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Removing energy subsidies in developing and transition economies

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Subsidies on the production and consumption of energy are used widely by governments to achieve a range of policy objectives. Many of these are non-economic objectives and include the maintenance of regional employment levels and the provision of adequate supplies of energy to the poor. However, because subsidies distort price signals and fail to reflect the true economic costs of supply, they lead to inefficient levels of production or consumption of the subsidised good. Fossil fuel consumption subsidies, for example, can result in overuse, inefficient use and wastage of energy. And because energy is an important source of pollution, including of greenhouse gases, they can also contribute to environmental damage.

The objective in this paper is to present work in progress on the implications of removing subsidies on the consumption of energy in the developing and transition economies. This set of subsidies has been chosen because of the important contribution these economies make to the projected growth in world energy demand and to potential global environmental issues. The paper considers the impacts of subsidy removal on energy consumption, production and trade as well as on the level of greenhouse gas emissions. The analysis is based on preliminary simulation results from ABARE's Global Trade and Environment Model (GTEM).

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Introduction

Subsidies on the production and consumption of energy are used widely by governments to achieve a range of policy objectives. Some developed economy governments for example cite the maintenance of regional employment objectives as a justification for subsidies on the production of coal. In the developing economies and the economies in transition (comprising the former Soviet Union and eastern Europe), energy consumption subsidies are frequently used to ensure that all members of the population, including the poor, have access to a minimum level of energy consumption. They are also used to encourage industrial growth with low cost energy. Despite increasing reliance on market based pricing mechanisms in developing and transition economies, energy consumption subsidies remain significant. World Bank estimates indicate for example that subsidies on the consumption of fossil fuels in these economies amounted to almost US$50 billion in 1995-96, or 1.3 per cent of GDP (World Bank 1997).

Because subsidies distort price signals and fail to reflect the true economic costs of supply, they lead to inefficient levels of production or consumption of the subsidised good. Fossil fuel consumption subsidies, for example, can result in overuse, inefficient use and wastage of energy (World Bank 1997). And because energy is an important source of pollution, including of greenhouse gases, they can also contribute to environmental damage. Where subsidies are provided directly from the government budget they can also impose a fiscal burden and can lead to crowding out of other more efficient expenditure or investment opportunities. This can have important consequences for economic output and growth.

The objective in this paper is to examine the implications of removing subsidies on the consumption of energy in the developing and transition economies. This set of subsidies has been chosen because of the important contribution these economies make to the projected growth in world energy demand and to potential global environmental issues (International Energy Agency 1998; ABARE 2000). The paper considers the impacts of subsidy removal on energy consumption, production and trade as well as on the level of greenhouse gas emissions. It also provides an assessment of the implications of subsidy removal for total economic output. The analysis is based on simulation results from ABARE's Global Trade and Environment Model (GTEM).

Economic impacts of consumption subsidies

The concept of consumption subsidies used in the paper is broader than direct government payments to consumers. Following analysis by the World Bank (1997) and the International Energy Agency (1999) an energy consumption subsidy is considered to be any policy or action by government that lowers the price paid by energy consumers relative to what it would have been in the absence of that policy or action. These can include policies or actions that allow producers to deliver goods to the market at prices lower than they would

be in the absence of such actions, as well as policies directed specifically at consumers. Included in this list are grants and direct payments, interest rate subsidies, soft loans and loan guarantees, tax instruments such as tax exemptions or deferrals, and administrative regulations that determine the price of energy.

Because consumption subsidies lower the price of energy, consumption of energy will expand beyond its level in the absence of subsidies. Unless the subsidy is designed to overcome a market failure this is likely to be harmful for economic efficiency. In an economy with limited resources, for example, the expansion in production that results from the increased demand following the use of consumption subsidies, will occur at the expense of other more efficient industries (Schneider et al. 1999). Equally, there are significant negative externalities in the form of environmental damage associated with the consumption of energy that are exacerbated by the impacts of subsidies. For example, fossil fuel combustion releases pollutants such as sulfur dioxide, nitrogen oxides and particulates into the atmosphere that can cause acute health problems as well as damage to structures and natural resources, including forests. Fossil fuel combustion is also the major contributor to greenhouse gas emissions. In such cases the removal of energy consumption subsidies can both increase economic efficiency and reduce environmental damage.

Because of the importance of energy in the world economy, the removal of energy consumption subsidies is also likely to have significant general equilibrium effects that make it difficult to predict the impacts of reform. Issues of importance in this context are the interaction between the markets for coal, gas and oil products and other sectors of the economy. When energy prices rise following the removal of subsidies, for example, there will be impacts on the costs of production of other goods, especially energy intensive goods. Relative price changes will also affect the competitiveness of goods on world markets and may lead to changes in trade flows. Also of importance is the extent of support or protection in other parts of the economy that can hinder the efficient reallocation of resources following the removal of subsidies. All of these impacts can have important consequences for economic growth.

Measuring energy consumption subsidies

Measuring energy consumption subsidies is complicated by the variety of policy instruments that governments can use to reduce the costs of an activity as well as by the often poor quality of available data. In these circumstances the most common method used is to adopt the ‘price gap’ approach (World Bank 1997, International Energy Agency 1999).

The basic idea underlying the price gap method is that subsidies to consumers lower end use prices and result in higher consumption levels. End use prices are compared with a reference price to measure the price gap. The reference price represents the efficient price that would prevail in a market undistorted by subsidies and corresponds to the opportu-

nity cost of the last unit of the good consumed. The reference price is usually taken as the border price adjusted for transport and distribution margins and any country-specific taxes in the case of traded goods, or the long run marginal cost of production in the case of goods that are not significantly traded. The approach is designed to capture the net effect of all the different policy instruments that affect a good's price (World Bank 1997). The price gap can be presented as a dollar value of subsidy per unit of subsided good or as a percentage of the reference price.

A number of issues and assumptions are important when using the price gap approach as a measure of subsidies. For example, the estimation of the reference price plays a key role in the calculation of the price gap and hence the size of the subsidy. Different reference prices can produce very different subsidy estimates. The choice of exchange rate used to compare domestic and international prices is also important. The use of official exchange rates will give very different results in some economies compared with the use of purchasing power parities. Purchasing power parity rates may differ from official rates because the relative cost of purchasing non traded goods can differ significantly between countries. Problems can also exist with the measurement of end user prices, especially where there are multiple prices in the one economy. This was the case for example in China's two-tiered coal market before the implementation of economic reform.

For the purpose of this study estimates of energy consumption subsidies have been taken from the World Bank (Rajkumar 1996). These data have been chosen because they provide a reasonably comprehensive set of subsidies for the developing and transition economies. The subsidies are measured in 1995-96, corresponding closely with the base year in GTEM. More recent data from the International Energy Agency (International Energy Agency 1999) have also been consulted. These, however, cover fewer countries than the World Bank data and they are less compatible with the GTEM country aggregation. Nevertheless, in most cases both sets of data indicate similar energy subsidy magnitudes. A brief summary of the World Bank data is presented in table 1. A more detailed data set giving estimates of fossil fuel subsidies by three classes of user — the power sector, industry and households — was provided directly to ABARE by the World Bank. It is these latter data that are used in the modeling exercise.

Table 1: **Subsidy rates on energy commodities, 1995-96**

	Petroleum products	Gas	Coal	Total
Russia		33	47	20
Other FSU	5	62	33	44
Eastern Europe		36	26	20
China	1		11	7
India			12	1
Korea			5	
Thailand	4			4
Indonesia	12			9
Mexico		39		4
South Africa	6			4

Source: Rajkumar (1996); World Bank spreadsheet provided to ABARE.

