United Nations ECE/CES/GE.20/2016/19

Economic and Social Council

Distr.: General
25 April 2016

English only

Economic Commission for Europe

Conference of European Statisticians

Group of Experts on National Accounts

Fifteenth session
Geneva, 17-20 May 2016
Item 6 of the provisional agenda
Valuation of Natural Resources and Mineral Exploration

The valuation of oil and gas reserves in the Netherlands after the implementation of 2008 System of National Accounts / European System of National and Regional Accounts 2010

Prepared by Statistics Netherlands[1]

Summary

This document provides an overview of the practice of valuation of oil and gas reserves in the Netherlands in the light of the 2008 System of National Accounts / European System of National and Regional Accounts 2010 revision. Building upon the framework established in 2009 we discuss the methodology and changes implemented since 2009. Measuring the oil and gas reserves at Statistics Netherlands combines the use of physical balance sheets that show remaining reserves, physical future extraction scenarios and National Accounts data so that together with unit resource rents calculations, monetary balance sheets can be compiled representing the net present values of the resources that remain. This approach allows the user to establish clear links between the subsoil assets shown in the physical balance sheets, the future extraction paths as compiled for environmental accounts (System of Environmental Economic Accounting Central Framework), and the monetary balance sheets relevant in National Accounts.

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I. Introduction

1. Mineral reserves have been measured at Statistics Netherlands (SN) for some 20 years. At the start, the government appropriation method was used and later on the Net Present Value (NPV) method (Veldhuizen et al., 2009). With the introduction of the SEEA Central Framework (SEEA- CF) and SNA 2008/ESA 2010, it became necessary to reassess the model used to estimate the monetary value of oil and gas reserves at SN. This paper provides a description of the reassessments and changes of the model and quantifies these changes in relation to the method previously used.

2. This paper is structured as follows. The first section provides an overview of the changes. The second section describes the reassessments made that did not result in a change of the results. In the third section the changes are further operationalized and quantified. The fourth section provides a sensitivity analysis of different discount rates and the final part of this paper concludes and provides two avenues for future improvements.

II. Changes of the approach applied after SNA 2008/ ESA 2010 at Statistics Netherlands

3. With the adoption of the SEEA-CF and the SNA 2008/ ESA 2010 four changes have been applied in the methodology of calculating monetary balance sheets for oil and gas reserves. These are:

A. Calculation of the unit resource rent based on the last known year instead of a three year moving average;

B. Revaluations of the resource stock no longer based on the unit resource rent, but on the *in situ* price;

C. Value of extractions and other items on the balance sheet no longer based on the unit resource rent but on the *in situ* price;

D. Physical extraction paths as projected by the Dutch Ministry of Economic Affairs/TNO are followed and if needed extrapolated.

A. Unit resource rent based on the last known year

4. Previously, stocks were based on a three year moving average (Veldhuizen et al. 2009). There were two main advantages of this approach. First, it decreased the volatility of the stock values due to annual oil and gas price changes. Second, it provided more conservative estimates of the stock value between 1990 and 2005, to prevent the over-assessment of the value of the stocks. Also, on the balance sheet for non-financial assets, totals of all assets would not be affected too much by oil and gas reserves. The differences for instance for gas once applying a single year average ranged between -13.4 billion and +27.1 billion euros for that period. On average that resulted in a 5 percent higher value for the balance sheet for gas. Also for oil the closing stocks were 5 percent higher when using a 1 year average of the unit resource rent between 1990 and 2005.

5. However, the use of the three year moving average has serious drawbacks. First, any production due to reappraisal of reserves that results in using or reusing fields that have become economically viable for exploitation (again) is not directly fully reflected in the monetary value. This comes only after three years. For example, in the Netherlands the Schoonebeek oil field has been redeveloped and resumed production in 2011 after it had

been abandoned for 15 years. Consequently, in the first year of exploitation the production of that field was not fully reflected in the unit resource rent.

6. Second, price fluctuations of these resources are not fully reflected in the value of the stock, making value changes of the stock seem implausible in the first year after resuming extraction.

7. Third and finally, according to the SEEA-CF the resource rent has to be split into two parts: the value of depletion and the part representing net income (SEEA-CF, p.219). The unit resource rent as a moving average can result in a negative net income when the value of the physical extraction is larger than the resource rent.

B. Revaluations of the resource stock no longer based on the unit resource rent, but on the *in situ* price

8. Revaluations were previously separated into two parts. First revaluations occurred because of price changes and second revaluations occurred due to time passing. The first was designated as the revaluation on the balance sheet, the second as part of the item “other changes in volume” (Veldhuizen et al., 2009).

9. SEEA CF proposes the “volume measure simply equals the evolution of the physical quantity in the ground” (SEEA-CF, para A5.40, p.225). This is particularly applicable in situations with a single homogeneous asset. The previous approach and the recommendation of SEEA each lead to different results. The reason for this difference is that the unit resource rent actually describes the price development of the extraction whereas the price should reflect the value of the assets in the ground, or *in situ* price (Schreyer and Obst 2015). The ratio between the monetary stock, measured as the discounted stream of future resource rents, and physical stock is the best measure currently available for the *in situ* price.

C. Value of extractions and other items on the balance sheet no longer based on the unit resource rent but on the *in situ* price

10. Not only revaluations have to be valued differently, the same goes for the other flow items on the balance sheet. SNA does not allow for consumption of natural capital, since natural capital, like mineral reserves, is one of the non-produced non-financial assets. According to SNA, extraction of the natural resource, like reclassifications and/or new discoveries, is to be classified as ‘other changes in volume’. SEEA-CF does allow for consumption of natural capital. According to SEEA-CF, the consumption should be based on the end-of-year stock value per unit of the resource times physical extraction throughout the reporting year. This means the extraction value should no longer be set equal to the resource rent, as was the case before, but should be calculated with the *in situ* price, as is also used for the revaluations. The monetary value of other changes, such as discoveries or other adjustments, should also be based on the end-of-year stock value. (SEEA-CF, para A5.39, p.225).

