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INVESTMENT IN ENERGY CONSERVATION

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Abstract

When measured with expert's methodology, energy conservation shows to be a better buy than energy consumption. Thus a private investor should have to prefer energy savings to energy purchases. In practice, however, one observes the amount of realised conservation to be much lower than the amount of potential conservation.

In this paper the dominant causes of this divergence are discussed to belong to three main categories. First, proper estimation of conservation opportunities is hindered through high subjective discount rates, short required payback periods, parameter uncertainty and folk quantification in general. Secondly, a number of characteristics of energy conservation investment have serious consequences on implementation : liquidity, length and size of the investment, investment information and rise, tax and inflation effects. Finally, we consider the influence of household demographics (income, ownership, age, etc.).

Solutions for bridging the gap between realised and economical conservation are provision of resources (external financing, government aid and creative financing), information initiatives, tariff policies, efficiency standards and the emergence of an energy efficiency industry.

Finally, the rather weak interest by Belgian government is demonstrated.

INVESTMENT IN ENERGY CONSERVATION

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Introduction

When government and utility companies plan energy supply facilities and therefore rely on demand forecasts, energy conservation must not be overlooked. Conservation, as a reaction to the burden of energy costs, influences energy consumption and therefore planning projections.

Moreover, energy conservation can be regarded as an energy policy competing with other supply strategies. The final goal then, is to respond to energy demand using a minimum of supply sources.
Of course, this is an economic concept meaning that the monetary benefits from savings must at least cancel out the costs of conservation.

In Part 1, the cost of energy conservation is compared to the cost of energy for the end-user and to the replacement cost of producing capacity.

Investments in energy conservation can be considered as investment opportunities like investments in bonds, stocks, etc...
Part 2 deals with the most current investment evaluation methods and their application.

The core of the paper consists of an investigation into the barriers impeding energy conservation breakthrough.

Next, proposed solutions are put forward and commented briefly.

Finally, an overview of Belgian government activities in energy conservation is given.
We would like to emphasize that most of the topics are based on Anglo-Saxon literature, by lack of other sources. This paper intends to construct a general framework for research in Belgium.

I. Energy conservation as an investment opportunity

Energy conservation is analysed as an investment opportunity, obtaining monetary benefits through reduced fuel costs (Gates, 1983) Funds being scarce, energy conservation is competing with other investment alternatives.

Calculations made by Gates suggest that conservation might yield substantially higher returns than alternative investments [1]:

Table 1 : Return on investment comparison for energy conservation vs. traditional investments *1

	Annual before-tax*2 ROI in %
Energy conservation	
set-back thermostat (2.78°C for 8 hours daily)	40
weatherstripping and caulking	31
furnace vent damper (retrofitting)	31
condensing cycle furnace	33
wall insulation	27
attic insulation	16
window coverings	17
solar domestic hot water system	11
Stocks	14
Bonds	12
Money market funds	10
Real Estate	14

*1 some hypotheses :

- conservation measures are applied to a home in a cold climate using 126.576 GJ fuel for space heating on natural gas costing

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[1] Calculations are "conservative" in that they do not take into account the tax-free nature of energy savings and the availability of tax credits. Contrarily, fuel price escalation rates are assumed to be high.

$ 4.266/GJ under supposed escalation rates of 15 % per year through 1990 and 10 %/yr thereafter.
A solar hot water system with electrical backup was installed (electricity costing 6c/kWh, increasing 10 %/yr).

- stocks : performance of 132 long term growth mutual funds measured by "Weisenberg Mutual Fund Index" over the period 1976-80 (dividends reinvested).
- Bonds : average return of public utility bonds rated Aa by Moody's over the period Sept. 1977-Sept.1981
- money market funds : 5 year average
- real estate : real estate funds used as a proxy for real estate returns (5 year average).

*2 not deflated : although real returns would be lower, the relative differences between investments would be essentially unchanged. [2]

Gates concludes that conservation activity seems to be inconsistent with possible yields. From society's point of view, optimal energy conservation levels occur when the cost of conserving an additional Joule is equal to the cost of producing one.

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[2] An inquiry into the proper "deflators" is certainly part of more elaborated research , we are carrying out.

For the individual, the efficient point is reached where the saving in the cost of using additional energy is just offset by additional capital costs that are necessary to achieve savings (Jaffee, 1984).

Gates estimates the average annualized cost for gas over the next 15 years to be \$ 8.53 per GJ (price to the end user) [3] During the same period conservation measures shown in table 1 save energy at a cost of about \$ 2.70 to \$ 6.20 per GJ (Gates, 1983). Johnson reports a cost of \$ 1.30 per GJ for retrofit measures (Johnson, 1984).

The difference illustrates individual consumers are not attaining the optimum conservation level.

In addition many authors point to a disparity between the price of energy and the cost of its replacement (Downs, Bradbury, 1984).

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[3] Formula to determine the annualised cost of escalating fuel cost

$$A = \sum_{i=0}^{n-1} \frac{Po\ (1 + E)^{i}}{(1 + d)^{i}} \left[\frac{d(1 + d)^{n}}{(1 + d)^{n}-1} \right]$$

where : P_o = current price of a fuel
E = nominal fuel escalation rate
d = discount rate
n = period considered

Table 2 : Average price and replacement costs of energy used in industry.

