5. THE SWEDISH SUBSIDY SYSTEM

The government has introduced a variety of subsidies for encouraging proprietors to implement energy conservation measures. The system can be divided into three categories:

- Renovation loans
- Interest rate subsidies
- Energy retrofit subsidies

The most advantageous of the means is the renovation loan, which is provided with an interest rate warranty, but also the other types reduce the cost for introducing energy conservation retrofits in the building. Note that the energy retrofit subsidies at present have been withdrawn until 1990-06-30 [24].

The subsidy system is not part of the original OPERA model and for using the system, the original input data file as the one in Figure 3, must be transferred to a new file where the retrofit costs etc. are changed in order to reflect the system. Unfortunately, it has not been possible to design a program that is totally independent of OPERA for the simulation of the subsidized costs. OPERA has been changed to some extent for taking care of the new input data file and also to find out if the subsidy system is to be examined.

The result from some OPERA runnings, with the subsidy simulation file in effect, showed only a minute influence from the subsidy system on the optimal retrofit strategy. Therefore, only the most advantageous of the systems has been dealt with here in closer detail, i.e. the renovation loans.

There are also other subsidies, not applicable for energy retrofit considerations and therefore not dealt with here, e.g. for:

- Installing elevators in existing multi-floor buildings
- Decreasing radon radiation inside the building
- Adapting existing flats for physically handicapped

A brief review can be found in [25].

Further, there is one more subsidy for energy measures, viz.:

- Direct monetary contributions to solar plants

Normally this type of subsidy is not applicable and thus it will not be dealt with here at all.

In the Swedish Building Code [8] and [26] there are certain limits to force the proprietor to make a building use less energy. However, [8] shows that there are possibilities to avoid the rules when retrofitting is of concern, if the costs are too high for e.g. an insulation measure. It is also said that the costs can be considered as too high if the existing U-value is so low, that an extra insulation will not entitle to energy retrofit subsidies. The new code [26] is not valid for old buildings and thus there are no mandatory limits for insulation measures in the existing housing stock.

5.1 Renovation loans

The renovation loans are the most advantageous form of subsidies. If the proprietor is entitled to loans, the government sets the highest intrest rate to 5.1 %, and 5.25 % for municipality ownership, for the first year [27]. Earlier, this rate was only 2.35 %.

The interest however, is increased with 0.25 % per year and further, the rate is based upon the original amount of borrowed money. The installments will not influence the money cost as long as the subsidy system is in effect. When the interest rate has increased to a level where it is cheaper to pay the ordinary interest, the subsidies are abolished. However, there are a lot of restrictions for this type of loan. The most important are:

- The building must be older than 30 years
- The result from the retrofits must be a substantially better building
- Only residential buildings are of concern
- No maintenance measures are entitled to renovation loans
- Energy retrofits are normally not entitled to loans, but may be included if they must be implemented when the rest of the building is retrofitted
- The residence must come up to a lowest acceptable standard
- Energy retrofits must not be too expensive, relative to the other measures made on the building
- Loans for heating equipment, not desired by the municipality, are mostly not entitled to be included
- The residence must be permanent
- The total renovation cost cannot be higher than the cost for a new building
- The standard must be normal, no luxury renovation
- The building must be sold by the municipality
- Etc

From most of these restrictions the municipality can make exeptions and the last mentioned above is rarely used nowadays. The restrictions discussed above are presented in detail in [28].

At present the government wants to encourage the construction of new buildings, instead of retrofitting old ones. A certain limitation has thus been set in the areas of Stockholm, Gothenburg and Malmö, and the annual amount of buildings to be retrofitted must not exceed 30 % of the amount retrofitted in 1986.

In the application for renovation loans, the assumed renovation cost, including costs for energy retrofits is calculated. If the proprietor is entitled to the loan, the total cost is devided in three parts:

- The base part, or first mortgage loan, 70 % of the renovation cost
- The residence loan, 25 - 30 % of the renovation cost
- 0 - 5 %, covered by the proprietor

The base part loan is a loan from a credit institution, like a mortgage bank, the second part is covered by the government and the third part is paid by the proprietor. If the proprietor is a municipality 0 % has to be covered this way, and if the landlord is a private person 5 % [29].

The interest rate for the base loan is not fixed by the government, but the same level is mandatory for five consecutive years. There are also some other rules for the credit, but of minor importance in this study.

The residence loan is covered by the government and the interest rate is set to what is valid for the moment. It is therefore not possible to know the exact level but at present it is about 12 %. The rate is set by the Governments Residence Financing Co, and also here the rate is fixed for five consecutive years.

There must also be a security for the loan and this is set by mortgages in the real estate and in the building. More details about the location etc of the mortgage bonds can be found in [28].

The government also sets a maximum interest rate for the first mortgage loan, and above this rate, no subsidies are paid.

