New Approach to Reduce Environmental Impacts of Land Use and Living - An Environmental Profile for three city districts in Stockholm

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1 - SYNOPSIS

The city of Stockholm's successful environmental efforts during last decades have traditionally been driven by projects based on separate problems. A new approach has been developed during recent years and now it's time to focus on environmental impacts of whole systems such as land use planning, construction of buildings, transports and the human dimensions of energy consumption.

2 - ABSTRACT

This paper will put focus on two parts of Stockholm's green investment programme:
The first part contains a general presentation of 13 projects and strategies used in the City of Stockholm's Green Investment Programme with emphasis on three city districts. The city of Stockholm has within the frame of national green investment allowances received 635 million Swedish crowns (79 MECU). The programme is organised in four sections:

- Increase green planning and infrastructure,
- more effective resource use,
- reduced spreading of environmentally harmful substances and
- stimulating changes in people's behaviour.

The green investment projects combine technology and co-operative procurement, environmental impact analysis, competitions, environmentally directed project counselling, and financial incentives for green investments with public education and advising. Procedures, goals and assessment of investments will be described in the first part of the paper.

The second part presents a quantitative tool, an Environmental Profile, used for the assessment of environmental performance primarily in three city districts. The tool is computer based and involves the possibility to compare the flows of energy and materials through the three city districts as well as various sub-parts thereof. Sub-parts considered are at present: the individual, the household, the building, the real estate boundary and the city district area. For each of these, it should be possible to assess material and energy flows for construction, operation and disassembling. In a first phase, material and energy flows are surveyed for the present situation in the existing housing areas Östberga and Skärholmen, while a reference case 1990 has been established for the new district Hammarby Sjöstad. In the next phase, various new solutions will be simulated and compared to the reference case. In the paper, the work with the Environmental Profile is presented and discussed, with special emphasis on the connections between material flows and energy efficiency.

THE STOCKHOLM GREEN INVESTMENT PROGRAMME

3 - INTRODUCTION

The City of Stockholm has a relatively long history of managing successful environmental projects. In recent years environmental work in Stockholm has entered a new phase. The development of Stockholm's environmental programme, "Environment 2000", was recently followed by the implementation of an environmental management system in all the city's administrations and companies (Stockholm 1995a). Together, "Environment 2000" and the environmental management system, have provided a firm basis for the effort to create Stockholm's Green Investment Programme.

By carrying through the city's green investment programme Stockholm is taking a further step towards becoming a sustainable city. The green investment programme takes a comprehensive look at the city's environmental impact in a new manner.

3.1 Vision: The sustainable city

Behind Stockholm's green investment programme is a vision of creating an ecologically sustainable city. Environmental work often tends to be problem oriented and thereby gets locked into a difficult position without positive visions. Instead, Stockholm tried to begin with the idea of what the city can and is willing to do to contribute to a lasting progress, both from a national and international perspective.

The concentration of people in large cities presents both advantages and disadvantages. We are all aware of the disadvantages: air pollution, waste disposal problems and spread of environmentally harmful substances. Though, we seldom tend to think about the advantages: that the concentration of people allows the possibility of developing environmentally effective infrastructures for water supply, sewage treatment, heating, cooling, traffic among others, which can be exploited effectively through thoughtful and responsible planning.

The internationally and widely accepted, overall environmental objectives behind world-wide sustainable development can be summarised as follows:

- Nutrients must be returned to the earth
- Resources must be conserved
- The spread of environmentally hazardous substances must be stopped
- Individuals must be given better preconditions for taking responsibility

Seen from both this overarching point of view and from the existing structure of the city of Stockholm we chose to focus on four programme areas; (i) Improved adaptations to environmental cycles, (ii) More efficient use of resources, (iii) Reduced spreading of environmentally harmful substances, and finally (iiii) Stimulating the process of change.