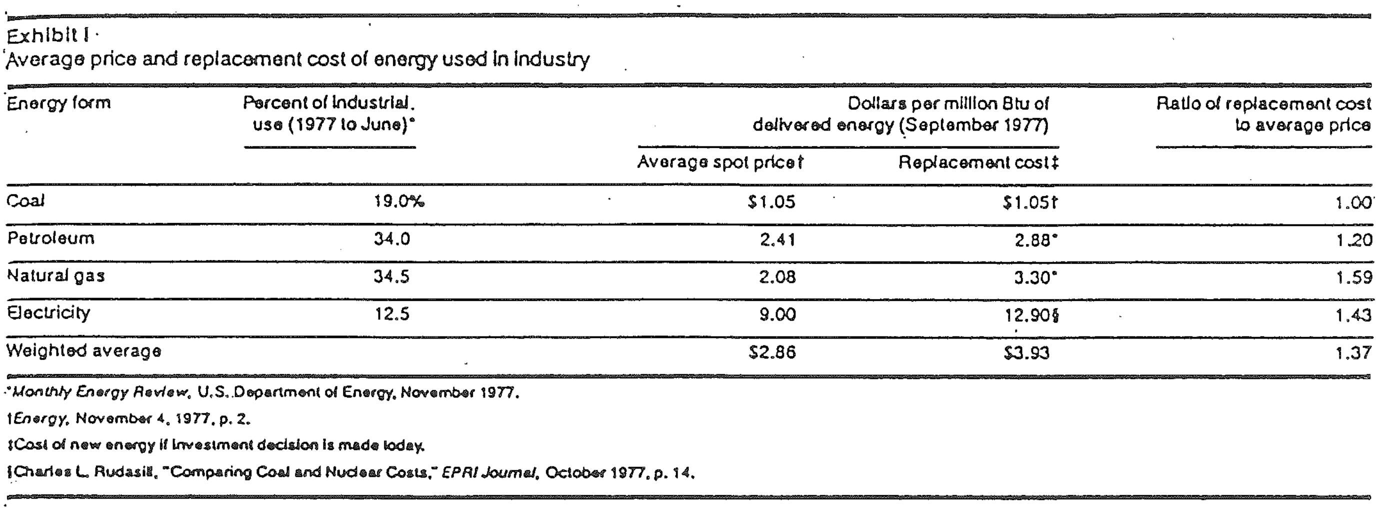

Exhibit I
Average price and replacement cost of energy used in industry

Energy form	Percent of industrial use (1977 to June)*	Dollars per million Btu of delivered energy (September 1977)		Ratio of replacement cost to average price
		Average spot price†	Replacement cost‡	
Coal	19.0%	$1.05	$1.05†	1.00
Petroleum	34.0	2.41	2.88*	1.20
Natural gas	34.5	2.08	3.30*	1.59
Electricity	12.5	9.00	12.90§	1.43
Weighted average		$2.86	$3.93	1.37

**Monthly Energy Review*, U.S. Department of Energy, November 1977.
†*Energy*, November 4, 1977, p. 2.
‡Cost of new energy if investment decision is made today.
§Charles L. Rudasill, "Comparing Coal and Nuclear Costs," *EPRI Journal*, October 1977, p. 14.

Source : (Hatsopoulos et al., 1978)

Also Esteves reports on energy conservation measures in a Residential Energy Conservation Action Program (RECAP) in New Jersey at a cost of 2-3 c/kWh, where the average residential rate is 11 c/kWh. At the same time, he estimates the costs of installing additional capacity to be $ 2000 - 3000/kW for nuclear plants and $ 400 - 700/kW for coal plants. Under a theoretical utilisation rate of 100 %, this would amount to a unit cost of 23-34 c/kWh and 5-8 c/kWh respectively (Esteves, 1984).

Not surprisingly, many authors point at the large amounts of energy we can save by means of available technology, being economic at today's energy prices (Beijdorff, 1979). For an illustration we again refer to Hatsopoulos et alii (Hatsopoulos et al.; 1978)

