



Energy Taxation and Subsidies in Europe: A Report on Government Revenues, Subsidies and Support Measures for Fossil Fuels and Renewables in the EU and Norway

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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 2007-2011.¹ The motivation for the current study is to provide a clear and transparent approach to understanding different estimates of subsidy and government support, and to put them in a broader context.

In recent years there have been various attempts, led by major international institutions, to estimate the level of “subsidies” and “support” offered to different energy sources around the world (examples include OECD, IMF, IEA, and IISD²).

Although there is a legitimate public interest in the question that these studies pose, the conclusions that they reach are influenced strongly by their methodologies. Most of the major studies are careful to acknowledge that their methodology assumes a particular perspective that leaves out potentially important factors. In addition, once these studies reach the sphere of public debate, they have been misinterpreted and in some cases misused by commentators.

Many of these existing 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”. A significant weakness of the reliance on benchmarks is that the assessment is entirely dependent on a subjective judgment of where the benchmark “should” be set. In many cases, there are other equally plausible benchmarks that could be selected, and that may lead to very different conclusions being reached. In addition, different benchmarks are typically applied across different products, and approaches to defining benchmarks may vary across countries. Consequently, estimates of support often cannot be compared across countries or energy sources. Moreover, some studies have been used in ways that are not intended by the authors, adding to confusion about what the results mean. For example, the OECD’s results have been cited in a European Commission working document as suggesting that fossil fuels in Europe received support of €26 billion in 2011.³ This figure appears to be derived by summing estimates across countries, which the OECD explicitly cautions against.⁴

¹ 2011 is the latest year for which comprehensive pan-European data were available at the time of writing.

² OECD (2013), “Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels 2013”. IEA (2012) *World Energy Outlook*. IMF (2013), “Energy Subsidy Reform: Lessons and Implications”. And finally, for example, IISD (2012), “Fossil Fuels – At What Cost? Government Support for Upstream Oil and Gas Activities in Norway” and other studies available at <http://www.iisd.org/gsi/>.

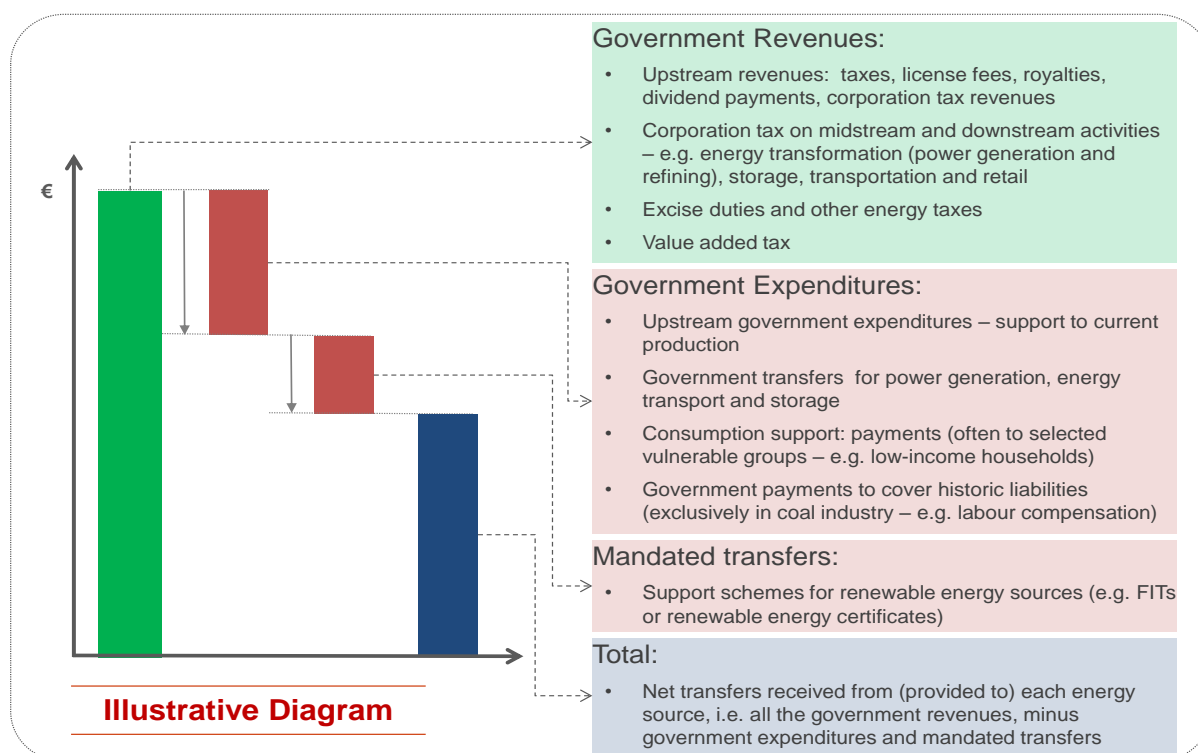
³ See European Commission (2013), “European Commission Guidance for the Design of Renewables Support Schemes”. Commission Staff Working Document.

⁴ Such aggregation ignores the variation in benchmark levels across countries – which underscores the often subjective nature of the benchmarks used. The OECD authors also note that even within a country, adding up the estimates may be “problematic”.

Methodology

We have approached the question of relative levels of “support” from a perspective that differs from those used in prior 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). This approach is summarised in Figure ES-1 below.

Figure ES-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.⁵

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. The information we rely on is all 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-2 (below).

Figure ES-2
Energy Value Chains Included in Our Analysis

	Oil & Gas	Coal	Renewables
Upstream Extraction; Infrastructure; Land rights			
Midstream Refining; Transportation; Storage; Electricity generation			
Downstream End-use of fuels by Industry; Households; Motor Vehicles			

We have also considered externalities⁶ 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.

⁵ For example, so-called “price gap” approaches, which are used by the IEA and IMF, interpret lower final energy prices relative to a benchmark prices as subsidies, but do not investigate the value chain above final consumption.

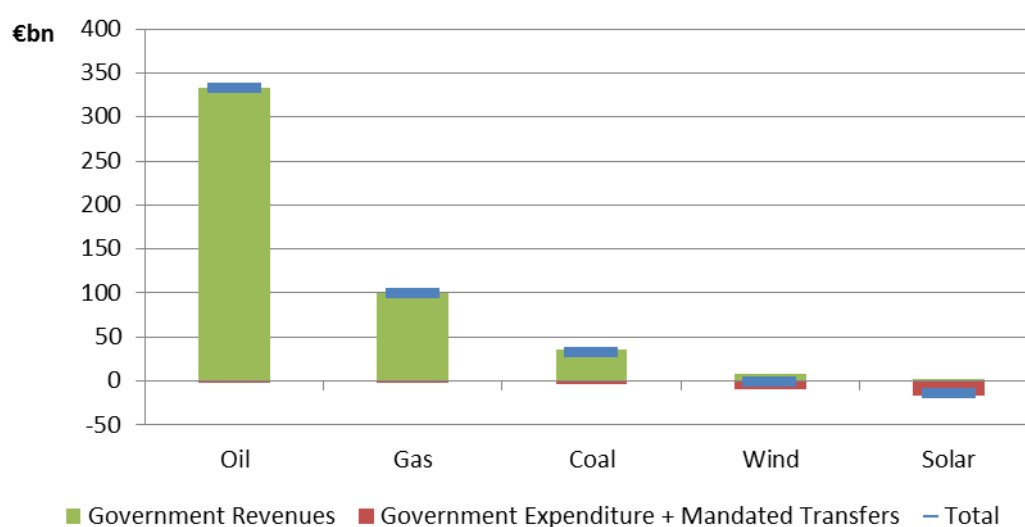
⁶ Externalities are costs that, as a result of an activity or market transaction, are imposed on a third party that is not directly involved in that activity or transaction. (Note that externalities can also be benefits that accrue to third parties.) There are a wide range of externalities sometimes 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.

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 is by far the largest contributor to government revenues. In contrast, wind and solar power are *net recipients* of support.

Figure ES-3 summarises our results for the five energy sources for 2011. 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-3
EU28 + Norway Net Government Revenues and Mandated Transfers (2011)



Source: NERA Analysis (all data sources discussed in Appendix B)

On the order of €480 billion in revenues were collected by EU28+Norway governments in 2011 from the five energy sources. Of this, close to 70 percent, or just over €330 billion, came from the oil sector. Gas contributed around one fifth of the revenue, or almost €100 billion. Coal accounted for around €36 billion in revenue, but also received transfers on the order of €4 billion. We estimate that wind contributed around €8 billion in government revenue, but received transfers amounting to around €9 billion, implying total net payments to the sector of €1 billion. Finally, we estimate that in 2011 solar power contributed around €2 billion to government revenues, but received transfers totalling close to €17 billion.

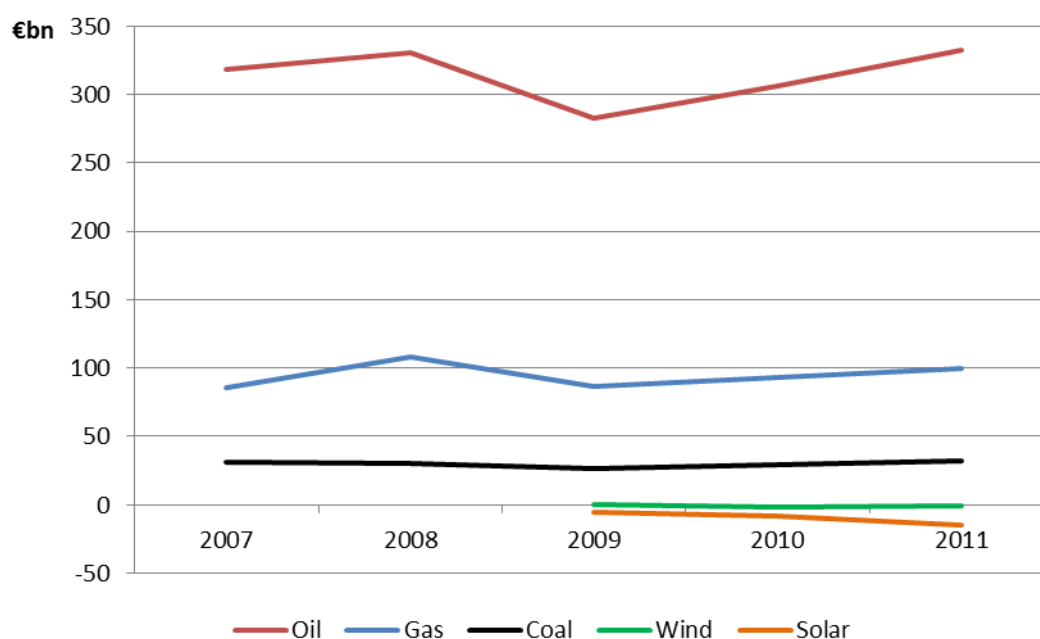
Duties on motor vehicle fuels account for the largest single source of government revenue from energy, ahead of VAT. Duties on these fuels yielded over €180 billion in 2011, and accounted for approximately 84 percent of all excise duty revenues from energy.

VAT paid on energy is also a very significant contribution 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.⁷

After excise duty and VAT, revenues collected from the upstream oil and gas sector contribute the most to government coffers, accounting for €83 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 – far above the average EU corporation tax of 23 percent.

The results for the years 2007-2010 are similar to the results for 2011 (Figure ES-4). The most significant change over time is that the magnitude of transfers to solar power has increased very significantly in absolute terms. The amount of installed solar generating capacity expanded rapidly during this period, resulting in large increases in public support for solar technologies. We do not have comprehensive European data that extend to 2012 or 2013, but we note that support to RES sources has continued to increase during these years.

Figure ES-4
EU28 + Norway Net Government Revenues and Mandated Transfers
(2007 - 2011)



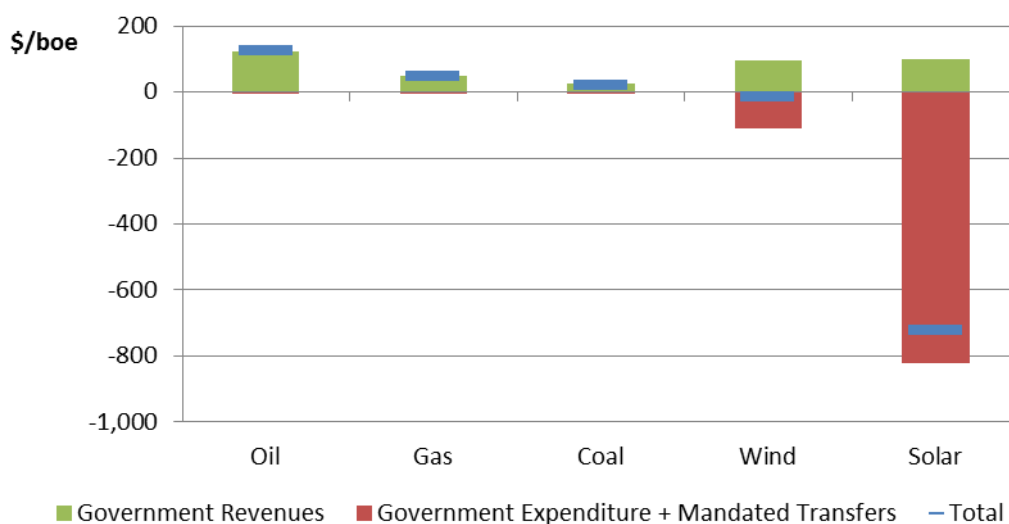
Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net transfer values for these years.

Figure ES-5 shows the net transfers to each fuel source per unit of primary energy consumption. The per unit results are shown 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

⁷ We allocate VAT collected on electricity in proportion to each energy source’s share of production across the EU.

net transfers to solar power per unit of energy amounts to more than \$700/boe. The net contribution to government revenues by oil per unit of primary consumption is highest, at \$124/boe, followed by gas (\$49/boe) and coal (\$24/boe).⁸

Figure ES-5
EU28 + Norway Net Government Revenues and Mandated Transfers (\$/boe)
(2011)



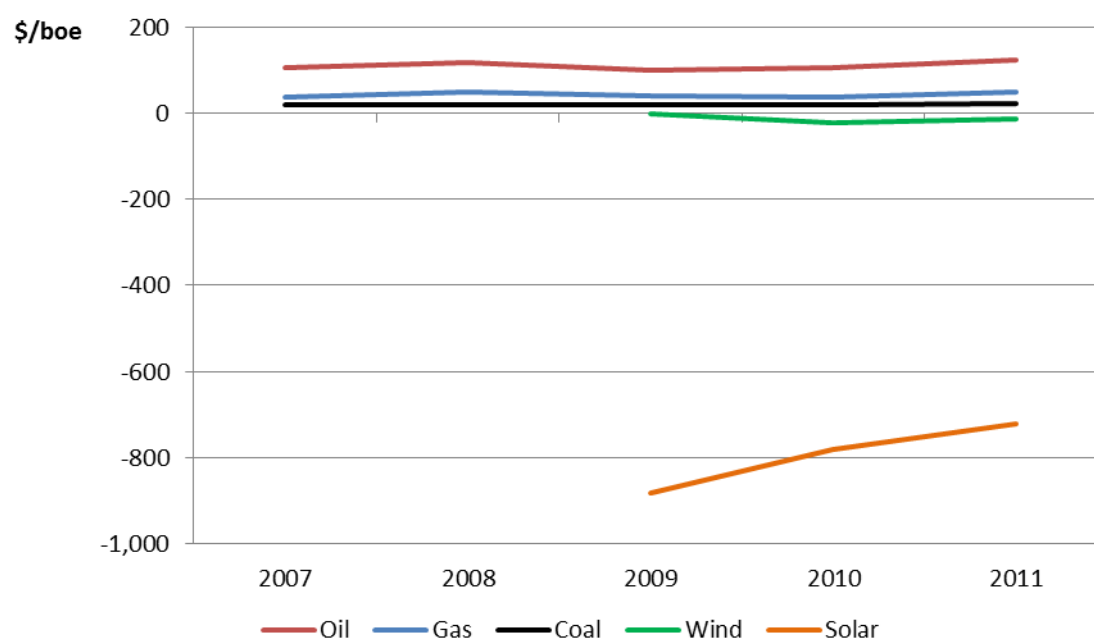
Source: NERA analysis

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-6 presents similar information, showing the net transfers (represented in Figure ES-5 by the blue lines) covering the full period from 2007 to 2011. Results are relatively consistent across years. 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.

⁸ 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-6
EU28 + Norway Net Government Revenues and Mandated Transfers (\$/boe)
(2007 - 2011)



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.

Externalities

The costs 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, or any mandated monetary transfers. 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 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 were priced at a level higher than the prices already imposed by existing policies, this would result in lower net revenues to government from every carbon-emitting fuel. 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 one should not simply “net off” the externality costs associated with carbon – or any externality – from government revenues.

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 CO₂ (often referred to as the shadow price of carbon). To reflect this uncertainty, we have used low, medium and high estimates of €10, 30, and 70/tCO₂.⁹ At the medium shadow price of €30/tCO₂, the externality costs would be €53 billion for oil, €29 billion for gas, and €35 billion for coal.

⁹ These values lie within the range that most sources regard as most likely, although the full range is much wider.

1. Introduction

In recent years there has been increasing interest in the question of government support for energy. A number of international organisations, including OECD and IMF, have conducted studies to estimate the level of subsidies. 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. To add clarity and transparency to the existing body of analysis, the International Association of Oil and Gas Producers commissioned NERA Economic Consulting to undertake a study with two primary objectives:

1. to better understand the approaches and data used by different organisations for estimating government support to the energy sector; and
2. to compare the taxation and subsidy regimes that apply to different energy sources across the EU 28 plus Norway.

The five energy sources considered in this report 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 2007-11 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. Our study 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 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.

As part of this work we have also prepared a case study of the tax regime applying to the upstream oil and gas sector in the United Kingdom, and this is included in Appendix A. Details of our estimation approach and data sources for individual categories of transfers are described in Appendix B. Finally, Appendix C includes a brief overview of different estimates of shadow price of carbon.

2. Overview of Literature

There have been a number of efforts in recent years to estimate “subsidies” and/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 – most 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 “subsidies” or “support” to fossil fuels.

Although there is a legitimate public interest in the question that these studies pose, the conclusions that they reach are influenced strongly by their methodologies. Different organisations investigating these questions have adopted wide ranges of scope, definitions of what should count as a “subsidy” or a form of “support”, and approaches to quantify them. Accordingly, the results produced by different studies, often addressing very similar questions, vary considerably.

This section begins by providing a brief overview of the how the concepts of “subsidy” and “support” are defined in some of these studies. It then reviews the most widely quoted studies with a view to illustrating how “subsidies” or “support” have been estimated in practice.

2.1. Defining and Measuring Subsidies

The concepts of “subsidy” and “support” are defined in many studies investigating governments’ treatments of different energy sources. Examples include:

- de Moor (2001),¹⁰ which states that: “subsidies comprise all measures that keep prices for consumers below market level or keep prices for producers above market level or that reduce costs for consumers and producers by giving direct or indirect support”.
- Uranium Information Centre (2005),¹¹ which identifies categories of activities that can be construed as representing subsidies. The categories, as described in Reidy and Diesendorf (2003),¹² include:
 - “Financial subsidies”, which include: “(1) direct subsidies and rebates; (2) favourable tax treatment; (3) provision of infrastructure and public agency services below cost; (4) provision of capital at less than market rates; (5) failure of government-owned entities to achieve normal rates of return; (6) trade policies, such as import and export tariffs and non-tariff barriers”;
 - “Research and development (R&D) funding; and
 - External costs (externalities) of energy production not accounted for in pricing systems.”

¹⁰ de Moor (2001), “Towards a Grand Deal on Subsidies and Climate Change,” *Natural Resources Forum* 25, 167-176

¹¹ Uranium Information Centre (2005), “Energy Subsidies and External Cost,” Melbourne, Australia.

¹² Reidy and Diesendorf (2003), “Financial Subsidies to the Australian Fossil Fuel Industry,” *Energy Policy* 31, 125-137

- the International Institute for Sustainable Development (IISD), which has undertaken several studies investigating the treatment of fossil fuels. Its approach is underpinned by the World Trade Organisation's (WTO) definition of subsidies, which it identifies in situations where:¹³
 - “Government provides direct transfer of funds or potential direct transfer of funds or liabilities,
 - Revenue is foregone or not collected,
 - Government provides goods or services or purchases goods,
 - Government provides income or price support.”

It is important to note that these definitions have their origins in different contexts – for example, the WTO's definition is intended for use in international trade disputes, in which a foreign party may believe it has been unfairly treated relative to a domestic party.¹⁴ In a similar context, the European Commission (EC) has outlined rules to identify cases of State Aid, which has some parallels with the question of defining subsidies or support. According to EC rules, a measure is considered to be a form of State Aid if:¹⁵

- “there has been an intervention by the State or through State resources which can take a variety of forms (e.g. grants, interest and tax reliefs, guarantees, government holdings of all or part of a company, or providing goods and services on preferential terms, etc.);
- the intervention gives the recipient an advantage on a selective basis, for example to specific companies or industry sectors, or to companies located in specific regions;
- competition has been or may be distorted; and
- the intervention is likely to affect trade between Member States.”

A common feature of these definitions is that they are very broad in scope, and aimed at providing a conceptual framework for thinking about subsidies or support. In some cases, specific measures are identified as representing forms of subsidies – for example, R&D spending by the government or direct transfers to consumers and/or producers. More commonly, however, establishing whether a particular measure may constitute a subsidy under these broad definitions often necessitates further judgments. For example, whether government policies lead to situations in which “competition has been or may be distorted” requires considerable analysis – most notably a hypothetical assessment of what constitutes a competitive situation. Whether government “revenue is forgone or not collected” requires the specification of a counterfactual against which any revenue can be regarded to have been

¹³ This description is due to IISD (2011), “Subsidies and External Costs in Electric Power Generation: A Comparative Review of Estimates”

¹⁴ For this reason, McKenzie and Mintz (2011) criticise the use of the WTO's definition for investigating subsidies in the energy sector. They note that this “definition of a subsidy is designed specifically to identify and remediate trade distortions. Importantly, it was not the purpose of the ASCM (i.e. the WTO's Agreement on Subsidies and Countervailing Measures) to add together a plethora of identified subsidies for the purposes of determining their impact on investment, output and emissions.”

¹⁵ http://ec.europa.eu/competition/state_aid/overview/index_en.html

forgone. Similarly, to establish whether capital has been provided at “less than market rates” or if government owned-entities are failing to achieve “normal rates of return” requires assessments of what market rates or what normal rates of return are.

Hence in practice, with only a few exceptions (for example, R&D spending), *identifying* whether a policy constitutes a form of “subsidy” requires the specification of a more detailed methodology that is often subject to various judgments. In addition, *estimating* the magnitude of a subsidy often requires further assumptions to be made. Consequently, the results reported by different studies are strongly influenced by their methodologies and the underlying judgements and assumptions – both with respect to how a subsidy or form of support is identified, and in how its magnitude is subsequently estimated.

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

- Price-gap approaches: which involve comparing prices paid by consumers (both final and intermediate) with benchmark or reference prices. Such approaches, therefore, do not consider the individual mechanisms that contribute to differences between consumer prices and benchmarks; and
- Programme-specific approach: which involve analyses of individual policy measures against criteria with a view to identifying whether these constitute a form of “support” or “subsidy”.

Both approaches have significant data requirements, although programme-specific approaches are more data intensive as they require the analysis of individual policy measures. Hence, many programme-specific approaches often focus on a particular country in isolation. Although many studies can be categorised as taking one of these two broad approaches, there can be important differences in the methodologies employed by individual studies that can lead to very different conclusions. For the remainder of this section, we provide brief overviews of four of the most widely quoted studies conducted by the following organisations:

1. the Organisation of Economic Cooperation and Development (OECD);¹⁶
2. the International Energy Agency (IEA);¹⁷
3. the International Monetary Fund (IMF);¹⁸ and
4. the IISD.¹⁹

These studies have been relied upon repeatedly by public bodies and organisations to highlight the (perceived) preferential treatment of specific energy sources. For example:

¹⁶ OECD (2013), “Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels 2013”

¹⁷ IEA (2013), “World Energy Outlook: 2013”

¹⁸ IMF (2013), “Energy Subsidy Reform: Lessons and Implications”

¹⁹ IISD (2012), “Fossil Fuels – At What Cost? Government Support for Upstream Oil and Gas Activities in Norway”

- in a recent Staff Working Document,²⁰ the European Commission cited a figure of €26 billion as the total level of support received by fossil fuels, apparently relying on an interpretation of the OECD inventory that the OECD itself cautions against (see section 2.2.5 below);
- the IISD's review of subsidies in electricity generation quotes estimates from the IEA, IMF and OECD, as well as its own analysis.²¹
- a review of energy subsidies by Oil Change International similarly reports estimates collected by IEA and OECD, summing estimates constructed using two very different methodologies;²² and finally
- a recent report by (Blyth (2013)) to the UK Parliament's House of Commons Environmental Audit Committee provides estimates of subsidies in the UK.²³ For fossil fuels, the study largely relies on the OECD's inventory. It also goes on to report subsidies received by nuclear power and renewable energy sources.

2.2. Studies Investigating Subsidies and “Support” to Fossil Fuels

2.2.1. The OECD's Inventory of Budgetary Support

Study Snapshot: OECD Inventory of Budgetary Support

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)

The OECD, relying on a programme-specific approach, has produced one of the most widely quoted studies on “support” to fossil fuels. The inventory, however, relies heavily on government documents produced individually by all the OECD 34 member states 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 has been subsequently applied to six non-OECD EU countries by IVM (2013).²⁴

²⁰ European Commission (2013), “European Commission Guidance for the Design of Renewables Support Schemes” Commission Staff Working Document. 5 November 2013

²¹ IISD (2011), “Subsidies and External Costs in Electric Power Generation: A Comparative Review of Estimates”

²² Oil Change International (2012), “Low Hanging Fruit: Fossil Fuel, Climate Finance, and Sustainable Development”

²³ Blyth (2013), “Written Evidence Commissioned by the Committee from Dr William Blyth, Oxford Energy Associates”

²⁴ IVM (2013), “Budgetary Support and Tax Expenditures for Fossil Fuels: An Inventory for Six non-OEC EU Countries”

The inventory 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.”

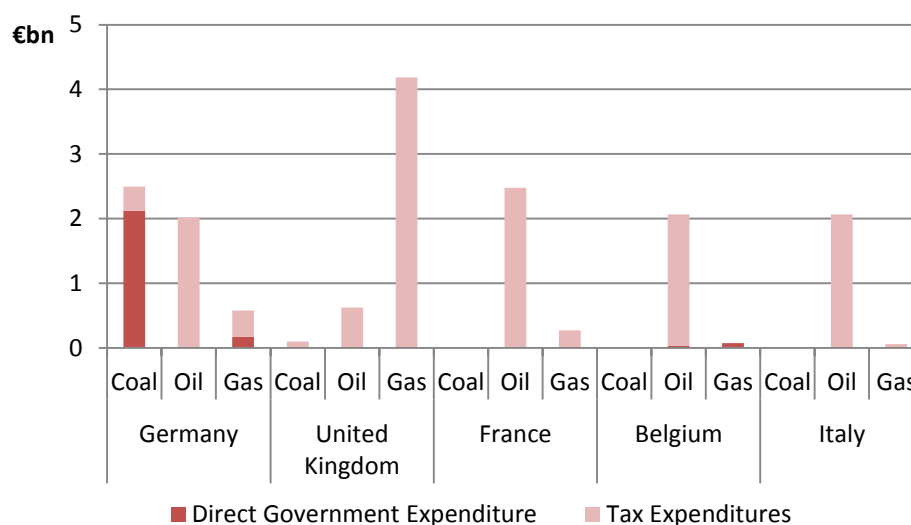
- The categories of items covered by the OECD inventory are: “tax expenditures that in some way provide a benefit or preference for fossil fuel production or consumption”; and
- a selection of measures “that do not affect current production or consumption... including... expenditures relating:
 - to past production activities (e.g. to compensate victims of mine land subsidence following the underground extraction of coal or hydrocarbons),
 - to research and development not directly relating to production, and
 - to activities such as the funding of strategic stockpiles.”

“Tax expenditures” represent the difference between the actual tax rate applied to a good or product and essentially a hypothetical higher “benchmark” rate. We discuss tax expenditures in further detail in section 2.2.5 below – in particular, explaining the limitations of using them to identify subsidies or support. The vast majority of “support” identified by the OECD inventory is, in fact, in the form of tax expenditures.

Figure 2.1 shows the five countries identified by the OECD inventory in which fossil fuels receive the largest “support”. To emphasise the importance of tax expenditures, we distinguish them from other measures that involve actual direct transfers from the government to the energy source, rather than foregone (hypothetical) tax revenue.²⁵ The only significant level of support identified in the top five countries that is not tax expenditure is government payments associated with coal mining in Germany.

²⁵ Note that we do not sum the estimates of “support” identified in the OECD inventory across countries, as the methodology used does not allow for cross-country comparisons for the bulk of the support identified (which is via tax expenditures). This feature of the study’s methodology is emphasised by the OECD authors, and we discuss this in more detail in section 2.2.1 below.

Figure 2.1
OECD Inventory: Five Countries Providing Highest “Support” in 2011



Source: OECD (2013) and NERA analysis as described in text

2.2.2. 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 database focuses on fossil fuels, and reports subsidies separately for oil, natural gas, coal and electricity.

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. Under the price gap methodology, prices below reference prices in importing countries are an indication of the level government support for a particular energy source. In energy producing countries, if actual prices are below reference prices, the price gap methodology identifies the opportunity cost associated with the lower price – i.e. the amount by which energy could be sold at higher prices elsewhere.

The IEA reported global subsidies to fossil fuels of \$523 billion in 2011 (and \$544 in 2012).²⁶ *The IEA's approach does not identify any subsidies in the EU*, however, because end-user fuel prices do not materially differ from the international reference prices against which the IEA makes its comparison. The IEA notes, however, that its approach generally underestimates total fossil fuel support because it does not detect policies that do not lower the downstream end user price below the applicable reference price.

