CASE STUDY AND SUSTAINABILITY ASSESSMENT OF Bo01, MALMÖ, SWEDEN

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INTRODUCTION

The Bo01 high-density mixed-use development in Malmö, Sweden, was based on innovative planning procedures and products. A very broad definition of sustainability required new approaches in collaboration by the city, developers, planners, and designers. The outcomes of the project included outstanding aesthetics in the plan and the individual elements, as well as spaces that foster social interactions at the city, neighborhood, and block scales. A density of 26 residential dwelling units per gross acre balances the 50% open space dedication. Comprehensive planning for energy, water, and waste systems resulted in significant improvements, especially in energy production (100% is from renewable sources) and solid waste management. A wind turbine provides most of the electricity while a district-wide system supplied by a geothermal storage network provides almost all of the heating and cooling resources. Measures taken to replace and sequester toxic soils on the brownfield site were coupled with the concept for the stormwater system. The surface stormwater system provides a model of effective design, due in part to high permeability requirements. While admirable by American standards, the energy efficiency of most of the 70 buildings failed to achieve the project goals. Similarly, on-site biodiversity measures achieved mixed results. The cost of the residential units precluded a mix of residents of various economic levels typical of the city.

KEYWORDS

Bo01, sustainable development, mixed-use, urban housing, Malmö, brownfield development

BACKGROUND

Urban planning and design case studies are reviews of context, processes, products, and outcomes intended to advance the profession through inspiration and assessment. They give innovative professionals in the environmental design fields the confidence to pursue complex projects and they dampen the enthusiasm of the naysayers through empirical examples of success. Finally, they identify failures and qualified successes, point to possible revisions, and suggest how successes might be transferred to other contexts. This review is of the initial

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mixed-use development of the Western Harbor (Vastra Hamnen) in Malmö, Sweden. The project is titled Bo01 to designate its 2001 opening date, while "Bo" is the Swedish verb "to dwell (Guardian, 2005).

CONTEXT

Malmö, Sweden (population, 300,000) is a former industrial city with a dismantled shipbuilding economy. Destroying saltwater habitat by filling and hardening the surface and ocean edge originally created the supporting docklands called the Western Harbor. Access to Copenhagen, Denmark, and to the rest of Europe, was substantially improved in 2000 with the completion of Öresund Bridge, which includes highway and rail infrastructure.

The automaker SAAB purchased the docklands after the collapse of the shipbuilding industry but sold the 350-acre property to the city in 1996 shortly after it closed its own factory there. In addition to being land claimed from the sea, the decades of industrial use left a legacy of contaminated soil. Approximately $33.4 million from the Swedish government and $2.1 million from the European Union subsidized the cost of site remediation and energy-efficient infrastructure and building elements (Koch & Kersting, 2011).

Figure 1 identifies the extent of the Western Harbor and its relationship to Bo01 and the city. In 1998, the city initiated the redevelopment of the area outlined in green by beginning construction of the University of Malmö, which serves 24,000 students today. The new university is an indicator of the city government's strategy of replacing the industrial economy by building a knowledge economic sector. An environmental component was added to this program, due in part to the impact of the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, which encouraged local governments to engage in climate change mitigation and sustainable development. The result of these two impulses was the redevelopment of the brownfield docklands as a sustainable extension of urban Malmö.

FIGURE 1. The City of Malmö, showing the Western Harbor boundary in red and the urban development district in green. The blue asterisk is the location of Bo01. At the left edge of the image is the Öresund Strait. Image: Google earth 55° 34′ 24″N, 13°01′37E″ 2011, and Aerodata International Surveys, 2013, accessed September 8, 2013.

