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HIGH AMBITION MEETS HIGH REALISM (WITH HIGHLY ACCEPTABLE RESULTS). QUANTIFIED AIMS AND MEASURED PERFORMANCE IN PILESTREDET PARK, OSLO

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Summary

In Pilestredet Park in Oslo, a multi-thematic environmental programme defines quantified aims within a wide variety of ecological themes. About 1000 dwellings will be built. The paper is based on measured results from the first project, containing 155 flats, and having a gross area above ground of 12000m2. Important results: 98% (weight) reuse of demolition materials. 75% reuse of construction waste. More than 25% (weight) reuse of materials in new buildings and landscaping. Visible reuse of old building components in outdoor areas. 50% reduction in energy consumption compared to national average, 25% reduction compared to recently revised building codes. System for delayed run-off of surface water. Green roofs and roof terraces. Clean site measures applied. Measures for reduced spreading of dust, noise and vibrations applied. Materials screened to prevent harmful substances from entering the material cycles. Resulting indoor air quality monitored. Architectural integration of measures related to saving of energy and spreading of daylight.

1. Place and players

Pilestredet Park in the city centre of Oslo is the new name of a 73.000 m2 site left vacant when the National Hospital of Norway moved out in 2001. Near half of the original 110.000 m2 of floor area were demolished and substituted by 75.000 m2 in new buildings. Adding refurbished areas, the finished project will have a gross floor area of about 135.000 m2, containing about 1000 dwellings together with shops, offices and educational facilities.

About 600 of the flats are being built by a joint development venture owned by the housing division of Skanska Norway, and OBOS, Norway´s largest cooperative housing organization. The author is partner in GASA architects, environmental coordinators in the design phase, and responsible for architectural design in cooperation with Lund & Slaatto architects. Most of the data presented in this paper relates to site H, which was the first to be completed, and where the basic strategies were developed. It contains 155 dwellings and has a gross area above ground of 12.000 m2. Figure 1 shows overview and a typical section of the development.

Pilestredet Park marks a transition from small-scale pilot studies to large-scale urban implementation of principles of sustainable building in Norway. The aims, the measures and the results are well documented and are relevant to a large class of similar developments.

Figure 1. Overview of Pilestredet Park (left) and a section of the finished building on site H (right)

2. Punch or popularity

Within the field of sustainable building, different projects play different roles. Many are focused on innovative concepts developed by individuals, groups of researchers or small firms. They provide a growing base of knowledge to be utilized by the building industry. A few projects, like Pilestredet Park, are large and initiated by ecological programs. They are carried out by leading market players, and are expected to be completed within normal time limits and with normal returns on investment.

This last group of projects implements the results of the smaller projects, and have the potential of moving entire industries in the direction of sustainability. One should think they were inherently popular. Not necessarily. The developers may be sceptical, because they do not know the economical implications of the environmental programmes and aims. Environmentalists may be suspiscious, because control must be handed over to profit-seeking developers. The researchers and research councils may think that the innovation and the risk involved are too limited. And for the ecoarchitects, approaching mainstream may not be fun at all. As environmental coordinator, the author met all the above reservations in the early stages of the project.
As work progressed, the worries and suspicions gradually went away, thanks especially to an enthusiastic site team from the contractor Skanska Norway lead by Arne Linja, an experienced engineer and builder.

3. Programming and implementation

For the Pilestredet Park project, The Directorate of Public Construction and Property in Norway (Statsbygg) developed a multi-thematic environmental programme. Two features sets this programme apart from other Norwegian examples. Firstly, it has an unusually broad scope, covering all the central ecological issues. Secondly, it sets up quantified aims, which in turn requires systematic analyses and finally verification by measurements.

During the design and construction process, some aims were proven to be unrealistic, and other referred to inadequate methods or units. These matters were adressed and the program modified. It is much better to put forward a quantified aim and find that it was unachieavable, than to resort to the diffuse environmental objectives that too often dominate development programmes.