2.2.3. IMF's energy subsidy reform

Study Snapshot: Energy Subsidy Reform – Lessons and Implications, IMF

Methodology type: Price gap

Methodology: Similar to IEA approach comparing end-user prices to benchmark price. Distinguishes between: (1) “pre-tax support” – measured by comparing (pre-tax) end-user prices with a benchmark pre-tax price; and (ii) “post-tax support” – compares end-user prices (including taxes such as VAT, General Sales Tax (GST), excise duties) with a benchmark price that includes an allowance for notional “benchmark” consumption taxes (such as VAT or GST) as well as certain externalities attributed to energy sources.

Scope: Global

The IMF has undertaken work on measuring energy subsidies, focusing on fossil fuels. It uses a price gap methodology that is very similar to the IEA's for measuring subsidies. Its definition of subsidies distinguishes between consumer and producer subsidies: “consumer subsidies arise when the prices paid by consumers, including both firms (intermediate consumption) and households (final consumption), are below a benchmark price, while producer subsidies arise when prices received by suppliers are above this benchmark.” When consumer prices are below the benchmark someone (e.g. the government) is assumed to be covering the difference.

The IMF estimates subsidies on two different bases:

²⁶ IEA. World Energy Outlook 2012; and IEA. World Energy Outlook 2013.

1. **pre-tax subsidies**, which are based on a comparison of pre-tax end-user prices with a benchmark price. For traded products, the benchmark price is based on an international benchmark price adjusted for distribution and transportation costs. The IMF assumes margins for distribution and transportation are similar across all countries. For non-traded products – mainly electricity – the benchmark price is “is the cost recovery price for the domestic producer, including a normal return to capital and distribution 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 some traffic externalities (e.g. congestion). For VAT, the IMF develops assumptions about what constitutes a reference rate of VAT: for example, in countries where no VAT is paid on the consumption of *any product*, it nonetheless assumes that the reference VAT is the same as in countries with similar incomes. The adjustment for GHG emissions in the benchmark price is based on an assumed carbon price of 34 USD/tCO₂e, which is taken from the United States Environmental Protection Agency.²⁷ Finally, for local air pollutants, the IMF assumes that countries have similar characteristics to the US and uses estimates from the US to quantify this externality.

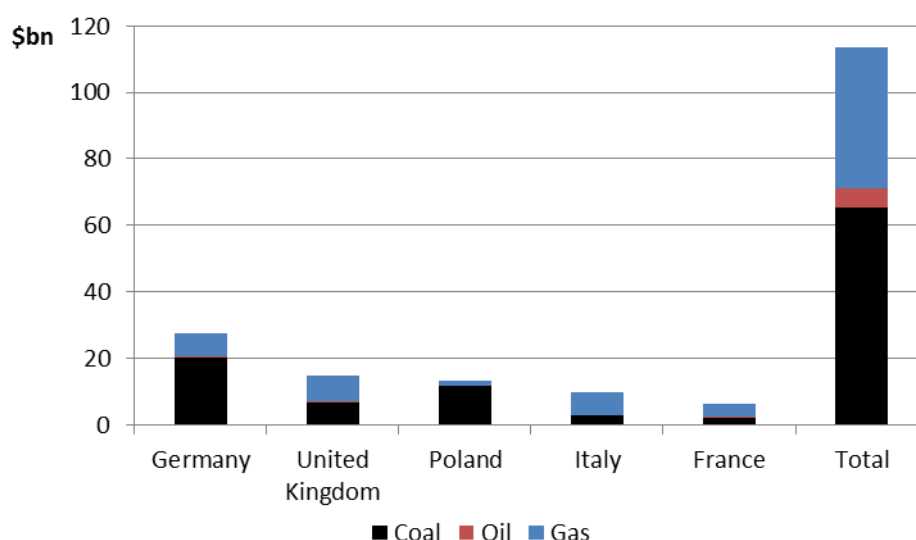
The IMF’s study acknowledges several limitations of its adopted methodology. For example, its price gap approach “does not capture subsidies that arise when energy suppliers are inefficient and make losses at benchmark prices.” However, there are more important limitations of its methodology that are also acknowledged by the authors, including: a lack of data for some products and/or countries; reliance on a snapshot of prices at a particular point in time and for selected groups only; lack of comparability across countries for some types of fuels because they reflect local characteristics; stylised assumptions about transportation costs; and – significantly, given the motivations for the current study – stylised assumptions for “corrective taxes”.

On the pre-tax basis, the IMF estimates total global fossil fuel subsidies of \$492 billion in 2011. However, the majority of this is accounted for by oil exporting countries, with Middle Eastern and North African countries accounting for about 48 per cent of the total. The IMF does not find any significant pre-tax subsidies in advanced economies.

On a post-tax basis, the IMF estimates total subsidies of \$2.0 trillion in 2011. Externalities account for the most significant share of this total, accounting for about \$1.3 trillion. A large proportion of the post-tax subsidy is attributed to the US, which the IMF estimates provides “subsidies” of \$410 billion. We have not attempted to analyse this estimate, as the US is outside the scope of our study. In the EU 28 + Norway, which are the focus of the present study, the IMF finds total post-tax “subsidies” of \$113 billion. Figure 2.2 shows the breakdown of subsidies by fuel across these countries as a whole, and in the five countries that, according to the IMF, account for the largest share of “post-tax subsidies”.

²⁷ This carbon price is based on the social cost of carbon approach. We discuss different approaches to estimating a carbon price in Appendix C.

Figure 2.2
IMF Estimates of “Post-Tax Subsidies”: EU-28 + Norway, 2011



Source: IMF. “Energy Subsidy Reform: Lessons and Implications.” 2013.

Note: The figure shows the total “post-tax subsidies” identified by the IMF for the EU-28+Norway, broken down by fuel. It also shows the IMF’s estimates for the five EU-28 countries accounting for the greatest amount of post-tax subsidy.

2.2.4. The IISD’s reports on subsidies

Study Snapshot: Several reports by IISD on different countries

Methodology type: Programme-specific

Methodology: Support is measured through the assessment of individual measures, with tax expenditures typically accounting for the majority of estimated support.

Scope: Selected individual countries

The IISD has undertaken several studies to estimate subsidies in different countries, including Canada, Indonesia, Russia, and Norway. The approach adopted by IISD in all of these studies involves a programme-specific review of individual policies, which is similar to the approach adopted by the OECD. In particular, the IISD adopts the WTO’s definition of subsidies (see above) and evaluates different policy measures to assess the extent to which each may constitute a subsidy.

The majority of “support” identified in the IISD’s country reviews is typically in the form of forgone government revenues – most notably, tax expenditures. For example, in the IISD’s report on Norway, two policy measures account for around 97 percent of the total “subsidy” identified, both of which are examples of forgone revenues by the government. Similarly,

more than half of the total support identified in the IISD's study on Canada is in the form tax expenditures.

The IISD's report on Norway (which is one of the countries included our study) focuses on upstream oil and gas production only, and reports figures for 2009. The two policy measures that account for the vast majority of the total "subsidy" are: (1) the reimbursement of exploration expenditures;²⁸ and (2) the fast deductions of investment.²⁹ In the case of the first measure, the IISD study acknowledges that the Norwegian "Ministry of Finance states that such reimbursement is not to be viewed as a subsidy". However, IISD nonetheless regards the measure to be a form of subsidy as it represents "a preferential treatment of deficit-running companies in the petroleum industry compared with such companies in other industries." In contrast, the OECD inventory does not record either of Norway's capital allowance provisions as "support". This difference underscores the extent to which subjective judgments have a very significant influence on estimates of support that are based on tax expenditure.

2.2.5. Comments on Existing Approaches

A feature of the estimates of "support" produced in some 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.

For example, as noted above, the OECD inventory appears to be the source of the European Commission's estimate of total government "support" of fossil fuels of €26 billion³⁰ – even though the OECD cautions against adding up its estimates (see Box 2.1). Other studies, for example, by the IEA and IMF, typically also rely on benchmarks for their reference prices. 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 it requires particular judgments about the levels at which taxes *should* be set, and these judgments are far from uniform.

To illustrate some of shortcomings of relying on benchmarking approaches – particularly when analysing taxation and other revenue-raising policies – we consider the OECD

²⁸ The reimbursement of exploration companies was introduced in 2004 with a view to encouraging new entry. It allows companies in a non-taxable position to reclaim 78 per cent (also the marginal tax rate on the profits from the sector) of their exploration expenditures in the year after they have been incurred.

²⁹ The fast deductions of investments refer to accelerated depreciation of capital allowances over six years for offshore investments. IISD concludes that this is a subsidy, because it allows for faster deductions than are available to other sectors. However, IISD concludes that the "uplift" provided for the partial additional depreciation over four years against the Special Tax of 50 per cent is not a subsidy, because it was introduced specifically in the context of the higher Special Tax rate. Thus even though IISD notes that in general "fast payback needs to be seen in the context of the high tax rate of 78 per cent, as these elements were enacted and balanced against each other", they apply this conclusion selectively to one capital allowance provision, but not the other.

³⁰ See footnote 20, above.

inventory, which is one of the most widely quoted sources on the budgetary support of fossil fuels. The OECD inventory provides a very useful and detailed compilation of a wide range of policies across a large number of countries, and we rely on it as a source of data for the current work. However, because the benchmarks that it relies upon are difficult to compare or sum across countries and across energy sources, its findings need to be used with an understanding of what it is appropriate to do with them, and what not.

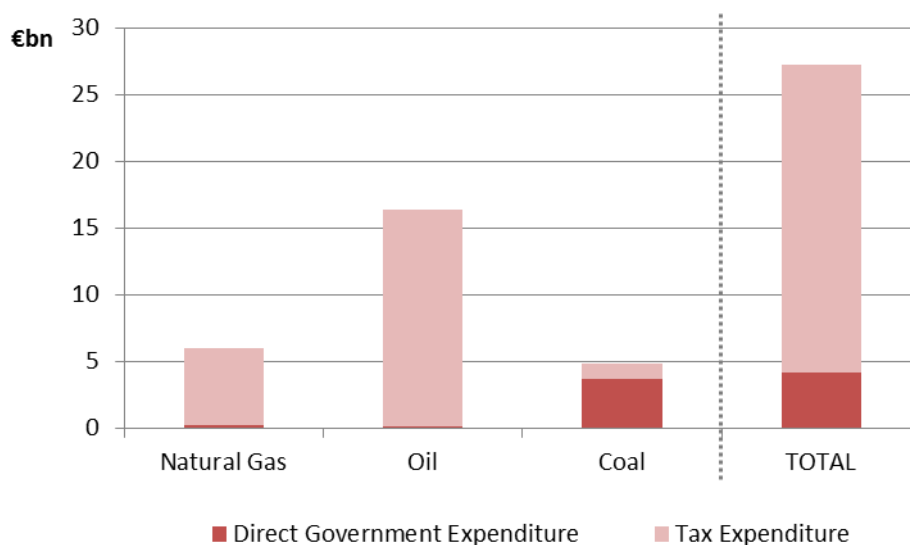
Box 2.1 **(Mis)-Interpretations of the OECD Inventory**

As noted above, the OECD inventory appears to be the source of the European Commission's estimate of fossil fuel subsidies in 2011 amounting to €26 billion.³¹ The data in the OECD inventory are not intended to be summed across countries, or even across fuels. However, when we sum all of the reported support and expenditure included in the OECD inventory for EU countries – *which the OECD explicitly advises against doing* – we find a total of approximately €27 billion in 2011, with an average amount over the years 2007 to 2011 of €26 billion. We therefore infer that the European Commission has derived its estimate for fossil fuel subsidies by summing up all figures in the inventory, with slight discrepancies possibly explained by exchange rate conversions.

We have carried out a line-by-line review of the OECD data, noting which items reflect direct government payments and which reflect tax expenditures. In Figure 2.3 we take the data for 2011 from the OECD inventory and, for the three fuels, break down the total amount of €27 billion total into direct government payments to each fuel and tax expenditures.

³¹ See footnote 20 above.

Figure 2.3
Government Transfers and Tax Expenditures in OECD Inventory Data (2011)



Source: NERA analysis of OECD (2013).

This analysis makes it clear that if one sums the OECD inventory across countries in this way (which should not be done in the first place) a large majority of the €27 billion is attributable to “tax expenditure” – which are not comparable across countries or fuels. Only around €4.1 billion actually reflects government payments to the sectors (of which €3.7 billion was directed towards the coal sector), which it may be appropriate to sum.

As Box 2.1 illustrates, 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 IISD 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,³² 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. For instance, depending on the subjective judgment of what constitutes the benchmark rate, different conclusions can be reached about whether domestically consumed natural gas in the UK is “supported” by the UK’s 5 per cent VAT tax. Subjective judgements about benchmarks – for example, about VAT – also underpin the approach adopted by the IMF.³³

³² VAT Directive 2006/112/EC

³³ As noted in section 2.2.3 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.

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.

A further limitation of approaches such as the OECD's inventory is that they focus on policies that apply at particular portions of the value chain of an energy source and ignore the broader context of the tax regime applying to the energy source's end to end value chain. This limitation is also acknowledged by the OECD inventory in the context of fossil-fuel production taxes. The inventory notes that "countries use varying approaches, such as royalty systems, resource-rent taxes, and cash-flow taxes to tax the super-normal profits that can be associated with resource extraction and ensure a fair return to the public when publicly-owned resources are sold. *All of these issues must be taken into account when assessing any particular feature of a tax system*" (emphasis added).

The importance of the overall context is illustrated by the historical experience of taxation applied to the upstream oil and gas sector in the United Kingdom, which we discuss in more detail in a case study included in Appendix A. The case study shows how, reflecting different government objectives, the regime has changed on several occasions, and it

illustrates how inferences drawn from focusing on an individual policy change and/or period can be misleading, because it misses the bigger picture.

The importance of taking into account a wider context applies not just to the kind of individual policy-by-policy analysis undertaken by the OECD. It also applies to the high level approaches adopted by the IMF and IEA. As noted above, the IMF's post-tax estimate of subsidies includes a component for externalities – including GHG emissions, local air pollutants, and a selection of transport externalities (for example, congestion and accidents). The IMF's approach appears to attribute these externalities *entirely* to the energy sources, and then considers whether end-user prices, inclusive of taxes such as excise duties, cover such externalities. In practice, however, other forms of taxation are typically applied, in conjunction with taxes levied directly on energy sources, to reflect externalities. Such taxes are ignored by the IMF's approach. For example, many countries use different instruments to, directly or indirectly, charge for the congestion externality – for example, road-pricing schemes or taxes levied directly on the sale of vehicles. The IMF's approach, however, ignores such revenues.

In practice, therefore, governments make a range of different decisions about whether, and how, to internalise externalities, through both regulations and pricing mechanisms. As we discuss below, in part for this reason, and because externalities are in a category that is distinct from government revenues and subsidies, we do not account for them in the way adopted by IMF. We discuss our approach in section 3.4, below.

3. Methodology

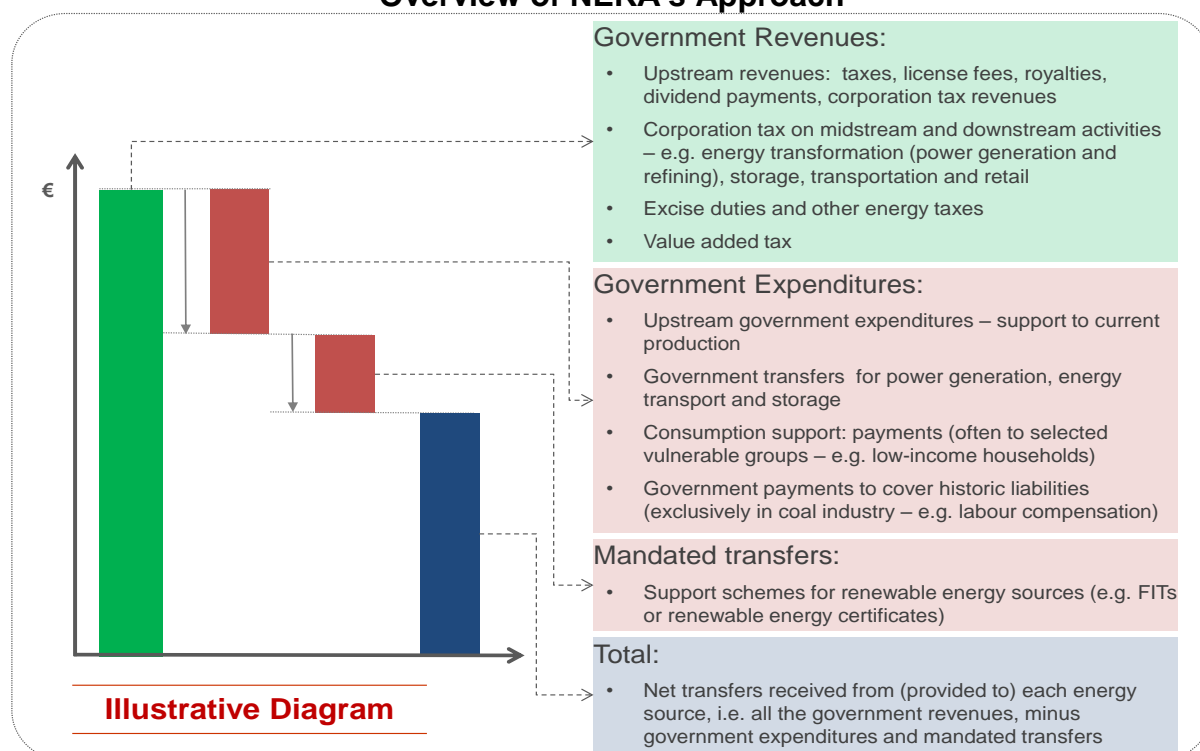
As the discussion in Chapter 2 shows, a number of studies have investigated governments' direct and indirect payments to and receipts from different energy sources with a view to assessing the extent of "support" provided by diverse government policies and mechanisms. In this chapter, we discuss our approach to addressing this question (summarised in Box 3.1). 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: here we discuss the different parts of the energy value chains, how we have decided which categories to prioritise, and how we allocate transfers between different energy sources. 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. Finally, we have also considered the externality associated with the release of greenhouse gas emissions, and we discuss this externality along with others in section 3.4.

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.³⁴ 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.

We also consider how to reflect externalities in our analysis – that is, the costs or benefits resulting from an activity that affect third parties that are not directly involved. There are a wide range of externalities often linked directly or indirectly to energy (for example, greenhouse gas emissions). Positive externalities lead to benefits or revenues accruing to third parties and negative externalities generate costs or damages to those parties. To the extent that firms are not charged for negative externalities, policies permitting these externalities may be considered a form of “support”: firms do not pay for the cost that their activity imposes on others. In practice, some government transfers (and government-mandated transfers) are motivated in part by the presence of such externalities.³⁵ We discuss externalities further in section 3.4 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

³⁴ 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.

³⁵ For example, the EU legislation on minimum excise duties on energy products is explicitly identified as being linked to emissions of CO₂.

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. This is an important consideration for understanding any support provided to energy sources. The strategic importance of energy sectors means that they typically face multiple government policies at different parts of their value chains, designed to achieve multiple objectives. Individual elements of policies, if viewed in isolation, may lead to some measures being viewed as “support”, when in fact they might be part of a broader set of policy objectives that seek to increase government revenues overall.

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). This allows individual policies affecting an energy source to be 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.³⁶

3.2. Scope of Transfers









Our analysis extends to all 28 countries of the European Union as well as Norway. To guard against the possibility that our results could be affected by one-off changes in policy, we have gathered available data on transfers over the period 2007 to 2011.³⁷ (In some cases data are not available over the entire period.)

The discussion in the preceding section highlights the importance of accounting for the full range of economic activities from each energy source. Our methodological 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, and so in practice, our estimates have been constrained by data availability. We note any omissions, and our approach to addressing these, in our discussion of individual categories below.

³⁶ We note that we do not consider macroeconomic or “multiplier” effects (which would require a very significant expansion of our scope). We also do not attempt to quantify the 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.

³⁷ Unfortunately many of the data sources on which we rely have not yet been updated for 2012.

Table 3.1
Activities Associated with Energy Sources

	Oil & Gas	Coal	Renewables
Upstream Extraction; Infrastructure; Land rights			
Midstream Refining; Transportation; Storage; Electricity generation			
Downstream End-use of fuels by Industry; Households; Motor Vehicles			

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.³⁸

The fiscal regimes applied in the different members states of the EU and Norway include a vast number of mechanisms that lead to transfers. We have identified major data sources that cover some of the most important categories of revenues and expenditures relating to energy. For revenues and expenditures not covered in our detailed analysis of major data sources, we have applied a materiality threshold to prioritise the most important transfers. In this respect, we have used an energy source and country-specific threshold of the smaller of €0.5 billion or 5 per cent of revenue or expenditure. We have used a variety of approaches to establish whether a particular item is likely to meet this threshold. Box 3.2 illustrates one example of our approach applied to the coal mining industry in Poland.

³⁸ 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.

Box 3.2

Materiality: Coal Mine Corporation Taxes in Poland

We have investigated the profitability of coal mines in Poland to establish the likely magnitude of corporation tax receipts. Our review of publicly available sources has suggested that in many years, profits have been negative, and that when profits have been made, these are typically small. We have therefore concluded that corporation tax receipts from coal production in Poland are therefore likely to be significantly below the materiality threshold. The appendices on revenue and expenditure items provide details of how we have established materiality for different transfers.

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 90 per cent of combined oil and gas production in the EU countries and Norway in 2011. 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 energies in proportion to an appropriate measure of activity for the relevant sector. For example, in the case 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.

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), priority grid access 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.

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). Appendix A includes a detailed case study of the tax regime applying to the upstream oil and gas sector in the UK, and shows how this has changed to reflect changing policies and markets, and the evolving

state of the UK's resource over time. 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. Further details of our approach are included in Appendix B.

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. Total corporation tax receipts across all business activities in Europe were approximately €322 billion in 2011.³⁹ 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. For example, for corporation tax receipts from electricity and gas retailers, we have used information from the UK on profitability to obtain an estimate of overall industry profits at the level of the EU. Average profitability in the UK is estimated to be £50 per fuel account.⁴⁰ With 26 million households and assuming an average of two accounts per household, profits in the UK amount to £2.6 billion. Based on the 2011 corporation tax rate of 26 per cent, total UK tax receipts are estimated to have amounted to nearly £0.7 billion. This meets the country-specific materiality threshold, and we have therefore included corporation tax from electricity and gas retailers in our study. The estimate for the UK has then been scaled to derive an estimate for the remaining countries in our study. Our approach to estimating corporation tax receipts is described in more detail in Appendix B.

³⁹ Eurostat, Taxation Trends in the European Union: Data for Member States, Iceland, and Norway – 2013 Edition.

⁴⁰ Ofgem, Electricity and Gas Supply Indicators.

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: nearly €200 billion of government revenues in 2011 were derived from such duties on the sale of coal, oil and gas and their derivatives.⁴¹ 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. For example, the excise duty applied to petrol ranges from €359 per 1,000 litres in Romania to nearly €750 per 1,000 litres in the Netherlands.⁴² 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.

Excise duties make up approximately 94 percent of all energy taxes in the EU28 and Norway. Additional energy taxes include revenues from carbon taxes in certain countries as well as revenues from the auctioning of allowances in the EU ETS. Appendix B provides additional details of our approach to estimating excise duty and other energy tax revenues.⁴³

3.3.1.4. Value Added Tax

Value added taxes (VAT) are another very significant source of government revenues from energy, with total VAT receipts from coal, oil and gas sales in the EU and Norway amounting to €118bn billion in 2011, with a further €43bn in VAT accruing to all of the energy sources that are included in the scope of this study through the sale of electricity. 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

⁴¹ European Commission, Excise Duty Tables: Part II – Energy Products and Electricity. A further €17bn of excise duties was raised on the sale of electricity.

⁴² European Commission, Excise Duty Tables: Part II – Energy Products and Electricity, July 2013.

⁴³ Note that due to certain inconsistencies in the data on excise duties and all energy taxes, as well as issues in allocating other energy tax revenues across fuels, we have primarily relied on excise duty data for the countries included in this study. Section B.1.3 in Appendix B provides further detail.

- **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. Further details of our approach to estimating VAT receipts are included in Appendix B.

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. There are relatively few midstream payments identified in the OECD and IVM inventories, the most significant of which is to support loss making coal-fired power generation in Poland.
- **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. Governments in the Czech Republic, Germany, Spain and Poland have allocated resources to provide compensation to workers.
- **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, capturing transfers made by the Czech and Polish governments.

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, which vary in their materiality as well as the extent to which reliable data is publicly available.

Governments also make contributions to research and development (R&D) funding in energy sectors. For example, the International Energy Agency (IEA) reports that the UK government's contribution to R&D funding in the energy sector in 2010 amounted to over £0.5 billion. However, a significant proportion of this funding was allocated to other energy sources (for example, nuclear power) and activities such as energy efficiency that are beyond the scope of this study. Government expenditure on energy-related R&D represents a demand on the public budget, and we have investigated the size of such transfers from sources such as the IEA's country-specific Energy Policies reviews.

Finally, our study also considers infrastructure investment that may lead to direct government expenditures (or mandated transfers – see next section). We discuss infrastructure investment and how it relates to our methodology in Appendix B. We have not been able to estimate a specific figure for this category, although we provide some illustrative figures for the scale of expenditures that could be associated with different energy sources.

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 are based on 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. CEER (2013) reports that nine EU countries provide priority grid connections and twelve EU countries provide priority grid access to renewable energy generators.⁴⁴ We have investigated the extent of the support that may be conferred by such policies. We have, however, not included a quantitative value of this support in our main results because of the significant uncertainties associated with any estimate. We discuss priority grid access in more detail in Appendix B.

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. In cases where only a sub-set of consumers benefit from price regulation, the cost is typically borne by a mixture of producers and other consumers, therefore representing a cross-subsidy between different groups. This feature of price regulation – i.e. a transfer between different groups – means that the cost of price regulation is typically borne by the energy source in question. We have therefore not included such price regulation in our estimates.⁴⁵

⁴⁴ The countries that provide priority grid access are: Belgium, the Czech Republic, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia and Spain.

⁴⁵ We note that the overall effect of such policies on consumption levels – i.e. on the quantity consumed – is not clear. Those being charged higher prices consume less than they otherwise would, and those being charged lower prices consume more. These two effects may not offset each other exactly, and there are potentially good reasons to suppose that overall consumption is higher than it otherwise would be.

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. In particular, the incidence of the transfer (i.e. the groups that bear the costs of payments mandated by government policy), is often spread across several groups. For example, the costs of FITs are borne by other energy companies (who face increased costs to pay the associated levies, and whose revenues also may be significantly affected by impacts on market prices and quantities) as well as by final consumers. In general we have not attempted to capture dispersed effects across the wider energy markets and economy. The impacts of the policies considered here are complex, and we make no attempt to trace their full impact.

To take one specific example, in Germany the rapid increase in generation from renewable energy sources has been partly responsible for a dramatic erosion recently of the financial viability of gas-fired power stations. The absolute fiscal contribution of gas to Germany's government is therefore likely to have fallen, in part as a result of renewable support policies. Moreover, independent studies have suggested that across the EU, the increase in renewable energy as a result of government support has been a very significant contributor to the reduction in carbon emissions covered by the EU ETS, which has in turn suppressed the EU ETS allowance price, reduced government revenues from the EU ETS, and affected the balance between coal-fired and gas-fired electricity generation. 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 externalities include: emissions of “local” pollutants, security of energy supply,⁴⁶ innovation spill-overs, “disamenity” value of wind farms and other generating capacity, water scarcity, road congestion – and many others.

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

⁴⁶ 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.

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. 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. Reflecting this, we do not recommend directly comparing government revenues collected from energy use with the cost of the externalities that may be linked to these energy sources (in different ways and to different degrees).

To illustrate how externality costs (or benefits) relate to our main analysis, we consider the example of greenhouse gas (GHG) emissions, given the importance of these emissions in motivating renewable energy policies.

3.4.1. The externality associated with greenhouse gas emissions

GHG emissions for EU countries and Norway are reported in the UNFCCC inventory database, and are attributable to different energy sources. There is, however, significant uncertainty about the cost imposed by these emissions.

We have conducted a review of estimates available in the literature of the cost of the externality associated with a tonne of CO₂ 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/tCO₂, respectively. These values reflect the range that most sources regard as the most likely cost of carbon, 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. 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.

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.

Within a welfare economics framework, the value that consumers place on the consumption of fossil fuels (or on any goods) must be at least equal to the amount consumers spend on them. (The value is equal to the amount consumers spend plus their “consumer surplus”.) The overall value to *society* is the difference between the cost of producing the fuels and the value that consumers place on them (the “total surplus”). In this framework, the extent to which taxes on GHG emissions can be passed onto consumers is an indicator of the value that consumers attach to fossil fuel use, and therefore of the overall contribution of these fuels to society’s total surplus. We note that estimating total surplus or the value to consumers is beyond the scope of our study.

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. If this required a *change* in government policy it would depart from the static framework that we have used for our analysis. The implication of such a change for government revenues would depend on how the demand for (and supply of) fossil fuel products responds to changes in prices. The range of impacts could vary between two extremes: at one end of the spectrum, there could be no demand response at all; in this case there would be additional government revenues from the instrument, on top of revenues from existing fiscal measures. At the extreme, the quantity of fossil fuel consumption could fall to zero – in which case total revenues from all taxes and other fiscal measures would also drop to zero. In neither of the two extremes would government revenues fall below zero. We discuss the different possibilities in more detail in section 4.4 below.

3.4.2. Existing policies for GHG emissions

As noted above, 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 CO₂ intensities of different fuels.⁴⁷ In addition, across the EU, the EU Emission Trading System (ETS) has been established to create a price for CO₂ (and other GHG emissions) that is intended to force emitters to internalise the emissions externality.⁴⁸ Many Member States have additional policies that set a price on carbon emissions. 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.

