Ea Energy Analyses

Welfare economic prices of coal, petroleum products and natural gas

UPDATE OF ADD-ONS TO INTERNATIONAL FORECASTS FOR PROJECTION OF DANISH PRICES AT CONSUMPTION

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Dansk Resume

Det overordnede formål med den nærværende opdatering er at udvikle en metode og et MS Excel-værktøj, der kan anvendes til en tilpasning af IEA pris prognoser (med IEA WEO New Policies som det centrale scenarie) til forløb for priser an dansk forbrugssted. Denne fremgangsmåde omfatter to hovedtrin:

1. Konvergens imellem IEA's prisscenarier med forward-/futures priserne for opnå en bedre overensstemmelse med aktuelle markedsforventninger på kort til mellemlangt sigt.
2. Estimering af pristillæg/-fradrag for at omdanne IEA priser (fra trin 1 ovenfor) til danske priser an forbrugssted over fremskrivningsperioden.

Denne rapport har fokus på trin 2, nemlig den opdatering af beregningsmetoder pristillæg/-fradrag til fastsættelse af koblingen imellem priserne an forbrugssted af kul, olieprodukter og naturgas. Disse tillæg/fradrag anvendes på post-konvergens (dvs. efter trin 1) fremskrivninger af internationale kul, råolie og naturgas, som IEA opgør i statistikker og prognosticerer i World Energy Outlook, herefter benævnt IEA-baserede priser.

De fremkommende pristillæg/-fradrag (og fremskrivninger heraf), bør ikke betragtes som prognoser; snarere som mulige udviklingsveje for de respektive omkostningselementer, som opfylder en række antagelser og forudsætninger. Det bemærkes at der både historisk og hele prognoseperioden henholdsvis er og vil være variation i de specifikke omkostningselementer, såvel som strukturelle (eller midlertidige) ændringer i forsyningskæden eller handelsstrømme til Danmark i forhold til resten af OECD. Dette må forventes at medføre forskelle i forhold til de skøn, der er baseret primært på historiske data.

Den anvendte tilgang er en opdatering og udvikling af metoden udviklet i 2011-projekt "Opdatering af samfundsøkonomiske brændselspriser: kul, olieprodukter og naturgas". [1]

De input IEA-baserede priser er statistikker og fremskrivninger baseret på de gennemsnitlige priser i OECD-medlemslande.

Mere specifikt udtrykker disse:

- Kul: gennemsnitspriser for kraftværkskul i OECD

- Råolie: gennemsnitlige importpriser i OECD
- Naturgas: Europæiske naturgaspriser (vægtet gennemsnit af rørbundet og LNG leverancer)

Da an forbruger priserne skal have en direkte relation til de internationale prognoser, er metoden baseret på en evaluering af de historiske relationer og komparative niveauer mellem danske en gros-og IEA-baserede priser. Pristillægene dækker hele spændet mellem de danske priser an forbrugssted og IEA-baserede priser. Dette omfatter alle egentlige omkostninger samt avancerne i forsyningskæden, hvor de måtte forekomme. Nogle af disse delelementer kan begrundes individuelt, imens andre - især avancer - udspringer af forskellen i prisniveauerne, fx en gros vs detailpriserne. Derfor er de mest centrale inputs der bruges til at udlede de samlede tillæg/fradrag *observerede priser* langs forsyningskæden. Forskellen i prisniveauet i forsyningskæden er benævnt 'price spreads'.

Rapporten kvalificerer de fremkommende 'price spreads' så vidt muligt med kvantitative vurderinger af enten omkostninger eller avance elementer, der bidrager til spændet imellem prisobservationer. Disse kvantificeringer har ikke nogen direkte indflydelse på den endelige pris niveauer, men leveres i et forsøg på at give så meget indsigt som muligt niveauerne på de samlede pristillæg/-fradrag.

Pristillæg/-fradrag for hvert produkt er beregnet for op til tre repræsentative forbrugssteder:

- Kul leveret *an kraftværk*
- Naturgas leveret *an kraftværk*, *an værk* og *an forbruger*.

Råolie raffineres til olieprodukter, der leveres som:

- Benzin an forbruger (ved bilen)
- Gasolie: diesel olie an forbruger (ved bilen), fyringsolie ved husholdningen, og gasolie an kraftværk og an værk.
- Fuelolie an kraftværk
- JP1 an lufthavn

Det antages hovedsageligt at omkostnings- og avanceelementer vokser med den generelle inflation. Særligt for olieprodukter indgår dog også den fremadrettede udviklingen af råolieprisen i forhold til den almindelige inflation, da blandt andet da energien fra råolien anvendes i raffineringsprocessen.

For at sikre konsistens og en gennemsigtig og en fortrinsvis simpel tilgang, er de forskellige tillæg/fradrag kvantificeret på bases af simple historiske gennemsnit (medmindre andet er angivet, fx i tilfælde af raffinaderispreads for olieprodukter). For det konkrete tillæg bruges længden af den medtagne historiske periode som indgår i gennemsnittene, for at udtrykker konkrete antagelse om hvilken periode med prisobservationer bedst beskriver niveauet fremadrettet.

Tillæg og fradrag til de IEA-baserede priser for kul er naturgas og olieprodukter præsenteres herunder:

Table 1: De endelige tillæg og fradrag til de IEA-baserede priser I DKK2013/GJ for kul er naturgas og olieprodukter vist for 2013 og 2035[1]

DKK2013/GJ	An kraftværk		An værk		An forbruger *husholdninger*		An forbruger *bilen/lufthavnen*	
	2013	***2035***	***2013***	***2035***	***2013***	***2035***	***2013***	***2035***
Kul	0.0	0.0						
Naturgas	-2.3	-2.3	-1.1	-1.1	9.5	9.5		
Benzin							56.3	59.0
Gasolie /diesel	23.0	25.7	33.9	36.6	43.0	44.3	49.1	51.8
Fuelolie	-5.2	-2.6						
JP1							20.1	22.9

I forhold til de tillæg, der var beregnet i den oprindelige analyse i 2011 [1], er tillægget for kul reduceret fra 0.18 DKK2009/GJ (svarende 0.2 DKK2013/GJ engang inflationskorrigerede) til 0.0 DKK2013. Reduktionen skyldes statistisk billigere danske import omkostninger i de seneste år i forhold til IEA's opgivne gennemsnit for kraftværkskul til OECD lande, eftersom kul er blevet billigere omkring Atlanterhavet i forhold til Stillehavet. Reduktionen er dog delvist kompenseret for ved at der i denne beregning inkluderes et estimat af omskibningsomkostninger for oversøisk kul.

Det samme er tilfældet for benzin tillægget. Fremskrivningen for 2013 gav 45.35 DKK2009/GJ i den oprindelige analyse eller 49.2 DKK2013/GJ inflationskorrigeret, dvs. 7.1 DKK2013/GJ lavere tillæg for 2013 som i den nuværende analyse.

[1] Tillæg/fradrag til kul og naturgas holdes konstant i faste priser i hele fremskrivningsperioden. Olieprodukternes tillæg er delvist knyttet til udviklingen på råolieprisen (via raffinaderiledet) i fremskrivningsperioden

Fradraget for fuelolie (relativt til international råolie) er øget fra -4.6 DKK2013/GJ som forventet i den oprindelige analyse for 2013 til -5.2 DKK2013/GJ i den aktuelle analyse. Tillægget til JP1 er reduceret fra 29.7 DKK2013/GJ i den oprindelige analyse, forklaret ved blandt andet den forholdsvis nylige tendens til faldende prisforskellen imellem af flybrændsel i forhold til råolie ved raffinaderiet.

Tillæggene til gruppen af gasoliebaserede produkter er betydeligt revideret i den nærværende analyse.

For det første er det blevet fastslået at spændet imellem motordiesel (ved fyldestationen) og fyringsolie (ved husholdingen) er konvergeret imod 0 i de seneste år, og derfor er an forbrug priserne ens for begge produkter i den aktuelle analyse. I den oprindelige analyse var tillægget til fyringsolie 34.1 2013DKK/GJ og 39.2 2013DKK/GJ for motordiesel.

For det andet er niveauet for tillæggene i den aktuelle analyse generelt højere, som illustreret af estimaterne for diesel- og fyringsolie anført ovenfor, samt gasolie an kraftværk tillægget der er øget fra 19.5 2013DKK/GJ til 23.0 2013DKK/GJ i den aktuelle analyse. Gasolie til fjernvarmeværker er øget med 1.2 DKK2013/GJ i 2013. Den observerede stigning i tillæggene til gasolieprodukter falder sammen med at diesel fortsætter med at vinde marked i sammensætningen af transportbrændsler i Danmark, og brugen af benzin er faldet siden den oprindelige analyse (se boks 2).

For vejtransportbrændslerne er der tilføjet en yderligere vurdering af prisvirkningen af iblanding af biobrændstof. Ren bioethanol vurderes at ligge 97.7 DKK2013/GJ højere end benzin uden iblanding og med fx 5% iblanding bliver den endelige blanding 4.9 DKK2013/GJ dyrere end ren benzin. Spændet imellem diesel og ren biodiesel (FAME) vurderes at være 62.7 DKK2013/GJ der med en 5% iblanding af biobrændsel giver et tillæg på 3.1 DKK2013/GJ til dieselprisen.

Tillæggene til naturgas har ændret sig betydeligt siden den foregående analyse, da der har været betydelige strukturel udvikling i det danske og europæiske naturgasmarked. Den danske gasspotpris er blevet et relevant udtryk for den danske engrosmarkedspris for naturgas siden den forrige opdatering blev udgivet. Både engros- og detailgasforsyningskontrakter er i stigende grad indekseret imod en spotpris.

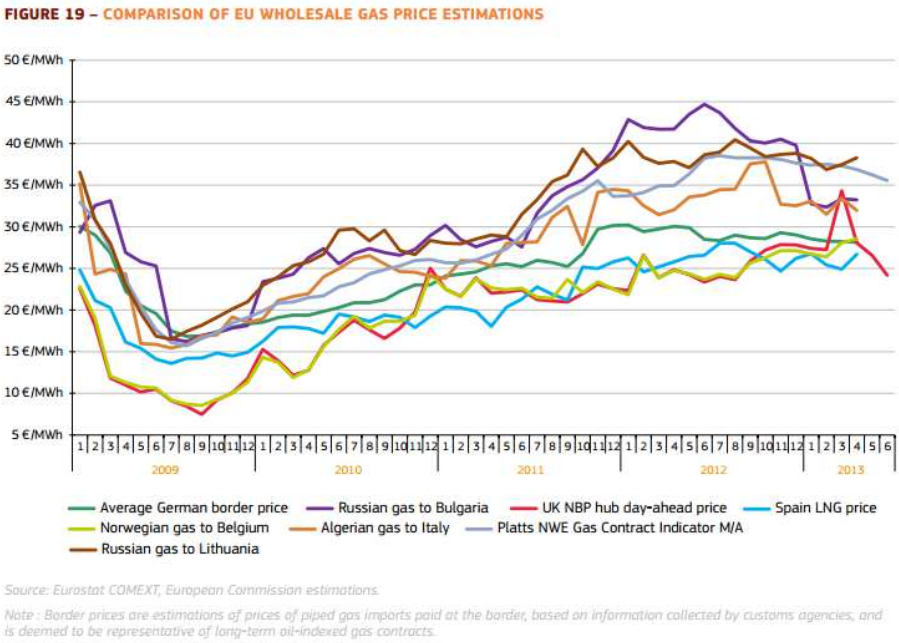

Figure 1: Comparison of EU wholesale gas price estimates. [2]

Dette har medført øget gennemsigtighed og har bragt detailmarginer ned for både decentrale kraftvarmeværker og husholdninger. Danske engrosmarkedspriser på naturgas som defineret af Gas Punkt Nordic (GPN), er laverer end de europæiske gennemsnit. Europæiske gasproduktionskilder er koncentreret i Nordsøen og det er som sådan logisk, at konkurrencen til traditionelle olieindekserede kontrakter er opstået først omkring denne produktionsbase. Nordvesteuropæiske gashubs er mere påvirket af gas-til-gas-konkurrencen og hub-baseret prissætning, end Syd-og Østeuropa.

Endelig, er nødforsyningskonceptet er blevet opdateret på baggrund af udvikling i infrastrukturen, til i højere grad at baseres på gaslagring end på reservation af rørledningskapacitet end tidligere, hvilket reducerer fradrag af irreversible omkostninger (sunk costs) fra rørledningsinfrastruktur i vurderingen af de samfundsøkonomiske omkostninger ved gasforsyning.

