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# Challenges in Mitigating Indonesia's $CO_2$ Emission: The Importance of Managing Fossil Fuel Combustion

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# Challenges in Mitigating Greenhouse Gas Emissions: The Importance of Policies for Fossil Fuel Combustion

**Abstract**
Indonesia is among the largest 25 carbon dioxide emitting countries when considering only fossil fuels, and among the top three or five when emissions due to deforestation and land use change are included. Emission per capita from fossil fuels are still low in comparison with other countries, but have been growing fast, and are likely to overtake those from deforestation and land use change in the future. This chapter argues the importance for Indonesia to start developing strategies to mitigate its emissions from fossil fuel combustion. It analyses the main drivers of the increase in emissions, identifies the options and challenges in reducing the future growth in emissions. Policy options are reviewed that would enable the Indonesian economy to keep on growing, but with a much lower carbon output.

Keywords: Climate Change, Energy Policy, Environmental Economics

## I. Introduction

Discussion on climate change issues in Indonesia has been dominated by the issue of $CO_2$ emission from deforestation and forest degradation. Few if any efforts have been devoted to creating policies to control $CO_2$ from fuel combustion. The main argument for this is that, despite serious doubt as to the reliability of $CO_2$ emission data from deforestation and forest degradation, at the moment it is thought to produce roughly around five times more $CO_2$ than fossil fuel combustion. In the mid 2000s, Indonesia was one of the top 3-5 $CO_2$ emitters as a result of deforestation and forest degradation; without this aspect, it is ranked 16$^{th}$ or lower (Sari et al., 2007). It has been the strategy of the Indonesian government to control $CO_2$ emission from deforestation as soon as possible and to defer control of $CO_2$ emission from fuel combustion, since its contribution is relatively minor.

An example of activities related to reducing emission from deforestation and degradation (REDD) is the establishment in Indonesia of the REDD or REDDI program by the Indonesian Ministry of Forestry in 2007. To facilitate its implementation, a multi-stakeholder forum (Indonesian Forest Climate Alliance or IFCA) was established, consisting of government officials, business people, NGO staff and international donor communities. Another example is the Indonesia-Australia Forest Carbon Partnership. This partnership provides support for (a) policy development and capacity building to participate in international negotiation and future carbon markets, (b) developing a forest carbon accounting and monitoring system, and (c) demonstrating activities, and the provision of related enabling assistance, to trial approaches to reducing emissions from deforestation and forest degradation.

Reducing deforestation is clearly important in controlling Indonesia's $CO_2$ emissions. However, we argue that it is also important to initiate immediate action to control $CO_2$ emission from fossil fuel combustion. We analyse the drivers of fossil fuel emissions growth, and reviews policy options to control it.

## II. $CO_2$ Emission from Fossil Fuel Combustion

During the 1970s, 1980s, and 1990s, the Indonesian economy, measured by its gross domestic product (GDP), grew at an average annual rate of above 7 percent, which was relatively fast compared to many other countries. The country's economy had also been transformed from a mainly agricultural to a more industrially dominated economy (Hill, 2000; Resosudarmo and Kuncoro, 2006; Resosudarmo and Vidyattama, 2007). This fast growing economy, with its significant industrial transformation, increased the

amount of $CO_2$ emitted from fossil fuel combustion. There are two important facts related to this increase.

First, in terms of $CO_2$ emission per capita from fossil fuel combustion, Indonesia's emission per capita are still low in comparison with other countries, well below the world average and also below the average for non-OECD countries (IEA, 2006). However, as it can be seen in Figure 1, it emissions have been growing relatively fast; from 1994 to 2004, they grew faster than those of other major countries, including China and India.

Second, energy use and fossil fuel emissions will continue to grow as GDP grows unless mitigating actions are taken. Emissions from deforestation and land use are now much greater than from fossil fuel combustion, but this should change as available forest areas decline. In the medium to long term, , $CO_2$ emissions from fossil fuel combustion are likely to outstrip those caused by deforestation and land use change (which are thought to be on a declining trajectory). Consequently, in order to maintain low-carbon growth in Indonesia, a two-pronged strategy must be implemented: reduce deforestation and related emissions, and bring fossil fuel emissions onto a lower trajectory. Starting soon will make a big difference over time. With regard to fossil fuel combustion, it is crucial to bear in mind the fact that investments in the energy sector have long lifetimes, often more than 35 years. Thus present investments in fossil fuel infrastructure lock in a carbon emission trajectory for a long time (IEA, 2003).