Under emissions trading systems like the EU ETS, the allocation of emission rights also has implications for the amount of government revenue that is raised from the policy. To date, under the EU ETS the majority of emissions allowances have been allocated for free to operators of installations that emit GHGs⁴⁹ – although in some countries certain sectors (notably the power sector) were required to purchase a significant proportion of allowances from the government.

Emitters who have the obligation to surrender allowances face a liability that is created as a result of government policy. The cost of this liability is determined by the value of emissions allowances. If allowances are allocated for free to emitters, the cost of the emissions liability is defrayed by the value of the allowances that are given freely.

In contrast, if allowances must be bought by emitters from the government, the amount paid is a direct transfer to the government, similar to a tax on carbon. By extension, if allowances

⁴⁷ European Commission (2011), Citizen’s Summary: EU Energy Taxation Proposal

⁴⁸ 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,

⁴⁹ Just under 94 per cent of total allowances between 2008 and 2012 were freely allocated.

were allocated entirely to non-emitters, or to individuals,⁵⁰ the obligation to surrender allowances would amount to a government-mandated transfer from operators with emissions to those who had freely received the allowances.⁵¹

Following this logic, the free allocation (and subsequent trading) of allowances effectively results in mandated transfers from emitters *to other emitters*. This has distributional impacts among emitters, depending on who was best able to abate (whether through technology, through reduced economic activity, or through fuel switching). However, the net value of these mandated transfers across all emitters is, by construction, zero. In cases where the distributional impact of trading led to a particular energy source becoming a net recipient of mandated transfers from another energy source, our methodology would identify this as a mandated transfer from one energy source to another.⁵²

There is a separate question concerning *who should bear responsibility* for the cost of the externality. This question is related to the question of how allowances *should* be allocated, because allocation can be seen as implicit acknowledgment of either the right to be compensated for accepting emissions or the right to emit. The question of how allowances should be allocated is ultimately a normative question whose answer is best addressed through political negotiation, political economy, and political philosophy, rather than economic analysis. Just as there is no objective answer to the question “What is the correct level at which to set the VAT rate on energy consumption?”, or “What is the right level of corporation tax on upstream production?”, there is also no objective answer to the question “What is the correct allocation of emissions allowances?” We consider it outside the scope of our study to attempt to answer this question.⁵³

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 3.4.1. We discuss the relationship of the two quantities –

⁵⁰ For example, as they would be under proposals to implement so-called “personal carbon allowances”.

⁵¹ This has parallels with support schemes for renewable energy sources, where an obligation is placed on others that imposes a cost on them and results in monetary transfers to renewables. For the reasons set out in section 3.3.3 above, we have not attempted to estimate how these costs are distributed across different groups or to reflect these costs in our analysis.

⁵² Note that in keeping with the restrictions to scope that we apply to other areas of our analysis, we have not attempted to account for the wider market impacts of the EU ETS – just as we have not attempted to account for the impacts of RES support policies on market prices or residual demand for non-RES sources.

⁵³ In the case of the EU ETS, the free allocation of allowances is part of a broader policy framework for addressing GHG emissions. The policy framework is wide-ranging in scope, with features such as: inclusion of only a sub-set of sectors and emitting facilities; gradual reduction over time in the overall cap on emissions; provisions to gradually change the way in which allowances are allocated to those sectors that are included within the scheme; and exemptions from provisions for the auctioning of allowances for sectors with specified characteristics. This policy framework reflects a number of considerations, and it is clear that alternative policy frameworks could have been adopted (for example, expanding or reducing the scope of sectors included, changing how the cap on emissions is adjusted, using alternative approaches to the allocation of allowances, etc.).

If one’s “benchmark” is that all allowances should be auctioned, then free allocation of allowances to emitters will appear to be “foregone revenue” – and therefore a form of support. If, on the other hand, one’s benchmark is that emission rights should be grandfathered, or that there should be a period of gradual adjustment starting from full grandfathering to full auctioning, then the approach taken under the EU ETS during Phases 1 and 2 will not imply that any revenue has been “forgone”.

the 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.

Appendix B describes in detail the data sources we have relied upon to develop our estimates. 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.

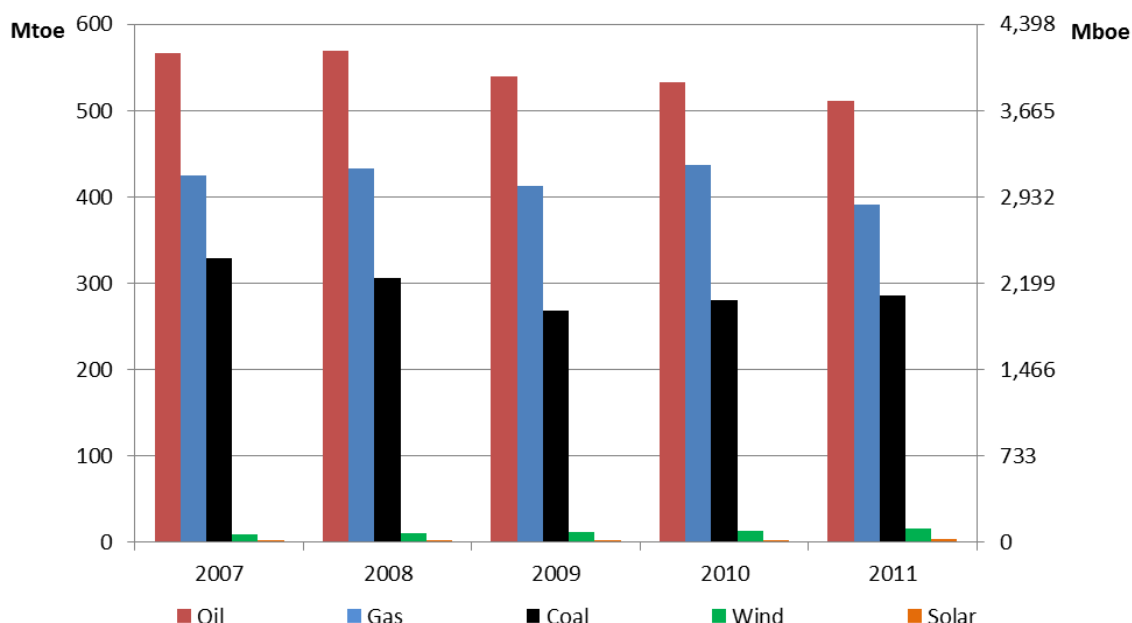
4. Results of NERA's Analysis

In this section we provide the main results of our 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 2011 data.

Our estimates show the value of transfers associated with different energy sources in recent years, which reflect the policies that have been in force during this period in individual EU countries and Norway. The results therefore reflect what has happened historically, and naturally cannot be used to make projections about net transfers under other policies. All the results presented in this report are nominal values, generally in millions or billions of Euros.

Our analysis compares different energy sources, so it is important to note that they vary significantly in their contributions to final energy consumption across the EU and Norway. This is also reflected in the magnitude of the transfers we have identified. To put some of 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 - 2011)



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.⁵⁴

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. For example, as noted above (section 3.3.3) in the case of mandated transfers, the incidence of the transfer (i.e. the groups that bear the costs of payments mandated by government policy), is often spread across several groups. For example, costs of FITs are borne by other energy companies, who pay the associated levies, as well as by final consumers. The costs borne by non-RES energy companies by FITs and other renewable support policies are mandated transfers that the government imposes on those obliged to pay for the RES sources. These costs manifest

⁵⁴ BP Statistical Review.

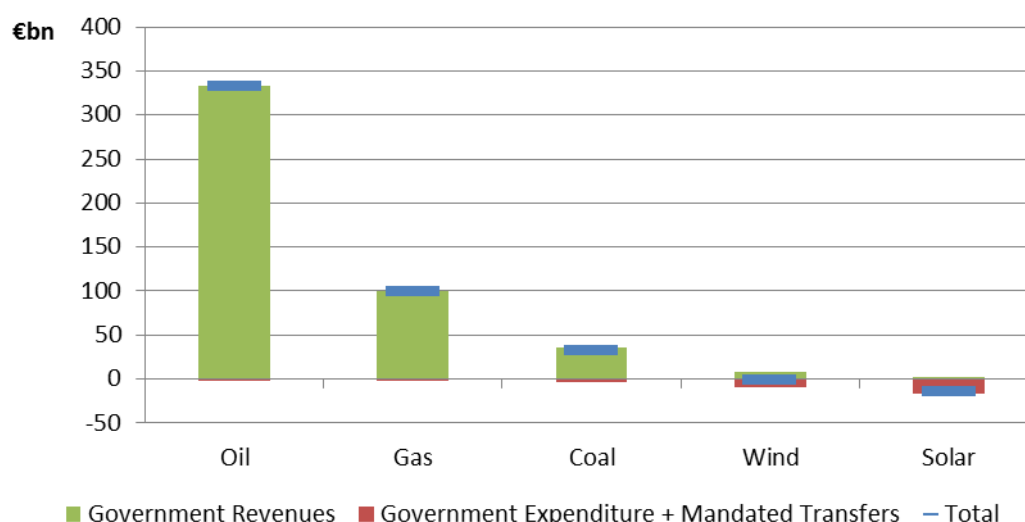
themselves in at least three ways – first, as direct costs in the form of allocation of responsibility to pay into the funds that remunerate RES generators (or in the case of RECs, the costs associated with procuring RECs). Second, the addition of RES supply to the system results in the displacement of generation by other capacity, which may reduce the profitability of this capacity. Third, and related, the addition of RES supply may affect the price of electricity in the market, making generation from other sources unviable. 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.

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 2011, we calculate that governments from the EU and Norway collected just under €480 billion in revenues from activities directly related to the combined production and consumption of oil, gas, coal, wind and solar energy. Total government expenditure plus mandated transfers to the five energy sources in 2011 was significantly less, at approximately €30 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 lines 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.

Figure 4.2
EU28 + Norway Net Government Revenues and Mandated Transfers (2011)



Source: NERA Analysis (all data sources discussed in Appendix B)

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

Table 4.1
EU28 + Norway Net Government Revenues and Mandated Transfers (2011)

	Government Revenues	Government Expenditures and Mandated Transfers	Total	Primary Energy Consumption
Source	€ billion	€ billion	€ billion	Mtoe
Oil	333	-0.2	332	511
Gas	100	-0.4	100	390
Coal	36	-4	33	286
Wind	8	-9	-1	16
Solar	2	-17	-15	4

Source: NERA Analysis (all data sources discussed in Appendix B)

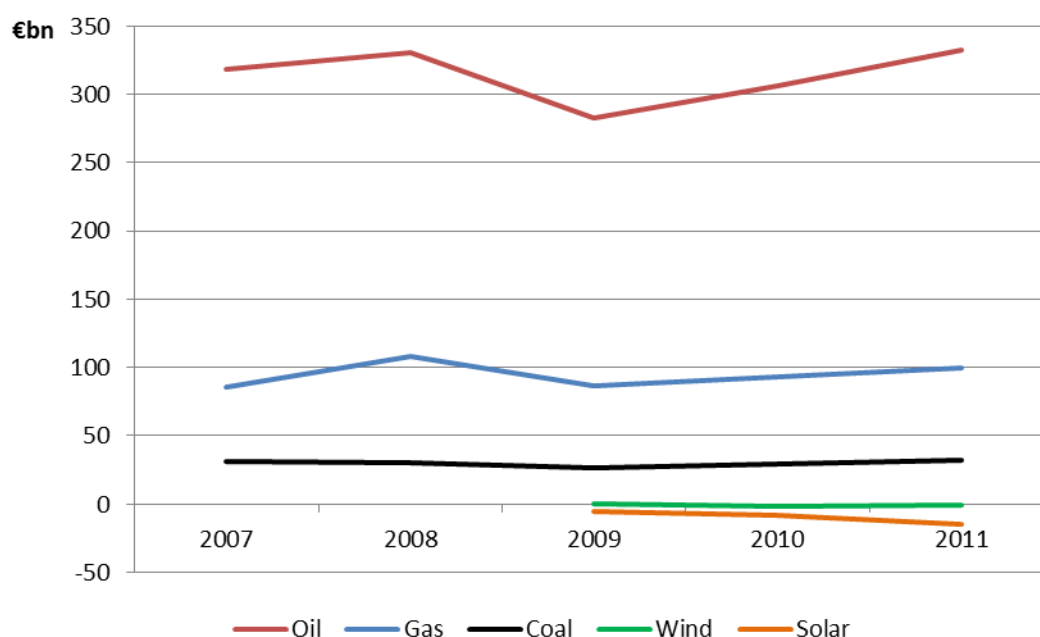
Across the different fuels, the majority of revenues are derived from oil, followed by gas.⁵⁵ Significant, but smaller revenues are allocated to coal, and relatively negligible amounts

⁵⁵ 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. Across the whole region gas production is marginally higher than oil production, but oil prices per unit of energy have tended to be higher than gas prices. Therefore, on this basis oil is allocated a higher proportion of the total revenues paid to government by upstream oil and gas activities. 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.

assigned to both the wind and solar sectors. Turning to expenditures and mandated transfers, the most significant support is focused on the solar sector (€17 billion), with smaller amounts paid out to wind (€9 billion) and even less to coal (€4 billion), gas (€0.4 billion) and oil (€0.2 billion). It is also apparent that, at least in the fossil fuel sectors, and overall, government revenues dwarf government expenditure across these fuels. 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 study we have focused on data covering the period 2007 to 2011. To prevent excessive duplication, we present the majority of our results for 2011. Whilst there is a degree of variation across years, particularly at the country level, this is fairly minor in the context of overall total values. The results for 2011 are therefore representative of the full period. 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 lines shown above in Figure 4.2.

Figure 4.3
EU28 + Norway Net Government Revenues and Mandated Transfers
(2007 - 2011)



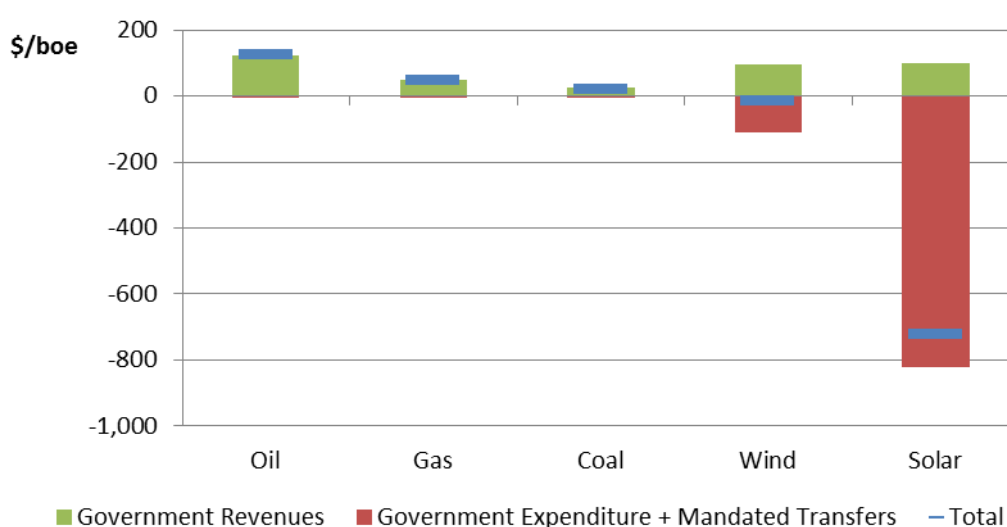
Note: Renewable support data are not available for 2007 and 2008, so we omit estimates of net values for these years.

The figure shows that there is little variation in net government revenues over time. The most pronounced change is the drop in net revenues between 2008 and 2009, principally due to lower oil and gas revenues. Although small in the context of overall quantities, transfers directed to solar energy have been increasing relatively quickly, due to the rapid deployment of solar power, which receives assistance from government support schemes. Indeed since 2011, support for solar and wind power has continued to increase significantly. In this study

we report data up until 2011 as this is the latest year over which comprehensive data exists across the majority of countries in the EU and Norway.⁵⁶

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.⁵⁷ Wind and solar consumption 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)
(2011)



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) across the different energy categories are broadly similar for oil (\$124 per boe), wind (\$95 per boe) and solar (\$100 per boe). Government revenues are around half of these values for gas (\$49 per boe), and considerably lower for coal (\$24 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,

⁵⁶ 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 and is expected to further increase dramatically in 2014 (BDEW. Erneuerbare Energien und das EEG: Zahlen, Fakten, Grafiken. 24 February 2014).

⁵⁷ 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.

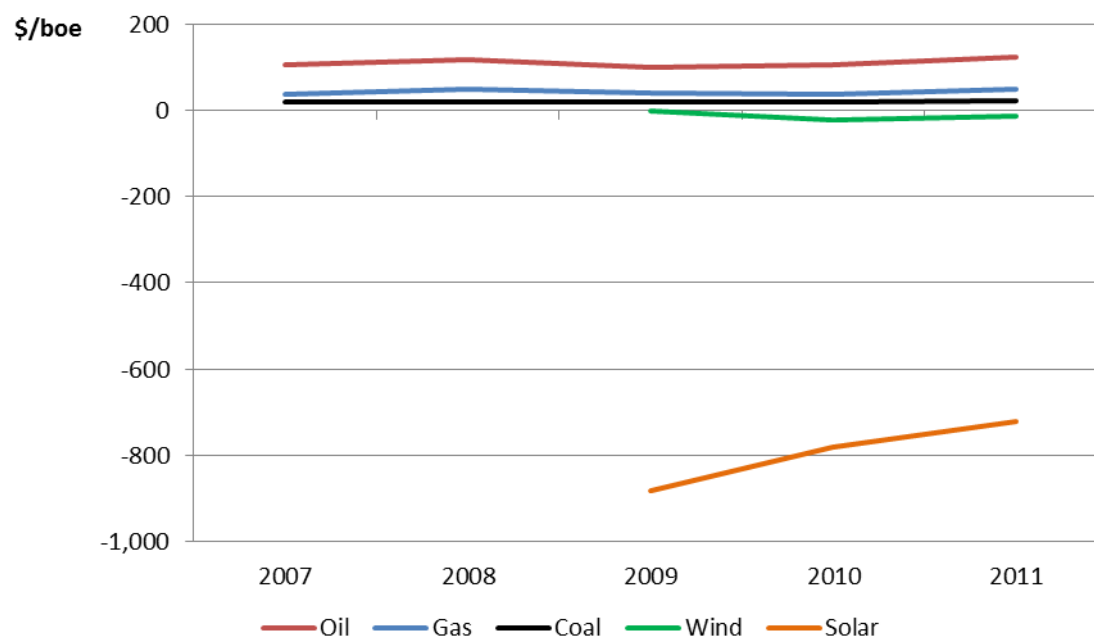
the relative efficiencies of the energy sources within those uses. Hence, coal revenues are particularly low because a significant share of coal consumption is used to generate electricity (over 80 percent), and the efficiency of conversion of coal into electricity is relatively low, at 30-40 percent. 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. The choice of primary energy as the denominator in this illustration is therefore purely for convenience, to allow a simple comparison of the energy sources in relative terms. There are other comparisons that could be made.

Government expenditures remain negligible for the fossil fuels. For wind and solar power, government expenditures and mandated transfers are considerable. However, we observe a distinct difference between government support for wind energy (\$109 per boe) and for solar energy (\$821 per boe) in 2011. This difference reflects the higher costs of solar power generation, compared to wind (which in many European countries has 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).⁵⁸

Figure 4.5 presents similar information, showing the net transfers (blue lines in Figure 4.4) covering the full period from 2007 to 2011. Like Figure 4.3, it shows relatively consistent results across years. (Note that because we do not have access to a comprehensive EU-wide source of RES support data for 2007 and 2008 we do not present any results for wind and solar for these two years.) For the years over which we do have renewable support data it is worth noting that solar support, which is increasing over time on an *absolute* basis (see Figure 4.3 above), is decreasing when measured in terms of energy consumed. This is because governments are supporting increasing amounts of solar capacity, but the costs of generating each unit of solar power are falling.

⁵⁸ 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. The most recent support costs for solar PV are significantly lower than \$821/boe (or approximately €350/MWh). For example, support for new large scale solar PV in the UK is currently less than €150/MWh, and support in Germany has fallen as low as €137/MWh for new developments at the time of writing. However, the legacy support levels are still relevant as they are paid each year over the lifetime of support mechanism, and even at current levels, support for solar (per unit of output) is still high relative to other renewable technologies.

Figure 4.5
EU28 + Norway Net Government Revenues and Mandated Transfers (\$/boe)
(2007 - 2011)



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.

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. A more detailed description of the various items, as well as further information on our approach to quantifying them and the data sources we have drawn on is included in Appendix B.

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:

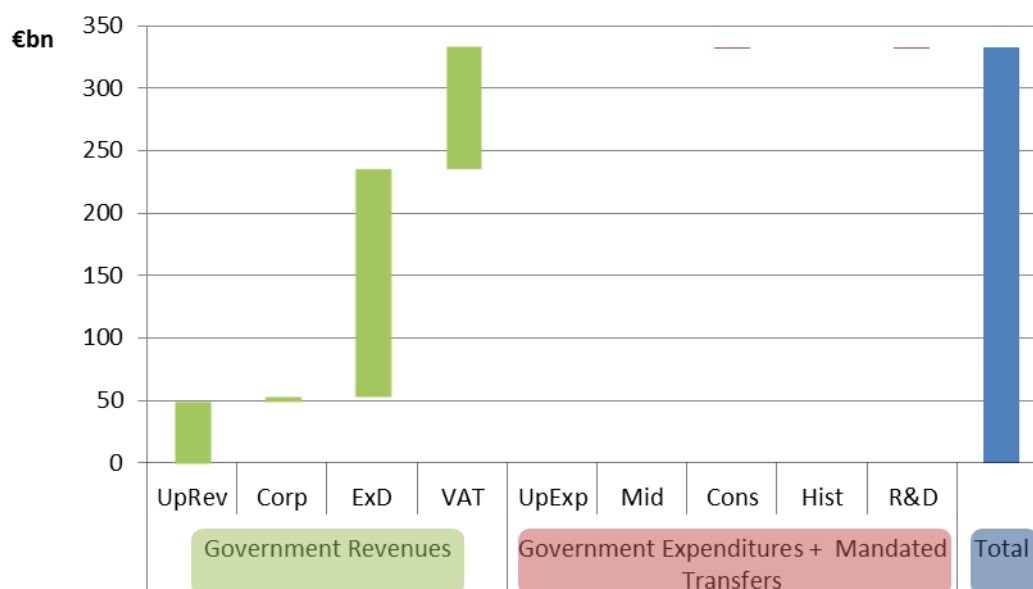
5. **Upstream government expenditures (UpExp):** Payments made to support current production of energy resources;
6. **Electricity generation, energy transport and storage support (Mid):** Transfers supporting “midstream” activities, including energy transformation and power generation (notably RES support mechanisms), as well as fuel storage and transport;
7. **Consumption support (Cons):** Payments (often made to low-income 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 (2011)



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 2011 were €333 billion, as shown by the blue bar on the right hand side of Figure 4.6. Upstream tax revenues from oil production amounted to €49 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 (€182)⁵⁹, followed by VAT receipts from their sale to final consumers. These two items combined provided almost €279 billion to governments across the EU and Norway in 2011. Government expenditure on oil is negligible (The chart reflects minor support in France to consumers in the form of subsidies to rural filling stations, as well as a small amount of R&D spending by governments.)

4.2.2. Gas

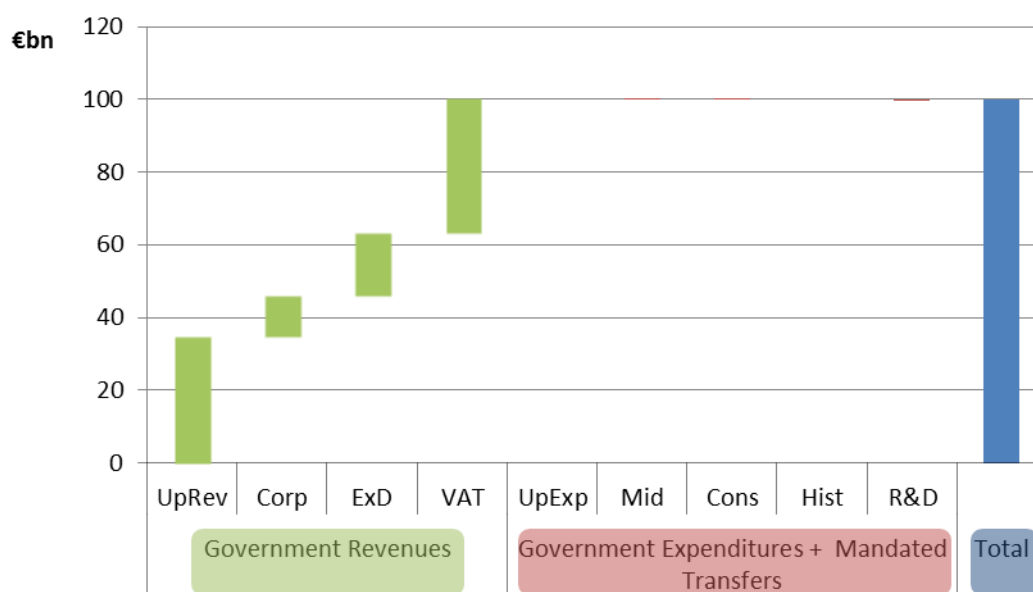
Gas provides the second largest contribution to government revenues of the energy sources reviewed. Net revenues in 2011 were €100 billion, which is a third of what we calculate for oil. In contrast to oil, significantly less excise duty is levied on direct sales of gas (and on electricity generated using gas as an input fuel, which we allocate to the fuel). VAT on gas and on electricity sales⁶⁰ from gas-fired generation sales (€37 billion) is the largest single

⁵⁹ Demand for transport fuels tends to be relatively insensitive to price, so excise duties provide a significant source of stable revenue to governments.

⁶⁰ 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. A more detailed description of our approach is provided in Appendix B.

contributor, followed by upstream tax revenues, at almost €35 billion.⁶¹ The majority of the corporation tax revenue estimate is derived from gas retail and distribution as well as power generation.⁶²

Figure 4.7
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Gas (2011)



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 (gas combined heat and power generation receives FIT payments in Estonia), 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.

4.2.3. Coal

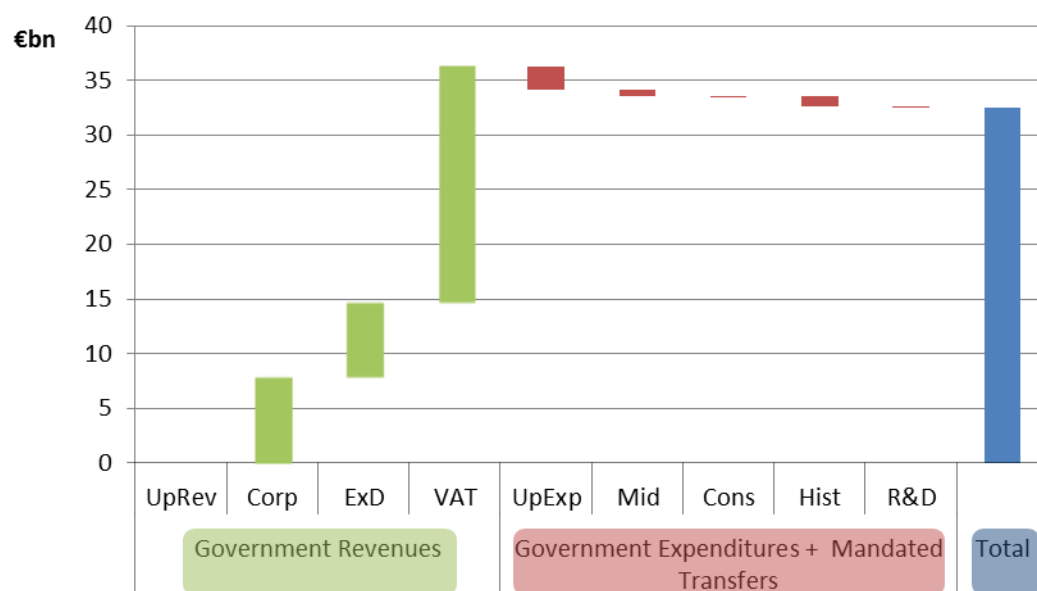
The coal sector provides revenues to government of approximately €36 billion, driven mainly by VAT receipts both on coal itself and on power generated using coal as an input. Net revenues from coal are considerably lower than those for oil and gas, at €33 billion. The bars

⁶¹ 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.

⁶² 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.

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 (2011)



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

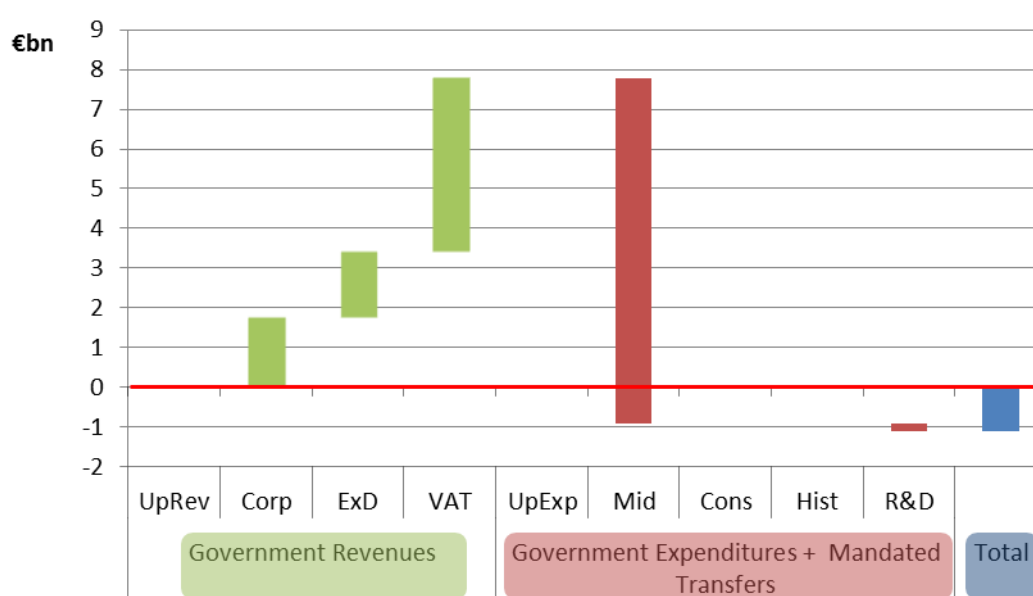
Excise duties on coal are fairly limited. Of the €7 billion shown here, €0.6 billion are from sales of coal itself, and the remainder is what we attribute to the electricity sales from power generated from coal.⁶³ Corporation taxes, estimated at approximately €8 billion, are principally from coal's contribution 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 (most notably in Poland) 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 2011 was slightly less than €4 billion. This is relatively small alongside government revenues, but considerably higher than support provided to other conventional, fossil fuel energy sources.

