Rethinking the design of school buildings

Karin Buvik
Karin.J.Buvik@sintef.no

NTNU 2008-05-29

School reforms in the last decades

- New subject matters
- New working methods
- More concern with social life and cultural events

1970
The old Borgen School

A school building boom started in the middle of the nineties.

Glimpse on the evolution of Borgen School follows

2005
Borgen community Centre. HUS sivilarkitekter

School development

Knowledge:
Standard tests on language, mathematics and nature studies

Competence:
Lack methods to evaluate «soft» competences:

- Self-confidence
- Communication abilities
- Engagement
- Co-operation abilities
- Endurance
- Problem-solving

(CCC = Cross Curricular Competences)

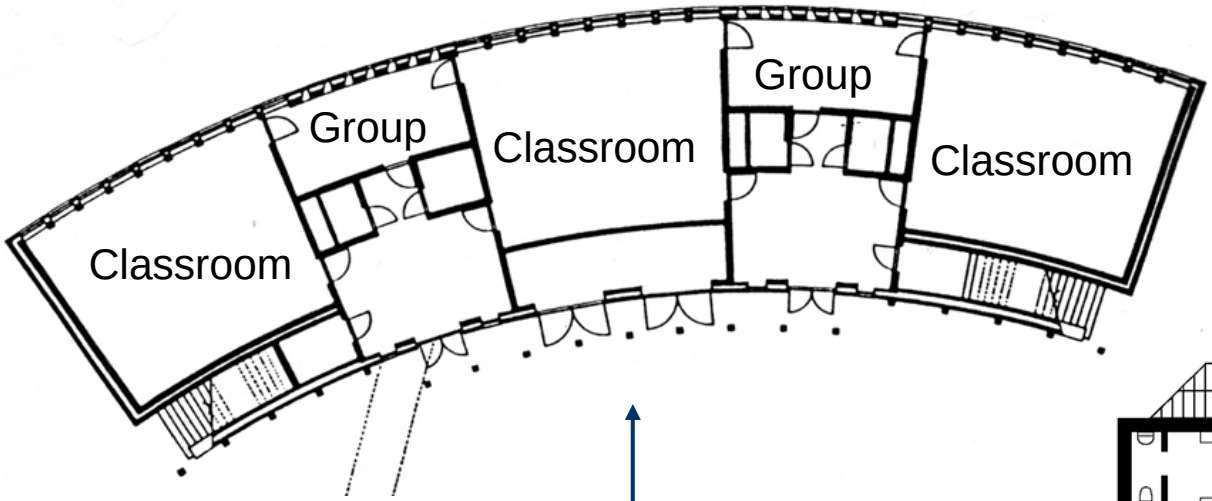
School planners and architects are searching for the connection between pedagogical objectives and physical design

The question is:
How can physical design support goal achievements; curriculum, working methods and social life in school?

Goals and intentions are to be «translated» to physical design.

Every school building accommodate a pedagogical idea
– Steen Larsen, Danish educationalist

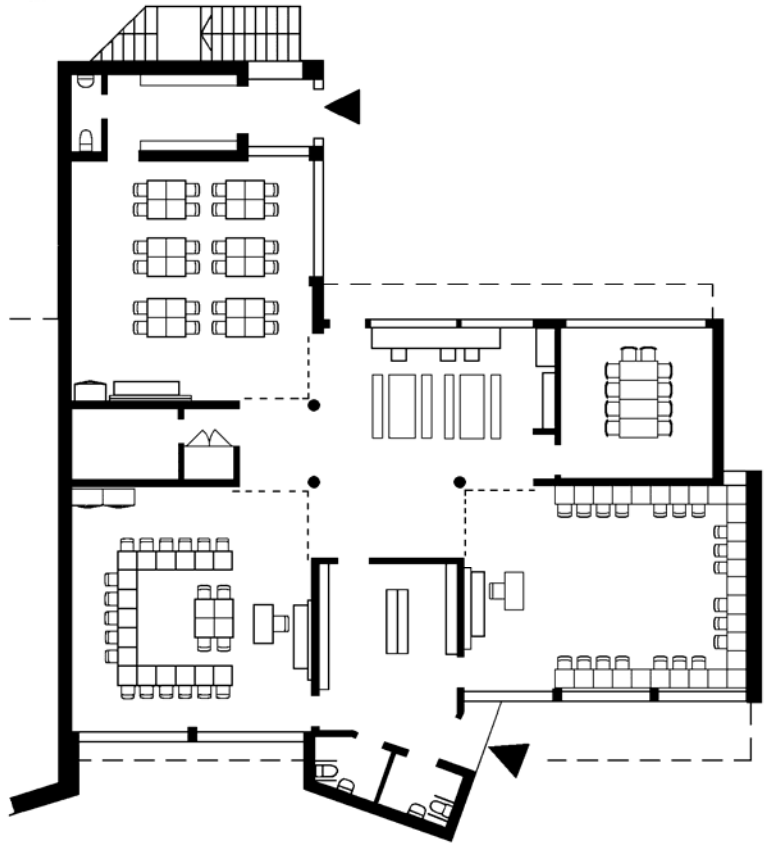
«Every school building accommodate a pedagogical idea»



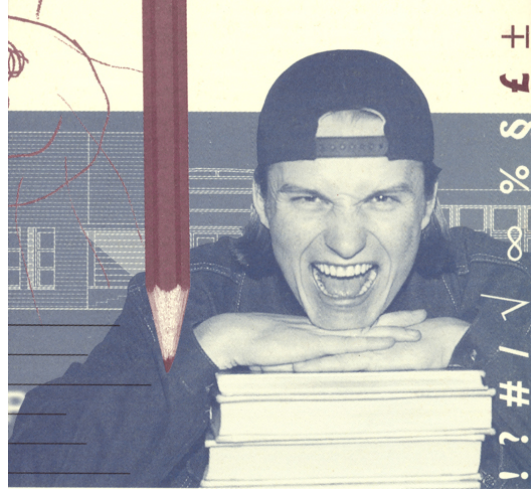
– Easy to uncover, even in the arrangement of three classes

Conventional plan with classrooms and rooms for smaller groups.
No common area for the classes

Different working methods are facilitated by common rooms and flexible walls



School building design



Questions to be considered:

- **Base areas; zoning and proportioning**
  Rooms for classes / Common areas
- **Teachers' office workplaces**
  Staff department / Workplaces dispersed within pupils base areas
- **Special functions**
  «Tailored» rooms / Multipurpose areas
  (Arnestad school : arts and crafts, music, home economics)
- **Furnishing**
  «Private», working places / Like a library (clean desk)
- **ICT**
  Separate room / Computers dispersed

The old Borgen School

The new Borgen Community Centre

Glimpse on the evolution of Borgen School

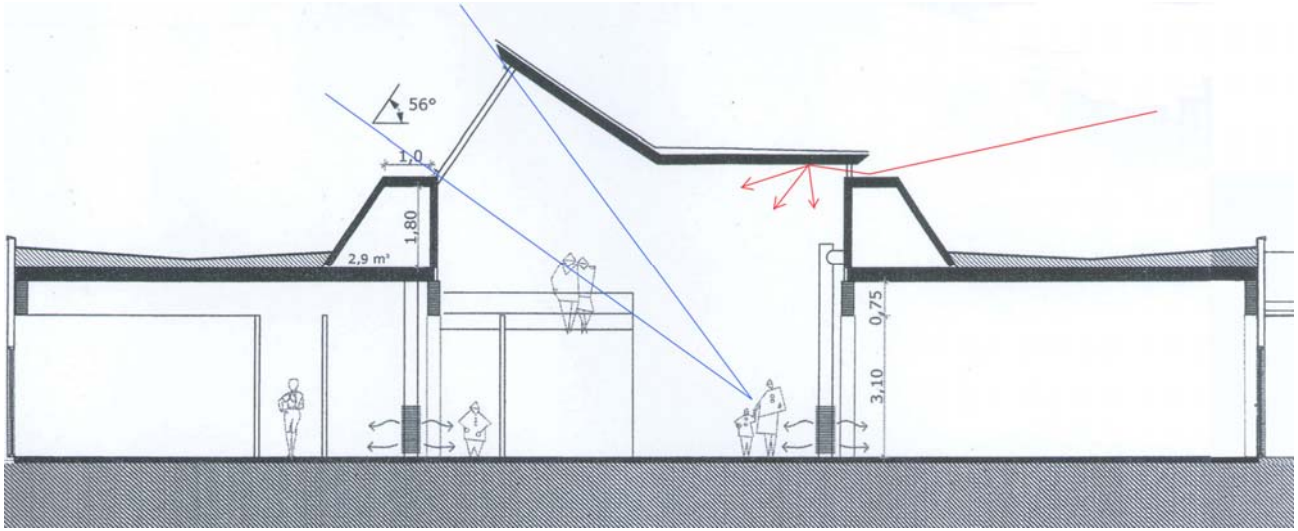
Comprehensive renewal

Transformation from school to community centre

Most visible features:

- Daylight openings on the roof and new façades
- Decentralised hybrid ventilation systems