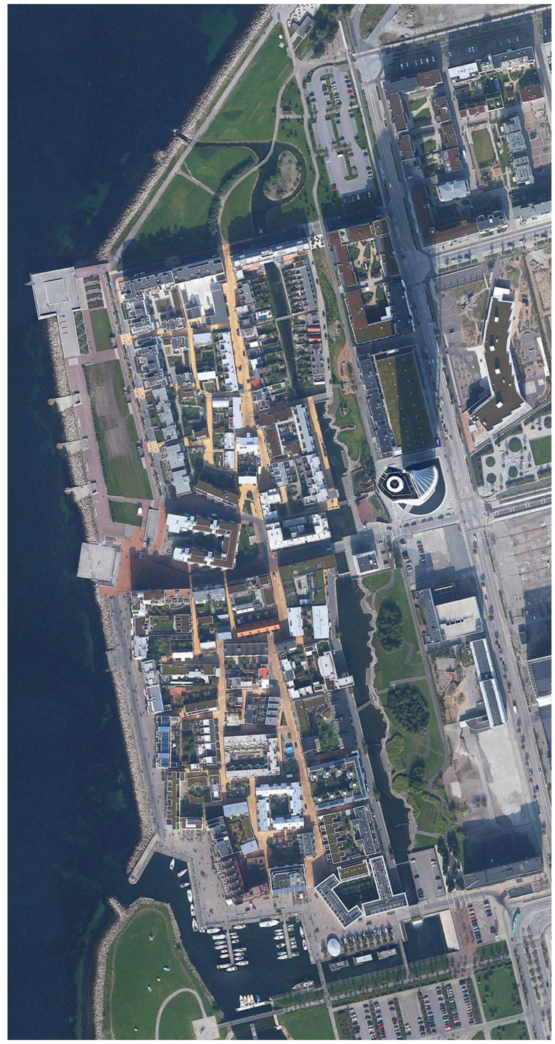
PROJECT DESCRIPTION

The first mixed-use development in the docklands undertaken by the city had the larger purpose of encouraging an international reconsideration of the city and its place in the 21st century. Bo01 became the setting and the subject of a City of Tomorrow international housing exhibition. The exhibition was intended to showcase sustainable planning and building technologies while providing socially supportive spaces and outstanding environmental values. The opening date of the exhibition established the planning and development timeline for the 54-acre seaside parcel (Figure 2). Today there are over 1,400 units and a population of 2,343 in Bo01 (Malmö, 2013).

PLANNING PROCESS

The sustainability accomplishments of Bo01 are attributable in part to the control the city exerted through ownership, goal formulation, and planning. The city hired Klas Tham, a well-known architect and planner, to establish the philosophical basis for Bo01 and serve as its preeminent designer and director. Tham balanced the technological goals of the project with an overarching concern for the social environment and elevating the aesthetic quality of the development. His remarkably holistic approach was transmitted to the city officials, departments, and developers through a "Creative Dialogue." Through a series of meetings and presentations, the participants developed the "Quality Program," which established performance requirements. The dialogue sessions modified and ratified the philosophy and goals of the project, but more importantly, they were a mutual learning opportunity for the city, project planners, and developers. The dialogue fostered an atmosphere of collaboration and innovation. The 20 developers selected for the project committed to material, technological, environmental, and architectural quality measures before any parcel was sold. Although time-consuming, the process resulted in rapid approval of the plans later submitted by the developers to the city. This was due to a clear understanding of the requirements and enhanced coordination and agreement between city departments (Givan, 2011).

FIGURE 2. The 2011 aerial view of Bo01 illustrates the seaside location and that the development is bracketed on every side with public open space. The Strait is on the left and the seawater canal is on the right. Image: Google earth 55° 34′ 24″N, 13°01′37E″ 2011, and Aerodata International Surveys, 2013, accessed September 8, 2013.

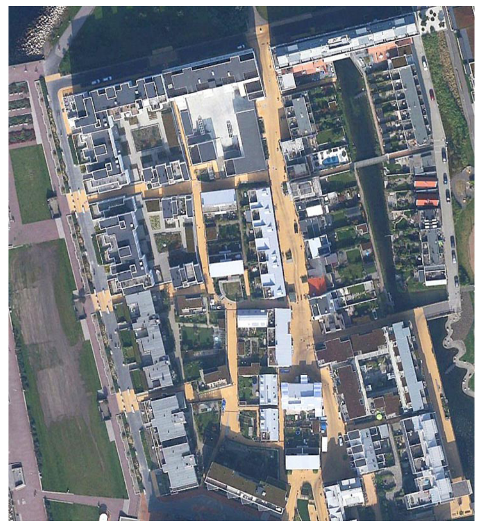


Since the city owned the property, it funded soil decontamination and the installation of the project infrastructure. The city was responsible for the master plan and sold small parcels to developers for site design, in coordination with the master plan and the Quality Program. The land purchase and decontamination of the soil in order to prepare it for redevelopment—rather than developing other sites with agricultural or habitat value—represents a substantial sustainability accomplishment.

MASTER PLAN

Comprehensive physical planning is a fundamental process of sustainable development and the master plan for the Western Harbor set the context for Bo01. A slightly distorted grid was created for all of the Western Harbor, establishing the vehicular and non-motorized transportation system. The variations in the grid shield use areas from the weather that buffets the district (Figure 3). In general, perimeter buildings form the coarse grain of the master plan while smaller buildings and spaces in the interior establish a more human scale within Bo01. This microclimate consideration was extended through the creation of largely enclosed mixed-use and residential courtyards. Twenty-six architecture firms and 20 development companies (City of Malmö, 2006) were assembled to create the amazing diversity of the neighborhood. This is in contrast to many multi-family projects where repetition of the same building design, regardless of orientation or context, results in a monotonous and depressing living environment.

FIGURE 3. In this view of the northern half of Bo01, the buildings on the west and north form a wind and weather barrier protecting the smaller and diversely organized interior buildings and courtyards. Unpredictable building orientation and placement create a dynamic character, full of surprising spaces and views within a pedestrian environment. Image: Google earth 55° 34′ 24″N, 13°01′37E″ 2011, and Aerodata International Surveys, 2013, accessed September 8, 2013.



