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Malmö and the urban energy challenge

Some considerations with inspiration from political ecology

Working paper, November 2009

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Photo: City of Malmö, malmo.se/sustainablecity (left)
Sabina Andrén (right)

Malmö and the urban energy challenge

Some considerations with inspiration from political ecology

Working paper based on a PhD course in political ecology, November 2009
Sabina Andrén, PhD candidate, Human Ecology Division, Lund University, Sweden

Key words

Energy, renewable, urban, sustainable development, socio-ecological system, human ecology and political ecology

Abstract

This paper elaborates on one of the big urban sustainability challenges: energy. A brief overview of the global context is given and then I turn to a case study of the contemporary energy system of the city of Malmö in Southern Sweden. In the light of the global energy challenge and with special attention to global warming, cities and regions are now making efforts to promote fossil-free, efficient and long-term sustainable energy solutions. The City of Malmö is in the process of adopting an ambitious energy goal aiming at a system completely run on renewable energy by 2030. Given that the contemporary energy system is to at least 2/3 dependent on non-renewable sources, I will highlight some of the main challenges to realize this long-term goal. The discussion in this paper will be inspired by the perspective of political ecology.

I. The energy challenge

The fossil-fuelled economy will come to an end, sooner or later but for sure. First, because the fossil energy sources are non-renewable and thus *quantitatively* finite. Second, and as important, because the *qualitative* aspects of a fossil-based economy are so detrimental to the global ecological systems – of which we are ultimately dependent – including to the social and economic dimensions of a sustainable development.¹ The global energy supply of today is based largely on fossil energy sources (around 80%), that is on oil, coal and fossil gas (IEA 2009). And a majority of the emitted greenhouse gases – around 80% in the EU for example – have its origin in the energy sector including transports (City of Malmö 2009a: 14).

This fossil-dependent energy system has a whole range of negative consequences to environment, health and to the economy, among which global warming arguably is the most pressing issue. According to the latest IPCC-estimates, the average global temperature is likely to rise a further 2-6°C in this century, the lower as well as the higher estimates negatively affecting socio-ecological systems at all levels (IPCC 2007). An increase in global temperature will have severe consequences such as sea level rises, changed precipitation patterns, a continued retreat of glaciers, permafrost and sea ice, expansion of deserts,

¹ The concept of sustainable development is used in this paper even though I am aware of that it is a contested and criticised one (cf. Krueger and Gibbs 2007). Especially problematic from the view of human ecology is the division of reality into three ‘dimensions’ (ecological, economic, social), which often results in a tendency to separate rather than to integrate. From a human ecological perspective, this categorising of reality should rather be seen as an example of the limits of the contemporary discourse to really grasp the fundamental *interdependence* of any socio-ecological system on our planet. Another critique concerns the lack of awareness of power dimensions, conflicting interests and inequality in the discourse. Rather than a neutral and consensus-driven process involving all stakeholders, we should expect that the quest for sustainability is highly embedded in existing power relations (e.g. Hornborg 2006). I however still chose to use the concept in my writings as I want to engage in the contemporary debate in a critical discussion of modern society, including the elaboration of *what* a sustainable development actually might be.

increases in the intensity of extreme weather events, species extinctions, and changes in agricultural yields. Even though the exact range and feature of these consequences can not be fully known, it is evident that global warming is threatening the socio-ecological systems at their fundamentals. In the worst-case 2100 scenario discussed by Schneider (2009), with a tripled atmospheric CO₂ level of 1000 ppm and global temperature rises of perhaps 7°C, the global ecosystems including our own civilization are put at stake as we know them.²

Much political and public debate is now committed to how to transform the contemporary energy system – including how to mitigate greenhouse gas emissions and adapt to climate change. As we will see, these issues are high on the agenda in Malmö too, and certainly very relevant considering its continued fossil-dependence and, also, its location at the coast line of the sea. The reasons for Malmö, and other local communities, to promote a phasing out of fossil energy are thus several, e.g. to:

- Lower the costs
- Improve local environmental quality and contribute to solve global problems
- Mitigate greenhouse gas emissions and adapt to climate change
- Increase local self-reliance and energy security
- Take responsibility for creating an energy system that is more fair and sustainable in a global and long-term perspective.

To put it short: the contemporary energy system is *not* sustainable, neither from an ecological, nor from a social or an economic point of view. To transform the contemporary fossil-based economy is therefore a key to anything that might possibly be more ‘sustainable’. Important to say, however, is that the ‘alternative’ energy sources called for have negative socio-ecological effects as well. For example, bio-fuels may not be that innocent concerning CO₂ emissions when seen in a broader life-cycle perspective (cf. Fargione et al. 2008). They are further criticised for having very negative effects of other kinds, such as heavy landscape exploitation, often in the South, including loss of bio-diversity. One main argument in the thesis to come will therefore be that any sensible ‘sustainability’ transformation necessarily must include a *quantitative* reduction in total energy use. This argument will not always be explicit in the following inquiry, but should be seen as an underlying premise.

What I will here call the ‘energy challenge’ touches upon all aspects of contemporary society – and will inevitably highlight some core issues surrounding the idea of a ‘sustainable development’. What would a global carbon-neutral economy look like?³ How can we envisage such huge transformation given the highly fossil-dependent socio-ecological institutions of today? What about the local and concrete scale: what possibilities and obstacles are there for a locally promoted transition to a fossil-free energy system in for examples cities and regions? Even at a first glance one is struck by the seemingly extreme difficulties. But, on the other hand: what alternatives do we have? To me, there seems to be no escape but we are already in the midst of it happening.

² This 1000 ppm CO₂ level should be compared with today’s level of around 380 ppm (2005) and a pre-industrial level of 280 ppm (IPCC 2007: 37).

³ As discussed by Lennart Olsson (lecture 091008) the contemporary system is a net-contributor of carbon dioxide to the atmosphere (*carbon-positive*), while a *carbon-neutral* economy would have reached a balance between emissions and uptakes. However, what we might need in a foreseeable future is actually a *carbon-negative* economy which systematically decreases the level of atmospheric greenhouse gases.

II. The context of the paper

This paper will discuss the local and contemporary energy system of the city of Malmö with the global energy challenge in mind. The perspective of political ecology will be used as an inspiration for the discussion and as a source for opening up some critical issues for further studies. Malmö is a small/middle-sized city with around 300 000 inhabitants placed in the Oresund region of Southern Sweden. For an overview of Malmö in the context of this research project a field presentation is available (Andrén 2009a). The paper is written as part of a PhD-project with the working title *Urban sustainable development – Case study Malmö*. The general purpose of the research project is to study the premises for urban sustainable development in the context of (relatively) affluent economies in Europe or, more generally, in the North.