## III. Drivers of $CO_2$ Emissions Growth

From 1980 until 2004 in Indonesia, the energy consumption per capita has grown slightly less than GDP per capita. Comparing 1980 to 2004, the ratio of GDP/capita has

increased by 2.3 times and energy/capita by 2.1 times. $CO_2$ emission can grow slower or faster than energy consumption, depending on changes in the energy mix and technology. In Indonesia, $CO_2$ emissions per capita have grown faster than energy use per capita; indicating that the carbon intensity of energy has increased as well. Comparing 1980 to 2004, the ratio of energy use/capita has increased 2.1 times and $CO_2$/capita by 3.3 times. Nevertheless, Indonesia's emissions intensity in terms of level (kg$CO_2$/$GDPppp) is similar to that of the world average, and it is still below the non-OECD average (IEA, 2007).

Internationally, increasing emissions intensity is uncommon. In many countries, GDP has grown faster than fossil fuel emissions, so $CO_2$ emissions intensity declined ($CO_2$ emission/GDP) over time. This is shown in the negative contributions to overall emissions growth of change in $CO_2$ emissions intensity, as illustrated in Figure 2. By contrast, $CO_2$ emission from fossil fuel combustion in Indonesia have grown faster than GDP growth during the 1994–2004 period; and so $CO_2$ emissions intensity has increased. Why this is the case?

Energy intensity declined from the early 1970s until the end of the 1980s, and then increased. The 1997/98 financial crisis which significantly reduced Indonesia's GDP did not change energy consumption (as reported in energy statistics) by much. During the recovery period of 1999–2004, Indonesia's energy intensity kept increasing. Hence, the first reason for increasing emissions intensity is increasing energy intensity of economic activity.

Figure 3 breaks down emission intensity into energy intensity and carbon intensity (see the APPENDIX for the breakdown/decomposition formula). This figure

shows that both energy and carbon intensity increased from 1994 until 2004. Hence, the second reason for increasing $CO_2$ emissions intensity is the increasing carbon intensity.

The good news is that the growth rates of both energy and carbon intensities declined during 1994–2004. Figure 3 also shows that the growth rates of carbon intensity from 1994 to 1999 and from 1999 to 2004 were always higher than those of energy intensity. This indicates that increasing carbon intensity of energy supply is the more important driver for the increase in emission intensity in Indonesia.

To understand why carbon intensity in Indonesia has increased significantly, we need to observe the level of emissions for the combustion of each type of fossil fuel (or energy source) used in the country.

## IV. Emissions by Type of Fossil Fuel Combustion

Figure 4 shows the share of $CO_2$ emission by type of energy use in 1984 and 2004. It can be seen from this figure that the contribution from oil combustion has declined from contributing 85 percent of total $CO_2$ emissions in 1984 to 53 percent in 2004. Meanwhile, the contribution of gas increased from 14 percent in 1984 to 21 percent in 2004, and that of coal from 1 percent in 1984 to 26 percent in 2004.

The broad trend in Indonesia's energy system is that although oil is still the main contributor of $CO_2$ emissions, its share has been decreasing. Most of the remaining oil products use is in the transportation sector, with oil use in electricity generation declining strongly. In the meantime, the share of coal has been increasing and takes up the role of oil in the stationary energy sector, whereas the share of gas roughly remains constant, with expanding gas production directed to a large degree at exports.

Figure 5 presents the residential, transportation, electricity, and industrial sectors shares of $CO_2$ in 1984 and 2004. The residential sector's share of $CO_2$ declined from 20 percent in 1984 to only 9 percent in 2004. The transportation and industrial sectors shares remained roughly constant. The electricity sector's share of $CO_2$ increased the most, from 13 percent in 1984 to 27 percent in 2004. While total emissions have been increasing by around 7.5% annually, emissions from electricity generation have increased by around 11% annually in the last two decades.

To understand why the electricity sector's contribution of $CO_2$ emissions increased so rapidly, we observe its energy sources. Figure 6 presents the energy use shares in the electricity sector and in other sectors. The share of coal use in the electricity sector has increased from zero in 1984 to 53 percent in 2004, an exceptionally fast rise. Coal use has increased in other sectors as well, but not as rapidly as in the electricity sector. This rapid rise in coal use is the main reason for the increased proportion of $CO_2$ emissions from the electricity sector compared to other sectors since the mid 1990s.

Growth in electricity demand remains strong, and so the future development of electricity supply, especially choices in fuels and technologies, are a crucial factor for Indonesia's future CO2 emissions.

## V. Policy Options

Before discussing Indonesia's policy options to control its $CO_2$ emission from fossil fuel combustion, let us review the types of energy it currently uses. Presidential Decree No. 5/2006 (Table 1) has been seen as the energy sector strategy to reduce $CO_2$

emission in Indonesia, though the decree was actually developed to reduce the use of oil, not to control emissions from fossil fuel combustion (Sari, 2007). Under this scenario for the future energy mix, fossil fuels remain the primary source of energy with an increased use of renewable energy as well as liquefied coal. Great emphasis is put on reducing Indonesia's dependency on oil due to its depleting oil fields, with greater reliance in particular on coal and gas instead.