The residence loan has a payoff time of up to 30 years while it is possible to get a longer payoff on the base part loan. The interest and amortizations are calculated as a fixed-yearly-instalment loan and the rate of interest is set to 8 %. The interest is calculated as:

$$FIP = A_{loan} \cdot \frac{r}{1 - (1 + r)^{-p}} \qquad (11)$$

where FIP = the fixed instalment
A_{loan} = the total loan
r = the discount rate
p = the payoff time

The base loan has a amortization plan that does not exactly follow the method with fixed-yearly-installments. The plan is determined for each case.

The society subsidizes the interest rate and the first year the rate is guaranteed to be 5.1 % for private owners and 5.25 % if the municipality owns the building. The rate is then increased with 0.25 % each year. Further, the interest is calculated on the total loan in spite of annual instalments. The subsidies therefore will be abandoned after some years . An example will show the situation:

Assume that A_{loan} above is 1000 000 SEK, the discount rate is 8 % and the payoff time 30 years. FIP in expression (11) will thus become 88 827 SEK. The interest cost is 80 000 SEK while the amortization is 8 827 SEK. Assume that the government now says that the interest is limited to 5.25 % and thus 52 500 SEK has to be paid. If the amortization is added the cost will be 61 327 SEK. If there was no guaranteed rate the interest would be some 12 % or 120 000 SEK, and the repayment about 4 143 SEK.

Next year, the real loan has decreased with 8 827 SEK, but the due interest has increased. This is because the rate increases with 0.25 % and has now become 5.5 %. The interest is still calculated on the 1000 000 SEK and the amount will become 55 000 SEK. The FIP above is also still 88 827 SEK but the interest part has decreased to 79 293 SEK calculated as:

$$(1000\,000 - 8\,827) \cdot 0.08 = 79\,293$$

The amortization will thus be:

$$88\,827 - 79\,293 = 9\,534 \text{ SEK}$$

Adding the interest will yield 64 534 SEK, which has to be paid year number two. In Table 2 the situation is shown for a number of years in running prices. Note that the subsidy is abandoned between the years 16 and 17 where the real interest exceeds the warranted. In [1] a case is considered with a warranted rate of 2.6 %, which was the case some years ago. In that case the subsidy was abandoned between the years number 20 and 21.

Table 2. Swedish subsidy system, running prices.

Year	FIP	Interest cost 8 %	Amortization	Warranted int. 5.25 % + 0.25 %	To pay	Next year loan	Real interest rate 12 %
1	88 827	80 000	8 827	52 500	61 327	991 173	120 000
2	88 827	79 293	9 534	55 000	64 534	981 639	118 940
3	88 827	78 531	10 295	57 500	67 795	971 344	117 796
16	88 827	60 825	28 002	90 000	118 002	732 314	91 238
17	88 827	58 585	30 242	92 499	118 120	702 072	87 878
29	88 827	12 672	76 155	122 499	95 163	82 247	19 008
30	88 827	6 580	82 247	125 000	92 117	------	9 870

It is, however, also necessary to calculate the present worth of the cash flow in Table 2. If the inflation is assumed to be 7 % annually, and the real discount rate is supposed to be 5 %, the situation can be depicted as in Table 3. The cash flow is first calculated in fixed prices and then transferred to a base year at present.

It is found that the originally 1000 000 SEK by use of the subsidy system has been changed to 654 112 SEK. The case where 2.6 % was used resulted in 466 600 SEK and it is thus obvious that the system is now less profitable to use.

Table 3. The Swedish subsidy system, fixed prices

Year	Running prices	Fixed prices 7 % inflation	Present worth 5 % real rate
1	61 327	57 315	54 586
2	54 534	56 366	51 125
3	67 795	55 341	47 806
4	71 120	54 257	44 637
29	95 163	13 376	3 250
30	92 117	12 101	2 800
Sum			654 112

In the tables above it is shown how the subsidy system influences the total cost of the building. There are however, also other facts that must be considered. Above it was assumed that the cost for the retrofits only was paid once, i.e. at the base year. If e.g. a heat pump is installed in the building, only the first cost for the pump can be included in the total loan. This is of course important to consider because the pump must be renovated after about 10 years and that cost is not subsidized. If an attic floor insulation is dealt with, the situation is different. This cost will probably emerge only once, and for such cases the method above will work well.

In the regulations of the renovation loans, there are also other constraints. Some energy retrofits have limitations for the cost included in the loan, and the cost for an attic floor insulation cannot exceed this cost even if found profitable. At least it cannot be included in the total loan over this limited cost. If the proprietor, nevertheless, finds it profitable to implement the insulation, it could be done but to a higher interest cost.

