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Statistical differences for primary energy products

Norwegian Energy Balance 2011-2014

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Symbols in tables	**Symbol**
Category not applicable	.
Data not available	..
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Not for publication	:
Nil	-
Less than 0.5 of unit employed	0
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Preface

In 2012 the UNFCCC asked for explanations to the high statistical difference between supply and use of petroleum products in the Norwegian official Energy Balance. In response to this Statistics Norway led a project that concluded with annex XII to the 2013 national inventory report (NIR 2013). A follow-up project run in 2013-2014 concluded with annex XII to NIR 2014. Remaining issues were further investigated in a third follow-up project in 2014-2015.

The three part-projects combined constitute the main parts of this document. Whereas the NIR annexes were written to the UNFCCC expert reviewers, this document has a broader target group.

Financial resources have been provided by the Norwegian Environment Agency and Statistics Norway in a joint venture.

Thanks to the Norwegian Petroleum Directorate and the other providers of supplementary data for quick and easy delivery of data and kind assistance in explaining them. The results in this project had been unachievable without your cooperation.

Statistisk sentralbyrå, 29 February 2016

Torstein Bye

Abstract

For several years there has been a problem regarding statistical difference between the supply and use of petroleum products in the Norwegian Energy Balance. This should not be unexpected from a country exporting almost 90 per cent of its petroleum products. Just minor discrepancies between production and export on the supply side of the balance may result in significant imbalances with the use side figures. There has, however, been a tendency for a positive bias in the statistical difference for a long time, which has caused uncertainty whether the domestic use of petroleum products might have been underestimated. Therefore a project was launched in 2012 in order to address the bias and make corrections if possible.

In Norway, most of the produced petroleum products are *primary*[1], while most of the domestic use relates to *secondary* petroleum products. Hence, separate energy balances for *primary and secondary* petroleum products were elaborated in the project. To further increase the transparency, more detailed product categories and one transfer item were elaborated as well. New data on primary petroleum products were identified and collected, in order to establish alternative export figures and new revision controls. No alternative data on secondary petroleum products was found, and hence these products were not prioritized.

The new export data is consistent with the production figures, and most discrepancies can be discussed with the data owner without breaking the confidentiality rules. Hence, the new data provides a solid basis for quality control. A similar crosschecking of the original export data from the external trade statistics (ETS) is tedious, or for some products almost impossible. Moreover, corrections must be made in the energy balance to obtain consistency between the export and production data.

All new data is readily available from the Norwegian Petroleum Directorate, one terminal and one pretreatment facility, respectively, and suitable for routine revision control. Compiling them for use in the energy balance is relatively simple. One dataset is not distributed by destination country, and in international reporting of country specific figures this data should instead be used to adjust the current ETS export data.

Based on new and original data, two alternative detailed energy balances for primary petroleum products were established, for revision purposes. Most causes of statistical difference for primary petroleum products were found due to the new data and revision methods, and the statistical differences for these products were significantly reduced.

The new export data will be used for all primary petroleum products in the energy balance instead of ETS export, due to superior revision possibilities. All corrections developed in this project will be considered implemented as well. Whenever an unacceptably high statistical difference occurs in a product category containing primary petroleum, the revision controls and the detailed energy balance setup developed in this project will be used to diagnose the problem. Routines are established to obtain consistency between the energy balance and ETS, including routines for coordinated revision and publishing.

The new export data on crude oil was used in the published energy balance for 2014, based on findings in this project. Moreover, revised export figures on crude oil from 2013 onwards in the ETS were published in November 2015.

[1] *Primary* means unrefined (incl. pretreatment like fractionation and stabilization). *Secondary* means refined into finished products or semi-manufactured products for use as raw material in manufacturing

Sammendrag

Det har i flere år vært problemer knyttet til statistiske avvik mellom tilgang og anvendelse av petroleumsprodukter i energibalansen. Dette er ikke uventet for et land som eksporterer nær 90 prosent av sine petroleumsprodukter. Kun små avvik i produksjons- og eksportdata kan lede til store avvik i balansen mellom tilgang og anvendelse. Det har vært en tendens til systematisk positivt statistisk avvik over flere år, noe som har skapt usikkerhet om hvor vidt det nasjonale forbruket av petroleumsprodukter har blitt underestimert. Dette prosjektet ble startet i 2012 for å finne årsakene til det positive avviket og gjøre korreksjoner om mulig.

I Norge er mesteparten av de produserte petroleumsproduktene *primære*[2], mens mesteparten av det nasjonale forbruket er av *sekundære* petroleumsprodukter. Derfor ble det i prosjektet utviklet separate energibalanser for *primære og sekundære* petroleumsprodukter. For å ytterligere øke gjennomsiktigheten ble det også laget en mer detaljert produktinndeling, samt en overføringspost. Nye data på primære petroleumsprodukter ble identifisert og innsamlet, for å etablere alternative eksporttall og nye revisjonskontroller. Det ble ikke funnet alternative data på sekundære petroleumsprodukter, og disse produktene ble derfor ikke prioritert.

De nye eksportdataene er konsistente med produksjonsdataene, og de fleste avvik kan diskuteres med dataeier, uten å bryte med reglene for konfidensialitet. Dermed danner de nye dataene et solid grunnlag for kvalitetskontroll. En tilsvarende sjekk av de opprinnelige eksportdataene fra utenrikshandelsstatistikken (UH) er svært arbeidskrevende, og for noen produkter nærmest umulig. Dessuten må det gjøres korreksjoner i energibalansen for å få konsistens mellom eksport- og produksjonsdataene.

Alle de nye dataene er lett tilgjengelige fra Oljedirektoratet, en oljeterminal og et forbehandlingsanlegg for råpetroleum, og kan revideres rutinemessig. Sammenstilling for bruk i energibalansen er forholdsvis enkelt. Ett datasett er ikke fordelt på destinasjonsland, og til landfordeling i internasjonal rapportering må disse dataene isteden brukes til å justere dagens eksportdata basert på UH-tall.

To alternative detaljerte energibalanser ble utviklet for revisjonsformål, basert på nye og opprinnelige data. De fleste årsaker til statistisk avvik for primære petroleumsprodukter ble funnet ved hjelp av de nye dataene og revisjonskontrollene, og det statistiske avviket for primære petroleumsprodukter ble betydelig redusert.

De nye eksportdataene vil bli brukt for alle primære petroleumsprodukter i energibalansen, istedenfor UH-eksport, på grunn av bedre kontroll med dataene. Alle korreksjoner som ble utviklet i prosjektet, vil også vurderes implementert. Hvis det oppstår store statistiske avvik i et produkt som inneholder primære petroleumsprodukter, vil revisjonskontrollene og den detaljerte energibalansen som er utviklet i dette prosjektet bli brukt for å løse problemet. Det er etablert rutiner for å oppnå konsistens mellom energibalansen og utenrikshandelsstatistikken, inkludert rutiner for koordinert revisjon, og publisering.

De nye eksportdataene på råolje ble brukt i den offisielle energibalansen for 2014, basert på funn i dette prosjektet. Reviderte tall for eksport av råolje fra og med 2013 ble publisert i utenrikshandelsstatistikken i november 2015.

[2] *Primær* betyr uraffinert (inkl. forbehandling som fraksjonering og stabilisering). *Sekundær* betyr raffinert til ferdige produkter eller halvfabrikater brukt som råvare i industrien.

Contents

1. Introduction

1.1. Background

For several years there has been a problem regarding statistical difference between the supply and use of fossil energy products in the Norwegian Energy Balance. This should not be unexpected from a country exporting over 90 per cent of its primary petroleum production. However, there has been a tendency for a positive bias in this statistical difference, which has caused uncertainty whether the domestic use of petroleum products might have been underestimated.

The Norwegian Energy Balance has been repeatedly questioned by the IEA and Eurostat because of this statistical difference, and UNFCCC expert review teams (ERTs) have questioned the quality of the Norwegian emission inventory because of this bias. Moreover, the national account has estimated consistently positive stock changes for the energy sector that might have the same causes as the statistical difference in the energy balance. There has previously been made serious effort to identify the causes of statistical difference in the energy balance and make corrections (see f. ex. Evensen 2006, Walle et al. 2006 and Vesterås 2012, unpublished), but the problem has been persistent.

In 2012 the UNFCCC strongly called for explanations and/or improvements, and in response to this Statistics Norway led a project that concluded with annex XII to the 2013 national inventory report (NIR 2013). The annex describes improvements, as well as unsolved issues left to further work. A follow-up project was run in 2013-2014, and the methods and results are described in annex XII to NIR 2014. Remaining issues relating to the supply and use of primary energy products were further investigated in a third follow-up project in 2014-2015. Henceforth, these three projects are called part-projects, and the three part-projects combined are called the project.

A main development in this project has been the elaboration of energy balances with more detailed product categories and a split between primary and secondary energy products. Furthermore, new data sources have been identified and collected in order to obtain an alternative method for estimating the export of primary petroleum products, and new revision controls have been elaborated. Two alternative energy balances for primary petroleum products have been set up in the project, based on the new and the original data sources for export. Both are provided with corrections based on findings in the project.

In earlier projects, only errors *found* have been systematically documented. The part-projects leading to this report have aimed at also documenting where errors have *not* been found. See NIR 2013 and NIR 2014 for more information on findings confirming the current data and methods, as well as details on minor findings.

Work on topics related to these projects has been carried out in separate projects. These include 1) the consistency between the energy account, the emission account and the national account, 2) creating a new IT platform for the energy balance, and 3) the establishment of an annual statistic on delivery (i.e. sale) of petroleum products, which is an improvement of the previous summing up of the monthly statistics. See NIR 2013 and 2014 for further details and an assessment of their impact on the energy balance.

1.2. Project organising

The Division for energy and environmental statistics has led the work with quality controls, estimations and contact with other institutions, and the work has included

close contact with the Division for external trade statistics. A temporary formalized cooperation between the Division for energy and environmental statistics and the Division for external trade statistics took place during parts of 2014 and 2015.

Several meetings have been held between Statistics Norway and Norwegian Petroleum Directorate (NPD), and there has been extensive contact and thorough discussion on the data quality throughout the project. Other collaboration partners have been contacted when needed, including one natural gas transporter, one terminal, one refinery and one petroleum pretreatment plant.

Because of the importance of the energy balance in the national emission inventory, the Norwegian Environment Agency has been involved in the process of quality controls in the former two part-projects.

The project has been supported financially by the Norwegian Environment Agency.

1.3. Relation between supply, use and statistical difference

The following set of equations describes the relation between domestic supply (S), domestic use (U) and statistical difference (SD) for primary energy products in the energy balance:

1. SD = S – U
2. S = primary production[3] + import – export ± stock changes
3. U = transformation + use in energy sector + flaring + use as raw material + end use

The elements in relation 1 to 3 that contains the highest amounts of petroleum products are by far production and export. The main data source on domestic use is the statistics on delivery of petroleum products.

It should be noted that losses *within a transformation process* (f. ex. conversion in refineries) do not cause statistical differences (SD), as long as the input and output products belong to different product groups. This is because the input in a transformation process is using primary products, which is compared to the production of primary products. The output gives a supply of secondary products, which is compared to the use of secondary products. Both are consistent, while the losses fall through the cracks.

1.4. Terminology

In this report, the energy balance that is published as official statistics is denoted the *published energy balance* (EB). The new energy balance developed in this project that uses export figures from the external trade statistics (ETS) is denoted *EB-ETS*, while the new energy balance that uses shipment data from the Norwegian Petroleum Directorate (NPD) and supplementary data for export figures is denoted *EB-NPD*. Both are denoted *detailed* EB, *revised* EB or *alternative* EB depending on the focus in the text.

NPD export means export figures based on NPD shipment data and supplementary data from one Norwegian terminal and one Norwegian crude petroleum pretreatment plant.

[3] Including fractionation upstream to a refinery and conversion at LNG plants.

Primary means unrefined (incl. pretreatment like fractionation and stabilization). *Secondary* means refined into finished products or semi-manufactured products for use as raw material in manufacturing[4].

Petroleum products (or *petroleum*) in this document means liquid or gaseous fossil energy products. *Fossil energy products* include solid products (coal and coke).

Primary petroleum products include the products given in the column headings in the appendix V tables. In the published EB primary petroleum products include crude oil, petrol (parts), NGL/LPG and natural gas.

Natural gas means dry gas (fractionated) or rich gas (unfractionated). *Rich gas* consists of dry gas and minor fractions of NGL products. Dry gas cooled down and compressed into a liquid is denoted *LNG* (liquefied natural gas). *Gas products* means dry gas, rich gas and wet gases.

NGL products, also denoted *wet gases*, consist of ethane, propane, butane, iso-butane, LPG, NGL (natural gas liquids), gasoline and condensate (occasionally sold and classified as crude oil).

LPG (liquefied petroleum gas) is used for mixtures or single gases within the following: butane, iso-butane, propane, butylene and propylene. Butylene and propylene are not energy products, and thus LPG is a mix of energy products and products used for non-energy purposes.

Loads going by ship or pipeline (shipments) to a terminal or refinery are termed *"import"* (with quotes), even though they come from a Norwegian origin, in line with the terminology in the received data. Shipments going out from the terminal (or refinery), even to Norwegian destinations, are termed "*export"*. True import and export (i.e. loads going from or to a foreign country) is always termed without quotes.

Shipment and *load* are used synonymously, meaning one delivery by ship or pipeline. A shipment or load may have several owners.

Turn of the year differences means statistical differences arising from time lag between production and shipment around the turn of the year, i.e. production takes place before and shipment takes place after the turn of the year.

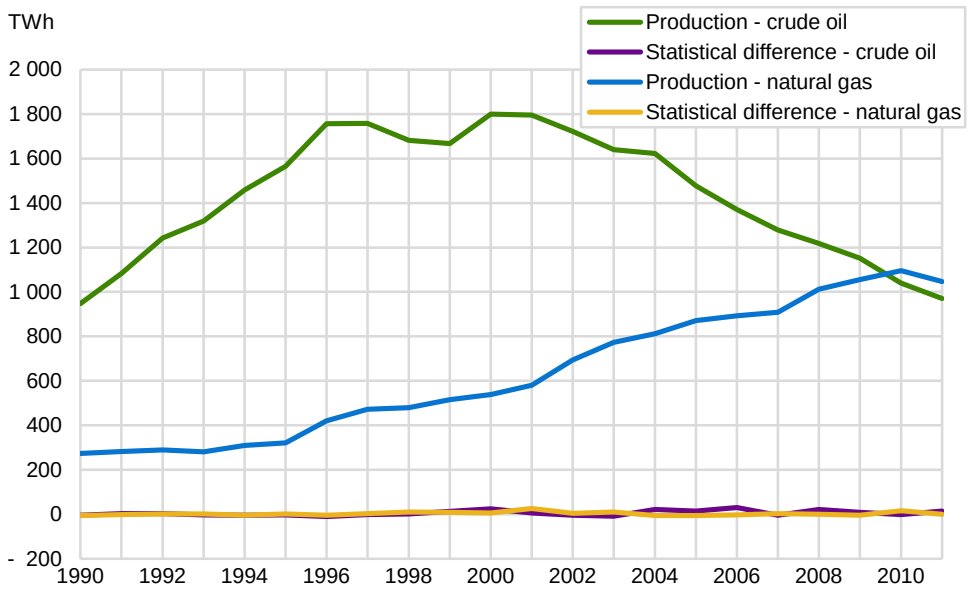
The domestic supply and use of petroleum products corresponds to the *reference* and *sectoral approaches* in the Norwegian greenhouse gas inventory respectively.

2. Purpose and priorities

The Norwegian view, when the energy balance has been questioned by international institutions due to high statistical differences, has been that a high statistical difference must be expected and tolerated, as a result of high production and export of petroleum products and a comparatively very low domestic consumption. Figure 2.1 shows the statistical difference for crude oil and natural gas compared to the respective production amounts (NIR 2013):

[4] Other than refineries and chemical crackers

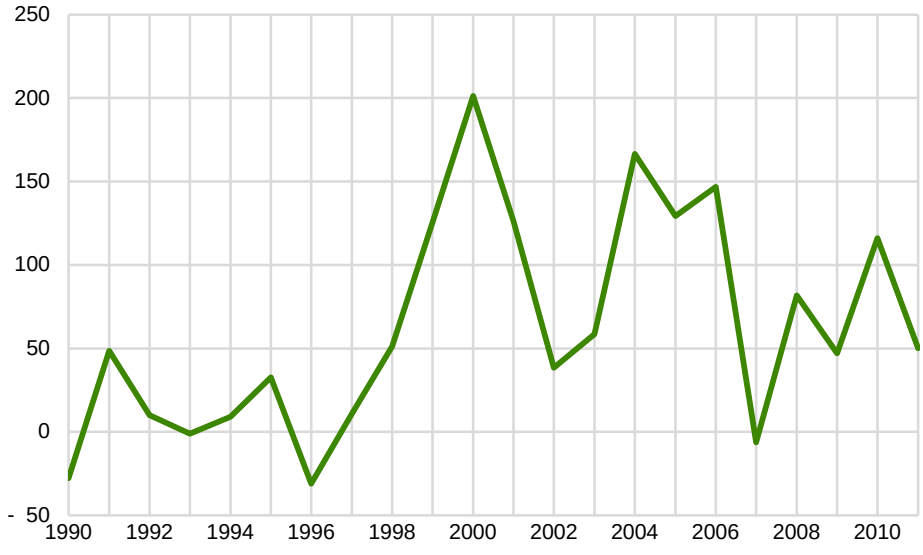
Figure 2.1 Production and statistical difference for natural gas and crude oil, 1990-2011[1]. TWh



1 TWh ≈ 85 ktoe.

This view is supported by the huge variation in the statistical difference, which indicated that the main causes were to be found in the big numbers, i.e. the production and/or the export of petroleum products, in which errors are considered less problematic, and not in the figures regarding domestic consumption. Total statistical difference, excluding electricity and district heating is shown in figure 2.2:

Figure 2.2 Total statistical difference of all energy products excluding electricity and district heating, PJ. 1990-2011



1 PJ ≈ 23.6 ktoe.

Despite this, Statistics Norway acknowledges a considerable self-interest in reducing the statistical differences, if possible, and hence improving the energy balance. Much effort has been put into reducing the statistical differences earlier (NIR 2013), but some fundamental inconsistencies remained unsolved.

The first part-project was initiated by a request from UNFCCC to document the quality of the energy balance, which forms a basis for controlling the reported greenhouse gas emissions, as well as other parts of the control method (reference

approach) and the actually reported emissions (sectoral approach). The follow-up project was also initiated by UNFCCC, focusing on remaining issues regarding the energy balance. The last part-project was initiated by Statistics Norway and the Norwegian Environment Agency. As a consequence, the priorities changed during the project, starting with a quite broad scope, which was gradually narrowed.

2.1. Purpose

The aims of the project were:

- Establish methods to identify sources of statistical differences of petroleum products (inconsistencies, calculation errors, under- and over-reporting, etc.), including:
    - establishing of new revision controls
    - collection of alternative and supplementary data
    - increase of transparency

  and to reduce them to an acceptable level.
- Provide test estimations of the energy balance with two alternative sets of export data, with correction of inconsistencies and errors where possible.
- Assess the quality of the main data sources on domestic supply.
- Give recommendations for implementation of new methods, data and revision controls in the regular production of the *published energy balance* (EB).

2.2. Priorities

The main priorities in the project were:

- Reveal major events in the petroleum production and transportation infrastructure, which could lead to imperfect or inconsistent data in the energy balance.
- Focus on petroleum products (i.e. liquid and gaseous fossil energy products) only, as they show the largest statistical differences and have the most complex material flows.
- Focus on recent reference years (2011-2014). Complete understanding of a few reference years was seen as more valuable than consistent correction through the whole time series of parts of the potential errors. Moreover, data are scarcer in earlier reference years.
- Focus on primary products (third part-project), as alternative data on secondary petroleum products could not be found during the project.
- Focus mainly on the supply side of the energy balance (third part-project), as the largest amounts are found there.
- Develop a more transparent energy balance setup, with a detailed split on both product types (vertically) and primary vs. secondary products (horizontally), as well as a transfer item.
- Develop methods for quality control of production and export figures on primary petroleum products.
- Collect additional data for revision control and estimation of alternative figures on petroleum export.
- Document not only errors, but also the parts of the supply and use estimations being of good quality (first two part-projects mainly).

3. Quality controls of domestic use except conversion

The domestic use of secondary petroleum products in the energy balance is covered by the following major data sources:

- Statistics on the sales of petroleum products
- Statistics on energy use in the manufacturing industries (for other products)
- Statistics on combustion in the energy producing industries
- Statistics on domestic use of natural gas

The focus of the quality controls has been on the statistics on sales of petroleum products and the statistics on energy use in the manufacturing industries. The rationale for selecting these two statistics for extra quality control was their importance as data sources in the energy balance and actual possibilities for performing such controls. In addition to these four data sources, data and quality control of conversion in refineries are described in chapter 4 and 5, respectively.

The controls were performed during the first part-project, and no significant errors were found. A draft description of the quality controls is given below, while more details are given in NIR 2013.