Critics of the Presidential have questioned the intention to increase the share of coal and liquefied coal as energy sources, bearing in mind that coal and liquefied coal have high CO2 emissions and cause other negative environmental effects. Others have questioned the plan to limit the use of geothermal energy to only 5 percent in 2025 despite the high potency of this resource in the country. It is unlikely that the energy plan laid out in th decree would effectively control $CO_2$ emission from fuel combustion in Indonesia. Other options must be considered.

The following is a list of possible policies to enhance economic development with low carbon emission. It is beyond the scope of this paper to assess the costs of implementing these policies and their effect on emissions, their impact on the economy and household incomes, and whether they would attract international support and funding.

A recent report by Indonesia's Ministry of Finance (2009) has investigated fiscal policy options for climate change mitigation in the energy sector (specifically pricing and institutional reform to accelerate geothermal power development), and in the land-use change sector (specifically using the intergovernmental fiscal transfer system to provide incentives to local governments). See also Jotzo and Mazouz (2010).

**Pricing policies**

Carbon pricing is widely seen as the most efficient economic instrument to control CO2 emissions. The principle is to place a consistent price on emissions, thus creating financial incentives for firms and households to substitute away from high-emissions activities and products, or improve efficiency of emissions producing activities. Emissions pricing can be achieved through a carbon tax or by creating a mechanism for carbon emission permit trading (Uzawa, 2003). A carbon tax would be imposed by government just like any other tax. Permit trading involves the government issuing permits for a certain total of tons of $CO_2$ emissions, and these permits are traded among emitters.

Tax or permit liability could start with selected industrial processes, where reliable measurement is possible, for example steel, aluminium and cement production, as well as electricity generation.

Experience in Europe, Australia and other countries shows that emissions trading tends to be better feasible politically, but it also poses greater complexity in implementation.

The distributional impact of carbon pricing on household income is an important factor for the viability of such policies. Carbon pricing is generally considered to be regressive, imposing relatively greater burdens on low-income than on high-income households, creating the need for targeted redistribution policies as for example proposed for Australia (Garnaut 2008). But for Indonesia, the situation could be quite different, with modelling showing that carbon pricing would have a progressive income effect, so the rich would pay relatively more than the poor (Yusuf and Resosudarmo, 2007).

At a more fundamental level, energy pricing policies affect CO2 emissions through the amount of energy consumed – energy taxes encourage energy savings, subsidies have the opposite effect. Indonesia has in recent years partially removed fuel and electricity subsidies, but significant energy subsidies remain in place for households and private transport. Reducing and removing these remaining subsidies, and introducing energy taxes, would dampen energy use and with it emissions growth. There are of course important distributional and political considerations which make reforming energy prices difficult to achieve.

**Electricity reform**

Indonesia is facing power shortages and has embarked on a 'crash programme' of rapid expansion of electricity generating capacity. The first wave of this programme is to be based almost exclusively on coal, which is the lowest cost but highest carbon emissions alternative (Narjoko and Jotzo 2007).

The goal of low-carbon electricity reform would be to lower the carbon intensity (kg of $CO_2$ per kwh of electricity) of power supply, while facilitating further expansion of the power system.

To achieve this goal, a set of policies needs to be developed to provide incentives for investment in electric power generation from clean resources; namely (1) expanding renewable electric generation, such as hydropower, geothermal, and, a longer-term possibility, biofuels, (2) shifting the fossil fuel mix away from coal and toward gas which is significantly less carbon intensive; (3) increase efficiency in fossil fuel power plants; and (4) in the long run, to provide incentives for the use of carbon capture and storage technology in fossil fuel fired power stations, if and when such technologies become available.

Policies that would help move toward these aims include pricing the carbon emissions from power stations, thus providing economic incentives to shift towards low-emissions alternatives; to ensure that energy inputs are costed at market rates and in particular that fossil fuels are not subsidised; putting the pricing arrangements for electricity supply on a market basis and provide longer-term regulatory certainty, both of which would encourage investment in the relatively more capital intensive renewable options; and regulatory measures to foster renewable energy generation.

**Industrial energy and emission efficiency**

The goal of these policies is to reduce power use by industries through improved energy efficiency, and also reductions in direct $CO_2$ emissions through the adoption of low-carbon energy sources in industry. In addition to energy pricing reform, the driving factors for this to happen are to increase public visibility, greater industry awareness, and improved information on and access to more efficient technologies and practices.