A point of departure is the tension that is revealed in adopting a place-based versus a system-based approach on urban sustainable development (Andrén 2009b). As has been shown, Malmö has made some progress when ecological sustainability is viewed as a local and place-based issue.⁴ Pollutants to air, water and soil have in many cases decreased shaping a cleaner and healthier local environment, even though many problems also remain unsolved. However, along with these place-based improvements, Malmö as well as other modern European cities shows a continued high – and by many judged as unsustainable – ecological footprint resulting from the citizen's consumption and life styles (cf. Global footprint network 2009). This means that the socio-ecological effects from total resource use in Malmö, including energy consumption, is still high but now dispersed in a global network of production, trade and consumption.

I have specifically chosen the energy system⁵ of Malmö as case study in my PhD work, as it fits well with the ambition of contrasting the local (place-based) and the global (system-based) sustainability challenges. Further, energy issues are central to contemporary policymaking on urban sustainable development and the tension between discourse and reality⁶ – as pointed at in earlier work (Andrén 2009b) – will constitute another focus in the thesis. The energy system of Malmö will thus be scrutinized in relation to the global sustainability challenges as well as the contemporary local policy goals. The investigation will include questions like: How much energy is consumed in Malmö and what energy sources are dominant? Who are the main users in Malmö and for what purposes? Who are the agents in control of the energy system? To what extent is the city's energy system founded on renewable or non-renewable energy? That is, how far from, or close to, a fossil-free energy system is actually a city like Malmö and what prospects are there of phasing out fossil fuels?

⁴ This picture will become another if one instead focus certain social issues in Malmö such as education, gender and segregation. However, in my thesis I will choose to focus on the *socio-ecological* aspects of urban sustainable development that has to do with the interconnections between global/local energy- and material flows and sustainability policies.

⁵ By the term 'energy system' I will mean the total primary supply of energy into the Malmö municipality, including the different energy types, as well as the total consumption of energy for different uses.

⁶ The word 'reality' will here be used neither in a strictly *objectivistic* sense (independent and given reality) nor in a totally *constructivist* (reality as a social construct), but rather as a mediating concept on what different indicators (bio-physical measures on for example CO₂-emissions or socio-ecological indicators such as the ecological footprints) help us to reveal about socio-ecological interactions. While these indicators are of course in themselves socially constructed they are still useful to guide us in understanding the interaction between the 'real' biophysical processes and socially 'constructed' ones.

Further, what are the socio-ecological effects we may expect if the City actually succeeds in a phasing out of fossil fuels? As the City is in the process of adopting a new Environmental program, including an Energy strategy, I see this work as an excellent opportunity to raise some critical issues concerning the energy challenge of Malmö. In the strategy, which is now discussed by the local politicians in a preliminary version, ambitious goals are presented with the ultimate vision of a totally fossil-free energy system by 2030 (City of Malmö 2009a: 24):⁷

The long-term vision for Malmö (year 2030) is for the energy system to consist of only renewable energy sources and be characterized by an effective and safe energy use which contributes to the long-term sustainability of the city. In order to take important steps towards this vision, by the year 2020 the energy use should have [decreased] by at least 20 % per capita compared to the average annual use during the period of 2001 to 2005. The share of renewable energy should be at least 50 % of the total energy use. For Malmö municipality's own operation, more ambitious goals have been set as a part of the public sector's strive to serve as a role model and positive example to others. The energy use in the municipality's departments and companies should during the same period have decreased by 50 % and consist of 100 % renewable energy.

My work is done in the interdisciplinary field of human ecology and will take advantage of a mix of quantitative and qualitative research methods (Andrén 2008a). A body of quantitative research results will act as a framework for engaging with different actors and stakeholders connected to the energy system of Malmö. The field study will mainly rely on a qualitative approach and will be inspired by participatory and action-oriented methods. Overall, my ambition is to transcend the role of the 'traditional' and disciplinary researcher making 'neutral' science. As has been earlier described (Andrén 2008b), I am in search of what can be called a *transdisciplinary* approach, by which I mean not to stay content only by bringing research forward but by actively taking part in an ongoing dialogue in different societal contexts. To me, the unsustainability of present society is not only a relevant research problem – but something that challenges me as a person on many levels: as a researcher, as a citizen, and as a human being. I simply find the global socio-ecological distress impossible to reconcile with staying detached. Rather, an important way forward for sustainable development research must be critical engagement in ongoing societal processes.

III. The political ecology perspective

Political ecology is an interdisciplinary research field with focus on how social relations and specifically power relations influence the use of ecosystems and environmental change. Traditional disciplines often have a tendency to concentrate either on the ecological/physical dimension (natural science) or on the social and institutional spheres (social science). Further, the acknowledgement of power dimensions and unequal social relations in the use of natural resources and in environmental change often seems to escape the discussion as such (science). While 'disciplinary' science thus tends to *separate* socio-ecological issues – 'ecology without politics and politics without ecology'⁸ – political ecology instead tries to *integrate* them. Ecology in this sense is seen as including both physical flows and social relations, and so is politics.

⁷ Please note that the Environmental program as well as the Energy strategy are still preliminary and are subject to political negotiation and decision making during this autumn (2009).

⁸ With inspiration from Lennart Olsson, lecture 091008.

Political ecology was first mentioned as a concept by Eric R. Wolf in the early 1970's (Wolf 1972). As in most new and interdisciplinary fields there are different sub-fields and choices of emphasis and scholars may have diverse backgrounds such as in anthropology, geography, human ecology, political science or political economy. Examples of works in the field of political ecology are Blaikie and Brookfield (1987), Peet and Watts (1996), Raymond and Bryant (1997), Keil et al. (1998), and Paulson and Gezon (2005). A recent overview of the field may be found in for example Paul Robbin's *Political Ecology: a critical introduction* (2004).

To apply political ecology in my context is to acknowledge that the global (and local) energy challenge is deeply embedded in a system of social relations which includes conflicting interests, inequalities, and the exercise of power (cf. Hornborg and Crumley 2007). To see this, we may only think of the uneven distribution of the burdens of global warming between rich and poor countries (Roberts and Parks 2007). 'Sustainable energy' in this sense is not only about physical and technical applications (which by the very definition of political ecology never *can* be isolated) but concerns as much culture, politics and economy. The fossil-based energy system of today is highly interwoven with the economic-political power relations of the modern world system. It should not be too controversial to argue that the contemporary fossil-fuelled capitalism is not only a *high-energy society* but a system with strong vested interests and power connections. The transformation to a fossil-free energy system will therefore be no easy, 'neutral' or consensus-driven process concerning only technological change and social engineering. There are definitely high stakes: which are the energy sources capable of substituting for fossil fuels and who is in control of them? Are they possible and profitable to develop on the 'free' market or do they demand political intervention and public investments? Further, what incentives are there for a total *reduction* in energy use, something that many have argued is necessary for an ecologically sustainable development. Is a low-energy society a realistic scenario and how will it be reconcilable with the logic of the present socio-economic system?