Communication area



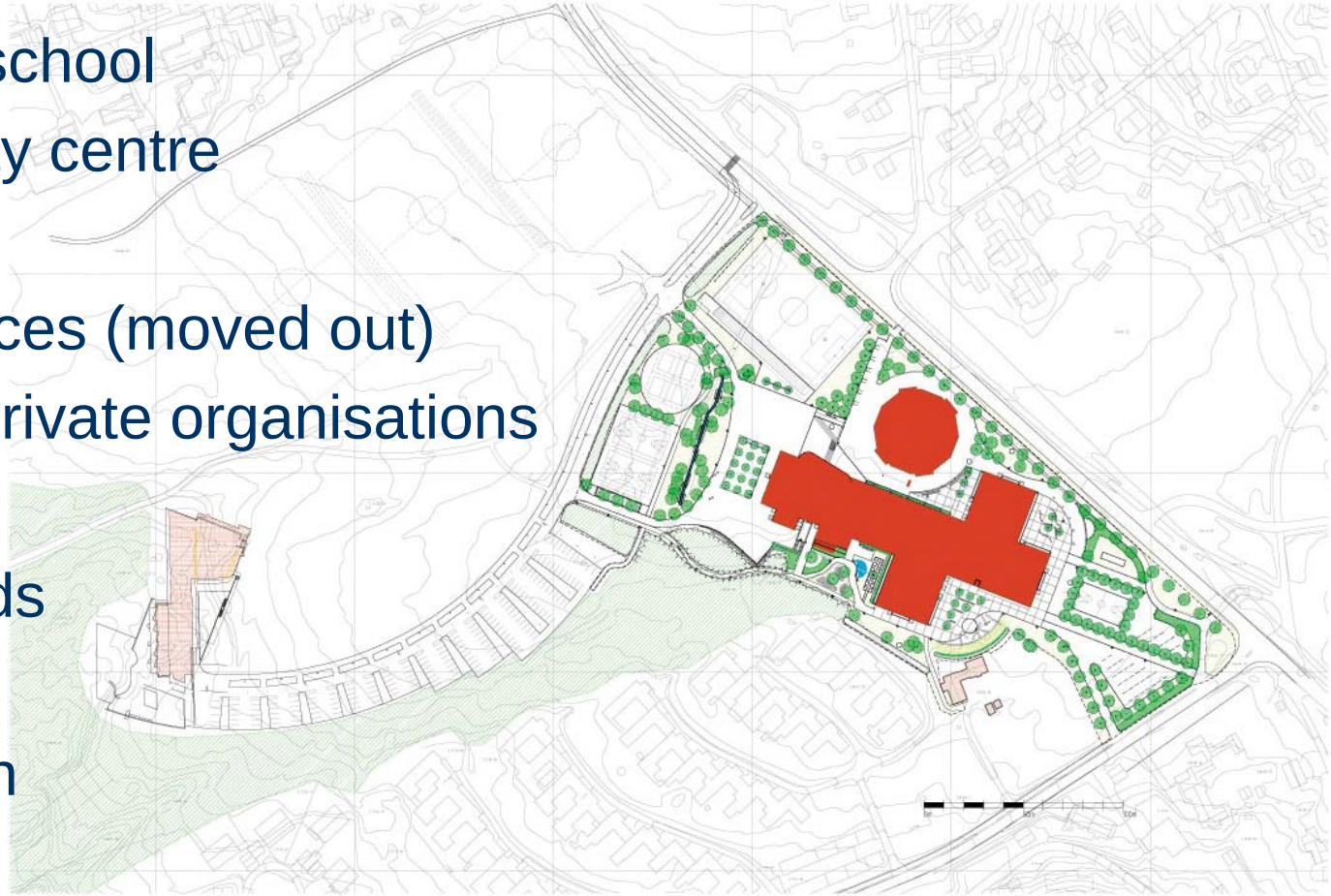
The renewed building

The old school

The old building was poorly ventilated, had minimum daylight, and was neither suited for modern working methods nor cultural and social activities.

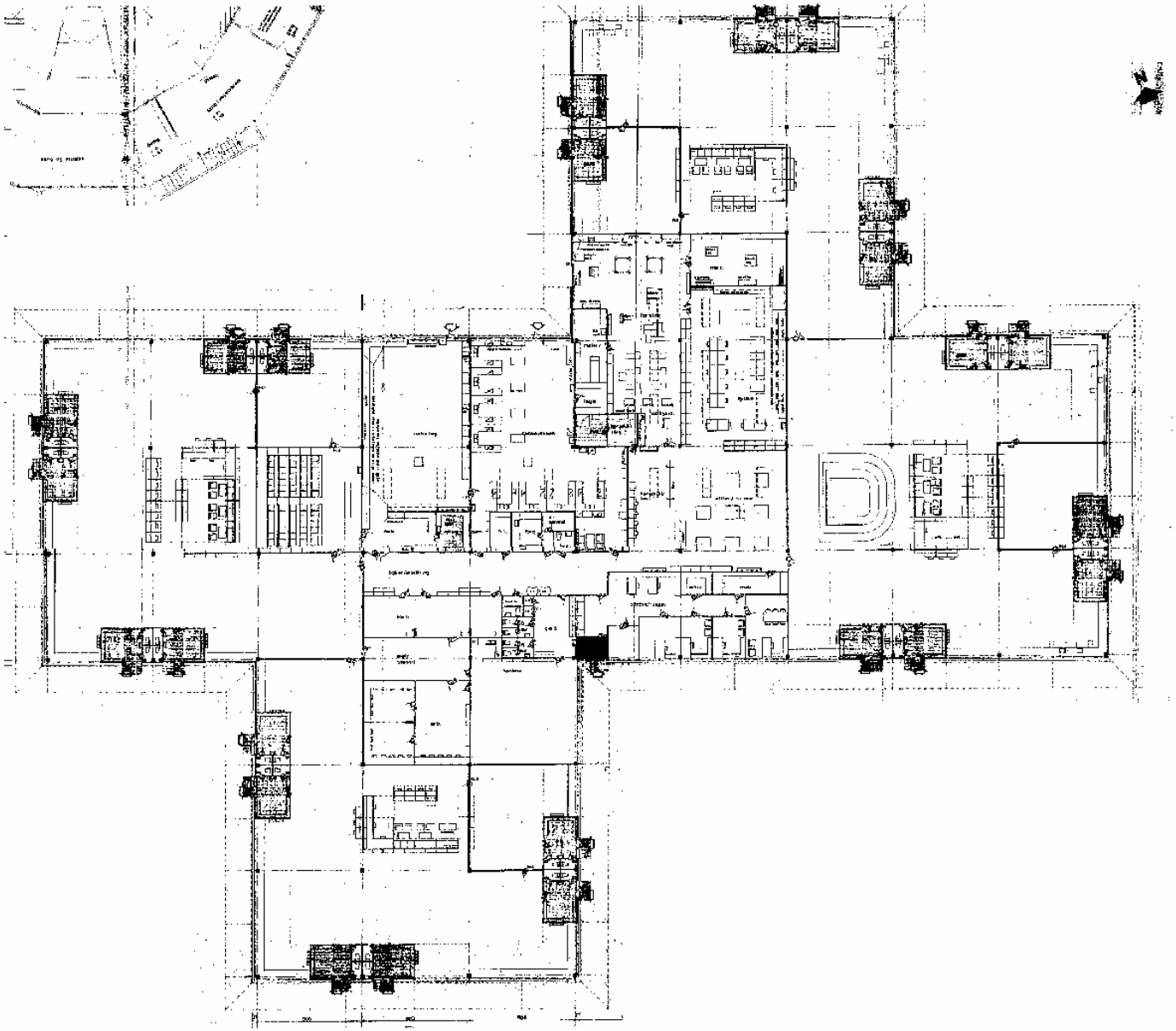
Borgen Community Centre

- Secondary school
- Youth activity centre
- Health care
- Dental services (moved out)
- Rooms for private organisations
- Gymnasium
- Football fields
- Church
- Kindergarten