Two controls of domestic use were performed during the last part-project, in close relation to controls of the supply side. These are described in chapter 4.

3.1. Statistics on sales of petroleum products

Statistics on sales of petroleum products (Statistics Norway 2015c) is one of the most important data sources in the energy balance. It defines the total domestic use of most secondary petroleum products, except conversion and other consumption in refineries. If these sales figures and the refinery data are correct, the causes of major statistical differences are to be found on the supply side.

Statistics Norway receives and publishes monthly sales statistics on petroleum products. The sources are the largest oil companies that operate in the Norwegian market, and import figures. The data received from the oil companies contain figures on monthly sales of petroleum products, divided into company, products, purchaser group, region, month and year. The figures are given in liters. The reporting oil companies are responsible for placing the deliveries in the right purchaser groups. There are uncertainties regarding the quality of the data received from the oil companies, especially the allocation to purchaser groups.

Previously, annual figures where based on adding up the monthly sales statistics. Now, the companies are instructed to send detailed information for every delivery each year, in addition to the monthly data. From this information a new annual sales statistics has been established, in which the sales of petroleum products are placed into the 34 purchase groups with higher accuracy. Furthermore, the annual sales statistics further aggregates the sales of petroleum products into 22 industrial groups, based on information merged from the business register.

Although the industrial distribution of the annual sales statistics differ from the distribution over purchaser group in the sum of monthly statistics over the year, only small differences are observed in total amounts when comparing the annual and sum of monthly volumes. The annual figures for the different reference years are between 1 per cent lower and 1 per cent higher than the sum of the monthly figures. Thus, minor random statistical differences might have occurred from

inaccuracies in the petroleum sales statistics, but it is not a likely explanation for any biases.

The new annual statistics were published for the first time 31 March 2014, covering the years 2009-2013 (Statistics Norway 2014b), and were implemented in the energy balance for the whole time series in autumn 2014, using 2009-2011 as junction years.

3.2. LPG – choosing data source for consumption

For the consumption of LPG there are known shortcomings in the sales statistics on petroleum products. The sales statistics is not a good source for inland consumption of LPG. Over 60 per cent of the sales are registered as used in the manufacturing sector, while the rest is spread almost equally over the other sectors. The overall sale does not cover all the inland consumption. Hence, consumption data for energy and non-energy purposes collected from manufacturing industries (Statistics Norway 2015d) is used for LPG consumption in the energy balance.

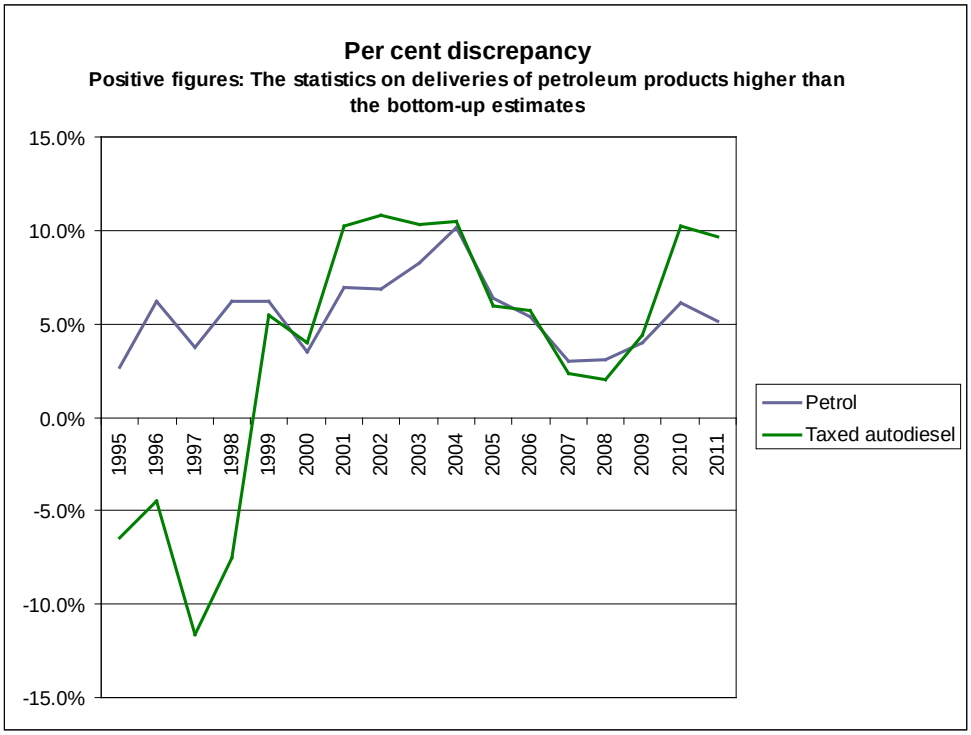
3.3. Bottom-up estimates for road transport

Road transport is one of the few areas where we have the possibility of directly checking data with alternative data sources. The road transport model used to calculate emissions from road transport also estimates fuel consumption using activity data on number, age and type of vehicle and driving lengths (Sandmo 2013). A complete match with sales figures are not to be expected, but if the figures from the sales of petroleum products were consistently lower than calculations from the road model, this could indicate under-coverage in the petroleum sales statistics.

As Figure 3 shows, the figures from the petroleum sales statistics lies well over the bottom-up calculations from the road model from 1999 onwards. This indicates that the petroleum sales statistics does not underestimate the sales of these energy products during this time period, and hence that it does not contribute to the positive statistical difference in the energy balance.

For taxed auto diesel there are some issues for the 1995-1998 time period, because the introduction of taxation of auto diesel for road transport was not complete until 1999. Buses were until then allowed to run on tax-free diesel, causing an underestimation of taxed auto diesel in the sales statistics. The consumption for this purpose has been adjusted in the energy balance.

Figure 3.1 Discrepancy between bottom-up calculations for road transport and petrol and taxed auto diesel figures from the statistics on sales of petroleum products, 1995-2011. Per cent



3.4. Alternative data on energy use in the manufacturing sector

The statistics on energy use in the manufacturing sector was subject to extra quality control. We used energy data collected by the Norwegian Environment Agency to examine the quality of the statistics on energy use of individual industrial entities in the manufacturing sector. The overall consistency and coherence between the data sources were good. A handful of units have risks of errors and need extra attention when editing the data. This regards in particular companies that use self-produced or purchased CO-gas, fuel gas and refinery gas. However, these potential errors are minor and do not significantly influence on the statistical difference in the energy balance.

Energy data from the Norwegian Environment Agency is now being used when editing micro data in the statistics on energy use in manufacturing.

4. Data sources of the supply side

The ordinary data sources from NPD and the external trade statistics (ETS) are described in this chapter, as well as new data collected as part of this project. For other data sources used in the published energy balance (EB), see documentation from Statistics Norway (2015a). Supplementary dataset variables are described in Appendix I – IV. The data format for all datasets is MS Excel.

4.1. Production and shipment data from the Norwegian Petroleum Directorate

The Norwegian Petroleum Directorate (NPD) collects data on both production and shipments of primary petroleum products from the oil companies electronically on a daily basis.

Production data

The production data displays net (i.e. saleable) amounts of produced primary petroleum by field, month and product. The amounts are given in mass and volume units. The volume is according to the products' liquid phase, except for LNG/ natural gas where volume in gaseous state is given. The collected data covers the Norwegian share only.

Shipment data

The shipment data covers all primary petroleum products, except natural gas in gaseous state (dry gas). The amounts are given in mass and volume units, as in the production data. It displays each single shipment (sale), including cargo number, shipment date, owner and destination country, which can be used for detailed quality checks. The owner's nationality is given in a separate variable, by which the Norwegian share is easily extracted.

In the beginning of the project the regular shipment data query lacked the variable *destination* (i.e. terminal or harbour name, etc.). A specially programmed query from NPD's master database (Diskos) containing *destination* was delivered to Statistics Norway on request in March 2013, just before the finalization of the first part-project. The information in this new variable proved very useful during the second and third part-project, as it made possible the development of new revision controls that reveal causes of statistical differences, as well as an alternative estimation of export by combining the shipment data with supplementary data from one terminal (section 4.2) and one petroleum pretreatment facility (section 4.3). The new destination variable also made the shipment data an alternative data source for primary LPG products domestically used as raw material[5].

A new IT solution for Diskos was developed at NPD through 2014 and 2015, and Statistics Norway received test data in November 2014. The database was launched in July 2015, and a routine delivery of shipment data with *destination* from NPD was established (see Appendix I for specifications). The new Diskos is still in a preliminary version, and is expected to be finalized in 2016.

Definitions and data quality

Shipments with a foreign final destination country are called NPD export in this document. The shipment dataset contains, however, information on destination of the *first* delivery in the delivery chain only, and does not trace the product streams beyond that (NPD, pers. comm. 2013c). Supplementary data (section 4.2 and 4.3) were used to determine the final destination of shipments going to a Norwegian primary destination and then further to a domestic or foreign destination, allowing the estimation of exported amounts by the alternative method. *Origin* in the shipment data refers to the sales point, i.e. main production field or terminal.

The infrastructure at one Norwegian crude oil terminal is particularly complex, and this also affects the recording of origin and destination in the shipment data. There are three ways of recording origin and destination of crude oil passing this terminal:

- Oil that arrives the terminal by pipeline and is sent to the adjacent refinery or intermediate stock has the terminal name as both *origin* and *destination*. Oil might go from the stock and back to the terminal for export.
- Oil that arrives the terminal by pipeline and is transported directly further by ship has the terminal name recorded as *origin* and the final destination recorded as the *destination*.
- Oil that arrives the terminal by ship has the main field name as *origin* and the final destination recorded as the *destination*. The final destination could be either the refinery, which has the same name as the terminal, or another Norwegian or foreign destination.

[5] Some shipments from the petroleum pretreatment facility should be added, c.f. section 4.3.

The data are expected to be of generally high quality when delivered to Statistics Norway. NPD and the different users of the data have mutual interest of getting as good data quality as possible.

The data are used by the tax authorities for fiscal purposes, and the measuring quality is regulated by law. Measuring device need to be officially approved, and spot checks of measurements are performed. Maximum allowed random measuring uncertainty on single shipments is 0.3 per cent. Biases are not allowed. Thus, when summing up over a year the measuring uncertainty is negligible.

Moreover, NPD perform monthly controls of the reported data per field/sales point and product against prognoses for the same fields. NPD administers and publishes the data, and would be interested in displaying correct data for that reason. The oil companies use the reported data to get information on own and the other licensees' production. This speaks in favour of a generally good quality of the delivered data.

In addition to the controls performed by NPD and the oil companies, effort was put into revising the production data by comparing monthly field production by month average for the same field and annual field production by the previous year using statistical techniques[6]. However, the production may vary greatly by month and year according to planned shut-downs for maintenance and difficult production conditions (NPD, pers. comm. 2013b), and hence this approach proved inadequate. Instead several controls against alternative datasets were developed (chapter 5).

Some incidents of partly missing dry gas mass data in the production data were revealed by controlling the density. These were caused by fields sending their production in two different pipelines, one of which to a foreign sales point that reported amounts in volumes only (NPD, pers. comm. 2012). In these cases density was used to estimate the missing mass data.

The amounts in the two datasets are expected to be equal on a total level, except for stock changes and time lags (NPD, pers. comm. 2013a). Stocks are measured and reported, and hence stock changes are readily estimated and corrected for. The time lags occur partly because production is measured per month while NPD export is measured at the shipment day. Moreover, a ship might stay for several days at the sales point before departing. Because of a ship size of typically 20 to 150 kt, this time lag causes a significant random difference between total production and total shipments corrected for stock changes. However, over time the differences due to time lags should fluctuate around zero.

In two cases the two NPD datasets classify a petroleum product differently:

1) The production at five fields landed at the same Norwegian terminal is classified as NGL in the production data and condensate in the shipment data.
2) The production at two fields landed at the same Norwegian terminal is classified as LPG in the production data and gasoline in the shipment data.

Statistics Norway gets data from NPD for the final energy balance about September, but revisions in NPD's master dataset might be done after that. Keeping track of versions is therefore important.

[6] A technique of estimating the absolute difference from the mean, raised to a variable (but universal) power, was used for 1) the production of a certain product type at a certain field in a certain month against the mean for all months, and 2) the average monthly production of a certain product type at a certain field against the previous year. The variable power allows making a due weighting of absolute differences versus relative differences. The limit value deciding which fields and months to revise was set by judgement, in order to obtain an adequate accuracy and a reasonable number of fields to revise.

It should be noted that Norwegian petroleum that is landed in a foreign country and then shipped to Norway should be included in the NPD export, since it is also included in the ETS import.

4.2. Supplementary data – export from one terminal

One Norwegian terminal is reported as destination for parts of the crude oil flow, even though the loads are reloaded and shipped further on to other destinations (as mentioned above). In the second part-project an attempt was made to determine the exported part of this product flow solely by use of the shipment data (NIR 2014). The uncertainty in the approach was emphasized, and despite the promising results that were obtained, further investigation showed that the characteristics used to identify the exported loads were insufficient.

In the last part-project supplementary data was collected from the mentioned terminal, identifying which shipments were truly exported and which went to domestic destinations.

The supplementary data consisted of three queries per reference year (specifications are given in Appendix II):

- Import to terminal
- Import directly to adjacent refinery
- Export from terminal

Information within the datasets was used to identify the flows between the import and export terminal, the refinery and an associated tank stock, in order to avoid double counting. *Name* (origin) and *Destination* in the NPD shipment data were used to find the complementary shipments, i.e. shipments not passing through the terminal.

CargoNo and *ShipmentNo* in the supplementary data are due to other numbering systems than *CargoNo* in the NPD shipment data. Hence, shipment by shipment comparison must base on amount and date. Only imports to terminal and refinery could be compared this way, as products were often split, reloaded and kept at the terminal for several days or weeks before being exported.

Transit loads occasionally goes through the terminal. These loads must be added to the NPD export, as they are 1) included in the ETS import and 2) not included in the NPD shipments. Transit loads were identified in the export from terminal data by the product name.

The supplementary terminal data was used to control the ETS import of crude oil to the terminal and the refinery crude oil feedstock data as well.

4.3. Supplementary data – export from one crude petroleum pretreatment plant

In the course of the project, it was revealed that fractionation of certain petroleum products at one Norwegian crude petroleum pretreatment plant was covered by neither the refinery statistics nor the (ordinary and supplementary) NPD data, as the fractionation occurred after the measuring point of the NPD production and shipment data but before the measuring point of the refinery statistics. The fractionation converts NGL, which is partly counted as petrol in the energy balance, into butane and propane, which is shipped directly from the pretreatment plant, and naphtha and ethane, which goes to an adjacent refinery as feedstock and fuel gas, respectively. To quantify the fractionated butane and propane and the subsequent export, a request was sent to the pretreatment plant. Datasets were

returned, which contained detailed data on amounts delivered from the pretreatment plant (specifications in Appendix III).

The amounts going to the refinery could be identified from the variable specifying product quality. Some shipments not going to the refinery goes to Norwegian destinations for use as raw material. These amounts should be included in the alternative NPD data on primary LPG products domestically used as raw material[7]. A special report from the pretreatment plant specifies the amounts going to Norwegian destinations. The remaining shipments go to foreign destination, and are included in the estimation of NPD export.

Information on *destination country* is not in the database. The *destination port* is recorded, and could possibly be linked to destination country by means of the shipment data or other supplementary data collected in the project. However, destination port cannot be extracted as a separate variable by the standard reports, and reprogramming the reports is a major task. As only Statistics Norway uses datasets from the reporting tool, reprogramming the tool in order to extract information on destination port is not prioritized at the pretreatment plant.

4.4. Supplementary data – export of natural gas through pipelines

As mentioned before, the NPD shipment database does not contain data on natural gas, except LNG. Hence, a request for detailed data on natural gas deliveries was sent to one non-profit company operating most of the Norwegian natural gas pipelines[8] in a joint venture pipeline grid on behalf of the oil companies. Early collected data were on an aggregated form, and not adequate for the project. Due to a negative statistical difference for natural gas in 2011, this product type was given a lower priority in the former two part-projects (as negative statistical differences are not associated with under-reporting of greenhouse gases). In the third part-project detailed data were delivered (specifications in Appendix IV), and thorough quality controls were performed.

There are data on both physical and nominated amounts. These amounts deviate insofar as the gas producers cannot deliver the nominated amounts. In such cases the freed capacity might be used by other producers, or it remains unoccupied. Statistics Norway collected data on both types of amount, as exiting amounts split by owner company were available as nominated amounts only. However, the split by owner company did not prove useful in the quality controls, except for confirming the data in physical amounts, and hence the data on physical amounts only were used in the final quality controls.

Data on exiting amounts was already collected routinely by Statistics Norway. The data is split on terminal or pipeline, and separate spreadsheets were provided for foreign and domestic destinations. The deliveries to foreign destinations were used as an alternative data source on natural gas export, while the deliveries to domestic destinations were used to control the current data on domestic end use in the energy balance. The supplementary natural gas data was made complete by adding NPD production data for fields not sending their natural gas production through the joint venture pipeline grid.

[7] These amounts are missing in the detailed energy balances estimated in this project. However, the amounts are minor and without significant consequences for the statistical differences.

[8] The company operates a pipeline grid, which covers 98 - 99 per cent of all natural gas pipeline transportation from the Norwegian continental shelf, as well as two processing terminals (Gassco 2015).

Some pipelines transport rich gas containing several NGL fractions. The supplementary natural gas data does not split rich gas landed in UK into the different fractions, while the NPD production data does. Hence, a correction was made by transferring the amount of NGL produced from the natural gas export in the detailed energy balance to the NGL/LPG export. This is in line with the correction made in the published energy balance. The correction makes no change in overall statistical difference across products in terms of mass and volume. However, NGL products have higher energy contents and thus the overall statistical difference in terms of energy is reduced.

The data on entering amounts was used in a thorough field-by-field revision control against the NPD production data. The data contained dry gas and fractionated wet gas products from fields sending their production through Norwegian terminals, and unfractionated rich gas from fields sending their production directly to UK. The deliveries to Norwegian terminals and UK were reported in two different spreadsheets. Dry gas was distinguished from wet gases by *Stream_label*, while the rich gas needed correction as in the published energy balance (as mentioned above). The data on dry gas and rich gas only was used in the revision controls. The entering amounts were split by pipeline grid entry point.

A part of the natural gas from one field is transported in a pipeline operated by the company outside the pipeline grid, and is thus not included in the entry data. It is, however, included in the exit data.

All supplementary natural gas data on physical amounts and the complementary NPD production data were used in a series of overall quality controls, to find out which input data to the published energy balance caused statistical differences for natural gas. This revision control was set up for 2011 and 2013 and partly for 2012, and could be set up for other reference years if needed.

4.5. ETS export and import data

Characteristics and processing routines – published ETS

Background, purpose and scope

The purpose of the external trade statistics (ETS) is to provide information about the commodity flows between Norway and other countries (Statistics Norway 2015b). The scope of foreign trade statistics is based on international guidelines from the United Nations Statistical Commission. The general recommendation is that the statistics should include all goods which add to or subtract from the stock of material resources of a country by entering (imports) or leaving (exports) its economic territory.

In addition to the geographical dimension, a country's economic territory also includes goods that are not necessarily located within the geographic area, but are still viewed as part of the material resources of a country. For these goods external trade is measured by the change of economic ownership.

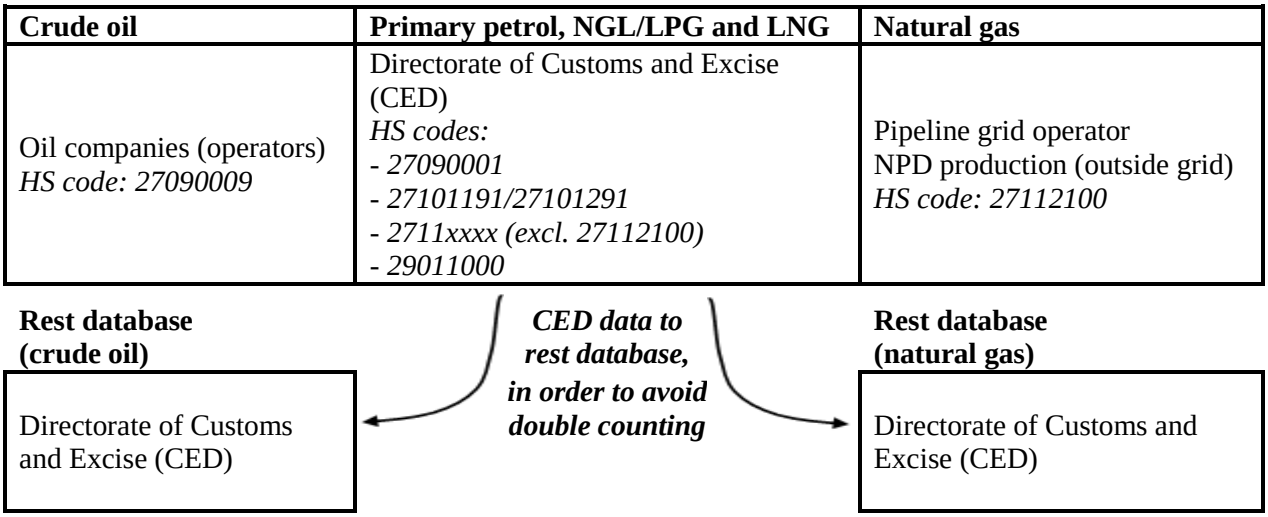
Data collection

The statistics are mainly based on information drawn from customs declarations. However, the responsible area of the customs authorities only covers Norwegian mainland and its territorial waters. As a supplement, data on important trade in goods to and from the remaining areas of the economic territory is collected directly from respondents and registers.

