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Update on Energy Taxation and Subsidies in Europe: An Analysis of Government Revenues from and Support Measures for Fossil Fuels and Renewables in the EU and Norway

Report for the International Association of Oil and Gas Producers

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Acknowledgments

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Executive Summary

This report, prepared by NERA Economic Consulting, presents the results of analysis that compares the taxation and subsidy regimes applying to oil, gas, coal, wind, and solar power in the EU28 and Norway during the period 2007-2015.[1] The current study updates and extends the results of a previous report published by NERA in 2014. NERA developed the analysis presented here to provide a clear and transparent approach to understanding different estimates of subsidy and government support, and to put them in a broader context of government revenues from different energy sources.

There are now a number of ongoing analyses undertaken by major international institutions to estimate the level of "subsidies" and "support" received by fossil-based energy sources around the world (examples include OECD, IMF and IEA).[2] The motivation for many of these studies is to help governments compare policies towards different energy sources on a like-for-like basis, to enable more efficient policy making. Underpinning these studies is the recognition that some sources of energy receive support from government policies that may provide them with a competitive advantage relative to other sources of energy. Often this is presented in the context of arguments that renewable sources of energy, such as wind and solar power, require additional support from governments, because they do not benefit from the types of support that different forms of fossil fuels receive.

As set out in NERA's original 2014 analysis, we believe the questions that are posed by these studies are important ones, and that they have made significant contributions to global conversations about how to improve energy policy. However, as we also pointed out in 2014, the conclusions set out by the different institutions are influenced strongly by their methodologies. Most of the major studies are careful to acknowledge how their methodological choices affect their findings. But often, when these studies are subsequently discussed in public, they are misinterpreted and in some cases misused by commentators.

Many of the studies adopt an approach that requires them to define a baseline or "benchmark" level of energy *taxation*, which they then compare to the tax rates applied to other selected sources of energy – possibly in different regions, or in different sectors. Taxation below these benchmark levels is counted as "support". Such approaches inevitably require subjective judgments about where benchmarks "should" be set. In addition, they often ignore wider features of policy and regulation that should be considered if one wishes to provide a complete picture of the treatment of energy within economies. In many cases, there are other equally plausible benchmarks that could be selected, which would lead to quite different conclusions. The approach that NERA has developed seeks to avoid the need for subjective benchmarks.

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1 2015 is the latest year for which comprehensive pan-European data were available at the time of writing.

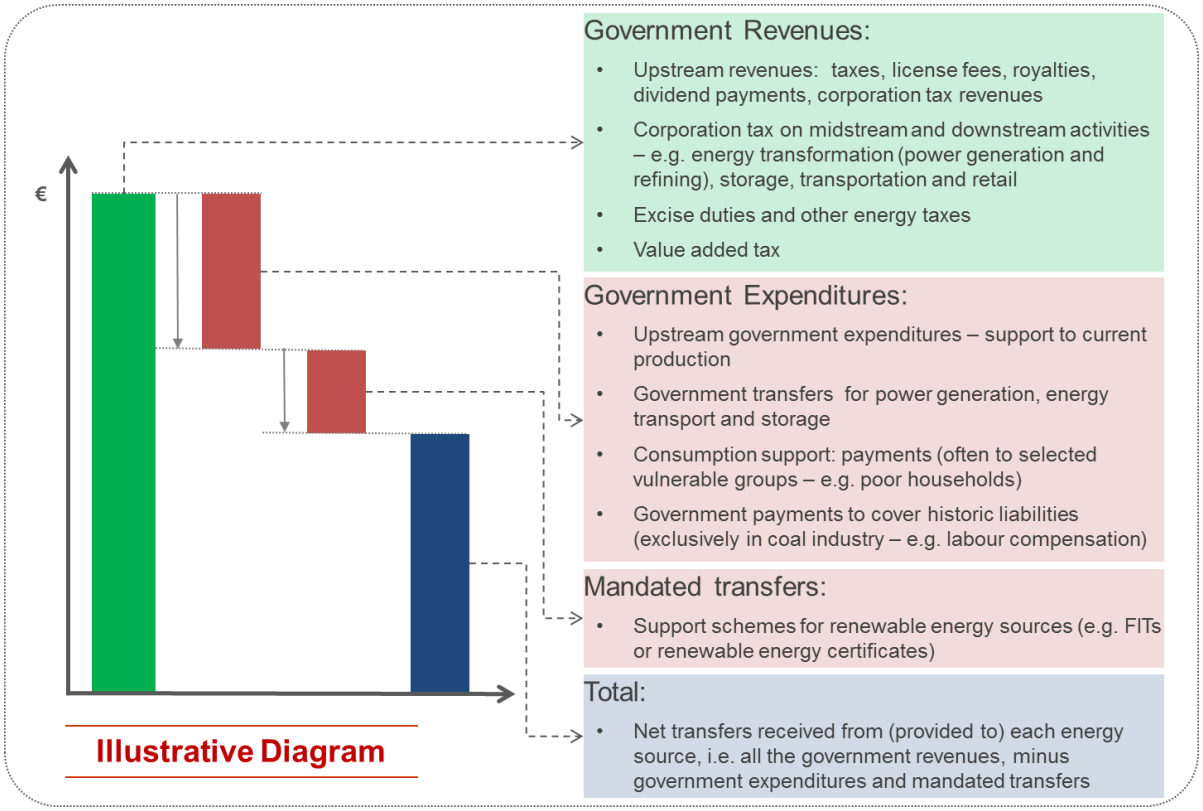
2 OECD (2017), *Inventory of Support Measures for Fossil Fuels 2017*; IMF (2015), "How Large Are Global Energy Subsidies?"; IEA (2017), *World Energy Outlook 2017*.

Methodology

We outline briefly here our high level methodology. A more complete explanation is presented in NERA (2014).

Our approach to estimating relative levels of "support" differs from most other studies. We estimate the full range of financial flows both to and from different sources of energy as a result of government policy, including direct subsidies, other transfers of funds, and major taxes. We start by cataloguing government policies that either lead to government revenues (e.g. taxes, duties, licensing fees, royalties) or government expenditures (direct capital grants, consumption support payments, production subsidies) that are linked to fuels or energy sources. On top of these, we include support that is provided indirectly through *government-mandated transfers* – transfers that are effectively required by government policies, but which may not involve direct contributions to or demands on government finances (for example, feed-in-tariffs). Our approach is summarised in Figure ES-1.1 below.

Figure ES-1.1
Overview of NERA's Approach



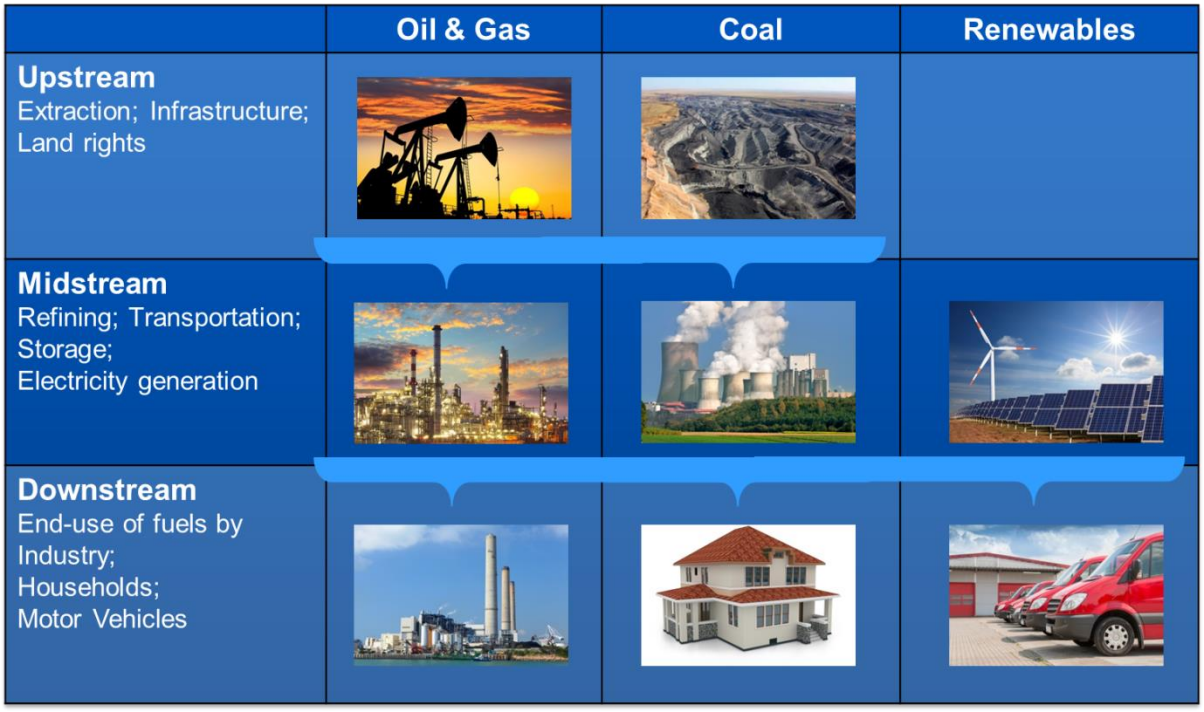
Our approach explicitly recognises that government expenditures on subsidies have an obvious counterpart in government revenues from taxation. Whereas other approaches *selectively* choose a subset of taxes to benchmark against, we take a more comprehensive approach, and estimate *all* material sources of revenue raised from different energy sources. This eliminates the need to select an arbitrary benchmark to compare to.

A major advantage of our approach is that it allows us to make cross-sector, cross-energy, and cross-country comparisons, which it is not possible to do in a meaningful way under many of the other approaches used in the literature. Our approach also makes the calculation of total support – and revenues – across sectors, energy, and countries more meaningful.

Our analysis focuses on cash flows to and from the five energy sources that we analyse, and our task is descriptive. We do not attempt to provide justifications for the differences between the energy sources. For example, one factor commonly presented as justifying differences in government support to different energy sources is that they contribute very differently to environmental and other externalities, and to wider public policy objectives. These are important areas of public policy, but they are not the focus of our analysis. Our aim is to provide a comprehensive analysis of cash flows that can form the basis for like-for-like comparisons across energy sources. These can then be used to inform policy making.[3]

To underpin our analysis, we have developed a database of government revenue, government expenditure, and mandated transfers for each of the five energy sources in all 28 EU Member States as well as Norway. All of the information we rely on is derived from publicly available data sources, supplemented with our own estimates where data are not readily available. The stages in the energy value chain to which we have applied our methodology are illustrated in Figure ES-1.2 (below).

Figure ES-1.2
Energy Value Chains Included in Our Analysis



Source: NERA (2014)

[3] We do include environmental taxes on externalities, as these are reflected in Eurostat's energy tax statistics.

We have also considered externalities[4] associated with the use of energy. It is beyond the scope of our work to deal comprehensively with all externalities related to the five energy sources considered here. However, to illustrate how externality costs (or benefits) relate to our main analysis, we consider the example of greenhouse gas (GHG) emissions.

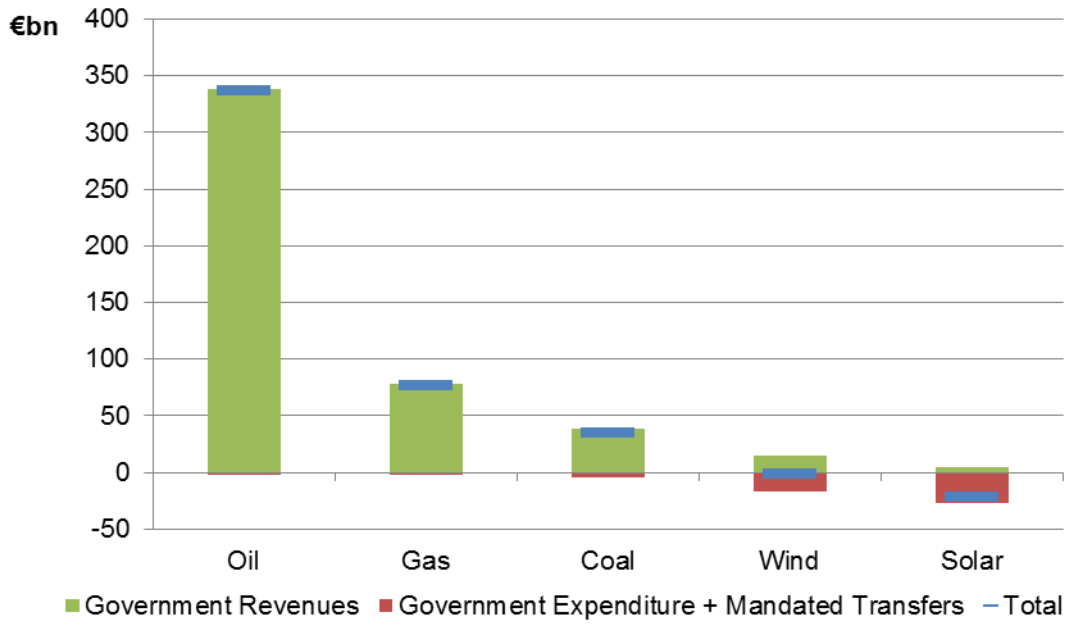
We summarise some of our key findings below.

Results: Government revenues and support to energy sources

We find that EU28+Norway governments receive far greater revenues from oil, gas and coal than these energy sources receive in the form of direct subsidies or other transfers. Oil remains by far the largest contributor to government revenues. In contrast, wind and solar power are still *net recipients* of support.

Figure ES-1.3 summarises our results for the five energy sources for 2015. The green bars represent revenues collected by the government in respect of each energy source, and the red bars represent direct government payment or mandated transfers *to* each energy source. The blue line represents the sum of these two – the "net transfer" amount.

Figure ES-1.3
EU28 + Norway Net Government Revenues and Mandated Transfers (2015)



Source: NERA Analysis

[4] Externalities are costs that, as a result of an activity or market transaction, are imposed on a third party that is not directly involved in that activity or transaction. (Note that externalities can also be benefits that accrue to third parties.) There are a wide range of externalities sometimes linked directly or indirectly to energy – among them greenhouse gas emissions, emissions of "local" pollutants, security of energy supply, innovation spill-overs, "disamenity" value of wind farms and other electricity generating capacity, water scarcity, road congestion, etc.

On the order of €475 billion in revenues were collected by EU28+Norway governments in 2015 from the five energy sources. Of this, a little over 70 percent, or almost €340 billion, came from the oil sector. Gas contributed around 16 percent of the revenue, or almost €80 billion. Net government receipts from both sectors were offset marginally by transfers from government of less than €2 billion to each sector. Coal accounted for just under €40 billion in revenue, but also received transfers on the order of €4 billion. Wind contributed around €15 billion in government revenue, but received transfers amounting to around €17 billion, implying total net payments *to* the sector of €2 billion. Finally, we estimate that in 2015 solar power contributed around €5 billion to government revenues, but received transfers totalling €27 billion.

Excise duties and other energy taxes, most notably those on motor vehicle fuels, account for the largest single source of government revenue from energy, ahead of VAT. Excise duties yielded over €257 billion in 2015.

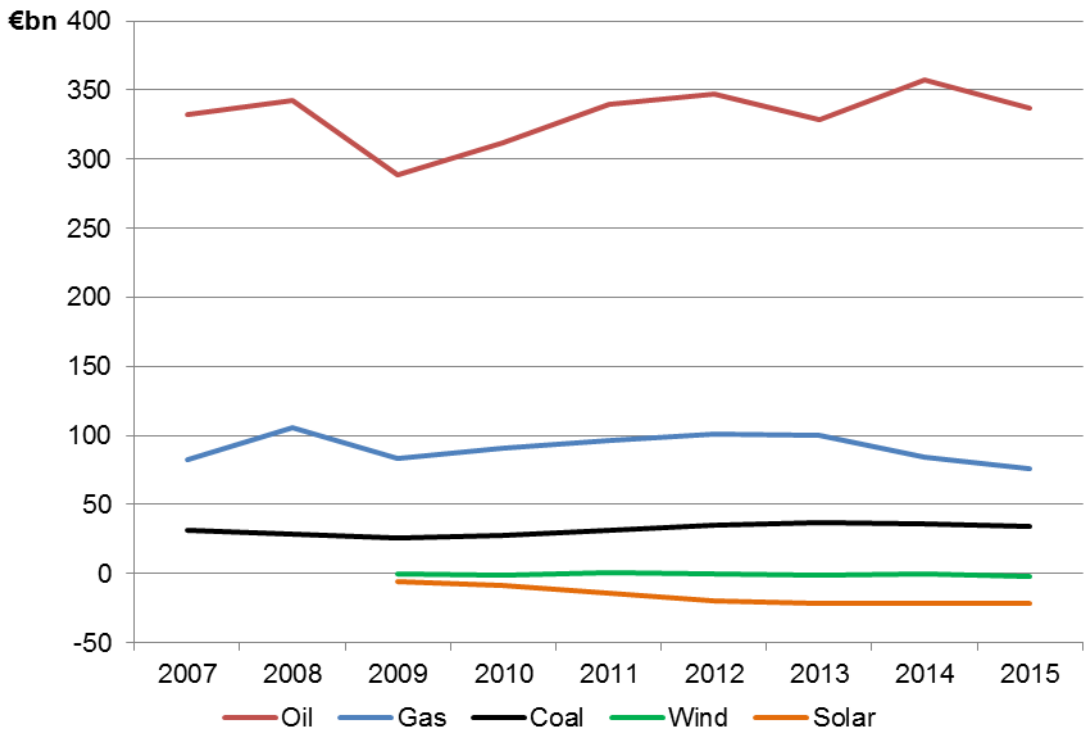
VAT paid on energy is also a very significant contributor to government revenues, accounting for €155 billion in 2015. A large share of VAT is paid on oil through motor vehicle fuels, but there is also a significant amount of VAT paid on electricity and on fuels used for space heating.[5]

After excise duty and VAT, revenues collected from the upstream oil and gas sector contribute the most to government coffers, accounting for €37 billion in total. The production of oil and gas is heavily taxed, with sector profits facing tax rates that can reach as high as 80 percent.

The net results for the years 2007-2014 – that is, subtracting support provided to the different energy sources from the revenues collected by government – are similar to the results for 2015 (Figure ES-1.4). There is some variation in net receipts from oil products during 2009, following the financial crisis, but net receipts recover to previous levels by 2011. In fact, the overall picture remains strikingly consistent over the 9-year period. As we discuss below, this is despite a gradual decline in the volume of fossil fuel consumption (across all three main fuel types) over the period.