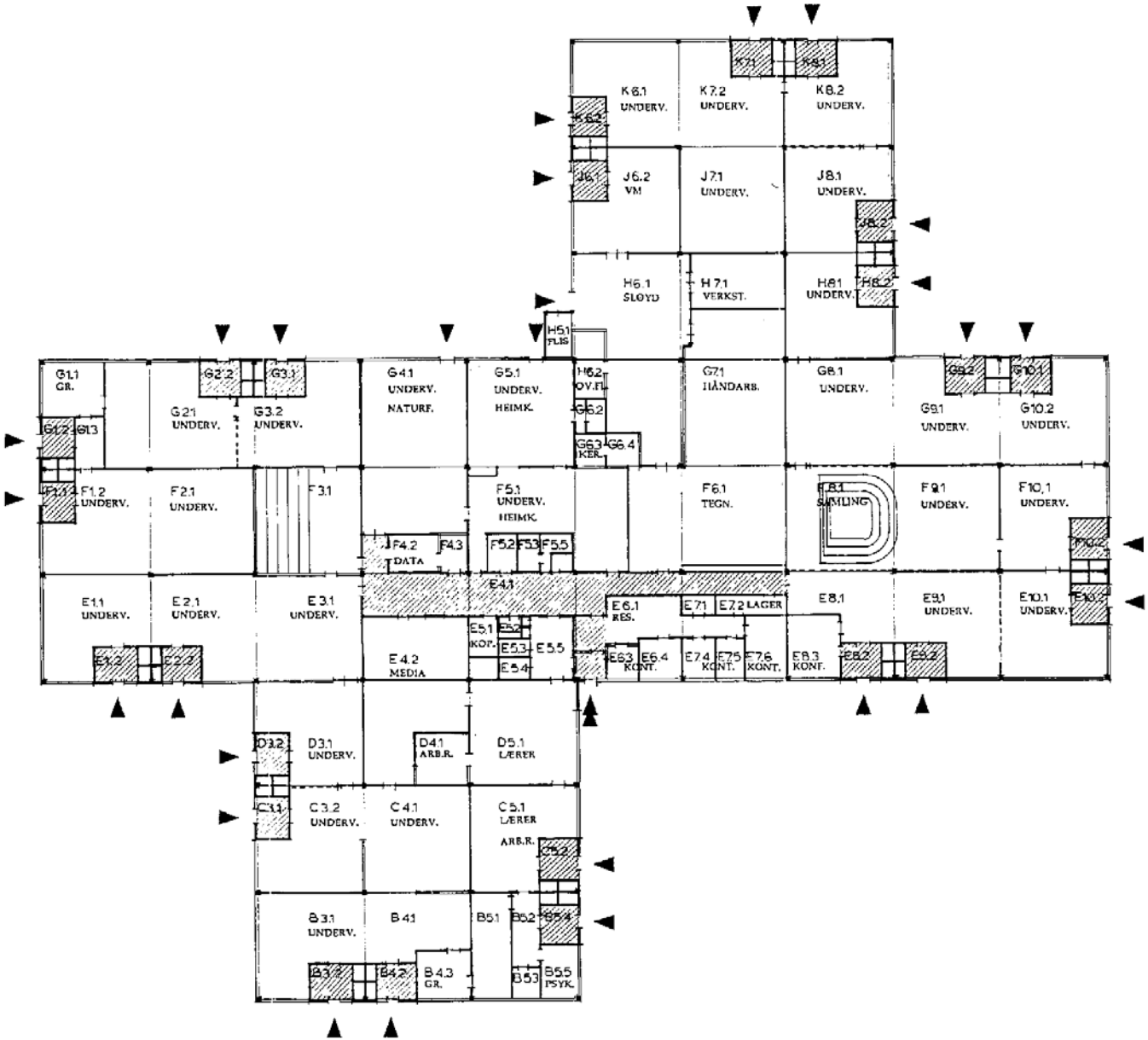
Borgen School. Original plan 1970

Open plan (landscapes). Decentralised entrances



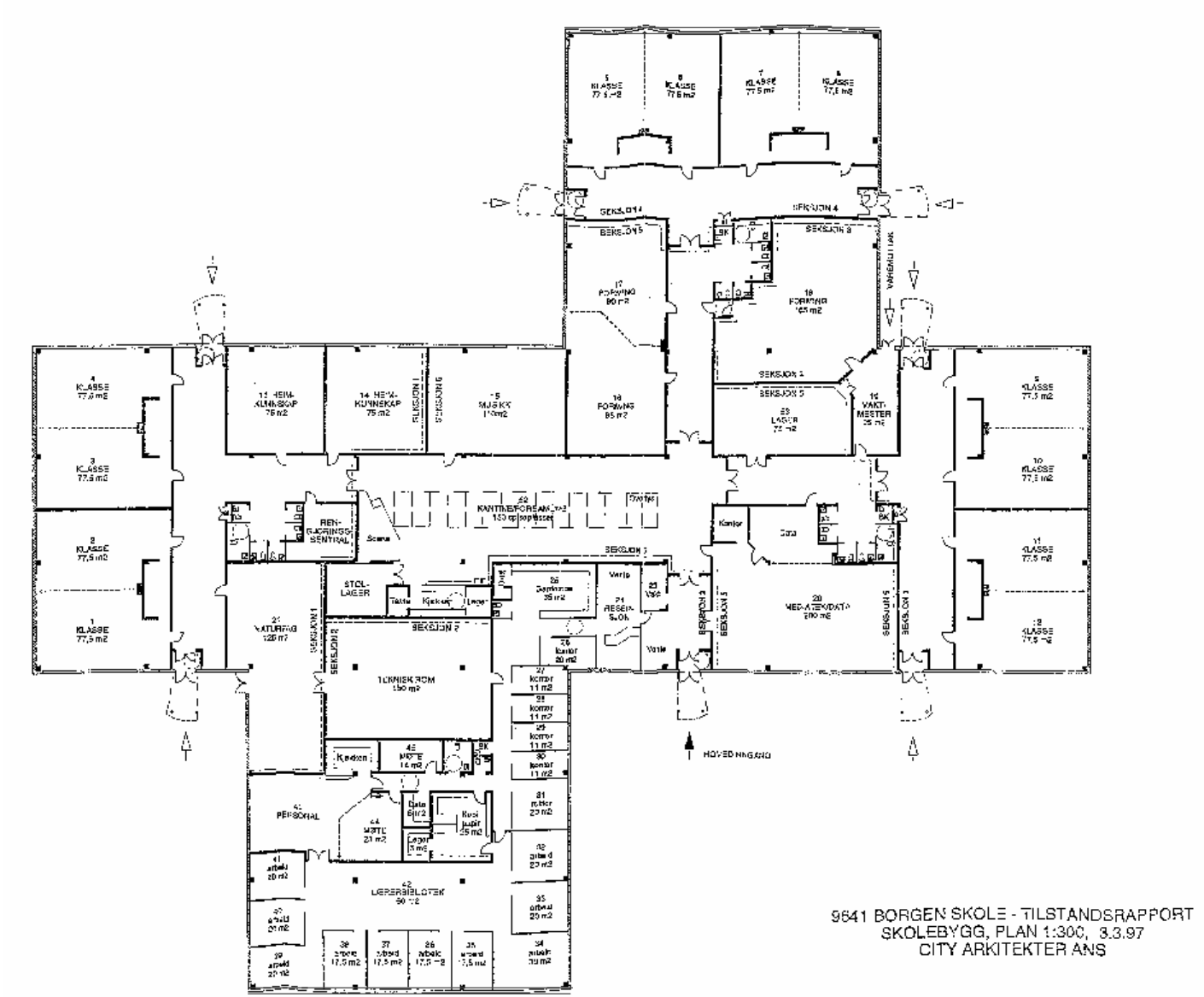
Borgen School. Plan 1994–2002

Classrooms. Lack of communication areas



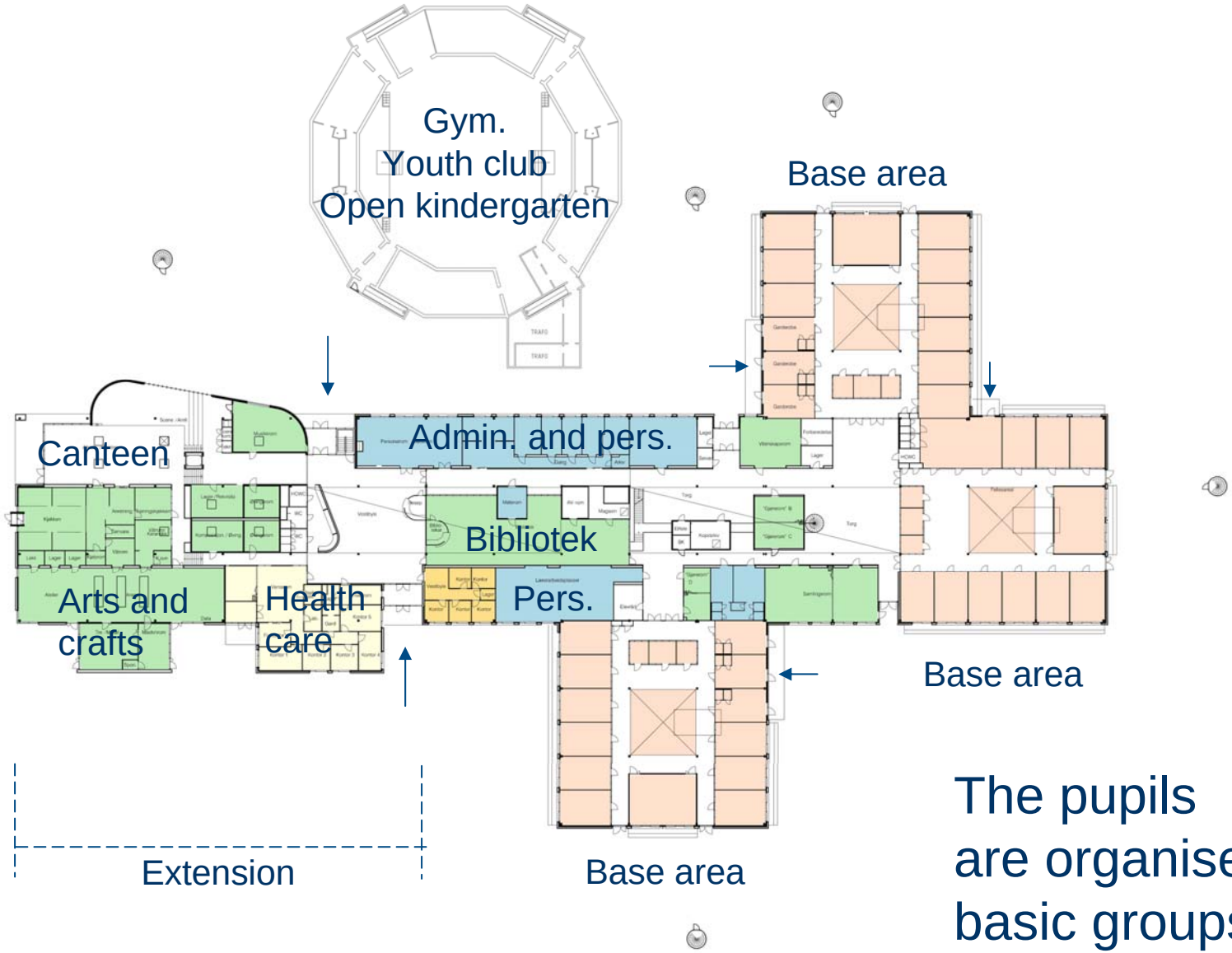
Borgen School. Plan 1997 – Not realised

Classrooms and corridors



Borgen Community Centre. Plan 2004

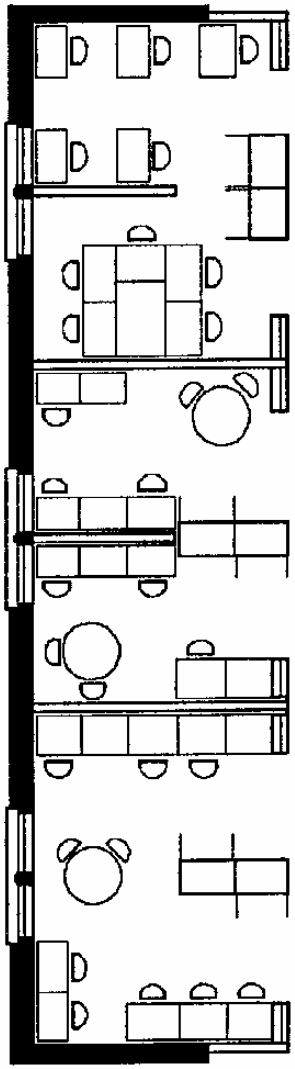
«Offices», common areas and workshops

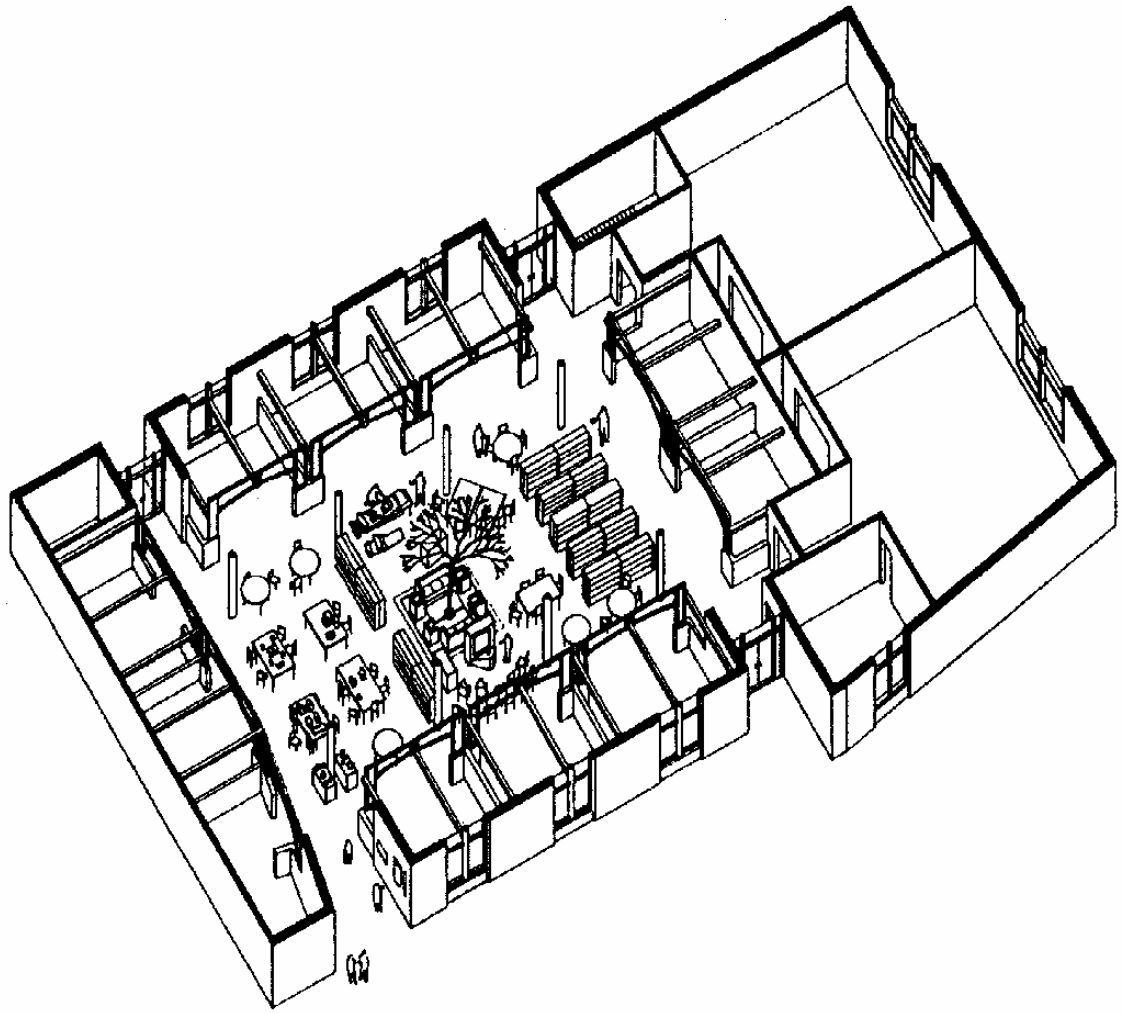


The pupils are organised in basic groups of 15

Source of inspiration

School in Minnesota, USA. Project





Pupils' «offices»

Borgen Community Centre. Common area

Borgen Community Centre
Pupils' «office»

Borgen Community Centre. Lecture room

SINTEF's role in the planning process

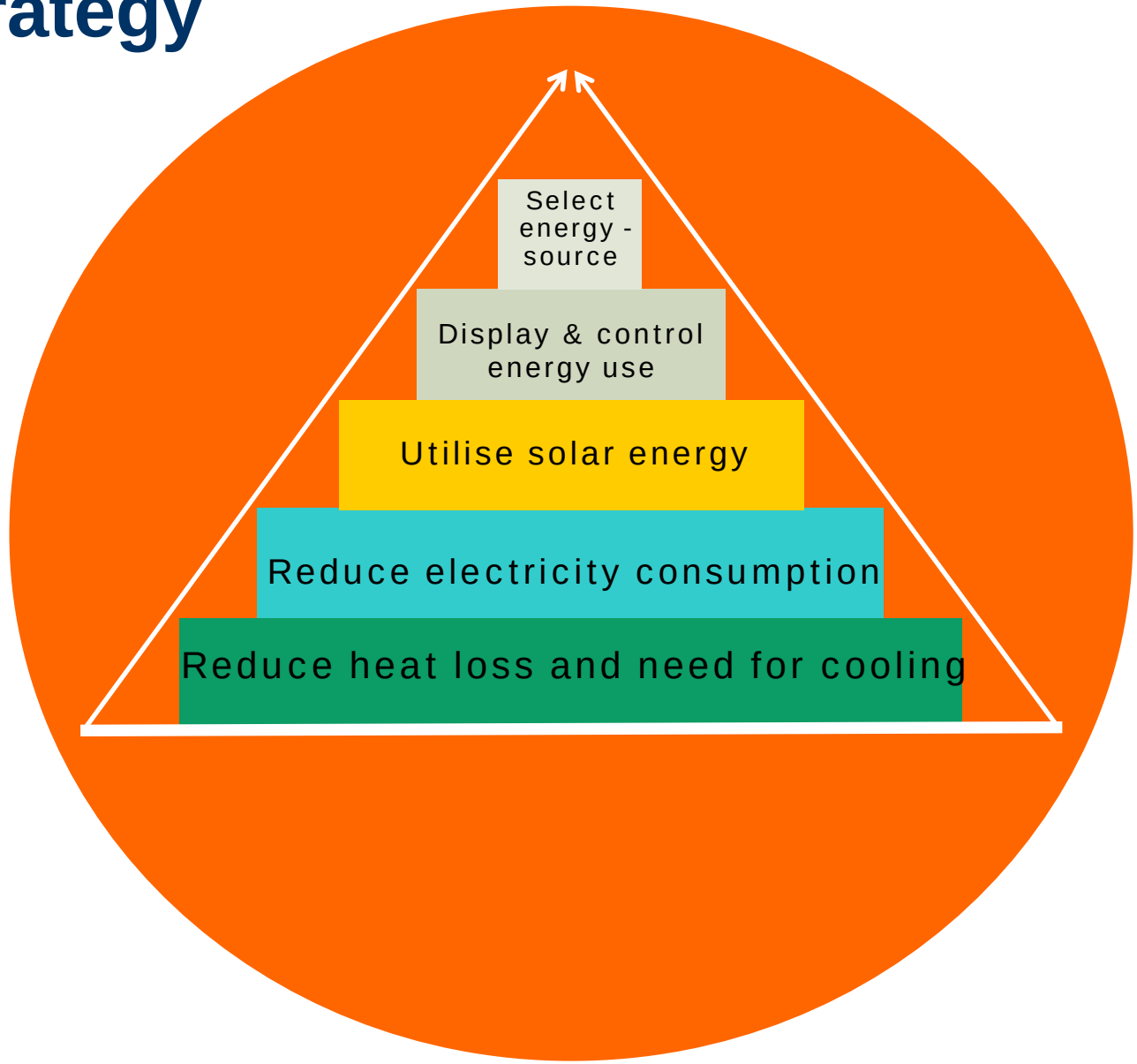
- (Participation in the design competition)
- Input to discussions about plan lay-out and functionality
- Input to discussions about environmental objectives
- Guidance to daylighting design and solar shading
- Consultative in design of ventilation systems
- Environmental assessments in the pre design phase

- Study report on application of photovoltaic cells
- Study report on application of double façades

Environmental objectives

- According to standard practice the school department should be space efficient and adaptable to various working methods and social events.
