

Balancing economics and environmental protection in supplying energy to new built residential areas





*Peder Vejsig Pedersen,
Cenergia Energy Consultants
Sct. Jacobs Vej 4
2750 Ballerup
Denmark*

Tel.: +45 4466 0099

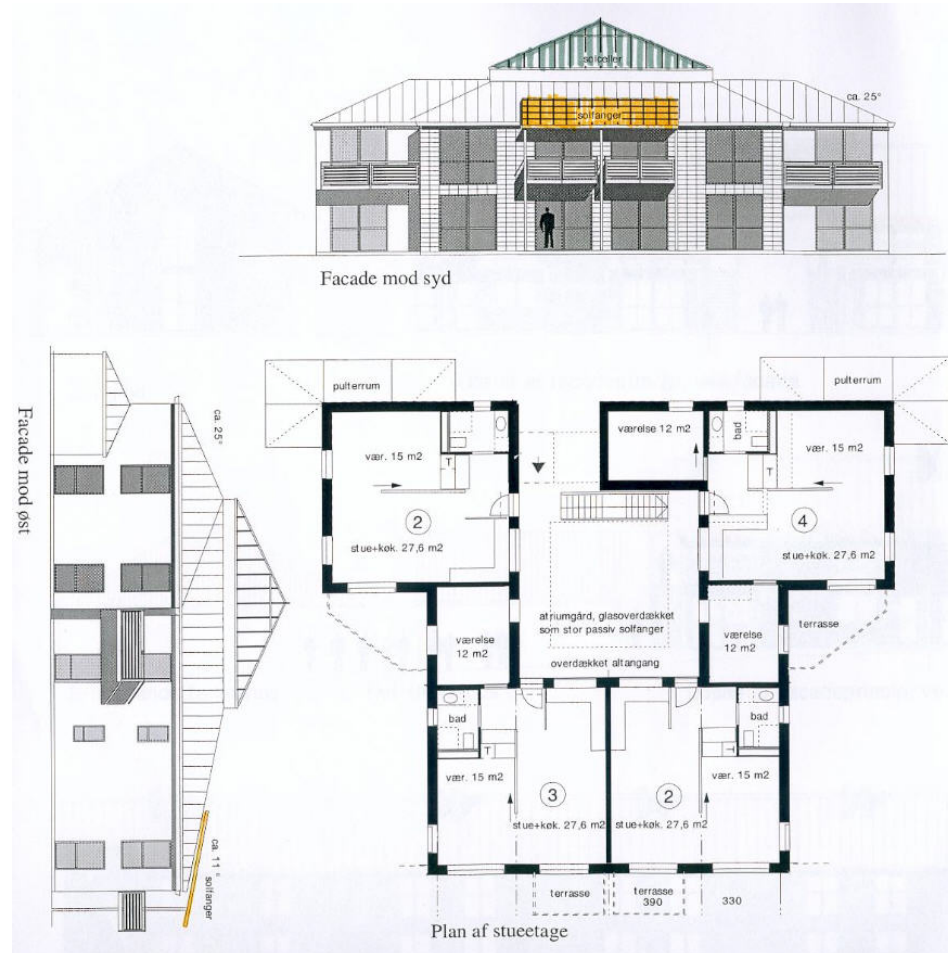
Fax: +45 4466 0136

Mail.: cenergia@cenergia.dk

Web: www.cenergia.dk

Rønnebækshave II, Næstved

– 8 passive housing units to be established in 2005



2-floor building with 8 dwellings, 4 dwellings in each floor.
PV and solar panels on roof.



Rønnebækshave II, Næstved

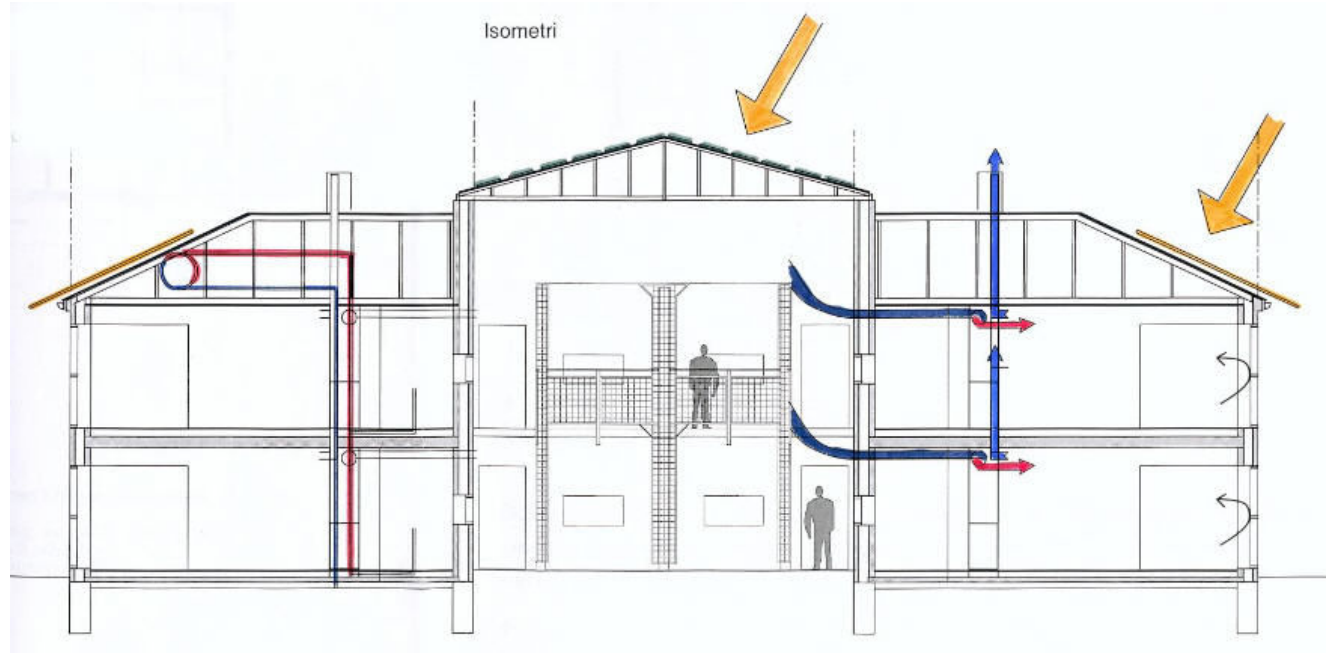
– 8 passive housing units to be established in 2005

Construction	U-value [W/m ² K]
Walls	0,15
Roof	0,08
Floor	0,1
Windows	0,85

U-values of constructions in the dwellings.

