# ENERGY EFFICIENCY IMPROVEMENTS IN ASIA: MACROECONOMIC IMPACTS

*Deepak Sharma, Suwin Sandhu, and Suchi Misra*

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## ABSTRACT

We examine various macroeconomic impacts of improving energy efficiency in the People's Republic of China, India, Indonesia, Japan, the Republic of Korea, Malaysia, and Thailand from 2010 to 2050. Energy efficiency policies would have a positive impact on private consumption, government expenditures, and investment and would lead to a significant increase in trade within Asia while reducing trade outside. Adopting them would shift employment from energy and mining to manufacturing and services. There will be a significant decrease in energy intensity in all countries under the high growth scenario which implies that sustained growth depends on efficient energy use. Without measures to improve efficiency, emissions would increase significantly in most countries. In the People's Republic of China, policies should emphasize reducing primary energy demand and emissions while minimizing the negative impacts on the economy. For India and Indonesia, policies should emphasize reducing primary energy demand and emissions while promoting economic growth. In Japan and Thailand, improvements in energy productivity could promote economic growth significantly and should be the policy focus. Best practice technologies in the Republic of Korea could significantly reduce primary energy requirements and emissions. They would also be most beneficial for Malaysia.

Keywords: energy efficiency, energy demand, economic growth, Asia

JEL Classification: Q40, Q43

# I. INTRODUCTION

Energy efficiency has lately emerged as a key policy strategy to address the twin challenges of energy security and climate change. According to the International Energy Agency (IEA), energy efficiency policies could significantly reduce the burden of energy import requirements, especially in import-dependent countries. Furthermore, it could contribute to more than half of the overall reduction in global greenhouse gas (GHG) emissions (IEA 2012a).

There is a widely held view that Asia is likely to be the main engine of global economic growth in the 21st century; which is often referred to as the "Asian Century." This economic rise will bring with it and perhaps will be driven by an unprecedented demand for energy. According to the Asian Development Bank (ADB), meeting this demand is likely to be a mega challenge for the region (ADB 2011). To meet this challenge, various policy options and strategies have been and are being considered. Improving energy efficiency is one of them.

Several studies have been conducted to estimate the potential for energy savings and the carbon emission reductions associated with energy efficiency improvements in Asia. They tend, however, to be micro assessments typically developing estimates of the life-cycle costs (or benefits) of specific measures to improve efficiency. While useful, such a focus precludes a deeper understanding of the macroeconomic—and hence policy-significant—impacts of alternative measures. For example, while a particular efficiency measure may result in large energy savings relative to others, it may be less attractive when looked at from broader macroeconomic considerations due to the complexity of underlying links with other sectors. This paper will help overcome this limitation.

Furthermore, most existing studies tend to focus on analyzing the impacts of demand-side efficiency improvements, for example, the impacts of introducing energy efficient end-use appliances and vehicles or building codes. Significant energy losses, however, occur in the transformation and primary supply stages, particularly in the electricity sector. These stages therefore offer considerable opportunities for improving efficiency and, by implication, macroeconomic benefits. Therefore, this paper equally emphasizes both demand and supply measures.

We examine the macroeconomic impacts of energy efficiency improvements—especially policy trade-offs—on economic output, employment, trade balance, energy demand/intensity, energy security, and carbon dioxide ($CO_2$) emissions/intensity in seven major Asian countries from 2010 to 2050: the People's Republic of China (PRC), India, Indonesia, Japan, the Republic of Korea, Malaysia, and Thailand. In the report *Asia 2050: Realizing the Asian Century*, ADB considered these seven as the engines that would lead the region toward prosperity (ADB 2011). Currently, they collectively account for 78% of the Asian population, 87% of economic output, 88% of primary energy, and 90% of GHG emissions (ADB 2011, IEA 2012b, WRI 2012). They are significant globally and also account for 45%, 24%, 35%, and 40% of the world's population, economic output, energy consumption, and GHG emissions, respectively (World Bank 2012).

# II. METHODOLOGICAL FRAMEWORK

## A. Modeling Approach

The core methodology is energy-oriented input–output analysis for each of the seven countries based on Global Trade Analysis Project databases (Narayanan, Badri, and McDougall 2012) as these tables are available in consistent (industry-classification) formats. These databases are extended by incorporating data from the IEA, the World Bank, and the United Nations (UN) to provide a disaggregated representation of energy production and consumption by sector as well as electricity generation using different technologies. The disaggregation enables an assessment of the economy-wide impacts of energy efficiency improvement policies.

The database for each of the seven economies contains links with other countries/regions that enable an assessment of the regional trade implications of energy efficiency improvements. Table 1 presents the lists of countries/regions, sectors, commodities, primary production factors, and final demand categories included in the model.

Table 1: Model Coverage

| Countries/Regions | Sectors | Commodities | Primary Production Factors |
|---|---|---|---|
| China, People's Republic of | **Energy sectors** | **Energy commodities** | Capital |
| India | Energy extraction | Coal | Labor |
| Indonesia | Coal mining | Coal products | Natural resources |
| Japan | Crude oil exploration | Crude oil | |
| Korea, Republic of | Natural gas production | Refined oil | |
| Malaysia | Uranium mining | Natural gas | |
| Thailand | Combustible renewable preparation | Uranium | |
| Central and West Asia | Non-combustible renewable preparation | Electricity | |
| East Asia | Non-electric energy conversion | | |
| South Asia | Coal products manufacturing | **Non-energy commodities** | **Final Demand Categories** |
| Southeast Asia | Petroleum refining | Paper products | Private consumption |
| Rest of the world | Electricity conversion | Chemical products | Government expenditure |
| | Traditional coal-fired power plant | Iron and steel | Investment |
| | Efficient coal-fired power plant | Non-ferrous metals | Net exports |
| | Traditional gas-fired power plant | Non-metallic minerals | |
| | Efficient gas-fired power plant | Other manufactured products | |
| | Oil-fired power plant | Mining products | |
| | Nuclear power plant | Agriculture products | |
| | Large-scale renewable power plant | Commercial services | |
| | Small-scale renewable power plant | Road transport | |
| | Electricity transmission and distribution | Rail transport | |
| | | Water transport | |
| | **Non-energy sectors** | Air transport | |
| | Industrial and services | | |
| | Paper manufacturing | | |
| | Chemical manufacturing | | |
| | Iron and steel manufacturing | | |
| | Non-ferrous metals manufacturing | | |
| | Non-metallic minerals manufacturing | | |
| | Non-intensive manufacturing | | |
| | Non-energy mining | | |
| | Agriculture | | |
| | Commercial services | | |
| | Transport | | |
| | Road | | |
| | Rail | | |
| | Water | | |
| | Air | | |

Source: Narayanan, G., Badri, A.A. and R. McDougall, eds. 2012. *Global Trade, Assistance, and Production: The GTAP 8 Data Base.* Purdue University: Center for Global Trade Analysis.

It is widely acknowledged that the traditional input–output model does not provide justifiable mechanisms for evaluating the impact of changes in technology due to the underlying assumption about the fixed proportionality of input–output coefficients. In reality, these coefficients are likely to change, for example, due to innovations, alterations in consumer and producer preferences, or policy adjustments (Rose 1984). This would have an impact on input prices and hence changes in technology through changes in factor inputs. Therefore, if one is to assess how energy efficiency improvements would influence technological change, one must make the input–output coefficients responsive to price changes. We achieve this by replacing the Leontief production function with more flexible production functions that allow for input factor substitutions in response to energy efficiency improvement policies (Sandu 2007).

## B. Scenario Descriptions

We develop six scenarios up to 2050. Two reflect different economic growth and energy pathways for the region, namely, the business-as-usual (BAU) scenario and the Asian century scenario (ACS). The BAU scenario reflects a continuation of historic trends in economic and population growth in the absence of any significant changes to energy and economic policy settings or other external shocks. The ACS, on the other hand, extends past success into the future by increasing economic growth by approximately 6% annually to 2050 which would then give the average Asian an income similar to that in Europe today (ADB 2011).

For each of these two economic growth scenarios, we develop three energy efficiency scenarios:

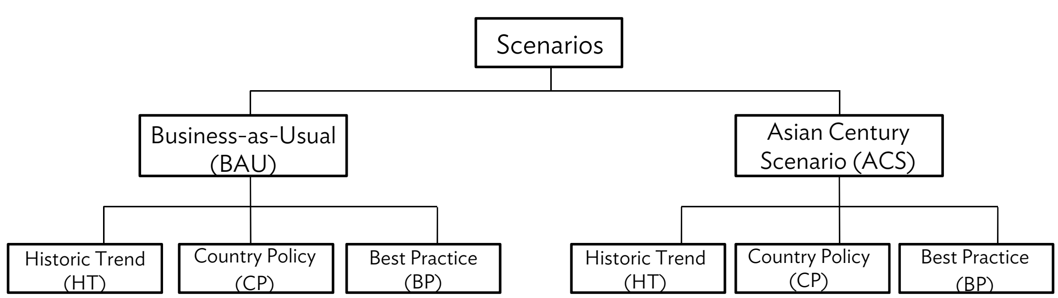
(i) The historic trend (HT) scenario assumes a continuation of historic, long-term energy efficiency improvement trends.

(ii) The country policy (CP) scenario assumes energy efficiency will grow with the country's existing energy plans and policies.

(iii) The best practice (BP) scenario assumes the aggressive implementation of efficiency measures based on energy efficiency improvement rates in Germany and Japan in the recent past.

These scenarios are summarized in Figure 1.

Figure 1: Energy Efficiency Scenarios




Source: Authors' compilation.

## C. Assumptions

The key assumptions underlying the BAU scenario and the ACS are summarized in Table 2. The population growth rates for 2011–2050 are taken from UN DESA (2012). The economic growth rates for 2011–2035 are based on APERC (2013), and for 2035–2050, they are estimated from population growth rates over this period using_an autoregressive integrated moving average forecasting model. The ACS assumes a considerably higher economic growth rate from 2011 to 2050, consistent with ADB (ADB 2011).

In the HT scenario, we make energy productivity growth projections for each of the seven countries to 2050 on the basis of the final energy consumption for the whole economy and for the industry and transport sectors. Final energy consumption is assumed to grow at long-term historical rates incorporating historic energy efficiency improvements provided by the IEA database for 1970–2010 (IEA 2012b). For the CP scenarios, energy productivity trends between 2010 and 2035 are estimated from the information published in the Asia Pacific Energy Research Centre energy outlook (APERC 2013). Beyond 2035, energy productivity is projected to grow at long-term trend rates reflecting ongoing energy efficiency improvement measures adopted by individual countries. For the BP scenarios, energy productivity trends are projected based on aggressive implementation of energy efficiency measures in Germany and Japan.

These scenarios further consider available supply-side technology options specifically for the electricity sector. In the HT scenarios, it is assumed that future shares of different electricity generation technologies (coal, oil, gas, nuclear, and renewables) from 2011 to 2050 will grow at long-term historical rates as estimated from the IEA database (IEA 2012b). In the CP scenarios, these shares will follow the targets set by individual governments and are based on the Asia Pacific Energy Research Centre outlook. In the BP scenarios, it is further assumed that the traditional coal-fired and gas-fired power plants will be completely replaced by efficient plants by 2050 and that small-scale, dispersed power plants based on renewable energy will play a greater role from 2020 onwards. Table 2 summarizes these assumptions.

## Table 2: Scenario Assumptions, 2010–2050

*(%)*

| | | People's Republic of China | | | | Japan | | | | Republic of Korea | | | | India | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BAU | ACS | | | BAU | ACS | | | BAU | ACS | | | BAU | ACS | | |
| **Economic and demographic assumptions** (% pa) | | | | | | | | | | | | | | | | | |
| Population growth | | -0.1 | -0.1 | | | -0.4 | -0.4 | | | 0.0 | 0.0 | | | 0.8 | 0.8 | | |
| GDP growth | | 4.9 | 6.3 | | | 0.6 | 1.1 | | | 1.9 | 3.4 | | | 7.2 | 8.8 | | |
| Labor productivity growth | | 1.5 | 1.5 | | | 0.4 | 0.5 | | | 0.8 | 1.3 | | | 1.6 | 1.6 | | |
| **Energy efficiency assumptions** | | | | | | | | | | | | | | | | | |
| **Demand-side measures** | | | | | | | | | | | | | | | | | |
| Energy productivity growth (% pa) | | | | | | | | | | | | | | | | | |
| Economy-wide | HT | 0.5 | 1.3 | | | 0.5 | 1.2 | | | 1.0 | 1.3 | | | 0.5 | 1.2 | | |
| | CP | 0.6 | 1.5 | | | 0.7 | 1.5 | | | 1.2 | 1.3 | | | 0.7 | 1.5 | | |
| | BP | 0.9 | 1.6 | | | 0.8 | 1.6 | | | 1.5 | 1.4 | | | 0.8 | 1.6 | | |
| Industry sector | HT | 0.6 | 1.4 | | | 0.4 | 1.0 | | | 0.1 | 0.2 | | | 0.4 | 1.0 | | |
| | CP | 1.0 | 1.6 | | | 0.6 | 1.3 | | | 0.5 | 0.8 | | | 0.6 | 1.3 | | |
| | BP | 1.2 | 1.7 | | | 0.9 | 1.7 | | | 0.9 | 1.0 | | | 0.9 | 1.7 | | |
| Transport sector | HT | 0.2 | 0.7 | | | 0.4 | 0.9 | | | 0.3 | 0.6 | | | 0.4 | 0.9 | | |
| | CP | 0.4 | 0.9 | | | 0.5 | 1.1 | | | 0.6 | 0.9 | | | 0.5 | 1.1 | | |
| | BP | 0.8 | 1.4 | | | 0.9 | 1.5 | | | 0.9 | 1.0 | | | 0.9 | 1.5 | | |
| **Supply-side measures** | | 2010 | 2050 | | | 2010 | 2050 | | | 2010 | 2050 | | | 2010 | 2050 | | |
| Electricity generation mix (%) | | | HT | CP | BP | | HT | CP | BP | | HT | CP | BP | | HT | CP | BP |
| Traditional coal-fired | | 77.6 | 81.3 | 2.2 | 0.0 | 27.9 | 31.9 | 22.6 | 0.0 | 44.2 | 52.0 | 20.7 | 0.0 | 68.0 | 61.9 | 8.3 | 0.0 |
| Efficient coal-fired | | 0.0 | 0.0 | 5.2 | 50.6 | 0.0 | 0.0 | 2.6 | 25.1 | 0.0 | 0.0 | 12.6 | 33.3 | 0.0 | 0.0 | 6.5 | 4.7 |
| Oil-fired | | 0.3 | 0.1 | 0.1 | 0.1 | 7.1 | 0.1 | 0.1 | 0.1 | 3.8 | 0.1 | 0.0 | 0.0 | 2.8 | 0.1 | 0.7 | 0.7 |
| Traditional gas-fired | | 1.7 | 7.4 | 3.6 | 0.0 | 27.9 | 39.2 | 23.7 | 0.0 | 20.8 | 21.0 | 0.0 | 0.0 | 12.3 | 18.5 | 9.6 | 0.0 |
| Efficient gas-fired | | 0.0 | 0.0 | 5.7 | 11.9 | 0.0 | 0.0 | 5.0 | 28.8 | 0.0 | 0.0 | 4.1 | 0.6 | 0.0 | 0.0 | 7.6 | 17.2 |
| Nuclear | | 1.8 | 4.9 | 8.8 | 10.3 | 26.4 | 12.9 | 2.8 | 2.8 | 29.9 | 25.2 | 59.1 | 46.7 | 2.7 | 3.9 | 8.3 | 8.3 |
| Renewable – large scale | | 18.7 | 6.3 | 4.4 | 23.6 | 10.6 | 15.8 | 43.2 | 19.3 | 1.3 | 1.7 | 3.5 | 1.4 | 14.2 | 15.6 | 9.0 | 7.5 |
| Renewable – small scale | | 0.0 | 0.0 | 0.0 | 3.4 | 0.0 | 0.0 | 0.0 | 23.8 | 0.0 | 0.0 | 0.0 | 18.0 | 0.0 | 0.0 | 0.0 | 1.5 |