DENSITY

The gross area of Bo01 is 54 acres, including the water area. The population density is 43 people per acre (compared to 7.6 people per acre for the city of Malmö) (Foletta & Field, 2011). There are over 70 buildings that provide 1,425 dwelling units. The resulting gross density is more than 26 dwelling units per acre. Compared to the 4.2 dwelling units per acre average density in the United States, the Bo01 rate represents a substantial reduction in the conversion of farm, forest, and habitat to human settlement. Although difficult to visualize, high dwelling density provides ecosystem benefits—or farm and forest preservation—that contribute to the sustainability of the city and region.

Mixing the plot sizes and architectural requirements so that the scale and character of the buildings differ on every block at Bo01 moderates the aesthetic impact of high residential density. The resulting variety and detail is outstanding. A mixture of unit sizes and ownership types enhances the heterogeneity of the population. One surprise has been a greater than expected number of young families that have purchased or rented dwellings in Bo01.

SCALE

Figure 4 illustrates five- to seven-story perimeter buildings that are located on the northern and western edges of the development. The scale of these building is a positive response to the adjacent expanse of the Strait and the parkland that separates the buildings from the water. The perimeter buildings protect two- and three-story internal buildings and their enclosed courtyards. All of the buildings engage the street at the ground level.

LANDSCAPE

Soil

Areas of the Bo01 site were contaminated with aromatic hydrocarbons. 7,850 cubic yards of these soils were removed and treated. They were replaced with clean fill and a 4′ thick layer of topsoil (City of Malmö, 2006).

Public Spaces

The landscape architecture at Bo01 is well designed and employs diverse and high-quality materials. Much of this urban landscape is comprised of plazas (Scania Plaza, Scania Portal, and Citizens' Square) and pedestrian circulation spaces, but there is significant green space dedicated to public use (Dania Park, the promenade, and Scania Park). Spaces dedicated to neighborhood use include Anchor Park and the many courtyard spaces associated with their enclosing buildings. There is even an "ecological playground" for children. Different landscape architects were awarded contracts for the various major open spaces. This, of course, resulted in contrasting design characteristics, but the spaces differ so greatly in context and exposure to the elements that the variety is largely in response to the setting.

FIGURE 4. Perimeter five-story buildings buffer smaller buildings on the interior blocks. Ankarspelet 23 Architect: Kim Utzon. Developer: MKB Fastighets AB. A portion of the Dania Park on the western edge of the development is visible in the foreground. Photo by author, 2012.

Biological Diversity

The shallow water in the Strait near Bo01 is biologically rich, partly due to dense eel grass vegetation. Therefore, one can assume that significant environmental damage occurred beginning in the 1840s when filling created the ship building yards. Furthermore, the biological diversity of the resulting brownfield was very low. However, there were nesting shore birds present. A 4.4-acre Bo01 habitat replacement project was undertaken elsewhere in the Western Harbor district (City of Malmö, n.d.) to compensate for potential habitat loss due to the redevelopment. In addition, establishing conditions favorable to species tolerant of human activity became part of the development program and a continuing activity by the city ecologist and local residents.

GREEN SPACE FACTOR

The ecologist for Bo01, Annika Kruuse, argues for an "increased ecological competence in the planning process as well as planning instruments, such as green space factor, for quality and quantity of greenery" (Ax:son Johnson Institute, pg.10, 2008). Two programs were developed for Bo01 to foster site sustainability. The first is the Green Space Factor requirement and the second is the Green Points system. The green space factor is a 1994 City of Berlin innovation

TABLE 1. Green Space Factor (Stenning, 2008; City of Malmö, 2002)

Type of area	Factor
Vegetation: Plant roots have direct contact with deep soil, and water can percolate into the ground water.	1
Vegetation: Plant roots don't have direct contact with soil more than 31.5″ deep, for example, gardens over architectural structure.	0.6
Intensive or extensive green roofs	0.8
Open water in ponds, etc. The area must have standing water for at least 6 months/year.	1
Non-permeable areas, including roofs	0
Stone paved areas, with open joints where water can infiltrate	0.2
Semi-permeable areas: sand, gravel, etc.	0.4
Green walls: climbing plants. The wall area that will be covered by vegetation within 5 years. Maximum calculated height: 30′	0.7
Trees with a trunk diameter of more than 1.4″ cm: calculated for the maximum area of 270 square feet. Two factors for each tree.	0.4
Shrubs taller than 9′: calculated for the maximum area of 54 square feet. Two factors for each shrub.	0.2

that essentially defines the percentage of the development parcel that must be permeable. The developers of parcels at Bo01 were required to achieve a green space factor of 0.5 (50%) or greater. The portion of the parcel that is impermeable receives 0 score while the proportion with permeable gardens and ponds receive a 1. Other measures, as shown in Table 1, were allowed to compensate where parcels were intensively developed with buildings and other impervious surfaces (City of Malmö, 2002). Therefore, a site with 25% impermeable roofs and paving, 25% green roofs, 25% garden space, and 25% permeable gravel paving would achieve a green space score of $(.25 \times 0) + (.25 \times .8) + (.25 \times 1) + (.25 \times .4) = 0.55$.