- According to the Norwegian assessment method ‘EcoProfile’ the building and yard should obtain the best quality class for each of the three main areas: *Environment, Resources, and Indoor climate.*
- The building should have a low purchased energy consumption with respect to space heating, ventilation and artificial lighting. Utilising renewable energy should be emphasised.
- The building and yard should be used as teaching tools to support the Nature and Environment Studies.

Design strategy



Design strategy

1. **Reduce heat losses**
   Building shape, zoning of room categories, area efficiency. Well insulated and tight building envelope without cold bridges. Efficient heat recovery of ventilation air.

2. **Reduce electricity consumption**

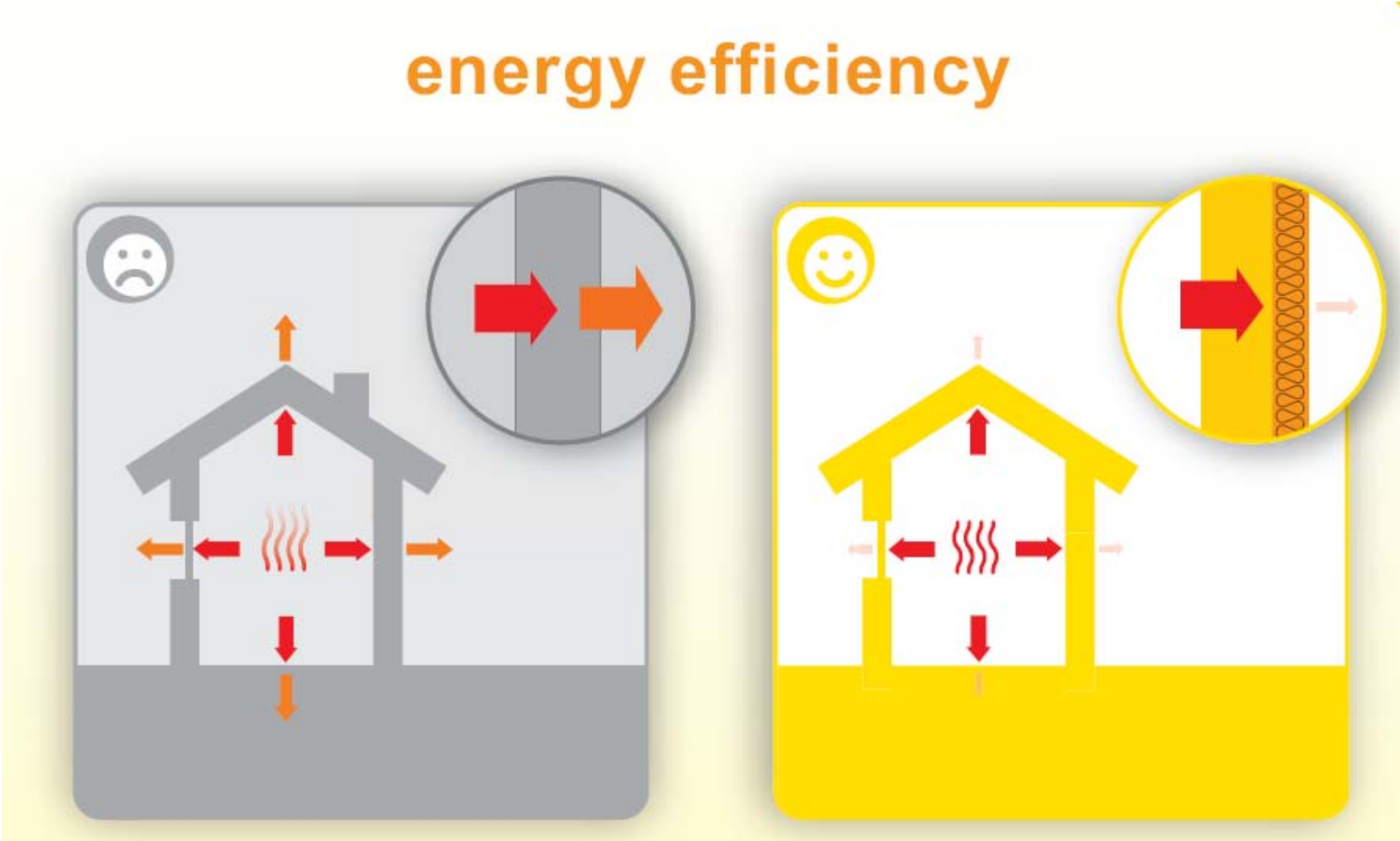
3. **Utilise solar energy**

4. **Display and control energy use**

5. **Select energy source**

Reduce heat losses

Borgen: Envelope insulation, window replacement, heat recovery



Poster from the SARA project

Design strategy

1. Reduce heat losses

2. **Reduce electricity consumption**
   Exploitation of daylight.
   Low pressure drops in the ventilation system.
   Reduce the need for cooling by utilising thermal mass in combination with night cooling and efficient solar shading.
   Energy efficient lighting and equipment.