Den samlede effekt bliver at den samfundsøkonomiske pris for naturgas til kraftværkerne er 2.2 DKK2013/GJ lavere end det europæiske gennemsnit engrospris som defineret af IEA, hvilket er en relativ forøgelse på 3.3 DKK2013/GJ i forhold til den forrige opdatering. Reduktionen af vurdering af salgsmargin for husholdninger og fjernvarmeværker er betydelig. Den samfundsøkonomiske naturgaspris til fjernvarmeværker skønnes at ligge 1.1 DKK2013/GJ under IEA engrosmarkedsprisen. Imens den samfundsøkonomi-

ske gaspris til husstande er reduceret til ligge 9.5 DKK2013/GJ over IEA engrosmarkedspriserne.

Executive summary

The overall purpose of the current update is to develop a method and an MS Excel tool that can be used to adapt the IEA price projections (with IEA WEO New Policies scenario as the central scenario) into projections of Danish consumer prices. This method comprises two main steps:

3. Converging the IEA projections with Forward/Future contract prices in the short- to medium-term to better express the current market expectations.
4. Estimate price add-ons to transform the IEA prices (from step 1 above) into Danish consumer prices over the course of the projection period.

This report has focus only on step 2, namely on updating of calculation add-ons for use in projecting prices at the point of consumption for coal, petroleum products, and natural gas (referred to as '*at-consumption prices'*). The add-ons are applied to post-convergence (i.e. following step 1) international price projections of coal, crude oil, and natural gas provided by IEA statistics and forecasts in the World Energy Outlook, hereby referred to as the *IEA-based* prices.

The add-ons (and projections thereof in the future) hereby set forth should not be regarded as forecasts; rather, as a possible development path of the respective cost elements provided fulfilment of a certain set of assumptions and pre-conditions. As such, it should be noted that both historically and throughout the projection period year-on-year variations are likely to arise in the levels of the specific cost components quantified, as well as that structural (or short-term) changes in the set-up of the supply chain and/or trade flows to Denmark as compared to the rest of the OECD are likely to bring about differences in the add-ons relative to the estimates based on historic data.

The approach applied is an update and improvement of the method developed in the 2011 project, entitled "Opdatering af samfundsøkonomiske brændselspriser: kul, olieprodukter og naturgas". [1]

The input IEA-based prices are statistics and projections based on average prices in OECD member countries.

Specifically, these are:

- Coal: OECD steam coal average prices
- Crude oil: OECD average crude import prices
- Natural gas: European natural gas prices (weighted average of pipeline and LNG deliveries)

Since the 'at-consumption' prices[2] shall be linked directly to the international forecasts, the methodology is based on evaluation of the historical linkages and comparative levels between Danish wholesale and IEA-based prices. Additionally, the add-ons must cover the entire spread between Danish at-consumption and IEA-based prices. This shall include all real costs, as well as trade margins in the supply chain where they occur. While some of these can be substantiated individually, others – particularly trade margins – arise from the difference in price levels, e.g. wholesale vs. retail prices. For this reason, the most important sources of information used to derive the total add-ons are observed prices along the supply chain. The difference in price levels along the supply chain are referred to as '*price spreads'*.

The report qualifies the price spreads as far as possible with quantitative assessments of either the cost or margin element contributing to the spread between price observations. These quantifications have no direct impact on the final price levels, but are provided in an effort to give as much insight as possible into the soundness of the final add-ons.

Add-ons for each product are calculated for up to three locations:

- Coal delivered *at power plant*
- Natural gas delivered *at power plant*, *at local district heating (DH) plant* and *at household*.

Crude oil is refined into petroleum products, which are delivered as one of the following:

- Gasoline at the tank
- Gas oil: as diesel at the tank, as heating oil at households, and as gas oil to both power plants and local DH plants.
- Fuel oil at power plant.
- Jet petroleum delivered at airport.

[2] In the context of the current analysis, 'at-consumption' price is to be understood as the equivalent of the 'an forbruger' price in Danish - i.e. the final price faced by the consumer excluding taxes

For the most part, the scale of add-ons is assumed to inflate with prices in general. However, for petroleum products in particular, refinery spreads change in line with both general inflation, and crude oil price developments specifically.
In order to ensure consistency and a transparent, straight-forward approach, the add-ons are quantified based on simple historic averages (unless otherwise specified, e.g. in the case of refinery spreads for petroleum products). The only modification applied is with respect to the length of the historic period used in estimation of the averages, expressing the assumption as to the time period of price observations with most relevance to the price level of the current and projected add-ons.

The final add-ons to the IEA prices for coal, natural gas and petroleum products are presented in Table 2:

Table 2: The final add-ons to the IEA-based prices quantified in DKK2013/GJ for coal, natural gas and the petroleum products for 2013 and 2035, respectively[3]

DKK2013/GJ	At power plant		At DH plant		At-consumption: household		At-consumption: at-the-tank / at airport	
	2013	***2035***	***2013***	***2035***	***2013***	***2035***	***2013***	***2035***
Coal	0.0	0.0						
Natural gas	-2.3	-2.3	-1.1	-1.1	9.5	9.5		
Gasoline							56.3	59.0
Gasoil /diesel	23.0	25.7	33.9	36.6	43.0	44.3	49.1	51.8
Fuel oil	-5.2	-2.6						
Jet petroleum							20.1	22.9

Relative to the add-ons calculated in the original analysis in 2011 [1], the add-on for coal is slightly reduced from 0.18 DKK2009/GJ (equalling 0.2 DKK2013/GJ once inflation-adjusted) to 0.0 DKK2013. The reduction stems from statistically cheaper Danish import costs in recent years relative to IEA OECD steam coal averages as coal has become cheaper in the Atlantic Basin relative to the Pacific Basin. The reduction is slightly compensated for, by the inclusion of and estimation of transhipment costs.

[3] The add-ons for coal and natural gas are held constant in real terms throughout the projection period. The petroleum product add-ons are partially linked to the crude oil price developments (via the Refinery Spread cost component) over the projection period

The same is the case for the gasoline add-on (the projection for 2013 equalling 45.35 DKK2009/GJ in the original analysis), reaching exactly 49.2 DKK2013/GJ once inflation-adjusted, i.e.7.1 DKK2013/GJ lower value for 2013 compared to the current analysis.

The add-on for fuel oil has increased from -4.6 DKK2013/GJ as projected in the original analysis for 2013 (once inflation-adjusted) to -5.2 DKK2013/GJ in the current analysis. The add-on for jet petroleum has notably decreased relative to the 29.7 DKK2013/GJ projected for 2013 in the original analysis, explained, among other things, by the relatively recent trend of decreasing refinery spread of jet fuel vis-à-vis crude oil.

The add-ons for gasoil group of products have also been considerably revised in the current analysis.

Firstly, it has been established that the price spread between motor diesel (at-the-tank) and heating oil (at-household) has been converging towards 0 in the recent years, hence, the at-consumption prices are identical for both products in the current analysis (as opposed to 34.1 2013DKK/GJ for heating oil and 39.2 2013DKK/GJ for motor diesel in the original analysis, respectively).

Secondly, the add-ons derived in the current analysis exhibit an overall increase vis-à-vis the original analysis, as illustrated by the estimates for diesel and heating oil stated above, as well as the gasoil at-power-plant add-on of 19.5 2013DKK/GJ derived in the previous analysis (as compared to the 23.0 2013DKK/GJ of the current analysis). Gas oil to district heating plants is increased by 1.2 DKK2013/GJ in 2013. The observed increase in the overall add-ons to gasoil products coincides with diesel continuing to gain dominance in the transport fuel mix in Denmark, and the use of gasoline continuously decreasing also in the period since the original analysis to date (see Box 2 for more information).

In terms of gasoline and diesel at the tank a further estimate of final blends including biofuel was made. For pure bioethanol a price spread in comparison to pure gasoline was found to be 97.7 DKK2013/GJ and with e.g. a 5% biofuel blend the price add-on on the final blend is 4.9 DKK2013/GJ added to the gasoline price. For diesel to pure biodiesel (FAME) the price spread was 62.7 DKK2013/GJ which with a 5% biofuel blend the price add-on estimated at 3.1 DKK2013/GJ.

The add-ons for natural gas have changed considerably since the previous analysis as there have been significant structural developments in the Danish and European natural gas markets. The Danish gas spot price has become a relevant price for expressing the Danish wholesale market price for natural gas since the previous update was published. Both wholesale and retail gas supply contracts are increasingly indexed on a spot-price basis.

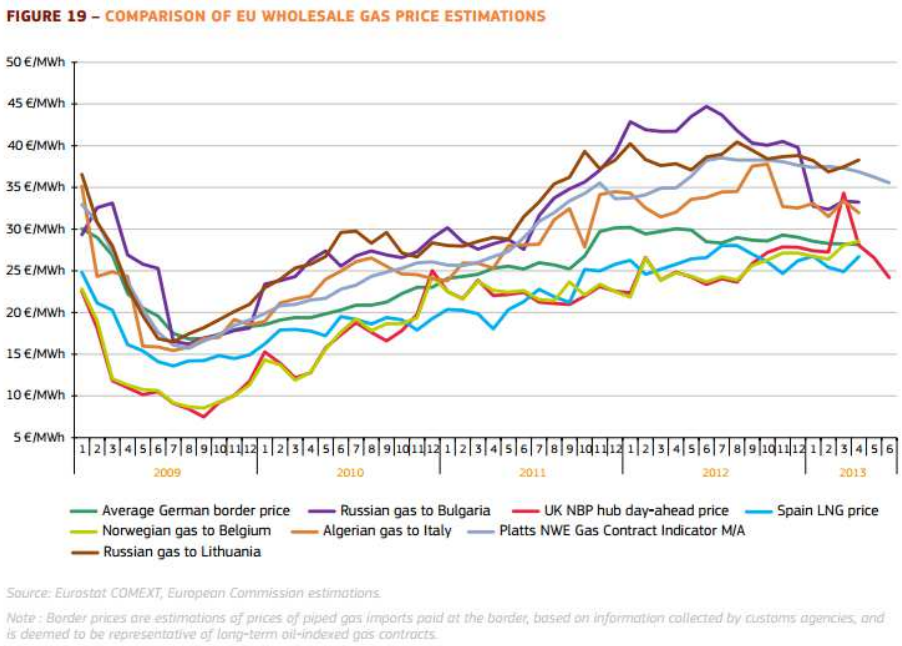

Figure 2: Comparison of EU wholesale gas price estimates. [2]

This has also brought about increasing transparency and indications of completion, which has brought retail margins down both for local-DH companies and household consumers. Danish wholesale gas prices as defined by Gas Point Nordic (GPN) are the lower echelon if European wholesale gas prices. The indigenous European sources are concentrated in the North Sea and as such it is logical that the competition to traditional oil-indexed contracts has arisen first around this basin. NW European gas hubs are more influenced by gas-to-gas competition and hub-based pricing, than Southern and Eastern Europe.

Finally, with infrastructure developments, the emergency supply concept has been updated to rely more on storage versus reservations of pipeline capacity than previously, which reduces the deduction of sunk costs from pipeline infrastructure in the assessment of economic costs of supply.

The net-effect is that at power stations, the economic fuel price is 2.2 DKK2013/GJ lower than the IEA European average wholesale price, as opposed to 3.3 DKK2013/GJ higher in the previous update. The reduction of sales margin estimations at households and district heating plants is considerable relative to the previous update. The economic cost of natural gas for Local DH plants is now estimated to be less that the IEA Average prices by 1.1 DKK2013/GJ. Meanwhile the economic cost of households is relative to IEA European Average to wholesale prices is reduced to 9.5 DKK2013/GJ.

Fuel add-on overview

			Price diff to IEA	Transportation cost					Total
Coal	at power plant	DKK2013/GJ	-0.3	0.3					**0.0**
Petroleum products			**Price diff to IEA**	**Refinery cost**	**Refining margin**	**Product premium**	**Distribution cost**	**Sales margin**	**Total**
Gasoline	delivered at customer	DKK2013/GJ	4.3	7.9	4.1	5.7	15.9	18.3	**56.3**
Diesel	delivered at customer	DKK2013/GJ	4.3	7.9	4.1	4.6	14.6	13.7	**49.1**
Heating oil	delivered at customer	DKK2013/GJ	4.3	7.9	4.1	4.6	4.9	23.3	**49.1**
Gas oil	at local DH	DKK2013/GJ	4.3	7.9	4.1	4.6	3.2	9.8	**33.9**
Gas oil	at power plant	DKK2013/GJ	4.3	7.9	4.1	4.6	2.1		**23.0**
Fuel oil	at power plant	DKK2013/GJ	4.3	7.9	4.1	-23.7	2.1		**-5.2**
JP1	delivered at airport	DKK2013/GJ	4.3	7.9	4.1	1.8	2.1		**20.2**
			Price diff to IEA	**Transmission tariff**	**Distrbution tariff**	**Sales margin**	**Sunk cost transmission**	**Sunk cost distribution**	**Total**
Natural gas	delivered at household	DKK2013/GJ	-3.3	1.5	18.2	10.0	-0.5	-16.4	**9.5**
	at local DH	DKK2013/GJ	-3.3	1.5	4.5	0.8	-0.6	-4.1	**-1.1**
	at power plant	DKK2013/GJ	-3.3	1.5			-0.6		**-2.3**

1 Coal

The following section describes the cost components constituting the final (delivered-at-power plant) coal price. Within the framework of the current analysis, the cost components constituting this final coal price are as follows (illustrated in Figure 3):

1) The IEA coal price
2) The spread between the IEA coal price and the price of Danish imports.
3) The transportation cost (barges & transhipment).