Following the example of Berlin and Malmö, the city of Seattle adopted a green space factor system in 2006, but it applies only to commercial development and sets a 30% standard (Stenning, 2008), instead of 50% as at Bo01, making it substantially less effective as a sustainability measure.

FIGURE 5. A combination of the green space factor and the green points requirements generate courtyards with vegetation diversity, biodiversity benefits, and a focus on stormwater infiltration. Photo by author, 2012.

GREEN POINTS

The Green Points list (Table 2) is another measure developed during the Creative Dialogue sessions and incorporated in the Quality Program to ensure that developers incorporate site sustainability measures but allow them to do so in a creative and context sensitive way. Biodiversity is a challenge in high-density urban developments, so developers agreed to incorporate at least ten of the 35 green point options within each development parcel. To achieve

TABLE 2. Thirty-Five Green Point Options (Stenning, 2008; City of Malmö, 2002)

A bird box for every apartment	A biotope for specified insects in the courtyard (water striders and other aquatic insects in a pond)
Bat boxes in the courtyard	No surfaces in the courtyard are impermeable (all surfaces are permeable to water)
All non-paved surfaces within the courtyard have sufficient soil depth and quality for growing vegetables	The courtyard includes a rustic garden with different sections
All walls, where possible, are covered with climbing plants	There is 11 square feet of pond area for every 54 square feet of paved area in the courtyard
The vegetation in the courtyard is selected to be nectar rich and provide a variety of food for butterflies	No more than five trees or shrubs of the same species
The biotopes within the courtyard are all designed to be moist	The biotopes within the courtyard are all drought tolerant
The biotopes within the courtyard are all designed to be semi-natural	All stormwater flows for at least 30′ on the surface before entering catch basins or pipes
The courtyard is green, but there are no mown lawns	All rainwater from buildings and hard surfaces in the courtyard is collected and used for irrigation
All plants have some household use	There are frog habitats within the courtyard as well as space for frogs to hibernate
In the courtyard, there is at least 54 square feet of conservatory or greenhouse for each apartment	There is food for birds throughout the year within the courtyard
There are at least two different old-crop varieties of fruits and berries for every 1080 square feet of courtyard	The facades of the buildings have swallow nesting shelves
The whole courtyard is used for the cultivation of vegetables, fruit and berries	The developers consult with ecological experts
Greywater is treated in the courtyard and re-used	All biodegradable household and garden waste is composted
Only recycled construction materials are used in the courtyard	Each unit has at least 21.5 square feet of built-in growing plots or flower boxes on the balcony
At least half the courtyard area consists of water	The courtyard has a certain color (and texture) as the theme
All the trees and shrubs in the courtyard bear fruit and berries	The courtyard has trimmed and shaped plants as its theme
A section of the courtyard is left for natural succession	There are at least 50 flowering Swedish wild herbs within the courtyard
All the buildings have green roofs	

good, long-term results, Bo01 has the services of an ecologist that monitors the stormwater system and green spaces. The ecologist also conducts an annual bird and bat inventory to compare the biological diversity with natural areas and encourages biological diversity through presentations to residents and school groups.

The biodiversity efforts of the city and development team are paying dividends. For example, nine species of seabirds breed at Bo01. Salamanders, frogs, and three species of bat are resident in the courtyards and the saltwater canal is proving to be valuable habitat for species of fish, shellfish, and crustaceans (Fry, 2009).

STORMWATER MANAGEMENT

Management of the quantity and improvement of the quality of stormwater runoff are important measures of sustainable development. Common critical issues such as channel flooding and downstream erosion are not relevant to Bo01 because it sits on the edge of the Oresund Strait. However, drainage of water away from the buildings and the quality of water entering the Strait are important here. To make the gravity flow system possible, the area between the Strait and the saltwater canal was raised 6′–9′. This was possible since the land and interior water bodies are artificial remnants of the industrial operations and could be configured by the redevelopment project without much environmental detriment.

Green roofs, water detention in courtyard ponds, and infiltration through gravel and other pervious paving initiates the stormwater system at Bo01. All of the stormwater conveyance is on the surface, which requires very accurate grading, novel structures, and outstanding construction quality (Figure 6). Water from downspouts and the stormwater that drains as sheet flow is directed through narrow channels to rain gardens and finally to either a saltwater canal or to the Strait. The runoff channels were designed to contain the five-year storm but the system has a much larger capacity due to the presence of green roofs and other pervious surfaces (Stahre, 2008). The saltwater canal near the eastern edge of the project receives stormwater from the eastern half of

FIGURE 6. The surface stormwater drainage system at Bo01 includes runnels that are less than 10″ wide and 14″ deep. The typical gravel infiltration bed and that the street side of the runnel is about 1½″ lower than the building side (Stahre, 2008). The grating and bridging provides access, safety, and extra detail. The black corrugated paving is a texture cue for the visually impaired. The multiple adjacent paving and drainage materials are similar to patterns in Japanese Zen gardens, such as Ryoanji. Photo by author, 2012.

the densely developed project. The western half includes the broad Dania Park and ample infiltration areas. Figure 7 illustrates the surface flow system and receiving waters for the stormwater runoff from the 31 inches of precipitation that is received annually.

