

Topwaste economic data documentation

Background

The purpose has been to find data for use in Kiss, Optiwaste and Balmorel etc. The main challenge has been to disaggregate so taxes, energy use, investments and financing cost, running costs are specified – all related to one ton of input.

Thanks to the Municipal Waste organization I Odense and RenoNord in Aalborg for sharing your information with Topwaste.

Limitation

General Data sources and project partners – only economy data presented – other data will be collected from EcoInvent 3. The data represents 2009 prices, and there is a suggestion about how to estimate material prices in future scenarios.

Taxes and subsidies

In all socioeconomic calculations all taxes should be left out, which in general is done. Subsidies also should be excluded, but we found none relevant (maybe relevant for biogas production?) In general this is done by specifying the taxes.

Interest rate

In this data collection the interest rate is set to zero – expected lifetime is specified and production divided by ton of output in lifetime, which makes it possible to apply financing costs in socioeconomic calculations.

Now and future

The collected data presents price level for 2009 in Danish kroner. The used pricing index is shown in figure 4 (in chapter with material prices).

For future prices of materials, we simply relate material prices directly to energy prices (by using the energy pricing index for all materials). The reason we chose this approach instead of relating to a general pricing index, is that for many materials the main cost in production is related to energy use – either in the mining phase or during the extraction phase. In the chapter with material prices there are shown some examples how the energy prices relate to material prices. Since the energy price is used in the project for several purposes this is chosen as an indicator for future material price development as well.

Datasets in this report

- Collection and transportation
- Recycling centers
- Incineration and slag treatment
- Avoided material costs by recycling

Collection and transportation

Mixed waste and paper in Odense and expected cost for separate bio waste collection.

Data are from the municipal waste company in Odense, who has provides us very detailed data, since this is considered as public data in opposition to many other municipalities, where the collections is run by private companies.

In Odense every household has a bin for mixed waste that is emptied every second week. For those who want there is also offered a separate collection of paper. The payment is based on the size of the container for mixed waste, which gives an incentive to sort paper out, since the paper bin is emptied for free. Multiple family houses are offered similar collections, even thou some are based on common bins in the backyard. Beside of this access is offered to several recycling centres which is included in the basic fee.

There are made plans for future separate collection of bio-waste, and the offset for the calculations has been that the bio fraction from single family houses is collected every second week, and for multiple family houses as needed. This means that the cost of collection will increase, for single family houses the cost will be around twice as high per collected ton of waste, for multiple family houses the increase is estimated to be 25%, due to other collection routines. First of all there is need for one extra waste bin for bio waste, so instead of one mixed bin there will both a bin for sorted bio waste and one for mixed residues. How often these needs to be emptied depends not solely on how filled they are, but also on the acceptance of smell from the bins. Our assumption is that there will be need for more collection of bins. Since the amount of waste will be the same, the cost per collected ton will have to increase.

The data from the municipality waste service in Odense are based on a very detailed data material from 2012. Each of the 18 trucks for collection of mixed waste and 5 for collection of paper were reported at a detailed level, showing the actual driven km, amount of collected waste and specific costs divided in diesel, investments, running costs and salary. Beside of this there is added an administration cost covering only the collection department. The waste is delivered inside Odense, so no additional hauling cost is included.

As described in the introduction all taxes and financing cost are excluded of the data sets, but are available in background material if needed for other purposes than Topwaste. All prices are regulated with price index to 2009 level. We have made an effort to compare the collected data to other more aggregated data sources, as the benchmark (MST 2011) and other municipalities on Funen to the extent it has been possible.