Rønnebækshave II, Næstved

– 8 passive housing units to be established in 2005

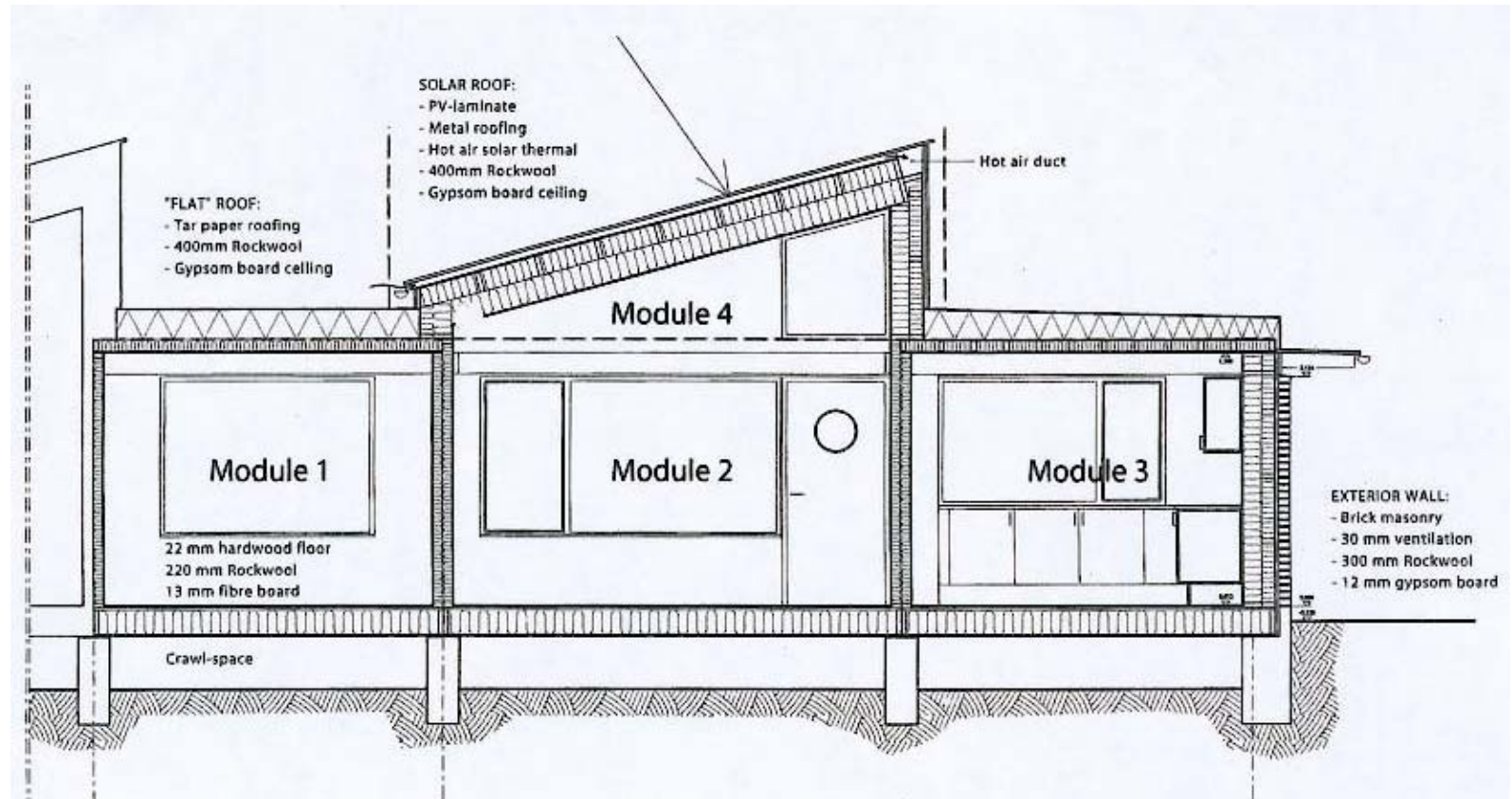


2-floor building with 8 dwellings. Passive solar gain in atrium in middle of the building. PV and solar panels on roof.

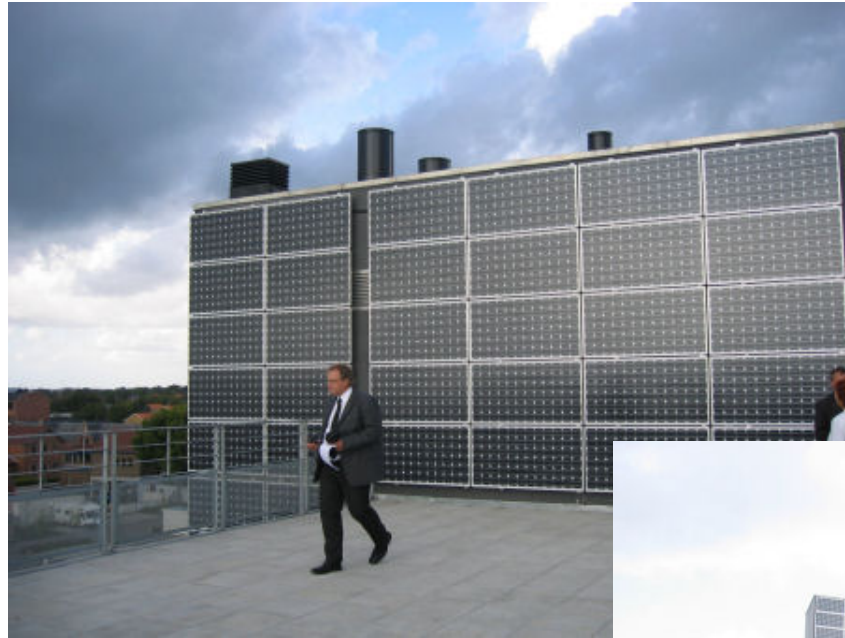
Solengen, Salpetermosevej



Solengen, Salpetermosevej



Dalgasparken, Herning

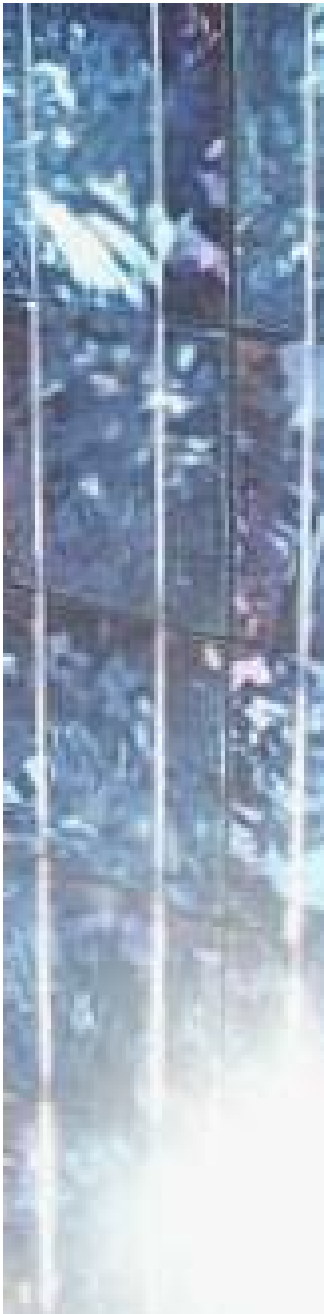


Hjem A/S, Herning



Analysis of optimised energy supply options for low energy housing using RUE and RES technologies based on the situation in Denmark.