In order to enlighten the subsidy system, an example dealing with a heat pumpis shown below. The costs for the heat pump are taken from Figure 3. The pump is supposed to cost 60 000 + 5 000 · P SEK where P equals the thermal power of the device. If it is assumed that the heat pump power will be of the magnitude 20 kW, the cost for the pump will be 160 000 SEK. The heat pump itself is supposed to last for 50 years, but there is also the installation and further, maintenance every 10 years, to a cost of 1 500 SEK per kW. This extra cost thus amounts to 30 000 SEK. The situation is depicted in Figure 9 .

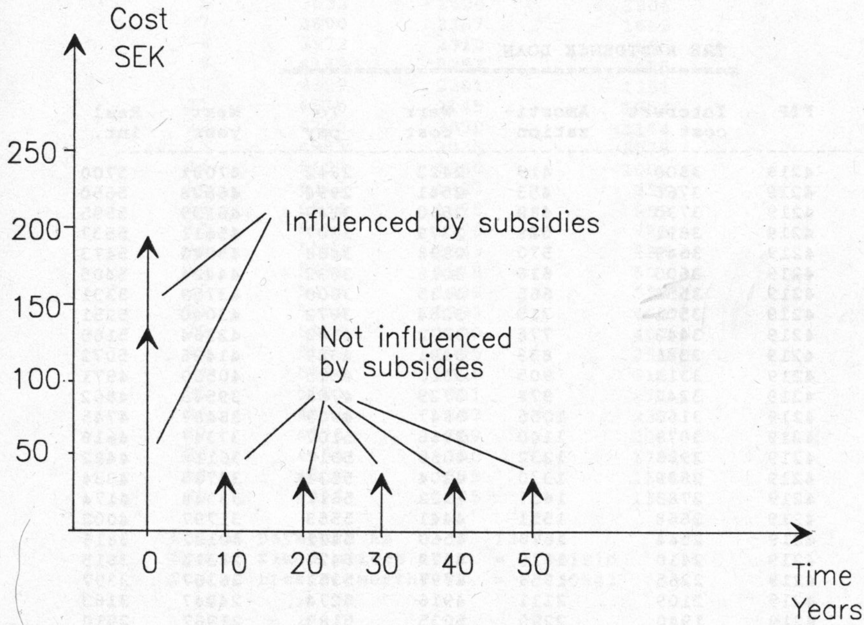

Figure 9. Cash flow from the heat pump installation.

The subsidy system will only affect on the initial cost i.e. the 160 000 SEK that are to be invested first. The 30 000 SEK for the extra costs are only affected the first time they are invested, but not at later payments.

The residence loan is now assumed to be 25 %, the first mortgage loan 70 % and the down payment 5 %. The interest rates for the different loans are assumed to be 12, 11 and 15 % respectively, while the amortization periods are supposed to be 30, 40 and 25 years. The residence loan part, of the heat pump cost will be

$$0.25 \cdot (160\,000 + 30\,000) = 47\,500 \text{ SEK.}$$

In Figure 10 the costs for the loan are presented as they are calculated in the program. The fixed installment is calculated to 4 219 SEK by use of the expression (11). The amortization rate is set to 8 % and the warranted rate to 5.1 % with an increase of 0.25 % per year. Note that the subsidies are abandonned year no 17.

THE RESIDENCE LOAN

Year Numb	FIP	Interest cost	Amorti- zation	Warr cost	To pay	Next year	Real int.
1	4219	3800	419	2422	2842	47081	5700
2	4219	3766	453	2541	2994	46628	5650
3	4219	3730	489	2660	3149	46139	5595
4	4219	3691	528	2779	3307	45611	5537
5	4219	3649	570	2898	3468	45040	5473
6	4219	3603	616	3016	3632	44424	5405
7	4219	3554	665	3135	3800	43759	5331
8	4219	3501	719	3254	3972	43040	5251
9	4219	3443	776	3372	4149	42264	5165
10	4219	3381	838	3491	4329	41426	5072
11	4219	3314	905	3610	4515	40520	4971
12	4219	3242	978	3729	4706	39543	4862
13	4219	3163	1056	3847	4903	38487	4745
14	4219	3079	1140	3966	5107	37347	4618
15	4219	2988	1232	4085	5317	36115	4482
16	4219	2889	1330	4204	5534	34785	4334
17	4219	2783	1437	4322	5611	33348	4174
18	4219	2668	1551	4441	5553	31797	4002
19	4219	2544	1676	4560	5491	30121	3816
20	4219	2410	1810	4679	5424	28312	3615
21	4219	2265	1954	4797	5352	26357	3397
22	4219	2109	2111	4916	5274	24247	3163
23	4219	1940	2280	5035	5189	21967	2910
24	4219	1757	2462	5154	5098	19505	2636
25	4219	1560	2659	5272	5000	16846	2341
26	4219	1348	2872	5391	4893	13975	2022
27	4219	1118	3101	5510	4778	10874	1677
28	4219	870	3349	5629	4654	7524	1305
29	4219	602	3617	5747	4520	3907	903
30	4219	313	3907	5866	4376	-0	469

Figure 10. Cash flow emerging from residence loan of 47 500 SEK.