The stormwater system components are exposed as unapologetic elements of the urban design (Figure 8). The granite blocks serve as visual markers to improve safety near the runnels.

Stormwater is directed to small, vegetated basins for infiltration and water quality improvement before discharge. Some of these basins are within the interior courtyards (Figure 9) while others receive water at the edge of the saltwater canal (Figure 10). The networked and distributed nature of these elements creates an unobtrusive and finely-scaled infrastructure. The fine materials and detailing make features of the stormwater system components whose function is evident even in the dry season.

Although all of the stormwater runoff is managed by the surface facilities, the percentage that receives treatment in the vegetated areas and the amount that overflows into the receiving waters during storms without treatment is unknown. One would expect 5%–7% of the project area to be dedicated to stormwater treatment landscapes in order to achieve significant water quality improvement. Bo01 does not achieve this, although a much higher percentage of green space is provided by the project. Instead, the stormwater is conveyed by the open drainage system to vaults along the saltwater canal where much of the water quality treatment occurs (Figure 10). The stormwater is pumped from the vaults to one of several treatment basins and water features within the courtyards. Therefore, the stormwater receives continuous treatment and serves as an ever-present aesthetic and environmental feature of the development.

Surveys of Bo01 residents confirm that the aquapoints (Figure 11) are highly valued

FIGURE 7. This plan of Bo01 diagrams the stormwater flow direction, the saltwater canal, and the smaller channels and basins that receive stormwater. Note the small "aquapoints in the interior of the project. Graphic by Stahre (Stahre, 2008), adapted by author.

FIGURE 8. The infrastructure is exposed rather than hidden from the residents. The granite blocks and corrugated edging prevent accidents by increasing visibility. Photo by author, 2012.

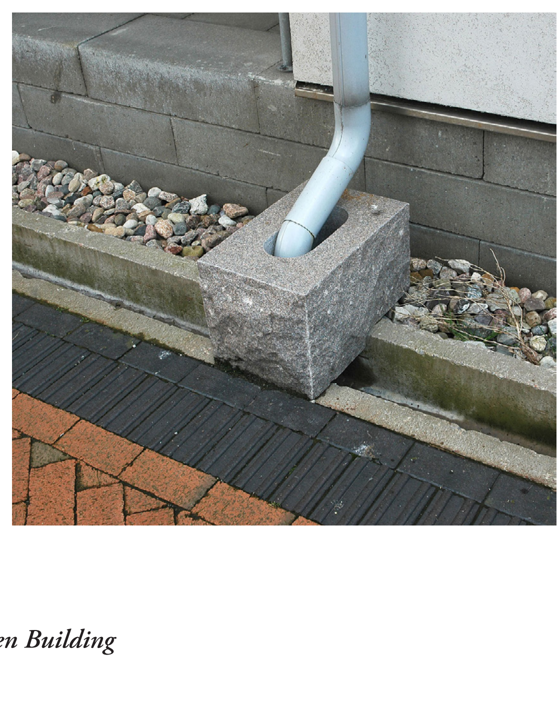


FIGURE 9. This fresh water marsh within a mixed-use courtyard is a more robust and effective stormwater treatment facility. The attractive vegetation and presence of water is a welcome contrast to the large paved areas near the Öresund Strait. Photo by author, 2012.

FIGURE 10. The stormwater areas are small but numerous. They treat small inflows and release them to another conveyance segment or into the saltwater canal as illustrated here. Recirculating the stormwater allows for multiple treatment opportunities. Photo by author, 2012.

FIGURE 11. This image shows another one of the "aquapoints" within a courtyard to which stormwater is recycled from a chamber along the saltwater canal. Photo by author, 2012.

features, as is the open drainage network. In fact, the surveys demonstrate a willingness to pay more for an open system than a closed one. It should be noted that Bo01 dedicates very little space to parking (0.7 spaces per unit) and roads, which are a primary source of highly contaminated stormwater runoff requiring extensive water quality treatment. Therefore, the runoff from this pedestrian-centric district is less highly contaminated than one would expect from mixed-use districts in the United States with extensive parking and vehicular streets.

SOLID WASTE MANAGEMENT

Organic kitchen waste is ground at the residence and collected in underground vaults, from which it is pumped to an anaerobic digestion chamber. The biological treatment of this slurry by bacteria creates biogas (methane), which is drawn off and used to power public buses or used to generate heat and electricity. Similarly, the non-organic waste is deposited in one of three vacuum tubes located in the residential courtyards or within the buildings. The waste is delivered to a central facility where it is either recycled or incinerated to contribute to the district heating system (City of Malmö, 2006).