Presented below is an overarching description of what is included in each of the four programme areas. The programme's large scope does not, however, allow a thorough description of all 13 projects in the green investment programme which are now proceeding with the assistance of governmental investment subsidies. The total subsidy to the programme is approximately 635 million Swedish Crowns (79 MECU), and the projects activities during 1998 through 2000 have been calculated to exceed over 6000 million Swedish Crowns (750 MECU) (Stockholm 1998a).

4 - IMPROVED ADAPTATION TO ENVIRONMENTAL CYCLES

A large part of the investments and subsidies are reserved for the creation of ecologically sustainable solutions within those activities that consume the greatest portion of the world's resources: construction, housing, transport, travel, waste and disposal handling. The project aims to create ecologically sustainable solutions that are applicable in many of the world's cities.

4.1 Residential Areas Adapted to Ecological-cycles

Sustainable development can scarcely be achieved without focusing on housing. Large amounts of society's resources are devoted to the construction of buildings and associated infrastructure, but even larger amounts of energy and other resources are consumed during the time that people use them. Construction, operation and renovation lead to a large consumption of energy, chemicals and other resources, both finite and renewable.

The form of residence is also an important factor concerning changes in our lifestyle. The municipality as a major owner of both land and buildings has to take its responsibility in order that new solutions for construction and housing be developed. The city must function as a prototype and, along with other actors, ensure that new technology is created with the assistance of new technology procurement, joint procurement and rewards for the best solutions. By employing comprehensive solutions and large-volume orders, the new ecological-cycle solutions can be made available to a larger market.

Stockholm's green investment programme is unique in that the goal is to adapt three entire residential districts to environmental cycles; one built from scratch—Hammarby Sjöstad—and two existing districts built in the 1960s – Östberga and Skärholmen. Corresponding projects have never been carried out in Sweden, and according to the authors knowledge nowhere else in the world.

The overall environmental goals for the city districts can be described as follows: Hammarby Sjöstad should be *twice as good* as the state-of-the-art technology available in present day construction field and for the restoration of the two districts, Skärholmen and Östberga, the environmental performance should be improved by one third compared to the present situation.

4.2 The city's strategy for reaching its goals

The city has formed a strategy for how environmental goals are to be reached within ecological-cycle adapted residential areas. The strategy is based on a combination of instruments which stimulate actors to strive to reach these goals. Competitions - or other forms - on producing the best ideas for using a given tract of land, in which contractors, entrepreneurs or various infrastructure companies compete with each other, are one tool. Joint procurement is used to press down the costs for environmentally suitable technology and to widen the range of interested parties who want to help reach the goals. New technology procurements are used to improve existing technologies and help them on the way to commercial applications. Development and demonstration projects are granted subsidies for testing systems and technologies deemed able to make a commercial breakthrough. An evaluation tool, an environmental impact profile presented in the second part of this paper, is used for choosing which project ought to receive a portion of the subsidies. Assisted by the tool, competition is created among the various actors such as property owners, construction firms, material deliverers and infrastructure companies. The proposals yielding the best environmental effects per invested resource receives support, which for reasons of competitive fairness may not exceed 30% of the cost for the environmental adaptation.

The project shall lead to, for example, larger and more competitive series of environmentally suitable products and installations than those currently on the market. Hence, the projects' environmental effects are not limited to the ongoing three-year period, but shall rather assist in the environmental adaptation of both the construction and infrastructure branches.

4.2.1 Competition – "Greenhouse for creative ideas"

One of the instruments mentioned above is competitions. Within the frame of the green investment programme the City of Stockholm has planned to hold competitions to stimulate and bring forth new creative ideas on environmental solutions. One of the competitions is called "Greenhouse for creative ideas" and it is an international competition on how to make two suburbs from the 1960s more environmentally friendly and sustainable.