A control plan was developed that translated the environmental programme into simple instructions for design development, surveys and calculations. For each task, a deadline was defined and the responsible firm and person named. If external control was required, this was noted in the plan. A control form was also developed, which summarized the status of aim achievement. For the construction phase, efforts were made to integrate the environmental requirements into the control systems that already were in operation within the participating firms.

A lesson learned from the implementation process is that the environmental programme should be structured into a few main themes, for example energy, water, materials, etc. It is more important that the themes are few than that they are clean. In the Pilestredet programme, aims related to materials appeared under several main chapters, like utilization of resources, external environment and health/security. In the control plan, the aims related to materials had to be extracted and grouped, because the measures to be taken were closely related, and in many cases should be handled by the same consultants or contractors.

The environmental programme should be separable from the implementation procedures. Programmes are for early stages and strategic decisions. The following up is for project leaders and consultants and contractors. Lately, environmental programming seems to be turning into an industry. If not treated with great caution, the formal structures, weighing procedures and fact files of new programming tools may produce mountains of words and figures that separate sustainable building theory from sustainable building practice.

A final advice is that (obviously) the environmental objectives must be formulated before the area plans are laid down. The town plan should lay the foundation for projects that meet the ecological requirements. In Pilestredet Park, the building volumes and locations were defined by an area plan that was implemented before the environmental programme. The rules embedded in the plan put limits to the utilization of solar energy and dayligt. The regulated combination of building heights and depths defined a potential maximum floor area that formed the basis for the bidding for the site. Later, it was very hard to change the cost/area equation. The depth of the buildings, 14m in this case, affects the internal layout of the plans in a profound way. Important architectural features of the projects were decided before a line was drawn by the architects.

4. Overview of measures

Figure 2 gives an overview of the measures that were implemented to reach the aims of the environmental programme. The energy and water measures are examples of solutions that had to be based on calculations. In other cases the environmental requirements were easily translated into design instructions. This was the case for outdoor areas, where 30% of the available area should be covered by plants of varying size.

