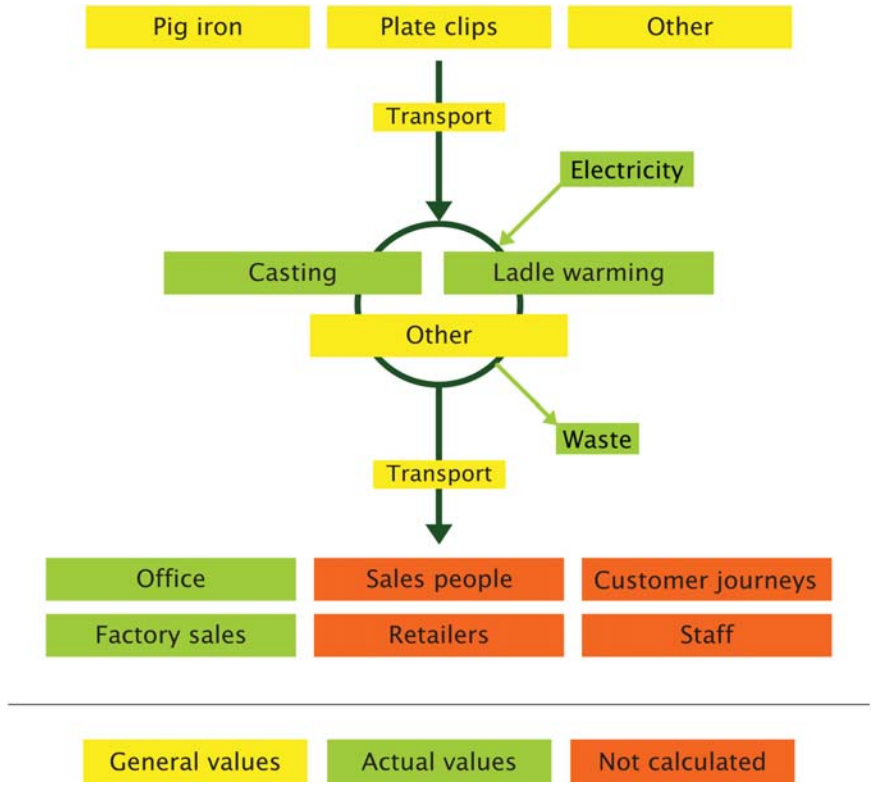
Measuring Carbon Dioxide.

Background:

Skeppshults Gjuteri AB, Skeppshult's Foundry, has carried out an investigation of the effects that products manufactured at Skeppshult's installation have on the environment. Focus has been placed on greenhouse gases, since the greenhouse effect is viewed as being the greatest threat to the environment today.

Below, there follows a short report on how Skeppshult's Foundry AB (below "foundry") has carried out its measurements. Emissions from greenhouse gases are indicated as grams of carbon dioxide equivalents per kilo of (foundry) goods. Carbon dioxide equivalents are a way of translating the effects of different gases on the climate to equivalent effects for carbon dioxide. A gas affecting the climate more per year will receive a higher figure and one which affects the climate less will receive a lower figure. For example, methane has a carbon dioxide equivalent of 21, that is, if a 1gram emission of methane corresponds to a 21 gram emission of carbon dioxide.

There follows an outline of different factors below which may affect emissions and an evaluation of safety within the different factors.



Raw Materials

Pig iron: the greatest raw material (weight wise) is pig iron. It has proven to be difficult to obtain figures from our supplier, and that is why we have used global median values. A modern sinter-based steelworks using haematite ore releases approximately 2 kg of CO2 per kilo of raw iron (pig iron, cast iron).[1] A pellet based steelworks, using magnetite ore only releases 0.35 kg of CO2 per kilo of raw iron. Our supplier may probably be found somewhere within this span. Of course, this makes a great difference to the end result. Since we have not received reliable information we expect the worst case possible scenario, that is, **2000 g/kg goods.**

Plate clippings: in order to obtain the correct alloy in cast-iron, a certain amount of plate clippings (that which is left over when other industries punch out pieces from sheeting) is mixed in. We had not included the effects from the production of the plates since we view that as recycling of an already finished product.