*continued on next page*

*Table 2 continued*

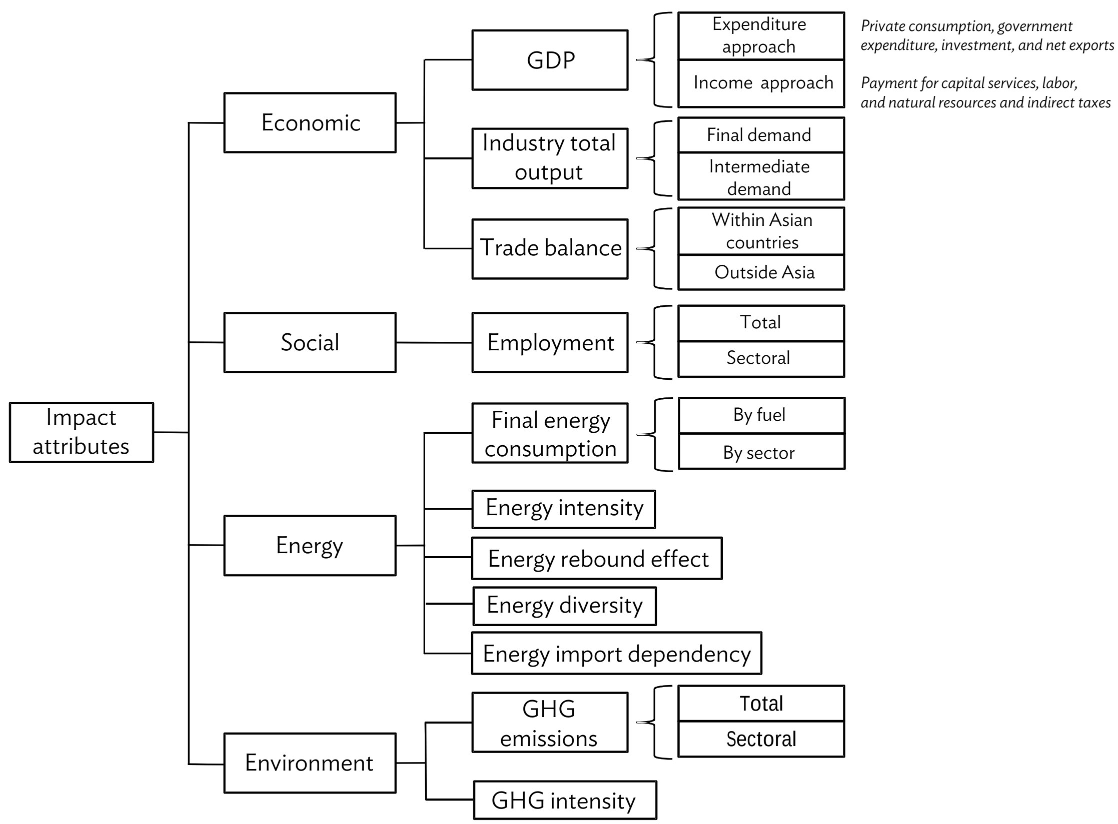
| | | Indonesia | | | | Malaysia | | | | Thailand | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BAU | ACS | | | BAU | ACS | | | BAU | ACS | | |
| **Economic and demographic assumptions** (% pa) | | | | | | | | | | | | | |
| Population growth | | 0.5 | 0.5 | | | 1.1 | 1.1 | | | 0.1 | 0.1 | | |
| GDP growth | | 5.2 | 7.2 | | | 4.8 | 6.4 | | | 4.4 | 5.9 | | |
| Labor productivity growth | | 1.5 | 1.6 | | | 1.3 | 1.5 | | | 1.6 | 1.7 | | |
| **Energy efficiency assumptions** | | | | | | | | | | | | | |
| **Demand-side measures** | | | | | | | | | | | | | |
| Energy productivity growth (% pa) | | | | | | | | | | | | | |
| Economy-wide | HT | 0.5 | 1.1 | | | 0.5 | 0.8 | | | 0.3 | 1.2 | | |
| | CP | 0.7 | 1.2 | | | 0.7 | 1.2 | | | 0.7 | 1.3 | | |
| | BP | 0.8 | 1.3 | | | 1.3 | 1.8 | | | 0.9 | 1.6 | | |
| Industry sector | HT | 0.2 | 1.0 | | | 0.6 | 0.8 | | | 0.3 | 1.3 | | |
| | CP | 0.4 | 1.2 | | | 1.0 | 1.4 | | | 0.6 | 1.5 | | |
| | BP | 0.9 | 1.4 | | | 1.2 | 1.7 | | | 1.1 | 1.6 | | |
| Transport sector | HT | 0.2 | 0.9 | | | 0.7 | 1.2 | | | 0.3 | 1.4 | | |
| | CP | 0.4 | 1.2 | | | 0.9 | 1.5 | | | 0.7 | 1.4 | | |
| | BP | 0.8 | 1.4 | | | 1.1 | 1.6 | | | 1.0 | 1.6 | | |
| **Supply-side measures** | | 2010 | 2050 | | | 2010 | 2050 | | | 2010 | 2050 | | |
| Electricity generation mix (%) | | | HT | CP | BP | | HT | CP | BP | | HT | CP | BP |
| Traditional coal-fired | | 40.1 | 74.7 | 70.3 | 0.0 | 34.4 | 40.6 | 17.0 | 0.0 | 18.8 | 22.8 | 16.9 | 0.0 |
| Efficient coal-fired | | 0.0 | 0.0 | 5.4 | 75.7 | 0.0 | 0.0 | 18.2 | 35.2 | 0.0 | 0.0 | 3.8 | 20.7 |
| Oil-fired | | 20.3 | 0.1 | 0.0 | 0.0 | 2.9 | 0.1 | 0.1 | 0.1 | 0.7 | 0.1 | 0.0 | 0.0 |
| Traditional gas-fired | | 23.6 | 10.6 | 1.6 | 0.0 | 56.5 | 49.5 | 32.1 | 0.0 | 74.8 | 66.5 | 64.1 | 0.0 |
| Efficient gas-fired | | 0.0 | 0.0 | 12.5 | 14.1 | 0.0 | 0.0 | 7.2 | 39.3 | 0.0 | 0.0 | 0.6 | 64.7 |
| Nuclear | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.9 | 6.9 | 0.0 | 0.0 | 6.5 | 6.5 |
| Renewable – large scale | | 16.0 | 14.6 | 10.2 | 5.1 | 6.2 | 9.8 | 18.5 | 9.2 | 5.6 | 10.6 | 8.1 | 4.1 |
| Renewable – small scale | | 0.0 | 0.0 | 0.0 | 5.1 | 0.0 | 0.0 | 0.0 | 9.3 | 0.0 | 0.0 | 0.0 | 4.0 |

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, HT = historic trend, pa = per annum.
Sources: World Bank. 2012. World Development Indicators. Washington, DC; United Nations, Department of Economic and Social Affairs, Population Division. 2012. *World Population Prospects: The 2011 Revision*; and, Asia Pacific Energy Research Centre (APERC). 2013. *APEC Energy Demand and Supply Outlook 5th Edition.* Tokyo.

## III. MACROECONOMIC IMPACTS

This section analyzes the economic, social, energy, and environmental impacts of energy efficiency improvements in the seven countries. The attributes used in the analysis are in Figure 2.

**Figure 2: Attributes for Assessing the Impacts of Energy Efficiency Improvements**




GDP = gross domestic product, GHG = greenhouse gas.
Source: Authors' compilation.

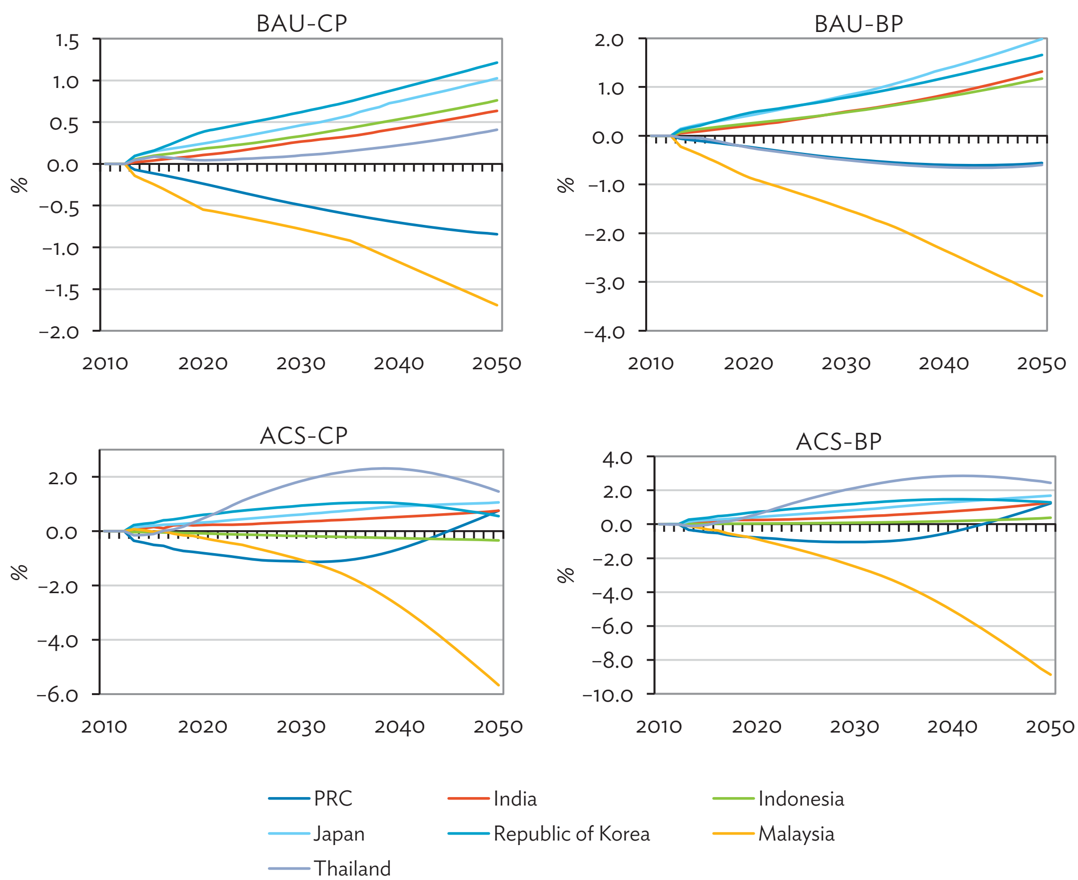
The analysis is done on an annual basis from 2010 to 2050, but the results are discussed separately for the short term (2010–2025), medium term (2025–2035), and long term (2035–2050).

## A. Economic and Social Impacts

### 1. Economic Growth

The impacts of energy efficiency improvements on economic growth are shown in Figure 3. The HT outcomes are used as a benchmark for analyzing the CP and BP outcomes both for the BAU scenario and ACS.

Figure 3: Changes in Gross Domestic Product Compared with Historic Trend Scenarios




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, PRC = People's Republic of China.
Source: Authors' calculations.

Overall, energy efficiency improvements will be critical for ensuring long-term, sustainable economic growth for all seven countries, but the intensity and timing of the economic impacts will vary. Energy efficiency policies (CP and BP scenarios) will result in modest reductions in the gross domestic product (GDP) for the PRC in the short to medium terms. In the long term, however, there will be appreciable GDP gains. For example, existing energy efficiency policies (CP) under ACS would result in a 0.04% loss of medium-term GDP and a 1.23% gain in long-term GDP compared with the HT scenario.

Malaysia's economy would apparently be adversely affected by energy efficiency policies. In the BAU-BP scenario, the short-, medium-, and long-term GDP would decline by 1.17%, 1.88%, and 3.29%, respectively. In contrast to the PRC and Malaysia, the other five countries would experience a net GDP gain from introducing energy efficiency measures. For example, existing country policies on energy efficiency would increase Indonesia's GDP by 0.25% in the short term, 0.43% in the medium term, and 0.76% in the long term compared to the HT scenario.

Introducing energy efficiency measures would have a positive impact on private consumption, government expenditure, and investment. Furthermore, these impacts would be evenly spread over the study period and will be particularly pronounced in the BP scenario. For India, adopting BP technology would cause private consumption in 2050 to increase by 0.55% and 0.90% in BAU and the ACS, respectively. This compares rather favorably with the corresponding increases in the CP scenario of 0.13% in BAU and 0.34% in the ACS.

It is worth noting that similar impacts would also be observed in the PRC and Malaysia where adopting energy efficiency policies would negatively impact medium-term GDP. For example, in Malaysia where GDP in the ACS-BP would be 8.87% less in 2050, investment, private consumption, and government expenditure would however be 7.17%, 1.74%, and 1.24% greater, respectively. This implies that net exports of goods and services for Malaysia would be more negatively affected thus offsetting the gains obtained from other contributors to GDP.

In contrast to GDP based on expenditure, GDP based on income would produce mixed results. Income from capital services would be positively affected by introducing energy efficiency policies in all seven countries. For example, in the PRC, income received from capital services in 2050 in the ACS would be 1.73% greater in the CP scenario and 2.97% greater in the BP scenario compared with the HT scenario.