The data in the table indicate that subsidies are widespread throughout the developing and transition economies. Some of the highest subsidy rates occur in the former

Soviet Union and eastern Europe. Contrary to some expectations average subsidy rates on energy consumption in China are moderate.

Modeling energy subsidies

The analysis in this paper is based on applications of ABARE's Global Trade and Environment Model (GTEM). GTEM is a multiregion, multisector, dynamic general equilibrium model of the world economy developed to address global change policy issues. It is derived from the MEGABARE model (ABARE 1996) and the GTAP model (Hertel 1997). The model code is available on ABARE's website at http//www.abareconomics.com.

GTEM is an appropriate framework for analysing complex issues such as subsidies because it takes into account the interactions between different sectors in an economy, as well as interactions between economies, and estimates the impacts of policies on key economic variables. These include the price of consumer goods and inputs into production, sectoral and regional output, trade and investment flows and, ultimately, regional income and expenditure levels. In addition, the intertemporal nature of GTEM permits the impacts of policies to be tracked over time.

GTEM also contains a sophisticated greenhouse gas emissions accounting framework. GTEM models emissions of three greenhouse gases – carbon dioxide, methane and nitrous oxides. This allows the impacts of policies such as the removal of subsidies on emissions of greenhouse gases to be tracked.

The GTEM database includes a high level of commodity disaggregation, including detailed treatment of energy and energy related sectors. This enhances the model's ability to analyse the impacts of policy changes on the energy sector. At its most disaggregated level, the GTEM database includes 45 regions and 50 industries or sectors. The database used to simulate the removal of subsidies in this paper has been aggregated to the 17 regions and 15 industries presented in table 2. The commodity aggregation has been chosen to include the three fossil fuels, petroleum products and the major energy intensive products that are likely to be affected by changes in subsidy policies. The regional aggregation identifies the major economies for which World Bank subsidy data are available as well as other major energy consuming and trading economies.

As discussed earlier, the starting point data on energy subsidies are from the World Bank. Where necessary, these have been aggregated to a regional and commodity structure that conforms with the GTEM database. For example, disaggregated data on subsidies to individual petroleum products (kerosene, gasoline, diesel, heavy fuel oil and light fuel oil) have been aggregated to GTEM's petroleum and coal products industry. Data on Middle East and Venezuelan subsidies have not been included in the GTEM database. This is because the magnitude of the price gap for petroleum products in these economies is arti-

Table 2: **Regions and sectors used in GTEM**

	Regions		**Sectors**
1	Australia	1	Coal
2	Canada	2	Oil
3	United States	3	Gas
4	Japan	4	Petroleum products
5	European Union	5	Electricity
6	Former Soviet Union	6	Iron and steel
7	Eastern Europe	7	Nonferrous metals
8	China	8	Chemicals, rubber and plastics
9	Indonesia	9	Non metallic mineral products
10	Korea	10	Other minerals
11	Thailand	11	Other manufacturing
12	India	12	Agriculture
13	South Africa	13	Processed food
14	Middle East	14	Trade and transport
15	Mexico	15	Services
16	Argentina		
17	Rest of World		

ficially large as a result of OPEC policies that maintain prices above long run marginal costs of production.

GTEM requires a reference case or a 'business as usual' simulation against which the impacts of a policy change can be measured. The reference case projects the growth in key variables in each region in the absence of any policy changes. In this paper the reference case represents the likely outlook to 2010 for world energy consumption in the absence of any policies to reduce or remove energy consumption subsidies in developing and transition economies.

In developing a reference case, assumptions have been imposed for the likely rates of growth in GDP over the projection period. The GDP growth rates used in the paper are based on historical data from 1995 to 1998 from the International Monetary Fund (IMF 1999). Short term projections to 2003 are derived from GTEM's GDP module and have been adjusted to take account of the Asian economic downturn that began in late 1997. Projected long term growth rates from 2004 to 2010 have been derived from GTEM's convergence procedure. Under this procedure, per worker GDP in all economies is assumed to converge toward that of the United States in the very long term. This hypothesis is based on a number of econometric studies that have found convergence of per worker GDP between economies to varying degrees (Baumol 1986; Barro and Sala-i-Martin 1992; Mankiw, Romer and Weil 1992; Bernard and Jones 1996). The GDP assumptions used in the paper are shown in table 3.

The shares of electricity production by different fuels (coal, oil, gas, nuclear, hydropower and other renewables) are also determined exogenously in the reference case. The shares to 2010 are determined on the basis of an assessment of government and other projections of the fuel mix for power generation (table 4).

Table 3: **GDP assumptions, reference case, average annual growth, %**

	1995–2000	2000–2010
Australia	4.18	3.55
Canada	3.44	3.26
USA	3.95	2.35
Japan	1.11	2.00
European Union	2.23	2.85
Former Soviet Union	–1.03	3.82
Eastern Europe	2.97	4.09
China	8.12	6.52
Indonesia	–0.07	5.21
Korea	4.65	5.31
Thailand	0.99	5.24
India	6.16	6.07
South Africa	1.75	4.27
Middle East	3.65	4.53
Mexico	4.94	4.46
Argentina	3.13	4.35

The results of the policy simulation presented in this paper represent the estimated impacts on key energy variables following the removal of energy consumption subsidies in the developing and transition economies. The simulation assumes that subsidies on coal, gas and petroleum products are removed progressively over a five year period from 2001 to 2005. The impacts on variables are projected to 2010. The estimated impacts of policy changes on economic variables are defined as the percentage deviations between the equilibrium levels of those variables in the reference case and their equilibrium levels in the policy simulation.

For example, the impact of subsidy removal on the level of energy consumption in an economy can be identified by comparing the growth in energy consumption in the policy

Table 4: **Share of electricity generated by each fuel under the reference case, %**

	Coal		Oil		Gas		Nuclear		Other	
	1995	2010	1995	2010	1995	2010	1995	2010	1995	2010
Australia	77.0	74.0	1.7	2.0	10.3	16.0	0.0	0.0	11.0	8.0
Canada	16.1	15.6	1.9	1.9	4.3	6.7	17.4	16.6	60.3	59.3
USA	51.2	49.4	2.4	1.0	14.8	26.3	19.9	13.7	11.7	9.6
Japan	17.5	22.0	22.3	9.0	19.3	22.0	29.4	34.0	11.5	13.0
European Union	34.2	23.8	9.4	8.8	10.8	22.8	35.0	30.7	10.7	14.0
Former Soviet Union	21.8	14.0	8.4	6.0	36.8	48.0	14.1	12.0	19.0	20.0
Eastern Europe	63.1	51.0	4.3	5.0	7.4	18.0	16.0	11.0	9.2	15.0
China	73.4	73.0	6.1	4.0	0.2	3.0	1.3	2.0	19.0	18.0
Indonesia	28.0	32.2	17.0	16.2	35.5	39.9	0.0	0.0	19.4	11.7
Korea	34.0	34.0	20.8	7.0	9.6	23.0	32.9	32.9	2.8	3.1
Thailand	18.5	33.0	30.4	6.0	42.2	54.0	0.0	0.0	8.8	7.0
India	72.0	70.0	2.9	2.0	5.9	8.0	1.8	2.0	17.4	18.0
South Africa	92.9	93.5	0.0	0.0	0.0	0.0	6.0	5.5	1.0	1.0
Middle East	11.3	14.0	37.7	25.7	38.4	44.8	0.0	0.0	12.5	15.4
Mexico	9.4	14.0	51.4	27.0	11.9	33.0	5.5	3.0	21.8	23.0
Argentina	2.5	3.3	4.8	4.2	40.0	45.1	10.9	12.3	41.7	35.0