Alf Hornborg (2009) argues that we must be prepared to face that the contemporary fossil-based capitalism has been an exclusive and privileged *cheap-energy era*, at least for the core of the world system. In fact, the modern energy system is heavily reliant on unequal social relations in global terms of trade and is revealed in the huge gap in living conditions between the poorest and the richest nations of the world as well as in the extremely uneven distribution of environmental burdens. A future energy system that is disconnected from the acquisition of energy extracted from ecological production of the past (fossil energy), will likely have to be much more dependent on the capacity of the ecosystems of the present (renewable energy). According to Hornborg (ibid: 241), this highlights the very *political* ecology of energy:

The prospect of peaking oil extraction presently prompts us to rethink processes of development and decline in the world-system. Rather than simply revive Malthusian concerns over the dismal destiny of humankind as a whole, we need to approach the popular notion of 'cheap energy' as an experience situated in societal space as well as in historical time. Energy has been perceived as 'cheap' only within core segments of world society, whose ideology of progress and development has tended to construe contemporary global inequalities as representing different stages in time. Draught-animals and wood fuel are here often perceived as elements of the past, yet remain an everyday reality for significant parts of the world's population. Conversely, fossil-fuel technology is conceived as a 'now' rather than a 'here' /... / As we begin to anticipate its demise, we might reflect on the fact that the war in Iraq and global climate change are opposite sides of the same coin. The structural problem of fossil-fuelled capitalism is to maintain imports of energy (e.g. oil) and exports of entropy (material disorder, e.g. in the form of carbon dioxide), two imperatives of 'development' that are both increasingly difficult to sustain.

IV. The Malmö energy challenge

After this introduction it is time to move to the energy system of Malmö. As presented above, this working paper intends to give an overview of the local and contemporary energy issues with a specific focus on:

- The broad feature of the energy supply and the energy consumption of Malmö
- The share of renewable versus non-renewable energy in the system
- The main challenges when contrasting the contemporary system with the suggested goals in the Energy strategy of Malmö
- Opening up questions for further studies, specifically a field study planned for the next step of the research project.

In this context it is of course important to define what is meant by renewable and non-renewable energy.⁹ *Renewable energy* is derived from processes – with their origin ultimately in the incoming solar radiation or in heat generated within the earth – which are replenished constantly and in a relatively short-term perspective. Included in this category is also electricity and heat generated from solar, wind, ocean, and hydroelectric power, biomass, and geothermal resources, as well as bio-fuels and hydrogen derived from renewable sources. Common forms of renewable energy for human use are wind and solar power, hydroelectric power, different types of bio-fuels, and geothermal energy. *Non-renewable energy*, on the other hand, is energy with an origin in finite resources that will eventually dwindle or become too expensive or difficult to retrieve. Fossil fuels, such as coal, petroleum products and fossil gas belong to the non-renewable energy carriers. Nuclear power is dependent on a finite resource, uranium, and should therefore be counted as non-renewable.

The big picture

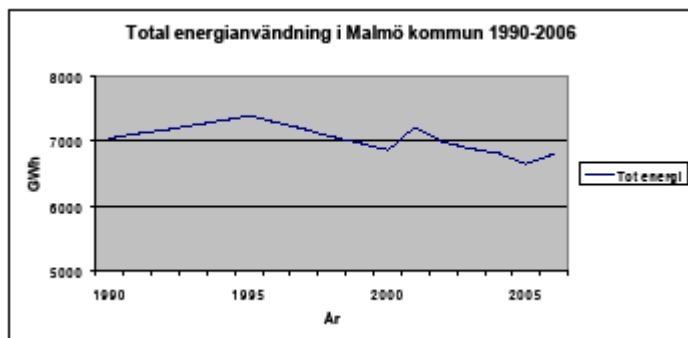
The total energy consumption of the Malmö municipality is shown in figure 1 (City of Malmö 2008a: 5ff). As we can see, the trend has stayed quite stable around 7 TWh/year in the last 15 years.¹⁰ As there has been a population growth of around 40 000 persons during this period, Malmö shows a decreased per capita energy consumption of nearly 20%. One interpretation is that Malmö has become more efficient in its energy use – at least relative to its number of inhabitants and in a place-based perspective. The per capita consumption was around 25 MWh/year in 2006, which is lower both than the Scanian average (33 MWh) and the Swedish average (46 MWh).¹¹ This should be no surprising figure though, as Malmö has a relatively mild climate, a concentrated (urban) structure and a large service sector in comparison to many other parts of Sweden. In a regional and national perspective, the Malmö per capita energy use is relatively low in the industry, agriculture and transport sectors. On the other hand, it can be noted that Malmö has a relatively high per capita energy use in the service sector, especially in the private sector such as offices, shops and other buildings. Applying the

⁹ These definitions were chosen with help of a search on Internet, mainly on Wikipedia, on ‘renewable’ and ‘non-renewable’ energy.

¹⁰ To grasp this abstract figure, and as a comparison, Sweden’s energy use is on average around 1TWh per day and the yearly global energy use over 90 000 TWh (2005) (Swedish Energy Agency 2008b: 12 f, 46 f).

¹¹ The exact Malmö figure from 2006 is 24,6 MWh/cap and year. The Scanian and the Swedish figures of 32,7 and 45,6 MWh/cap are from 2004 but a rough comparison can be made despite this. In the global comparison following below, the exact global figure is 20,7 MWh/cap (2005).

global perspective, the Malmö per capita figure of 25 MWh/year is only a little above the average world per capita of 21 MWh/cap (Swedish Energy Agency 2008a: 137). I interpret this as a sign that Malmö belongs to the core regions of the world where deindustrialization and economic restructuring has taken place and where resources have been available for modernisation and efficiency measures of the local energy system. We will have reason to further discuss the extent to which this impression of a *relatively* high energy efficiency is counteracted by a large shadow side of embodied energy consumption from a system-based perspective.



Text in all diagrams to be translated

Figure 1.
Total energy use in Malmö 1990-2006
(City of Malmö 2008a: 5)

The energy types adding up to final energy use in Malmö 1990-2006 are presented in figure 2 below (City of Malmö 2008a: 6). All types show a quite stable or slightly increasing trend, except for fuel oils which was formerly a common source of heating but which have diminished rapidly in use (80%). The consumption of electricity, petrol and district heating energy has each increased by 4-6% during the period. The total energy use is distributed between some main sectors in accordance with figure 3. As we can see, households (33%) and transports (29%) are the two largest consumers followed by other services (19%), which consists of the private service sector, for example offices, shops and other buildings. The industry sector adds up to a relatively small share (10%) and public services to 9% of total energy use.