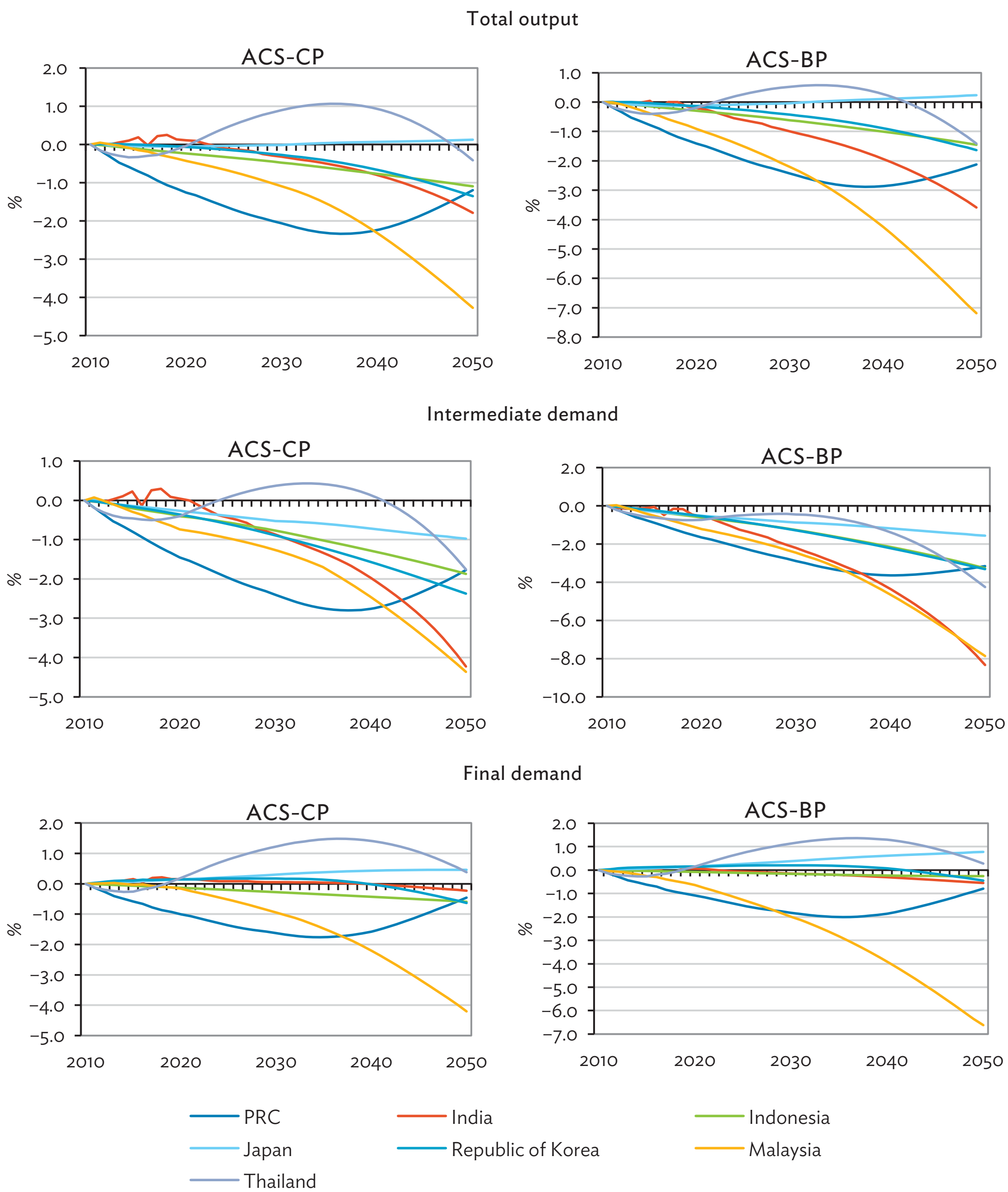
The impact of energy efficiency policies on "other income" would be mixed. Income from labor would be negatively affected in the PRC and India but positively affected in Japan, the Republic of Korea, and Malaysia. No significant impacts are observed for Indonesia and Thailand.

It is worthwhile to reiterate that this analysis is not limited to just adopting energy-efficient technologies in a strict technical sense, but also includes adopting relatively expensive alternative technologies such as renewable sources and nuclear power for generating electricity. These are shown as supply-side measures in Table 2.

### 2. Total Industry Output

This attribute refers to the total intermediate and final output of domestic industry. The impacts of energy efficiency improvements are shown in Figure 4.

Figure 4: Changes in Total Output for Asian Century Scenarios




ACS = Asian century scenario, BP = best practice scenario, CP = country policy scenario, PRC = People's Republic of China.
Source: Authors' calculations.

Except in Japan, the total output would be adversely affected by introducing energy efficiency policies though it would be mostly felt by the intermediate sectors of the economy. The most significant reduction in industry output would occur in Malaysia, driven by reductions in both intermediate and final demand; this impact would be greatest in the BP scenario. Industry output in the PRC would also be significantly affected, particularly in the medium term where the total output in the CP and BP scenarios would be 2%–3% less than in the HT scenario. The severity of the impact would however decrease in the long term (2050) to 1% and 2% for the CP and BP scenarios, respectively, when compared to the HT scenario.

The impact would be less significant for Indonesia and the Republic of Korea. In both these countries, industry output in the CP and BP scenarios would decrease by 1%–1.5% compared with the HT scenario. As in the other countries, demand for intermediate uses would drive the reduction in output. The medium-term impact of energy efficiency policies on industry output would be almost neutral (0.2%) for Japan and modest (1%) for Thailand. Increased demand for final consumption would drive these gains.

The HT scenario suggests increasing trends in structural shifts in these countries, i.e., a move away from energy-intensive industries (including mining and manufacturing) toward the less energy-intensive service sector. These trends will accelerate with the introduction of energy efficiency policies (Table 3).

The importance of the service sector increases in all countries. This shift is particularly strong if the economies grow at an accelerated rate (as in the ACS). For example, the share of the industry sector in the PRC would decrease from 61.3% in 2010 to 59.4% in 2050 in the BAU-HT scenario; it would further decrease to 56.1% in the ACS-HT scenario.

This transition from industry to services is particularly quick with stronger energy efficiency policies. Again for the PRC, the share of the industry sector would decrease to 55.3% in the CP scenario and 54.8% in the BP scenario compared with 56.1% in the HT scenario. While this transition would be gradual for most countries, for Thailand and Indonesia the share of the industry sector would increase further in the medium term but would decrease in the long term. The changes in the economic structures of Japan and to a lesser extent the Republic of Korea would be negligible, which is not surprising since their economies are already very service-oriented.

### 3. Trade Balance

Energy efficiency policies would in general lead to a significant increase in trade within Asia and would reduce trade outside Asia. The effects would, however, differ across countries.

India would improve its total trade balance by about $120 billion in 2050 in the BAU-CP scenario; its trade position would further improve by an additional $50 billion in the BAU-BP scenario. Indonesia and the Republic of Korea would also improve their trade balances; however, under the ACS these improvements might not materialize. For example, while net trade in Indonesia and the Republic of Korea would increase by $31 billion and $10 billion, respectively in 2050 in the BAU-CP scenario, in the ACS-CP scenario they would become net importers of goods and services ($96 billion and $19 billion for Indonesia and the Republic of Korea, respectively).

In contrast, Thailand would become a net importer of goods and services by almost $50 billion in 2050 if its economic growth continues at HT rates, but it would become a net exporter if the economy grows at the accelerated rate with a trade balance exceeding $50 billion in 2050. Malaysia would be a big loser in terms of international trade as the trade balance in 2050 could deteriorate by $40 billion to $315 billion. The PRC would be the biggest loser ($950 billion in 2050) if its economy grows at a moderate rate, but under the ACS this trend would reverse by 2040 putting the balance in positive territory ($11 billion in the CP scenario).

## Table 3: Percentages of Value-Added by Sector
(%)

| | | BAU | | | | | | | | | ACS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HT | | | CP | | | BP | | | HT | | | CP | | | BP | | |
| | 2010 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 |
| China, People's Republic of | | | | | | | | | | | | | | | | | | | |
| Agriculture | 8.7 | 8.8 | 9.0 | 9.1 | 9.0 | 9.2 | 9.5 | 9.0 | 9.3 | 9.7 | 8.9 | 9.2 | 9.9 | 9.1 | 9.5 | 10.1 | 9.2 | 9.6 | 10.3 |
| Industry | 61.3 | 60.6 | 60.2 | 59.4 | 60.2 | 59.4 | 58.1 | 59.9 | 58.9 | 57.2 | 60.2 | 59.2 | 56.1 | 59.4 | 57.9 | 55.3 | 59.2 | 57.7 | 54.8 |
| Service | 30.0 | 30.5 | 30.9 | 31.4 | 30.9 | 31.5 | 32.4 | 31.0 | 31.8 | 33.1 | 30.8 | 31.6 | 34.0 | 31.5 | 32.6 | 34.6 | 31.6 | 32.8 | 34.9 |
| India | | | | | | | | | | | | | | | | | | | |
| Agriculture | 16.4 | 16.5 | 16.6 | 16.6 | 16.5 | 16.6 | 16.7 | 16.6 | 16.8 | 17.1 | 16.5 | 16.6 | 17.0 | 16.5 | 16.7 | 17.2 | 16.6 | 16.9 | 17.6 |
| Industry | 37.1 | 36.8 | 36.4 | 35.7 | 36.6 | 36.0 | 35.1 | 36.2 | 35.4 | 33.8 | 36.7 | 35.9 | 33.2 | 36.5 | 35.3 | 31.5 | 36.1 | 34.6 | 29.7 |
| Service | 46.4 | 46.7 | 47.1 | 47.6 | 46.9 | 47.4 | 48.2 | 47.2 | 47.9 | 49.1 | 46.8 | 47.5 | 49.9 | 47.0 | 48.0 | 51.3 | 47.2 | 48.5 | 52.6 |
| Indonesia | | | | | | | | | | | | | | | | | | | |
| Agriculture | 15.6 | 15.8 | 15.9 | 15.9 | 15.9 | 16.0 | 16.0 | 16.0 | 16.2 | 16.5 | 16.1 | 16.2 | 16.6 | 16.1 | 16.4 | 16.8 | 16.2 | 16.5 | 17.0 |
| Industry | 38.6 | 40.8 | 40.7 | 40.4 | 40.6 | 40.3 | 39.8 | 40.2 | 39.6 | 38.5 | 40.0 | 39.2 | 37.9 | 39.8 | 38.7 | 37.0 | 39.6 | 38.4 | 36.3 |
| Service | 45.8 | 43.3 | 43.5 | 43.7 | 43.5 | 43.7 | 44.1 | 43.8 | 44.2 | 45.1 | 43.9 | 44.5 | 45.5 | 44.1 | 44.9 | 46.2 | 44.2 | 45.1 | 46.7 |
| Japan | | | | | | | | | | | | | | | | | | | |
| Agriculture | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.9 | 3.9 | 3.8 | 3.9 | 3.9 | 3.8 | 3.9 | 3.9 |
| Industry | 33.6 | 32.9 | 32.8 | 32.6 | 32.8 | 32.7 | 32.5 | 32.7 | 32.6 | 32.3 | 32.7 | 32.3 | 31.8 | 32.6 | 32.1 | 31.4 | 32.4 | 31.9 | 31.1 |
| Service | 62.6 | 63.2 | 63.4 | 63.6 | 63.3 | 63.4 | 63.7 | 63.5 | 63.6 | 63.9 | 63.4 | 63.9 | 64.4 | 63.6 | 64.0 | 64.7 | 63.7 | 64.3 | 65.0 |
| Korea, Republic of | | | | | | | | | | | | | | | | | | | |
| Agriculture | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.6 | 4.6 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.6 | 4.5 | 4.6 | 4.6 |
| Industry | 45.5 | 45.3 | 45.3 | 45.1 | 45.1 | 44.8 | 44.3 | 44.7 | 44.1 | 43.1 | 45.2 | 45.1 | 45.3 | 44.9 | 44.6 | 44.0 | 44.8 | 44.3 | 43.6 |
| Service | 50.1 | 50.2 | 50.3 | 50.4 | 50.4 | 50.7 | 51.1 | 50.8 | 51.3 | 52.3 | 50.3 | 50.4 | 50.2 | 50.5 | 50.9 | 51.4 | 50.7 | 51.1 | 51.8 |
| Malaysia | | | | | | | | | | | | | | | | | | | |
| Agriculture | 9.2 | 9.3 | 9.4 | 9.6 | 9.4 | 9.5 | 9.8 | 9.4 | 9.6 | 10.0 | 9.3 | 9.5 | 9.7 | 9.4 | 9.6 | 10.2 | 9.5 | 9.8 | 10.5 |
| Industry | 51.8 | 50.9 | 50.4 | 49.8 | 50.5 | 49.9 | 48.8 | 50.2 | 49.3 | 47.5 | 50.9 | 50.5 | 49.6 | 50.6 | 49.6 | 47.3 | 50.2 | 48.8 | 45.5 |
| Service | 39.0 | 39.8 | 40.1 | 40.6 | 40.1 | 40.5 | 41.4 | 40.3 | 41.1 | 42.5 | 39.8 | 40.1 | 40.6 | 40.0 | 40.7 | 42.5 | 40.4 | 41.4 | 44.0 |
| Thailand | | | | | | | | | | | | | | | | | | | |
| Agriculture | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.1 | 11.2 | 11.3 | 11.1 | 11.3 | 11.4 | 11.1 | 11.2 | 11.4 | 11.1 | 11.2 | 11.4 |
| Industry | 52.5 | 52.9 | 52.9 | 52.7 | 52.8 | 52.5 | 52.1 | 52.4 | 51.8 | 50.6 | 52.0 | 51.0 | 50.0 | 52.1 | 51.2 | 49.5 | 51.9 | 50.9 | 48.9 |
| Service | 36.6 | 36.1 | 36.2 | 36.3 | 36.2 | 36.5 | 36.8 | 36.6 | 37.1 | 38.0 | 36.9 | 37.8 | 38.6 | 36.8 | 37.6 | 39.1 | 37.0 | 37.8 | 39.6 |

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, HT = historic trend scenario.
Source: Authors' estimates.

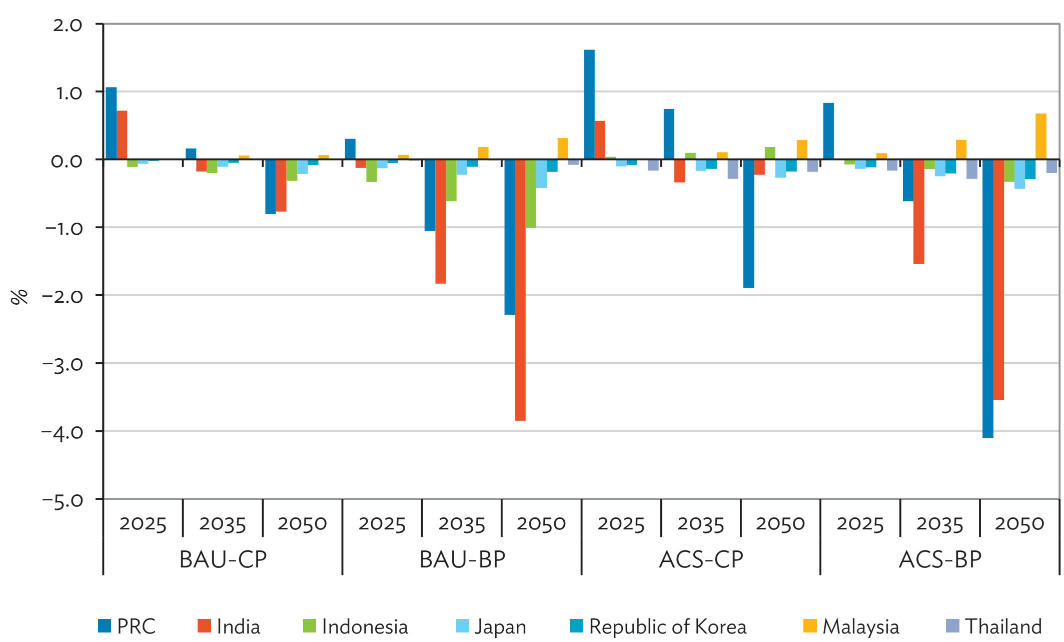
In terms of net trade in goods and services, the relative shares among different industries would vary considerably. Energy efficiency improvements would have a positive impact on mining and energy industries by reducing imports of products in energy-importing countries and increasing exports in energy-exporting countries. In the BAU scenario, imports of mining products in the PRC would decrease by $1,104 billion in 2035 in the CP scenario compared with the HT scenario, and in Indonesia, the export of energy products would increase by $11.7 billion in 2035 in the BP scenario.