D. Physical extraction paths as projected by the Dutch Ministry of Economic Affairs/TNO are followed and if needed extrapolated

11. Previously, only projections made by the Ministry of Economic Affairs / TNO were used. These were based upon the extractions plans; say the projections compiled by the extraction companies. The TNO report (Oil and gas report/ Natural resources and

geothermal energy Annual Report) provides the best estimates available. Projections in the report are updated annually and can thus recurrently be applied for the calculations of the monetary value. In the past, before 2000, the combined annual extractions of natural gas by the extraction companies amounted to 80 billion cubic metres. This was based on the extraction ceiling of natural gas set by the government of that amount and only allowing for small divergences. After 2000 policy makers were becoming worried about the too swift depletion of natural gas, particularly from the large Groningen field. They gave preference to the smaller fields on the continental shelf (North Sea) which resulted in downward adjustments, particularly for the Groningen accumulation. This adjustment in policy resulted in a linear declining pattern, where, in the final year of extraction, the reserves have completely been exhausted (Veldhuizen et al 2009). More recent discussion, due to increasing earthquakes and damage to dwellings in and around the Groningen gas field, has resulted in policies being put in place with a hard production limit set to the Groningen Field from 2015 onwards. Set by the Minister of Economic Affairs at around 33 billion cubic metres. To safeguard supply in an average winter, the limit could be set at a level of 27 billion m^3 from the Groningen accumulation by the Council of State, overruling the Minister. The immediate consequence, lower annual maximum extractions in an attempt to reduce the risk of further damage to structures.

12. The TNO report usually provides an extraction path 25 years ahead, which is an almost full extraction path for all fields together. This is based upon the extractions plans for each individual gas field. Only for the remainder after 25 years, we have to develop a declining path that is plausible, together allowing us to calculate the NPV with these data. If the extraction path is not fully provided, i.e. the projected annual extractions do not add up to the remaining reserve present in the field, we project a linearly declining extraction path until the field is depleted.

13. There have not been any restrictions in the amounts of oil to be extracted annually. Annual physical production had already been declining before 2001. Like natural gas a linearly declining extraction path has therefore been applied for oil. The redevelopment and re-opening of the Schoonebeek oil field in 2010, with applying the latest extraction technologies, has influenced the opening and closing stocks. As a result also the extraction path has changed.

III. Reassessing some assumptions and methods following SNA 2008 / ESA 2010

14. Some basic assumptions previously made were reassessed but did not change in the current model for calculating stocks and changes. They are:

A. The government sector (S.13) is the legal and economic owner of the reserves;

B. The discount rate is set at 4 percent;

C. Subdividing the resource rent for oil and for gas is done using gross production as weights;

D. The UN classification for energy and mineral reserves is adopted in favour of the McKelvey-Box.

A. The government is the legal and economic owner of the oil and gas reserves

15. Currently, the oil and gas reserves are recorded in the government sector. A drawback of that classification is that part of the revenue of the extraction flows to the extraction companies and the net wealth of government is then overestimated. ESA 2010 does not provide clear guidance on the issue of dividing the reserves in the institutional sectors. According to ESA 2010 a distinction can be made between 'resource lease' (15.23), and 'permits to use a natural resource' (15.27). If the former is the case, the situation remains as it were, where the government is the sole proprietor of the mineral assets. However if the latter is the case, the situation is changed. A choice has to be made whether (a) the owner can extend or withhold permission to continued use of the asset from one lease period to the next; or (b) the owner may allow the resource asset to be used for an extended period of time in such a way that in effect the user controls the use of the resource during this time with little, if any, intervention from the owner; or (c) the owner permits the resource asset to be used to extinction (ESA 2010, para. 15.23-27, p.378-0).

16. The last option, (c), is not the case as it would entail a sale or expropriation. In the case of option (a), the permit is regarded as a lease and the asset remains on the balance sheet of the lessor. With option (b), an asset is created which differs from the asset itself, but where the value of the resource asset and the asset allowing use of it are linked. The natural resource is then still part of the balance sheet of the institutional unit issuing the permit, but the permit itself is then part of the balance sheet of unit to which it has been issued (AN.222).

17. Option (b) does not describe the Dutch state of affairs very well, as the Dutch government is able to make decisions about the extraction of the resource, making option (a) a better fit. In the case of confusion on this issue, the SNA 2008 can also be employed. Here, it is stated that in case of doubt the reserves are entirely part of the balance sheet of the legal owner, in our case the government. (SNA 2008, para.13.50).

B. Discount rate set at 4 percent

18. The discount rate is set at 4 percent. The discount rate used for government financed projects has been used in the past for the discount rate of both the produced assets (via the Perpetual Inventory Method, PIM) and the mineral reserves. A working group regularly reviews the government discount rate and advises the government on an appropriate rate, usually maintained for four years (Werkgroep discontovoet, 2015). The common practice at the national accounts is to revise or benchmark NA figures every five years. Given the links between the produced assets and mineral reserves and the fact that both are part of the balance sheet for non-financial assets, a new discount rate can be set every 5 years. During the most recent NA (benchmark) revision the discount rate was held equal at 4 percent for produced assets, which resulted in the same discount rate for mineral reserves. A sensitivity analysis is added in this paper to assess future possibilities.