Table 3 : Energy savings and costs projected for 1985

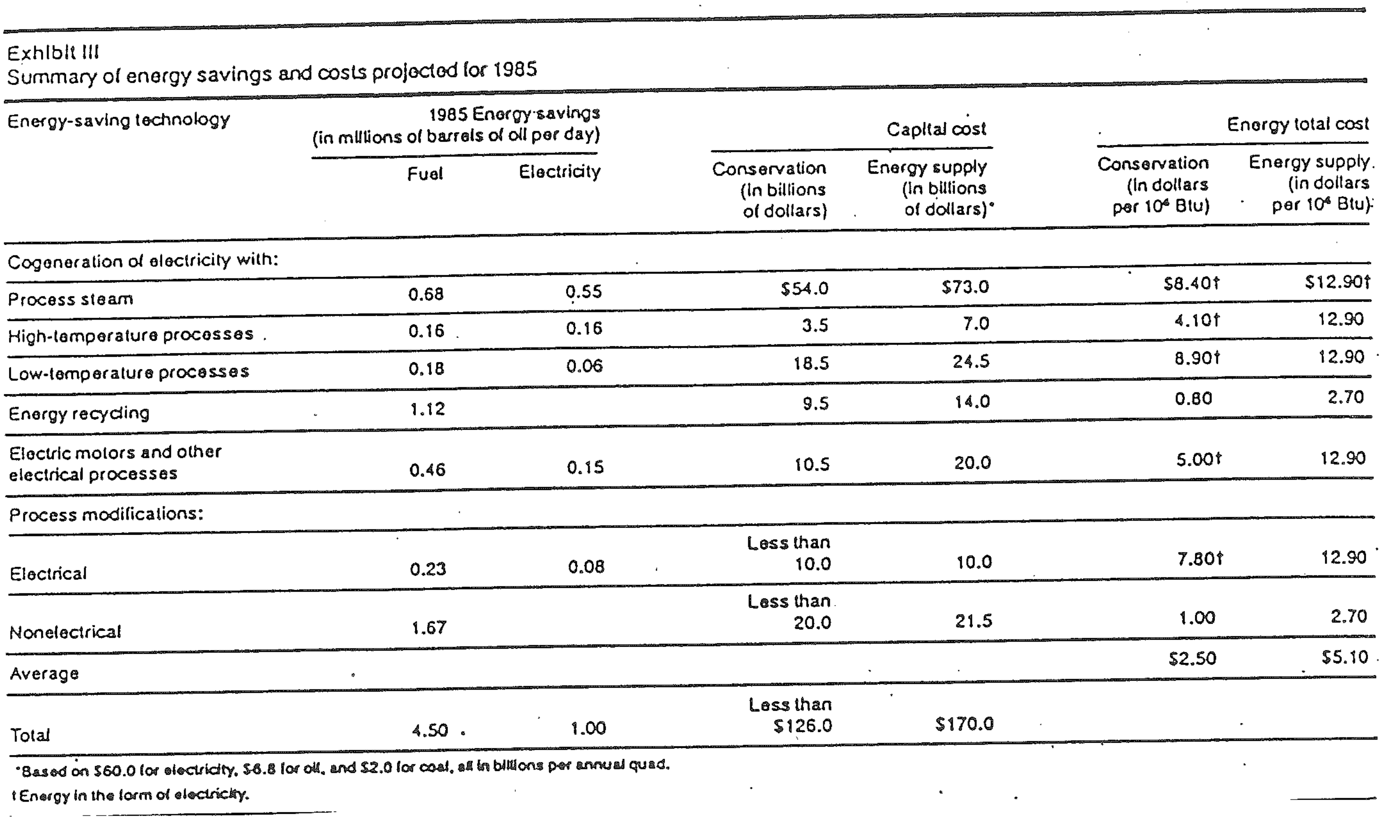

Exhibit III
Summary of energy savings and costs projected for 1985

Energy-saving technology	1985 Energy savings (in millions of barrels of oil per day)		Capital cost		Energy total cost	
	Fuel	Electricity	Conservation (In billions of dollars)	Energy supply (In billions of dollars)*	Conservation (In dollars per 10⁶ Btu)	Energy supply (in dollars per 10⁶ Btu)
Cogeneration of electricity with:						
Process steam	0.68	0.55	$54.0	$73.0	$8.40†	$12.90†
High-temperature processes	0.16	0.16	3.5	7.0	4.10†	12.90
Low-temperature processes	0.18	0.06	18.5	24.5	8.90†	12.90
Energy recycling	1.12		9.5	14.0	0.80	2.70
Electric motors and other electrical processes	0.46	0.15	10.5	20.0	5.00†	12.90
Process modifications:						
Electrical	0.23	0.08	Less than 10.0	10.0	7.80†	12.90
Nonelectrical	1.67		Less than 20.0	21.5	1.00	2.70
Average					$2.50	$5.10
Total	4.50	1.00	Less than $126.0	$170.0		

*Based on $60.0 for electricity, $6.8 for oil, and $2.0 for coal, all in billions per annual quad.
†Energy in the form of electricity.

Source : (Hatsopoulos et al., 1978)

Based on estimates of the energy savings produced by the above mentioned energy-saving technologies, they estimate that approximately 25 % of projected 1985 energy use in US Industry could be saved at a 25 % reduction in capital cost ($ 126 billion vs. $ 170 billion) and an overall 50 % reduction in the unit cost of energy ($2.50 vs. $ 5.10 per million Btu)

II. Evaluation methods in energy investment analysis

A. Payback analysis

1. Simple payback SPB

The payback period is the year when the aggregated positive cash flows first exceed the aggregated negative cash flows (Duff,1984). Alternatively, SPB is defined as the time required for the future fuel cost savings produced by an energy conservation investment to equal the initial investment (Turiel et al., 1980).

In practice SPB is approximated by : $$\mathrm{SPB} = \frac{I_o}{S_1} \qquad (1)$$

where I_o = initial investment and installation costs
S_1 = net cash flow of the first year [4] .

As such, SPB is an approximate way of indicating how much time is required for the consumer to recapture his investment (Turiel et al., 1980). The obtained payback period by formula (1) is then compared with that of other investments and with the required PB (by the decision maker).

advantages :
- SPB recognises the inherent risk in forecasts by forcing an early recovery of invested capital (Duff., 1984)
- SPB provides a simple yardstick

disadvantages :
- SPB does not incorporate the time value of money (Duff, 1984). In practice, even only first year's savings are considered.
- Future energy price evolution is not accounted for
- The life of a conservation measure is not taken into account
- SPB gives no idea of "net benefits"

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[4] Net cash flow is the result of additional investment, insurance costs, operating and maintenance costs versus savings.
For a discussion of taxation see page 27

- SPB is difficult to compare with other profitability measures used for stocks, bonds and the like (Gates,1983)

Remark : the reciprocal of SPB is sometimes used as a measure of rate of return on investment (Duff, 1984).
E.g. a four year PB-period would be said to represent 25 % ROI/year.

2. Discounted payback DPB

DPB is the value of n for which expression (2) first becomes negative, for specified E and d (Herendeen et al., 1983)

$$\frac{I_o}{S_1} - \sum_{i}^{n} \frac{1 + iE}{(1 + d)^i} \qquad (2)$$

where d = discount rate
E = price increase rate.

Alternatively, cash flows are now converted to equivalent values at some fixed time, usually time zero (Duff, 1984)

$$I_o - \sum_{i}^{n} \frac{S_i}{(1 + d)^i} \qquad (3)$$

where DPB-period is the value of n for which the expression first becomes negative

$S_i = SQ_i P_i$

SQ_i = saved energy consumption in year i

P_i = price of energy vector in year i

which is often simplified as : $S_i = SQp_1 E^{i-1}$

where Q and E are held constant over the period

advantages :
- the same advantage as under SPB about risk and uncertainty holds
- time value of money is introduced
- fuel price escalation rates can be incorporated

disadvantages :
- altough the time value of money up to the cutoff is considered cash flows in later periods remain ignored (by applying (2) only S_1 is estimated) consequently, the life of a conservation measure is not taken into account
- comparison with investment alternatives remains difficult.

Projects with payback periods lower than the maximum tolerated payback are accepted. When one aims to select just one project, the alternative with the shortest payback is preferred.

B. Methods using time value of money without restricted time horizon

1. Present value PV

(Present worth, present discounted value, net present value, life cycle cost, etc.)

The life-cycle cost of owning and operating an appliance is equal to the first cost or purchase price (installation included) (usually assumed to be paid in cash) plus the operating and maintenance costs over the lifetime of the appliance, all discounted to present value. In the long run, the consumer benefits from the purchase of a product with the lowest life-cycle costs (Turiel et al., 1980)

$$LCC = I_o + \sum_{i=o}^{n} Q_i \frac{P_o (1 + E)^i}{(1 + d)^i} + \sum_{i=0}^{n} \frac{M_i}{(1 + d)^i} \qquad (4)$$

where : Q_i = fuel consumption in year i
n = lifetime of the appliance
P_o = fuel price in year 0
M_i = maintenance costs in year i

Formula (5) presents a simple case of net present value calculation [5]

$$NPV = \sum_{i}^{n} S_i \, (1 + d)^{-i} - I_o \tag{5}$$

2. Uniform annual cash flow UACF

(uniform annual cost, annual cost, net annual value, etc..)