Trade in manufactured products would be adversely affected by adopting energy efficiency measures in all countries except Japan. In the ACS, net imports of manufactured products from the PRC would peak in 2040 (additional $1.06 trillion and $1.26 trillion in the CP and BP scenarios compared with the HT scenario) before improving slightly by 2050, though the PRC will still be a net importer of manufactured products. While Thailand would also be a net importer of manufactured products in the BAU scenario—up to $50 billion in 2050—it could become a net exporter under the ACS. Introducing energy efficiency policies would increase manufactured exports for Japan; the ACS-BP scenario would increase exports by $46 billion in 2050.

### 4. Employment

The impact of adopting energy efficiency policies on employment will be significant and will differ across the countries (Figure 5).

**Figure 5: Changes in Total Employment**
(Million persons)




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, PRC = People's Republic of China.
Source: United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), Statistical Division. 2012. ESCAP Online Statistical Database. Employment. http://www.unescap.org/stat/data/statdb/DataExplorer.aspx

In the PRC, there will be a significant adverse impact on employment in the long term in the ACS-CP and BP scenarios. There may be modest employment gains in the short to medium terms though. In India, the impact will be somewhat negative in the ACS-CP scenario at 0.02% (200,000) less than in the HT scenario. The number of unemployed would rise by 3.5 million in the ACS-BP scenario as more advanced technology requires less labor to operate. The employment impacts will be much milder for Indonesia, Japan, the Republic of Korea, and Thailand. In Indonesia, long-term employment will be just 0.2% (300,000) less in the ACS-BP scenario. However, in the CP scenario, there will be a modest gain in employment. The employment impacts for Thailand will essentially be neutral in the BAU scenarios and somewhat negative (200,000) in the ACS-CP and BP scenarios. The employment impacts will be largely positive for Malaysia at 700,000 new jobs in the ACS-BP scenario compared with an increase of 300,000 new jobs in the ACS-CP scenario.

Adopting energy efficiency policies would result in a shift in employment from energy and mining to manufacturing and services. For energy-rich countries, employment in energy and mining would decline. The most affected countries are likely to be Indonesia and Malaysia where energy and mining are major industries. These two countries are also net exporters of energy. For Malaysia in the ACS, introducing the BP scenario would lead to a 32% reduction in employment in mining. This loss would, however, be offset by an increase of 15% in the service sector, 11% in the manufacturing sector, and 2% in the agriculture sector. For energy-deficient countries, jobs would simply shift from the manufacturing sector to the service sector in all except the PRC and the Republic of Korea where the jobs would continue to be concentrated in the manufacturing sector.

## B. Energy Impacts

This section discusses the impacts of implementing energy efficiency policies (CP and BP scenarios) in terms of the energy attributes in Figure 2.

### 1. Total Final Energy Demand

Table 4 shows final energy consumption under the six scenarios.

In the HT scenario, there will be a very large increase in final energy demand in the PRC, India, and Indonesia. In the PRC, the final energy demand (in the BAU scenario) would increase by more than five times from 1,520 million tons of oil equivalent (Mtoe) in 2010 to 7,900 Mtoe in 2050. Final energy demand for Indonesia would increase nearly sevenfold, and in India it would increase more than 13-fold from 449 Mtoe in 2010 to 6,043 Mtoe in 2050. This is largely due to the anticipated economic growth in these three countries. Energy consumption in the PRC would peak by the middle of the century. Consequently, the rate of growth in final energy demand will decrease.

Final energy demand will also increase in Malaysia and Thailand although at a much slower rate than in the PRC, India, and Indonesia. This is perhaps due to the fact that these two economies are in the upper-middle income group and hence require less energy to stay on their economic growth trajectories (see Medlock 2009).

Japan would experience a modest decline in final energy demand, especially over the long term even though its economy will continue to grow. The low population growth rate appears to be the main reason for this. Final energy demand in the Republic of Korea would continue to grow at a much slower rate than in the other developing countries.

## Table 4: Total Final Energy Demand
(Million tons of oil equivalent)

| | | BAU | | | | | | | | | ACS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HT | | | CP | | | BP | | | HT | | | CP | | | BP | | |
| | 2010 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 |
| China, People's Republic of | 1,520 | 3,871 | 5,845 | 7,892 | 3,690 | 5,325 | 6,482 | 3,514 | 4,803 | 5,022 | 3,981 | 6,055 | 5,794 | 3,481 | 4,680 | 3,679 | 3,369 | 4,288 | 1,974 |
| India | 449 | 1,269 | 2,662 | 6,043 | 1,234 | 2,524 | 5,436 | 1,183 | 2,320 | 4,512 | 1,285 | 2,844 | 6,363 | 1,248 | 2,613 | 3,680 | 1,194 | 2,356 | 1,397 |
| Indonesia | 148 | 320 | 502 | 985 | 311 | 475 | 889 | 294 | 427 | 711 | 385 | 688 | 1,256 | 370 | 630 | 969 | 358 | 583 | 727 |
| Japan | 325 | 331 | 330 | 328 | 320 | 316 | 308 | 310 | 303 | 288 | 330 | 321 | 294 | 313 | 293 | 245 | 302 | 276 | 216 |
| Korea, Republic of | 154 | 210 | 238 | 275 | 198 | 213 | 221 | 184 | 184 | 153 | 238 | 306 | 419 | 227 | 272 | 313 | 221 | 257 | 268 |
| Malaysia | 40 | 87 | 130 | 183 | 82 | 118 | 146 | 77 | 102 | 98 | 92 | 157 | 275 | 86 | 132 | 137 | 80 | 110 | 26 |
| Thailand | 79 | 155 | 235 | 402 | 147 | 215 | 338 | 136 | 181 | 227 | 150 | 210 | 296 | 151 | 213 | 210 | 145 | 194 | 116 |

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, HT = historic trends scenario.
Source: Authors' estimates.

Accelerated economic growth under the ACS would not lead to a uniform increase in final energy demand. While increased economic growth (compared with the BAU scenario) would increase energy demand in India, Indonesia, the Republic of Korea, and Malaysia even further, demand in the PRC, Japan, and Thailand would decline. This implies that the economic health of the former would continue to rely on the increased availability of energy while economic development in the latter might break the energy–economic growth connection.

There are significant contrasts in the impacts of the HT, CP, and BP scenarios over the three time frames. In the CP and BP scenarios, introducing energy efficiency policies would lead to a modest slowdown in growth in energy demand in the short to medium term; the impact appears to be more significant in the long term, especially in the ACS. There are also significant contrasts in the impacts across countries.

A modest deceleration of growth in energy demand would take place in Indonesia, the Republic of Korea, Malaysia, and Thailand over the short to medium term but would become more significant in the long term. In Indonesia, energy demand in the ACS-BP scenario would decrease by about 7% in 2025, 15% in 2035, and 42% in 2050 compared to demand in the ACS-HT scenario.

For Indonesia, the Republic of Korea, and Malaysia, greater energy savings will be achieved under the ACS. Compared with the HT scenario, energy demand in the BAU scenario in Malaysia decreased by 5 Mtoe in the CP scenario and 10 Mtoe in the BP scenario in the short term; 12 Mtoe in the CP scenario and 28 Mtoe in the BP scenario in the medium term; and 37 Mtoe in the CP scenario and 85 Mtoe in the BP scenario in the long term. The corresponding figures in the ACS are 6 Mtoe and 12 Mtoe in the short term; 25 Mtoe and 47 Mtoe in the medium term; and 138 Mtoe and 249 Mtoe in the long term. In Thailand, there will be more energy savings in the BAU scenario in the short to medium term, but this trend will be reversed in the ACS where savings will be only in the long term.

In the HT scenario, the total final energy demand for Japan would increase from 325 Mtoe in 2010 to 331 Mtoe in 2025 and then decrease slightly to 330 Mtoe in 2035 and 328 Mtoe in 2050. This is partly due to slower GDP and population growth. In the CP and BP scenarios, final energy demand will steadily decrease in the short to medium term. In the long term, growth in energy consumption will slow down significantly. The reduction in the ACS is more pronounced than in the BAU scenario, especially in the long term.

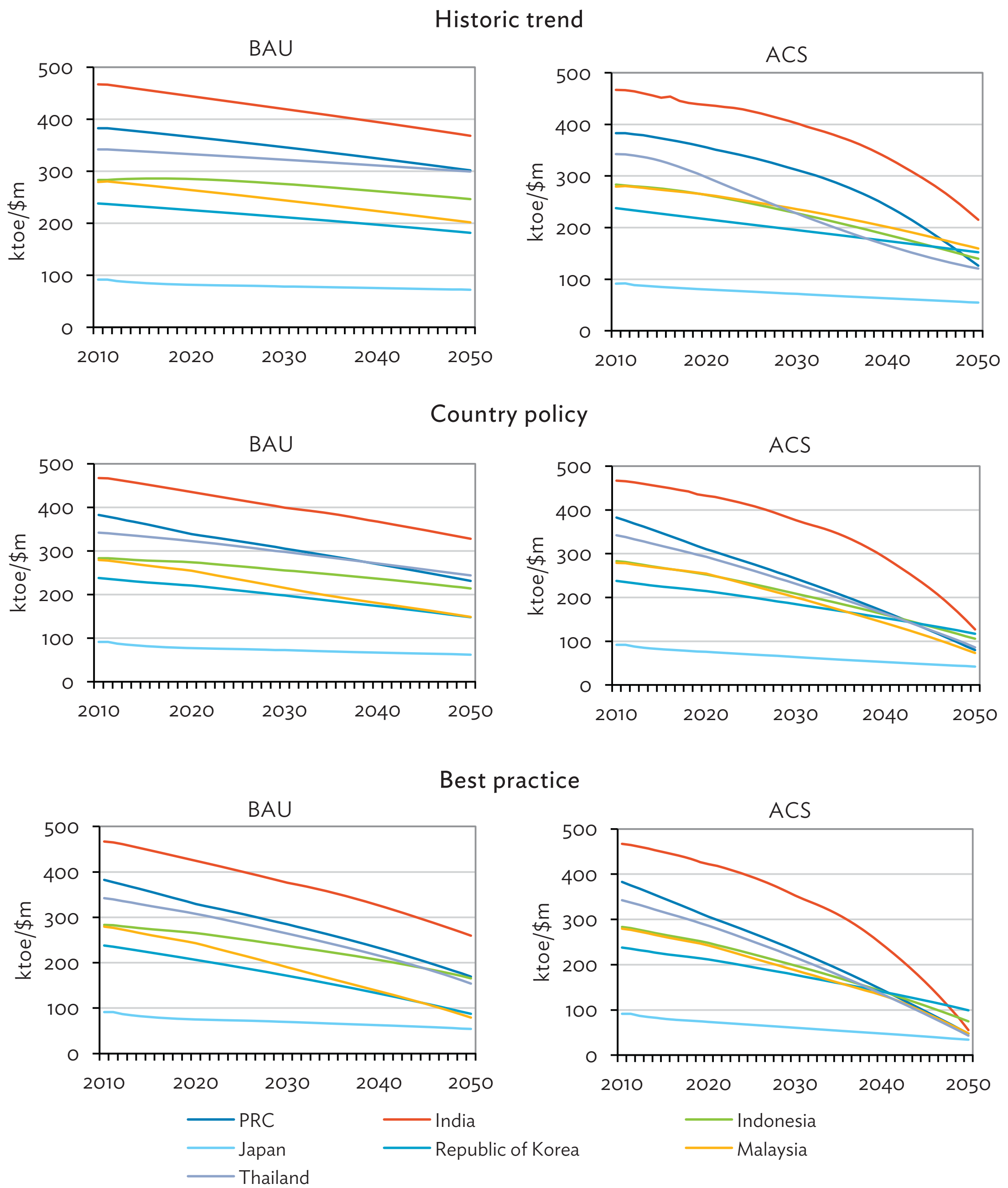
There are significant contrasts in energy consumption in the PRC and India depending on the scenario. Trends would be modest for Indonesia, the Republic of Korea, Malaysia, and Thailand reflecting their relatively low energy productivity compared with the most energy-productive countries in the world (Germany and Japan) and their ambitions to improve. This suggests that concerted efforts will be required if they want to catch up. In contrast, no appreciable difference in energy consumption is observed for Japan among the various scenarios reinforcing the status of Japan as an energy-efficient economy compared with the other six.

### 2. Energy Intensity

Energy intensity denotes the energy intensiveness of the economy. In thispaper, it is expressed in terms of primary energy used, i.e., 1,000 tons of oil equivalent (ktoe) to produce $1 million ($m) of GDP at 2010 prices.

There are considerable contrasts in 2010 in energy intensity across the seven countries. The PRC, India and Thailand have relatively high energy intensities ranging between 342 ktoe/$m and 467 ktoe/$m followed by Indonesia (283 ktoe/$m), Malaysia (279 ktoe/$m) and the Republic of Korea (238 ktoe/$m). Japan has the lowest energy intensity among these countries at 91 ktoe/$m. Energy intensity trends for all six scenarios are shown in Figure 6.

### Figure 6: Energy Intensity Trends, 2010–2050




ACS = Asian century scenario, BAU = business-as-usual scenario, ktoe/$m = 1,000 tons of oil equivalent per $1 million, PRC = People's Republic of China.
Source: Authors' estimates.

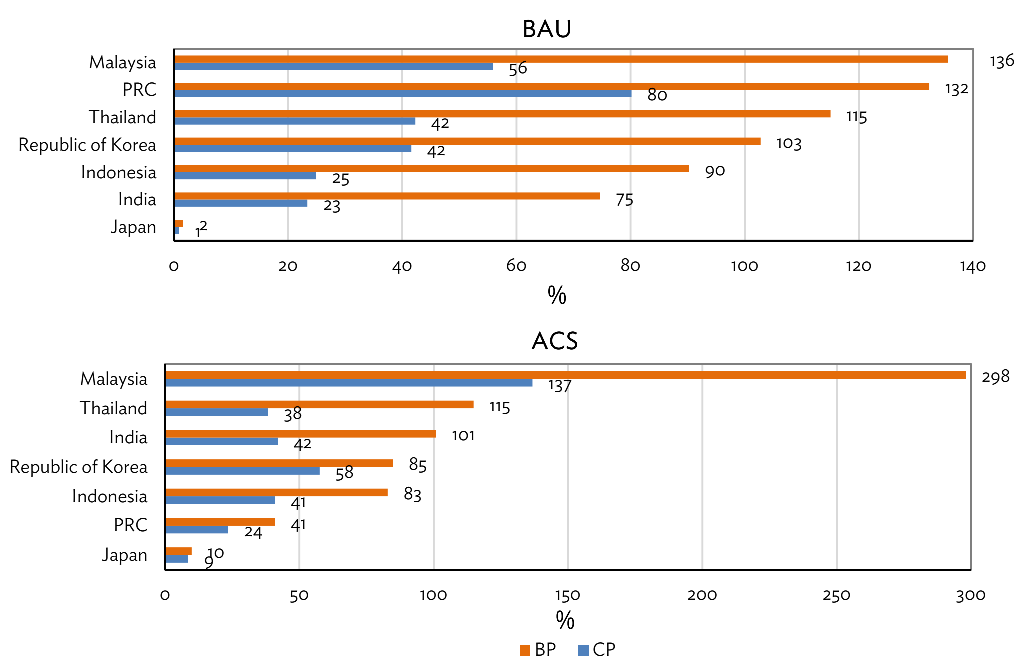
From 2010 to 2050, there is a significant decrease in energy intensity in all countries most noticeably in the PRC, India, Indonesia, and Thailand, which are all currently energy-intensive. The reduction is less significant in the Republic of Korea and Malaysia. There is a modest reduction even in Japan, the most advanced economy in the group. Energy intensity is likely to steadily decrease throughout the period. Under the ACS, India is the only exception as most of the reduction would occur in the long term. Prior to 2035, energy intensity in India will decrease at an annual average rate of 1.3% in the CP scenario and 1.7% in the BP scenario. After 2035, it will decline at an average rate of 6.4% per year in the CP scenario and 10.9% in the BP scenario. The decline in energy intensity is generally more significant in the ACS than in the BAU scenario. This implies that the sustained growth in the Asian countries depends on the efficient use of energy.