3. Utilise solar energy

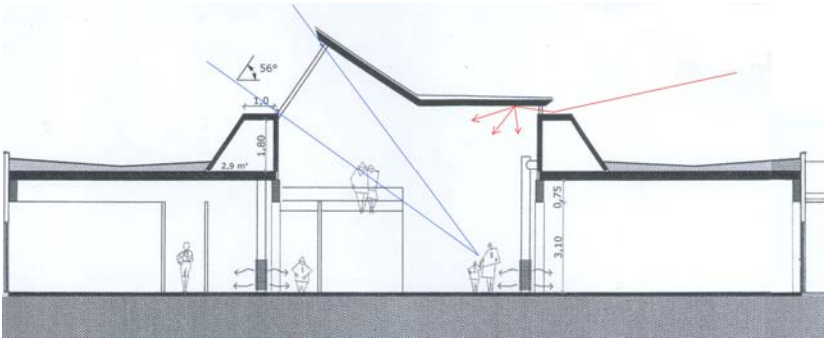
4. Display and control energy use

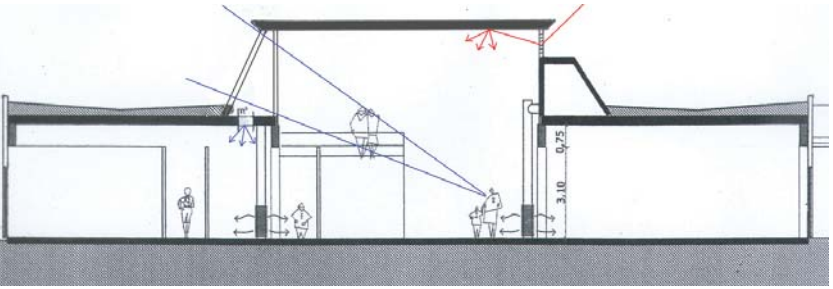
5. Select energy source

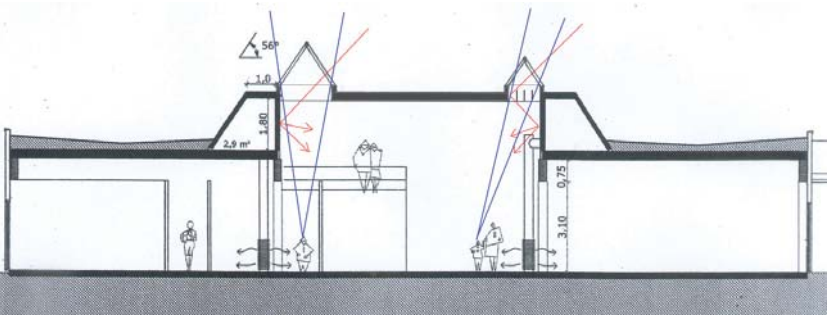
Reduce electricity consumption

Borgen: New hybrid natural ventilation system, new daylighting openings, solar shading

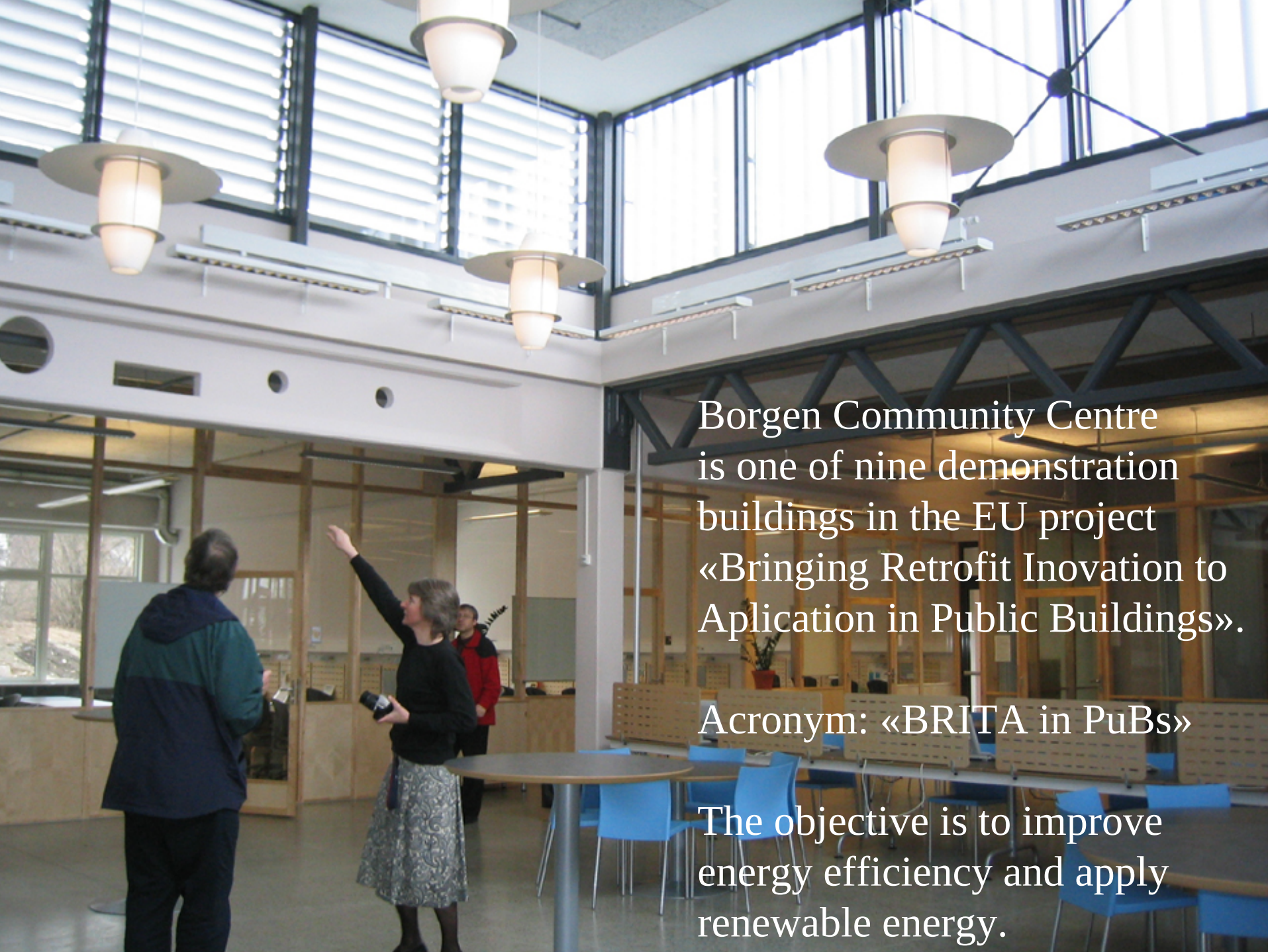
Studies of alternative daylighting design







HUS sivilarkitekter



Borgen Community Centre is one of nine demonstration buildings in the EU project «Bringing Retrofit Inovation to Aplication in Public Buildings».

Acronym: «BRITA in PuBs»

The objective is to improve energy efficiency and apply renewable energy.

