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The development of a sustainable urban district in Hammarby Sjöstad, Stockholm, Sweden?

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Abstract By 2012, Hammarby Sjöstad, a former large industrial harbor area in southern Stockholm, Sweden, will be a fully developed residential district containing approximately 11,000 apartments and accommodating 35,000 people. The transformation of the area began in 1996, and the development soon became renowned for its ambitious environmental program, inspired by Agenda 21 (United Nations in Rio declaration on environment and development. United Nations Department of Economic and Social Affairs (DESA), Rio de Janeiro, 1992) and the Sydney 2000 Olympics in Australia (Newman in Landsc Urban Plan 44:219–226, 1999). Using results based on literature reviews, in-depth interviews, discussions with focus groups, and quantitative data, this paper attempts to gain insight into how the environmental program influenced the planning and performance of the district with regard to sustainable urban development. In doing so, three important conclusions were maintained that could be valuable for similar projects concerning the planning and development of sustainable urban districts. First, the environmental program proved vital to the development process of Hammarby Sjöstad, specifically in its drive to create a sustainable urban district. When planning on improving the sustainability of future districts, such a program should be introduced and integrated earlier in the planning stage of the district. Second, the metabolic flows of Hammarby Sjöstad were reduced as a result of the integrated system—the Hammarby Model—of Hammarby Sjöstad. In order to reduce the metabolic flows in future urban districts even further, it is important to facilitate the integration of technical innovations into existing integrated systems. Third, this case study showed that there was a loss of valid and credible data related to the aims and goals of the environmental program of Hammarby Sjöstad. In future urban districts, it is of the utmost importance to include a clear structure of the assessment process in the

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environmental program, which would ensure the quality of gathered data and facilitate the development of even better sustainable urban districts in the future.

Keywords Sustainability · Urban planning · Case study · Metabolism

1 Introduction

Today, more people are living in towns and cities than in rural areas. In Europe, approximately 75% of the population lives in urban areas, accounting for 69% of the continent's energy use and thus most greenhouse gas emissions (European Environment Agency 2010a, b). Overall consumption, energy use, water use, and waste generation are associated with a growing number of urban households. As a result, urban sustainable development has climbed high on the political agenda over the last couple of decades.

In the mid-1990s, there was strong interest from leading local politicians in Stockholm, Sweden, to host the 2004 Olympic Games. Hammarby Sjöstad, a former large industrial and harbor area in Stockholm, was suggested as a site for the Olympic Village in the Swedish application for the Olympic Games 2004 (City of Stockholm 1996b). Inspired by the UN Brundtland Report (World Commission on Environment and Development 1987), Agenda 21(United Nations 1992), and the call for environmental focus in the applications by the International Olympic Committee, the local leading policymakers in Stockholm wanted Hammarby Sjöstad to become a sustainable urban district. In order to succeed, an environmental program specific for Hammarby Sjöstad was formulated, stating that the aim for the district was that *"it should impose as little demand as possible upon resources, and be an environmentally well-adapted city district, whilst being at the forefront of international strivings towards sustainable development in densely populated urban areas"* (City of Stockholm 1996a, p. 4). The outline of the program was inspired by the Sydney 2000 Olympics, which aimed to reduce the metabolic flows of the district in order to create a sustainable urban district (Newman 1999).

This paper, based on literature reviews, in-depth interviews, discussions with focus groups, and quantitative data, aims to understand to what extent the environmental program of Hammarby Sjöstad influenced the planning and performance of the district in respect of sustainable urban development. In doing so, the paper intends to gain insight into how the planning and development of such districts can be further developed.

2 Aim and objectives

Since the development of Hammarby Sjöstad was initiated in 1996, a number of *evaluations* and *research projects* have been carried out focusing on different aspects of the development process of the district. The City of Stockholm has initiated *evaluations* in order to gather experiences from the project with regard to the environmental aims and goals, and its municipal organization (Forsgren 2008; Fränne 2005a). Earlier research projects primarily focused on the development of wastewater treatment (Hellström 2005); the governance and management process for the project (Svane 2005; Engberg and Svane 2007; Green 2006); the Environmental Load Profile (ELP)[1] (Forsberg 2003; Brick 2008);

[1] The Environmental Load Profile (ELP) is a Swedish Life Cycle Assessment (LCA)-based tool for the built environment developed as an instrument to evaluate the environmental performance of Hammarby Sjöstad.

and the influence of financial inputs of Local Investment Programmes (LIP)[2] (Bylund 2006). This earlier research is commendable, but it fails to address the issue of what the outcome of the implementation of the specific environmental program for Hammarby Sjöstad was. Consequently, the City of Stockholm's Executive Office assigned the task of conducting a case study of Hammarby Sjöstad to the Department of Industrial Ecology at the Royal Institute of Technology (KTH) in Stockholm in 2008. The aim of this case study was to understand to what extent the environmental program of Hammarby Sjöstad, accepted by the Stockholm City Council in June 1996, influenced the planning and performance of the district in respect of sustainable urban development. To do so, it was necessary to:

- Research how Hammarby Sjöstad's environmental program was implemented in the planning and development process of the district, and identify elements, both supportive and hindering, to the achievement of the vision, aims and goals of the program.
- Evaluate the performance of the Hammarby Sjöstad district in relation to the operational goals.

3 Case study method

3.1 The implementation of the environmental program

In order to understand how the environmental program was implemented in the planning and development process of the district, a qualitative case study methodology based on "how" and "why" related questions shown in Table 1 (Yin 2003) was used. The questions were developed in cooperation with key stakeholders involved in the planning and development of Hammarby Sjöstad and later discussed during in-depth interviews and focus group meetings.

3.1.1 In-depth interviews

A total of 19 individuals were interviewed. Individuals invited to the in-depth interviews included key stakeholders involved in the planning and development of Hammarby Sjöstad found during the literature review and mentioned by the interviewees themselves. Among the respondents were representatives from the project management team of Hammarby Sjöstad, the Stockholm Water Company, Fortum, Stockholm City Council officials,

Footnote 1 continued
Initiated in 1997, the ELP was developed as a research project in order to evaluate the vision "the environmental performance of the city district should be *twice as good* as the art technology available in the present day (1996) construction field".

[2] The Local Investment Programmes (LIP) represents Sweden's largest single environmental initiative. The Swedish Parliament earmarked SEK 6.2 billion in grants for LIPs over the period 1998–2002 with the aim of improving ecological sustainability. The programs covered the entire environmental field—from energy efficiency and energy switching to projects aimed at creating good residential environments, treating emissions to air and water and increasing biodiversity. Some of the programs were launched in Hammarby Sjöstad.