Figure 1: **Deviation from the reference case in a GTEM simulation**

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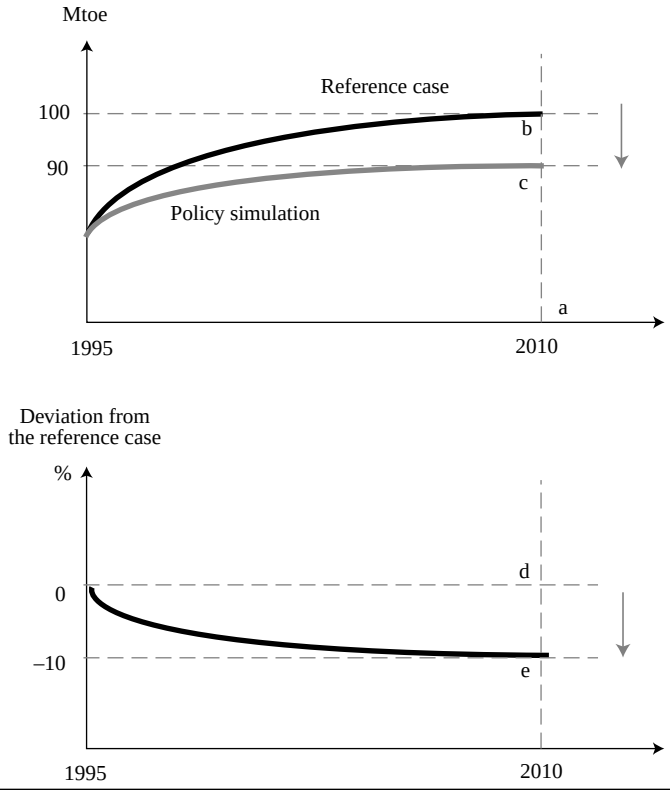


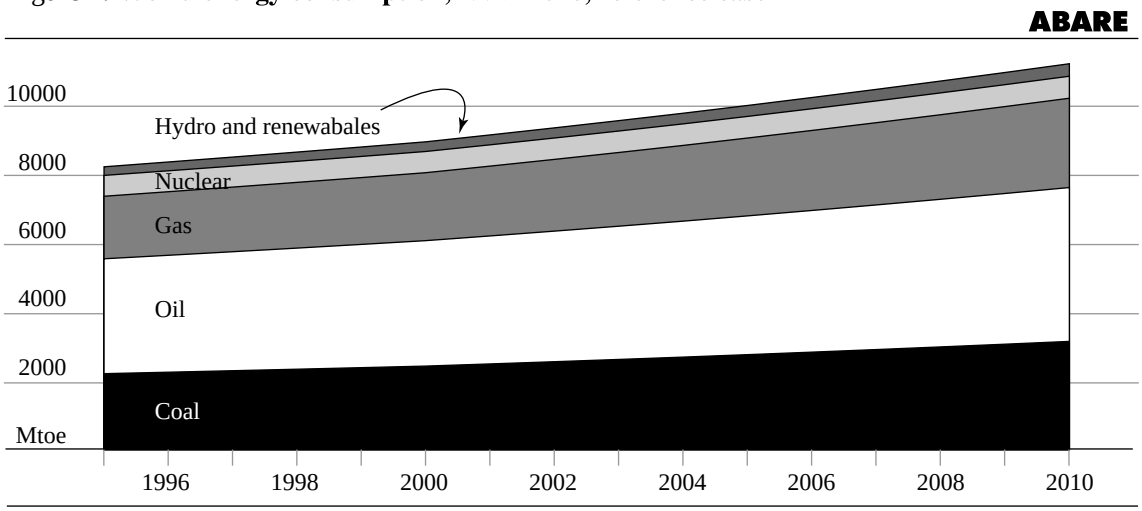
simulation against energy consumption growth in the reference case, as illustrated in figure 1. To provide a numerical example, consider that reference case energy consumption at 2010 is projected to be 100 million tonnes of oil equivalent (distance *ab*). Following the removal of energy consumption subsidies, energy consumption at 2010 is projected to be 90 million tonnes of oil equivalent (distance *ac*). This corresponds to the 10 per cent decrease in energy consumption from the reference case (distance *de*). Hence the effect of the removal of subsidies in this example is to decrease energy consumption by 10 per cent compared with the reference case projection for 2010.

Reference case projections

As well as providing a 'business as usual' case against which the impacts of subsidy removal can be compared, the reference case indicates the importance of developing economies in the world energy outlook and their increasing share of world greenhouse gas emissions.

Global energy consumption is projected to grow strongly over the projection period at an average annual rate of 2 per cent between 1995 and 2010 (figure 2). Total energy consumption is 11.3 billion tonnes of oil equivalent at 2010, compared with 8.2 billion tonnes of oil equivalent in 1995. Oil continues to satisfy the largest share of energy demand and is driven mainly by continued strong growth in the demand for transport fuels in developed,

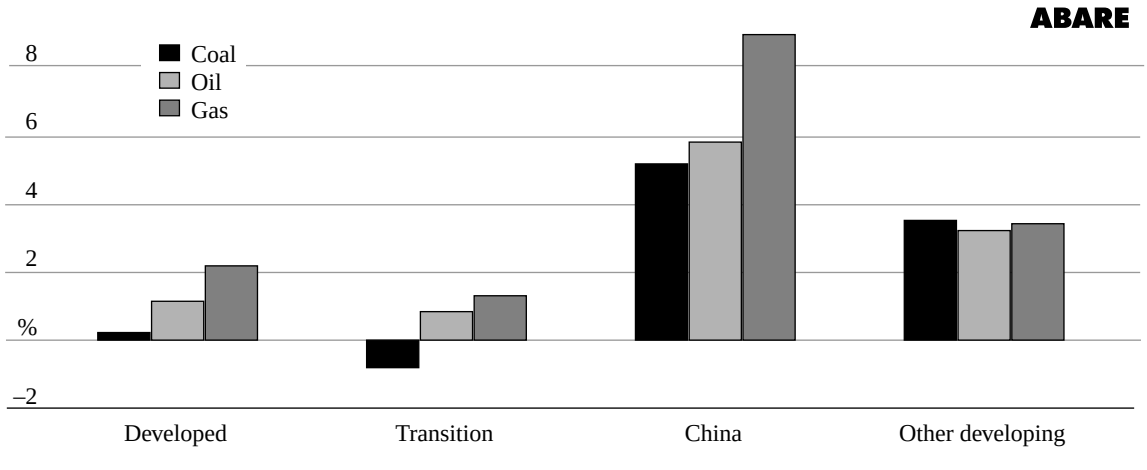
Figure 2: **World energy consumption, 1995–2010, reference case**



transition and developing economies. Coal remains the second most important primary fuel source. Growth in coal demand is underpinned by strong growth in power generation, especially in the developing economies. Gas demand grows more rapidly than the other fossil fuels and increases its share of energy consumption in all regions. This reflects the rapid increase in gas fired power generation. The shares of nuclear, hydropower and other renewable energy sources fall over the projection period, mainly reflecting continued problems with siting of nuclear and hydro projects and the relatively high costs of non-fossil fuel power generation.

Most of the absolute growth in world demand for fossil fuels between 1995 and 2010 occurs in the developing countries (figure 3). This reflects strong growth in economic output, high population growth and the increased consumption of personal energy services such as transport, space heating and electrical appliances which accompany rising per person incomes. Energy consumption increases significantly less in the developed and

Figure 3: **Average annual growth in fossil fuel consumption, 1995–2010, reference case**



transition economies, mainly because economic and population growth rates are lower in these regions.