Policies could include reporting and assessment of $CO_2$ emissions and energy/electricity consumption by large businesses in the PROPER program (Resosudarmo and Irhamni, 2008). PROPER is a program that releases environmental performances of industries to the general public through various media. The policies could also include programs to increase energy efficiency in specific industries and household appliances.

**Securing international support**

Financial and technical support for low-emissions measures and policies is increasingly becoming available from international sources, with significantly greater opportunities possible as the outcome of international negotiations on a post-Kyoto Protocol climate agreement. International support may help make it possible to adopt a low carbon growth strategy by providing better access to cleaner technologies, by paying for some

or all of the incremental cost of cleaner technologies, and potentially by helping to pay to offset any negative impacts on household incomes of such measures.

The main existing channel of carbon finance to developing countries is the Clean Development Mechanism (CDM) under the Kyoto Protocol. It gives emissions offset credits to specific projects that reduce emissions, for example using renewable energy sources rather than fossil fuels for energy generation, or for capturing gases from landfills. These credits can be sold to countries that have emissions targets, and businesses in those countries (currently mainly the EU and Japan). The CDM is largely run by private businesses, typically in cooperation between developing and developed countries. Total investment in the CDM is estimated at $25 billion or more until 2012. Indonesia's share in the global CDM market and absolute magnitude of projects has been relatively small compared to its estimated reduction potential, owing to the restrictive nature of the CDM, institutional difficulties and the general investment climate which has been seen as less conducive than in countries like China or India (Roesad et al 2008).

Future mechanisms under a follow-up agreement to the Kyoto Protocol could include 'programmatic CDM', policy-based commitments, or emissions targets for sectors or whole economies of developing countries. Programmatic CDM could potentially provide financing for measures such as minimum efficiency standards, and other programs, involving governments in implementation as well as private business.

Policy-based commitments would have developing countries implement agreed policies to lower emissions. In return for meeting agreed benchmarks for implementation, the country would receive permits or credits for emissions saved that

could be sold in international markets, technology or capital goods provided by by developing countries, or other agreed incentives.

A national emissions target provides the most comprehensive incentive to reduce emissions throughout an economy. Emissions targets and international trading currently apply to developed countries that have ratified the Kyoto Protocol. Under a post-2012 agreement they could be expanded to more countries, could be made more flexible to make them more attractive and reduce economic uncertainty, and include entry-level targets for developing countries. Difficult issues around equity and relative stringency of targets between different countries will need to be resolved to make emissions targets for developing countries a reality.

Technology investment support would provide direct international financing for investment in low-carbon technologies, and/or for research and development. International support for low-carbon technologies is one of the pillars of the Bali Roadmap towards a post-Kyoto international climate agreement, favoured by the current governments of the United States and Australia and part of the new Asia Pacific Economic Cooperation (APEC) climate policy. It might also enter the provisions under a post-2012 UNFCCC-based agreement. Indonesia could benefit from international technology support schemes for modernising some of its power and industrial installations, and to assess and support the introduction of future technologies like CCS.

Indonesia stands to gain under each of these possibilities. To achieve the best outcome, engagement in international mechanisms and taking on commitments needs to be tailored to the policy options that can be put in place domestically, and in line with the technical potential for emissions reductions in different sectors of the economy.

# VI. Final Remarks: Conclusion

This chapter has shown the importance of $CO_2$ emissions from fossil fuel combustion in reducing Indonesia's carbon footprint. Although currently $CO_2$ emissions related to deforestation and land use change are much higher than that those from fossil fuels, it is likely that in the future, the situation will be reversed. Considering investments in the energy sector usually have long lifetimes, a start needs to be made soon to control $CO_2$ emission from energy use, in ordert to limit future carbon liabilities.

The challenge is evident from the fact, shown in this chapter, that the main driver behind increasing fossil fuel $CO_2$ emission in Indonesia is the increase in carbon intensity of energy supply. The main reason for that in turn is the increased use of coal as a source of energy, particularly in the electricity sector. Demand for electricity and other forms of energy meanwhile continues increasing at fast rate.

A variety of policy options to control $CO_2$ emission exist. Quantitative research and modelling is badly needed on the costs of implementing these policies, their impact on the economy and household incomes, and the degree to which different policies could reduce emissions. The choice of policy instrument, and of the level of policy ambition, would also – and perhaps strongly – depend on the opportunities to attract international support and funding, including under a post-Kyoto Protocol climate agreement.

A key recommendation is thus that, as soon as possible, Indonesia undertake a comprehensive economic study with a goal of finding the strategies to achieve sustained and economic growth with low carbon emissions. Within such analysis and policy decisions, it is important to understand the impacts on growth, income distribution and

poverty. An important question that needs to be addressed is how to make sure that the poor are not burdened with the costs of moving to a cleaner energy system.