Table 1 Questions discussed during the interviews and focus group meetings

No	Category	Example of questions discussed
1	*The vision and overarching aims* of the environmental program of Hammarby Sjöstad accepted by the Stockholm City Council in 1996 (City of Stockholm 1996a).	How did the vision affect the development of Hammarby Sjöstad? How was the vision implemented?
2	The formulation process of *the operational goals* of the environmental program of Hammarby Sjöstad accepted by the Stockholm City Council in 1996 (City of Stockholm 1996a).	How were the operational goals formulated? How did the operational goals affect the development of Hammarby Sjöstad? How was the achievement of the operational goals measured and documented?
3	*The governing* and *economical incitements* of the Hammarby Sjöstad project.	How was Hammarby Sjöstad governed? How did the LIP affect the implementation of the environmental program of Hammarby Sjöstad? Were there other economical incitements affecting the implementation of Hammarby Sjöstad's environmental program?
4	*The cooperation* between different actors of the Hammarby Sjöstad project.	What important experiences and inquires are there from the planning and implementation of Hammarby Sjöstad's environmental program, which are associated with the cooperation between the officials of the City of Stockholm, developers, architects, consultants, etc.?
5	*The Hammarby Model* of Hammarby Sjöstad.	How did the Hammarby Model affect the implementation of Hammarby Sjöstad's environmental program? Should this kind of model be developed and used in future development of urban areas?
6	*The residents* of Hammarby Sjöstad.	How did the residents of Hammarby Sjöstad influence the implementation of Hammarby Sjöstad's environmental program?
7	*The city planning and the architecture* of Hammarby Sjöstad.	How did the city planning and the architecture of the district affect the implementation of Hammarby Sjöstad's environmental program?
8	*The infrastructure* of Hammarby Sjöstad.	How has the infrastructure of the district affected the implementation of Hammarby Sjöstad's environmental program?
9	*The technologies* used in Hammarby Sjöstad.	What technologies used in Hammarby Sjöstad have been important to the implementation of the area's environmental program? Why and how was it important?
10	*Earlier performed research* focusing on Hammarby Sjöstad.	What earlier evaluations have been performed focusing on Hammarby Sjöstad? How was the ELP used in Hammarby Sjöstad?

building proprietors, consultants, GlashusEtt,[3] and public officers from the City of Stockholm (city managers, city planners, and developers).

Every interview was conducted face-to-face and lasted approximately 90 min. During each interview, all questions in Table 1 were discussed. All individuals were invited to the interviews by e-mail or letter. The respondents chose the place of the meeting, and they all

[3] GlashusEtt is a center for environmental information and communication in Hammarby Sjöstad. Here, the residents in the district can get advice on how to reduce their environmental impact.

received the questions for the interview by e-mail or letter a few days before the meeting. Each interview was recorded and transcribed.

3.1.2 Focus group meetings

In order to widen the thoughts on the questions in Table 1, and to verify the results from the in-depth interviews, four focus group meetings were held among stakeholders in the planning and development of Hammarby Sjöstad. All four focus group meetings had different themes. The first dealt with experiences from previous research (category 3, 4, 5, 9, and 10 in Table 1); the second with experiences from the vision and formulation of goals (category 1, 2, 4, and 5 in Table 1); the third with experiences from planning the district (category 3, 4, 5, 6, 7, 8, and 9 in Table 1); and the fourth with technological solutions used in the district (category 3, 4, 5, 8, and 9 in Table 1).

The criterion for the choice of focus group members was that he or she was found relevant as a result of the literature review or that an earlier interviewed respondent found the individual relevant to the study (Pandis and Brandt 2009). A total of 57 stakeholders attended the focus group meetings, and each meeting had 12–15 members. Out of the total of 57 stakeholders, 13 of these also attended the in-depth interviews. The group members included representatives from the project management team of Hammarby Sjöstad, the Stockholm Water Company, Fortum, Stockholm City Council officials, building proprietors, consultants, GlashusEtt, public officers from the City of Stockholm (city managers, city planners, and developers), researchers, architects, and representatives from technical enterprises.

The meetings were all successful and lasted approximately 2 h and were conducted as such:

1. First, each participant presented his or viewpoint on a few questions related to the theme of the focus group. These questions had been sent to the participants prior the meeting.
2. Second, there was a joint discussion in the group related to what had been presented.

All focus group meetings were recorded and transcribed.

3.2 Literature review

The literature reviewed former official documents, reports, published academic articles, and operative documents, focusing on the planning and implementation of the main environmental actions in the development of Hammarby Sjöstad. The objective was to explore the Hammarby Sjöstad project and the extent of earlier research on the subject matter and to identify gaps in earlier research that would guide subsequent data collection. All in all the literature review totaled over 1,000 pages.

3.3 Assessment of the operational goals

In order to evaluate the performance of the Hammarby Sjöstad district in relation to the aims and goals given by the environmental program, an assessment of the quantitative operational goals was made. Quantitative data were collected to measure the extent to which the operational goals were achieved. The quantitative data were found during the literature search, as well as directly from public administration personnel, developers, and entrepreneurs involved in the Hammarby Sjöstad project.

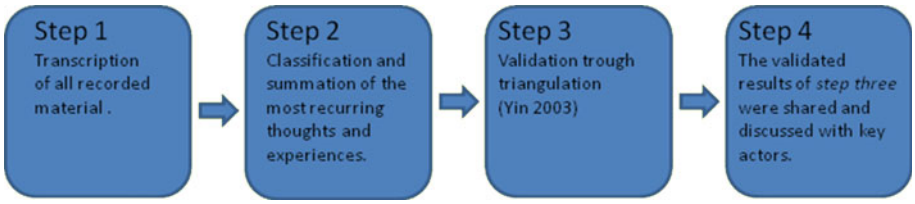

Fig. 1 The four steps in the analytical process

3.4 Analytical process

Figure 1 envisages the analytical process of the case study. In "Step 1", all recordings from in-depth interviews and focus group meetings were transcribed. During the transcription, focus was paid to the respondents' answers to the questions and emotional expressions were not transcribed (Kvale and Torhell 1997). In "Step 2", all transcribed materials were collected and classified in a table (Pandis and Brandt 2009). The classification was made according to the 10 categories in Table 1 and according to the type of source. This allowed comparisons between the results from the interviews and the focus groups, so that the most recurring thoughts and experiences relevant to the case study could be summarized.

To reduce the likelihood of misinterpretation, triangulation (Yin 2003) was performed in "Step 3". Accordingly, the summarized results of "Step 2" were compared with results found in the literature review and the assessment of the operational goals of the environmental program.

