing cultivation habits of tens of millions of smallholders. Capturing the abatement potential from "REDD smallholder agriculture" would require massive investments in agricultural extension services to enable rural communities to use already cleared lands more efficiently and with less carbon intensity.

Opportunity costs for avoiding forest conversion into estate crops or timber plantations are high, reaching close to 30 USD per avoided tCO_2e, due to the high economic returns obtainable from crops such as palm oil and pulpwood. These costs can be significantly reduced if those plantations can be established on already degraded or deforested areas, as the costs then represent only forgone revenue from one-time timber extraction for the initial land clearing and possibly some additional input costs or marginally lower yields. Prospects for this are good as several organizations (e.g., WRI) are trying to develop land swap systems, and the private sector is showing growing interest. However new spatial plans and an appropriate financial incentive system, e.g. carbon-based permit fees for new concessions, would be needed for making the use of degraded land a real opportunity at scale.

Afforestation and reforestation

Afforestation and reforestation represent a sequestration opportunity of 300 $MtCO_2e$ by 2030 at a cost of 5 to 6 USD per avoided tCO_2e. This implies (re-)establishing forests on more than 10 million ha of degraded non-forested and forested land and would be in addition to the already established reforestation program (GERHAN) of the Ministry of Forestry. Realizing large sequestration volumes requires the set aside of these afforested and reforested areas for conservation. Developing commercial timber and estate crop plantations as part of the reforestation program could help to reduce the pressure on remaining forest areas, but at the same time these activities will sharply reduce the abatement potential of reforested areas. This is because large volumes of CO_2e would be emitted at the end of the plantations' rotation period.

Sustainable forest management

Our estimates indicate that reducing emissions from the degradation of production forest (HPH) through a combination of better planning, reduced impact logging, and improved post-harvest management could deliver an emission reduction of more than 200 $MtCO_2e$ at a cost of slightly more than 2 USD per tCO_2e. Current policies on timber extraction and cutting cycles in production forests are already based on sustainability but do not consider nor calculate total biomass removed, which is typically many multiples of the merchantable timber. In addition, further loss of carbon stock can occur for several years after logging if conditions are not conducive for quick forest regeneration.

Activities to reduce emissions from timber extraction include the construction of an adequate network of forest roads and skidding trails to minimize skidding damage, the employment of modern harvesting equipment, and the use of a geographical information system to make harvesting as focused as possible.

The alternative – stopping logging altogether – would have the same effect on emission reduction, but has a much higher opportunity cost and would not allow Indonesia to further develop its forest products industry.

Intensive silviculture

Intensive silviculture should be considered as an additional activity to increase the growth rates (and therefore the sequestration rates) of Indonesia's production forests. Intensive silviculture is based on broadening silvicultural activities from their current limited application. Typical activities include enrichment planting, thinning between the cycles, and also fertilization, improved seedlings, and better breeding techniques. Intensive silviculture is relatively expensive at close to 10 USD per t of additional sequestered CO_2e, but represents an abatement opportunity of nearly 100 $MtCO_2e$ annually. In addition, the application of intensive silviculture represents significant employment opportunities for forest communities, e.g., plant nurseries.

Prevention of forest fire

Fire prevention outside peatland is a significant emission reduction opportunity as well and could prevent 43 $MtCO_2e$ in 2030. Necessary actions to reduce emissions from forest fires include prohibiting fire as a tool for land preparation, providing appropriate and practical technologies (and, if appropriate, financial incentives) for manual land clearing, developing appropriate early-warning systems based on fire risk status and field-based fire detection, strengthening fire brigades, ensuring strong enforcement and large penalties for rule violations, and building public awareness of the local economic and social costs of forest fires.

The cost to reduce emissions from fire prevention in forests outside the peatland is relatively high at more than 5 USD per ton of abated CO_2e. The high costs are caused by the fact the forest fires are scattered across a much larger land area than peat fires.

Methodology

The estimated annual rate of deforestation and gross emissions used in this analysis is 1.1 million ha, which is based on the historical deforestation rate in 2000–2005 provided by the Ministry of Forestry. Approximately 75 percent (or 0.8 million ha) of the total deforested area is expected to occur on dry-land forests and the remaining 25 percent in peatland forest areas.[18] We assume that the carbon density of Indonesian forests cleared in the future will remain the same as that of forests cleared over the last five years, which is 192 tC/ha.[19] Land use assumptions were cross-checked with projections for additional land demand for pulpwood and palm oil plantations,[20] and to meet increasing domestic demand for agricultural products.[21] Together the datasets suggest a total need for additional forest land of 21–28 million ha by 2030.

18 As described by Hooijer et al. (2006)
19 IFCA 2008
20 IFCA 2008, RISI 2009, NLK 2009
21 Tondak (1999)

Net emissions from the LULUCF sector are calculated by taking the absorption potential of Indonesia's existing natural forests (with the exception of primary, non-managed forests, as suggested by IPCC[22]) and also man-made forests (e.g., palm oil plantations) into account as long as those meet the forest definition of the Indonesian Government[23] as described in the IFCA report (Exhibit 13).

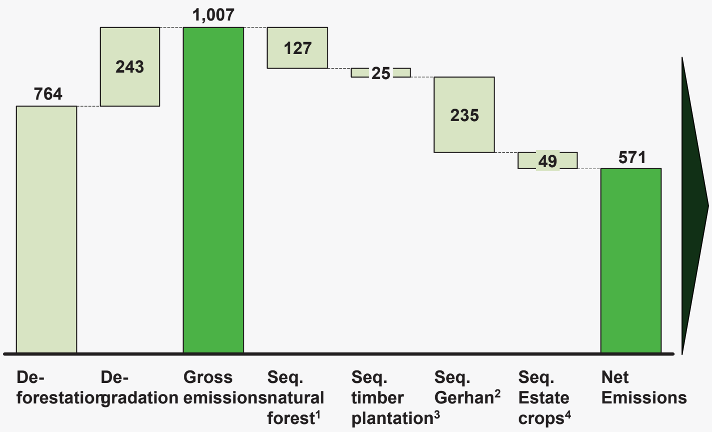
Net emissions are calculated by taking absorption of natural forest and plantations into account

PRELIMINARY

Exhibit 13

Indonesia's emissions from deforestation and forest degradation and absorption 2030

Million tons CO_2e



- Absorption in natural secondary forests is decreasing as a consequence of area reduction and degradation
- Absorption in plantations and reforestation projects are likely to increase steadily until 2030, however as soon as those areas will reach the end of their rotation cycle e.g. oil palm after 25 years the absorption potential will decrease and net emissions increase

1 Annual increment of $4m^3$ per ha or 4.4 t CO2e/ha per year in Indonesia secondary forest
2 400,000 ha land rehabilitated inside and outside forest annually between 2003 and 2007; sequestration of 18.3 t CO2e/ha/year, rotation period 35 years
3 271,000 ha of new established timber plantation, sequestration of 29.3 t CO2e/ha/year; rotation period of 10 years
4 434,000 ha of new established estate crops plantations, sequestration of 5.1 t CO2e/ ha/year; rotation period of 30 years

SOURCE: Min. of Forestry – Rekalkulasi Penutupan Lahan Indonesia Tahun 2008; Forestry Statistics 2007; Sheil et al. 2009; Burschel et al. 2001; Indonesia GHG Emission Cost Curve, Indonesia – 2nd National Communication

The calculation of the absorption in the forest types described above is based on assumptions for annual growth rates, carbon content per cubic meter of biomass, future area development, and crop rotation period. The rotation period is a critical element of the calculation, as large parts of the sequestered carbon will be released at the end of the rotation period, reducing the annual absorption rate significantly. This is especially true for short-rotation pulpwood plantations, which are therefore not an ideal tool to increase the carbon sink of Indonesian forests in the long term.

AGRICULTURE

2030 – emissions: 164 $MtCO_2e$, abatement potential: 105 $MtCO_2e$

Agricultural carbon emissions are mostly not carbon dioxide, but other GHGs like methane and nitrogen oxide. Such emissions come from three major sources: water management practices for rice crops, artificial fertilizer application, and the burning of crop residues.

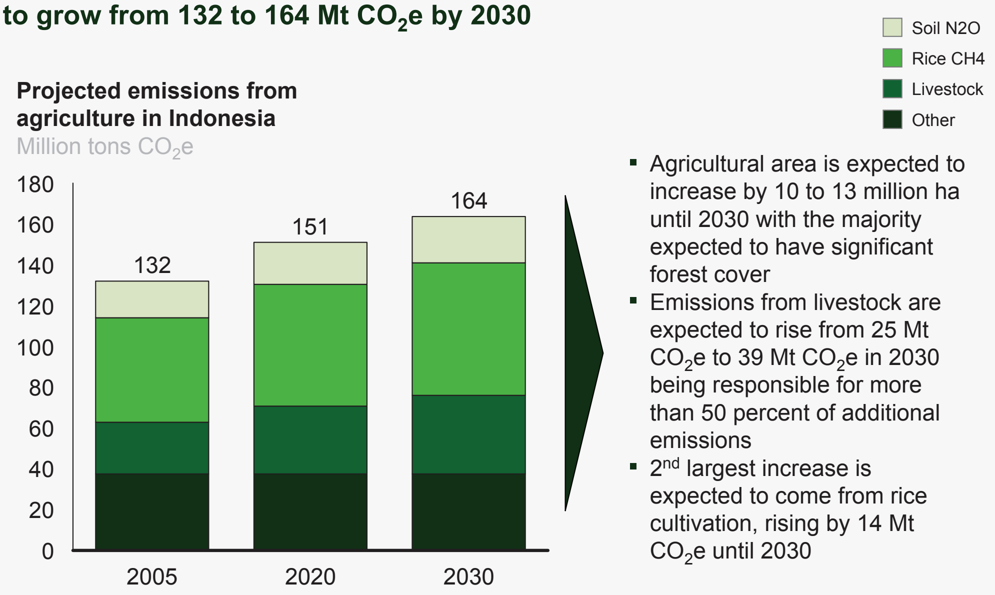
Sectoral emissions

Agriculture is Indonesia's third-highest emitting sector, behind LULUCF and peat, with emissions of 132 $MtCO_2e$ in 2005 (based on land use at the time). Emissions from this sector are expected to grow by 25 percent to 164 $MtCO_2e$ in 2030 (Exhibit 14).

22 IPCC – Good Practice Guidance for Land Use, Land-Use Change, and Forestry
23 Forests are described as non-annual plants reaching a height of minimum 5 m and with a crown cover of more than 30 percent of a defined area, normally one hectare

Exhibit 14

In a business as usual trajectory emissions from agriculture are expected to grow from 132 to 164 Mt CO_2e by 2030



- Agricultural area is expected to increase by 10 to 13 million ha until 2030 with the majority expected to have significant forest cover
- Emissions from livestock are expected to rise from 25 Mt CO_2e to 39 Mt CO_2e in 2030 being responsible for more than 50 percent of additional emissions
- 2nd largest increase is expected to come from rice cultivation, rising by 14 Mt CO_2e until 2030

SOURCE: EPA; Indonesia GHG Abatement Cost Curve

Abatement potential and cost

The abatement potential for this sector is estimated to be approximately 105 MtCO_2e per year or approximately 63 percent of the sector's emissions by 2030 (Exhibit 15).

Improving the management of water and nutrients for rice farming offers significant abatement potential of 45 MtCO_2e or 43 percent of the sector's emissions. Rice water management involves mid-season and shallow flooding drainage to avoid anaerobic conditions, which otherwise lead to significant methane emissions. Nutrient management refers to a shift from nitrogen based fertilizers to sulfate fertilizers.

A third of the sector's abatement opportunity comes from the restoration of degraded land (i.e., agricultural land degraded through excessive disturbance, erosion, organic matter loss, salinization or acidification), which would account for emission reductions of 35 MtCO_2e. Typical abatement activities include re-vegetation (e.g., planting grasses), improving fertility by nutrient amendments, applying organic substrates such as manures, biosolids, and composts, reducing tillage and retaining crop residues.