RENEWABLE ENERGY

The energy emphasis at Bo01 was primarily development of renewable energy resources rather than highly energy-efficient buildings. Bo01 has the distinction of creating 100% of its energy from renewable sources including a wind turbine, solar tube and flat panel collectors, and geothermal (heat pump), in addition to the waste-to-energy conversion systems noted above. The 3MW Boel wind energy plant is located about 1½ miles away in the northern part of the Western Harbor. Additional electricity for use in the dwellings and to power the heat pumps, fans, and water pumps is generated on-site by photovoltaic cells. The distribution of renewable energy produced by the project is 6,300 MWh/year for heating, 4,459 MWh/year for electricity, and 1,000 MWh/year for cooling (European Commission, 2013).

In general, the largest energy demand in buildings is space heating and cooling. An efficient district heating system—augmented by solar collectors—provides this at Bo01. The heating/cooling system uses geothermal technology. Heat pumps connected to an aquifer contribute heat in the winter and cooling in the summer (City of Malmö, 2006). To provide heat in the winter, warm summer seawater (70°F, 21°C) is stored in a limestone aquifer. Conversely, cool winter seawater (61°F, 16°C) is stored in an aquifer for use in district cooling during the summer. Ten wells, 210′ deep, were drilled into the aquifer. The wells, spaced 50′ apart, are organized into two rows 600′ apart. The warm water is pumped to the district heating system and accounts for the majority of the heating resource.

The district heating system is augmented by 1,200 m^2 of flat panel solar collectors and 200 m^2 of evacuated-tube collectors (Figure 12). These two types of solar collectors on ten buildings generate 15% of the energy used to heat the buildings.

ENERGY USE GOAL

An average energy maximum of 33.3 kBTU per square foot of floor area per year (105 kWh per m^2) was adopted as the sustainability target before the project was constructed (City of Malmö, 2006). This target was a 40% reduction of the Swedish average. Several of the buildings within Bo01 have met this target, such as a building constructed by Passivhus Norden, which achieved an energy use of 20.6 kBTU/sq ft/year (Koch & Kersting, 2011) or the 27.6 kBTU/sq ft/year performance of the LB-hus, but most of the buildings have not met the target. A study in 2003 reviewed one year of energy use records and found that the average use for buildings with heat recovery was 40.3 kBTU/sq ft/year while for buildings without heat recovery the average use was 59 kBTU/sq ft/year (Nilsson, 2003). To put this performance in perspective we can compare it with the energy performance of multifamily units in the United States. The average energy use for multifamily units (more than 5 units in the building) in the U.S. is much higher than the Swedish average of 55.5 kBTU/sq ft/year. In the northeast U.S. the average use is 94 kBTU/sq ft/year while in the midwest it is 68 kBTU/sq ft/year (US Energy Information Administration, 2009). In other words, in the U.S. the average energy use in similar dwellings and in a similar climate is 41% higher than the Swedish average energy use. Although overall Bo01 failed to meet the 33.3 target, individual buildings within the project do demonstrate highly efficient buildings whose design and energy technology can be transferred to other projects in the Western Harbor and internationally.

FIGURE 12. The Tegelborgen building by architect Månsson Dahlbäck and developer MKB features evacuated-tube solar collectors. Photo by author, 2012.

There are two reasons for less widespread success in meeting the Bo01 target. First, the calculation method (ENorm) used by the developers to estimate building energy performance was not accurate due to overestimation of solar heat gains (Nilsson, 2003) through the large windows that are a feature of many of the buildings (Figure 4). Second, there were no special heat conservation practices implemented in the buildings with the exception of ventilation heat-recovery in some of the structures. Triple glazing for windows is standard in modern Swedish buildings. Insulation thickness in the buildings also followed standard practice in Sweden. The affluence of the residents may also limit their economic motivation to conserve energy in order to reduce monthly costs.

SUSTAINABLE TRANSPORTATION

Because of the short distance to the central district of Malmö, Bo01 is well served by paths dedicated to pedestrian and bicycle use. A little more than five miles of bike paths extend from Bo01 through the Western Harbor. This district continues the trend of non-motorized transportation in a city where over 290 miles of bicycle paths are provided. In Malmö, 40% of trips to school or work are made by bicycle and 30% of all trips are by bicycle (Reepalu, 2013).

All residents of Bo01 are within 1,500 feet of a bus stop and buses operate on a seven-minute schedule (City of Malmö, 2006). The central train station, with its associated bus transfer center, is 1.5 miles from Bo01. Car ownership is higher in Bo01 than anticipated and therefore the .7 parking spaces per unit that are provided do not adequately meet the demand. To compensate, a parking garage was recently built at the edge of the development. Nevertheless, car ownership remains lower than in the city as a whole and residents of the Western Harbor walk and bicycle significantly more and drive significantly less than Malmö residents overall. Bus ridership is about equal to the city average (Foletta & Field, 2011).