Growth in fossil fuel consumption results in increasing emissions of greenhouse gases over the projection period. This is strongest in the developing economies where economic activity and fossil fuel consumption rise rapidly. China, which is the largest emitter of greenhouse gases among the developing countries, has one of the highest projected emissions growth rates. China's share of global greenhouse gas emissions is expected to increase from around 15 per cent in 1995 to 22 per cent in 2010. Emissions from India also grow strongly and India's share of global emissions rises from 5 per cent to 6 per cent over the projection period. Emissions from the transition economies fall between 1995 and 1999 and grow slowly between 1999 and 2010 as a result of the ongoing slow economic growth in significant parts of this region.

Simulation results

Overview of impacts

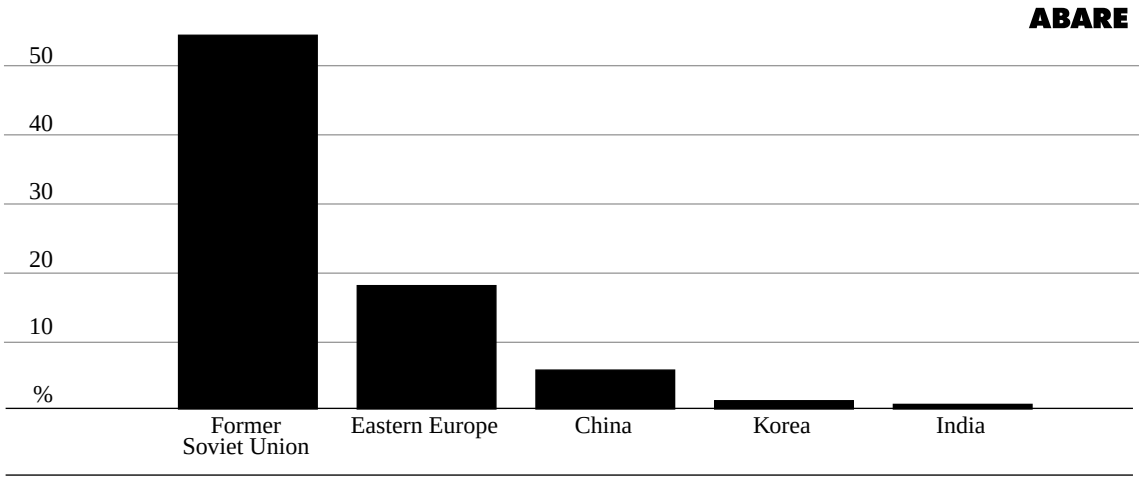
When subsidies on the consumption of energy are removed there will be complex interactions within an economy, including on energy prices, consumption and trade. Because energy is a fundamental input to production processes these will be felt in the wider economy as well as by households. And because energy is widely traded, the changes that occur in energy subsidising economies will be transmitted to some extent to world markets. The chain of impacts arising from the removal of subsidies can be summarised as follows:

- in economies where energy subsidies are removed, the consumer price of energy rises in the first instance;
- as a result, consumption of energy in these economies falls;
- where these economies are also large producers of energy, some domestic production of energy will be diverted to world markets;
- the combination of lower energy consumption in economies that remove subsidies and increased supplies on world markets leads to downward pressure on world energy prices;
- energy consumption in other economies rises in response to lower prices;
- greenhouse gas emissions fall in economies that remove subsidies but this is partially offset by a rise in emissions from other economies.

Energy price impacts in economies that remove subsidies

The simulation results show that in economies that remove subsidies, most consumer prices for energy rise relative to the reference case at 2010. The magnitude of the increase is

Figure 4: **Change in coal prices following removal of subsidies, 2010, relative to the reference case**



related to the size of the subsidy. In China, for example, where subsidies on coal are moderate, average consumer coal prices are 6 per cent higher at 2010 when subsidies are removed than in the reference case (figure 4). In India, where the overall structure of coal subsidies is lower than in China, consumer prices are almost one per cent higher at 2010 than in the reference case and average consumer prices also rise in Korea following the removal of a small subsidy on household consumption of coal. Coal subsidies in the former Soviet Union and eastern Europe are larger than elsewhere and, as a result, consumer price rises in these markets relative to the reference case are more significant.

A similar situation is apparent in gas markets (figure 5). The major subsidisers of gas are Indonesia, where the largest subsidies are provided to the household sector, and the former Soviet Union and eastern Europe. In these regions, households are also the most significant beneficiaries of gas subsidies. When these are removed consumer gas prices by 2010 rise predictably in Indonesia and the former Soviet Union relative to the reference case but

Figure 5: **Change in gas prices following removal of subsidies, 2010, relative to the reference case**

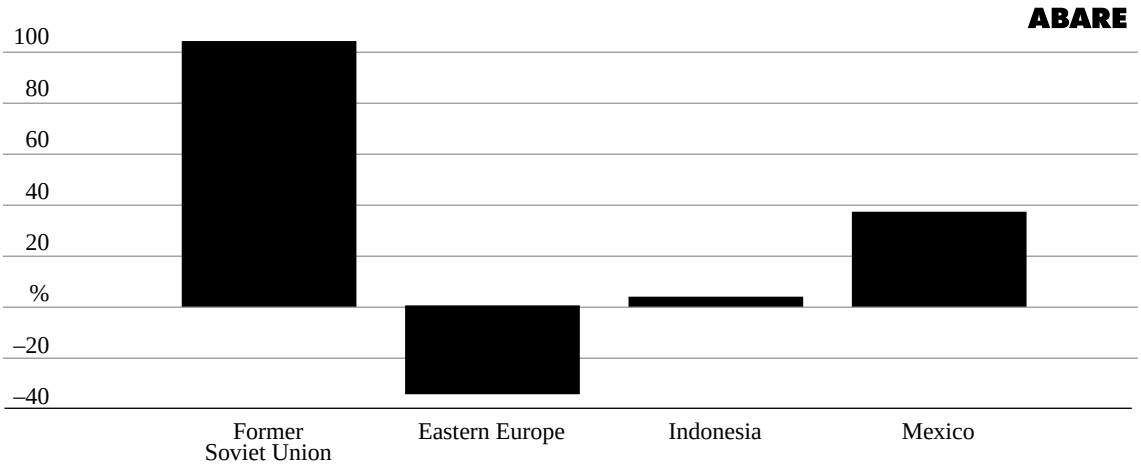
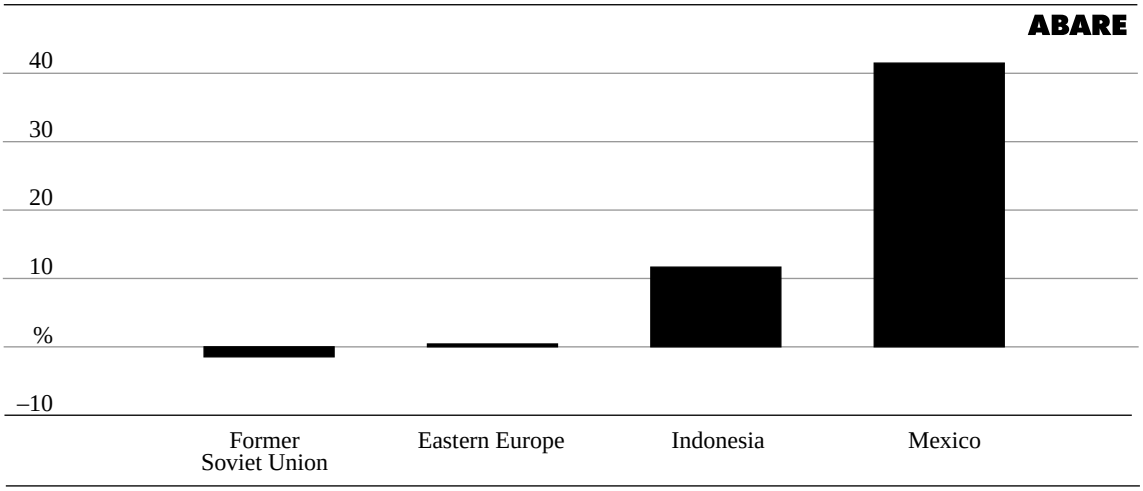


Figure 6: **Change in petroleum product prices following removal of subsidies, 2010, relative to the reference case**



actually fall relative to the reference case in eastern Europe. This is because the former Soviet Union diverts production from domestic to export markets as domestic consumption contracts and eastern European economies are able to purchase lower priced imported gas. Mexico also provides large subsidies to gas users in all sectors and consumer gas prices rise strongly relative to the reference case after subsidy removal.