The vast majority of the data is collected through the custom declaration system (TVINN), which is the Directorate of Customs and Excise' (CED) electronic information system for the exchange of customs declarations with the businesses. However, preliminary and final figures for exported volumes of crude oil and natural gas in gaseous state are based on monthly reports collected from the

operators and the Norwegian Petroleum Directorate (NPD), as export from territorial waters directly to foreign destinations is not covered by the declaration duty. The data sources on petroleum products in the ETS export is shown in figure 4.1:

Figure 4.1 ETS[1] export – data sources on physical amounts by product



[1] External Trade Statistics

The preliminary data on crude oil is collected from the field operators, while the final data is collected from all the oil companies in order to get correct prices. The datasets contain data on each shipment, which allows for detailed crosschecking against the NPD data. *Note that due to strict confidentiality rules care must be taken when checking any discrepancies found in this control with the NPD.*

Crude oil landed by pipeline at one UK terminal is covered by an additional data source in the final ETS, which contains a split by destination country of the crude oil being shipped from the terminal to a subsequent destination. This data is measured out from the terminal, and is hence consistent with the NPD shipment data on crude oil. However, this additional data is not used in the regular ETS export data (i.e. Statbank tables), and hence neither in the EB.

ETS data on natural gas exported in pipelines within the joint venture pipeline grid (c.f. section 4.4) is exit amount data being collected from the pipeline grid operator. Data on natural gas exported by pipelines outside the grid is selected from the NPD production data.

Data on the remaining primary petroleum products (incl. LNG) is obtained from CED through the TVINN system. CED provides a detailed but fundamentally different data source compared to any of the NPD and supplementary data. Deliveries of products in the CED data are characterized by a declaration number, which is different from the cargo number etc. found in the NPD and the supplementary data. Moreover, the measuring point is at the national border, and merging and splitting of loads occur after the initial shipment and before export. Crosschecking CED data with NPD data is therefore very difficult, and investigating discrepancies would in many cases require additional information from f. ex. forwarding agents.

Export of crude oil and natural gas via the Norwegian mainland is custom declared, and to avoid double counting this declaration data is removed from the regular micro data obtained from TVINN and placed in a separate database, called the *rest database*, for documentation purposes.

Product codes In the ETS products are classified by Harmonized system (HS) codes. The first six digits are according an international standard classification (CN), while the latter two are national and decided by CED. The codes correspond to the Norwegian customs tariff. The HS codes of product used in the EB are listed in appendix VI.

Revision Information from customs declarations is subject to statistical controls in the TVINN system. The controls to check the estimated quantity, country and price are developed by the Customs in cooperation with Statistics Norway.

Data controls at Statistics Norway take place at different levels - some as soon as the data is loaded into the system (automatic recoding of variables). The manual part of the revision consists of different types of validity and probability tests. The former are controls of absolute errors, such as missing transport code, while the other type of test may check unlikely country codes or unreasonably high quantities for a specific type of good. The system aims to intercept the most serious errors in the data. Data collected from sources other than CED also undergo similar checks.

In the project a consistency check was performed between the declaration (HS) code and the declaration text in the ETS data. Some inconsistencies were identified. However, according to information from the Division for external trade statistics, a similar check was already established as part of the regular revision routines that the HS code was correct. Hence, no corrections were made in the ETS data based on this check.

Furthermore, an assumption was made that the exported naphtha in the ETS exceeding the produced naphtha from the refineries (379 to 976 ktonnes[9] annually in the project period) is actually primary (unrefined) condensate products. This is justified as no use of naphtha in chemical industries except refineries is reported to Statistics Norway in the manufacturing energy and raw material survey (Statistics Norway 2015d). Moreover, incidents were observed in the ETS micro data of naphtha being exported from oil companies not owning a refinery, and the classification of unrefined condensate products as naphtha was known to occur in the ETS export.

This coding practice in ETS is probably a result of fractionation of crude petroleum at terminals giving a product that is termed *naphtha* or *gasoline*, which is more processed than crude condensate but not as processed as secondary (refined) naphtha produced at refineries. This fractionated product is registered in both the ETS and the NPD data.

Coherence with the NDP and supplementary data

Crude oil and wet gas amounts being landed by pipeline in the UK is measured in to the terminals in the ETS export data, while out from the terminals in the NPD export data. The same would apply to crude oil and wet gas products being landed by pipeline in any foreign country. This has several implications:

- NPD export data counts the fractionated/stabilized oil and gas products, while the ETS export data counts the unfractionated/non-stabilized products. Hence, corrections must be done.
- Stock changes must be treated differently.

Distribution by destination country of crude oil being landed by pipeline in the UK is made by an additional dataset in the ETS, in a separate appendix table, and should be equal to the distribution by destination country in the NPD export. Wet gases are not covered by this additional dataset, and hence the distribution of wet gases by destination country differs between ETS and NPD export.

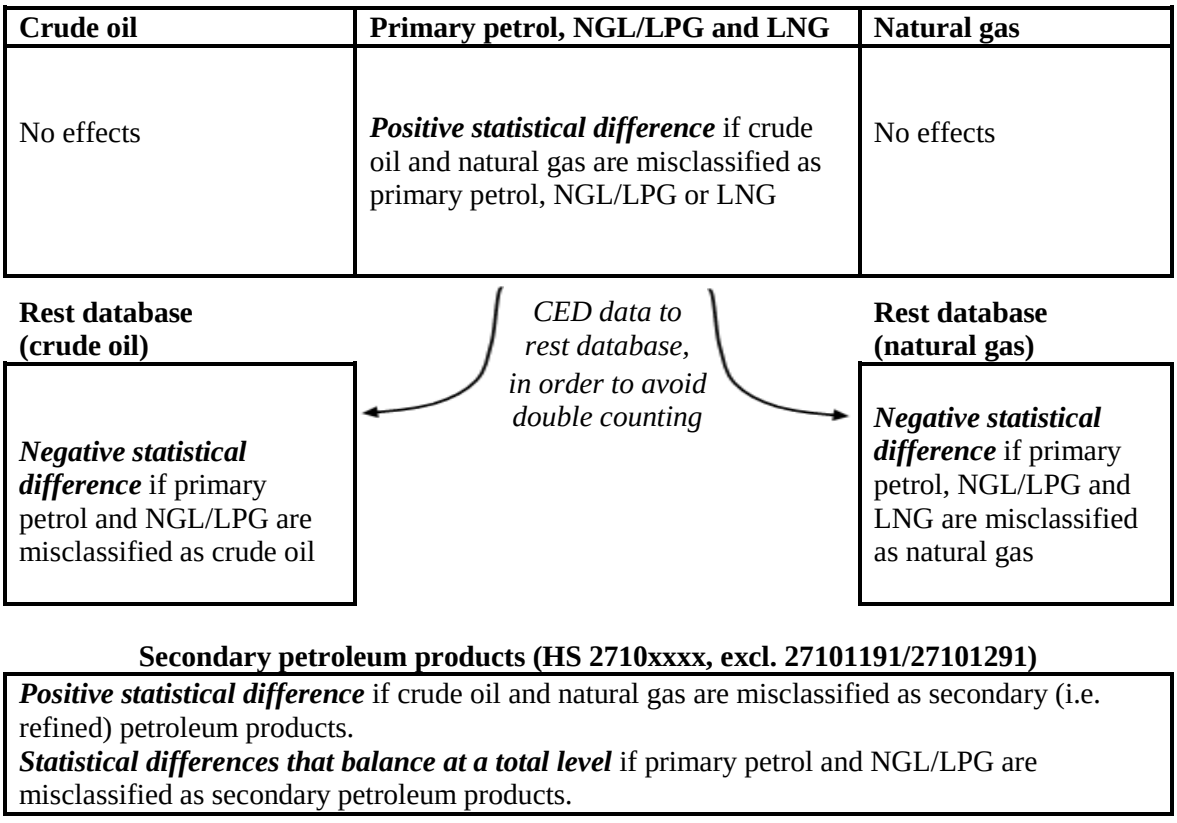
[9] Adjusted for stock changes.

ETS and NPD data, other than those on crude oil and wet gas products landed by pipeline in UK, are measured at the same point in the two data sources, i.e. at the delivery point[10].

Product misclassification and the rest database – source of statistical difference?

Crude oil and natural gas exports being custom declared are removed from the CED data to avoid double counting in the final ETS dataset, and placed in a rest database. At an early stage of the project, this step in the ETS data processing was seen as a likely source of statistical difference. Figure 4.2 gives a schematic picture of the effect on the statistical differences in case of product misclassifications.

Figure 4.2 ETS[1] export – effect of product misclassifications in CED data on statistical difference



[1] External Trade Statistics

The different input data on petroleum products in the ETS export are economically very important, as the values involved are enormous. It must therefore be believed that the data, at least for economical (i.e. tax or custom) purposes, are of high quality. However, there are some elements in the data collection and processing that might impair the data quality for statistical use and/or give rise to statistical differences:

1. Data on the different products are collected from different sources and need to be fitted together (figure 4.1). Misclassification of products may therefore lead to loss or double counting of data, for instance if condensate is misclassified as crude oil or vice versa (figure 4.2). The HS codes for petroleum products have quite technical description texts, and products that look similar may belong to different codes. It has been demonstrated that shipping agents, who are responsible for the classification in the CED data, sometimes make mistakes when

[10] When it comes to transportation costs, the measuring point in the ETS is at the national border.

classifying petroleum products (Walle et al. 2006, p. 43-44). The situation is further complicated by the fact that condensate is sometimes sold and classified as crude oil (f. ex. Gudrun blend), and that this practice has changed over time.

2. New pipelines and fields sending their well stream directly to foreign destinations are not automatically included in the ETS export data. There are previous examples that such pipelines or fields have been missing in the ETS.
3. Some petroleum streams have different measuring points in the production and the ETS export, i.e. non-stabilized crude oil and rich gas landed by pipeline in UK. In the energy balance there has been established methods for splitting these streams into the fractionated petroleum products as reported from the NDP. However, detecting any new pipelines of this kind requires high expertise and careful monitoring, and the difference in measuring point therefore poses a risk of inconsistency between NPD production and ETS export.
4. Wet gas products in parts of the rich gas landed at one UK gas terminal are swapped for natural gas and recorded as natural gas in the NPD data (NPD, pers. comm. 2014). This natural gas is expected to be approximately comparable in the NPD production and ETS export. However, minor inconsistency might occur as the swapping relates to the economical value and not for instance the volume or energy content.
5. The final[11] ETS export figures are released in May the next year. Corrections reported from the oil companies to the NPD data after that time may be implemented in the ETS data, but are undesired. This calls for early (March-April) and coordinated revision routines in the affected statistics.

The import data do not contain any of these risks.

The ETS and the NPD export data are different in several aspects at a detailed level, and hence they could not be easily controlled against each other. The comparisons were tedious and probably insufficient for routine controls. However, the ETS micro data contains information on exporting enterprise and site of exportation, which was exploited in the project.

4.6. Refinery mass balance

In this project a mass balance for conversion in refineries was set up, based on the monthly reporting from the refineries. The mass balance showed a discrepancy between the use of raw materials (feed stock and blend stock) and the produced amounts. Hence, a special report from the refinery in question was delivered for this project. The report shows the whole mass balance for 2011, including the saleable production, used raw materials, residuals and an estimated loss. The reported loss was the estimated residual in the mass balance.

5. New revision controls

This chapter describes revision controls developed during the project. The most important corrections made as result of the controls are summarized in chapter 7.

It should be noted that the controls presented in this chapter have partly been performed independent on the publishing of the energy balance and the external trade statistics (ETS). Some errors that were revealed have been corrected in the published figures, but some are not. Hence, figures in this chapter are not necessarily consistent with figures found in published statistics.

[11] A «final final» version is published in May 1 year and 5 months after the reference year.

5.1. NPD production versus shipments and stock changes – time series

According to NPD, the NPD shipments should be consistent with the production data, when correcting for stock changes (NPD, pers. comm. 2013a). Based on this information, a new revision control was developed based on the running difference between NPD production and shipments of crude oil, i.e. the estimated stock changes, compared to the reported stock changes. The method based on production and stock figures reported by month, and shipment figures summed by month. The starting point for the time series, i.e. the point in time when the total estimated stock was set equal to the total reported stock, was set to December 2007. The period 2008-2014 was analyzed, and the results are shown in figure 5.1 and 5.2:

Figure 5.1 Estimated stocks vs. reported stocks, 2008-2014

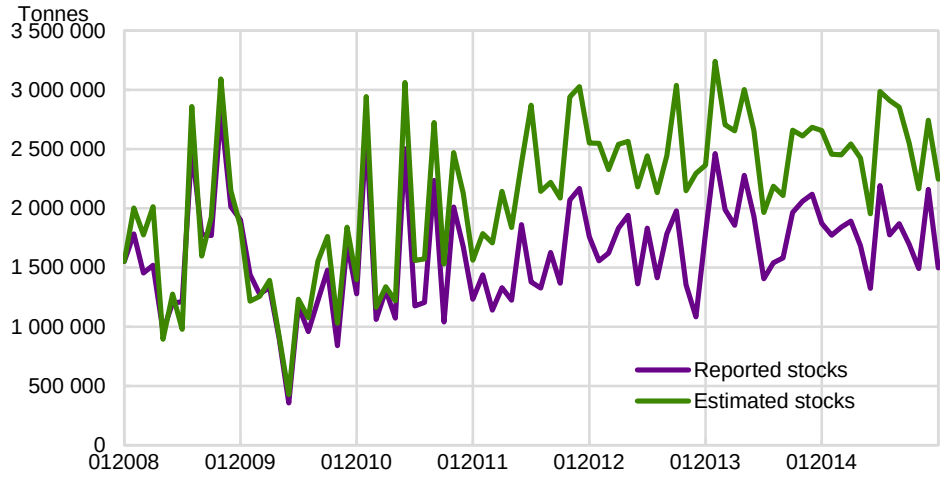


Figure 5.2 Difference between estimated stocks and reported stocks, 2008-2014

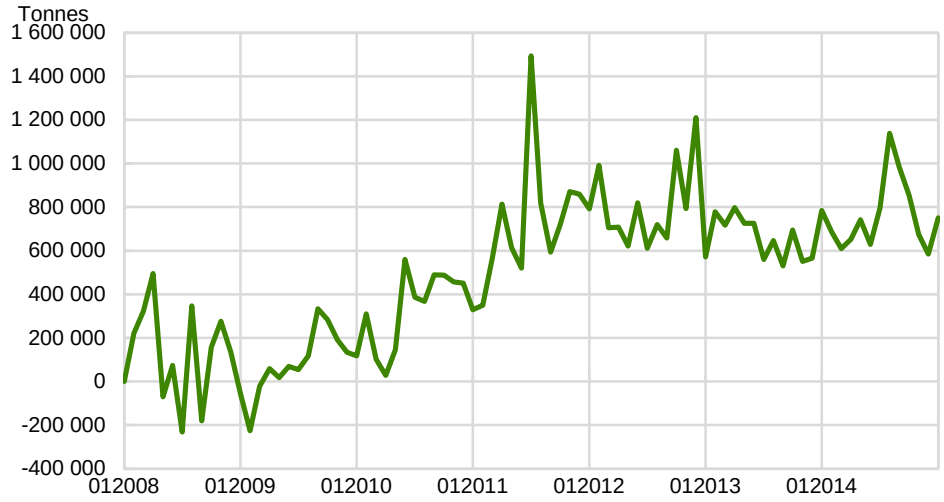


Figure 5.1 shows that reported stocks and estimated stocks are well correlated. When reported stocks increase, the estimated ones increase as well, and vice versa. The estimated stocks tend to fluctuate somewhat more than the reported ones, which may be due to time lags on the shipments. This may in turn cause random statistical differences in the energy balance, but no bias. However, during 2010 and 2011 the estimated stocks show a bias, as the positive deviation the reported stocks does not equalize over time.

This picture becomes even clearer in figure 5.2. The deviation results from an over-reporting of production or an under-reporting of shipments, which causes a positive statistical difference. By using December as reference month for calculating yearly

stock change, in line with the energy balance, a positive statistical difference by 414 ktonnes for crude oil in 2011 might be explained by this revision control while the bias in 2010 amounts to 318 ktonnes. For 2012 to 2014, mainly random statistical differences seem to exist due to inconsistency between production and shipments, after corrections are made in the NPD data.

In earlier versions of the shipment data significant deviations (in terms of statistical difference) were detected, and new data was provided. Hence, the revision control proved very useful. It is effective in distinguishing real errors from the random variation, but it does not identify the fields or sales points that cause the difference. Another revision control was developed for that purpose (section 5.2).

5.2. NPD production versus shipments and stock changes – sales points

In the project relation tables for fields in the production data vs. sales points in the shipment data were set up, based on the description of producing fields on NPD's Fact pages (NPD 2015). These tables were used to control the production against the sum of shipments and stock increase. For crude oil the reference years 2005 – 2014 were set up in a time series. 2011 – 2014 were investigated for any deviation indicating a potential error, a.o. by contacting NPD, and some investigation of 2009 and 2010 was performed as well.

The relation between fields in the production data and sales points in the shipment data is clear for most fields. However, Gullfaks, Vigdis and Tordis occasionally send their oil through the Tampen Link pipeline to UK, making the sales point control a bit more tedious and imprecise. Previously, other fields in the Tampen area switched between Tampen Link and pipelines going to the Norwegian mainland as well. Still, the sales point by sales point revision control proved very effective in identifying errors in the crude oil data.

Significant errors (under-reporting, etc.) in terms of statistical difference were revealed by this control as well, and new data was provided. Potential annual under-reporting of around 200 ktonnes from one or two UK sales points (i.e. terminals) remains and needs further investigation. Moreover, swapping of crude oil[12] loads from one of these sales points to the other was revealed. The sales point by sales point control indicates that not all loads were swapped, as the annual discrepancy for the two sales points were inversely correlated, but this also needs further investigation to be confirmed. NPD is contacted, and answer is expected early 2016.

The streams of rich gas are more complex than the crude oil streams, as several fields send their gas to more than one sales point. Hence, the quality control of the wet gas components is a bit more tedious. The control was performed ad hoc, on suspicion, but not by a standardized setup. Still, the sales point by sales point revision control proved useful for rich gas as well, in particular to streams going to UK where under-reporting appeared to be a significant problem.

5.3. NPD export versus ETS export

Serious effort was put into comparing the ETS export data on primary petroleum products with the NPD export data (i.e. NPD shipments and supplementary terminal data) shipment by shipment. This priority was due to the fact that a vast majority of the domestic production is exported, and thus the causes to statistical difference were expected to be found in the production and/or the export data. This was supported by the early findings, showing that the statistical difference varied

[12] I.e. condensate sold and reported as crude oil,

very much (figure 2.2) compared to the domestic consumption in the different sectors (Statistics Norway 2015a).

Initial study – control against NPD shipments

ETS export data and NPD shipment data on crude oil both contain micro data on every single shipment, including date of export or shipment, and might thus be compared on the most detailed level. However, a load is considered exported when passing the national border, and therefore oil transported to foreign countries by pipeline is reported as pipeline transport in the ETS[13], but as the subsequent shipments in the NPD data. For the different wet gas products, the data source is customs declarations. The customs declarations and NPD use different number systems to identify the shipments, making the link between the shipments in the two data sources weaker for those products.

It was deemed necessary to examine exports at this detailed level in order to evaluate possible systematic errors in the ETS. An early case study was performed (first part-project), comparing shipments from 01.2010. The month before and after were included in the study, to take consideration of time lags.

The case study focused on the following products: Crude oil (HS 27090009), condensate (HS 27090001), isobutane (29011000) and LNG (27111100). The following variables were used in the comparison, if present in the ETS data: Cargo number (crude oil shipped by tanker only), owner company (all products but pipeline transported crude oil), shipment date, destination country (except production being landed in a foreign country) and product amount.

General findings

With some investigation it was possible to make a good comparison between the NPD shipment data and ETS export data containing cargo number (i.e. crude oil shipped by tanker). For the other products, for which custom declarations formed the data basis, detailed comparison was difficult or impossible. The causes of the difficulties were:

1. Though recognizable, the cargo numbers for oil shipped by tanker were typed in different ways and could not be matched automatically. For the other products no link between the cargo number in the NPD data and the cargo identification (declaration number, etc.) in the ETS data could be established.
2. Some loads had been split, merged or sold. This applies in particular to crude oil shipped by pipeline, which is measured at different points in the two datasets, with extensive splitting and reloading of loads between them.
3. Some loads were registered on different dates, and some times even in different years (around New Year).
4. Some loads were registered on different destination countries. This was typically the case if the load went through a transit country.