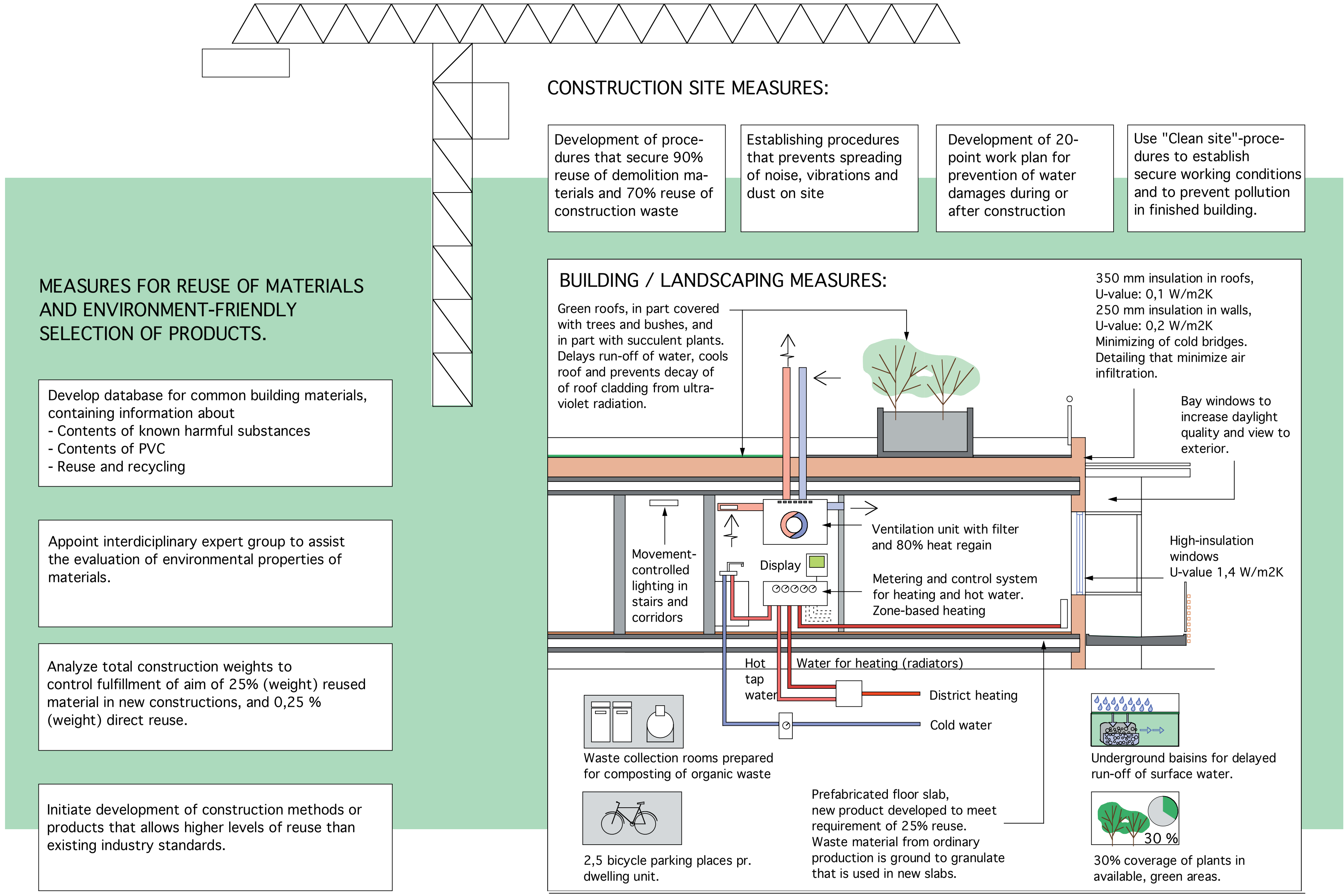

Figure 2 Overview of measures

5. Demolition and reuse

The environmental programme specified that 90% (weight) of the demolition masses should be reused. Just a few years ago, the national average in Norway was 5%. Selective dismantling was applied wherever practicable. In this way, slate cladding and wooden structures from the roofs were sorted out for reuse. Granite details were stored for future use in landscaping. Concrete, brick and plaster were ground in an on-site plant. Some of the ground-down materials were used in landscaping, but most was reused in roads and landfills as close to the site as possible. Before and during demolition, surveys were carried out to spot and extract harmful substances.

The buildings along the perimeter of the site were left standing as long as possible, working as a sound barrier between the stone-crushing plant and the surrounding streets.

Table 1 shows the accumulated reuse of materials, which turned out to be 98%, which is remarkable. Directly reused materials accounted for 2.7%, almost ten times the aim of 0.25%.

Table 1 Reuse of demolition materials in Pilestredet Park
Sources: Skanska Norway/Arne Linja and Master thesis by J.T Midtbø NTNU 2004

Material	Measure	Direct reuse [tons]	Recycled [tons]	Deponi [tonn]
Reinforced concrete w/ porous concrete aggregate				209
Ground brick/ concrete	Crushed on site and sorted in fraction 0-8mm, 8-22,4mm, 22,4-120mm. Used in fills and concrete production. Ca. 9000 tons used in Pilestredet Park		47 773	
Ground pure concrete			16 169	
Polluted brick and concrete	Used in land fills for land slide prodection in Skedsmo municipality. Approved by the government.		18 536	
Asphalt	Transported to disposal for processing			107
Wood	Ground and used for energy		997	
Steel reinforcement	Recycled		2 999	
Other metals	Recycled		173	
Electric cables	Delivered to plant for processing of EE-waste (electric and electronic)			56
Classified waste	Delivered to plant for processing			107
Mixed waste	Mainly asphaltic roof membranes. Delivered to planf for sorting			976
Gypsum boards	Returned for recycling		285	
Glass without PCB				329
Glass with PCB				3
Granite components and foundations	Stored for future use in landscaping and housing projects	2 328		
Other materials stored for reuse	Mainly sold on market for used building components. Windows, doors, sanitary equipment etc. stored for sale or reuse on site.	119		
Sum		2 447	86 932	1 787
Total weight of Demolition masses		91 166		
Weight % of total mass		2,68 %	95,36 %	1,96 %
Weight % for reuse or recycling	98,04 %			