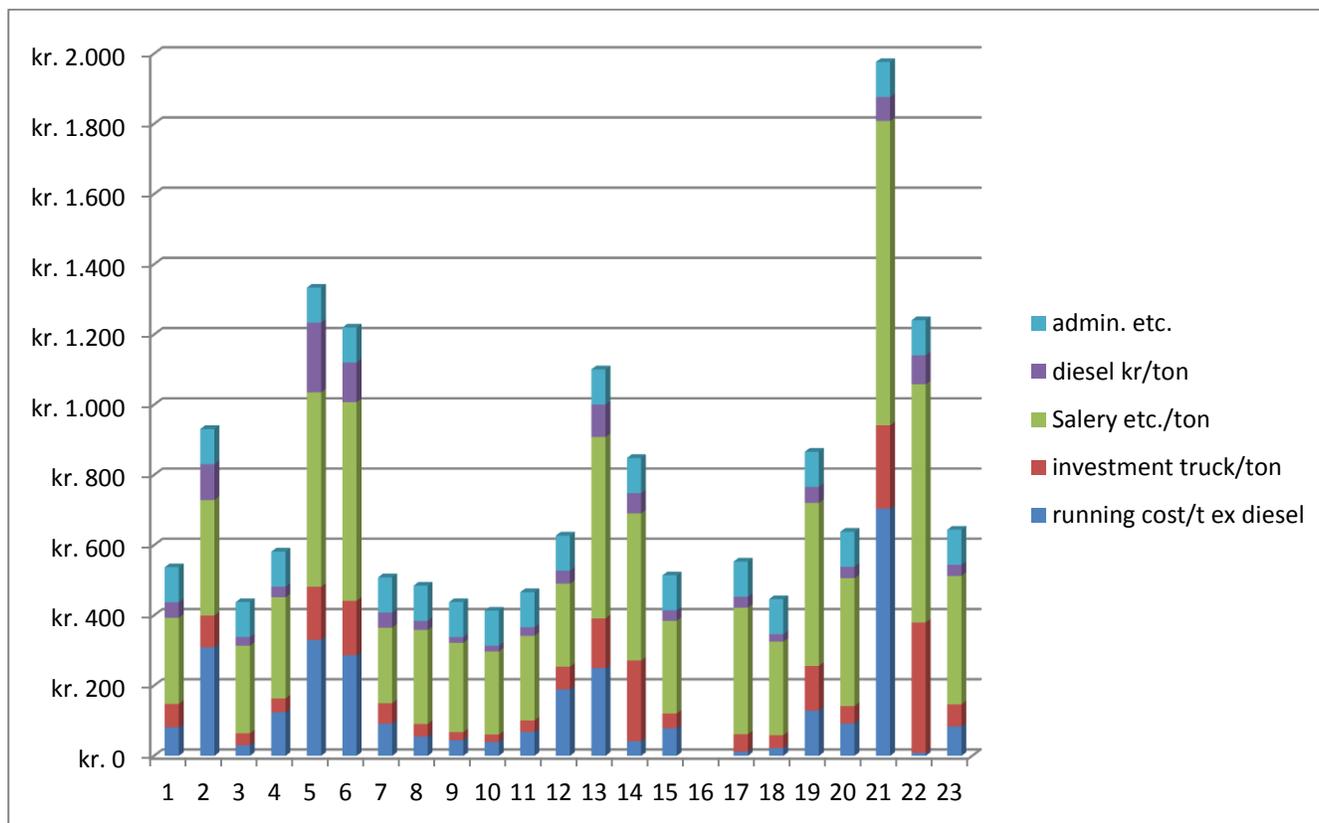


Figure 1 shows the cost (DKr) in 2012 for each municipal waste collection truck in Odense. Dataset numbered 1-14 represent each truck collecting mixed waste in Odense, both in individual houses and multifamily houses. Dataset number 15 represents the weighted average for mixed waste collection. Dataset from 17-22 represents each truck used for paper collection in both in individual houses and multifamily houses. Dataset number 23 shows the weighted average for separate paper collection.

The datasets for 2012 are indexed to 2009 level by use of a price index factor of 0.9425 when presented in table 1. The data are provided by the Municipal Waste treatment in Odense with details for every truck, which has made it possible to aggregate to the needs in Topwaste. The differences between the trucks are caused by several reasons where the most important is the density of houses in the area and the annual use of the truck – the more dense the lower cost per ton, but this tendency can be overruled by a low utilization rate of a truck. The more detailed information about collection in different areas is not presented except for considerations for future separate collections of bio-waste mentioned above.

The use of other collection systems as users bringing their waste to more central places as street places container, is already used for collection of recyclables in many areas. But in some cities as Aarhus this has the recent years been expanded to include collection of mixed waste. The main benefit of this is the cost of collection, which typically can be reduced by more than 50%, due to ease of emptying the containers by truck,

only needing one operator. In multifamily housing areas similar systems are used in many cities. Due to the cost reducing's such systems will probably be more commonly used I future.

| | | Today's collection only mixed and paper | | Scenario with bio-waste collection – paper can be added as in base scenario for today since this in not changed. | | | |
|----------------------------------------------------------------------------|--------------|-----------------------------------------|-------|------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------|--------------------------------------|
| | | single and multifamily | | single family 2 times increase in cost | | Multi family 1,25 times increase in cost | |
| Prices for collection of waste – 2009 level For one ton of waste | | paper | Mix | mix no bio | Bio | mix no bio | bio |
| Lifetime for investment cost | years | 7 | 7 | 7 | 7 | 7 | 7 |
| Investment cost (2009) (no interest and full load) | DKK/(ton*km) | 7.82 | 7.10 | 14.2 | 15.64 | 8.88 | 9.78 |
| Running cost (2009) (no energy - no taxes) | DKK/(ton*km) | 68.60 | 76.98 | 153.96 | 137.20 | 96.23 | 85.75 |
| Transportation distance per ton of waste | Km per ton | 7.55 | 5.57 | 5.57 | 7.55 | 5.57 (80% as mixed waste) | 7.55 (20% collected as bio) |
| Diesel use | MJ/(ton*km) | 2.99 | 5.15 | 5.15 | 2.99 | 5.15 | 2.99 |

Table 1 shows the aggregated numbers from figure 1, recalculated to 2009 price level in the first columns representing the cost level today with separate collection of paper waste and mixed waste. For the scenarios introducing separate collection of bio-waste, it has been assumed the cost will double per ton for single family houses, since the amount of waste is the same, but collected more often. In multifamily houses the increase is assumed to be only 25% since the collection of waste bins is done in bins covering more households, and only will be collected if needed. These assumptions goes for both investment and running costs, since both more bins, trucks, diesel and personal will be needed. The assumed collection rate of bio-waste is 20% of the total mixed waste produced, which represent about 2/3 of the bio-fraction in the produced mixed waste. If this increased the distribution of the cost for collection of the bio-fraction and mixed residues might change, but will not change the total collection costs significantly.