Crude oil

The ETS dataset on crude oil lifted by tanker showed a good consistency with the NPD shipment data for the selected month. All 69 shipments by tanker registered by NPD as export were found in the ETS data, and all but two in the ETS export data were found in the NPD export data. The two shipments amounted to 102 ktonnes, and a time lag of more than one month could be the explanation.

Crude oil exported by pipeline showed poor consistency between the two datasets for the selected month, but improving when the month before and after were included (Table 5.1).

[13] Field specific data are collected from the field operator.

Table 5.1 Crude oil products landed in UK, by month. Thousand tonnes.

	ETS	NPD	
Period	Unstabilized crude oil	Stabilized crude oil	Other fractions[1]
12.2009	1 429	1 567	36
01.2010	1 435	1 081	36
02.2010	1 289	1 701	28
Total	4 153	4 349	100

[1] Ethane, propane and butane. Re-import to Norway, amounting to 32 thousand tonnes over these three months, is included.

Since unstabilized crude oil in the ETS was compared with the NPD data on stabilized crude oil, the fractions purged out when stabilizing the oil (ethane, propane and butane) had to be included in the NPD data. When including these fractions, all three months showed a somewhat higher amount in the NPD data (4 349 vs. 4 153 ktonnes). However, due to huge monthly variation, especially in the NPD amounts, this aggregated comparison cannot be used to identify the relatively small statistical differences in the energy balance,

A more detailed comparison of pipeline transported oil was however impossible, due to the difference in measuring point between the two datasets. Therefore, no conclusions could be drawn about the sources to statistical differences in crude oil amounts from this initial study, although shipments by tanker showed rather good consistency between the two datasets.

Condensate

There were some additional difficulties when comparing this condensate:

- Condensate and gasoline (naphtha from 2014) are quite similar products in the NPD data. They are sometimes classified as condensate (HS 27090001) and sometimes as naphtha (HS 27101191[14]) in the ETS. However, HS 27101191 also covers secondary naphtha from refineries.
- Some condensate is produced from a rich gas stream, which is all counted as natural gas in the ETS but as its fractionated products by NPD, due to differences in measuring point.

Accordingly, condensate, naphtha (in ETS data) and gasoline (in NPD data) must be viewed together:

Table 5.2. Condensate-like products, by month. Thousand tonnes

	ETS		NPD	
Period	Condensate	Naphtha	Condensate[1]	Gasoline
12.2009	3	68	314	60
01.2010	175	257	249	61
02.2010	39	203	260	53
Total	**217**	**528**	**823**	**174**

[1] Condensate from rich gas, amounting to 41 ktonnes over the three months, is included.

On an aggregated level the amount of condensate and naphtha in the ETS export amounted to 745 ktonnes over the three months, while condensate and gasoline in the NPD export adds up to 997 ktonnes. One main cause of the difference seemed to be time lag, as the ETS export varied greatly over months. A smaller part of the difference, 41 ktonnes, was due to different measuring points for one rich gas stream, as mentioned above.

There were found very few matches on a detailed level, and shipments from one Norwegian terminal were not found at all. Since cargo number is not present on the ETS dataset, split and merged loads could not be linked to each other across the datasets. Furthermore, the allocation of shipments to destination country was somewhat different in the two datasets, possibly because of transit loads. To

[14] HS 27101291 from 2012.

perform a meaningful comparison on a detailed level, a link between cargo number and declaration number would be necessary.

Isobutane

According to the NPD export data for the selected months, all isobutane (HS 29011000) was shipped from one terminal by several owners. In the ETS export data isobutane from just one owner was registered. Three shipments were found in both datasets, one in the ETS data only and 16 in the NPD data only. The total amounts were 9 and 30 ktonnes in the ETS and NPD export data, respectively. Similar findings were made for both neighbouring months.

This suggested an under-registration or misclassification of isobutane in the ETS, causing a positive statistical difference in NGL/LPG in the energy balance, or classifying of isobutane by alternative HS codes covered in the NGL/LPG product category. Further investigation would be needed to sort this out.

LNG

At the time of this study, LNG produced at field was given HS code 27111100, while LNG produced at LNG plants on land were given HS code 27111900[15]. Hence, no further distinction had to be made before comparing the ETS and NPD data.

Some of the LNG shipments in the NPD dataset were given in Sm^3 only. These were converted to tonnes by using the average 2010 natural gas density of 0.0007519 tonnes per Sm^3, based on the NPD production data. The results of an aggregated comparison of the ETS and NPD export is given in table 5.3.

Table 5.3 LNG, by month. Thousand tonnes

Period	ETS	NPD[1]
12.2009	135	137
01.2010	300	387
02.2010	288	259
Total	**723**	**783**

[1] Parts of the data were converted from Sm^3 based on a density of 0.0007519 tonnes per Sm^3.

A detailed comparison was tried but did not give meaningful results, as parts of the NPD data were given in Sm^3 only and had to be converted to tonnes by applying the average density. The amount data was the main link between loads across the two datasets. Many of the shipments were of similar size, and hence the approximate estimates based on average densities turned out to be a poor identifier. Moreover, because of transit countries, destination country was a poor identifier as well. Hence, the detailed comparison of LNG was far too uncertain for finding causes of statistical differences.

Conclusions from the initial study

Due to incompatible information in the two datasets, and partly due to differences in measuring point, detailed comparisons of the ETS and NPD export data were tedious and not always meaningful. Detailed comparison of crude oil shipped by tanker showed a good agreement between the two data sources, and the two occurrences of mismatch could have natural causes, like time lag. The detailed comparison of isobutane showed a systematically lower amount in the ETS data, probably due to under-reporting or misclassification in the ETS, which might have caused a positive statistical difference in the NGL/LPG product category. For the other products no conclusions could be drawn from the detailed comparisons.

The aggregated comparisons showed a consistent pattern where the NPD export exceeded the ETS export for all products investigated in this study, when viewing crude oil transported by pipelines and ships together. We did not find any obvious reason for this bias, but regarded it a call for further investigation as it correspond-

[15] This practice was established in order to distinguish between export from off-shore and export from the mainland in the national accounts.

ed to the positive statistical difference in the published energy balance. For products having customs declarations as data basis, detailed revision controls as in this initial study would require additional information (f. ex. from forwarding agents), which is not readily available.

Follow-up study on crude oil – control against NPD export

As the initial study pointed to inconsistencies between the ETS export and NPD shipment data, a follow-up comparison of the two data sources was performed on the reference years 2013 and 2014. The study was a joint effort of the Division for external trade statistics and the Division for energy and environmental statistics. Only crude oil was covered, due to 1) the possibility of making detailed comparesons, and 2) the size of the statistical difference for crude oil relative to the other products.

The supplementary terminal data was included in the comparison, to complete the NPD export data. The preliminary ETS data was used due to a simpler data structure, but updated with corrections made for the final ETS. The comparison was made on both the regular ETS data and on the additional country specific data on one UK terminal.

The follow-up study had three stages:

1. Detailed comparison shipment by shipment (excl. export by pipeline).
2. Looking up mismatching loads in the supplementary terminal data.
3. Aggregated comparison sales point by sales point.

The ETS and NPD shipments were organized by field, to increase transparency. Even loads with foreign owners were included, in order to reveal any mix-up of nationalities. Stage 3 supplemented the findings at stage 1 and 2, so that more targeted investigation could be made at stage 1 and 2 in an iterative process. At stage 3 foreign loads were excluded, to get right field totals. Though tedious, this control combined with follow-up inquiries to NPD revealed all significant inconsistencies in the crude oil figures between the two datasets, which is a major achievement.

5.4. NPD production versus ETS export – enterprises

In this trial revision control micro data on crude oil (HS 27090009) from the ETS statistics was aggregated by enterprise and compared with the NPD production data. In order to obtain production data by enterprise, the production was multiplied by the enterprises' owner share. As some crude oil goes to domestic refineries, crude oil feedstock (less the imported part) was subtracted.

As the control is tedious to set up and the owner shares may vary through the year, the control is not quite precise. Moreover, a similar control could be more easily set up between ETS export and NPD shipments if necessary, as the owner company is specified in the NPD shipment data. Hence, the revision control described in this section turned out to be less useful.

5.5. NPD shipments versus supplementary terminal data – fields and shipments

Supplementary data from one Norwegian crude oil terminal and an adjacent oil refinery was specially collected, in order to identify loads going to a first destination in Norway and a subsequent destination abroad (c.f. chapter 5.2). The data consists of three data sets identifying eight product flows:

1. Deliveries to terminal from Norwegian fields by pipeline (i.e. goes to stock).
2. Deliveries to terminal from Norwegian fields by ship.

3. Deliveries to terminal from foreign destination by ship.
4. Deliveries to refinery (directly) from Norwegian fields by ship.
5. Deliveries to refinery (directly) from foreign destination by ship.
6. Deliveries from terminal to refinery or temporary stock by pipeline. Loads from Norwegian fields.
7. Deliveries from terminal to external destinations by ship. Loads from Norwegian fields.
8. Deliveries from terminal to external destinations by ship. Foreign loads in transit.

Deliveries to terminal, to refinery (directly) and from terminal were reported in three separate data sets. Transport by pipeline is identified as "Pipeline" in the variable *Vessel name*, in stead of a ship's name. Loads from Norwegian fields are distinguished from other loads by the variable *Product*, by an abbreviation of the Norwegian field name.

The NDP export corresponds to flow 7 (above), after filtering away external destinations in Norway by *Country* ≠ "NO". The NPD export must be supplemented by any loads in transit (flow 8). The datasets covering deliveries to the terminal and refinery respectively were used for quality control against the NPD shipment data.

The supplementary data on deliveries to the terminal and/or the refinery was, with three exceptions, highly comparable with the NPD shipment data. Hence a detailed shipment by shipment quality control against the NPD shipment data could be performed on the import data, and a sales point by sales point quality control could be performed on both the import and the export data. The three exceptions were:

1. A handful of shipments from one field to one UK destination being owned by one specific company were systematically (and erroneously) reported with the Norwegian terminal as origin in the NPD shipment data[16]. This reporting practice was changed in 2015, and from this reference year the producing field is recorded as the sales point, making the two data sets consistent in this respect.
2. The supplementary data does not distinguish between Norwegian and foreign parts of the oil from border fields. All UK loads were identified by comparing with the NPD shipments. In 2012 there were two UK loads amounting to 20.3 ktonnes, while zero in 2011, 2013 and 2014. One minor UK load is reported in 2015 so far. These amounts are almost negligible. Moreover, export of these amounts is unlikely, as it would be a detour (Birgersen, pers. comm. 2015). Hence no significant inconsistency should be expected in the export figures from foreign loads going from border fields to the terminal.
3. Condensate is occasionally shipped to the refinery, either directly or via the terminal, for use as feedstock. The loads are recognized by the letters "CO" in the end of the product name. As all the loads go to the refinery, they do not bring inconsistency the estimated NPD export figures. However, in the conversion item in the published energy balance they are counted as crude oil, and hence a correction of the conversion figures was made.

According to item 1, from 2015 onwards the comparability with the NPD shipment data are even higher and no bias in the estimation of NPD crude oil export should be expected from inconsistencies between the NPD shipments and the

[16] See chapter 5.1 for description of the recording of origin and destination for shipments passing this terminal.

supplementary terminal data, as inconsistencies are expected to apply to domestic deliveries only.

There are of course discrepancies due to the turn of years, as the ships may stay for several days or even weeks at the terminal before departing and loads are sometimes temporarily stored at the terminal. These discrepancies were sometimes found to be significant (see below), but level out over the years.

One general relation was observed between the supplementary data (SD) and the NPD shipments:

1. NPD shipments to terminal = SD "import"[17] to refinery + SD "export"[18] from terminal

For one major product flow that is transported to the terminal by pipeline, the NPD destination can be further divided into *refinery or stock* and *external destinations*. A significant amount goes from the terminal to the stock also by pipeline, and the amount could be identified in the NPD shipments by date and amount. Moreover, a major part of the product flow is omitted in the "to terminal" data set, i.e. the one transported to the terminal by pipeline and "exported" by ship. For this product flow the following additional relation was found in the recorded deliveries:

2. NPD shipments to terminal = SD "export"[19] to refinery or stock + SD "export"[20] from terminal – SD "import" to stock

If all deliveries from the stock go to external destinations, the following relations apply:

3. NPD shipments to external destinations = SD "export" to external destinations – SD "import" to stock
4. NPD shipments to refinery or stock = SD "export" to refinery or stock
5. SD "export" to refinery or stock = SD "import" to refinery + SD "import" to stock

Accordingly, these relations can be used to check the amounts going from the stock to external final destinations and the refinery, respectively.

For the recorded deliveries from all other sales points the following relation was observed:

6. SD "export" from terminal = SD "import" to terminal

Turn of the year discrepancies make inaccuracies in the relations above. For one sales point there was a big turn of the year discrepancy in 2014-2015 (ca. 230 ktonnes) and with a particularly long storage period (about one half year). For another sales point there was a big turn of the year discrepancy in 2012-2013 (ca. 300 ktonnes). Other turn of the year discrepancies were due to loads coming in late December and departing early January, and amounted to less than 200 ktonnes per sales point.

5.6. Supplementary terminal data versus refinery data

The supplementary terminal data contains data on amounts of crude oil going to the adjacent refinery. These figures are expected to be consistent with the use of crude oil feedstock reported from the refinery, and hence a comparison was made in the project. No significant discrepancies on amount were found.

[17] Includes «import» to the refinery of Norwegian oil, i.e. not truly import.

[18] Includes «export» from the terminal to other Norwegian destination, i.e. not truly export.

[19] Includes «import» to the refinery of Norwegian oil, i.e. not truly import.

[20] Includes «export» from the terminal to other Norwegian destination, i.e. not truly export.

However, a few incidents of condensate delivered to the refinery by ship were found ("CO" in the end of the product name). This condensate is counted as crude oil feedstock in the reports from the refinery, which gives a too low conversion of condensate and a too high conversion of crude oil. This causes a positive statistical difference for condensate and a negative one for crude oil in the published energy balance.

5.7. ETS import versus supplementary terminal data – shipments

ETS micro data on import of crude oil was compared shipment by shipment with the supplementary terminal data on "import" to the terminal and the refinery. Product types except from Norwegian fields were compared, and only the variables on date and amount were available for comparison. The match was most often approximate, and hence the comparison must be made manually. However, quite few loads were imported from foreign countries, and thus the comparison was easily accomplished.

Except for loads of condensate (c.f. section 5.6), there was a good match between the "import" to the terminal and the refinery and the ETS import of crude oil.

5.8. Natural gas grid entry versus NPD production

Most natural gas (dry gas) amounts in the NPD production data are entry amounts into the joint venture pipeline grid (c.f. section 4.4) reported by the grid operator. Hence, a good match between the NPD data and the supplementary data on natural gas was expected. For some entry points the amounts are reported from other companies: zone I fields, zone A/F fields (the zone F part) and one additional field. The zones are described on the grid operator's homepage (Gassco 2015).

Some groups of fields share the same pipeline, and some groups of fields form commercial arrangements in which NPD measure before and the grid operator measure after the arrangement. Inconsistencies in reported amounts occurred for those fields, but balanced when summed up within the group. The results of a comparison for 2011 and 2013 are summarized in table 5.4.

Table 5.4 Revision control of pipeline grid entry amounts versus NPD production, 2011 and 2013. Million Sm^3 gas.

Product flows and differences	2011	2013	Data source
NPD production, total	***97 536.7***	***105 519.5***	***Sum***
NPD dry gas	97 050.8	104 456.9	NPD production, excl. Snøhvit.
Wet gas, zone I fields	323.1	774.5	NPD production, converted to Sm^3 gas
Wet gas, zone A/F fields	162.8	288.1	NPD production, converted to Sm3 gas
All pipelines entry, total	***97 601.9***	***105 349.1***	***Sum***
Grid total entry	95 124.2	103 260.4	Supplementary entry data
Operator's pipeline outside grid	727.6	658.5	NPD production less grid entry point (=exit point amount)
Other fields outside grid	1 750.0	1 430.3	NPD production
Difference, total	***-65.1***	***170.4***	***NPD, total – Entry, total***
Difference, zone I fields	-152.8	-132.5	NPD production[1] less grid entry
Difference, zone A/F fields	160.7	243.8	NPD production[1] less grid entry
Difference, other field reported by oil company	-71.6	61.0	NPD production less grid entry
Difference, other entry points	-1.5	-1.9	NPD production less grid entry
Remaining difference	0.0	0.0	Difference, total – specified differences

[1] Incl. wet gases converted to Sm^3 gas.

Practically all differences between pipeline entry and NPD production were found in fields, in which NPD got production data from other sources than the grid operator. The differences were at a relatively low level (table 5.4) and partly balancing over zones/entry points and years. Hence, the pipeline grid entry data seems to be a minor source of statistical differences in the energy balance. Swapping of loads might cause the kind of differences observed for the zone I and A/F fields, but further investigation was not prioritized.

A detailed comparison similar to those for 2011 and 2013 was made for 2012 later in the project. The quality was at the same good level, and making a table 5.4 setup with 2012 data was thus not prioritized. As the revision control was somewhat tedious to set up and no signs of poor quality in the dry gas data were found in the 2014 EB-NPD, no similar control was performed on the 2014 data.

Previously, a part of the natural gas from one field being transported in the operator's pipeline outside the grid was missing in the operatpr's reporting to the NPD production data. This natural gas flow was reported retroactively during the first part-project, and is now included in the NPD production data.

5.9. Grid entry versus grid exit

The pipeline grid entry and exit (physical) amounts were compared at an aggregate level. As the operator's pipeline outside the grid was not part of the entry data, this amount must be added to the entry total. The amount from this pipeline was estimated from the NPD production for the field in question less the pipeline entry amount. The result of the comparison is shown in table 5.5:

Table 5.5 Revision control of grid entry amounts versus grid exit amounts, 2011 and 2013. Million Sm^3 gas.

Product flows and difference	2011	2013	Data source
Entry total, all operator's pipelines	***95 851.9***	***103 918.8***	***Grid entry + other pipeline[1]***
Exit total, all operator's pipelines	***95 844.4***	***103 982.2***	***Sum***
Grid exit, domestic destinations	1 638.7	1 537.0	Grid operator, transported amounts
Grid exit, foreign destinations	94 205.7	102 445.2	Grid operator, transported amounts
Difference	***7.4***	***-63.4***	***Entry - exit***

[1] Estimated as NPD field production minus pipeline entry amount.

There were only very minor differences between the entry and exit amounts. Hence, the pipeline grid exit data seems to be no likely source of significant statistical difference in the energy balance.

5.10. Supplementary natural gas pipeline export data versus ETS export

A comparison was made of total pipeline exit amounts (incl. outside grid) to foreign destinations with the ETS export of natural gas (excl. LNG) on an aggregate level. The result is shown in table 5.6:

Table 5.6 Revision control of total pipeline exit amounts to foreign destinations vs. ETS export, 2011 and 2013. Million Sm^3 natural gas.

Product flows and difference	2011	2013	Data source
Supplementary export data, total	***95 955.7***	***103 875.5***	***Sum***
Foreign destinations, grid	94 205.7	102 445.2	Grid operator, transported amounts
Foreign destinations, outside grid	1 750.0	1 430.3	NPD production
ETS export, total	***96 500.1***	***103 847.4***	***ETS***
Difference	***-544.4***	***28.1***	***Supplementary – ETS***

The difference observed for 2011 corresponds well with the statistical difference that was found in the published energy balance at that time (Statistics Norway 2013c). The grid operator's data on exit amounts going to foreign destinations is used as data source also in the ETS, and that data was already controlled and found

of good quality (section 5.8). Hence, investigating the data on export from fields outside the grid in the ETS was a natural starting point. It was found that for one field, the gas amount had been reported several times with quite varying amounts, and different versions of the figures were used in the published EB and the ETS.

The difference observed for 2013 was minor, indicating good consistency between the natural gas production and export data this year. The quite large statistical difference for natural gas in 2013 was due to LNG (c.f. appendix V).

5.11. Supplementary data on domestic natural gas deliveries versus EB consumption

All natural gas deliveries (excl. LNG) to domestic destinations go through the grid operator's pipelines, and the amounts are covered by the supplementary data on exit amounts to domestic destinations. As reinjection of natural gas into the fields is not included in the energy balance (EB), this amount must be subtracted before comparing with the domestic consumption in EB.

On the other hand, domestic consumption in EB covers flaring and use for energy purposes at the producing field, which are not covered by the supplementary data. Hence, these uses must be subtracted from the domestic consumption in the EB before comparing the data. The comparison is shown in table 5.7:

Table 5.7 Quality control of domestic mainland consumption data in EB vs. grid operator's exit data, 2011 and 2013. Million Sm^3 gas.