Ideas can vary from details to broader solutions concerning changes from a systems point of view. The point of departure for these ideas is the current situation reviewing the basic conditions in each area. The goal is to create a list of practical ideas that will work as a menu for the contractor, residential property owner etc., from where they could select good and practical solutions to apply in Skärholmen and Ötsberga. By keeping track of the good ideas, the results from the competition may also become a platform for further development of environmental adaptations and application of them in other similar city districts around the world.

The international competition is intended for professionals and university students within or outside of Sweden who can provide suggestions for sound environmental solutions.

4.2.2 Hammarby Sjöstad - ecological new construction

Hammarby Sjöstad is a new development located in the vicinity of the Stockholm inner city. The area is situated around Hammarby sjö (Hammarby Bay of the Baltic), a former harbour and industrial area comparable with the London Docklands. This development will comprise about 8 000 apartments together with business activities, totally holding about 20 000 inhabitants. The development will become one of the century's largest new building projects in Sweden. This gives the project an unique opportunity to bring forth new environmentally suitable technologies that may later be used in other construction projects.

The City of Stockholm (Stockholm 1995a) has declared that Hammarby Sjöstad will serve as a fore-runner for ecologically sustainable construction and living. It will be in the forefront of international activity striving for sustainable development in densely populated urban areas with the environmental programme of Stockholm, 'Environment 2000', as a starting point (Stockholm 1995b). It is stated that the constructions should aim at closing the material cycles as locally as possible and that the use of natural resources should be kept at a minimum. One overall goal *'Twice as good'*, about 15 general goals, and about 50 operational objectives are included in the environmental programme of Hammarby Sjöstad (Stockholm 1995a). The overall goal is to be reached within year 2015 using a combination of instruments.

The first phase in Hammarby Sjöstad, which includes about 1 250 flats, should result in the following environmental improvements in year 2005 (Stockholm 1998b):

- Reduced use of non-renewable energy by 11000 MWh/yr.
- Reduced release of carbon dioxide by 800 tonnes/yr.
- Reduced release of nitric oxides by 1000 kg/yr.
- Reduced release of sulphur dioxide by 2400 kg/yr.
- Reduced release of phosphorous to water by 1500 kg/yr. and to the atmosphere by 260 kg/yr.

4.2.3 Skärholmen and Östberga

Skärholmen and Östberga, both situated in the southern part of Stockholm, are two city districts comprising around

3 600 apartments and holding approximately 10 000 inhabitants. The environmental goals for the two districts are based on the Hammarby Sjöstad environmental programme and the city's *"Programme for Green Building in Stockholm"*. Considering that the Hammarby Sjöstad environmental programme concerns new construction, the level of ambition for the achievable ecological performance characteristics for Skärholmen and Östberga should be lower, and has accordingly been set at *one third* - instead of *twice as good* as today's standard construction.

The follow-up tool for Hammarby Sjöstad will be used, and through co-operation between the three projects, a deepening of our knowledge in these fields should be obtained.

Restoration of the existing flats is to be carried out such that energy use will be reduced by 30 percent. Materials with environmentally harmful substances will be replaced, and all new furnished material shall be capable of recycling or reuse. Products containing substances on the National Chemical Inspectorate's lists for limited usage and observation must not be used. In connection with the renovations, a special objective shall be the creation of conditions for energy efficiency and environmentally suitable operation and maintenance of the properties. Local responsibility for handling surface water as well as recycling facilities for litter are to be arranged. Green spaces are to be re-established and resources devoted for allotments within the district. The environmental objectives shall be measurable, and follow-ups and evaluations shall take place following the project's completion: for example, by applying the experience gained from the Hammarby Sjöstad project.

Education about environmental issues will be intensified in schools and nurseries. Adverse environmental effects from households will be reduced through changes in the residents' daily habits. The environmental impact from workplaces, such as crafts and small industries will also be reduced. The sale of environmentally-labelled daily goods and food shall reach 30 percent of the total consumption. No chemical insecticides or weed-killers nor artificial fertilisers shall be used in the district. Environmental fuels shall be used in the area's maintenance. Road salt, against ice on the roads at winter shall not be used.