For the todays scenario there has not been done any differentiation between single and multifamily houses and the figures represents an average. If an average is wanted, the figures can be weighted to represent the relevant shares of the two types of households. In Denmark as average the individual houses represents 67%.

The calculations of waste collection per ton are shown here because they are needed for the Kiss tool, but in fact the calculation per ton is a quite unusual way. Usually waste management tenders are done by collected unit – number of bins and number of annual collections. In this way the cost is related to the work, which makes more sense since the amount of waste is the same regardless how it is collected. If the same amount of is collected more often I more bins the cost per ton tends to increase accordingly, unless co-collection of fractions are possible.

Transportation cost, long distance

| Cost of long haul transportation, 2009 price level | | 15-20 ton trucks | >30 ton trucks |
|----------------------------------------------------|--------------|------------------|----------------|
| Investment costs | DKK/(ton*km) | 0.12 | 0.06 |
| Running cost | DKK/(ton*km) | 1.18 | 0.59 |
| Diesel consumption | MJ/(ton*km) | 3 - (4) | 1,5 – (2) |
| Cost of diesel no taxes (7 DKK/litre diesel) | DKK | 0.48 | 0.24 |

Table 2 shows data for transportation are calculated as costs in Denmark in 2009, based on the investment cost in a >30 ton and 15-20 ton truck. The cost is based on salary at Danish levels and diesel at 7 DKK per litre without VAT and some diesel taxes. Production cost of diesel without all energy taxes is almost half, which should be used in socio economic calculations.

The energy use per tonkm is found in the EcoInvent3 database, for transportation for >32 ton trucks and 15-20 ton meeting the EUROCLASS 5 standards. The data are changed from kg of fuel from litre of fuel.

The EcoInvent 3 datasets used for diesel consumption ads about 2 times the actual transportation distance to include return drive and trucks that are not fully loaded. The numbers in brackets shows the energy use based on average load according to EcoInvent 3. If it is relevant to use transportation data for waste, assuming not fully loaded, the figures for investment, running costs and cost of diesel also should be increased accordingly.

Long haul transportation of waste does only pay of if trucks are fully loaded, why we assume this usually is the relevant case. So the calculation includes same distance for empty return drive (not double as in EcoInvent 3) and these data are used for the base line scenario for our calculations in Topwaste.

If long distance transportation takes place outside Denmark, the cost is much lower – in fact the running costs could be about half per tonkm, since the main part is salaries, which for example in Poland and Germany is much lower.

Cost of recycling centers

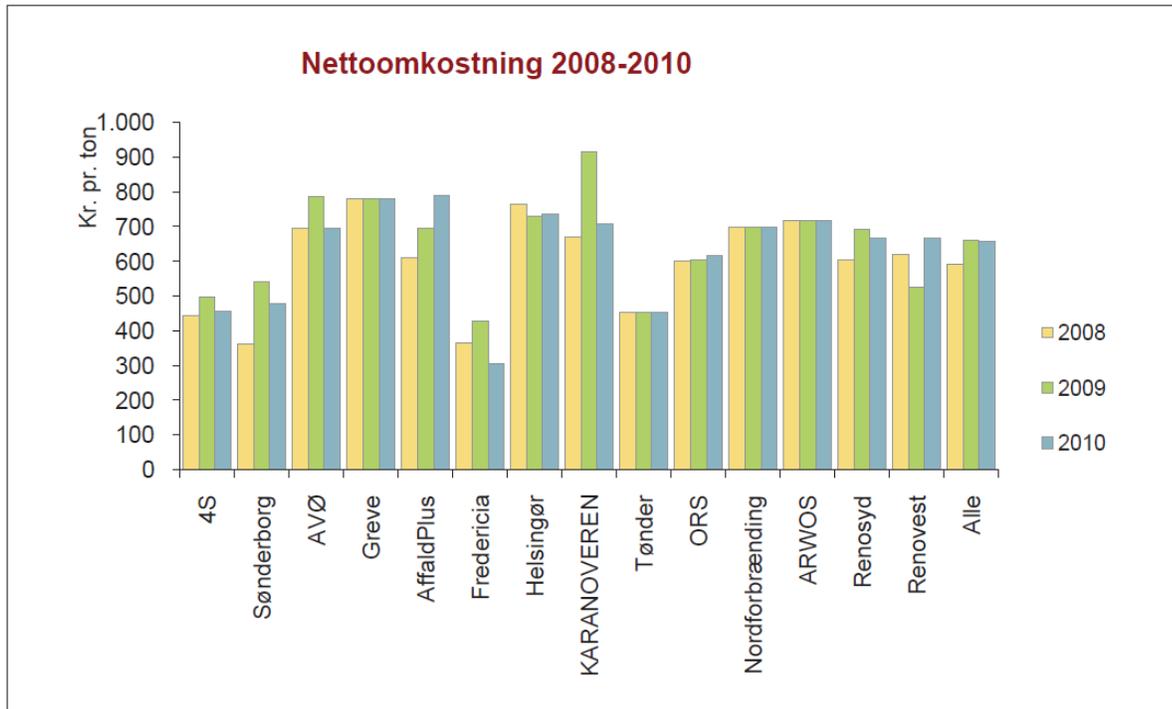


Figure 2 shows the cost per ton of waste and recycling materials collected at municipal recycling centers in 2008-2008. For Odense renovation system (ORS) the total was 604 DKr in 2009 and 616 DKr in 2010 including sale and discharge of materials including waste taxes, but no VAT.

