



ECFIN *Economic Brief*

ECONOMIC ANALYSIS FROM EUROPEAN COMMISSION'S DIRECTORATE GENERAL FOR ECONOMIC AND FINANCIAL AFFAIRS

Measuring Fossil Fuel Subsidies

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1. Introduction

Over the past few years fossil fuel subsidies (FFS) have received increasing attention. International organisations such as the OECD, the IMF, the IEA and the World Bank are estimating the magnitude of government subsidies to fossil fuel consumption and production, and are researching the economic and social effects of FFS reform. Their research suggests that the removal of FFSs is beneficial in a number of ways: it reduces the budget deficit; leads to a more efficient allocation of resources and thus increases long run economic growth potential. It also acts to reduce fossil fuel consumption, leading to lower global CO₂-emissions and climate change mitigation. These arguments - along with domestic economic and fiscal problems in the aftermath of the financial crisis - have convinced governments to initiate often unpopular FFS reforms.

Global leaders are also showing increasing support for reform. Barack Obama has repeatedly called for a phase-out of FFSs in his state-of-the-

union addresses. Jim Kim, the President of the World Bank urged governments to remove global subsidies of USD 1.9 trillion, and redirect funds to fight climate change. The Commission President Jean-Claude Juncker also made clear his commitment to increase energy efficiency and to reduce fossil fuel import reliance in the European Union in his 2014 political guidelines for the next European Commission¹. Reforming FFSs would be a means of achieving this goal.

At the 2009 summit in Pittsburgh G20 countries committed to "rationalise and phase out over the medium term inefficient FFSs that encourage wasteful consumption" (IEA et al., 2010, p.5). Even though many countries agree that phasing-out FFSs would be useful for their economies and the environment over the medium-term, reform is only slowly gaining ground. The peer review process

Summary

The current environment of low energy prices offers a window of opportunity to reform fossil fuel subsidies (FFSs). Carefully prepared FFS reforms could lead to more robust fiscal positions and contribute to potential growth through a reduction in economic distortions and the mitigation of climate change due to lower CO₂-emissions. While advanced economies have mostly phased out generalised consumer FFSs, these are still prevalent in the developing world. However another type of subsidisation, i.e. the under-taxation of fossil fuels relative to economically optimal levels, is widespread in developed and developing countries alike. The G20 effort to advance FFS reform suffers from the lack of an established definition of what constitutes a subsidy, which makes the assessment of public support and cross-country comparison very difficult. Based on the different available methodologies, this Economic Brief aims at shedding some light on the magnitude and allocation of subsidies across fossil fuels and across regions.

¹ See European Commission (2014).

of G20 countries could be a powerful tool to advance FFS reform, but it suffers from the lack of an established definition of subsidies which makes the assessment of public support and cross-country comparison very difficult. In the annual reporting exercise each country decides what sort of public support they consider as inefficient FFS and want to report to the group. The large drop in the price of oil through the second half of 2014 could provide a window of opportunity for governments to press ahead with FFS reform.

The aim of this paper is to shed more light on existing FFSs, taking account of different forms of public interventions and different types of fossil fuels. The paper is structured as follows. Section 2 gives a general introduction to fossil fuel subsidies, explaining their basic economic effects, discussing the motivation for having FFSs and the arguments for removing them. It describes in detail the sources of data on FFS, along with the methodologies employed by the IEA, the IMF and the OECD to estimate them and presents the main FFS estimates. Section 3 moves on to discuss the allocation of subsidies across different fossil fuels and regions. Section 4 presents IEA and IMF estimates for the largest world countries and regions, along with recent efforts to reform fossil fuel subsidisation. Section 5 concludes this Economic Brief.

2. An economic overview of fossil fuel subsidies

The Organisation for Economic Co-operation and Development (OECD) defines a subsidy as "any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers or producers" (OECD, 2005, p.114). The majority of FFSs affect the end user price and the quantity of fossil fuels used, through their impact on the demand and supply of different fossil fuels.² Consumer subsidies keep prices below market level and raise the demand for fossil fuels, while subsidies to producers reduce their costs of production and encourage them to increase output. The quantity used increases in both cases, and in general both consumers and producers benefit from a subsidy, as consumers pay less for fossil fuels while producers receive a higher price than they would under market conditions. The incidence of the subsidy, i.e. the actual shares captured by producers and consumers depends on the demand and supply elasticities of the particular fossil fuel market.

² There are some subsidies that do not affect the current production or consumption of fossil fuels, such as R&D support for fossil fuel exploration. These subsidies (termed General Services Support Measures by the OECD) are discussed later on in this report.

2.1. What is the motivation for having fossil fuel subsidies?

In addition to their impact on the price and quantity of fossil fuels used, subsidies also have effects on the environment, on employment, and on other factors of the economy. The main motivation for subsidising fossil fuels in most countries is a social one, as access to basic energy services raises the living standards of the poor. Affordable modern energy services can also promote general economic development; for example cheap energy is a comparative advantage for energy-intensive manufacturing industries. Fossil fuel consumption subsidies are also seen as a way to share natural resource wealth with the population in energy producing countries. Production subsidies are meant to boost domestic energy supply (thought of as strategically important by many countries) and thus reduce import dependence. In some European countries specifically, subsidies to coal are meant to maintain regional and sector-specific employment, and to make the decline of an industry more gradual. While all these goals seem worth government support, energy subsidies in general have not been successful at delivering them. At the same time, energy subsidies promote the wasteful use of resources and harm the economy and the environment in a number of ways.

2.2. The motivation for removing fossil fuel subsidies: their adverse effects

The main motivation for the phasing out of FFSs is that they are very costly to taxpayers, crowd out high-priority government expenditure and do not necessarily benefit the target group. FFSs often fail to achieve their most important policy objective, i.e. instead of supporting the poorest segment of society, consumption subsidies work in a regressive way, as most of the benefits are captured by the richest households. For instance, in Egypt, the lowest income quintile captured only 1% of diesel consumption subsidies, while the richest 20% reaped over 70% of the benefits (Sab, 2014). This regressive feature of fossil fuel subsidisation is also intuitive since the wealthiest households are also the largest residential consumers of energy. However, it is also true that the poor spend a much larger share of their income on fossil fuels than the rich. This means that even though the poor benefit less from FFSs in absolute values, they still might be disproportionately affected by the phasing out of subsidies (IEA et al., 2014). This adverse impact on the poor can be eliminated or at least mitigated by well-targeted income support measures aimed at the most vulnerable households.

FFSs are not only fiscally costly and inequitable, they are also economically inefficient. They distort market

price signals, and thus investment and consumption decisions, leading to an inefficient allocation of resources and lower economic growth in the long run. In the absence of subsidies, net importing countries would lower their demand for fossil fuels, which would reduce import dependence and improve their trade balance at the same time. Economic actors would be more inclined to invest in alternative energy sources and better technologies, increasing the energy efficiency and decreasing the energy intensity of these economies. In net exporting countries the removal of subsidies would decrease wasteful consumption at home and boost export capacity. Fossil fuel consumption subsidies are also considered to discourage private investment in the energy sector, thus reducing economic growth (IEA et al, 2010). A removal of FFSs could raise the potential for economic growth in the long run. However, both the exact extent of the increase in long-term output and the development of the transition process to the new equilibrium are uncertain.³ These depend on a number of variables, such as: (1) whether the country undertaking reforms is an importer or exporter of energy; (2) how many countries decide to remove fossil fuel subsidies at the same time, i.e., whether the removal is unilateral or multilateral (a multilateral removal would likely have a large impact on global fossil fuel demand and thus on fossil fuel prices, leading to terms-of-trade effects)⁴; (3) the extent and structure of FF subsidisation in the country prior to removal; (4) the importance of energy inputs in industrial output, the reliance of industry on subsidised energy, and the size of the energy-intensive manufacturing sector; (5) substitutability of energy for households and industrial consumers; and most importantly: (6) how the money saved through FFS removal is spent by the government (is it spent on growth-enhancing investment, or used to pay for cash transfers to the electorate).