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# APPENDIX: Decomposition Formula

The definition of energy and carbon typically comes from Kaya's decomposition formula as follow (Kaya, 1990; Yamaji et al., 1991; Kwon, 2005):

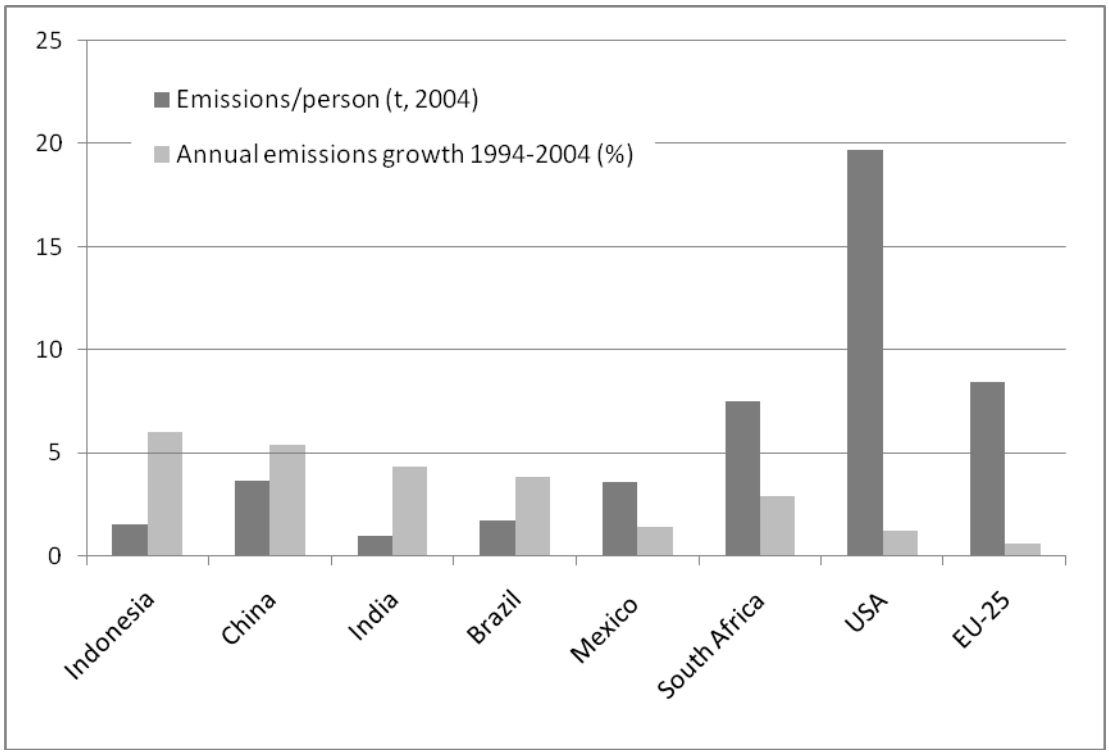
$$\partial CO_{2_t} = \partial P_t \cdot \frac{\partial Y_t}{\partial P_t} \cdot \frac{\partial E_t}{\partial Y_t} \cdot \frac{\partial CO_{2_t}}{\partial E_t} \tag{A1}$$

or

$$\partial CO_{2_t} = \partial P_t \cdot \partial y_t \cdot \partial e_t \cdot \partial c_t \tag{A2}$$