Based on more detailed information about distribution of costs on different waste categories (from 2011), the cost for discharge for incineration and landfill was 278 DKr including taxes. The taxes included was 56 DKr per ton as average for all waste handled at the recycling center, which is based on 475 DKr per ton for landfilling and 150 DKr per ton for incineration. The revenue by sale of recycling materials – mainly paper/cardboard and metal, was calculated as an average of 97 DKr per ton of waste handled at the recycling centers. This means that the net cost for waste discharge collected at recycling centers in Odense in 2009 in average was $(278-97-56)=125$ DKr excluding waste taxes, and the cost for handling was about $604-56-125=423$ DKK per ton without discharge of materials.

Since this is based on information from 2009-2011 from Odense, no attempt has been done to adjust to price development, and the can be used to represent 2009 as used in Topwaste. A share of these costs used for electricity for compacters and transportation using diesel, but is has not been possible to isolate this from the total due to lack of information.

Cost of waste incineration

The data delivered by RenoNord has been aggregated to fit the needs for use in Topwaste. The cost from 2012 was converted to 2009 pricing level and the total of 662 DKr per ton treated municipal waste was found excluding financial cost of 102 DKr per ton, (which is relatively high due to some relative expensive loans).

| DKr/ ton | |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 394/371 | Running cost per ton (no taxes) – (2012 price level/adjusted to 2009 level) |
| 271/291 | Capital investment per ton zero interest rate - 20 years lifetime, 98% utilization/286000 tons annually (2006 price level/adjusted to 2009 level) |
| 665/662 | Total treatment cost (DKr 2012/2009) total per ton MSW |
| 7,35 | GJ heat sold |
| 0,67 | MWh electricity sold |
| -0,12 | MWh electricity used |

Table 3: Cost, investment and efficiency for RenoNord, 2009

The income from energy sale (electricity and heat) was about 376 DKr per ton of waste. The total of taxes on waste treatment and energy sale is about 370 DKr per ton of waste.

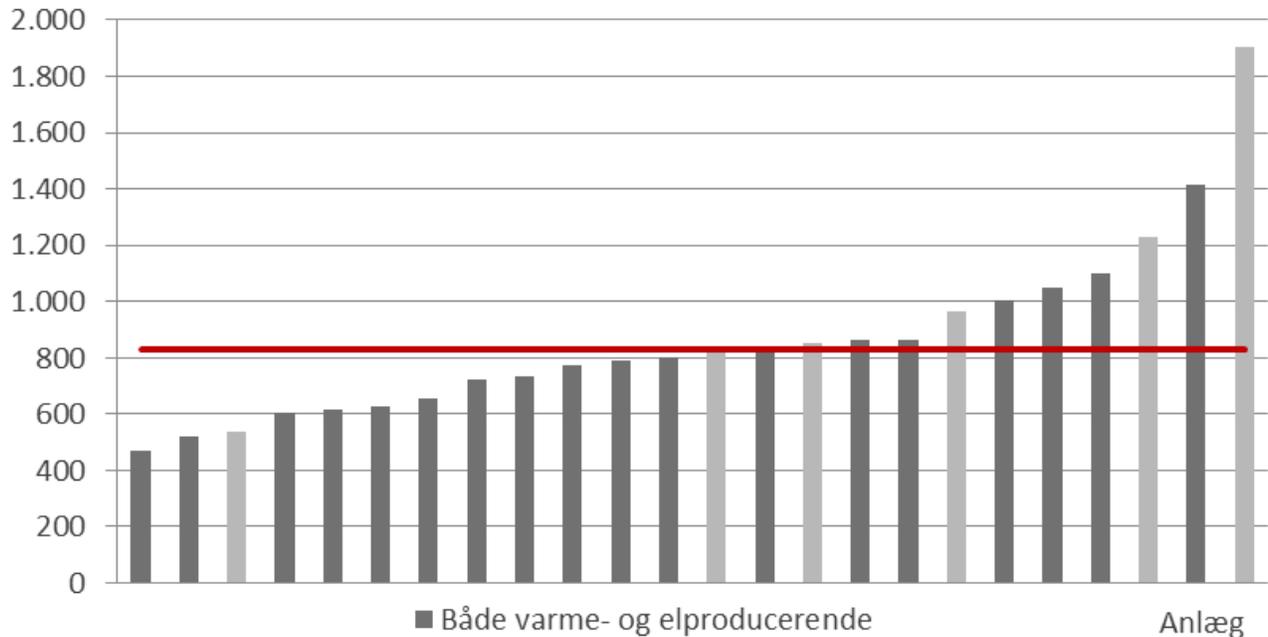


Figure 3 shows cost in DKr for waste incineration at all heat and electricity producing plants in 2011 inclusive financing but exclusive taxes and energy sale. RenoNord has a price level of 662 + 102 for financing (=763 DKr per ton 2009) which places RenoNord in little lower than the average for all incinerators in DK. (Miljøstyrelsen, 2012: BEATE "Benchmarking of affaldssektoren 2012, (data fra 2011), Forbrænding")