As a result of these trends, the energy intensities of these countries will converge. In the BAU scenarios, the convergence will take place in countries with similar energy-use patterns. The intensities for the PRC, India, Indonesia, and Thailand will converge in 2050. Similar trends are likely for the Republic of Korea and Malaysia. In the ACS, the convergence will take place in all countries except Japan in the HT and CP scenarios where its energy intensity is the lowest. Under the ACS-BP scenario, however, the result would be a true convergence in energy intensities.

### 3. Energy Rebound Effect

The rebound effect arises from the behavioral response of the economy in which energy reductions from improvements in efficiency are partly or wholly offset by increased consumption. Estimates of the rebound effect in the seven countries are summarized in Figure 7.

Figure 7: Energy Rebound Effect




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, PRC = People's Republic of China.
Source: Authors' estimates.

In the BAU scenario, a very strong rebound effect is observed for the PRC and Malaysia, a moderate yet significant effect will occur in the Republic of Korea and Thailand, a still appreciable effect is observed for India and Indonesia, and the effect will be weak in Japan. The BP scenario generally shows a larger rebound than the CP scenario in all seven countries. More aggressive economic growth under the ACS does not always lead to a lower rebound effect. Our analysis shows that this is true only in the PRC and Thailand in the CP scenario; and in the PRC, Indonesia, and the Republic of Korea in the BP scenario.

Annual energy productivity growth rates for the PRC and Thailand in the ACS-HT scenario are 1.3% and 1.2%, respectively, compared with 0.5% and 0.3% in the BAU-HT scenario. For Japan and Malaysia, on the other hand, these values are 0.6% and 0.8% in the ACS-HT scenario compared with 0.3% and 0.5% in the BAU-HT scenario. This means that more energy in the ACS would be saved through energy productivity improvements leaving little room for further improvement from measures to increase demand-side efficiency.

The magnitude of the rebound associated with efficiency improvements in energy-intensive sectors is generally higher than in non-energy-intensive sectors. If the rates of efficiency improvements in energy-intensive sectors are high regardless of improvements in non-energy-intensive sectors, this would lead to a larger rebound. Take the Republic of Korea, for example. The annual productivity growth from demand-side efficiency measures in the energy-intensive industry sector in the ACS-CP scenario is higher (0.6%) than that in the BAU-CP scenario (0.4%). In this case, the rebound is relatively larger in the ACS at 58% compared with 42% in the BAU scenario. In contrast, annual productivity growth from demand-side efficiency measures in this sector in the ACS-BP scenario (0.7%) is lower than in the BAU-BP scenario (0.8%). Here, the rebound effect is lower in the ACS at 85% compared with 103% in the BAU scenario.

The magnitude of the rebound effect differs from country-to-country possibly due to a combination of factors. A higher rate of energy productivity growth from energy efficiency measures generally leads to a larger rebound. Energy productivity from efficiency measures for Malaysia is assumed to grow by 28% (0.4% per year) in the ACS-CP scenario and by 48% (1% per year) in the ACS-BP scenario. These rates are the highest of the seven. Countries that are likely to experience higher population and GDP growth are also expected to have larger rebounds. Both of these rates are assumed to be relatively high for Malaysia—1.1% per year in population growth and 6.4% per year in GDP growth—from 2010 to 2050.

Countries that can rely on domestic energy resources to meet their demands are likely to have a larger rebound than those that rely on energy imports (Sorrell 2009).

## 4. Energy Diversity

We use the Herfindahl Index as a proxy for the diversity of a country's energy fuel mix (lower values suggest greater diversity). Estimates of the Herfindahl indices for the seven countries are summarized in Figure 8.

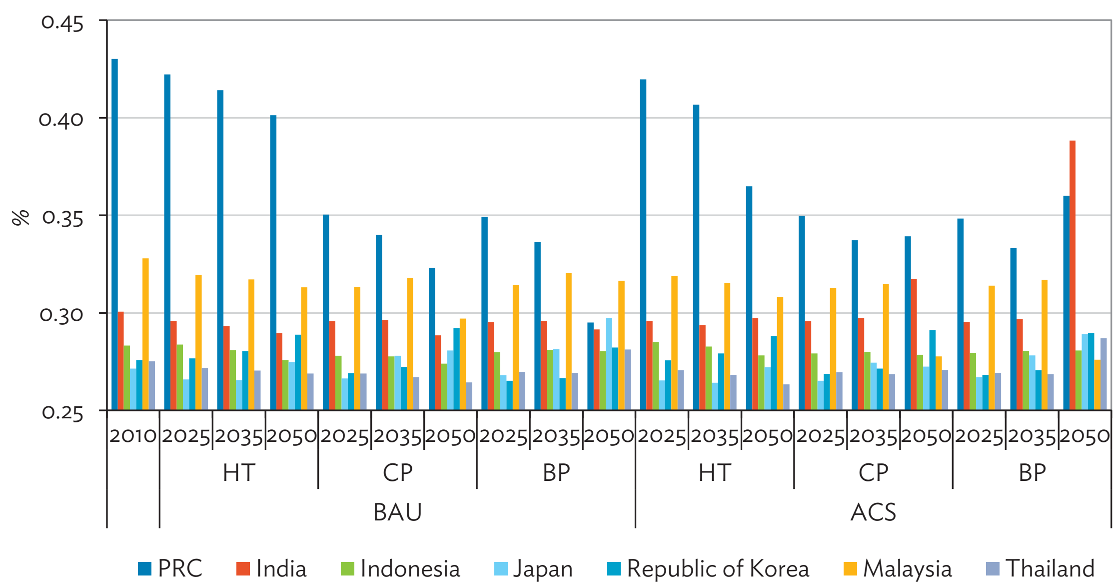
No noticeable improvement in energy diversity is observed except in the PRC where it will improve modestly in the medium to long term. Notwithstanding, the PRC would still be the least diverse of the seven due mainly to the overwhelming reliance on coal and oil.

In India, energy diversity decreases in both the CP and BP scenarios. The index will increase from 0.301 in 2010 to 0.317 in the CP scenario, and to 0.388 in the BP scenario, in 2050 in part because of the increasing share of oil in primary energy consumption. Its share will increase from around 35% in 2010 to more than 55% in 2050.

Energy diversity will converge across countries except in the PRC. This suggests that the primary energy sources would remain broadly the same: coal and oil in India, Indonesia, and Japan, coal and nuclear in the Republic of Korea, oil and natural gas in Malaysia, and oil in Thailand.

In addition, contrasts in energy diversity throughout the study period will be minimal, which suggests that energy efficiency policies would have little impact on the fuel mix.

Figure 8: Herfindahl Index




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, HT = historic trends scenario, PRC = People's Republic of China.
Source: Authors' estimates.

## 5. Energy–Import Dependency

In this section, energy-import dependency is expressed in terms of the ratio of net energy imports to total primary energy consumption. Table 5 shows this indicator for the seven countries under the six scenarios.

Japan and the Republic of Korea are the most dependent as about 80% of their demands are met by imports. With the introduction of energy efficiency policies, noticeable improvements in dependence can be achieved for the Republic of Korea especially in the medium to long term, but dependence will remain high for Japan. This is probably due to differing attitudes toward nuclear energy in these two countries.

The energy-import dependence of Thailand is relatively modest (around 44%); it will not noticeably improve particularly in the BAU scenario (still 44%). Some improvement would be observed in the ACS with dependency reduced to about 35%. This is partly due to reduced energy demand as a result of more active energy efficiency policies.

The PRC and India depend less on imports, though levels will increase in the PRC because of its increasing reliance on imported oil. In India, the level will decrease slightly as a result of increased reliance on domestic coal, nuclear, and renewables.

As energy-exporting countries, Indonesia and Malaysia would be big winners in introducing energy efficiency policies. Under the ACS-BP scenarios, for example, the ratio of net energy exports to consumption would improve from 77.6% in 2010 to 418% in 2050 for Indonesia, and from 24.5% to 284% for Malaysia, indicating an enhanced energy-export capacity.

## C. Environmental Impacts

This section discusses the environmental impacts of implementing energy efficiency policies in terms of greenhouse gas (GHG) emissions and intensities.

### 1. Greenhouse Gas Emissions

Without energy efficiency improvement measures, total GHG emissions would increase significantly in most countries given the ongoing trends in economic growth and energy consumption. This is shown in Table 6.

The PRC and India would experience a significant increase in total GHG emissions from 2010 to 2050 in the HT scenario, but emissions would be greatly reduced in the CP and BP scenarios. In the PRC, the BP scenario would lead to a reduction in total GHG emissions by about 30% in 2035 and 53% in 2050 compared with the HT scenario. This is equivalent to avoided emissions of more than 21 billion tons in 2050 (18.422 billion tons in the BP scenario instead of 39.457 billion tons in the HT scenario).

From 2010 to 2050, a modest increase in total GHG emissions will occur in Indonesia, the Republic of Korea, Malaysia, and Thailand. However, it will be significantly offset by energy efficiency improvements. In Malaysia, the BP scenario would lead to a 34% reduction in total GHG emissions in 2035 and a 60% reduction in 2050 compared to the HT scenario. This means that total GHG emissions in Malaysia would increase from 184 million tons in 2010 to 410 million tons in 2035 before dropping to 347 million tons in 2050. In the HT scenario, emissions would have reached 879 million ton in 2050.

In the BAU scenario, total GHG emissions would be slightly higher in Japan in the long term. In the ACS, emissions would increase only in the medium term (2010–2035) and would decline slightly after 2035. As in the other countries, emissions would be greatly reduced by introducing energy efficiency measures.

It is worth noting that adopting BP technologies would result in more significant reductions in total GHG emissions compared to the CP scenario. This impact would be more apparent in the long term. In India, implementing energy efficiency policies would result in a reduction of total GHG emissions in 2025 of 3.3% in the CP scenario and 7.1% in the BP scenario compared to the HT scenario. The corresponding figures for 2035 are 3.7% and 11.8%, and for 2050 are 11% and 32.6%, respectively.

## Table 5: Net Energy-Import Dependency
(%)

| | | BAU | | | | | | | | | ACS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HT | | | CP | | | BP | | | HT | | | CP | | | BP | | |
| | 2010 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 |
| China, People's Republic of | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 15 | 16 | 17 | 15 | 15 | 18 | 16 | 16 | 20 | 15 | 16 | 18 |
| India | 22 | 22 | 22 | 22 | 22 | 22 | 21 | 22 | 21 | 20 | 22 | 21 | 20 | 22 | 21 | 17 | 22 | 21 | 3 |
| Indonesia | –78 | –101 | –106 | –117 | –108 | –117 | –136 | –114 | –131 | –180 | –117 | –142 | –217 | –125 | –160 | –292 | –130 | –175 | –418 |
| Japan | 80 | 81 | 83 | 86 | 81 | 83 | 83 | 81 | 83 | 82 | 81 | 83 | 85 | 81 | 82 | 82 | 81 | 82 | 81 |
| Korea, Republic of | 79 | 80 | 81 | 82 | 70 | 68 | 62 | 72 | 70 | 66 | 80 | 81 | 82 | 70 | 68 | 62 | 70 | 67 | 61 |
| Malaysia | –24 | –29 | –35 | –47 | –33 | –54 | –82 | –40 | –73 | –189 | –30 | –40 | –71 | –36 | –68 | –123 | –43 | –97 | –284 |
| Thailand | 44 | 44 | 44 | 43 | 44 | 44 | 44 | 44 | 44 | 45 | 43 | 41 | 38 | 43 | 43 | 38 | 43 | 42 | 35 |

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, HT = historic trends scenario.
Source: Authors' estimates.

## Table 6: Total Greenhouse Gas Emissions
(Million tons of carbon dioxide equivalent)

| | | BAU | | | | | | | | | ACS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HT | | | CP | | | BP | | | HT | | | CP | | | BP | | |
| | 2010 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 | 2025 | 2035 | 2050 |
| China, People's Republic of | 7,378 | 19,118 | 29,029 | 39,457 | 15,741 | 22,549 | 27,068 | 15,043 | 20,291 | 18,422 | 19,623 | 29,877 | 27,447 | 14,844 | 19,765 | 14,738 | 14,429 | 18,106 | 7,045 |
| India | 2,060 | 5,670 | 11,837 | 26,694 | 5,482 | 11,401 | 23,751 | 5,270 | 10,438 | 17,982 | 5,739 | 12,668 | 28,826 | 5,543 | 11,837 | 17,226 | 5,321 | 10,645 | 7,086 |
| Indonesia | 469 | 1,034 | 1,659 | 3,396 | 1,039 | 1,613 | 3,068 | 984 | 1,446 | 2,278 | 1,247 | 2,288 | 4,414 | 1,241 | 2,155 | 3,450 | 1,204 | 1,996 | 2,465 |
| Japan | 1,146 | 1,177 | 1,186 | 1,216 | 1,102 | 1,090 | 1,021 | 1,067 | 1,035 | 868 | 1,175 | 1,161 | 1,110 | 1,081 | 1,017 | 825 | 1,043 | 952 | 661 |
| Korea, Republic of | 526 | 715 | 813 | 936 | 578 | 590 | 548 | 544 | 511 | 358 | 809 | 1,033 | 1,391 | 664 | 755 | 776 | 648 | 715 | 666 |
| Malaysia | 184 | 409 | 620 | 879 | 382 | 485 | 620 | 355 | 410 | 347 | 434 | 748 | 1,352 | 399 | 544 | 622 | 369 | 440 | 83 |
| Thailand | 267 | 522 | 794 | 1,359 | 493 | 712 | 1,106 | 456 | 602 | 674 | 507 | 708 | 1,010 | 505 | 710 | 701 | 487 | 640 | 347 |

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, HT = historic trends scenario.
Source: Authors' estimates.

In the ACS, introducing energy efficiency measures would reduce total GHG emissions more significantly compared with the BAU scenario. In the PRC, the improvement would be 17.7% in the BP scenario in 2025 in the BAU scenario compared to 24.4% in the ACS.

GHG emissions would also be reduced in energy-intensive sectors. Energy efficiency measures would result in a significant reduction in GHG emissions from the energy sector. In the PRC, the CP scenario would reduce GHG emissions by 5.158 billion tons in 2035 in the BAU scenario. This is approximately 80% of the total GHG emissions for the year.