The payments in Figure 10 must also first be transferred to fixed prices due to inflation, which is set to 7 %, and secondly, due to the fact that the costs appear in the future. The expression (1) is used for both of the calculations and the real discount rate is estimated to 5 %. The result is presented in Figure 11.

Transfer calculations

Year	To pay	Fixed prices	Present worth
1	2842	2656	2529
2	2994	2615	2372
3	3149	2571	2221
4	3307	2523	2076
5	3468	2473	1937
6	3632	2420	1806
7	3800	2367	1682
8	3972	2312	1565
9	4149	2257	1455
10	4329	2201	1351
11	4515	2145	1254
12	4706	2090	1164
13	4903	2035	1079
14	5107	1980	1000
15	5317	1927	927
16	5534	1875	859
17	5611	1776	775
18	5553	1643	683
19	5491	1518	601
20	5424	1402	528
21	5352	1293	464
22	5274	1190	407
23	5189	1095	356
24	5098	1005	312
25	5000	921	272
26	4893	843	237
27	4778	769	206
28	4654	700	179
29	4520	635	154
30	4376	575	133

Sum of payments is = 136938
Sum of fixed prices is = 51810
Sum of present worths is = 30583

Figure 11. Transferring cash flow to fixed prices and present worths.

As shown in the figure the total payments for the residence loan is 136 938 SEK, but if fixed prices are considered the cost will be 51 810 SEK. The present worth of all the payments, however, will only be 30 583 SEK, a reduction by about 35 %.

The first mortgage loan, or base loan, has been dealt with in the same way. In Figure 12 the cash flow is presented and the transfer calculation is depicted in Figure 13. Note that the amortization period now is 40 years, the interest rate is 11 %, and the loan is 70 % of 190 000 SEK.

THE BASE PART LOAN

Year Numb	FIP	Interest cost	Amorti- zation	Warr cost	To pay	Next year	Real int.
1	11153	10640	513	6783	7296	132487	14630
2	11153	10599	554	7116	7670	131932	14574
3	11153	10555	599	7448	8047	131333	14513
4	11153	10507	647	7781	8427	130687	14447
5	11153	10455	698	8113	8811	129988	14376
6	11153	10399	754	8446	9200	129234	14299
7	11153	10339	815	8778	9593	128419	14216
8	11153	10274	880	9110	9990	127539	14126
9	11153	10203	950	9443	10393	126589	14029
10	11153	10127	1026	9775	10802	125563	13925
11	11153	10045	1108	10108	11216	124454	13812
12	11153	9956	1197	10440	11638	123257	13690
13	11153	9861	1293	10773	12066	121964	13558
14	11153	9757	1396	11105	12502	120568	13416
15	11153	9645	1508	11438	12946	119060	13262
16	11153	9525	1629	11770	13399	117432	13097
17	11153	9395	1759	12103	13862	115673	12917
18	11153	9254	1900	12435	14335	113773	12724
19	11153	9102	2052	12768	14567	111721	12515
20	11153	8938	2216	13100	14505	109506	12289
21	11153	8760	2393	13433	14439	107113	12046
22	11153	8569	2584	13765	14367	104528	11782
23	11153	8362	2791	14098	14289	101737	11498
24	11153	8139	3014	14430	14206	98723	11191
25	11153	7898	3256	14763	14115	95467	10860
26	11153	7637	3516	15095	14017	91951	10501
27	11153	7356	3797	15428	13912	88154	10115
28	11153	7052	4101	15760	13798	84053	9697
29	11153	6724	4429	16093	13675	79624	9246
30	11153	6370	4783	16425	13542	74840	8759
31	11153	5987	5166	16758	13399	69674	8232
32	11153	5574	5579	17090	13244	64095	7664
33	11153	5128	6026	17423	13076	58069	7050
34	11153	4646	6508	17755	12895	51561	6388
35	11153	4125	7029	18088	12700	44532	5672
36	11153	3563	7591	18420	12489	36942	4899
37	11153	2955	8198	18753	12262	28744	4064
38	11153	2299	8854	19085	12016	19890	3162
39	11153	1591	9562	19418	11750	10327	2188
40	11153	826	10327	19750	11463	0	1136

Figure 12. Cash flow for the first mortgage loan, running prices

From Figure 12 it is obvious that the subsidy is abandonned year number 19 where the real interest cost is 12 515 SEK and the warranted interest cost is 12 768 SEK.