Other information: there are more raw materials but they are so small in scope that they have not been considered in this context, because their carbon dioxide equivalent is felt to be very small.

Transportation

Sand: Our moulds are made from pressed sand and the sand is used up to a certain extent. Thus new sand must continually be brought to the factory. The sand comes from Baskarp by Lake Vättern's southernmost end, that is, locally "produced". Distance-wise it is 109 km and we purchase 346 tonnes per year (2007), which translates into 37.714 tonnes per kilometre. From our conveyor, DSV, we have received information on carbon dioxide emissions from lorry transports, and they are 44 .65g/ton per kilometre.[2] This gives a total emission of one .683 .928 kg of carbon dioxide divided amongst the amount of goods (624.597 tonnes 2007), which means **2.7g per kg of goods.**

Other alloy compounds: Both the iron and sand for moulding is mixed with different alloy compounds in order to achieve the correct properties. It is not clear whether the alloy compounds emit carbon dioxide because there does not appear to be sufficient research in this area. However, emissions from transport can be measured. We purchase the main bulk of alloy compounds from Kernfest-Webac's installation in Hällekis which means a distance of 167 km.

The different alloy compounds from Hällekis are:

Ecosil S20	approx 93 ton/per year
Bentonite	approx 47 ton/per year
Calcined petroleum coke	approx 10 ton/per year
Total	*approx 150 ton/per year (from Hällekis)*

In addition, we purchase silicone carbide of approx 13 ton/per year from Carbomax in Västerås (333 km) and approximately 20.7 tons of Perlix, an agent for binding slag, from Giab in Halmstad (60 km).

The accumulated transportation of alloy compounds becomes 30.621 tonnes per kilometre. With the information from DSV this means 1.367 kg of carbon dioxide. Divided over the amount of goods (624.597 tonnes 2007) this amounts to **2.2g per kilogram of goods.**

The factory

Casting: The cast iron moulds (so-called buns) in the foundry consist of pressed sand which is mixed with among other things soot (coal). One must assume therefore that part of the coal is released as gases when the hot metal comes into contact with the sand in the buns. The foundry committee will be carrying out tests in the autumn of 2008 on how much gas is released at the moment of casting. Until these tests are completed one can only roughly estimate on the basis of information from Peter Nayström (the foundry committee, the environment and environmental technology section) that 30% of the soot will remain in movable parts. It is also assumed that all moving parts turn into methane at the point of casting.

Some of the methane burns off at the point of casting and we assume that half of the methane has time to burn off before the bun goes out and that the burning of the methane has the following reaction

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

That is, 1 mol of the methane gives rise to 1 mol of carbon dioxide. However, the molecular mass for carbon dioxide is 2.7 times greater, that is, 1g of burnt methane gives 2.7g of carbon dioxide.

The foundry purchased 93 tonnes of Ecosil S20 in 2007. Ecosil S20 consists of 80% soot → 74.4 tons soot → 22.32 tons of movable parts. In 2007 we delivered 624.597 tonnes of goods (household, sub-contracted and construction). This gives 35 .735g (22.32/624 .597) of methane per kilo per goods. If half of it burns up and the other half turns into methane this gives 17.87g of methane and 48.24g of carbon dioxide. Methane has a carbon dioxide equivalent of 21, that is, an emission of 1g corresponds to an emission of 21g of carbon dioxide.

The total carbon dioxide equivalent emissions at the point of casting then becomes

$$17.87 * 21 + 48.24 = \mathbf{423.46\ g/kg\ goods}$$

Ladle warming: Before the first casting the ladle is warmed up to avoid cooling the iron down too much. This is done with a gas oil burner, which is directed at the ladle. The gas oil

consists of up to 95% propane, and that is why calculations are made on propane C_3H_8. If we assume the occurrence of a complete burn-off, the reaction will be as follows:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

That is, 1 mol of propane gives rise to 3 mol of carbon dioxide. As the propane and carbon dioxide at the same mol weight, one can say that 1 gram of gas oil gives 3 grams of carbon dioxide when burning. In 2007, 800kg of gas oil were used, which ought to give, then, 2.400 kg of carbon dioxide. Calculated per kilo of goods (624.597 tonnes) this amounts to **3.84 g per kg.**

Electricity consumption in the factory: All electricity in the foundry comes from certified wind power electricity, meaning therefore that electricity consumption does not contribute to the greenhouse effect. **0 g per kg.**

Machinery: All machines run on electricity or air pressure. The compressors run on electricity, so that the air pressure machines indirectly run on electricity. For the carbon dioxide load see under electricity consumption above.