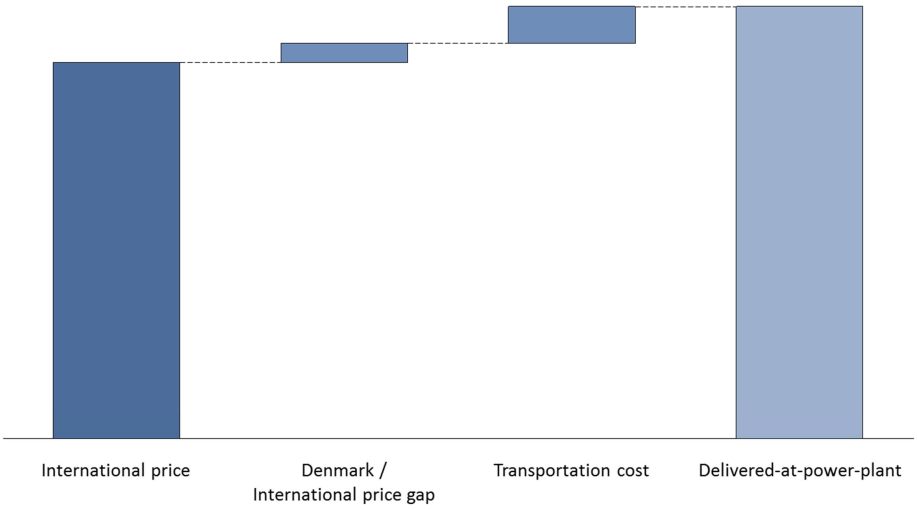

Figure 3: Illustrative example of components comprising the coal price projection (DKK/GJ)

The cost components included in the current analysis, as well as the final price projected (delivered-at-power-plant), are representative of the boundaries of the analysis framework. The cost components analysed and quantified within the analysis represent the price of coal when it reaches the power plant coal yard. As such, all other costs originating beyond this point (e.g. losses during storage, capital costs associated with maintaining stock, etc.) are beyond the scope of the current analysis – and are to be interpreted as an integral part of power plant operational costs.

1.1 Coal add-on components quantified

IEA-Denmark price spread

As a starting point, IEA OECD steam coal imports' prices are utilised, with historic prices (collected from IEA Energy Prices and Taxes publications [3] and provided by the Danish Energy Agency) being compared with prices realised by Danish coal importers.

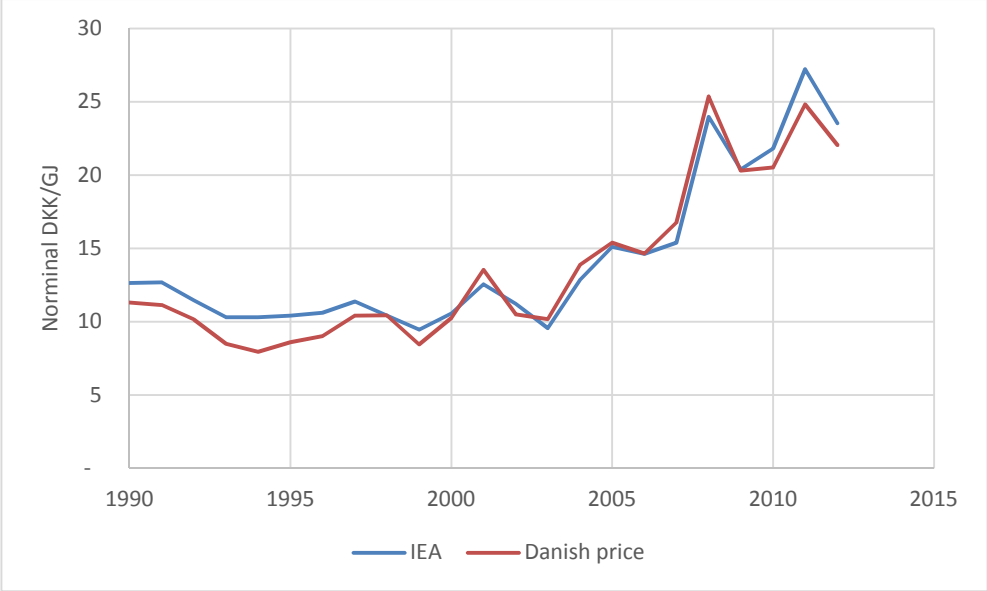

Figure 4: Historical annual IEA OECD steam coal import price [3], and the price of coal imports realised in Denmark, during the period from 1990 to 2012.

There are observable price differences between the international prices and the Danish import prices, as illustrated by Figure 4, however, these are minor in both relative and absolute terms. As is also stated in [1], annual fluctuations in the price spreads can be explained by a number of factors (e.g. not all coal is traded in spot markets at spot prices), including different ways of accounting for stock values. For example, coal purchased when the price of coal peaked in 2008 may have been delivered and/or consumed in the following year, which (if accounted for following the first-in-first-out principle) would lead to a delay in the reflection of global market price situation in the Danish price levels.

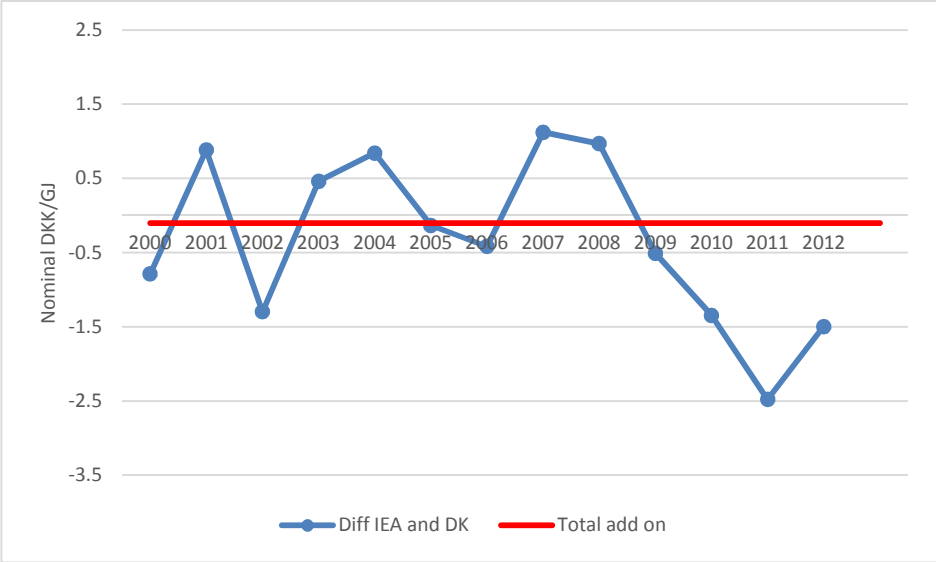

Figure 5: The difference between the annual IEA OECD steam coal imports' price, and the price

of coal imports in Denmark ($Price_{DK}$-$Price_{IEA}$), during the period from 2000 to 2012 and the total fuel add-on.

The data on Danish coal imports' prices is obtained from the latest edition of the 'Årlig international indberetning' statistics provided by the Danish Energy Agency (an earlier edition is publicly available [4]).
In line with the original analysis [1], the cost gap is derived as the average of the annual price differences starting from year 2000 (and updated to include historic data up to 2012). As can be seen in the graph, the difference has been predominantly positive within the period 2000 to 2009. However, given the negative development of the price gap from 2010 to 2012 (caused, among other things, by relatively lower prices in Europe and the Atlantic basin due to sluggish demand in Europe following the 2008 crisis and abundant exports from the US due to weaker domestic demand in the increasingly gas-based power generation sector), the overall historic average price gap has average difference of -0.3 DKK2013/GJ for 2000-2012.

Transportation cost

The Danish coal import prices [4] are the prices paid for coal when it reaches a Danish harbour. As such, the Danish import prices are a combination of the price paid for all coal imports arriving at Ensted harbour (which is transhipped and hence needs transport to a power plant), as well as the price paid for coal delivered directly to power plants. Therefore, a local transportation cost component is added to account for the cost incurred for barges to deliver the coal from Ensted to their respective final destinations.

The additional transport cost component is only relevant for coal transhipped through Ensted, i.e. coal imports from Columbia and South Africa. Based on the 'Årlig international indberetning' data, the fraction of the coal transhipped through Ensted (i.e., coal originating in Columbia and South Africa) is 63% of total Danish coal imports (average for the period 2005–2012). In all likelihood the fraction of this coming from Colombia will increase in the future as South African coal exports are increasing eastbound.

The following simple estimation accounts for the cost of transport from Ensted transhipment port to the power plant. Firstly, the average voyage distance between Ensted and Danish power plants is estimated to be 150 nautical miles. Using a Handysize bulk carrier traveling at a speed of 14 knots, with a dead weight tonnage of 30,000, as a proxy for the coal barges, a roundtrip from Ensted to a power plant would take roughly 2 days sailing, plus an estimated total of 1 day for loading, discharge, and waiting.

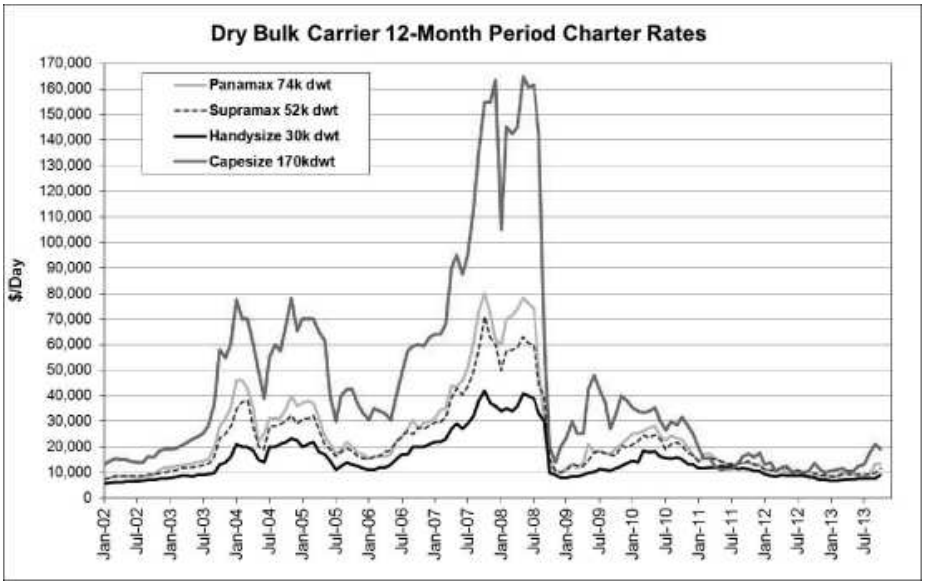

Figure 6: Historical development of dry bulk carrier time charter rates for different vessel sizes (Baltic Exchange).

Based on Figure 6, which depicts time charter shipping rates, chartering the vessel from a third party, may cost about $US 10,000/day. This is roughly 180,000 kr. per roundtrip, 6 kr./ton, or 0.24 kr./GJ of coal transported.

As the time charter rates cover the cost of ship and crew, but not bunkers, this fuel cost must be added. Per roundtrip, a ship from the assumption above would consume about 24 tons of bunker oil, at a cost of roughly 650 $/ton, i.e. 0.2 kr./GJ. To this we add an estimated 0.1 kr./GJ for additional handling costs at the transhipment port. All told, the direct cost of transhipment amounts to around 0.54 kr./GJ. When applied to 63% of the imported coal, this yields an average transhipment cost of roughly 0.34 kr./GJ.