Slag recovery

The municipal waste system I Odense has treated slag from their own incinerator plant in cooperation with an external operator. This was done until 2012 where the operator took over the processing. Some data has been collected about the cost of operation. The recovery of metals was about 5% iron and 3% aluminum. The residue was cleaned to be used for road filling instead of landfilling.

The cost of the treatment in 2012 at the municipal waste deposit was about calculated to be between 50-80 DKr per ton including sale of metals, but the metal value was low due to the quality. The main reason for the processing was to avoid expensive landfilling of the slag, which would have been expensive.

Sale prices for recycled materials

The export prices for different *Paper& cardboard, glass, plastics, metals and fertilizers* are all calculated in the same way, by use of the export prices from Danish statistics.

Figure 5-9 shows that due to the economic turbulence in 2008/2009 the prices jumped up and down, and therefore we have decided to use the average for the following 5 years as a best estimate for a realistic price level for all materials in the project.

For the years 2010-2014 the prices are recalculated to 2009-level by use of standard price index (see Figure 4), and the average price per ton is calculated for the period. This average price is used to represent the price level in 2009.

For future prices it is suggested to use the energy pricing index. To illustrate the relevance of this choice the prices of diesel for professional use (including some taxes) is shown as an index in Figure 4, and as real prices in Figure 5 and 6 together with the price development for each material. It seems obvious there is a relation as stated in the first chapter of this document.

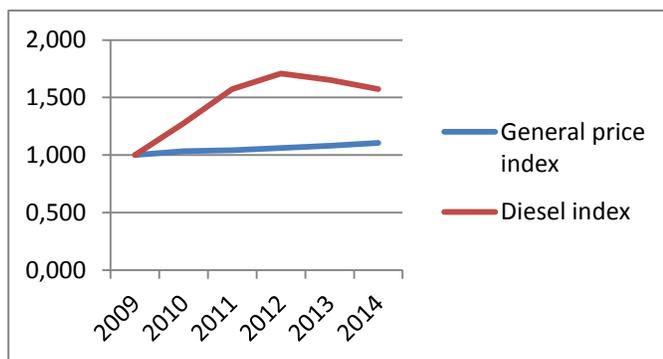


Figure 4, shows the General pricing index in Denmark for the period used and the Diesel index, for Agro Diesel which is about 7 DKr per liter including some taxes.

Paper& cardboard

The average prices found in this way for mixed paper and newspaper is 952 DKr. per ton and for cardboard 874 DKr per ton. Compared to the average sales prices obtained at the recycling center in Odense in 2010/11 which was for mixed paper 836 DKr/ton, newspaper 972 DKr/ton for and cardboard 864 DKr/ton, this seems quite reliable.