The fourth and final step consisted of a feedback meeting in which the validated results of "Step 3" were shared and discussed with the key stakeholders mentioned earlier. The comments and reflections from this meeting aided identification of the final results and conclusions of the case study. Thus, the analytical process was conducted up to the point of saturation, when no new insights were gained from the empirical material.

3.4.1 Validity and reliability

A number of strategies were deployed during the evaluation to achieve validity and avoid confirmation bias. First, the *multiple sources of data enabled triangulation* (Yin 2003) between the transcribed interviews, the transcribed focus group meetings, the different forms of documents, and the collected quantitative data. This meant that the examination was performed within and across the different sources of data. Second, *project meetings were conducted* in order to discuss the progress of the evaluation and its findings. Third, the *analytical process was conducted by a team of two*, which limited the confirmatory bias. This arrangement enabled both of the researchers to gain an in-depth understanding of the case study and to have regular meetings at which the emerging findings were discussed. Finally, *a working journal was kept* in order to achieve transparency of the evaluation and research process. In this journal, the working process, problems identified, research strategies, and ongoing research activities were described.

3.4.2 Limitations

First, the term *sustainable development* means different things to different people in different situations (Robinson 2004). This, of course, results in different definitions of what a

sustainable urban districts is (Basiabo 1996). In this paper, the sustainability of Hammarby Sjöstad relates only to the ecological aspects of sustainability, not the social and economical. This is due to the aims and goals specified by the environmental program of Hammarby Sjöstad (City of Stockholm 1996a). Second, the comprehensive evaluation of this case study was performed even though the development of Hammarby Sjöstad will continue until 2012. This was justified as 63% of the residential blocks were already in use in the district (Stadsbyggnadskontoret 2008), as were most of the workplaces, business premises, and infrastructure. Third, no residents of Hammarby Sjöstad were represented at the in-depth interviews and group meetings. This was due to their absence in the planning and development stage of the district, as Hammarby Sjöstad was a former large industrial and harbor area with no residents. Moreover, this was not a case study focusing on the perspective of the users. Fourth, the only primary data used in this case study were of a qualitative nature. All quantitative data originated from previously reported measurements and calculations.

4 Case study background

4.1 Sustainable development

In A Blueprint for Survival (Ecologist 1972), a distinguished panel wrote that "The principal defect of the industrial way of life with its ethos of expansion is that it is not sustainable". They meant that the foundation of survival for the human being is endangered due to the disruption of ecosystems, the growing population, and the consumption and depletion of resources. A sustainable society would, according to the panel, cause minimum ecological disruption, practice conservation, and maintain a constant population.

In the UN Brundtland Report from 1987, the call for sustainability was renewed and sustainable development was defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development 1987). This concept was later emphasized at the first World Summit on Sustainable Development in Rio de Janeiro in 1992 with the creation of Agenda 21, suggesting that all countries should formulate economic policies with minimum impact on the environment, and encourage social promotion of individuals and the community (United Nations 1992). Agenda 21 aimed at involving local authorities and suggested that they should adopt policies toward sustainability through processes of shared governance (United Nations 1992). In other words, the success of grand decisions and initiatives by policymakers concerning sustainable development was thought to be effectively achieved by acting on the local level of development, application, and implementation.

4.2 The sustainable city

In urban planning, no consensus exists wherein human settlements embody sustainability, and several sets of principles exist for sustainable cities, generally including environmental, economical, and social considerations (Basiabo 1996; Haughton and Hunter 2003; Haughton 1997). In 1990, the European Commission adopted two general approaches in contemporary urban sustainability: revitalizing cities by making them more compact and regenerating existing urban land (EU Commission 1990). Herbert Girardet argued that compactness alone would not lead to a sustainable city and distinguished the *circular*

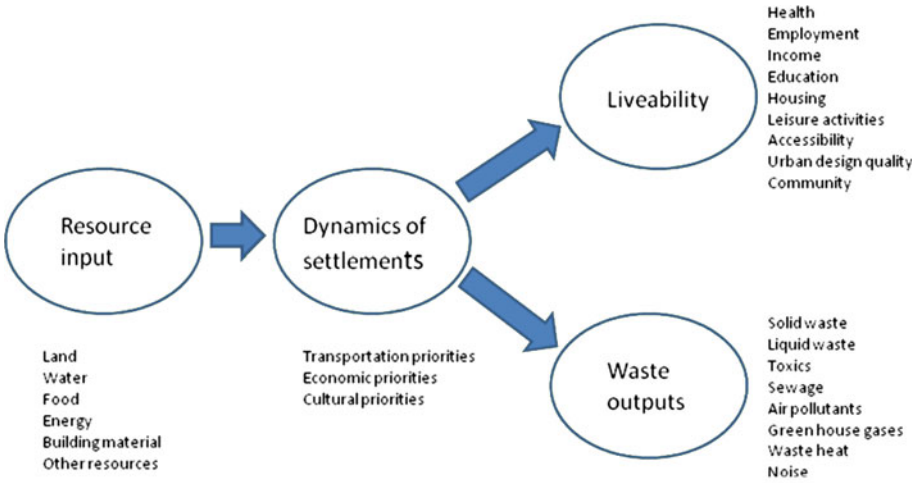

Fig. 2 The extended metabolism model for human settlements (Newman 1999)

metabolism of sustainable cities from the *linear metabolism* of modern cities (Girardet 1992). Girardet used the biological metabolism approached, and for a city to be sustainable, he meant that everything exported from the city (such as sewage, exhaust gases, and wastes) must be used to generate new plant nutrients, energy and new materials possible to be imported to the city all over again.

In the last decade, this perspective started receiving more and more attention in the municipal political agenda. Indeed, linear thinking has been leading us to increased consumption of natural resources and disposal of waste in the environment. Since then a number of scholars have done research in the field of urban metabolism (Newman 1999; Kennedy et al. 2007). As the metabolism approach to cities defined by Girardet was a purely biological, Peter Newman later extends the model (Fig. 2) and states that *"it is possible to define the goal of sustainability in a city as the reduction of the city's use of natural resources and production of wastes while simultaneously improving its liveability, so that it can better fit within the capacities of the local, regional, and global systems"* (Newman 1999). Liveability is about the human requirement for social amenity, health, and well-being (both individual and community well-being). Furthermore, Newman presented some typical sustainability indicators for cities covering metabolic flows and livability, which were developed for Sydney and other Australian settlements (State of the Environment Advisory Council 1996).

In addition, scholars in the field of industrial ecology have also been promoting the concept of metabolism and "closing the loop", as a mean to increase environmental performance (Tibbs 1992; Ayies et al. 1997; Dunn and Steinemann 1998; Korhonen 2001).