C. Gross production of oil and gas as resource rent weights

19. Distribution the total resource rent over oil and natural gas is done using gross output as weights. The reason for this approximation is the lack of data on net operating surplus for oil and gas separately. Also, information on production costs for oil and gas separately is lacking. The division is then done with gross output as weights as a plausible alternative. It is, however, possible to separate these two assets in a different manner, as is shown by Statistics Canada. The capital expenditures for each resource are based on the

share of total depth of wells drilled in a year. The annual operating costs are allocated between oil and gas in proportion to each resource's share of the total number of wells in operation during a year (Statistics Canada, 2006). However, that would not completely solve the difference in costs associated with the extraction, because oil extraction in the Netherlands requires more initial cost and effort per euro of revenues compared to natural gas. Quantifying these differences has proven difficult.

D. The UN classification for energy and mineral reserves is adopted in favour of the McKelvey-Box

20. With the introduction of SEEA – CF the use of the McKelvey box has been abandoned. As stated by SEEA - CF (para. 35 (a), p xii,): "For mineral and energy resources, the relative likelihood of recovery of the resources is now determined by using the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC-2009) rather than by following the logic inherent in the McKelvey box described in SEEA-2003". The classification format currently applied is shown in the appendix. Consequently, terms such as "proven resources", "probable resources" and "possible resources" are no longer used. Now it is more about the commercial recoverability of the resources as asserted by SEEA-CF and the CRIRSCO and SPE-PRMS frameworks. With class A. Commercially recoverable resources, where extraction and sale have been confirmed to be economically viable and; Class B. Potentially commercially recoverable resources, where extraction and sale are expected to become economically viable in the foreseeable future. These two classes A and B determine the physical resources of oil and gas here relevant for valuation of the resources for the Netherlands, excluding class C. Non-commercial and other known deposits.

21. The use of a different classification system has not changed the physical balance sheet for the country though. From the perspective of SEEA – CF the SEEA class A together with class B represents the total amount of physical reserves which are quantified and subsequently monetized. This perspective is in line with the SNA 2008 which proscribes that "[…] known deposits of minerals that are not commercially exploitable in the foreseeable future are not included in the balance sheets of the SNA." (SNA 2008, para. 10.168). The SNA term "foreseeable" has been deemed to also describe any potentially recoverable resources which are included in class B. Already in practice at SN, the combination of proven and probable reserves was the most realistic estimate for the Netherlands (Veldhuizen et al 2009) and now the commercially (class A.) and potentially commercially recoverable resources (class B.) are. Therefore, the results for the Netherlands show similar figures with previous quantifications. Other approaches towards the classification of the reserves are possible. For instance the UK regards the proven and probable reserves both as part of class A and monetizes therefore only class A (Khan, Greene and Hoo, 2013).

IV. Operationalizing and quantifying the changes

22. The changes have resulted in changes, next to the adjustment in the physical extraction scenarios, mainly on the monetary aspects of the valuation or monetisation of the reserves.

23. Changes occurred to both flows and/or different stock levels for the mineral reserves. Each change is described in detail and quantified, i.e. moving average, revaluation, extraction, and extraction scenarios.

A. Unit resource rent based on the last known year

24. In this exercise the data used are the most recent data, in which all changes have been applied, such as the new calculations of extraction and revaluation. The only way in which both models shown below differ is the unit resource rent, and therefore all differences can be attributed to that.

25. To recapitulate, when no market value of an asset can be applied directly because of the lack of market transactions of the *in situ* asset, the recommended approach is to use the net present value (NPV) method. SNA 2008 asserts that the value of mineral reserves is usually determined by the NPV method and when returns are spread out over a lengthy period, a discount rate must be applied (SNA 2008, para.13.24).

26. ESA goes even further and requires the NPV method: “Reserves of mineral deposits located on or below the earth’s surface, that are economically exploitable given current technology and relative prices, are valued at the present value of expected net returns resulting from their commercial exploitation of the assets.” (ESA 2010, para.7.53).

27. In a similar guise, SEEA states that “NPV approaches (...) are typically used to value mineral and energy resources.” (SEEA-CF, para.5.192).

$$NPV^{t} = \sum_{\tau=t}^{\infty} \frac{RR_{t-1}^{\tau}}{(1+r)^{\tau-t+1}} = \sum_{\tau=t}^{\infty} \frac{rr_{t-1}^{\tau} Extr_{t-1}^{\tau}}{(1+r)^{\tau-t+1}}$$

Where,

RR_{t}^{τ} = resource rent in year τ as expected at the end of year *t*,

rr_{t}^{τ} = unit resource rent in year τ as expected at the end of year *t*,

$Extr_{t}^{\tau}$ = extraction in year τ as projected at the end of year *t*, and

$(1+r)^{\tau-t+1}$ = discount rate for discounting extractions in year τ to prices of year t.

Source: Veldhuizen et al (2009)

28. The method for calculating the resource rent is similar to the method used in Veldhuizen et al (2009). This means that the resource rent is based on the net income from extraction, which is defined as total revenue from sales less all costs incurred, including user cost of produced capital. In practice, the user cost is calculated by taking first the gross operating surplus of the industry ‘Extraction of crude petroleum and natural gas’. Decommissioning costs of produced assets, for example oil rigs, are not taken into account when calculating the resource rent. Data on the gross operating surplus for the industry mentioned is derived from the Dutch national accounts. The user costs of the produced capital are derived from the Dutch growth accounts. In general, they contain the costs of using these assets during a year, revaluations, opportunity cost of holding the assets and the sum of taxes less subsidies.