Product flows and difference	2011	2013	Data source
Domestic mainland consumption, EB	***1 617.1***	***1 562.4***	***Sum***
Total consumption	1 802.7	1 745.9	Published EB (internal data) and ETS micro data
Consumption at producing field	-185.6	-183.5	Published EB (internal data)
Domestic mainland consumption, grid operator's exit data	***1 637.6***	***1 527.4***	***Sum***
Domestic destinations	1 638.7	1 537.0	Grid operator, transported amounts
Correction, reinjected gas	-1.1	-9.7	Grid operator, transported amounts
Difference	***-20.5***	***35.0***	***EB – Operator's data***

The differences found in this control were minor and with opposite directions. It was also checked that all power plants fired by natural gas and LNG producing plants were included in the operator's exit data. This indicates that the EB figures on domestic consumption were no likely source of systematic statistical difference.

5.12. Refinery mass balance

In order to check the consistency between converted primary petroleum and produced secondary petroleum, a mass balance for the refineries was set up for 2011. Inconsistencies in the conversion data does not itself cause statistical differences, as the input products and output products are different. However, it might cause statistical differences in the next turn, as errors in the conversion data may cause inconsistencies in the products upstream or downstream to the refinery.

An apparent imbalance of 350 kt was found in the data reported from one refinery (NIR 2014). Hence, a special report was acquired from the refinery, which was used to control the refinery data in the published EB. The report showed the whole mass balance for 2011, including the saleable production, used raw materials, residuals and an estimated loss.

6. Detailed energy balance for revision purposes

Energy balances (EB) with a detailed setup were established in this project as a tool for detecting and isolating big statistical differences. These project EBs were detailed in three respects:

- Split between primary and secondary products for all petroleum products (horizontal split).
- Split of official EB products (main products) into specific products as present in the basic data (vertical split).
- Transfer items for product classification changes.

All three detailing methods were based on recommendations from the first part-project, in order to increase transparency. A more transparent energy balance setup was deemed necessary to pinpoint the specific products and parts of the product flow in which inconsistencies caused statistical differences. For simplicity, some of the consumption categories were aggregated. This detailed setup is not meant for implementing in the published EB, but for quality control.

Input data was not sufficiently detailed for making a perfect split at this level, and this was neither a priority in the project. Hence, the products within a main product must be viewed together.

Tables showing detailed energy balances for primary petroleum products with original (ETS) alternative (NPD with supplementary sources) input data on export are given in Appendix V.

6.1. Horizontal split

One initial idea in the project was to control whether there might be fossil energy consumption not accounted for in the emission inventory. As mentioned above, a presumption in this project was that most statistical differences were due to errors in the primary product data, and not lacks in the consumption data. There is very minor end use of primary (unrefined) petroleum products in Norway. Hence, if it could be demonstrated, through a horizontal split of the energy balance, that a vast majority of the statistical difference was due to inconsistent data upstream to the conversion process, the problem with statistical differences, as regards greenhouse gas calculations, would be largely solved.
For product categories in the official EB covering both primary and secondary products the horizontal split would give an increased transparency, supporting the general idea of isolating the statistical differences to narrower categories. As regards petroleum products, this applies to petrol only.

Hence, a horizontal split of the energy balance was developed in the project, between primary products, which are mainly exported or converted to secondary products in refineries, and secondary products, which are partly consumed in Norway. Energy balances for both primary and secondary products were developed. However, as alternative data sources for secondary products are scarce, the energy balance for primary products was prioritized[21]. There is a handful occurrences of end use of primary petroleum products in Norway, and these were included in the primary product balance.

6.2. Vertical split

Most categories of petroleum products in the official EB consist of several different products. Micro data on all these products is available for the entire or parts of the balance, and hence a vertical detailed split by each single product could be made.

[21] See NIR 2014 for detailed energy balance on secondary petroleum products.

A proper split lacks on some items for some products, and hence statistical differences for products within the same product category must be viewed together. This regards for instance primary petrol products, for which feedstock at the refineries is classified as condensate in the detailed energy balances, in line with former practice in international reporting, while NPD production is classified as either NGL or gasoline.

6.3. Transfer items

One transfer item was established in the detailed energy balance for transfers occurring upstream to refineries. This item covers fractionation at a crude petroleum pretreatment plant and the production of LNG at LNG plants. Remaining transfers were placed in the conversion item.

No transfer items are per date included in the official EB.

7. Main findings and results

When studying the results, it should be kept in mind that a positive statistical difference means the domestic supply is too high or the domestic use is too low, cf. relations in section 1.3. Supply of primary petroleum products mainly comes from production, of which the major fraction is exported, while relatively small amounts are imported. The main domestic use is conversion to secondary petroleum products in refineries.

7.1. Early findings

General findings

Looking at the historical statistical differences, an abrupt change was found around 1999/2000. After these years the energy balance tended to show positive statistical differences. Investigations had been made prior to this project to find any structural changes that could explain this shift, and two events had been identified:

- In 1999 a crude petroleum pretreatment facility was established in connection with three existing terminals and one existing refinery. However, the material flows between the pretreatment facility, the three involved terminals and the refinery are complex, and no lacks or errors in the energy balance had so far been discovered.
- In 2001, a non-profit company was established, in order to operate a joint venture grid that includes most of the Norwegian natural gas pipelines (c.f. chapter 4.4) on behalf of the oil companies. On 1 January 2002 the company took over the operatorship of the joint venture grid. Under-reporting from the oil companies on natural gas export might have occurred the first year after the company was established, as a one-time incident, and explain the high statistical difference of natural gas in 2001. However, no under-reporting had been securely identified so far.

Effort was made to reveal any other major structural changes that could explain the statistical differences in more recent years, a.o. through meetings with the NPD, but no incidents were found. Smaller and more regular incidents occur, though, which might cause statistical differences of the size in question and hence requires alertness in the data preparation. These include:

- Opening of new fields near the national border that sends their well stream directly to a foreign country.
- Opening of new pipelines outside the joint venture grid that goes to a foreign country.

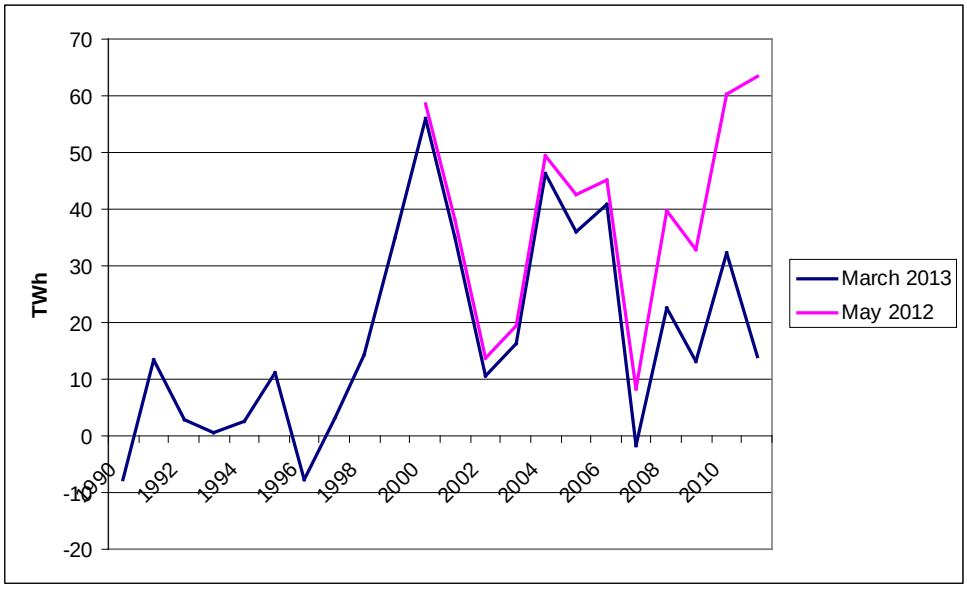
- Redirecting of petroleum products into pipelines outside the joint venture grid that goes to a foreign country.
- Reclassifying of produced petroleum into new product types, f. ex. when condensate from several fields are mixed with crude oil from a new field making the whole amount become a crude oil blend.

These general findings served as guidance on how and where to look for explanations and data that could be used for correction later in the project.

Specific findings in the first part-project

Some specific findings were made in the first part-project, leading to significantly reduced statistical difference for 2010 and 2011. Main findings are summarized below, for details see first part-project report (NIR 2013). Figure 7.1 presents a comparison of the overall statistical difference in two early versions of the EB:

Figure 7.1 Overall statistical difference, 1990-2011. TWh



1 TWh ≈ 85 ktoe

Though small as percentage of total production (figure 2.1), an increasing statistical difference was observed during the first part-project (May 2012). The size and increase of the difference was worrying, and called for further investigation. A scrutiny of the ETS export was performed, and it turned out that the lion's share of the corrections were to be made within the export figures:

1) Export from certain oil and gas fields, previously missing in the ETS for the years 2010-2011, were included. The export from these fields totaled 3.5 TWh and 4.3 TWh for crude oil and 17 and 11 TWh for natural gas for the two years respectively. The statistical differences were lowered accordingly.

2) The export figures for condensate seemed to be significantly and increasingly underestimated in the ETS the recent years. Hence, in the energy balance the ETS figures were to be replaced with alternative figures from NPD, as they matched the production figures better. The NPD figures were already implemented in the energy balance for 2010, but not for 2011. Implementing the NPD figures for 2011 lowered the statistical difference by 18 TWh.

NPD is used as data source for export of condensate in the published EB for years after 2007, and was decided to be so until the figures in the ETS has been improved or verified.

3) By replacing preliminary ETS figures with final figures, coal export for 2011 increased by almost 3 TWh due to revisions in the ETS, and the statistical difference dropped accordingly. Such revisions from preliminary to final figures must be expected in the ETS, and should be dealt with by coordinating the time of publishing, so that final ETS figures could be used even in the preliminary EB figures.

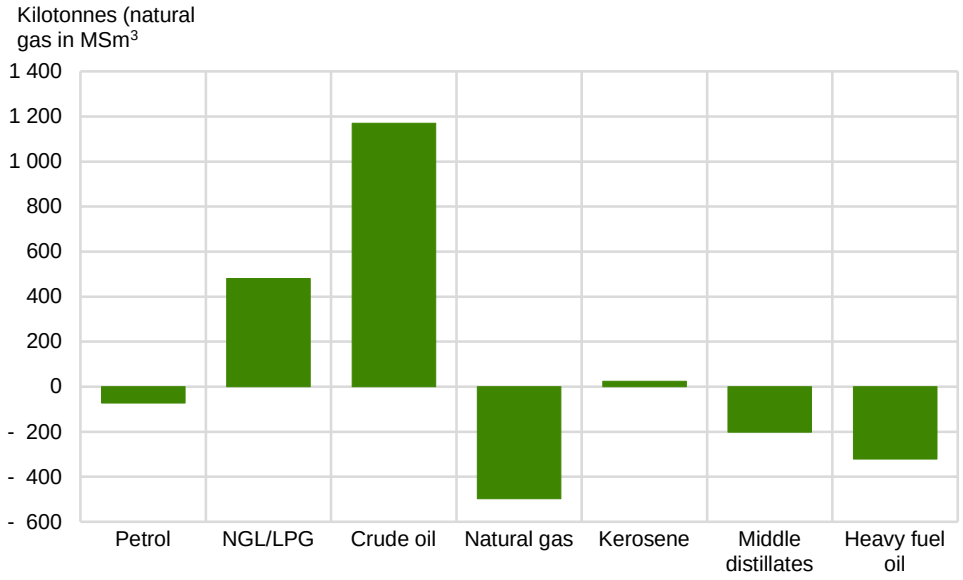
4) The ETS records export of rich gas as export of natural gas (dry gas) only, as the measuring point is at the border (i.e. in the pipeline). Since rich gas has higher energy content than dry gas, the export of energy was underestimated. Correcting the energy content of this export gave an increased gas export of 4-6 TWh per year, reducing the statistical difference accordingly. Note that corrections of energy content do not change the overall energy balance across products in terms of mass and volume.

As a result of these and some other minor corrections made during the first part-project, the total statistical difference dropped by 49 TWh for 2011, to about a quarter of the original size, and by 28 TWh for 2010, to about half the original size, compared to the level before these specific findings.

Statistical differences at the beginning of the second part-project

In the EB published 8 November 2013 the findings described in the first part-project report and some early findings from the second part-project (NIR 2014) were implemented. This version of the EB formed the starting point for the detailed revision controls and estimations in part-project two and three. This EB for selected products is presented in figure 7.2:

Figure 7.2 Statistical differences in the published EB for 2011 as published 8 November 2013, by main product category



As the figure shows, the published EB still contained significant statistical differences early in part-project two. There were positive differences for crude oil, NGL/LPG and kerosene, and negative differences for petrol (which include condensate and parts of NGL), natural gas and most of the refined products. The previous problems with high and increasing statistical differences for condensate were now largely solved in the published EB, however, with some remaining inconsistencies leading to differences even for LPG/NGL.

The overall statistical difference was just slightly positive, by 452 ktoe. However, most product specific differences were unrelated, and hence the total absolute magnitude of differences was much larger and called for further action.

7.2. Findings based on new data, new revision controls and detailed energy balance setup

The detailed energy balance (EB) setup and the alternative data sources achieved in the two last part-projects proved very useful in discovering lacks and inconsistencies in EB. By the end of the project, most sources of statistical difference were eliminated in the revised EB using export figures from the NPD shipment data and the supplementary terminal and pretreatment facility data EB-NPD. Two relatively small sources were identified but remain to be confirmed and eventually eliminated.

In the revised EB using export figures from the external trade statistics (EB-ETS) most sources of statistical difference in the EB for crude oil were identified and some were corrected. New ETS figures on crude oil export as from 2013 were published 16 November 2015, based on findings made in this project. However, in the EB-ETS tables given in appendix V the May 2015 figures are applied, due to limited time resources. For natural gas most sources of statistical difference were securely or probably identified in the EB-ETS, but not revised as published figures were used in the compilation. For NGL/LPG significant sources of statistical differences still remains in the ETS, as no good method for detailed revision control could be found.

Statistical differences by the end of the project

Figure 7.3 shows the statistical differences for main primary product categories according to the revised figures estimated in this project. Random statistical differences of about 500 ktoe or more for crude oil and about 100 ktoe or more for the other main products should be considered high, while no bias should occur. Figure 7.4 and 7.5 show the statistical differences for detailed primary product categories according to the revised figures estimated in this project. Table 7.1 shows revised statistical differences for main primary products as per cent of domestic consumption. Detailed energy balance tables for primary energy products are given in Appendix V.

Note that the detailed EBs estimated in this project used published data from the time the estimations were done. Hence, figures used in diagrams and text are not necessarily consistent with the current published EB. By using data from the time of estimation, improvements due to the new methods and data are displayed. This approach was chosen, as the main purpose of the project was to establish a method to reduce statistical differences to an acceptable level. Figures in the report are meant to show the potential of the alternative methods and data, to show the size of specific corrections, and to give guidance on where to pay extra attention in the future, in order to get EB figures of high quality.

Table 7.1 and figure 7.3 to 7.5 show the statistical differences obtained in the revised EBs by the end of the project. A description of all major improvements is given in the next section.

Table 7.1. Statistical difference in revised energy balances, by main primary product. Per cent of domestic consumption. 2011-2014

	EB-NPD				EB-ETS			
Reference year	Petrol	NGL/LPG	Natural gas	Crude oil	Petrol	NGL/LPG	Natural gas	Crude oil
2011	4.1	-0.4	-0.2	2.8	37.9	-3.5	-7.0	6.6
2012	-2.0	-4.0	-1.4	-1.5	40.9	14.4	-5.1	-0.2
2013	0.2	8.3	1.2	1.7	42.5	-29.9	12.9	12.1
2014	3.7	19.3	-0.4	3.0	-2.8	11.0	-2.4	4.2

Figure 7.3 Statistical differences based on two alternative data sources on export, by main primary product. 2011 - 2014

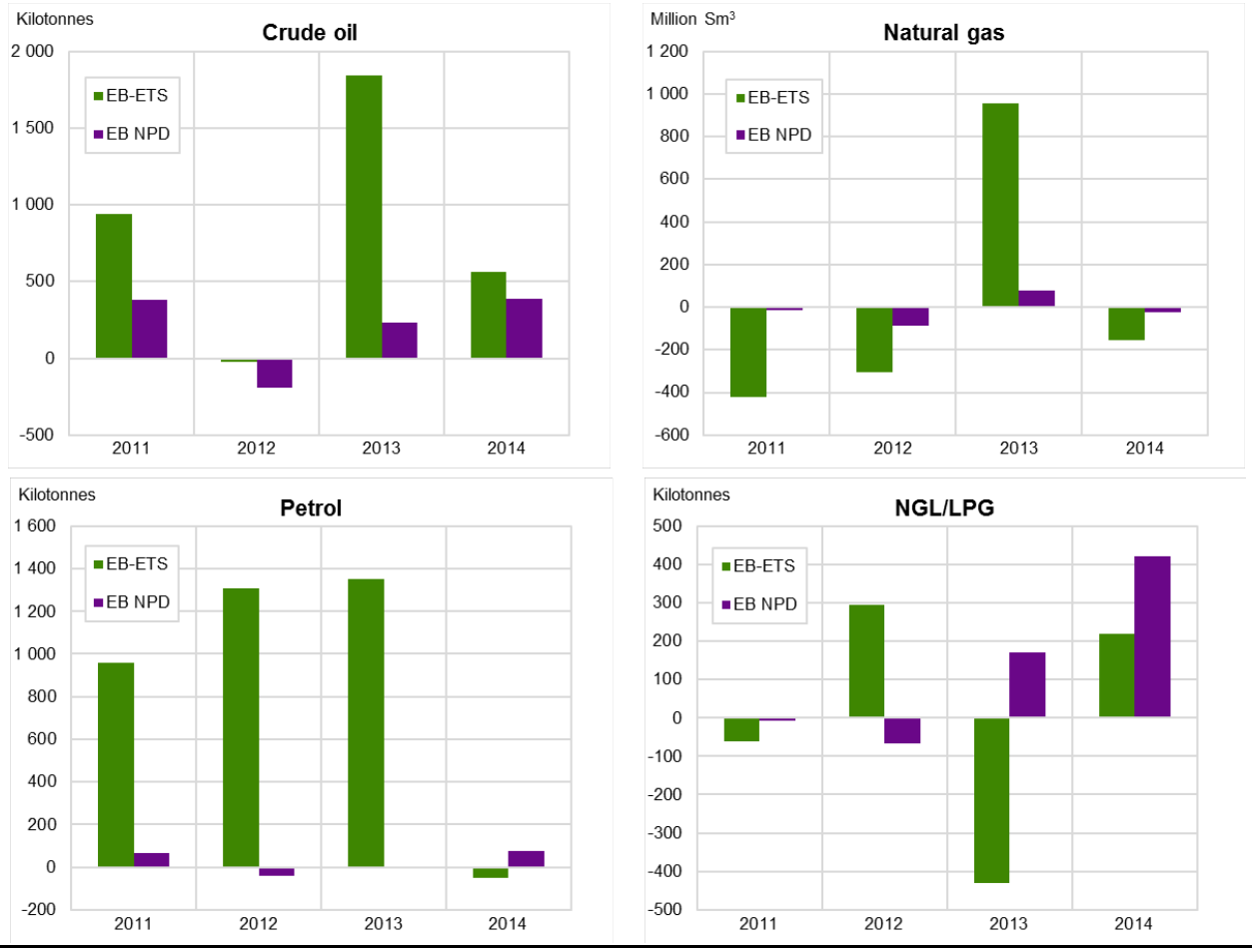


Figure 7.4 Statistical differences based on ETS export data, by main and detailed primary product (dry gas and LNG in mill. Sm^3, gaseous state). 2011 - 2014

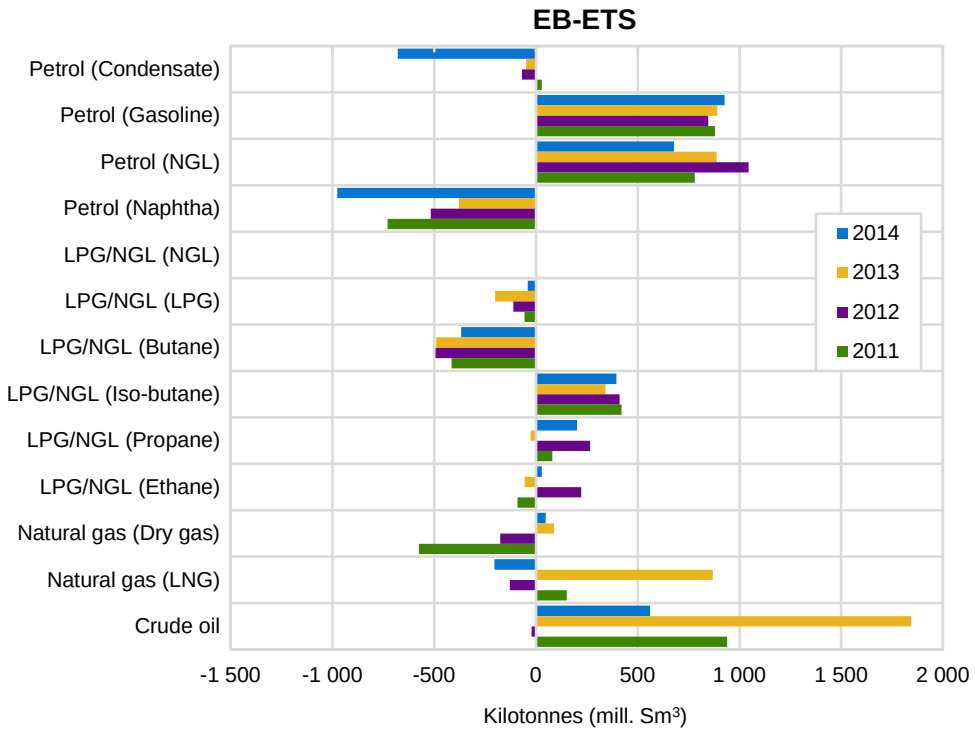


Figure 7.5 Statistical differences based on NPD export data, by main and detailed primary product (dry gas and LNG in mill. Sm^3, gaseous state). 2011 - 2014