Present value is converted into a level series of cash flows. Next, UACF between alternatives is compared. This method may be interesting for comparison of investment alternatives with a different lifetime (Duff, 1984)

$$PV = UACF \left(\frac{(1 + d)^n - 1}{d\,(1 + d)^n} \right) \tag{6}$$

or

$$UACF = PV \left(\frac{d(1 + d)^n}{(1 + d)^n - 1} \right) \tag{7}$$

In using PV and UACF, alternatives are ranked from highest to lowest net present (annual) values, under the requirement that the net present (annual) value must be positive. The latter condition follows from the discount rate used being the minimum accepted rate of return (MARR).

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[5] Net cash flow can now also incorporate end-of-life salvage value.

3. Internal Rate of Return IRR

(Rate of return ROR, internal discount rate IDR, profitability-index, etc.)

The value of d for which NPV in formula (5) equals zero is searched for. The IRR is the discount rate that causes the sum of the discounted annual net cash flows for the life of the investment to be zero (Gates, 1983) :

$$\sum_{i}^{n} S_i \left(\frac{1}{(1 + IRR)^i} \right) = 0 \qquad (8)$$

Refering to formula (2) , the IRR is the value of d for which the expression equals zero for specified E and n (Herendeen et al., 1983).

Projects with highest rates of return are implemented, if their IRR exceeds the MARR. A practical way of selecting amongst alternatives is the following (Duff, 1984) :

a. arrange alternatives in order of increasing amount of investment.

b. starting with the second alternative, calculate the cash flows associated with the increment of investment of the second alternative over the first.

c. calculate the IRR on the incremental cash flows

d. if the incremental IRR > MARR, accept the alternative; otherwise, reject.

e. select the next alternative and calculate the incremental cash flows over the last alternative accepted.

f. if there are no more alternatives, the last alternative accepted, is the optimum. Otherwise compare the next alternative in the list with the last alternative accepted, starting at step c.

4. Benefit - Cost Ratio B/C

Another approach is to consider all benfits and costs separately, discount both groups and compare them (instead of forming net cash flows). This allows for applying different discount rates (e.g. conservative project evaluation with $d_{benefits} > d_{costs}$) :

$$NPV = \sum_{i}^{n} B_i/(1 + d_b)^i - \sum_{i}^{n} C_i/(1 + d_c)^i \qquad (9)$$

$$B/C = PV(B) / PV(C) \qquad (10)$$

where : B = benefits
d_b = rate used for discounting benefits
C = costs
d_c = rate used for discounting costs

Projects with the highest B/C ratio's are selected under the condition that the ratio exceeds one.

The procedure mentioned under internal rate of return can again be followed, except that in step c the B/C - ratio for the incremental cash flows is calculated and in step d, if $B/C \geq 1$, the alternative is accepted.

Conclusion : DCF - methods require that all cash flows are estimated over the life of the investment (Gates, 1983) (Phung, 1979). Changes in energy prices and savings over time are all accounted for. However, calculation of the IRR does not tell us what is the MARR the consumer has in mind for that kind of investment.

In what follows, we will refer to formula (11) as fairly typical for energy conservation projects, where usually only I_o is considered insurance costs are rather rare (e.g. windmills) and salvage value is zero.

$$NPV = \sum_{i}^{n} \frac{MS_i}{(1 + d)^i} - \sum_{i}^{n} \frac{O_i}{(1 + d)^i} - I_o \qquad (11)$$

where MS_i = savings (in monetary terms) in year i .
O_i = operating and maintenance costs in year i

III. Factors interfering with energy conservation decisions

A. Difficulties in estimating conservation opportunities properly

Referring to formula (11) many difficulties for applying it can be noted.

1. High discount rate

Hausman estimated the discount rate to be used in modeling energy demand for room air conditioners : 25 % real value [6] (Hausman 1979). This substantially exceeds values used in "engineering calculations" to determine lifecycle costs [7] A clear implication of the latter values is that estimates of consumer demand for energy-saving appliances, which are usually characterised by higher initial purchase price, may be overly optimistic.

"A simple fact emerges that in making decisions individuals behave in a manner which implies a much higher discount rate than can be explained in terms of the opportunity costs of funds available in credit markets " (Hausman, 1979)

In a study on refrigerators, Gately found implicit discount rates from 45 to 300 % for buyers who choose a low efficiency unit over a high efficiency one. (Gately, 1979)

The problem is not limited to the residential sector. Many industries require too high a rate of return on conservation investments - higher than for their regular capital projects as illustrated by Hatsopoulos (Hatsopoulos et al., 1978) (Table 4) :