6. Construction

In the Skanska/OBOS projects, steel columns and beams carry hollow, prefabricated floor slabs. The perimeter walls have a wooden framework filled with 200mm mineral wool, and clad on both sides with gypsum boards. An outer layer of 50 mm is added as a part of a plaster facade system.

When new constructions are supposed to contain 25% reused weight, as specified in the environmental programme for Pilestredet Park, one has to find out something about how heavy things are. Table 2 shows the calculated weight of the building at site H. As expected, concrete dominates the picture. It is surprising, however, to find that the floor leveling cement weighs almost two and a half times as much as the loadbearing steel system. Even with a recycled weight of 80%, the steel contributes modestly to the requred quarter of the total weight. To close in on the aim, a new type of slab was developed by Contiga, a large Norwegian producer of prefabricated concrete components. Waste products from their own production was crushed and used as aggregate in new slabs. In addition, spill water was reused. This resulted in 24% recycled material weight. Crushed stone from the demolished buildings was reused in the foundations of the new building. Overall, the recycled weight directly linked to the new buildings reached 21 %. When crushed concrete and brick used in outdoor areas are counted in, the reused weight in new buildings and landscaping reach a level of 45,7%, far exceeding the aim of 25%.

During construction, waste was sorted locally, on each floor, and outside, in marked containers. Minimizing and returning of packaging was negotiated with the suppliers of materials and building components. The resulting reuse of construction waste was 75 %, well above the 70% aim set in the environmental programme. The results of the efforts to reuse materials are summarized in Figure 3.

Table 2 Reused weight in new constructions
Sources: Skanska Norway / Arne Linja and Master thesis by J.T. Midtbø, NTNU 2004

	Material	Tons	Weight %	Reused Matr. [T]	Reused Matr. [%]	% reuse of tot. material weight
1	Sum hollow floor slabs	6720	43,2 %	1612,8	24,0 %	10,38 %
2	Sum crushed stone	1055	6,8 %	1055	100,0 %	6,79 %
3	Sum prefab. concrete units	3250	20,9 %	0	0,0 %	0,00 %
4	Sum in situ cast concrete*	2206	14,2 %	169	7,7 %	1,09 %
5	Sum floor leveling cement	768	4,9 %	0	0,0 %	0,00 %
6	Sum gypsum boards	485	3,1 %	145,5	30,0 %	0,94 %
7	Prefabricated bathroom units	393	2,5 %	0	0,0 %	0,00 %
8	Sum steel constructions	203	1,3 %	162,4	80,0 %	1,04 %
9	Sum asphalt	193	1,2 %	0	0,0 %	0,00 %
10	Sum mineral wool	82	0,5 %	57,4	70,0 %	0,37 %
11	Sum steel reinforcement	78	0,5 %	78	100,0 %	0,50 %
12	Steel handrails, walls, struts	59	0,4 %	29,5	50,0 %	0,19 %
13	Sum windows	43	0,3 %	0	0,0 %	0,00 %
14	Steel doors	10	0,1 %	0	0,0 %	0,00 %
15	Sum reused granite and cobblestone	0	0,0 %	0	0,0 %	0,00 %
	Sum selection	**15545**	**100,0 %**	**3309,6**	**21,3 %**	**21,3 %**