With the closure of the Ensted Power Station and expected rebuilding of Danish coal plants to biomass-firing, the future of the Ensted transhipment port is uncertain. The view is taken that, should the Ensted transhipment port not be the point of transhipment in the future, transhipment would have to take place in another commercial port, as the coal power stations require blends of different coal sources to make suitable fuel. This could for instance imply relying on transhipment in ARA (Amsterdam, Rotterdam, Antwerp), which is the hub of Northwest European coal trade. For most Danish power plants this would slightly reduce the total freight distance from the exporting coal harbour to the power station, but increase the shipping distance with smaller and comparatively more expensive vessels. One can speculate that the net-effect of this would be a slight increase in the overall transportation costs, yet this is

not deemed to be neither sufficiently certain nor material to be included in the applied add-on.

1.2 Summary of coal add-on

As the IEA-based price over the evaluation period was on average calculated to 0.3 DKK 2013/GJ lower than the average Danish import price, the transhipment cost assessment of 0.3 DKK 2013/GJ constitutes the only add-on to the coal price delivered at the power station. The add-on is thereby calculated to be 0.0 DKK 2013/GJ.

It should, however, be noted that the add-on is based on average values, and varies substantially from year to year. The exact value of the add-on is also dependent on the development of the supply chain set-up and the trade flows to Denmark relative to the rest of the OECD (in the current analysis the add-ons are based on historical averages, and hence the underlying key circumstances are implicitly assumed to stay relatively unchanged or comparable vis-à-vis the historical situation).

2 Petroleum products

The following section covers the updating of calculation add-ons relating to petroleum product prices at the point of consumption. Within the framework of the current analysis, the add-on calculation components are comprised of:

1. The IEA crude oil price
2. The cost gap between the IEA crude oil price, and the price of crude oil delivered-at-refinery in Denmark
3. The refining cost
4. The refinery margin
5. The product premium
6. The distribution cost
7. The retail margin

2.1 Add-on components quantified

IEA-Denmark cost gap

Once again, as a starting point, historic IEA crude oil import prices are used (these are collected from IEA Energy Prices and Taxes publications and the World Energy Outlook 2011-2013). These IEA prices are then compared with the price of crude oil delivered-at-refinery in Denmark. Historic fluctuations in the price difference between the two have been observed, as illustrated by Figure 7.

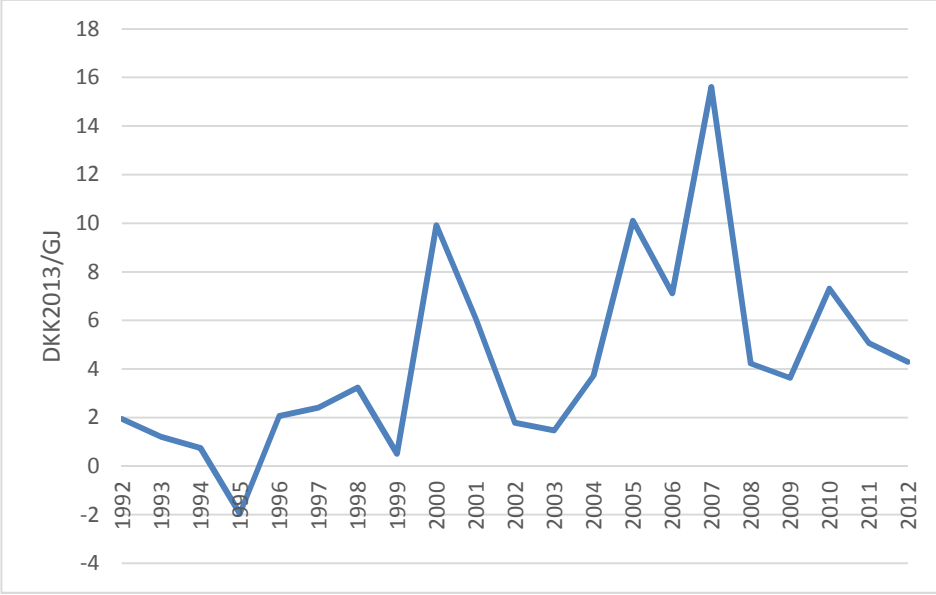

Figure 7: The difference between the annual IEA crude oil price, and the price of crude oil delivered-at-refinery in Denmark ($Price_{DK}$-$Price_{IEA}$), during the period from 1992 to 2012.

The price of crude oil delivered-at-refinery in Denmark is obtained from Energiregnskab, which is published by Statistics Denmark [5], and represents the total cost of crude oil in Denmark divided by crude oil use in GJ. The Danish and IEA methods of reporting are obviously not entirely consistent with each other, thereby resulting in the above-described fluctuations. These fluctuations are likely to be primarily attributable to differences in accounting for stock values. Following the earlier add-on calculation approach [1], the IEA-Denmark crude oil cost gap is derived based on the simple yearly average price difference over an extended period of time (a 20-year period was chosen, covering 1992 2012), amounting to 4.3 DKK 2013/GJ.

The IEA-Denmark cost gap ($Price_{DK}$-$Price_{IEA}$) is then held constant in real terms at 4.3 DKK 2013/GJ throughout the projection period.

Refining spread components

Following the original add-on calculation approach [1], the refining spread components are also updated using the latest available data. Refining spread components comprise the price difference between the crude oil price, and the price of the refined petroleum products at-refinery:

$$\begin{aligned} Petroleum\ product\ price\ at\text{-}refinery \\ = Crude\ oil\ price\ at\text{-}refinery \\ + Refinery\ margin \\ + Refining\ cost \\ + Product\ premium \end{aligned}$$

Figure 8 displays the purchase price development of petroleum products and crude oil over time in Denmark, as well as illustrating the different product premiums of the petroleum products (vis-à-vis crude oil in this case).

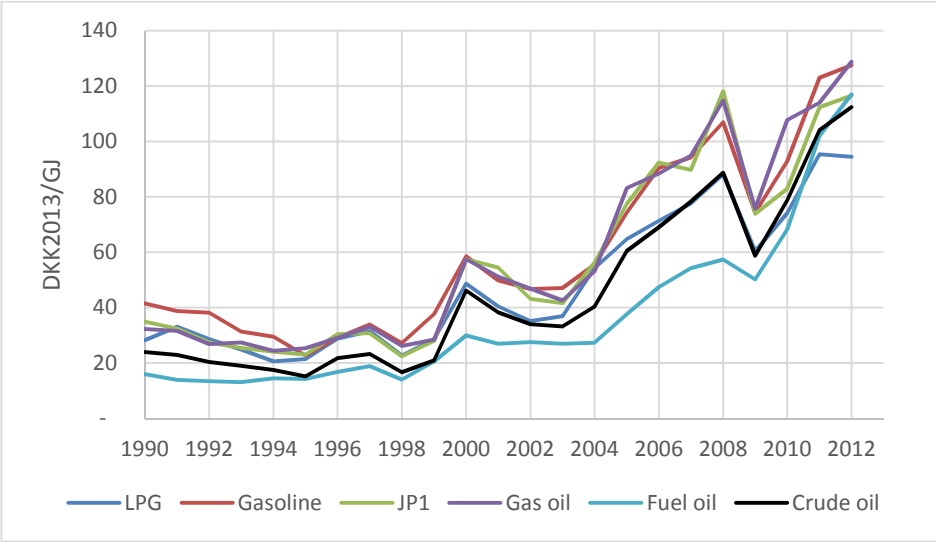

Figure 8: Petroleum product and crude oil price (purchase price at-refinery/imports without distribution costs) development in Denmark over time, 1990 – 2012. Data source: [5]

Refining mix

The first step in this process involves updating the share of each of the refined petroleum products in the refining mix. Table 3 below displays the updated refinery shares for each of the petroleum products based on data from Statistics Denmark [5].

Table 3: Refinery share for each of the different petroleum products in 2012 vis-à-vis 2009

Petroleum product	Product description	2009 Refinery share [1]	2012 Refinery share
LPG	Liquefied Petroleum Gas	2%	1%
Gasoline		29%	19%
JP1	Jet petroleum	6%	12%
Gasoil	Gasoil product group includes Motor diesel, Heating oil and Gasoil	45%	45%
Fuel oil	Assumed to be delivered to centralised plants.	18%	23%

Relative to 2009, the data suggests that in 2012 the share of jet fuel (JP1) in the refinery mix has doubled (12% versus 6%). Furthermore, the share of fuel oil has also increased (23% versus an earlier 18% share). These gains were offset by a large decrease in the share of gasoline, which saw its share fall from 29% to 19%.

Historic refinery spread

The next step involved updating the historical refinery spread. This is derived based on the difference between the average Danish petroleum product purchase price at either Danish refineries or imports terminals, and the crude oil price delivered-at-refinery in Denmark. This is found for each year, and the average for the 1992-2012 period of 12.0 DKK2013/GJ is then used as an estimate of the annual refinery spread.

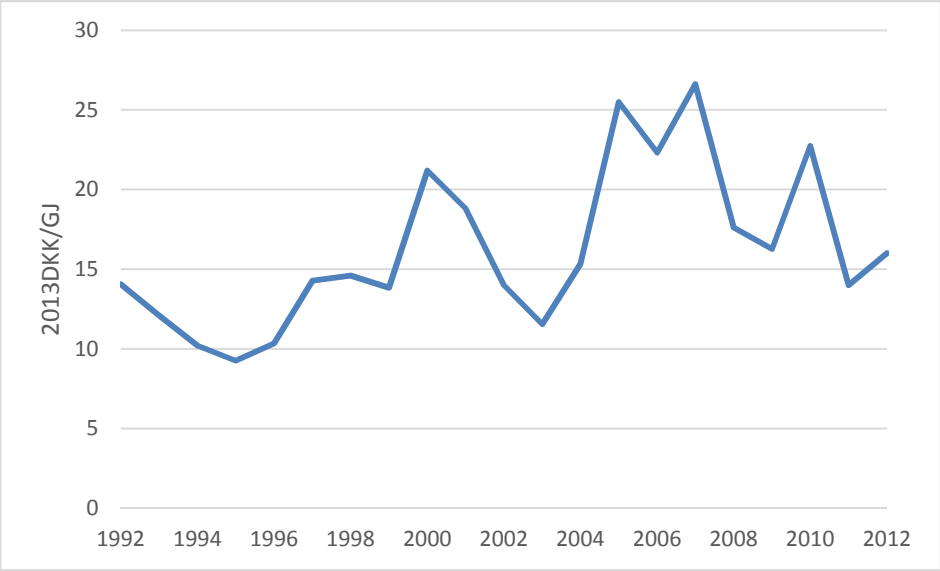

Figure 9: The difference between the annual average petroleum product purchase price in Denmark, and the price of crude oil delivered-at-refinery in Denmark ($Price_{petroleum\ prod.}$-$Price_{crude\ oil}$), during the period from 1990 to 2012.

It is assumed that the refinery spread is affected by the change in the crude oil price. The sensitivity of the refinery spread to the crude oil price (based on the original analysis [1]) is 5.65% of the yearly price development in the international crude oil price. This oil price development-induced change in refinery spread is allocated to refining cost (80%) and refinery margin (20%), respectively. The split is based on the assumption that the majority of oil price development-induced change in the refinery spread (set to 80% in the current analysis) is due to increased energy costs and cost of the stock held (i.e. refining costs), the remainder of which, i.e. 20%, could arise from the opportunity of increasing profit margins. It should be noted that the split in this case is illustrative as it has not been possible to isolate the actual cost/margin split based on historic data.