		1. Yearly energy use for heating and DHW kWh/m ²	2. As 1. but including district heating losses kWh/m ²	3. Yearly electricity use for pumps and ventilation kWh/m ²	4. Yearly total electricity use (1.+3.) multiplied by a factor of 2.5 kWh/m ²	5. Yearly total energy use in kWh/m ²
	District heating:					
A	Normal housing project – non ideal users	110	137.5	4	10	147.5
B	Normal housing project – calculation results	96	120	4	10	130



C.	Housing project based on EPD demands 2006	72	99.5	4	10	109.5
D.	Housing project based on expected demands in 2010	48	75.5	3	7.5	83
E.	Housing project as D. but using low temperature district heating with pulse operation and solar DHW	48	62	3	7.5	69.5
F.	Housing project as E. but as “passive housing”	30	44	3	7.5	51.5 (46 % of EPD 2006)



	Electrical heating:					
G	Passiv haus design	30		3	82.5	82.5
H	Passiv haus design in combination with small heat pump	15		3	45	45 (36% of EPD 2006)

For Denmark district heating is normally based on waste incineration and CHP. The calculation of key figures for energy use is made in the way proposed by the Danish Building Research Institute in relation to the new building regulation for 2005. Here electricity use in connection to heating demands incl. pumps and fans are multiplied by a factor of 2,5. Case D - F illustrates that it is necessary to reduce distribution losses for district heating if this shall be an option for low energy housing. Case G and H illustrates that small heat pumps is a good option for a “passiv haus” standard.

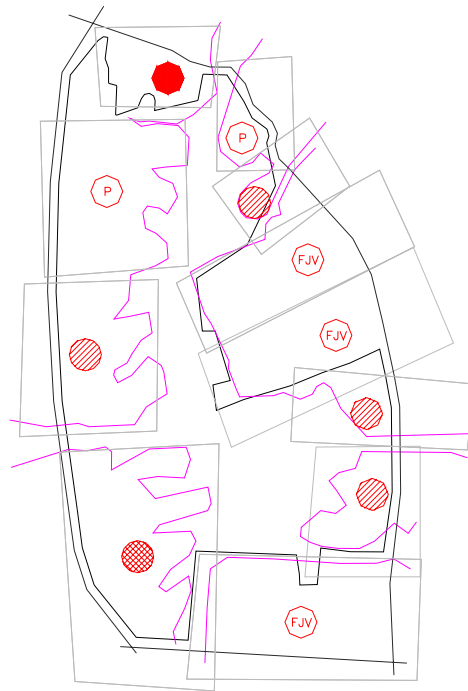
ULLERØDBYEN – HILLERØD



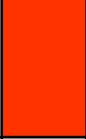
- Example of energy supply options



ULLERØDBYEN – HILLERØD

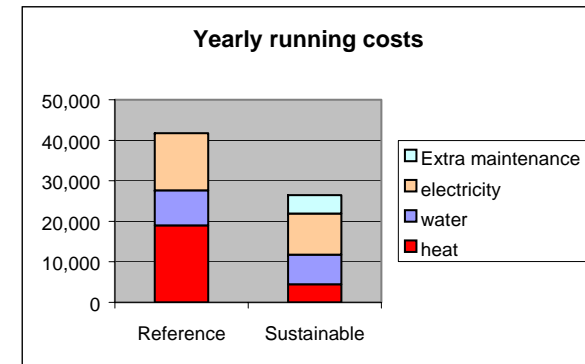
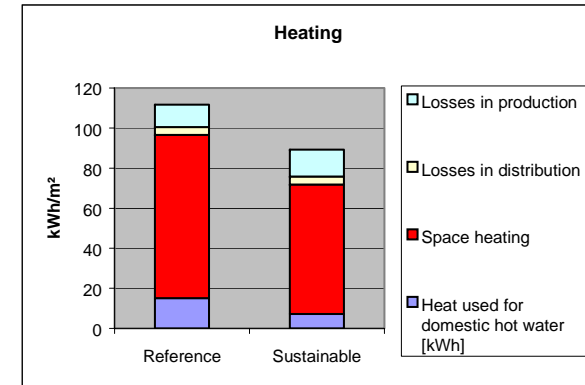
- Example of energy supply options



Signs :	
Fjv.	Existing district heating
	Optimised district heating
	Local biomass or CHP district heating
	Energy supply based on high % renewables
P	Zero energy / passiv housing



Yearly consumptions and savings per m ²	Reference	Sustainable	Savings
Heat used for domestic hot water [kWh]	15.1	7.2	52.1%
Space heating	81.4	64.6	20.7%
Losses in distribution	4.0	4.0	0.0%
Losses in production	11.2	13.4	-19.8%
Heating and hot water [kWh/m ²]	111.7	89.2	20.1%
Electricity [kWh/m ²]	33.0	23.76	28.0%
Water inclusive hot water [m ³ /m ²]	1.08	0.92	15.0%
Consumption hot water [m ³ /m ²]	0.32	0.28	15.0%
Yearly emission [kg]			
CO2	76253	38016	50.1%
SO2	223	488	-119.0%
Nox	249	715	-186.5%
Damages of air pollutants in euro per year			-2651
Yearly running costs			
Reference	Sustainable		
heat	18,986	4,460	
water	8,640	7,344	
electricity	14,080	10,138	
Extra maintenance	0	4,486	
Total yearly running costs	41,706	26,428	
Economy			
Investment in standard project		2,600,000	
Additional investment		149,547	
Total		2,749,547	
Increase		5.8%	
Simple Payback Time, years		9.8	
Net Present Value		178,900	
Profitable investment			



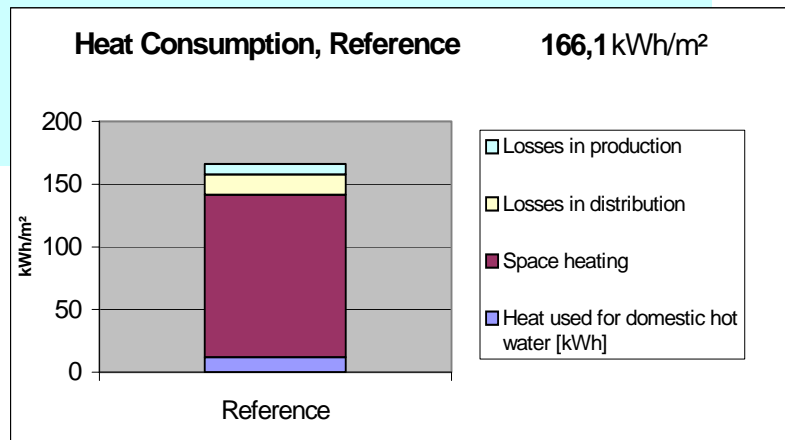
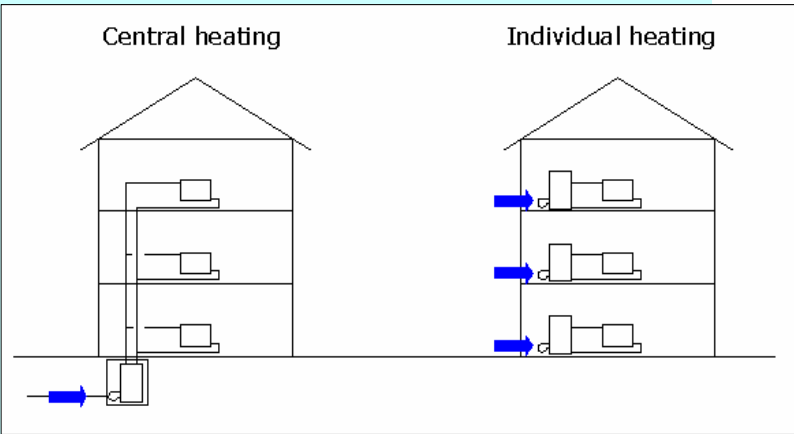
Example of calculation results with ASCOT.