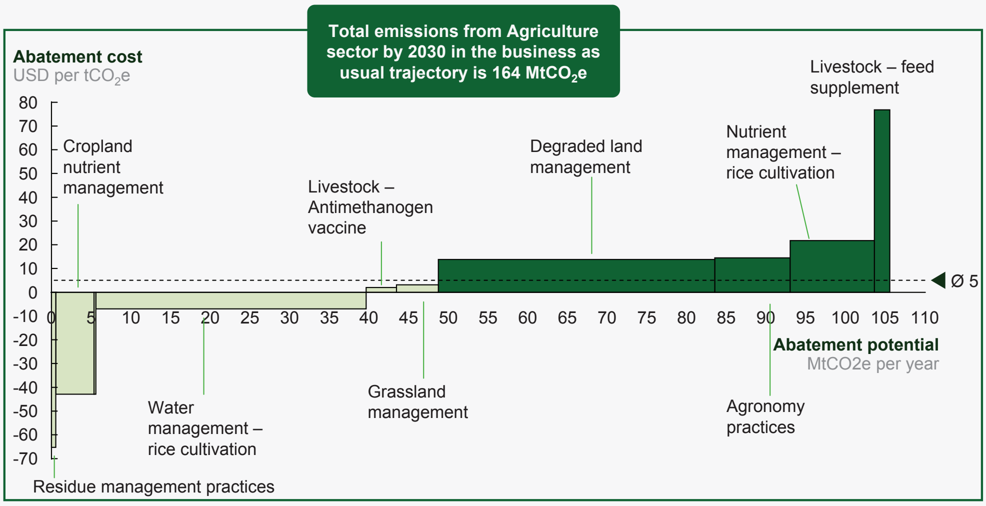
The average abatement cost in the agriculture sector is 5 USD per tCO_2e. The restoration of degraded land through the creation of a carbon sink (building up organic matter within the soil) comes at a cost of 13.8 USD per tCO_2e, while improving rice water management and rice nutrient management has a cost of -7 and 21.7 USD per tCO_2e per year respectively. The improving nutrient management lever is expensive because of the significantly higher prices of non-nitrogen based fertilizers, e.g. phosphor- or sulfate based fertilizers such as Diammonium phosphate, which are up to 30 percent more expensive than nitrogen-based fertilizers.

The greatest implementation challenge in the agricultural sector is geography and the fragmentation of stakeholders, as these abatement programs would have to be implemented across a vast number of Indonesia's mostly smallholder farmers. This would require extensive investment in educational programs to change entrenched farming practices. Transaction costs for these abatement levers are not yet well understood in Indonesia.

Exhibit 15

105 Mt CO_2e could be abated by improving water management in rice cultivation and the restoration of degraded land

Societal perspective; 2030



Note:
The curve presents an estimate of the maximum potential of all technical GHG abatement measures below EUR 60 per tCO2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play. Assuming a 4% societal discount rate

SOURCE: Indonesia GHG Abatement Cost Curve

POWER

2030 – emissions: 810 $MtCO_2e$, abatement potential: 225 $MtCO_2e$

Demand for power is expected to rise by eight times from 2005 to 2030 – driven by rapid economic development, increased electrification of rural Indonesia (from 60 percent of households today to 100 percent by 2020), fast growth of manufacturing and services, and the expected realization of latent and suppressed demand for power.

Sectoral emissions

Indonesia's emissions from the power sector are expected to grow seven-fold from 110 $MtCO_2e$ in 2005 to 810 $MtCO_2e$ in 2030 due to strong demand growth and an increasing dependence on coal (Exhibit 17). Emissions from the power sector in 2030 are expected to exceed levels of the peat sector today.

Demand for power is expected to grow from 120 TWh in 2005 to 970 TWh in 2030. While several demand projections exist for Indonesia, demand estimates developed by PLN, the state electricity utility company, appear to be the most consistent with our general approach, using projections based on those of a comparable economy. However, since PLN does not project beyond 2025, we have extrapolated the demand to 2030 using the historical growth rate.

On the supply side, Indonesia has ambitious plans to capture as much as 9 GW (from 1 GW today) of geothermal energy by 2030, which would then account for 8 percent of total power generation. However, the continued policy emphasis (as described by the National Energy Blueprint) on increasing the share of coal in the energy mix will negate most efforts of clean power generation, leaving Indonesia's electricity emission factor, i.e., emission per unit of electricity, relatively unchanged from 2005 to 2030.

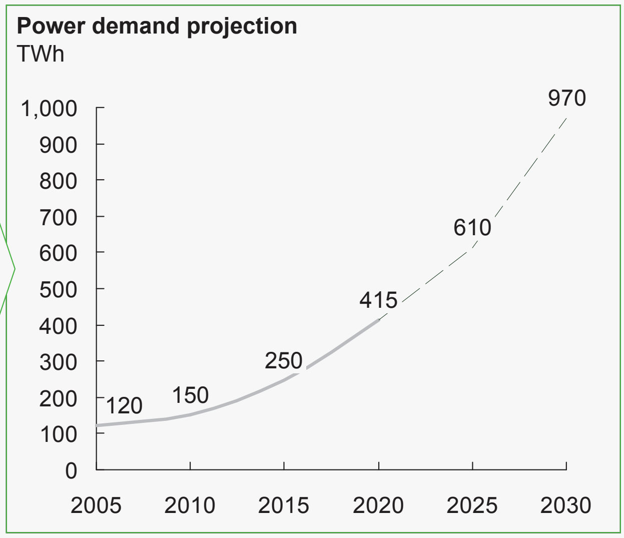
Exhibit 16

The power sector is expected to see an 8-10 fold increase in demand from 120 to 970 TWh over the next 25 years

RUPTL (PLN)
Projection

…driven by several factors including:

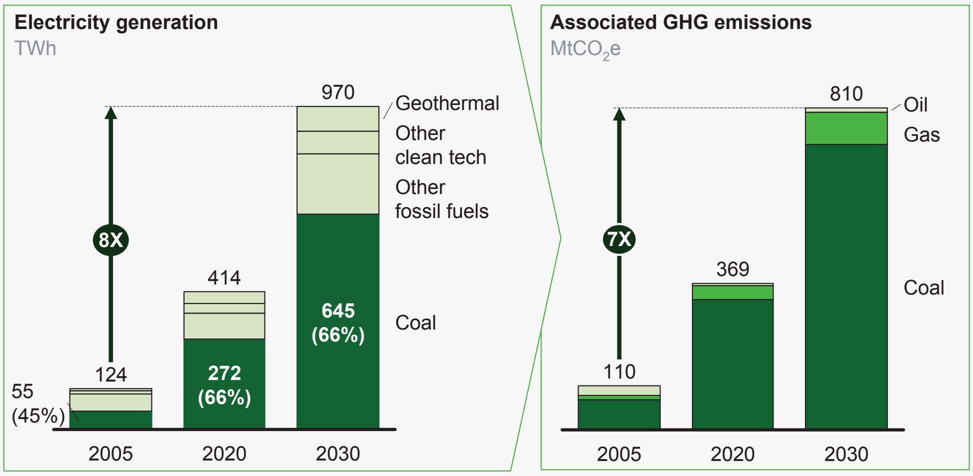
1. Growth in residential consumption
2. Electrification of rural Indonesia
3. Realization of latent and suppressed demand
4. Manufacturing and services growing faster than before



SOURCE: RUPTL 2007-2018, RUKN 2008-2027 (Ministry of Energy & Mineral Resources)

Exhibit 17

Coal is expected to take on a greater share of the total BAU energy mix leading to a seven-fold increase in GHG emissions in 2030



Key observations

- While geothermal capacity continues to grow in absolute terms, it's relative share in the overall mix remains small
- Current plans outlined in the National Energy Blueprint push for a switch from oil to coal so as to limit excessive price fluctuations caused by volatile oil price

Note: Projections from PLN are until 2018, hence proportion of technologies is assumed to remain constant after 2020

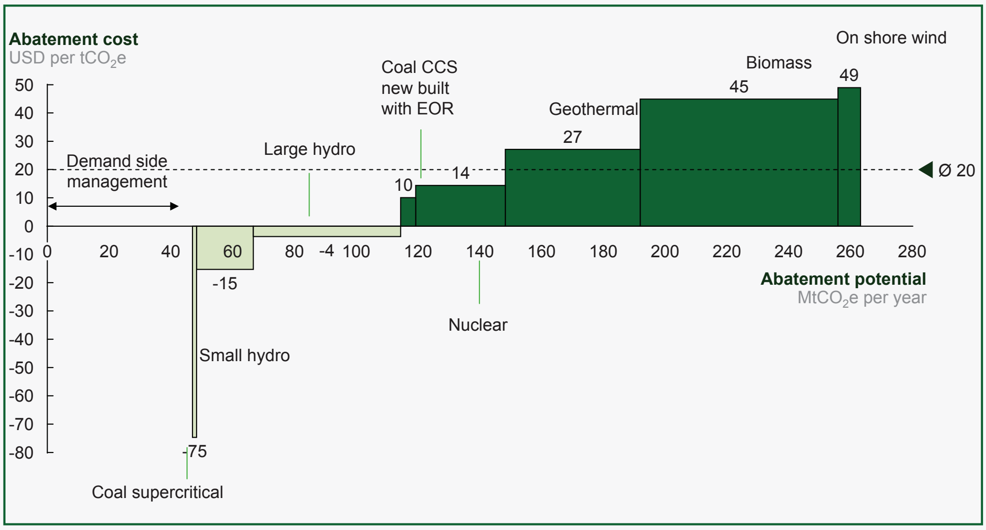
SOURCE: Indonesia GHG Abatement Cost Curve, PLN, ESDM, IEA

Abatement potential and costs

There are several opportunities to abate as much as 225 $MtCO_2e$ in 2030 through increased penetration of clean and renewable energy sources and the increased use of clean coal technologies. An additional reduction can be attributed to reduced demand from other sectors. In particular, demand-side management levers (e.g., switch from incandescent to LED light bulbs) in the buildings, transportation, and cement sectors could see a net effect of reducing emissions by 47 $MtCO_2e$ (56 TWh) in 2030 (Exhibit 18).

The power sector could provide approximately 260 $MtCO_2e$[1] of reduction potential in 2030

Exhibit 18



1 Inclusive of demand side reductions in other sectors; currently estimated at 57 TWh

SOURCE: Indonesia GHG Abatement Cost Curve

As relatively clean technology, hydro-electricity plants offer the largest abatement opportunity. Hydro in Indonesia remains mostly underdeveloped, with only 5 GW developed of the total 32 GW of exploitable potential expected in 2030. Capturing the additional 27 GW capacity (based on 70 TWh installed) of hydro power would result in an abatement potential of 65 $MtCO_2e$ at a negative cost of -7 USD per tCO_2e.

Indonesia is home to a significant share of the world's known conventional geothermal resources. Additional use of geothermal sources, beyond what is already planned, could provide abatement of some 50 $MtCO_2e$, adding an additional 6 GW of capacity (47 TWh) at an abatement cost of 27 USD per tCO_2e. Although a proven technology, limited feasibility assessments in Indonesia often leads to much higher exploration and development costs of geothermal projects in Indonesia. Experts have suggested that these costs could be as much as 125-175 percent higher given the scarcity of strong technical information available on geothermal sites.

The single largest lever by volume is biomass power plants. In this context biomass refers to fuels derived from timber, fuel crops and agricultural waste. Together these represent a 64 $MtCO_2e$ abatement opportunity. The high cost of biomass in this analysis is caused by two factors: the first is that given the Indonesia's geographical context, fuel supply usually resides some distance from where power demand exists leading to high transportation costs for the fuel; the second is that the model considers only grid-connected applications of biomass power. Implementing biomass in smaller, off-grid and distributed applications could provide for additional, and lower-cost, options; however, the limited availability of off-grid demand data in Indonesia limits a more detailed analysis.