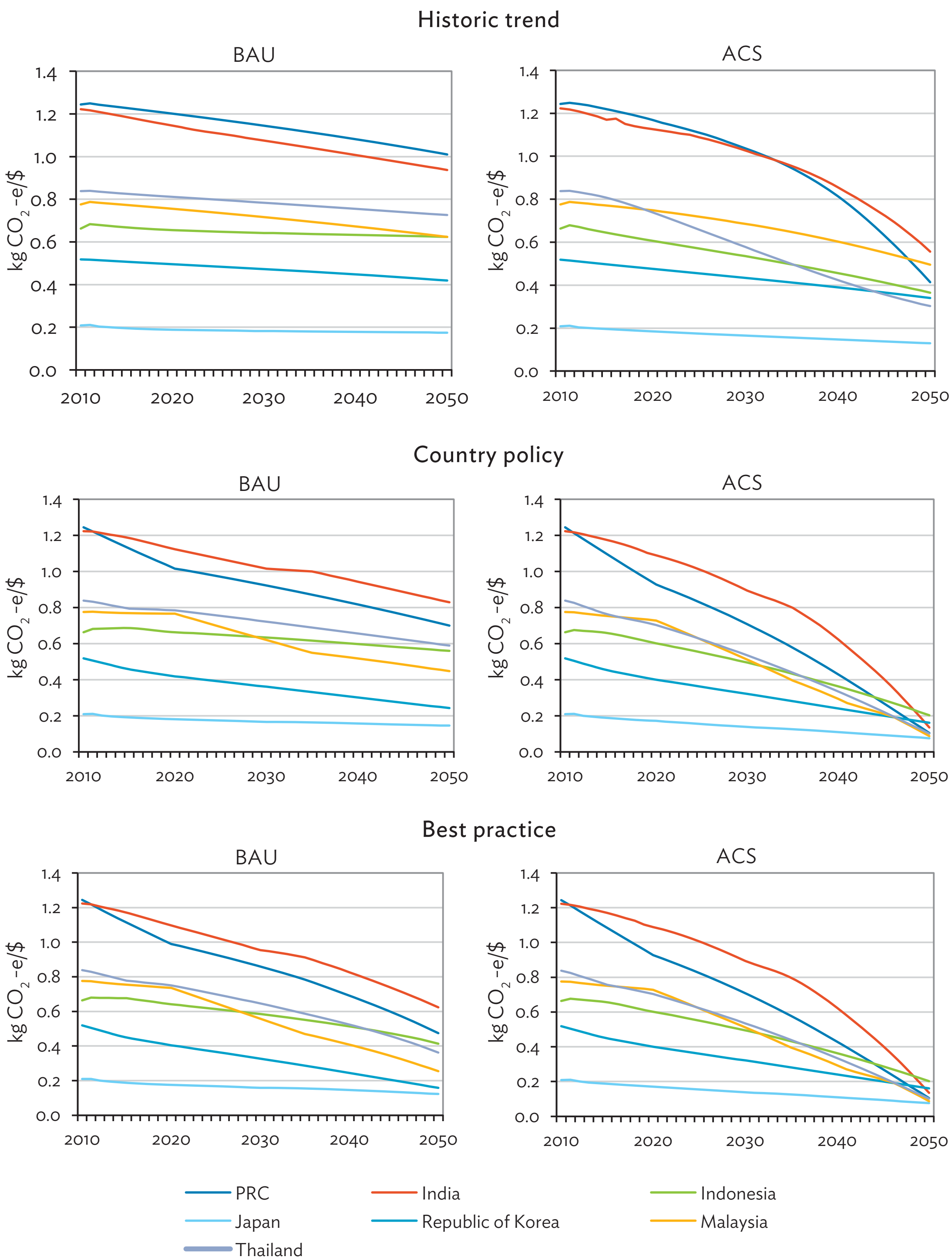
The manufacturing and transport sectors are the most significant non-energy sectors contributing to GHG emissions; introducing energy efficiency policies would lead to modest reductions. In Malaysia, implementing aggressive measures would reduce GHG emissions by 25 million tons in the manufacturing sector and by 10 million tons in the transport sector in 2035 in the BAU scenario—approximately 12% and 5% reductions, respectively.

### 2. Greenhouse Gas Intensity

In the context of this study, GHG intensity denotes the carbon dioxide ($CO_2$) intensiveness of the economy. It is expressed in terms of kilograms (kg) of $CO_2$ equivalent ($CO_2e$) per $ of GDP at 2010 prices.

The trends in GHG intensity (Figure 9) are similar to those observed for energy intensity (Figure 6). There is a significant difference in 2010 in GHG intensity across the seven countries. The PRC and India have very high levels (more than 1.2 kg $CO_2e$/$), and intensities are also quite high in Indonesia, the Republic of Korea, Malaysia, and Thailand (more than 0.5 kg $CO_2e$/$). In contrast, Japan has a relatively low GHG intensity of approximately 0.2 kg $CO_2e$/$.

Figure 9: Greenhouse Gas Intensity Trends, 2010–2050




ACS = Asian century scenario, BAU = business-as-usual scenario, kg $CO_2e$/$ = kilograms of carbon dioxide equivalent per dollar, PRC = People's Republic of China.
Source: Authors' estimates.

There will be a broad convergence in GHG intensity across countries in the long term except in Japan where emission intensity is already significantly lower than those in the others. This is particularly true in the ACS where GHG intensity would grow from approximately 0.3 kg $CO_2e$/\$–0.4 kg $CO_2e$/\$ in the HT and CP scenarios. In the BP scenario, however, a fuller convergence is observed with GHG intensities for the six countries reaching the same level as Japan (below 0.2 kg $CO_2e$/\$).

The BP scenario would have a more significant impact on GHG intensity than the CP scenario. In Indonesia, energy efficiency improvements in the BAU scenario would lead to a 22% reduction in GHG intensity in the CP scenario and to a 33% reduction in the BP scenario in 2035 compared with the HT scenario. In 2050, the corresponding reductions would be 31% and 47%, respectively.

Energy efficiency policies would in general contribute to greater reductions in GHG intensity in the ACS than in the BAU scenario. Existing energy efficiency policies in the PRC would result in a 10% reduction in GHG intensity in the BAU scenario, and a 22% reduction in the ACS by 2050.

## IV. POLICY TRADE-OFFS AND IMPLICATIONS

We extend the discussion in the previous section by providing a more complete policy perspective. Specifically, we discuss policy trade-offs between major attributes such as economic growth, primary energy requirements, and GHG emissions. The policy implications of the CP and BP scenarios on energy diversity and import dependency, employment, and trade balances are also discussed.

### A. The People's Republic of China

Figure 10 summarizes key macroeconomic impacts and their policy implications for the PRC.

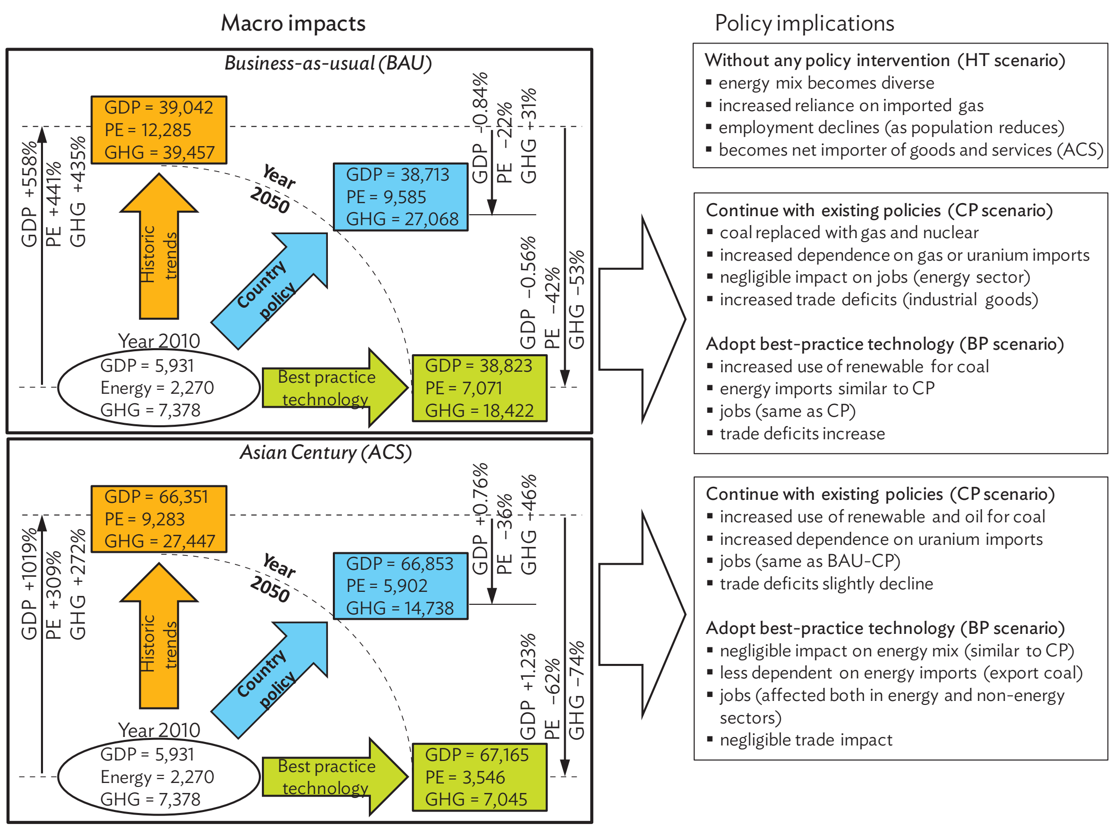
In the BAU–HT economic growth scenarios, the GDP over the next 40 years would increase more than sixfold (from \$5.9 trillion to \$39 trillion). If present energy efficiency trends continue, primary energy requirements will increase more than fivefold from 2.3 gigatons of oil equivalent (Gtoe) to 12.3 Gtoe, and GHG emissions will increase from 7.4 gigatons (Gt) to 39.5 Gt.

In the ACS, the economy would be more than 11 times larger (\$66.4 trillion) than its current size. Surprisingly, however, primary energy requirements and GHG emissions would be less (9.3 Gtoe and 27.4 Gt, respectively) than those in the BAU scenario. This implies that energy productivity improvements could make major contributions to sustainable economic growth. Efficiency improvements should therefore be a major focus of energy policies.

Continuing present energy efficiency trends (HT) to 2050 would slightly diversify the energy mix in both the BAU scenario and the ACS. Coal and renewable energy would be partly replaced by natural gas and to a smaller extent by nuclear and oil. This improvement will, however, be at the expense of increased reliance on imported energy, particularly natural gas. Employment would be less reflecting mainly a declining population after reaching its peak in 2025 (UN Population Division 2012). The trade position will be reversed; the PRC will become a net importer of industrial goods.

The severity of these impacts could be reduced by adopting a suite of policy measures aimed at improving demand and supply efficiency and increasing the use of alternative electricity generating technologies and fuels. By pursuing currently planned policies, the PRC could reduce its primary energy requirements by 36% and GHG emissions by 46%. To achieve this, a concerted effort to reduce the share of coal in the country's energy mix (from currently 60% to 47% in the BAU scenario and 35% in the ACS) is needed. Coal would be replaced by other energy sources in an approximately equal proportion which would lead to increased use of gas and nuclear power and hence an increased reliance on natural gas and uranium imports.

Figure 10: Summary of Impacts and Policy Implications for the People's Republic of China




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

In the BP scenario, primary energy demand could be reduced by 62% and GHG emissions by 74%. In addition to an increased use of natural gas and nuclear power (the CP scenario), the use of renewable energy would also rise to 17% (currently 12%). The share of coal would drop to just 26% in the ACS, thus potentially making the PRC a net exporter of coal by 2050.

Compared with the HT scenarios, the impact on GDP of adopting energy efficiency policies would be small. While the impact would be negative in the BAU scenario (GDP will decrease by 0.84% in the CP scenario and 0.56% in the BP scenario), it would be positive in the ACS. These macroeconomic impacts along with the impacts discussed earlier suggest that the policies in the CP and BP scenarios should emphasize reducing primary energy demand and reducing GHG emissions while minimizing the negative impacts on the economy.

The CP and BP scenarios will have a limited ability to improve employment. In fact, up to 0.55% of jobs could be lost in these scenarios compared with the HT scenarios. Job losses in the energy sector due to declining demand would be partly offset by new jobs in the non-energy sectors, particularly in the industry sector. This implies that introducing energy efficiency policies (the CP and BP scenarios) would result in a transfer of employment as well as income for labor from energy to non-energy sectors.

Finally, introducing energy efficiency policies would raise the trade deficit in the BAU scenario, but this may not be bad especially if it contributes to rebalancing world trade patterns that have caused economic problems in the recent past. The trade deficits would largely result from increased imports of industrial goods. However under the ACS, the impacts would be negligible, and energy efficiency policies would have modestly positive impacts.

## B. India

Figure 11 summarizes key macroeconomic impacts and their policy implications for India. In the BAU-HT scenarios, there would be more than 16-fold increase in the GDP over the next 4 decades from $1.7 trillion in 2010 to $28.5 trillion in 2050. If current energy efficiency trends continue, primary energy requirements will increase more than 13-fold from 0.8 Gtoe to 10.5 Gtoe, and GHG emissions will increase more than 12-fold from 2 Gt to 26.7 Gt.

In the ACS, the GDP would increase spectacularly by more than 30 times to $5.8 trillion. In contrast with the PRC, however, primary energy requirements and GHG emissions would be higher at 11.2 Gtoe and 28.8 Gt than in the BAU scenario.

The continuation of present energy efficiency trends to 2050 would not have any observable impact on the energy mix or on energy-import dependency. Job numbers would, however, double reflecting growing population and increasing personal wealth. In addition, India would become a net importer of goods and services.