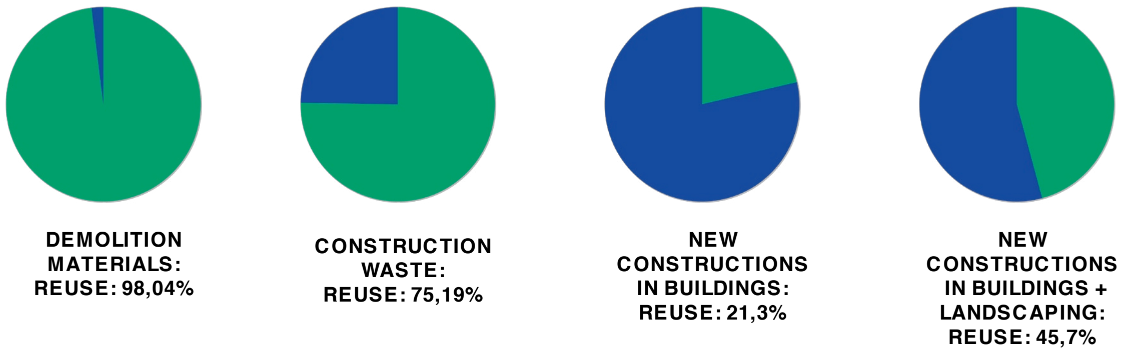

Figure 3 Overview of results regarding reuse of materials (weights)

Clean site measures were applied throughout. Apart from preparing a good, future indoor climate, a tidy site improves safety. Common injuries caused by stumbling or threading on nails are avoided. By storing plaster boards on bucks, the floors are made accessible for cleanining or vacuuming. At the same time, lifting heights are reduced, preventing back strains and injuries. Such synergetic effects of environmental measures should be studied more closely.

To prevent moisture from being trapped inside the concrete slabs, larger drainage holes were made during production. Plastic strips were put on top of the framework of the internal walls. In this way, water from the uncovered, upper slabs was prevented from entering the constructions below.

The spreading of dust and dirt was reduced by sprinkling during critical parts of the demolition process. A rig for cleaning the trucks´ wheels and undercarriages was built on site. Noise and vibrations were measured continously. Many sources of noise, like loading of trucks and ramming of poles, cannot be muffled in practical ways. For those, time limits were set up in cooperation with the municipal health authorities. Abundant information to neighbours was emphasized.

These measures has contributed to eliminate complaints and conflicts during the long construction period. The absence of protests may also be related to the fact that the development opens a formerly closed hospital area to the public. New pathways shorten walking distances and improve communication for pedestrians and bicyclists. Never the less, the Pilestredet Park case illustrates that care may and should be taken to ease the disturbances that follow urban transformations.

7. Landscaping: Water, roofscaping, recycling and bicycling

Pilestredet Park is one of rather few urban development projects that deserve the name ”park”. Large areas with many big and old trees, are preserved. New squares, gardens and courtyards are built (Figure 1). A system of water channels and dams work together with underground stone baisins to delay run-off of surface water. Planted areas on common roof terraces and succulent layers on roofs serve the same end (Figure 4)

Granite details from foundations, doors, windows and staircases in the old hospital are reused in landscaping. Ground concrete and brick are reused in concrete slabs that pave the new internal pathways. Old cobblestone form lateral stripes in the pavement (figure 5). In the south-facing courtyard in site H, white gravel is utilized to reflect daylight to the surrounding facades (Figure 6).

Bicycle parking places are built both near the main entrances and in designated indoor areas. To save floor area, a two-storey bikeparking solution was chosen, based on a Norwegian design.

Figure 4 Detail of succulent layer on roof. Protects membrane from ultraviolet degrading.