ASCOT can be downloaded from Cenergia's website :

www.cenergia.dk.



	A	B	C	D	E	F	G	H	I	J	K
1	Data of the reference project										
2	Wall, floor, roof.		0,45								
3	Window		5,4								
4	Distribution	Insufficient insulation									
5	Building category	Building block with flats									
6	Heating supply system	District heating									
7	Efficiency of the internal heating system		95%								
8	Reference, electricity	kWh/m ²	31,0								
9	Reference, water inclusive hot water	m ³ /m ²	0,85								
10	Reference consumption hot water	%	30%								
11	Weather data										
12	Station	DK, Copenhagen									
13											
14	Unit definition										
15	Size of the building	m ²	2000								
16											
17	Data of the energy project										
18	Distribution	Central heating system									
19	Heating supply system	District heating									
20	Efficiency of the internal heating system		95%								
21	Economic data										
22	Investment of reference project	euro/m ²	1300								
23	Set aside (maintenance)	%	3,0%								
24	Expected economic lifetime	years	30								
25	Discount rate	m	5,0%								
26	Tax of interest	s	0,0%								
27	Inflation of energy	ie	2,5%								
28	Inflation of maintenance	iu	2,0%								
29	NPV calculation factors										
30	Factual costing interest, savings	rrb	2,439%								
31	Factual costing interest, expenses	rru	2,941%								
32	NPV factors, savings	frvb	21,1								
33	NPV factors, expenses	frvu	19,8								