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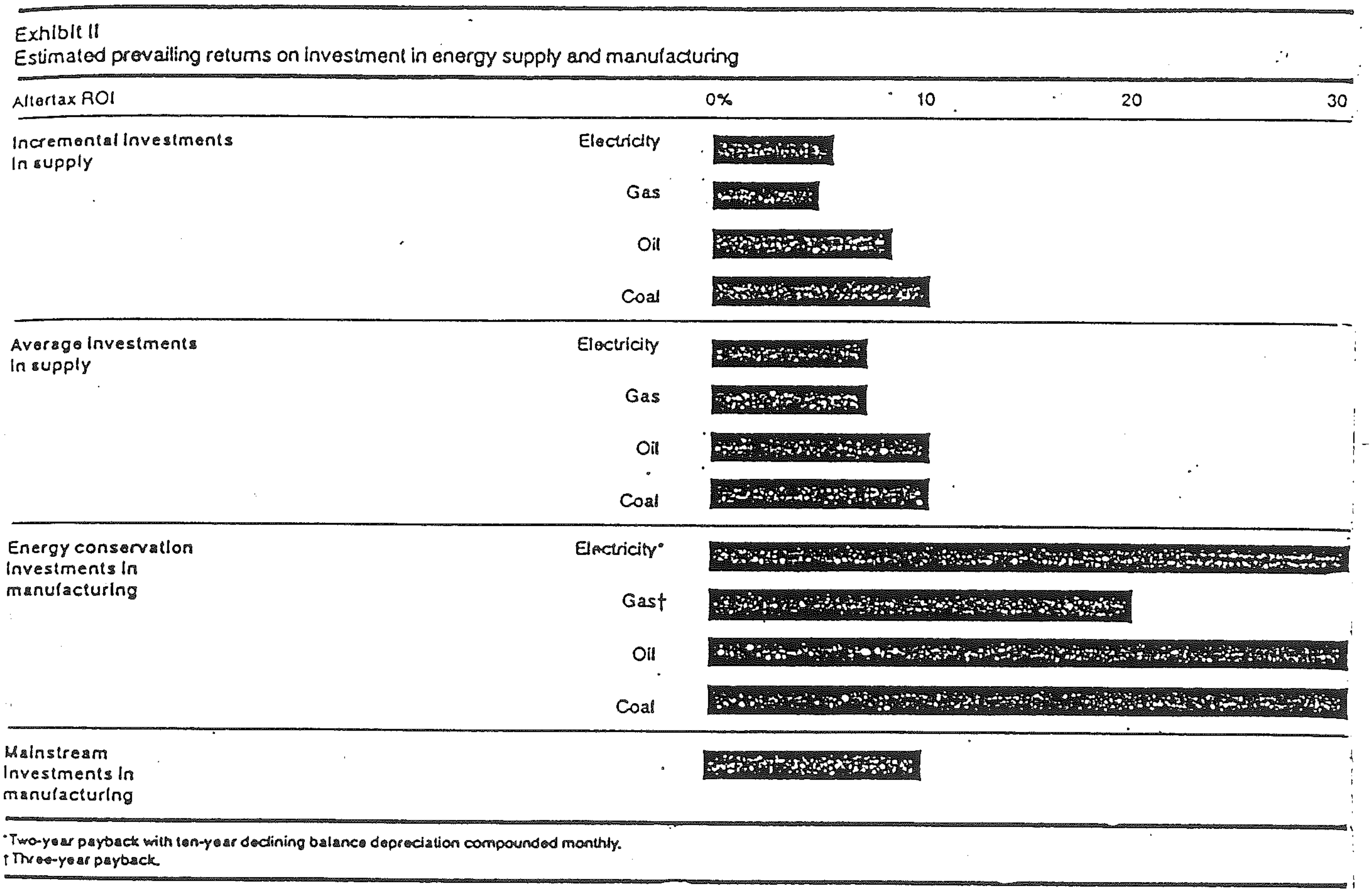
[6] When the model is adapted for the fact that durable lifetime is not independent of appliance efficiency - in the sense that individuals expect medium efficiency models to last longer - a discount rate of about 15 %/year is found.

[7] Herendeen uses a real discount rate of 2 % (Herendeen et al.,1983); Turiel (Turiel et al.1980 and Beijdorff (Beijdorff,1979) use 5 %; etc.

Table 4 : Estimated MARR for energy suppliers and manufacturers



Different ROI-criteria for utilities and manufacturers produce an economic disparity. While utilities are making incremental investments in new facilities that yield only 8 % on assets (as a market force), energy users are turning down investments in conservation equipment if the projected annual return from the outlay falls short of 30 %. Investments in energy efficiency are not evaluated on an equivalent basis with investments in new energy supplies. (Hatsopoulis et al. 1978)

E.g. Verbruggen states that industrial energy users amortise investments in autoproduction of electricity in less than 5 years (required PB $\leqslant$ 5 years), where utilities producing electricity depreciate their plants over 20 years at a real discount rate of 8.6% (Verbruggen,1985) [8]

In industry, one considers expansion of production capacity as mainstream investments. Energy conservation projects are ranked under discretionary investments carried out when capital is abundant. (Hatsopoulos et al., 1978)

2. Short payback

Proper discounting of the capital investment over a reasonable economic lifetime shows that many important conservation options have a lower unit cost than today's world energy prices and/or supply costs. One of the main reasons of the limited impact of energy conservation is the short payback time most private consumers demand for a cost saving measure. (Beijdorff, 1979)

In costs over a "reasonable economic lifetime" we assumed implicitly that the consumer accepts this longer amortisation period. In industry, maximum payback time allowed for cost saving measures seems to be about 2 years. In the domestic sector, Beijdorff estimates that 2 to 4 years is the maximum period most home owners are willing to accept as payback of this type of investments (Beijdorff, 1979). Struyk mentions 1 to 3 years. (Struyk, 1984)

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[8] Of course, utilities can supply to several customers by means of the same equipment (meaning that a bankruptcy of firm A can be compensated by supplying to firm B, etc.) The fact remains that this situation is a hindrance to rational energy use and conservation.

Capper and Scott, using a sample of 42 electrically heated Scottish houses of similar design and size, found their calculations complicated by the uncertainty about the time horizon the individuals take into account for additional insulation investment. They therefore conclude in the following way (Capper and Scott, 1984) (Table 5) :

Table 5 : Rate of return on additional insulation investment (for a 30 week heating season in 42 Scottish houses)*

	Time Horizon	
Tariff	7 years	30 years
High	7 %	18 %
Low	-	6 %

*. IRR's are considerably lower than in Table 1, since we are dealing with <u>additional</u> investment. A "law of diminishing returns" on insulation investment is most likely to exist (cf. Figure 1)

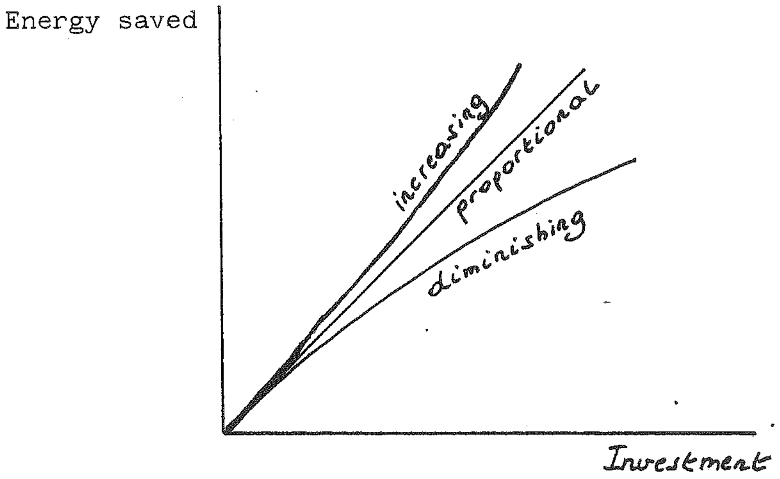
3. Parameter uncertainty

The initial cost of the system (I_o) may be known with a high degree of certainty if it is commercially available. There may be substantial uncertainty if it is an experimental or prototype system. (Duff, 1984)