Some important trends may be detected from these diagrams. Following deindustrialization and the restructuring of the Malmö economy, briefly described in Andrén (2009a), the energy use of the industry sector has been cut down with 1/3 between 1990 and 2006. The energy consumption from the household and the public sector also shows a decreasing trend (11% and 21%), despite the above mentioned population growth. Transport shows only a very small change (-2%) and we see in recent years rather an *increase* in energy use, which is problematic as this sector is heavily dependent on fossil fuels. The largest expansion, however, stems from the sector 'other services' which shows an increase as high as 49%. The per capita energy use in this sector is more than 70% higher than the Scanian and national average. This development may be interpreted as the other side of the coin of the deindustrialisation and economic restructuring that have taken place in Malmö. If earlier industry was a large energy consumer it is today instead offices, shops, services and other activities connected the modern high-consumption society.

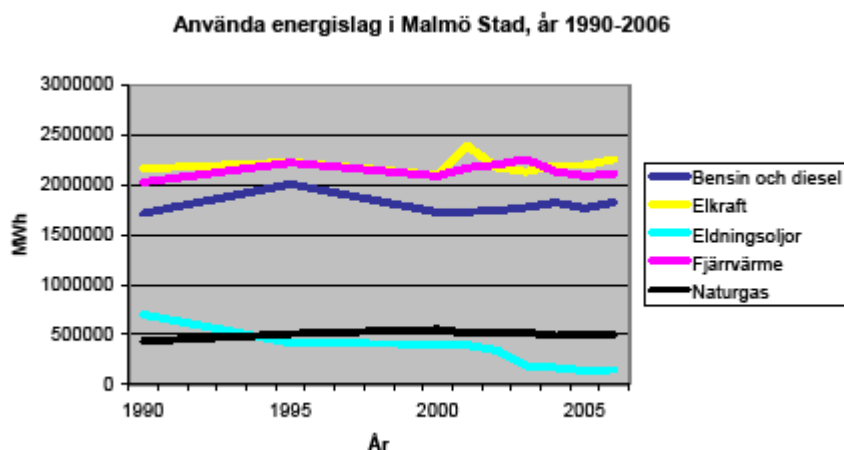


Figure 2. Energy types in final energy use in Malmö 1990-2006 (ibid: 6)

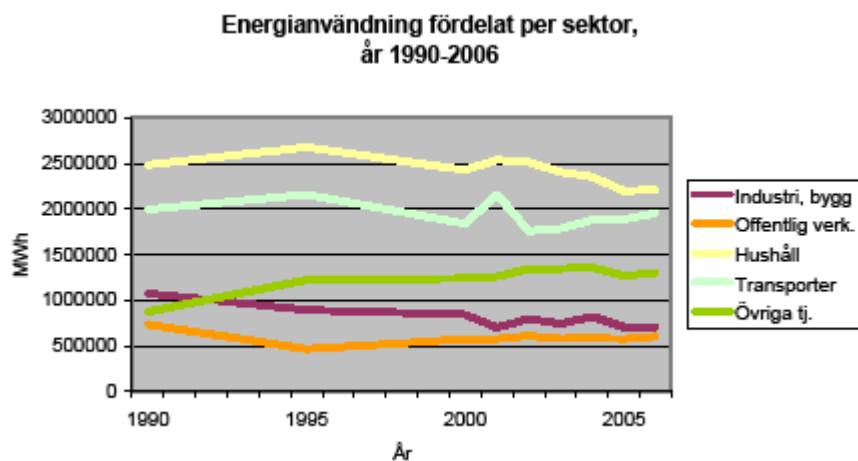


Figure 3. Energy use in different sectors in Malmö 1990-2006 (ibid: 7)

Energy balance of Malmö

Let's have a closer look at the energy system of Malmö as presented in appendix 1.¹² The proportions of inputs of different energy types are shown at the upper side of the sankey diagram and the outputs as using sectors below. It is important to understand, that this diagram only catches one *part* of a more complex system of energy types and transfers.¹³ For example, the input of electricity is in turn produced by other energy sources, and the fossil fuel inputs are final products in a long chain of extraction and refinement. What we here gather is thus a rough picture of a system at one point in a series of energy transformations. As we can see, final energy use was 6,83 TWh with losses of around 5% in comparison to the primary energy supply of 7,74 TWh in 2006. These losses mainly belong to the production of electricity and district heating, but there are of course other losses along the chains which are not detected in this diagram.

¹² This estimate is from 2006. The figures will have changed in 2009 since a new thermal power station, *Öresundsverket*, starts to produce electricity and heat water on a large scale (see below). Other recent investments in Malmö for example in wind-, solar power, and biogas will also, although to a smaller extent, contribute to a revised diagram. This changed feature of the energy system will be treated in further work.

¹³ In a thermodynamic perspective, energy can neither be 'produced', nor 'consumed', only transformed between different states. What we normally view as energy is rather a certain state of energy, a useful quality of energy for the carrying out of work (*exergy*). When exergy is consumed the quality of the energy is degraded.

The box in the middle demarks the amount of energy produced in units situated in the Malmö municipality. The share of locally ‘produced’ energy in this translation is 38%, but as we will see this ‘local’ production heavily relies on non-local resources, for example fossil fuels and imported biomass. Of course it is not surprising that a contemporary urban structure will exhibit this feature; the potential of energy production from locally situated sources (solar and wind power, geothermal power and urban biomass production, etc.) are still modestly used. While it is interesting to ask how Malmö municipality could make better use of local resources for energy production, it is simultaneously important to acknowledge that concentrated urban structures are, at least so far, primarily energy *consumers* and not producers. The main challenge for a city like Malmö may very well lie in the ability to build ‘sustainable’ relations in energy production on a regional basis rather than searching for solutions within its central urban structure.¹⁴

To better grasp the energy sources used in Malmö, let’s now turn to the main groups a little more closely. Following the diagram in the appendix, I will describe them in the order from left to right, with some exceptions. Besides a brief presentation of each category, I will hint at some questions that I find interesting for further studies. Special attention will be given to the renewable vs. the non-renewable part of the energy consumption. Before ending this paper by summarizing some critical issues for further work, I will estimate the total share of renewables in the Malmö energy system of 2006 so as to highlight the challenge of the Energy goal of the City for 2030.