The environmental measures will also be suitable for other environmental programmes and urban areas. Special measures are planned in addition to renovations of residential buildings. For example, the district school will be rebuilt following the same ecological performance objectives as applies to all other buildings. Energy consumption for transport shall be reduced by 30 percent by the creation of better conditions for public transport, bicycles and car-pooling for residents.

4.3 Transports adapted to Ecological-cycles

Transport of people and goods and the use of machinery comprise a large portion of a city's environmental impact. Diffuse traffic emissions are the greatest air pollution problem in Stockholm today. In addition, these emissions occur in those places where many people live, work and study.

Air pollution at ground-level is considered a contributing factor to allergies; at the same time living in a major city corresponds to approximately 50 percent over-representation of lung cancer. According to the Swedish Environmental Protection Agency, approximately 1 000 cancer cases occur nationally each year due to air pollution, which in Stockholm translates to about 100 cases per year.

The two projects concerning ecological-cycle adapted transport are: Extensively increase the production of bio gas from sewage and organic waste and thereby make it available for use in vehicular transports; Increase the number of different vehicle models using alternative fuels through technology procurements. Also, quick battery-charging stations for electric vehicles will be built, and the number of tanking opportunities for ethanol mixtures along E15 and E85 will increase.

4.4 Adaptation of waste disposal to Ecological-cycles

The recycling of nutrients must be well functioning if we shall create a large sustainable city. Phosphorus is a limited resource that continually is being mined. In addition, the nitrogen cycle is being disrupted through the production of agricultural fertilisers fixating atmospheric nitrogen in an energy consuming process. Top soil constituents are not returned to the fields and the humus content falls, while at the same time the eutrophication of waterways continues.

Adaptations of waste disposal to ecological-cycles means the creation of an organic cycle between the city and the countryside by e.g. constructing composting centres for organic wastes. This results in pure plant nourishment being returned to fields and the resultant bio gas can be used in environmentally friendly vehicles.

The project will lead to a reduced petrol consumption, reduced emissions of carbon dioxide and reduced yearly use of artificial fertilisers.

5 - EFFICIENT USE OF NATURAL RESOURCES

An effective use of limited resources is a necessity for long-term sustainable development, not only in Stockholm and in other large cities, but for the entire world. The vision for the future of a tenfold increase in efficiency, commonly known as factor ten, between now and the year 2020 has already been widely accepted by many actors throughout the industrialised world (Bingel 1997)

5.1 Efficient use of energy carriers

Two major projects are represented within this field. At first all electric light bulbs in the City of Stockholm's traffic signals are being replaced with light emitting diodes, a measure that has a tenfold gain in electric efficiency. Electricity consumption is reduced by approximately 4 GWh/yr., while the need for maintenance is drastically reduced. The fact is that the expected lifetime for light emitting diodes has not been determined; the first diodes are now 30 years old and still working.

The other project concerns targeted energy counselling to property owners and inducements to carry out measures that reduce energy use by 10 percent in a large number of Stockholm properties. Co-operative endeavours have also begun with local organisations and civic administrations that have become active in energy counselling issues. The project is expected to lead to a reduced electricity usage of 5,4 GWh/yr. and reduced district heating by 16 GWh/yr., which corresponds to reduced emission of approximately 2 200 tonnes carbon dioxide, 2,4 tonnes nitric oxides and 2,4 tonnes of sulphur dioxide.

5.2 Increased recycling

One strategic task in the effort for increased recycling is to further develop waste water handling. The project aim at not only developing and testing new methods for the handling of sewage sludge for recycling purposes, but developing methods to recycle the various sludge components. On a yearly basis, the project will result in the decreased release of 300 tonnes of iron; the return of 48 m^3 of phosphate to agricultural land and an increased bio gas production which corresponds to 1000 m^3 petrol. In addition, the release of heavy metals is reduced by 140 kg cadmium, 140 kg chrome, 12 kg mercury, 60 kg nickel and 1800 kg zinc per year.