Similarly, solar power is considered as a grid-connected system in this model which limits its potential scale and leads to a relatively higher cost. Solar power could provide significant savings if off-grid solar applications were considered, but these would require additional analysis. In the current model which looks only at grid-connected power, the cost of solar exceeds the \$80/tCO_2e threshold built into the analysis.

To realize this potential abatement and develop power infrastructure on a low-carbon-growth trajectory, Indonesia must overcome several barriers. A comprehensive, detailed, and publicly available mapping of available energy sources in Indonesia as well as sufficient regulatory support may help attract more investment to develop their potential. The most recent publicly available information relies on antiquated data and often does not include a feasibility analysis of the available resources.

TRANSPORTATION

2030 – emissions: 502 MtCO_2e, abatement potential: 100 MtCO_2e

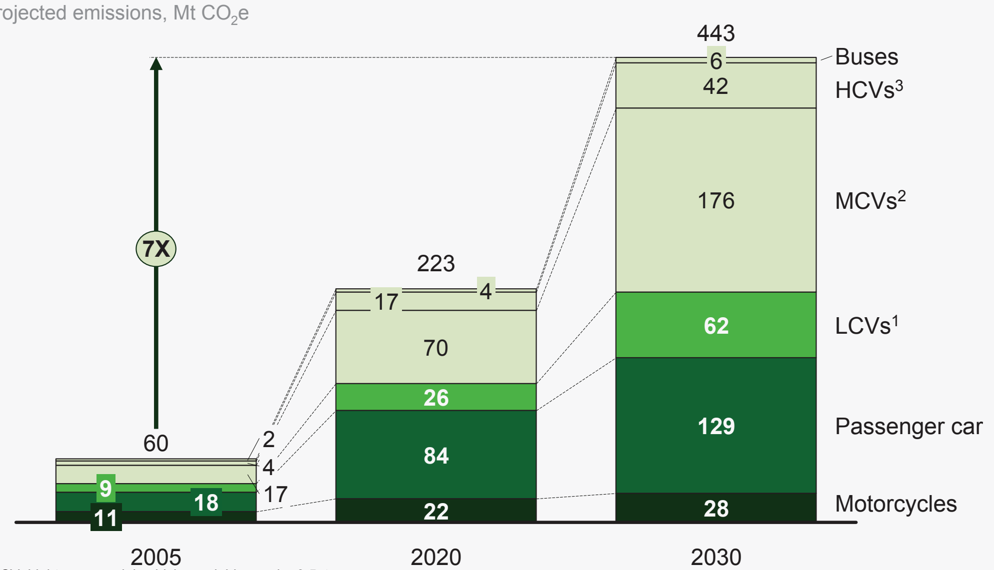
Sectoral emissions

Emissions from the transportation sector will increase seven-fold between 2005 and 2030 (from 60 to 443 MtCO_2e) in the business-as-usual scenario, driven by strong growth in the number of personal and commercial vehicles (Exhibit 19). As personal income levels triple over the next two decades, this will lead to a tripling in penetration of personal vehicles from 115 vehicles per 1,000 inhabitants today to 312 in 2030.

Exhibit 19

Indonesia will see a seven-fold increase in business-as-usual emissions from the road transport sector

Projected emissions, Mt CO_2e



1 LCV: Light commercial vehicles weighing under 3.5 tons
2 MCV: Medium commercial vehicles weighing between 3.5 – 16 tons
3 HCV: Heavy commercial vehicles weighing over 16 tons

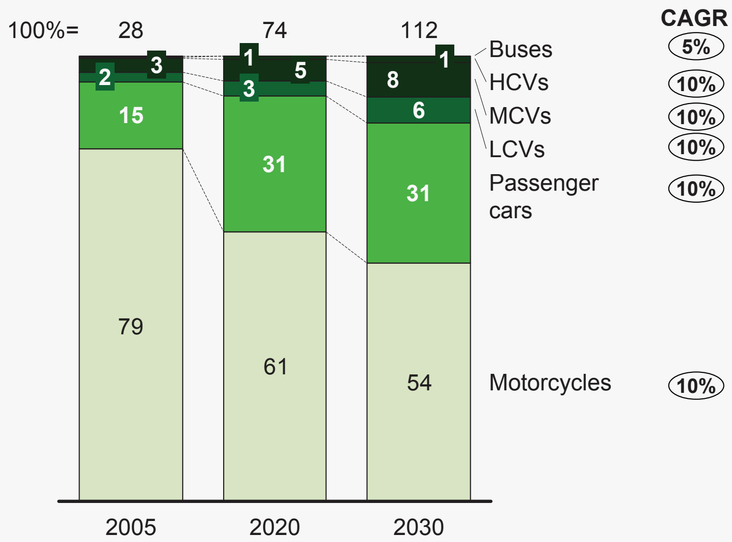
SOURCE: Asia Clean Air Initiative, Swisscontact, PUSTRAL, GAIKINDO, Expert Interviews, Indonesia GHG Abatement Cost Curve

Tied to this rise in wealth will be an increased volume of goods to be transported across the country, which will drive an even faster increase in the share of commercial vehicles from 5 percent to 15 percent of the overall vehicle population (Exhibit 20). With heavier, lower-fuel-economy vehicles traveling longer distances, the share of emissions from commercial vehicles is expected to grow from 10 percent to 20 percent of the total emissions in 2030.

Exhibit 20

The share of commercial vehicles will increase from 5 to 15% as the need for transporting goods rises with increased economic activity

Millions



SOURCE: Ministry of Transportation, Ministry of Industry, GAIKINDO, PUSTRAL, Expert interviews

Abatement potential and associated costs

There exists the potential to reduce transportation sector emissions by 20 percent (approximately 100 Mt) by 2030 across three principal mitigation levers: improvements to internal combustion engines; moving from gasoline-powered vehicles to hybrid and electric vehicles; and the adoption of biodiesel fuel made from palm oil (Exhibit 21).

Three quarters of the total emission reduction potential (or 75 $MtCO_2e$) lies in improvements to conventional internal combustion engines (ICE) across all vehicle classes, which could be encouraged through higher fuel efficiency standards. Such measures are all available at a negative abatement cost. It is important to stress here that while the abatement cost is negative over the life of the technology there can often be a significant upfront cost which needs to be born by the consumer. Without specific regulations in place, the manufacturer is unlikely to incorporate more expensive technologies as their products will appear more expensive to the consumer. Specific regulatory measures will need to be undertaken by the Government of Indonesia to help manage these forms of principle-agent issues.

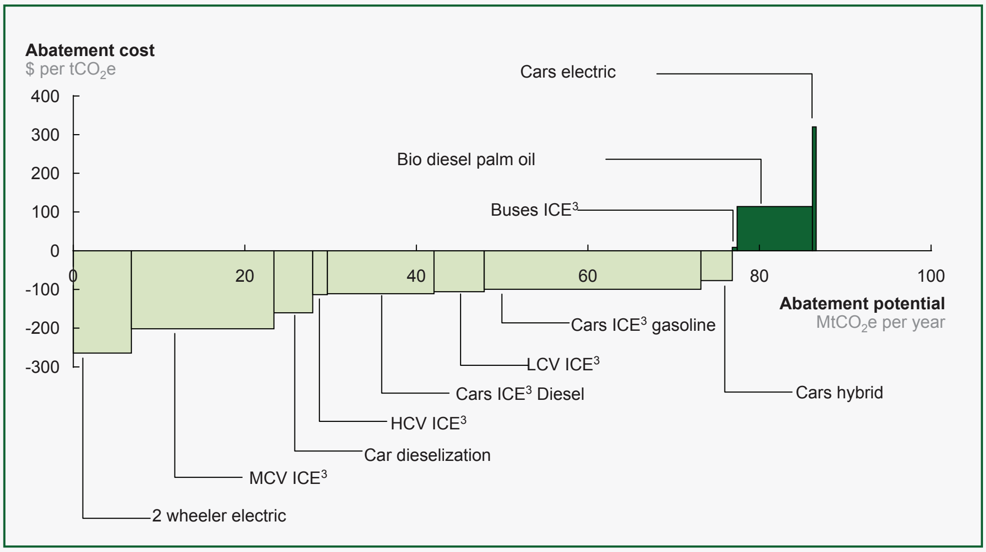
Shifting from gasoline-powered vehicles towards hybrid and electric vehicles represents the next largest opportunity of 15 $MtCO_2e$. Switching to electric motorcycles is a relatively attractive option at a cost of -162 USD per ton of CO_2e abated. Though the costly batteries associated with these new technologies would act as a cost barrier in a developing country such as Indonesia, continued innovation that lowers cost and new sources of international financing could result in increased penetration of these vehicles.

While a significant portion of the opportunity is available at a negative abatement cost, implementing most of these levers will require significant upfront investments in vehicles and infrastructure in related sectors. International financing will need to be made available in order for Indonesia to capture many, if not most, of these opportunities in the near term.

Many ICE improvements are dependent on the availability of the appropriate fuel types, which could imply changes or additions to current refining practices in Indonesia.

Exhibit 21

About 89% of the abatement potential can be obtained at a negative cost to society[1]



1 Assuming a societal discount rate of 4%
2 Current potential based on global cost assumptions for palm oil at USD 0.52 / liter
3 Internal combustion engine (ICE)

SOURCE: Indonesia GHG Abatement Cost Curve

Biodiesel made from palm oil would provide an additional 10 $MtCO_2e$ of abatement potential, but at a very high incremental cost compared to the current projected cost of diesel. However, the abatement potential from the use of biodiesel from palm oil is particularly sensitive to the availability of sustainable palm oil. It is important that any increase in supply of palm oil for the transportation sector not compete with efforts to avoid deforestation as highlighted in the LULUCF section. Should the biofuels come from plantations which have displaced forests the abatement opportunity would be significantly reduced and hence lead to the lever becoming even more expensive.

Sustainable public transit systems are another important mitigation measure in the transportation sector. However, they have not been included in this analysis as local data on public transportation costs and effectiveness are limited. Several studies are currently underway, the results of which could later be incorporated into this model.

PETROLEUM AND GAS

2030 – emissions: 137 $MtCO_2e$, abatement potential: 41 $MtCO_2e$

Sectoral emissions

For petroleum, the scope of this analysis includes production (including gas flaring) and refining activities. Excluded are emissions related to exploration and development of petroleum reserves, shipping, and petrochemicals. This analysis also excludes emissions related to the final consumption of petroleum products by the end user, as these are treated within the individual consuming sectors detailed elsewhere in this report.

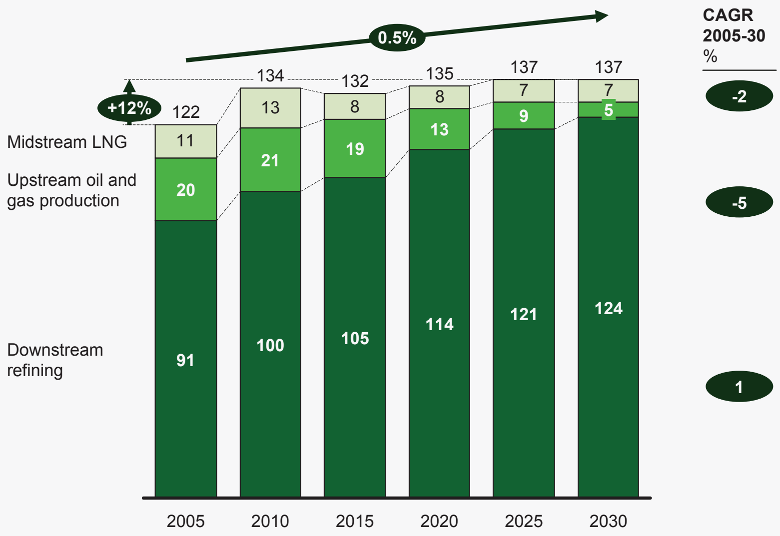
For natural gas, the scope of this analysis includes production and liquefaction of natural gas into liquefied natural gas (LNG).