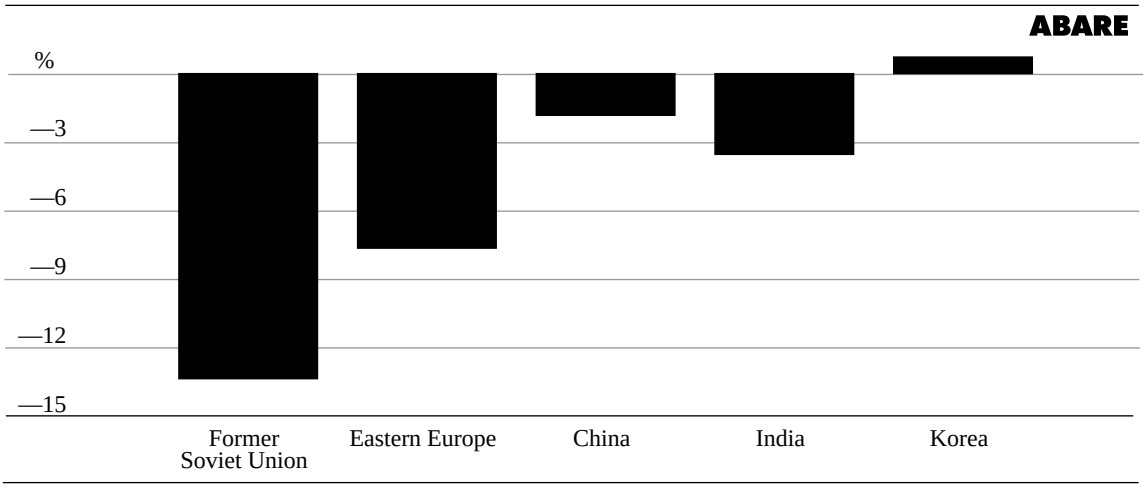
In the petroleum products sector subsidies are more widespread across economies and end use sectors than subsidies on other fuels. The highest subsidy rates are provided to power generation and industry in Mexico as well as to the power sector in the former Soviet Union and to households in India. The latter include subsidies on LPG and kerosene. When subsidies are removed consumer prices at 2010 are higher than in the reference case in most economies (figure 6). The exceptions are India and the former Soviet Union where subsidies are only applied to a small proportion of total consumption. In these economies the rise in average domestic consumer prices is offset by falls in world prices.

Energy consumption impacts

As a result of energy price rises following the removal of subsidies, energy consumption falls in most of the subsidising countries at 2010 relative to the reference case. The size of the consumption fall is related to the magnitude of the price rise and the relevant price elasticity of demand. Because subsidies of different magnitudes are often applied to different fuels in the same economy there are also shifts in relative fuels prices that lead to inter-fuel substitution within that economy.

In the former Soviet Union coal consumption at 2010 is 13 per cent below the reference case following the removal of large subsidies and the consequent significant increase in consumer coal prices (figure 7). In eastern Europe where coal subsidies are also high, total coal consumption at 2010 is 8 per cent below reference case levels. The same applies to the

Figure 7: **Change in coal consumption following removal of subsidies, 2010, relative to the reference case**

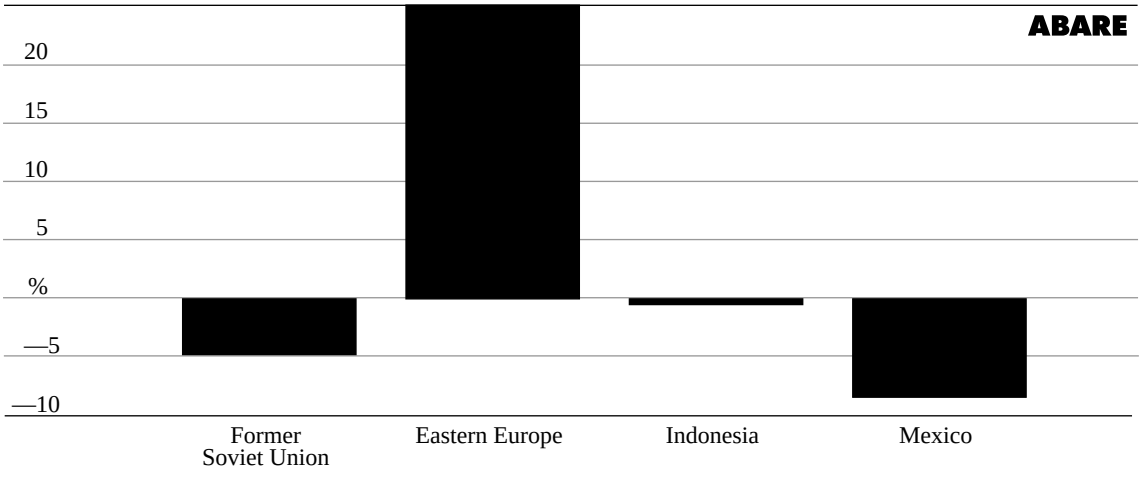


other coal subsidising economies except Korea where coal consumption rises relative to the reference case following the removal of a small subsidy on household consumption of coal. This is because the overwhelming majority of Korea's coal consumption is from imports and Korea benefits from lower world prices for coal.

In the case of gas, consumption falls relative to the reference case in all the subsidising economies following the rises in consumer prices, with the exception of eastern Europe (figure 8). This occurs because, as discussed above, when consumption of gas in the former Soviet Union declines, domestic production is diverted to export markets, principally eastern Europe. The consumer price of gas is lower in the eastern European economies at 2010 than in the reference case and their demand for gas rises.

Subsidies on the consumption of petroleum products are more widespread across economies and end use sectors than subsidies on other fuels. Consumption falls relative to the refer-

Figure 8: **Change in gas consumption following removal of subsidies, 2010, relative to the reference case**

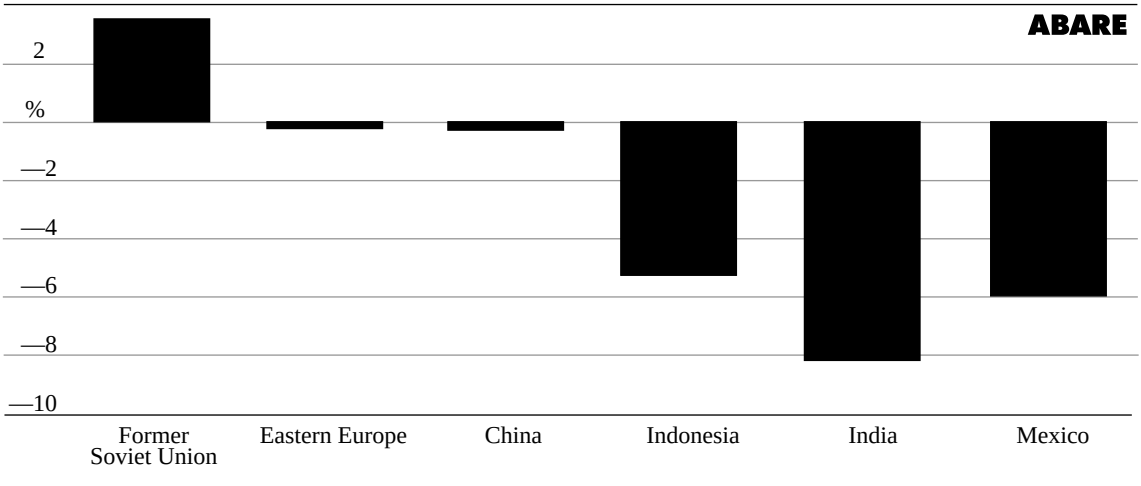


ence case in all economies except the former Soviet Union following the removal of subsidies (figure 9). In the case of the former Soviet Union, where world price effects lead to lower average prices for petroleum products, the consumption of petroleum products at 2010 is 1.5 per cent above reference case levels.