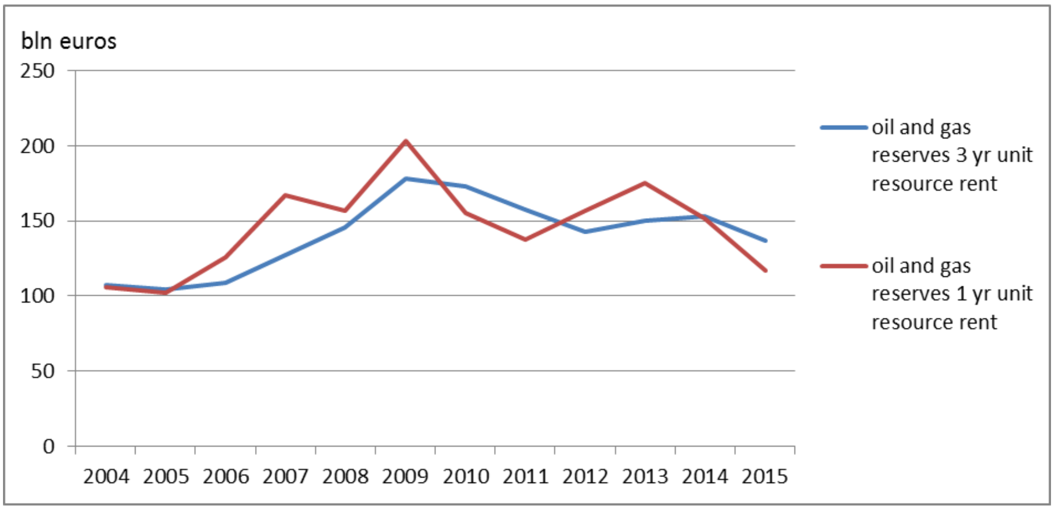
29. Operationalizing the NPV formula for our own purposes and using a one year unit resource rent, the opening stock is calculated as:

Opening stock value (*t*) = $\sum_{\tau=t}^{\infty} \frac{rr^{t-1} Extr_{t-1}^{\tau}}{(1+r)^{\tau-t+1}}$

30. Whereas it used to be calculated as:

Opening stock value (t) = $\sum_{\tau=t}^{\infty} \frac{rr^{t-3,t-1} Extr_{t-1}^{\tau}}{(1+r)^{\tau-t+1}}$

Figure 1. Monetary stock values with different unit resource rent



31. Figure 1 presents the closing stock levels for the two different unit resource rents. It becomes immediately clear that the 1 year unit resource rent is much more volatile than the 3 year average unit resource rent. A major cause of this volatility is of course the upswing and downturns in the commodity markets for fossil fuels. Averaging them out over several years gives a smoother result, and also a more conservative estimate. The yearly differences range from -20 to + 40 billion euros. The difference between the two is significant, the 1 year unit resource rent gives a 4 percent higher stock value for the period displayed in graph 1. This finding is congruent with the previous study (Veldhuizen et al., 2009), where the difference amounted to 5 percent over the period 1990-2005.

B. Revaluations of the resource stock no longer based on the on the unit resource rent, but on the *in situ* price

32. Revaluations of stocks were previously calculated as the difference between the opening stock and the opening stock after revaluation. The stock after revaluation was defined as:

Stock value after revaluation (t) = $rr^{t} \frac{Extr_{t-1}^{t}}{(1+r)} + \sum_{\tau=t+1}^{\infty} \frac{rr^{t} Extr_{t-1}^{\tau}}{(1+r)^{\tau-t+1}}$

33. The only difference with the opening stock is the applied unit resource rent that represents the reporting period (t) instead of year t-1. Therefore revaluations were solely determined by the change in the unit resource rent between the current and the previous reporting period.

34. The current stock value after revaluation is calculated as the physical opening stock multiplied by the end of year *in situ* price:

Stock value after revaluation *(t)* = $\frac{NPV^{t}}{PS^{t}} \cdot PS^{t-1}$

35. And thus the revaluation equals:

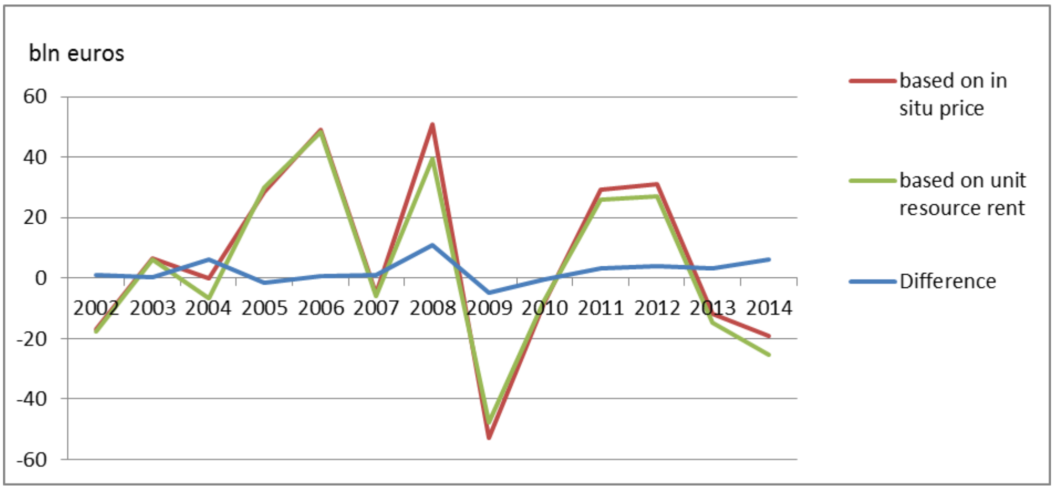
Revaluation *(t)* = $\frac{NPV^t}{PS^t} \cdot PS^{t-1} - NPV^{t-1}$

Where:

PS = Physical stock level

NPV = Net present value or monetary stock level

Figure 2. Revaluations to monetary stock values



36. Figure 2 shows the magnitude of revaluations for the two methods for a time series and the differences in between. These were calculated based on stock values with a single year unit resource rent. At the minimum, the difference in revaluation amounted to -5 billion euros. At maximum, the difference was +11 billion euros. Overall the revaluations for the current method are higher than in the previous method. This is in line with the findings on the monetary stock levels, which were also higher on average.