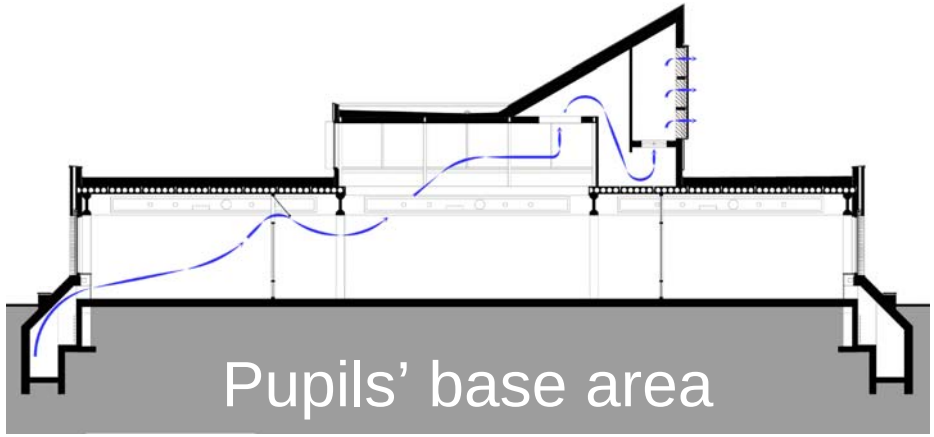
Daylighting

Daylighting

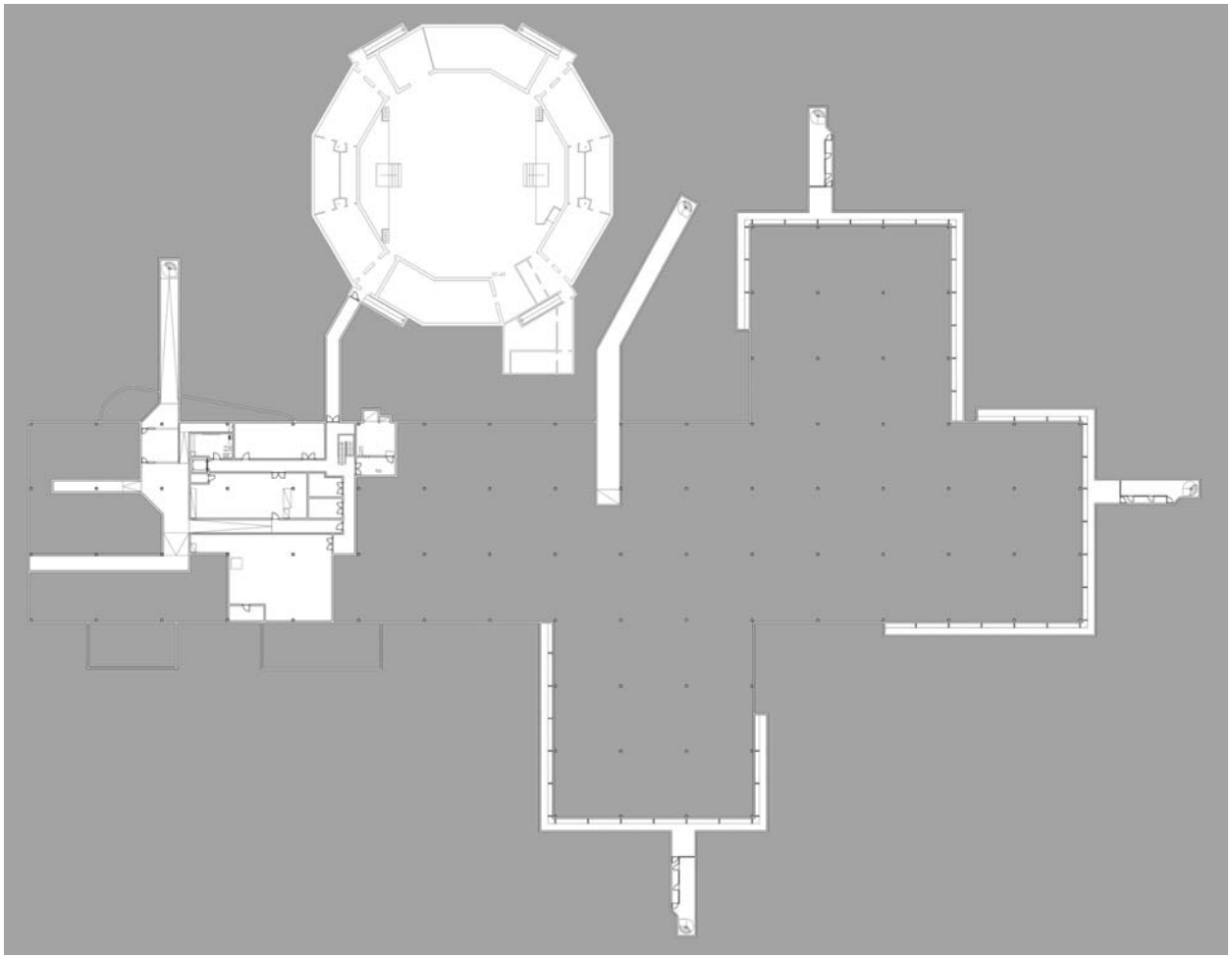
Solar shading

Decentralised ventilation solution

- 5 separated ventilation systems
- Inlet air via culverts
- Hybrid ventilation systems in pupils' base areas. Outlet air via heat recovery units placed on roof top



Ventilation systems based on culverts



Culverts contribute to preheating of ventilation air in winter and cooling in summer.

Culverts bring along ventilation air with low speed. Thus air temperature can be kept low in summer without giving the felling of drafts.

Hybrid ventilation

Design strategy

1. Reduce heat losses

2. Reduce electricity consumption

3. **Utilise solar energy**
   Optimum window orientation, thermal mass activation, solar collectors, photovoltaics

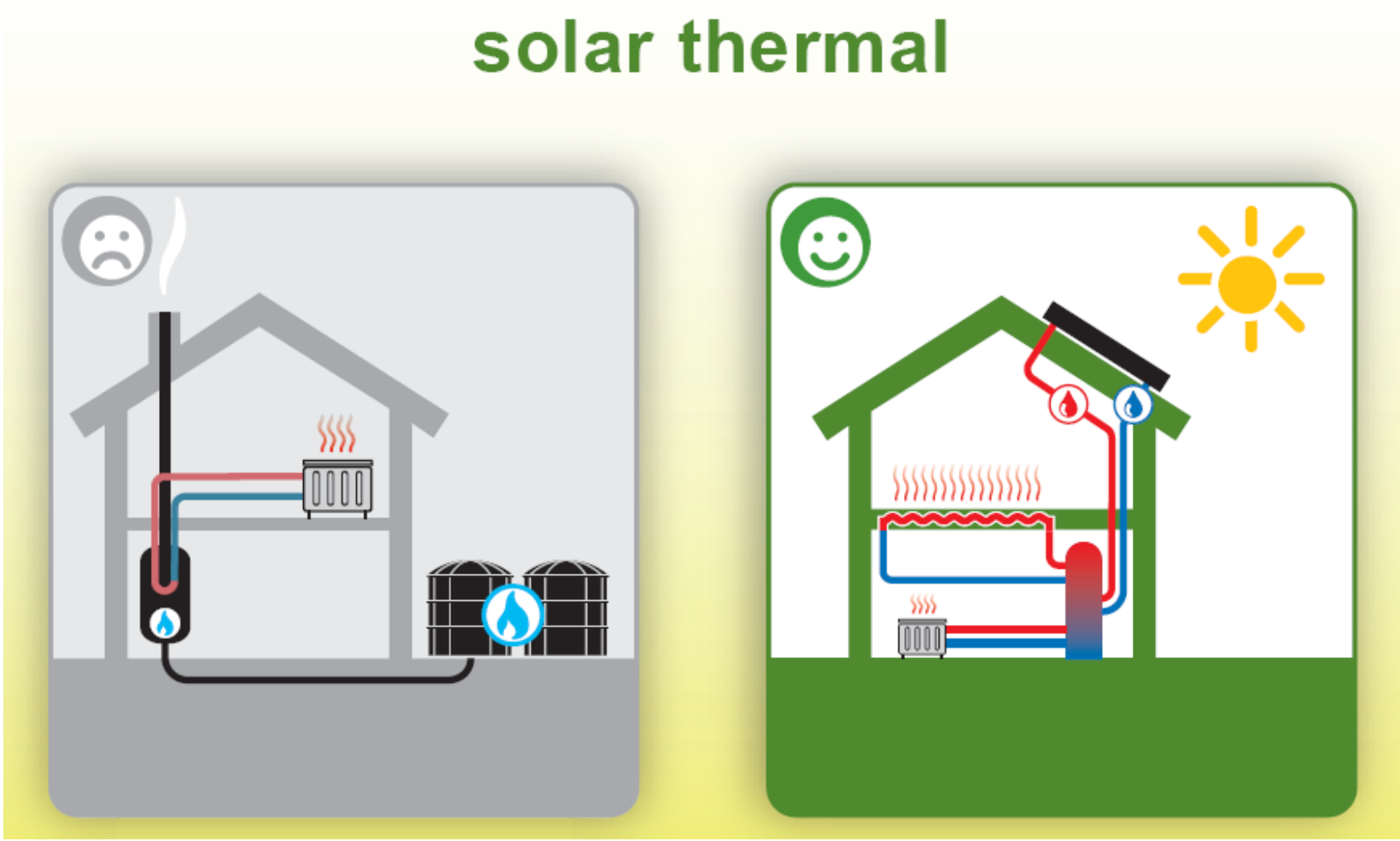
4. Display and control energy use

5. Select energy source

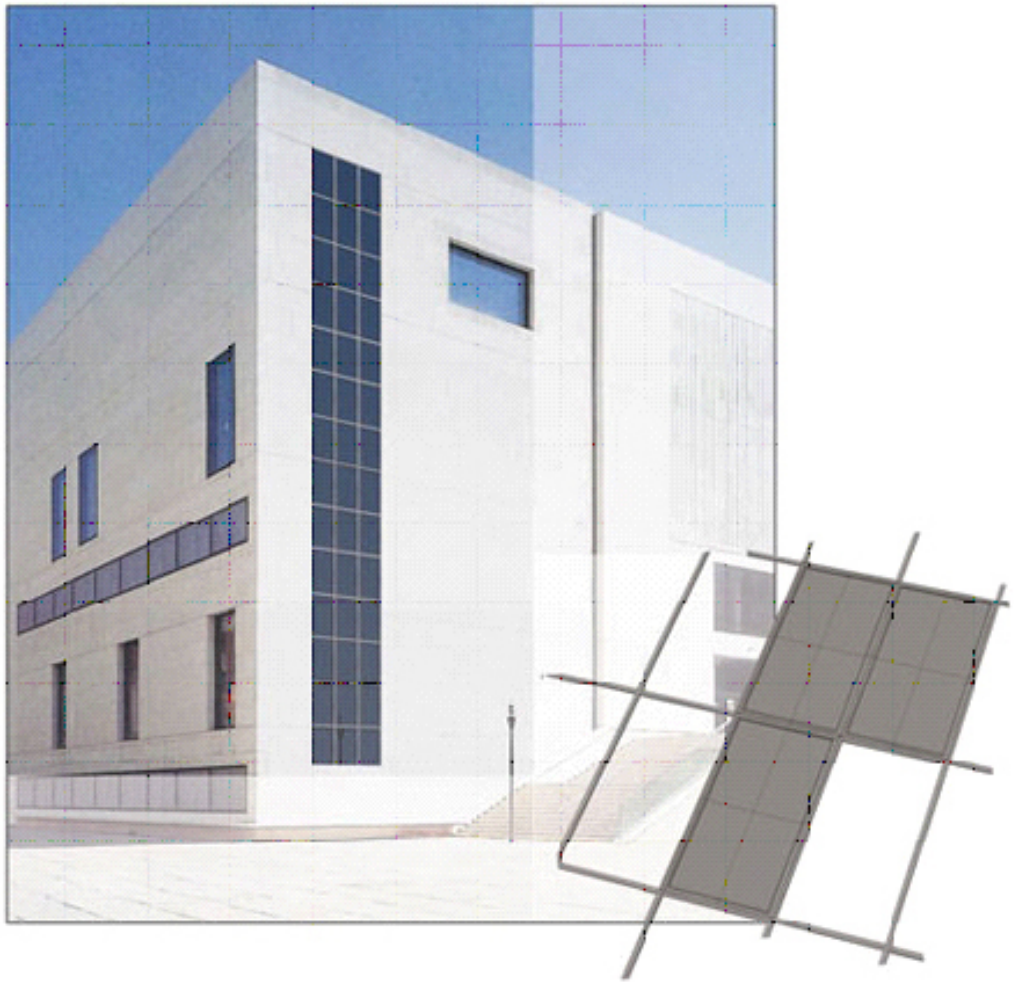
Utilise solar energy

Borgen: Skylights facing north to avoid over heating, materials with high thermal mass capacity, solar collectors for demonstration (BRITA project)

Solar energy



Poster from the SARA project



Liquid based solar collector

Three layers of glass and two cavities.

In the rear cavity a dark liquid absorb the heat from the sun. To maximise the absorption of solar heat the rear layer of glass is also an absorber (dark colour).

The two front layers with their cavity are designed as a low energy glazing in order to minimise the heat loss from the solar collector. Low emissive coating and argon gas will be used to make the U-value as low as possible.

To help a small Norwegian enterprise to penetrate the marked, a new type of solar collector will be integrated for testing and demonstration purposes in Borgen Community Centre.

BRITA in PuBs

Design strategy

1. Reduce heat losses

2. Reduce electricity consumption

3. Utilise solar energy

4. **Display and control energy use**
   Feedback on consumption. Smart house technologies. i.e. demand control of heating, ventilation, lighting and equipment.