6 - REDUCED SPREAD OF ENVIRONMENTALLY HARMFUL SUBSTANCES

A range of activities have been and currently are taking place in Stockholm, which result in environmentally harmful substances being dispersed and accumulated in limited areas. Investigations has indicated that the levels of heavy metals on land and in water or marine sediments in Stockholm are very high and in certain cases exceed previously recorded peak values from other industrial areas in Sweden. The same is true for hazardous organic substances.

The spread of environmentally harmful substances comprises a serious threat to ecosystems and can directly affect human health. In order to reach a sustainable society, the leakage of various substances must be impeded and old environmental debts must be addressed.

The projects in Stockholm concentrate on; recovering heavily polluted soil and marine sediments, removing PCB-contaminated oil-filled cables from electrical transmission networks and preventing mercury leakage from buildings holding dentist's surgeries. A natural direction for decontamination is the development and application of new, cost-effective decontamination technologies, a development that creates the conditions for a growing Swedish enterprise within the environmental technology branch.

Realisation of these two projects will lead to the recovery of approximately 300 tonnes of heavy metals and creosote, 190 tonnes lead, 100 tonnes copper, 43 m^3 of PCB-contaminated oil, and around 30 to 100 kg mercury.

7 - STIMULATING THE PROCESS OF CHANGE

In the future, knowledge, insight and motivation for a changed lifestyle will constitute at least as important motors for the development of a sustainable society as does today's traditional administrative steering.

The two projects within this area aim at; using one-on-one guidance, straightforward examples and proximity to target groups, catalysing the development at a personal level, and to produce environmentally friendly negotiation methods that work in the real world. Stimulating residents and local business' own process of change is especially important for residential areas adapted to ecological-cycles to function properly. These efforts will be conducted at the city-district level based upon each districts conditions.

THE STOCKHOLM ENVIRONMENTAL PROFILE

8 - INTRODUCTION

As mentioned earlier the overall environmental goals for Hammarby Sjöstad is *twice as good* as the state-of-the-art technology available in present day construction field, and for the restoration of the two districts, Skärholmen and Östberga, the environmental performance should be improved by 30 percent compared to the present situation. To achieve this, it will be necessary to establish figures for the resource use and environmental impact of a reference level and the present situation and then make comparisons between these levels and planned and implemented new solutions. The approach should also preferably make it possible to simulate the environmental performance in advance, i.e. already before construction of the new area and implementation of new solutions in the existing areas.

Considering the large scale of the City district project, it will be necessary to promote a development where all actors do consider the environmental impact within their area of responsibility. It will therefore be necessary to describe the environmental impact in a multidimensional framework. In one dimension, this framework must be able to show the impact at e.g. the individual level, the household level, building level, real estate level and the area level. In another dimension it will be necessary to discuss the impact within different activity sectors in a building, e.g. cooking, washing, heating requirements etc. It should be possible to compare both new solutions with each other and with the performance of the reference level selected. If the environmental impact may be described in a consistent way, it will also be possible to make priorities on what developments are desirable, both regarding different actors and activity areas. The most important aspect of the model is, however, to function as support for various actors involved with the project to reach the overall goals of Hammarby Sjöstad, Östberga and Skärholmen.

To support the fulfilment of all these ambitions - both of policy-makers and contractors - the *Environmental Profile* has been developed, as a tool to simulate and follow up the impact from construction work and living.

9 - PARAMETERS CONSIDERED

The environmental profile comprises primarily parameters characterising the outer environment (Table 1).

Table 1. Parameters used to describe impact on the outer environment in the Hammarby Sjöstad Environmental Profile.