[5] We allocate VAT collected on electricity in proportion to each energy source's share of electricity production across each country.

Figure ES-1.4
EU28 + Norway Net Government Revenues and Mandated Transfers
(2007 - 2015)



Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net transfer values for these years.

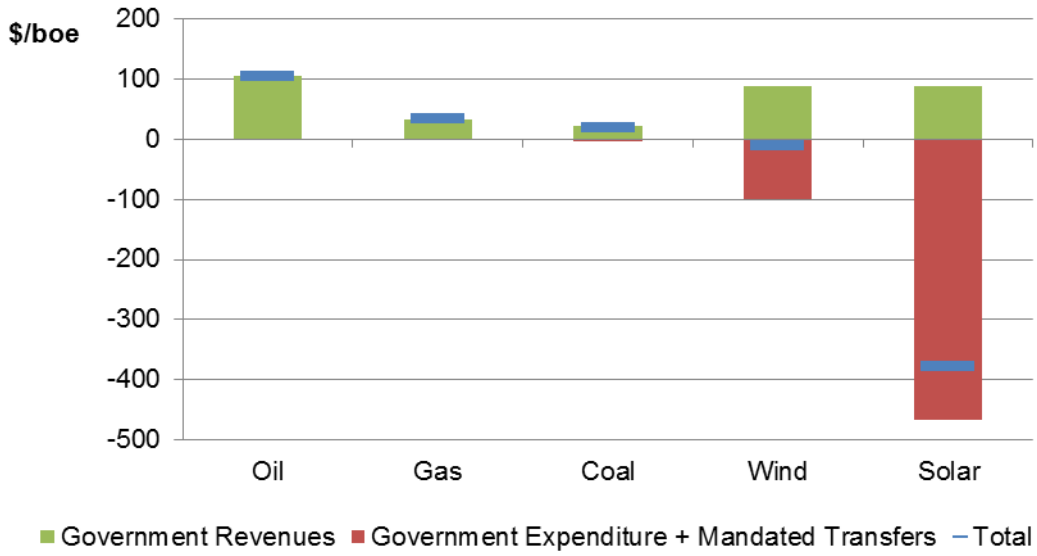
Two further features can be seen in the figure. The first is the increase in the magnitude of transfers to solar power, in absolute terms, up until around 2012. The amount of installed solar generating capacity in Europe expanded rapidly during this period, resulting in large increases in public support for solar technologies. After 2012, significant reductions in the cost of solar power, alongside policy changes in various countries that reduced in the capacity deployed, appear to have led to a stabilization of the annual net support provided to the technology.

Another recent development is that since 2013, net receipts from gas appear to be declining, which appears to be due to a combination of reduced consumption and reduced prices.

Figure ES-1.5 shows the net transfers to each fuel source per unit of primary energy consumption. We present the per-unit results in US Dollars per barrel of oil equivalent ("boe"), to facilitate comparison with the price of a barrel of crude oil. The magnitude of the net transfers to solar power per unit of energy amounts to almost $380/boe. The net

contribution to government revenues by oil per unit of primary consumption is highest, at $105/boe, followed by gas ($33/boe) and coal ($20/boe).[6]

Figure ES-1.5
EU28 + Norway Net Government Revenues and Mandated Transfers ($/boe) (2015)

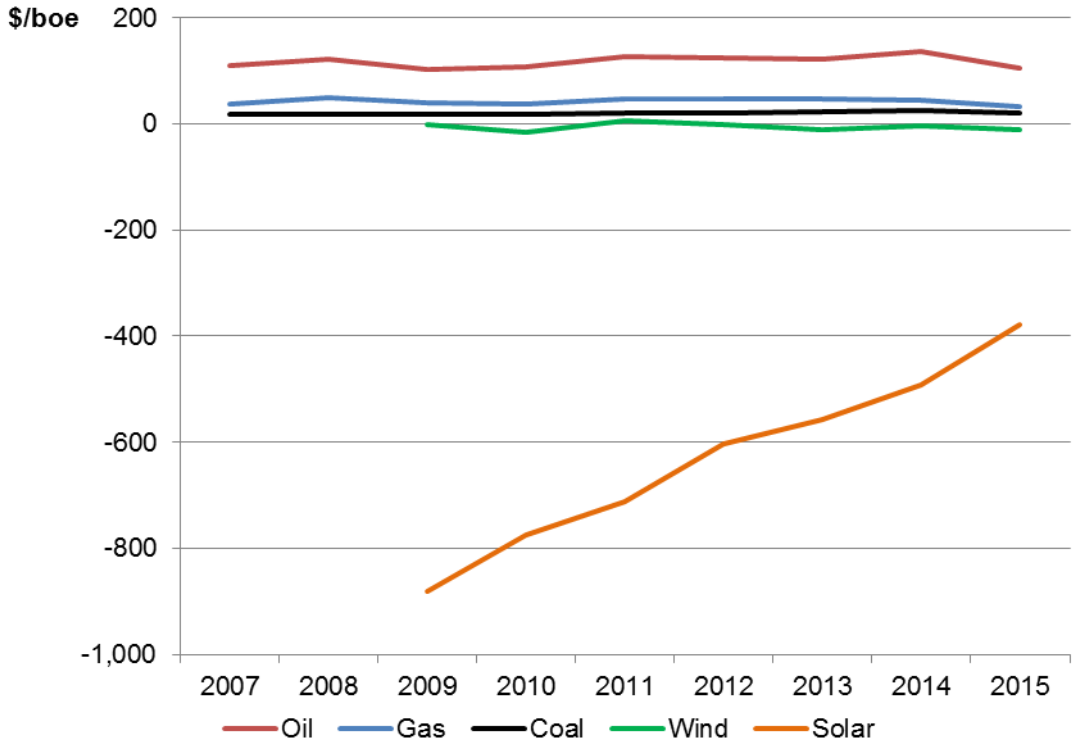


Source: NERA analysis
Note: Values have been converted into barrels of oil equivalent using a conversion rate of 7.33 barrels of oil to 1 tonne of oil.

Figure ES-1.6 presents similar information, showing the net transfers (represented in Figure ES-1.5 by the blue lines) covering the full period from 2007 to 2015. Results are relatively consistent across years, with the exception of solar energy, whose falling costs have meant that support levels have been declining over time. Nonetheless, it is clear from our results that solar still power receives the largest net transfer, both in absolute terms and per unit of energy consumed.

[6] The bulk of revenues from oil are collected from excise duty and VAT, whereas gas and coal provide a significant share of government revenues via their use in electricity generation. Due to the relative efficiencies of the fuels, the value of the primary consumption denominator used in the per boe calculation is greater for coal than for gas, relative to receipts.

Figure ES-1.6
EU28 + Norway Net Government Revenues and Mandated Transfers ($/boe)
(2007 - 2015)



Source: NERA analysis.
Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net transfer values for these years.

Overall, we find that the net contributions to, and dependence on, government funding across the five energy sources has remained largely consistent across the nine years that we have now analysed.

Externalities

The costs (and benefits) associated with externalities differ from the other categories included in our study. For one, externality costs do not reflect any direct transfers between energy sources and the government.[7] It is also important to recognise that an externality cost – for example, of GHGs – represents a cost that is borne by society *as a whole*, not simply by the government. Thus direct comparisons to government revenues alone are likely to be misleading. If the costs of the carbon externality, for example, were reflected in government policies designed to "internalise" it, this would affect not only government revenues, but also benefits to consumers and producers across the economy. The ultimate implications for

[7] Some externalities, however, are effectively paid for via mandated transfers – for example, the wider electricity system costs of intermittent renewables.

government revenues would depend on how the demand for carbon-emitting products and alternatives responded to changes in their relative prices.

One cannot simply assume that if carbon or other externalities were priced at a level higher than the prices already imposed by existing policies, this would result in lower net revenues to government from all carbon-emitting fuels. Government revenues for individual fuels might stay the same, or decline, or they could even increase, depending on how responsive both demand and supply are to price. Thus simply "netting off" or subtracting the externality costs from government revenues will not provide an accurate estimate of net revenues (or subsidies) with a different price for the externality.

Finally, it is important to recognise that there are many other policy measures that may be used by governments to address the externalities associated different energy sources, apart from attempting to price them directly. These policies have their own associated costs. It should not be assumed, therefore, that without carbon and other externality prices at certain levels, energy producers and consumers do not face any costs associated with the externalities they cause.

With these caveats in mind, we estimate the implications of different assumed values of the externality cost of carbon. There is significant uncertainty about the cost of the externality per tonne of CO_2 (often referred to as the shadow price of carbon). To reflect this uncertainty, we have used a range of carbon prices between €10 to 70/tCO_2.[8] At a central shadow price of €30/tCO_2, the externality costs in 2015 would have been €51 billion for oil, €26 billion for gas, and €32 billion for coal.

[8] These values lie within the range that most sources regard as most likely, although the full range is much wider.

1. Introduction

As global efforts to shift towards cleaner forms of energy have intensified over the past decade, a growing body of literature has developed focused on characterising government support for different forms of energy. A number of international organisations, including OECD and IMF, have conducted studies to estimate the level of subsidies to fossil fuels in particular, which are often perceived to benefit from government support, at the expense of cleaner forms of energy such as renewables. However, the conclusions reached by these studies are strongly influenced by methodological choices, and often the results are difficult to compare across countries and products.

In 2014 NERA Economic Consulting published an analysis of government support to different energy sources that was commissioned by the International Association of Oil and Gas Producers. The aim of that study was to add further clarity and transparency to the existing body of analysis at the time, and to compile the associated data in a way that could be compared across countries, focusing on the EU28 plus Norway.

The current report updates and extends NERA's previous analysis, to cover the years 2012-2015. The five energy sources considered are oil, gas, coal, wind, and solar power.

Because energy sources both receive financial support from *and* contribute revenue to the government, NERA's study examines financial flows *to and from* the five energy sectors in the period 2007-15 in the EU28 and Norway. Government revenues are generated from energy through a variety of taxes, duties, royalties, levies and charges. On the other hand, energy sources receive direct transfers through government expenditures providing direct subsidies, grants and support payments. In addition, energy sources also receive revenues from government-mandated transfers through support schemes such as feed-in-tariffs or renewable energy certificate schemes. Like our earlier study, the current update has catalogued these diverse financial flows to and from different energy sources to provide a comprehensive perspective, across the EU and Norway, on the issue of energy taxation and subsidies.

In the next chapter (Chapter 2) we summarise and comment on the existing literature addressing the question of government support for different energy sources, and briefly review some of the most widely quoted studies. Chapter 3 describes the methodological framework of our study. We summarise the economic activities and the scope of transfers we have considered, and we explain how our approach addresses the question of government support – and how it avoids some of the limitations of other approaches. Chapter 4 presents the findings of our study, and Chapter 5 concludes.

2. Overview of Literature

As noted above, various organisations and groups have established research efforts in recent years to estimate "subsidies" or "support" provided by governments to different sources of energy. The motivations for these studies vary, although often they aim to investigate whether government policies confer advantages to specific sources of energy – notably fossil fuels. In particular, the commitment by the G-20 group of countries in 2009 to "rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption" is often cited as the key motivation for investigating the scale of energy "subsides" or "support" to fossil fuels.

The conclusions of these studies are often influenced strongly by their methodologies. Researchers have adopted different scopes, different definitions of what should count as a "subsidy" or a form of "support", and different approaches to quantify them. The findings produced by different studies therefore can differ considerably, even though they are ostensibly addressing very similar questions.

The methodological approaches for measuring subsidies adopted in the literature can be categorised into two broad types:

- **Price-gap approaches**: which compare prices paid by consumers (both final and intermediate) to benchmark or reference prices. These approaches do not consider the underlying factors that cause consumer prices and benchmarks to differ; and
- **Programme-specific approaches**: which involve analyses of individual policy measures against criteria to determine whether they constitute a form of "support" or "subsidy".

Both approaches have significant information requirements, although programme-specific approaches require the analysis of individual policy measures. There are other important methodological choices that can lead to differences in the conclusions of different researchers. In what follows, we provide brief overviews and updates on recent research undertaken on the topic by four organisations:

1. the Organisation of Economic Cooperation and Development (OECD);[9]
2. the International Energy Agency (IEA);[10]
3. the International Monetary Fund (IMF);[11] and
4. the Overseas Development Institute (ODI) and Climate Action Network (CAN).[12]

[9] OECD (2015), *Inventory of Support Measures for Fossil Fuels 2015* and *Companion to the Inventory of Support Measures for Fossil Fuels 2015*; OECD (2017), *Inventory of Support Measures for Fossil Fuels 2017*.

[10] IEA (2017), *World Energy Outlook 2017*

[11] IMF (2015), "How Large Are Global Energy Subsidies?"

[12] ODI and CAN (2017), "Phase-out 2020 – Monitoring Europe's fossil fuel subsidies".

2.1. Studies Investigating Subsidies and "Support" to Fossil Fuels

2.1.1. The OECD's Inventory of Support for Fossil Fuels

Study Snapshot: OECD Inventory of Support for Fossil Fuels (2013, 2015, 2017)	
Methodology type	Programme-specific
Methodology	Support identified consists primarily of tax expenditures, defined as the difference between the actual tax rate applied to an energy product and a country-specific benchmark tax rate
Scope	OECD member states (including Norway and 21 of the EU 28 member states) plus selected "partner economies"

The OECD, relying on a programme-specific approach, has produced a widely quoted series of studies on "support" to fossil fuels, with reports published in 2013 and 2015 and another one scheduled to be published in late 2017, summarising in each case updates to its inventory of support measures in OECD member states. The inventory relies heavily on government documents produced individually by all the OECD 34 member states (plus selected "partner economies") to estimate the level of support in each country. As the inventory acknowledges itself, conventions vary across member states with respect to which measures are considered a form of support (particularly with respect to "tax expenditures", which are discussed below), making it difficult to compare the results across countries and products. The OECD methodology was applied to six non-OECD EU countries by IVM (2013), but this work has not been repeated since.[13] As part of NERA's current study, we have undertaken a review of two of the larger non-OECD EU countries (Bulgaria and Romania) that were assessed by IVM previously. The results of our updated "inventories" of these two countries are presented in Appendix A.

The OECD notes that its definition of "support" is "deliberately broad, and is broader than some conceptions of 'subsidy'. It covers a wide range of measures that the authors deem to provide a benefit or preference for a particular activity or a particular product, either in absolute terms or relative to other activities or products."

So-called "tax expenditures" are by far the most important category of support in the OECD framework. These represent the difference between the actual tax rate applied to a product and a hypothetical higher "benchmark" rate that might have been charged instead. In 2015, tax expenditures represented 95 percent of the estimated support for oil, 85 percent for gas and 38 percent for coal. (The aggregate share across the three fossil fuels combined is 84 percent.)

The 2015 edition of the OECD inventory report[14] noted progress relative to the 2013 edition, with support for fossil fuels as measured by the OECD exhibiting a downward trend. The

[13] IVM (2013). [to be added].

[14] OECD (2015), "Companion to the Inventory of Support Measures for Fossil Fuels 2015".

decrease affected in particular oil (which accounts for the bulk of the total "support" that the OECD identifies) and, to a lesser extent, coal. According to the OECD, two factors lay behind these developments, namely, the contemporaneous decline in international oil prices, and reform efforts on the part of several member state governments (for example, the phasing out of reduced excise tax on diesel use in the non-transport sector in the Netherlands in 2013).

2.1.2. IEA database of energy subsidies

Study Snapshot: IEA World Energy Outlook (and accompanying online database)	
Methodology type	Price gap
Methodology	Support is measured by comparing end-user prices to a benchmark based on the price at the nearest international hub (and for electricity, the annual average cost of generating electricity), adjusted to include costs of distribution and marketing, and, where applicable, VAT (other taxes are not included in the benchmark price).
Scope	Global

The IEA maintains a database of energy subsidies for a number of countries, and reports results in its World Energy Outlook annual publication. The IEA has adopted a "price gap" approach to defining and measuring subsidies that involves comparing final prices faced by end-users (or electricity producers) to a "reference price". The reference price is intended to correspond to the "full cost of supply." The amount by which actual prices paid by consumers are lower than the reference price – i.e. the price gap – is taken to be the level of subsidy.

With the exception of electricity, reference prices are based on comparable prices in the nearest international hub. Reference prices include an adjustment to reflect transport-related costs, and the nature of adjustments varies between countries that are net exporters and importers of the fuel. In addition, the IEA reference price for a given country also includes an adjustment for VAT where VAT is levied on the energy source, although other taxes (e.g. excise duties) are excluded from the reference price. For electricity, the reference price is based on an assessment of the average cost of producing electricity.

The IEA reported global subsidies to fossil fuels of $262 billion in 2016 (down from $455 in 2014 and $544 in 2012).[15] According to the IEA, the marked decrease since 2014 was due in part to lower international energy prices of subsidised fuels, which narrowed the gap between international benchmarks and end-user prices, but also reflected pricing reforms undertaken in various countries.[16]

One significant point that emerges from the IEA's analysis is that *their approach does not identify **any** fossil fuel subsidies in the EU*. This is because end-user fuel prices in Europe do

[15] IEA. World Energy Outlook 2017; and IEA. World Energy Outlook 2013.

[16] See http://www.iea.org/weo/energysubsidies/ for further discussion.

not materially differ from the international reference prices against which the IEA makes its comparison.

2.1.3. IMF's estimates of global energy subsidies

Study Snapshot: How Large Are Global Energy Subsidies?, IMF (2015)	
Methodology type	Price gap
Methodology	Similar to IEA, end-user prices are compared to a benchmark price. Distinguishes between: (1) "pre-tax subsidy" – measured by comparing (pre-tax) end-user prices with supply cost; and (ii) "post-tax subsidy" – compares end-user prices (including taxes) with a benchmark price defined by supply cost plus a "benchmark" consumption tax (for raising government revenue) as well as a tax internalising the externalities attributed to different energy sources.
Scope	Global

The 2015 IMF Working Paper "How Large Are Global Energy Subsidies?" (which builds on earlier IMF work on this topic) sets out to measure energy subsidies, focusing on fossil fuels and using a price gap methodology similar to the IEA's. The definition of subsidies distinguishes between consumer and producer subsidies. Whereas estimates of producer subsidies are sourced from OECD (2013), consumer subsidies are estimated on two different bases:

1. **pre-tax subsidies**, which are based on a comparison of pre-tax end-user prices with supply costs..
2. **post-tax subsidies**, which compare end-user prices inclusive of all taxes with a benchmark price that reflects assumptions about a "*reference rate*" of VAT (or GST) and allowances for the externalities of greenhouse gas (GHG) emissions, local air pollutants, and vehicle externalities (e.g. congestion).