SOCIAL SPACES AND AESTHETICS

Klas Tham emphasized the aesthetic and social components of sustainability in developing the philosophy and guiding plan for Bo01. Sustainability in energy, resource use, and water should not compromise the quality of life of the residents. Therefore, Tham promoted a neighborhood with great variety in the architecture and the landscape. He wanted the residents to love the way their neighborhood looked and the way it functioned. He wanted it to sustain and satisfy them as well as be environmentally sustainable. Consequently, placemaking that takes advantage of the setting and the design creativity of planners, architects, and landscape architects was critical to the success of Bo01. Since slightly more that 50% of the area is open space, many social spaces were designed within a diverse landscape.

LANDSCAPE ARCHITECTURE

Indeed, there are many beautiful and compelling places. The simple and powerful Dania Park, designed by Sweco, relates to the sea with prow-like extensions over the water and bastions of stone, but contrasts these with notches for warm weather access by swimmers and sun seekers (Figure 13). Another simple and powerful place is the promenade and stepped wooden berm by Danish landscape architect Jeppe Aagaard Anderson that follows the Strait for 660′. It teems with residents and visitors in the summer.

The Scaniatorget (Scania Portal) by 13.3 Landskapsarkitekter steps into the water of the Strait. Rough-hewn stone blocks, from which broad wooden platforms cantilever, form the

FIGURE 13. Daniaparken includes a protective edge, swimming and sunning facilities, as well as a large panel of turf, promenades, and ornamental gardens near the buildings. Architect: Sweco FFNS ark AB. Developer: City of Malmö. Photo by author, 2012.

FIGURE 14. Scania Portal (Scaniatorget) includes etched pathways for stormwater to reach the sea with an austerity and restraint reminiscent of Zen gardens. Landscape Architect: 13.3 Landskapsarkitekter. Developer: City of Malmö. Photo by author, 2012.

FIGURE 15. The Winter Garden (Vinterträdgård), designed by Monica Gora, is an atrium nestled among the Södertorpsgården buildings designed by Arkitektgruppen i Malmö AB. The Scania Portal plaza is in the foreground. It is framed by the Södertorpsgården buildings while in the background the iconic landmark of Bo01, the 627′ tall Twisting Torso by architect Santiago Calatrava/Samark Arkitektur & Design AB punctuates the skyline. Photo by author, 2012.

plaza (Figure 15). The stone blocks feature whimsically carved stone runnels (Figure 14) directing stormwater to the Strait. The wood deck invites seaside picnics and outposts for views of the docks to the north (Figure 13) and the investigation of the runnels by visitors. Inland views feature Dania Park's lawn and promenade to the northeast, the diverse bounding architecture, and the gem of the Winter Garden (Figure 15) nestled between the buildings facing the esplanade. Since the plaza of the Scania Portal connects with Citizen's Square (Figure 16), the two spaces serve as the central civic space of the community.

There are opportunities for residents to engage each other at the building and community scales. Several spaces within and adjacent to Bo01 can host community and even citywide celebrations. The broad lawn and walks along the sea in Dania Park are capable of containing thousands of people, as is Scania park at the northern edge or the huge Ribersborgsstranden green space at the southern edge of Bo01. At the neighborhood scale the Citizens' Square and the Scania Portal are the main paved urban spaces.

In contrast to the seaside parks with their hardened, protective edges, Anchor Park offers more detail and an introverted character rather than the dramatic views and scale of the western landscapes (Dania Park, Scania Portal, Promenade, and Scania Park). Designed by Stig Andersson, the 7-acre (2.9 ha) linear park (Figure 17) follows the saltwater canal along the eastern edge of Bo01. The canal is fed by pumping seawater to the midpoint of its length. From there the water flows north to the Strait and south to the Marina (Persson & Tanner, 2005). A concrete walk with insets of natural stone boulders and cylindrical concrete seating defines the canal's orientation and edge. The exaggerated biomorphic, concrete walkway separates the water from a linear panel of turf that is punctuated by alder, oak, and beech groves in a nod to Swedish native habitat types. These are too small to provide real ecosystem functions and therefore are also of little educational value. In the case of the alder stand, the correct water regime is absent due to a construction error (Persson & Tanner, 2005).

Although the character of the hardened canal edge is memorable, it removed the opportunity for a saltwater biotype that would have greatly enhanced the diversity of the project. Welcome bits of whimsy are the abstracted waterstrider planks distributed throughout the park. At times they are functional as bridges, but more often they are shore-water connections inviting exploration of the depths or singularly exquisite (and exposed) sunbathing spots.

CONCLUSION

Bo01 was a high-risk enterprise inspired by a city in crisis. Mounting the largest European housing exposition was an intrepid step exposed to the scrutiny of the international community. In order to succeed, innovative

FIGURE 16. The Citizens' Plaza (Scaniaplatsen) is a two-level space divided by a stone sculpture that is animated by stormwater recirculating from a cistern on the seawater canal to the east. The fountain is one of several "aqua points." The ubiquitous granite runnels connect all parts of the project. The plaza broadens beyond the building and connects to the Scania Portal forming the heart of the community. Photo by author, 2012.