The process of derivation of the refinery spread for year *n* based on the developments in crude oil price is illustrated below:

$$Refinery\ spread_{n+1} = Refinery\ spread_n + 0.0565 * (Crude\ oil\ price_{n+1} - Crude\ oil\ price_n)$$

The respective split of the change in the refinery spread (based on developments in crude oil prices) into refinery cost and refinery margin is then derived as follows:

$$Refinery\ cost_{n+1} = Refinery\ cost_n + 0.8 * [0.0565 * (Crude\ oil\ price_{n+1} - Crude\ oil\ price_n)]$$

$$Refinery\ margin_{n+1} = Refinery\ margin_n + 0.2 * [0.0565 * (Crude\ oil\ price_{n+1} - Crude\ oil\ price_n)]$$

The dependence of the refinery spread on the change in the crude oil price can be partially explained by the fact that higher oil prices are commonly an indication of increased demand, and as such, require a more tight market that can translate into additional costs. In addition, higher crude oil prices mean that the cost of refinery losses (e.g. oil consumed for energy needs during the refining process) increase. Finally, higher demand also indicates more favourable market conditions on the supplier's side (and along the supply chain), hence potentially opening up opportunities for higher profit margins to be obtained. The price add-on of 5.65% of the crude oil price development can be seen in Figure 10:

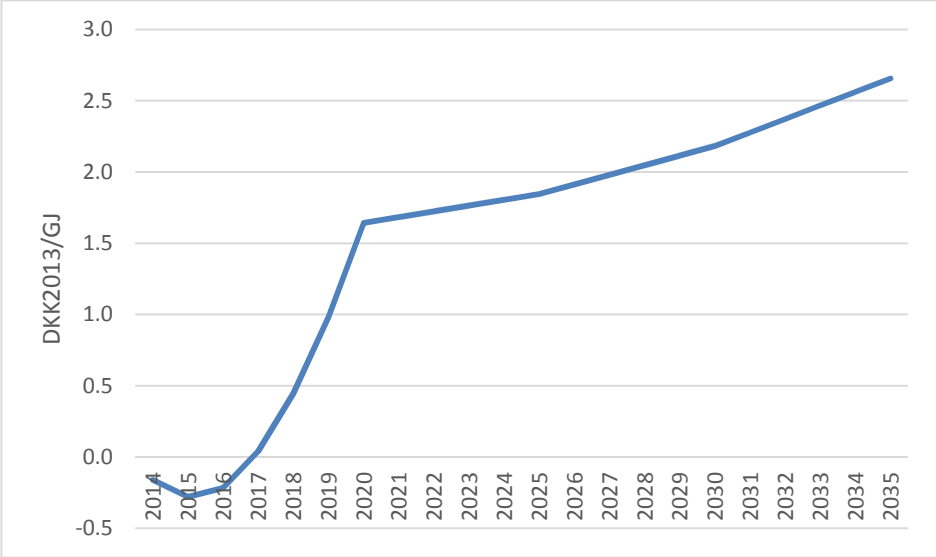

Figure 10: The price add-on of 5.65% of the crude oil price development in the period from 2014 to 2035 in DKK2013/GJ.

Refinery margin

Refinery margin is calculated based on the average value over a 20-year period (1992–2012) of quarterly refinery margins reported by BP's Statistical Review of World Energy 2013 [6] converted into real prices, and equals to 4.1 DKK 2013/GJ. The refinery margin is held constant in real prices throughout the projection period.

Refining cost

The refining cost is derived as the final component of the refinery spread, i.e. as the remainder once the crude oil price at-refinery and the refinery margin have been subtracted from the average petroleum product purchase price. Table 4 shows the refining costs in real terms.

Table 4: Refinery margin and refining cost for 2014, 2020 and 2035 in real terms.

Refinery spread component	Unit	2014	2020	2035
Refinery margin	DKK 2013/GJ	4.1	4.5	4.7
Refining cost	DKK 2013/GJ	7.8	9.2	10.0

Table 4 shows that the spread development is quite limited over the projection period. The cost development of the refinery spread components is, as described above, governed by the changes in crude oil prices. Thus, radical changes to the refinery spread will only be seen in the case of large crude oil price changes.

Product premium

The individual historic oil product premium is derived as the difference between the individual petroleum product price, and the average product price, given the appropriate refinery share. The premium is calculated for each petroleum product for each year (illustrated in Figure 11), and the average for the 1992-2012 period is then used as an estimate for the corresponding future annual product premium.

As can be seen in Figure 11, fuel oil and LPG exhibit negative product premiums (vis-à-vis the *average* petroleum product price), whereas the gasoline and gas oil product group have positive product premiums. A decline in the product premium of jet fuel (JP1) is observable in the last couple of years, though it is still priced above crude oil (as illustrated by Figure 8).

Fuel oil has in recent years been gaining ground on the other refined products. Fuel oil here represents a broad pallet of fuel oils, including marine bunkers, for which tightening of regulation on pollutants such as sulphur means that more refining is going into the average fuel oil product consumed.

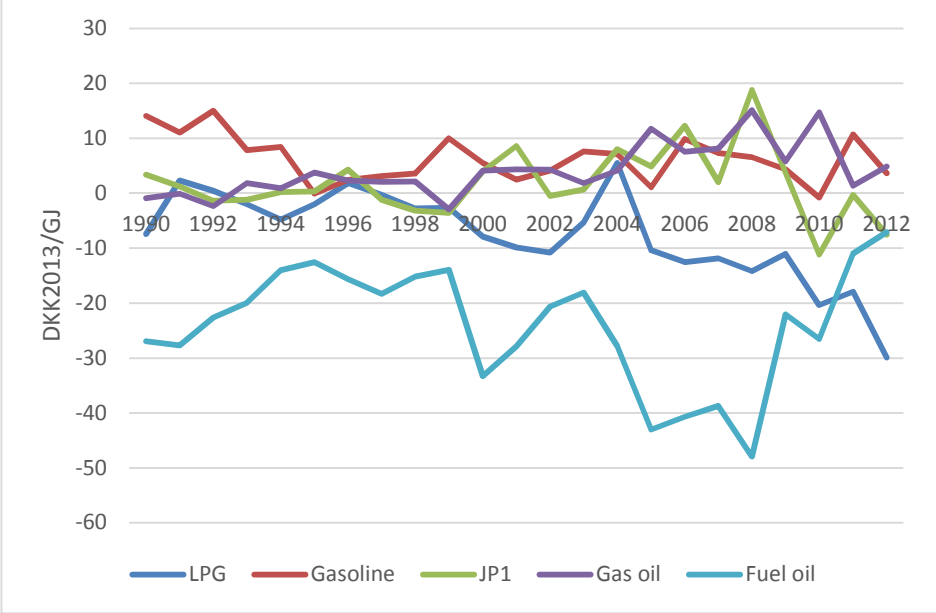

Figure 11: The difference between the annual average petroleum product price at-refinery in Denmark, and the price of individual petroleum products at-refinery in Denmark (Price $_{Individual}$ – Price $_{Average}$), during the period from 1990 to 2012. Data source: [5], own calculations.

Table 5 presents the average annual product premiums for the selected petroleum products.

Table 5: Average annual product premiums for different petroleum products in Denmark. The premiums represent historic averages for the period 1992-2012. Data source: [5], own calculations.

Petroleum product	Average annual product premium (DKK 2013/GJ)
LPG	-8.0
Gasoline	5.7
JP1	1.8
Gas oil	4.6
Fuel oil	-23.7

The cost components of the at-refinery petroleum product prices are to this point identical for all of the different petroleum products – with the exception of the product premium, as seen in Table 5. The product premiums thus determine the differences in purchase prices (at-refinery prices) for the different petroleum products.

Box 1: International perspective on the development of the refinery spread of jet fuel (JP1) over time

At the time of the previous update in 2011 [1], the five-year average spread (for the period of 2005 – 2009) between jet fuel and Brent Crude was 19%, whereas in the previous few years the spread has narrowed in percentage terms. The five-year average spread as of this update (i.e. period of 2008 to 2012) has the spread at an only 14% fraction of the jet fuel price. Recent market information indicates that there is over-supply in the European jet fuel market at least in the short-term [14].

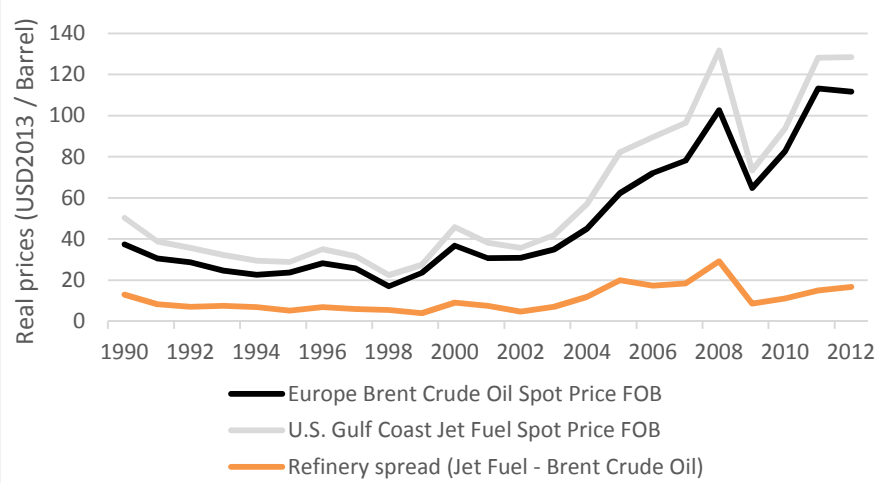

Figure 12: Annual average spot prices in real prices, USD2013/Barrel, of European Brent Crude Oil (FOB), US Gulf Coast Jet Fuel (FOB), and the respective Spread over time, 1990 – 2012. Data source: EIA [12], inflation adjustments in line with the GDP Deflator of the World Bank [13]

Distribution costs and sales margins

Depending on the specifics of the particular petroleum product and its application, there is a large variety of transportation costs and sales margins.

Gasoline

Gasoline delivered at the tank (i.e. pump price at gas station) is subject to distribution costs and sales margins. The distribution costs include the cost of terminal operation, depot, and those associated with gas stations. The distribution costs (in real terms) derived as per the original analysis [1] are deemed to still be relevant today. The sales margin is updated based on the difference between observed consumer prices and the ex-refinery prices, less the distribution costs. Throughout the projection period, both distribution costs and sales margin are assumed to develop in line with the general inflation level and are therefore held constant in real terms throughout the projection period at 15.9 DKK 2013/GJ.

The sales margin is updated based on the latest available historic data (from 2002-2012), and applies the assumption that the delivered price at the tank incorporates the distribution and sales margin cost components:

$$\begin{aligned} &Gasoline\ delivered\ at\ the\ tank\ price \\ &\quad = Gasoline\ purchase\ price\ (ex\text{-}refinery) \\ &\quad + Distribtion\ cost \\ &\quad + Sales\ margin \end{aligned}$$

Historic data from Statistics Denmark [5] regarding the historic annual gasoline purchase price (ex-refinery) has been collected, as well as historic data on the price paid for gasoline by the final consumers (delivered-at-customer, both for households and businesses). The sales margin is then computed as the average of the annual differences between the observed annual delivered at the tank price (the price being volume-weighted based on the consumption by households and industry, respectively), the observed annual gasoline purchase price (ex-refinery,) and the transportation cost (held constant in real terms) over the period from 2002 to 2012. The resulting sales margin is 18.3 DKK 2013/GJ.

Motor diesel

The calculation approach for motor diesel is identical to that of gasoline. In line with the original analysis [1], distribution costs and sales margins apply. The distribution cost derived as per the original analysis [1] is deemed to be up-to-date, and is therefore maintained. The distribution cost is held constant in real prices throughout the projection period and amounts to 14.6 DKK 2013/GJ.

The sales margin is updated following the same approach as for motor diesel based on data from Statistics Denmark [5], i.e.:

$$\begin{aligned} &Diesel\ sales\ margin = \\ &\quad Diesel\ delivered\ at\ the\ tank\ price\ (observed\ ) \end{aligned} \quad [5]$$

$$-Diesel\ purchase\ price\ (observed\ ex\text{-}refinery\ )\ [5]$$
$$-Distribution\ cost\ (constant\ in\ real\ terms)$$

The average of the annual sales margins over the 2002-2012 period is then calculated and the resulting sales margin is found to be 13.7 DKK 2013/GJ.

Box 2: Significant dynamics in the transport fuel mix over time

A contributing factor to the overall development of the add-on for diesel could be the different transport fuel consumption dynamics. There has been steady growth in the use of diesel for transport in Denmark (and Europe in general), the consumption has gone up by nearly 50% in the period from 2000 to 2012 [11]. In the same period, the consumption of gasoline has decreased by 30%, as illustrated in Figure 9 below:

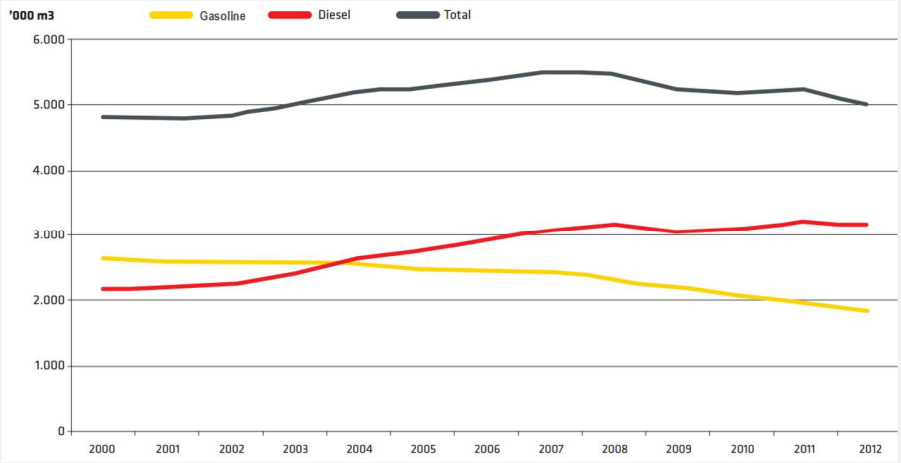

Figure 13: Development in the fuel use (in '000 m^3) for transport over time in Denmark. Figure source: EOF [11]

Biofuels

Based on Energi- og Olieforum [7], the historical price difference between gasoline and bioethanol is found to be approximately 97 DKK 2013/GJ or 3.2 DKK/L gasoline equivalent. The price difference for diesel and biodiesel (FAME) is approximately 62.7 DKK 2013/GJ or 2.3 DKK2013/L diesel equivalent. Since quota on biofuels were introduced in 2011 the average price differences were based on data from 2011 to 2013. Assuming that the final blend will consist of 95% gasoline and 5% bioethanol, the price in terms of DKK/GJ is found as:

$$final\ blend\ price =$$
$$95\% * gasoline\ price\ at\ the\ tank\ (DKK/GJ)$$
$$+ 5\% * (\ gasoline\ price\ at\ the\ tank\ (DKK/GJ)$$
$$+ price\ difference\ between\ gasoline\ and\ bioehtanol\ (DKK/GJ)\ )$$

The same method is used for diesel and biodiesel. “Energistyrelsen’s Energistatistik” [8] conversion factors for gasoline, diesel and biofuels are used to convert the prices to DKK/L (both volume and gasoline/diesel equivalent).