Transfer calculations

Year	To pay	Fixed prices	Present worth
1	7296	6819	6494
2	7670	6699	6076
3	8047	6569	5674
4	8427	6429	5289
5	8811	6282	4922
6	9200	6130	4574
7	9593	5974	4246
8	9990	5814	3935
9	10393	5653	3644
10	10802	5491	3371
11	11216	5329	3116
12	11638	5167	2877
13	12066	5007	2655
14	12502	4848	2449
15	12946	4692	2257
16	13399	4539	2079
17	13862	4388	1915
18	14335	4241	1762
19	14567	4028	1594
20	14505	3748	1413
21	14439	3487	1252
22	14367	3243	1109
23	14289	3014	981
24	14206	2801	868
25	14115	2601	768
26	14017	2414	679
27	13912	2239	600
28	13798	2075	529
29	13675	1922	467
30	13542	1779	412
31	13399	1645	362
32	13244	1520	319
33	13076	1402	280
34	12895	1292	246
35	12700	1190	216
36	12489	1093	189
37	12262	1003	165
38	12016	919	144
39	11750	840	125
40	11463	766	109

Sum of payments is = 486919
Sum of fixed prices is = 145093
Sum of present worths is = 80164

Figure 13. Transfer calculations for the first mortgage loan

Figure 13 shows that the present worth of the loan has decreased from 133 000 SEK to 80 164 SEK, a reduction by about 40 %.

In the example shown here, 5 % of the cost, i.e. 9 500 SEK, must be covered in some other way, e.g. by use of an ordinary bank loan, to an interest rate of 15 %. The rate of the ordinary loan is higher than the inflation and the real discount rate could motivate. The values imply an interest rate of about 12 % , and the extra 3 % could thus be considered as a profit for the bank. The total cost for the loan as a present worth will therefore be:

- The residence loan	27 342
- The first mortgage loan	81 580
- The ordinary loan	11 252

- Sum	121 999

This is a reduction with about 36 %, from 190 000 to 122 000 SEK. The calculation procedures can be found in appendix C and the program, written in C, is called SYS.C. Note that SYS.C is linked with two other programs called SUB.C and LEAST.C. All output to SUB.DAT comes from SUB.C where there is a main program, while SYS.C and LEAST.C work as functions of the first program.

There is also an input data file, LOAN.DAT, shown in Figure 14, that provides SYS.C with all the necessary input values.

```
30,40,25
.25,.70,.05
.12,.11,.15,.051,.0025
.08,.07
1.24
530.,0.2
530.,0.3
378.,0.3
378.,0.3
40.,1.6
210.
75000.,2.
110.
```

Figure 14. Input data file LOAN.DAT for subsidy calculations

By changing the input data in LOAN.DAT with an ordinary editor it is possible to study the influence of different interest rates, amortization periods etc. Note that the cost for the asset of consideration is set in SYS.C, i.e. the variable named "kost", see Appendix C. If different values are tested it is found that the rate of subsidy will not change, and thus the percentage value sent back to SUB.C from SYS.C, can be used for all measures that are subsidized at the base year. The values and the corresponding names in SUB.C, MINKVA.C and SYS.C are:

Subject	Value	Name
The residence loan amortization period	30	bosam
The base loan amortization period	40	botam
The ordinary loan amortization	25	egtid
Residence loan as part of total loan	.25	boslan
Base loan part of total loan	.70	botlan
Ordinary loan as part of total loan	.05	eglan
Interest rate residence loan	.12	bosran
Interest rate base loan	.11	botran
Interest rate ordinary loan	.15	egran
Warranted rate	.051	garran
Annual increase in warranted rate	.0025	okn
Interest rate in annuity calculations	.08	ambos
Annual inflation rate	.07	infl

5.1.1 How to calculate the approved total loan.

Above it is shown how the cost for the total loan changes when the subsidies are transferred to a base year, using the present worth method. When an existing building is to be retrofitted, the limit for the approved cost is that for a similar new building. This means that retrofits implemented in one part of the building might be very expensive as long as other retrofits are cheap. An extra amount, no matter how much, of attic floor insulation might therefore be approved but it may be hard to superinsulate all of the building because of the "new building cost" limit.

When the approved cost for a new building is calculated there are certain values for e.g. the external wall cost that must not be exceeded. In [30] there are two values used for external walls, one for facades of bricks and one for wooden facades. The cost is limitid to 765 SEK/m^2 and 610 SEK/m^2 respectively. These values might also be multiplied by a time coefficient, at present 1.3, and the approved cost for the more expensive alternative will become 994 SEK/m^2. The approved cost can be increased by insulating the building more than a so called reference object, determined in the Swedish building code [26]. In this way the approved can be increased cost with 5 SEK for each kWh/year that falls below the energy demand for the reference building. The value shall be multiplied by the time coefficient. There is, however, a limit at 37 500 SEK per apartment in the building [31].