On a pre-tax basis, the IMF estimate of total global fossil fuel subsidies remained largely unchanged relative to its earlier work, published in 2013: In 2013, the IMF estimated subsidies "received" in 2011 to total $492 billion. In the 2015 publication, the estimate for 2011 was $523 billion and the value forecast for 2015 $333 billion. Similar to the IEA's results, the IMF attributes most pre-tax subsidies to developing countries, meaning that European countries are predominantly affected by post-tax subsidies (mainly in the form of non-internalised externalities)[17] Unfortunately IMF does not report its estimates at a country level, and does not group regional estimates in a way that allows one to estimate values at the EU level.

[17] The IMF has made use of the IEA results for its estimate of pre-tax subsidies, so the reasons for the decline between 2011 and 2015 are the same as those identified by the IEA. The total value of global fossil fuel subsidies in 2015 reported by the IEA in the 2017 WEO was $310 bn.

Compared to IMF's earlier analysis, its latest estimates of "post-tax subsidies" are far higher: IMF (2013) estimated post-tax subsidies in 2011 to amount to $2.0 *trillion*. IMF (2015) re-estimated these subsidies to be equal to $4.2 trillion and attributed post-tax subsidies of $4.9 trillion to 2013, with a further increase to $5.3 trillion projected for 2015.

The IMF attributed the difference to a number of factors, including increased coverage of air pollutants (which increased coal-related post-tax subsidies by 24 percent), revisions to the estimated damage associated with pollution (including upward revision of mortality risk), and more detailed country-level assessments of externalities (as opposed to extrapolation from a few countries). As in 2013, IMF found that coal received the biggest share of post-tax subsidies (a little under 60 percent), with around three quarters of the subsidy to coal attributable to local air pollution, and around one quarter attributable to climate change.

2.1.4. ODI and CAN's reports on subsidies

Study Snapshot: Phase-out 2020 – Monitoring Europe's fossil fuel subsidies, ODI and CAN (2017)	
Methodology type	Programme-specific
Methodology	Support is measured through the assessment of individual measures, with "fiscal support" accounting for the majority of estimated support. Measurement of fiscal support draws on the 2015 OECD Inventory.
Scope	Selected EU countries accounting for around 80 percent of EU greenhouse gas emissions and EU programmes[18]

ODI and CAN distinguish three kinds of subsidy:

1) "fiscal support" (budget expenditure, tax "exemptions" [19], price support) where the authors rely among others on the 2015 OECD Inventory (discussed above);

2) "public finance" (grants, loans, equity funding, insurance and guarantees) provided both within and outside the EU by "public finance institutions" such as development banks, export credit agencies and majority state-owned banks, where importantly these financial flows are wholly counted as subsidies, as opposed to only counting the concessional element in them. This implies that e.g. loans extended by public financial institutions on a fully or near commercial basis (i.e., offering conditions that are the same as or similar to those offered by private finance institutions) are nonetheless wholly treated as "subsidies".

3) "investment by state-owned enterprises" ("SOEs"), which is similar to public finance, except that the investment is made not by a public finance institution, but by a "state-

[18] The countries are listed in footnote 21.

[19] ODI uses "exemptions" where OECD uses the term "expenditures".

owned enterprise" (i.e., a private non-financial company in which the government controls a stake of 50 percent or more).[20]

Averaging over the 2014-2016 period, ODI and CAN report annual fossil fuel "subsidies" of around €112 billion in the 11 EU countries in their sample (or associated with EU programmes).[21] Of these, close to 80 percent fall into the fiscal support category, while public finance and SOE investments each attain a share of a little over 10 per cent. Within the fiscal support category, measures in the transport sector dominate (representing 56 percent of fiscal support and 44 percent of total annual subsidies), a mainstay of which are tax "exemptions", or reduced rates of tax, on diesel (often introduced to encourage its use over petrol to reflect its lower GHG emissions footprint). In the public finance category, more than 70 percent of subsidies are "international", i.e., representing investments made outside the EU.

2.1.5. Comments on Existing Approaches[22]

As we pointed out in our 2014 report, a common feature of the estimates of "support" produced in many of the studies summarised above is that they rely on hypothetical "benchmarks" to identify subsidy and support. These benchmarks are often selected in a way that is subjective, and that may not be appropriate when considered in a wider context. As noted above, the IMF does not find any significant "subsidies" in EU countries when analysing pre-tax prices, but it does when it considers post-tax prices. This highlights the importance of clearly articulating the nature of the "support" that is identified by different analyses. Tax regimes and mechanisms for raising revenue vary significantly across countries. When benchmarks are used to compare levels of taxes this requires particular judgments about the levels at which taxes *should* be set, and these judgments are far from uniform.

As noted above, by far the most significant forms of "support" identified in the OECD inventory are so-called "tax expenditures" – and this is also true of the ODI and CAN study. Tax expenditures represent the difference between the actual tax rate applied to a commodity and what is essentially a hypothetical higher "benchmark" rate. For example, in the UK, the VAT rate applied to natural gas consumed by the domestic and residential sector is 5 per cent. Different VAT rates are applied to different commodities and categories of consumption: the VAT rate on food items is 0 per cent; on residential electricity consumption it is 5 per cent; and on gasoline it is 20 per cent. Although EU legislation defines a "standard rate" of VAT of 15 per cent,[23] the legislation includes provisions for various exemptions to apply to some types of products, including natural gas, electricity and heating. Thus, it is not straightforward to determine what an appropriate "benchmark" VAT rate is. Subjective

[20] In contrast, government transfers to state-owned enterprises are included in the fiscal support section.

[21] These countries (Czech Republic, France, Germany, Greece, Hungary, Italy, the Netherland, Poland, Spain, Sweden, and the United Kingdom) account for around 80 percent of EU greenhouse gas emissions.

[22] [Consider further editing of this section to reduce repetition of previous report.]

[23] VAT Directive 2006/112/EC

judgements about benchmarks – for example, about VAT – also underpin the approach adopted by the IMF.[24]

The commentary accompanying the OECD's inventory includes a detailed discussion of the issues associated with measuring "support" in the form of tax expenditures. An important limitation of the inventory's findings is that estimates of support cannot be compared across countries or across energy sources. The authors note that "a simple cross-country comparison of the tax expenditures can lead to a misleading picture of the relative treatment of fossil fuels". This is because tax expenditures reported in the OECD inventory are based on estimates constructed by and for individual member states, and there is a lack of consistency across countries in their approaches to issues that are fundamental to the identification and estimation of tax expenditures. In particular, there is:

- a lack of consensus among countries on how a benchmark should be defined. The report notes that several approaches are used. For example, the authors discuss that some countries set a benchmark with respect to "a conceptual view about what constitutes 'normal' taxation of income and consumption" whereas others only rely on a benchmark that is explicitly defined in law.
- a lack of consensus among countries on how to measure the *size* of tax expenditures. For example, the authors note that when quantifying tax expenditures, some countries do not take into account expected changes in consumer behaviour (for example, changes in consumption patterns) in response to tax changes, whereas others do take them into account.

The use of tax expenditures also poses challenges in conducting comparisons of "support" across different energy sources. Typically, tax expenditures are identified by comparing tax rates across a small group of fuels. For example, in Finland, the tax rate applying to gasoline is used as the benchmark for transport fuels, and a tax expenditure on diesel is identified on this basis. If the rate on diesel were used as the benchmark instead, there would be no support identified, because the rate on gasoline is higher. It also is not clear how tax rates should be compared across a broader range of fuels that are subject to different taxation regimes. To give an example, in the UK, the climate change levy (CCL) covers electricity, gas and solid fuels, but not oil and its derivatives. Instead, oil is covered by the hydrocarbon oils duty. The existence of such differences shows the challenges of drawing conclusions on the relative "support" offered to different energy sources solely on the basis of selectively analysing tax expenditures.

[24] As noted in section 2.1.3 above, the IMF includes a notional rate of VAT in its (post-tax) benchmark prices – even in countries where no VAT is paid on ***any*** product.

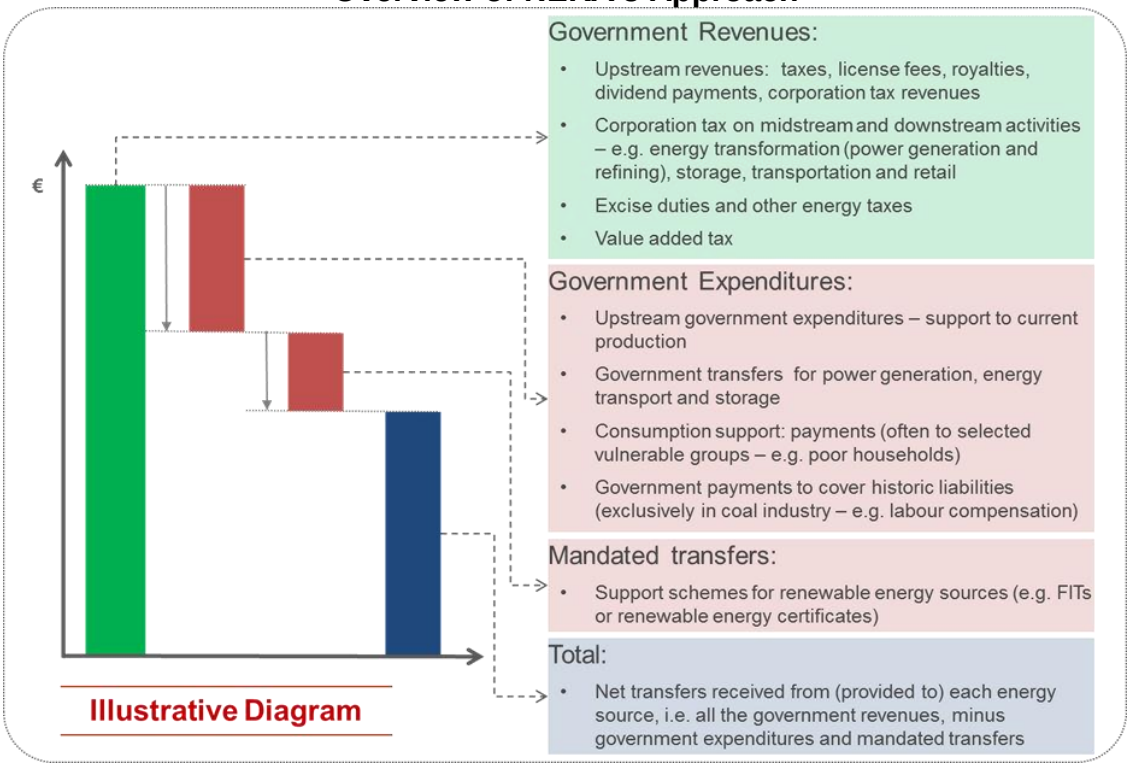
3. Methodology

As the discussion in Chapter 2 shows, a number of studies have investigated governments' direct and indirect payments to and receipts from different energy sources with a view to assessing the extent of "support" provided by diverse government policies and mechanisms. In this chapter, we discuss our approach to addressing this question (summarised in Box 3.1), which closely follows the methodology developed for our 2014 study. We begin by describing key features of our approach in section 3.1, and note its main advantages over the approaches used by others. We then outline the scope of government revenues, expenditures, and other transfers that we consider in section 3.2. To facilitate the comparison of net financial flows among the different countries and energy sources, we have classified them into a set of categories. These categories are described in more detail in section 3.3.

Box 3.1
Approach to Comparing Support Across Energy Sources

We have approached the question of relative levels of "support" from a perspective that differs from those used in other studies. We estimate the full range of financial flows both to and from different sources of energy as a result of government policy, including direct subsidies, other transfers of funds, and major taxes. We start by cataloguing government policies that either lead to government revenues (e.g. taxes, duties, licensing fees, royalties) or government expenditures (direct capital grants, consumption support payments, production subsidies) that are linked to fuels or energy sources. On top of these, we include support that is provided indirectly through *government-mandated transfers* – transfers that are effectively required by government policies, but which may not involve direct contributions to, and demands on, government finances (for example, feed-in-tariffs). This approach is summarised in Figure 3.1 below.

Figure 3.1
Overview of NERA's Approach



Our approach explicitly recognises that government expenditures on subsidies have an obvious counterpart in government revenues from taxation. Whereas other approaches *selectively* choose a subset of taxes to benchmark against, we take a more comprehensive approach, and estimate all material sources of revenue raised from different energy sources. This eliminates the need to select an arbitrary benchmark to compare to.

A major advantage of our approach is that it allows us to make cross-sector, cross-energy, and cross-country comparisons and to calculate totals, which it is not possible to do under many of the other approaches used in the literature. We also consider individual policies and sectors of the economy, so we can reflect details that may be overlooked by more high level methodologies (for example, the price gap approaches used by the IEA or IMF).

3.1. Key Features of Our Approach

As noted on the preceding page, our approach is to estimate two "government transfer" quantities for each energy source: 1) total revenues collected from the energy source by government, and 2) total expenditures that benefit the energy source. [25] Taken together, these two quantities allow us to estimate the net total effect on public finances of government policies and mechanisms affecting a particular energy source. Expenditures are the total demands on public finances (including, for example, direct payments from governments); revenues are the total contributions to public finances (including, for example, excise taxes). We discuss the specific categories of government revenues and expenditures we have considered in sections 3.3.1 and 3.3.2 (respectively) below.

In addition, our analysis extends to transfers that are mandated by government policies, but which may not involve direct contributions to, and demands on, government finances. Like direct transfers, government-mandated transfers also involve transfers to or away from an energy source (and often between sources) with a view to supporting a policy objective. For example, many government policies provide feed-in-tariffs (FITs) to renewable energy sources and these are typically paid for by consumers or other electricity suppliers, with the financial flows between consumers and producers prompted by the policy often bypassing public coffers altogether. One way to view mandated transfers is to consider the net financial burden placed on the energy source by taxes and other key government policies. Viewed this way, taxes such as VAT and corporation tax impose a financial burden on the energy source. Conversely, policies such as direct grants or mandated transfers such as FITs for renewable energy sources lead to support for the energy source. We discuss government-mandated transfers further in section 3.3.3 below.

Our approach provides a transparent assessment of the *net* government transfers to/from each energy source, taking account of transfers across the entire value chain, from production, transformation, transport, and storage, to distribution and consumption. In turn, these *net* transfers to/from each energy source provide an indication of the extent to which government policies may support them. Importantly, by focusing on transfers across the entire value chain, our results of the overall net contribution of each energy source are not distorted by selectively focusing on policies affecting only certain activities

Our approach avoids many of the shortcomings of existing approaches by including: (i) the full range of an energy source's value chain – from production to final consumption; (ii) transfers from government as well as transfers to government (including transfers mandated by government policy).[26] This allows individual policies affecting an energy source to be

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[25] It is also possible to understand our methodology from the perspective of the energy sectors themselves, in which case the two categories become 1) sector payments to government, and 2) sector revenues due to government policy – whether received directly from governments, or as a result of government mandates or other policy.

[26] Note that we do not account for "subsidised" or concessional finance extended to different energy sources e.g. through concessional loans provided by state-owned or state-backed financial institutions (such as Germany's KfW, which benefits from a state guarantee and passes on its low cost of debt to the recipients of its loans e.g. in the renewable energy space). In such cases, the concessional element – i.e., the difference between "preferential" and "market" financing terms – is a form of support from government. We also do not consider macroeconomic or "multiplier" effects (which would require a very significant expansion of our scope). Finally, we do not attempt to quantify the

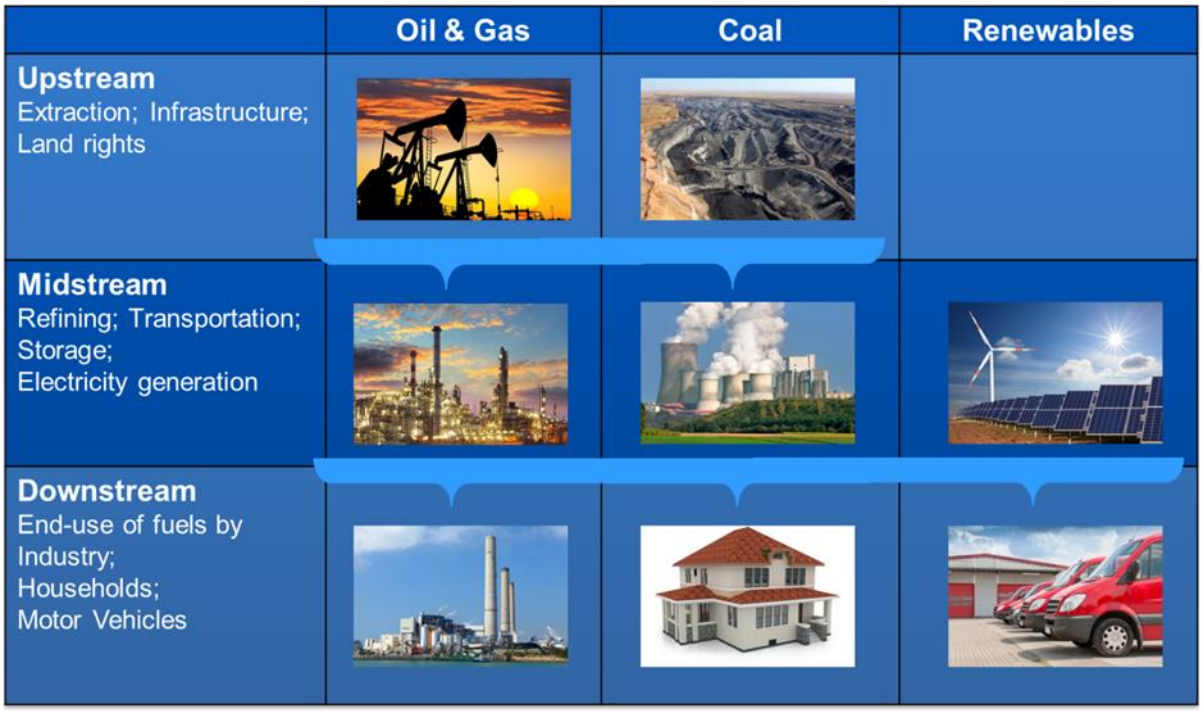
analysed within the wider context of government taxation and regulation. Importantly, the approach allows for more meaningful comparisons between the net contributions to (or demands on) government finances of different energy sources and other objectives in the public interest. Unlike many of the approaches outlined above, our methodology enables comparisons across energy sources and across countries.