37. Calculating volume changes on the monetary values of the remaining reserves or resources will now yield the same results as the volume change on the remaining reserves shown by the physical balance sheets.

38. All data concerning these physical balance sheets are compiled annually by TNO, the Netherlands Organisation of Applied Scientific Research, at the request of the Ministry of Economic Affairs. The volumes of gas and oil in these annual reports are presented in standard cubic metres, which are abbreviated as Sm^3 and refer to the reference conditions: 15 degrees Celsius and 101.325 kPa (TNO/Ministry of Economic Affairs, 2007, Veldhuizen et al., 2009).

39. Table 1 and table 2 present the combination of physical and monetary variables needed to calculate the volume change. The physical variables are presented in million standard cubic metres and the monetary variables in billion euros. The tables show that both the physical and the monetary variables have the same annual volume changes. The volume change of the physical variables is calculated as the end of year stock divided by the start of year stock (or t-1 end of year stock). The monetary volume change is calculated as the end of year stock divided by the revaluated start of year stock.

Table 1. Physical and monetary partial balance sheet for natural gas

Year	*2002*	*2010*	*2014*
Physical resource, opening stock 1-1 [A]	1738	1390	1044
Physical resource, closing stock 31-12 [B]	1689	1304	932
Monetary value of the resource, opening stock 1-1 [C]	122	150	143
Revaluations [D]	-17	-9	-20
Monetary value of the resource, closing stock 31-12 [E]	102	132	110
Volume change physical resource = B/A-1	-0.03	-0.06	-0.11
Volume change monetary value of the resource = E/(C+D)-1	-0.03	-0.06	-0.11

Table 2. Physical and monetary partial balance sheet for oil

Year	*2002*	*2010*	*2014*
Physical resource, opening stock 1-1 [A]	28	50	47
Physical resource, closing stock 31-12 [B]	26	46	35
Monetary value of the resource, opening stock 1-1 [C]	1	5	8
Revaluations [D]	0	1	1
Monetary value of the resource, closing stock 31-12 [E]	2	5	7
Volume change physical resource = B/A-1	-0.07	-0.09	-0.26
Volume change monetary value of the resource = E/(C+D)-1	-0.07	-0.09	-0.26

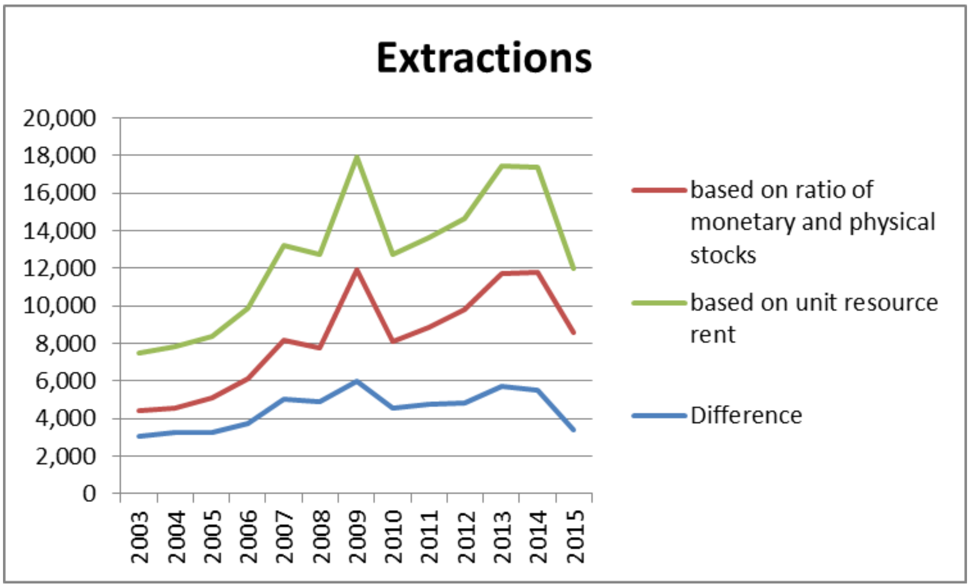
C. Value of extractions and other items on the balance sheet no longer based on the unit resource rent but on the *in situ* price

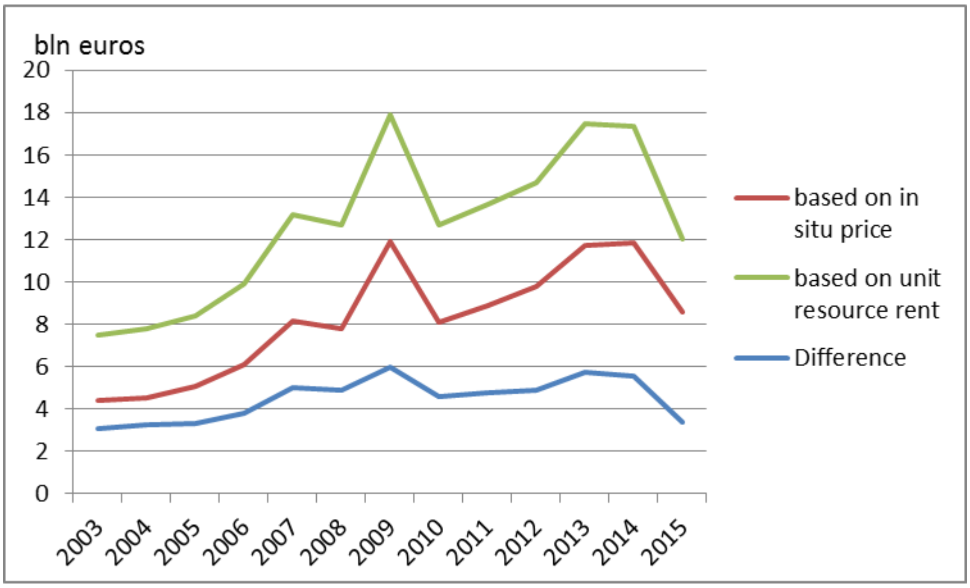
40. In the physical balance sheets four reduction and/or addition items are identified. These are 1.) extractions, 2.) new discoveries, 3.) reappraisals of existing reserves and 4.) other reductions/additions (= remainder). The balance sheets are compiled separately for oil and for natural gas reserves. Extractions pertain to all extracted oil and natural gas, and thus include the (net) underground storage of natural gas in the course of the reporting year. Reappraisals are subdivided into three categories. They can occur as a result of new information, new technology and relative price changes. These, however, are not shown in the final balance sheet. Usually it is difficult to distinguish between price changes (i.e. higher commodity prices) that allow for the application of new technologies on the one hand and application of new technologies that result in price changes (i.e. cost reductions) that make exploitation worth the effort. Both result in positive reappraisals, but separating them in a quantitative sound manner is not a straightforward task. The remainder is made up of any remaining inconsistencies.