Extraction of non-renewable energy carriers, *[kWh]*	**Use of renewable energy carriers** *[kWh]*	**Emissions to the air** *[g]*	**Emissions to the ground** *[g]*	**Emissions to the water** *[g]*	**Presence of hazardous compounds** *[g]*
		Sulphur dioxide, SO_2	Hazardous waste	BOD[1]	
		Sulphur, S	Nitrogen	COD[2]	
		Nitrogen oxides, NOx	Phosphorus	Nitrogen	
		Nitrogen, N	Radioactive	Phosphorus	
		Carbon dioxide, CO_2	Wastes	Metals	
		Carbon monoxide, CO			
		Hydrocarbons, HC			
		Fossil carbon, C			
		Particles			

For emissions, we have chosen to account for both different substances and chemical elements. The substances were chosen in accordance with those established in the Environmental Programme for the Hammarby Sjöstad. Elements were chosen to facilitate a comparison with Material Flow Assessments for certain substances that are currently introduced for the City of Stockholm.

The fluxes that are included in the Profile are those that occur due to decisions made for the Hammarby Sjöstad. In principle therefore, a Life Cycle Assessment Approach has been made, where both upstream, process and downstream flows have been considered when information was available. Thus, emissions to air, may occur far away from the Hammarby Sjöstad e.g. at a power station located elsewhere, but are included into the accounting if they are the consequence of the establishment and life in the new area.

[1] BOD = Biochemical Oxygen Demand
[2] COD = Chemical Oxygen Demand

10 - THE STRUCTURE OF THE MODEL - ACTIVITIES AND ACTORS

The fundamental approach in the development of the model is to calculate resource use and emissions - characterised by a number of parameters as shown in Table 2 - for three time phases of a principal life cycle of the city districts (construction, operation and demounting). The results are calculated and presented in Excel.

Besides the three phases within the life-cycle, the model is based on two groups of actors that may influence on the environmental performance, (i) the municipal enterprises being responsible for technical services (energy supply, water supply and waste water management, waste management) and (ii) the inhabitants. Table 2 shows the technical services considered in the model.

Table 2. Technical services supplied by the Stockholm City municipal enterprises.

Service supplied	Service unit
District heating	Production, kWh
Electricity	Production, kWh
District cooling	Production, kWh
Drinking water supply	m^3
Waste water collection and treatment	m^3
Waste collection and treatment	kg

In the model each service unit supplied according to Table 2 may be characterised by a certain environmental impact, this in turn characterised by fluxes according to Table 1. The impact from each service unit may be related to the mode of production in different units, both present and potential future options, such as solar energy, warm water production and heating during part of the year. The environmental loads thus calculated for the technical services supplied, are in turn being used to calculate the contribution to the environmental load due to the activities of the second group of actors, the individuals living in the districts.

The results from the model may be extracted within five different organisational areas represented by the individual level, the household level, the building level, the real estate level and the area level. Together with the three time phases considered, this makes up a matrix of five organisational levels and three time levels as illustrated in Table 3. Beside this, under each cell of the matrix according to Table 3, results may be extracted in a number of sub areas (activities) as shown in the table.

The second group of actors (Table 3, Column 1) comprises the individuals living in the houses. In this way the individual behaviour may be accounted for and may be included in the environmental load over e.g. the Hammarby Sjöstad life cycle.
Builders and project designers belong to a group of actors that may have an influence on the individual behaviour. They have an influence on the environmental load in the construction phase, but also the conditions for the possible life styles of the individuals. A second group that may have an influence on the overall environmental performance in the operation phase is building and area administrators.

11 - INPUT DATA AND CALCULATIONS

Input data that represents the reference level are given as default values in the programme and may not be changed or influenced by the various users. Some input data for the activities concerning the individual level are established according to statistics about Stockholm e.g. the statistical amount of people living in a building or their behaviour in the area, and these can not be changed while running simulations of the operational phase. On the other hand different builders and project designers may simulate the environmental loads, from small parts to the overall load, by changing e.g. the materials and equipment used, the material transport

system used, the type of technical solutions used and thus the heating and electricity demands etc. Thus, one important aspect is that builders and project designers will be able to use the Environmental Profile to try out more environmentally benign solutions already in the project design phase.