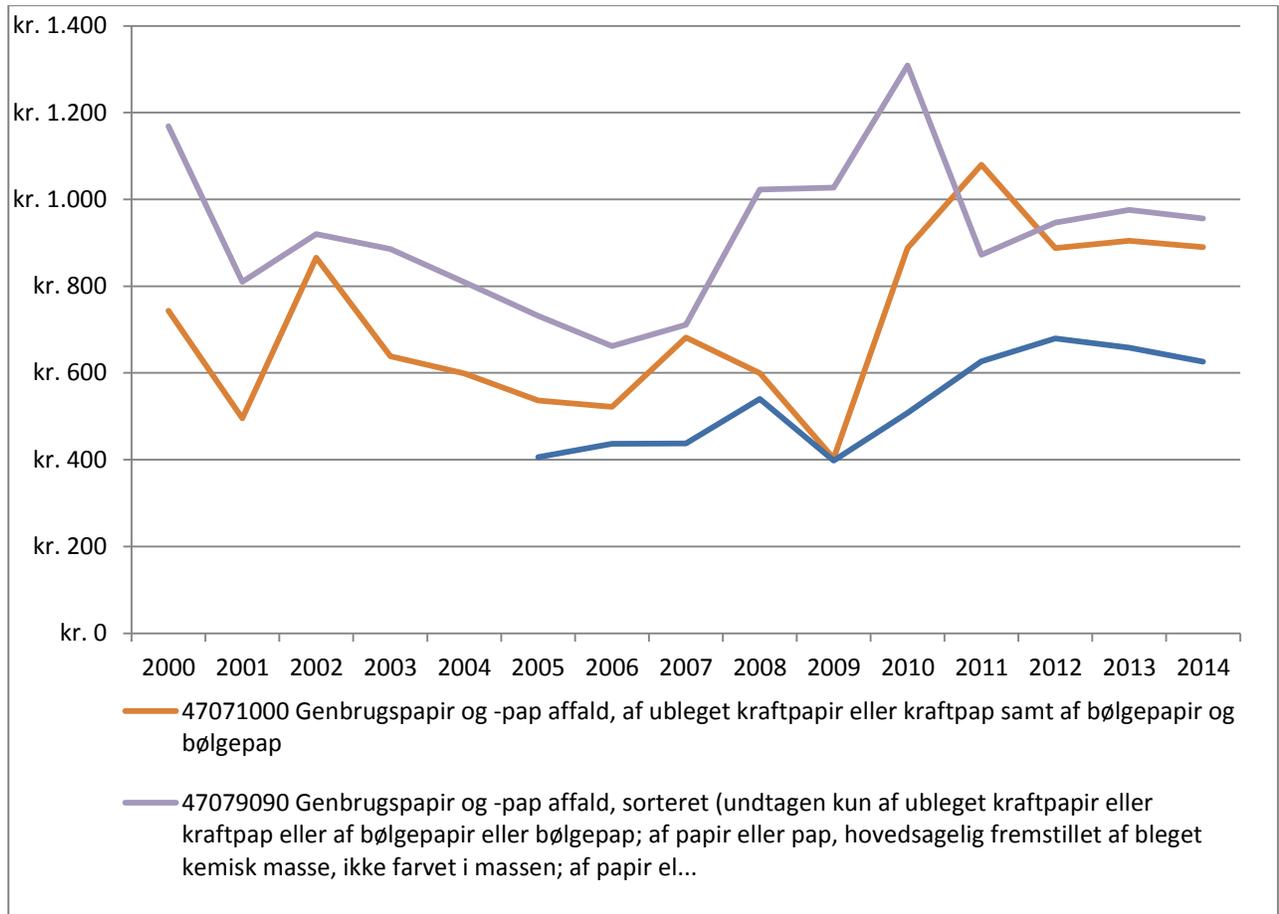


Figure 5 shows the development in Export prices for “47071000 – Cardboard” and “47079090 - Mixed paper and newspaper” from Danish national statistics (years 2009-2014) at www.dst.dk in the table “KN8M: Imports and exports CN (EU Combined Nomenclature) by imports and exports, commodities, country and unit”. The Blue is the diesel price (see text above)

Glass cullets

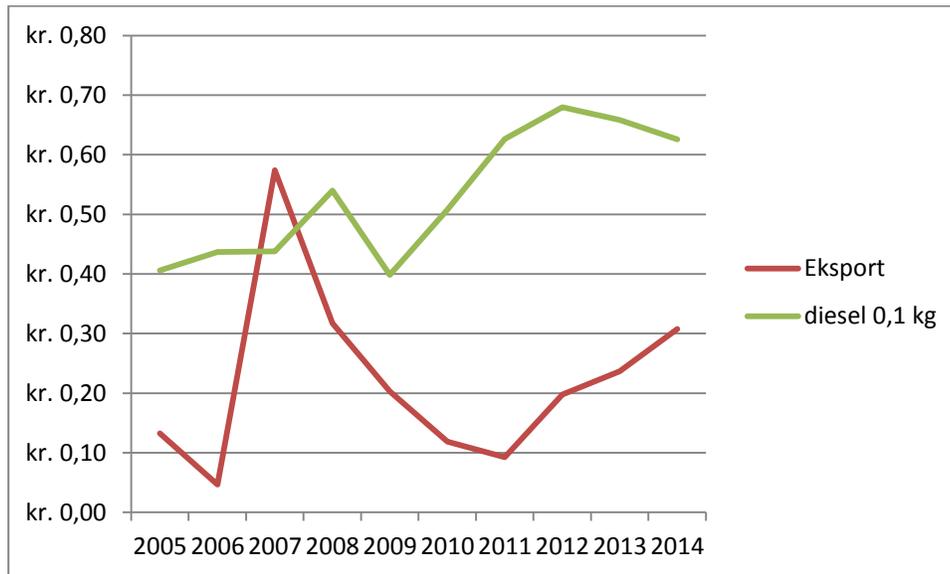


Figure 6 shows export prices for mixed glass cullets. To exemplify the close relation to energy prices diesel prices are shown also.

There are several categories of sorted glass. The cheapest is mixed color glass cullets. As shown in figure 6 the prices has dropped after the economic crises, but are increasing again the latest years, and the level of 180 DKr (unspecified colors) calculated as an average of 2010-2014 in price level 2009 might be too low, but the statistics for 2010/2012 matches fine with the pricing of 105 DKr that the municipal waste company in Odense has obtained.

Mixed secondary plastic

According to the statics, negative pricing for mixed secondary plastic started from 2010.

The Municipal waste system in Odense payed in 2010/11 about 1400 DKr per ton, to have this fraction transported and reused somewhere in Germany.

Other fractions as clean PE foil can represent a positive value, but is typically not collected at municipal waste systems. It is obvious that the negative pricing will not last in the future, especially when incineration cost about 400 DKr per ton (including taxes).