3.2. Scope of Transfers

Our analysis covers the 28 countries of the European Union as well as Norway, over the period 2007 to 2015.[27]

The discussion in the preceding section highlights the importance of accounting for the full range of economic activities from each energy source. Our scope therefore extends to expenditures and revenues across the entire value chain – from production to final consumption. The specific activities that we have investigated for each energy source are summarised in Table 3.1. We have relied upon publicly available data sources, noting any gaps and our approach to addressing them in our discussion of individual categories below.

Table 3.1
Activities Associated with Energy Sources



Source: NERA (2014)

impacts on employment of different energy sources, on which there is a wide and expanding literature of varying quality. Our focus is on the energy sources themselves, and not their interactions with the wider economy.

[27] Unfortunately many of the data sources on which we rely have not yet been updated for 2016. In addition, some of the data are not available over the entire period in selected categories or countries.

Table 3.1 does not include any upstream activities associated with renewables, although renewables may in practice enjoy privileged access to public land or seabed (e.g. in the case of offshore wind) and will often require "supporting" infrastructure (e.g. grid reinforcements or back-up capacity because of their intermittent nature). At the same time, it is often difficult to quantify these benefits conferred to renewables in terms of budgetary flows, and we therefore do not consider them in what follows, although we discuss certain related issues concerning externalities in section 3.4.[28]

In most cases, we have not attempted to account for transfers associated with employees. Examples of such transfers include national insurance contributions, social security payments, or any state pension contributions made by employers. Similarly, we have not tried to reflect income tax payments by employees. This reflects the view that labour typically does not "belong" to a particular sector. The only exceptions to excluding labour-related transfers are compensation payments made by the government to coal miners, typically associated with structural adjustments as well as health liabilities. Such payments are a direct consequence of the involvement of employees in coal production, and not because they are employees per se.[29]

For revenues from energy production activities, we have focussed on the group of countries that together account for at least 90 per cent of production of an energy source within the EU and Norway. We have then derived estimates of revenues from remaining production activities by scaling our estimates in proportion to the residual production in each country. For example, for oil and gas, this threshold has led us to produce detailed estimates of upstream revenues for: Norway, Netherlands, United Kingdom, Germany, Denmark and Italy. Collectively, these countries accounted for more than 90 per cent of the average combined oil and gas production in the EU countries and Norway in the 2007-2015 period. We have scaled the estimates for these six countries to estimate total revenues from oil and gas production across the remainder of the EU

In some cases, we have been able to collect revenues or expenditure data that are aggregated across the energy sector as a whole – for example, VAT receipts on electricity. We have allocated such transfers to individual energy sources in proportion to an appropriate measure of activity for the relevant sector. For example, in the case of electricity VAT receipts, we have allocated total receipts to individual fuel sources on the basis of the respective electricity production from each fuel. This approach has also been used by other reports measuring support – for example, the OECD's inventory of budgetary transfers.

[28] We note that there is a growing literature that attempts to quantify the "system integration costs" associated with intermittent renewables and other forms of electricity generation. Estimates of such costs range from below €5/MWh of electricity to more than €25/MWh. See, for example NERA, *UK Renewable Subsidies and Whole System Costs*, February 2016, or Hirth et al., "Why Wind is not Coal: On the Economics of Electricity Generation", *Energy Journal*, Vol. 37, No. 3, 2016. However, we have not attempted to account for such costs in what follows.

[29] We are not aware of any reason to think that excluding employee-related contributions from our analysis materially affects our overall conclusions about the relative comparison of different energy sources.

3.3. Categories of Revenues and Expenditures

To facilitate the comparison between different energy sources, we have allocated transfers to different categories of revenue and expenditure. The different categories are shown in Table 3.2 below.

Table 3.2
Categories of Government Revenues and Expenditures

REVENUE CATEGORIES	EXPENDITURE CATEGORIES
Direct Transfers	
Upstream extraction and production taxes	Resource extraction support
Corporation tax	Electricity generation and supply support and other midstream sector expenditure[3]
Excise duties and other energy taxes[1]	Consumption support
Value added tax	Historic liability transfers[4]
	R&D Payments
Mandated Transfers	
See note 2 below	Electricity generation and supply support and other midstream sector expenditure[3]
See note 2 below	Price regulation[5]

Source: NERA analysis

Notes: 1. EU ETS revenues are classified in Eurostat among energy taxes but are not included within excise duties.
2. For mandated expenditures, the corresponding "revenue" category is typically funded through levies or other instruments whose costs are shared between consumers and other producers – for example, balancing costs associated with renewable energy sources are reflected in higher bills for customers. We do not quantify these costs imposed on consumers and other producers, but note that they may be significant.
3. Includes support to RES and CHP electricity generation technologies (FITs, RECs, ROCs) and grid infrastructure investment support which can either be in the form of direct or mandated transfers.
4. Includes decommissioning payments, compensation payments to workers and spending on repairing environmental damages.
5. The impact of price regulation has not been quantified – see discussion below.

We provide an overview of these categories in the sub-sections below, distinguishing between direct revenue categories, direct expenditure categories, and transfers mandated by government policy. In this report, we limit ourselves to setting out the main features of our approach to defining these categories. Further details about our methodology can be found in our 2014 report.

3.3.1. Direct Government Revenue Categories

3.3.1.1. Upstream extraction and production taxes

Royalties, hydrocarbon taxes such as the petroleum revenue tax in the UK or the special tax in Norway, and other similar upstream levies are major sources of direct government revenue from fossil fuels. A variety of approaches are used by countries to extract revenues from hydrocarbon production related activities, and these approaches often change over time (in part, in line with the evolution of government policy objectives). Examples of instruments included within the royalties and upstream levies category include: royalties levied on the value of the underlying resource (e.g. the value of oil, gas or coal), taxes levied on cash flows, taxes on profits, and fees charged up-front by government when awarding contracts.

We have also estimated returns to the government in the form of dividends from state-owned energy companies involved in upstream fossil-fuel production – in particular, oil and gas companies. State ownership in such companies is often one of the ways that governments share revenues from the extraction of the natural resource. Such companies therefore represent an important example of an alternative to royalties or fossil-fuel specific product taxes. To reflect this, we have included such dividends within the scope of our study. We have, however, not included revenues from state-owned energy companies operating in other activities – for example, transmission network companies. Unlike upstream fossil fuel extraction companies, the sharing of profits with society is typically not a primary motive for state-ownership. Instead, state-ownership typically reflects a combination of historical reasons, perceived strategic nature of the company's activity, and an alternative to regulation in the case of infrastructure companies that have natural monopoly characteristics (e.g. electricity transmission grids or gas transport networks).

3.3.1.2. Corporation tax

Corporation taxes – i.e. taxes imposed on the profits of companies – are another significant source of government revenues from the energy sources. Although aggregate statistics for corporation taxes are available, we are not aware of any publicly available sources that provide a breakdown of corporation tax that can be easily attributed to the different *energy* sources. The only exceptions to this are corporation tax receipts from upstream oil and gas activities, where the significance of the tax contribution of the companies has led governments to report these explicitly. To facilitate the estimation of such revenues, we have distinguished between companies in different vertical segments of the value chain of each energy source, and have limited our scope to estimate only corporation tax receipts that meet the materiality threshold.

3.3.1.3. Excise duties and other energy taxes

Excise duties represent one of the most significant sources of government revenue from the energy sector. Duties are levied on a number of oil and gas derivative products, including petrol, kerosene, automotive diesel, industrial gas oil, fuel oil, natural gas, coal, and electricity. Rates of excise duties vary significantly across EU member states. We have obtained estimates of revenues from excise duties from data published by the European Commission and Eurostat. To allocate receipts to fuels, we have relied on the allocation reported by the European Commission. Excise duty revenues from electricity are smaller and,

similarly to the methodology applied to VAT, we have allocated these to the different energy sources based on the source's contribution to the generation mix in each country.

3.3.1.4. Value Added Tax

Value added taxes (VAT) are another very significant source of government revenues from energy. Unlike excise duties, available sources on VAT revenues do not typically report a breakdown of VAT that can be readily allocated to specific energy sources. We have therefore constructed estimates using a variety of sources. There are three main categories of VAT receipts for which we have adopted different approaches to estimate government revenues:

- **VAT on the final consumption of energy (other than electricity)** – for example, products like natural gas, kerosene, petrol and diesel. We have estimated VAT receipts from such products using energy price data and published VAT rates for domestic and business consumption by country ;
- **VAT on the final consumption of electricity.** We have allocated VAT receipts on electricity consumption to our different energy sources in proportion to their share of the generation mix in each country; and
- **VAT on intermediate consumption by businesses that rely on energy sources as inputs**. VAT on intermediate consumption is typically refunded to businesses. Because the value added of businesses' final output includes the value of their energy input, the VAT paid on the final output also includes the VAT that would have been associated with the energy used. We have therefore estimated VAT collected on intermediate consumption by treating it as final consumption. This approach provides a convenient way of reflecting the proportion of final VAT that is directly attributable to the energy source, ignoring the VAT associated with the rest of a business's output

For companies in the energy sector, a similar consideration arises in relation to their own VAT. VAT receipts on the final consumption of *energy products*, in part, reflect the value added associated with the inputs that are used in upstream and mid-stream activities in the energy sector. For example, for the electricity sector, VAT receipts reflect, among other things, the contribution of capital equipment to the final electricity price. Although some of these inputs lie outside the direct scope of the energy sector, our methodology effectively includes VAT associated with them, because of their integral role in the final output. This approach also means that we do not "penalise" electricity sources that are more reliant on capex relative to opex. For example, a major contributor to the final price of electricity produced by gas is the cost of the gas itself, whereas for wind power, a majority share of the cost is accounted for by capital equipment.

3.3.2. Direct Government Expenditure Categories

In this section we provide an overview of our methodology regarding direct transfers made from the government to the different energy sources – including payments to producers and consumers as well as funds made available to cover historic production liabilities. Support to current production and consumption provides incentives to increase the supply and use of different energy sources. Payments made regarding historic liabilities, on the other hand, do not promote current activity, but are often the result of underinvestment in the past. These include payments covering decommissioning costs, compensating workers for health-related

issues due to poor labour conditions, or restoring land that has suffered from environmental damage due to resource extraction activities.

We have relied primarily on the OECD's inventory (as well as the supporting work carried out by IVM (2013) for six non-OECD EU countries), to identify and estimate government expenditures. Both organisations have carried out a detailed review of support across the oil, gas and coal sectors in all EU countries. We rely on the OECD and IVM only as a data source for *direct* payments to these sectors, excluding entries that are categorised as tax expenditures, because we account separately (and much more comprehensively) for taxes. We do not attempt to replicate this work, or significantly add to it. We have, however, carried out our own validations of some of the more significant data items. Our detailed analysis of the OECD and IVM inventories split out payments into different categories, broadly corresponding to parts of the value chain. These categories include:

- **Upstream payments** – in support of energy extraction activity. Production support is the largest category of direct government expenditure. It is exclusively provided to the coal sector, most notably in Germany and Spain. These support programmes are being gradually phased out.
- **Midstream payments** – in support of energy transformation (e.g. electricity generation or refining) as well as energy storage and transportation.
- **Downstream payments** – in support of final consumption, such as consumption grants or price caps for certain types of consumer. Downstream payments are the second largest category of support and are more prevalent in the oil and natural gas sectors. The majority of payments consist of excise duty refunds provided by the government to certain sectors, such as agriculture or public transport. These are distinct from tax expenditures in that the full excise rate is initially paid (and captured within our data). Only after initially paying the full rate of tax can eligible consumers request refunds on this tax payment, which then reduce the initial government revenue.
- **Decommissioning payments** – where governments (partially) cover the cost of asset disposal, such as closing coal mines. This category is exclusively applicable to the coal sector and typically is a result of either a lack of provision for decommissioning costs, or the premature closing of mines where the owner has been unable to afford to carry out adequate decommissioning.
- **Compensatory payments to workers** – where governments assume liabilities related to both health issues from historic production activities and structural unemployment. This category also relates exclusively to the coal sector. The closure of mines in certain countries left many otherwise unskilled workers unable to re-enter the labour force, and facing significant health problems.
- **Environmental damage compensation** – where governments assume the cost of restoring areas of land that suffered from environmental damage as a result of historic production activities. This is a relatively minor expenditure category.

In addition to relying on the estimates included within the OECD and IVM studies we have also considered certain additional areas of government expenditure that are not included in these inventories, in particular contributions to research and development (R&D) funding in energy sectors.

3.3.3. Government Mandated Transfers

As noted above, we have defined transfers in a broad sense so that they also include government mandated obligations that lead to payments by others. Even though the government does not, in most cases, directly earn revenues or incur significant expenditures from such policies, these policies nonetheless lead to such revenues and expenditures being accrued and incurred by others. Perhaps the clearest example of such mandated transfers is a feed-in-tariff (FIT) provided to electricity generated from renewable energy sources. FITs are typically paid for by consumers and other electricity producers/suppliers.

In addition to FITs, we also include other mechanisms through which renewable energy sources are supported – for example, renewable energy certificates (RECs), and other similar support schemes. In the case of fixed FITs (as opposed to "premium FITs"), our estimates relate to the incremental support over and above the market value of the electricity supplied. Estimates have been collected from data collected by the Council of European Energy Regulators (CEER).

Another example of government policies that impose costs on some segments of the energy sector and confer benefits to others are provisions granting "priority access" to the power grid for renewable electricity generators. Priority grid access provides support to electricity generators and imposes a cost on the wider industry – and is therefore similar to other mandated transfers. We have, however, not included a quantitative value of this support in our main results because of the significant uncertainties associated with any estimate.

Many EU countries also apply price regulation whereby selected groups of consumers (and sometimes all consumers) pay prices that differ from the market value of the energy provided. Such price regulation leads to an implicit transfer to some (or all) consumers. The findings of the IMF study, which does not highlight any significant support in the EU based on a comparison of final energy prices with international benchmarks, suggest that there appear to be no major cases in the EU of price regulation leading to significantly lower prices being faced by all consumers.

More generally, because the analysis that we present here is static, it does not attempt to capture what may be important implications of the policies that lead to mandated transfers. The cascade of policy interactions and associated fiscal implications is important for understanding how government policies affect the wider energy system, and has implications for many of the issues considered in our study, but these complex interactions are well beyond the scope of our work.

3.4. Externalities

Externalities are costs (or benefits) that, as a result of an activity or market transaction, are imposed on (or that accrue to) a party that is not directly involved in that activity or transaction. There are various externalities that are often linked to different activities along the value chains of different energy sources, some more directly than others. Examples of such externalities include (among others):

- emissions of "local" pollutants,

- security of energy supply – including the costs of grid reinforcement and generation back-up capacity, [30]
- innovation spill-overs,
- "disamenity" value of wind farms and other generating capacity,
- water scarcity,
- road congestion,
- etc..

To the extent that externalities are not already reflected in government policies and transfers, their occurrence could be considered a form of "support". For example, if firms releasing greenhouse gas emissions do not face the cost of the associated externality (whatever it may be), then they are imposing a cost on society that they do not bear in full themselves.

However, it is important to recognise that this is a cost borne by society *as a whole*, and therefore differs from both direct government expenditure and transfers mandated by the government. Comparing this cost directly to government revenues alone therefore is unlikely to provide a full understanding of how externalities relate to support and government revenues. Government policies linking financial transfers to externalities are typically complex and involve several instruments. For example, a range of externalities are linked to road transport, including GHG emissions, emissions of local pollutants, congestion, accidents, noise, and others. Governments charge for such externalities (potentially to internalise them) in a variety of ways, including taxes levied on fuels, taxes on vehicles (often with charges differentiated by vehicle type and technology), road pricing schemes, etc. Governments also regulate such externalities directly, through technology standards, inspection and certification regimes, restrictions on driving, etc. The variety of instruments used reflects, in part, the way in which the cost of the externality depends on several factors – and may not even be related directly to the fuel used. These policies also impose costs on producers and consumers that are greater than the direct and indirect charges that may be reflected in government taxes and other revenues. In light of these complexities, we do not recommend directly comparing government revenues collected from energy sources to the costs of the externalities that may be linked (in different ways and to different degrees) to these energy sources.

To illustrate how externality costs (or benefits) relate to our main analysis, we follow our previous 2013 report and consider the example of greenhouse gas (GHG) emissions, given the importance of these emissions in motivating renewable energy policies. There is, however, significant uncertainty about the cost imposed by these emissions.

[30] As noted, this is relevant to a number of energy sources, and covers various issues, including the intermittency of renewable electricity sources, and concerns about dependency on imports – including imports of fuels and imports across electricity transmission interconnectors. Such externalities may be the *objective* of government policies. For example, EU legislation (Directive 2006/67/EC followed by Directive 2009/119/EC) requires countries to retain minimum petroleum reserves with a view to maintaining security of supply. Individual member states use different approaches to maintaining strategic reserves. In some cases, the obligation is passed on to energy companies. The benefits accruing to society from energy companies holding such supplies represent a positive externality.

We have conducted a review of estimates available in the literature of the cost of the externality associated with a tonne of CO_2 emissions (often referred to as the "shadow price" of carbon). The range of estimates available is very wide, and we have selected, low, medium and high values of €10, 30 and 70/tCO_2, respectively. These values span the range that most sources regard as the most likely cost of carbon during the relevant period – although estimates in the literature range from low estimates that are negative to high values that are several multiples of the highest value we have considered.[31]

As noted, the cost of the GHG externality (as well as costs or benefits associated with other externalities) is of a very different nature to the government expenditure and mandated transfers that are the main focus of this study. The GHG externality represents a cost that is borne by society as a whole, not simply by the government, and it is therefore appropriate to consider the externality within the context of the *full value* that products with GHG emissions contribute to society. This value is not reflected solely in government revenues.