⁶³ 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.⁶⁴ Net transfers from wind (government revenues minus government expenditures and mandated transfers) were slightly negative in 2011, at around negative €1 billion. This is shown below in Figure 4.9. Total revenues (before expenditures and other transfers) were almost €8 billion. Estimated corporation tax receipts, excise duties, and VAT (the largest contributor, at over €4 billion) are all based on wind's share of total electricity output across the EU and Norway.⁶⁵

Figure 4.9
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Wind (2011)



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.⁶⁶ The reported support is based on data collected by the Council of European Energy Regulators from a

⁶⁴ Solar technologies are also used to produce useful heat. We have not attempted to quantify the contribution of solar thermal energy to government revenues.

⁶⁵ 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, although over the period we consider (2007-2011) offshore wind output in Europe was relatively minor in the context of total wind output.

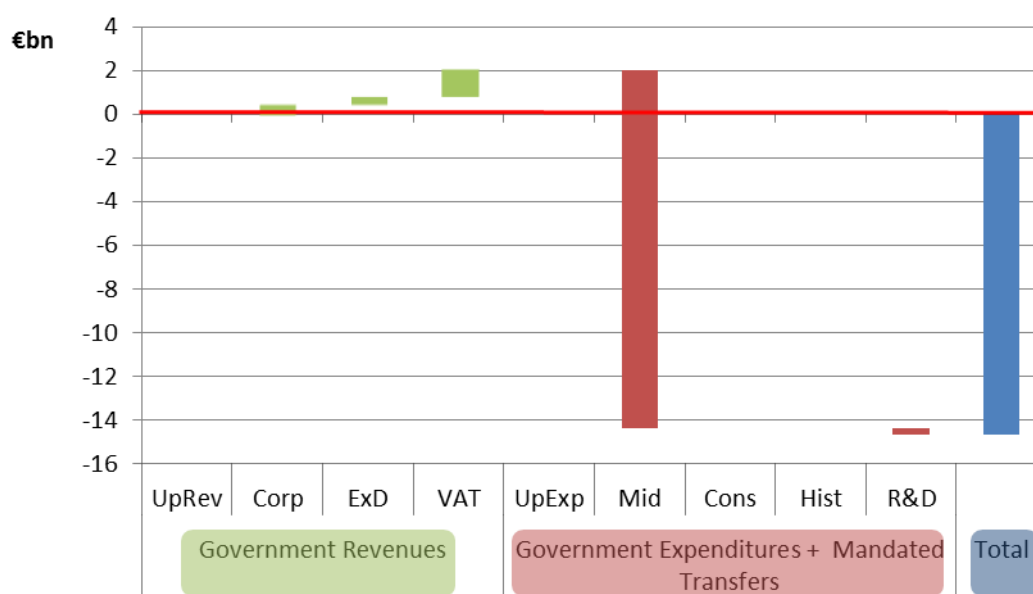
⁶⁶ In certain locations, and dependent on conditions, wind farms can be cost-competitive with more conventional thermal power generation, but overall still require support, particularly in the growing offshore wind sector.

large sample of European countries. The total estimate for wind of almost €9 billion in 2011 reflects the additional support provided for output above the level of the wholesale price.⁶⁷ Government spending on R&D in the wind sector of almost €0.2 billion is also included.

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 2011 for solar were highly negative, at almost –€15 billion.

Figure 4.10
EU28 + Norway Government Revenues, Expenditures, and Mandated Transfers: Solar (2011)



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.

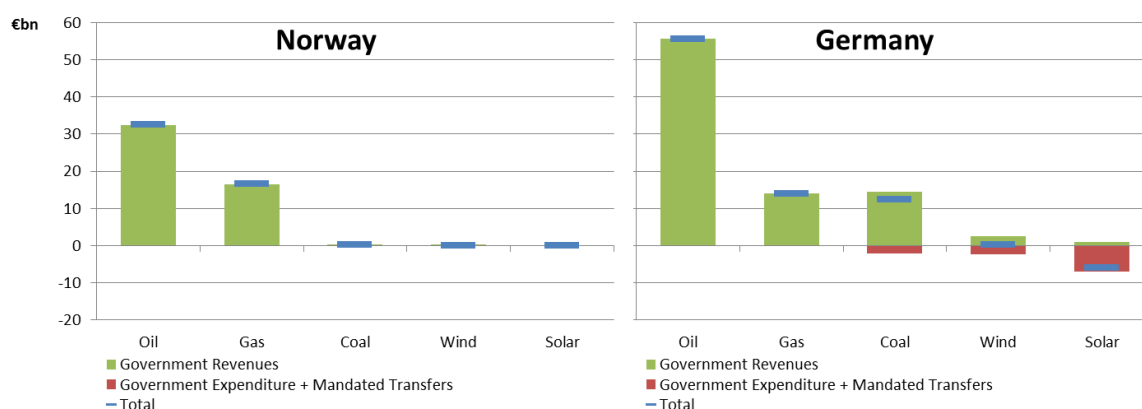
We estimate that €2 billion was collected by European governments in revenue from corporation tax, excise duties and VAT related to the electricity generated by solar. On the other hand, government support, either via direct payments or through policies obliging others to fund solar capacity and output, was in excess of €16 billion. Total support for solar has risen over the three years for which we have pan-European renewable support data, from €6 billion in 2009, to €8 billion in 2010, and then doubling in 2011. This is due to increasing roll out of solar capacity rather than increasing costs, as discussed above in section 4.1 (and shown in Figure 4.5).

⁶⁷ 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. Further detail on the data source and our approach is included in Appendix B.

4.3. Differences among Individual Countries

Norway is a relatively small economy when set against the rest of Europe, but it has a disproportionately large oil and gas sector. In Figure 4.11 below we present the headline results for Norway, alongside those of Germany – a much larger economy, but with significantly lower oil and gas production. As expected, revenues from the oil and gas sectors dominate all other transfers in Norway. Total government revenues in Norway across these two sectors were €49 billion in 2011. However, despite Norway's leading position in oil and gas production, and the high tax revenues that they provide, combined government revenues from oil and gas are actually significantly higher in Germany (at €70 billion in 2011). This is because revenues from oil and gas *consumption* (derived from excise duty and, to a lesser extent, VAT receipts) contribute a significant amount to government revenues in Germany.

Figure 4.11
Comparison of Norway and Germany Net Government Revenues (2011)



We can conclude from this analysis that although Norway's oil and gas revenues contribute materially to the overall revenues from oil and gas – and from energy generally – in the 29-country bloc that we analyse, the main conclusions that we draw would not be significantly different if we were to exclude Norway and focus only on the EU-28.

4.4. Externalities

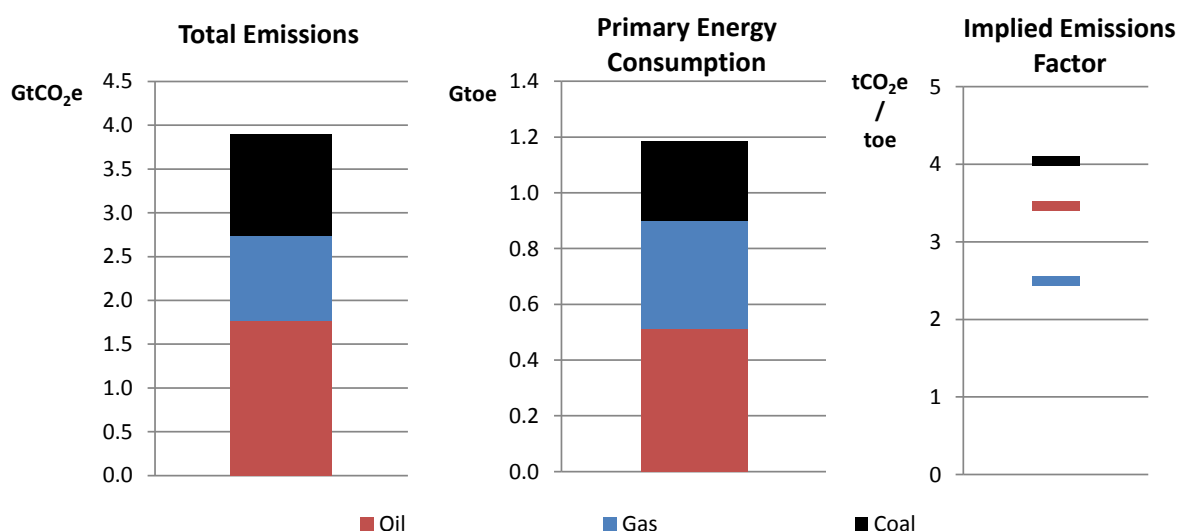
This section presents estimates of the cost of the greenhouse gas emissions externality associated with the use of different fossil fuel based energy sources. This cost differs in important ways from the categories presented in the preceding sections. The cost does not reflect any direct transfers between 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 4.12 shows total GHG emissions in the EU28 + Norway that can be attributed to the three major fossil fuel energy sources from 2007 to 2011.⁶⁸ Among

⁶⁸ The figure therefore excludes emissions from some sources – for example, industrial process emissions or non-combustion emissions from agriculture.

anthropogenic GHGs, carbon dioxide (CO₂) is by far the most abundant, as it is a by-product of the combustion of hydrocarbons. In addition, other GHGs are also produced – for example, methane. The figure includes – for the sub-set of emissions covered – all the greenhouse gases recorded by the UNFCCC expressed in carbon dioxide equivalents (CO₂e). To put the total emissions in context, the middle bar in Figure 4.12 shows the primary energy consumption of the different fossil fuels in the EU28 and Norway and the right hand chart indicates the implied emissions factors of the different fuels (calculated by dividing total emissions by primary energy consumption).

Figure 4.12
GHG Emissions in the EU28 + Norway, 2007 - 2011



Source: NERA analysis of UNFCCC data

Note: The figure shows the total emissions associated with each fuel, based on the volume of each fuel consumed. Estimates include fugitive emissions. 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.

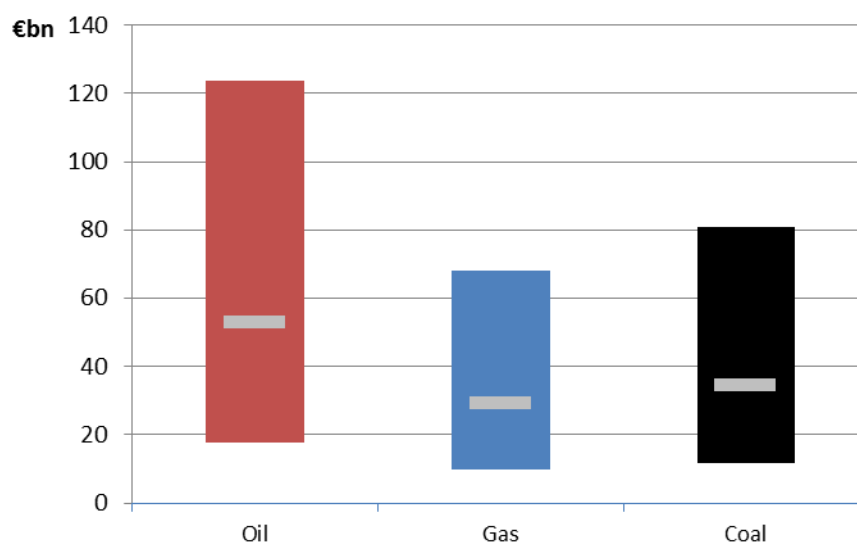
Total emissions have declined from 4.3 billion tonnes of CO₂e (GtCO₂e) to 3.9 GtCO₂e over the period shown. The shares of emissions attributable to individual energy sources have remained fairly stable over the period, with shares over the period as a whole of 46 percent for oil, 25 percent for gas, and 29 percent for coal.

As discussed in Appendix C, 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 CO₂.⁶⁹ To reflect the uncertainty about its true value, we have used low, medium and high estimates of €10, 30 and 70 /tCO₂e for the shadow price of carbon. These values lie within the range that

⁶⁹ Carbon cost estimates are primarily based on two approaches: estimating the damage caused by emissions; or estimating the cost of abatement technology that reduces the level of emissions, for the same level of production. Further detail is provided in Appendix C.

most sources regard as most likely, although the full range of values available is much wider than this. Figure 4.13 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/tCO₂e. At this shadow price, the externality costs would be €53 billion for oil, €29 billion for gas, and €35 billion for coal.

Figure 4.13
GHG Externality Costs - Low, Medium, and High



Source: UNFCCC, NERA analysis of literature as explained in Appendix C

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 markets with inelastic demand, the cost would simply be passed through to consumers. The net contribution to government revenues of each of the energy sources via all of the other fiscal measures and policies *would remain unchanged*, and there would be *additional* government revenues. These revenues, which by assumption would have been set at a level that reflected the carbon externality, would offset exactly the (social) costs imposed by the carbon emissions. Ultimately, these costs would be borne by consumers.
- If instead, demand *did* respond to prices (because of substitution to lower-carbon goods, services, and intermediates), the instrument would affect quantities of consumption and production, as well as prices, which would have further implications for the values of the government transfers associated with each of the energy sources. The net contribution of each energy source would therefore change in ways that cannot be known *a priori*. In this case, as above, the total revenues from the instrument would reflect the damage associated with the carbon externality, but the level of emissions would differ, and because sales volumes and profits would change, the costs would be *shared* among consumers, producers, and the wider economy and government.

- In the extreme case that the imposition of the externality cost resulted in fuel prices that were so high that the quantity demanded fell to zero, the net contribution of fossil fuels to government revenues would also be zero.

Thus, one should not simply “net off” the externality costs shown in Figure 4.13 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 2011. 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 (€333 billion in 2011). 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 half of oil (€100 billion) and coal revenues are lower still (€36 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 (almost €4 billion in 2011), 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 2011 wind power received €9 billion of support and solar almost €17 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 2011

	Oil	Gas	Coal	Wind	Solar
Categories of Government Revenue	<i>EUR Billions</i>				
Upstream Taxes (incl. upstream corporation tax)	49.0	34.5	-	-	-
Corporation Tax (midstream and downstream)	4.2	11.4	7.9	1.8	0.5
<i>Power Generation</i>	0.3	4.4	4.4	1.0	0.3
<i>Power Transmission and Distribution</i>	0.1	1.6	1.7	0.4	0.1
<i>Electricity Retail</i>	0.1	1.5	1.7	0.4	0.1
<i>Gas Retail and Distribution</i>	-	3.8	-	-	-
<i>Coal Supply (excl. Power Generation use)</i>	-	-	0.1	-	-
<i>Crude Refining</i>	0.8	-	-	-	-
<i>Gasoline and Diesel Retail</i>	2.9	-	-	-	-
Excise Duties and Other Energy Taxes	181.9	17.4	6.8	1.7	0.4
VAT	97.5	36.9	21.6	4.4	1.2
Subtotal (government revenues)	332.6	100.2	36.3	7.8	2.0
Categories of Government Expenditure and Mandated Transfers					
Resource Extraction Support	-	-	2.1	-	-
Electricity Generation, Energy Transport and Storage Support	-	0.0	0.7	8.7	16.4
<i>RES Power Generation</i>	-	-	-	8.7	16.4
<i>Other</i>	-	0.0	0.7	-	-
Consumption Support	0.1	0.2	0.0	-	-
Historic Liability Transfers	-	-	0.9	-	-
R&D Transfers	0.1	0.1	0.1	0.2	0.3
Subtotal (government expenditures and mandated transfers)	0.2	0.4	3.8	8.9	16.7
Net Government Revenues and Mandated Transfers	332.3	99.8	32.5	-1.1	-14.7

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 €480 billion in revenues were collected by EU28+Norway governments in 2011 from the five energy sources.** Of this, close to 70 percent, or just over €330 billion, came from the oil sector. Gas contributed around one fifth of the revenue, or almost €100 billion. Coal accounted for around €36 billion in revenue, but also received transfers on the order of €4 billion. We estimate that wind contributed around €8 billion in government revenue, but received transfers amounting to around €9 billion, implying total net payments to the sector of €1 billion. Finally, we estimate that in 2011 solar power contributed around €2 billion to government revenues, but received transfers totalling close to €17 billion.
- **Duties on motor vehicle fuels account for the largest single source of government revenue from energy, ahead of VAT.** Duties on these fuels yielded over €180 billion in 2011, and accounted for approximately 84 percent of all excise duty 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 €83 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 – far above the average EU corporation tax of 23 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.
- The cost of the GHG externality is of a different nature to actual transfers (either direct transfers to or from governments, or those mandated by government policies). It is borne by society as a whole, rather than by governments. Moreover, there is uncertainty surrounding the magnitude of such costs. If such costs were “internalised” through some government policy, then the impact on net government revenues would be uncertain. We therefore advise against a simple comparison of the cost of the externality with net government revenues.

Appendix A. Case Study of Tax Regime Applying to the Upstream Oil and Gas Sector in the United Kingdom

A.1. Introduction

We include a case study of the fiscal regime applied to the UK to illustrate the overall tax burden and the complex nature of upstream oil and gas taxation. The discussion of the UK's fiscal regime highlights how it has changed on several occasions to reflect developments in markets, government policy, and the changing nature of the UK's oil and gas resource itself. Our intention in this section is not to provide a detailed analysis of the effectiveness of different policy measures. The UK experience underlines the need to understand a system of taxes within the broader context of government policy objectives, the nature of the underlying resources (e.g. technical challenges of extraction and its corresponding costs), and interaction with other parts of the taxation regime.

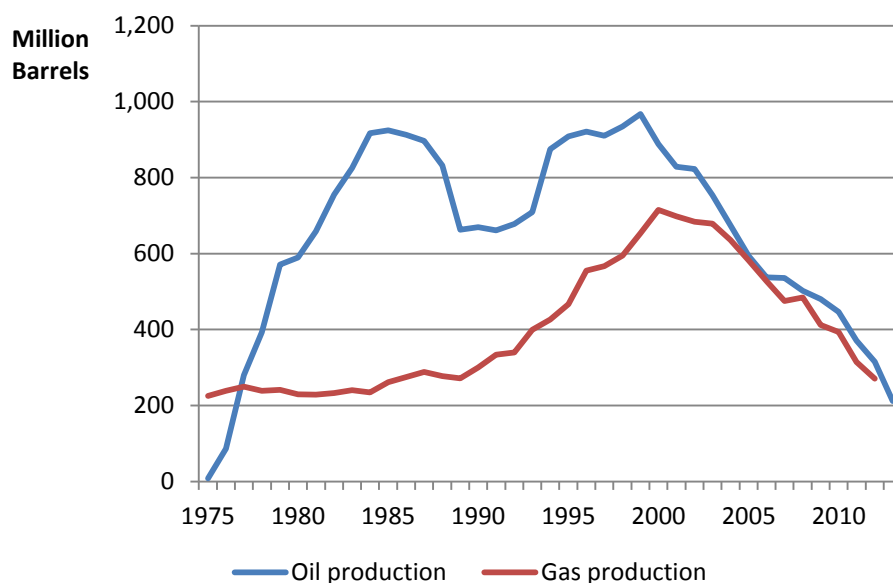
Exploration and production decisions are influenced by a range of key factors. These include the prevailing market price for oil and gas, the tax burden, technology, and costs. The degree of political uncertainty about control over the resource as well as the design of the fiscal system also affects production decisions. Energy companies must invest significant up-front capital in order to both explore and test the feasibility of a site as well as to set up the necessary extraction equipment and supporting infrastructure.

In the analysis of any fiscal system, it is often complicated to isolate the specific effect that changes to the regime may have had on either production or government revenues. In the UK, over the period we review, there have been significant variations in oil and gas prices as well as changing technological requirements and costs. However, it is clear that the government has modified its policies based in part on an appreciation that taxation can affect the economic viability of certain projects. The objective of changes has also been to try to capture a greater share of the profits made available through particularly high oil prices since the turn of the decade, while also providing incentives to extract resources in cases where extraction is more complex.⁷⁰

Over the past thirty years, the UK offshore continental shelf (UKCS) has been one of Europe's main sources of oil and gas. Oil and gas production in the UK, however, has been declining since the turn of the century – production of oil and gas peaked in 1999 and 2000 respectively, and has since declined steadily. UK oil and gas production are shown separately in Figure A.1).

⁷⁰ The government recently commissioned a review of UK offshore oil and gas recovery and its regulation. This review, known as the Wood Review, highlights the government's policy to provide incentives for extraction of the resource and sets out various strategic and regulatory proposals. We have not considered the content of the Wood Review in detail, as it was published after the drafting of this report.

Figure A.1
UK Oil and Gas Production (1975-2013)



Source: DECC Oil and gas: field data; BP Statistical Review

Oil production began to pick up in the 1970s and early 1980s before a brief decline in the second half of the decade (due in part to an explosion on a large oil and gas platform).⁷¹ Output then steadily increased through the 1990s, peaking in 1999, and has since been falling year-on-year as the resources of the large, older fields are depleted and new developments tend to be smaller, more complex, and therefore more costly to extract from. The evolution of gas production has followed a similar trend since 1990, although previously gas production remained relatively constant even in periods when oil production grew rapidly. Both energy sources have been subject to the same general taxation regime in the UK throughout the period we review.

A.2. Taxation Mechanisms

Sub-surface resources in the UK are the property of the Crown. The UK government, acting on behalf of the Crown, has therefore sought to earn a 'fair' return from the extraction and sale of oil and gas products by allocating production licences to private companies and recovering value for the government via different fiscal instruments. The UK operates a concessionary regime whereby the Crown transfers its ownership of the land to companies that are then allowed to extract and sell the resource. This is distinct from a contractual regime in which the state retains ownership and contracts a third party company to extract the resource on its behalf.

Because licensees are granted the right to make use of a state-owned resource, and due to the significant profits (i.e. economic rents) that can be earned from oil and gas production, the

⁷¹ A serious explosion in 1988 halted production on the Piper Alpha platform, which until then had accounted for approximately 10 percent of oil and gas production on the UK Continental Shelf.

sector has been subject to a specific taxation regime since the 1970s, which is distinct from other businesses. The main components of this regime have changed over time and are described in detail below. They include (or have included) the charging of a royalty, a Petroleum Revenue Tax (PRT), a ring fence corporation tax (RFCT), and an additional Supplementary Charge (SC), which has been added to corporation tax since 2002.

A.2.1. Royalties

Initially royalties were one of the core components of the petroleum taxation regime in the UK. Licenced extraction companies were required to pay 12.5 percent of the gross value of oil and gas produced, less the cost of transporting and storing the fuels at an onshore terminal. This measure directly taxed the value of the resource as it was removed from the ground, regardless of cost (and therefore irrespective of the economic viability of the project) and hence acts as an increase in operational expenditures.

Fields receiving development consent after March 1982 were no longer required to pay royalty charges. At the same time, the Government introduced an increase in PRT (see section A.2.2 below), to make the regime more profit-based, rather than revenue based. From 1 January 2003, royalties ceased to be collected on all fields.

A.2.2. Petroleum Revenue Tax (PRT)

PRT is a tax on net revenues (or *profits*) from individual production fields, rather than companies. Losses from one field cannot be used to offset the taxes due on a profitable field, as would be the case when standard corporation tax is applied to an individual company's assets. PRT was introduced in the 1975 Oil Taxation Act as a tax applied to oil and gas extraction alongside royalties and standard corporation tax. It was the main source of government revenue from oil and gas production through most of the second half of the 1970s and the 1980s – periods in which oil prices were typically high (although not throughout the period). PRT is calculated in half-yearly periods.

PRT was designed to apply to particularly large oil fields (such as Brent and Forties) that were established when it was introduced. The initial headline tax rate was set at 45 percent of a field's profits. The rate was increased in 1978 to 60 percent and then again in 1982 (when royalties no longer applied to new fields) to 75 percent. PRT is applied to profits after any royalty payable but prior to corporation tax which then applies to the remaining, post-PRT, amount. For example, a company in 1980 making annual pre-tax profits of £100 would have been required to pay £60 in PRT. The company would then pay corporation tax (at 52 percent) on the remaining £40, rather than on the full pre-tax profit of £100. The full tax burden from PRT and corporation tax in this case would be £80.80.⁷² In order to limit its impact on smaller (and more expensive) fields the PRT included three main allowances:

- **Uplift** – companies can offset an additional allowance of 35 percent of their capital expenditures against profit, on top of the actual capital expenditure. This is in lieu of

⁷² This is a simplified example and assumes that the company has no loss-making fields. PRT is a field- (and company-) specific tax and losses in one field that a company operates cannot be offset against profits in another field.

deduction of interest charges (which are specifically not allowed to be deducted for PRT purposes);

- **Oil Allowance** – exempted up to one million tonnes of oil a year from PRT and up to 10 million tonnes over the lifetime of a field (to shelter smaller, marginally economic fields from PRT);⁷³
- **Safeguard** – provides a safety net to less profitable fields, limiting the PRT liability of a field in order to ensure a post-tax return on capital of at least 15 percent.⁷⁴

As oil production began to fall from the late 1980s, the government responded by eliminating PRT on new fields that received development consent from 1993. Existing (pre-1993) fields continued to pay PRT, although at a reduced rate of 50 percent. At the same time as the rate of PRT was reduced, a special relief for exploration and appraisal costs was also abolished. PRT remains a significant source of government revenue from oil production today even though it does not apply to new fields.

A.2.3. Ring Fence Corporation Tax (RFCT)

Oil and gas companies pay corporation tax, in a similar way to other businesses operating in other sectors of the economy, but at a higher rate. Corporation tax is a tax on profits, after accounting for both capital and operational expenditures in a given period. In the oil and gas sector, the calculation of corporation tax on profits from extraction activities is kept separate from the calculation of profits on any other activities. This “ring-fencing” is intended to prevent companies from using losses incurred elsewhere to offset profits (and associated tax liability) in the extraction business.

Oil and gas companies had been subject to the same standard rate of corporation tax as other businesses in the UK until 2008. This standard rate was 52 percent in 1975 and has decreased over time, falling to 40 percent in the mid-1980s and to 30 percent at the end of the 1990s. Since 2008, the standard rate paid by businesses in the UK has again fallen, decreasing to 23 percent in 2013. Recent reductions did not apply to oil and gas producers, however: their corporation tax rate has remained at 30 percent. Where the PRT is charged (on fields given consent prior to 1993), it is treated as a deduction for tax purposes, as illustrated in the simple example above (see second paragraph of A.2.2).

A.2.4. Supplementary Charge (SC)

Between 1993 and 2002, fields that received development consent after 1993 were subject only to the prevailing rate of corporation tax. New fields therefore faced a significantly lower marginal tax rate than had applied to fields granted extraction licences prior to 1993. Although it is not straightforward to isolate the impact of policy changes on production, or revenues, the lower marginal tax rate appears, to some extent, to have had the desired effect of boosting production (see Figure A.1) by making previously untapped resources

⁷³ This is the allowance provided to certain fields granted development consent after March 1982. The allowance (annual and cumulative) available to fields granted development consent prior to March 1982 was half these amounts.

⁷⁴ Nakhle (2008), “Petroleum Taxation – Sharing the Oil Wealth: A Study of Petroleum Taxation Yesterday, Today and Tomorrow”

economically more attractive.⁷⁵ Around the time of peak production in 1999, and as oil prices started to recover from their low levels in 1998, the government applied an additional tax in order to extract more revenue from the benefits accruing to the sector. Both a reintroduction of PRT and an additional corporation tax were considered. Neither option was implemented, however, and in 2002 the government formally introduced a third headline measure, the Supplementary Charge (SC).

The SC acts in the same way as an additional corporation tax. The rate was initially set at 10 percent, taking the *combined* corporation tax rate to 40 percent. The only significant difference between the two is that interest payments cannot be deducted from the profits to which the SC applies.⁷⁶ (For example, a company extracting from a “new” field that earned a profit of £100 before interest payments and taxes in 2003, would have to pay £10 in SC. If the interest payments were £5, the company would then pay a further £28.50 in standard ring-fence corporation tax (£95 multiplied by 30 percent), taking the total tax burden on profits to £38.50). The SC rate was subsequently doubled to 20 percent in 2006 and then increased again to 32 percent in 2011.

Thus, as of the time of writing, two structures now apply to oil and gas activities:

- Fields that received development consent before 1993: PRT, RFCT and SC; and
- Fields that received development consent after 1993: RFCT and SC.

At the time of the introduction of the SC, in 2002, the government simultaneously introduced a 100 percent ‘First Year Allowance’ for capital expenditures for those fields that paid the SC. This remains in place today and allows companies to deduct their capital costs on plants and machinery from taxable profits in the same period in which they are incurred. This accelerated capital depreciation scheme benefits companies by permitting them to defer tax payments to later years, thereby enhancing the net present value of projects.⁷⁷ Of course, this benefit must be seen as part of the wider taxation regime, which still collects substantial revenues from the production of oil and gas in the UK. Both the depreciation treatment and the elevated profit taxes are reflected in our inventory of government transfers, because our analysis is based on the actual tax revenues collected.

The increase in the SC rate was partly justified by the significant rise in the price of oil observed since the turn of the century from around \$20 per barrel in 2001 to over \$100 per barrel (in nominal terms) by 2011. This has provided incentives to tap many fields that were not previously considered viable. However, under the full corporation tax rate, including the SC, of 62 percent, certain reserves remained unexploited, and consequently generated no revenue for the government.