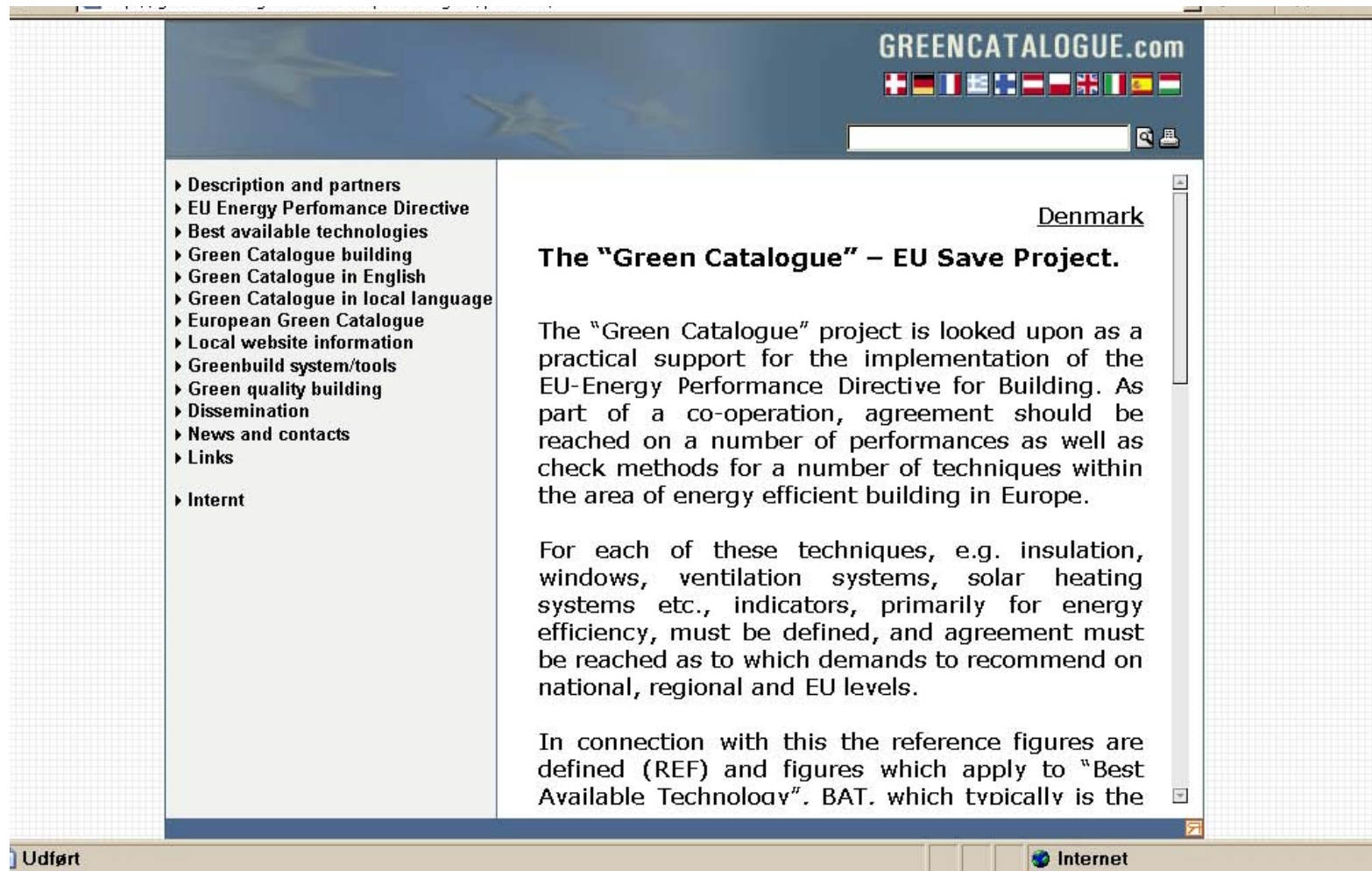


Reference data in ASCOT



	B	D	E	F	G	H	I	J	K
1	lo	Savings	Operation	Maintenance	NPV-S	NPV-M	NPV		
2	Heating	euro/m ²	kWh/m ²	euro/m ²	euro/m ²	euro/m ²	euro/m ²	euro/m ²	
3	Passive solar heat design	10,00	16,7	0,00	0,30	26	6	10	<input type="checkbox"/>
4	Ventilation with heat recovery	27,00	28,8	0,42	0,81	46	24	-6	<input type="checkbox"/>
5	Airtightness	4,00	15,6	0,00	0,12	25	2	18	<input type="checkbox"/>
6	Energy savings through water saving	0,00	1,8	0,00	0,00	3	0	3	<input type="checkbox"/>
7	Energy savings / tenant behaviour	0,80	15,8	0,00	0,02	25	0	24	<input type="checkbox"/>
8	Energy efficient windows, U-value=1,4	2,50	78,0	0,00	0,08	123	1	119	<input checked="" type="checkbox"/>
9	Super energy efficient windows, U=1,1	9,17	83,1	0,00	0,28	132	5	117	<input type="checkbox"/>
10	Cold bridges, 50% improvement	5,00	2,5	0,00	0,15	4	3	-4	<input type="checkbox"/>
11	Additional insulation, 100mm walls	32,00	17,1	0,00	0,96	27	19	-24	<input type="checkbox"/>
12	Additional insulation, 100mm roof	7,00	12,0	0,00	0,21	19	4	8	<input checked="" type="checkbox"/>
13	Additional insulation, 100mm floor	17,00	9,7	0,00	0,51	15	10	-12	<input type="checkbox"/>
14	Improved distribution (insul.+BEMS)	14,00	8,0	0,00	0,42	13	8	-10	<input type="checkbox"/>
15	New heating system	10,00	0,0	0,00	0,30	0	6	-16	<input type="checkbox"/>
16	Active solar heat	6,17	5,3	0,33	0,19	8	10	-8	<input type="checkbox"/>
17	Sum of chosen initiatives	33,50	67,2	0,00	1,01	158	20	105	<input type="checkbox"/>
18	Water	euro/m ²	%						
19	General water conservation initiatives	2,50	15%	0,00	0,08	14	1	10	<input checked="" type="checkbox"/>
20	Water conservation / tenant behaviour	0,83	15%	0,00	0,03	11	0	9	<input checked="" type="checkbox"/>
21	Collection of rainwater	16,67	32%	0,38	0,50	23	17	-11	<input type="checkbox"/>
22	Local bypass of rainwater	3,33	0%	0,13	0,10	0	4	-8	<input type="checkbox"/>
23	Sum of chosen initiatives	3,33	30%	0,00	0,10	24	2	19	<input type="checkbox"/>
24	Electricity (lightning)	euro/m ²	%						
25	Energy efficient lighting	3,30	5%	0,00	0,10	7	2	2	<input type="checkbox"/>
26	Electricity savings through ventilation	8,00	10%	0,00	0,24	14	5	1	<input type="checkbox"/>
27	Electricity savings / tenant behaviour	0,83	10%	0,00	0,03	14	0	13	<input type="checkbox"/>
28	Hard white goods - Grade A	1,67	3%	0,00	0,05	4	1	2	<input type="checkbox"/>
29	Roofed clothes drying yards	5,00	5%	0,00	0,15	7	3	-1	<input type="checkbox"/>
30	Daylight optimisation	1,67	2%	0,00	0,05	3	1	0	<input type="checkbox"/>
31	Prepared for PV	1,67	0	0,00	0,05	0	1	-3	<input type="checkbox"/>
32	Sum of chosen initiatives	0,00	0%	0,00	0,00	0	0	0	<input type="checkbox"/>
33	Materials	euro/m ²							
34	Environmentally acceptable paint	3,33	0,00	0,00	0	0	2	-5	<input type="checkbox"/>
35	PVC free building	5,00	0,00	0,00	0	0	3	-8	<input type="checkbox"/>
36	Exclusive of compregnated wood	1,67	0,00	0,00	0	0	1	-3	<input type="checkbox"/>
37	Environmentally / work correct insulation	6,67	0,00	0,00	0	0	4	-11	<input type="checkbox"/>
38	Sum of chosen initiatives	0,00	0	0	0	0	0	0	<input type="checkbox"/>
39	Indoor climate	euro/m ²							
40	Indoor c. marked surface materials	3,33	0,00	0,00	0	0	2	-5	<input type="checkbox"/>
41	Sum of chosen initiatives	0,00	0	0	0	0	0	0	<input type="checkbox"/>
42	Waste	euro/m ²							
43	Waste sorting	4,17	0,00	0,00	0	0	2	-7	<input type="checkbox"/>
44	Composting	3,33	0,00	0,00	0	0	2	-5	<input type="checkbox"/>
45	Sum of chosen initiatives	0,00	0	0	0	0	0	0	<input type="checkbox"/>
46	Green areas	euro/m ²							
47	Initiatives for acquiring green areas	3,33	0,00	0,00	0	0	2	-5	<input type="checkbox"/>
48	Sum of chosen initiatives	0,00	0	0	0	0	0	0	<input type="checkbox"/>
49	Securing of project quality	euro/m ²							
50	Control through independent consultant	7,50	0,00	0,00	0	0	4	-12	<input checked="" type="checkbox"/>
51	Sum of chosen initiatives	7,50	0	0	0	0	4	-12	<input type="checkbox"/>
52	Total	44,33			1,33	182	26	112	<input type="checkbox"/>

Economic input data for the ASCOT calculation



Partners from : Denmark, France, Austria, Germany, Spain, Italy, UK, Finland, Greece and Poland.

(Final conferences : Salzburg / Copenhagen november 2004)

GREEN CATALOGUE WORKING DOCUMENT

BAT INTERNATIONAL

REVISED, March 2004, NMo/Tbo

Technology	Relevant Indicators	Performance Requirements				Check Systems
		Present (normal standard)	BAT	2006 (EPD)	Future (2010)	
1. Insulation	U-Value [W/m ² K] External Wall:	I: 0,25-0,6 II: 0,25-0,45 III: 0,7-1,1	I: 0,1-0,2 II: 0,1-0,3 III: 0,1-0,2	I: 0,25-0,6 II: 0,25-0,45 III: 0,2-0,7	I: 0,25-0,6 II: 0,2-0,4 III: 0,1	EnEV Passivhaus- Institut
	Roof:	I: 0,2-0,6 II: 0,2-0,3 III: 0,5-0,6	I: 0,1 II: 0,1-0,2 III: 0,1	I: 0,2-0,6 II: 0,2-0,25 III: 0,1-0,5	I: 0,2-0,6 II: 0,15-0,2 III: 0,1	
	Floor (ground/ unheated rooms)	I: 0,25-0,6 II: 0,35-0,45 III: 0,6-3	I: 0,18 II: 0,1-0,3 III: 0,12	I: 0,25-0,6 II: 0,35-0,45 III: 0,2-2	I: 0,25-0,6 II: 0,3-0,4 III: 0,1	

Zone I: FI
 Zone II: D, FR
 Zone III: GR, ES



Mærkenr : 104123

Store ejendomme

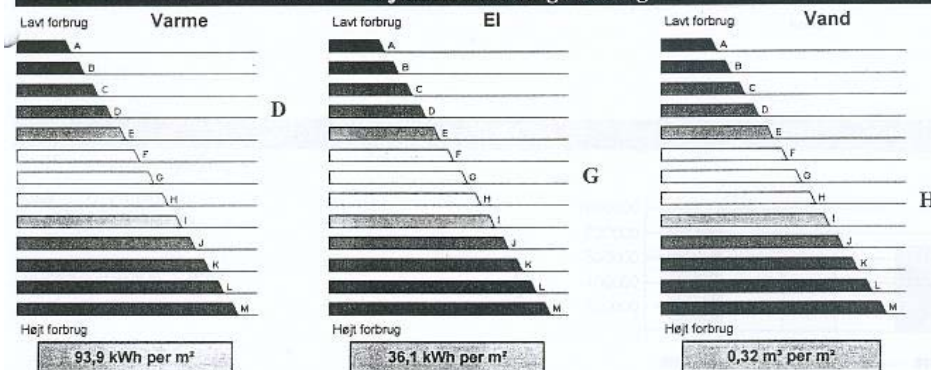
Energiledelsesordningen for store ejendomme, ELO