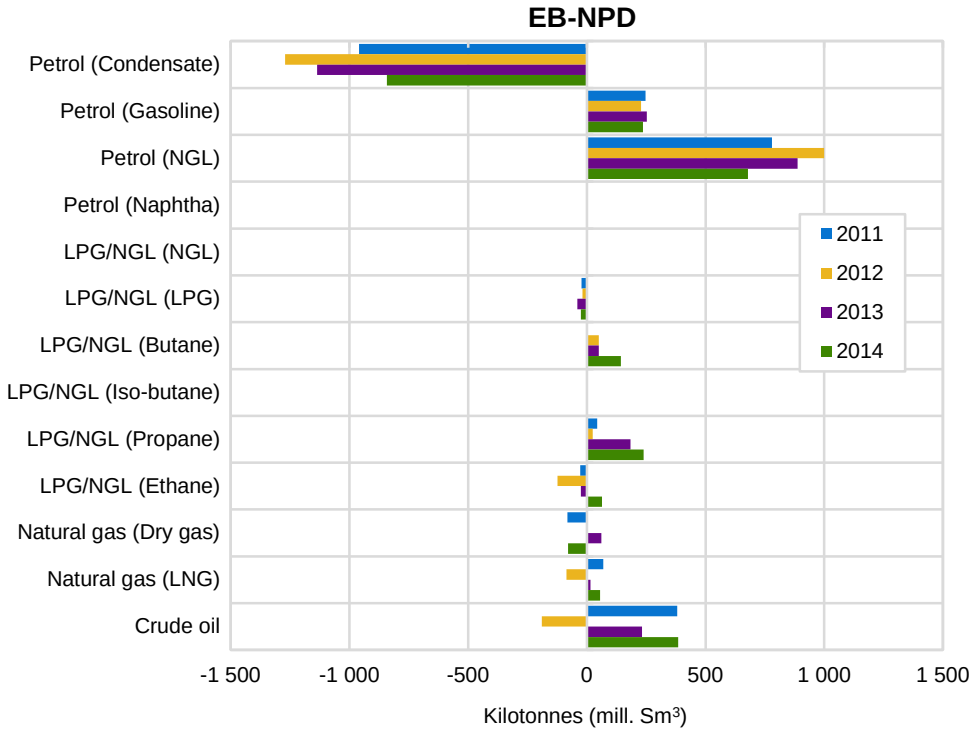


Table 7.1 and figure 7.3 to 7.5 show significant reductions in statistical differences obtained by using NPD shipments with supplementary data (NPD export) for export data instead of ETS export. Substantial improvements were obtained for all main products in most reference years.

Although a bit chaotic, figure 7.4 and 7.5 give a more transparent picture of the two alternative energy balances. In these two figures, statistical differences of detailed products within a main product should be seen in relation to each other. Major shifts occur between the petrol products due to inconsistent product naming, which might be a result of heavily overlapping in terms of chemical composition. Hence, care should be taken when using the statistical difference as a control of condensate and other detailed petrol product figures.

Note that the published EB for 2014 used NPD shipments with supplementary data as crude oil export figures for the first time, as the preliminary ETS resulted in a statistical difference of staggering 5 725 ktonnes (9 per cent of the total export and 45 per cent of the domestic use). One major error was corrected in the final ETS, which was published only days after the publishing of the preliminary published EB. The follow-up study described in chapter 5.3 was based on the final ETS data.

Description of findings

Findings calling for corrections in the energy balance of more than about 100 ktoe (≈4 PJ) are described below. Major findings confirming the current data and methods in the published EB are also described. Some minor findings are described in NIR 2014.

Measuring point

ETS (final) and NPD data on export by pipeline are measured at different points:

- ETS counts deliveries from the Norwegian continental shelf to foreign destinations as export, and subsequent deliveries to Norway as import.
- NPD shipments are measured (physically) when the landed production is transported out from the terminal (i.e. landing site) to a further destination (NPD pers. comm. 2015b).
- NPD production data is measured (physically and by estimations, *ibid.*) when the landed production is transported into the terminal, as is the ETS export, but counted as the fractionated products.

This difference in measuring point has some implications to the estimations:

1. Fractionation at the foreign terminals is accounted for in the NPD data, while natural gas fractionated from crude oil at one UK terminal and deemed lost[22] is not covered at all. In the ETS data both fractionated and lost products are covered, but all amounts are counted as crude oil or natural gas (according to the predominant product type). Hence, corrections must be made in the EB-ETS export or production figures, mostly in line with today's corrections in the published EB, but with an additional correction of lost natural gas.
2. Stock change at foreign terminals must be excluded from the EB-ETS stock change figures.
3. Petroleum products landed in UK and shipped to Norway must be included in the EB-NPD export figures.
4. Distribution by country in the two export data is different for all foreign terminals, except for crude oil at one UK terminal when using the additional ETS data for that terminal. This is relevant to international reporting of country specific figures only.

Crude oil

NPD export vs. ETS export

Major achievements were obtained by comparing crude oil export data from ETS with NPD shipments and supplementary data from one Norwegian terminal (NPD export) at a detailed level. As this revision control was quite tedious, only 2013 and 2014 data was investigated. The comparison revealed several lacks and errors,

[22] I.e. partly used for fuel and partly flared.

mainly in the ETS, which were relatively small compared to the total export (below 2 per cent) but substantial compared to the domestic supply (about 10 per cent).

Findings in the ETS export 2013:

- All shipments from one major field in one month were missing (-631 ktonnes).
- Crude oil landed at two foreign terminals was missing (-471 ktonnes).
- 10 shipments, of these 6 from one field, were missing (-565 ktonnes).
- British oil from two Norwegian border fields was included in the export (+408 ktonnes).

Findings in the NPD export 2013:

- Methane (i.e. natural gas) fractionated from unstabilized crude oil at one UK terminal (307 ktonnes) is deemed lost, and hence excluded from all NPD data (NPD, pers. comm. 2015b). The methane is used for fuel or flared. Due to different measuring points for NPD shipments and ETS export, this lost methane causes a negative statistical difference for crude oil in the energy balance when using ETS export figures. It should be further discussed whether this methane should be included in the energy balance or not, and if so, what part of it. The amounts are measured (*ibid.*), and hence reporting seems possible.
- Three incidents of double recording and one incident of punching error (+130 ktonnes).

Findings in the ETS export 2014:

- Crude oil landed at one Norwegian terminal was missing (-1 162 ktonnes) , as the oil was classified as condensate in the NPD data when reported to Statistics Norway[23]. Since condensate and crude oil have different data sources in the ETS, even the condensate was missing in the monthly ETS, and a true under-reporting occurred.
- Crude oil landed at three foreign terminals, including the two in 2013, was missing (-257 ktonnes).
- British oil from one Norwegian border field was included in the export (+190 ktonnes), as it was in 2013.
- In the preliminary monthly ETS figures for 2014, export of crude oil from one major field was missing (-2 812 ktonnes). The field was included in the final ETS published in May 2015.

Findings in the NPD export 2014:

- Methane from unstabilized crude oil landed at one foreign terminal (509 ktonnes) is excluded from all NPD data.

Furthermore, some shipments at the end of the year seem to be missing in either data source. Updated datasets should therefore be collected when compiling the final energy balance figures.

A former revision control checking the products' nationality is reestablished in the ETS as result of these findings.

NPD production vs. NPD shipments and stocks

Other major achievements in the project were the development of two revision controls for NPD production and shipment data (chapter 5.1 and 5.2). As all data involved in these revision controls is reported from NPD, detailed data may be exchanged during the revision allowing for deep investigation of discrepancies.

[23] The production was formerly classified as condensate, but when oil from a new field (Gudrun) was mixed with the condensate from April 2014, the entire production was sold and counted as crude oil (Gudrun blend).

Findings in the production data:

- Oil transported by pipeline between two Norwegian fields was reported on both fields (384 ktonnes in 2014) (NPD, pers. comm. 2015c). 2014 data are updated in the NPD database, while older data will be updated when the new database is finalized in 2016. No transport between the two fields occurred in 2013 and 2012, while a positive bias in the 2010 and 2011 statistical differences of around 300 – 400 ktonnes might be due to this double counting.

Findings in the shipment data:

- The sales point by sales point control indicates an under-reporting of around 200 ktonnes crude oil[24] from one or two UK sales points together in each of the years, as well as a varying degree of swapping of these loads from one of these sales points to the other. The under-reporting is not corrected, as it needs to be confirmed by NPD. It seems to be generally more difficult to get complete data on foreign sales points. Hence, careful revision should be performed in order to get that data complete.
- Occasional incidents of missing and double recording of shipments were revealed in the preliminary version of the new NPD database, due to imperfect programming and data handling (NPD, pers. comm. 2015a and d). The errors were corrected, and new data provided. The programming and data handling routines are expected to be correct in the new database. The revision controls seem to have contributed to the quality of the new NPD database.
- Parts of the amount shipped from one field to one foreign sales point in 2011 (-150 ktonnes) and 2012 (-133 ktonnes) lacked, due to missing reporting from one licencee. The amounts were requested by NPD, and new data reported.
- Some corrections were made in the shipment data for 2010 as well, due to findings in the project. These include changing nationality to Norwegian for several shipments and collect data for one missing shipment for one field in 2010 (+589 ktonnes), and deleting several loads from a particular group of fields in 2010 (-768 ktonnes). Unexplained difference of 333 ktonnes for one field over the two years 2009 and 2010 still remains to be resolved (if prioritized).

NPD shipments vs. supplementary terminal data

The comparison of NPD shipment data with the supplementary terminal data revealed good consistency between the two data sources. Differences were mainly due to stock changes and loads staying at the terminal at the turn of the year. Only minor differences (<100 ktonnes) were found due to underreporting or wrong classification of shipments. Data on owner country is not provided on the terminal datasets, which could potentially have been a problem when it comes to border fields. However, just a very minor amount of foreign oil from border fields goes to the terminal (Birgersen, pers. comm. 2015), and most of it goes to the refinery.

Note that transit loads, i.e. foreign loads passing through Norwegian territory, occasionally go through the terminal. These loads must be included in the NPD export from the supplementary terminal data, as they are included in the ETS import but not in the NPD shipments. The loads are recognized in the terminal data by the product code.

Supplementary terminal data vs. refinery data

Crude oil feedstock in the reports from one refinery contains a few deliveries of condensate by ship. This causes a negative statistical difference for crude oil and a positive one for condensate. The condensate totaled 200 ktonnes in 2012, but minor or no amounts the other years.

[24] I.e. condensate sold and reported as crude oil,

Refinery mass balance

An apparent imbalance of 350 kt in the 2011 data from one refinery was controlled against a special report acquired from the refinery. The apparent imbalance was mainly due to residues, including coke residue burnt as fuel in the calciner and the cracker, flaring and use of self-produced fuel at the plant, which is all included in the published EB, in addition to an insignificant loss[25]. A minor difference between the monthly reports used in the energy balance and the special report occurred, as the monthly reports are preliminary figures. It should be considered to use final figures in the energy balance.

It was checked if there was a hidden imbalance in the special report, as the output products contain additives (blendstock) and no additives were found on the input side. However, the additives are subtracted on the output side (Johansen, pers. comm. 2015), and hence there was no imbalance in the refinery statistics. A minor amount of LPG feedstock was found to be counted as naphtha in the regular refinery data, which gives consistent estimations in the new detailed energy balances.

Stock changes

The ETS defines deliveries from the Norwegian continental shelf to foreign destinations as export, and the measuring point is at landing, i.e. before the stocks. When using ETS export, foreign sales point amounts should thus not be corrected by the stock change, as the ETS and the NPD production use the same measuring point for these amounts. When using NPD export data, even foreign sales point amounts must be corrected by the stock change, as all NPD export amounts are measured after the stocks.

Crude oil stocks at one other UK terminal were previously not reported to Statistics Norway. Reports are now routinely delivered to Statistics Norway, as a result of the project. However, amounts back in time are not available due to data virus at the owner company (NPD, pers. comm. 2015d). Reported monthly stocks in 2015 ranged from 78 to 111 ktonnes for this terminal, and hence the inaccuracy due to missing stock change figures seems to be minor.

Corrections of production and export in EB

Note that the published EB has made a correction, insofar as ETS is data source on export of crude oil. The correction is made because crude oil landed at foreign terminals by pipeline is counted differently in the ETS and the NPD data: ETS counts unstabilized crude oil, while NPD counts stabilized crude oil and fractionated wet gas products. The fractionated wet gas products are thus added to the crude oil production and the wet gas export in EB-ETS. Moreover, rich gas landed at foreign terminals by pipeline is all counted as natural gas in the ETS, while as dry gas and the fractionated liquid products (wet gases and crude oil[26]) in the NPD data, due to different measuring points. The fractionated liquid products are added to the export in the EB-ETS, while a corresponding amount is converted to MSm^3 and subtracted from the natural gas export. These corrections should not be done when NPD export is used as data source[27].

Note that the current correction does not take into account the lost methane at one UK terminal. When using ETS export this causes a statistical difference. When using NPD export the amount misses in both production and export data, and hence no statistical difference occur. However, it should be discussed if the methane should be included in both items.

[25] Not even the loss gives rise to a statistical difference, as the input materials to refineries are regarded consumed (i.e. converted) in the energy balance, and the output is regarded new (secondary) production. The loss is thus 'amounts that was never produced', and since they are not even used, no statistical difference occurs.

[26] Condensate sold and classified as crude oil.

[27] At some sales points the fractionated wet gases are swapped for crude oil or natural gas (i.e. the main product in the product flow), and hence correction is not necessary.

Also note that crude oil and other petroleum products being landed in UK and shipped to Norway are counted as export and subsequent import in ETS. Hence, these shipments should be included in the NPD export as well.

Summary

The new export data from NPD and one Norwegian terminal provided consistent export figures and a solid basis for revision controls against the production data and crude oil feedstock data from one refinery. Two of the new revision controls apply NPD data only, and deep investigation of discrepancies could be done.

The statistical differences in EB-NPD range from -190 to 385 ktonnes, which is a considerable achievement compared to the published EB when estimated by traditional methods[28]. There is still a slight positive tendency, which might be due to some remaining under-reporting in the NPD shipment data as well as some remaining double reporting in the production data in early years. The statistical differences in EB-ETS range from -22 to 1 844 ktonnes, due to different kinds of under-reporting (some over-reporting occurred as well). An inconsistency due to methane that is lost from unstabilized crude oil at one UK terminal is not corrected for. Hence, the real statistical difference in EB-ETS is assumed to be around 300 to 500 ktonnes higher.

One incident of major under-estimation occurred in the preliminary monthly ETS, due to a missing field. The field was included in the final ETS published in May 2015.

Natural gas

Production of dry gas

The comparison between the supplemented[29] joint venture pipeline grid exit amounts and the ETS export of natural gas showed good consistency for 2013 but a somewhat high difference for 2011 (-544 MSm^3), which explain the negative statistical difference of natural gas in the published EB that year. The ETS uses the operator's exit data as data source, and the difference was thus readily linked to a field outside the pipeline grid. The gas amount from this field had been reported several times with quite varying amounts, and different versions of the figures were used in the published EB and the ETS, with the published EB figures being the lowest.

The current figures downloaded from Diskos on the Internet (9 December 2015) are even lower than those used in the published EB (-104 MSm^3), indicating that the production figure in the published EB was 104 MSm^3 too high and the ETS export was 648 MSm^3 too high. This emphasizes that version control of data between the energy balance and ETS should be performed prior to publishing, as well as focusing on collecting recent figures.

Export of dry gas

Very good consistency was found between the NPD production data and the pipeline grid entry data for 2011 and 2013, when taking into account the differences in measuring point (c.f. chapter 5.8). The minor differences observed (-65 and 170 MSm^3 respectively) could very well be a result of time lags. As the statistical differences were low in the 2012 and 2014 EB-NPDs and the revision control was somewhat tedious to set up, no similar estimation of overall differences were made for these years.

As mentioned above ('Production of dry gas'), the ETS uses the grid operator's exit data as data source for export through the grid. No inconsistency is expected for this part of the export, which counts about 98 per cent of the natural gas export.

[28] The last published EB used NPD export figures, as a result of this project, resulting in a considerably improved statistical difference.

[29] I.e. supplemented with production data on fields exporting their gas through pipelines not being part of the grid.

For the remaining 2 per cent, NPD production data for selected fields is used as micro data. Data quality on natural gas (gaseous state) export seemed to be generally good in the ETS. However, care should be taken to ensure consistent versions of reported figures, as well as the inclusion of all fields outside the grid, especially new ones.

Domestic deliveries of dry gas

There was also a very good consistency between the grid entry and exit data (both in physical amounts), and between the exit data on domestic deliveries (incl. reinjection) and the corresponding published EB data.

Previously, parts of the natural gas from one field (about 700 -800 MSm^3) delivered to the mainland as raw material in manufacturing was missing in the NPD production data. This natural gas flow was reported retroactively during the first part-project, and is now included in the NPD production data.

Export of LNG

The ETS export of LNG in 2013 was low (3 598 MSm^3) compared to the other years (4 200 to 5 400 MSm^3), and 853 MSm^3 lower than the corresponding NPD shipments that year. The main part of the statistical difference of natural gas in the EB-ETS this year was due to LNG. The low ETS export was not further investigated in the project, and should be followed up.

Other corrections

Corrections in the EB-ETS due to different measuring point for rich gas landed at a UK natural gas terminal are described in section 'Crude oil' above.

Summary

The data quality of natural gas exported through the joint venture pipeline grid, which constitutes about 98 per cent of the natural gas export, seems to be excellent. Nevertheless, significant statistical differences in the energy balance have occurred. The reasons are inconsistent export figures on LNG in 2013 (853 MSm^3) and different versions of natural gas amounts reported for one field outside the pipeline grid in 2011 (-544 MSm^3). The 2013 ETS export of LNG was remarkably low and a probable explanation of the statistical difference, while the 2011 difference was due to different versions of amount data for the actual field, with the production data being the most correct one. No difference occurred due to missing fields outside the grid, which has previously been a problem.

The statistical differences in EB-NPD range from -86 to 77 MSm^3. The statistical differences in EB-ETS range from -423 to 957 MSm^3.

Primary petrol

Complex naming and product flows

In the published energy balance the ETS export of condensate (HS 27090001) is replaced with NPD shipments of condensate, while the ETS export of naphtha (HS 27101291) is not replaced. This correction has improved the overall statistical difference for petrol significantly.

However, it does not take into account the complexity of the naming and product flows of condensate-like products affecting the NPD shipments and the ETS export data. Moreover, the production of NGL has been split 50:50 on petrol and NGL/LPG in the published EB, based on approximate information from NPD and an evaluation of the density of the products. The data collected in the project showed that this 50:50 split contributed to the statistical difference of petrol by -260 to +50 ktonnes, and to the statistical difference of NGL/LPG by the same size but with opposite sign.

In the EB-NPD all primary petrol export was based on NPD shipments. The split of NGL on petrol and NGL/LPG products was made in the conversion item, based on exact data from the pretreatment plant performing the fractionation of the NGL, including a report specifying the amount going to Norwegian destinations. One

case of inconsistent classifying between the NPD production and NPD shipments was corrected for. This inconsistency was due to LPG produced at two fields, of which the part landed at one Norwegian terminal was classified as gasoline in the NPD shipment data.

Note that the data from the pretreatment plant on deliveries of fractionated NGL products (propane and butane) to external destinations cannot be readily distributed by destination country. Total reports and reports for single destinations (discharge ports) may be provided, but not total reports distributed by destination or destination country. As the NGL products are shipped to about 100 different destinations, getting these data distributed by country seems quite difficult.

Condensate in crude oil feedstock

As mentioned under *crude oil*, an inconsistency occurs whenever condensate feedstock is delivered to Norwegian refineries by ship. This condensate is reported by the refineries as crude oil feedstock, giving a too low conversion of condensate and a too high conversion of crude oil.

Other corrections

Corrections in the energy balance due to rich gas landed at a UK natural gas terminal and counted differently by NPD and ETS are described in section 'Crude oil' above.

Summary

The new method and the supplementary data from the pretreatment plant provide a consistent estimation method as well as low statistical differences for primary petrol. The statistical differences in EB-NPD range from -42 to 73 ktonnes. However, it should be noted that distribution by destination country is not available in the pretreatment plant data. Hence, when it comes to international reporting these data could be used to make a correction of the ETS export, but they cannot be used directly.