Another economic inefficiency caused by fossil fuel subsidisation is the increased volatility of world energy prices. Many countries that heavily subsidise fossil fuel consumption employ fixed price regimes for electricity, natural gas, petroleum and petroleum products (diesel, gasoline, LPG, kerosene). Set prices are only seldom reviewed; therefore a sudden and pronounced increase in the world price for a fossil fuel doesn't usually translate into an increase in domestic prices in these countries. As governments shield

the domestic economy from hikes in fossil fuel prices, companies and consumers do not have any incentive to change or adjust their fossil fuel consumption during periods of high prices.⁵ Therefore a significant part of the global demand (for crude oil, for example), does not react to changes in international crude oil prices. This means that if there is a disruption on the supply side, prices need to undergo a strong adjustment until the world market reaches a new equilibrium. In this way fixed price regimes with high fossil fuel consumption subsidies contribute to more volatile energy prices globally. A removal of FFSs, and a move from fixed price regimes towards market-based pricing mechanisms for fossil fuels would contribute to reducing the volatility of global energy prices.

FFSs act to reduce the end user price and increase the consumption of fossil fuels, thus having **an adverse effect on the environment and accelerating climate change.** Studies by the IMF suggest that the complete elimination of FFSs would decrease global CO₂-emissions by 15-23% (Parry et al., 2014 and Clements et al., 2013). A reduction in emissions of such magnitude could make a significant contribution to meeting global targets on climate change.

2.3. How are fossil fuel subsidies measured?

Three international organisations (the IEA, the IMF and the OECD) collect data on fossil fuel subsidies in a systematic way, albeit with different methodologies. The International Energy Agency (IEA) provides estimates annually of consumer FFSs for 40 developing countries, including the world's top subsidisers.⁶ They are calculated using the price-gap approach, that is, based on the differential between the end user price of a specific fossil fuel and a reference price (the international market price adjusted for transport and distribution costs) of the same fuel. The Organisation for Economic Co-operation and Development (OECD) uses a completely different, inventory based approach to estimate the value of FFSs in its member states.⁷ This method identifies all government measures (subsidies and tax breaks) that support fossil fuel production or consumption, and calculates and adds up the value of all these measures based on the government's budget. The International Monetary Fund's (IMF) study provides the most comprehensive pre-tax and

³ FFS removal can have negative transitory effects on the economy in the short to medium term due to job losses in the energy sector, higher inflation and lower disposable income. Hence, an important part of FFS reform is to ensure measures counterbalancing these negative effects and making the transition process gradual and sustainable. Clements et al. (2013) offers a broad overview of FFS reform strategies in various countries.

⁴ In the case of a multilateral removal of FFSs, energy prices are expected to fall significantly due to the fall in global demand. This has negative terms-of-trade effects on energy exporting countries. For more information, see IEA et al. (2010).

⁵ This offers an explanation to why global oil demand remained so resilient to the oil price hike of 2008 for example: a number of countries didn't adjust their consumption in any way to higher global crude oil prices.

⁶ The estimates are published yearly in the World Energy Outlook (WEO).

⁷ The OECD's newest estimates are published in its study, the Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels (2013). This is an updated version of an earlier report.

post-tax subsidy estimates for 176 countries.⁸ Pre-tax subsidies are mostly based on the price-gap approach, and are therefore similar to IEA estimates (although for some OECD countries, producer subsidies are also included). Post-tax subsidies include the negative externalities associated with the use of fossil fuels (that are not internalised through corrective environmental taxes by the government), such as local air pollution, faster climate change and congestion.⁹ For a more detailed discussion of methodologies of the IEA, the IMF and the OECD, and for a critical review of these approaches, please see Box 1.

2.4. Estimates of global fossil fuel subsidies

The IEA estimates that FFSs in 2013 totalled USD 548 billion, or 5% of the total GDP of the 40 countries included in the analysis (IEA, 2014).¹⁰ The OECD estimates that in the 2005-2011 period an annual average of USD 55-90 billion was spent on fossil fuel (production and consumption) subsidies in its member states (OECD, 2013). This is much lower than the IEA's estimate, but understandably so: governments in developed countries don't set fossil fuel prices (as do some in developing countries), and use sophisticated methods to subsidise fossil fuel production and consumption to a much lesser extent than the countries included in the IEA's analysis. The IMF's estimate for global pre-tax subsidies in 2011 totalled USD 492 billion (or 0.7% of global GDP at the time), relatively close to the IEA's estimate of USD 523 billion for the same year (IEA, 2012). The IMF estimates that global post-tax subsidies amounted to USD

2.0 trillion in 2011, representing 2.9% of global GDP or approximately 8.5% of worldwide government revenue (Clements et al., 2013). Thus the value of the negative externalities associated with the use of fossil fuels is roughly three times as high as actual government support for fossil fuels.

BOX 1: The Methodological issues of measuring fossil fuel subsidies

The IEA

The International Energy Agency defines an energy subsidy as "any government action directed primarily at the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers" (IEA, 2014, p. 315). The price-gap approach is used by the IEA to estimate fossil fuel consumption subsidies for developing countries. This approach looks at the difference between a reference price and the price paid by end users. If this difference is positive, the particular fossil fuel is subsidised. The reference price is equal to the import parity price (the price of the fossil fuel at the nearest international hub, with transport and distribution costs and the VAT added) for fossil fuel importing countries, while it equals the export parity price (the price of the fossil fuel at the nearest international hub, minus transport and distribution costs and the VAT) for exporters. Many energy exporting countries and the Organisation of the Petroleum Exporting Countries (OPEC) disagree with this methodology. According to their view, the reference price for an energy exporting country should be the cost of production of the fossil fuel, and not the international market price (IEA et al., 2010). According to economic theory however, the legitimate reference price is equal to the export parity price for OPEC members, as these countries are making implicit losses (or not realizing implicit profits) on each barrel of oil that is not exported.

The OECD

The OECD defines a subsidy as "any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers or producers" (OECD, 2005, p.114). Even though this is in line with the IEA's definition, the OECD takes a different approach to estimate the extent of consumption and production subsidies together in its member states, using a "broad concept of support that encompasses direct budgetary transfers and tax expenditures that provide a benefit or preference for fossil-fuel production or consumption, either in absolute terms or relative to other activities or products." In other words, the OECD aims to measure all FFSs that are explicitly included in the general government budget. In its Inventory, the OECD analysed over 550 government measures that can be considered fossil fuel subsidisation. The 2010 Joint Report of the IEA, the OECD, and the World Bank distinguishes seven basic types of FFSs, based on the official type of government intervention. These seven types are as follows: (1) trade instruments such as tariffs; (2) regulations such as price controls that result in consumer prices being below market level; (3) tax breaks either for consumers or producers of fossil fuels; (4) credit to fossil fuel producers; (5) direct financial transfer either to reduce end user prices or to lower the costs of producers; (6) risk transfer such as loan guarantees; (7) energy-related services provided by the government at less than full cost.

The IMF

⁸ Available in the IMF publication "Energy Subsidy Reform: Lessons and Implications" (2013).