BBR nr: 101-003043-001
 Adresse: Sankt Annæ Gymnasium, Sjøler Boulevard 135
 Post nr: 2500 By: Valby
 Anvendelse: Gymnasium (kodenr.: 6220)
 BBR areal: 19.436 m² Heraf opvarmet areal: 19.436 m²
 Opvarmingsform: Fjernvarme
 Bygningsgennemgang: 16-03-2004
 Næste bygningsgennemgang senest: 2005

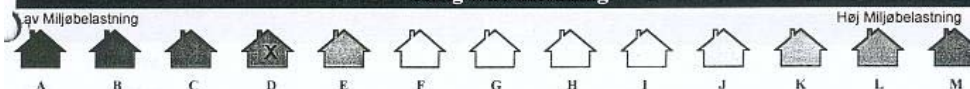
Udarbejdet af: Københavns Energi
 Adresse: Studiestræde 54
 Post nr: 1554 By: København V
 Konsulent: Harald Funch Kofod
 Sagsnr.: Sankt Annæ Gymnasium
 Indberettet: 22-03-2004

Underskrift:

Ejendommens årlige forbrug



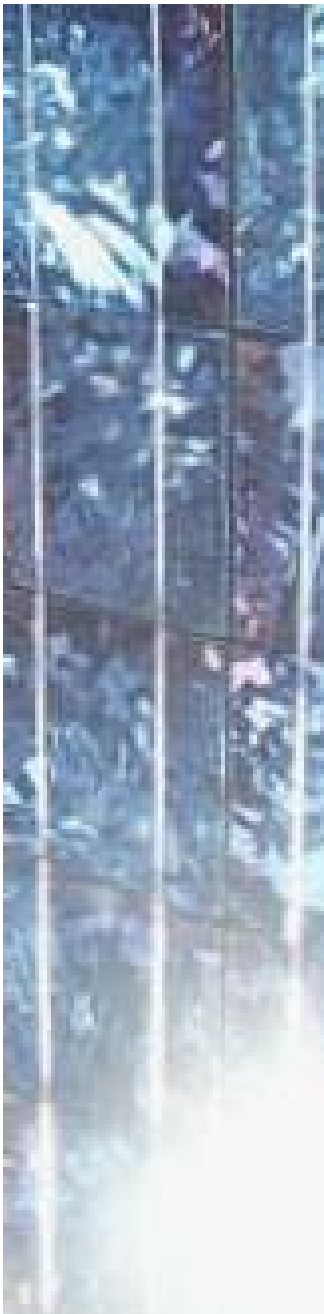
Markeringen på skalaen afhænger af ejendommens forbrug. Jo tættere markeringen er på A, jo lavere er ejendommens forbrug sammenlignet med andre tilsvarende ejendomme. Varmeforbrugets bidrag er klimakorrigeret.

Årlig CO₂ udledning

Markeringen på skalaen afhænger af ejendommens CO₂ udledning. Jo tættere markeringen er på A, jo lavere er ejendommens CO₂ udledning sammenlignet med andre tilsvarende ejendomme.