The reference building is supposed to have a mean average U-value of about 0.25 W/m^2· K, which means that the reference building is very thorougly insulated compared to the general building stock in Sweden today. The system with an average U-value which must not be exceeded, is unfortunately very hard to implement in the OPERA model, where each building asset is dealt with separately. It has subsequently been necessary to assume that the total cost for the retrofit will be approved as a loan by the authorities.

5.1.2 Simulation of the subsidies

When the building is to be retrofitted, and the loan is approved by the authorities, the subsidy is about 35 %. It must be observed that it is only the first cost that is subsidized. All future costs have to be paid whithout any subsidies, even if they originate from a subsidized retrofit.

When insulation measures are of concern, OPERA models the cost for them as found in expression (4). The C_2 and C_3 costs are assumed to occur only once during the life-cycle of the building. The C_1 cost may occur more often, and subsequently C_2 and C_3 will be subsidized to a full degree while C_1 only will be subsidized on first implementation.

The expression, given in Figure 3 for attic floor insulation, showed that C_1 equalled 0 SEK and thus there is no need for examining the influence of often occuring retrofits in this specific case. The C_2 and C_3 costs will be subsidized and the calculations are made in the INSUL function, see appendix C. The result from INSUL is that the C_2 and C_3 values are reduced by about 35 %, or the reduction factor calculated in SYS.C. If C_1 differs from 0, it will influence the C_2 and C_3 values returned by the function INSUL. The costs for a number of insulation levels are calculated and then a straight line is elaborated using the method of least squares.

When OPERA was originally designed, the subsidy system was not included and therefore some changes had to be implemented in the OPERA code itself and the input data file changed. If the first parameter occuring in the input data file equals 2, it tells OPERA that the subsidy system is utilized and this will make the program calculate the inevitable retrofit cost in a slightly different way compared to the original situation. Setting the value to 1 makes OPERA believe that it is the old subsidy system that is to be simulated which will yield errors in the optimal solution of today. If a 0 is encountered, the program calculates as described in [1] and [2]. Note that the program SUB.EXE changes the OPERA data file automatically.

The output data file from this transferring program, will not affect the constant C_1 but will give it a somewhat different meaning. When OPERA encounters a value of 2 in the first parameter, the C_1 constant is used only for retrofitting at the base year, when it will be subsidized, due to the coefficient calculated above. This subsidy will be subtracted from the total inevitable cost, which is elaborated in OPERA.

The expression for the external wall insulation cost which in Figure 3 is:

$$300 + 200 + 2\,000 \cdot t_{ew}$$

will be changed into:

$$300 + 321 + 1\,284 \cdot t_{ew}$$

The cost function has been calculated by calculating the cost for a number of insulation levels and afterwards by the method of least squares. The first values will be:

t_{ew}	Cost	t_{ew}	Cost
0.00	321	0.15	513
0.05	385	0.20	577
0.10	453	0.25	648

The costs for the window retrofits are reduced in the same way by the subsidies when first implemented in the building. All of these calculations are made in the FORTRAN program and only the reduction coefficient is transferred from SUBV.C via the input file.

Some equipment has to be changed more often like boilers or compressors in heat pumps. The simulation of these retrofits is made in a function called BOILVAL in the SUB.EXE program, see appendix C. The present value coefficient, called "precoe" in the program, is first calculated. Then it is used with the reduction factor, "red" for elaborating a factor which will be multiplied with the applicable costs. Each call to BOILVAL provides SUB.EXE with coefficients for both the boiler itself and the piping cost. When the oil-boiler is of concern the equipment is to be changed every 15 years. With a project life of 50 years and a discount rate of 5 %, the present value coefficient will equal 1.7655. The subsidized present value "SPV" could be calculated as follows, if "PV" is the present value factor and "re" is the reduction coefficient:

$$SPV = OB_c \cdot PV - OB_c + OB_c \cdot (1 - re)$$

which gives:

$$SPV = OB_c \cdot (PV - re)$$

If re equals 0.35 as calculated above, the SPV will become:

$$SPV = OB_c \cdot 1.4075$$

which is a reduction of the original present value with about 20 %. The boiler cost function is thus multiplied with the factor:

$$1.4075 / 1.7655 = 0.7972$$

and the subsidized oil boiler cost will subsequently be:

$$OB_c = 43\ 850 + 47.8 \cdot P \text{ SEK}$$

where P = the thermal load of the boiler.

Note that if the life of the component is changed, this will affect the present value coefficient and subsequently the subsidizing factor calculated above.