Office: The office does not contribute to the greenhouse effect as this electricity too comes from wind power, and therefore does not produce greenhouse gases.

Factory sales: Factory sales do not contribute to the greenhouse effect as this electricity too comes from wind power, and therefore does not produce greenhouse gases.

Waste: Waste is separated into three main groups: flammable, wood, unsorted, metal, paper and cardboard/corrugated cardboard. Flammable waste consists for the most part of packing material and other flammable items. Wood for the most part comes from disposable and damaged pallets. The rest comprises unsorted waste. One problem with the waste is that the containers of waste are not closed, which leads to some refuse from other containers ending up in our containers. That is why some of the refuse may be reclassified from flammable to unsorted, despite the fact that everything the foundry has thrown in there is flammable. The foundry will try to make the containers closed in order to reduce the amount of waste, and in part to improve sorting. It is estimated that the amount of waste could be reduced by approximately 50% if the containers were closed.

Altogether, the vehicle collected waste from the foundry 21 times in 2007. Each collection of waste meant a distance of 31.2 km. With these data and an estimated weight of 15 times each time, this means a carbon dioxide emission of (21 * 31.2 * 15 * 44.65) 438.82 kg. Divided on all goods (624.597 tonnes) this becomes **0.70 g per kg.**

After the Factory

Deliveries from the factory: Our freight company, DSV, published a transport report for 2007. Most of our household goods travel with DSV, but we have only received information from DSV and we suppose that DSV is representative of the other companies. DSV transport gives 85.6 tonnes of household goods. These transports gave rise to 2.555.53 kg (from lorries) + 444.93 kg (from ferries) = 3.000.46 kg. This gives us a median emission of (3 000.46 / 85600) **35 g per kg.**

Summary

The total carbon dioxide equivalent emissions are 2.000 + 2.7 + 2.2 + 423.46 + 3.84 + 0.70 + 35 = **2 468 g per kg** goods. This is from the raw material in the factory to the finished product in the store. Our most average frying pan (28 cm) weighs 2.7 kg and this gives 6.663 kg of carbon dioxide equivalent.

How reliable is this figure? Not completely reliable, but it does provide a good indication. Minor factors have been excluded, others are unreliable, some are unknown, due to lack of research in this area.

What do the figures say? Is 6.7 kg a lot? What needs to be included in the calculations is the lifespan of the products. Skeppshult provides a 25 year cast-iron guarantee. Thus emissions ought to be seen be viewed over a 25 year period.

An example: According to the Swedish Environmental Protection Agency Naturvårdsverket, the average Swedish citizen releases a 7.2 tonne of carbon dioxide equivalents per year.[3] Our cast iron products have 25 year cast-iron guarantees. A frying pan from Skeppshult then constitutes ((6.7/25)/7200) 0.0037% of the annual emission from the average Swedish citizen.

Another example: The average car (new cars 2007) released 181g of carbon dioxide equivalent per kilometre. The distance equivalent to one frying pan from Skeppshult becomes then 6.7 / 0.181 = 37 km, which corresponds to (37/25) 1.5 km per year. In other words, if you cycle 1.5 km per year you will have paid your debt in carbon dioxide for your frying pan.

Skeppshults Gjuteri AB (Skeppshult's Foundry AB)

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[1] From web site of LKAB http://www.lkab.com/?openform&id=30E2, annual report 2006, page 39 and others.
[2] The figures from report of DSV about our transports during 2007.
[3] From web site of Naturvårdsverket: http://www.naturvardsverket.se/sv/Klimat-i-forandring/Utslappsstatistik-och-klimatdata/Utslapp-av-vaxthusgaser-per-person-i-Sverige/