1. Electricity

In the last decade the Swedish electricity market has been deregulated and integrated with the Nordic countries (except Iceland) on a common market called *Nord pool*. The provision of electricity to Malmö thus belongs to a wider regional network and is the feature of a larger system, of which the control is only indirect and partial. Electricity is a product purchased by many different actors, from huge companies and public bodies to individuals and households. This creates different segments of the market, with different types of contracts and business conditions. For the average individual there is some degree of freedom, for example the right to choose power company and the possibility to earmark the contract demanding for example ‘green’ electricity (that is, electricity with a certain environmental brand). Even though the market is dominated by large suppliers, there is a formal possibility for local actors to produce electricity and to connect the producing units to the grid. Individuals as well as companies and public bodies may use this opportunity but the conditions are not advantageous for a small-scale producer. The municipality produced around 345 GWh of electricity from wind power, waste management and sewage treatment in 2006. However, as we can see from the sankey diagram (local production-box in the middle), the net-input of electricity is only a little larger than the demand from the energy-producing sector itself. As the City of Malmö has declared its ambition to promote solar power and wind power,¹⁵ among other efforts, I find it interesting to further investigate the conditions for a local expansion of renewable-based electricity production.

¹⁴ By this I do *not* mean that Malmö shouldn’t try to enhance energy production within the city, only that the total demand for energy will likely require larger-scale solutions which an urban structure like Malmö may have problems to solve.

¹⁵ See for example the initiatives *Solar City Malmö* and the ‘Wind power academy’ (*Vindkraftsakademin*) at: <http://www.solarcity.se> and <http://www.vindkraftsakademin.se>.

The recent renovation of the huge combined power and heating plant *Öresundsverket* is a good example of how electricity belongs to a larger regional context. This plant is an investment of around 3 billion SEK by the energy company E.ON and is situated in the Northern harbour area of Malmö (eon.se). Opening in 2009 it is now one of the biggest and most modern plants in Northern Europe. It has a production capacity of 400 MW of electricity which can be compared to one of the now closed-down nuclear reactors at Barsebäck of 600 MW. The plant also generates heat water with a production capacity of 250 MW. *Öresundsverket* is fuelled by fossil gas and will deliver around 3 TWh electricity and 1 TWh heating per year. This makes Malmö as a geographical area a net-exporter of electricity and the city's district heating system will be covered by 40% only from this plant.

As will be further discussed, there is no wonder that much debate have risen on the establishment of *Öresundsverket*. First, it is 100% fossil-fuel based, something that really seems to contradict all talk about the need for a sustainability transformation of the energy system. Second, the carbon dioxide emissions will almost double at a local level due to the added emissions from this plant.¹⁶ This place-based view is however challenged by the argument, put forward by the company, that the total *regional* emissions will instead decrease by 1 million tons/year as the plant replaces old coal-based production in the North European system. Once again we see the tension between place-based and system-based arguments, but the main question should perhaps rather focus on the fact that huge fossil-based investments are still seen as a favourable solution as such. Even if the City of Malmö and other actors articulate their devotion to renewable energy, we must not forget that this is still mirrored only modestly when it comes to the practical results. For example, the celebrated wind power farm *Lillgrund* recently opened in the Sound outside of Malmö, and owned by the energy company Vattenfall, has a total production capacity of only around 1/10 of that of *Öresundsverket* (0,33 TWh). By this I do not mean that investments like *Lillgrund* is negligible, on the contrary, only that we must keep the right perspective and face that much still is required if regional electricity production is to be phased out of fossil fuels.

What has been forwarded as a sustainability argument in favour of *Öresundsverket* is that the fossil gas-system might be converted into biogas in the future. The infrastructure needed for these two gases are roughly the same. If we for a moment set aside all questions on the sources to produce this biogas – and the socio-ecological consequences of such huge demand of biomass of one sort or another – such conversion would be a radical contribution to increase the share of renewables in the regional system of electricity production. I will have reason to return to the question of the premises for a full-scale substitute of biogas for the increasing fossil gas dependence of contemporary Malmö.

How much of the electricity used in Malmö is to be classified as renewable energy? As we have seen, the electricity market has to be assessed in a broader context. I will here choose to use the assumption that the electricity used in Malmö mirrors an average Swedish mix of electricity production. This will not be totally accurate as there are certainly divergences from the national case due to specific local demands and broader market influences. We know that in the Swedish case, hydroelectric power and nuclear power are totally dominant with around 45% each (Swedish Energy Agency 2008a: 84). The remaining 10% is divided between electricity produced from fossil fuels or biomass and from wind power. I will choose to follow these rough proportions and use an approximate figure for the Malmö case, not arguing that this is *exactly* the right figure but for the purpose of getting the big picture.

¹⁶ The yearly CO₂ emissions from *Öresundsverket* will amount to around 1,3 million tons, while the local emissions in the rest of Malmö, according to the municipal Environment dep., is around 1,4 million tons.

2. District heating

Continuing I will use district heating as the next main label of this account even if the energy inputs behind heat water production – fossil gas, waste, bio-fuels and industrial waste heat – are to some extent also directed to other purposes. District heating was introduced in Sweden in the 1950's with a large expansion phase in 1975-1985 (ibid: 93). The district heating system in Malmö requires around 2,5 TWh per year (average) and covers over 90% of the households in the municipality. The district heating net is owned by E.ON and is currently in expansion. The heating supply in 2006 originated from the following plants with share of total yearly supply in brackets (City of Malmö 2009a; SYSAV 2009; malmo.se):¹⁷

- SYSAV waste management plant. Waste incineration generating heat water (around 50%) and electricity (around 0,2 TWh).
- Heleneholm combined power and heating plant fuelled by fossil gas (80-90%) and oil to a smaller extent. The plant is producing heat water (25%) and electricity (around 0,3 TWh).
- Flintrännen district heating plant. Heat water production (around 10%) from the combustion of biomass.
- Evonik Norcarb AB. Waste heat captured from the production process of the company and transferred to the district heating net (5%).
- Sjölanda sewage treatment plant. Waste heat captured from sewage by heat pumps (5%).

Of these plants, Heleneholm and Flintrännen are owned by E.ON. SYSAV is owned by a group of municipalities in Southern Scania. The heatpumps at Sjölanda sewage treatment plant are run by VA Syd, which is a statutory joint authority of the Malmö and Lund municipalities. Evonik Norcarb AB is a private company. The municipality of Malmö thus only has partial control of these plants such as by the part-ownership of SYSAV and Sjölanda and by political measures. The control of the district heating system – and the connected electricity production – is one of the questions I'd like to put forward in my studies. For example, what are the incentives (and obstacles) for a transformation to a fossil-free and high-efficiency heating system?

a. Fossil gas

Fossil gas is used on an increasing scale in the Malmö energy system. Fossil gas consists mostly of methane (CH₄) and is a cleaner fossil fuel than oil and especially coal. The carbon dioxide emissions using fossil gas may be reduced by 40% and 25% compared to coal and oil respectively (Swedish Energy Agency 2008a: 98 ff). Fossil gas has become an attractive alternative as the distributing system has been expanded in southern Sweden since the 1980's. While the total share of fossil gas in the Swedish energy mix is minor (1,7%), the municipalities connected to the gas distribution system has a much higher share, often around 20% (2006).