Under these definitions, total emissions from Indonesia's petroleum and gas sector are expected to increase in the medium term from 122 $MtCO_2e$ in 2005 to 135 $MtCO_2e$ in 2020, mainly on account of additional refining capacity expected to come online. However, in the longer term, emission increases from refining are expected to be offset – as mature oil and gas fields are shut down and replaced with newer, more efficient ones – so that emissions stay relatively constant at 137 $MtCO_2e$ in 2030 (Exhibit 22).

Business-as-usual emissions in the petroleum and gas sector

$MtCO_2e$ per year*

Exhibit 22



* Including indirect emissions

Source: Indonesia GHG Abatement Cost Curve

Upstream

Production of oil is expected to remain relatively flat at around 1.1 million barrels per day. Current forecasts for oil production in Indonesia do not include any additional large discoveries. Most oil fields are beginning to mature and only smaller fields are coming online to offset the very mature fields, which are expected to be shut down in the near future.

Flaring and in some cases even venting of associated gases continues to remain a problem in Indonesia. Current estimates suggest that 25–30 percent of all flaring activities in Southeast Asia are occurring in and around Indonesia, which is significant given that Indonesia only accounts for around 12 percent of all oil production in the region. However, flaring emissions in Southeast Asia have been reducing at a fairly strong pace; current estimates from the U.S. National Oceanic and Atmospheric Administration (NOAA) show reductions of around 5 percent per year from 2000 to 2004. In 2005, the most recent year with data available, gas flaring in Indonesia was estimated to be around 3 billion cubic meters (BCM) per year.

Midstream

Natural gas liquefaction is currently estimated at 44 BCM per year, with the majority of it being exported. Most of the emissions associated with LNG are the result of gas compression and methane leakage during the processing and transporting of the gas. Current estimates suggest a decline in the volume of LNG being produced over the next 20 years and almost halved by 2030, as it is expected that increasingly larger shares will be diverted for domestic consumption where the need for liquefaction would be reduced.

Downstream

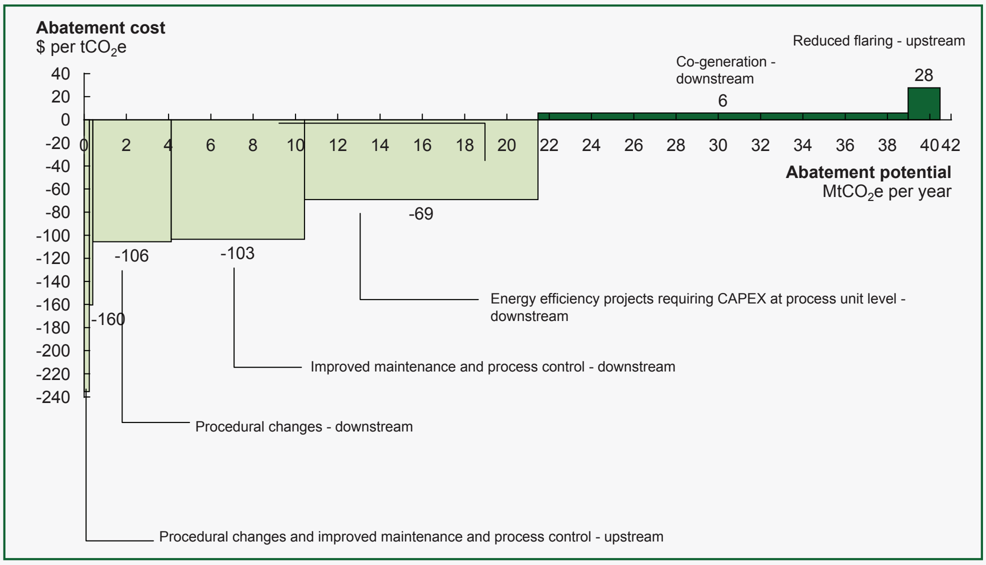
Refining capacity in Indonesia has remained constant for the past few years at around 1 million barrels per day. All refining capacity in Indonesia is owned and operated by state-owned Pertamina, which has announced plans to add an additional 500,000 barrels per day refining capacity in the next 5–10 years, increasing total refining capacity up to 1.5 million barrels of oil per day. This planned capacity addition is included in the current emission analysis.

Abatement potential and associated costs

The petroleum and gas sector has an opportunity to reduce emissions by as much as 30 percent by 2030 through a focused effort across three abatement areas: improved maintenance and process control, energy efficiency programs, and reduced flaring. (Exhibit 23).

Exhibit 23

Indonesia GHG abatement cost curve for the Petroleum sector in 2030



SOURCE: Indonesia GHG Abatement Cost Curve

Improved maintenance and process control across the production and refining subsectors could result in a little over 7 $MtCO_2e$ of abatement and is net-profit-positive (-103 USD per tCO_2e), which implies significant savings over the life of the abatement measures. Specific programs within these levers include conservation programs, energy-awareness programs, and measures to reduce fouling build-up in pipes, optimize well and separator pressures, and optimize the spinning reserves of rotating equipment.

Implementation of energy-efficiency programs could provide an additional 27 $MtCO_2e$ of abatement at negative cost (for energy efficiency programs) or modest cost (for implementing cogeneration[24] units). While the levers identified within this category require high capital investments, significant operational savings can be captured through reduced energy requirements.

Reduced flaring through the implementation of a zero-flaring program could offer 2 $MtCO_2e$ of abatement at a relatively higher cost of 28 USD per tCO_2e. The relatively small abatement is a result of significant anticipated reductions in flaring emissions in the business-as-usual scenario (currently at 5 percent per annum). In the near future, carbon capture and storage could offer a significant abatement opportunity for the petroleum and gas sector. However, given the limited deployment of this technology and as yet unknown cost structures, this abatement lever has been excluded from this analysis.

24 Process by which the plants use waste energy to produce heat or electricity

CEMENT

2030 – emissions: 86 MtCO$_2$e, abatement potential: 13 MtCO$_2$e

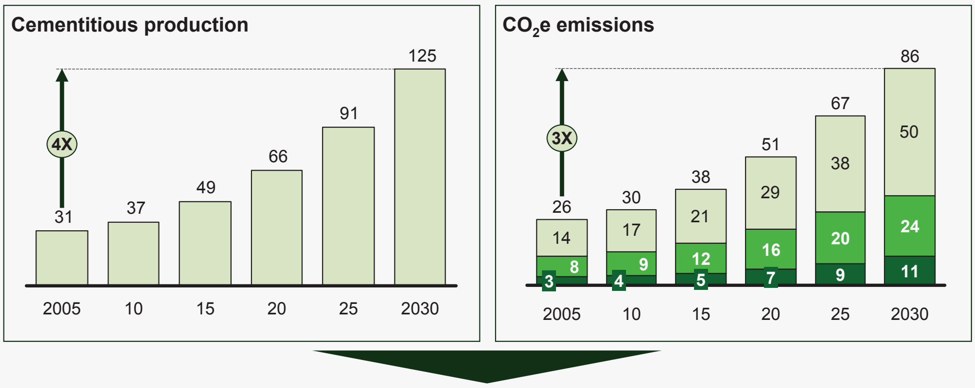
Sectoral emissions

With strong economic growth expected for Indonesia for the next 20 years, cement sector emissions will see a three-fold increase from 26 MtCO$_2$e in 2005 to 75 MtCO$_2$e in 2030. This will be driven by significant growth in the production of cementitious material in Indonesia from 31 million tons in 2005 to 125 million tons in 2030 (Exhibit 24) driven primarily by strong economic growth.

Exhibit 24

Cement demand and related GHG emissions are projected to more than triple by 2030

Mt, Mt CO$_2$e



Key observations

- Cementitious production and related CO$_2$e emissions are projected to more than triple by 2030 compared to 2005 production and emissions levels
- Emissions are growing at a lower annual rate than production, driven by increased clinker substitution, an improved average fuel efficiency of production capacity resulting from optimized retirement of least fuel efficient kilns first and build out of best available technology as replacement

SOURCE: Indonesia GHG Abatement Cost Curve

The majority of these emissions are generated from production of clinker, a key element of cement production. The process involves the calcination of limestone and clay, a chemical reaction that releases a significant amount of CO$_2$e as a byproduct. Replacing clinker with substitutes such as fly ash or slag can significantly reduce direct emissions from the cement sector.

Abatement potential and associated costs

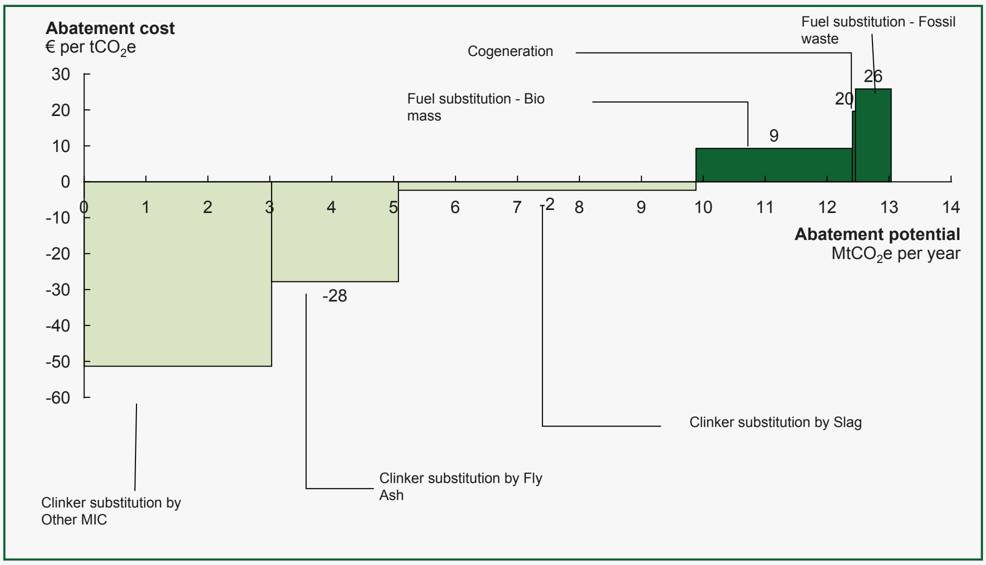
The cement industry in Indonesia has ambitious plans to reduce emissions through a significant increase in clinker substitution. In fact, almost 14 MtCO$_2$e of reduction is already incorporated in the business-as-usual figures (i.e., comparing 2005 emission intensities with those in 2030).

In addition, given other existing technologies, the cement sector could further reduce its emissions by 12 percent (or 9 MtCO$_2$e) by 2030. Although clinker substitution continues to represent the largest opportunity for abatement, at approximately 7.5 MtCO$_2$e at an average negative cost of -25 USD per tCO$_2$e, incorporating alternative fuels, particularly from industrial and municipal waste, could further reduce emissions from the cement sector by 4.5 MtCO$_2$e at a moderate average cost of 8 USD per tCO$_2$e (Exhibit 25).

Within the cement industry there are other abatement levers such as carbon capture and storage (CCS) and waste heat recovery, which could provide further abatement potential in the future. However, CCS

Exhibit 25

Indonesia GHG abatement cost curve for the Cement sector in 2030



SOURCE: Indonesia GHG Abatement Cost Curve

technologies are still at a nascent stage, and waste heat recovery is currently not technically feasible given the higher moisture content of most raw materials in cement production.

Challenges in the implementation of abatement, such as the availability of clinker and fuel substitutes, will continue to make it difficult to realize both the ambitious plans of the industry and the further capture of additional abatement potential. Most of the additional abatement potential will only be captured through policy changes and enhanced incentive structures. Clinker substitutes such as fly ash are of limited availability in Indonesia. Attempts to import quantities of fly ash from other countries such as Malaysia or Japan have not been successful given the current regulatory framework which prevents such imports.