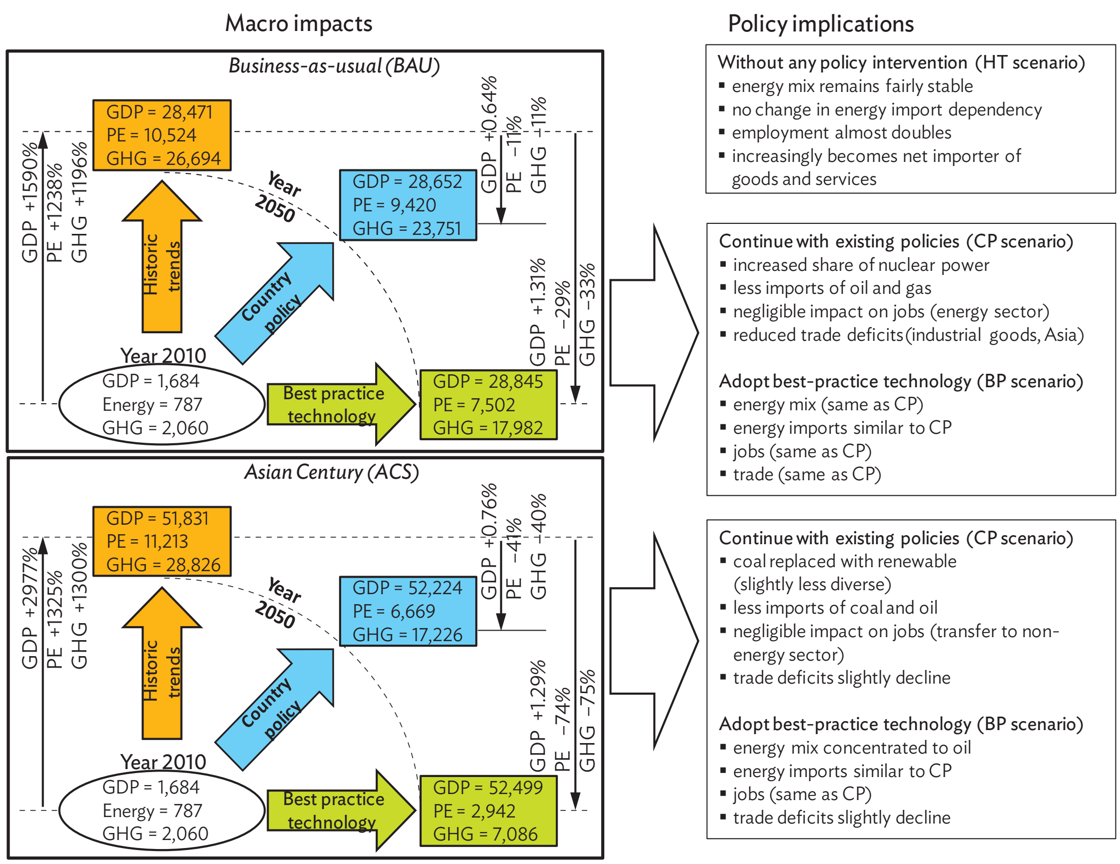
The severity of these impacts could be reduced by adopting a suite of policy measures aimed at improving demand and supply efficiency and increasing the use of alternative electricity generating technologies and fuels. By pursuing existing and currently planned policies, India could reduce its primary energy requirements and GHG emissions by nearly 40%. To achieve this, a concerted effort directed at increasing the share of nuclear in the power generating mix (from 3% currently to 8% in both the BAU scenario and the ACS) will be needed. Coal-fired power plants would also need to be partly replaced by gas-fired plants. This would lead to an increased use of gas and nuclear power and hence increased natural gas and uranium imports.

In the BP scenario, primary energy demand and GHG emissions could each be reduced by nearly 75%. The share of coal-fired power plants in total electricity generation would drop to 62% (in both the ACS and the BAU scenario) in 2050.

Compared with the HT scenario, the impact of adopting energy efficiency policies on the GDP would be modestly positive. Unlike the PRC, the GDP would be positively affected both in the BAU scenario (by 0.64% in the CP scenario and 1.31% in the BP scenario) and in the ACS (by 0.76% in the

CP scenario and 1.29% in the BP scenario). These macroeconomic impacts along with the impacts noted above imply that the policies in the CP and BP scenarios should emphasize reducing primary energy demand and GHG emissions while promoting economic growth.

Figure 11: Summary of Impacts and Policy Implications for India




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

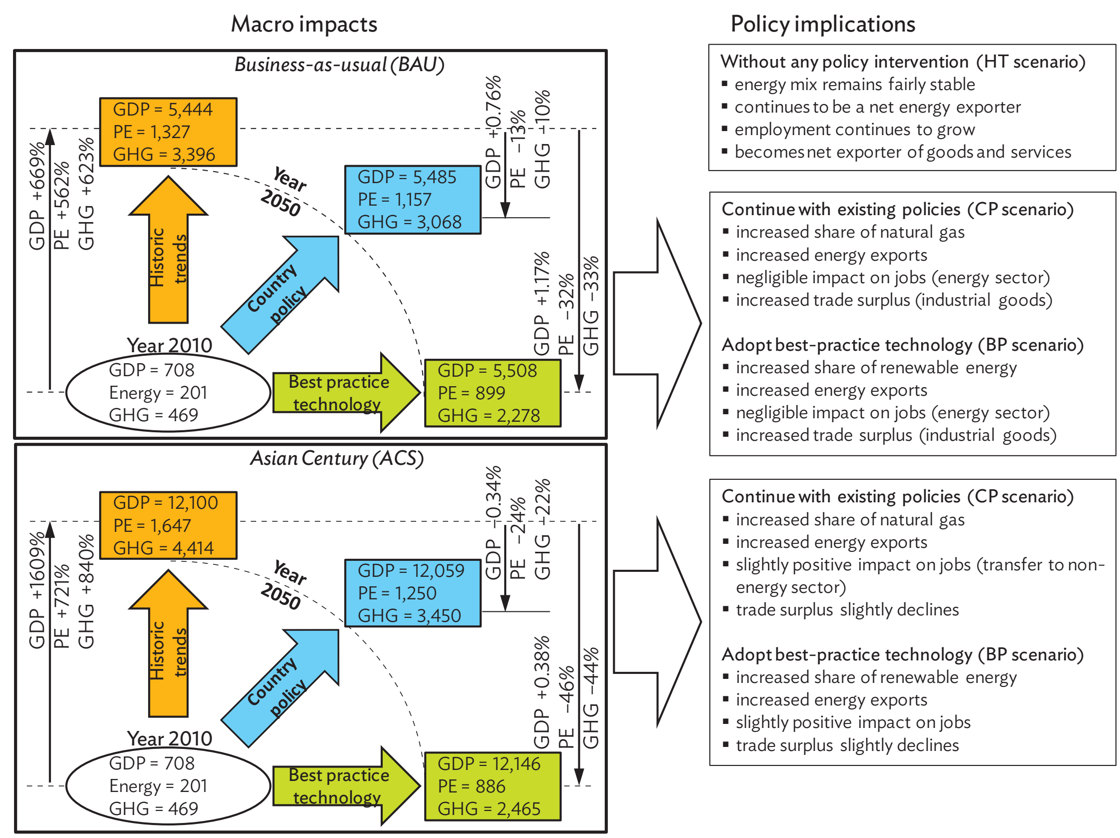
The CP and BP scenarios will have a limited ability to improve employment. Up to 0.5% of jobs could be lost in these scenarios in comparison with the HT scenario. Similar to the PRC, the job losses in the energy sector due to declining demand would be partly offset by new jobs in the non-energy sectors, particularly in the industry sector. This implies that adopting energy efficiency policies would result in a transfer of employment as well as income for labor from the energy to the non-energy sectors.

Finally, in terms of trade balance, introducing higher energy efficiency targets would reduce trade deficits in both the BAU scenario and the ACS because of the increase in industrial output and its export potential. Additional surpluses from the industry sector would come at the expense of increasing trade deficits in the service sector, however.

## C. Indonesia

Figure 12 summarizes key macroeconomic impacts and their policy implications for Indonesia. In the BAU-HT scenarios, the GDP would increase more than sevenfold from $7 billion to $5.4 trillion by 2050. If present energy efficiency trends continue, primary energy requirements will increase more than sixfold from 0.2 Gtoe to 1.3 Gtoe, and GHG emissions will increase nearly sevenfold from 0.5 Gt to 3.4 Gt.

Figure 12: Summary of Impacts and Policy Implications for Indonesia




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

In the ACS, the economy will be 17 times larger ($12.1 trillion). Primary energy requirements and GHG emissions would be 1.65 Gtoe and 4.4 Gt higher than in the BAU scenario.

The continuation of present energy efficiency trends to 2050 would not have a noticeable impact on the country's energy mix. An increased use of coal will be accompanied by reduced use of oil and renewable energy. Given that Indonesia has its own coal resources, there would be no significant impact on energy-import dependency. Jobs would grow in consonance with the growing population and personal incomes. In addition, Indonesia would become a net exporter of goods and services, a major factor driving GDP.

In the CP scenario, Indonesia could reduce its primary energy requirements by 24% and its GHG emissions by 22%. To achieve this, a significant effort is needed to promote the use of natural gas for the BAU scenario and renewable energy for the ACS. In the BP scenario, the primary energy demand could be reduced by 46% and GHG emissions by 44%. The share of coal in the total energy mix would be further reduced and that of renewable energy would increase in both the ACS and the BAU scenario.

The impact of adopting energy efficiency policies on the GDP compared with the HT scenario will be modestly positive except in the BAU-CP scenarios where it will be negative. In the ACS, the impact of continuing with existing policies would lead the economy to contract by 0.34% compared with the HT scenario, while adopting BP technologies would cause it to expand by 0.38%. These macroeconomic impacts and the impacts discussed above suggest that policies in the BP scenario should emphasize reducing primary energy demand and GHG emissions while contributing to economic gains.

The impact of these policies on job creation would, however, be negligible. In fact, jobs will be 0.8% fewer than in the HT scenario. Even in the ACS, introducing existing policies would lead to a mere 0.1% increase in jobs in 2050.The number of job losses in the energy sector due to declining demand would be partially offset by additional jobs in the non-energy sectors, but this will happen only if the economy grows very rapidly as in the ACS. This implies that adopting energy efficiency policies in the CP and BP scenarios would result in some transfer of employment and wages from the energy to the non-energy sectors.

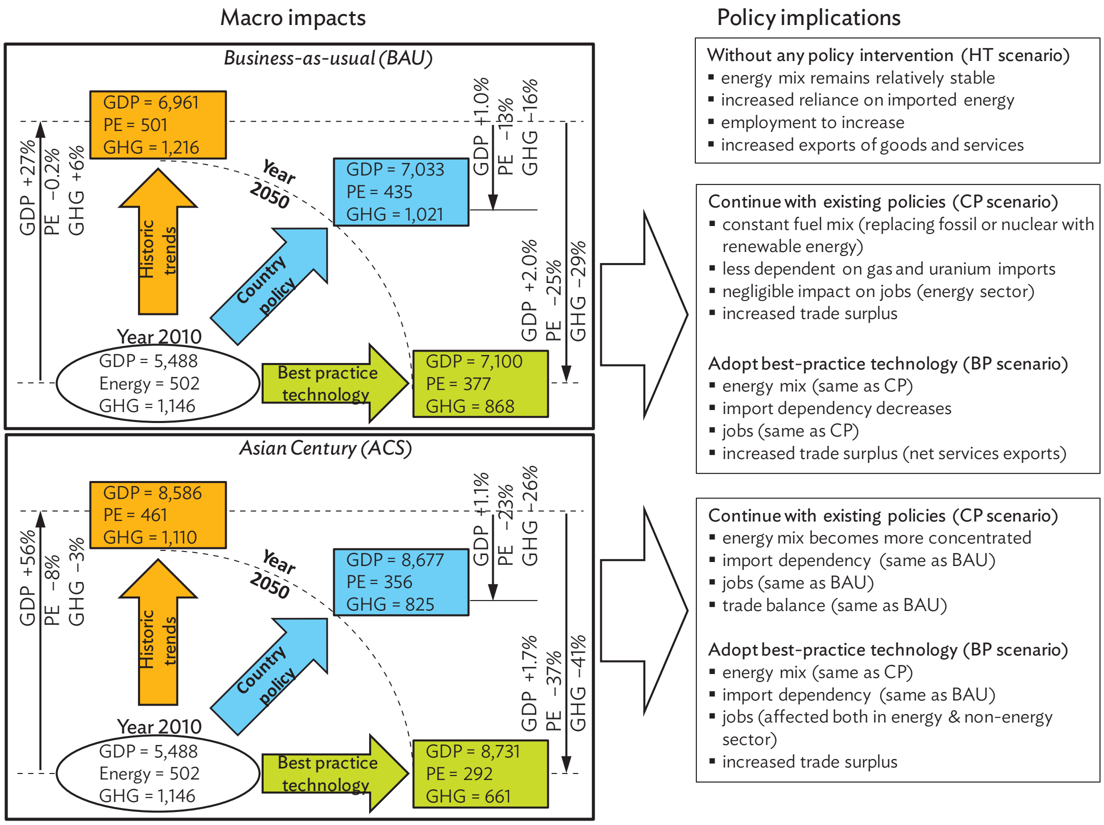
Finally, introducing higher energy efficiency targets would improve the trade surplus in the BAU scenario and the ACS although higher growth would take place in the CP scenario. This improvement will occur due to increased exports of energy resources. Additional surpluses would also come from the industry sector.

## D. Japan

Figure 13 summarizes macroeconomic impacts and their policy implications for Japan. The economy is likely to grow at a slow rate over the 40-year period. In the BAU-HT scenarios, the GDP would increase by just 27% (from $5.5 trillion to $7 trillion) by 2050. If the present energy efficiency trends continue, primary energy requirements will not grow (currently 0.5 Gtoe), but GHG emissions would grow by 6% from 1.15 Gt to 1.22 Gt.

In the ACS, economic growth for Japan would be 56% greater (GDP $8.6 trillion) in the HT scenario than its current size. Similar to the PRC, its primary energy requirements and GHG emissions would be less at 0.46 Gtoe and 1.1 Gt. This implies that improvements in energy productivity could significantly promote economic growth and hence should be the focus of policy makers.

**Figure 13: Summary of Impacts and Policy Implications for Japan**




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2110 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

If present energy efficiency trends continue to 2050, there would be no appreciable change in the overall energy mix. However, there would be increased reliance on natural gas imports as the share of nuclear decreases. Employment (jobs) would increase modestly in line with GDP, and the trade balance would continue to improve as exports of goods and services increase.

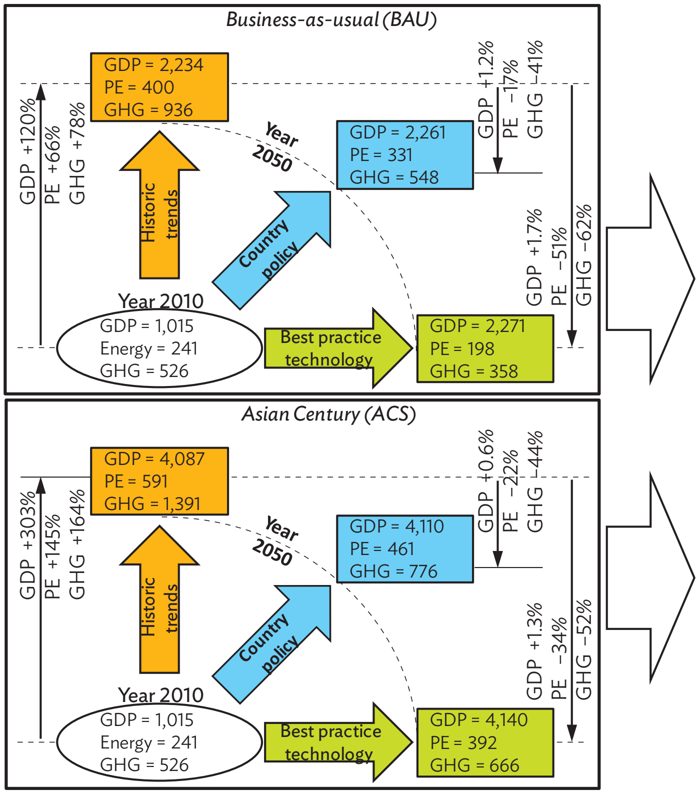
In the CP scenario, Japan could reduce its primary energy requirements by 23% and GHG emissions by 26%. For generating electricity this will, however, require reducing reliance on fossil fuels and nuclear power and increasing the use of renewable energy thus reducing reliance on energy imports. If Japan adopts the BP scenario, primary energy demand could be reduced by 37% and GHG emissions by 41%.