4.3 Hammarby Sjöstad: the sustainable urban district

By 2012, Hammarby Sjöstad will be a fully developed residential district containing approximately 11,000 apartments and accommodating 35,000 people. The urban development of Hammarby Sjöstad began in the early 1990s as the demand for housing in Stockholm rapidly increased. The area was regarded as attractive for residential purposes

since it is a natural continuation of the south of Stockholm's inner city, allowing thousands of new apartments and several thousand square meters of working space to be built, while at the same time avoiding further exploitation of green spaces. This is all in accordance with the EC approach to contemporary urban sustainability in 1990 *"to revitalizing cities by making them more compact and regenerating existing urban land*" (EU Commission 1990). In 1991, the first detailed comprehensive local area development plan for the city district was presented by Stockholm city planners (The Stockholm Town Building Office 1991).

In the mid-1990s, there was strong interest from leading politicians in Stockholm to host the 2004 Olympic Games, and Hammarby Sjöstad was suggested as a site for the Olympic Village in the Swedish application for the Olympic Games 2004 (City of Stockholm 1996b). Inspired by the UN Brundtland Report, the Agenda 21, and the call for environmental focus in the applications by the International Olympic Committee local leading policymakers in Stockholm wanted to create a sustainable urban district in Hammarby Sjöstad. In order to succeed, an environmental program (see Sect. 4.3.1) specific to Hammarby Sjöstad was formulated (City of Stockholm 1996a).

At the end of 1995, the Stockholm City Council accepted the application for the 2004 Olympic Games, which increased the political interest in the Hammarby Sjöstad city district (Engberg and Svane 2007; Bodén 2002; Green 2006). The City of Stockholm increased its ownership and right of possession within the district, and a special steering committee was formed. This committee consisted of the heads of the Stockholm City's offices and infrastructure companies. In order to shape and pursue the application for the Olympic Games, the steering committee was directly subordinate to the City of Stockholm's Executive Office.

On June 17, 1996, the environmental program for Hammarby Sjöstad was accepted by the Stockholm City Council (City of Stockholm 1996a), and in August 1996, Stockholm's application for the Olympic Games 2004 was sent to the International Olympic Committee. That same year the Quality Programme for Design of Hammarby Sjöstad was compiled and passed, the development contracts for Sickla Udde[4] were negotiated, the regulatory detail plan for Sickla Udde was initiated, and the Hammarby Model was formed (see Sect. 4.3.2) (Pandis and Brandt 2009). When the Olympic Games were awarded to Athens in September 1997, there were some uncertainties as to what would happen to the development of Hammarby Sjöstad. However, because the planning process for the district had progressed so far, the City of Stockholm decided to continue as planned and to retain the ambitions of the environmental program as a whole (Pandis and Brandt 2009).

4.3.1 The environmental program of Hammarby Sjöstad

Public officers from the City of Stockholm initiated Hammarby Sjöstad's environmental program in 1995. The intention was that it would work as a planning tool, coordinating the development of the district, and creating consensus on the different objectives for the district.

The outline of the program was inspired by the Sydney 2000 Olympics and aimed at reducing the metabolic flows of the district to a minimum. It incorporated a guiding vision of Hammarby Sjöstad, which stated: *"The environmental performance of the city district should be twice as good as the state of the art technology available in the present day construction field. As work progresses, the stated operational goals must continue to evolve*

[4] Sickla Udde is the name of the first area developed within the Hammarby Sjöstad project.

in this specific direction. In order to achieve these goals lifestyles need to be re-examined, new technological solutions developed, and a more holistic view of planning implemented" (p. 4); *"The city district is to be planned and built in accordance with the principles of the natural cycles"* (p. 4); and *"Hammarby Sjöstad is to serve as a spearhead for the movement towards ecological and environmentally friendly construction work and housing, and be at the forefront of international striving for sustainable development in densely populated urban areas"* (p. 7) (City of Stockholm 1996a).

To clarify the vision further, the program contained overarching aims. Examples of such aims included as follows: *"The natural cycles should be closed at as local a level as possible"*; *"Energy should be derived from renewable sources, and as far as possible obtained from local sources"*; *"Transport needs are to be reduced"*; and *"The knowledge, experience and technology generated in the process are to be disseminated in such a way as to contribute towards sustainable development in other areas"* (City of Stockholm 1996a, p. 7). These overarching aims acted as the starting point in the formulation of the operational goals created in an attempt to quantify the aims and render them of practical use in the development process for Hammarby Sjöstad. These goals were divided into nine different categories as shown in Table 2 and were all examples of reduced metabolic flows (Newman 1999; City of Stockholm 1996a).

4.3.2 The Hammarby Model

The Hammarby Model (Fig. 3) is an eco-cycle solution aiming to close the material and energy cycle of the Hammarby Sjöstad. It was created in cooperation between Fortum (formerly Birka Energy), the Stockholm Vatten AB and the Stockholm Waste Management Administration (formerly SKAFAB). The model is based on well-tried infrastructural

Table 2 Examples of operational goals divided into nine categories (City of Stockholm 1996a)

Category	Example of operational goals
Energy	"The total requirement of supplied energy is not to exceed 60 kWh/m^2 of which electricity is not to exceed 20 kWh/m^2 and the total being the sum of all residential energy consumption that includes energy from solar cells/collectors." (p. 15)
Transportation	"80% of all commuting using public transport, cycling or walking." (p. 16)
Material flows (waste and recycling)	"The total amount of recyclable and waste material, both of which is the responsibility of municipal authorities and various commercial interests, is to have been reduced by 20% in weight." (p. 16)
Water and drainage	"Water consumption (excluding re-circulated water) per person/equivalent is to have been reduced by 50% compared with the average supply to new housing in the inner city area." (p. 17)
Building materials	"Recoverable materials are to be used as far as is technologically and economically possible." (p. 17)
Land use	"100% of all developed land is to be recreated within, and adapted to, the district." (p. 18)
Contaminated soil	"Areas of contaminated soil are to be sanitised prior to development, to such an extent that they no longer represent a risk to either public health or the environment." (p. 18)
Lake restoration	"All storm water from roads and parking areas is to be purified." (p. 18)
Emissions/disturbances	"All housing is to have a noise-free side, where the equivalent noise level outside the window does not exceed 40 dB (A)." (p. 18)