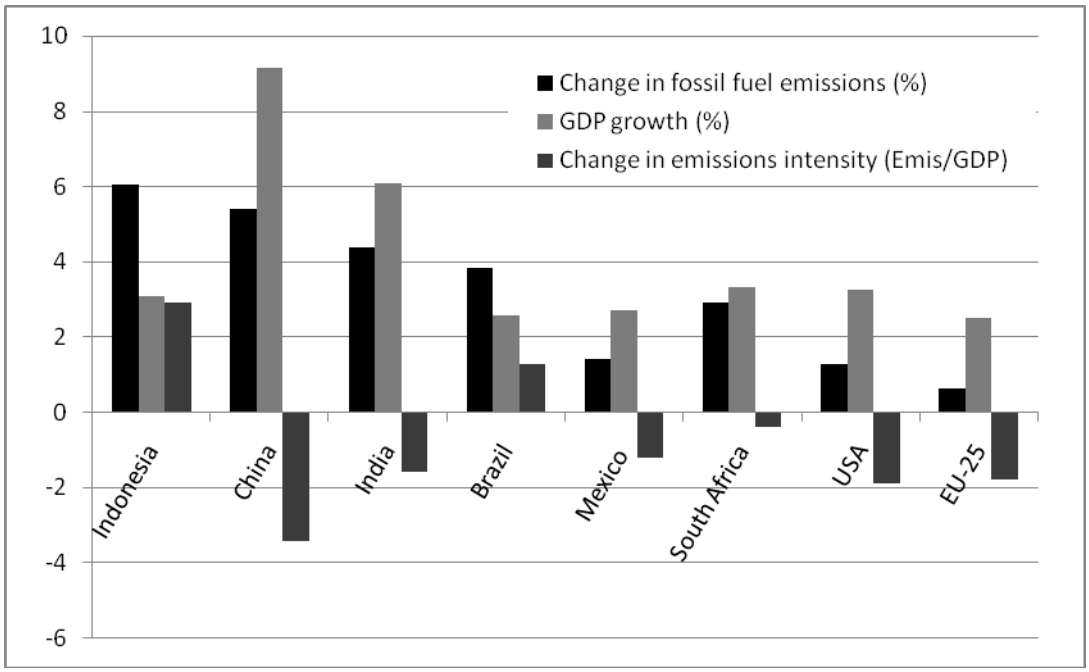
where *t is* index for year, ∂ is change in one year, $CO_2$ is the amount of $CO_2$ emission, *P* is population, *Y* is GDP, *E* is the amount of energy use, *y* is GDP per capita, *e* is energy intensity, *c* is carbon intensity.

**Figure 1**
**Fossil Fuel $CO_2$ Emissions per Capita and Their Growth Rates**



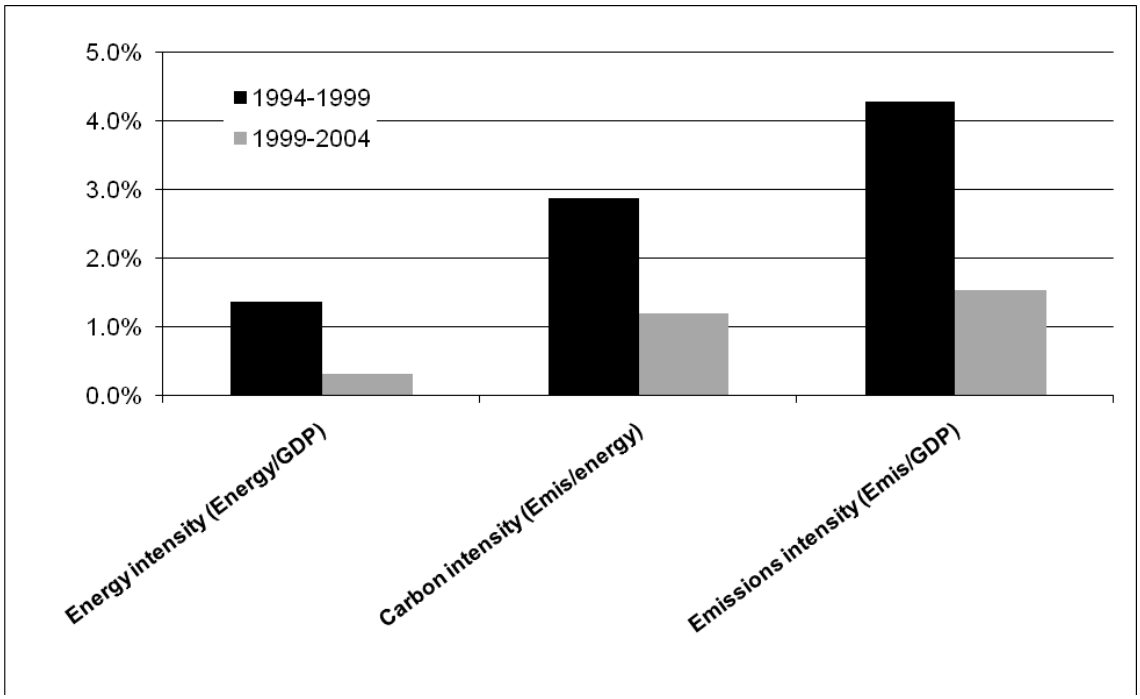

Source: International Energy Agency (2007) [http://www.iea.org/]