The future savings can be considered as reasonably well known if savings are expressed in energy terms. Nevertheless, uncertainty about physical savings can be important where only a part of complementary conservation measures has been implemented. Also, additional investment often follows the law of diminishing returns (cf. Figure 1) i.e. the largest part of conservation has already taken place and the additional investment acts to a certain extent as a mere substitution.

Increasing returns are possible in the case of synenergetic effects.

Figure 1 : Investment and energy saved



In converting to monetary terms (used in all mentioned evaluation methods), there is a great deal of uncertainty since the pattern of fuel price escalation is quite unpredictable. (Duff, 1984)

The <u>lifetime</u> of experimental systems may be unknown.

4. Folk quantification*

* entirely based on Kempton/Montgomery (Kempton and Montgomery,1982)

"Folk units" are familiar to and used by ordinary people, because they are easily visualised, multipurpose and appropriately scaled.
E.g. gasoline is well quantified in folk units

quantity = gallons,	litres
price = $ / gallon	BF/litre
output = miles travelled	kms travelled
efficiency = miles / gallon	litres/100km

Therefore, consumers measure and compare energy efficiency much more easily for cars than for houses. Consider for instance, the problem of space heating. Input quantities are expressed in MJ, kWh or litres at best. Price is sometimes difficult to trace since several residential energy uses are aggregated into one or two utility bills. Output is degree-days of heating, thus depending upon variable meteorological circumstances (see Appendix 1). Comparison of energy use before and after a particular conservation action (e.g. turning thermostat lower) is clouded because metereological circumstances seldom reproduce themselves.

Dollars (francs) provide the only folk measure available for comparison of fuels and even for comparisons through time. Moreover, dollars relate to other activities or expenditure categories. "The predominance of dollar measurements leads us to predict that even if more consumers learned about the energy expert's method, most would continue to use the folk payback method". (bounded rationality)

Energy use of household appliances is often estimated by nonenergy factors such as running time or quantity of human labour substituted for.

The calculation of savings by non-specialised people provides some insight in the slowness of energy conservation adoption :

- expert method $MS_1 = P_1(Q_o - Q_1) = P_1Q_o - P_1Q_1$ (12)
- folk method $MS_1 = C_o - C_1 = P_oQ_o - P_1Q_1$ (13)

Clearly, with constant energy prices both methods yield equal results, but rising energy prices cause the folk method to underestimate savings. For longer paybacks, the folk method lengthens the computed time to payback, because it does not adjust for escalating prices.

The calculation of the payback period n can be found in Appendix 2.

Here we simply state the results :

- expert payback model : $n = \ln(1 + fi/(1 + f)(1 - r))/\ln(1 + f)$ (14)

  where : f = real price increase

  $i = I/C_o$ = investment as a proportion of fuel cost

  $r = Q_1/Q_o$ = energy change ratio

- folk payback model : $n = i/(1 - (1 + f)r)$ (15)

Now, we can compare both models as i,f and r vary.
Figure 2 keeps i constant at 1 ($I = C_o$) and r at .7 (meaning a 30 % reduction in energy use) :

Figure 2 : Expert vs. Folk payback model
C.p. effects of fuel price escalation

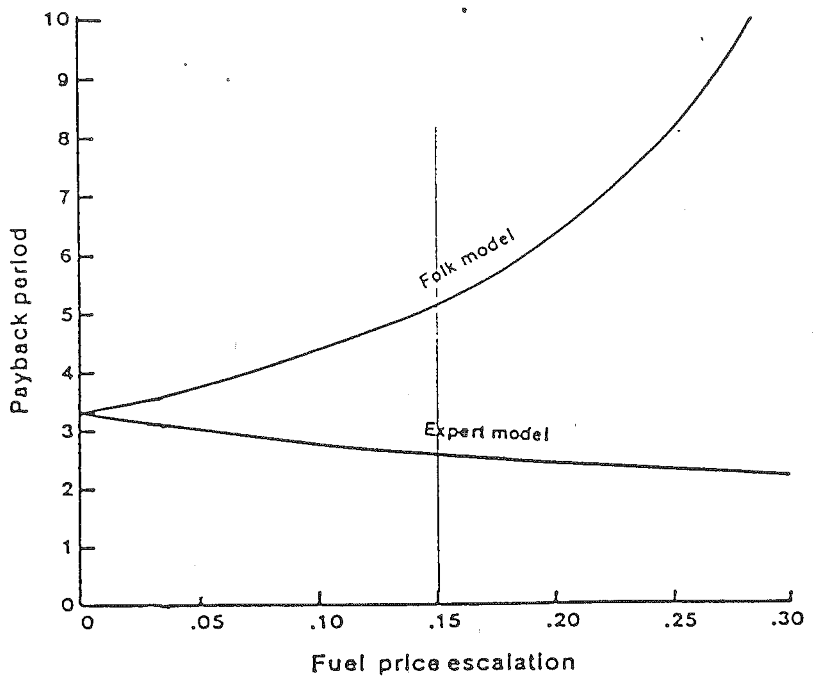


Fig. 2. Payback period as a function of fuel price escalation, as computed by the folk model and the expert model. The curves are derived from Eqs. (6) and (7). Both curves assume an investment equal to one year's fuel cost, and a 30% decrease in energy use due to the investment.

The methods yield equal results if fuel prices remain constant. The expert's payback decreases as fuel price escalates at a higher rate. For f = .15 the folk method estimate is already more than twice the payback of the expert method.