⁷⁵ Government revenues also increased from 1993 to 1997. Whilst it is not straightforward to directly associate the revenue change to the policy change, presumably by making more viable the exploitation of certain more costly fields, the government has earned additional revenue from these fields. The alternative for these specific resources would have been no production and therefore no government revenue (and no wider economic benefits).

⁷⁶ The PRT is also deductible against profits used to calculate the SC, as it is for corporation taxes.

⁷⁷ The standard rate of capital allowance for plants and machinery used in mineral extraction is 20 percent per year on a reducing balance basis. (HMRC. Capital Allowances Investment Schemes. Available here: http://www.hmrc.gov.uk/capital_allowances/investmentschemes.htm#f)

In recognition that further development of oil and gas resources on the UKCS relied upon drilling in smaller fields and at fields with more complex technical requirements, the government accompanied the increase in SC with a “Field Allowance” scheme (introduced in 2009⁷⁸ and extended in later years).

Under the scheme (which remains in effect) small and technically challenging projects can now seek approval from the Department of Energy and Climate Change (DECC) to qualify for the Field Allowance, which exempts them from part, or all, of the SC. This allowance now covers various offshore fields.

Separately, due to the complexity of production and low margins available from onshore shale gas extraction in the UK, shale gas sites are expected to be exempt from the SCT – possibly subject to certain limitations – and therefore to be taxed at the higher oil and gas corporation tax rate of 30 percent.⁷⁹ The Field Allowance (or the “Pad Allowance” that has recently been proposed by the UK government – which refers to drilling sites for unconventional oil and gas resources, where fields are not well defined) therefore would reduce the marginal tax rate for some sites, but is intended to increase production by making oil and gas reserves that otherwise would be left in the ground commercially viable – thereby increasing government revenues and overall economic activity.

A.2.5. Decommissioning

Decommissioning costs (also referred to as *abandonment* costs) are treated as capital expenditure and can therefore be used to reduce tax liabilities on oil and gas production. Prior to March 2008, if a company were to incur a loss on its activity in a particular year it was able to ‘carry-back’ expenditure on decommissioning for up to three years. These costs could therefore offset the amount of tax payable in earlier years and reduced the overall tax on the asset over a limited period. From March 2008, this period of ‘carry back’ was extended. Companies are now able to offset their decommissioning costs as far back as April 2002 (when the SCT was introduced), with the offsetting expenditure applied to profits in the most recent years first.

On top of this, the government has recently sought to provide certainty to oil and gas production companies with regards to the tax relief they will be eligible for at the point of decommissioning their activities in a particular site. Following a consultation in 2012, the government introduced Decommissioning Relief Deeds (DRD) in the 2013 Budget. From late 2013, these contracts can now be agreed between the company subject to decommissioning costs and the government, which protects the company from any adverse changes to the treatment of decommissioning costs that may come into force after the agreement of the DRD. It is therefore an additional measure designed to provide a degree of security to oil and gas producers with respect to the fiscal treatment of decommissioning costs.

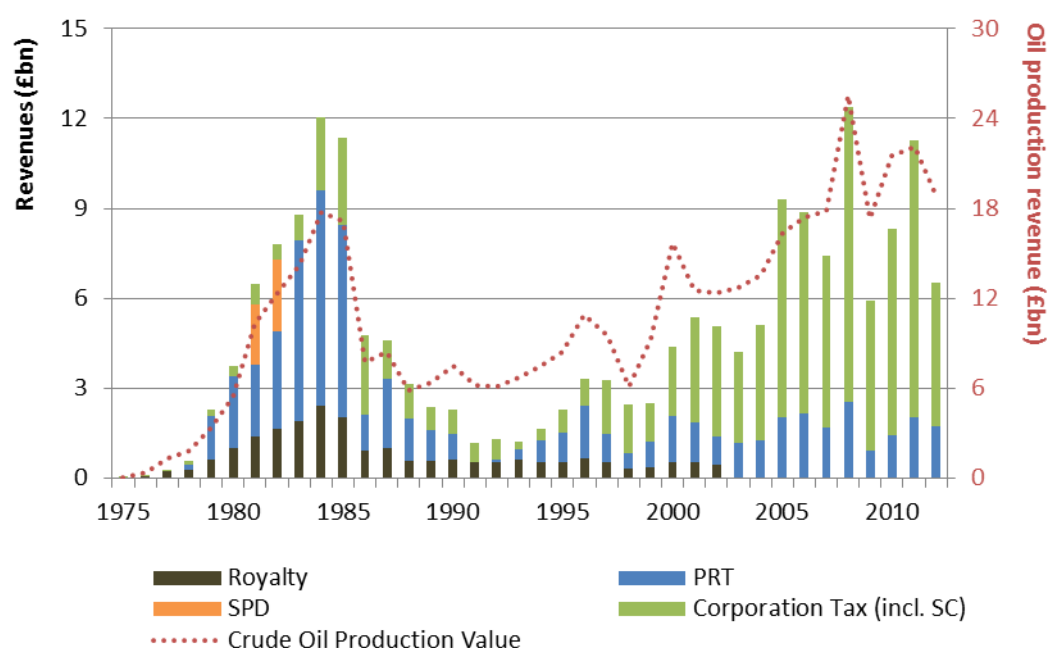
⁷⁸ See <http://www.hmrc.gov.uk/oilandgas/guide/sc.htm>

⁷⁹ This was proposed by the Chancellor of the Exchequer in the 2013 Budget. A consultation regarding the exact detail of the tax regime and a possible extension to all unconventional hydrocarbon resources has concluded with a final decision expected in the 2014 Budget. This announcement is expected to provide further detail regarding the level of production and time period over which the SCT exemption may apply. (HM Treasury. Consultation outcome: Harnessing the potential of the UK’s natural resources: a fiscal regime for share gas. 10 December 2013).

A.3. Analysis of Tax Revenues and the Marginal Rate

The first production peak on the UKCS was in 1986 (see Figure A.1 above) and up to that point, the main revenues from upstream oil and gas activity came from PRT. Since then, RFCT and SC have dominated government receipts. Figure A.2 shows the evolution of government revenues since 1975, split by the type of tax. The dotted red line shows an estimate for the production value of the oil only⁸⁰ (right hand axis), calculated by multiplying the average annual market price of crude oil by annual UK production.⁸¹

Figure A.2
Production Value and Government Revenues by Tax Scheme (Nominal)



Source: HMRC (tax revenues); EIA (crude oil market price); DECC (oil production); Federal Reserve Bank of Saint Louis (UK/US historic exchange rates)

Note: A Supplementary Petroleum Duty (SPD) tax was introduced in 1981, payable on top of the PRT, but this was removed within two years.

Total annual revenues, measured in nominal terms, first peaked in the mid 1980s at £12 billion, coinciding with record production levels. They then fell dramatically both as a result of reduced output as well as a reduction in the marginal tax rate in 1993, following the

⁸⁰ We have not included the production value of gas since gas price data are unavailable for the early part of the period shown.

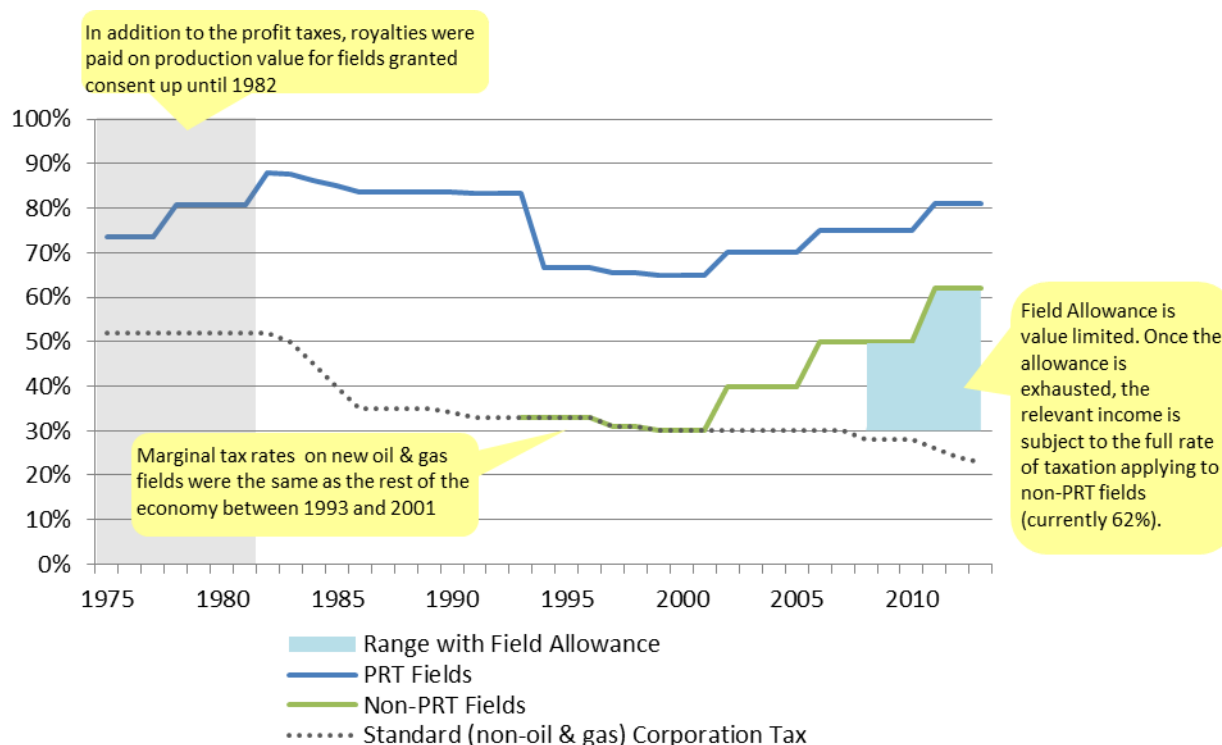
⁸¹ Note that the production value is based on the crude oil extracted and does not consider the value of the natural gas that is extracted. We only include oil here as published natural gas prices are available for just a subset of the period covered by the chart (from 1996 onwards). Gas prices have historically been linked to oil prices and production levels on the UK Continental Shelf have also been closely linked. Therefore we anticipate that adding gas would not alter the trend shape, although it would increase the absolute level of the production value.

reduction in the PRT rate and its complete removal for new fields. Since the late 1990s, PRT revenues have been sustained to some degree by increased oil prices, despite the decline in remaining proven reserves in PRT-paying fields. However, as the figure makes clear, since 2000 the majority of revenues has come from the combination of standard corporation tax as well as the SCT.

Figure A.3 shows the marginal rate of tax applied to the profits from oil and gas extraction activities. As a reference, the figure also shows the standard corporation tax applied to other areas of the UK economy outside the oil and gas sector (the dotted series). Fields granted consent prior to 1993 paid both the PRT and standard corporation tax on their profits.⁸² Their marginal rate of tax is shown by the blue line. The marginal rate increased from 74 percent in 1975 up to almost 90 percent in 1981, due to the rise in the PRT. It then fell slightly in the mid 1980s, due to a decrease in the corporation tax rate, and then sharply in 1993 as the PRT was lowered from 75 percent to 50 percent. In the eight years prior to 1993, the marginal tax rate for oil and gas companies was consistently 50 percentage points higher than the rate applied to other sectors of the economy. Since the early 1990s the step changes in the marginal rate of tax have been due to the introduction and subsequent increase in the SC.

⁸² Note that royalties were payable per unit of output, rather than profit and therefore are not included in this illustration. We have approximated the impact of royalties on the marginal rate between 1975 and 1981 by estimating the total profit across all extraction companies (based on PRT and Corporation Tax payments) and applying the burden of the PRT, corporation tax as well as royalties to this estimate. This analysis indicates that the marginal tax rate between 1975 and 1981, including the impact of royalties, ranged between 83 and 96 percent. The annual average over this period was an 88 percent marginal tax rate. This is the same as the rate in 1982 when policy change meant royalties ceased to be collected from new fields but the PRT was increased from 60 to 75 percent.

Figure A.3
Marginal Tax Rate on UK Petroleum Production



Source: HMRC, NERA Analysis

Note: As noted above, certain fields receive Field Allowances (in some cases for only a portion of the field's active life), which results in marginal rates of taxation between 30 percent and the rate applying to Non-PRT Fields.

The marginal tax rate for fields that were given consent since 1993 is shown by the green line in Figure A.3. As discussed above, initially new production fields were only subject to the standard corporation tax rate, which the Government reduced to 30 percent in 1999. From 2002, on top of the corporation tax rate, these fields have also faced the SCT, with the exception of those that are granted exemption through the Field Allowance.⁸³

In 2011 the marginal rate of taxation on pre-1993 (PRT) fields was 81 percent. For non-PRT fields the marginal rate of taxation was 62 percent. The standard corporation tax rate applied to non-oil and gas businesses in the UK that year was 26 percent. Although different fields pay differing rates of tax on their profits, depending upon when they were developed and also the degree of complexity in the extraction process, it is clear that oil and gas production has always paid a marginal tax rate on profits at least as high as other sectors of the economy, and the vast majority of production has paid – and continues to pay – a significantly higher rate.

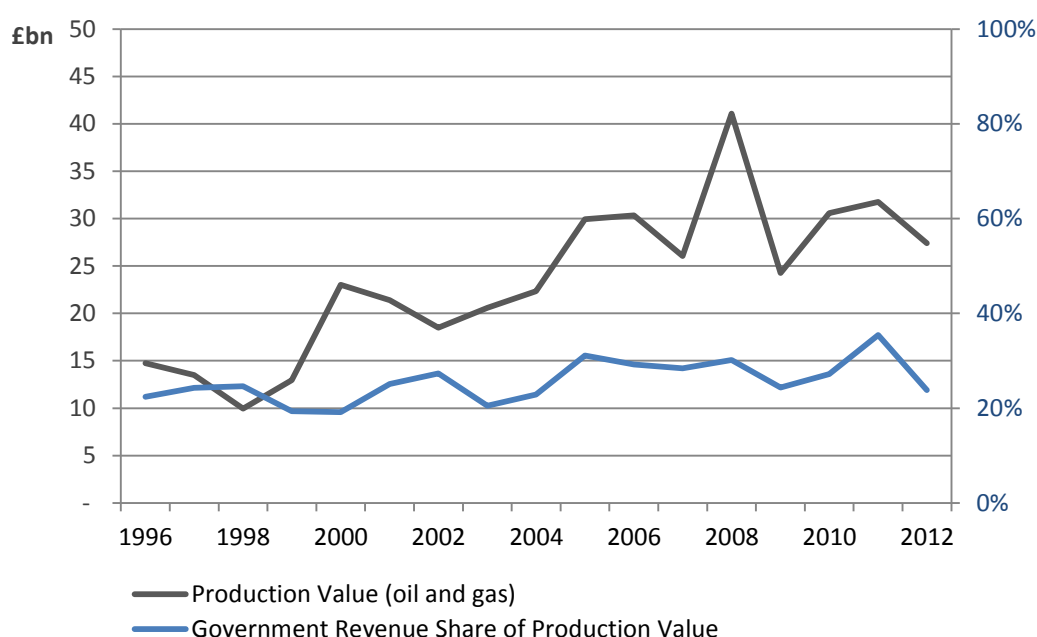
⁸³ As noted, the establishment of lower rates of total taxation under the Field Allowance in 2009 was designed to incentivise the development of smaller, less profitable fields, which would nonetheless provide some additional revenue to the government, and at higher marginal rates than apply to other areas of the economy.

A.4. Conclusions

Resources in the UK continental shelf have provided an important source of revenue to government over the past four decades. In addition to direct tax revenues, the UK government has derived other benefits from the development of its oil and gas resources, including the development of technological expertise and benefits associated with employment connected to the industry. Successive governments have employed a variety of fiscal instruments to capture a proportion of profits from oil and gas extraction – to compensate the Crown and share with society the benefits arising from the extraction and use of national resources. The focus of the present study is not to analyse the effectiveness of these measures at raising revenues or promoting growth. Instead, the brief history of the fiscal regime outlined here serves to illustrate the overall tax burden placed on upstream oil and gas and the sometimes complex interaction between different instruments.

It is difficult to determine how the rates at which taxes (and other fiscal measures) are set affect total government revenues from oil and gas extraction. There are a number of other variables that make an analysis of the effects of government policy difficult. Figure A.3 above shows significant variation in the marginal tax rate applied to oil and gas extraction *profits* over time and dependent on the characteristics of the field. Figure A.4 (below) compares government revenues (which are typically reported April to March in the UK) to the oil and gas production value (estimated on a calendar year basis). The figure shows the two series from 1996, when natural gas NBP price data starts to be available. This analysis suggests tax rates (n.b. on *production value*, not on *profit*) ranging from 19 percent in 2000 to as high as 35 percent in 2011.

Figure A.4
Government Revenue as a Proportion of Oil and Gas Production Value



Source: HMRC (tax revenues); EIA (crude oil market price); BP Statistical Review of World Energy (natural gas NBP prices); DECC (oil and gas production); Federal Reserve Bank of Saint Louis (UK/US historic exchange rates)

The average rate of tax on *production value* (i.e. the ratio of tax receipts to production value) is shown by the blue line in Figure A.4 (right hand axis) and the estimated total production value of oil and gas is shown by the grey line (left hand axis). Over the first decade for which we have sufficient data (1996 – 2005) the average rate was 24 percent. In more recent years, from 2006 to 2012, the average rate has risen to 28 percent. Total tax receipts reflect a number of factors, including the volume of production, price of oil, the marginal rates of tax applied, and costs. Thus, increasing the marginal rate of taxation does not necessarily lead to higher government tax revenues.

For example, nominal government revenues, depicted in Figure A.2, were at their highest in 2008 at a time when the marginal tax rate *on profits* was either 75 percent for older PRT fields or 50 percent for more recent fields. This contrasts with the much earlier peak in nominal revenues of around the same level (so even higher if measured in real terms) in 1984, when marginal tax rates were 86 percent.⁸⁴ In 2008 oil and gas production was only slightly more than half that of 1984, but the oil price – the main driver of the second peak in revenue – was more than five times its level in 1984.

⁸⁴ All fields paid the PRT at this time.

Appendix B. Detailed Approach to Estimating Transfers

This appendix provides further detail on our approach to estimating the different categories of government revenues and expenditure, expanding on the summary paragraphs included above in the methodology section (Chapter 3 of the main report). For each category we include information on the data sources that we have relied upon, any key assumptions that we have taken, and the estimation techniques used, where actual data on revenue or expenditures are not readily available.

B.1. Estimating Government Revenues

B.1.1. Government Revenue from Extraction and Production (including Upstream Corporation Tax)

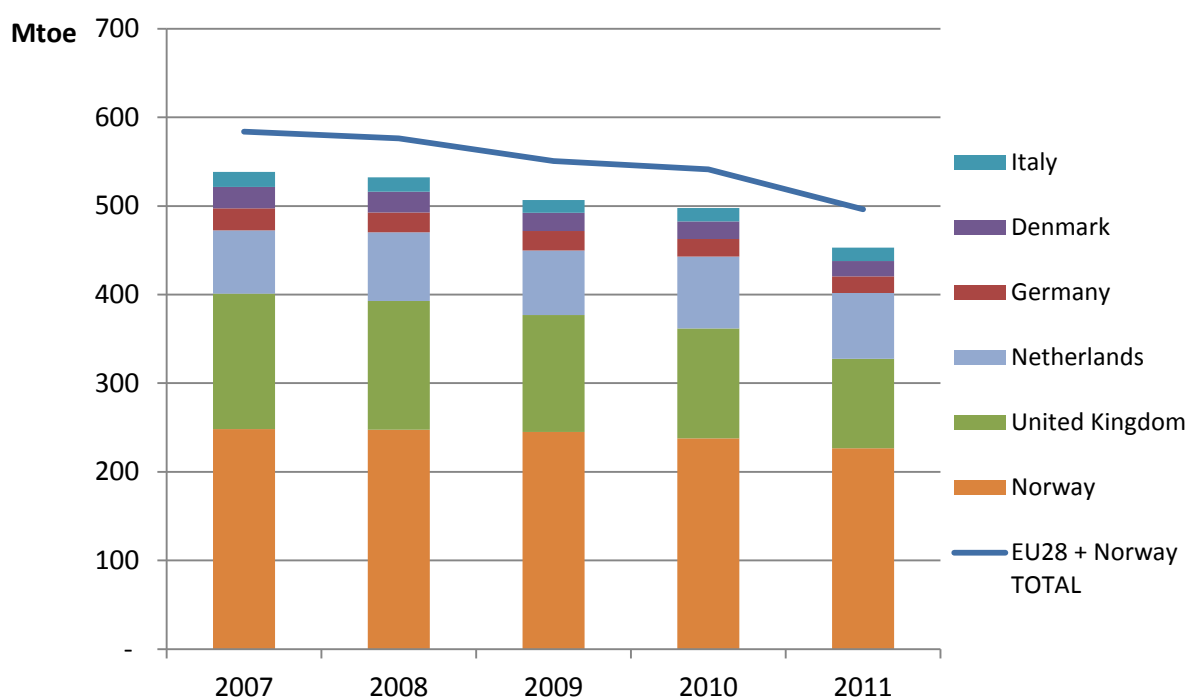
Government revenues from the extraction and production of the different energy sources are dominated by the oil and gas sector. Countries endowed with oil and gas resources apply particularly high marginal tax rates to extraction in order to capture a share of the value of the resource for the state. We have also considered, in separate paragraphs, whether there are any material government revenues received from the coal, wind and solar sectors associated with the extraction and production of energy, but found these to be immaterial.

B.1.1.1. Oil and gas

There are various different taxation regimes in Europe to capture state revenue from oil and gas extraction. Taxation tools used by governments include royalty charges, licence fees, special hydrocarbon taxes as well as more burdensome corporation taxes. Not only do the regimes differ across countries, but they have also changed over time. In this study we have limited our review of upstream tax revenue for the oil and gas sector and the coal sector to the top six countries in the region in terms of production output, which cover more than 90 percent of total production in the EU28 + Norway. Figure B.1 shows total production of oil and gas in the region between 2007 and 2011 and the contributions of the top six countries, (based on production in 2011).⁸⁵

⁸⁵ The top six oil and gas production countries in the region have consistently been the same between 2007 and 2011 with the exception of 2010, in which Romania was the sixth largest producer, displacing Italy. We have focused our detailed analysis on the top six producers in 2011, which are also the top six when measuring total production over the full 2007 to 2011 period.

Figure B.1
Oil and Gas Production in the EU28 + Norway (2007 - 2011)



Source: EIA and NERA analysis

Norway, the United Kingdom and the Netherlands account for over 80 percent of oil and gas production in the EU28 + Norway in 2011, with Germany, Denmark and Italy combined accounting for a further 10 percent. We have reviewed detailed estimates of the government revenues from the upstream oil and gas sector in each of these six countries from a variety of sources. For the government revenues associated with the remaining (approximately 10 percent) share of production, we assume that the average revenue per tonne of oil equivalent for the top six producers is likely to be a reasonable estimate. For the top six producers, we find an average government revenue of €168 per toe produced in 2011. We have calculated the average government revenue for each year (2007 – 2011) and applied this rate to each of the remaining smaller EU producers in that year to estimate total government revenue across the 29-country bloc.

Government revenues from oil and gas production are estimated at €83 billion in 2011. Given the joint nature of the oil and gas extraction industry it is standard practice in many countries to report these revenues together. Attributing government revenues to liquid and gaseous fuels in these countries therefore requires a degree of judgment. For illustrative purposes in our main results, we have allocated the revenues across the two fuels according to their share of total production revenue, calculated by multiplying production, measured in

tonnes of oil equivalent units, by the annualised price of crude oil and natural gas at the well-head.⁸⁶ On this basis we assign approximately €49 billion to oil and €35 billion to gas.

In the following paragraphs we provide detail on the estimates of government revenues from our review of the top six countries shown in Figure B.1. For the most part we have drawn on data from National Accounts, supplemented, where necessary, from industry analyses available in the public domain.

■ Norway

Norway accounted for almost half of oil and gas production in the region covered by our study in 2011. It is a major net exporter of energy and the oil and gas extraction industry is a significant contributor to the overall economy, both in terms of state revenues as well as in providing direct and indirect employment. Our primary data source for state revenues in Norway is the Norwegian Petroleum Directorate (NPD), which publishes annual reports on the industry. The NPD's "Facts" publication includes state revenues from three principal sources, including:

- the Petroleum Tax, which is similar to corporation tax but includes a special additional tax due to the high profitability of the sector;
- profits earned by state-owned Petoro, which represents Norway's Strategic Direct Financial Interest (SDFI) in the sector; and
- state dividends from Statoil, Norway's largest producer, which was originally state-owned.⁸⁷

In 2011 the Norwegian state received €28 billion in Petroleum Tax revenues, €16 billion in profits from the SDFI, and almost €2 billion in dividends from shares in Statoil, giving a total revenue of approximately €45 billion. In addition, the state collects an Area Fee from licences to extract. In the NPD data the Area Fee revenue is combined with CO₂ and NO_x tax revenues, so it is difficult to isolate the contribution to government revenues from Area Fee receipts. We have therefore supplemented the NPD data with information from the 2011 Extractive Industries Transparency Initiative (EITI) report, which splits the Area Fee, CO₂ and NO_x tax revenues. According to the EITI, the Area Fee accounted for 40 percent of the combined revenues of these three elements, or almost €200 million in 2011. For all other years we have assumed that 40 percent of the combined Area Fee, CO₂ and NO_x tax revenues that are reported by the NPD are attributable to Area Fees.⁸⁸ These amounts are allocated to the total government revenues from oil and gas extraction in Norway.

⁸⁶ Production data in each country and year are obtained from the EIA. Annualised crude oil prices are based on European Brent prices published by the EIA. Annualised natural gas prices are based on UK NBP prices published by ICIS Heren.

⁸⁷ For example, see: Norwegian Petroleum Directorate. Facts 2011: The Norwegian Petroleum Sector. Chapter 3. July 2011. We have also reviewed additional material auditing the national reporting for the Extractives Industries Transparency Initiative, which Norway participates in. The EITI is a non-profit organisation formed of a coalition of governments and companies whose aim is to improve openness and transparency in the reporting and management of revenues from resource extraction around the world. For example, see: Deloitte. Extractive Industries Transparency Initiative Reconciliation of Cash Flows from the Petroleum Industry in Norway 2011.

⁸⁸ Carbon tax revenues are included elsewhere in our analysis, under the category of 'excise duties and other energy taxes'.

■ United Kingdom

The United Kingdom is the second largest oil and gas producer of the countries included in our study, and the largest in the EU, over the period we have considered. In 2011 the UK accounted for 20 percent of production in the EU28 + Norway, and almost 40 percent of production in the EU. UK production has declined over the largest decade due to the depletion of large oil fields and due to increasing complexity in extraction from new sources. Appendix A provides a detailed case study describing the UK taxation regime.

We have relied on government revenue data published regularly by Her Majesty's Revenue and Customs (HMRC), which oversees collection of government revenues in the UK. For each accounting year from 2006/7 to 2011/12, running from April to March, HMRC publishes government receipts from corporation tax (including supplementary charges that apply only to the oil and gas sector) and the Petroleum Revenue Tax.⁸⁹ To align these data with the calendar years that we use for our analysis we have assigned the revenue from the accounting year to the corresponding calendar year with the most overlap. For example, we have assigned tax revenues from April 2010 to March 2011 to the 2010 calendar year.

As noted above, the corporation tax component comprises the standard corporation tax, which is set at a higher level than the corporation tax rate applied to the rest of the UK economy, *plus* an additional “supplementary” charge.

The Petroleum Revenue Tax is a legacy tax that only applies to oil and gas fields granted approval prior to 1993.

In the past the government also collected revenue from royalty payments tied to the production value of the resource, but the royalty regime has since been phased out in favour of the above taxes. In 2011 government revenues from the Petroleum Revenue Tax were €2.3 billion, and revenues from corporation taxes were €10.6 billion, resulting in total UK government revenues of almost €13 billion.

■ Netherlands

The Netherlands accounted for 15 percent of oil and gas production in the EU28 + Norway in 2011. The majority of this was gas production: the Netherlands is the second largest gas producer in the region after Norway. The Dutch government earns revenues from gas extraction via royalties and licence fees paid in return for concession rights, as well as corporation tax. In addition, the state-owned company EBN maintains a stake in all extraction activities. The government therefore also receives revenues from dividend payments made by EBN.

The revenue data for the Netherlands that we use is taken from the country's National Accounts, which report oil and gas revenues associated with each relevant fiscal instrument.⁹⁰ We have also validated this information using the Netherlands Environmental Accounts.⁹¹ In

⁸⁹ HMRC. Statistics of Government Revenues from UK Oil and Gas Production. August 2013.

⁹⁰ Statistics Netherlands. National Accounts of the Netherlands 2012. September 2013.

⁹¹ Statistics Netherlands. Environmental Accounts of the Netherlands 2012. November 2013.

2011 the government received €8 billion in revenue from ‘income from land and subsoil assets’ (which correspond to royalties and licence fees), €1.6 billion from corporation taxes and just over €2 billion from dividend payments. Total annual revenues were slightly less than €12 billion.

■ Germany

Germany was the fourth largest producer of oil and gas in the EU28 + Norway in 2011, accounting for 4 percent of the total output. The country’s production is relatively evenly split between oil and gas. The German state charges royalties on extraction as well as the standard rate of corporation tax on the profits of extraction companies.

We have identified limited information regarding total government revenues from oil and gas production in Germany in the public domain. The annual reports produced by the industry association for German oil and gas producers (WEG) provide information about royalty payments, which in 2011 totalled approximately €0.9 billion.⁹² We have not identified any public source for corporation taxes specific to the sector.

To estimate corporation tax receipts from Germany upstream producers we developed a proxy for sector profitability that relies on Eurostat’s Structural Business Statistics (SBS). This dataset includes information about the gross operating surplus attributed to petroleum and natural gas extraction. Between 2008 and 2011 (data from 2007 is withheld) this ranged between €640 million and €1.2 billion. This is almost certainly an overestimate of the profit that would be subject to corporation tax, as it excludes depreciation and capital expenditure. The standard corporation tax rate in Germany was 30 percent over this period, implying a range of corporation tax revenues of between €192 and €358 million.