BUILDINGS

2030 – emissions: 215 MtCO_2e, abatement potential: 43 MtCO_2e

Sectoral emissions

Emissions from the buildings sector will increase from 71 MtCO_2e in 2005 to 215 MtCO_2e in 2030, driven by growing consumption of residential and commercial energy of 5–7 percent per annum (Exhibit 27).

Abatement potential and associated costs

By leveraging existing technologies, the buildings sector could reduce its emissions by 22 percent in 2030, representing 48 MtCO_2e – with most reductions (more than 70 percent) coming at negative abatement costs. (Exhibit 26).

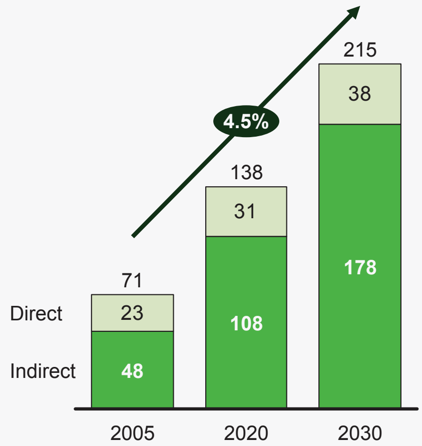
These abatement opportunities are focused around six areas. In order of lowest-cost abatement lever, these include:

- Alternative water heating replacements (8.8 Mt)
- More efficient lighting replacements (11.3 Mt)

Exhibit 26

Buildings sector business-as-usual emissions are expected to grow from 71 to 215 Mt CO_2e between 2005 and 2030

Projected emissions
Million tons CO_2e



Key Assumptions

Residential Consumption

	2005 (Gwh)	Growth[1]
Electricity	41,171	5.0%
Gas	15,544	3.6%
Oil	42,878	1.4%
Coal	2,557	1.7%
Other fuel	337,702	0.5%

Commercial Consumption

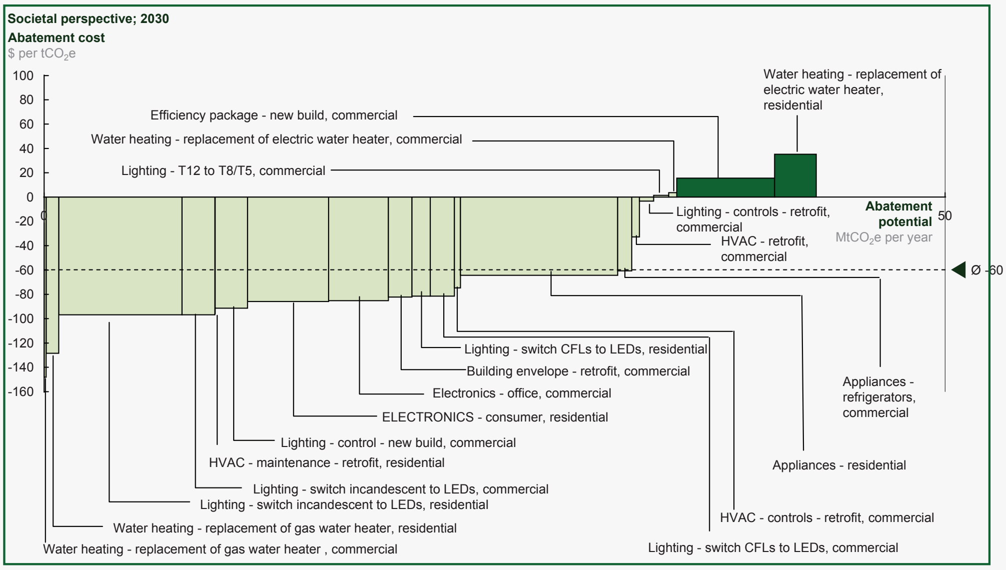
	2005 (Gwh)	Growth
Electricity	17,036	6.7%
Gas	2,749	3.0%
Oil	11,352	2.3%
Coal	972	0.0%
Other fuel	1,013	-0.1%

1 From 2005 to 2030

SOURCE: Global Insight; RISI; WMM; PLN; IEA; Indonesia GHG Abatement Cost Curve

Exhibit 27

Indonesia has 43 Mt CO2e abatement opportunity in Buildings sector – with over 79% at negative costs



1 VAC stands for ventilation and air conditioning

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below $90 per tCO2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play

SOURCE: Global GHG Abatement Cost Curve v2.0

- More efficient electronics replacements (6.4 Mt)
- More efficient appliances replacements (9.3 Mt)
- Retrofit building packages (3.2 Mt)
- New building packages (8.2 Mt)

The buildings sector is unique in that not only are many of the opportunities at negative cost (i.e., they save money in the long term), but the launch of a few specific programs towards more efficient lighting, electronics, and appliances would allow the relatively quick capture of 50 percent of these abatement opportunities (Exhibit 28).

Exhibit 28

74% of Buildings sector abatement opportunities could be captured in the short-term through government and private sector programs

Quick Win opportunity[1]		Abatement Potential $MtCO_2e$/year	Abatement costs USD / tCO_2e
Light bulb subsidy program (both residential and commercial)	▪ Incentivize utility companies to sell CFL/LED bulbs at a lower cost by offering cash for the energy costs they save/avoid ▪ California's PG&E sell CFL bulbs for 25-50 cents and are awarded 12% of costs they avoid (324-450M USD)	14.4	-164
Consumer Electronics tax refund & trade-in program	▪ Provide government tax refunds to consumers who purchase an energy efficient electronics, e.g. TV, computers, printer ▪ Incentivize electronics manufacturers to offer a trade-in program for old electronics	7.8	-86
Consumer Appliance tax refund & trade-in program	▪ Provide government tax refunds to consumers who purchase an energy efficient appliance, e.g. refrigerator, stoves ▪ Incentivize appliance manufacturers to offer a trade-in program for old appliances	9.5	-64

1 Programs identified here refer to global examples of programs which have successfully captured the related abatement opportunity. The abatement potential and abatement cost described refer to their potentially impact in Indonesia if implemented

SOURCE: Press search

Examples of major initiatives that could be launched in the near term include government programs to subsidize the purchase of more efficient light bulbs and to provide a tax refund and/or trade-in for the purchase of more energy-efficient consumer electronics and appliances.

Utility companies could be subsidized to sell more efficient light bulbs at low cost, e.g., California's PG&E sells compact fluorescent (CFL) bulbs for 25–50 cents, and the government awards PG&E with 12 percent of the costs they avoid, i.e., 324–450 million USD over the three-year program.

Consumers could be encouraged to purchase more energy-efficient electronics (e.g., TV, computer) and appliances (e.g., refrigerator, stove) through government tax refunds and/or trade-in incentives.

The capture of these negative cost opportunities could require broader initiatives to raise the energy efficiency standards of new buildings, develop high-efficiency standards for appliances, and make available innovative financing schemes for enabling retrofits to the existing building stock, such as through energy services companies. Important behavioral changes instilled through civic education programs in schools and universities will be instrumental to the success of these initiatives, especially those focused at the consumer.

APPENDICES

Methodology and scope

This study focuses on technical abatement opportunities costing less than 80 USD per ton of CO_2 equivalent (tCO_2e), as shown on Indonesia's greenhouse gas abatement cost curve (Exhibit 3). We have defined technical abatement opportunities as those that do not have a material effect on people's way of life. Our approach and results are both consistent with the national imperative of continued development and sustainable growth.

The cost curve model analyzes a total of eight economic sectors employing the IPCC methodology for calculating sector emissions (see box). We look at six sectors in detail from the bottom up: LULUCF, peat, power, transportation, cement, and petroleum and refining, and at two using top-down estimates: agriculture and buildings.

IPCC Methodology

The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environment Program and the World Meteorological Organization, is the primary UN scientific advisory body publishing reports on the science and economics of climate change in order to provide a detailed fact base to policy makers and negotiators. One of its activities is to support the United Nations Framework Convention on Climate Change (UNFCCC) through its work on developing methodologies for National Greenhouse Gas Inventories, which it publishes in the form of detailed guidelines.

The DNPI has relied on the IPCC's national emission reporting guidelines and good practice guides for calculating Indonesia's emission profile. IPCC Guidelines provide three methodological tiers, varying in complexity, to be chosen on the basis of national circumstance (Annex 1 vs non-Annex 1) and availability of data.

Tier 1 is a simple first order approach, whereby emissions are calculated based on IPCC default parameters, and DNPI analysis is consistent with a Tier 1 assessment at a minimum. Tier 2 is a more accurate approach that provides more detailed sector level and nationally specific parameters for calculating emissions, and the DNPI has developed Tier 2 level assessments wherever national sector level emissions data were made available through either multi-stakeholder workshops or expert interviews. At this time, a lack of detailed data precludes the DNPI from using Tier 3 methodology, the highest order method that includes detailed modeling and/or inventory measurement systems with data available at a higher resolution.

The DNPI has shared its methodology for all sectors with UNFCCC reviewers. Under current practice, reviewers do not endorse or certify national emission inventories unless submitted as a part of the national communication framework.

Development of the abatement cost curve

The global greenhouse gas abatement "cost curve" developed by global consultancy McKinsey & Company[25] summarizes the technical potential to reduce emissions of greenhouse gases at a cost of up to 80 USD per ton CO_2e[26] of avoided emissions. The cost curve shows the range of emission reduction actions that are possible with technologies that either are available today or are highly likely to be available by 2030.

25 McKinsey & Company (2009) Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve

26 Following IPCC definitions, the abatement cost curve shows technical measures with economic potential under USD 80 per tCO2

The combined axes of an abatement cost curve depict the full range of available technical opportunities[27] (or levers), their relative impact in terms of carbon abatement (emission reduction potential by volume), and their estimated cost for a specific year. Each opportunity is examined independently to quantify both the abatement and cost dimensions.

The basic logic of the cost curve is that it displays the abatement potential and the corresponding cost for each mitigation opportunity relative to a business-as-usual scenario in any given year, for a given price of fossil energy. In other words, the cost curve is a tool for assessing the emissions reduction potential of different abatement measures and for comparing their respective incremental costs. It is not designed to predict the actual price of carbon.

To ensure comparability across sectors and sources, all emission sources and sinks (points of carbon emission absorption) have been measured in a consistent way, using CO_2 equivalents measured in metric tons (tCO_2e). The merit order of abatement levers is based on the lowest cost measures (in USD per tCO_2e) as of 2030.

Viewed as a whole, the abatement cost curve illustrates the "supply" of abatement opportunities independently from the possible "demand" that may or may not currently exist for any particular abatement opportunity.

By definition, any abatement potential is attributed to the sector in which a particular lever is implemented. For example, if an abatement lever in a consuming sector (e.g., LEDs in buildings) reduces electricity consumption, the resulting emission reduction in the power sector is attributed to the consuming sector (in this case, buildings). Therefore, the business-as-usual emission calculations for all consuming sectors include indirect emissions from the power, transportation and petroleum and gas sectors.

Uncertainty can be significant for both abatement volumes and cost estimates. There are two key sources of this uncertainty: the feasibility of implementing abatement measures (for example in the LULUCF and agriculture sectors) and the cost of development for key technologies.

As noted above, uncertainty also exists on several of the estimates available at the time of conducting this study, especially in the peat sector. There are still gaps in today's understanding of climate change-related sciences, particularly as regards to natural emission sources. This report tries to bring transparency and openness to the dialogue on the scientific evidence incorporated into this study.

Calculating an abatement potential

Abatement potential is defined as the difference between the emissions volume of a particular source under a business-as-usual scenario and the emissions volume after the abatement lever has been applied.

The emissions baseline is calculated from several driver values, such as the carbon intensity of a specific fossil fuel, the production volume of a basic material, or the fuel consumption of a vehicle. Each abatement lever changes (usually reduces) specific driver values, for which the quantification is determined by literature reviews and expert discussions. For example, fuel consumption can be reduced by 70 percent through improvements to passenger vehicles. This leads to an abatement potential of 30 percent of initial fuel combustion emissions for this specific lever.