In China, the World Bank estimates that there is a small average subsidy on petroleum products of 1 per cent, although the subsidy on petroleum products used in the power sector is 8 per cent. When this is removed there is little change in the consumption of petroleum products at 2010 relative to the reference case, mainly because an even larger subsidy of 16 per cent on coal consumption in the power sector is removed at the same time. This increases the relative attractiveness of oil in power generation. Petroleum products also do not decline strongly relative to the reference case in China because a large proportion of demand is from the transport sector where fuel substitution policies are limited.

The electricity sector provides a useful example of the general potential for interfuel substitution following subsidy removal as electricity can be generated from coal, oil and gas as well as nuclear, hydro and other renewables. As a result, substitution possibilities are greater in electricity generation than in other economic activities such as transport. The results indicate that the majority of economies that subsidise the use of heavy fuel oil in the power generation sector shift out of that technology to some extent following the removal of subsidies. In Argentina, for example, the removal of a 10 per cent subsidy on petroleum products in electricity generation results in a greater shift into gas fired electricity at 2010 than in the reference case. In Mexico, the removal of both petroleum product and gas subsidies in the electricity sector leads to some increase in the share of coal fired power generation at 2010 relative to reference case levels. The increase in coal use in Mexico is met from imports from the United States and Canada. Similar changes occur in India when a subsidy on coal use in electricity generation is removed. At 2010, the share of coal in

Figure 9: **Change in petroleum product consumption following removal of subsidies, 2010, relative to the reference case**

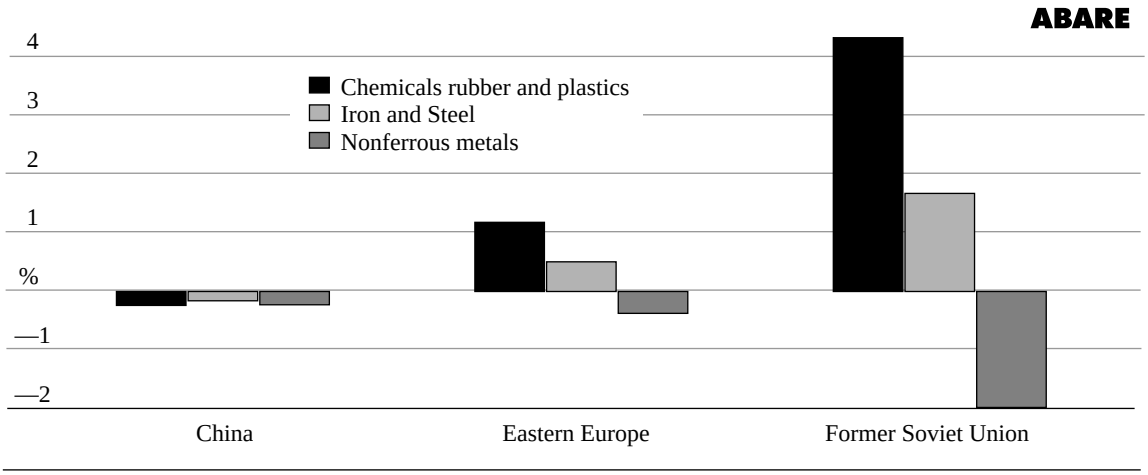


total electricity output is lower than in the reference case while gas fired generation increases its share of the total.

Impacts on energy intensive industries

One of the major factors driving the changes in energy consumption that result from the removal of subsidies is the shift in patterns of energy intensive production. As figure 10 indicates, there are significant declines in energy intensive output at 2010 relative to the reference case in some economies. In the case of the iron and steel industry, for example, production falls in China, Indonesia, India and South Africa relative to the reference case. The outlook is similar for nonferrous metals production although production also declines in the former Soviet Union and eastern Europe. These declines relative to the reference

Figure 10: **Change in the production of selected energy intensive products, 2010, relative to the reference case**

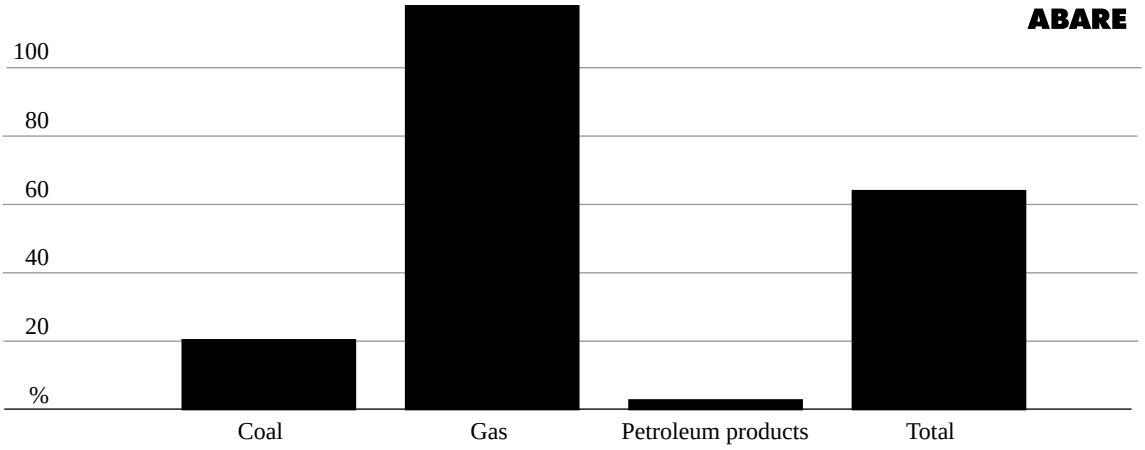


case occur because the increasing price of energy inputs to production increases the cost structure in these industries and reduces their competitiveness. In the former Soviet Union and eastern Europe some increases in energy intensive outputs occur because of the price declines they experience in petroleum products and natural gas respectively. For example, at 2010 the production of chemicals, rubber and plastics in both regions is higher than in the reference case because these industries are large users of petroleum products and gas.

Trade and world price impacts

Given the changes in prices and consumption that result from subsidy removal there are consequential impacts on the domestic production of energy and on energy exports. In most cases where economies that subsidise energy consumption are also large producers of energy, energy production does not fall as significantly relative to the reference case as consumption. There is a shift in production from domestic to export markets. This occurs because the price that producers receive from domestic consumers falls relative to the

Figure 11: **Change in exports of fossil fuels from economies removing subsidies, 2010, relative to the reference case**



prices they can receive on export markets. On average, exports of coal from economies that remove subsidies are 20 per cent higher at 2010 than their level in the reference case and exports of petroleum products are 3 per cent higher (figure 11). In the case of gas, exports rise significantly above reference case levels because of the impacts of gas exports from the former Soviet Union. Eastern Europe and the European Union are the recipients of most of the additional gas exports.