¹⁷ As already noted, the system is now radically changing as Öresundsverket will be covering a large share of the heating provision (40%). The fossil gas segment will thus increase compared to the 2006 diagram. In total, the district heating system will be dominated by energy from waste incineration and fossil gas combustion.

The estimation of the total fossil gas share of the Malmö system is according to the diagram in the appendix around 17%. As already noted, in 2009 these figures will change as Öresundsverket now will be included. We will have reason to return to the fact that the fossil dependence of Malmö seems to increase rather than decrease at the moment. At this point one may only conclude, that the different actors in control of the energy system have chosen to stick with fossil gas and the sustainability debate is 'solved' by saying that fossil gas may act as a bridge in the conversion to biogas-driven systems. The complex of questions that opens up here will be subject to further studies. How possible is a transformation from fossil gas to biogas? And what socio-ecological consequences will this new system entail in terms of a place-based and a system-based sustainability assessment?

b. Waste

In Malmö there is a large waste management plant where waste is collected from Malmö and the surrounding region. It is owned by the SYSAV-group consisting of 14 municipalities in southern Scania including around 660 000 inhabitants (sysav.se). The waste collected is either used in energy production (incineration), recycled (material recycling) or, but to a minor extent, deposited. In 2008 SYSAV received almost 850 000 tons of waste from households, industry and other sources. Over half of this volume was used as an input to the thermal power station in Malmö, generating 1,2 TWh of heating and 0,18 TWh of electricity, of which around half of the electricity was sold. According to SYSAV's own statistics, around 60% of the household waste is used in energy production, 24% is used in material recycling, some 11% is due to biological treatment and some 3% is deposited (SYSAV 2006: 15).

The share of energy from waste in the Malmö district heating system amounted to around 40% in 2006. From 2010, with the new constellation of energy producing units mentioned above, this share will increase to around 50% (City of Malmö 2008b: 5). It is thus evident that the Malmö municipality is quite dependent on waste as a source for heating. The advantages and disadvantages of waste-based energy production will be further discussed in work to come. Now I will only open up a few questions, of which one is: Is waste to be counted as a *renewable* energy source? From the website information from SYSAV it is argued that waste can be regarded mainly as a 'bio-fuel' as it consists of 85% 'renewable' resources counted in weight. This estimate is supported by the organisation Swedish Waste Management (*Avfall Sverige*), a stakeholder association in the field of waste management and recycling (avfallsverige.se). However, a lower share will be the conclusion if one instead of weight or volume focuses on how much the different origins of the waste contributes to the *energy content* when incinerated. In a study from 2006 on the Norwegian waste system (Profu 2006), it was assessed that around half of the energy content stems from renewable and the other half from fossil sources. I find this reasoning relevant, as what should be in focus is arguably the contribution to *energy* production rather than shares of volumes or weight. As a preliminary assumption, subject to further investigation, I have thus chosen to follow the assumption that average waste in Malmö can be viewed as a 50% renewable and 50% fossil energy source.¹⁸

¹⁸ Of course there may be differences in the waste content between the Malmö case and the average Norwegian case. However, I can not see that it is inappropriate to use this study here for purpose of a general assessment.

The discussion on waste is an old one, but deserves continued attention. On the whole, I think it boils down to a more fundamental discussion of ‘waste’ as a ‘resource’ and especially as an energy source. In 1997 a ‘Strategy on sustainable resource use’ was presented by a Swedish government commission (Kretsloppsdelegationen 1997). In this report, as well as in the EU directive referred to, a hierarchy of how waste should be treated is presented which in Sweden has been called the ‘Resource use hierarchy’ (*Kretsloppstrappan*):

1. Minimise the production of waste in the first place
2. Reusing instead of letting resources become waste
3. Recycling of materials
4. Energy production
5. Depositing

The contemporary society is a large waste producer and the trend shows no clear signs of decoupling but rather one of increasing volumes from already high levels. In Malmö, the total collected waste volume from all types of sources amounts to over 500 kg per capita and year (City of Malmö 2009b: 41). From this level, around 50% belongs to some of the broad fractions such as cardboard, paper, plastics, glass, metals, wood, garden refuse, etc., which may be used for some kind of material recycling. But over 250 kg falls into the category of ‘unclassified waste’ out of which material reuse and recycling is more difficult. Based on the above presented hierarchy of resource use, one must ask if the contemporary system is a long-term sensible and sustainable use of resources. Even if a (smaller or bigger) share of the waste may be regarded as renewable, it is nevertheless materials that could have alternative uses before final combustion. Further, if Malmö to such a large extent is dependent on waste incineration for its district heating, one must be aware of the risk that the *incentives* of securing a large supply of waste for combustion may override those in favour of reusing and recycling. As waste will certainly continue to be an important input to the Malmö energy system in the foreseeable future, I find it very important to further scrutinize the sustainability aspects of this system.

c. Waste heat

Waste heat from the industrial sector is used as an input to district heating systems in many Swedish municipalities, although with still quite a small share (around 4-6% in recent years) (Swedish Energy Agency 2008b: 29). The same rough figure also counts for Malmö where waste heat is estimated to contribute with 5% of total input (City of Malmö 2008b: 5). The waste heat is delivered mainly from *Evonik Norcarb AB*, a company producing carbon black which has a fossil-based raw material input to this process.

Is waste heat to be regarded as a renewable energy source? Given that many industrial processes today – including in the case of *Evonik* – are fuelled by electricity and/or fossil sources, waste heat is obviously not a primarily renewable energy source. On the other hand, waste heat that is taken care of – and simply not ‘thrown’ away – must be appreciated as a valuable source in a more sustainable energy mix. The eco-efficiency is higher in an industrial process that reuses its waste heat than in one where all is lost. While the long-term goal must be an industrial sector that is high in eco-efficiency and run on renewable resources, one may still judge the use of waste heat as a good thing even in the contemporary and largely fossil-based system.

d. Bio-fuels

The use of bio-fuels in Malmö belongs mainly to the production of heat water at the Flintrännan district heating plant (eon.se). The plant, owned by E.ON, is fired by a mix of different bio-fuels (by-products from sawmills and the wood industry; forest fuels such as chipped logs, branches, tops; energy forest products cultivated on arable land such as Salix; chipped wood waste from recovered wood products). The annual consumption is approximately 300,000 cubic meters of bio-mass of which around half is delivered by ship and the rest by road and rail. When Öresundsverket now is established, the production at Flintrännan will probably be closed down or left to act as a reserve capacity.