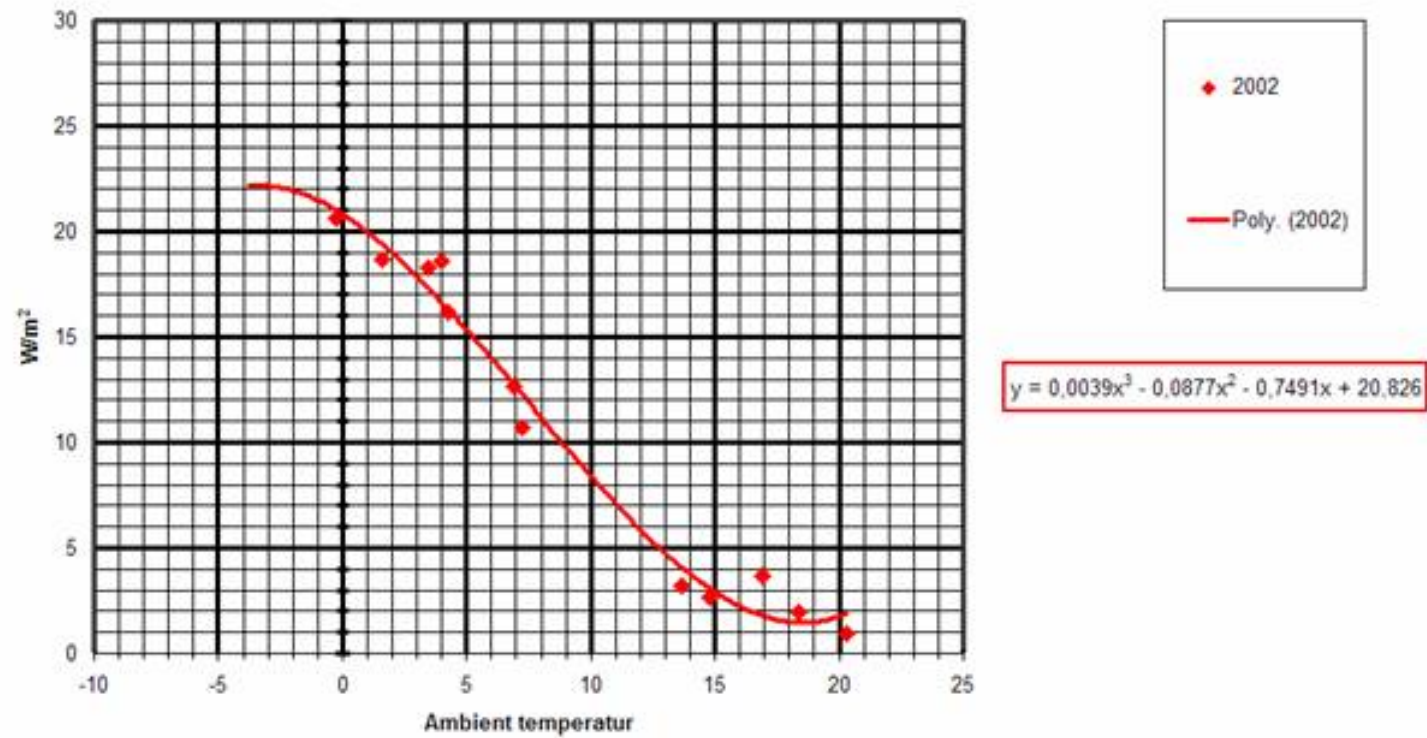
Samlet forbrug og CO₂ udledning

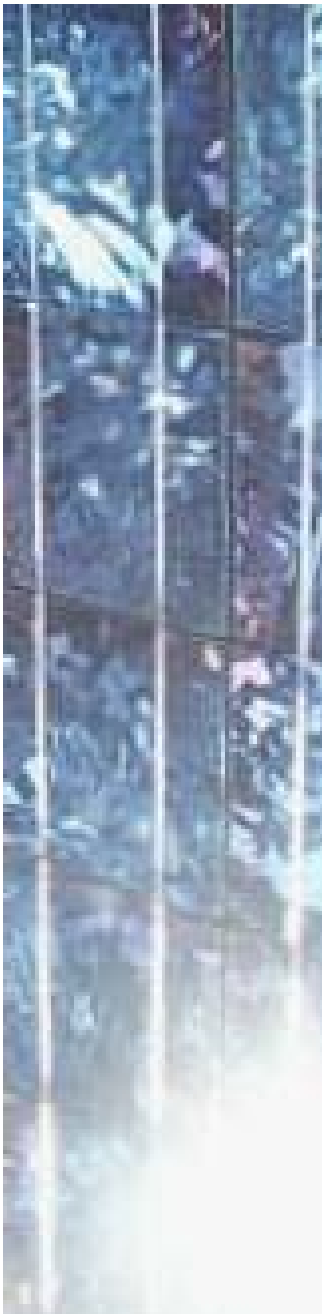
	Varme	EI	Vand	I alt
Seneste års forbrug, aflæst	1.782 MWh	701.652 kWh	6.280 m ³	
Opgjort periode	01-01-2003 til 31-12-2003	01-01-2003 til 31-12-2003	01-01-2003 til 31-12-2003	
Enhedspris inkl. moms og afgifter	537,50 kr. per MWh	1,75 kr. per kWh	29,99 kr. per m ³	
Årets udgift inkl. moms og afgifter, dog undtaget evt. fast afgift	957.825 kr.	1.227.891 kr.	188.322 kr.	2.374.038 kr.
Årets CO ₂ udledning	256 tons	417 tons		674 tons



Tonw Hall Heat Characteristic for 2002

© Dansk Energi-Diagnostik





Energy Diagnostic System

© Dansk Energi-Diagnostik

Input in Blue Cells

Output in Red cells

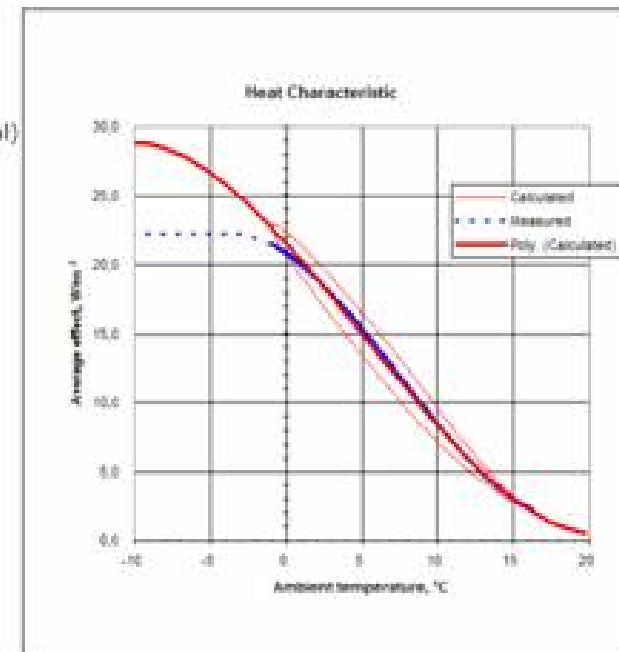
Building: Town Hall

Users	100 persons	Area:	24,8 m ² / person
Hot Water Consumpti	5 liter/day * person		2000 kWh/year
Electricity consumptk	500 kWh/year * person		50000 kWh/year (total)

Ambient temperature	0	20	°C
Room temperature:	18	23	°C
Basement temperature	18	23	°C
Air change	0,3	0,6	h ⁻¹ -air change
Specific Heat loss:	1,34	1,66	W/m ² °C,

Temperatures in distribution network:

Ambient temperature	-12	0	20	°C
Suply:	60	50	23	°C
Return:	40	35	23	°C



“Demohouse” - 6 FP- Ecobuilding project.

**Demohouse – Design and
Management Options for
improving the energy performance
of Housing in Europe
(6 FP – Ecobuildings) 2004 – 2009.**



“Demohouse” - 6 FP- Ecobuilding project.

SIXTH FRAMEWORK PROGRAMME
PRIORITY 6
ECOBUILDINGS



Contract for:

**SPECIFIC TARGETED RESEARCH OR INNOVATION
PROJECT**

DEMOHOUSE

Project full title: Design and Management Options for improving the energy performance of Housing

GYLDENRISPARKEN

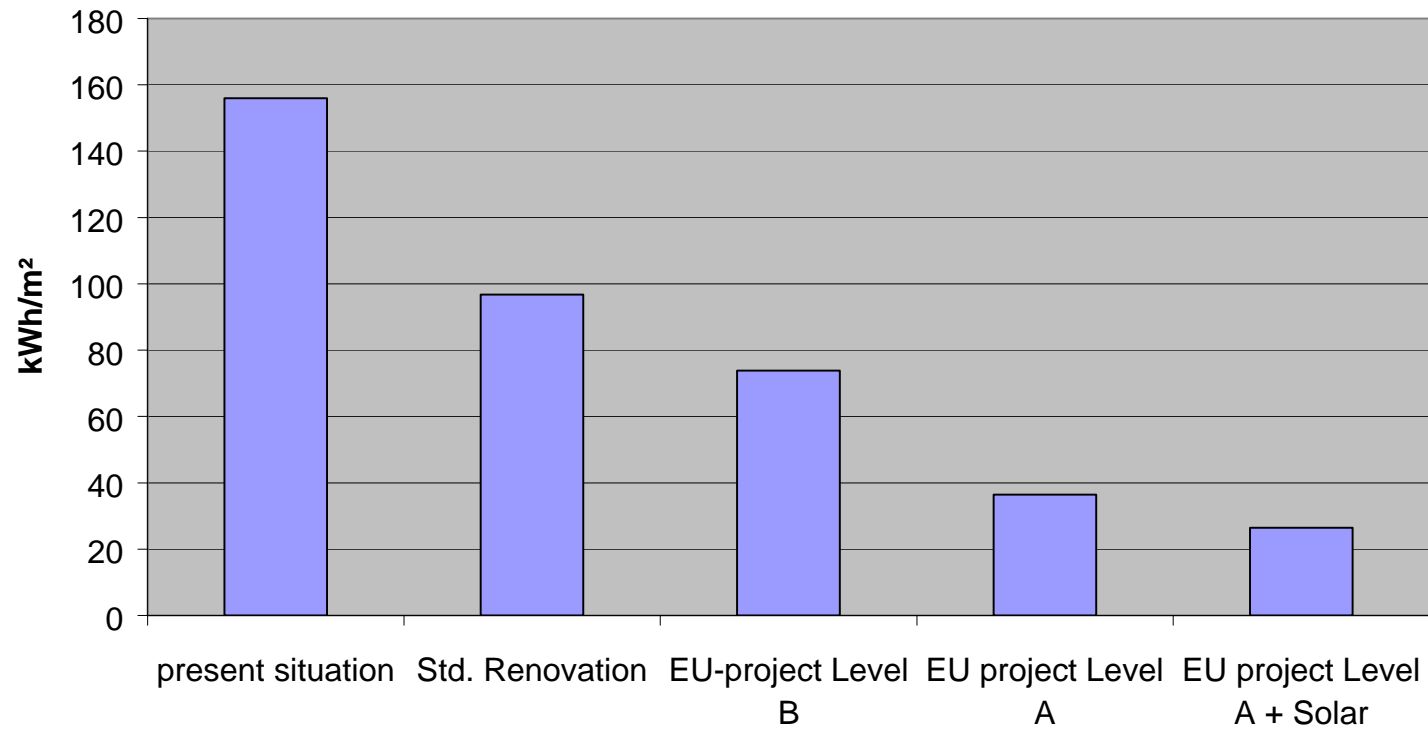
The housing blocks Gyldenrisparken include 500 apartments divided between several blocks of flats with a total built up area of 43410 m². The heat for the housing blocks is supplied by district heating and the consumption of heat is considerably higher than one would expect in new modern apartments. The housing blocks are built as a concrete panel assembly construction in 1965-69 and just now the buildings are about to be thoroughly renovated.