For Östberga and Skärholmen which are in the operational phase, actual data characterising the buildings will be used as input data. In this phase, on the other hand, the aim is to use actual behaviour of the individuals as input variables for calculations of the environmental load. For the demolition phase finally, the aim is to use data on various types of resource and waste handling practices to make a rough estimate of the contribution of this phase to the environmental load for different solutions. However this part has not been fully developed yet, but are under construction.

Table 3. Structure of the Environmental Profile, showing important ways of potential results extraction possibilities.

Organisational levels Time Phases	**Individual**	**Household**	**Building**	**Real Estate**	**Area**
Construction			Materials Auxiliaries Transports	Construction below ground Construction above ground Lighting Wires and piping	Construction below ground Construction above ground Lighting Wires and piping
Operation	Bath/Shower use Toilet use Washing Cleaning Cooking Waste production	Lighting Towel dryer	Heating Electricity District cooling Storm water	Construction above ground Storm water Wires and piping Lighting	Construction above ground Storm water Wires and piping Lighting
Demounting			Reuse Recycling Energy recovery Landfilling	Reuse Recycling Energy recovery Landfilling	Reuse Recycling Energy recovery Landfilling

12 - PRESENTATION OF RESULTS

With the approach used, profiles may be calculated separately for each activity, each actor, the three time phases and for the whole area or parts thereof. At the household-, building-, real estate- and area levels, the environmental load is expressed per m^2 living area. The total accountings for the production-, operation and demounting phases cover all the developed areas for which the Profile is being extracted.

Results within the Profile are being shown in the form of tables and diagrams. In the tables, both the reference value and the value for the actual situation is being shown, together with the improvement in per cent. The Figures 1-4 below shows the results from a first simulation of some actuall proposals for Hammarby Sjöstad.

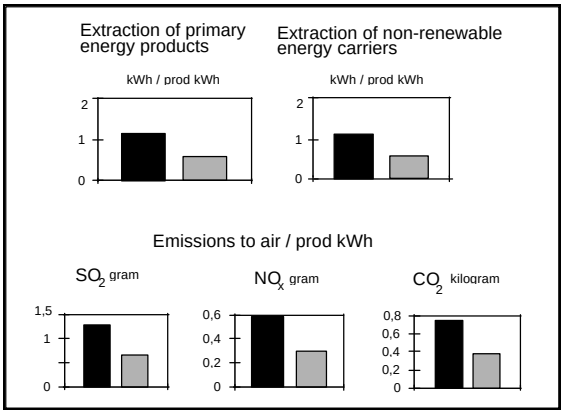

Figure 1: *Example of simulation results for electricity production and supply in the Environmental Profile for Stockholm. Black bars refer to the reference level, grey to the simulated situation.*

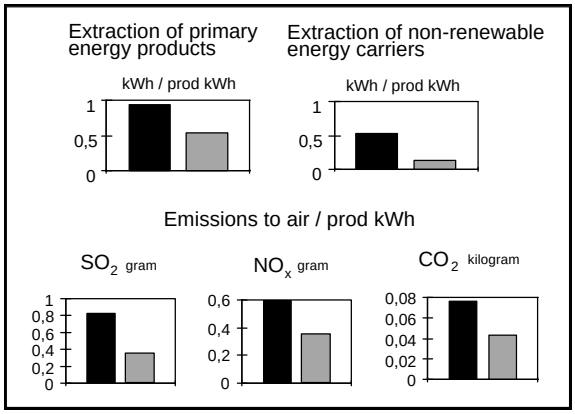

Figure 2: *Examples of simulation results for district heat production and supply in the Environmental Profile for the south of Stockholm. Black bars refer to the reference level, grey to the simulated situation.*