⁹ Post-tax subsidies include more than just negative externalities: they include any sort of preferential tax treatment of fossil fuels, be it a lower rate of taxation of energy than of other consumer products, or the lack of corrective taxation to account for the external costs of fossil fuel use. For more detail, refer to Box 1.

¹⁰ The IEA's newest 2014 World Energy Outlook report identified 40 countries that support fossil fuel consumption, i.e., in these countries the price of fossil fuels for end users is below the international market price (adjusted for transport and distribution costs), or below the costs of production for electricity. The governments in these countries set fix prices for fossil fuels. The 40 countries include almost all Middle Eastern (especially Gulf) and Central Asian (CIS) countries, most North African economies and some countries from the Sub-Saharan Africa region (Nigeria, Ghana). They also include many of the developing economies of Eastern and South-East Asia, notably China, India, Indonesia, and some South American countries (Venezuela and Ecuador). Advanced economies (with the exception of South Korea and Taiwan) are not identified as fossil fuel subsidisers, as developed countries don't employ fix price regimes to set fossil fuel prices below market levels for their entire populations. Their sophisticated measures of fossil fuel subsidisation are not captured by the IEA's methodology, see Box 1 for details. For more information on which countries the IEA includes in its analysis, and for detailed estimates, visit www.iea.org/subsidy.

The International Monetary Fund (IMF) distinguishes producer and consumer subsidies to energy. "Consumer subsidies arise when the prices paid by consumers, including both firms (intermediate consumption) and households (final consumption), are below supply costs, including transport and distribution costs. Producer subsidies arise when prices are above this level" (Clements et al., 2013, p.5). The benchmark price is the international market price - adjusted for transportation and distribution costs - for internationally traded products - while it equals the cost-recovery price for energy products that are not internationally traded. The IMF further distinguishes pre-tax subsidies and tax subsidies for fossil fuel consumption. Pre-tax subsidies are defined in a similar way to the IEA's approach to subsidies, i.e. the difference between the opportunity cost of supplying a consumer with fossil fuel (the international market price) and the price paid by the end user. The tax subsidy is the difference between the efficient level and the actual level of taxation for a given fossil fuel. The efficient level of taxation means first that the tax controls for the externalities associated with the use of the fossil fuel such as pollution and its effects on health, environmental costs, congestion, all of which reduce overall welfare but are not taken into account by the user of the fossil fuel. This approach has a direct consequence for assessing post-tax subsidies for coal which is the most polluting fossil fuel, hence the negative externalities associated with the use of coal are by far the largest. Second, efficient taxation implies that fossil fuels are taxed the same way as other consumer products. Intuitively, the sum of pre-tax and tax subsidies is equal to the overall subsidy to the particular fossil fuel, called the post-tax subsidy. While pre-tax subsidies have mostly been phased out in the developed world, they are still common in developing countries. Tax subsidies are prevalent in both developed countries and emerging economies.

While the IMF provides the most comprehensive source of data for FFSs; some estimates are still missing from the study, as subsidies are not estimated for each country or for each fossil fuel. Petroleum subsidies are estimated most thoroughly for all 176 countries included in the analysis, using the price-gap approach, with production subsidies included for some OECD countries. Natural gas and coal subsidies are estimated for only 56 countries (with production subsidies to coal included for some OECD countries). Subsidies to electricity are estimated for 77 countries using multiple approaches and multiple data sources.

Comparison of the different methodologies

The IMF approach is unique in the sense that it considers the inefficient taxation of fossil fuels as subsidisation. Thus the government's failure to deal with a market failure (such as the negative externalities associated with fossil fuel consumption) is itself a form of subsidisation according to the IMF. This approach is the most logical economically, as inefficient taxation (either not taxing fossil fuels enough to control for negative externalities, or taxing energy differently than other consumer products) is just a hidden subsidisation of fossil fuels. As the IMF concept of FFS is broader than that of the IEA or the OECD, the IMF estimates tend to be higher than the estimates of the other two organisations.¹¹

The price-gap approach (as used by the IEA) does not require an inventory of the different types of government interventions. Instead, it relies on the data of end user prices and estimates for reference prices to calculate the price-gap for each fossil fuel. These numbers are then multiplied by the quantities of the corresponding fossil fuel used in the analysed time period to calculate the abso-

lute value of FFSs. This relative computational ease and simplicity is the main advantage of the price-gap approach. Compared to the OECD methodology, there is no need to compile information on the different types of government interventions, to estimate the value of each intervention or to aggregate the estimates. However, one clear advantage of the OECD methodology is that it can cover more sophisticated methods of public support. Some forms of government intervention have no impact on the consumer price of the fossil fuel (such as vouchers to low-income households, state support for the decommissioning of old power plants, and other producer subsidies, e.g. R&D support). While the OECD measures these subsidies as well, the IEA cannot, due to the limitations of the price-gap approach.

The estimates of the International Energy Agency vary greatly year-on-year (for example the 2009 estimate is about USD 110 billion lower than the 2010 one), which is a direct consequence of the fixed price regimes many countries still employ. If the international market price of a fossil fuel increases, while the price for end users is kept constant, consumption subsidies necessarily increase. In importing countries this increase in subsidies is reflected by an increase in the budget deficit as the country has to pay more for fossil fuel imports while prices for domestic consumers remain unchanged, i.e. in these countries, IEA FFS estimates are explicit in the budgetary sense. For exporters, the same increase in the international price has rather a positive impact on government revenues and on the government balance. However, due to the higher international market prices, exporting countries are giving up on higher gains for every unit of fuel not exported, than before. Therefore the opportunity cost of subsidising fossil fuels rises in exporting countries, even if this is not reflected explicitly by the deterioration of the fiscal position.

OECD estimates for FFSs are always explicit, i.e. they represent specific budgetary expenditures (or tax breaks) and therefore directly impact the budget. IEA fossil fuel estimates are only explicit for fossil fuel-importing countries. Importers that sell fossil fuel domestically below world prices have to pay for this difference (between the import and the domestic price) directly through their budget. For exporting countries, fossil fuel consumption subsidies (as estimated by the IEA's price-gap approach) are implicit and represent the opportunity cost of supplying domestic consumers with energy at lower-than-world prices. While charging market prices from domestic consumers would improve the budget balance, these subsidies are not explicitly included in the budget.

OECD and IEA estimates for FFSs are therefore not directly comparable. The data from the two international organisations are complementary. In advanced economies, most subsidies are explicit as fossil fuel prices are not in general subsidised for the entire population. Additionally, a number of government interventions are in place in developed countries that are considered as subsidies but would not be captured by the IEA's price-gap approach (such as R&D support, rehabilitation of old mining sites, etc.). The budgets of advanced countries are also more transparent in general, therefore the OECD's inventory approach is more likely to yield precise estimates. In developing countries, consumption subsidies are the dominant form of subsidisation, and many of these subsidies are also implicit, and would therefore not be captured by the OECD's methodology. Therefore for emerging economies, the IEA's price-gap approach for estimating FFSs is clearly more suitable.