5.1.3 Influence on the optimal strategy

The new file, called SUB.DAT, is designed as shown in Figure 15, but the operators do not have to edit the file on their own. Running the program SUB.EXE will automatically transfer the original HOUSE.DAT file to a SUB.DAT . However, the operators must edit the file LOAN.DAT which can be found in Figure 14, which informs the program of the applicable interest rates etc.

```
2
273.00,273.00,616.00,819.00,
1.,0,2.8,27,1.,0,2.4,29
0.80,0.50,1.20,
3.5
0.,50.,0.,0.,0.
.6
'OIL-BOILER',110.,.75,5.
42000.
0.04,0.05,0.04,0.05,
2.
1.5
1.2
50.,50.,50.,50.,30.
50.00,0.05,0.00,0.358
0.00,166.95,340.31
0.00,244.00,321.05
300.00,321.05,1284.20
50.00,282.52,192.63,2.8,450.
0.,1100.
0.,1300.
0.,1500.
100000.,100000.
 43850.8,   47.8,0.75,15.0,  128.4,50.0
 14473.9,   72.4,0.95,25.0,    0.6,50.0
 28947.7,   43.4,0.95,25.0,  192.6,50.0
 38526.0, 3210.5,2.50,50.0, 1272.9,10.0
 41657.6,   45.4,0.80,20.0,  128.4,50.0
 31891.5, 4783.7, 66.43, 20.54,15.0, 133.5,40.0,0.10, 7.0
-.5,-.7,1.4,6.,11.,15.,17.2,16.7,13.5,8.9,4.9,2.
-2.9,-3.0,-.1,5.3,11.,15.4,17.7,16.4,12.2,7.1,2.7,.0
-12.2,-12.4,-8.9,-3.5,2.7,9.2,12.9,10.5,5.1,-1.5,-6.8,-10.1
56,250.,.1,10.
14,20.,21.,-14.
10000.,50.
 8486.2, 3818.8,10.0, 2.0,10.0
'UPPLAND 5'
1
1,0,0,0,0,0,0,0,1
4167.,4167.,4167.,4167.,4167.,4167.,4167.,4167.,4167.,4167.,4167.,4167.
4.3,8.94,18.57,28.82,44.5,53.48,50.54,36.63,23.12,13.54,5.82,3.08
8.27,17.97,41.86,61.97,87.58,90.91,89.07,75.07,53.11,28.3,10.75,5.36
29.66,43.69,73.68,75.29,82.59,76.28,78.5,79.81,79.37,61.57,32.7,21.22
8.27,17.97,41.86,61.97,87.58,90.91,89.07,75.07,53.11,28.3,10.75,5.36
.1,.6,.7
.233
.3658357,0.515,0.245
.175,120.
.2763422,300.,700.,2400.,600.,.64
.195,.195,.195,.145,.145,.145,.145,.145,.145,.145,.195,.195
830.,1030.,1230.,1640.,2060.,2380.,2900.,3520.,4300.,5420.,6760.,8400.
16.,20.,25.,35.,50.,63.,80.,100.,125.,160.,200.,250.
352,320,368,320,368,352,336,368,336,352,352,336
392,352,376,400,376,368,408,376,384,392,368,408
6000.,55.,245.
.405,.256,.218,.202,.179
```

Figure 15. The file SUB.DAT which presents retrofit subsidies to OPERA

The first value in the file SUB.DAT equals 2, showing that the file is supposed to reflect the subsidy system. Some of the values from Figure 3, have not been affected at all while others have been changed in liason with the above discussion. There are also values added to the original input data file in order to inform OPERA of the new situation. In the FORTRAN and C codes, presented in appendix A, B and C, the precise way of how OPERA deals with the subsidies is shown. Look for statements like "IF(LAN.EQ.2)" where these lines occur.

In Figure 7 the optimal strategy from an OPERA running without subsidies is presented. A natural gas system combined with triple-glased windows should be chosen. When the subsidies are included the strategy will be slightly changed, see Figure 16, and the total LCC will have decreased from 1.20 to 1.07 MSEK. The heating system should be changed, not from the oil-boiler to a natural gas system, but the oil-boiler should be combined with a heat pump yielding a bivalent equipment instead.