Farthest to the right in the diagram of appendix 1 there is a small share of ethanol in the Malmö energy input (less than 1%), which is mainly used as a motor-fuel. In Sweden, the use of bio-fuels for transports have radically increased in recent years, but from very low levels (2,7% in 2007).¹⁹ In Sweden around 85% of the ethanol used is imported from Brazil. As well known, there is a growing critical debate on the life-cycle of bio-fuels. One example is the reports from Fargione et al (2008) that bio-fuel production may not always be that efficient in terms of net green-house gas savings as first (perhaps) believed. Further, severe socio-ecological consequences such as heavy landscape exploitation in the South, harsh working conditions for the people in primary production and a pressure on food prices caused by ethanol production competing with food production, are now subject to intense debate (cf. Rathmann 2009; Berndes 2003; Gaia Foundation 2008; Grain 2007). One important issue for my work must therefore be to critically reflect on the premises for the substitution of bio-fuels for fossil fuels in the Malmö transport system.

3. Oil and petroleum products

The remaining part of the input to the Malmö energy supply consists of petroleum products, (oil 5% and petrol/diesel oil 23%), resulting in a total petroleum share of 28% which is roughly around the Swedish average (32%).²⁰ If we assume that the import of petroleum products to Malmö mirrors average Swedish conditions, then around 1/3 is imported from Russia and a little less than 30% each from Norway and Denmark.²¹ The use of oil has, as seen, radically decreased in Malmö in the last 15 years. A small share is still used in the district heating system as well as in the heating of private houses and as an input to industry. The bulk part, however, belongs to the transport sector and the use of petrol and diesel. Following the same trend as in the rest of Sweden, only a small share of total transports is driven by 'alternative' fuels such as electricity, gas and ethanol. From the diagram in the appendix, it is evident that the Malmö transport sector is heavily dependent on fossil fuels. With the recent municipal decision to build a tramway system, some parts the city traffic may be shifted to electricity driven transports in the coming decade. However, in light of the 2030 goal of a totally fossil-free transport system, much more will definitely be required. This challenge must be of concern for my further work.

¹⁹ Ethanol, biogas and FAME (fatty acid methyl esters) here included (Swedish Energy Agency 2008 b: 20 ff).

²⁰ The Swedish figure is from 2007 (Swedish Energy Agency 2008 a: 103 ff) and the Malmö figure from 2006.

²¹ The exact import figures are Russia 33%, Denmark 28% and Norway 27% (ibid). A few percent of the import to Sweden stems from other countries such as Venezuela, Great Britain, Iraq and the Netherlands. The detailed feature of the Malmö import of oil products is not yet investigated, but is probably constituted mainly by import through the ports of Malmö/Copenhagen and Gothenburg.

V. The share of renewable and non-renewable energy

We have now analyzed the main inputs and users in the energy system of Malmö and it is time to put the pieces together and try to answer the question outlined earlier: How big is the share of renewables in the Malmö energy system? As we have seen, it's not easy to define the 'renewableness' of different energy inputs. For example, electricity belongs to a broader regional production system and waste is both fossil and non-fossil in its origin. Waste heat from industry turned out difficult to assess, as its contemporary origin is fossil but at the same time this energy type constitutes a valuable input to a more efficient energy system. For reasons argued above, I will in the following choose to present the share of renewables *including* waste heat.²² Based on assumptions elaborated in the previous sections and with the purpose of getting the big picture rather than going into deep detail, the calculation may thus be compiled as:

Energy input to Malmö 2006	Total input in GWh	Assumption	Renewable share in (%)	Renewable share in GWh
Electricity	2326	Average Swedish production mix (hydroelectric power 45%; nuclear power 44%; fossil fuels, biomass and wind power 11%) gives a rough estimate of around 50% renewable energy.	50%	1163
Fossil gas	1299	Non-renewable	-	-
Waste	1087	I follow the assumptions of 50% renewable energy in waste (incineration) based on arguments in section 2b.	50%	544
Waste heat	156	Waste heat is a non-renewable energy source if originating from a non-renewable input. As argued above, I anyhow find it appropriate to include in the final estimate.	0-100%	156
Bio-fuels incl. ethanol	717	Renewable	100%	717
Petroleum products	2153	Non-renewable	-	-
Other ²³	4	-	-	-
Total	7742		33% ²⁴ Waste heat incl.	2580

Table 1. The share of renewable energy, incl. waste heat, in the primary energy supply of Malmö 2006

²² As the input of waste heat is only a few percent of total energy supply (2%), the figures will not diverge much in any case. The share of renewables is 31% with waste heat from industry excluded, and 33% included.

²³ This category consists of different but very small inputs, of which many are of fossil origin, and is left out of this estimate as they are negligible in comparison to the large segments.

²⁴ This figure results from dividing the supply of renewables (2580 GWh) by the total primary energy supply of 7742 GWh.

VI. Raising questions

The share of renewables in the Malmö energy system, including waste heat, was thus around 33% in 2006. This estimate is not contradicted by what I have been able to gather from other sources. For example, in a collaboration project between seven Nordic cities the share of renewables in the Malmö energy mix was estimated to 30% in 2003 (Nordiskt storstadssamarbete 2006: 13). As a comparison, the *direct* input of fossil fuels (petroleum products and fossil gas) was around 45% in 2006. This share will now increase as a larger part of the district heating system becomes fossil gas-based. Further, and which will be a key issue in my thesis, the fossil-based share will increase still more if one takes into consideration the *indirect* fossil-dependence of the Malmö energy system. The reasons for this have been hinted at in the sections above and may be summarized as:

- *The input of fossil fuels to the production of electricity.* Even though this share is small in the Swedish energy mix, which is the assumption I have here chosen to follow, it would increase if I instead took into consideration the broader region of the Northern European market, as this is more fossil fuel-dependent than Sweden.
- *The indirect input of fossil fuels in waste generated from households and industry.* Most kinds of goods consumed in today's society – that in a later stage of their life-cycle become 'waste' of one kind or another – have an indirect dependence on fossil fuel inputs. Without giving any exact figures here we principally know that as there is a heavy reliance of fossil energy in the global economy (over 80%), and Sweden and other industrial countries are highly connected to an internationally linked economy through trade. Thus, in an interconnected system like this, we can assume that in most kind of goods there is an embedded fossil-energy content, something that many researchers have noticed and tried to calculate (e.g. Odum and Odum 2001). One could in fact expand this discussion by arguing that this 'hidden' share of fossil fuels is crucial for the upholding of the contemporary system of large waste production as such. In this view, the earlier statements on the 'renewableness' of waste seem highly doubtful. Rather, the contemporary waste-intensive society must be seen as directly linked to a fossil-dependent economy at a larger scale.
- *Waste heat from industry and other sources is dependent on fossil energy,* directly if the industry in question uses fossil sources as the major input, and indirectly by the fossil-energy dependent infrastructure of which these units are part.
- *Even behind the assumed 100% renewability of bio-fuels* such as wood products (chips, firewood, pellet, etc.), ethanol and biogas there is an indirect fossil 'footprint' stemming from the dependence on fossil-fuels in the production and distribution of these products. Moreover, the concept of 'renewability' as such must be subject to critical scrutiny if it is allowed to include heavy (and unsustainable) exploitation of socio-ecological systems as put forward in for example the ongoing debate of bio-energy production in the South.