**Figure 2**
**Average Annual Growth Rates 1994-2004**



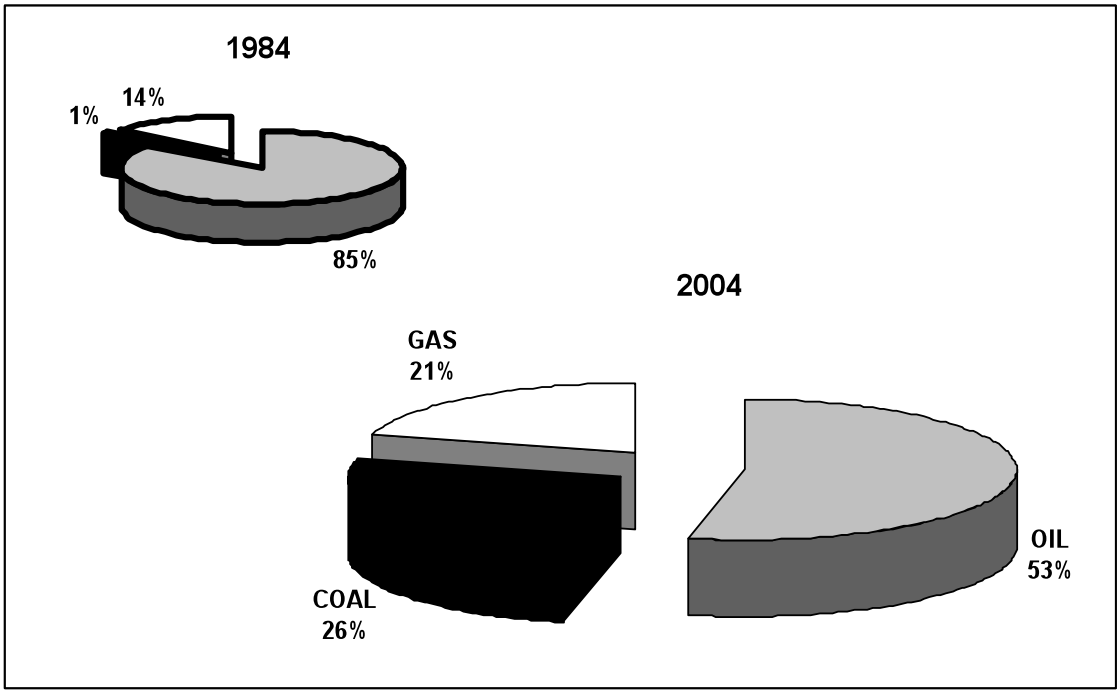

Source: International Energy Agency (2007) [http://www.iea.org/]

**Figure 3**
**Average Annual Growth Rates 1994-2004**



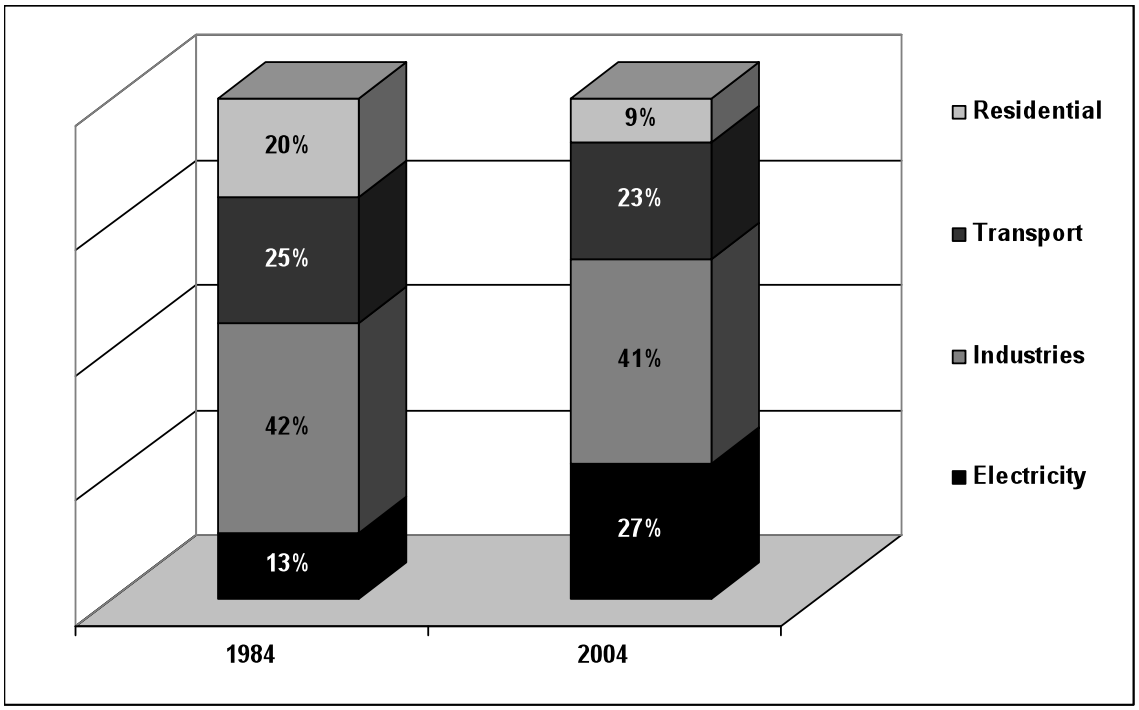

Source: International Energy Agency (2007) [http://www.iea.org/]