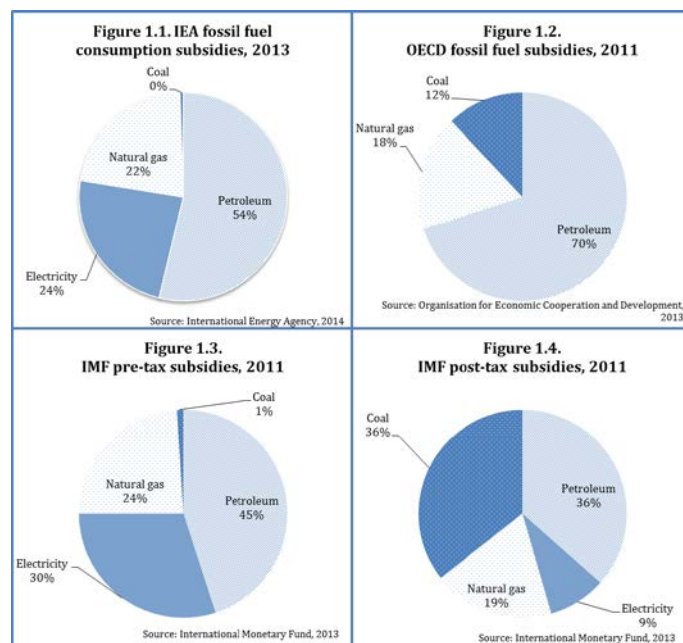
¹¹ In this Economic Brief, a subsidy should always be considered a pre-tax subsidy, unless stated otherwise.

3. The allocation of fossil fuel subsidies across different fossil fuels and regions

3.1 Allocation by type of fossil fuel

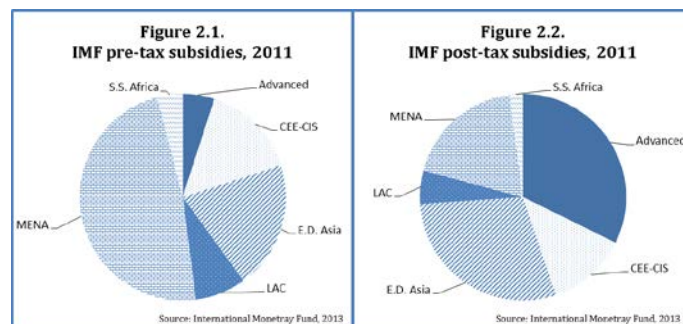
The following chart (Figure 1.) presents estimates for the allocation of subsidies across different fossil fuels. All point to a predominant share of petroleum products, ranging from 36 to 70%, depending on the method used. According to IEA data, petroleum and petroleum products receive over half of all consumption subsidies. The rest is split nearly evenly between the subsidisation of electricity and natural gas; subsidies to coal consumption are negligible accounting for less than 1% of the global total. The OECD's estimates are very different, with petroleum getting 70%, natural gas 18%, and coal 12%. Much of the difference is simply due to the fact that the two international organisations analyse different groups of countries while part of it is explained by methodological dissimilarities. The OECD does not include a separate category for electricity. Only when electricity is generated exclusively from a fossil fuel is subsidisation of electricity considered to be the subsidisation of that particular fossil fuel. This should raise the shares of coal and natural gas (and to some extent, the share of petroleum), depending on the country's structure of electricity generation, relative to an analysis that includes electricity support as a separate category. The OECD also tends to overestimate the share of petroleum subsidies in general, due to the particularities of its inventory approach, as the heavy taxation of transport fuels (which are mainly petroleum products) in OECD countries means that any tax breaks or reductions for petroleum are calculated against such a high benchmark, leading to high subsidy estimates. The IMF's estimates for pre-tax subsidies in 2011 are very similar to the IEA's 2013 estimates, due to the similar methodology and the fact that most of global pre-tax subsidies are handed out in the forty emerging economies analysed by the IEA. Post-tax subsidy estimates, which include negative environmental and other externalities paint however a very different picture of global subsidies. Coal - a fossil fuel subsidised to a negligible extent according to IEA and IMF pre-tax estimates - is on par with petroleum as the most heavily subsidised fossil fuel in post-tax terms (each accounting for 36% of a global total of USD 2.0 trillion in post-tax subsidies). This high share of coal is due to the under-taxation of coal: while the average price of coal was around USD 5/GJ in 2011, the IMF estimates that corrective taxes on coal should be USD 3.3/GJ just to account for the negative externalities associated with increased CO₂-emissions (i.e. their contribution to advancing climate change) (Parry et al., 2014). Taxes on coal as the most polluting fossil fuel are nowhere near this efficient

level (not even in developed countries), therefore coal is heavily subsidised globally on a post-tax basis.



3.2. Allocation by region

How and to what extent fossil fuels are subsidised varies greatly by region. Using the IMF's categorisation for economic regions and using IMF data, Figure 2 shows the shares of the different economic regions in pre-tax and in post-tax subsidies.¹²



Pre-tax subsidies

According to IMF estimates, pre-tax subsidies in 2011 amounted to USD 492 billion: around 0.7% of global GDP and 2.5% of worldwide government revenue. One economic region - **the Middle East and North Africa (MENA) - accounted for 48% of this total.** Here, FFSs amount to almost 9% of regional GDP or 22% of regional government expenditure. Generalised fossil fuel subsidies (subsidies that

¹² The categories the IMF employs are the following: advanced economies, countries of Central and Eastern Europe and the Commonwealth of Independent States, Emerging and Developing Asia, Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa. A detailed list of each group by country can be found Clements et al. (2013).

benefit everyone, independent of income and other factors) are widespread in both the energy exporting and energy importing countries of the region, though subsidies are usually higher for exporters of energy. The most common method of subsidisation is the use of fixed price regimes by the government: for example electricity, gasoline, diesel, kerosene are sold to domestic consumers (and often also to industrial users) at a fixed price set by the government. These prices are typically much lower than international prices: according to the German Federal Enterprise for International Cooperation¹³, gasoline prices in Saudi Arabia in 2012 were around USD 0.07/litre. The subsidisation of gasoline use is the most regressive form of fossil fuel subsidisation. Worldwide, the top income quintile reaps 61% of the benefits, and the lowest income quintile receives only 3% of all gasoline subsidies (Arze del Granado, Coady and Gillingham, 2012). Over half of pre-tax subsidies in the MENA support the consumption of petroleum and associated products; the remainder is split between natural gas and electricity support.

The region with the second largest subsidies is Emerging and Developing Asia. Here, a number of countries, notably Indonesia, India, Pakistan and Bangladesh provide generous state support for fossil fuel use. While the region as a whole accounts for around a fifth of worldwide subsidies, these subsidies make up less than 1% of regional GDP. Countries of Emerging and Developing Asia are heterogeneous when it comes to energy subsidies: some still employ traditional fixed price regimes, while others have managed to phase out or are in the process of phasing out these subsidies. Most of the state support in the region benefits the use of petroleum or electricity.

Central and Eastern Europe and the Commonwealth of Independent States account for approximately 15% of global subsidies. Some countries in the region (Russia, Turkmenistan, Uzbekistan, and Kazakhstan) still employ fixed prices regimes and subsidise mostly natural gas and electricity.