5. Select energy source

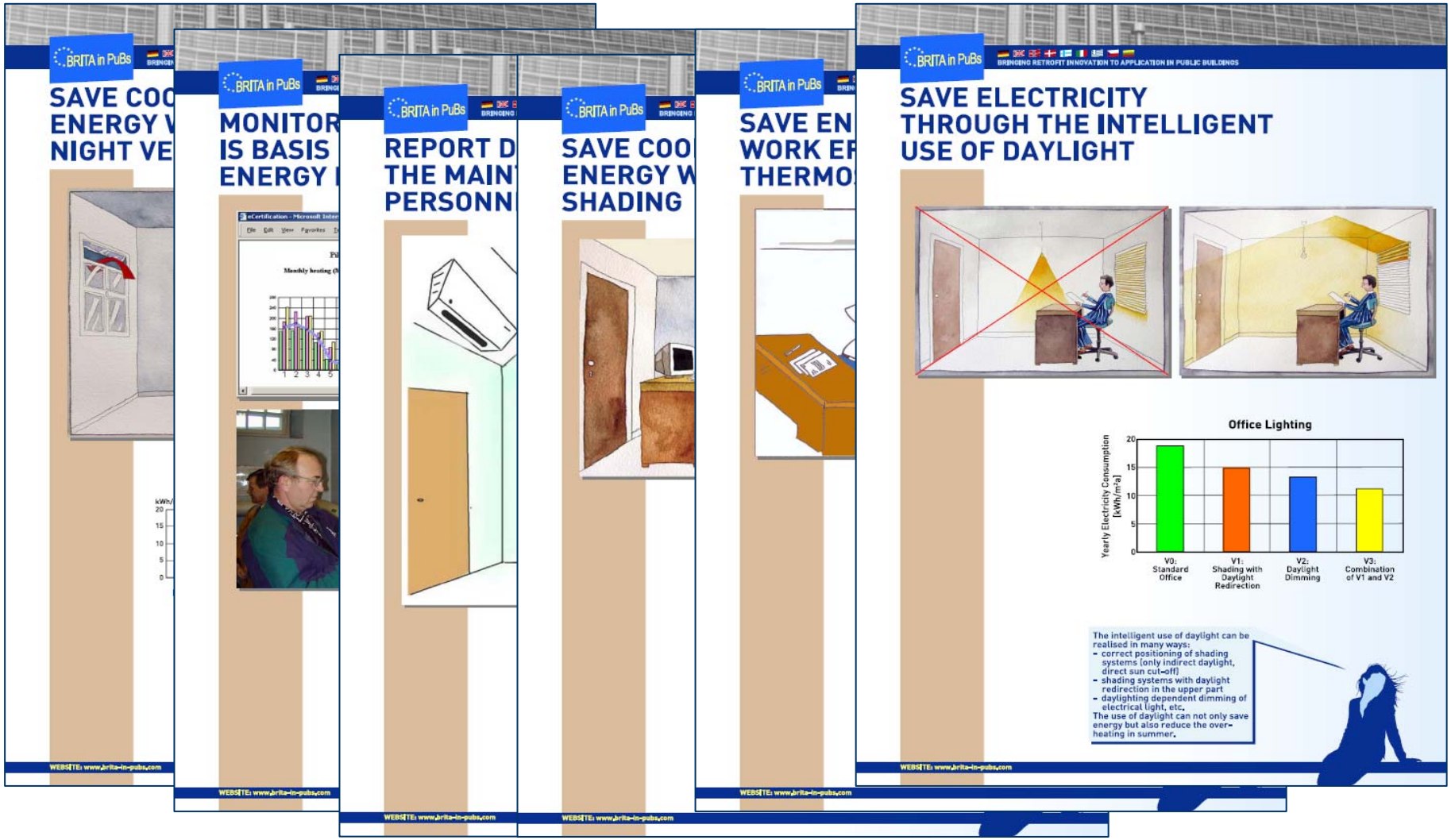
Display and control energy use

Borgen: Sensors, registering daylight level and presence, control the use of artificial light.

Sensors, registering temperature, CO_2 level and presence, control ventilation air rates.

Blackboard information sheets (BRITA project) to support manual control.

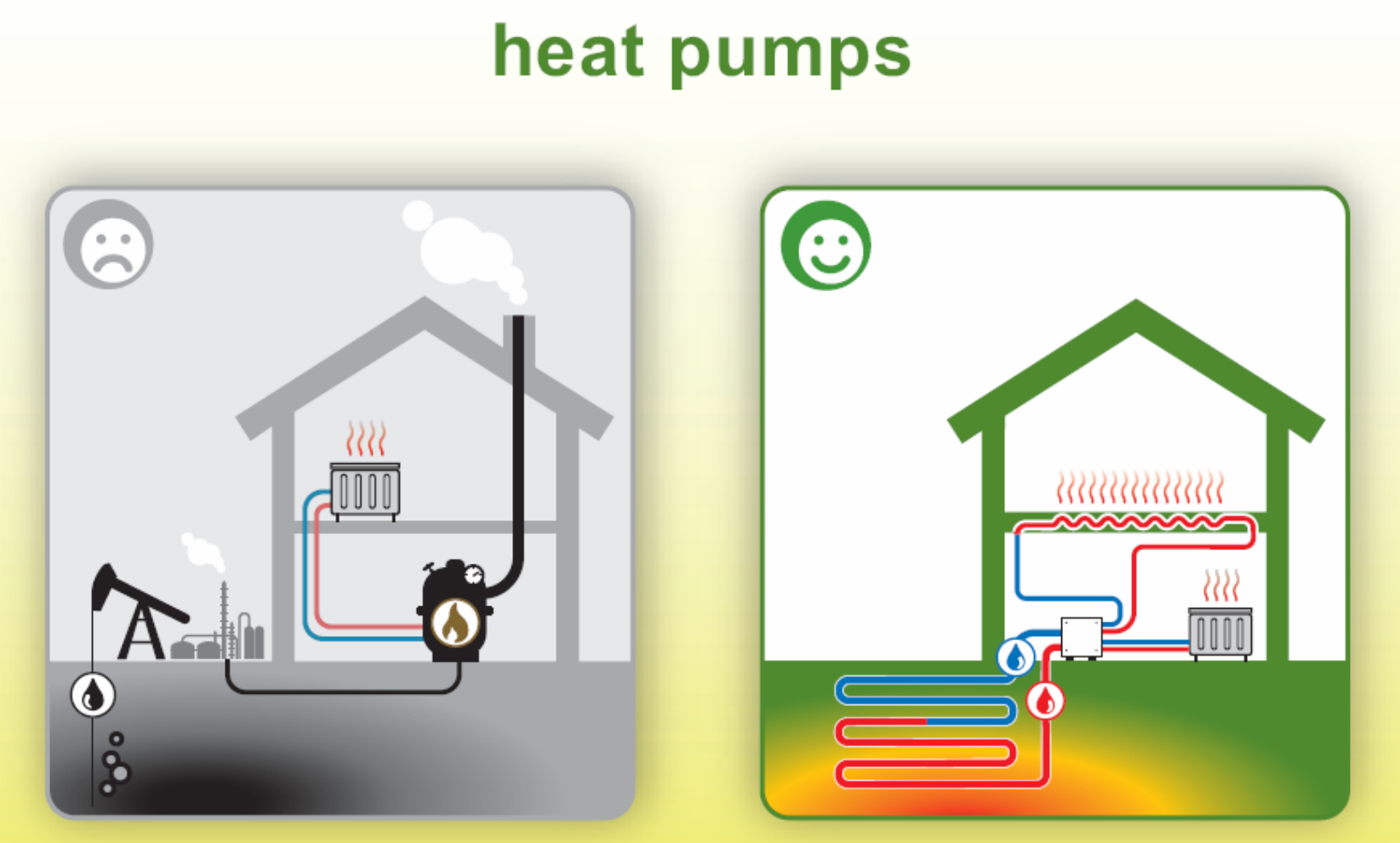
Blackboard information sheets



Design strategy

1. Reduce heat losses
2. Reduce electricity consumption
3. Utilise solar energy
4. Display and control energy use
5. **Select energy source**
   Heat pump, district heating, firewood, gas, electricity …

Renewable energy



Poster from the SARA project

Heat pump at Borgen Community Centre

- The heat pump gives about 2.5 to 3 times more energy than the electricity used to run the compressor
- The heat pump is dimensioned to 60 % of peek demand

  Under normal conditions this is enough, and the backup system of oil burners are used only a few days during winter

Heat pump at Borgen Community Centre

- The heat pump system produces low temperature hot water by 45–50 ˚C. Heat is distributed by water to radiators placed under the windows. The system is reversed in summer, to provide cooling.
- The heat pump system is also used for preheating DHW to about 40 ˚C. Additional electric heating raise the water temperature to 75 ˚C.
- Depending on the financial rate and electric energy prices, payback time was calculated to 10–13 years. Since making this calculation, the rate has decreased and energy prices increased, and payback time is expected to be much shorter.

Estimated energy savings

The purchased energy consumption is calculated to 50% of new, existing Norwegian school buildings.