In Figure 3 i and f are held constant at 1 and .15 respectively :

Figure 3 : Expert vs. Folk payback model
C.p. effects of varying energy change ratio

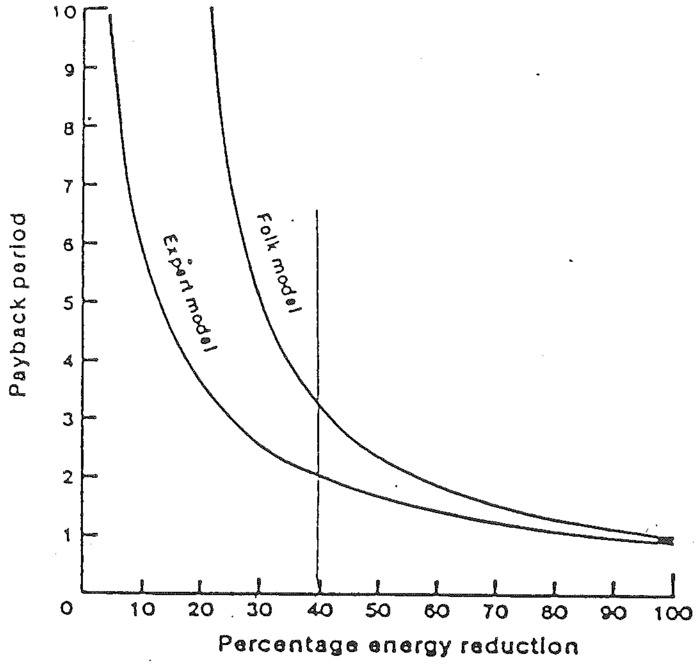


Fig. 3. Payback period as a function of energy reduction, computed by the folk and expert models. Both curves assume annual fuel price increases of 0.15 and an investment equal to one year's fuel cost.

Figure 3 shows that when energy reduction (1 - r)100 is large, estimates of the payback period are approximately equal. When energy reduction is less than about 40 % the folk method significantly overestimates the payback period.

In Figure 4 f = .15 and r = .7 :

Figure 4 : Expert vs. Folk payback model

C.p. effects of varying investment proportion

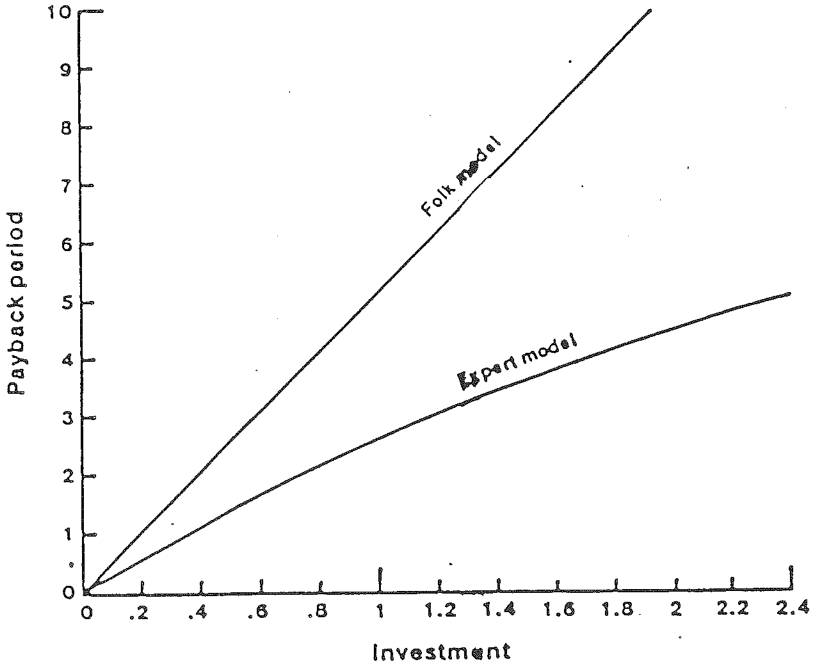


Fig. 4. Payback period as a function of investment (investment is expressed as a proportion of annual fuel cost), computed by folk and expert models. Both curves assume annual fuel price escalation of 0.15 and a 30% decrease in energy use due to the investment.

When the investment is less than one third of annual fuel costs, the payback period is short and the two models are comparable. For large investments, the folk method yields much longer payback periods.

The real price increase in this illustration by Kempton and Montgomery is unlikely high, probably to highlight the differences caused by applying both methods (adding inflation supports the argument). Nevertheless, in the event of decreasing nominal prices, the developed model yields an adverse outcome because it then leads to an overestimation of savings by the folk model. The conclusions are valid in the case of increasing nominal prices, a condition that holds over last years.

B. Investment related characteristics

1. Liquidity, length and size of the investment

Energy conservation is often embodied in other kinds of capital. Energy conservation measures only increase the second hand market value of an asset if they coincide with the taste of the next buyer. People will tend to insist on very short payback periods for conservation measures, when they are willing to accept a much longer payoff period for the asset itself (e.g. 30 years for a house) (Beijdorff,1979) consequently, liquidity is rather low for conservation investment.

Poor liquidity becomes less critical if conservation is viewed as part of an investment portfolio.

Consumers will trade off higher initial capital costs against a reduction in operating costs (capital cost - energy efficiency tradeoffs) (Hausman, 1979). A more energy efficient product often carries a higher price tag. In Turiel's analysis of 8 appliances, the general rule is that the LCC decreases continuously with increasing energy efficiency. Energy cost savings by using a more efficient model more than compensate for the extra initial cost.

Rising energy prices create both substitution and income effects. The substitution effect occurs because rising energy prices change the design characteristics of new homes. "To the extent that newly constructed units embody the currently cost-effective construction techniques for the conservation of energy, the spread between prices of new and existing units will widen, and new construction will be stimulated. To the extent that existing units could be retrofitted with energy conserving features, and to the extent that the capital costs of such retrofitting were competitive with the costs of building similar features into newly built units, the substitution effect would disappear.

The evidence so far, however, indicates that the retrofitting of existing units, particularly the oldest ones, is being done slowly." (Jaffee, 1984)

The income effect occurs through the rising cost of home-ownership. "To the extent that energy prices contribute to the affordability problem, demand will be shifted to lower priced units, which tend to be existing units, thereby narrowing the difference in price between newly constructed and existing units." (Jaffee, 1985) Jaffee concludes that it is difficult to estimate the net effect of the offsetting factors quantitatively.