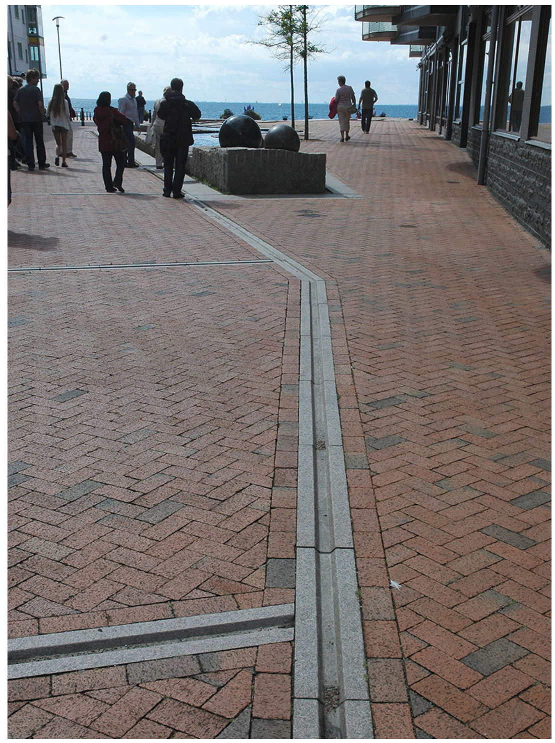


FIGURE 17. Ankarparken, designed by landscape architect Stig Andersson and developed by the City of Malmö. The blue Lanternan building is in the distance. It was designed by Metro Arkitekter AB and developed by Plastikkirurgicentrum. Photo by author, 2012.

planning methods that emphasized the collaboration of government, designers, and developers were created through "Creative Dialogues" to produce a consensus of what could be accomplished under a time constraint. The result was the Quality Program, a simple document outlining the minimum standards for architecture, landscape, energy, water, waste management, and biodiversity. Included in the Quality Program are the Green Space Factors and the Green Points list that reinforce the master plan and resulted in beautifully diverse and effective landscapes (City of Malmö, 2002). The holistic definition of sustainability by the visionary planner resulted in aesthetics and social opportunities that matched the high levels of technical performance. The project supports human physical and psychological health through immediate access to open space, walkable neighborhoods, and opportunities for social interaction or solitude.

There were missteps, of course. The cost of the units was too high to serve moderate and low-income residents. The desirability of living in Bo01 exacerbated this problem since demand caused unit prices to double between 2001 and 2007. However, the success of the development validated the planner's contention that high quality architecture, landscape architecture, and attention to the social environment were important aspects of sustainability. The energy efficiency goals set in the Quality Program were not met due to the method used to calculate the energy budget of the proposed buildings and perhaps because the energy supply was not a limiting factor.

There are many significant accomplishments equal to the amazing 100% renewable energy system. With over half of the development area dedicated to open space, the population density is a positive example of a compact urban settlement that doesn't diminish the residents' quality of life for the sake of density. The landscape is diverse and beautifully illustrates responsiveness to the environmental context. The public spaces are compelling and attract local and foreign visitors to the seaside. The semipublic courtyards offer increased detail and privacy, create supportive microclimates, and implement biodiversity measures. The demonstration of a surface-only stormwater management system is an important achievement. The designers showed how planning and attention to detail can solve functional, aesthetic, and safety concerns and create a project feature valued by the residents.

The impact of Bo01 is significant. Thousands of professional planners, architects, landscape architects, and others interested in innovative housing and urban development visited the project during the exposition and since. The high profile of the project caused the positive and negative aspects of the project to be publicly disseminated internationally. Within Sweden, and especially within Malmö, the successes of Bo01 and the subsequent revisions to correct problems have been incorporated into other developments.

The goals of the next phase of the redevelopment of the Western Harbor (Flagghusen, a 16-building, 600 apartment unit project) were adjusted to increase the parking capacity slightly (.75 parking spaces per unit), to increase the density significantly, to decrease the purchase and rental cost of the units, to improve both the energy use calculation methods and to rely on more cost effective methods to achieve more modest building energy efficiency goals (120 kWh per m^2 instead of 105) (Foletta & Field, 2011; Ritchie, 2009). The green space factor and green points concepts have been adopted by the city for system-wide application. Surveys of the residents illustrate great satisfaction with the neighborhood and the units with the exception of some consternation about a presumption by the citizens of Malmö that public funds were expended to provide facilities for wealthy residents. This exaggeration was perpetuated by the local media when the exposition company received a loan from the city to avoid bankruptcy resulting from a lower than projected number of fair visitors (Jansson, 2005).

Perhaps more than any other development Bo01 created a community with the variety, detail, and diversity that eludes master-planned communities with fewer participating architects, landscape architects, and developers. The character of the project interior is outstanding.

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