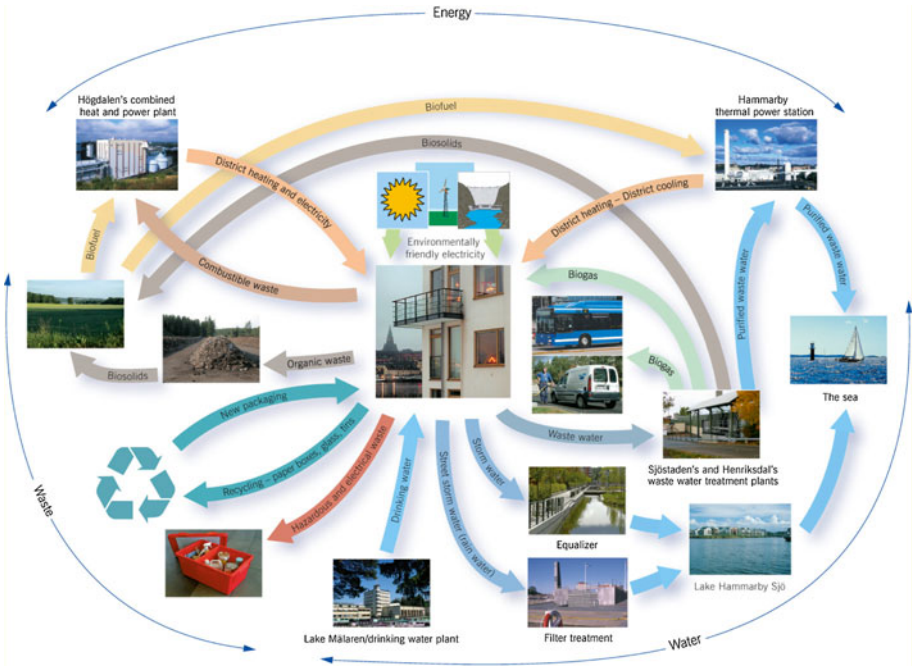

Fig. 3 The Hammarby Model (GlashusEtt 2006, p. 15)

techniques, used in several Swedish municipal areas, and was formed in order to achieve the central aims and goals of Hammarby Sjöstad's environmental program. It handles energy, waste, sewage, and water for both housing and offices, aiming to reduce the metabolic flows in accordance with the ideas of sustainable urban districts by Girardet and Newman (Girardet 1992; Newman 1999).

In brief, all buildings in Hammarby are connected to a district heating network. One of the main sources of energy in this network comes from domestic waste from which energy is recovered in a combined heat and power plant (CHP). Moreover, the purified wastewater represents another source of energy. After the treatment processes, it still contains heat that can be extracted and upgraded using a heat pump and fed into the district heating network. The remaining refrigerated water can then be used for cooling purposes in commercial and office areas. Finally, sludge resulting from the wastewater treatment process is digested in order to produce biogas that once upgraded can be used for transport purposes and for cooking application in biogas stoves. To summarize, most of what comes out of the district in the form of waste (domestic waste or wastewater) returns into the district in the form of energy (electricity, district heating and cooling, and transport fuel). In other words, in Hammarby, households that are usually at the consuming end of the supply chain become producers of valuable goods.

5 Findings

Findings of the case study are presented elsewhere. First, findings related to the implementation of the environmental program in the planning and development process of

Hammarby Sjöstad project are presented. Second, the outcome of the assessment of the operational goals of the program is outlined, aligned with some findings related to why some of the goals were attained and some not.

5.1 The implementation of the environmental program

5.1.1 The environmental program as a whole

Evidence provided by the in-depth interviews and focus group meetings shows that the vision *"the environmental performance of the city district should be twice as good as the state of the art technology available in the present day construction field"* (City of Stockholm 1996a) was vital for communicating the goals and gathering various actors from the different branches within the project. This confirmed findings by earlier studies that the vision had positive attributes, as it communicated the goals of the project, both internally and externally, and inspired actors to try new technical solutions (Forsgren 2008; Revisionskontoret 2007). According to the in-depth interviews and focus groups, the reason for the significance of the vision was its broad political support and its simplicity. The political support for the vision, also reported in earlier studies, highlights the importance of the political consensus created by the vision (Vestbro 2005).

Other results of the in-depth interviews and the focus group meetings underlined the fact that the environmental program was introduced late in the planning process of the district. According to the literature review, the comprehensive planning of Hammarby Sjöstad was initiated around 1990, when potential developers for Sickla Udde were identified by a preliminary land designation (Bodén 2002; Engberg and Svane 2007). Hammarby Sjöstad's environmental program was first accepted by Stockholm City Council in June 1996 (City of Stockholm 1996a).

5.1.2 The overarching aims and operational goals

The in-depth interviews and focus group work revealed that the overarching aims and operational goals influenced the choice of technological solutions in Hammarby Sjöstad, creating a focus on the environmental issues in the development process for the district. This further supports earlier research pointing out that the system-based Hammarby Model was created as a result of the overarching aims: *"The natural cycle should be closed at as local a level as possible"*; *"Energy should be derived from renewable sources, and as far as possible obtained from local sources"*; and *"Sewage is to be utilised for energy extraction, and its nutrient content returned to agricultural soil"* (Hellström 2005). In addition, the influence of the overarching aims and operational goals of the choice of technical solutions in Hammarby Sjöstad is manifested in the installation of solar cells (Brogren and Green 2003), the use of FX-ventilation systems (Danielski and Kunze 2008), the construction of the Hammarby Sjöstadsverket,[5] the provision of infrastructure for local storm water treatment, and the installation of the automated vacuum waste collection system.[6]

[5] Hammarby Sjöstadsverk is a R&D facility platform for development and exchange of knowledge and technologies in water treatment and related environmental technology.

[6] The automated vacuum waste collection system, also known as a pneumatic refuse collection or Automated Vacuum Collection (AVAC) system, transports waste at high speed through underground tunnels to a

Moreover, the interviewees and focus group members described the formulation process for the operational goals as insufficient. This statement is further supported by our assessment of the operational goals, which revealed that a number of goals had not been realized, some goals were vague and unrealistic, several goals lacked reference values, there was no baseline with which to compare the results obtained, and there were uncertainties with regard to the allocation of responsibility related to the assessment. The literature review revealed that the lack of reference values had been mentioned in earlier evaluations performed by the City of Stockholm. It also revealed that the developers in Hammarby Sjöstad found the operational energy goal *"The total requirement of supplied energy is not to exceed 60 kWh/m^2 of which electricity is not to exceed 20 kWh/m^2 and the total being the sum of all residential energy consumption that includes energy from solar cells/collectors"* unrealistic at an early stage of the development process and that this goal was adjusted upwards to 100 kWh/m^2 in 2005 by the City of Stockholm (Byggherregruppen 1997; Fränne 2005b).

5.1.3 The coordinated project organization

According to our study, the coordinated project organization was important in achieving the aims and goals of the environmental program. The literature review showed that the project organization was resourceful in gathering actors from different branches and in integrating external and internal contributions to the project. For example, the coordinated project organization initiated environmental competitions that encouraged the developers to find new environmental technological solutions in the construction process (Green 2006). Furthermore, the organization facilitated the formation of the Hammarby Model, the creation of the LogistikCenter[7] (Ekerlund and Stuhrmann 2003), and the formation of GlashusEtt.