Heating oil

The delivered-at-household heating oil price is also subject to distribution costs and sales margins. Based on the original analysis [1], the distribution cost for heating oil should be comparable to the cost of supplying diesel to gas stations. The distribution cost derived in the original analysis in 2011 [1] is therefore inflation-adjusted and becomes 4.9 DKK 2013/GJ. The sales margin is then found as the remainder of the price spread (equivalent to the price spread of diesel).

The price difference between heating oil at the household and motor diesel at the tank is used to estimate the sales margin of heating oil. This difference historically is depicted on Figure 14.

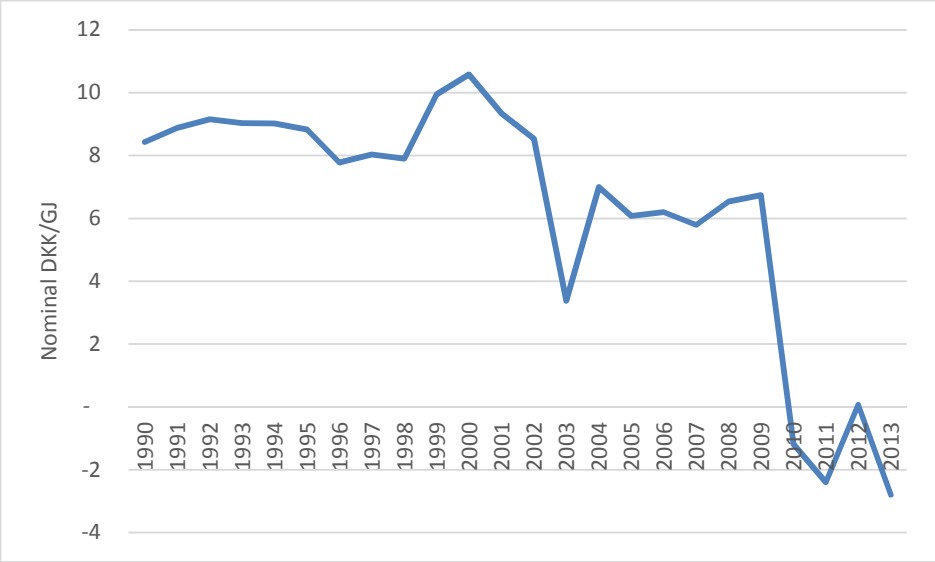

Figure 14: Historical product price difference between diesel and heating oil (P_{diesel} - $P_{heating\ oil}$) in nominal DKK/GJ [7]..

The average historical price difference for the 2009-2013 period was 0.08 DKK/GJ, but the price difference appears to be converging to zero. Figure 14 provides a basis for the assumption that the price difference between diesel and heating oil is nearly zero. As such, for the projection period it is assumed that the heating oil cost delivered at households is equal to the diesel price delivered at the tank. The sales margin thereby calculated as 23.3 DKK2013/GJ for motor diesel, which is held constant in real prices.

Gas oil for local DH plant

Gas oil for use in local DH plants is subject to transportation costs and a sales margin. As in the original analysis [1], the costs associated with transporting

gas oil to a local DH plant are assumed to be the same as those associated with transporting motor diesel to a fuelling station. The sales margin is then estimated to be 9.8 DKK2013 /GJ based on the residual difference between the ex-refinery gasoil price and statistically observed gasoil prices delivered at district heating plants from the Danish District Heating Association (less the yearly applicable levels of energy and CO2 taxes).

Gas oil and fuel oil delivered-at-power-plant

Gas oil delivered-at-power-plant is subject to transportation costs, which are deemed not to have changed fundamentally since the previous analysis, and hence the price level has only been inflation-adjusted. The transportation cost is held constant in real prices throughout the projection period and amounts to 2.1 DKK 2013/GJ.

Jet fuel

Lastly, the transportation of jet petroleum (JP1) at-airport is deemed comparable with the costs of distributing oil to power stations, and is therefore also subject to a transport cost of 2.1 DKK 2013/GJ.

2.2 Summary of petroleum product calculation add-ons

The table below summarises the calculation add-ons to petroleum product prices in relation to a European oil price based on IEA statistics and projections.

Table 6: Summary of petroleum product calculation add-ons for 2013 in DKK2013/GJ.

	Crude		Refinery spread		Distribution spread		Total
	IEA-DK	Cost	Margin	Premium	Costs	Margin	
Gasoline	4.3	7.9	4.1	5.7	15.9	18.3	**56.3**
Diesel				4.6	14.6	13.7	**49.1**
Heating oil					4.9	23.3	**49.1**
Gas oil DH					3.2	9.8	**33.9**
Gas oil P.P.					2.1	-	**23.0**
Fuel oil				-23.7	2.1	-	**-5.2**
JP1				1.8	2.1	-	**20.2**

Additionally, to account for biofuel blends 97.7 DKK2013/GJ should be added to the bioethanol blend fraction in gasoline and 62.7 DKK2013/GJ to the biodiesel blend fraction in motor diesel.

2.3 CO_2 price effects

The current analysis omits the CO_2 price effects from the petroleum product cost component calculations. This is done for several reasons. Firstly, despite the fact that refineries are subject to the EU Emission Trading Scheme, the currently very low CO_2 price (EUA) has a very limited effect on fossil fuel prices (e.g. the refinery margins). Secondly, the original analysis [1] indicates that even in the case of substantial CO_2 price increases in the future, the effect thereof on the petroleum product prices would be marginal. Thirdly, it is not clear to what extent the upwards price pressure on petroleum products origi-

nating from increasing CO_2 prices would translate in deteriorating refinery margins, as opposed to increasing consumer prices. In addition, extreme CO_2 pricing within the EU is likely to prompt increased refining activity outside of the ETS-compliance area in the long-run, and as such, limit CO_2 price effects in the total refining price add-on.

Therefore, and in order for the fossil fuel price update approach to be as sound and straightforward as possible, the CO_2 price effects have hereby been disregarded in the analysis.

3 Natural gas

The following section describes the cost elements added to the international (NW Europe) gas price projection based on the IEA World Energy Outlook, to achieve the projection of future natural gas prices at the point-of-consumption, i.e. at:

- Centralised power stations (delivered-at-power-plant price, e.g. at the three power stations which are directly connected to the natural gas transmission system)
- District heating plants or large industrial consumers (delivered-at-plant price) – i.e. an annual consumption near 10 mio. Nm3.
- Delivered at household price, i.e. typical consumption less than 6000 Nm^3/year.

The cost elements are itemized according to the different stages of the supply chain. Methodologically speaking, the present update follows the methodology utilised in the previous publication by Ea and Wazee in 2011 [1], with a few critical differences based on recent years' developments in the natural gas markets.

Danish Market Price for Gas – Gas Point Nordic

Firstly, the natural gas spot market price has gained relevance as an indicator of the 'true market value' of natural gas in Denmark since the publication of the original analysis [1]. This is due to the following considerations:

- Gas contracts for bulk supply (beaching and imports) have been increasingly decoupled from a traditional oil indexation formula and are now predominantly indexed to spot prices.
- The pricing formula in contracts between gas suppliers and district heating companies is now predominantly indexed to the spot prices in Denmark (Gas Point Nordic, GPN), Germany (Net-connect Germany, NCG) or the Netherlands (Title Transfer Facility, TTF).
- The supplier-of-last-resort contract (*forsyningspligt*) was set to tender in 2013 based on competitive offers of a margin on top of the TTF price. Prior to the tender the default supplier's had all increased the proportion of spot market indexation in their pricing formula, thereby exposing the entire gas market for households to the Gas Point Nordic price.

Seasonality of the gas price

Natural gas prices have a higher degree of seasonality than most of the other energy commodities covered in this report. The starting point for international gas prices based on the IEA assumptions are annual prices implicitly weighted according to time of consumption and price. This is therefore also taken into

account when defining the relevant price spread between the Danish price and the IEA-based prices. The historical Danish spot price is seasonally weighted according to a monthly consumption profile.

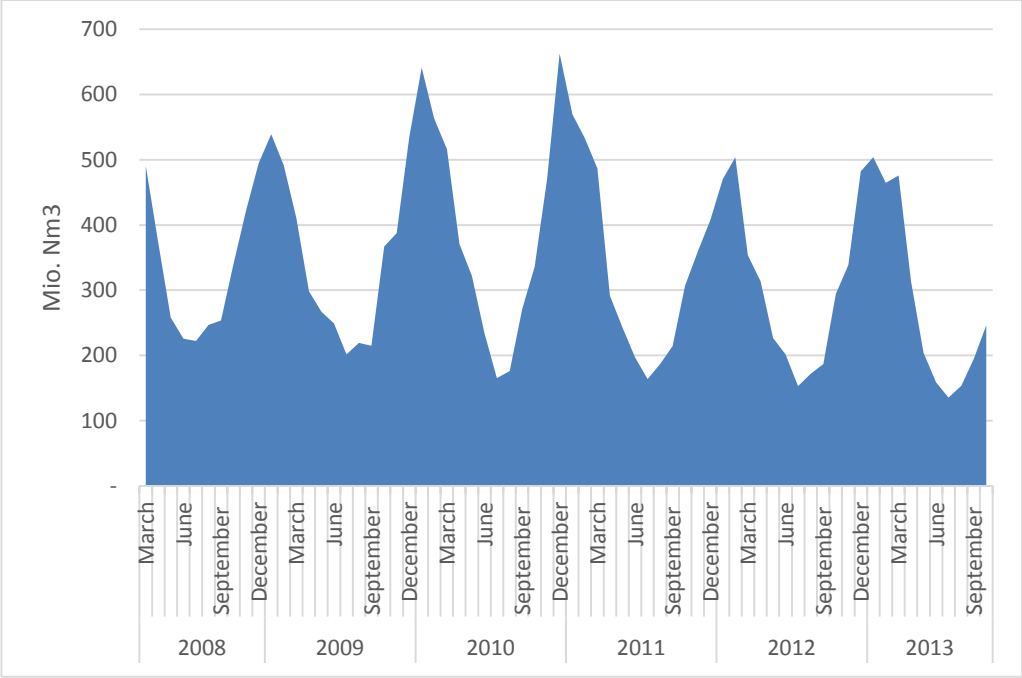

Figure 15: Monthly consumption of natural gas in Denmark during the years 2008 to 2013, in million normal m^3 [9].

Storage costs

The cost and value of storage in the natural gas market are reflected in the seasonality of natural gas spot prices. As spot prices form the reference for Danish wholesale gas prices, the cost of storage is therefore not considered as a separate cost component, which is in contrast with the previous analysis [1].

Sunk costs for network-bound supplies

Sunk infrastructure investments are particularly relevant for natural gas as their delivery is pre-dominantly based existing pipeline infrastructure. Therefore, in making economic analysis from a societal perspective, a significant proportion of the costs facing the consumers are seen as transfer payments rather than real economic costs. This is important, since the projects or measures analysed, will generally not be able to prevent costs incurred historically, nor will they in many cases reduce real costs of a system with sufficient capacity. In the previous update [1] this issue was considered extensively and discussed with stakeholders and the approach of the present update does not make general changes to the principles applied.