If the cost of the GHG externality (whatever it may be) were reflected through a new policy instrument designed to "internalise" its full costs, then this would have an impact on the prices of fossil-fuel based sources. The range of impacts could vary between two extremes: at one end of the spectrum, the demand response would be quite limited; in this case there would be additional government revenues from the pricing instrument, on top of revenues from existing fiscal measures. At the other extreme, there could be a drastic reduction in fossil fuel consumption (which could even fall as low as zero); in this case total revenues from all taxes and other fiscal measures would also decrease significantly. In neither of the two extremes would government revenues from the energy source fall *below* zero.

There are instances where government policies explicitly aim to account for externalities, and many European countries have already put in place individual policies that are intended to address the externality associated with GHG emissions. For example, EU legislation on minimum excise duty rates on energy products are justified on the basis of CO_2 intensities of different fuels.[32] In addition, across the EU, the EU Emission Trading System (ETS) has been established to create a price for CO_2 (and other GHG emissions) that is intended to force emitters to internalise the emissions externality.[33] Many Member States have additional policies that set a price on carbon emissions – including "floor prices" designed to keep the price above a certain minimum level. All of these policies internalise a cost of carbon, although they do so at different levels per tonne of emissions. Many of the policies provide direct revenues to government, and also impose costs on wider markets that are shared between consumers and producers – and between different fuels.

In our analysis, we estimate government revenues from existing carbon pricing mechanisms (which is included in data on energy taxation). We calculate the cost *of the externality* separately, as discussed in section 4.4. We discuss the relationship of the two quantities – the

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[31] Details of the methodological approaches used in the literature, as well as a summary of the main estimates we have considered, are included in Appendix C of our previous report for IOGP.

[32] European Commission (2011), Citizen's Summary: EU Energy Taxation Proposal

[33] The EU ETS imposes an overall cap on emissions from installations in sectors covered by the policy, and firms must surrender emissions allowances or other emission rights, which they can trade, to cover their emissions,

government revenues from the pricing of the carbon externality, and the social costs associated with the carbon externality – in Chapter 4 below.

3.5. Data and sources

We have drawn on a wide range of sources to carry out this study. Where possible we have relied upon pan-European datasets that cover all, or at least the significant majority, of the 28 EU Member States and Norway. For example, excise duty data – the largest single government revenue item – come from European Commission DG Customs and Tax Union publications.

Likewise, data from the OECD inventory, and the additional coverage provided by the IVM report, provide the majority of direct government expenditure data that we include. Notwithstanding some of the limitations of its application discussed above (and acknowledged by the OECD), the study represents one of the most in-depth analyses of support across different member countries of the OECD, many of which are also included within our study. We rely on the OECD inventory only as a data source for *direct* payments to the coal, oil, and gas sectors. We do not include entries that are categorised as tax expenditures.

Data about support for renewable electricity generation, much of which is provided in the form of mandated transfers, is based on a survey carried out by the Council of European Energy Regulators. For those countries that were not included within the survey we have applied the average support rate for wind and solar power, across the countries for which we do have data, to the electricity generated from these sources.

Data on energy and electricity consumption, which inform many of our estimates, are sourced from the Eurostat energy database. Energy prices are also taken from Eurostat as well as the IEA, which are a key input to estimating VAT revenues from the different energy sources. We have supplemented these pan-European datasets with official government reporting from selected countries – for example, in the case of upstream oil and gas revenues – as well as industry data, such as profit estimates, to inform our calculations of corporation tax. The collection of less readily available information and sources has been beyond the scope of this study, but the dataset that we have developed could be further supplemented with additional information if it became available.

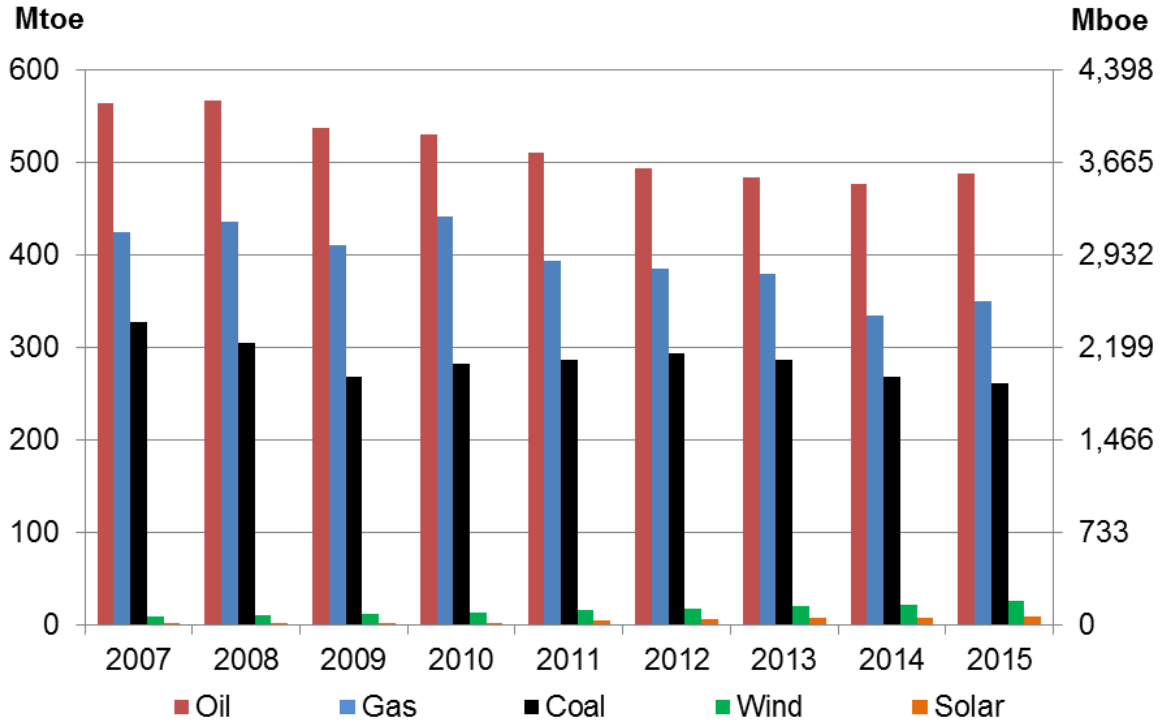
Wherever possible we have sought to use information from public sources. In some cases, due to limitations of time and resources, we have had to make assumptions, which we have attempted to validate by drawing on other relevant information.

4. Results of NERA's Analysis

In this section, we provide the main results of our updated analysis and include supporting discussion to some of the key findings. Unless otherwise noted, we present the results for the region covering the EU28 and Norway as a whole, with a focus on 2015 data. All the results presented in this report are nominal values, generally in millions or billions of Euros.

To put our results in context, Figure 4.1 shows primary energy consumption (of the five energy sources included in this study) in the EU and Norway split into the five energy sources that we cover.

Figure 4.1
Primary Energy Consumption of Different Energy Sources (2007 - 2015)



Source: Eurostat
Note: 1. The figure presents the primary energy consumption of the five energy sources covered by this study. It excludes other energy sources, such as nuclear power, hydroelectric power, biomass, and other renewable energy technologies;
2. Primary energy consumption is presented both in million tonnes of oil equivalent units (("Mtoe", on the left-hand axis) and million barrels of oil equivalent ("Mboe" on the right-hand axis) using a conversion factor of 7.33 barrels of oil to 1 tonne of oil.[34]

Oil and gas have consistently accounted for the largest shares of consumption of the energy sources. The consumption of electricity produced by wind and solar technologies still accounts for a very minor share of the total, although this share has been increasing over time.

To reflect the large differences between the volume of consumption of the five energy sources, we have generally presented our results below in two complementary formats. We present estimates of both absolute monetary values and in terms of monetary value per unit of energy consumed.

Finally, the analysis that we present here does not attempt to capture all of the monetary transfers associated with some of the policies that we have analysed. The incidence of the transfer (i.e. the groups that bear the costs of payments mandated by government policy), is

[34] BP Statistical Review.

often spread across several groups. For example, costs of FITs are borne by non-RES energy companies, who pay the associated levies, as well as by final consumers. In general we have *not* attempted to capture the dispersed affects across the wider energy markets and economy that result from the mandated transfers that we consider. These dispersed effects can have a significant effect on energy markets – for example, in Germany and neighbouring countries over the past five years, support for renewable energy has contributed to lower prices in the wholesale electricity market than might otherwise have been observed. Low prices, in turn, have affected the profitability of fossil-fired power stations, often imposing significant costs on their owners by reducing their asset values. Such effects are outside the scope of our analysis.

In the sections that follow we first present summary results for all of the five energy sources, comparing them alongside each other on the same chart. Then, in sections 4.2.1 to 4.2.5 we present more detailed results specific to each energy source, examining where the main government revenues, expenditures and other transfers arise across the different categories that we have described above in Chapter 3.

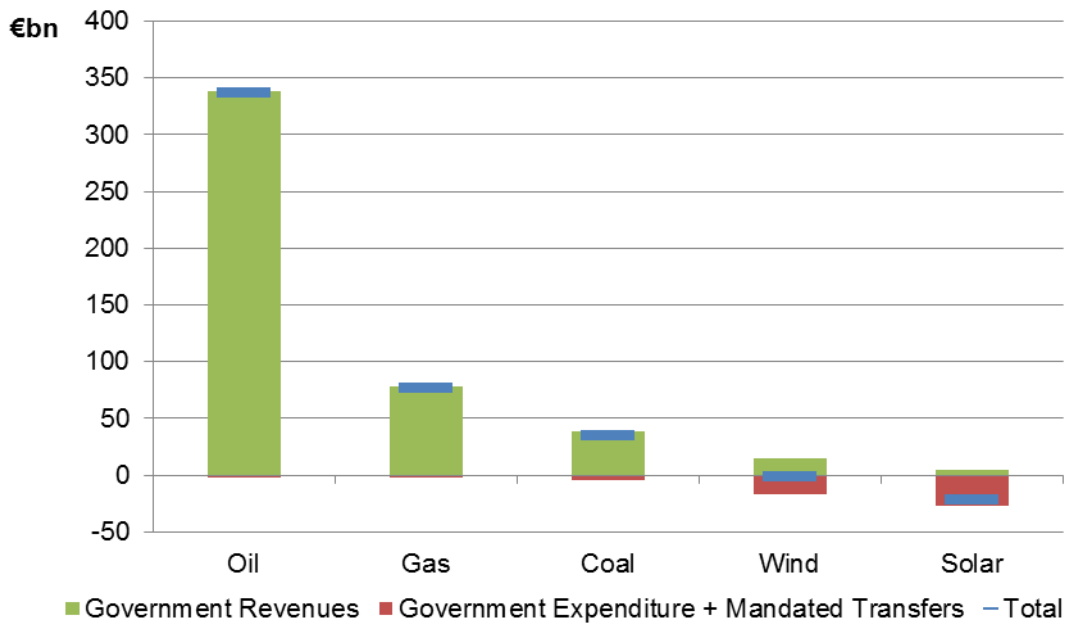
4.1. EU-Wide Results for All Energy Sources

In the methodology section above, we outline how we have attributed different categories of government revenue, expenditure and mandated transfers to the five energy sources that are included in this study. At an aggregate level, in 2015, we calculate that governments from the EU and Norway collected just under €475 billion in revenues from activities directly related to the production and consumption of oil, gas, coal, wind and solar energy. Total government expenditure plus mandated transfers to the five energy sources in 2015 was significantly less, at approximately €52 billion. Figure 4.2 shows the allocation of these overall amounts across the energy sources. The green bars represent revenues to the government; the red bars represent direct expenditure by the government as well as mandated transfers received by each energy source. The blue markers indicate the net government revenue (revenue minus expenditure and mandated transfers). The same data are presented in tabular form in

Table 4.1, which also includes a measure of the scale of consumption of the different energy sources in the EU28 and Norway.[35]

[35] [Consider placement of sensitivity with respect to "refunds"?]

Figure 4.2
EU28 + Norway Net Government Revenues and Mandated Transfers (2015)



Source: NERA Analysis
Note: 'Net government revenues and mandated transfers' (blue markers) are calculated by subtracting government expenditure and mandated transfers from total government revenues.

Table 4.1
EU28 + Norway Net Government Revenues and Mandated Transfers (2015)

Source	Government Revenues *€ billion*	Government Expenditures and Mandated Transfers *€ billion*	Total *€ billion*	Primary Energy Consumption *Mtoe*
Oil	338	-1.6	337	488
Gas	78	-1.7	76	350
Coal	39	-4.4	34	262
Wind	15	-17	-2	26
Solar	5	-27	-22	9

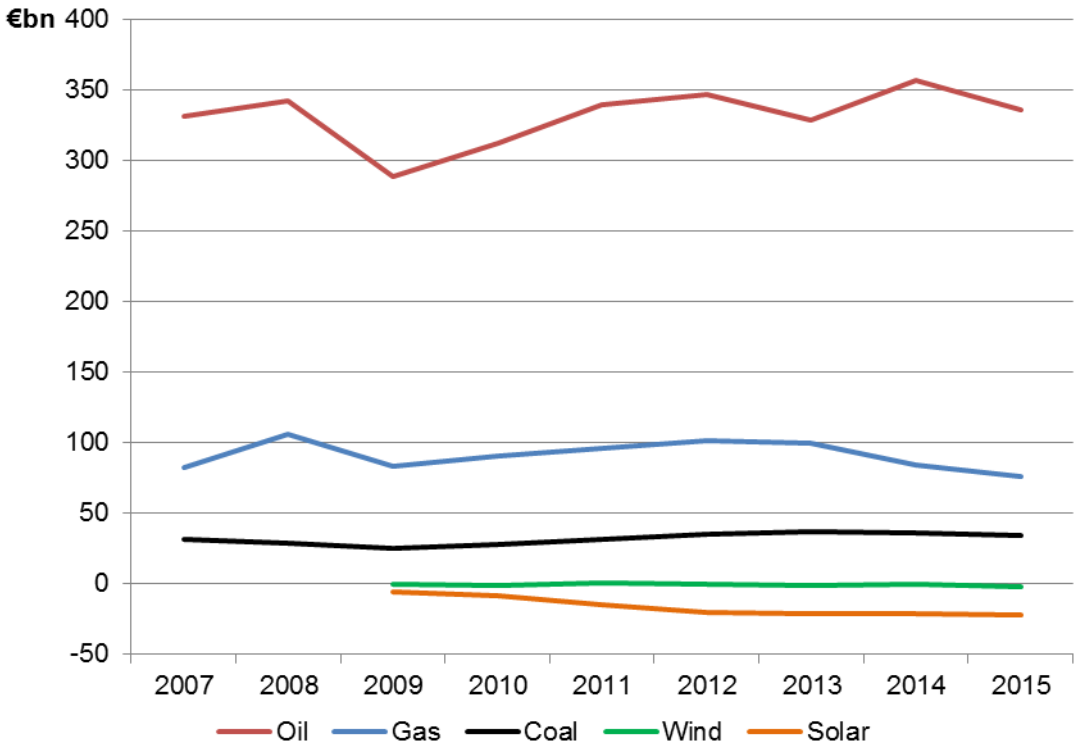
Source: NERA Analysis

Across the different fuels, the majority of revenues are derived from oil, followed by gas.[36] Significant, but smaller revenues are allocated to coal, and relatively negligible amounts assigned to both the wind and solar sectors. Turning to expenditures and mandated transfers, the most significant support in 2015 is focused on the solar sector (€27 billion), with smaller amounts paid out to wind (€17 billion) and even less to coal (€.4 billion), gas (€1.7 billion) and oil (€1.6 billion). It is also apparent that at least in the fossil fuel sector government revenues dwarf government expenditure. We break down the main contributions to these overall figures for each energy source in sections 4.2.1 to 4.2.5 below.

For this updated study we have focused on the period 2007 to 2015. To avoid duplication, we present the majority of our results for 2015. In Figure 4.3 we present the net government revenues (revenues minus expenditures and other mandated transfers) for all years. These points correspond to the blue markers shown above in Figure 4.2.

[36] The production of oil and gas is linked in many countries, which makes it more difficult to attribute government revenues to one or the other fuel. In each country, we have allocated revenues from the production of oil and gas to the two energy sources in direct proportion to their share of production revenue, calculated by multiplying production, measured in tonnes of oil equivalent, by an annualised market price for crude oil and natural gas. There are other ways of allocating government revenues between the two fuels that may be equally plausible, but they would not materially affect any of our key findings.

Figure 4.3
EU28 + Norway Net Government Revenues and Mandated Transfers
(2007 - 2015)



Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net values for these years.

The figure shows that there is limited variation in net government revenues over time. The most pronounced change is the drop in net revenues between 2008 and 2009 and a smaller reduction in 2015 in the oil and gas sector, principally due to lower oil and gas revenues. Transfers directed to solar energy grew fast until 2012, resulting in increasingly negative net revenue, [37] but have stabilised since.

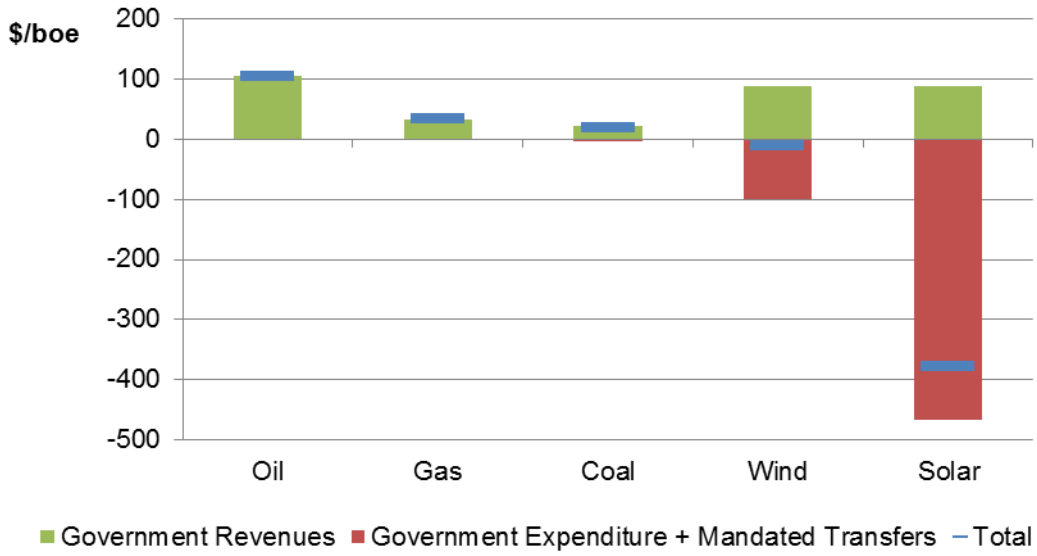
Figure 4.2 and Figure 4.3 (above) compare government expenditures, revenues, and mandated transfers for the different energy sources on an absolute basis. Because the total energy consumption associated with the five energy sources spans a very wide range, we also compare them on a per-unit basis. Figure 4.4 presents the results shown in Figure 4.2 in terms of value per unit of *primary energy* consumed.[38] Wind and solar consumption

[37] For example, in Spain total support for wind increased by 20 percent between 2011 and 2012 and support for solar increased by over 30 percent (based on data published by CNE). In Germany total renewables support also increased by over 30 percent between 2011 and 2012 (BDEW. Erneuerbare Energien und das EEG: Zahlen, Fakten, Grafiken. 24 February 2014).