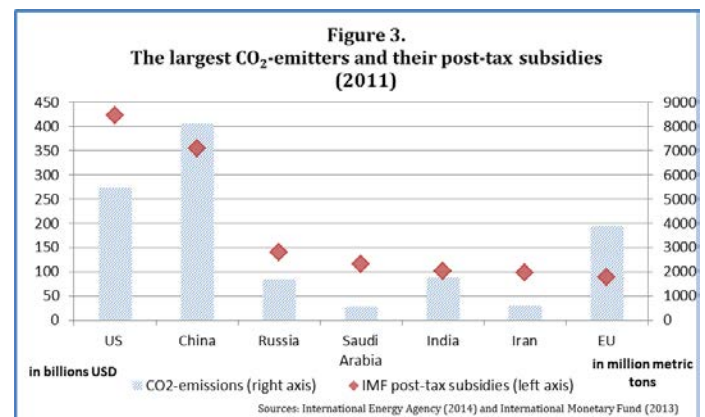
The rest of the regions only supply a relatively small share of global FFSs, with some important exceptions in Latin America: Venezuela and Ecuador are relatively important subsidisers. Venezuela boasts the highest rate of subsidisation¹⁴ for any country in the world (according to IEA data for 2013): the ratio of the subsidy to the international reference price for Venezuela is 93%.¹⁵

The contribution of advanced economies to global pre-tax subsidies is very low, especially when considering

their economic weight. These countries have almost completely phased out generalised fossil fuel subsidies, and instead use targeted measures to help meet the basic energy needs of poor households, such as heating grants for those living on a low income. Some forms of FF subsidisation, especially producer subsidies, such as R&D grants are prevalent among developed countries. Interestingly, advanced economies are the biggest subsidisers of coal, providing over half of all coal subsidies. This is due to the efforts of a few advanced economies to slow down the decline of their traditional but uncompetitive coal mining industries and to give coal mining regions time to diversify their economy away from coal.

Post-tax subsidies

The allocation of post-tax subsidies across economic regions presents a different picture. In post-tax terms, advanced economies are large subsidisers, accounting altogether for about a third of total subsidies. Emerging and Developing Asia lags not far behind, providing about 30% of global post-tax subsidies. All other regions are underrepresented in post-tax terms (when compared to their shares in pre-tax subsidies); the Middle East and North Africa especially so, as their share in total post-tax subsidies is only around one-fifth, down from a half in pre-tax terms.



Using IMF data Figure 3 shows the seven largest post-tax subsidisers with their respective post-tax subsidies and CO₂-emissions (as estimated by the IMF). This evidence suggests that CO₂-emissions are closely linked to post-tax subsidies: the five biggest CO₂-emitters¹⁶ are also amongst the largest post-tax subsidisers in the world. As no country currently imposes corrective taxes that are high enough to completely internalise the negative externalities associated with fossil fuel consumption, there is a strong positive correlation between CO₂-emissions and post-tax subsidies. How much CO₂ a country emits depends not only on the amount of fuel consumed, but also on the mix of fuels used. Coal combustion emits the most CO₂ per unit of energy (almost double the amount for natural gas). A higher reliance on coal thus

¹³ Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

¹⁴ The subsidisation rate is equal to the ratio of the subsidy and an international reference price.

¹⁵ In 2012, Venezuela had the lowest prices at 0.011/litre for gasoline and 0.023/litre for diesel (GIZ, 2014).

¹⁶ China, the US, the EU, India and Russia.

leads to higher emissions of CO₂ per unit of energy and implies higher post-tax subsidies, unless high corrective environmental taxes are imposed, either on coal or on CO₂ emissions themselves. As the EU applies high environmental taxes, European post-tax subsidies are low, relative to CO₂-emissions (and fossil fuel use). In Saudi Arabia and Iran, the situation is reversed: these countries have high post-tax subsidies relative to their CO₂-emissions, because their governments support fossil fuel consumption with high pre-tax subsidies. The next section discusses the subsidy estimates and recent reform efforts of the seven largest post-tax subsidisers.

4. Fossil fuel subsidies in the largest post-tax subsidisers

This section reviews the amount and distribution of FFSs in the seven largest post-tax subsidisers, i.e. in the US, China, Russia, Saudi Arabia, India, Iran and the EU. The data used for the analysis comes from two main sources, the IEA and the IMF estimates. For developing countries we present the most recent IEA estimates, along with the post-tax FFS estimates of the IMF. For the analysis of the FFS situation in developed countries, where no IEA data is available (because of the lack of generalised FFSs to consumers) we use IMF pre- and post-tax subsidy estimates. IMF post-tax subsidies - which are presented both for developed and developing countries - allow for cross-country comparison.

4.1 MENA countries: Iran and Saudi Arabia

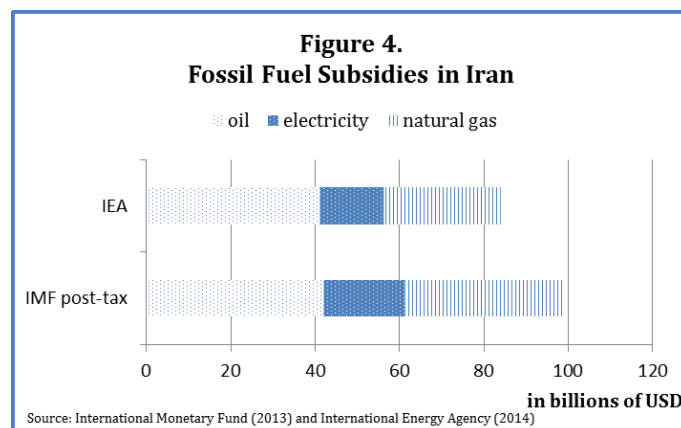
Fossil fuel consumption subsidies are most widespread in the countries of the Middle East and North Africa. According to the 2014 World Energy Outlook of the International Energy Agency, five of the top ten subsidisers in the world were MENA countries. **The two largest subsidisers are also in the Middle East: Iran with USD 84 billion and Saudi Arabia with USD 62 billion together account for over a quarter of total pre-tax FFSs of USD 548 billion.** These remarkably high FFSs in the MENA region are not only extremely costly but also greatly inequitable. While almost 9% of regional GDP is spent subsidising fossil fuels, less than 1% of GDP is spent on food subsidies. In Egypt, for instance, a fifth of the budget is spent on fossil fuel subsidisation; i.e. three times the country's spending on education and seven times its spending on health-care.

Power generators in most Middle Eastern countries can purchase oil at artificially low, subsidised prices, thus a third of the electricity in the Middle East is produced by oil-fired power plants, which burn over 2 million barrels of oil a day according to the IEA (worldwide consumption of crude oil is around 90 million barrels a day). In the absence of these

subsidies, electricity generated from oil could not even compete with renewable energy or with nuclear power. At the same time, these subsidies result in high opportunity costs to Middle Easterners as the 2 million barrels of oil used daily for electricity generation could be exported (or stored and exported at a later date). Export revenues foregone translate into less investment in infrastructure development or education, which could support economic growth in the long run.

Iran

Iran is the largest pre-tax subsidiser in the world, with subsidies worth USD 84 billion (or USD 1083 per person) in 2013 according to the IEA (see Figure 4.). These consumption subsidies amount to over a fifth of Iran's GDP, the highest value for any country. Oil accounts for 49% of the total, followed by natural gas (33%) and electricity (18%). IMF estimates for post-tax subsidies for 2011 (which include externalities and the preferential tax treatment of fossil fuels) are a little higher (reaching USD 99 billion) and are distributed roughly similarly across the same three sources of energy.