Increased exports of energy relative to the reference case from the economies where subsidies have been removed exert downward pressure on world energy prices. For example, the world price of coal at 2010 is 4 per cent below its level in the reference case and the average world price of petroleum products is 2 per cent lower (figure 12). Because by far the greatest increases in exports occur in gas markets, the world price for gas falls further than for other fuels relative to the reference case.

Figure 12: **Change in world prices following removal of subsidies, 2010, relative to the reference case**

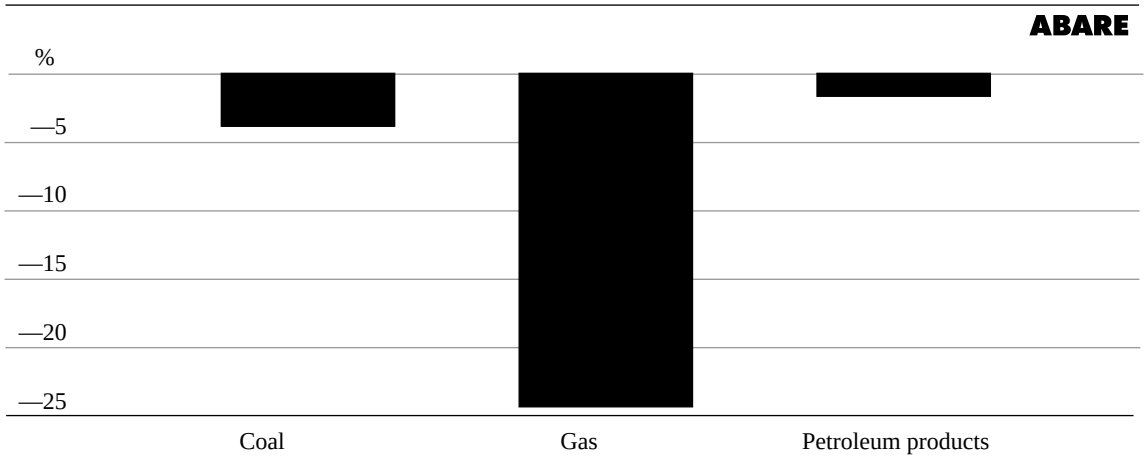
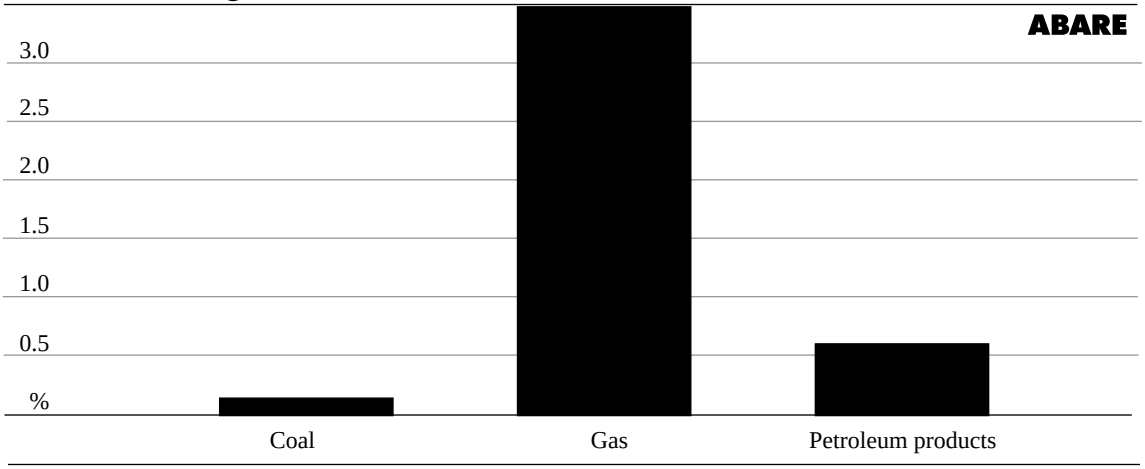


Figure 13: **Change in consumption of coal, gas and petroleum products in developed economies following removal of subsidies, 2010, relative to the reference case**



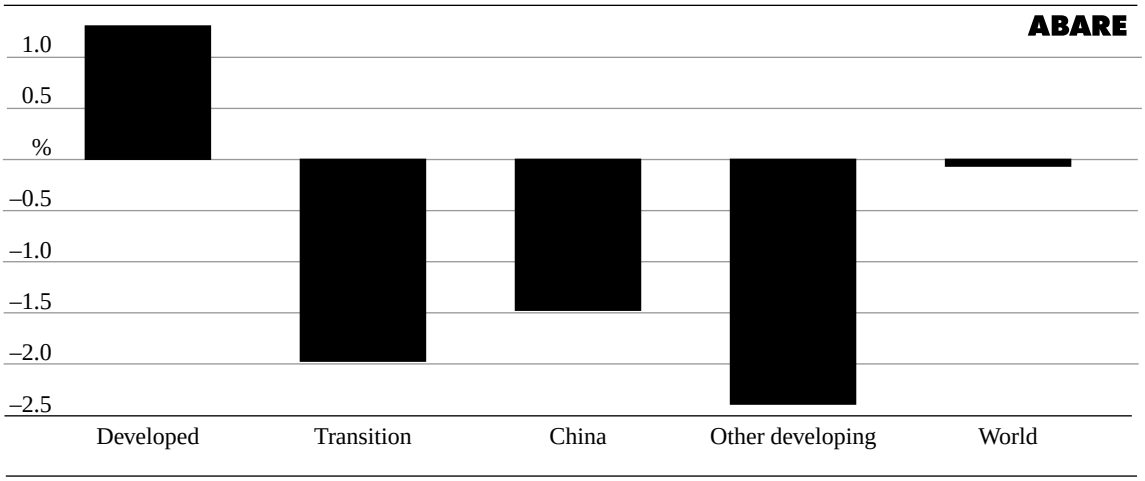
Impacts on other regions

The downward impacts on world energy prices lead to increases in energy consumption relative to the reference case in the developed economies and in other economies that do not subsidise energy consumption. For example, coal consumption in the developed economies at 2010 is 0.15 per cent higher than in the reference case and petroleum products consumption rises by 0.6 per cent (figure 13). Gas consumption rises more strongly by 2010 relative to the reference case because of the large impacts on the world price of this fuel.

Lower prices for energy commodities mean that the production of energy intensive goods in developed economies becomes relatively more competitive and the output of these goods rises. In Australia, for example, falling world consumption of coal leads to reduced Australian coal exports relative to the reference case. Australian coal exports are projected to be 1.4 per cent lower in 2010 than in the reference case but this still implies strong growth over the period from 1995. However, reduced energy prices and improved competitiveness in production of energy intensive goods relative to developing country producers leads to an expansion in energy intensive industry in Australia by 2010 relative to the reference case. For example, production of nonferrous metals in Australia at 2010 is 1.4 per cent higher than in the reference case and exports of nonferrous metals are 1.7 per cent higher than reference case levels. Despite the reduction in coal exports, Australia benefits on balance from the expansion in the industrial sector and gross domestic product at 2010 is slightly above its level in the reference case.

Increases in developed country energy consumption following the removal of subsidies do not completely offset the declines in the developing and transition economies. As a result, world fossil fuel consumption at 2010 is below reference case levels (figure 14).