Using a merit order logic for the levers, adhering to the principle of lowest cost first, the lever with the next higher cost is applied on a new baseline after reductions from all previous levers have been applied.

Calculating abatement costs

Most abatement costs are defined as the incremental cost of implementing a low-emission technology compared to the business-as-usual case, measured in USD per ton of CO_2e abated emissions. Abatement costs include annualized repayments for capital expenditure and operating expenditure. The cost therefore represents the pure "project cost" to install and operate the low-emission technology. Capital availability is not considered a constraint.

27 See "How to read the greenhouse gas abatement cost curve"

The full cost of most abatement levers also incorporates investment costs (calculated as the annual repayment of a loan over the lifetime of the asset), operating costs (including personnel and materials costs), and possible cost savings generated by use of the alternative (especially energy savings).

In some cases, abatement comes from changes in allocation of resources rather than using alternative technologies. In such cases, abatement levers are developed by considering opportunity or replacement costs. For example, avoiding deforestation by smallholders has an estimated opportunity cost of around 1 USD per tCO2e, as this represents the revenue smallholders would expect to receive from agricultural purposes after they cut down the forest. If they don't deforest their farmland, they will lose this revenue. Naturally, stopping smallholders from cutting down forests will require more than simply paying them such an amount. However opportunity cost analysis yields the most appropriate way to easily understand the relative scale of certain abatement opportunities.

The full abatement costs (either technological or opportunity) estimated here do not include transaction costs, communication or information costs, subsidies or explicit carbon costs, taxes, or the consequential impact on the economy (for example, advantages from technology leadership). These costs all depend on policy choices and dependencies, and so do not form part of this exercise, which is to form a fact-base for policy-making.

Operating expenditure is assessed as a real amount to be expensed in each year and capital expenditure is accounted as annualized repayments. Repayment periods are calculated as the functional life of the respective piece of equipment. The interest rate used is the actual long-term bond rate of 4 percent, based on historical global averages.

All costs in the model are based on current cost and estimated projections. Estimates are based on the best available projection methods, such as models (if available), expert views, and educated extrapolation. Given the long horizon of approximately 25 years, a certain estimation error is inherent in the approach. Macroeconomic variables such as lifetime of assets, interest rates, oil prices, and exchange rates have the highest impact on results and error margins. Individual cost estimates per lever are of lower significance and will not substantially distort overall results for each lever.

Transaction costs – costs incurred in making an economic exchange above and beyond the technical project costs (e.g., education, policing, and enforcement costs) – are not included in the cost curve. Implementation cost for abatement levers are considered part of the transaction costs, involving such aspects as information campaigns and training programs.

Pure behavioral changes by individuals are also excluded from the cost curve, although they do present additional abatement potential. Behavioral changes are driven by various price and non-price factors, such as public education, awareness campaigns, social trends, or policy changes. For this reason, behavioral shifts are analyzed separately from the primary cost curve as "further potential" with no abatement cost attached.

Rather than taking the perspective of any specific decision-maker, the cost curve analysis takes a societal perspective, illustrating cost requirements to the society as a whole. At a global scale, this societal perspective enables the usage of the abatement cost curve as a fact base for discussions about what levers exist to reduce greenhouse gas emissions, how to compare reduction opportunities and costs between countries and sectors, and how to discuss what incentives (e.g., subsidies, taxes, and carbon pricing) to put in place.

For example, with this analysis, the question can be asked and answered, "If a government wanted to make different abatement measures happen, how much would different measures reduce emissions by, and what is the minimum cost (to achieve this emission reduction from a societal perspective)?"

Estimating greenhouse gas emissions

Estimates of annual GHG emissions used in international climate change negotiations may vary, depending on the different factors included or excluded (e.g., peat fires, land use changes) and the year chosen as a reference. Given the weight of peat fires in Indonesia's emissions, for example, total emissions may vary considerably each year according to the occurrence of fire.

The current emissions number represented in this study is higher than some and lower than other estimates published by other sources. However this variance does not reflect any major difference in assumptions or interpretation of data.

Many of the differences between our estimates and other previously-published estimates can be explained by:

1. **More complete inclusion of emission sources.** This estimate includes estimates of emissions from forest degradation, peat fires, and peat soil decomposition. Few published estimates of Indonesia's emissions take peat soil decomposition into account. While there are a limited number of published estimates for peat soil emissions to work from, the consensus that they are an important factor is now very clear in the wider scientific literature.

2. **LULUCF emissions are reported as net emissions.** In accordance with IPCC guidelines, emissions from land use, land-use change, and forestry (LULUCF) activities, follow a net approach that calculates the change in time-averaged carbon stock. For example, emissions resulting from timber harvesting are calculated as the loss of carbon from production forests to the time-averaged carbon stock at the end of the rotation cycle, which includes biomass regrowth. Differences in carbon stocks in different regions have been taken into account based on estimations provided by the IFCA report.

3. **Annual average approach to peat fire emissions.** Peat fires are a major source of emissions, but their severity varies widely depending on annual rainfall in different parts of the archipelago. In general we follow the approach of the Ministry of Environment by using the estimates published by van der Werf et al. (2008), however as we use the 2000–2006 average our estimates vary slightly if compared with specific years during this period.

Peat science

Peat is an accumulation of partially decayed vegetation matter. It forms usually in marshy areas, when plant material is inhibited from decaying fully by acidic and anaerobic conditions. It is composed mainly of marshland vegetation, for example, trees, grasses, and fungi, as well as other types of organic remains, such as insect and animal corpses. Peat forms over thousands of years, growing at a rate of about a millimeter per year and is, under the right conditions, the earliest stage in the formation of coal (Exhibit A1).

Peatlands cover approximately 3 percent of the global land mass, storing a tremendous amount of 528 Gt of carbon, equivalent to one-third of total global soil carbon. This carbon is under threat, as it is released as CO_2 to the atmosphere through two mechanisms (Exhibit A2):

1. **Drainage** of peatlands, which leads to aeration of the peat material and hence to oxidation (aerobic decomposition). This oxidation results in high CO_2 emissions as 50 percent to 60 percent of the peat dry matter is carbon

2. **Fire** in degraded peatland results in further CO_2 emissions; fire in non-degraded and non-drained peatlands is extremely rare because of their naturally high moisture content

Currently, the most rapid degradation of peatland occurs in Southeast Asia and especially in Indonesia, which holds roughly 22 million ha of peatlands (5 percent of the total global peatland area). Indonesia's peatlands are being deforested, drained, and burned to be developed primarily for estate crop plantations, timber plantations, and smallholder agriculture.

Exhibit A1

Thousands of years of very slow decomposition of organic matter creates an enormous carbon storage in peat soil

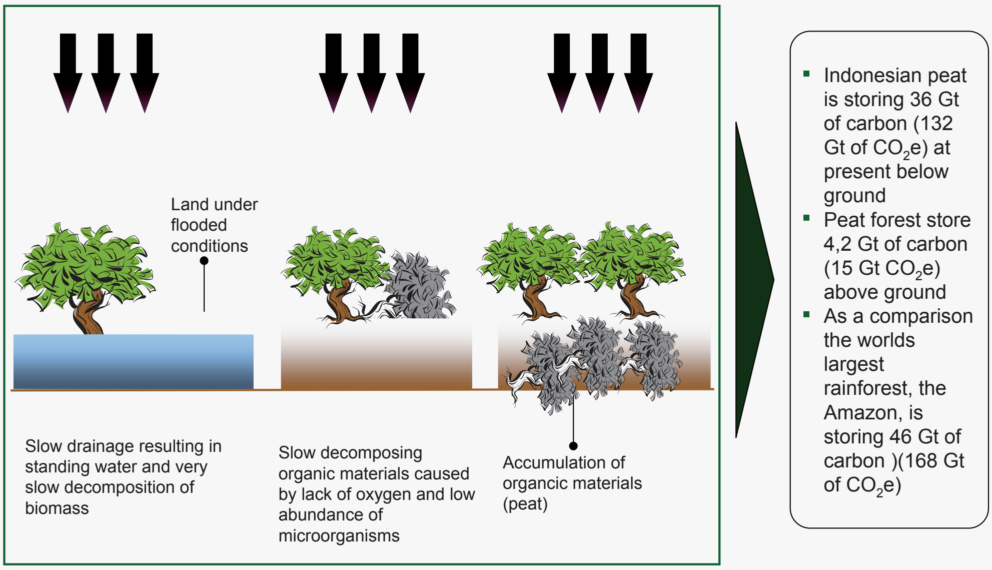
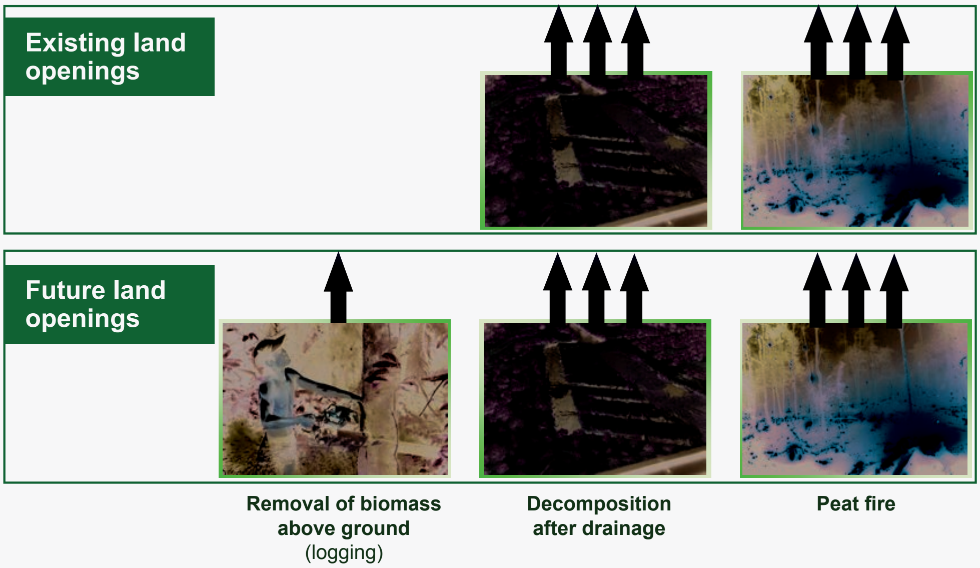


Exhibit A2

Peat emissions are a result of decomposition and fires of already degraded land; new land openings will increase emissions in the future



Scientific challenges related to emissions from Indonesian peatlands

While peat science has a long history in the Nordic region, scientific knowledge related to tropical peat is still at an early stage. Since the dramatic peat fires of the 1997 and 1998 El Nino events, scientists have shifted their focus to tropical peatlands and especially to emissions related to land use change. While the knowledge of peat fire related emissions has made good progress and scientists have been able to narrow down the uncertainty (Van der Werf 2008), the picture of emissions related to peat decomposition is not fully clear.

Uncertainties around emissions from peat decomposition are large, as they are related to several factors.

Soil and root respiration

Most of the currently published research results were not able to fully exclude natural emissions of soil and root respiration from their carbon flux measurements. However, results from a small number of projects that have successfully done that report that 40 to 60 percent (Couwenberg et al. 2009) of the below ground carbon emissions from peat soils come from respiration and not as a result of peat decomposition. Since soil respiration is a natural emission, these emissions should not be counted for UNFCCC purposes. The implication is that emissions from peat decomposition may be overestimated by a factor of two in some published studies.

Subsidence as a consequence of drainage

Peat subsidence is, to a different extent, influenced by three different factors:

- Mechanical compaction of the biomass as the water content of the peat soil is drained
- Shrinkage of biomass after drying
- Decomposition, as carbon from biomass components of cellulose, hemicellulose, and lignin are oxidized

At present it is commonly accepted that extensive subsidence in the first and second year after drainage is mainly a result of the dewatering of the peat body. However, it is not clear how large the influence of the above mentioned factors is in the following years. Some scientists (Hooijer et al. 2006) state that decomposition is responsible for up to 60 percent of subsidence, while at the low end, Kool et al. (2006) report values around 1 percent. The low range is more likely to be correct in areas where the peat is not compressed by heavy machinery, e.g., secondary forests and shrub land.