[38] Per unit values are calculated by dividing the data presented in Figure 4.2 by the primary energy consumption of each energy source (shown above in Figure 4.1), in barrels of oil equivalent (boe). Primary energy consumption is the gross inland consumption less non-energy use of each energy source. All energy consumption data are taken from Eurostat.

correspond to the consumption of electricity that was produced using these respective technologies.

Figure 4.4
EU28 + Norway Net Government Revenues and Mandated Transfers ($/boe) (2015)



Source: NERA analysis
Note: Values have been converted into barrels of oil equivalent using a conversion rate of 7.33 barrels of oil to 1 tonne of oil.

On a per boe basis, government revenues (before taking into account government expenditures and mandated transfers) are broadly similar for oil ($105 per boe), wind ($88 per boe) and solar ($87 per boe). Government revenues are lower for gas ($34 per boe) and coal ($22 per boe). We note that revenues measured on this basis (i.e. per unit of primary energy consumed), reflect the way in which these energy sources are used, and, in particular, the relative efficiencies of these uses of different energy sources. Hence, coal revenues are particularly low because a significant share of coal consumption is used to generate electricity, and the efficiency of conversion of coal into electricity is relatively low, at 30-40 percent. Conversely, solar and wind revenues appear higher than coal and gas, because the renewables sources are assumed (by definition) to have a conversion rate from primary energy use of 100 percent.[39]

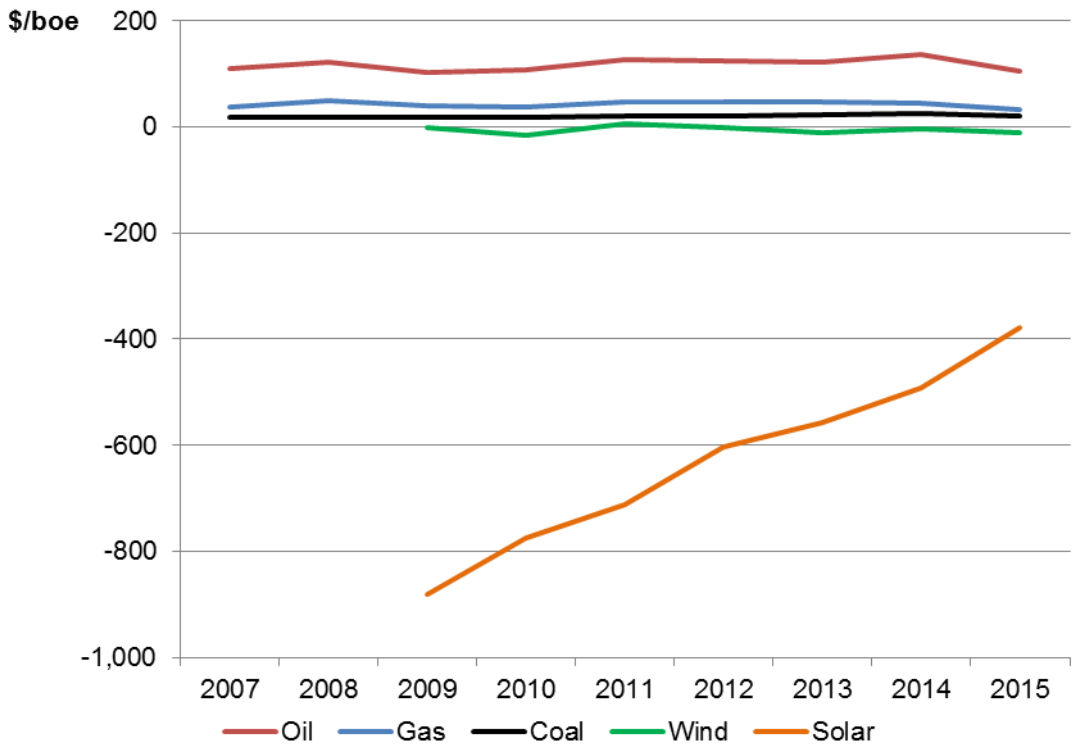
Government expenditures per boe remain negligible for the fossil fuels. For wind and solar power, government expenditures and mandated transfers continue to be considerable, at $99 per boe for wind and $466 per boe for solar energy. This difference reflects the at least historically higher costs of solar power generation, compared to wind (which in many

[39] This is the approach followed e.g. by the IEA (see e.g. IEA, *Key world energy statistics 2017*, p 72; https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf).

European countries led governments to offer significantly higher per unit support levels to encourage the development of the solar power sector and enable it to compete with other technologies in competitive power markets).[40]

Figure 4.5 presents similar information, showing the net transfers (blue markers in Figure 4.4) covering the full period from 2007 to 2015. Like Figure 4.3, it shows relatively consistent results across years, save for solar energy, which has increased over time on an *absolute* basis (see Figure 4.3 above), but decreased when measured in terms of energy consumed. This is because governments are supporting increasing amounts of solar capacity, but the costs of supporting additional units of solar power are falling.

Figure 4.5
EU28 + Norway Net Government Revenues and Mandated Transfers ($/boe)
(2007 - 2015)



Source: NERA analysis.
Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net values for these years.

In the following sections we present further details of these results, showing the different categories of government revenue, expenditure, and mandated transfers to provide a better understanding of the relative contributions of different taxation and support policies.

[40] The costs of solar power reflected here are on an annualised *cash flow* basis, and therefore reflect both the capacity added in each year as well as the *legacy* costs of more expensive solar technologies that were installed in earlier years. .

4.2. Breakdown of Transfers for Each Energy Source

In this section we present details showing how the overall figures presented above are split between the various categories of transfers across the energy supply chain (from upstream to downstream) to make clear the key sources of revenue and expenditure for oil, gas, coal, wind and solar. We have broken down the different transfers into the following headline items (the abbreviation in brackets corresponds to the labelling convention used in the charts below). Items 1-4 provide revenues to the government, whereas items 5-9 represent sources of direct government expenditures or transfers mandated by government policy.

Government Revenues:

1. **Upstream government revenues** (UpRev): Taxes, license fees, royalties, dividend payments, and other revenue-raising instruments applied to resource extraction and energy production activities, inclusive of corporation tax revenues;
2. **Corporation tax on midstream and downstream activities** (Corp): Estimated corporation tax receipts from energy transformation (power generation and refining), storage, transportation and retail (including the sale of petroleum products, natural gas, coal and electricity to businesses and households) parts of the supply chain;
3. **Excise duties and other energy taxes** (ExD): Excise duties paid on energy consumption as well as additional, country specific and EU-wide energy taxes;
4. **Value Added Tax** (VAT): As applied to the consumption of energy products;

Government Expenditures and Mandated Transfers:

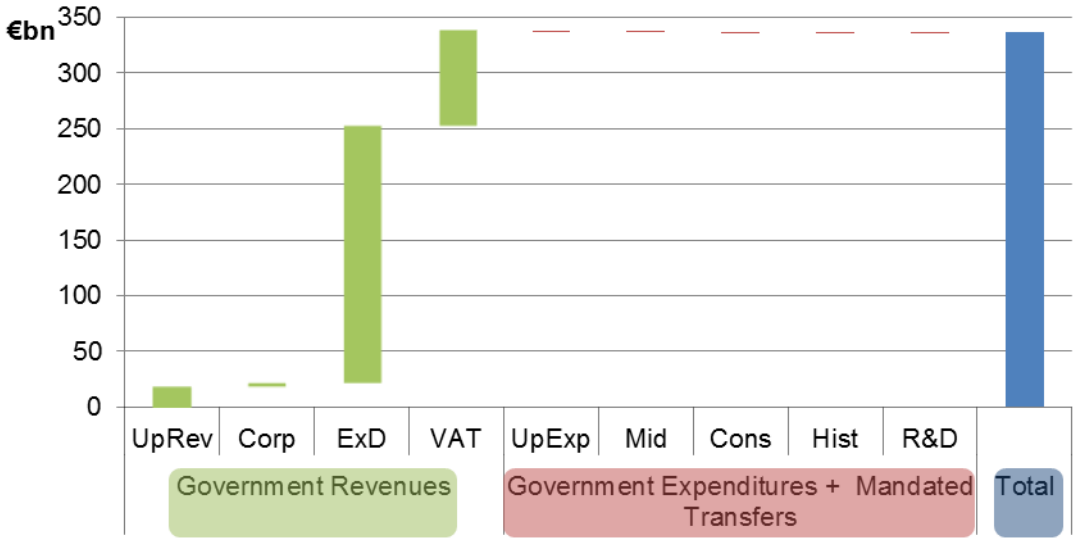
5. **Upstream government expenditures** (UpExp): Payments made to support current production of energy resources;
6. **Electricity generation, energy transport and storage support** (Mid): Transfers supporting "midstream" activities, including energy transformation and power generation (notably RES support mechanisms), as well as fuel storage and transport;
7. **Consumption support** (Cons): Payments (often made to poor households or remote communities) to support the purchase of energy products;
8. **Government payments to cover historic liabilities** (Hist): Payments made to compensate workers and communities in relation to historic production activities. These occur exclusively in the coal industry and relate to labour compensation, repairing environmental damages and supporting the decommissioning of mines.
9. **Government R&D payments** (R&D): Payments made by government to fund research and development into improving the technology used to produce, transform and consume the different energy sources.

The following sections present the detailed breakdown of our results for each energy source, highlighting the orders of magnitude of the different items of government revenue, expenditure, and mandated transfers.

4.2.1. Oil

The comparison in Figure 4.2, above, shows that the vast majority of government revenues from the different energy sources we have reviewed are derived from the production and consumption of oil-based products. Figure 4.6 shows the different sources of government revenues and expenditures across the supply chain.

Figure 4.6
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Oil (2015)



Source: NERA analysis
Note: The y-axis scale (€bn) varies in charts for oil, gas, coal, wind and solar (Figure 4.6 to Figure 4.10) to accommodate the different magnitude of the results across the energy sources

Net government revenues from oil in 2015 were €337 billion, as shown by the blue bar on the right hand side of Figure 4.6. Upstream tax revenues from oil production amounted to €20 billion – down materially relative to our previous results from 2011, which were €50 billion, with corporation tax on midstream (refining and downstream retail) adding a small amount. By far the largest contribution to government revenues from oil comes from excise duties on petroleum products (€230)[41], followed by VAT receipts from their sale to final consumers. These two items combined provided almost €315 billion to governments across the EU and Norway in 2015. Government expenditure on oil is negligible in comparison.

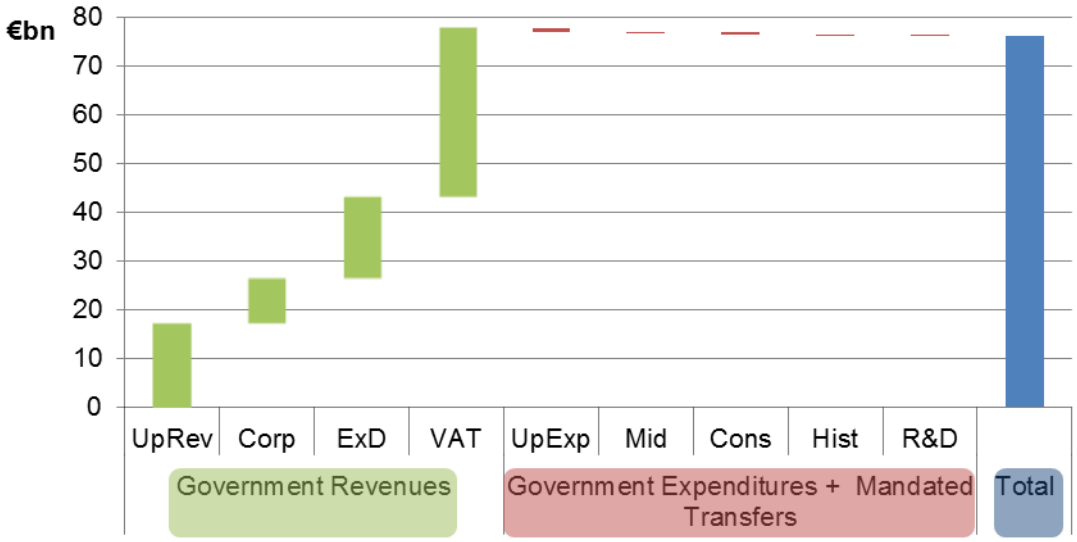
4.2.2. Gas

Gas provides the second largest contribution to government revenues of the energy sources reviewed. Net revenues in 2015 were €76 billion, which is less than a third of what we

[41] Demand for transport fuels tends to be relatively insensitive to price, so excise duties provide a significant source of stable revenue to governments.

calculate for oil. In contrast to oil, significantly less excise duty is levied on direct sales of gas (and on electricity generated using gas as an input fuel, which we allocate to the fuel). VAT on gas and on electricity sales[42] from gas-fired generation sales (€34 billion) is the largest single contributor, followed by upstream tax revenues, at €17 billion.[43] The majority of the corporation tax revenue estimate is derived from gas retail and distribution as well as power generation.[44]

Figure 4.7
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Gas (2015)



Source: NERA analysis
Note: The y-axis scale (€bn) varies in charts for oil, gas, coal, wind and solar (Figure 4.6 to Figure 4.10) to accommodate the different magnitude of the results across the energy sources

As for oil, we have identified only very limited government expenditures to support gas. There are minor amounts assigned to midstream activities, small amounts of consumption support, and allocations from government R&D budgets, reflecting spending both on gas production and combustion technologies, as well as carbon capture and storage (CCS) techniques.

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42 For electricity generation, we allocate government receipts on VAT in proportion to each energy source's share in electricity generation in each of the 29 countries in each year..

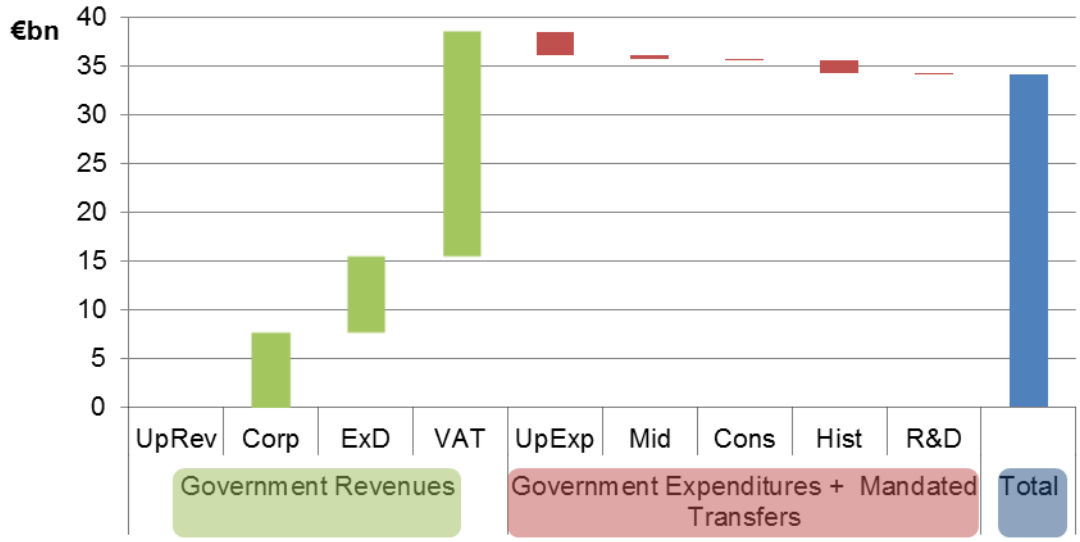
43 As noted in the introduction to this chapter, we have not been able to directly assign tax revenues from upstream oil and gas production to the respective energy sources, as production of both fuels is often carried out at the same site and by the same company. We have therefore allocated the combined revenues from oil and gas production to the two energy sources in proportion to their share of estimated total revenue in a given year.

44 As for VAT, we have assigned estimated corporation tax revenues from power generation to each energy source in proportion to its share of electricity output in each country and year.

4.2.3. Coal

The coal sector provides revenues to government of approximately €39 billion, driven mainly by VAT receipts both on coal itself and on power generated using coal as an input. Net revenues from coal are considerably lower than those for oil and gas, at €34 billion. The bars in Figure 4.8 also show there is still a certain amount of support provided by government to the coal industry, principally across a handful of European countries.