On the other hand, the governing structure for the project was described as unsuccessful and ineffective in the in-depth interviews and focus group meetings. For once, the coordinated project organization agreed on writing the phrase "strive for compliance" in the development contracts for Hammarby Sjöstad, making the environmental program less authoritative (Engberg and Svane 2007). The phrase referred to the operational goals of the program and was the outcome of negotiations that took place due to the late arrival of the program and inconsistencies between some of the operational goals of the environmental program and the goals of the City's Programme for Ecological Construction[8] (Engberg and Svane 2007; Green 2006). Moreover, the literature review showed that the coordinated project organization did not strive to improve the formulation of the environmental program in order to make it more authoritative as the project proceeded (Engberg and Svane 2007). Furthermore, the literature review, as well as the in-depth interviews and focus group meetings, outlined that the political interest in the Hammarby Sjöstad project

Footnote 6 continued
collection station where it is compacted and sealed in containers. When the container is full, it is transported away and emptied. The system helps facilitate separation and recycling of waste.

[7] The LogistikCenter of the Hammarby Sjöstad project was created in cooperation between the City of Stockholm, developers and entrepreneurs. This was done in order to secure the time schedule of the project, to reduce the environmental load and also to attain a pleasant work and housing area.

[8] The development of the City's Programme for Ecological Construction was initiated in 1995 in cooperation between the different public administrations within Stockholm City Council, as well as in dialogue with the developers. The program was present in the development process, parallel to the environmental program for Hammarby Sjöstad.

decreased once Athens had been awarded the 2004 Olympic Games in 1997 (Green 2006; Bodén 2002; Vestbro 2005; Pandis and Brandt 2009).

5.1.4 The economical contribution of the LIP

The LIP was identified by the interviewees and focus group members as important in achieving the operational goals of the environmental program for Hammarby Sjöstad. The literature review showed that the LIP supported the construction of the Hammarby Sjöstadsverk, where methods were developed to improve wastewater treatment both in Hammarby Sjöstad and in other districts. Furthermore, the literature review indicated that the LIP helped initiate the installation of solar cells, solar panels (Brogren and Green 2003), fuel cells, biogas stoves, green roofs, and the development of local storm water treatment in Hammarby Sjöstad. Due to lack of documented data and reference values (see Chapter 5.4), the influence of these technical innovations on achievement of the operational goals was difficult to assess.

5.2 The assessment of the operational goals

5.2.1 The lack of valid data

It was found in the literature review that some important objectives were lacking in the environmental program. These included guidelines for the assessment process, a description of the allocation of responsibility related to the assessment process, and a comprehensive description of purpose and the goal formulation process. This is further supported by the assessment of the operational goals. In Table 3, which presents some of the results of the assessment, it becomes obvious that data specific to Hammarby Sjöstad are scarce. Moreover, the quantitative data found primarily consisted of statistics on measured and calculated energy consumption, amount of waste produced, and means of transportation used (Pandis and Brandt 2009).

The only comprehensive assessment tool found for the district was the ELP, developed during the development of the Hammarby Sjöstad project in order to assess the performance of the Hammarby Sjöstad district in respect of the vision *"twice as good"* (Brick 2008; Forsberg 2003). The results of the ELP tool proved to be based on theoretical data gathered in the planning stage of Hammarby Sjöstad, differing from actual measurements of, for example, energy consumption in buildings (Danielski and Kunze 2008; Brick 2008; Forsberg 2003). Furthermore, the interviewees and focus group members pointed out that the feedback, with regard to the achievement of the aims and goals of the environmental program, was unsatisfactory during the development of Hammarby Sjöstad, and that they did not fully understand the results generated by the ELP.

5.2.2 Achieved operational goals

According to Table 3, the following operational goals of the environmental program were achieved or partly achieved:

- "80% of the extractable energy from waste, and waste water, is to be utilised. However, first priority will be given to recycling and re-using materials, and to reclaiming the energy expended within the housing units themselves."

Table 3 Examples of achievements of central operational goals

Operational goals (City of Stockholm 1996a)	Example of achievement (Pandis and Brandt 2009)
Energy (p. 15)	
"The total requirement of supplied energy is not to exceed 60 kWh/m^2 of which electricity is not to exceed 20 kWh/m^2 and the total being the sum of all residential energy consumption that includes energy from solar cells/collectors."	The assessment shows that no residential buildings reached the goal, and the energy consumption varies to a large extent between the different buildings. The buildings with the lowest energy consumption use 95 kWh/m^2, of which 48 kWh/m^2 is electricity. Buildings with the highest energy consumption use 220 kWh/m^2, of which 43 kWh/m^2 is electricity.
"80% of the extractable energy from waste, and waste water, is to be utilised. However, first priority will be given to recycling and re-using materials, and to reclaiming the energy expended within the housing units themselves."	The assessment shows that 95% of the waste from Hammarby Sjöstads was combusted at the Högdalen combined heat and power plant, utilizing 90–100% of the energy content of the waste. Wastewater from Hammarby Sjöstad was treated at Henriksdal wastewater treatment plant, where biogas was generated from the extracted wastewater sludge. After Henriksdal wastewater treatment, the purified wastewater passed through heat exchangers at the Hammarby thermal power station, where the heat is regenerated as district heating.
Transportation (p. 16)	
"80% of all commuting using public transport, cycling or walking."	Inquiries among the residents of Hammarby Sjöstad performed in 2007 shows that 79% of the entire commuters walk, cycle or use public transport.
"15% of all motor vehicle transportation within the area using renewable energy (bio-based or electrical)."	No information was found on the subject of this goal during the assessment process. However, what was found was that the automated vacuum waste collection system that was used in the district reduced the transportation of household waste by trucks.
Material flow (waste and recycling) (p. 16)	
"The total amount of recyclable and waste material, both of which is the responsibility of municipal authorities and various commercial interests, is to have been reduced by 20% in weight."	Since the waste from Hammarby Sjöstad was not collected and treated separately, no specific statistics for waste of the district was found during the assessment of this goal. The total amount of recyclable waste material in Sweden has increased between 1994 and 2002. Also, a comparison between the amount of recyclable and waste material could not be performed due to the lack of references.
"The total amount of material delivered to the landfill, the remaining fraction, is to have been reduced by 60% in weight."	95% of all waste generated in the City of Stockholm was combusted, accounting also for Hammarby Sjöstad.
"The source-sorting of waste is to have been extended in accordance with regulations applying to producer responsibility, and should at least include the following categories: organic material, textiles, environmentally harmful waste, and hazardous waste."	Waste in Hammarby Sjöstad was sorted according to the responsibility of the producers. Newspapers, organic waste, and combustible household waste were sorted by the residents in refuse chutes connected to the automated vacuum waste collection system. Commodities hostile to the environment and other materials were sorted in local disposal rooms and at disposal plants near the district.