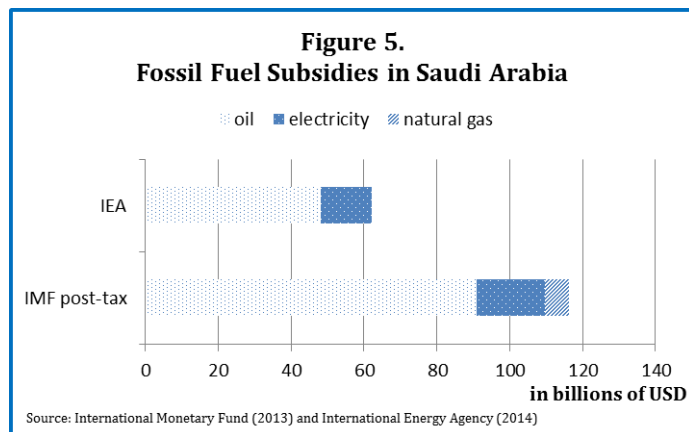


Iran was the first country in the Middle East to introduce significant reforms to its system of fossil fuel subsidisation. The reform plan aimed to bring domestic fossil fuel prices close to international levels over five years. E.g., the Targeted Subsidies Reform act aimed to raise gasoline, diesel, kerosene and LPG prices to 90% of Persian Gulf FOB prices. The first phase of the package involved substantially increasing the domestic prices of petroleum products, natural gas and electricity. For instance, the price of diesel was increased 9 to 18-fold (different prices were charged from different consumers) (Hassanzadeh, 2012). Half of the savings was originally planned to be spent on cash transfers to poorer households, to compensate those most affected by the increase in energy prices. However, due to lack of data and administrative challenges, the government changed its plans and made the whole population eligible for the cash transfers of around USD 40-45 per person per month (everyone was free to apply, although the wealthy were encouraged not to, with little success). Although these transfers

were more expensive than the ones originally planned, they made the system more equitable, as all citizens received equal transfers while regressive fossil fuel subsidies were lowered. The poor, who don't own vehicles and don't use many household energy appliances benefited significantly, and were actually better off after the reforms: for an average poor family of five, the monthly transfers of around USD 200 could easily amount to half of their labour income. Iran's example also demonstrates that the success of the reform steps also rests on popular support for the measures, ensured by an extensive public relations campaign to inform the public on the benefits of reform, and the universal compensatory cash transfer scheme that counters the adverse impact of subsidy removal on the disposable income of poor and middle class households (Guillaume, Zytek and Farzin, 2011). A second phase of the price increases was delayed in 2012 due to Iran's economic problems and was only implemented in 2014. While according to 2013 data, Iran still has the highest pre-tax subsidies of any country, the 2014 and 2015 estimates will likely be significantly lower.

Saudi Arabia

Saudi Arabia is the second largest pre-tax subsidiser in the world, with consumption FFSs amounting to USD 62 billion. This is split between oil and electricity subsidisation, with over 75% of the total accounted for by subsidies to oil (See Figure 5.). IMF post-tax subsidy estimates equal USD 116 billion, and are also dominated by petroleum.

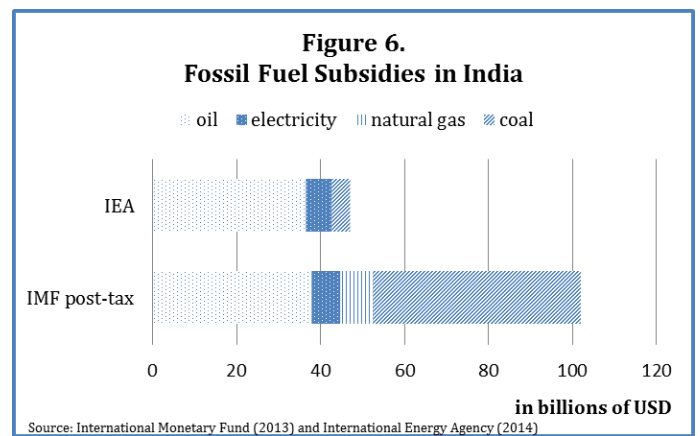


Saudi Arabia - as most other countries in the MENA region - sets fixed prices for energy products (gasoline, diesel, electricity) for domestic consumers. Diesel prices in Saudi Arabia equalled USD 0.067/litre while gasoline cost USD 0.16/litre in 2012 November (GIZ, 2014). These prices clearly discourage investment in more expensive but fuel-efficient cars. Without subsidies, the payback period for investing in a more fuel-efficient car would decrease from sixteen to only three years (IEA, 2014). Subsidised electricity prices motivate consumers to buy cheap incandescent light bulbs instead of expensive energy efficient ones, and more importantly to rely on inefficient air-conditioners. An extraordinarily high 70% of Saudi Arabian electricity con-

sumption is used for air-conditioning, thus an increase in the energy efficiency of air-conditioners used would lead to substantial savings in electricity consumption (and in subsidies). While the Saudi government has not yet proceeded to undertake bold FFS reforms, it has recently tried to address some of these issues by setting minimum standards for energy efficiency. However, letting world prices guide consumers' behaviour (or even getting prices closer to international levels) would be a more effective way of influencing investment decisions and raising energy efficiency both in Saudi Arabia and throughout the Middle East.

4.2 India

India is currently the third largest subsidiser in the world after Iran and Saudi Arabia with pre-tax subsidies of USD 47 billion in 2013 according to the IEA (see Figure 6.). 78% of these subsidies support the consumption of petroleum and petroleum products, while support to electricity (13%) and natural gas consumption (9%) accounts for the remainder. The International Monetary Fund estimates that post-tax subsidies to coal and petroleum products both amounted to over 2% of the GDP, while subsidies to electricity and natural gas were much lower (at around 0.4% of GDP each).

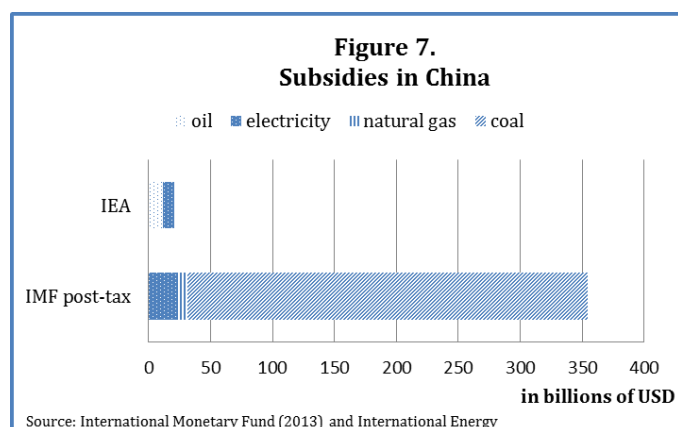


India has traditionally had high energy consumption subsidies to protect and help the large number of people living below the poverty line in the country (approximately one quarter of the population). However, as in other countries, FFSs have not been an efficient method of alleviating energy poverty and have also been very costly fiscally: in the 2012-13 fiscal year almost 14% of the government budget of India was spent subsidising fossil fuels (IISD, 2014). The government of India therefore embarked on reforming FFSs in 2010. Previously, petrol, diesel, LPG (liquefied petroleum gas), and kerosene prices have been regulated in the country, with oil marketing companies selling these products below costs and central government transfers controlling for the difference. In June 2010 petroleum pricing was liberalised in India. Deregulation of diesel pricing - while delayed for a few years due to high food inflation - followed

suit in 2014.¹⁷ However, India still has a long way to go in phasing out its FFSs: LPG and kerosene are still heavily subsidised. LPG subsidies are thought to be particularly regressive: 62% of urban households use it for cooking, while in rural areas only 9% of households do. Thus 76% of LPG support goes to urban households, and over 40% of subsidies are captured by the richest 7% according to research by the Energy and Resources Institute (Chawla et al., 2005). Kerosene is used for lighting in poorer households and the subsidisation of this fossil fuel does indeed benefit the poor (IISD, 2012). However, the use of kerosene for lighting (as opposed to electricity or solar lamps) is expensive, inefficient, and causes indoor pollution. Therefore subsidisation of new electricity infrastructure or the installation of solar lamps would be a more efficient way of supporting the poor.