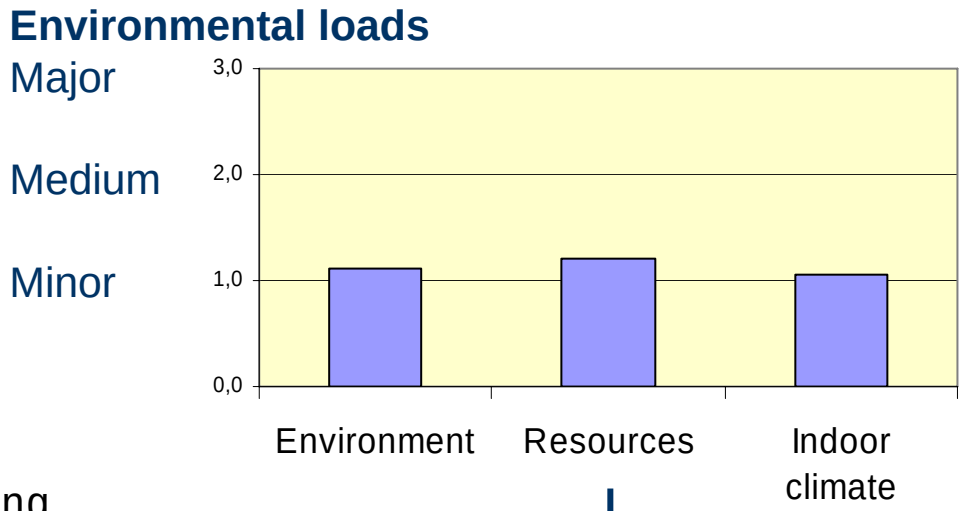
	National Benchmark
Purchased energy consumption	220 kWh/m^2/a

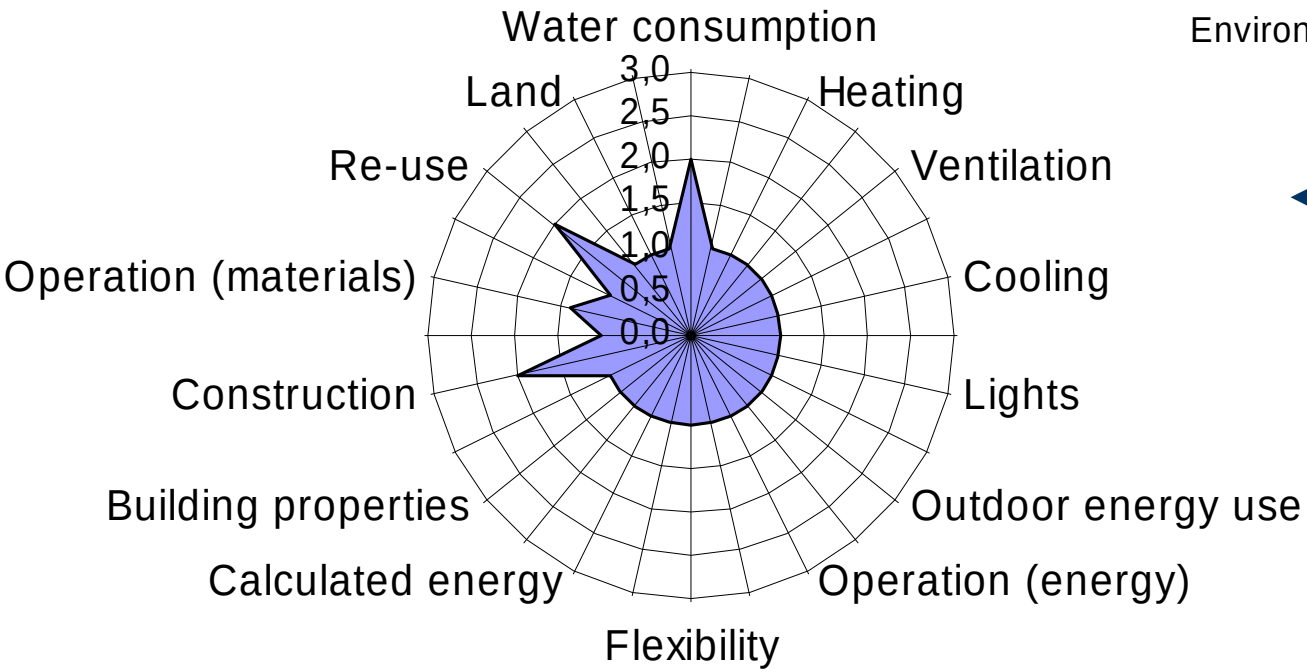
	Budget for Borgen	
	Energy kWh/m^2/a	Power W/m^2
Space heating	29	30
Heating ventilation air	20	41
Water heating	13	10
Fans and pumps	15	6
Lighting	23	14
Equipment	11	8
Cooling	0	0
Total	**111**	

Measured before retrofit: 280 kWh/m^2 a

EkoProfil assessments

Pre-design phase





OBS-list for further work

Participants in the building process

- Byggeier: Asker kommune
- Prosjektledelse byggeadministrasjon: Sohlberg & Toftenes
- Prosjekteringsledelse: Åke Larson Construction
- Arkitekter: HUS arkitekter Trondheim AS / HUS pka-Oslo
- Landskapsarkitekter: Sundt & Thomassen landskapsarkitekter
- Konsulenter VVS: Dagfinn H. Jørgensen
- Konsulenter elektro: Elconsultteam
- Konsulenter bygningsteknikk: Ing. Seim & Hultgreen
- FoU-rådgivere skolemiljø og energibruk: SINTEF og NTNU

eco buildings

- EU's Sixth Framework Programme announced calls for proposals within the field of Sustainable Energy Systems – Ecobuildings
- Four projects awarded finance: BRITA in PuBs, Sara, Eco-Culture, Demohouse
- The four projects include a great number demo-buildings

BRITA in PuBs SARA ECO-Culture demohouse

Bringing Retrofit Innovation to Application in Public Buildings

Abstract

- The aim is to increase the market penetration of innovative and effective retrofit solutions to improve energy conservation and implement renewable energy sources, with moderate additional costs
- Public buildings of different types are chosen to reach groups of differing age and social origin. Public buildings are used as engines to heighten awareness on energy efficiency

Structure: 3 main pillars

Demonstration buildings:

- College
- Cultural centre
- Nursery home
- Community centre
- Church
- Library, etc.

Research work:

- Project planning needs and financing strategies
- Design guidelines
- Internet-based knowledge tool
- Quality control tool-box

Dissemination:

- Training of users and maintenance personnel
- Training of students
- Publishing the work to different target groups

Participants

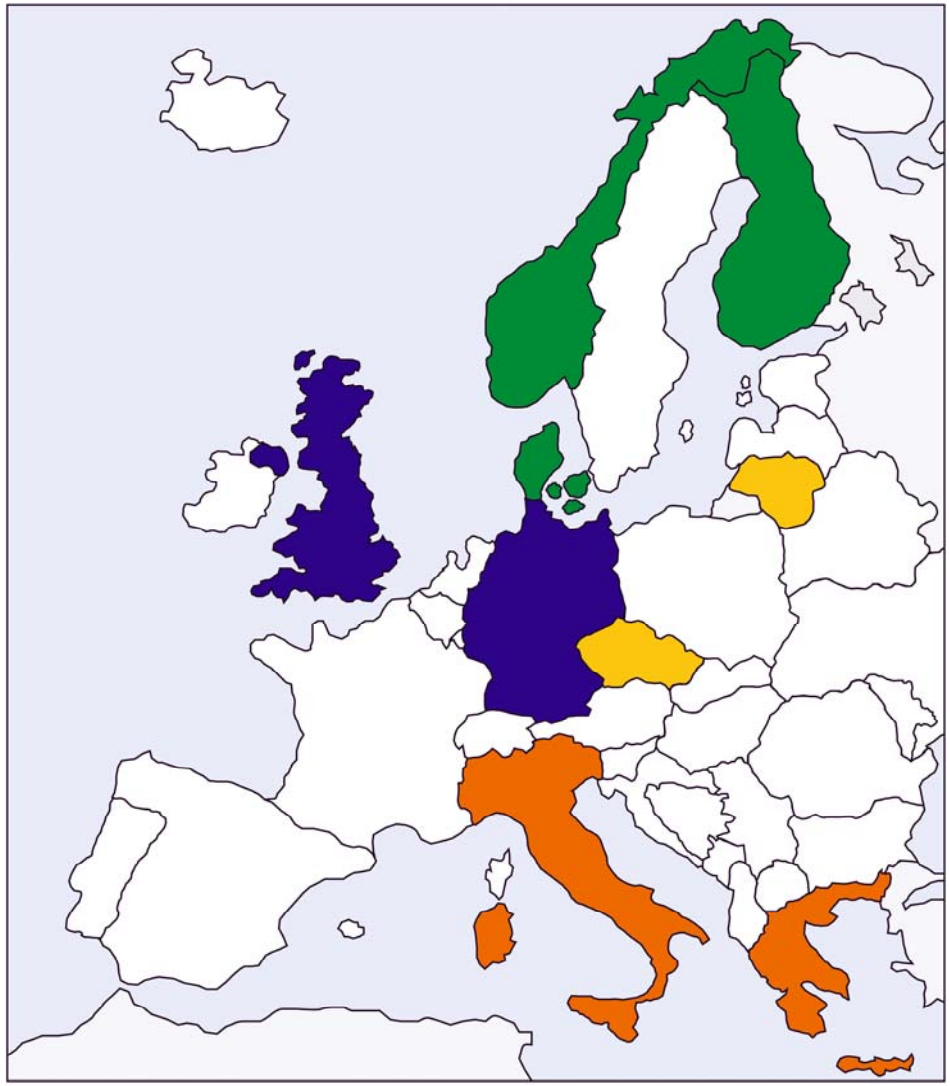
9 countries from 4 European regions:

North:
Norway, Finland, Denmark

Central:
UK, Germany

South:
Italy, Greece

East:
Czech Republic, Lithuania



The role of Asker Municipality in the BRITA project

- Monitoring
- Evaluation
- Dissemination
- Training courses for building operation staff

Statement from the municipality

Stein Grimstad, head of project department

Borgen Community Centre stands as a very successful project, representing a major contribution to improve environment and indoor climate.

I register with pleasure that our goal of reducing energy consumption by at least 50 % has been achieved by a good margin. Our experience with the technical principles applied to the building represent a good foundation for future buildings in our municipality.

The building has also been awarded a prize for being an environmental friendly building, and the response from the users are very positive.

Costs

- **Extra costs compared to conventional building**

Elementer	NOK	EURO
Bygningsintegrerte ventilasjons-konstruksjoner	3.800.000	463.415
Spesialutviklede ventilasjons-elementer	930.000	113.415
CO2 styring	372.000	45.366
Varmegjenvinningssystemer	254.200	31.000
SD- anlegg	750.000	91.463
Planlegging og prosjektledelse	700.000	85.366
SUM	6.806.200	830.025
Totale prosjektkostnader	183.000.000	22.317.073

Pay-back time: 7 years

Lessons learnt on hybrid ventilation

Statements from the municipality

Too short distance from inlet tower to filter and heat exchanger, use of wrong materials and lack of a properly slanted floor towards the drain, has resulted in development of some fungus.

Now the hybrid ventilation systems function very well after some amendments. Design should be focused on:

- Preventing moisture from rain and snow to enter the ventilation culverts from air inlet towers.
- Preventing sound to be carried from room to room through ventilation culverts.
- Constructing underground culverts along existing buildings is complicated and expensive. Other solutions should be searched for.

Lessons learnt on control

Statements from the municipality

- IR sensors for light regulation combined with burglar alarm has caused problems because unwanted light hits the sensor and triggers the alarm. These should be separate systems.

- Extensive and complicated BEMS system requires a long testing and adjustment period. Technical personnel should be educated during the building period to get acquainted with the technical installations before the building is opened.

Bringing Retrofit Innovation to Application in Public Buildings

BRITA in PuBs

www.brita-in-pubs.eu

http://www.skoleanlegg.utdanningsdirektoratet.no