Relation between drainage depth and decomposition

At present, three potential models of the relation between drainage depth and composition are discussed. The most established model is a linear relationship developed by Wösten et al. (1997). Other potential models being discussed are following an S-curve or even an inverted U-curve shape approach. However none of the latter models have yet been published in peer reviewed publications.

Carbon storage in Indonesian peatland

While the extent of the Indonesian peatland area, the carbon content of peat and the average bulk density are commonly acknowledged, actual peat thicknesses and development of the bulk density profile along the horizontal peat profile are still highly uncertain.

All of the above mentioned factors and uncertainties have significant impact on estimates of current and future emissions from peat decomposition as well as on the overall abatement potential within the peat sector. The uncertainty results in publications presenting large ranges from 60 MtCO_2e annually at the low end up to 800 MtCO_2e at the high end for decomposition emissions alone.

Reconciliation of DNPI's estimates with the second national communication

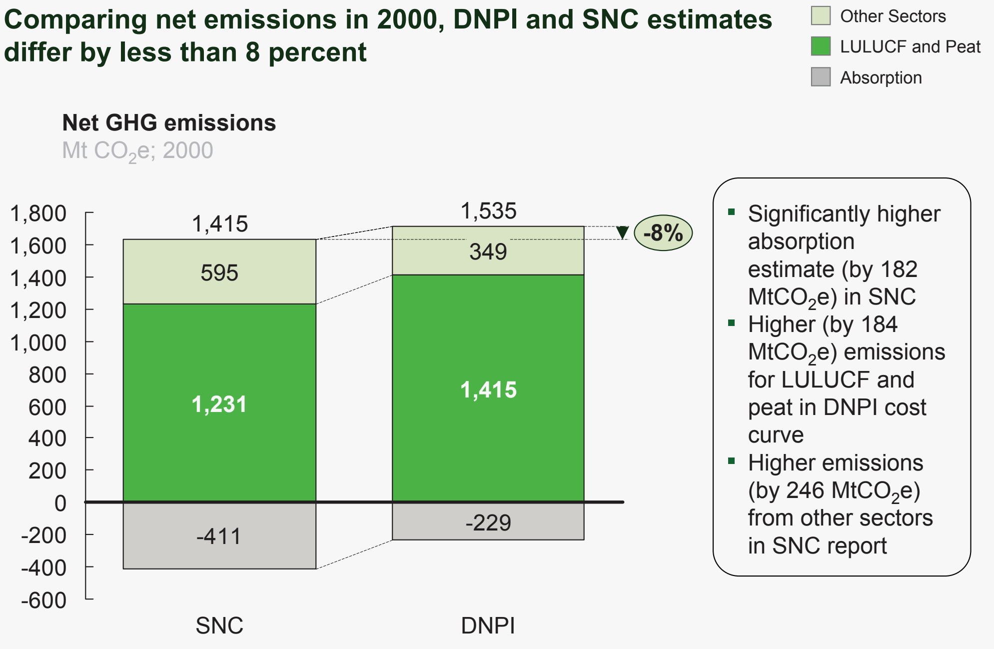
In order to forecast Indonesia's emissions in 2020, it is critical to first have a good understanding of current emissions. On August 27, 2009, the DNPI released an interim report providing an assessment of Indonesia's 2005 and projected CO_2 emissions (to 2020 and 2030) as well as the scale and cost of CO_2e abatement opportunities across different economic sectors. On November 24, 2009, the Ministry of Environment released its Second National Communication, which provided an estimate of Indonesia's emissions in 2000. The following reconciliation of the estimates from these two bodies is based on the revised estimates contained in the SNC dated December 5, 2009.[28]

The overall estimates of CO_2 net emissions in 2000 from the DNPI and the SNC are very similar, differing by about 8 percent (Exhibit A3).

28 The SNC is currently under further revision.

Exhibit A3

Comparing net emissions in 2000, DNPI and SNC estimates differ by less than 8 percent



There are however some significant differences in the composition of emissions reported by the DNPI and in the SNC in the LULUCF and peat sectors, other non-LULUCF sectors, and in absorption.

1. LULUCF and peat sectors

The DNPI estimates emissions from LULUCF and peat to be 184 MtCO2e higher than estimated in the SNC, mostly made up of differences in timber extraction and peat decomposition (Exhibit A4).[29] Sources for estimating emissions are in general not provided in the current SNC report, which makes direct comparisons between DNPI and SNC difficult. In general, both reports follow an IPCC compliant approach to deforestation, by calculating the change in time-averaged carbon stock, resulting in very similar emissions estimates for deforestation. However, differences in figures for timber extraction and peat decomposition might be a result of somewhat different methodologies. For example, the SNC's emissions are specifically for the year 2000, while the DNPI uses an average of the years 2000 to 2006. As harvesting levels depend on market demand, timber extraction can differ between years, and thus the DNPI chose to estimate emissions on an average of six years of data.

2. Other (non-LULUCF) sectors

The estimate in the SNC for emissions from other sectors is 595 MtCO2e, whereas the DNPI's estimate from other sectors is approximately 349 MtCO2e. The higher estimates in the SNC appear due to the larger number of sectors covered. For example, the SNC covers the waste sector, which was not included in the DNPI analysis. However, for those sectors covered by both analyses, the consistency varies significantly. Estimates for the cement and transportation sectors appear to be very consistent; however, the DNPI's emissions from the power sector (residential and electricity) are significantly higher than those reported in the SNC (Exhibit A5). The differences in the residential (30 percent) and electricity (100 percent) segments are difficult to account for as details on the underlying assumptions used in the SNC calculation were not available at the time of publication.

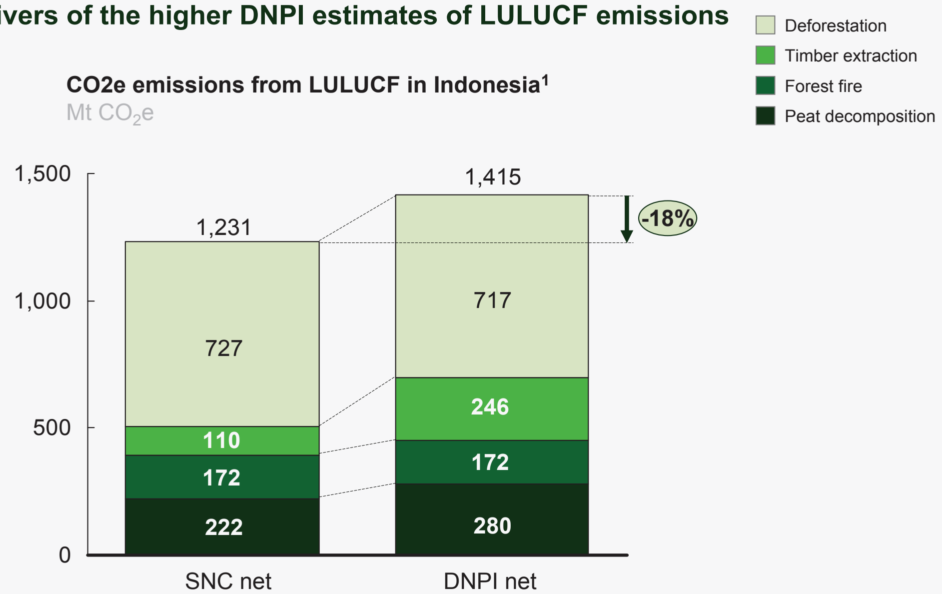
29 Regarding emissions from fire, the SNC and DNPI report estimates for peat fires from the same source (Van der Werf, 2008) and hence report identical emission estimates. For estimating future emissions, the DNPI uses an average of peat fire-related emissions from 2000–2006, which adjusts for potential biases occurring in any given year (for example, the year 2000 was an unusually wet year in Indonesia, and hence there were fewer peat fires than would be normally expected)

Exhibit A4

Peat decomposition and timber extraction are the main drivers of the higher DNPI estimates of LULUCF emissions

CO2e emissions from LULUCF in Indonesia[1]

Mt CO_2e



1 Base year 2000 for all estimates
2 Base year 2000
3 Using SNC estimates of absorption

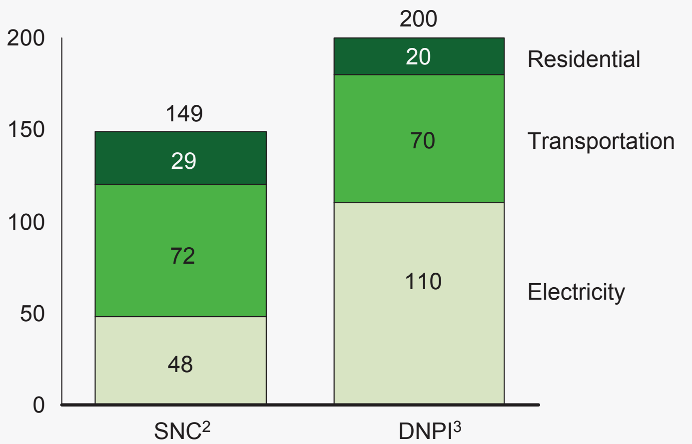
SOURCE: Indonesia 2nd National Communication; DNPI Indonesia Greenhouse Gas Emissions Cost Curve

Exhibit A5

Energy sector emissions are ~35% higher in the DNPI analysis compared to the SNC

Energy sector emissions[1]

Mt CO_2e



- Residential and electricity related emissions from the DNPI model are 30 and 100% higher (respectively) than those of the SNC
- Additional details on assumptions would be required to account for the significant variance

1 Includes a comparison of only those sectors covered by both analyses – Residential, Transportation and Electricity. The SNC cover an additional two sectors Petroleum & Refining and Manufacturing
2 SNC uses a 2000 base year
3 DNPI uses a 2005 base year

SOURCE: Indonesia 2nd National Communication; DNPI Indonesia Greenhouse Gas Emissions Cost Curve

3. Absorption effects

The DNPI estimates absorption to reduce emissions by 229 MtCO2e, whereas the SNC estimates an absorption reduction of 411 MtCO2e. The difference is likely to be a result of different assumptions for the absorbing area and absorption rate. The underlying methodology and the assumptions and sources used in the SNC calculation were not available at the time of publication.