The statistical differences in EB-ETS range from -51 to 1 351 ktonnes. Detailed revision control could not be readily made for these products, due to different coding of data, splitting and merging of loads and the occurrence of transit loads. Hence, the main sources of statistical difference for primary petrol in the EB-ETS were not revealed.

NGL/LPG

LPG and propylene

The definition of LPG covers both saturated (propane and butanes) and unsaturated (propylene and butylenes) hydro carbons (see f.ex. Marathon Petroleum 2012). All production of LPG at refineries is included in the EB. However, based on commodity explanation texts in the ETS export micro data, LPG from one refinery was found to be propylene, which is not an energy product. The propylene was partly exported and partly used as raw material in domestic chemical industry.

The exported product is classified as HS 27111400, which is included in the EB, and not for instance HS 29012200 (manufactured propylene). The raw material part, however, is not included in the EB. This inconsistency caused a statistical difference of 100 to 300 ktonnes in the published EB. Corrections were made by excluding this LPG from the EB-NPD and partly from the EB-ETS. The amount is still included in the ETS export figures, as it makes up a part of a HS number. It is not obvious how to treat production of non-energy products at refineries in EBs, and hence it should be further discussed how to correct for this inconsistency in the published EB.

Under-reporting from foreign terminals

Sales point by sales point control indicated an under-reporting of 412 to 530 ktonnes ethane from one foreign sales point to the NPD shipment data in 2012-2014. The under-reporting was later confirmed by NPD (NPD, pers. comm. 2015e), and the export was corrected in the EB-NPD by the produced amounts

from the relevant fields[30]. No correction was needed in the EB-ETS, due to different measuring points (the ethane is part of a rich gas stream, which is all counted as natural gas in the ETS).

Moreover, a possible under-reporting of around 450 ktonnes of other NGL products from the same sales point to the NPD shipment data in 2014 was identified. This finding is not corrected, as it needs to be confirmed by NPD. As stated above, it seems to be generally more difficult to get complete data on foreign sales points.

Stock figures are also missing from this sales point, as they have never been reported to NPD. The stock figures were requested in the project, and the request will be followed up by NPD in 2016 (NPD, pers. comm. 2015e).

Other corrections

Corrections in the energy balance due to unfractionated oil and gas landed at foreign terminals and counted differently by NPD and ETS are described in section 'Crude oil' above.

Corrections in the EB-NPD according to the complex naming routines and product flows for condensate and NGL-products are described in the section 'Petrol'.

Summary

The new method and the supplementary data from one pretreatment plant provide a consistent estimation method as well as reduced statistical differences for NGL/LPG in both detailed EBs. As for primary petrol, it should be noted that distribution by destination country is not available in the pretreatment plant data.

A probable under-reporting from a foreign sales point to the NPD shipment data in 2014 made the statistical difference in EB-NPD somewhat high this year. The statistical differences in EB-NPD range from -67[31] to 421 ktonnes.

In the EB-ETS propylene was counted as LPG in the export figures (as in the published EB), but not in the production figures and the raw material figures. This gave a negative contribution to the statistical difference. The statistical differences in EB-ETS range from -432 ktonnes to 295 ktonnes.

8. Conclusions, recommendations and further work

8.1. Conclusions

In this project, new data has been collected, new revision controls and a detailed energy balance (EB) setup have been developed, and new correction methods have been established, all of which contributing to higher data quality in the energy balance and bringing the statistical differences for primary petroleum products down to an acceptable level. The new data is readily available and suitable for routine delivery. Compiling them for use in EB is relatively simple.

The new data and revision controls will be implemented in the routine production of the published EB, and the new correction methods will be considered as well. New revision controls will be employed in the production of the external trade statistics (ETS), and improved communication routines between the Division for energy and environmental statistics and the Division for external trade statistics are

[30] The export in 2012 might have been slightly over-corrected by up to 80 ktonnes. No under-reporting indicated in 2011.

[31] This negative statistical difference might be due to an over-correction of the ethane export in 2012.

established. This will contribute to enhanced quality of EB as well as to the ETS. Improvements in the ETS will even contribute to reduce the positive stock changes within oil and gas extraction in the national account.

All significant causes to statistical differences between 2011 and 2014 were found, and all was related to the supply side of EB, which corresponds to the reference approach in the greenhouse gas inventory. This supports the previous Norwegian position in these matters. The errors being found were significant compared to the domestic use of primary petroleum products, but minor compared to the total production and export. Three minor follow-ups on under-reporting to NPD remain.

New data

The new data to be used in the published EB include:

1. Detailed shipment data from the NPD, including the new variable *destination*. The data covers all primary petroleum products, except natural gas in pipelines.
2. Supplementary shipment data on crude oil from one Norwegian terminal, including:
    a. Shipments in to terminal (“import”)
    b. Shipments in to adjacent refinery (“import”)
    c. Shipments out from terminal (“export”)
3. Supplementary shipment data on NGL/LPG (butane and propane) from one Norwegian crude petroleum pretreatment plant, including:
    a. Total shipments
    b. Shipments to Norwegian destination
    c. The data is not distributed by destination country. Hence, in international reporting this data should be combined with the ETS export data.
4. Exit point data from the operator of the major Norwegian natural gas pipeline grid.
5. Stock data from two UK terminals, which has previously been missing. Data from one of them is implemented in the regular data collection from May 2015, whereas data from the other remains to be collected.
6. Field description from NPD Fact pages (NPD 2015), for updating the relation tables for fields vs. sales points. Note that these relation tables are different for crude oil and wet gases.

Another data source should be considered:

7. Final annual data from refineries, instead of the preliminary monthly data being used in EB today.

New export figures (NPD export) were estimated from the NPD shipments (1) supplemented with data from the terminal (2) and the pretreatment plant (3), resulting in considerably reduced statistical differences. An early attempt was made to estimate the crude oil export solely by use of the NPD shipment data. Despite promising results, further investigation showed that the supplementary terminal data was needed for proper identification of the exported loads.

In the published EB corrections are made to obtain consistent export and production figures. The corrections are quite complicated, and they are somewhat incomplete. These are not needed when NPD export replaces the current ETS export figures in EB. At present, the published EB uses NPD export figures on crude oil (2014) and condensate (2007 to 2014).

Fractionation of NGL at the pretreatment plant has been estimated by a somewhat rough method in the published EB. The converted NGL has been counted 50:50 as petrol and NGL/LPG in the published EB. By using the new NPD export data, this split will be done in a more precise and consistent way.

Some additional data were collected and used for quality control in the project, including ETS micro data, detailed entry data from the natural gas grid operator, and a mass balance report from one Norwegian refinery. The controls based on this data could be useful in explaining statistical differences, if the new datasets 1 to 6 (7) listed above, the new revision controls and the suggested corrections of estimation methods do not give the desired quality in the EB.

A new IT solution for the NPD database (Diskos) was developed at NPD during the project, and a routine delivery of shipment data with the *destination* variable is now established. Diskos is still in a preliminary version, and some imperfection in programming and data handling routines were revealed in the project. Diskos is expected to be finalized in 2016, and this project seems to have contributed positively to the quality of the database.

Detailed energy balance

A detailed EB setup was developed in this project, in order to increase transparency. The detailed setup comprise a 'vertical' split, i.e. of (main) products in the published EB into more detailed products, a 'horizontal' split, i.e. between primary and secondary products, as well as one transfer item for fractionation of primary petroleum products taking place outside refineries. The detailed EB is suitable for additional quality control in the routine EB production, if needed.

Two alternative detailed EBs were set up in the project, one with the original ETS export data[32] (EB-ETS) and one with the new NPD export data, i.e. NPD shipments with supplementary data (EB-NPD), to evaluate which data source gives the lowest statistical differences. Low statistical differences indicate high quality in input data and estimation methods.

New revision controls

Crude oil: Five new revision controls were developed for checking crude oil amounts. The first two apply NPD data only, and hence output from these controls can be submitted to NPD for further check. The new controls are:

1. NPD shipment data should be consistent with the NPD production data, when correcting for stock changes. Based on this, the monthly running difference between NPD production and shipments of crude oil, i.e. the estimated monthly stock changes, was compared with the reported stock changes (2008-2014). This revision control is effective in distinguishing real errors from random variation at a total level, and is easily set up.
2. Relation tables for fields vs. sales points were set up, and these were used for a sales point by sales point control of the production against shipments plus stock increase (2005-2014). This revision control distinguishes real errors from random variation at sales point level, and is easily set up. A similar control of fractionated wet gas products is feasible, but a bit more imprecise, as rich gas flows are more complex than the crude oil flows. In the project, this control on wet gas products was performed on suspicion and not by a standardized setup.
3. Both the NPD shipment data and the supplementary terminal data contain shipments to the terminal. Moreover, the terminal data contain shipments to the adjacent refinery, to stock and out from the terminal. The NPD and terminal data are consistent, with some manageable exceptions. The data were crosschecked shipment by shipment and field by field. Consistency both within the terminal data and against the NPD shipments was controlled.
4. The ETS export data was crosschecked against the NPD export data field by field and shipment by shipment. The ETS and NPD export data are different in several aspects at a detailed level, and hence matching the

[32] Published May 2015.

shipments is tedious. Due to confidentiality rules, results from this revision control cannot be submitted to NPD for data check.

5. In the monthly reporting from one Norwegian refinery there is a discrepancy between the use of raw materials and the produced amounts. A special mass balance report for 2011 was collected from the refinery, showing that the discrepancy was due to residuals, flaring and use of self-produced fuel at the plant, all accounted for in the published EB, and an insignificant loss.

Several errors in the NPD data were detected in the first two controls[33], mostly due to under-reporting in the shipment data, and new data was provided to the project. A small annual under-reporting of crude oil from one or two UK sales points seems to remain, as well as a small double counting of oil sent by pipeline between two Norwegian fields. These errors are expected to be corrected in the finalized Diskos, and no major errors will then remain in the NPD crude oil data on the analyzed period.

Some loads of condensate delivered by ship to the refinery were found by the third revision control to be classified as crude oil feedstock in the refinery data, leading to a negative statistical difference for crude oil and a corresponding positive one for condensate. The feedstock data should be considered corrected in the published EB.

Several errors were found in the ETS crude oil data by the fourth revision control, and the errors had different causes. Initially, misclassification and/or inconsistent naming of primary petroleum products was seen as a likely cause of statistical differences when using ETS export data in EB, as the data on different products are collected from different sources and needs to be fitted together in a consistent way. However, only one significant incident of misclassification occurred, while the remaining difference had other causes.

Revised ETS figures on crude oil export from 2013 onwards were published 16 November 2015, based on the findings in this project (Statistics Norway 2015b). The new figures on 2013 and 2014 were 1.6 and 1.9 per cent higher, respectively. Estimations in this project, however, applied the ETS figures published May 2015, as the revised ETS figures came too late. The improved ETS quality does not lead to increased quality in EB, as NPD export is chosen as data source. However, consistency between EB and ETS will improve.

Some minor remaining random errors were found in the NPD shipment data as well, in addition to one potential inconsistency due to methane that is purged out and deemed lost[34] when stabilizing crude oil at one UK terminal. This methane is missing in both the shipment and the production data from NPD, and hence the NPD data is internally consistent. In the ETS export this methane is included, but this is not corrected for in EB. It remains to decide how to treat this methane in EB.

Moreover, in the ETS export all unstabilized crude oil landed at this UK terminal is counted as crude oil, while in the NPD production and export the stabilized crude oil and the fractionated products except lost methane (i.e. partly burnt for fuel and partly flared) are counted. In the published EB the crude oil and NGL/LPG figures are currently corrected as if ETS export counts unstabilized crude oil without the methane part. Hence the correction has been made incorrectly. The inconsistency is

[33] Note that errors that are significant in terms of statistical difference, might be minor in terms of total production.

[34] Partly flared and partly burnt as fuel.

avoided when using NPD export figures. However, it should be considered to include the lost methane in the EB.

A minor difference was found in the fifth revision control between the monthly refinery reports used in EB, which contain preliminary figures, and the special refinery report, which contain final figures.

The first three revision controls will be implemented in the regular EB production, while the fourth will be implemented in the regular ETS production. The fifth should be considered if the preliminary monthly refinery reports are chosen as data source on conversion and high statistical differences on crude oil or condensate occur.

Natural gas: Five revision controls were used for checking natural gas amounts, of which two were new:

1. Data from the major natural gas grid operator on amounts per exit point is used in the ETS export, while data on entry amounts is reported from the grid operator to NPD and comprises most of the NPD production data being used in EB. The grid entry and exit data were compared and found to be highly consistent.
2. The grid entry data were compared with the NPD production data and found to be highly consistent.
3. It was previously assumed that statistical difference on natural gas was caused by fields outside the grid that missed in the ETS export. This was found not to be the case. However, it was found that the statistical difference in one year was due to one field outside the grid, for which EB production and ETS export (also being used in EB) used different versions of the NPD production data.
4. Significant statistical for another year was found to be due to LNG. Time series of LNG export in ETS and NPD data, respectively, indicate that the export of LNG in one year is significantly underestimated in ETS. All primary LNG comes from one field, and checking this LNG export seems feasible.
5. All deliveries to domestic exit points go through pipelines operated by the grid operator. Data on these amounts was compared with consumption figures in the published EB, and no significant differences were found.

As found in crude oil control 4, natural gas (i.e. methane) lost from unstabilized crude oil at one UK terminal is missing in both NPD production and NPD export figures. It remains to decide how to treat this natural gas in EB, in order to obtain consistency with other statistics.

Condensate and NGL/LPG: For condensate and NGL/LPG (wet gases) three revision controls were applied:

1. A sales point by sales point control was made, similar to crude oil control 2. However, rich gas flows, from which parts of the wet gases are fractionated, are more complex than the crude oil flows. Hence, the control was applied for selected sales points on suspicion only, and not as a standardized overall control. In this control a probable under-reporting of several NGL/LPG products from one UK sales point was revealed.
2. Detailed crosscheck of NPD export against ETS export was attempted. However, the crosscheck did not give meaningful results for these products, due to different shipment coding, splitting and merging of loads, and occasional transit loads.
3. NPD shipments to domestic destinations were controlled against consumption figures in the published EB, and no significant differences were found.

Moreover, based on commodity explanation texts in the ETS export micro data, LPG from one refinery was found to be propylene, which is not an energy product. The propylene was partly exported and partly used as raw material in domestic chemical industry. It remains to decide how to treat this non-energy LPG product in the published EB.

The detailed EBs with ETS export and NPD export provided a particularly useful additional control of the wet gas product amounts. These main products could be split into several detailed products, and hence transparency was considerably increased.

Revised statistical differences

Initially, both the NPD and the ETS data contained errors that would give significant statistical differences. However, by means of the new overall revision controls most errors in the NPD data were identified and corrected, resulting in low statistical differences. Similar overall controls of the ETS export data cannot be made, and detailed crosscheck against the NPD export data can only be made for crude oil and natural gas (excl. LNG). Hence, statistical differences still remain high for several products when using ETS export figures in the EB, and NPD export is now the chosen export data on primary petroleum products in the published EB.

Table 8.1. Statistical difference in revised energy balances, by primary petroleum product. Per cent of domestic consumption (average of differences 2011-2014).

	Average of real values				Average of absolute values			
Export data	Petrol	NGL/LPG	Natural gas	Crude oil	Petrol	NGL/LPG	Natural gas	Crude oil
New (NPD)	1.5	5.8	-0.2	1.5	2.5	8.0	0.8	2.2
Original (ETS35)	29.6	-2.0	-0.4	5.7	31.0	14.7	6.8	5.8

The table shows that using NPD export figures gives both lower bias (c.f. real values) in the statistical difference for most products and lower variation (c.f. absolute values) for all products. By correcting remaining probable under-reporting of NGL/LPG and crude oil in the NPD export, the statistical differences by use of NPD export could be further decreased.

Turn of the year differences are quite high for crude oil at several sales points. Hence, in future published EBs, random statistical differences within ±500 ktoe should be tolerated for this product, but they should balance over years. For the other three products, random statistical differences within ±100 ktoe should be expected. No significant bias should occur.

8.2. Further work and remaining decisions

The main remaining tasks are to implement the new data and revision controls in the regular EB production routines, decide which new corrections to be implemented, and communicate the project results to other relevant parts of Statistics Norway. Only two minor follow-ups on statistical differences remain.

Further work

The following will be implemented in forthcoming energy balance production:

1. Replace ETS export with NPD export for all primary petroleum products in the production of EB for which ETS is source today. Note that by changing data source to NPD export in published EB, the differences between the ETS and NPD export due to differences in measuring points must be dealt with in an appropriate way, in order to avoid inconsistency against ETS and the national accounts.

[35] Published May 2015.

2. Improve the split between petrol and NGL/LPG in the published EB, based on new data.
3. Establish a method for correcting the country specific export figures on NGL/LPG in international reporting, based on new data.
4. Implement the new revision controls in the regular EB production. One of the controls will be performed at the Division for external trade statistics.
5. Work towards improved reporting to NPD from foreign terminals, including currently missing stock data from one terminal and complete reporting of shipments.
6. Implement coordinated data collection, revision and publishing in EB and ETS, according to recently established routines.

A project for developing a new IT platform for the energy balance is expected to be finalized in 2016. The project will restructure the EB production system into a data warehouse. The result will be a more automated, robust and transparent production system, and thereby reduced risk of errors in the data compiling. It remains to decide which of the new corrections to implement in the new IT platform, and how to implement them. The corrections to be considered are:

1. Establish a method for treating non-energy products like propylene (LPG) produced at refineries.
2. Make corrections for condensate imported to Norwegian refineries and counted as crude oil feedstock in the refinery reports.
3. Clarify whether methane fractionated from unstabilized crude oil at a UK terminal and deemed lost should be included in the production and export figures.
4. Collect final annual refinery data after the end of the reference year.
5. Establish a transfer item for the fractionation made at the pretreatment plant, in order to increase transparency.

It should also be considered to find more permanent and stable IT platforms for the detailed EB and the new revision controls.

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Appendix I: Specification of shipment data (new database)

Variable	Specification	Content
name		Name of sales point (field or terminal)
billOfLading		Delivery date
cargoNo		Cargo number
destination		Destination (terminal, port, etc.)
destinationCountry		Destination country
owner		Owner company
ownerCountry		Owner country
share	%	Owned share (%)
oilVolume	Sm^3	Oil Volume (Sm^3)
oilVolume	bbl	Oil Volume (barrels)
oilMass	t	Oil Mass (tonnes)
butaneVolume	Sm^3	Butane Volume (Sm^3)
butaneMass	t	Butane Mass (tonnes)
gasolineVolume	Sm^3	Gasoline Volume (Sm^3)
gasolineMass	t	Gasoline Mass (tonnes)
isobutaneVolume	Sm^3	Isobutane Volume (Sm^3)
isobutaneMass	t	Isobutane Mass (tonnes)
condensateVolume	Sm^3	Condensate Volume (Sm^3)
condensateMass	t	Condensate Mass (tonnes)
ethaneVolume	Sm^3	Ethane Volume (Sm^3)
ethaneMass	t	Ethane Mass (tonnes)
propaneVolume	Sm^3	Propane Volume (Sm^3)
propaneMass	t	Propane Mass (tonnes)
lngMass	t	LNG Mass (tonnes)
lpgVolume	Sm^3	LPG Volume (Sm^3)
lpgMass	t	LPG Mass (tonnes)
naturalGasVolume	Sm^3	Natural Gas Volume (Sm^3)
nglVolume	Sm^3	NGL Volume (Sm^3)
nglMass	t	NGL Mass (tonnes)

In the old database *destination* was not included. Moreover, the amount of the different product types were organised in rows instead of columns with product type specified in a separate variable. The amounts were given per cargo, and must be multiplied by *fraction* to get an addable amount.

Appendix II: Specification of supplementary data from crude oil terminal

Variable	Content
Date	Shipment date
Shipment No	Shipment number
Vessel Name	Vessel Name
Country	Departure (import) or destination (export) country
NSV	Net volume (Sm^3)
NBBL	Net volume (barrels)
NWA	Net weight (tonnes)
GWA	Gross weight (tonnes)
Product	Product quality (abbreviated name of field or foreign quality)
Density	Product density (tonnes / Sm^3)
Cargo No	Cargo number (identifying shipments)

Separate files are delivered for import to terminal, import directly to adjacent refinery and export from terminal respectively.

Appendix III: Specification of supplementary data from petroleum pretreatment plant

Variable	Content
BOL date	Bill of laden date (shipment date)
Cargono	Cargo number
Vessel	Vessel name
Delivery	Cargo part number (to identify split)
Total quantity	Weight (metric tonnes in vacuum)
<no name>	Product quality (abbreviated name of field or refinery)
Account	Company (abbreviated name)
Quantity	= Total quantity

Separate files are delivered for propane (C3) and butane (C4). Separate tables for each company within the files.

Appendix IV: Specification of supplementary data from natural gas grid operator

a) Produced amounts at entry, area A, B, C, D and E (2011-2013)

Field placed in zone G and H are included.