4.3 China

The IEA estimates that China is the world's 9th largest pre-tax subsidiser, with subsidies worth USD 21 billion in 2013. **On a post-tax basis, China is the world's second largest subsidiser**, second only to the United States with subsidies of USD 353 billion or 4.8% of the country's GDP (according to IMF estimates for 2011, see Figure 7.). Coal is responsible for 91% of these post-tax subsidies. While pre-tax subsidies for coal consumption have been phased out, the government fails to control for the grave negative externalities associated with the use of coal. The extent of this externality is explained by the fact that China is the single largest consumer of coal in the world, itself consuming almost as much coal as the rest of the world combined.



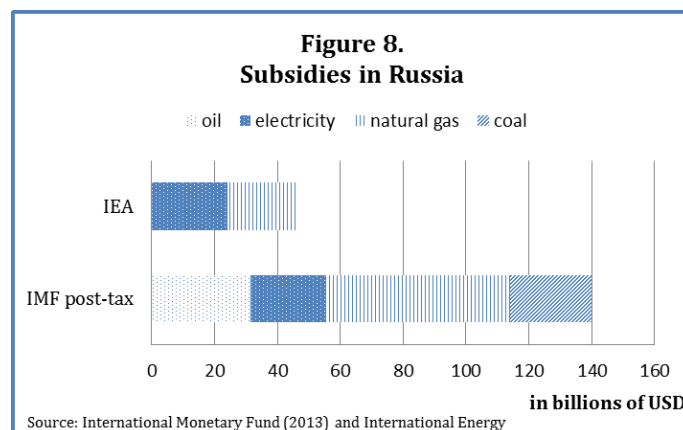
China has embarked on bold reforms to bring its energy prices closer to international levels. For example all price controls for coal were eliminated in 2007 and the country moved towards a market based pricing mechanism. Today,

¹⁷ The rationale behind diesel subsidies is that this reduces transportation and freight costs (as trucks predominantly use diesel fuel), so essential goods become cheaper. However, diesel can also fuel private vehicles and government subsidies to diesel incentivise the purchase and use of diesel fuelled vehicles instead of less polluting gasoline fuelled ones.

power companies and coal mines are free to negotiate their contracts (and the price of the coal purchased) with each other (IEA, OECD and World Bank, 2010). In 2012 the country also adopted a three-tiered electricity pricing system for residential consumers in relation to their level of consumption. Approximately 80% of households were unaffected by these changes, while electricity bills got higher for the largest residential customers (IEA, 2014). This meant that on average richer households had to pay more for their electricity than poor ones, therefore subsidies became more progressive and better targeted. The value of subsidies to electricity consumption also fell as a result of the reforms from USD 11.8 billion in 2012 to USD 7.2 billion in 2013.

4.4 Russia

In post-tax terms Russia is the world's third largest subsidiser of fossil fuels, with the total value of subsidies reaching USD 136 billion or 7.3% of GDP in 2011 according to the IMF (see Figure 8.). In pre-tax terms it is the fourth largest subsidiser, with subsidies of USD 46.5 billion in 2013 according to IEA data. As petroleum and coal subsidies have been phased out after the fall of the Soviet Union, this sum is divided roughly evenly between electricity and natural gas consumption support. This makes Russia the world's largest subsidiser of electricity and the world's second largest subsidiser of natural gas consumption. Russia also subsidises fossil fuel production heavily. The development of new oil and gas fields, especially in the Arctic enjoys generous financial support from the government. Federal support to upstream oil and gas companies amounted to USD 14.4 billion in 2010 (Gerasimchuk, 2012).

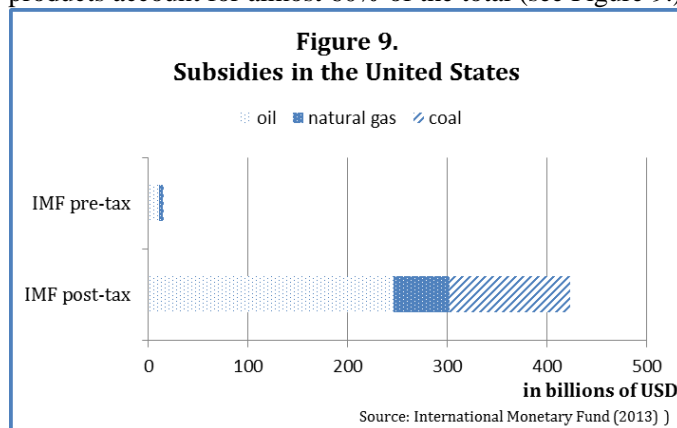


Russia has a 4-tier pricing system for natural gas. Its state-owned giant, Gazprom sells natural gas at different prices to residential and industrial domestic consumers (households pay less for gas than do factories). These domestic prices are much lower than export prices to CIS countries, which are in turn also much lower than the prices charged by Gazprom from EU importers. Gazprom actually sells natural gas to domestic consumers below cost, and makes up for these losses from the high profit margins of its natural gas exports

to the European market. As over 50% of Russia's natural gas production is used domestically, this discount for Russian consumers is clearly very costly. In the past decade efforts have been made to increase domestic gas prices, especially for the industrial sector (the Russian government allowed Gazprom to raise prices by about 14-25% a year) (IEA, OECD and World Bank, 2010). Reforms have been halted due to the financial crisis and Russia's economic problems.

4.5 United States

In absolute terms the United States is the largest subsidiser in the world, with post-tax FFSS equal to USD 410 billion in 2011 according to IMF data. While pre-tax subsidies make less than 0.1% of the country's GDP¹⁸, post-tax subsidies sum up to 2.7% of GDP, a very high ratio for a developed country.¹⁹ Subsidies to petroleum and associated products account for almost 60% of the total (see Figure 9.).



The reason for petroleum's dominance in American post-tax subsidies is the very low taxation of transport fuels in the United States (in fact, the US has the lowest price for gasoline and diesel for any advanced economy). The revenue from gasoline and diesel taxation in the United States just about covers expenditure on road infrastructure building and maintenance, however, it fails to account for the negative environmental and health effects of fossil fuel use. Second in terms of post-tax subsidies is coal (almost 30% of the total), as coal is not taxed heavily enough to address the negative externalities associated with its use. The remaining relatively small share (13%) of post-tax subsidies goes to natural gas. Natural gas is the cleanest fossil fuel, therefore

¹⁸ The OECD estimate for the US is very similar to the IMF pre-tax subsidy estimate: the former amounts to USD 13 billion, the latter to USD 14.5 billion.

¹⁹ In fact, the only developed country with higher post-tax fossil fuel subsidies (as a share of GDP) is Luxembourg. Luxembourg has one of the lowest taxes on transport fuels in Europe, leading to significant "refuelling tourism" from neighbouring countries. Luxembourg had the lowest gasoline and diesel prices for any EU-27 country (in the week of 08/12/2014, according to data from the Weekly Oil Bulletin of the Directorate General for Energy of the European Commission).

efficient taxation of this energy source is lower than that of either coal or petroleum.

A notable example for a production subsidy in the form of a tax break is the so-called excess of percentage over cost depletion option. This allows natural minerals companies to deduct a favourably high percentage of their gross income (as an expense) to account for depletion in their reserves (IEA et al., 2010). The state also supports R&D activities related to fossil fuel production. Such support had a large part to play in developing technologies to exploit unconventional natural gas reserves, especially in the initial technological steps that eventually led to the shale gas boom in America. A specific example for a fossil fuel consumption subsidy in the US is the exemption of farmers from excise duties on transport fuels.²⁰ There are no generalised fossil fuel subsidies in the United States. As an advanced economy, the country does not fix the prices of energy products below international levels for domestic consumers. Instead, there are targeted transfer schemes in the United States that help the poor meet their basic energy needs, such as the LI-HEAP (the Low Income Home Energy Assistance Program), an initiative which assists low income families with their energy costs.