Table 3 continued

Operational goals (City of Stockholm 1996a)	Example of achievement (Pandis and Brandt 2009)
Water and drainage (p. 17)	
"Water consumption (excluding re-circulated water) per person/equivalent is to have been reduced by 50% compared with the average supply to new housing in the inner city area."	No information concerning the district as a whole was found during the assessment of this goal.
"All storm water is to be treated locally."	The storm water of Hammarby Sjöstad is treated locally, by filtration and sedimentation, and at the Henriksdal wastewater treatment plant beside the district.
"The nitrogen content of purified waste water from the Hammarby Sjöstad area is not to exceed 6 mg/l, and the phosphorus content 0.15 mg/l."	This goal was almost achieved in respect of the content of nitrogen in purified wastewater. Today, the wastewater from Hammarby Sjöstad, passing the Henriksdal wastewater treatment plant, contains 7.1 mg nitrogen/l. This goal was achieved in respect of the content of phosphorus in purified wastewater. The wastewater from Hammarby Sjöstad that passes through the Henriksdal wastewater treatment plant contains 0.13 mg phosphorus/l.
Building materials (p. 17)	
"Materials containing substances from the Swedish National Chemicals Inspectorate's restricted list are no longer to be used."	No comprehensive study of materials and chemicals used during the development of Hammarby Sjöstad has been found in the assessment.
"Recoverable materials are to be used as far as is technologically and economically possible."	No comprehensive study of the usage of revocable material during the development of Hammarby Sjöstad has been found in the assessment. Excavated earth has been used as far as technologically and economically possible, but no developer used recoverable materials in their constructions within the district.
Land use (p. 18)	
"100% of all developed land is to be recreated within, and adapted to, the district."	The district is developed in a former large industrial harbor where little initial natural environment existed. Today, 40% of the local plans of the district are represented by green areas such as courtyards and recreation grounds.
Contaminated soil (p. 18)	
"Areas of contaminated soil are to be sanitised prior to development, to such an extent that they no longer represent a risk to either public health or the environment."	This goal has been achieved, and all areas of contaminated soil have been sanitized.
Lake restoration (p. 18)	
"There is to be an increase in water turnover."	No comprehensive study of an increase in water turnover in Hammarby lake has been found in the assessment.
"All storm water from roads and parking areas is to be purified."	All storm water from streets with 8,000 vehicles/day or more is purified before letting it into the recipient Hammarby Lake. The storm water from streets with less than 8,000 vehicles/day is let out into the recipient without purification.

Table 3 continued

Operational goals (City of Stockholm 1996a)	Example of achievement (Pandis and Brandt 2009)
Emissions/Disturbances (p. 18)	
"All housing is to have a noise-free side, where the equivalent noise level outside the window does not exceed 40 dB (A)."	No comprehensive study with regard to this goal was found in the assessment.

- "The total amount of material delivered to the landfill, the remaining fraction, is to have been reduced by 60% in weight."
- "The nitrogen content of purified waste water from the Hammarby Sjöstad area is not to exceed 6 mg/l, and the phosphorus content 0.15 mg/l."

These goals were all related to the formation of the system-based Hammarby Model. It is a model primarily based on well-tried technologies with supplementary technical innovations (such as fuel cells, solar cells, solar panels, biogas stoves, and green roofs), attempting to reduce the metabolic flows of the district in accordance with the principals of biological ecosystems. The fact that these goals were attained shows that the creation of the Hammarby Model was essential to the implementation of the environmental program, as it reduces the metabolic flows of the district. Furthermore, it proves that it was the well-tried technological solutions—linked with the Hammarby Model—that helped achieve several of the operational goals and not technological innovations. This finding is further supported by the fact that technical innovations such as fuel cells, solar cells, solar panels, biogas stoves, and green roofs were used to a small extent in the Hammarby Sjöstad development (Pandis and Brandt 2009). Moreover, it is supported by the results of the assessment of the operational goals, showing that the achieved goals where closely related to performance of, for example, the Högdalen's combined heat and power plant and Henriksda's wastewater treatment plant.

The following goals were also achieved according to Table 3:

- "80% of all commuting using public transport, cycling or walking."
- "100% of all developed land is to be recreated within, and adapted to, the district."
- "Areas of contaminated soil are to be sanitised prior to development, to such an extent that they no longer represent a risk to either public health or the environment."

These goals were all related to the early planning stages of Hammarby Sjöstad, and they were taken into account in the first detailed comprehensive local area development plan for the district (The Stockholm Town Building Office 1991).

5.2.3 Operational goals never achieved

Literature, interviewees, and focus group members point out that Hammarby Sjöstad has become an attractive place to live due to the architecture of the district and the location close to the center of Stockholm (Green 2006). Yet, some of the operational goals of the environmental program were never achieved. Due to lack of valid and credible data, one can only speculate as to the reasons why. Partly, the explanation lies in the fact that there were conflicts between goals within the project. For example, earlier research showed that the energy goal *"The total requirement of supplied energy is not to exceed 60 kWh/m^2 of which electricity is not to exceed 20 kWh/m^2 and the total being the sum of all residential energy consumption that includes energy from solar cells/collectors"* conflicted with the

ambition to create large apartments with large windows facing Hammarby Lake in the north (Svane 2005; Green 2006). Furthermore, the goal *"The entire energy supply is to be based on renewable energy sources"* (City of Stockholm 1996a, p. 15) conflicted with the desire to build houses with flat roofs that prohibited installation of solar cells and solar panels (Brogren and Green 2003; Green 2006; Svane 2005).

Moreover, the behavior of the residents influenced the achievement of the operational goals. The interviewees and focus group members reported that the behavior of the residents in Hammarby Sjöstad hampered the achievement of several goals of the environmental program. They also pointed out that the idea in Hammarby Sjöstad was to solve most of the environmental issues with different technological solutions at a system level, so that the residents would not be burdened with this responsibility (Pandis and Brandt 2009). The assessment of the operational goals showed that several of them were influenced by the behavior of the residents. One example was the goal *"Water consumption (excluding re-circulated water) per person/equivalent is to have been reduced by 50% compared with the average supply to new housing in the inner city area."* This goal depended on the technology installed in houses and the amount of water used by residents. According to the results of our assessment, average water consumption in the households of Hammarby Sjöstad today is the same as for new housing in the inner city area of Stockholm (Pandis and Brandt 2009).