Variable	Content
DAYTIME	Date of measurement (1. in each month)
FIELD	Producing field (abbreviated)
STREAM_LABEL	Specification of chemical product and field/terminal
STREAM_CODE	Code specific to *stream_label*
NET_MASS	Weight (kg)
NET_VOL	Volume (Sm^3, dry gas only)
ENERGY	Energy content (MJ)

b) Produced amounts at entry, area F and I (2011-2013)

Variable	Content
OBJECT_CODE	Pipeline (abbreviated)
TRUNC(D.DAYTIME,'MONTH')	Date of measurement (1. in each month)
PROFIT_CENTRE_CODE	Producing field (abbreviated)
SUM(D.NET_MASS)	Weight (kg)
SUM(D.NET_VOL)	Volume (Sm^3, dry gas only)
SUM(D.ENERGY)	Energy content (MJ)

c) Transported physical amounts at exit (2003-2014)

Content	Method for organising
Domestic or foreign destination	Sheets
Year of delivery	Tables
Destination (end of pipeline)	Columns
Month of delivery	Rows
Amount (Sm3)	Cells

d) Nominated amounts at exit, by owner company (2011 and 2013)

Content	Method for organising
Domestic or foreign destination	Sheets
Year of delivery	Sheets
Destination (end of pipeline)	Tables
Month of delivery	Columns
Owner company (abbreviated)	Rows
Amount (Sm3)	Cells

Appendix V: Detailed primary product energy balances

Appendix V shows eight tables with detailed primary (unrefined) petroleum product energy balances for 2011 – 2014 using original (ETS) and alternative (NPD[36]) export figures. Some consumption items are aggregated. Detailed product groups within a main product group must be viewed together, due to different product naming practices.

Table V.1 Detailed energy balance for primary petroleum products, using NPD export figures. 2011.

Main product group	Petrol	Petrol	Petrol	Petrol	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	Natural gas	Natural gas	Crude oil
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	3 352.1	881.2	1 203.8	0.0	0.0	664.7	1 151.6	490.8	2 966.7	1 118.4	101 867.9	4 314.9	82 269.3
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	379.5	0.0	416.2	254.9	0.0	57.9	0.0
Imports	153.6	0.0	0.0	0.0	0.0	0.0	10.7	0.0	49.0	7.3	0.0	1.4	1 139.5
Exports	3 312.9	638.3	0.0	0.0	0.0	107.1	1 551.1	499.9	3 054.2	513.1	95 515.9	4 304.8	69 262.3
Changes in stocks (+ = decrease)	-8.2	3.7	0.0	0.0	0.0	0.0	19.3	10.3	-25.3	-0.3	0.0	0.0	-449,9
Gross domestic supply	184.5	246.6	1 203.8	0.0	0.0	557.6	9.9	1.1	352.5	867.3	6 351.9	69.3	13 696.6
Energy converted	1 143.5	0.0	423.8	0.0	0.0	397.6	0.0	0.0	0.0	0.0	803.0	0.0	13 316.0
Energy industries own use	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	451.3	4 631.1	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.5	14.7	0.0	0.0
Statistical differences	***-959.0***	***246.6***	***780.0***	***0.0***	***0.0***	***-22.2***	***-0.9***	***1.1***	***43.2***	***-27.6***	***-81.9***	***69.3***	***380,6***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	56.4	0.0	0.0	0.0	0.0	393.8	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	122.7	10.8	0	309.3	399.1	591.1	0.0	0.0

[36] With supplementary data

Table V.2 Detailed energy balance for primary petroleum products, using NPD export figures. 2012.

Main product group	**Petrol**	**Petrol**	**Petrol**	**Petrol**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**Natural gas**	**Natural gas**	**Crude oil**
Detailed product group	**Condens ate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	3 340.0	859.8	1 567.5	0.0	0.0	679.3	1 218.1	472.8	2 972.5	1 376.7	114 992.3	4 651.4	75 107.8
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	459.8	0.0	521.1	261.8	0.0	93.7	0.0
Imports	251.1	0.0	0.0	0.0	0.0	0.0	15.2	0.0	34.3	8.4	0.0	0.6	1 168.4
Exports	3 287.6	618.9	0.0	0.0	0.0	201.4	1 574.4	464.8	3 151.8	903.5	108 664.0	4 831.8	63 532.6
Changes in stocks (+ = decrease)	-8.9	-12.5	0.0	0.0	0.0	0.0	-23.6	-9.2	-8.1	-0.8	0.0	0.0	-92.9
Gross domestic supply	294.6	228.4	1 567.5	0.0	0.0	477.9	95.2	-1.2	367.9	742.6	6 328.3	-86.1	12 650.7
Energy converted	1 565.1	0.0	567.5	0.0	0.0	431.4	0.0	0.0	0.0	0.0	579.1	0.0	12 840.9
Energy industries own use	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	451.4	4 734.9	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.3	24.5	0.0	0.0
Statistical differences	***-1 270.5***	***228.4***	***1 000.0***	***0.0***	***0.0***	***-18.0***	***50.9***	***-1.2***	***24.5***	***-123.6***	***0.2***	***-86.1***	***-190.3***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	58.2	0.0	0.0	0.0	0.0	475.8	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	3.5	44.3	0	343.4	376.6	513.8	0.0	0.0

Table V.3 Detailed energy balance for primary petroleum products, using NPD export figures. 2013.

Main product group	**Petrol**	**Petrol**	**Petrol**	**Petrol**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**Natural gas**	**Natural gas**	**Crude oil**
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	2 898.3	882.3	1 496.2	0.0	0.0	654.4	1 207.8	428.7	2 792.7	1 522.1	109 340.5	4 288.9	71 482.4
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	446.1	0.0	552.6	337.1	0.0	222.2	0.0
Imports	73.7	0.0	0.0	0.0	0.0	0.0	18.8	0.0	68.3	14.8	0.0	0.0	1 815.9
Exports	2 926.0	644.8	0.0	0.0	0.0	54.6	1 625.1	420.7	2 902.2	1 017.6	102 810.6	4 450.3	59 589.1
Changes in stocks (+ = decrease)	42.0	14.5	0.0	0.0	0.0	-18.2	2.8	-7.5	46.8	-1.9	0.0	-45.1	-97.8
Gross domestic supply	87.9	251.9	1 496.2	0.0	0.0	581.6	50.4	0.5	558.2	854.6	6 530.0	15.8	13 611.4
Energy converted	1 223.4	0.0	608.5	0.0	0.0	418.1	0.0	0.0	0.0	0.0	661.8	0.0	13 378.8
Energy industries own use	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	541.7	4 710.3	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.5	16.2	0.0	0.0
Statistical differences	***-1 135.5***	***251.9***	***887.7***	***0.0***	***0.0***	***-40.6***	***50.4***	***0.5***	***183.7***	***-24.7***	***60.8***	***15.8***	***232.6***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	516.5	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	167.9	0.0	0.0	374.5	309.1	564.3	0.0	0.0

Table V.4 Detailed energy balance for primary petroleum products, using NPD export figures. 2014.

Main product group	**Petrol**	**Petrol**	**Petrol**	**Petrol**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**Natural gas**	**Natural gas**	**Crude oil**
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	2 097.2	937.7	1 465.5	0.0	0.0	677.8	1 291.7	439.5	3 000.2	1 704.8	108 010.6	5 223.7	73 555.2
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	533.3	0.0	608.0	315.7	0.0	229.2	0.0
Imports	195.7	0.0	0.0	0.0	0.0	0.0	22.5	0.0	4.2	68.5	0.0	0.0	1 181.2
Exports	1 999.1	689.7	0.0	0.0	0.0	104.7	1 699.5	449.1	3 144.0	1 108.9	101 319.8	5 376.8	62 031.2
Changes in stocks (+ = decrease)	-34.5	-11.1	0.0	0.0	0.0	-7.1	-5.3	10.6	28.6	-0.4	0.0	-21.0	335.8
Gross domestic supply	259.4	237.0	1 465.5	0.0	0.0	566.0	142.7	1.0	497.0	979.6	6 690.8	55.1	13 041.1
Energy converted	1 101.2	0.0	787.6	0.0	0.0	374.4	0.0	0.0	0.0	0.0	699.0	0.0	12 656.3
Energy industries own use	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	521.6	4 945.5	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1	8.0	0.0	0.0
Statistical differences	***-841.8***	***237.0***	***677.9***	***0.0***	***0.0***	***-25.0***	***142.7***	***1.0***	***239.3***	***63.2***	***-79.5***	***55.1***	***384.8***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	34.2	0.0	0.0	0.0	0.0	503.6	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	179.0	0.0	0.0	257.7	365.8	614.2	0.0	0.0

Table V.5 Detailed energy balance for primary petroleum products, using ETS export figures. 2011.

Main product group	**Petrol**	**Petrol**	**Petrol**	**Petrol**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**Natural gas**	**Natural gas**	**Crude oil**
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	3 352.1	881.2	1 203.8	0.0	0.0	664.7	1 151.6	490.8	2 720.4	1 101.1	101 867.9	4 314.9	82 269.3
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	379.5	0.0	416.2	254.9	0.0	57.9	0.0
Imports	153.6	0.0	0.0	0.0	0.0	0.0	10.7	0.0	49.0	7.3	0.0	1.4	1 139.5
Exports	2 324.7	5.6	0.0	730.0	0.0	141.3	1 968.5	80.5	2 770.6	556.9	96 009.0	4 222.4	68 730.3
Changes in stocks (+ = decrease)	-8.2	3.7	0.0	0.0	0.0	0.0	22.8	10.3	-24.7	-2.5	0.0	0.0	-423.3
Gross domestic supply	1 172.7	879.3	1 203.8	-730.0	0.0	523.4	-403.9	420.6	390.2	804.0	5 858.9	151.8	14 255.2
Energy converted	1 143.5	0.0	423.8	0.0	0.0	397.6	0.0	0.0	0.0	0.0	803.0	0.0	13 316.0
Energy industries own use	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	451.3	4 631.1	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.5	14.7	0.0	0.0
Statistical differences	***29.2***	***879.3***	***780.0***	***-730.0***	***0.0***	***-56.4***	***-414.7***	***420.6***	***80.9***	***-90.9***	***-574.9***	***151.8***	***939.2***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	56.4	0.0	0.0	0.0	0.0	393.8	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	122.7	10.8	0	309.3	399.1	591.1	0.0	0.0

Table V.6 Detailed energy balance for primary petroleum products, using ETS export figures. 2012.

Main product group	Petrol	Petrol	Petrol	Petrol	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	Natural gas	Natural gas	Crude oil
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	3 340.0	859.8	1 567.5	0.0	0.0	679.3	1 218.1	472.8	2 802.8	1 330.2	114 790.4	4 651.4	75 107.8
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	427.7	0.0	508.8	261.8	0.0	93.7	0.0
Imports	251.1	0.0	0.0	0.0	0.0	0.0	15.2	0.0	34.3	59.5	0.0	0.6	1 168.4
Exports	2 286.0	0.0	0.0	516.2	0.0	293.9	2 083.4	52.8	2 728.3	564.1	108 638.6	4 873.9	63 165.5
Changes in stocks (+ = decrease)	-8.9	-12.5	0.0	0.0	0.0	0.0	-26.1	-9.2	-8.2	0.8	0.0	0.0	-91.9
Gross domestic supply	1 296.1	847.3	1 567.5	-516.2	0.0	385.4	-448.5	410.9	609.4	1 088.1	6 151.8	-128.2	13 018.8
Energy converted	1 365.4	0.0	523.1	0.0	0.0	431.4	0.0	0.0	0.0	0.0	579.1	0.0	13 040.6
Energy industries own use	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	451.4	4 734.9	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.3	24.5	0.0	0.0
Statistical differences	***-69.3***	***847.3***	***1 044.4***	***-516.2***	***0.0***	***-110.5***	***-492.8***	***410.9***	***266.0***	***221.9***	***-176.3***	***-128.2***	***-21.9***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	58.2	0.0	0.0	0.0	0.0	475.8	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	3.5	44.3	0	343.4	376.6	513.8	0.0	0.0

Table V.7 Detailed energy balance for primary petroleum products, using original ETS figures. 2013.

Main product group	**Petrol**	**Petrol**	**Petrol**	**Petrol**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**LPG/ NGL**	**Natural gas**	**Natural gas**	**Crude oil**
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	2 898.3	882.3	1 496.2	0.0	0.0	654.4	1 208.9	428.7	2 645.6	1 482.5	109 340.5	4 288.9	71 482.4
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	446.1	0.0	552.6	337.1	0.0	222.2	0.0
Imports	68.9	0.0	0.0	0.0	0.0	0.0	18.8	0.0	68.3	14.8	0.0	0.0	1 815.9
Exports	1 833.9	6.0	0.0	379.0	0.0	215.3	2 171.3	79.3	2 964.9	1 006.6	102 782.5	3 597.5	57 966.2
Changes in stocks (+ = decrease)	42.0	14.5	0.0	0.0	0.0	-18.2	7.1	-7.5	46.4	-4.3	0.0	-45.1	-109.5
Gross domestic supply	1 175.2	890.7	1 496.2	-379.0	0.0	421.0	-490.4	341.9	348.0	823.6	6 558.0	868.6	15 222.5
Energy converted	1 223.4	0.0	608.5	0.0	0.0	418.1	0.0	0.0	0.0	0.0	661.8	0.0	13 378.8
Energy industries own use	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	541.7	4 710.3	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.5	16.2	0.0	0.0
Statistical differences	***-48.2***	***890.7***	***887.7***	***-379.0***	***0.0***	***-201.2***	***-490.4***	***341.9***	***-26.5***	***-55.8***	***88.9***	***868.6***	***1 843.7***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	516.5	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	167.9	0.0	0.0	374.5	309.1	564.3	0.0	0.0

Table V.8 Detailed energy balance for primary petroleum products, using original ETS figures. 2014.

Main product group	Petrol	Petrol	Petrol	Petrol	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	LPG/ NGL	Natural gas	Natural gas	Crude oil
Detailed product group	**Condensate**	**Gasoline**	**NGL**	**Naphtha**	**NGL**	**LPG**	**Butane**	**Iso-butane**	**Propane**	**Ethane**	**Dry gas**	**LNG**	**Crude oil**
Unit	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	MSm^3	MSm^3	kt
Primary energy production	2 097.2	937.7	1 465.5	0.0	0.0	677.8	1 293.1	439.5	2 829.1	1 658.7	108 010.6	5 223.7	73 773.6
Fractionation and LNG production	0.0	0.0	0.0	0.0	0.0	0.0	533.3	0.0	608.0	315.7	0.0	229.2	0.0
Imports	195.7	0.0	0.0	0.0	0.0	0.0	22.5	0.0	4.2	68.5	0.0	0.0	1 181.2
Exports	1 836.7	0.2	0.0	976.3	0.0	120.6	2 225.5	54.4	3 001.4	1 097.7	101 193.0	5 636.1	61 770.5
Changes in stocks (+ = decrease)	-34.5	-11.1	0.0	0.0	0.0	-7.1	9.6	10.6	19.4	-0.1	0.0	-21.0	32.6
Gross domestic supply	421.7	926.5	1 465.5	-976.3	0.0	550.1	-367.0	395.7	459.3	945.1	6 817.6	-204.1	13 217.0
Energy converted	1 101.2	0.0	787.6	0.0	0.0	374.4	0.0	0.0	0.0	0.0	699.0	0.0	12 656.3
Energy industries own use	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	521.6	4 945.5	0.0	0.0
Losses in transportation and distribution	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1	8.0	0.0	0.0
Statistical differences	***-679.5***	***926.5***	***677.9***	***-976.3***	***0.0***	***-40.9***	***-367.0***	***395.7***	***201.6***	***28.7***	***47.2***	***-204.1***	***560.8***
Final consumption, excl. non-energy use	0.0	0.0	0.0	0.0	0.0	34.2	0.0	0.0	0.0	0.0	503.6	0.0	0.0
Non-energy use	0.0	0.0	0.0	0.0	0.0	179.0	0.0	0.0	257.7	365.8	614.2	0.0	0.0

Appendix VI: HS codes used in the energy balance

Main product group	Detailed primary product	HS code[1]
Petrol	Condensate	27090001
Petrol	Gasoline	27101291
Petrol	NGL	27101291
Petrol	Naphtha	27101291
LPG/NGL	NGL	27111900
LPG/NGL	LPG	27111200/27111300 (energy), 27111400 (non-energy)
LPG/NGL	Butane	27111300
LPG/NGL	Iso-butane	29011000
LPG/NGL	Propane	27111200
LPG/NGL	Ethane	27111900
Natural gas	Dry gas	27112100
Natural gas	LNG	27111100
Crude oil	Crude oil	27090009

[1] Formerly, products belonging to HS codes 271012xx had codes 271011xx.

Appendix VII: Measuring units and conversion factors

Several measuring units are frequently used when presenting energy balances and statistical differences. In this report the different product amounts are given in metric kilotons (kt), except natural gas (incl. LNG) that is given in million standard cubic metres (MSm^3). When adding the products together, metric kilotons of oil equivalents (ktoe) is used. The table below shows the conversion from ktoe to the different product amounts in kt and MSm^3, in addition to petajoule (PJ) and terawatt hours (TWh):

Table VII.1 Conversion factors for product amounts from ktoe to kt, MSm^3, PJ and TWh

Measuring unit	Conversion factor
kt of condensate	1
kt of NGL/LPG	1
MSm3 of natural gas	1
kt of CO2	3,15
PJ[1]	0.0423
TWh[1]	0.0118

[1] Average for this report. The real values vary slightly between the different products.

1 PJ corresponds to about 24 ktoe, and 1 TWh corresponds to about 85 ktoe.

1 TWh = 3.6 PJ.

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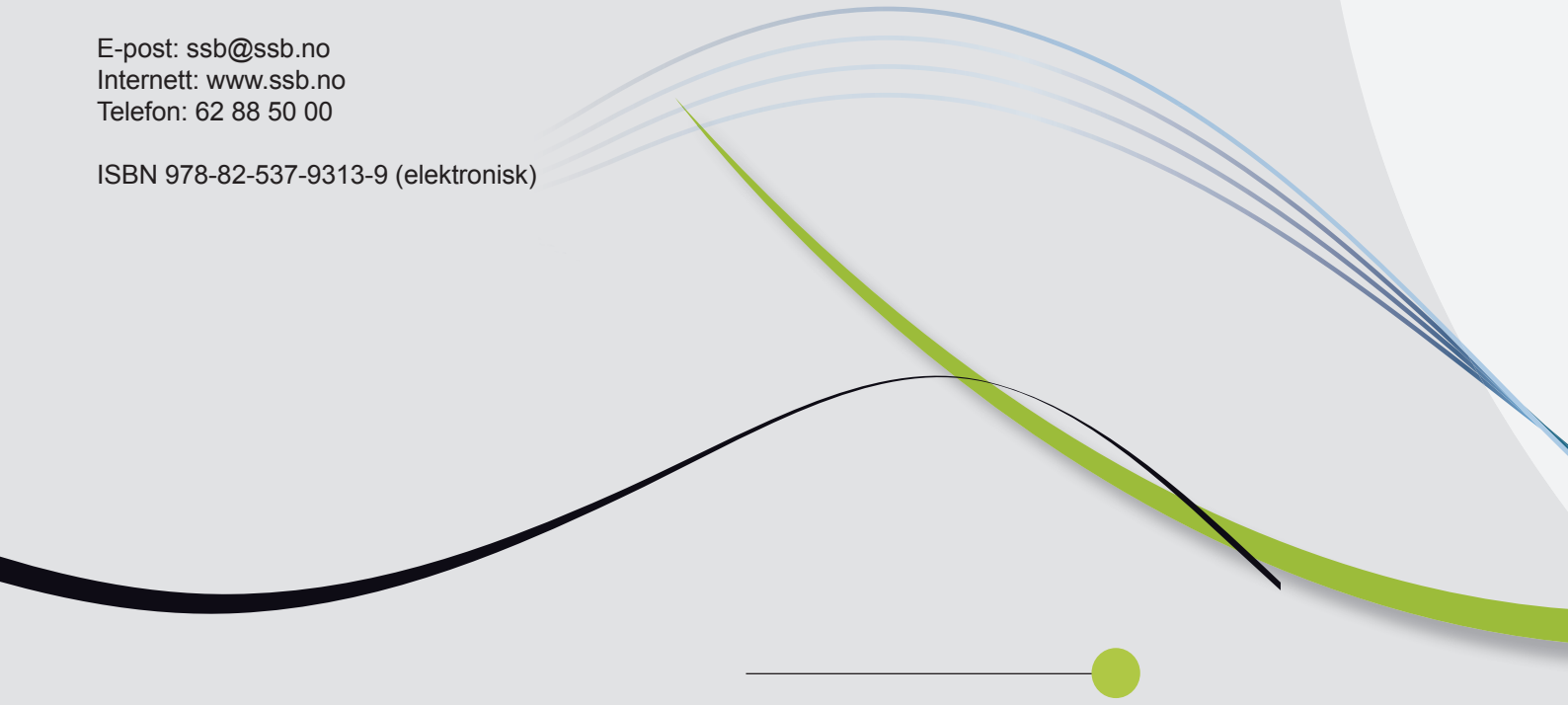

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