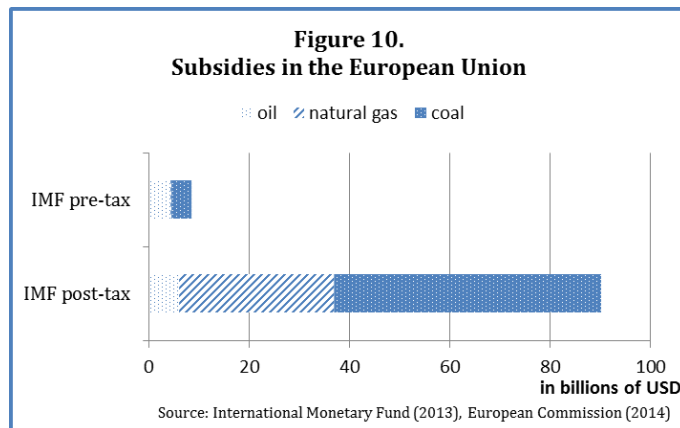
4.6 European Union

Pre-tax subsidies are estimated to be very low in the European Union; they amount to less than USD 10 billion or less than 0.1% of EU-27 GDP (see Figure 10.).²¹ Countries in the European Union have phased out generalised energy subsidies, poor families are instead assisted in meeting their energy needs through targeted schemes and social safety nets. The IMF estimates that post-tax subsidies in the European Union in 2011 amounted to USD 89 billion, which is less than 5% of global post-tax subsidies. Considering that the European Union produces about 20% of the world's GDP, this is a relatively low share. There are two reasons for this low post-tax subsidisation in the EU. First, the EU countries have low pre-tax subsidies (as do most other advanced economies). Second, taxes on energy consumption are high in the EU, even when compared to other

²⁰ This exemption is based on the assumption that farmers use transport fuels to cultivate land, and not to travel on roads, hence they aren't required to contribute to the amortisation of road infrastructure. The purpose of excise duties is to finance the cost of building and maintaining road infrastructure.

²¹ The OECD estimates energy subsidies of USD 54 billion in the EU (excluding Malta and Cyprus). This estimate is rather high partly because of producer subsidies, and partly because of the many tax exemptions in a number of EU member states. For example, several countries apply a lower VAT rate to specific energy products. Often governments have fuel tax reductions for certain professional and industrial uses, such as: reduced excise duties on petrol/diesel for taxi drivers, public transportation companies, garbage collectors, domestic aviation companies, or farmers.

developed countries, e.g. the US. This means that the EU also has lower tax subsidies than the rest of the world, i.e. the market failure of negative externalities associated with fossil fuel use is addressed to a higher degree with corrective taxes and thus the taxation of energy consumption is closer to efficient levels than in other parts of the world. The bulk of post-tax subsidies - approximately 60% - is supporting the production or consumption of coal, as this fossil fuel is undertaxed with respect to its negative externalities even in the European Union. A third of post-tax subsidies support natural gas, while support to petroleum and associated products is responsible for the remainder (approximately 6%).



Based on still a different methodology, the European Commission also published a report on energy subsidies, the "Subsidies and Costs of EU Energy" (2014), which includes subsidies to renewables in its estimates.²² The EC estimates that the value of government interventions to energy in 2012 in the EU equalled USD 145 billion (including support to renewables). Government interventions benefiting renewables were larger than support to the use of fossil fuels in 2012. Support to coal is estimated at USD 13 billion, while support to natural gas amounted to USD 8 billion. Support to oil products is negligible as the analysis doesn't cover transport fuels. The biggest subsidisers in absolute numbers in the European Union were Germany, the UK, Spain, and Italy, respectively.²³

²² The report introduces the concept of government interventions and external costs. Government interventions are subsidies excluding externalities, while external costs are simply the negative externalities that have not been internalised by corrective taxes. The methodologies of the IMF and the EC differ. The IMF considers the favourable tax treatment of fossil fuels (for example through a lower VAT rate) a tax subsidy, therefore this is included in post-tax subsidy estimates but excluded from pre-tax subsidy estimates. Tax exemptions are government interventions in the EC methodology. Another reason the EC report's estimates are not comparable with IMF (or OECD) data is that the EC report excludes from the analysis fossil fuels used in transportation (mainly petroleum and petroleum products) but estimates subsidies and costs of renewable energy in the EU.

²³ External costs are estimated to be in the range of USD 193-399 billion in 2012, with a central estimate of USD 257 billion. This esti-

The European Union is taking steps to reduce fossil fuel subsidisation. EU legislation²⁴ stipulates the phase-out of state aid to the production of coal from uncompetitive mines by the end of 2018. The Council is working on the revised version of the EU energy taxation directive. This directive aims to tax energy products based on their energy content and the amount of CO₂ they emit, in order to incentivise the more efficient use of resources and to mitigate climate change. An important part of the proposal is the introduction of minimum tax rates on energy and CO₂ content across the EU.

5. Concluding remarks

This paper gives a broad overview of pre- and post-tax fossil fuel subsidies across different regions of the world. Pre-tax subsidies are more visible and easier to estimate, but their amount is far below that of post-tax FFSs which in 2011 were approximately four times as large as global pre-tax subsidies. Pre-tax subsidies are mostly concentrated in specific countries, mainly in energy exporters and/or the developing world, such as the countries of the MENA and Central Asia, India, Indonesia, Russia, Venezuela. Post-tax subsidies are common throughout the world because of the negative externalities associated with the use of fossil fuels and the favourably low taxation of these fuels.

Advancing FFS reform is a task for both emerging and advanced economies if they want to succeed in achieving the declared objectives of curbing climate change and improving the sustainability of public finances. The reform process of FFS removal should be carefully planned and well communicated. Poorer segments of society need to be protected from energy poverty through countervailing measures, while effective communication of the benefits of reform - and the costs of FFSs - is important to gain the support of the electorate.

The current environment of low energy prices offers a window of opportunity to proceed smoothly with FFS reform, both on the pre-tax and on the post-tax level. At the same time, governments should resist a possible pressure from producers to introduce or increase producer subsidies to offset the potential losses for energy producing companies. Developing countries can use the current benign momentum to phase-out pre-tax subsidies, and then continue their reform efforts by considering corrective environmental taxes on fossil fuels which would build external costs into con-

mate is significantly higher than that of the IMF also because the EC uses a higher external cost estimate of CO₂-emissions than does the IMF (EUR 50 instead of USD 36 per ton of CO₂-emissions), and because the EC also considers energy resource depletion as an external cost.

²⁴ The Council Decision, 2010/787/EU, published OJ L 336, 21.12.2010, p. 24-29.

sumers' decisions. Developed countries should reflect on the taxation of certain fossil fuels, notably coal, to get closer to the socially optimal level of energy taxation and to promote a less polluting energy mix. While respecting the condition of budget neutrality, the FFS reform gives an opportunity to create extra fiscal space and reconsider the composition of public finances in a broader sense. For instance, higher taxation of energy could be used to lower other taxes, such as labour, or offer a possibility for adjustment on the expenditure side within a country specific context. Finally, the positive environment of low energy prices could give a new boost for G20 members to undergo the FFS peer review process which so far is joined only by three countries, namely the US, China and Germany.

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