An alternative approach to estimating government receipts from the German upstream oil and gas sector would be to assign total tax revenues to Germany based on the average revenues per tonne of oil equivalent of production observed in Norway, the Netherlands, the UK, Denmark and Italy – that is, adopting the same approach that we have taken for all other EU countries that are not amongst the top six producers. Using this approach, we would estimate €3.2 billion in government revenue to Germany. This would require corporation tax receipts to be of the order of €2.3 billion. There is clearly a significant variation between these two estimates. In the absence of further publicly available information we have adopted the first estimation approach, as gross operating surplus provides a reasonable approximation of profit.

■ Denmark

Denmark was the third largest *oil* producer in the EU28 + Norway in 2011. Like Germany, it accounted for 4 percent of total oil and gas production (measured in toe) in the region. Upstream activities in Denmark are subject to the standard rate of corporation tax, plus an additional hydrocarbon tax applied to profits. Royalties are also paid to the state (although these are a relatively minor contributor to government revenues), as is an Oil Pipeline Tariff

⁹² For example, see: WEG. Jahresbericht 2012 Zahlen und Fakten. June 2013. An alternative industry source suggests royalty payments may be between 40 and 100 percent higher than the WEG published data over the period concerned. However, we have relied on the WEG data given that the data are publicly available and more transparent than alternative sources.

that is charged on the volume of oil transported through the pipeline network. Up until 2012, under a profit sharing arrangement, all oil and gas production companies were required to pay the state 20 percent of their pre-tax profits over and above standard corporation tax. In 2012 this system was replaced by direct involvement in the sector by the state in exchange for an extension to the licence period and additional amendments to the concession.

In 2011 total government revenues from oil and gas extraction were €4 billion, split between corporation tax (€1.3 billion), hydrocarbon tax (€1.3 billion), royalties (€0.1 million), Oil Pipeline Tariff (€0.3 billion); and profit sharing (€1.2 billion). These data were collected from annual publications on the sector by the Danish Energy Ministry.⁹³

▪ Italy

Italy is the sixth largest oil and gas producer in the region, accounting for 3 percent of total production, and like Germany has a relatively even split between oil and gas output when measured in tonnes of oil equivalent. The central government receives revenues from royalties as well as the standard corporation tax. An additional “Robin Hood Tax”⁹⁴ is applied on top of the corporation tax to capture a share of windfall profits. Local governments also receive some revenue from oil and gas extraction activities, but we consider these to be negligible.⁹⁵

As was the case for Germany, we have not identified a public source that details precisely the total government revenues from oil and gas production. Royalty fees are published by the Italian Directorate-General for Mineral and Energy Sources. These totalled €400 million in 2011.⁹⁶ We also reviewed a publication by a Nomisma Energia, a consulting firm commissioned by the government, which presents a chart showing total government revenues, inclusive of royalties, up until 2011. This indicates total government revenues around €1 billion over recent years (ranging from €0.7 to €1.5 billion).⁹⁷ This estimate is corroborated by a presentation by the Italian Petroleum and Mining Industry Association (Assomineria) to parliament which includes an estimate for total revenues of €1.6 billion in 2012, including both royalties and corporation taxes.⁹⁸ The estimates are also similar, although slightly lower (up to 50 percent in 2011), than alternative non-public estimates we have reviewed from industry sources.

B.1.1.2. Coal

Our analysis has found no material government revenues from the production of coal across Europe. As far as we are aware there is no pan-European data source that specifically details

⁹³ For example, see: Energi Styrelsen. Oil and Gas Production and Subsoil Use in Denmark 2012. June 2013.

⁹⁴ The “Robin Hood Tax” is an additional resource income tax that was introduced in 2008.

⁹⁵ Wood Mackenzie. Global Economic Model. Q4 2013.

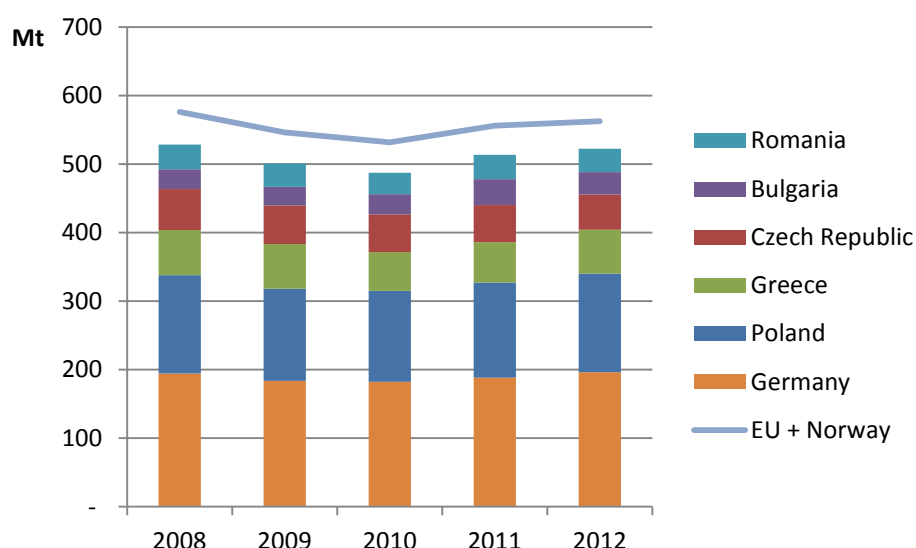
⁹⁶ Ministero dello Sviluppo Economico. Gettito Royalties Anno 2013. Available here: <http://unmig.sviluppoeconomico.gov.it/unmig/royalties/2013/2013.asp>

⁹⁷ Nomisma Energia. Tassazione della produzione di gas e petrolio in Italia: Un confronto. January 2012.

⁹⁸ Assomineria. Indagine conoscitiva sulla strategia energetica nazionale e sulle principali problematiche in materia di energia. September 2013.

government revenues from coal extraction and production. As such we have reviewed the top six coal-producing countries in the EU and Norway, covering slightly more than 90 percent of total production in the region. Figure B.2 shows coal production in 2011 from these top six countries as well as the total production in the EU + Norway.

Figure B.2
Coal Production in EU + Norway (2011)



Source: EIA

In many parts of Europe, especially in recent years, coal production has tended to be loss-making due to declining coal prices brought about through increased international competition. The coal sector therefore differs significantly from the oil and gas sector – for example, it is often relied upon to promote domestic energy self-sufficiency rather than to generate profits from exports. In the following sections we summarise the data sources that we have relied on to come up with estimates of the government tax revenues from coal production in the top six coal producing countries in the EU. As for oil and gas extraction, our approach is to take the average revenue (measured on a per tonne of oil equivalent basis) and apply this to production in the remaining countries. However, for coal extraction we have not found any evidence of significant profits made by the sector and therefore assume there is no material contribution from corporation taxes.

■ Germany

Germany is the largest coal producer in Europe. In 2011, Germany coal production accounted for 34 percent of the total for the EU28 + Norway. According to the OECD inventory, hard coal production in Germany is “uneconomic” and the costs of producing coal are well above the price of imports.⁹⁹ As such the ownership of hard coal mines has been transferred to a holding company which is heavily supported by the state. Annual income support provided to coal production by the region of North-Rhine Westphalia ranged between €1.7 and €2.3

⁹⁹ OECD. Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels 2013. 2013.

billion from 2007 to 2011. Coal mining is also exempt from the payment of mining royalties.¹⁰⁰

We have not identified any public sources that provide information on possible government revenues from coal production in Germany. Given that hard coal is loss-making, we assume that there are no government revenues from this activity in Germany in the form of corporation tax, royalties or licence fees for extraction. Lignite production also takes place in Germany, carried out by private companies, without receiving direct support. This is likely to be directly used in power generation stations. As such it is difficult to distinguish any profits from the coal production part of the supply chain from the power generation. The profit from lignite production may well manifest itself in the profits of power generation that uses the fuel as an input. We examine corporation tax revenues from midstream activities below in section B.1.2.

■ Poland

Poland is the second largest coal producer in the EU28 + Norway, accounting for a quarter of production in 2011. The Polish energy system relies heavily on indigenous bituminous coal, which provides approximately half of its primary energy supply.¹⁰¹ The state fully owns two of the three biggest coal producers and holds a majority stake in the remaining company. According to the OECD inventory current coal production is not subsidised by the state and contract prices are negotiated freely. However, the OECD inventory report also notes that several reforms of the industry intended to make it profitable and hand it over to private companies have proven unsuccessful. We have not attempted to resolve this apparent contradiction. We have not been able to identify any data sources that provide information on the tax payments made by the sector over recent years. However, an IISD report on the coal mining industry includes several estimates of profit between 1990 and 2006. In all but two years the net financial profit was reported as negative;¹⁰² the exceptions were 2004 (profit of \$734m) and 2006 (\$126m).¹⁰³ Based on this evidence we have assumed that any government revenues from coal production in Poland are not material in the context of our study.

■ Greece

The third largest coal producer in the EU is Greece. In 2011, 11 percent of coal in the EU28 + Norway was produced here. The main domestic source of energy in Greece is lignite, which is principally used for power generation.¹⁰⁴ The OECD inventory does not identify any explicit production support measures for lignite in Greece and as recently as 2009 the government awarded extraction licences to several private companies. This suggests that lignite extraction is likely to be commercially viable. Currently, the majority of lignite

¹⁰⁰ OECD (2013).

¹⁰¹ OECD (2013).

¹⁰² It is not clear from the source whether this refers to profit before or after tax. However, given that it has often been negative, it is reasonable to assume that at least corporation taxes were zero or negligible.

¹⁰³ IISD. Lessons learned from the restructuring of Poland's coal-mining industry. March 2010.

¹⁰⁴ OECD (2013).

extraction is carried out by the state-controlled Public Power Corporation (PPC) which uses the fuel directly as an input to its power generation plants. We assume that there are no, or limited, profits reported from coal production itself, but that the PPC benefits from “lignite-fuelled units that are substantially less expensive than other units.”¹⁰⁵ Given that the PPC is a vertically integrated, and state owned, company, we have not identified any direct tax revenues accruing from coal production in Greece. We have not attempted to quantify any wider economic impacts (costs or benefits) associated with the existing state ownership structure.

■ Czech Republic

The Czech Republic accounted for 10 percent of coal production in the region in 2011. Six coal mines are currently in operation in the Czech Republic, five of which extract lignite and the other bituminous coal. CEZ, the largest Czech electricity producer, is the largest consumer of coal in the country, which it uses for power generation. CEZ also owns a lignite mining company that accounts for approximately half of all lignite production.¹⁰⁶ As in the Greek case, we assume that government revenues from taxing coal *production* (for example, corporation taxes) are limited or negligible because the majority of extracted coal is used as an input to power generation. It seems likely that potential profits from indigenous coal production, relative to purchasing the fuel on the market, would therefore be manifested primarily through profits on sales of electricity.

The Czech state does charge royalties on coal mining leases. These royalties are collected and directly allocated as compensatory payments to municipalities adversely affected by coal mining as well as to carry out works to remediate environmental damage. Royalties were approximately €7m per year over the past five years, so we consider them to be immaterial for the purpose of our study.¹⁰⁷

■ Bulgaria

Bulgaria was the fifth largest coal producer in the EU28 + Norway, accounting for 7 percent of the total output in the sector in 2011. According to the IMV analysis of budgetary support and tax expenditures for fossil fuels, the vast majority (90 percent) of coal production in Bulgaria is lignite produced in mines located next to four coal power generation plants, which together generate over 60 percent of Bulgarian electricity.¹⁰⁸ Brown coal reserves, in another area of the country, which the IMV distinguish from lignite reserves, are also used for power generation. The largest coal mining company is the state owned Bulgarian Energy Holding (BEH).¹⁰⁹ The data we have reviewed suggests that, for the most part, extracted coal is used directly for power generation by vertically integrated companies. We have not identified any

¹⁰⁵ European Commission. Decision on the granting or maintaining in force by the Hellenic Republic of rights in favour of Public Power Corporation S.A. for extraction of lignite. 5 March 2008.

¹⁰⁶ OECD (2013).

¹⁰⁷ NERA analysis of ‘OECD (2013)’.

¹⁰⁸ IMV Institute. Budgetary Support and Tax Expenditures for Fossil Fuels: An Inventory for six non-OECD EU Countries. January 2013.

¹⁰⁹ IMV Institute. Budgetary Support and Tax Expenditures for Fossil Fuels: An Inventory for six non-OECD EU Countries. January 2013.

estimates of government revenue accruing directly from coal *production* activities in Bulgaria and therefore assume these to be immaterial.

Bulgaria levies a concession charge for the exploration and extraction of natural resources. However, this can be waived under certain circumstances for a period of up to five years as per the Law for underground resources.¹¹⁰ We have not identified any estimates for concession payments made in relation to the extraction of coal in Bulgaria.

▪ Romania

Romania accounted for 6 percent of all coal production in the EU28 + Norway in 2011. The National Hard Coal Company is the only hard coal producer in Romania, and is fully state owned. Coal prices were only partially deregulated in 2012, and prior to this, were controlled by the state. According to the IMV analysis of fossil fuel subsidies in Romania, there continue to be significant losses made by various coal production units.¹¹¹ Under EU State Aid rules, subsidies are being phased out and many coal production sites are facing closure. We have not identified any data reporting on the financial results of the National Hard Coal Company, but assume, at least across all its operations, that it is a net loss-making entity. The IMV study identified direct subsidies to the National Hard Coal Company of approximately €40 million in 2011, which was slightly lower than the subsidy in previous years. We therefore do not estimate any government revenues from coal production in Romania.

B.1.1.3. Wind

Governments may receive revenues from wind farms located on public land. For example, in the UK the Crown Estate owns the seabed up to 12 nautical miles offshore. Offshore wind developments therefore pay a fee to the Crown Estate as part of their licence conditions. We do not have comprehensive data on government revenues accruing from the wind sector across Europe. However, we have estimated the likely magnitude using data from the UK, which has the largest offshore wind resource in Europe. Between 2009 and 2011 the Crown Estate earned revenues of between £30m and £33m from its 'Energy and Infrastructure Portfolio'.¹¹² This portfolio includes revenues from tidal energy, carbon dioxide and gas storage, marine minerals, licence fees for cables and pipelines as well as offshore wind rights. The Crown Estate sources do not break down revenues by individual sources, so we have not been able to identify the share of this revenue that can be attributed to wind licenses. We know, however, that it cannot be more than around £30m a year. Another example is Spain, where wind farms pay local and regional taxes. However, these payments represent negligible amounts. Based on both UK and Spanish evidence the government revenues from wind are well below our materiality threshold, so we have not attempted to include estimates of revenues from land concessions to the wind sector within our dataset.

¹¹⁰ IMV Institute. Budgetary Support and Tax Expenditures for Fossil Fuels: An Inventory for six non-OECD EU Countries. January 2013.

¹¹¹ IMV Institute. Budgetary Support and Tax Expenditures for Fossil Fuels: An Inventory for six non-OECD EU Countries. January 2013.

¹¹² The Crown Estate. Annual Report and Accounts 2013. June 2013.

B.1.1.4. Solar

We do not assign any “upstream” government revenues to the solar sector for land concessions or other similar fees.

B.1.2. Corporation Tax

Corporation tax is a tax imposed by governments on the profits earned by businesses. The tax is generally applied as a proportion of profit. It is therefore a useful revenue raising tool for the state, extracting funds from those organisations that are most able to pay. The rates of corporation tax in Europe are set by individual countries and differ to some degree. The standard rate of corporation tax across the EU28 + Norway in 2012 ranged from 10 percent in Bulgaria and Cyprus to 36 percent in France, with an average rate for the EU27 of 23 percent.¹¹³ Total government receipts from corporation taxes in Europe across all sectors of the economy in 2011 were approximately €322 billion.¹¹⁴ The upstream oil and gas sector is a significant contributor to overall corporation tax receipts.

Based on the data sources reviewed above in section B.1.1, combined corporation tax revenues from the top six oil and gas producing countries from 2007 to 2011 ranged between €28 and €47 billion.¹¹⁵ Including additional hydrocarbon taxes levied on top of corporation tax raises the total to between €30 and €51 billion over the same five-year period.¹¹⁶ This contribution alone accounted for 14 percent of all corporation tax receipts across the European economy in 2011, even though oil and gas production accounted for just 2 percent of the total value added in the economy (excluding financial and insurance services).¹¹⁷ We have estimated a further €26 billion in potential corporation tax revenues from midstream and downstream activities across the different energy sources, as detailed in the discussion below.

Whilst Eurostat and the European Commission publish high level information on corporation tax rates and corresponding receipts for different countries, we are not aware of any publicly available data sources that break down corporation tax receipts by sector. Even if such sector-level data were available, it would be still more complicated to attribute corporation tax receipts to individual energy sources, given the integrated nature of companies through

¹¹³ Eurostat. Taxation Trends in the EU. 2013 Edition. Table 4.

¹¹⁴ We have reviewed corporation tax receipt data from 2007 to 2011. The total amount collected by the EU and Norwegian governments ranges from €265bn in 2009 to €415bn in 2011 with an annual average of €336bn. As the tax is a function of company profits receipts are higher in periods of growth. This is borne out by the below average tax receipts observed in the data for 2009 and 2010. (Source: European Commission, National List of Taxes 2013 and NERA analysis)

¹¹⁵ This includes the Petroleum Tax in Norway, which is similar to a corporation tax, but includes an additional element not faced by other sectors of the economy, in a similar way to the UK regime of charging corporation tax as well as an additional ‘Supplementary Corporation Tax’. However, unlike the UK, the NPD data does not provide a split between standard corporation tax and the additional contribution included in the Petroleum Tax, so we include the full amount in this illustration.

¹¹⁶ These include the additional contribution from the Petroleum Revenue Tax in the UK and the Hydrocarbon Tax in Denmark.

¹¹⁷ Value added is a proxy for GDP calculated by taking the value of production and subtracting the value of intermediary goods. We have used Eurostat SBS data on the value added at factor cost of different activities in the economy to derive this estimate. The total value added of the economy excludes financial and insurance services.

the energy supply chain. There are further complications associated with the way that some companies structure themselves to ensure that their operations are tax-efficient in terms of the profit they are able to retain.

Our approach, therefore, has been to try to identify the most significant parts of the energy supply chain in terms of profits earned and then to rely on available data points to create corporation tax estimates across the energy sources covered by this study. This has allowed us to assess the materiality of corporation tax revenues from different parts of the energy supply chain. We have also drawn on Structural Business Statistics (SBS) published by Eurostat, which report information such as turnover, value added, and gross operating surplus for different sectors of the economy. SBS gross operating surplus data provides a proxy for the profits made by a particular sector. It is a measure of gross output, less the cost of intermediate goods and the cost of labour input. It does not deduct any capital expenditure so overestimates actual reported profits made by companies operating in a particular sector. The sectoral breakdown in SBS data is not always appropriate for the energy supply chains we are examining, and data completeness across European countries is an issue. However, at a high level the SBS dataset has served to inform and validate several of our estimates.

One exception to the general lack of disaggregated data is corporation tax receipts from the production of oil and gas (discussed above). This upstream activity is one of the major contributors to total corporation tax receipts in countries that have significant energy resources, so governments publish detailed information on tax receipts from energy extraction. A discussion of potential government revenues from coal production is discussed above (section B.1.1.2). We do not attribute any corporation tax revenues to coal production in our estimates. Wind and solar differ from fossil fuels in that the energy resource is not physically “extracted” from the ground. Instead equipment is used to transform the abundance of existing wind or solar energy into electrical output. A direct comparison across fuels is complicated by this difference. This is discussed further in the power generation subsection of section B.1.2.1 below.

The following two sections provide further information on our estimates for corporation tax receipts across midstream and downstream activities for all of the energy sources. Absent the kind of detailed government revenue information that *is* available for the upstream oil and gas sector, there is reason to think that the approach we have adopted for other sectors and stages of the supply chain may over-estimate government receipts from corporation tax, to the extent that some companies are able to organise their operations in ways that reduce their corporation tax burden. We have not attempted to quantify this effect, as the contribution to government revenues from corporation tax outside the upstream oil and gas sector is comparatively small.

B.1.2.1. Midstream corporation tax

The previous section underlines the important contribution of the oil and gas production industry to total corporation tax receipts across the region covered by our study, making up 14 percent of total corporation tax in 2011. The lion’s share of corporation tax receipts from all energy is therefore derived from upstream operations. However, there are various ‘midstream’ and downstream activities that are also relevant. Within ‘midstream’ here we include activities such as power generation, fuel storage and transportation, processing or refining of fuels, and trading. It is common for the same company to engage in many or all of

these activities at once, as well as upstream and downstream areas, as a vertically integrated entity. This makes it particularly difficult to obtain data on profit margins at different stages of the supply chain. To inform our analysis we have identified data points from publicly listed companies, country-level data, and where available, pan-European sources and applied these data as appropriate to arrive at our estimates for the full EU28 + Norway region. Various data points and estimates are summarised in the following bullet points:

▪ **Trading**

Trading is commonly used by energy companies as a risk management tool to hedge against exposure to commodity prices in the futures market, so for the purposes of our analysis we have assumed that on balance it does not make a significant contribution to company profits. Any profit that trading activity generates is likely to materialise in either the upstream or downstream market segments and therefore be visible in the data points that we rely on for these parts of the supply chain.¹¹⁸

▪ **Power Generation**

In order to assess the profits made by power producers we have reviewed a number of sources, focusing on the financial accounts of Europe's largest electricity generators. These companies tend to operate across various countries as well as parts of the supply chain. It is therefore not always possible to isolate the profits earned on power generation in a particular country from operations in other regions or covering separate activities. These often include storage, retail supply or energy extraction.

The data points we rely on to estimate profits, and subsequently corporation tax receipts, from power generation are drawn from Enel, whose main market is in Italy, E.ON, based in the German market, and Centrica, located in the UK. These companies report measures of the profitability specific to their power generating activities. We have then divided the reported profit by the output (in TWh) generated over the same period. The profits reported by this sample of large power generators cover their portfolio of generation technologies. These include coal, gas and renewables, notably wind (nuclear activities, where applicable, are often reported separately). It is however, important to note that these portfolios are weighted towards conventional thermal technologies rather than renewables.¹¹⁹

Our analysis of 2011 data finds that Enel earned an operating income of approximately €20 million per TWh; E.ON reported earnings before interest and taxation (EBIT) of €25 million per TWh; and Centrica reported operating profit of €17 million per TWh. We then supplemented these company specific indicators of profitability with Eurostat SBS data. Across the EU28 + Norway in 2011, Eurostat report a gross operating surplus for electricity

¹¹⁸ Certain energy companies also engage in speculative trading, that can be profit making. However, gains by one trading organisation are often offset by losses in another. Also, we consider speculative trading to be too far removed from the actual energy sources (oil, gas, coal, electricity, and derivatives thereof) to be relevant to the scope of our study.

¹¹⁹ Recent evidence from Germany suggests that the increasing deployment of renewables is altering the profitability of conventional power generation, as RWE recorded its first annual loss in 60 years in 2013 – attributed, in part, to the expansion of renewable generation with negligible marginal costs (RWE press release. “RWE posts first net loss in 60 years”, 4 March 2014; and *Financial Times*. “Germany’s RWE slides into €2.8bn net loss for 2013”. 4 March 2014). Our results focus on data prior to, and including, 2011 and we do not explicitly quantify such additional impacts of RES support policies on fossil fuels due to the complexity of capturing different market interactions.

generation of approximately €67 billion. Total electricity production during the year was slightly over 3,000 TWh, giving an estimate of gross operating surplus of €21 million per TWh.

The estimates in the previous paragraph are all based on slightly different measures of profitability. Gross operating surplus, operating income and operating profit are measures that do not incorporate the capital expenditures, which reduce the profits of a company that are subject to corporation tax. However, the highest of the estimates, from E.ON, does include the depreciation of capital assets.

We have chosen to estimate corporation tax receipts from power generation using a proxy for profitability in the power generation sector of €20 million per TWh. This is in the middle of the range of the estimates outlined above, yet it is likely to overestimate profitability once capital expenditures are included.

To estimate corporation tax receipts accruing from power generation we have multiplied the volume of electricity generation in each country (in TWh) by the above €20 per TWh value and then applied the relevant corporation tax rate. Within each country we assign corporation tax revenues to the different energy sources in proportion to their share of total power generation.¹²⁰ For the EU28 + Norway we estimate a total of €10.4 billion of corporation tax receipts to power generation from the energy sources included in our study, attributed as follows: Coal (€4.4bn); Oil (€0.3); Gas (€4.4); Wind (€1bn); and Solar (€0.3bn).

The actual profitability of power generation varies both by technology and across years. For example, “spark” and “dark” spreads provide a measure of the difference between the price of electricity on the wholesale market and the cost of the input fuel used to generate electricity. “Spark” spreads compare the price of gas to that of electricity, and “dark” spreads compare the price of coal to electricity. These spreads are a proxy for the short-run profitability of gas and coal power generation, respectively.¹²¹ The two spreads have changed places with each other (one higher during one period, the other higher during another period) over time and across countries in recent years in Europe. This suggests that the relative profitability of generation from the two fuels is also likely to have fluctuated over time.

In contrast, there is no cost of input fuel for wind or solar power generation, so the profitability of these two sources is almost entirely dependent on the revenue (and hence the subsidy) they receive (which is determined by the climatic conditions that determine how much electricity they are able to produce). However, renewable subsidies are, in theory, designed in such a way that investors can expect to earn, on average, profits similar to investors in conventional plant. Our approach abstracts from these nuances and simply assigns estimated corporation tax revenues from power generation to the different energy

¹²⁰ For example, gas fired power output in Spain in 2011 was approximately 85 TWh, and corporation tax in Spain is 30 percent. The corporation tax that we attribute to electricity generated by Spanish gas capacity is therefore 85 TWh x €20 million per TWh x 30 percent = €510m.

¹²¹ As noted above, however, the spark spread and dark spread do not reflect depreciation or other forms of capital expenditure, and therefore are an imperfect indicator of the profits relevant for corporation tax.

sources in direct proportion to their share of power generation in a given year and country.¹²² We provide an alternative approach to estimating corporation tax from power generation in the wind and solar sectors in Box B.1.

Box B.1

Alternative Approach to Estimating Corporation Tax on RES Equipment

Using the approach described above, we estimate government corporation tax revenues of €1 billion for wind and €0.3 billion for solar from electricity generation. The capital expenditure on wind and solar power generating equipment and infrastructure (turbines and solar panels) is particularly high relative to subsequent operational costs. It is also typically higher, on a per MWh basis, than the cost of conventional thermal plants. There is therefore a risk that the approach above could underestimate the actual corporation tax receipts from renewable technologies. An alternative approach that we consider here is to estimate corporation tax receipts on the purchase and installation of wind and solar power generation equipment.

To estimate the corporation tax on wind and solar equipment and its installation we have obtained information on capacity added in each year and multiplied this by an estimate of equipment and installation costs, per unit of capacity, to obtain the total capital cost. Wind capacity additions are reported by Eurostat which we have validated with data from the European Wind Energy Association (EWEA).¹²³ Between 2007 and 2011, annual capacity additions of wind turbines ranged between 8.4 – 10.2 GW. We have relied on solar capacity expansion data from Eurostat. In 2007, solar capacity added was only 1.7 GW, but there has been a dramatic growth in deployment over the last few years. In 2011 22 GW of new solar capacity was added. The German market has accounted for almost half of solar capacity additions in the EU since 2007.

We have reviewed a number of sources to derive approximate estimates of capital costs for wind and solar power.¹²⁴ The costs of wind turbines actually increased from the turn of the century until around 2010, but then began to decline again. (Although capital costs increased over this time, the overall cost of generating fell.) We assume a total installed cost of €2 million per MW of capacity for all years and countries. This

¹²² Clearly in any given year not all generation technologies are equally profitable. However, a more detailed assessment would require a much more detailed analysis of the European power sector than is possible within the scope of the current study. As noted above, there are reasons to think that the approach we have adopted should yield estimates of profitability that are plausible across the relevant energy sources – namely, that spark and dark spreads have not uniformly favoured one or another fuel over the period and countries in question, and that RES subsidies must be set taking into account the profitability of conventional generation alternatives. Moreover, even quite large differences in the total profitability attributed to individual fuels in any one year would not materially change the estimated government revenues from any of the principal energy sources included in our study, relative to the other sources.

¹²³ Eurostat energy database; and EWEA. Wind in Power Annual Statistics (2009 – 2012).

¹²⁴ Sources that we reviewed include industry associations (EWEA and EPIA), international organisations (IEA and IRENA) and government statistics.

is based on the range of \$1.4-2.7 million reported by the IEA and similar to estimates published by EWEA and IRENA.

Solar PV costs have decreased significantly over recent years. We take our central estimates from an IRENA publication on renewable power generation costs, which reports that the cost for German residential systems have fallen from around \$7 million per MW in 2008 to just \$2.2 million per MW in 2012. We have assumed capital costs of €7 million per MW in 2007, falling by €1 million per year to €3 million in 2011 for all capacity added in the EU + Norway. These costs cover both the equipment as well as the installation of the system. The significant majority of solar PV equipment in Europe has been imported from China in recent years, due to its lower cost. Therefore, for the purposes of estimating the corporation tax paid to European governments we only include the installation costs. These are approximately half of the total according to figures published in the IRENA report.

To estimate the corporation tax revenue from wind and solar equipment we have had to assume a net margin from the provision of capital and installation services. Assuming that 5 percent of total costs represent company profits and applying the corporation tax for each country, in each year, we have estimated corporation tax receipts on wind equipment to range between €242 and €294 million. The contribution from solar ranges from €105 million in 2007, rising steeply to almost €0.5 billion in 2011, due to the significant increase in capacity. Therefore, even with this relatively favourable treatment of wind and solar industries, the corporation tax receipts are relatively small, and certainly do not change the headline results.