Last but not least, the limited use of technical innovations—such as fuel cells, solar cells, solar panels, biogas stoves, and green roofs—within Hammarby Sjöstad and that fact that the Hammarby Model did not help integrate such technologies, contributed to the fact some operational goals were not achieved (Pandis and Brandt 2009).

6 Discussion and conclusions

In this paper, we have tried to understand how Hammarby Sjöstad's environmental program from 1996 influenced the planning and performance of the district in terms of sustainable urban development. In doing so, we found that Hammarby Sjöstad had partly become a sustainable urban district, relating to the ecological aspects of sustainability, but that not all aims and goals of the program were achieved. Below, the findings of the paper are discussed and some interesting conclusions drawn. In addition, a number of suggestions for further research are presented, as this case study provided many more interesting research questions.

6.1 The success of the environmental program for Hammarby Sjöstad

This case study proved that Hammarby Sjöstad's environmental program is vital to the developing process of the area in its drive to create a sustainable urban district. The vision of the program, together with its overarching aims and operational goals, created a comprehensive perspective for the whole district, taking into account many different aspects in the design of the district, including transportation, energy flows, waste handling, and wastewater treatment. Moreover, the program and the coordinated project organization had broad political support, backing the development of existing and new technologies. Subsequently, Hammarby Sjöstad's environmental program brought the integration of environmental issues in urban district planning to a new level in Stockholm. This in turn underlines the importance of formulating a comprehensive environmental program in order to facilitate the creation of sustainable urban districts. The existence of an environmental

program, specific to an urban district, reveals the environmental aspects of the project, making them visible, feasible, and possible to address.

On the other hand, this case study shows that Hammarby Sjöstad's environmental program was introduced late in the planning process. This resulted in a hasty formulation process of the operational goals, leading to inconsistencies between the internal goals of the project and vague governance of the project. Ultimately, this obscured the implementation of the program and the achievement of the aims and goals of the project. To facilitate the implementation of an environmental program for future urban districts and improve the sustainability of these districts even further, the program should be introduced and integrated in the early planning stages of the district. This would help prevent a hasty formulation process and conflicts between internal goals in the project. It would also allow the creation of a well-thought-out governance structure. This is further supported by the fact that operational goals for Hammarby Sjöstad, supported by the early detailed comprehensive local area development plan for the district, were achieved.

6.2 The reduction in the metabolic flows in Hammarby Sjöstad

It is shown in this case study that the metabolic flows of Hammarby Sjöstad were indeed reduced as a result of the integrated system—the Hammarby Model. This points to the fact that Herbert Girardet, Peter Newman, and Christopher Kennedy were right, as they believed that a circular metabolism, rather than a linear, would help create sustainable cities (Kennedy et al. 2007; Girardet 1992; Newman 1999). Moreover, it supports the ideas of scholars in the field of industrial ecology promoting the concept of metabolism and "closing the loop" as a mean to increase environmental performance of urban districts (Tibbs 1992; Ayies et al. 1997; Dunn and Steinemann 1998; Korhonen 2001).

One can say that the reduction in the metabolic flows of Hammarby Sjöstad was vital to the characterization of Hammarby Sjöstad as a sustainable urban district, as technical innovations such as fuel cells, solar cells, solar panels, biogas stoves, and green roofs were used to a small extent. In order to improve the sustainability of future urban districts, one has to reduce the metabolic flows further. To do so, it is important to facilitate the integration of technical innovations into the installation of existing system-based technologies. Furthermore, it is important to focus, not only on the ecological aspect of sustainability, but also on the dynamics of the district and the liveability, as presented in the *"Extended Metabolism Model of the City"*, Fig. 2 (Newman 1999).

6.2.1 The lack of valid and credible quantitative data

This case study reveals that there was a lack of systematic assessment of the project goals during the construction process of Hammarby Sjöstad. This lack translated into a loss of valid and credible quantitative data, which made the assessment of the operational goals difficult and sometimes impossible, as shown in Table 1. Comparing within and across the different data sources, the case study showed that there were several reasons for the lack of systematic assessment of the project goals. First, the environmental program was introduced late in the planning and development process for the district, resulting in a hasty formulation of the operational goals. Subsequently, several goals were vague, unrealistic and without reference values. Second, there was a shortage of written guidelines and no demands written in the environmental program related to the assessment process, resulting in uncertainties with regard to the allocation of responsibility related to the assessment process. Third, there was a weak understanding of the ELP tool that due to uncertainties

with regard to the allocation of responsibility related to the assessment process became the only tool used to assess the environmental performance in Hammarby Sjöstad as a whole. This was problematic since the results of the ELP tool were based only on theoretical values from the design phase of the different stages of the Hammarby Sjöstad project and not on actual measured values.

In the development of future urban sustainable districts, it is therefore of the utmost importance to include a clear structure for the assessment process in the environmental program. This would ensure the quality of the assessment process and facilitate the development of even better sustainable urban districts in the future. With the lack of valid and credible quantitative data, it is impossible to ensure the sustainability of a given urban district. Furthermore, it will be difficult to interpret how to improve the performance of future urban districts in relation to urban sustainable development.

6.3 Further research

As the Hammarby Sjöstad project had been underway since 1990, and a large number of residential blocks, workplaces, business premises, and infrastructure were already in use, this case study was carried out in 2008 even though the construction of the district will continue until 2012. Therefore, there may be a need for additional evaluations focusing on the final development stages of the district. Such evaluations could determine whether this case study has influenced the construction process in the final stages of the project and also decide whether there has been any progression in the use of technical innovations. Moreover, as no residents were represented in this case study and the results showed that several operational goals in Hammarby Sjöstad were impeded by the behavior of the residents, further investigations are needed. These could encompass investigations on how the behavior of the residents can be influenced through technical adaptation and sustainable design of infrastructural systems, buildings, apartments, and office spaces in order to further improve the environmental performance in urban districts.

As shown in this paper, the formation of the Hammarby Model proved to be essential to the implementation of Hammarby Sjöstad's environmental program and the reduction in the metabolic flows of the district. However, the amount of energy generated by the model has not yet been quantified, opening the way for further research that could provide a deeper understanding of the Hammarby Model and thus guide the implementation of similar models in other districts.

Finally, there was a lack of a systematic assessment of the project goals during the development of Hammarby Sjöstad, which translated into a loss of valid and credible quantitative data, and cumbersome and sometimes unfeasible assessment procedures. In order to improve the systematic assessment of project goals during future projects and to ensure the quality of future assessment processes, further research is needed. The focus of such research should be the formulation of operational goals, the assessment process, and the organization needed to secure the quality of the assessment process.

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