In general, the perspective is that in the fuel prices derived in this report, elements which change the societal economic costs should be included. Thereby, significant proportions of the natural gas and distribution infrastructure costs are deducted from the final consumer prices. However, where an increase or decrease in consumption would carry an *opportunity cost* they are not deducted. This is the case particularly in relation to gas storage, which carries a

market value. A reduction in gas consumption in Denmark, would decrease the utilisation of the gas storages, but this capacity can be sold e.g. for mitigating seasonality in German gas consumption, and thereby carry that opportunity cost and not be considered sunk.

For this reason within the context of the current analysis a distinction is being made between *economics prices* and *consumer prices* in relation to the gas add-on calculation

Box 3: Definitions of consumer vs. economic prices in the context of current analysis

Consumer price:	the final price faced by the consumer excluding taxes (irrespective of whether it represents real costs being incurred, or transfer payments)
Economic price:	expression of real societal costs being incurred (i.e. excluding transfer payments and sunk costs)

3.1 Add-on components quantified

The following section describes the quantification of cost components, which, when added on top of the IEA-based European gas prices yield the Danish economic gas price at the points of consumption, i.e. at power plants (delivered-at-power-plant), district heating plants (delivered-at-plant) and household consumers.

Gas Point Nordic add-on

The natural gas spot market price will only form the basis for assumptions on future price projections based on 2010-2012 data. A cost gap of -3.3 DKK 2013/GJ is obtained between the international natural gas price based on the IEA, and the Danish natural gas price based on the average spot price on Gas Point Nordic.

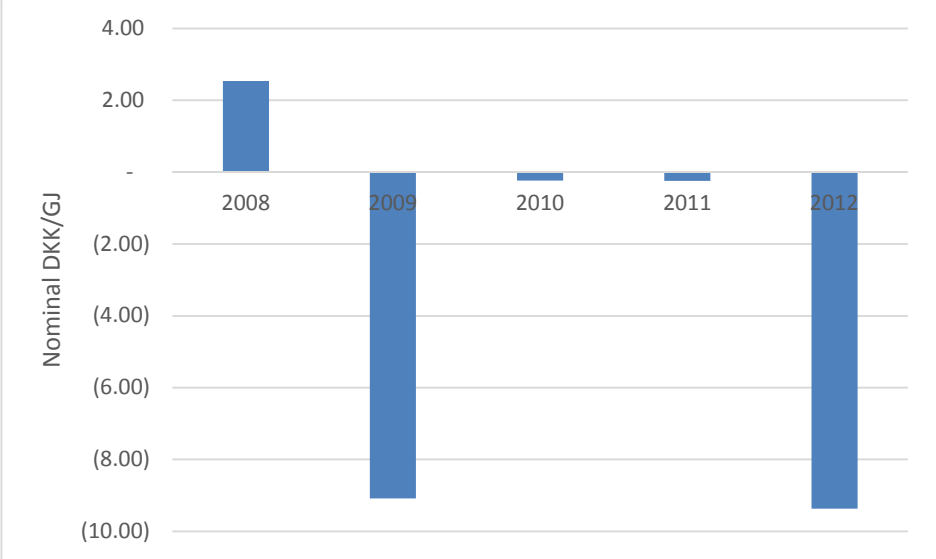

Figure 16: The difference between the annual IEA natural gas price and the natural gas spot market price in Denmark ($Price_{DK}$-$Price_{IEA}$) during the period from 2008 to 2012.

Given infrastructure expansions, hub-based gas prices are expected to converge increasingly in the future. For instance the increased import/export capacity between Denmark and Germany will decrease the price gap between Danish and Germany hub prices. However, the IEA-based prices are based on an average of import prices and not hub-based prices. How much hub-based gas price convergence will impact the IEA average prices requires detailed insight into the price impact of and composition of prices (e.g. proportion of hub index prices to oil indexed prices etc.) in each of the individual countries reporting to the IEA statistics. Since the magnitude of convergence is unknown the approach based on historical data described above is kept.

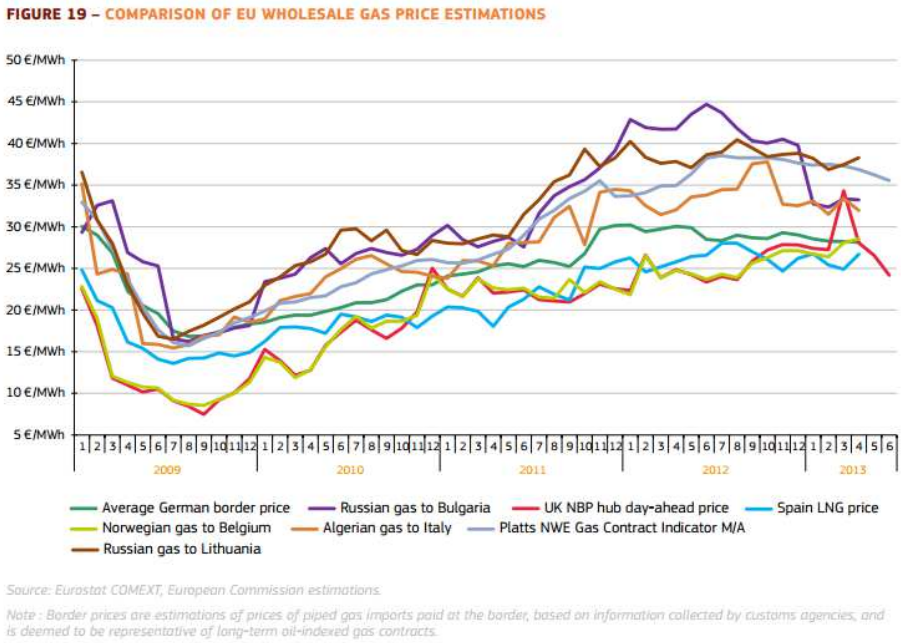

Figure 17: Comparison of EU wholesale gas price estimates. [2]

The above comparison of EU wholesale gas price estimates shows how European wholesale prices diverge significantly. The most well developed and liquid gas spot market in Europe is still the UK's National Balancing Point, which over the past decade has featured among the lowest wholesale gas prices in Europe. The spot prices in the Northwest Europe have all been gaining relevance in recent years, prices are converging between NBP, TTF in Holland, Zeebrugge in Belgium, the German Gaspool and NCG (Net Connect Germany) and Danish Gas Point Nordic. The indigenous European sources are concentrated in the North Sea and as such it is logical that the competition to traditional oil-indexed contracts arises first around this basin.
In summary, the projection of Danish wholesale gas price on Gas Point Nordic defined as:

$$GPN = IEA - 3.3 \text{ DKK } 2013/GJ$$

The cost gap is assumed to stay constant in real terms in the projection period. Arguments can be made for either a narrowing or widening of the spread. A more sound qualification of this issue would require analysis of tendencies relating to supply, demand, pricing and infrastructure developments in each of the countries including in the IEA average prices, which are beyond the scope of the present analysis.

While there are significant wildcards in the developments of the European gas markets, there is a logic to the Danish wholesale gas prices in fact being below the European averages. So while the historical averages differences are main-

tained at constant level in the price projections, monitoring this development going forward will be essential.

Transmission

The natural gas transmission system is the main arteries of the natural gas supply infrastructure. These investment are recouped through cost based transmission tariffs. Transmission tariffs have three components:

1. A capacity-based tariff allowing entry into the Danish transmission system.
2. A capacity-based tariff allowing exit from the transmission system, either into the distribution system, exports at border crossings, or for direct consumption in one of the three centralised gas-fired power plants (Avedøre, H.C. Ørsted and Skærbæk).
3. A volume-based tariff for exit from the transmission system.

The title for natural gas traded on Gas Point Nordic is transferred within the transmission system, meaning that the entry tariff is included in the spot price. Therefore, only the costs relating to the exit are included in the transmission cost component.

Transmission tariff				
Demand load factor (customer):	0.56			
Demand load factor (hourly):	0.47			
Household		(**HCV**)		
Exit Capacity	8.04	DKK/kWh/hour/year	0.50	DKK/GJ (LCV)
Volume tariff	0.00261	DKK/kWh	0.80	DKK/GJ (LCV)
Emergency supply	0.00067	DKK/kWh	0.21	DKK/GJ (LCV)
Transmission tariff			**1.51**	**DKK/GJ (LCV)**
Sunk costs			**0.50**	**DKK/GJ (LCV)**
At plant		(**HCV**)		
Exit Capacity	8.04	DKK/kWh/hour/year	0.60	**DKK/GJ (LCV)**
Volume tariff	0.00261	DKK/kWh	0.80	**DKK/GJ (LCV)**
Emergency supply	0.00045	DKK/kWh	0.14	**DKK/GJ (LCV)**
Transmission tariff			**1.54**	**DKK/GJ (LCV)**
Sunk costs			**0.60**	**DKK/GJ (LCV)**

Table 7: Calculation of the add-ons for natural gas transmission and emergency supply.

The calculations in the table above covers combines the contribution from the capacity based tariffs and the volume based tariffs relating the transmission system costs and cost of emergency supply. The final cost levels are differentiated between household consumer and all other (larger) consumers.

Firstly, smaller consumers do now have hourly meters and therefore constitute the residual demand in relation to the supply from a local M/R-station[4] and the cumulative offtake from larger consumers who are metered hourly. These two groups have separate combined load factors based on system statistics from Energinet.dk. The load factor is relevant as it is used to calculate how much capacity the gas transporter would need to purchase (assuming only use of hourly capacity products) to supply a portfolio of consumers in this category. These load factors have been confirmed with Energinet.dk as reasonably representative. Secondly, the costs are differentiated based on the level of security of supply offered granted households, vis-à-vis large industrial or district heating.

Note that while consumers face both the price implication of entry and exit from the transmission system, in terms of the economic costs a sizable proportion of transmission costs are considered sunk costs. The exit capacity tariffs are taken as representing the historical proportion the overall transport payment set to cover historical capital expenditure with negligible opportunity cost and are hence considered sunk.

Emergency supply

The emergency supply by Energinet.dk mainly consists of storages and interruptible consumers, as seen in Figure 18. The figure shows that emergency supply has shifted to be supplied by use of storage rather than use of existing pipelines without market value and thus are not perceived as sunk cost.

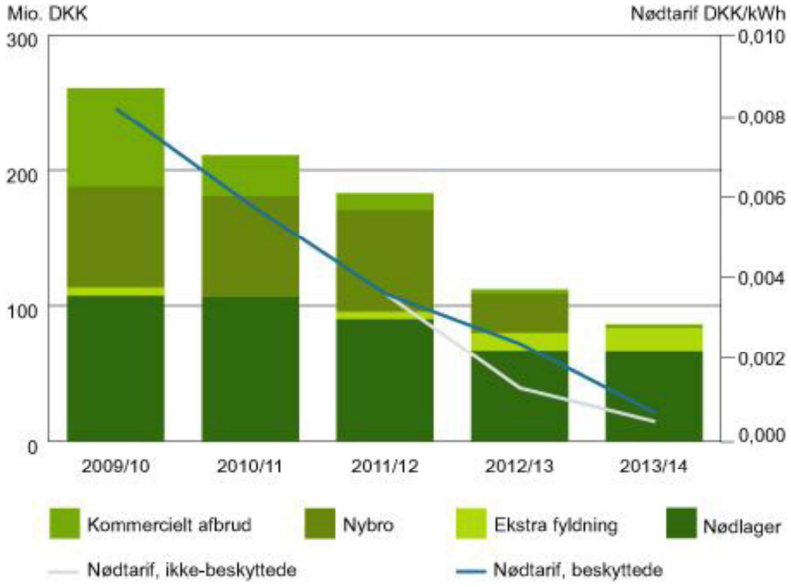

Figure 18: Emergency supply development in recent years. Source: "Gas i Danmark" by Energinet.dk

Distribution

[4] Metering and Regulation

All consumers of natural gas, with the exception of the three centralised gas-fired power stations, receive supply through the local distribution network. Three companies have localised gas distribution monopolies in Denmark.

Distribution tariffs are cost-based regulated tariffs and it is therefore reasonable to use them to express the economic costs of distribution. However, as with transmission, a significant proportion of the distribution system is considered to be sunk costs, and is therefore deducted for the purpose of making economic analysis.

The distribution cost component for supplying district heating companies is based on the tariff for satisfying consumers with an annual offtake of approximately 10 mio. Nm^3. The distribution costs for households are based on the tariff for a standard household with an annual consumption of 0-6000 Nm^3.

The distribution tariffs are averaged (volume-weighted) over the three distribution companies.