**Figure 4**
**Share of Emissions by Types of Fossil Fuel Combustion**



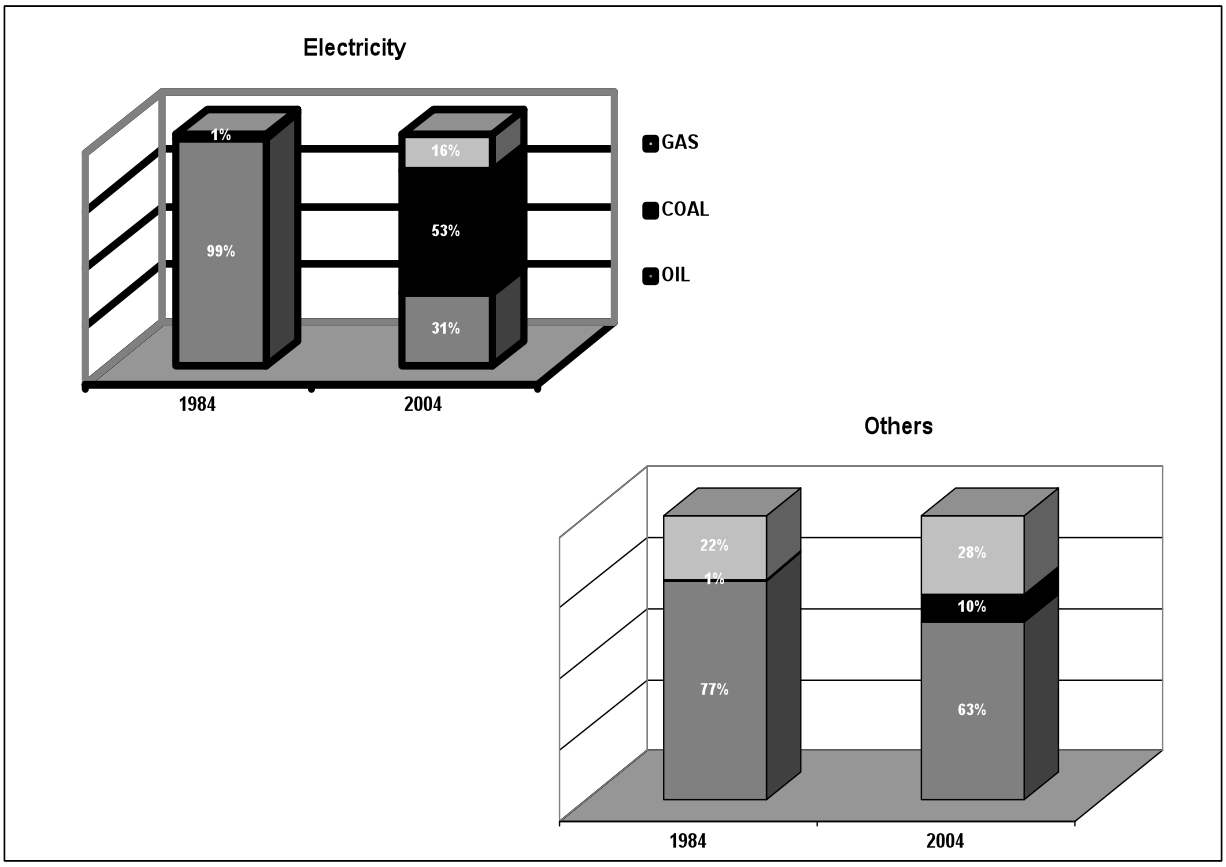

Source: International Energy Agency (2007) [http://www.iea.org/]

**Figure 5**
**Emissions by Sectoral Source**




Source: International Energy Agency (2007) [http://www.iea.org/]

**Figure 6**
**Types of Energy Used in Electricity**




Source: International Energy Agency (2007) [http://www.iea.org/]

**Table 1**
**Planned Future Energy Mix**

| Presidential Decree No. 5/2006 | | |
|---|---|---|
| **Source of energy** | **2005** | **2025** |
| **OIL** | **52%** | **20%** |
| **COAL** | **15%** | **33%** |
| **GAS** | **29%** | **30%** |
| **NRE (New Renewable Energy)** | **4%** | **15% (5% biofuel, 5% geothermal, 5% other renewables)** |
| **TL (Liquefied Coal)** | | **2%** |

Source: *Keppres No. 5/2006.*