Even though Japan is an energy-efficient economy, it could benefit from energy efficiency policies. Its GDP would be positively affected both in the BAU scenario (increasing by 1% and 2% in the CP and BP scenarios, respectively), and the ACS (increasing by 1.1% and 1.7% in the CP and BP scenarios, respectively). The trade balance will improve in both the BAU and the ACS with higher growth in BP as the industry sector increases output for international markets. In fact, in the BAU scenario, Japan could become a net exporter of services in the long term.

## E. The Republic of Korea

Figure 14 summarizes macroeconomic impacts and their policy implications for the Republic of Korea.

**Figure 14: Summary of Impacts and Policy Implications for the Republic of Korea**




Policy implications

**Without any policy intervention (HT scenario)**
- more concentration toward coal
- increased reliance on imported coal
- employment increases moderately
- increasingly export goods and services

**Continue with existing policies (CP scenario)**
- reduced reliance on coal, but increased nuclear
- less dependent on energy imports
- negligible impact on jobs (energy sector)
- increased trade surplus

**Adopt best-practice technology (BP scenario)**
- energy mix (same as CP)
- import dependency decreases
- jobs (same as CP)
- trade balance unaffected

**Continue with existing policies (CP scenario)**
- energy mix (same as BAU)
- import dependency (same as BAU)
- jobs (same as BAU)
- trade surplus moderately declines

**Adopt best-practice technology (BP scenario)**
- energy mix (same as BAU)
- import dependency (same as BAU)
- jobs moderately affected
- trade surplus moderately declines

ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

In the BAU-HT scenarios, GDP would more than double (from $1 trillion to $2.2 trillion) in the next 40 years. If present energy efficiency trends continue, primary energy requirements will increase by 66% from 241 Mtoe to 400 Mtoe and GHG emissions will increase by 78% from 526 million tons (Mt) to 936 Mt. In the ACS, economic output would triple to $4.1 trillion. To support this growth, primary energy requirements would have to increase by 145% to 591 Mtoe and GHG emissions would increase by 164% to 1.4 Gt.

Continuing current energy efficiency trends to 2050 would reduce energy diversity leading to increased dependence on imported coal. Overall, however, aggressive energy efficiency would improve the trade balance and provide moderate employment gains.

In the CP scenario, primary energy requirements will decrease by 22%, and GHG emissions will decrease by 44%. To achieve this, coal must be substituted with nuclear; the share of nuclear will increase from 13% in the HT scenario to 33% in the CP scenario. This will reduce dependence on imported coal.

In the BP scenario, primary energy requirements could be reduced by 51% and GHG emissions by 62%. Unlike other countries, these reductions would occur in the BAU scenario. The share of coal-fired power plants in total electricity generation would decrease to 62% in both the ACS and the BAU scenario. However, the magnitude of the impact on energy diversity and energy-import dependency would be the same as in the other scenarios.

Compared with the HT scenario, GDP would be positively affected by adopting energy efficiency policies. From 2010 to 2050 in the BAU scenario, GDP will increase by 1.2% and 1.7% in the CP and BP scenarios, respectively, and in the ACS, growth will be 0.6% and 1.1% in the CP and BP scenarios, respectively.

Overall, the employment impacts of energy efficiency policies will be modestly negative. There will be 1.1% fewer jobs in the ACS-BP scenarios compared with the ACS-HT scenarios; this is equivalent to 300,000 persons in 2050 (around 0.6% of the estimated population). Moreover, the number of job losses in the energy sector due to declining demand would be partially offset by new jobs in the non-energy sectors particularly in the service sector.

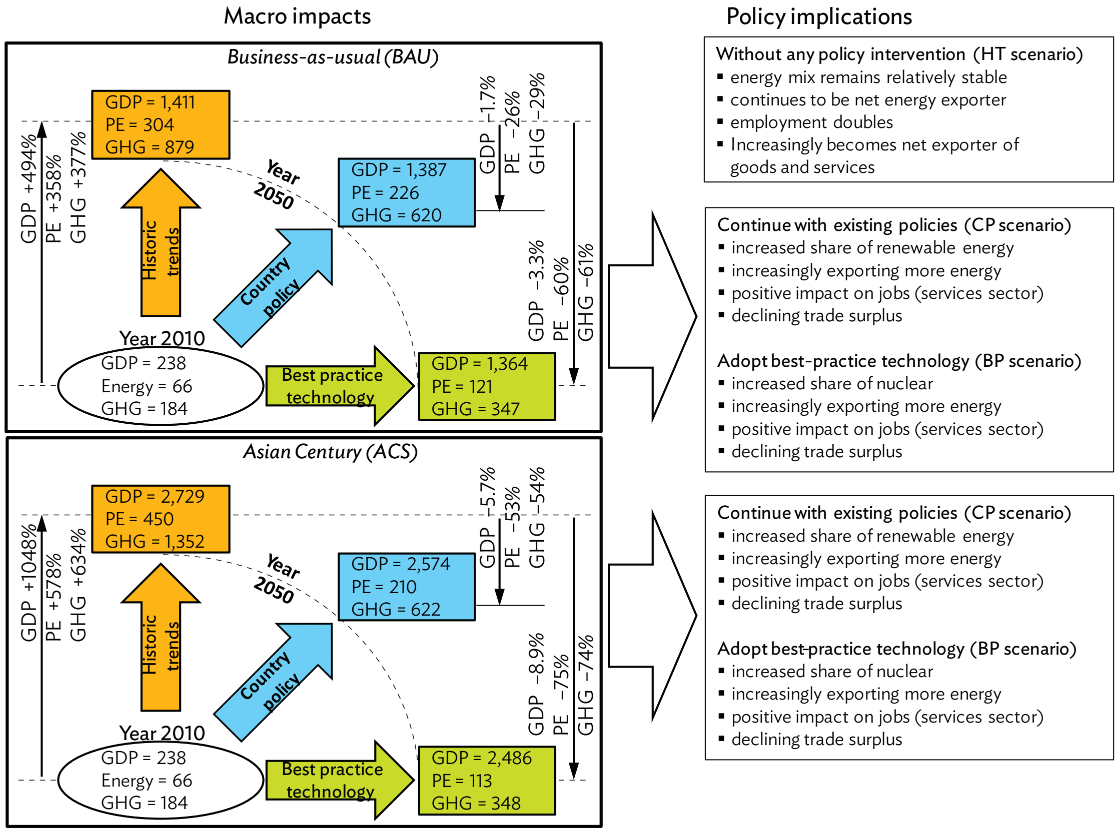
Introducing higher energy efficiency targets would improve the trade balance, particularly in the BAU scenario as the industry sector increases output for international markets; however, if the BP scenario is adopted, increasing exports of industrial goods would be offset by increasing imports of services.

## F. Malaysia

Figure 15 summarizes macroeconomic impacts and their policy implications for Malaysia.

In the BAU-HT scenarios, GDP would increase more than sixfold by 2050 from $200 billion to $1.4 trillion. In the HT scenario, primary energy requirements would increase more than fourfold from 66 Mtoe to 304 mtoe, and GHG emissions would increase from 184 Mt to 879 Mt. In the ACS, the economy would be more than 11 times greater at $2.7 trillion, but primary energy requirements and GHG emissions would be higher compared with the BAU scenario by 450 Mtoe and 1.4 Gt, respectively.

Figure 15: Summary of Impacts and Policy Implications for Malaysia




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

If present energy efficiency trends continue to 2050 (HT scenario), there would be a noticeable impact on the energy mix but no significant impact on energy-import dependency. Job numbers would double reflecting population growth and increasing wealth. In addition, Malaysia would become a net exporter of goods and services, a major factor in GDP.

By pursuing currently planned policies (CP scenario), Malaysia could reduce its primary energy requirements by 53% and GHG emissions by 54%. To achieve this, the share of renewable energy in the primary energy mix must increase from 3% currently to 7% in 2050. In the BP scenario, primary energy demand could be reduced by 75% and GHG emissions by 74%. The share of coal in the total energy mix would decrease and would be replaced by nuclear (in both the ACS and the BAU scenarios). Compared with the HT scenario, the impact of adopting energy efficiency policies on GDP would be significant. It will increase by 1.7% in the BAU-CP scenarios or by 8.9% in the ACS-BP scenarios. These impacts suggest that the policies in the BP scenario would be most beneficial for Malaysia.

These policies will also be favorable in terms of creating jobs as they could add up to 2.8% more in the ACS-BP scenarios compared with the HT scenario. The job losses in the energy sector due to declining demand would be more than offset by new jobs in all non-energy sectors, specifically in the service sector. Finally, introducing higher energy efficiency targets would affect the trade balance. Malaysia is likely to become a net importer of services; currently it is a net exporter.

## G. Thailand

Figure 16 summarizes macroeconomic impacts and their policy implications for Thailand. In the BAU-HT scenarios, GDP would increase by more than five times from $300 billion in 2010 to $1.9 trillion in 2050. Primary energy requirements will increase significantly from 109 Mtoe to 557 Mtoe, and GHG emissions will increase from 0.3 Gt to 1.4 Gt.

In the ACS, the GDP will be $3.3 trillion; however, primary energy requirements and GHG emissions would decrease by 423 Mtoe and 1 Gt compared with the BAU scenario. This implies that improving energy productivity would contribute significantly to economic growth and should therefore be the focus of the energy policy.

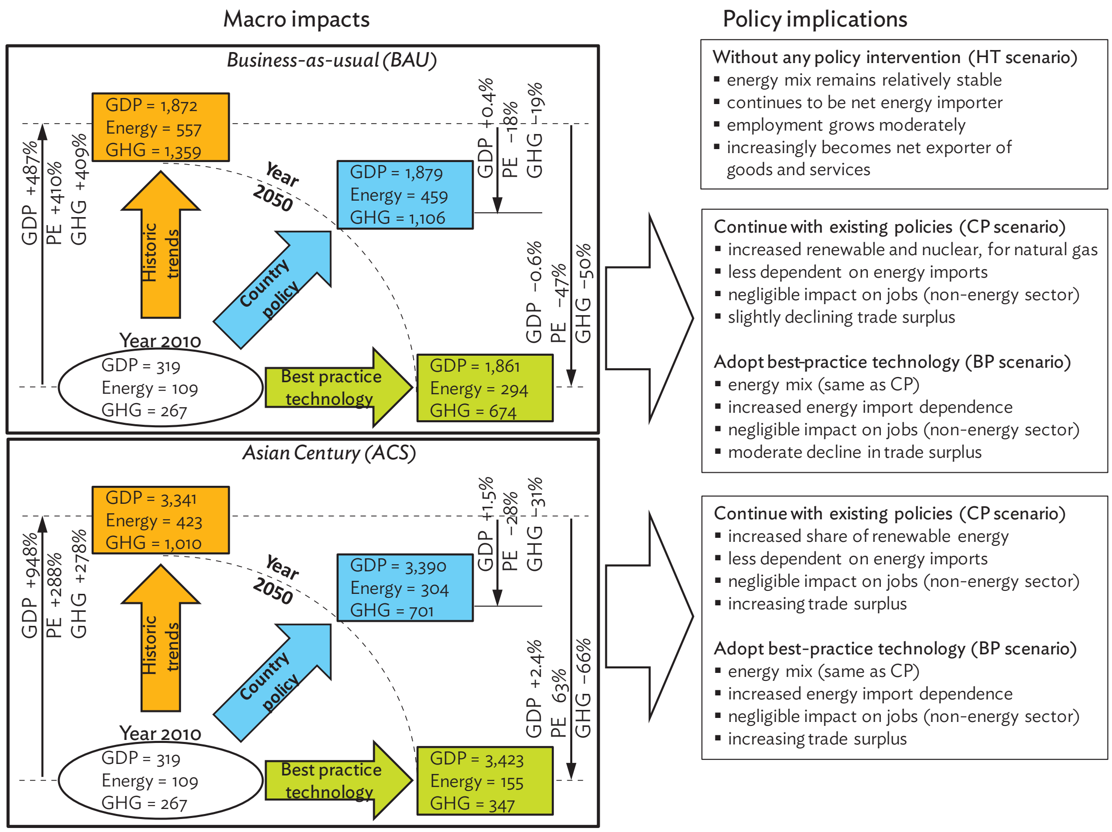
The HT scenario will have a minimal impact on the overall energy mix. Thailand will continue to be a net energy importer given its reliance on imported fossil fuels. The number of jobs would increase moderately in line with increasing GDP. The trade balance would improve considerably in the BAU scenario due to increased exports of goods and services. In the ACS, the country would become a net importer of services, but it would export more industrial goods and agricultural commodities.

By pursuing currently planned policies (CP scenario), Thailand could reduce its primary energy requirements by 28% and GHG emissions by 31%. To achieve this, a significant effort will be needed to reduce the share of imported fossil energy and to increase the share of renewable energy for generating electricity. The share of nuclear power would also increase; it will create the need to import uranium. If the country adopts the BP scenario, primary energy demand could be reduced by 63% and GHG emissions by 66%.

Compared with the HT scenario, the impact of adopting energy efficiency policies on GDP would be favorable similar to the impact on India and Japan. The GDP would increase in the ACS by 1.5% and 2.4% in the CP and BP scenarios, respectively. Implementing current policies under the BAU scenario would also provide a 0.4% gain in GDP. These impacts suggest that policies in the CP and BP scenarios would result in reduced primary energy demand and GHG emissions while maintaining (in fact enhancing) economic growth.

These polices will have a marginally negative impact on employment as there will be 0.45% fewer jobs compared with the HT scenario, but jobs lost in the energy sector due to declining demand would be more than offset by new jobs in other sectors particularly agriculture, industry, and services. The ACS would have a higher positive impact on employment. Higher energy efficiency targets would improve the trade balance particularly in the ACS as all non-energy sectors increase their outputs for international markets.

Figure 16: Summary of Impacts and Policy Implications for Thailand




ACS = Asian century scenario, BAU = business-as-usual scenario, BP = best practice scenario, CP = country policy scenario, GDP = gross domestic product, GHG = greenhouse gas, HT = historic trends scenario, PE = primary energy.
Note: The units of measure used for GDP = $ billion at 2010 prices, GHG = million tons of carbon dioxide equivalent, and PE = million tons of oil equivalent.
Source: Authors' assessment.

## H. Summary

The policy trade-offs among key economic, energy, and environmental attributes over the long term vary across countries. Reductions in energy demand and in GHG emissions would accompany higher GDP growth in all cases in India, Japan, and the Republic of Korea. In the PRC, Indonesia, and Thailand there would be positive impacts on GDP in some cases and negative impacts in others. Malaysia, on the other hand, would face negative impacts on GDP under all the scenarios though some attributes like employment would improve with the implementation of policies. Care must therefore be taken in selecting appropriate energy efficiency targets to achieve policy objectives.

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## Energy Efficiency Improvements in Asia

*Macroeconomic Impacts*

The paper finds that energy efficiency policies in Asia are expected to have a positive impact on private consumption, government expenditures, and investment. Such policies would also lead to a significant rise in trade within the region while reducing trade outside. Without measures to improve efficiency, emissions would increase significantly in most countries studied.

### About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to approximately two-thirds of the world's poor: 1.6 billion people who live on less than $2 a day, with 733 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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