GYLDENRISPARKEN

Yearly Savings of Energy for Heating





GYLDENRISPARKEN

Standard renovation.

Apart from the usual building improvements a standard renovation of the Gyldenrisparken contains 100 mm insulation of the external surfaces, new windows with standard specifications, new heating distribution system and single water saving measures.

EU-project level B.

In addition to the standard renovation the EU-project level B contain a requirement controlled air exhaust with effective DC fans, insulation of the roof, use of BEMS, low-energy windows as well as more comprehensive water saving measures.

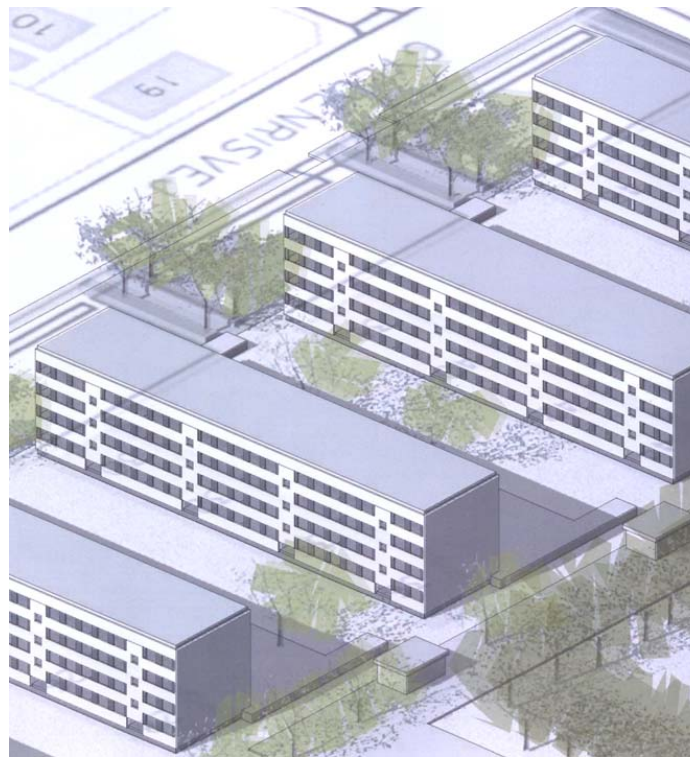
EU-project level A.

In addition to the cost-saving suggestions in level B the EU-project level A will contain ventilation with heat recovery, super low-energy windows with U-value of $0.85\text{W}/\text{m}^2\text{K}$ and inclusive an increased effort regarding air tightness of the apartment.

GYLDENRISPARKEN

EU-project level A + Solar

In addition to the cost-saving suggestions in level A the EU-project level A + solar will contain, 64 m² solar collectors as additional heat source for domestic hot water and 100 m² PV-modules.



GYLDENRISPARKEN

Consumption.

Calculated yearly consumption of water, heat and electricity:

Yearly consumption	present situation	Std. Renovation	EU-project niveau B	EU project niveau A	EU project niveau A + Solar
Space heating, kWh/m ²	130	72	57	19	19
Hot water heating, kWh/m ²	26	25	17	17	7
Total heating, kWh/m ²	156	97	74	36	26
Total water, m ³	2880	2736	2160	2160	2160
Domestic hot water, m ³	950	903	713	713	713
Elektricity, kWh/m ²	12	12	8	8	4

GYLDENRISPARKEN

The environmental improvement can be calculated as a reduction in the yearly CO₂ emission from the heat and electricity consumption (heat: 0,2 kg/MWh and electricity: 0,6 kg/MWh).

Calculated yearly CO₂ emission per housing block from the heat and electricity consumption:

Yearly CO2 emission kg/a per building block	present situation	Std. Renovation	EU-project niveau B	EU project niveau A	EU project niveau A + Solar
Heat consumption	89830	55726	42529	20999	15239
Electricity consumption	20736	20736	12960	12960	6960
Total CO2 emission	110566	76462	55489	33959	22199

A reduction of the CO₂ emission will be obtained if the project is carried out – 52% for level B and as much as 80% for level A + Solar.

GYLDENRISPARKEN

Running Costs

Expenses for the consumption are:

The yearly total running costs per housing block:

Running costs per housing block, euro.	present situation	Std. Renovation	EU-project Level B	EU project Level A	EU project Level A + Solar
Heating	36,173	22,440	17,126	8,456	6,136
Water	9,896	9,402	7,422	7,422	7,422
Elektricity	6,309	6,309	3,943	3,943	2,118
Total	52,378	38,150	28,491	19,821	15,676

GYLDENRISPARKEN

Budget

The budget for the energy- and water related improvements in the project are as shown in the next table. The standard project contains no eligible costs. The EU-project – level B contains a total of extra construction costs of 81,611,- EURO. Level A calls for an extra investment of a total of 127.785,- EURO.

Budget per block, euro	Std. Project	EU project Level B	EU project Level A	EU project Level A + solar
Insulation of gable	16,107	0	0	0
Insulation of roof	67,651	0	0	0
Insulation of facade	139,168	0	0	0
DC fans	0	12,886	0	0
Ventilation with heat recovery	0	0	77,315	77,315
Heating system	128,859	0	-64,430	-64,430
BEMS	8,949	17,897	17,897	17,897
Windows	85,906	28,993	57,987	57,987
Water savings	6,443	12,886	12,886	12,886
Solar heating system	0	0	0	34,362
Photovoltage	0	0	0	53,691
Air tightness	0	0	17,181	17,181
Sum	453,083	72,662	118,837	206,890
Design	45,308	8,719	14,260	24,827
Total	498,391	81,382	133,097	231,717
Support 35%	0	28,484	46,584	81,101
Total EU-Project				
Green Quality Process				70000
Meetings				17,000
Monitoring				67,000
Total eligible costs (96 flats)				600,196
EU support 35%				210,069

GYLDENRISPARKEN

Economic viability

The economic viability is based on the extra costs in energy savings measures and savings in energy and water compared to a standard renovation. The calculated payback time is without EU support or other EU related costs.

		Std. Renovation	EU-project Level B	EU project Level A	EU project Level A + Solar
Total costs	euro	498,391	81,382	133,097	231,717
Savings	euro	14,228	9,659	18,329	22,474
Payback time	years	35.0	8.4	7.3	10.3

In the future the costs for heating system in the budget can be reduced based on more experience and optimisation. This will probably lead to payback times of around 5 years for the level A example.

POLAND



Renovation of old housing block in Warsaw

GÖTEBORG