41. Previously, extractions were set equal to the resource rent (RR), which could also be written as the unit resource rent times the physical extraction of the resources. Therefore, the value of the extraction was calculated as:

Extraction value (t) = $RR^t = rr^t \cdot Extr^t$

Figure3. Value of extractions from the remaining resources





42. From figure 3 it appears the extraction value, here expressed as a positive entry, is much lower for the current method applied than for the previous method. On average, the difference per year between both methods is around 4.5 billion euros. In relative terms, the annual extraction values at average have become 35 percent lower in the newly applied approach. Again, these lower values for extraction for the current method is in line with the higher monetary stock values, as described above.

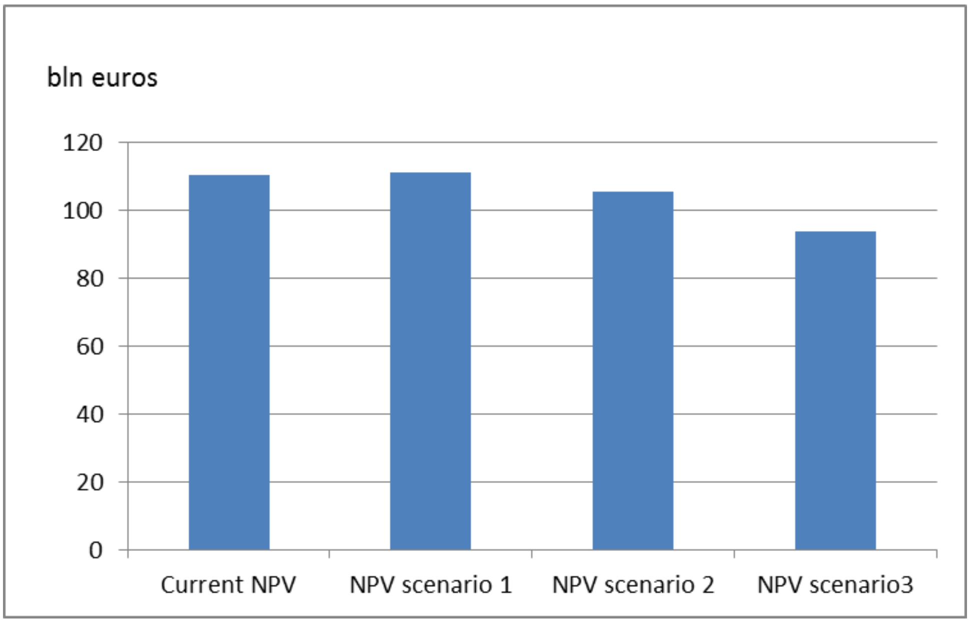
D. Physical extraction paths as projected by the Dutch Ministry of Economic Affairs/TNO are followed and, if need be, extrapolated

43. An extraction path for natural gas is derived, starting from the 'Natural resources and geothermal energy report' as explained (TNO and Ministry of Economic Affairs,

(1988–2015). Some difficulties have been met in the application of the figures from the report. This is because of the strong changes in the political arena primarily with regard to gas extraction from the Groningen accumulation, up to the point where reliable long term projections proved no longer feasible for recent reporting periods. In the last report, no update was given for the 25-year extraction path, as is done normally. In practice this meant that the report no longer provided a complete and comprehensive extraction path, because the expected extraction from the Groningen accumulation for the next 25 years has been skipped completely. To deplete the remaining reserves in the field, a linearly declining extraction scenario was applied. To assess the consequences for different scenarios and the impact on the net present value, three alternative scenarios are displayed, next to the official extraction path or scenario, all in figure 4. Each scenario has a different ceiling for extraction of natural gas from the Groningen gas field. Not all natural gas is extracted from this large field. There are also smaller fields in production like off-shore fields. As explained before, the scenarios are based on a single year unit resource rent. Next to that, it uses NA data and physical production data based on preliminary 2014 figures. Crude oil production is not considered, because it is of no particular interest here. It has not entered the public debate on extraction ceilings and the trend of extraction has been pointing downwards for some time.