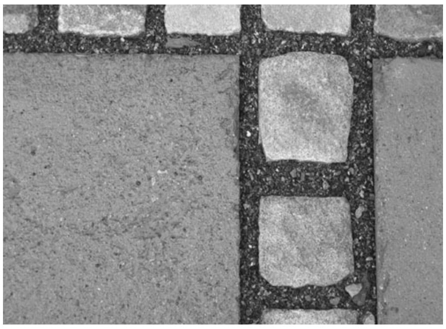

Figure 5 Detail of paving containing reused materials from demolished buildings.

Figure 6 White gravel used for light reflection. Dark figures are reused tree trunks from site.

8. Energy: Insulation, recovery and control

The overall aim for energy consumption in Pilestredet Park is 100 kwH/m2y. This is about half of the national average for housing, and 25% below recently revised building codes. The effect of a wide variety of measures was calculated. A ”package” of measures was chosen that was based on increased insulation, a high degree of heat recovery and demand control of the heating system. High degree of air tightness and avoidance of cold bridges was given high priority during design and production. A Building Energy Management System (BEMS) also named ”smart house” solution was installed in every appartment. It allows zone-differentiated control of the water-based heating system, and an ”away-function” is delivered as as standard option. The energy measures are shown in Figure 2.

The accumulated energy consumption was measured in 6 flats over a 1-year period. Figure 7 shows the results, that range from well below to significantly above the aim of 100 kWh/m2y. This reflects different dweller habits regarding the use of installations and equipment. The energy monitoring exposed weaknesses in the measuring and control equipment of the BEMS system. Several dysfunctional metering points were discovered. As the energy used for heating is reduced in this type of building, so is the effect of advanced control systems. In future installations, a simplified heating system should be considered. Emphasis may be put on controlling energy-consuming electrical equipment.

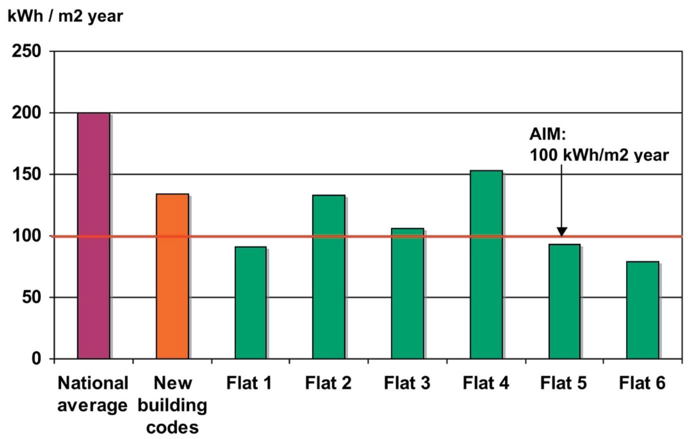

Figure 7 Measured energy consumption in 6 flats in Pilestredet Park

The energy measurements show that a strategy of high density, high insulation and high degree of heat re-gain may represent a low-energy alternative. The costs per gross m2 of the energy measures are about 2% of the total price, and the pay-back times are varying from 3 to 25 years.

9. Architectural integration

Close, cross-diciplinary design development is a vital part of sustainable building. It should produce an architecture where all the ecological measures are naturally and seamlessly integrated. The energy-saving measures must not appear as strange or expensive add-ons.

In Pilestredet Park, a park-like atmosphere has been sought after. The area plan specifies that pattern of free-standing buildings should be established, in contrast to the closed quarters of the surrounding areas. This is a distinct quality of the overall plan, and is enhanced by giving the facades light colours and the out-door areas a green appearance with planting and surfaces of a high quality.