Figure 4.8
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Coal (2015)



Source: NERA analysis
Note: The y-axis scale (€bn) varies in charts for oil, gas, coal, wind and solar (Figure 4.6 to Figure 4.10) to accommodate the different magnitude of the results across the energy sources

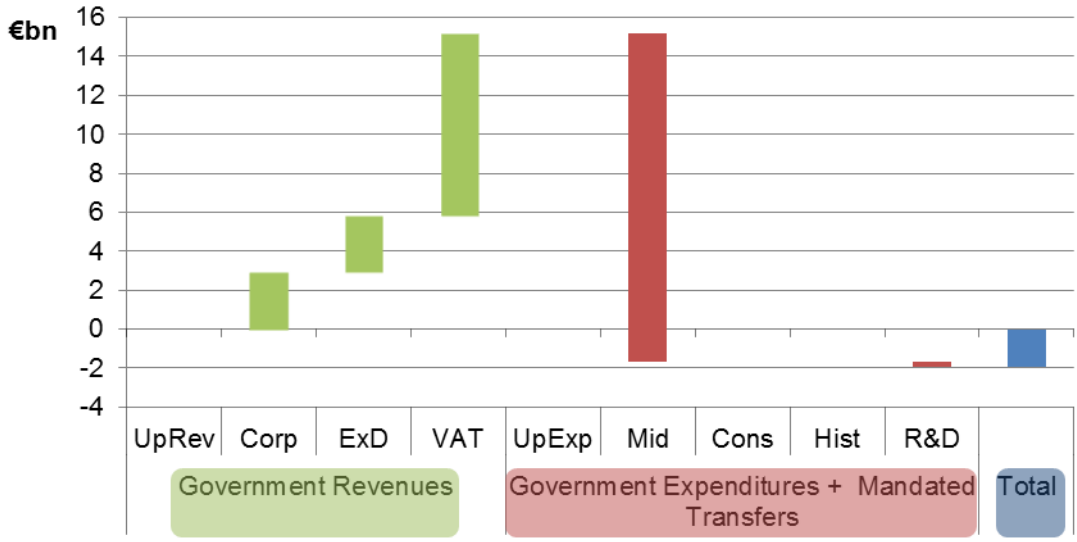
Excise duties on coal are fairly limited and tend to arise primarily from the electricity sales from power generated from coal.[45] Corporation taxes, estimated at approximately €8 billion, are principally from coal's contribution to power generation and the downstream sales of electricity, with a very limited amount from direct coal supplies for non-electricity generating use. The coal sector receives the most amount of support out of the fossil fuels included in this study. Most of this is concentrated in coal mining. For example, in Germany annual support provided to coal mining companies to keep them in operation is approximately €2 billion. There is also some support provided to coal-fired generators ('Mid' in the chart) in several countries as well as payments made to compensate both workers and local communities related to historic production. Compensation covers health issues faced by workers as well as repairs to environmental damage. Total government support to coal in 2015 was above €4 billion. This is relatively small alongside government revenues, but considerably higher than support provided to other conventional, fossil fuel energy sources.

[45] As for VAT and corporation tax, we have allocated excise duties collected on electricity sales to each energy source in proportion to its share of power generation in each country and respective year.

4.2.4. Wind

The wind and solar sectors are distinct from the fossil fuels as the energy sources are used almost exclusively for power generation.[46] Net transfers from wind (government revenues minus government expenditures and mandated transfers) were slightly negative in 2015, at around negative €2 billion. This is shown below in Figure 4.9. Total revenues (before expenditures and other transfers) were around €15 billion. Estimated corporation tax receipts, excise duties, and VAT (the largest contributor, at over €9 billion) are all based on wind's share of total electricity output across the EU and Norway.[47]

Figure 4.9
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Wind (2015)



Source: NERA analysis
Note: The y-axis scale (€bn) varies in charts for oil, gas, coal, wind and solar (Figure 4.6 to Figure 4.10) to accommodate the different magnitude of the results across the energy sources

The overwhelming item of support for wind comes in the form of FIT or supplier obligation / REC scheme payments to provide production support to wind generators. The reported support is based on data collected by the Council of European Energy Regulators from a large sample of European countries. The total estimate for wind of almost €17 billion in 2015 reflects the additional support provided for output above the level of the wholesale price.[48] Government spending on R&D in the wind sector of almost €0.3 billion is also included.

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[46] Solar technologies are also used to produce useful heat. We have not attempted to quantify the contribution of solar thermal energy to government revenues.

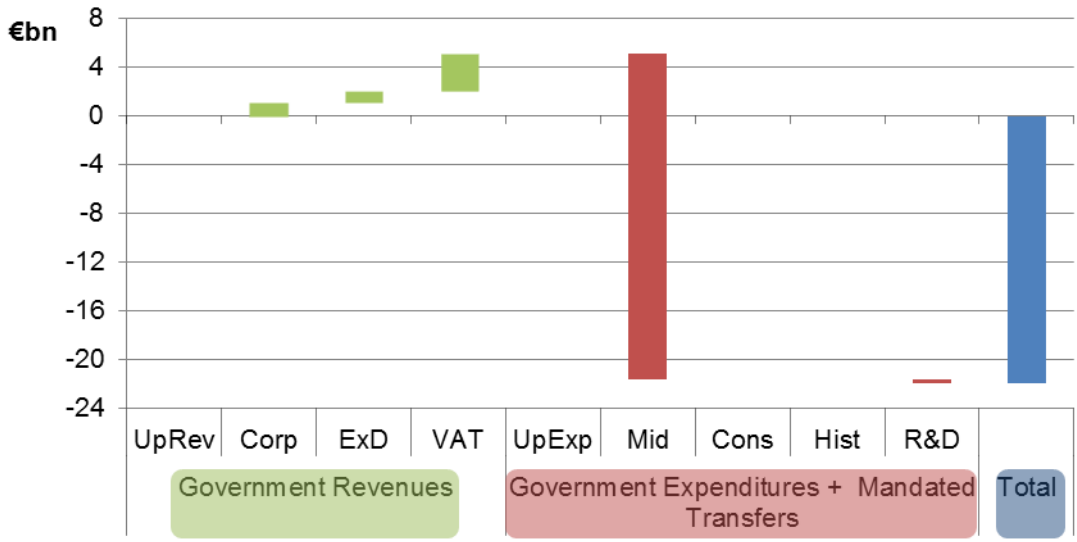
[47] The data for wind cover both onshore and offshore wind. Offshore wind is a less mature technology than onshore wind and tends to be more expensive. It therefore receives a higher level of support per unit than onshore wind.

[48] In the case of FIT payments an estimate of the average wholesale price has been deducted from the total (per unit) FIT payment to calculate the support provided.

4.2.5. Solar

Solar power generation is generally more costly than wind, although solar costs have fallen dramatically in recent years, leading to increasing deployment of solar capacity in Europe. Net transfers in 2012 for solar were highly negative, at almost –€22 billion.

Figure 4.10
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Solar (2015)



Source: NERA analysis
Note: The y-axis scale (€bn) varies in charts for oil, gas, coal, wind and solar (Figure 4.6 to Figure 4.10) to accommodate the different magnitude of the results across the energy sources.

We estimate that €5 billion was collected by European governments in revenue from corporation tax, excise duties and VAT related to the electricity generated by solar. On the other hand, government support, either via direct payments or through policies obliging others to fund solar capacity and output, was in excess of €26 billion. Total support for solar had risen over the first four years for which we have pan-European renewable support data, from €6 billion in 2009, to €8 billion in 2010, and almost doubling in 2011, but has remained stable since 2012. The initial growth is due to increasing roll-out of solar capacity rather than rising costs, as discussed above in section 4.1 (and shown in Figure 4.5), with capacity growth and falling costs having balanced one another since 2012.

4.3. Country-Level Results: The Impact of Brexit

In our previous (2014) report we included a section that highlighted the breakdown of energy revenues and expenditure for two quite different countries – Norway and Germany – to show that our results were not heavily influenced by the fact that Norway is a major producer of oil and gas, and benefits to a significant degree from the upstream revenues associated with their production.

In this update, in light of the UK's decision in 2016 to exit the European Union, we present the results of our analysis at the country level for the UK on its own, as well as for the EU+Norway, without the UK.

Figure 4.11 shows the results of our analysis for the UK both on an absolute basis in billions of Euro and in terms of US Dollars per boe in 2015.

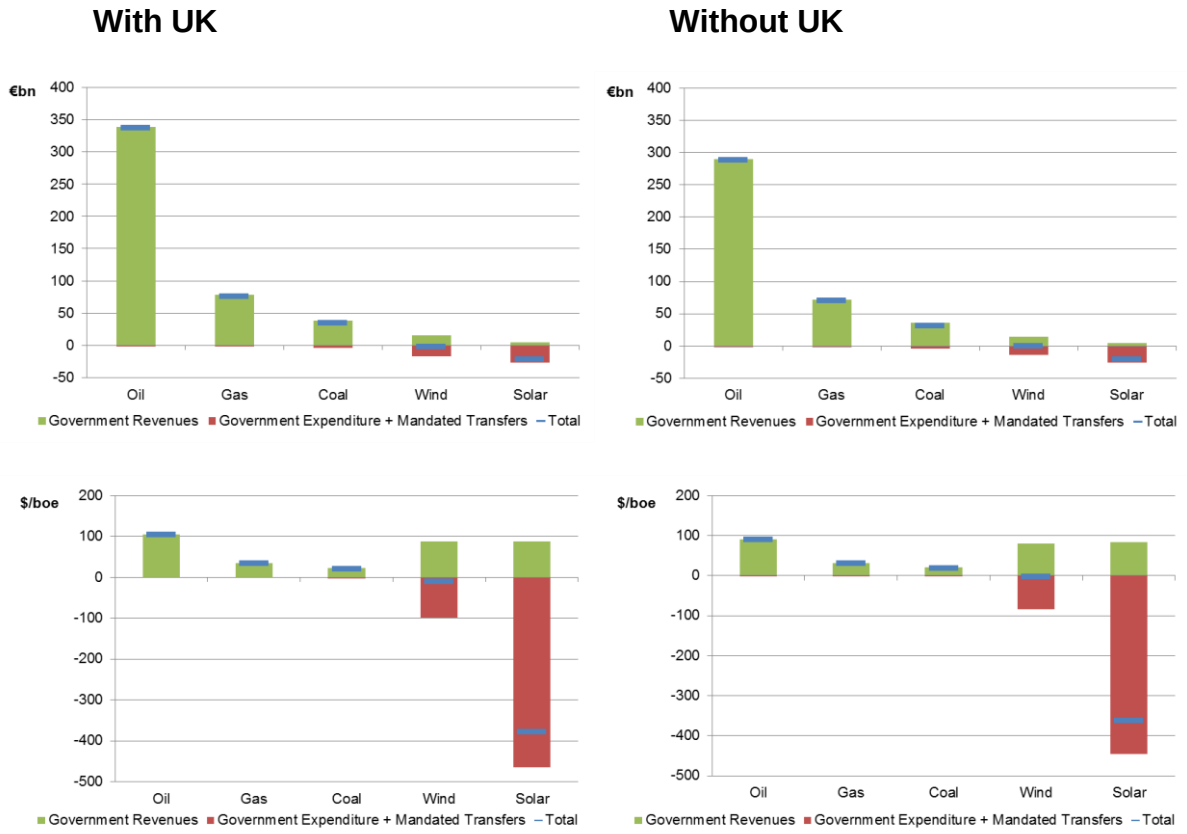
Figure 4.11
UK Net Government Revenues and Mandated Transfers (2015)

Source: NERA analysis

The UK's share in the total EU28 + Norway 2015 revenues reported above (see Figure 4.2) is most significant in the case of oil (€48 billion out of €338 billion, or 14 percent) followed by wind (9 percent) and both gas and coal (8 percent each). On the expenditure side, the UK has the most significant presence in the wind sector (close to €3 billion out of €17 billion in 2015, or 16 percent) followed by coal (8 percent) and solar (4 percent).

On a per boe basis, the 2015 net support estimates for the UK look at high level quite similar to the rest of Europe. Looking closer, it appears that relative to other countries, the UK had higher net expenditure on wind, per unit of energy (-$62/boe, compared to -$11/boe for the EU and Norway). And for solar, this is reversed – although solar is still the most heavily subsidized per unit of energy among the five sources that we consider, it is subsidized less in the UK (-$216/boe) than in the rest of Europe (-$378/boe in the aggregate). Gas also contributes somewhat less per unit of energy to the UK's Treasury than in other countries ($15/boe for the UK versus $33/boe for the EU28 + Norway).

Figure 4.12
Comparison of EU + Norway Net Government Revenues and Mandated Transfers With and Without the UK (2015)



Source: NERA analysis
Notes: The values without the UK are shown on the right-hand side.

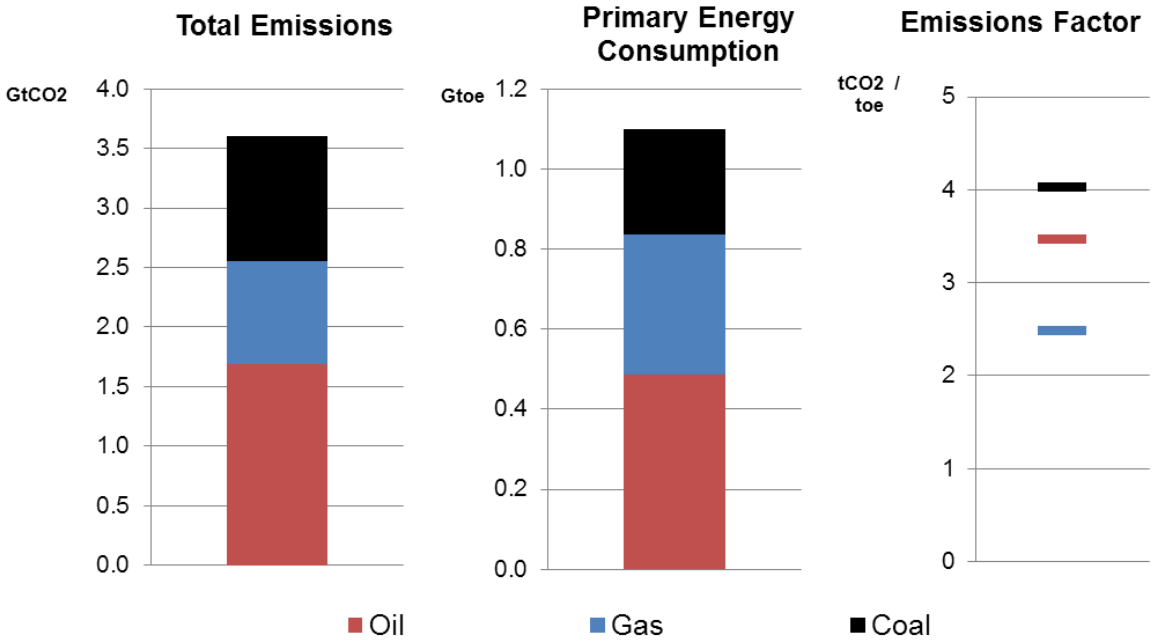
From the results presented above, it is clear that our findings concerning the balance of revenues from and support provided to energy sources across Europe would not change as a result of the departure of the UK from the EU. Although in some minor details, the UK's revenues and expenditures differ from the rest of Europe (as would any individual European country's), in most important respects, our findings apply to the UK as well as other European countries.

4.4. Externality Example – Greenhouse Gas Emissions

This section presents estimates of the cost of the greenhouse gas emissions externality associated with the use of different fossil fuel based energy sources. This cost differs in important ways from the categories presented in the preceding sections. The cost does not reflect any direct transfers between energy sources and the government (or any mandated transfers). Instead, as explained in section 3.4 above, the cost is borne by society as a whole, and not just the government.

The left hand bar in Figure 4.13 shows total GHG emissions in the EU28 + Norway that can be attributed to the three major fossil fuel energy sources in 2015. To put the total emissions in context, the middle bar in Figure 4.13 shows the primary energy consumption of the different fossil fuels in the EU28 and Norway and the right hand chart indicates the associated emissions factors of the different fuels.[49]

Figure 4.13
GHG Emissions in the EU28 + Norway, 2015



Source: NERA analysis of UNFCCC and Eurostat data
Note: The figure shows the total emissions associated with each fuel, based on the volume of each fuel consumed. Emissions intensities of the three fuels (i.e. tCO2e per toe, boe, MWh, or TJ) differ – coal is more emissions-intensive than oil, which is more emissions-intensive than gas. The volumes of emissions shown in the figure therefore reflect both the emissions intensities of the fuels and the total consumption of each.

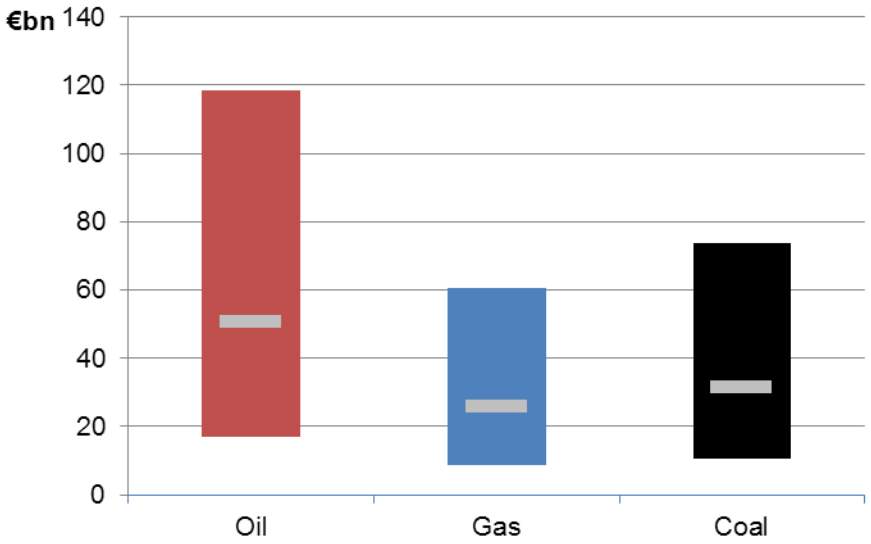
Total emissions in 2015 have declined from 3.9 billion tonnes of CO_2e ($GtCO_2e$) in 2011 (the last year covered in our previous report) to 3.6 $GtCO_2e$ in 2015. The shares of emissions attributable to individual energy sources have remained fairly stable over the period, with shares over the 2011-2015 period around 45 percent for oil, 25 percent for gas, and 30 percent for coal.

As discussed above, there are a wide range of values available in the literature for the shadow price of carbon – i.e. the externality cost associated with a tonne of CO_2. To reflect the uncertainty about its true value, we have used low, medium and high estimates of €10, 30 and 70/tCO_2e for the shadow price of carbon. These values lie within the range that most sources

[49] We have estimated total 2015 emissions by applying the emissions factors from our previous analysis to 2015 energy consumption data (from Eurostat).

regard as most likely, although the full range of values available is much wider than this. Figure 4.14 shows the ranges of cost of the GHG externality associated with the fossil fuel based energy sources. The grey horizontal segments show the cost of the externality evaluated at the medium shadow price of €30/tCO_2e. At this shadow price, the externality costs would be €51 billion for oil, €26 billion for gas, and €32 billion for coal.