- The current scenario represents the officially published 2014 figures. At the time of calculating these official figures, the actual extraction ceiling was applied.
- The first alternative scenario to be considered constitutes an extraction path as if the entire public debate and consequently lowering of the extraction ceiling had not emerged. In this scenario the projections from 2013 are maintained, minus the extractions for 2014.
- The second alternative scenario has a lower ceiling as a direct consequence of the lowered maximum annual extraction allowed for the Groningen accumulation. This was decided by the Ministry shortly after the calculation of the official figures, but further adjusted not much later again into scenario 3. Scenario 2 could only be applied when the upcoming winter turned out to be very harsh.
- The third and final alternative scenario uses the most recent insights and policy decisions. Here the extraction ceiling for natural gas from the Groningen field is lowered to the point where the minimum amount really needed in the Netherlands is extracted. Further reductions of the physical extraction levels are applied from 2020 onwards in this scenario as a result of the introduction of a new nitrogen production plant, allowing the substitution of natural gas from Groningen with natural gas from abroad. Groningen gas has lower calorific value compared to other fields. As a result, appliances in the Netherlands were made compatible for this type of (Groningen) gas. Gas imported from elsewhere with higher caloric value needs its quality therefore to be adjusted by blending it with nitrogen before it can feed into the gas distribution system. The new nitrogen production plant constructed in the years to come and expected to be ready for production in 2020 will facilitate the additional import of high caloric natural gas. Moreover the foreseen partial transition to other heating systems and the expected gain in energy efficiency will further reduce the burden placed onto the Groningen extractions (Rijksoverheid, 2015).

Figure 4. NPV 2014 closing stock of the remaining natural gas reserves



44. By applying the standard discount rate of 4 percent, the highest stock value for scenario 1 and the lowest value for Scenario 3 are generated. Taking the current stock value for natural gas as the baseline, the NPV scenario 1 value is 0.8 percent more, the value of 2 is 4.4 percent less and NPV scenario 3, 14.8 percent less. In euros the differences are +0.9 billion euros for the first, -4.9 billion euros for the scenario 2 and -16.3 billion euros for the last scenario in comparison to the official calculations. It becomes clear that extraction of natural gas further into the future has a large impact on the stock values for natural gas.

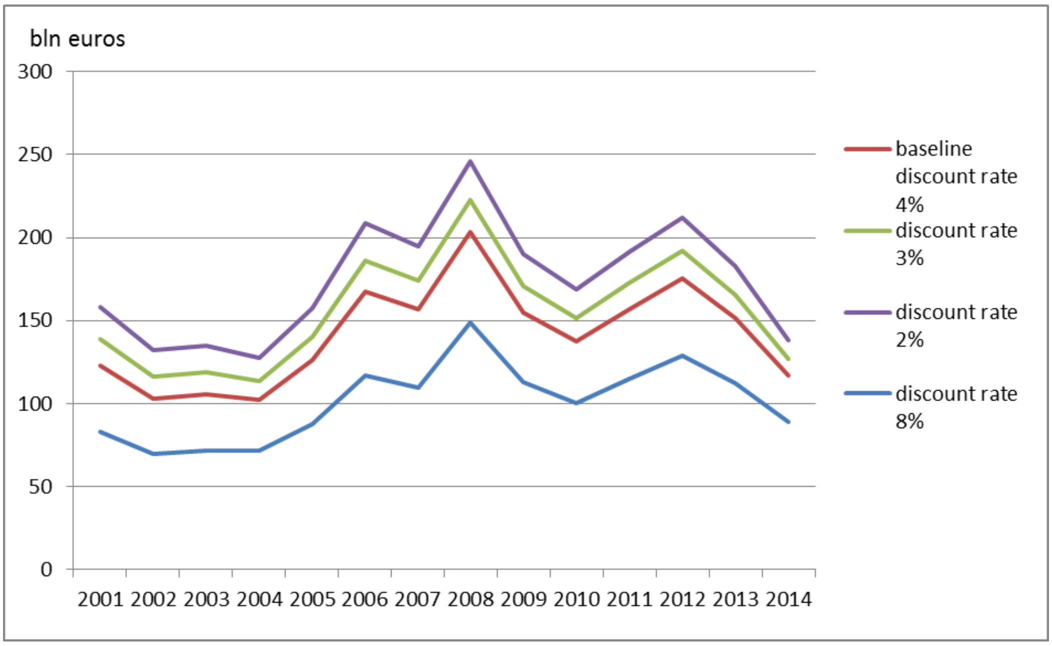
V. Sensitivity analysis: Different discount rates

45. The above example on extraction scenarios shows the quantitative effect of the discount factor where it translates future resource rents in the net present value. The choice of the level of the discount rate is important and as previously shown by Veldhuizen et al (2009) "[…] the monetary valuations are extremely sensitive to changes of the discount rate." In that study four distinct discount rates were chosen: a baseline model with a 4 percent discount rate, and three alternative rates, 2 percent, 6 percent and 10 percent. In the sensitivity analysis below, three alternative rates are considered, next to the 4 percent baseline model, they are a 2 percent, 3 percent rate and an 8 percent rate.

46. A working group composed of experts instated by the Dutch government reviewed the Dutch discount rates in 2015 for government financed projects (Werkgroep discontovoet, 2015). The advice given in this report is to change the general real discount rate to 3 percent. Next to that, considering natural resources an even lower rate can be chosen. From a societal perspective individuals or enterprises usually demand quicker return than society at large, which has a long-term perspective, and places greater importance on future returns. That perspective is operationalized by the use of a lower discount rate, in our case 2 percent. (Khan, Greene and Hoo 2013; SEEA-CF, para. A5.76, p.231). At the other end of the extreme, a discount rate of 8 percent is also considered. The working group quoted in the report that New Zealand and Canada use a discount rate of that magnitude (Werkgroep discontovoet, 2015). Therefore the 8 percent rate is used as the most extreme rate which is still plausible because of its application in other countries. The rates

presented here provide a range of plausible discount rates which can be considered, also for future work.