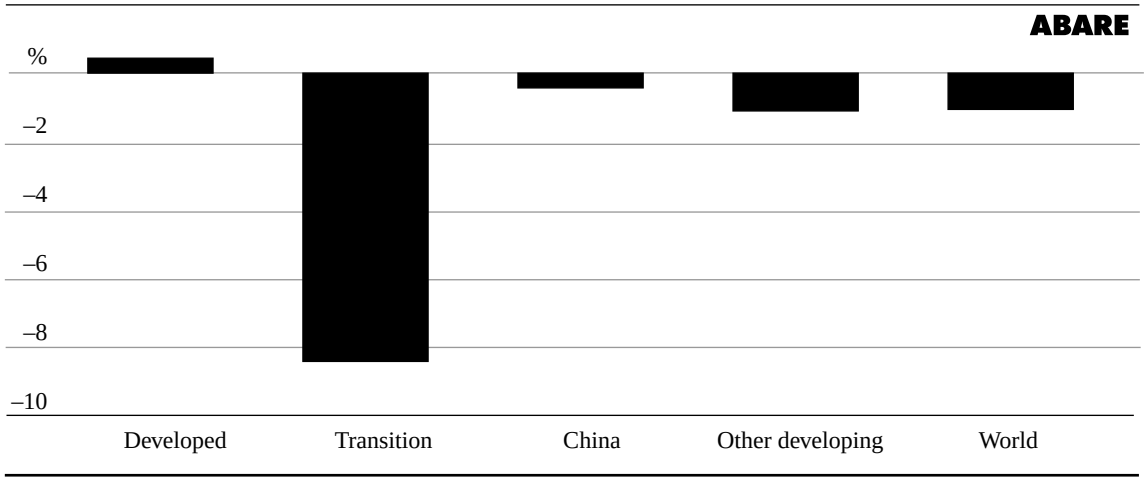
Figure 14: **Change in consumption of fossil fuels following removal of subsidies, 2010, relative to the reference case**



Impacts on greenhouse gas emissions

Because the combustion of fossil fuels is the most important contributor to greenhouse gas emissions, any changes in energy consumption that arise from the removal of energy subsidies will have important consequences for world emissions. Following the decline in energy consumption in the developing economies after energy subsidies are removed, emissions in this region fall by around 1 per cent at 2010 relative to the reference case (figure 15). Emission reductions are much larger in the transition economies because energy consumption falls are greater. However, in the developed economies where energy consumption rises relative to the reference case, greenhouse gas emissions at 2010 are also higher than reference case levels. The net effect at the world level is that greenhouse gas emissions at 2010 are 1.1 per cent lower than they would be if subsidies remained in place.

Figure 15: **Change in emissions of greenhouse gases following removal of subsidies, 2010, relative to the reference case**



It should be noted that these estimates of emission reductions are based on the simulation results only and that these exclude any consideration of possible greenhouse gas emission response policies in economies that are Annex B parties to the Kyoto Protocol. If Annex B parties to the protocol implemented emission reduction policies simultaneously with the removal of subsidies in other economies, the impacts on emissions could be different from those outlined above.

It should also be noted that the impact on world emissions reported in this paper are considerably smaller than other research has found. The International Energy Agency, for example, estimates that following the removal of subsidies in eight large developing countries, world emissions of greenhouse gases could fall by 4.6 per cent (International Energy Agency 1999). However, the nature of the analysis in the two studies is quite different with the International Energy Agency adopting a partial, single country approach to analysing energy consumption and greenhouse gas emission impacts. That is, no account is taken in that study of the potential for interfuel substitution in an economy that could reduce the impacts of subsidy removal on energy consumption and emissions. The analysis is also likely to overstate the potential reduction in emissions because it ignores the impact of lower demand in economies that subsidise fossil fuels on world fossil fuel prices. As analysis in this paper shows, this could have a marked impact on energy consumption and greenhouse gas emissions in these economies.

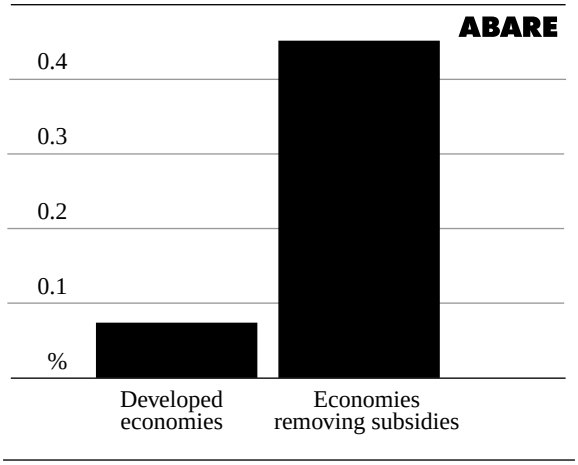
Further differences in the results arise because the International Energy Agency considers the impact of subsidy removal only on carbon dioxide emissions whereas GTEM includes emissions of the three major greenhouse gases. There will be a greater percentage reduction in emissions when only carbon dioxide is included because it is the largest source of emissions in the energy sector. Finally, the energy subsidy data set used in the two studies is different and in some cases the International Energy Agency estimates of subsidies are higher than those of the World Bank. In China, for example, the International Energy Agency includes a subsidy of 73 per cent on the consumption of coking coal and 8 per cent on steaming coal. The World Bank average subsidy for coal consumption is 11 per cent, considerably less than the weighted average of the International Energy Agency's estimates. Because coal is the most emission intensive of the fossil fuels this will result in much larger estimates of emission reductions when International Energy Agency estimates of subsidies are used. And because China is the world's largest emitter of greenhouse gases after the United States, there will be a larger impact on potential world emission reductions.

Economic impacts

Because the removal of subsidies has impacts on prices, the structure of production and trade flows, there will be consequences for economic efficiency and growth. These will extend not only to economies that subsidise energy but to others that are affected by the

removal of subsidies through price and trade linkages. There will be additional benefits to economies that subsidise energy where subsidies are provided as direct transfers from government. In this case the removal of subsidies will reduce the fiscal burden and may lead to increased opportunities for growth-creating investment.

Figure 16: **Change in real GDP following removal of subsidies, 2010, relative to the reference case**



The simulation results indicate that both economies that subsidise energy consumption and other economies benefit when subsidies are removed. In the economies that remove subsidies, GDP at 2010 is almost half of a per cent higher than in the reference case (figure 16). In the developed economies where access to cheaper energy provides a competitive advantage, GDP rises by 0.1 per cent relative to the reference case.

It is worth noting, however, that there are some impacts of the removal of energy consumption subsidies that cannot be captured in GTEM. In the standard GTEM framework it is only possible to evaluate the resource allocation or efficiency benefits of removing energy subsidies. The productivity benefits that might also be generated by removing subsidies are not captured although these could be significant. For example, the removal of energy subsidies in developing and transition economies, by resulting in greater transparency and accountability, could lead to better investment decision making in energy exploration, production and supply as well as more efficient introduction of technology (International Energy Agency 1999). This could have the effect of increasing economic growth beyond the estimates reported above.

Conclusions

The results presented in this paper indicate that there are complex interactions within an economy when an economic policy instrument such as a subsidy on the consumption of energy is removed. These include direct impacts on the price of the formerly subsidised good and consequential impacts on the level of its consumption. Where subsidies are removed on more than one fuel there may be changes in the relative prices of alternative fuels that can be used in the same end use, such as electricity generation, that lead to inter-fuel substitution. And because energy is widely traded, the price changes that occur in energy subsidising economies will be transmitted to some extent to world markets.

Because the removal of energy subsidies will influence world energy consumption there will also be interactions with other international policy issues such as global climate change

responses. Analysis presented in this paper indicates that world emissions of greenhouse gases could be lower following the removal of subsidies than they are in a reference case in which it is assumed that no subsidy removal takes place.

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