Distribution tariff

Current distribution tariff		**HMN Naturgas**	**Naturgas fyn**	**DONG**
Household	DKK 2013/Nm^3	0.58	1.24	1.38
Local DH plant	DKK 2013/Nm^3	0.16	0.28	0.33
Energy saving activities		19%	11%	12%
Total distribution		66%	6%	28%

Energy saving activities based on 2014 data from the Danish Energy Regulation Authority [10] are considered not to be part of distributing natural gas and thus are deducted when calculating the distribution costs.

Distribution tariff

		Household	**Local DH**
Average distribution tariff*	DKK 2013/GJ	18.2	4.5
Sunk cost	DKK 2013/GJ	16.4	4.1

**without energy savings activities*

The lion's share of the distribution tariff covers historical infrastructure investments costs, which would not be impacted by changes in consumption. As with transmission costs these investments are considered sunk. The estimation from [1] is that 90% of the costs covered by the distribution tariffs (less energy savings) are sunk.

Box 4: Uncertainty in natural gas transportation

Developments in the socio-economic transportation costs of natural gas are very susceptible to e.g. changes in consumption, natural gas transit, the amount of upgraded biogas, and the use of the Danish natural gas storages. In the current study, the calculation of the socio-economic transportation costs is based on the prices reported by the grid companies, less costs of facilities that are considered to be sunk costs.
The prices reported by the transportation companies may involve adjustments with respect to the regulation-prescribed accounting practices, and since the projections of the transportation costs are based on historical prices, they do not contain an evaluation, which includes the uncertainty associated with many of the factors noted above.
The method applied in the current analysis is therefore different from the approach taken in the future gas infrastructure analysis study "Gasinfrastrukturen - Den fremtidige anvendelse af gasinfrastrukturen" by the Danish Energy Agency [15], which presents dynamic development of the average transportation costs over the transition period (with continued use of natural gas), as well as in the envisioned future state dominated by biogas and other renewable gasses.

Sales margins argins

Centralised power stations purchase directly at wholesale market prices and therefore do not incur retail margins. As mentioned in the introduction of the chapter, significant recent market developments have resulted in a movement towards more wholesale price transparency, which also translates into transparency for downstream prices. This also means that the sales margins for natural gas have been significantly depressed in relation to the original analysis [1].

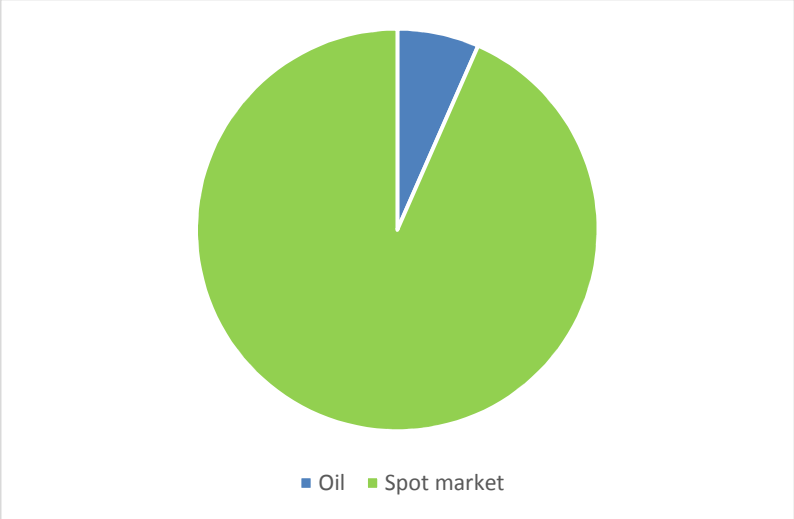

Figure 19: Division of spot price-indexed contracts based on sample contracts.

Spot price-indexed contracts are now predominant in the supply of district heating companies with natural gas. For the present analysis, the pricing formula for a large number of contracts with district heating companies have been made available by natural gas companies. One company provided data on 358 supply contracts valid from 2012 and 2013. Another supplied a more limited sample of 7 contracts. Taken together, 341 of the contracts where indexed to spot market prices, either TTF, NCG or GPN.

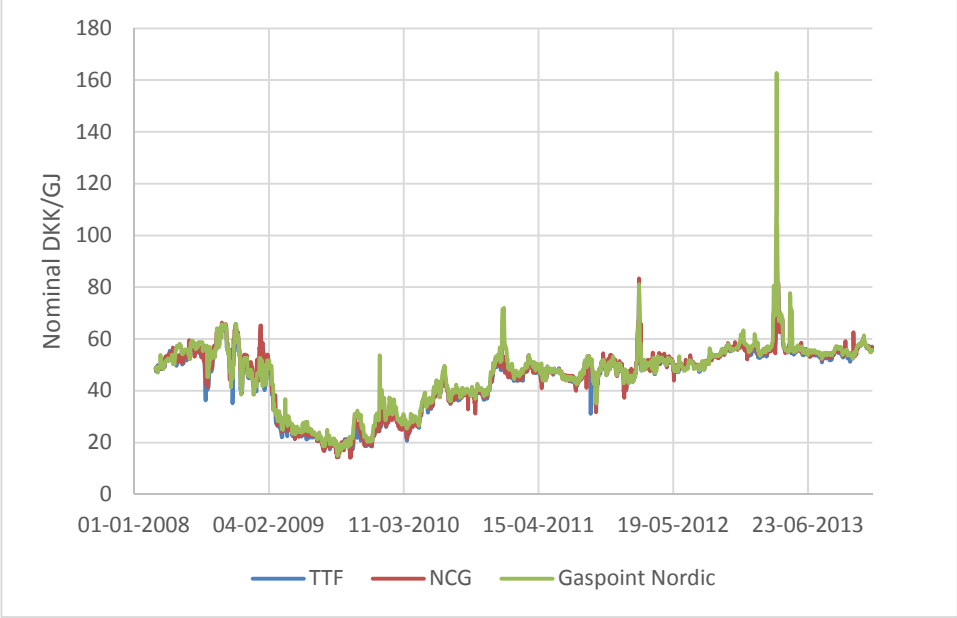

Figure 20: Historical development of the prices and Gas Point Nordic, TTF and NCG hubs.

It can be observed from Figure 20 that prices on the three referenced hubs generally move together, but there are times where the prices diverge significantly. Table 8 presents an estimation of the price differences over time on the hubs. This approximation is to be used to estimate a relative transportation and risk premium, which should be associated with deliveries indexed to hubs abroad. These are based on daily spot market prices in the years 2011-2013.

Table 8: Difference between gas hubs: TTF – GasPoint Nordic and NCG – GasPoint Nordic in nominal terms.

Gas hubs	TTF – GPN		NCG - GPN	
Unit	DKK2013/GJ	øre2013/Nm^3	DKK2013/GJ	øre2013/Nm^3
Average hub price difference	1.3	5.6	0.9	3.7

The pricing formula for spot indexed contracts directly includes the calculation add-on between the relevant spot price and the consumers' price before distribution charges. For the contracts indexed to spot markets abroad, the cost and risk of transport to the Danish trading hub is also included, and the hub-

price spread for these contracts is therefore deducted to make the calculation add-ons comparable. Based on the available sample of contracts, the sales margin is 0.8 DKK 2013/GJ, which is assumed to stay constant in real terms.

Households are also benefiting from the increased transparency and competition both in terms of wholesale and retail margins. As previously mentioned, households are now predominantly exposed to the spot market, which has led to increased transparency. The Danish Energy Regulatory Authority benchmarks the retail prices of households each quarter and compare these to the spot market price and Gas Point Nordic. There is evidence of both increased consistency between prices, and declining retail margins, as shown on Figure 21.

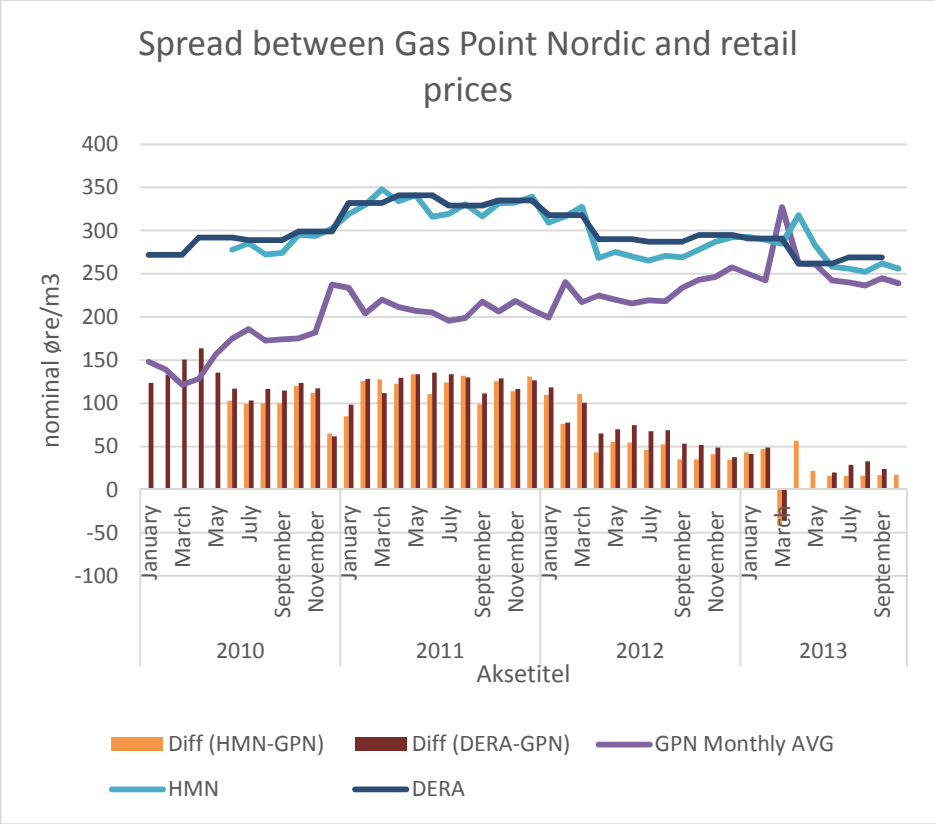

Figure 21: The Danish Energy Regulatory Authorities quarterly household gas price benchmark, as well as one company's (HMN) 'Supplier-of-last-resort' price (until March of 2013 where a standard spot indexed price is provided). These are compared with the Gas Point Nordic spot price. The household prices include the cost of exit from transmission system, but exclude distribution tariffs.

There is consistency between the household prices offered by the sample company (HMN), and the national benchmarking published by the Danish Energy Regulation Authority (DERA), and consequentially consistency in the price spread. Given the structural changes in the retail gas markets, an average of 2013 and 2012 is selected to provide the best proxy for retail margins going forward. The DERA spread is used as this reflects an average for the

whole country, but as mentioned previously, the difference is not significant. The spot to retail consumer spread is therefore assessed to be 47 øre/Nm^3 (12 DKK/GJ). However, this includes the transmission exit charge, which is previously calculated. The retail sales margin alone therefore amounts to 10 DKK/GJ.

Box 5: Current status of the 'supplier-of-last-resort' provision

> Via tender, Naturgas Fyn won the role of 'supplier-of-last-resort' in all of Denmark from May of 2013. NGFs' winning bid was a mark-up of 8.9 øre/Nm^3 in their own distribution area, and 9.7 øre/Nm^3 in the rest of the country. This mark-up is on top of the TTF price. The winning tender does not, however, imply that all consumers previously on the 'supplier-of-last-resort' tariff are now customers at NFG. Most stay with their current retailer who has been restricted from raising the margin on their current supply contract. Therefore, while the supplier-of-last-resort has historically been the dominating type of supply, this changed as of 2013.

3.2 Summary of natural gas add-ons

The table below surmises the calculation add-ons to natural gas prices in relation to a European gas price based on IEA statistics and projections.

Table 9: Summary of calculation add-ons for natural gas prices in relation to a European gas price based on IEA statistics and projections

Add-ons to the IEA gas price (DKK 2013/GJ)		Spread IEA-GPN	Transmission, emergency supply	Distribution	Sales margin	Total add-on
Power plant	Consumer prices	-3.3	1.5	-		**-1,8**
	Economic prices		0.9			**-2.2**
Local DH plant	Consumer prices		1.5	4.5	0.8	**3.5**
	Economic prices		0.9	0.5	0.8	**-1.1**
Household	Consumer prices		1.5	18.2	10	**26.4**
	Economic prices		1.0	1.8	10	**9.5**

The total calculation add-ons to the European natural gas prices based on the IEA price reflect the fact that hub-based prices now used as a reference wholesale market price in Denmark have over a 5-year period on average between lower than the IEA-based prices. Additionally, distribution and transmission tariffs have been lowered because of a greater proportion of assets being depreciated. Increased competition and transparency appears to have eroded sales margins. All told, the total add-ons to the natural gas price have been reduced in the present update.

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