Figure 5. Effect of alternative discount rates on the NPVof the remaining reserves



47. Apart from the different discount rates, the model used here is fully congruent with the official model. It uses the official extraction scenario and the single year unit resource rent. Figure 5 shows net present values of closing stocks for each discount rate for 2001-2014. A higher discount shows lower time preference and as a consequence places a lower weight on future resource rents, thus lowering the net present value and vice versa. The differences are not negligible. Compared to the baseline situation with a 4 percent discount rate, the 3 percent discount rate raises the NPV of remaining reserves of oil and natural gas by 11 percent. The 2 percent discount rate raises the value by 23 percent and application of the 8 percent discount rate lowers the NPV by 28 percent.

VI. Conclusion and further research

48. This report describes the calculations of the monetary value of oil and gas reserves and the changes which have been implemented since the adoption of SEEA – CF and SNA 2008 / ESA 2010. Physical balance sheets and physical extraction scenarios constituting projections about future extraction are compiled by Statistics Netherlands, based upon the information extracted from the Annual Report 'Natural resources and geothermal energy in the Netherlands', compiled by TNO and the Dutch Ministry of Economic Affairs. This provides the starting point for calculating the monetary balance sheets with the NPV method.

49. Changes made to the monetary balance sheets bring them in line with recommendations from SEEA – CF and from SNA 2008/ESA 2010. First, the three year average unit resource rent is no longer used and instead the most recent single year unit resource rent is applied. As expected the stock values have become more volatile and the calculated average value over the period 2002-2014 is 4 percent higher. Second, the revaluations are no longer based on the unit resource rent or extraction price, but on the in situ price derived from the ratio between monetary and physical stocks. Third, changing the

calculation of revaluations as described allows us to change the other items on additions and reductions to stock in the balance sheet in the same way, i.e. the new derived in price of the in situ resource can be applied to physical extractions, discoveries, reappraisals and other changes. Fourth, the extraction path is aligned with government decided extraction ceilings. The Dutch government reduced the maximum allowed amount of natural gas extractable from the Groningen field in its attempt to reduce the risk and frequency of earthquakes. No limit was imposed on oil as a result of such kind of debate. It meant the total value of oil and gas reserves has become lower because of that policy decision, since a larger amount of natural gas will now be extracted further into the future. It is illustrated that the choice of a particular discount rate plays an important role in determining the NPV of the resource. The sensitivity analysis shows that lowering the discount rate to 2 percent will raise the NPV by 23 percent compared to the value based upon the official discount rate of 4 percent. A discount rate of 8 percent will decrease the NPV by 28 percent.

50. The adoption of SEEA-CF and SNA 2008/ESA 2010 has meant that several assumptions had to be re-examined. This hasn’t changed the approach applied at Statistics Netherlands. The government sector remains the owner of the reserves, since it has the power to decide on the amounts to be extracted. Second, the discount rate was not altered, because a uniform discount rate for both produced and non-produced assets was preferred. Third, production values of natural gas (including natural gas condensate) and crude oil are still used as weights to split the resource rent. Other sources were not available or are not sufficiently reliable. Fourth and last, the classification of all resources based on the McKelvey box is no longer used in favour of the SEEA-CF and the CRIRSCO and SPE-PRMS classification. This has not led to different estimates for the physical reserves assessments and hence didn’t affect the calculation of the monetary values of the reserves.

51. Future work can be done on the estimates for decommissioning costs. So far, the resource rent has not included decommissioning costs of produced assets. As explained by Khan, Greene and Hoo (2013), any decommissioning costs have to be subtracted from the income or, as in our case, from the operating surplus, to end up with a correct estimate of the resource rent. However, the total amount of decommissioning costs is hard to predict at the start of an asset’s service life. Next to that, from a supply-and-use framework, the costs can only be booked when the economic activity takes place. It has led Eurostat to recommend entering the decommissioning costs as both gross fixed capital formation (GFCF) and consumption of fixed capital (CFC) at the end of the asset’s service life. Using that information from the national accounts directly will not improve the estimates of the resource rent and alternative estimates have to be made before decommissioning costs can be made part of the NPV calculations.

52. Second and finally, a different discount rate can be considered. The rates in this paper present a range of options, between 2 percent and 8 percent. Also a time-dependent discount rate can be applied. It means that for each reporting period a specific discount rate can be chosen. That option will add to the flexibility of the model to comply with changing rates of return over time and is relatively easy to implement. These considerations have to be made for the upcoming benchmark revision of the Dutch national accounts for the reporting year 2015.

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Appendix

Figure 1 Classification of mineral and energy resources following SEEA – CF

Table 5.6
Categorization of mineral and energy resources

	SEEA classes	Corresponding UNFC-2009 project categories E Economic and social viability	 F Field project status and feasibility	 G Geologic knowledge
Known deposits	A: Commercially recoverable resources[a]	E1. Extraction and sale have been confirmed to be economically viable	F1. Feasibility of extraction by a defined development project or mining operation has been confirmed	Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence
	B: Potentially commercially recoverable resources[b]	E2. Extraction and sale are expected to become economically viable in the foreseeable future[c]	F2.1 Project activities are ongoing to justify development in the foreseeable future Or F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay	
	C: Non-commercial and other known deposits[d]	E3. Extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay Or F2.3 There are no current plans to develop or to acquire additional data at the time due to limited potential Or F4. No development project or mining operation has been identified	
Potential deposits (not included in SEEA)	Exploration projects Additional quantities in place	E3. Extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F3. Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data Or F4. No development project or mining operation has been identified	Estimated quantities associated with a potential deposit, based primarily on indirect evidence (G4)

Notes
[a] Including on-production projects, projects approved for development and projects justified for development.
[b] Including economic and marginal development projects pending and development projects on hold.
[c] Potential commercial projects may also satisfy the requirements for E1.
[d] Including unclarified development projects, non-viable development projects, and additional quantities in place.
Source: UNFC-2009, figures 2 and 3.

Source: Table 5.6, SEEA – CF