Figure 4.14
GHG Externality Costs - Low, Medium, and High



Source: UNFCCC, Eurostat, NERA analysis

As noted in section 3.4, if the true cost of the externality (whatever the true cost may be) were reflected in government policies designed to "internalise" it, this would affect not only government revenues, but also wider economic benefits to consumers and producers. The ultimate implications for government revenues would depend how the cost is reflected in the prices of fossil-fuel based products, and the subsequent demand responses to changes in prices. In the extreme case that the imposition of the externality cost resulted in fuel prices that were so high that the quantity demanded would be drastically reduced, the net contribution of fossil fuels to government revenues would tend to zero. Thus, one should not simply "net off" the externality costs shown in Figure 4.14 above from the estimates of net government revenues shown in previous sections.

4.5. Summary of Results

A summary of the results of our analysis on government revenues, government expenditures and mandated transfers is shown in Table 4.2 below, providing a more granular breakdown of the data for 2015. The table provides more details for the various "line items" than what we have presented in the figures above. Measured on an absolute basis, government revenues from oil production and consumption are by far the highest of the energy sources we have reviewed (€338 billion in 2015). These are driven by excise duties, with significant contributions from both VAT payments on the sale of petroleum products as well as upstream

revenues from oil production. Gas revenues are less than a quarter of oil (€77 billion) and coal revenues are lower still (€34 billion). Government revenues from wind and solar are relatively small and, in fact, lower than government support to these renewable technologies.

Measured as revenue per unit of energy consumption (boe), oil is still the highest contributor out of the five energy sources. On a per unit of consumption basis both wind and solar revenues are higher than gas and coal, which is, in part, explained by the fact that we use primary energy consumption as the comparator, which reflects the relative efficiencies of coal and gas in generating electricity.

Unlike oil and gas, coal does receive significant direct government transfers in certain countries (in excess of €4 billion in 2015), about two thirds of which subsidises current production of coal as well as power generation activities. The significant majority of the remaining subsidy reflects compensatory payments to miners and funds provided to decommission old sites and repair environmental damage. Wind and solar are the most significant recipients of government support via mandated transfers, through RES support policies such as FITs. In 2015, wind power received €17 billion of support and solar almost €27 billion. Wind output is significantly higher, however, so that on the basis of per unit energy consumption, solar is by far the greatest recipient of government support.

Table 4.2
Summary Results for 2015

Categories of Government Revenue	Oil	Gas	Coal	Wind	Solar
	EUR Billions				
Upstream Taxes (incl. upstream corporation tax)	19.9	17.5	-	-	-
Corporation Tax (midstream and downstream)	3.5	9.3	7.8	3.0	1.1
Power Generation	*0.2*	*3.2*	*4.2*	*1.6*	*0.6*
Power Transmission and Distribution	*0.1*	*1.2*	*1.7*	*0.7*	*0.3*
Electricity Retail	*0.1*	*1.3*	*1.9*	*0.6*	*0.2*
Gas Retail and Distribution	*-*	*3.6*	*-*	*-*	*-*
Coal Supply (excl. Power Generation use)	*-*	*-*	*0.1*	*-*	*-*
Crude Refining	*0.8*	*-*	*-*	*-*	*-*
Gasoline and Diesel Retail	*2.3*	*-*	*-*	*-*	*-*
Excise Duties and Other Energy Taxes	229.3	16.6	7.8	2.9	0.9
VAT	85.5	34.4	22.9	9.3	3.0
Subtotal (government revenues)	**338.1**	**77.8**	**38.5**	**15.2**	**5.1**
Categories of Government Expenditure and Mandated Transfers					
Resource Extraction Support	0.1	0.9	2.4	-	-
Electricity Generation, Energy Transport and Storage Support	0.8	0.0	0.4	16.8	26.7
RES Power Generation	*-*	*-*	*-*	*16.8*	*26.7*
Other	*0.8*	*0.0*	*0.4*	*-*	*-*
Consumption Support	0.4	0.5	0.0	-	-
Historic Liability Transfers	0.0	0.0	1.4	-	-
R&D Transfers	0.3	0.2	0.1	0.3	0.3
Subtotal (government expenditures and mandat	**1.6**	**1.7**	**4.4**	**17.1**	**27.1**
Net Government Revenues and Mandated Trans	**336.6**	**76.2**	**34.2**	**-1.9**	**-22.0**

Notes: 1. Total column reflects government revenues minus government expenditure and mandated transfers
2. Subcategories in italics provide a breakdown of the main category results. Only the grey shaded lines are included in the total calculation.

5. Conclusions

We have assembled a comprehensive database to estimate government revenue, expenditure, and government-mandated transfers for oil, gas, coal, wind, and solar power in all 28 EU Member States as well as Norway. This database has allowed us to conduct a cross-sector and cross-country comparison of governments' relative treatment of different energy sources. We can also aggregate our results. Some of the key findings of our analysis are:

- **EU28+Norway governments receive far greater revenues from oil, gas and coal than these energy sources receive in the form of direct subsidies or other transfers.** Oil is by far the largest contributor to government revenues. In contrast, wind and solar power are *net recipients* of support.
- **On the order of €474 billion in revenues were collected by EU28+Norway governments in 2015 from the five energy sources.** Of this, more than 70 percent, or just over €338 billion, came from the oil sector. Gas contributed around a little over 15 percent of the revenue, or almost €78 billion. Coal accounted for around €39 billion in revenue, but also received transfers on the order of €4 billion. We estimate that wind contributed around €15 billion in government revenue, but received transfers amounting to around €17 billion, implying total net payments to the sector of €2 billion. Finally, we estimate that in 2015 solar power contributed around €5 billion to government revenues, but received transfers totalling close to €27 billion.
- **Excise duties and other energy taxes, which come mainly in the form of duties on motor vehicle fuels, account for the largest single source of government revenue from energy, ahead of VAT.** Excise duties yielded over €250 billion in 2015, thus accounting for more than half of all revenues from energy.
- **VAT paid on energy is also a very significant contributor to government revenues.** A large share of VAT is paid on oil through motor vehicle fuels, but there is also a significant amount of VAT paid on electricity and on fuels used for space heating.
- **After excise duty and VAT, revenues collected from the upstream oil and gas sector contribute the most to government coffers, accounting for €37 billion in total.** The production of oil and gas is heavily taxed, with sector profits facing tax rates that can reach as high as 80 percent.
- **Both wind and solar power receive net support from government through a combination of direct payments and mandated transfers.** It is clear from our results that solar power receives the largest net transfer, both in absolute terms and per unit of energy consumed. In absolute terms, total support for wind and solar has increased over time, although measured per unit of energy consumption, support has declined over the period analysed.
- **Greenhouse gas externality costs in 2015, assuming carbon prices of €30/tCO_2, would have been €51 billion for oil, €26 billion for gas, and €32 billion for coal.** Although we do not recommend direct comparisons of such externality costs to government revenues from or support for different energy sources, we recognise the importance of externality costs, which can be considered alongside our analysis of fiscal transfers to inform overall energy policy.

Appendix A. Update to Inventory of Support Measures for Bulgaria and Romania

This section presents a summary of NERA's update to the work undertaken by IVM (2013) to assess support provided to oil, gas, and coal in Bulgaria and Romania. IVM's study (and therefore NERA's current work) follows the approach developed by OECD to identify measures that "support" fossil fuels – including both direct budgetary transfers and "tax expenditures".

We have investigated recent information about the policies identified by IVM to estimate the value of support provided over recent years since IVM's original research. Where we have identified possible additional sources of support not previously identified by IVM we have also sought to include these.

The tables below present the information we have collected, for the years 2012-2015, alongside information previously collected by IVM for 2011.

BULGARIA

IVM policies

Fossil Fuel	IVM policies	Updated IVM policies	IVM support estimate (BGN million)	Updated support estimate (BGN million)					Rationale for updated support estimate	Source 1
			2011	2012	2013	2014	2015	2016		
Oil	**Consumer support: Reduced excise duty on gasoil in agriculture** *Planned* reduction in excise duty amounted to 70 BGN million per year for 2012 and 2013.	**Source 1: European Commission Excise Duty Tables** As at 1 July 2016, there appears to be no reduced excise duty for gasoil used for agriculture purposes [p.18].		0.0	0.0	0.0	0.0	0.0	As at 1 July 2016, there is no longer reduced excise duty. As policy is not included in the total support figure anyway, we simply assume 0 for entire period 2012-2016, without making further adjustments.	https://ec.europa.eu/taxation_customs/sites/taxation/files/docs/body/excise_duties-part_ii_energy_products_en.pdf
	Consumer support: Excise tax return for motor fuels used in agriculture Reimbursed excised tax amounted to 69 BGN million, averaged over 2008-09.	**Source 1: European Commission Excise Duty Tables** As at 1 July 2016, there appears to be no tax return on excise duty for motor fuels used in agriculture for gasoil [p.18], kerosene [p. 30], or natural gas [p.51].		0.0	0.0	0.0	0.0	0.0	As at 1 July 2016, there is no longer reduced excise duty. As policy is not included in the total support figure anyway, we simply assume 0 for entire period 2012-2016, without making further adjustments.	https://ec.europa.eu/taxation_customs/sites/taxation/files/docs/body/excise_duties-part_ii_energy_products_en.pdf
Gas	**Consumer support: Excise duty exemption on natural gas for household use** Households exempted from excise duty in 2012, amounting to 0.2 BGN million for 2012.	**Source 1: Source 1: European Commission Excise Duty Tables** As at 1 July 2016, excise duty on use of natural gas by households appears to remain exempted [p.46].		0.2	0.2	0.2	0.2	0.2		
Coal	**Consumer support: Excise duty exemption on coal and coke for sale to individuals** Individuals exempt from excise duty, amounting to 0.9 BGN million for 2009.	**Source 1: Source 1: European Commission Excise Duty Tables** As at 1 July 2016, excise duty on use of coal and coke by households appears to remain exempted [p.55].		0.9	0.9	0.9	0.9	0.9	As at 1 July 2016, excise duty remains exempted. As policy is not included in total support figure anyway, we simply take the last known estimate provided by IVM (0.9 BGN million in 2009) and assume this for the period 2012-2016, without making further adjustments.	https://ec.europa.eu/taxation_customs/sites/taxation/files/docs/body/excise_duties-part_ii_energy_products_en.pdf

New policies

Fossil Fuel	New policy	New policy detail	IVM support estimate (BGN million)	New support estimate (BGN million)					Rationale for updated support estimate	Source 1
			2011	2012	2013	2014	2015	2016		
All	**Producer support: State aid given to HECG generators**	**Source 1: Client Earth article** Romanian government has provided state aid benefitting High Efficiency Co-Generation plants (which use fossil fuels) in the order of €1.3bn for the entire period 2007-Sept 2016. This is an average of around €133m annually. The legality of this state aid provision is currently under review.	N/A	260.1	260.1	260.1	260.1	260.2	State aid amounts to €133 million annually between 2007-Sept 2016, as provided by Client Earth article.	https://www.clientearth.org/clientearth-challenges-unlawful-bulgarian-fossil-fuel-subsidy/

ROMANIA

IVM policies

Fossil Fuel	IVM policies	Updated IVM policies	IVM support estimate (RON million)	Updated support estimate (RON million)					Rationale for updated support estimate	Sources
			2011	2012	2013	2014	2015	2016		
Oil	**Consumer support: Fuel Tax Refund for Agriculture** Fuel tax refund to farmers amounted to 1.9 lei million and 4.3 lei million in 2010 and 2011, respectively.	**Source 1: Revista Economică** Starting 2014, state aid for reducing excise duty on diesel used in agriculture is implemented in accordance with Decision no. 1174/2014. The amounts granted by APIA for diesel fuel is provided for the period 2013-2015 [Table 1, p.71]. **Source 2: Ministry of Agriculture and Rural Development website** Discusses a potential new Decision (no. 3 of 11 January 2017), but not able to find official document/further details.	4.3	40.3	76.4	470.5	539.1	539.1	We take the annual state aid figures presented in Revista Economică for diesel between 2013-2015. We interpolate for 2012, and for 2016 we take the same figure as 2015.	http://economice.ulbsibiu.ro/revista.economica/archive/68106dascalu&nasta.pdf http://webcache.googleusercontent.com/search?q=cache:7MlQYC5KDqUJ:www.madr.ro/en/communication/3564-updating-subsidies-for-diesel-used-in-agriculture.html+&cd=1&hl=en&ct=clnk&gl=uk&client=firefox-b-ab
	Consumer support: Fuel Subsidies for Railways Fuel tax refund to railways amounted to 295 lei million in 2011.	**Source 1 and 2: Railway Pro and Energynomics articles** Starting 2014, fuel excise tax is no longer refunded to railway carriers. **Source 3: European Commission Excise Duty Tables** As at 1 July 2016, fuel excise duty for railways does not appear to be provided at a reduced rate [p. 20].	295.0	295.0	295.0	0.0	0.0	0.0	Starting 2014, fuel excise tax is no longer refunded to railway carriers. Prior to 2014, we take the last known estimate provided by IVM.	http://www.railwaypro.com/wp/diesel-fuel-excise-seriously-affects-fair-transport-competition/ http://www.energynomics.ro/en/railway-operators-discriminated-by-the-fuel-excise-reimbursement-only-to-road-transport/ https://ec.europa.eu/taxation_customs/sites/taxation/files/docs/body/excise_duties-part_ii_energy_products_en.pdf
Gas	N/A	N/A								
Coal	**Producer support: Excise tax exemption for coal used as an input for fuel production** IVM does not describe policy in detail in report. Tax exemption amounted to 54.7 lei million in 2006.	**Source 1: European Commission Excise Duty Tables** As at 1 July 2016, coal for business use in heating does not appear to be exempt from excise duty.		0.0	0.0	0.0	0.0	0.0	As at 1 July 2016, there is no excise tax exemption on coal for business use in heating. As policy is not included in the total support figure anyway, we simply assume zero for the entire period 2012-2016, without making further adjustments.	https://ec.europa.eu/taxation_customs/sites/taxation/files/docs/body/excise_duties-part_ii_energy_products_en.pdf
	Producer support: Capital related expenses for ortho-lignite exploitations Ortho-lignite received its last subsidy in 2007. This amounted to 54.2 lei million, averaged over 2006-07.	Ortho-lignite remains not eligible for state aid since 2007. **Source 1: European Commission No 1407/2002** "Since January 2007, the lignite is no longer entitled to any operational grant or welfare" [p.417]. **Source 2: International Journal of Academic Research in Business and Social Sciences report** "One third of this electricity is generated from low grade C coal (ortho-lignite), which is not eligible for State aid under the Coal Regulation" [p.6].		0.0	0.0	0.0	0.0	0.0	Ortho-lignite remains not eligible for state aid since 2007.	http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0253&from=en http://hrmars.com/hrmars_papers/Realities_and_Perspectives_concerning_Mining_Energy_Sector_in_Romania.pdf
	Producer support: Direct budgetary support for coal production Production aid (intended to cover difference between production cost and revenue) amounted to 195.6 lei million, averaged over 2010-12.	**Source 1: Candole Partners for Greenpeace Romania** The aid to be granted by the EC over 2011-2018 is intended exclusively to facilitate closure of three uncompetitive mines over this period. Therefore, to avoid double counting, we set this to zero.	178.7	0.0	0.0	0.0	0.0	0.0	The aid to be granted by the EC is intended exclusively to facilitate closure of three uncompetitive mines over 2011-2018. Therefore, to avoid double counting we set this to zero over the entire period.	http://www.greenpeace.org/romania/Global/romania/energie/Costs%20of%20Coal%20to%20Romania_EN-Report.pdf
	General services support: Exceptional costs and social protection in the coal mining sector Aid amounted to 39.4 lei million, averaged over 2010-12.	**Source 1: Candole Partners for Greenpeace Romania** The Romanian government will continue to provide CNH environmental and social subsidies. The total amount of these subsidies is 103.82+211.38=315.2 lei million over the period 2011-18 [p. 28]. This amounts to 39.4 lei million annually.	53.1	39.4	39.4	39.4	39.4	39.4	The support is 39.4 lei million annually, as provided in the Greenpeace report.	http://www.greenpeace.org/romania/Global/romania/energie/Costs%20of%20Coal%20to%20Romania_EN-Report.pdf

	General services support: Support for mine decommissioning EC's granted 1.169 lei bn for the closure of 3 uncompetitive coal mines owned by CNH over 2011-2018.	**Source 1: Romanian government press release** EC's decision to grant 1.169 lei billion over 2011-18 still holds. **Source 2: European Commission document (2012)** Breakdown of 1.169 lei billion for each year of 2011-2018. Of this, 784 lei million covers current production losses and 385 lei million covers exceptional costs of the decommissioning plants.	127.2	213.1	175.4	174.0	143.5	97.5	We take the annual state aid figures as presented in the European Commission document (2012).	http://gov.ro/en/government/cabinet-meeting/state-aid-for-the-uncompetitive-coal-mines-closure http://ec.europa.eu/competition/state_aid/cases/241737/241737_1352982_64_2.pdf

New policies

Fossil Fuel	New policy	New policy detail	IVM support estimate (RON million)	New support estimate (RON million)					Rationale for updated support estimate	Sources
			2011	2012	2013	2014	2015	2016		
Oil	**Consumer support: Fuel Tax Refund for Road Transport**	**Source 1 and 2: Railway Pro article** Starting 2014 and until 2019, road tranporters (excluding public transport companies) are partially refunded €0.04 per liter of their fuel excise duty. **Source 3: IEA database** Final consumption of oil products in road transport is 4.88 Mtoe for 2015.	N/A	232.5	232.5	232.5	232.5	232.5	Road transport are partially refunded €0.04 per liter of their fuel excise duty. We multiply this by the 4.88 Mtoe of oil products consumed by road transport in 2015 to calculate the total support for 2015. As policy is not included in total support figure anyway, we simply apply this figure to the entire 2012-2016 period, without making further adjustments.	http://www.railwaypro.com/wp/diesel-fuel-excise-seriously-affects-fair-transport-competition/ https://www.iea.org/Sankey/#?c=Romania&s=Final%20consumption
Coal	**Producer support: Land acquisition subsidy for coal plants**	**Source 1: Bankwatch Network article** In 2015, the Romanian government allocated €3 million of the state budget to buy land for Oltenia Energy Complex to facilitate coal mine expansions.	N/A	0	0	0	13.3	0	Land acquisition subsidy is €3 million for 2015, as provided in the Client Earth article.	https://bankwatch.org/press_release/the-runcurel-expropriations-europe-s-second-most-harmful-subsidy

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