Mixed metal ("Municipal mixed metal") and aluminum

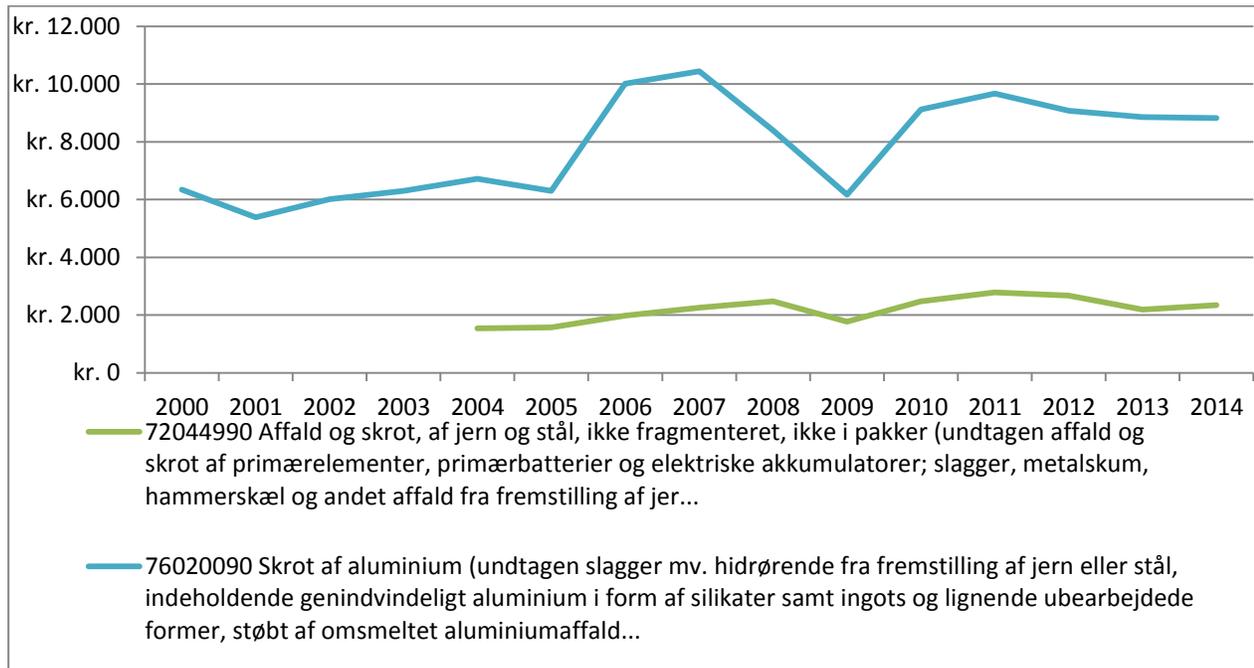


Figure 7 shows to categories for metal for recycling for DST. 7244990: Mixed iron and steel in 2009 values based on average of 2010-2014: 2345 DKr per ton.

The metals collected at the municipal recycling centers "kommunejern" is a mix of Iron, Steel, aluminum and other metals sorted by households at the recycling center. The pricing level is about lower due to the need for sorting, even if some of the metals represent a higher value. The municipality of Odense got about 1400 DKr per ton in 2010/11.

76020090: Mixed qualities of aluminum, has an average value of 8566 DKr. But mixed with other metals, maybe as iron can and Aluminum cans has a lower value due to the need for sorting and the lower price of iron.

Copper and Brass

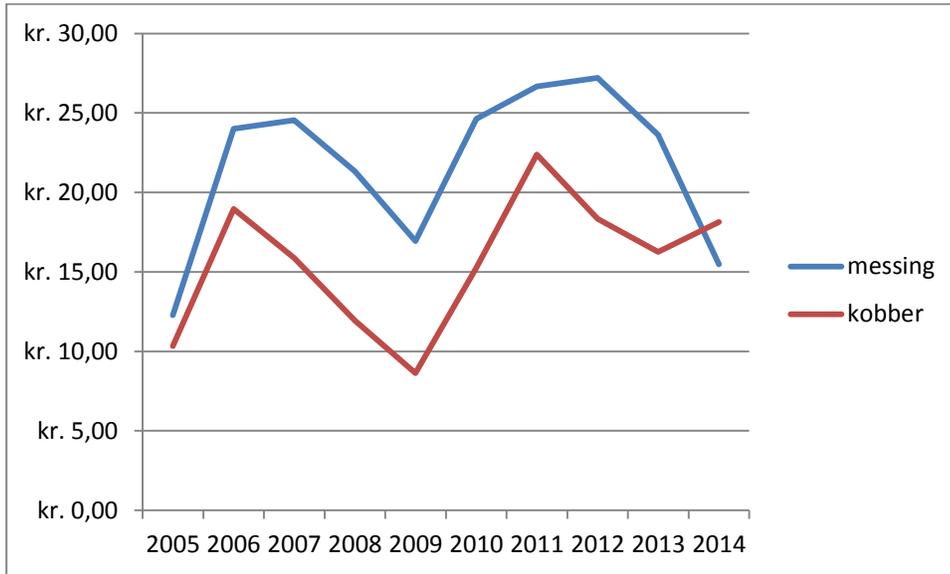


Figure 8 shows prices of copper and brass (alloy of zinc and copper) in DKr per kg. The calculated average for 2009 is 22.000 DKr per ton for brass and 17.000 DKr per ton copper.