To sum up, the fact that Malmö today relies to some 2/3 on non-renewable energy sources – compared to the 2030 goal of zero reliance – must be seen as a huge challenge. Even though there is some progress made in comparison to the situation in for example the 1970's, when the oil-based input was heavy, it must be considered problematic that such a vast part of the total energy supply is still directly (and certainly indirectly) fossil-dependent. Especially problematic are some key-sectors such as transports and district-heating, which do not show any clear signs of a transformation to renewable energy sources at this moment.

The City of Malmö will soon adopt new Energy goals, stating that the municipality aims at a totally fossil-free energy system in 2030. While this is an ambitious claim and worthy of support, there is reason to call attention to the fact that Malmö is far from a clear and convincing trend of systematically increased use of renewable energy sources in proportions that can compete with the fossil-based ones. On the contrary, the fossil-based energy system seems to have quite a firm grip on contemporary Malmö. In my work to come, I'd like to scrutinize what efforts are now needed to really come to grips with the challenges of transforming a system – that is at its fundamentals still very fossil-dependent – into a more sustainable energy system. Based on my findings so far, and in the light of the readings of the literature in political ecology, I will bring some critical topics with me into the next step of the research process. These will act as themes for a qualitative interview study with selected stake holders and actors in influence of the energy system of Malmö and may be summarized as follows:

- **Local – Global**
Interconnections between the local and the global, or the place-based versus the system-based, energy challenges
- **Substitution – Reduction**
Quantitative reduction versus qualitative transformation: efficiency, substitution, sources, users, consumption levels. The premises for bio-energy as a substitute for fossil energy.
- **Renewable – Non-renewable**
A scrutiny on the categories in use. For example, what is renewable energy, really?
- **Control, power, agency**
Control of the energy system: structure, agents, power, conflicts, incentives, governance.
- **Discourse – Reality**
The gap between discourse and reality, for example between policy making/public discourse and what indicators such as ecological footprints, carbon footprints, energy/material- and land use statistics reveal about current state of affairs.
- **Processes of change**
Transformation – Processes of change – The scope of politics, the market, consumers/citizens – stakes and stakeholders.
- **Special attention!**
Special attention to some sectors and topics: biogas, fossil gas, electricity, district heating, waste, transports, the service sector ...

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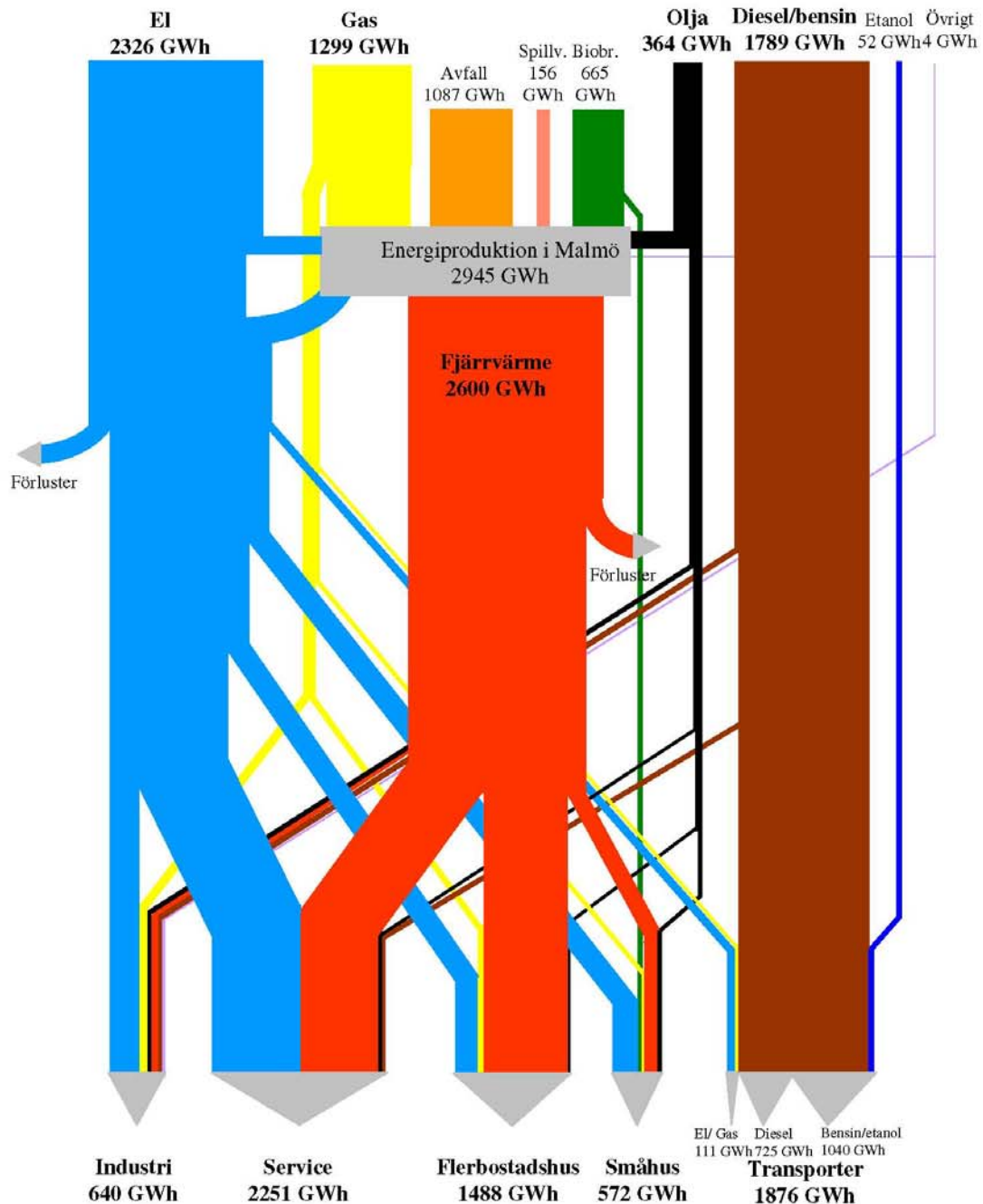
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Appendix 1. Energy balance of Malmö 2006

Text in diagram to be translated

Energianvändning och energiproduktion i Malmö 2006, normalårskorrigerade värden
 Total bruttotillförsel: 7742 GWh, Total slutanvändning: 6827 GWh



Source: City of Malmö and Grontmij AB (2008).

The figures are adjusted to the climate of an average year (*normalårskorrigerade*). The consultants stress that there are some statistical limitations in the background material from which this diagram is constructed.