Bibliography

Cross sector

- **Indonesia's Technology Needs Assessment on Climate Change Mitigation**, Ministry of Environment (March 2009)
- **The Economics of Climate Change in Southeast Asia: A Regional Review**, Asian Development Bank (April 2009)
- **Pathways to a Low-Carbon Economy : Version 2 of Global Greenhouse Gas Abatement Cost Curve**, McKinsey & Company (2009)
- **Payment Mechanism, Distribution and Institutional Arrangement: Second Draft**, IFCA (October 2007)
- **Indonesia Low Carbon Option study: Phase 1 Status: Report and Findings**, Ministry of Finance and World Bank (November 2008)
- **Pathways to a Low-Carbon Economy for Brazil**, McKinsey & Company
- **Climate Change & Fiscal Policy Issues: 2008 Initiatives**, Fiscal Policy Office Ministry of Finance Republic of Indonesia, (December 2008)
- Nancy L Harris, Silvia Petrova, Fred Stolle, and Sandra Brown et al, **Identifying optimal area for REDD intervention: East Kalimantan, Indonesia as a case study**, IOP Publishing LTD (September 2008)
- Van der Werf et al, **CO_2 emissions from forest loss**, Nature Geoscience vol. 2 (2009)
- **Economic and fiscal policy strategies for climate change mitigation in Indonesia**, Ministry of Finance and Australia Indonesia Partnership (2009)

Agriculture

- **Adapting to Climate Change: The Case of Rice in Indonesia**, World Bank (2008)
- **Yearly report: Research and Development for Agricultural Land Resources**, Ministry of Agriculture (2008)
- http:// faostat.fao.org/, **FAOSTAT, 2007, FAOSTAT Agricultural Data**, (May 2009)
- Ministry of Forestry, **Indonesia Forestry Statistics**, 2007
- **Guidelines for National inventory - AR4 -WG3 Chapter 8: Agriculture**, Cambridge University Press, IPCC, 2007
- **Global Anthropogenic Non-CO_2 Greenhouse Gas Emissisions**, USEPA, 1990-2002 2006
- **Greenhouse Gas Mitigation Potential in U.S Forestry and Agriculture**, USEPA, EPA 430-R-05-006, 2005
- **Inventory of U.S. Greenhouse Gas Emissions and Sinks**, USEPA, 1990-2005 (2006)
- Hooijer et al, **Peat CO_2: Assessment of CO_2 Emissions from Drained Peatlands in SE Asia,**. Delft Hydraulics report Q3943 (2006)
- European Union, ReGrin, **Peat lands: Potential for Agriculture and Environmental Aspect, Ministry of Agriculture**, ICRAFT (2008)
- Euroconsult Mott MacDonald and Deltares, **Master Plan for the Rehabilitation and Revitalization of the Ex-Mega Rice Project Area in Central Kalimantan : Summary of Main Synthesis Report**, (October 2008)

Forestry and peatland management

- **Methodology for Monitoring and Setting Baseline for Deforestation and Forest Degradation**, IPCC

- **Towards the Inclusion of Forest-Based Mitigation in A Global Climate Agreement: Project Catalyst**, The Climate Works Foundation (May 2009)
- **G.R. Van der Werf, J. Dempewolf , Climate Regulation of Fire Emission and Deforestation in Equatorial Asia**, ect PNAS Vol.51 (December 2008)
- IFCA, Forestry Research and Development Agency (FORDA), **Consolidation Report Reducing Emission From Deforestation And Forest Degradation in Indonesia**, Ministry of Forestry(2007)
- Adinugroho W.C., I Nyoman N. Suryadiputra, Bambang H. Saharjo, and Labueni Siboro et al, **Manual for the Control of Fire In Peatlands and Peatlands Forest. Climate Change, Forests and Peatlands in Indonesia Project**, Wetlands International – Indonesia Programme and Wildlife Habitat Canada (2005)
- **Reducing Emission from Deforestation and Forest Degradation (REDD): An Option Assessment Report**, Meridian Institute (March 2009)
- Suryadiputra, I N.N., Alue Dohong, Roh, S.B. Waspodo, Lili Muslihat, Irwansyah R. Lubis, Ferry Hasudungan, and Iwan T.C. Wibisono, **A Guide to the Blocking of Canals and Ditches in Conjunction with the Community. Climate Change, Forests and Peatlands in Indonesia, Project**. Wetlands International – Indonesia Programme and Wildlife Habitat Canada (2005)
- Murdiyarso, D., Atie Puntodewo, Atiek Widayati, Meine Van Noordwijk et al, **Determination of Eligible Lands for A/R CDM Project Activities and for Priority Districts for Project Development Support in Indonesia**, Center For International Forestry Research (CIFOR) (2006)
- Wosten, H, **Strategies for Implementing Sustainable Management of Peatlands In Borneo**, European Commission INCO-DEV 2005
- **Do Trees Grow On our Money? The Implications of Deforestation Research Policies To Promote REDD**, Kanninen, M. Daniel Murdiyarso, Frances Seymour, Arild Angelsen, Sven Wunder, Laura German, Center For International Forestry Research (CIFOR) (2007)
- Hooijer et al, **Peat CO_2: Assessment of CO_2 Emissions from Drained Peatlands in SE Asia**, Delft Hydraulics report Q3943 (2006)
- Grieg-Gran. M, **Cost of Avoiding Deforestation**, International Institute for Environment and Development (2006)
- Van Beukering et al, **The Economic Value of Peatland Resources**, Wetlands International (2008)
- Matthews. E, **State of World Forests – Indonesia**, World Resource International (2002)
- Uryu et al, **Deforestation, Forest Degradation, Biodiversity Loss and CO_2 Emissions in Riau, Sumatra**, Indonesia, WWF (2007)
- **Climate Change**, Financing Global Forest; Eliasch Review (2008)
- Verwer et al, **Review of Carbon Flux Estimates and Other GHG Emissions From Oil Palm Cultivation on Tropical Peatlands**, Alterra (2008)
- Van der Werft et al, **Climate Regulation of Fire Emission and Deforestation in Equatorial Asia**, PNAS (2008)
- **Forestry Executive Data Strategic**, Forest Planning and Statistic, Forest Planology Agency, Ministry of Forestry (2008)
- **Forestry Statistics of Indonesia, 2007**, Forestry Planning and Statistic Agency, Forestry Planology Agency, Ministry of Forestry
- Wahyunto, Bambang Heryanto, Hasyim Bekti dan Fitri Widiastuti et al, **Maps of Peatland Distribution, Area and Carbon Content in Papua**, Wetlands International – Indonesia Programme and Wildlife Habitat Canada 2000-2001(2006)

- Wahyunto, S. Ritung dan H. Subagjo **Maps of Peatland Distribution, Area and Carbon Content in Kalimantan**, Wetlands International – Indonesia Programme and Wildlife Habitat Canada 2000-2002 (2004)
- Wahyunto, S. Ritung dan H. Subagjo, **Maps of Peatland Distribution, Area and Carbon Content in Sumatera**, Wetlands International – Indonesia Programme and Wildlife Habitat, 1990-2002 (2003)
- Wahyunto, S. Ritung, Suparto, H. Subagjo, **Climate Change, Forests and Peatlands in Indonesia**, Wetlands International – Indonesia Programme and Wildlife Habitat Canada (2005)
- **Statistics of Timber Culture Estate**, Bureau of Statistic (2006)
- **Statistics of Timber Concession Estate**, Bureau of Statistic (2006)
- **Statistics of Timber Concession Estate**, Bureau of Statistic (2004)
- **Forest Inventory and Maps, Forest Planology Agency, Forest Resources Monitoring**, Ministry of Forestry (2008)
- **Environment Statistics Of Indonesia**, Bureau of Statistic (2008)
- **RISI – Analytical Cornerstone 2009**
- **NLK Associates - Global pulp mill database 2009**

Power, Petroleum and Gas

- **Electricity for All: Options for Increasing Access in Indonesia**, World Bank (2005)
- **Energy Information Administration, Country Analysis Brief: Indonesia**, www.eja.doe.gov (2007)
- **Key Indicators of Indonesia Energy and Mineral Resources**, Center for Data and Information on Energy and Mineral Resources (PUSDATIN ESDM) (2007)
- **Indonesia Power Report Q1 2008 Including 5-year Industry Forecasts**, Business Monitor International (2007)
- Mr. Jérôme Garcia, **Indonesia Energy Statistics and Balances in the IEA Databases, Training Session Coal Statistics**, NMC Section, Energy Statistics Division (2008)
- Hardiv Situmeang, **Carbon Capture and Storage – Financing Challenges and Opportunities, Investment Drivers, Incentives and Financing Options - The Role of Developing Countries** (2008)
- **Geothermal Today**, US Department Of Energy (2005)
- **EU-Indonesia Infrastructure Forum: Indonesian Power Sector**, European Business Chamber of Commerce in Indonesia (2006)
- Zuhal, **Presentation on the Policy for Indonesia Sustainable Development**
- Tri Murni Soedyartomo Soentono, **Presentation on Indonesia Country Report**, National Nuclear Agency of Indonesia (2008)
- **Indonesia Country Report Annex 3, From Ideas To Action: Clean Energy Solutions For Asia To Address Climate Change**, International Resources Group (IRG) (2007)
- **Projection CO_2 Sources For Power Sector (For Discussion Only)**, CSS-Working Group PLN (2009)
- Teddy Lesmana, **Presentation for the Community Based Educational and Partnership Actions - Carbon Neutral Initiative for Community Empowerment and Climate change Mitigation in Indonesia** (2008)
- **Electricity Governance Initiative: Case of Indonesia, Final Report**, World Resource Institute (2007)
- **Power Generation Cost Assumption**, International Energy Agency (2007)
- **Rencana Usaha Penyediaan Tenaga Listrik 2009 - 2018**, PT. PLN (Dec 2008)

- **Rencana Umum Ketenagalistrikan Nasional 2008 – 2027**, Menteri Energi dan Sumberdaya Mineral (Nov 2008)
- **Electricity Governance Initiative: Case of Indonesia, Final Report**, World Resource Institute (2007)
- **Power Generation Cost Assumption**, International Energy Agency (2007)
- **World Energy Outlook 2009**, International Energy Agency (2009)
- **BP Statistical Review of World Energy 2008**, BP (2009)
- **Indonesia Associated Gas Survey**, The World Bank (2006)
- **Petroleum Report Indonesia 2007-2008**, Embassy of the USA, Jakarta, (2008)
- Chris Elvidge, **Preliminary estimation of annual gas flaring volumes in South and South East Asia**, NOAA – National Geophysical Data Center (2006)

Cement

- **Mitigation Approach of Climate Change in Industry**, Agency of Industrial Research and Development, Ministry of Industry (2008)
- **Status of Efforts on CO_2 Emission Reductions for Industry Sector**, Ministry of Industry (2009)
- **Statistical Yearbook of Indonesia 2008**, Bureau of Statistics (2008)
- **Annual Report Highlights 2008**, PT. Holcim Indonesia
- **Annual Report Highlights 2008**, PT. Semen Gresik
- **Annual Report Highlights 2008**, PT. Indocement
- **WBCSD CO_2 Inventory Form**, PT. Holcim Indonesia
- **WBCSD CO_2 Inventory Form**, PT. Indocement
- **McKinsey GHG Abatement Cost Curve V2.0**, McKinsey & Company, (2009)

Transport

- **Emission Factors**, swisscontact (2005)
- **Promoting Green Diesel Technology and Introducing Green Diesel Passenger Cars in Indonesia – Executive Summary and Summary of Recommendations**, PUSTRAL UGM (2007)
- **Clean Air Jakarta – Project Implementation Report For Clean Bus Program**, Swisscontact
- **Final Report Clean Bus Program Phase II 1999-2000**, Swisscontact
- **Implementation Report CAP Jakarta Phase III 2001-2003**, Swisscontact
- **Fuel economy and & Vehicle Kilometers Traveled**, Swisscontact
- **Lampiran & Asumsi Update November 2008**, PUSTRAL UGM (2008)
- **Urgensi Paket Kebijakan Dan Program Komprehensif Dalam Penghematan BBM Transportasi**, Tim Pemantauan dan Evaluasi Kinerja Transportasi Nasional (TPEKTN) (2008)
- **Vehicle Emission Per Sub-Category**, Swisscontact
- **Averting an Infrastructure Crisis: A Framework For Policy And Action**, The World Bank (2004)
- **Potential for Biofuels for Transport in Developing Countries**, ESMAP (2005)
- **Energy Efficiency and Climate Change Considerations for On-road Transport in Asia**, ADB-DFID (2006)
- **APEC Biofuels Task Force: Initial Findings and Next Steps Forward**, NIST, Brazilian National Institute of Metrology, and INMETRO (2007)
- **Palm Oil in Biodiesel- A Greenenergy Perspective**, Greenenergy

Buildings

- **Technical Potential to Reduce Fossil Fuel Usage Through Solar Water Heating**, National Renewable Energy Lab (NREL) (2007)
- **"LED Sector: The Future's Bright, The Future's Green"**, Daiwa Analyst Report (2007)
- Presentation by Paul Waide **"Why Were Here: The Potential To Lower Global Lighting Energy Consumption"**, IEA
- Rubenstein, Neils, and Colak ,**"Daylight, Dimming, and The California Electricity Crisis"** LBNL (2001)