At recycling centers these metals often represent a small fraction which most often ends up as mixed metals (see above).

Fertilizers

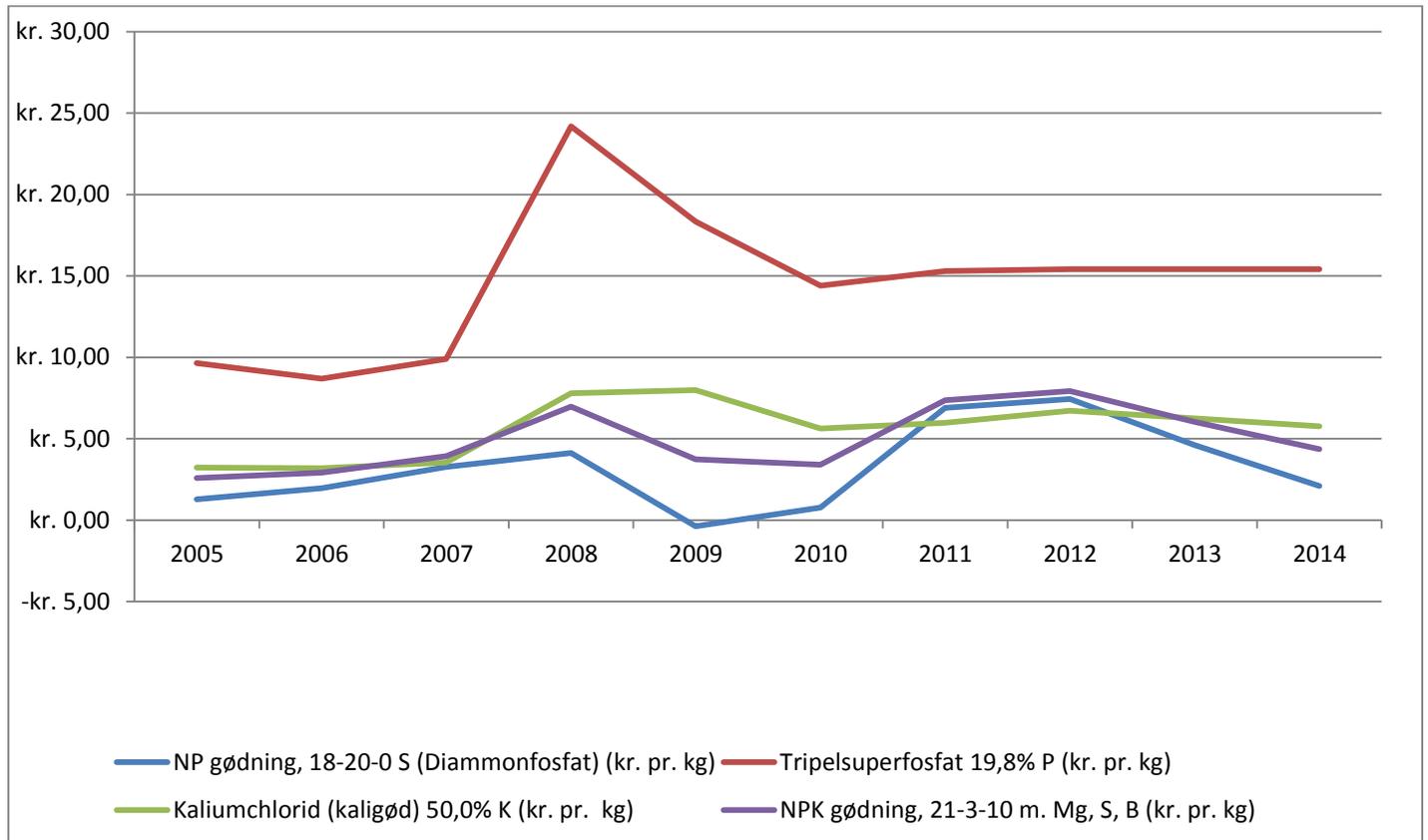


Figure 9. Import prices from Danish statistics: LPRIS35, Prices at agricultural input by product and unit. The average from 2010 – 2014 is calculated in 2009 price level without taxes. The prices for pure N, P and K are calculated based on the content of pure substances in the different mixtures found in the statistics. K and P was found from prices of these in fertilizer types containing only one substance in a given concentration, the N was calculated from NPK by subtracting the prices for K and P.

For a control the listing price for NPK fertilizers at DLG (Main Danish farm supplier) in 2012 was found to be at same level but added N-tax of 5.00 DKr per kg N.

4.11 DKr per kg N (excl. Taxes – 5 DKr per kg nitrogen)

14.25 DKr per kg P (phosphorous)

5.70 DKr per kg K (potassium)

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