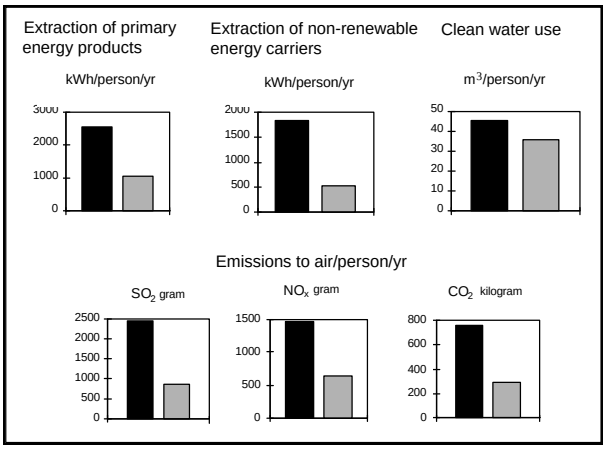

Figure 3: *Examples of simulation results at the individual level. Black bars refer to the reference level, grey to the simulated situation.*

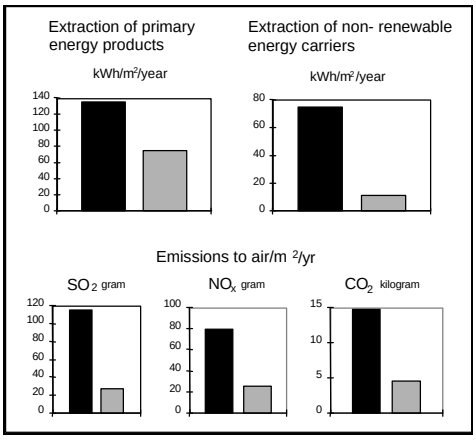

Figure 4: *Examples of simulation results for a building in the operation period. Black bars refer to the reference level, grey to the simulated situation.*

13 - DISCUSSION

The environmental profile has been used for primary simulation tests. The model works practically and may predict actual results for the construction and operation phases at the individual-, the household- and the building levels. The reference level for Hammarby Sjöstad and the present level for Östberga and Skärholmen have been defined. Some parts of the model, however, have yet to be firmly established. We are now proceeding in our work towards more strictly defining the system boundaries of the model. This holds for e.g. the boundaries used in the inventory of the different material and energy flows. To some extent, a life cycle approach has been used in the gathering of data. Practically, however, there remains a lot to compile in order to have a complete life cycle inventory made as a basis for the assessments that may be made. In practice, the work at the moment has similarities both with a Life Cycle Inventory and a Material Flow Assessment for the areas considered.

The next step in development of the profile is to establish a dialogue with different stake holders in the projects. In this process, the profile will be presented and discussed with respect to its structural and operational characteristics, its potentialities and limitations. Hopefully this dialogue will aid in establishing the Profile as a widely accepted tool for the evaluation of environmental performance of the different projects. This dialogue, therefore, will be of major importance for the future development of the profile.

For larger areas such as cities and regions, material flow approaches of a similar character are available (Brunner and Baccini 1992; Frostell et al. 1994; Burström et al. 1997a; Burström et al. 1997b) where strict geographical boundaries have been used. In these cases the ”Hinterland” , i.e. secondary flows, are not considered. For regions, such an approach may be justified by the fact that the information has a strict connection to the local environmental loads and thus represents a type of environmental accounting. For other purposes, such as discussing the degree of environmental adaptation, however, this approach is not satisfactory. Here, a life cycle approach would be necessary. Such an attempt for buildings is being made by (Glaumann et al. 1998). For a project like e.g. Hammarby Sjöstad, however, such an approach necessitates an enormous inventory effort to be made. Therefore, some type of compromising will most certainly have to be done for the Hammarby Sjöstad Environmental Profile. These issues will form an important part of the future work in establishing the environmental profile.

14 - ACKNOWLEDGEMENTS

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