Figure 8 Facades surrounding south-facing courtyard in site H in Pilestredet Park

Energy considerations put limits to the window sizes. The balconies are placed away from the bay windows of the living rooms, to enhance daylight levels. The fronts of the balconies are made transparent to allow better wiew to the outside and better daylight reflection to the inside. The bay windows are integrated into vertical glass structures, introducing crispness, transparency and reflectivity to the facades. Set against the dry and flat plaster walls, they create a play of contrasting qualities. In the balconies, wooden struts give warmth to the overall picture. Wires for foliage are integrated. The windows are set in the outer parts of the wall constructions. In this way, deep niches which accentuate heaviness are avoided. Stepped-back top floors with pergolas and glass roofs give lightness to the upper parts of the facades. Figure 8 show a typical section of the facades in site H.

10. Screening of materials, indoor climate

The environmental programme specified that substances known to produce allergic reactions should be avoided. The OBS-list developed by the Norwegian Anti-pollution Directorate (SFT) shoud be consulted, and substances on this list should only be allowed in very low concentrations. PVC should be avoided. In several cases, the screening procedures influenced the choice of products. It even initiated development of new products. The materials that constitute the 5 larges weight fractions, the programme says, should be subject to lifecycle analysis according to internationally accepted procedures. Considerable resources are needed to produce the required documentation. In the case of site H, this meant that the life cycles for materials representing 87 % of the total weight were analyzed.

The Norwegian Institute for Air Research (NILU) carried out a series of measurements of the indoor air quality. The results were good, showing low levels of humidity, dust and volatile organic compounds. Those are are factors that may be affected by poor execution of building details or evaporation from materials. figure 9 shows NILU´s intrument set-up. Table 3 shows measured TVOC.

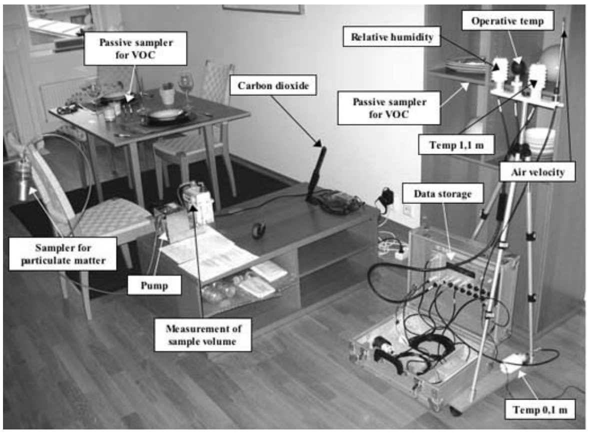

Figure 9 Instrument set-up for measurements of indoor air quality. (NILU)

Table 3 Measured concentrations of VOC in flat in site H
Source: Norwegian Institute for Air Research (NILU)

Compound	Concentration (μg/m^3)
Dibutylenglycol	9
Dodecane	8
Nonanal	7
Decanal	7
alfa-Pinene	7
Dibutylenglycol (derivate)	7
Hexanoic acid	7
Benzoic acid	5
Benzaldehyde	5
Undecane	4
Tetradecane	4
Acetic acid	4
Tridecane	4
Toluene	4
Dodecamethyl cyclohexasiloxane	4
Pentadecane	3
Hexadecane	3
3-Carene	3
Nonanoic acid	2
TVOC[a]	**180**

a) TVOC = total concentration of volatile organic compounds

11. Concluding remarks

The Pilestredet Park development show that a multi-thematic environmental programme with emphasis on quantified aims may be implemented in large and complex projects within strict time limits. It initiates analyses and design developments that must be tested through monitoring. The measurements produce a wide variety of data, which form a valuable basis for further development. The results reached in Pilestredet Park has become a reference for similar projects in Norway.

Myths regarding the realism and costs of sustainable architecture and urbanism are popular because they liberate the minds from hard and cross-diciplinary thinking. Systematic accumulation of knowledge is the only long-time remedy.

12. References

The data in section 5 and 6 were collected during the monitored demolition and construction carried out by contractor Skanska Norway, represented by site manager Arne Linja. The data were structured and processed by Jon Terje Midtbø as part of his master thesis (see below).

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