■ Storage

Energy companies provide storage facilities for stocking oil, gas and coal at various strategic locations to serve markets across Europe. Storage serves to provide security of supply to end users. It also allows energy suppliers to manage risk as well as permit flexibility through the supply chain. Compulsory stocking obligations for oil are in place at a European level to maintain sufficient reserves in the event of a supply disruption. The reserves that are kept to fulfil these obligations are provided by a mix of energy companies and national agencies, depending on the country. Similarly, in some countries, such as Spain, coal power plants are required to maintain sufficient stockpiles to fuel a certain number of hours of generation.

We have not identified sources that explicitly report the profit from the provision of storage, as this tends to be a service provided by energy companies that are also engaged in other, more significant activities such as extraction, refining and power generation. We assume corporation taxes from storage activities are not material to our study, and therefore do not include any estimates for this part of the supply chain.

■ Refining

We have obtained data on crude oil refining activity in the EU as well as profit margin estimates for simple and complex refining of crude oil. Simple refining is often loss-making and we therefore attribute no profit to this activity. Refining (gross) margins in North West Europe (Rotterdam) ranged between \$2-7 per barrel over the course of 2007 to 2011, and remained consistently below \$5 per barrel from 2009 until the end of 2011.¹²⁵ Gross refining margins only consider the difference in the price of the crude input and refined product output. An estimate of the *net* margin on a representative or average “complex” refinery, taking into account the cost of the crude input as well as opex and capex costs incurred by refiners, was approximately \$2.4 (or €1.7) per barrel in 2009.¹²⁶ The annual average daily refining throughput in the EU between 2007 and 2011 ranged between 13.7 and 12.2 million barrels.¹²⁷

Assuming an average of 12.5 million barrels a day, this implies an annual throughput of 4.6 billion barrels. Only a proportion of this throughput is profit making, however. Applying a factor of 40 percent¹²⁸, which is likely to be an overestimate of “complex” refining throughput, implies that profit is made on around 1.8 billion barrels of crude each year, generating profits of around €3 billion. We have allocated the estimated throughput to the different European countries based on their share of total refining capacity.¹²⁹ Applying the relevant corporation tax rates for each country yields estimates of corporation tax from crude oil refining across Europe ranging from €1 billion in 2007 down to €0.8 billion in 2011.

¹²⁵ BP. *Statistical Review of World Energy*. June 2013.

¹²⁶ Pöyry. “Survey of the Competitive Aspects of Oil and Oil Product Markets in the EU”. December 2009.

¹²⁷ BP (2013).

¹²⁸ Pöyry (2009) suggests that the share of complex refining capacity out of total capacity in different European regions ranges between 32 and 42 percent. Refinery complexity is a continuum, and there is no precise definition of what distinguishes a complex refinery from a simple one, but this value appears to be a reasonable estimate.

¹²⁹ Refining capacity reported by Europia, available at <https://www.europia.eu/Content/Default.asp?PageID=397>

We have not identified data that would allow us to estimate profits from gas refining across European countries. However, we assume that any contribution to government revenues from gas refining does not exceed our materiality threshold.

B.1.2.2. Downstream corporation tax

The downstream element of the supply chain covers activities such as transporting fuel directly to consumers and the marketing of the final product – including retail supply of electricity and gas, heating oil, etc. In the case of transport fuels this is often via a service station, but for most coal, gas and power the energy is commonly transferred to the end user either directly or via a network of pipelines or distribution grids.

To estimate corporation tax receipts in this segment of the market we have focused on the retail supply of electricity, gas and coal to both residential and business customers as well as petrol and gasoline retail markets. We have also estimated corporation taxes from energy transportation, including electricity transmission and distribution as well as the distribution of gas through mains pipelines.

▪ Electricity retail

Our central estimate of profitability in the electricity retail market is based on information published by Ofgem, the UK energy regulator, in relation to the UK domestic market. Ofgem collects information on electricity and gas suppliers' costs and prices, and computes estimates of the net margin on a typical UK household bill on a monthly basis. In December 2011 the rolling average net margin for a typical household in a year was £30 (€35).¹³⁰ There are just over 26 million households in the UK and total domestic electricity consumption was 112 TWh in 2011. These data points imply a profitability of UK residential electricity supply of approximately €8 million per TWh. Scaling this up to the size of the total EU28 + Norway residential market, with a total supply of electricity of 845 TWh in 2011, suggests a total profit of approximately €6.9 billion.

We do not have publicly available information on the profit margins of non-residential electricity supply. We have therefore assumed that the two markets yield similar profit per unit of sales, so the net margin on a non-residential electricity bill is similar to that of the residential market.¹³¹

Applying an estimated profit of €8m per TWh to total non-residential electricity consumption in the EU28 + Norway, gives estimated annual profits in 2011 of €16.6 billion. As a check on this estimate, we also calculated total revenues from non-residential electricity supply in the

¹³⁰ We use the rolling average net margin as it reflects the historical average over the previous 12 months, rather than a spot net margin which is specific to the month in which it is reported.

¹³¹ In practice margins on non-residential supply may be lower than for households because the total energy costs of customers are higher – particularly for the largest and most energy intensive consumers – providing greater incentive for firms to “shop around” more actively for the best deal. Additionally, large industrial customers with significant energy needs are often given the option to purchase their electricity directly from the wholesale market, via traders. The impact of the assumption about the relative profitability of residential and non-residential electricity supply markets is fairly immaterial in the context of our results.

region, using data on consumption by sector and prices from Eurostat. Total revenues were approximately €276 billion in 2011. Our estimated €8.3 billion in profits corresponds to a net margin of approximately 6 percent. Based on our experience in the market, this appears a representative profit margin, and in fact may be an overestimate (in the UK, for example, margins have averaged significantly lower in recent years).

■ **Electricity transmission and distribution**

The electricity grid provides a network to transport power from generators to consumers. We include an estimate of corporation tax receipts from operating the grid as it is a key part of the electricity supply chain, and to provide a consistent approach to the treatment of gas supply. To approximate the profitability of the electricity transmission and distribution across the region we rely on information from the Eurostat SBS database. In 2011 gross operating surplus from electricity transmission in the EU28 + Norway was €11 billion, with a further €36 billion from distribution. As discussed above, gross operating surplus is an overestimate of profit as it does not reflect capital expenditures. As an approximation we have assumed that actual profits relevant to estimating corporation tax are only half what is reported under gross operating surplus. Applying this factor, we estimate total profits on electricity transmission and distribution to be approximately €9 million per TWh supplied.

Applying the country-specific corporation tax rates to these profit estimates gives a range of total corporation tax revenues from electricity retail, transmission and distribution (produced by oil, gas, coal, wind or solar generation technologies) of between €6.2 and €7.5 billion over the period from 2007 to 2011. These totals have then been allocated to the different energy sources according to their share of generation in each country and year.

■ **Gas retail and distribution**

Our approach to estimating corporation taxes for the gas retail and distribution market is similar to the one described above for electricity. Our estimate of supply margins in the residential sector are again based on Ofgem's monthly analysis. The 12-month rolling average net margin for gas supply in the UK in December 2011 was £40 (€46) per year per typical household.¹³² Considering the number of households connected to the gas network in the UK and their total gas consumption, we have estimated profits in this section of the market of approximately €4m per TWh. Scaling this estimate up to total residential gas supply in the EU28 + Norway gives an estimated total profit of €4.2 billion in 2011, and corresponding corporation tax receipts of €1.2 billion.

For the non-residential supply market, as per the approach taken to estimate profits for electricity supply, we assume that per unit profits are half those earned in the residential market. We estimate total non-residential profits from gas supply to be €3 billion across the region, providing a corporation tax estimate of €0.9 billion.

For gas distribution, we again refer to Eurostat SBS data. The gross operating surplus from gas distribution in the EU28 in 2011 was €13 billion. If we apply a factor of 50 percent to

¹³² This is generally reflective of net margins over the period from 2007 – 2011 (based on Ofgem data), although net margins were slightly lower than this level in 2009.

reflect the capital expenditure that reduces the profit relevant to corporation tax, we estimate total corporation tax receipts from gas distribution to be €1.8 billion.

▪ **Downstream coal supply**

The majority of coal consumption is in the power generation sector. However, coal is also an input to industrial processes and there is a limited market for household consumption of coal, most notably in Poland. We have carried out an analysis of potential corporation tax receipts from the sale of coal outside of the electricity sector. Our analysis is based on coal prices collected from the IEA Data Services and consumption across different sectors, reported by Eurostat. We have not identified public estimates of the average profit margin made by coal supply firms. If we assume a retail net margin of 2 percent our analysis suggests total profits between €186 and €237 million from 2007 to 2011.¹³³ Our estimates for likely corporation tax receipts therefore are in the range of €43 - 55 million over the period. We therefore assume that downstream coal supply provides an immaterial contribution to corporation tax receipts and exclude them from our main results.

▪ **Gasoline and diesel retail**

The majority of the downstream petroleum market is made up of sales of gasoline and diesel fuel used for transportation. We have reviewed information regarding the profitability of filling stations. Retail supply of gasoline and diesel is a particularly competitive market with low per unit profit margins. However, large volumes of fuel are sold.

The principal data source that we rely on for our estimate is a report by CBRE, a commercial property consultancy with significant experience in the downstream petroleum market.¹³⁴ CBRE reported estimates of profit per litre from gasoline and diesel sales for fifteen different European countries.¹³⁵ We have compared these profits to end-user prices of gasoline and diesel published by the European Commission. This implies an average net margin of approximately 2 percent of gross sales across the countries covered by CBRE's study. For comparison, the UK Petroleum Industry Association (UKPIA) publish information on the spread between the cost of gasoline and diesel from the refinery and the retail price. The data for 2011 indicated this spread to be 6 percent of the final price. This 6 percent must cover the cost of transporting fuel from the refinery to a storage facility and then on to the filling station, marketing and promotion costs, and the operational costs of the filling station. Anything left over counts towards the retailer's profit.

Total revenues from the sale of gas and diesel in the EU28 + Norway in 2011 were approximately €505 billion, based on prices reported by Eurostat and consumption information from the European Commission Oil Bulletin. Assuming a net margin of 2 percent suggests EU-wide profits from the supply of gasoline and diesel of €10.4 billion. Applying

¹³³ Even if the profit margin were up to 5 percent of the value of the coal, which is a high margin for the retail of a commodity, resulting corporation taxes would remain immaterial in the context of our study.

¹³⁴ CBRE. Market View: European Petroleum Retail Sector. September 2012.

¹³⁵ The countries include: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Hungary, Italy, Netherlands, Norway, Poland, Slovakia, Switzerland and the United Kingdom.

the relevant corporation tax rates for each country, we have estimated the contribution to corporation tax revenues across the region to be of the order of €2.9 billion.

B.1.2.3. Summary of corporation tax receipts

We have reviewed the supply chains of the different energy sources and identified the most significant areas of profitability. Assessing profits and corporation tax revenues is complicated by the fact that companies often operate across various parts of the supply chain. Information on company profits also is often only partially available in the public domain, and sometimes is not available at all. The information we have identified has allowed us to develop estimates of the likely corporation tax revenues from the most significant parts of the supply chain and to gain a sense of their relative order of magnitude both compared to other corporation tax contributions as well as to overall government revenues. Our estimates should, however, be treated with appropriate caution. They represent what we consider to be a reasonable attempt to estimate government revenues across a relatively diverse range of economic activities, based on the available evidence from a sample of countries and certain pan-European sources, and given the extent to which they materially affect the key results of our investigations. They should not be relied upon for purposes other than those for which we have developed them, and at a country level they may represent significant over- or under-estimates. Table B.1 summarises the estimates described in this section for 2011 at the EU28 + Norway level.

Table B.1
Estimated Corporation Tax Revenues for the EU28 + Norway in 2011

Part of Supply Chain	Oil	Gas	Coal	Wind	Solar
	<i>€ billion</i>				
Upstream	17	24	-	-	-
Midstream					
<i>Trading</i>	-	-	-	-	-
<i>Power Generation</i>	0.3	4.4	4.4	1.0	0.3
<i>Storage</i>	-	-	-	-	-
<i>Refining</i>	0.8	-	-	-	-
Downstream					
<i>Electricity retail</i>	0.1	1.5	1.7	0.4	0.1
<i>Power transmission and distribution</i>	0.1	1.6	1.7	0.4	0.1
<i>Gas retail and distribution</i>	-	3.8	-	-	-
<i>Coal supply</i>	-	-	0.1	-	-
<i>Gasoline and diesel retail</i>	2.9	-	-	-	-
TOTAL (incl. Upstream)	21.4	35.8	7.9	1.8	0.5
TOTAL (excl. Upstream)	4.2	11.4	7.9	1.8	0.5

Source: NERA analysis based on various sources outlined in text above

Notes: Oil and gas upstream corporation tax revenues are based on data for the top six producing countries and have been allocated to the two energy sources in proportion to their share of total oil and gas production value

The summary in Table B.1 shows that corporation taxes recovered on upstream oil and gas extraction activities account for a large proportion (around 62 percent) of total corporation tax revenues across the supply chains of the different energy sources. Excluding upstream revenues, which are recovered in significant amounts only by a handful of countries that have significant oil and gas reserves, we have estimated corporation tax revenues for the oil sector

of €4 billion; €11 billion for gas; €8 billion for coal; €2 billion for wind and €0.5 billion for solar. After upstream oil and gas revenues, the most significant contributions come from power generation (split among the relevant technologies), electricity and gas supply, and gasoline and diesel sales.

B.1.3. Excise Duties and Other Energy Taxes

Excise duty tax revenues are the single largest item among the different categories of government revenues and expenditures that we have reviewed and included in this study. According to data from Eurostat, the EU28 + Norway raised over €230 billion from energy taxes in 2011.

By far the most significant component of energy taxes is excise duties. The remainder is made up of taxes on greenhouse gas emissions, most notably carbon.¹³⁶ The European Commission has published excise duty tables showing the revenue collected by all EU member states on an annual basis from 2008 until 2012. The tables provide tax receipts from excise duties applied to different types of fossil fuel energy sources - including fuel oil, LPG, gasoline, diesel, natural gas, coal and coke - as well as electricity.¹³⁷ This has formed the basis of our data for this category of government revenue. We have not identified excise duty receipts, split by fuel, for 2007. Therefore, for 2007 we have taken total energy taxes in that year, as reported by Eurostat, and allocated them to the different fuels in proportion to the average split across oil, coal, natural gas and electricity over the years for which we do have relevant data (2008 – 2011). Croatia and Norway are not included in the excise duties reports. We have therefore supplemented European Commission data with additional information for these two countries. For Norway, we relied on overall energy tax data (discussed in more detail in the following paragraph). We have allocated energy tax revenues to the respective fuels in proportion to their share of final energy consumption, measured in tonnes of oil equivalent units.

As excise duties are a subset of total energy taxes, albeit the significant majority, we have carried out an analysis of the difference between energy taxes reported by Eurostat and the excise duty revenues reported by the European Commission's Taxation and Customs Union Directorate General (DG TCU). In theory total energy taxes reported by Eurostat should equal excise taxes plus additional energy taxes and carbon taxes. Between 2008 and 2011 we have estimated that the auctioning of carbon allowances under the EU ETS raised revenues ranging from €1 – 1.3 billion.¹³⁸ Other carbon taxes are in place, notably in Scandinavian countries, for which we have not obtained estimates.

¹³⁶ Taxes on NO_x and SO_x emissions are generally reported to Eurostat by member countries under the umbrella of environmental taxes. They are therefore not included among energy taxes. We do not include them within our data as it is not possible to split revenues from pollution taxes that are not associated with energy (for example NO_x and SO_x tax revenues are combined with other taxes such as landfill tax for reporting purposes).

¹³⁷ See, for example: European Commission Directorate General Taxation and Customs Union. Excise Duty Tables: Tax receipts – energy products and electricity. July 2013.

¹³⁸ Based on data reported by the European Environment Agency (EEA) emissions trading viewer, and EUA prices published by Point Carbon.

In 2011 excise duties, reported by DG TCU, accounted for 94 percent of total energy tax revenues reported by Eurostat in the EU27.¹³⁹ Revenues from *excise duties* are broken down by fuel type (*energy tax* revenue data are not reported by fuel type). Because energy tax data are not split by fuel type and because for some countries the data on excise duty receipts actually *exceeds* that of energy tax receipts (as noted in footnote 139), we have chosen to include only the excise duty data.¹⁴⁰ Reported energy taxes for the EU27 + Norway in 2011 were approximately €230 billion, of which €216 billion were collected as excise duties.¹⁴¹ At the level of the EU28 and Norway, our approach therefore under-reports total energy taxes by approximately €14 billion.¹⁴² Figure B.3 shows the government revenues from excise duties that we calculate for the different energy sources for 2007 to 2011. Between 84 and 87 percent of all government revenues come from sales of oil-based products, such as gasoline and diesel.

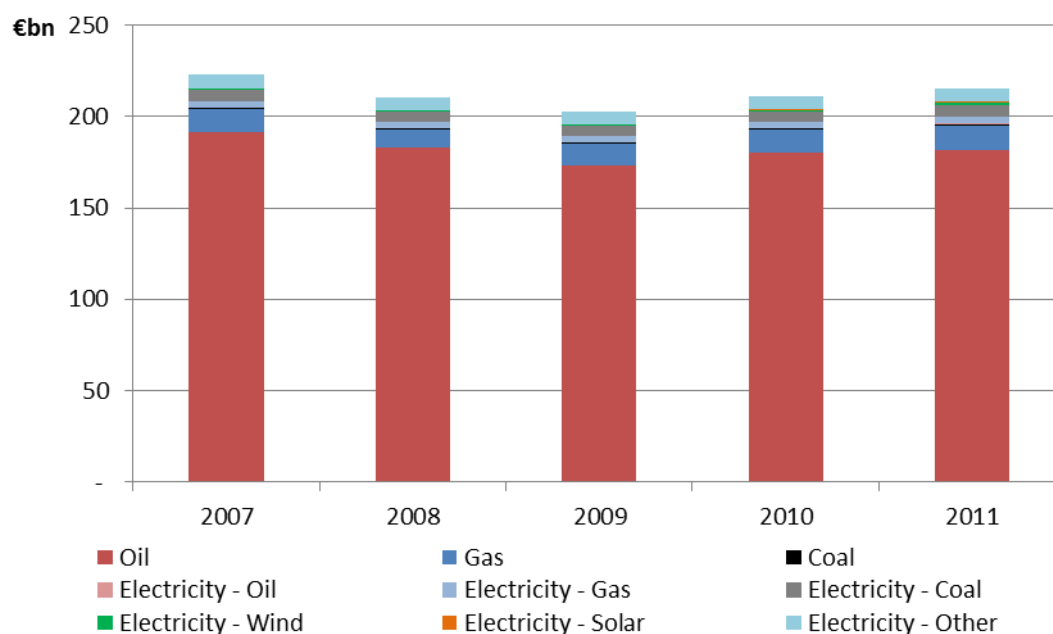
¹³⁹ This is representative of the years over which we compared the two data sources. In each year between 2008 and 2011 excise duties made up between 94 and 96 percent of total energy tax revenues. Note that there are a few countries and years in which the data indicate higher excise duties than energy taxes in a given year. The difference is generally within a few percentage points, and we have not attempted to investigate the reasons for the apparent discrepancies.

¹⁴⁰ As noted in the previous paragraph, figures for Norway are based on the energy tax data reported by Eurostat, as only EU countries are included in the DG TUC excise duty receipts data publication.

¹⁴¹ Eurostat data does not include energy taxes paid in Croatia in 2011. As a result we have reported the value for the EU27 here, rather than the EU28. We expect the contribution in Croatia to be negligible relative to the total.

¹⁴² Note that this €14 billion would be allocated across the five energy sources.

Figure B.3
Excise Duty and Other Energy Taxes Government Revenues Allocated to Energy Sources (2007-2011)



Source: DG TCU (excise duty revenues) and Eurostat (energy taxes and electricity generation).

Notes: 1. Allocation among fuels for 2008 – 2011 based on excise duty tax receipts in each year;
 2. 2007 data based on average 2008-2012 allocation for each country;
 3. Norway data based on energy tax receipts;
 4. The “Electricity – Other” category represents the share of electricity generated by sources other than oil, gas, coal, wind and solar. It is shown here for completeness but is excluded from our main results.

As well as including energy taxes collected on the consumption of coal, oil and gas, we have also included those collected on the consumption of electricity. Electricity excise duties are relatively small compared to oil and gas revenues, but are nonetheless significant and higher than the corresponding tax receipts on coal consumption (as shown above in Figure B.3). We have allocated excise duties associated with electricity consumption to each energy source based on its share of electricity production in the relevant year and country. For example, in 2011 excise duties collected on the sale of electricity in Germany were €7.2 billion. Electricity generated from wind turbines in 2011 accounted for approximately 9 percent of total electricity output. We therefore allocated just over €600 million ($€7.2 \text{ billion} \times 0.09$) of excise duty revenue to wind in Germany in 2011.¹⁴³

¹⁴³ The share of electricity generation by technology/fuel for each country and year were obtained from Eurostat. Note that we do not include all excise duties from the sale of electricity, as our study does not include a range of different technologies and fuels used to generate electricity, such as nuclear, hydropower, or biomass power generation.

B.1.4. Value Added Tax

After excise duties, value added tax (VAT) on the different energy sources is the second largest single line item contributing to government revenues. We estimate that annual VAT contributions to government revenue across the different energy sources range between €127 and €162 billion from 2007 to 2011. VAT is applied to the final price of a good or service. The rate of VAT varies across countries, and within countries it can also vary by the product type. For example, in the UK the sale of gas and electricity to domestic customers is subject to a lower rate of VAT (5 percent) than the standard rate applied to many other goods and services in the economy (currently 20 percent). VAT rates have also varied over time.

We are not aware of any single data source that breaks down VAT revenues by product type (or by energy source) across Europe.¹⁴⁴ To calculate an estimate of VAT revenues we have relied on a variety of different data sources, as well as selected assumptions. The three principal pieces of information required in order to estimate VAT revenues are:

- VAT rates, expressed as a percentage, applied to different energy products over recent years for each country considered in this study;
- The final price of the different energy products, inclusive of VAT, for each country and year;
- Final consumption of the different energy products for each country and year.

Both standard and sector specific ‘lower’ rates of VAT are published by the European Commission.¹⁴⁵ Most countries apply a similar rate across all goods and services in the economy. However, there are various cases, such as the UK residential market, in which energy is subject to a reduced rate of VAT. Based on the European Commission, supplemented with country specific research, we created a database with the VAT rate in each country between 2007 and 2011 applied to petroleum products, natural gas, coal and electricity.

We obtained price information from a variety of sources. Where possible we collected price information for both domestic and business consumers. This is because prices differ across consumer groups and because, in certain instances, VAT rates also differ. End user prices for natural gas and electricity, for each country in the EU, are published by Eurostat. These are broken down into residential customer prices and industrial user prices. We used price information for petroleum products reported in the European Commission’s Oil Bulletin, supplemented in the case of Norway with data from the Norwegian Petroleum Institute (Norsk Petroleumsinstitutt).¹⁴⁶ In our analysis we used prices for gasoline, diesel, fuel oil,

¹⁴⁴ We have reviewed VAT receipts from various individual country tax and customs authorities in Europe for comparison. In certain cases VAT receipts from petroleum product sales are available, however these tend to be net of reimbursements made to businesses (for example VAT receipt data on oil products in France obtained from the French Customs Authorities, CPDP, is approximately 20-30 percent lower than our estimates, which we understand to be because it excludes receipts from commercial transporters who receive VAT reimbursements).

¹⁴⁵ European Commission. Vat Rates Applied in the Member States of the European Union as at 1 July 2013; Eurostat. Taxation Trends in the EU. 2013 edition.

¹⁴⁶ European Commission DG Energy. Market Observatory & Statistics. Oil Bulletin. Available here: http://ec.europa.eu/energy/observatory/oil/bulletin_en.htm; and Norsk Petroleumsinstitutt. Norsk forbrukerpriser - årgjennomsnitt. Available at <http://www.np.no/priser/>

heating oil, and LPG in each country. Public information on coal prices in different EU countries is less readily available. We sourced coal prices from the IEA for some countries, covering end user prices for domestic consumers, prices for industrial users and the price paid for power generation supplies. These data are incomplete. For some countries we only obtained prices for particular customer segments. In this case, we applied an average adjustment factor, derived from other countries with more complete data, to infer, for example, domestic prices from industrial prices. For countries where we were unable to obtain price data, we have estimated average prices based on those reported for neighbouring markets.

Final consumption information for each fuel (the different petroleum products, natural gas, solid fuels and electricity) was sourced from Eurostat, the EU Oil Bulletin and Norsk Petroleumsinstitutt (for Norwegian petroleum product consumption). We extracted consumption data by consumer segments, enabling us to obtain the respective split between domestic and non-domestic sectors for each fuel type.

Based on these data we then calculated the estimates for government revenues from VAT following the four steps outlined below. For each country, year, fuel type and customer segment (residential and non-residential), this involved:

1. Starting with the end-user fuel price per unit, inclusive of all taxes;
2. Identifying the per unit VAT component of the final price, based on the country- (and fuel-) specific VAT rate;
3. Multiplying the per unit VAT component of the end-user price (2) by the final consumption of the product.¹⁴⁷

Our estimates indicate total VAT receipts across the different energy sources of €162 billion in 2011. As per our approach to treating excise duties collected on the sale of electricity, we have allocated the estimated VAT from electricity consumption in proportion to each fuel's share of electricity production in the relevant year and country.

In many countries the end user electricity price faced by households and industry includes an element that is used to provide support to renewable generators. For example, in Germany a line item on the electricity bill is specifically used to cover the cost of the EEG (the renewable support scheme in Germany). An alternative approach to allocating the VAT from electricity sales across the five energy sources would deduct the VAT on this part of the end user electricity price and, instead, allocate it to the different renewable technologies that it is used to support. This method should provide results similar to estimating VAT in proportion to the *total revenues* of power generators using different technologies, rather than only the revenues from the electricity market. Adopting this alternative approach would reduce by approximately €3.6 billion the VAT revenues allocated to oil, gas and coal and would add approximately €0.8 billion of revenue to wind and over €2 billion to solar. When measured in terms of barrels of oil equivalent of primary energy consumption our estimates indicate that wind revenues might increase by approximately \$9 per boe and solar revenues by

¹⁴⁷ We have not included as “consumption” the transformation of energy products, such as power generation or coke production, due to data availability. Also, in many countries input fuels to power generation are not subject to VAT.

approximately \$100 per boe.¹⁴⁸ However, in our main results we adopt the approach of allocating revenues from sales of electricity to each energy source in direct proportion to their share of generation, as outlined above, because this approach reflects better the value of the final end-use product, which is electricity.

B.2. Estimating Government Expenditures and Mandated Transfers

Combined government expenditure on the different energy sources is significantly less than government revenues received through taxation. However, government spending is heavily weighted towards wind and solar energy sources and, to a lesser extent, coal. We have estimated total government expenditures of approximately €30 billion in 2011, which can be broken down to: €0.2 billion for oil, €0.4 billion for gas, €3.8 billion for coal, €8.9 billion for wind; and €16.7 for solar. Our analysis has also estimated the corresponding values for the years 2007-2010.

In estimating government expenditure in the oil, gas and coal sectors we have relied heavily on the OECD inventory of fossil fuel support as well as the complementary work carried out by the IVM, on behalf of the European Commission, covering the remaining EU countries that are not OECD members.¹⁴⁹ We have reviewed this work in detail, examining each line item within the inventory to validate its compatibility with our approach to measuring government expenditures. The majority of the inventory, both in terms of line items and value, relates to tax expenditures. As described in the methodological section of this report (Chapter 3 above) tax expenditures are not relevant to our analysis as they rely on country- and fuel-specific benchmark tax rates that cannot be compared in the way that is required for our work. For those line items that do relate to direct government expenditure we have segmented them into different categories corresponding to different parts of the supply chain as well as particular types of support that do not directly impact on current production or consumption.

It is important to note that the OECD inventory is incomplete due to data availability issues (something the OECD authors are careful to acknowledge). Where possible the OECD carried out estimations of support levels, however this was not feasible in all instances. Where data were noted as unavailable we have not attempted to estimate such support ourselves, as in most cases the amounts are likely to be immaterial, and it is beyond the scope of our study to carry out a detailed country-by-country review of individual tax items.

We supplement the OECD work with certain additional areas of support that we have reviewed and consider to warrant inclusion. This includes R&D support for the different energy sources.

We have estimated the financial support to wind and solar generators provided through Feed-in-Tariffs and supplier obligation or quota schemes, as well as further support provided

¹⁴⁸ Under this alternative approach total net government revenues and mandated transfers across all revenue and expenditure categories for wind would increase from -\$13 per boe (under our standard approach) to approximately -\$4 per boe. Total net revenues for solar would increase from -\$821 to -\$610 boe.

¹⁴⁹ Croatia is the only exception to this coverage as they have only recently joined the EU. We have not attempted to review government support in Croatia.

through electricity grid reinforcement. We also consider non-financial support to renewables provided through priority grid access, but we find this not to exceed our materiality thresholds. In the following paragraphs we summarise the data and sources of the different categories of expenditure included in our report.

B.2.1. Resource Extraction Support

Support for resource extraction is taken from the OECD inventory and is exclusively received by the coal sector. In several European countries coal extraction is loss-making and has been supported by governments in order to promote energy security and to manage the declining competitiveness of the sector relative to imports. We have validated the data in the OECD inventory against State Aid to coal mining that is reported by the competition authority of the European Commission.¹⁵⁰ The two sources are broadly consistent and we have relied on the OECD inventory because it provides a more detailed breakdown of the different types of payment. In all countries support is in the process of being phased out under EU rules. However, significant transfers have been made over the period of our assessment, most notably in Germany and, to a lesser extent, Spain. Between 2007 and 2011 support to the German coal mining industry ranged between €1.5 to €2.5 billion, which was approximately 80 percent of the total coal extraction support across the region.