*** LCC TABLE FOR BASE CASE 1.00 ***
VALUES IN MSEK

	EXIS. SYST.	NEW OIL	ELE. HEAT	DIST. HEAT	GR.W HEAT	NAT. GAS	TOU DIST	TOU ELEC.	BIV. GR.HP	BIV.O. AIR HP
NO BUILD. RETR.	1.46	1.48	1.67	1.41	1.25	1.18	1.41	1.67	1.17	1.30
SAVINGS:										
ATTIC FL. INS	.03	.03	.05	.02	.00	.00	.02	.06	.00	.01
FLOOR INS.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
EXT. WALL INS.	.08	.08	.14	.07	.00	.00	.06	.15	.00	.02
INS. WALL INS.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TRIPLE-GLAZING	.13	.13	.15	.13	.11	.10	.13	.15	.10	.11
TRIPLE-GL. L.E.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TR.-GL. L.E. G.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
WEATHERSTRIP.	.01	.01	.02	.01	.00	.00	.01	.02	.00	.00
EXH. AIR H. P.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUM. OF RETRO.	1.21	1.24	1.30	1.18	1.12	1.08	1.18	1.29	1.07	1.16
SUM. OF COMB.	1.22	1.24	1.31	1.19	1.13	1.08	1.19	1.30	1.07	1.17
DISTRIBUTION:										
SAL. OLD BOILER	.00	.02	.02	.02	.02	.02	.02	.02	.02	.02
NEW BOIL. COST	.06	.06	.02	.03	.10	.05	.03	.02	.14	.20
PIPING COST	.00	.00	.00	.01	.11	.01	.01	.00	.09	.00
ENERGY COST	.49	.49	.59	.46	.23	.54	.45	.58	.45	.27
CONNECTION FEE	.00	.00	.00	.01	.00	.01	.01	.00	.00	.00
BUIL. RETROF. C	.55	.55	.57	.55	.55	.28	.55	.57	.19	.56
INEVITABLE COST	.12	.12	.12	.12	.12	.19	.12	.12	.19	.12

Figure 16. LCC table presented by OPERA, subsidies included.

In this case the subsidy system affected the proprietor's actions for the most profitable result, and a slightly changed strategy should be chosen. The building retrofit, however, was the same, i.e. triple-glazed windows were to be installed. Note that the LCC for the two competing systems was almost the same and in this case it is not possible to be certain of the best strategy because of uncertainties in the input data. Note also that not very many building retrofits were profitable to install as long as the optimal solution was chosen. When the subsidy system is utilized there is an increased number of retrofits found profitable in the other heating system strategies but not in the optimal one.

5.2 Interest rate subsidies

Another means for retrofit subsidies is the interest rate subsidies. The subsidy is paid even if the proprietor does not borrow any money at all, but in that case he must get money from elsewhere. As is the situation, when the renovation loan is utilized, a total loan is calculated. The building measures are combined with certain amounts that will influence the total loan. One example is the cost for the painting of the external walls, which may be added to the total loan. The amount is set to 35 SEK/m^2 and this value is to be multiplied with the valid time coefficient, which at present is 1.3. Some of the measures are assumed to be of ten years duration while others are supposed to last for twenty years. The total loan must thus be divided in two parts, one for ten year measures and one for twenty year measures, and the total loan is supposed to be amortized as shown in Table 4. After, say 5 years, the total loan for measures of 10 years duration is assumed to have decreased to 68.89 % of the original amount.

The interest rate for long term state finances is used for the subsidy calculations. 0.4 % is added to the rate, which at present equals about 11.8 %, and 40 % of this new rate is paid out as subsidies, or about 4.7 % of the total loan. This value is used if the proprietor is the municipality and the like. If the landlord is a private person this rate is decreased with a further 2 %. The private subsidies is thus about 2.7 % of the total applicable loan.

Table 4. Applicable rest of total loan, interest rate subsidy system

Year	Total loan 10	Total loan 20	Year	Total loan 20
1	100	100	11	68.34
2	93.1	97.81	12	63.62
3	85.64	95.45	13	58.53
4	77.59	92.9	14	53.03
5	68.89	90.15	15	47.09
6	59.5	87.18	16	40.67
7	49.36	83.97	17	33.74
8	38.41	80.5	18	26.25
9	26.58	76.75	19	18.16
10	13.8	72.71	20	9.43

If the original loan is 100 000 SEK for 20 years' measures, and if the proprietor is a private person, the subsidy at year number 9, which is paid by the state, yields:

$$100\,000 \cdot .7675 \cdot .027 = 2\,072 \text{ SEK}$$

Some 200 values exist within the system which may be added to the total loan. Several values can be lumped together e.g. painting of windows and implementing extra glazing. Other walues are constrained, e.g. external wall insulation where the maximum amount of insulation is set to 10 cm or a new U-value of 0.25 $W/m^2 \cdot K$.

It is obvious that the interest rate subsidies yield less profit to the proprietor than the renovation loans, and calculations of the present worths of the subsidies result in 18.8 % and 26.4 % as contributions from the government for ten and twenty year measures respectively. It was then assumed that the inflation was 7 % and the real interest rate 5 %.

Above, it is shown that the influence on the optimal strategy is minute from the renovation loans, which yielded a subsidy of about 35 %, and thus the influence will be even less when interest rate subsidies are considered. This subsidy system is subsequently not included in the program package.

5.3. Energy retrofit subsidies

At present this form of subsidies does not exist. The government has decided that no energy retrofit subsidies shall be paid before 1990 06 30 [24]. In the rules for the subsidy system it is said that the subsidy shall not exceed 20 % of the total approved cost for the item subsidized. This means, however, that the subsidy is of the same size as the interest rate system dealt with above. The influence on the optimal retrofit strategy will thus be very small even if the system were in full use, and thus it is not implemented here at all.