B.2.2. Electricity Generation and Supply and other Midstream Sectors

B.2.2.1. Electricity Generation Support

The most significant ‘government expenditure’ on the energy sources covered by this study is support to wind and solar power generation technologies. As discussed in the main report (section 3.3.3) payments to the wind and solar sector are not, in fact, always in the form of direct payments from the government. Support is also provided via policy obligations on electricity suppliers to source a certain quota or share of power from renewable sources. Here we consider both forms of support; direct payments and supplier obligations, to constitute government expenditure.

We have relied upon data on renewable energy support for each country collected by the Council of European Energy Regulators (CEER). CEER have undertaken two surveys of their members, requesting data on the rates of support for different renewable technologies, the electricity output supported and total support costs in a given year. These two reports were published in 2011 and 2013 and include renewable support estimates for the three years from 2009 to 2011.¹⁵¹

The CEER data on total support costs covers 16 countries for 2009 and 18 countries for 2010 and 2011. Whilst several countries did not provide cost data to the CEER, the figures represent approximately 88 percent of wind and 95 percent of solar output in the EU28 + Norway, which we consider to provide sufficient coverage from which to derive a reasonably

¹⁵⁰ DG Competition. State Aid to coal mining by Member State (2006-2011). Available at: http://ec.europa.eu/competition/state_aid/studies_reports/expenditure.html

¹⁵¹ CEER. Report on Renewable Energy Support in Europe. May 2011; CEER. Status Review of Renewable and Energy Efficiency Support Schemes in Europe. June 2013.

accurate estimate of support. The data that we report, obtained from the CEER, covers support via Feed-in-Tariff (FIT) or supplier obligation schemes.¹⁵² The 2009 data excludes any additional support provided to the sector in the form of investment grants or loans. However, the data for 2010 and 2011 does include grant support. Any such one-off payments are spread across the lifetime of the asset in order to prevent distortions in inter-temporal comparisons and provide equivalent treatment to that of FIT payments.

Across the countries covered by the CEER reports, total RES support in 2009 was estimated at €19 billion, rising to €34 billion in 2011. Wind and solar accounted for just over half of all renewables support in 2009, increasing to approximately 60 percent in 2010 and almost 70 percent in 2011 as solar deployment, which receives one of the highest levels of support per unit of output, has expanded. These figures are higher than EU level estimates over the same period referenced by the European Commission in their impact assessment of the proposed energy and climate change policy framework to 2030.¹⁵³ We have not identified any more detailed information about the European Commission approach to calculating these amounts, and therefore rely exclusively on the CEER data in our analysis.

For those countries included in the CEER dataset that have support information for only certain years, we have applied the technology specific average per unit support rate from the year's in which we have observations to the wind and solar output in the year's lacking data. We have calculated the average technology specific support rate across the countries covered by the study. For the countries that are not included in either CEER report, we have then applied this average rate to wind and solar output respectively to create an estimate for support.

As we noted in the government revenue section, the UK applies a Climate Change Levy (CCL) to sales of electricity, as well as other energy types, to business consumers. Renewable electricity, that is approved and certified, is exempt from the CCL. The energy regulator awards Levy Exemption Certificates (LECs) to renewable power generators for every MWh of output produced that can then be used to avoid payment of the CCL. These certificates therefore hold an implicit value and are used as an additional means to support renewable technologies in the UK. We have used data published by HMRC to derive the number of LECs awarded to wind and solar generators between 2007 and 2011. LECs are often sold alongside the power that they correspond to, so their price is not publicly observable. However, we estimate their value to be the rate of CCL as this is the price a consumer would have to pay without a LEC. It therefore represents the maximum willingness to pay of a business consumer and is an appropriate estimate of value given that there has been excess demand for LECs over the period considered.

¹⁵² Note, the support under FIT regimes is calculated as the FIT payment, per unit of output, minus an estimate of the average baseload electricity price over the relevant period (as this proxy for the value of the electricity would otherwise be earned by the generator). The support under a supplier obligation scheme is calculated by multiplying the number of RECs or ROCs awarded by an estimate of the market price for these certificates.

¹⁵³ The European Commission cite RES support in the EU of €13.7 billion in 2009, €18.6 billion in 2010 and €30.1 billion in 2011. These numbers are not broken down by country or by technology. (European Commission. "Impact Assessment: A policy framework for climate and energy in the period from 2020 up to 2030." 22 January 2014.

In addition to renewable electricity generation support, the OECD inventory also identifies several cases of support for coal and gas power generation. Support is relatively minor - between 2007 and 2011 total support has ranged between approximately €100 and 700 million – and is largely allocated to the coal sector, where Poland is the most significant contributor. Similar to the case of support for coal extraction, these transfers tend to support struggling coal power plants that have obligations to use a certain quota of domestically produced fuels. There is also minor support, via a FIT scheme, to natural gas power generation with Combined Heat and Power (CHP) technology in Slovenia.

B.2.2.2. Priority Grid Access

In addition to support through FITs or RECs, renewable electricity generators in some European countries also receive non-financial benefits through provisions granting “priority access” to the power grid. Priority grid access provides support to electricity generators and imposes a cost on the wider industry – and is therefore similar to other mandated transfers. CEER (2013) reports that nine EU countries provide priority grid connections and twelve EU countries provide priority grid access to renewable energy generators.¹⁵⁴

Estimates of the total value of these provisions are difficult to come by. One way of estimating their value is to consider what renewable generators would have to pay in a competitive market for contractual terms that secured priority access to the grid. An indication of the cost of such contracts can be deduced from the terms agreed between renewable generators and the retail suppliers to whom they sell their power to gain access to final customers. Recent National Grid analysis for the UK Department of Energy and Climate Change (DECC) has examined the discounts, relative to the wholesale market price, that are typically agreed between intermittent renewable generators in the UK and retail suppliers under power purchase agreements that provide a firm commitment to buy all power produced by the renewable generator. DECC’s research suggests that the size of this discount ranges from 5 to 13 percent of the wholesale electricity price.¹⁵⁵

We have investigated the importance of priority grid access for renewable electricity generators in Europe based on this information. Applying a 5-13 percent discount to a snapshot of 2011 wholesale electricity prices in the twelve countries that provide priority grid access to renewable energy sources suggests that the total annual value of this policy across Europe might have ranged between €300 and €900 million. This is approximately between 1 and 4 percent of the total support that we estimate based on CEER’s analysis in 2011 (€23 billion). We have not attempted to develop more detailed estimates of the total value of this support.

¹⁵⁴ The countries that provide priority grid access are: Belgium, the Czech Republic, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia and Spain.

¹⁵⁵ National Grid EMR Analytical Report, December 2013, Annex 7 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/267614/Annex_D_-_National_Grid_EMR_Report.pdf).

B.2.2.3. Grid Infrastructure Investment Support

In this section we consider investments in the electricity transmission and distribution grid. The cost of maintaining and developing the electricity grid is ultimately borne by electricity consumers, although the precise means of allocating the direct and indirect costs of the network among different producers and different types of consumer varies across countries. Transmission system operators (TSOs) invest significant amounts in order to improve the condition of the network and to manage connections between generating plants, midstream infrastructure, and customers. Existing power grids in the EU were commonly designed around a limited number of conventional thermal power generation plants that produce large amounts of electricity on one site. In recent years the power generation mix has begun to shift away from thermal generation towards smaller scale renewable plants, which are spread across many sites in different locations, and this may impose pressures on the network.

The cost that a particular type of generation technology imposes on the grid can depend on the state of the infrastructure that is in place and the location of the capacity. This varies both between countries and also within them. Wind and solar technologies may impose a higher-than-average cost on the grid for two main reasons. Wind farms are often located in remote areas (including at sea) where wind conditions are optimal, but which tend to be far removed from demand. In recent years this has required new connections to be developed between the supplier and the customer. Additionally, wind and solar technologies are intermittent - meaning that they only generate some of the time, dependent on the strength of the wind and sun – which may impose additional system costs in terms of reinforcement, balancing and in requiring increasing amounts of more expensive back up capacity to be available.

The cost of connecting any new generating capacity is ultimately borne by customers, but depending on the regulatory regime for transmission pricing and cost allocation, the addition of wind and solar capacity may result in consumers bearing higher transmission and distribution costs than would be the case if more conventional forms of capacity were connected. Whether this is categorised under our methodology as a form of government-mandated transfer depends on the details of the regulatory frameworks. For example, under a transmission charging regime in which renewables generators must pay for the full incremental transmission costs that they impose on the grid (including not only their connection costs, but also the costs of any grid reinforcement that is required to manage intermittent generation), then for any capacity to be built in the first place, the support that it receives from government (through FITs, green certificates, and the like) must be enough to cover the costs that it must pay to the TSO / network. In this case, the FIT or certificate support captures all of the mandated government transfer. On the other hand, under a charging regime in which any (RES) generating source *must* be connected, and any connection (or other system) costs are simply pooled to be recovered from customers, this amounts to an *additional* transfer from customers that has not been reflected in the government's main RES support instrument. In the latter case, not accounting for the network costs might be considered to underestimate the value of the support afforded by government policy. However, any judgment of support here would first require an endorsement of one or another “standard” way of allocating costs for network services, which we have sought to avoid in other contexts for our analysis.

The estimation of the incremental cost, if any, imposed by intermittent wind and solar generation technologies often requires detailed and complex system modelling. We are not

aware of pan-European data sources available to assist in informing the likely magnitude of such costs. Various studies forecast necessary spending on upgrading the electricity network across Europe over the coming decades, but these relate to expected *future* costs.¹⁵⁶ These studies provide forecasts for future investments, in a world with significantly more intermittent generation, higher overall electricity demand and sophisticated “smart” grids, whereas we are interested in the actual spending made by TSOs over the past five years.

Between 2007 and 2011 solar output across the EU28 + Norway has risen by approximately 42 TWh and wind output by 75 TWh. These increases are significantly below the increases in the Power Perspectives modelling (one-seventh what is projected in the future for solar, and around 40 percent of what is projected for wind). A crude scaling of the estimated network costs of €0.1 billion per TWh per year estimated in the Power Perspectives analysis would suggest that the annual incremental cost imposed by wind and solar on grid investments is likely to have been of the order of up to €3.5 billion, and possibly significantly less.¹⁵⁷

We have not identified relevant data of a pan-European nature that explicitly highlights any incremental cost imposed on the grid by additional solar and wind capacity between 2007 and 2011. For this reason, and because of the risk of double-counting government-mandated transfers that are in fact already reflected in estimates of core EU RES support mechanisms, we do not include any values of such support within our dataset. With significant grid upgrades expected over the coming years, this may well become a more important item of support in future years.

¹⁵⁶ Examples include the European Commission impact assessment on a proposal for trans-European energy infrastructure (2011), and ‘Power Perspectives 2030’, a contributing paper to the European Climate Foundation’s (2011) Roadmap 2050. According to the former approximately €140 billion of spending is required in the EU by 2020 (i.e., approximately €17 billion per year) on high voltage transmission and smart grid applications at both transmission and distribution level, on top of maintenance and refurbishment costs. The ‘Power Perspectives’ report expects that the required spending from 2020 to 2030 on the transmission grid could be as much as €138 billion in a high RES scenario, or around €14 billion per year. This is around one-tenth of the capital expenditure that is expected to be required for generation assets during the period. However, much of the grid costs would go to replace outdated grid infrastructure and is intended to improve connectivity between countries irrespective of the use of RES generation capacity, which is spending that is not relevant to our study.

The Power Perspectives report models various scenarios. In their base case (“On Track”) it forecasts €68 billion worth of capital expenditure from 2020 to 2030 in the case where the RES share of total generation is 50 percent in 2030. The report also considers a “High RES” scenario in which the RES share reaches 60 percent in 2030, with an additional 290 TWh of solar and 190 TWh of offshore wind, relative to the base case. The investment required in the transmission network over the ten years between 2020 and 2030 in this High RES scenario is expected to be approximately €70 billion higher, at €138 billion.

European Commission working paper. “Impact Assessment accompanying the document: Proposal for a Regulation of the European Parliament and of the Council on guidelines for trans-European energy infrastructure and repealing Decision No 1346/2006/EC”. October 2011; and, European Climate Foundation. Power Perspectives 2030: On the road to a decarbonised power sector. November 2011.

¹⁵⁷ This tentative analysis is based on a linear relationship between additional renewable capacity and the required investment in the grid. In practice the relationship is unlikely to be linear, because below certain penetration levels, the system impacts of intermittency are more limited. These impacts may have begun to be relevant (at the time of writing) in some EU countries with high RES penetration, but we suspect that they have not yet been very significant.

B.2.2.4. Other Midstream Support

The only additional government support for midstream activity that we have identified is provided to Spain. Minor payments are made to support the transportation of coal, as well as coal stockpiling at power stations in order to ensure sufficient reserves at the plant to fuel power generation for a given number of days. Data points are taken from the OECD inventory. Total support for both stockpiling and transportation ranged between €10 and €26 million from 2007 to 2010 and were zero in 2011. These figures are included for completeness as they form part of the OECD dataset, even though they are immaterial.

B.2.3. Consumption Support

Consumption support in 2011 was €2.4 billion, approximately three quarters of which was provided to petroleum products, such as transport fuels. Most downstream support in the OECD inventory is in the form of tax expenditures, which we do not include within our analysis. However, we do include any tax refunds that are made and these make up by far the most significant share of this category of expenditure. For example, in France road freight that can show it purchased diesel within the country is eligible to receive a partial refund on the excise duty included in the diesel price. This is distinct from a tax expenditure in that the full excise duty is initially paid and only returned subsequently. However, from the perspective of incentivizing the use of diesel, it is similar to a tax expenditure. We include tax refunds principally for consistency as the full tax payment that is initially made is included in our government revenue data.

Consumption support also includes grants made to support energy use by fuel poor households that either come directly from government or are funded indirectly through an uplift on consumer energy bills. Support is also provided to filling stations in remote areas of France and to subsidise rail transport fuel in Romania, however, these contributions are minor. We have sourced all data for this category from the OECD inventory.

B.2.4. Historical Liability Transfers

Historic liabilities are exclusively sourced from the OECD inventory and relate to the coal sector. We have also cross-checked the OECD data with approved State Aid to the coal mining industry that is reported by the European Commission DG Competition. This category of government expenditure refers to liabilities incurred by coal producers with respect to historic production. Examples of support in this area include payments made to coal miners as compensation for health issues suffered as a result of their working conditions and as a result of the long term structural unemployment caused by closing down coal production sites. These payments are approved by the European Commission under State Aid rules. Other areas of support cover government payments to fund decommissioning of coal mines and payments made to compensate for environmental damages caused in the past. Total payments in this category in 2011 were approximately €0.9 million. Germany, Spain, the Czech Republic and Poland accounted for the majority of these payments.

It is important to note that historic liability transfers do not impact current production levels. Whilst they do constitute support to the coal industry, and likely reflect an underinvestment by coal producers in the past, payments are currently made in order to improve social welfare and not to promote the extraction and use of coal.

B.2.5. Research and Development Transfers

As discussed in the main body of the report, governments make contributions to research and development (R&D) funding in energy sectors. Government expenditure on energy-related R&D represents a demand on the public budget. The OECD inventory, which we have relied on as our principal data source for government expenditures, includes very limited coverage of R&D support. We have investigated the size of such transfers focusing on specific countries, using the IEA's country-specific Energy Policies reviews as well as the IEA/OECD database of R&D spending.

The IEA/OECD database of R&D support provides a breakdown of government expenditure on R&D in the energy sector, broken down into different energy sources.¹⁵⁸ The data are collected by the IEA from its members via a questionnaire, circulated to the relevant government departments responsible for reporting this information. The coverage of the data is limited to OECD members and, of those, various data points are not reported.¹⁵⁹ We have taken the available estimates for R&D spending in the following sectors: coal, oil & gas, wind, solar and carbon capture and storage technology (CCS).

To reflect expenditure by those countries that are not in the IEA/OECD database, or that are missing data points, we have calculated the average spending on each sector over time and across countries as a fraction of total GDP. We have then used these fractions to estimate the average expenditure in each energy category across each country for which data are missing. For example, R&D spending in the wind sector across the 15 countries for which the IEA/OECD database includes estimates totalled €160 million in 2011. These countries accounted for a combined GDP of €11.9 trillion in the same year. We then apply the share of wind R&D in total GDP (0.001 percent) to the GDP of countries with missing data to arrive at an estimate of expenditure on wind R&D.¹⁶⁰

The oil and gas sectors are not separated within the IEA/OECD database. Across all countries in the study, our estimate for 2011 spending specifically on the combined oil and gas sector is €161 million. We have split the total for each country based on each energy source's relative share of domestic production, measured in tonnes of oil equivalent. In 2011 this leads to €94 million allocated to oil and the remaining €67 million allocated to gas. Because CCS has the potential to support large-scale fossil fuel combustion across any of the three main fossil fuels, we have then allocated total CCS R&D spending (€122 million in 2011 for EU28 + Norway) to each of the fuels in proportion to its share of electricity generation in each country.¹⁶¹

¹⁵⁸ The database is available via the OECD iLibrary here: http://stats.oecd.org/BrandedView.aspx?oeed_bv_id=enetech-data-en&doi=data-00488-en

¹⁵⁹ There are 7 countries covered by our study that are not OECD members. These are: Bulgaria, Romania, Croatia, Cyprus, Malta, Latvia and Lithuania.

¹⁶⁰ This approach implicitly assumes that R&D spending is proportional to GDP and the average across the countries for which we have data provides a representative split for the energy sectors that receive the funds.

¹⁶¹ CCS spending will not necessarily benefit the different energy sources in direct proportion to their current share of electricity generation. For example, it may disproportionately benefit the coal sector due to the higher carbon content of coal per unit of energy. CCS technology is also likely to be used in areas other than electricity generation, notably in energy-intensive industry where combustion takes place on site. However, absent further information on the precise beneficiaries of CCS R&D funding we have chosen the approach of allocation based on electricity generation. The

Table B.2 provides a breakdown of the allocation of R&D support to the different energy sources, including the respective shares of the contribution towards CCS.

Table B.2
R&D Support Estimates for EU28 + Norway (2007-2011)

	2007	2008	2009	2010	2011
Energy Source	<i>€ millions</i>				
Oil	147	145	118	118	98
Gas	117	126	127	129	146
Coal	86	92	93	69	76
Wind	62	85	103	168	176
Solar	182	276	257	289	338
TOTAL	594	723	699	773	834

Source: IEA/OECD Database on R&D budgets; IMF World Economic Outlook Database (GDP estimates) and NERA analysis.

Total R&D support across all years and all energy sources ranges between €594 million in 2007 and €834 million in 2011. This is relatively small in the context of total government revenues and expenditures, although it is more significant when compared to other expenditures. Solar technology consistently receives the highest level of support, with the relative ordering of the other energy sources varying by year.

expenditure is relatively small in the context of total R&D spending on the energy sources and an immaterial data item in the wider context of our study.

Appendix C. Shadow Price of Carbon Used in the Study

C.1. Overview of Approaches

There are different approaches available for deriving an estimate of the value of the negative externality associated with greenhouse gas (GHG) emissions (commonly referred to as the shadow price of carbon) for use in policy discussions. Two approaches frequently used are:

- the ***social cost of carbon*** approach, which reflects estimates of the marginal damage to society caused by emissions. For example, this approach is used by the United States Environmental Protection Agency (EPA);
- the ***abatement cost*** approach, which reflects the expected cost of reducing emissions to achieve an overall target emission level selected to achieve a politically or socially accepted level of risk related to climate change. This approach is used by the UK government in its policy and investment appraisal framework.

Social cost of carbon estimates are derived from models that are subject to a high degree of uncertainty, and the academic and policy literature contains a large number, and a wide range, of estimates. Abatement costs are often estimated by comparing the relative costs of technologies that deliver the same product or service but with different carbon intensities, so the uncertainty associated with these estimates is typically lower – although they can also be very uncertain, particularly when projecting costs far into the future. Additionally, abatement costs also may be inferred from market data for emissions that are covered by a cap and trade system, where the cost of allowances provides a natural estimate of the target-consistent abatement cost. There are different cap and trade systems that may be considered relevant to this study, among them the EU ETS and the emissions trading system established under the Kyoto Protocol.

For the present work, we provide a brief survey of approaches to estimating the shadow price of carbon, drawing on examples of both the social cost of carbon and the abatement cost approach. In addition, we have also reviewed market data on emissions allowances in the EU ETS. We discuss some of the widely used estimates in the following section.

C.2. Review of Estimates Available in the Literature

C.2.1. The United States Environmental Protection Agency

The US EPA conducted significant work in 2010¹⁶² to bring together estimates of the social cost of carbon that had been estimated using three different Integrated Assessment Models (IAMs).¹⁶³ In 2013, the EPA published an update of its collected estimates of the social cost of carbon, following revisions to the underlying models.¹⁶⁴

¹⁶² EPA (2010), “Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis”, February 2010

¹⁶³ The three IAMs used by the EPA are DICE, FUND and PAGE.

¹⁶⁴ EPA (2013), “Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis”, November 2013

Social cost of carbon estimates vary significantly with the choice of discount rate. The choice of discount rate and the general uncertainty of modelling scenarios far into the future have led EPA to find a very wide range of estimates: from as low as -29 USD/tCO₂ to as high as 955 USD/tCO₂.

To reflect the general uncertainty associated with its estimates, and to acknowledge the significance of the discount rate, EPA published a range of central estimates of the carbon cost. These include averages from the three underlying models for three different discount rates, as well as an average of the 95th percentile value. The most recent EPA estimates (from 2013) of the cost of 2010 emissions are shown in Table C.1 below.

Table C.1
Estimates of Social Cost of Carbon – US EPA

	Average			95 th Percentile
<i>Discount rate</i>	5.0%	3.0%	2.5%	3.0%
\$/tCO ₂ (2007 \$)	11	32	51	89
€/tCO ₂ (2011 €)	9	25	40	70

Source: US EPA (2013), NERA analysis

Note: Original values reported in 2007 dollars have been converted to 2011 Euros.

C.2.2. Review of Social Cost of Carbon Estimates by Richard Tol

The economist Richard Tol has undertaken several reviews of estimates of the social cost of carbon reported in the literature. Tol is also the original developer of the IAM model FUND, which is one of the models used by the EPA for its estimates of the social carbon cost of carbon. Tol (2009) reviews 232 published estimates of the social cost of carbon, and fits a probability distribution to them.¹⁶⁵ The estimates collected in Tol (2009) are shown in Table C.2 below.

Table C.2
Estimates of Average Social Cost of Carbon – Tol (2009)

<i>Discount rate</i>	3%	1%	0%
\$/tC (1995 \$)	50	120	147
€/tCO ₂ (2011 €)	16	38	47

Source: Tol (2009), NERA analysis

Note: Original values reported in 1995 dollars and tonnes of carbon have been converted to 2011 Euros and tonnes of CO₂.

¹⁶⁵ Tol (2009), “The Economic Effects of Climate Change,” Journal of Economic Perspectives, Volume 23, Number 2, Pages 29-51

C.2.3. The UK Department for Energy and Climate Change

The UK Department of Energy and Climate Change (DECC) publishes estimates of the carbon price based on an abatement cost approach. Estimates produced by DECC distinguish between:

- the carbon price in “traded” sectors, which corresponds to the price in sectors that are covered by the EU ETS. The estimates of the carbon price essentially reflect a forecast of the price for emissions allowances; and
- the carbon price in “non-traded” sectors, which corresponds to the price in sectors that are currently not included in the EU ETS. The non-traded price reflects a number of components of abatement cost, most notably the cost of the technologies believed to be required to achieve the emissions reductions assigned to these sectors.

The future forecasts of the traded and untraded carbon costs converge by 2030, but there is a significant difference in costs over the intervening period. This reflects the current low price of emissions allowances in the EU ETS. The estimates produced by DECC are used in cost-benefit analysis by UK government bodies, and have also been used by the European Environment Agency in its analysis of the cost of industrial emissions in Europe.¹⁶⁶ The latest estimates¹⁶⁷ produced by DECC for emissions released in 2010 are reported in Table C.3 below.

Table C.3
Shadow Cost of Carbon Estimates Reported by DECC

	Traded		Non-Traded	
	£/tCO ₂ (2013 £)	€/tCO ₂ (2010 €)	£/tCO ₂ (2013 £)	€/tCO ₂ (2010 €)
Low	12	14	28	32
Central	12	14	56	65
High	12	14	84	96

Source: DECC, NERA analysis

Note: Original values reported in 2013 GBP been converted to 2011 Euros.

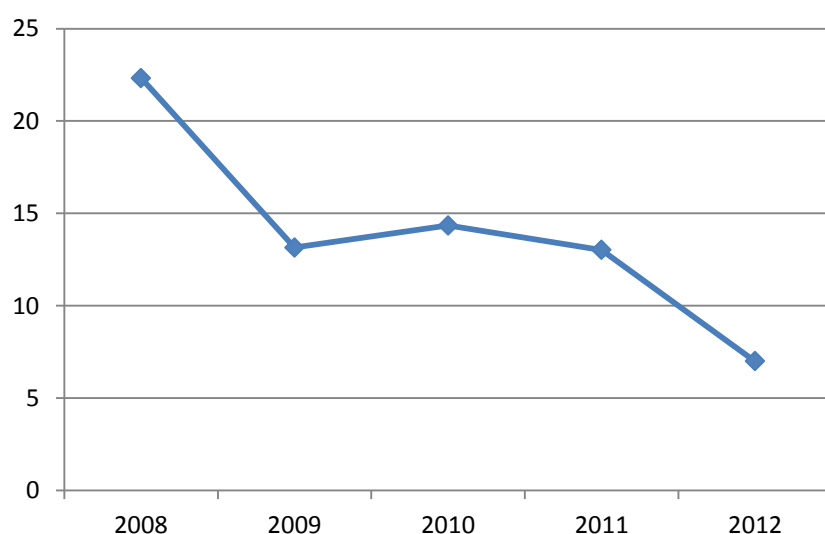
C.2.4. The Market Value of Emissions Allowances

As noted above, the price of emissions allowances in the EU ETS (EU allowance units or EUAs) provides an estimate of the target-consistent carbon abatement cost for those sectors that it covers. The average annual price of EUAs between 2008 and 2012 is shown in Figure C.1 below. Prices generally declined over this period— from around €22/tCO₂ in 2008, to around €13-14/tCO₂ in 2009-2011 and even further to around €7/tCO₂ by 2012.

¹⁶⁶ EEA (2011), “Revealing the Costs of Air Pollution from Industrial Facilities in Europe”

¹⁶⁷ Produced by DECC at the end of 2013.

Figure C.1
Average annual EUA prices (2008-2012; nominal)



Source: BlueNext, PointCarbon and NERA calculations.

C.2.5. Other Estimates Used

In addition to the estimates reported above, there are a very large number of studies and reports that have developed and applied estimates of the shadow price of carbon for policy analysis. Some particularly relevant examples include:

- the European Investment Bank (EIB), which uses carbon prices in its cost-benefit analysis of projects.¹⁶⁸ These carbon prices are based on a review undertaken by the Stockholm Environment Institute (SEI) and commissioned by EIB, drawing on both the abatement cost and social cost of carbon literature. The EIB used low, central and high values of 11, 28 and 44 €/tCO₂ (in 2011 Euros), respectively, for emissions released in 2010.¹⁶⁹
- The Intergovernmental Panel on Climate Change (IPCC), which discussed the social cost of carbon in its 2007 report, noted that estimates of the cost of carbon range from -\$10/tC to \$350/tC, with a mean value of \$43/tC.¹⁷⁰
- Stern (2007),¹⁷¹ which comments extensively on the potential social cost of carbon, and suggests that it might be around \$85/tCO₂. The values reported in Stern (2007) have been

¹⁶⁸ EIB (2008), “The Economic Appraisal of Investment Projects at the EIB”

¹⁶⁹ Based on the original values of 10, 25, and 40 €/tCO₂ in 2006 Euros.

¹⁷⁰ IPCC (2007), “Climate Change 2007, Impacts, Adaptation, and Vulnerability – Working Group II”, Chapter 20

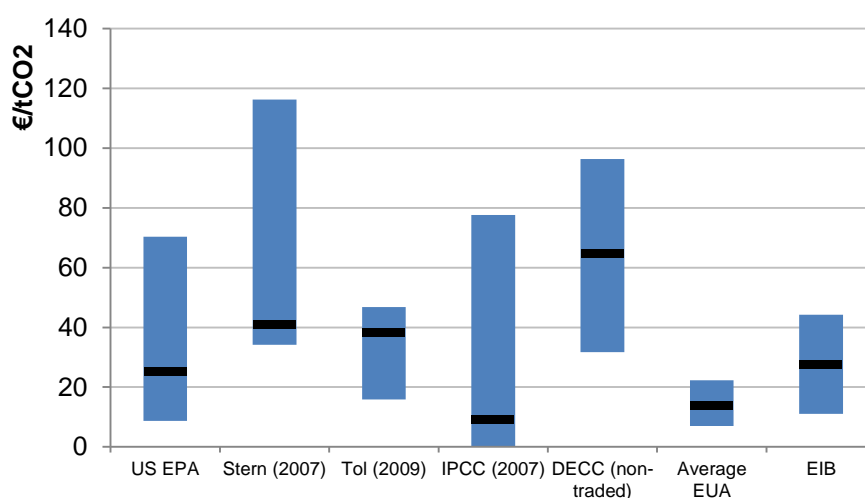
¹⁷¹ Stern (2007), “The Economics of Climate Change – The Stern Review”

used subsequently by others – for example, the World Bank in a recent project assessment in South Africa.¹⁷²

C.3. Summary of Estimates and Carbon Prices Used

The various estimates discussed above are summarised in the Figure C.2. The figure focuses on estimates that lie within the main ranges reported in the literature, although as noted above, the full range of estimates considered in the above sources is much wider.

Figure C.2
Summary of Estimates of the 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/tCO₂, respectively. These values lie within the range of estimates that are commonly referred to in the literature.

¹⁷² The World Bank has previously used a lower value of \$25/tCO₂, which is also reported in Stern (2007), and the original source of this value is a review by Richard Tol in 2005. Source: World Bank (2010), “Project Appraisal Document on a Proposed Loan in the Amount of US\$ 3,750 million to Eskom Holdings Limited”

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