Jaffee's conclusion is at the roots of the individual's concern that there may not be a market for home efficiency improvements [9] and that one amortises over the period of expected occupation instead of over the life of the dwelling (Collins, 1984). If energy considerations were central to the pricing of houses, the prices of older units would decline in relation to those of new units (and the formers' owners would suffer capital losses in selling value or in measures to keep up) (Downs and Bradbury, 1984), since improvements in energy efficiency have been made faster in new units.

But, according to Jaffee, higher debt-service costs have been much more important than higher energy costs in reducing the affordability of owning a house, so that construction costs and home prices do not show any special sensitivity to energy prices. In his analysis of the average monthly costs of homeownership in the US over the period 1974 - 80, the following items provide the bulk of costs :

debt service	72.4 %
heating and utilities	11.1 %
real estate taxes	8.6 %

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[9] There is certainly such an explicit market in Denmark where each building must carry an energy label.

Still, it is true that homeowners have greater control over heating and utility costs than over other costs. Homeowners weigh energy costs in their home purchase decisions and are undertaking efforts to conserve energy. So it seems reasonable to conclude that heating costs as controllable item of housing expenses are important and that higher costs affect home-buying decisions. Nevertheless, the general issue of affordability is dominated by the level of house prices and the costs of financing (Jaffee, 1984).

The building recession is working against energy conservation. Indeed, the bulk of improved efficiency must be expected from new, more efficient equipement. (Beijdorff, 1979)

The size of a conservation measure may be prohibitive, e.g. in the case of heat pumps, windmills (Edworthy, 1984), etc. Another hindrance is that investment in conservation measures is often additional to already large capital outlays, such as in building a house. Of course, income plays a role of paramount importance.

The minimum size of a conservation investment may also be a handicap in comparison with alternative investments, such as bonds or stocks, that are almost available at any given quantity and price.

2. Investment information and risk

Information on energy conservation may be difficult to acquire. General information provided by government, utilities and media does not tell what can be expected for a particular case - i.e. that of the decision-maker. Since the effect of conservation measures is a function of building conditions (amongst other factors), an on site examination ond engineering heat-loss analysis is needed for different measures (but many energy audits are based on simplistic models). [10] Since this is virtually impossible to apply in each case, the best one can do is use information on similar buildings (if one can find such information) (Gates,1983).

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[10] We again refer to the earlier mentioned complex interactions between diverse conservation measures.

Indeed, reliable savings estimates may be hard to find. For instance, many studies on insulation do not specify thickness, quality or the way of application. Are we dealing with engineering studies on idealised dwellings or on actual units ? Are we dealing with measures applied as a supplement to other measures (and thus yield diminished incremental returns due to interactions) or are we dealing with measures applied to units with no energy efficiency at all. Additionally, there are uncertainties about the exact measuremant of the effects (Neels and Murray, 1984). It is also clear that information supplied by utilities is biased towards particular fuel types.

Once one has decided to apply a certain conservation measure of which he has obtained a fairly good idea about reductions in energy use, there still remains the search for cost estimates. Obtaining cost estimates by contractors is time consuming (Gates, 1983), with the complication of finding competent contractors, since a trained retrofit industry is lacking. (Collins,1984).

The energy cost-capital cost trade-off curve pertains to the efficient technology. Efficiency is defined as providing a given saving in the cost of energy used at the lowest possible capital cost. This requires full information on existing technology. The curve will shift as new technology becomes economically efficient through innovations or economies of scale (Jaffee 1984). The possibility of technological change can already on itself be an explanation of a high discount rate (Downs and Bradbury, 1984; Hausman, 1979)

It is clear that investment information on energy conservation measures is obtained at a high cost. Related uncertainties cause a great deal of perceived investment risk.

Perceived investment risk for conservation measures, stems from various general factors :

- concern about predicted savings
- concern about durability and integrity of conservation measures

- distrust of government, of utilities or other organisations with vested interest (confusion as a consequence of sometimes contradicting statements)
- doubt in the contractor's ability
- fear to invest in a rapidly vetusting technology
- distrust of new ideas (human inertia)

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The course of future energy prices is the major unknown in the investor's evaluation and, consequently, contributes to the risk of the investment. Many studies report that decreasing pressure on energy prices causes the interest in energy conservation to diminish rapidly (DPWB, 1984; Dyke and Chan, 1984; NEOM; Sumner,1984)

3. Tax effects

Conservation measures result in savings on utility bills and savings are tax free. Consequently, comparing with alternative investments must be done on an after-tax basis. The difference between conservation investment and taxable investment increases as the marginal tax rate rises (Gates, 1983). Where tax deductions for conservation investment are available, the attractiveness is even higher (Beijdorff,1979

Tax subsidies lower the initial capital cost and make the tradeoff towards lower operating costs more favorable (Hausman, 1979).
We can introduce a tax credit in formula (11)

$$NPV = \sum_{i}^{n} \frac{MS_i}{(1+d)^i} - \sum_{i}^{n} \frac{O_i}{(1+d)^i} + \frac{\tau_j * TDI_o}{(1+d)^j} - I_o \qquad (16)$$

where TDI_o = the tax deductable part of I_o
τ_j = the marginal tax rate in year j
j = the year of taxation

Also, for corporations, depreciation on the investment must be multiplied by the appropriate taxation rate, discounted and accounted for as a benefit, following the several possible depreciation schemes.

4. The impact of inflation

Conservation investments derive a portion of their appeal from the expectation that energy prices will continue to rise at an escalation rate above inflation (e.g. Turiel et al.: 1 to 3 % in real terms) (Turiel et al.,1980) and thus, savings will become more valuable. In this sense, conservation investments protect the investor from income deterioration due to inflation (Gates,1983; Struyk, 1984). Most estimates put the escalation of energy prices higher than the inflation rate (Dyke and Chan, 1984; IEA, 1984; Johnson, 1984)

The higher the escalation rate, the more benefits are produced and the sooner the initial investment is regained. Prices of energy conservation measures are expected to rise at about the rate of inflation (Dyke and Chas, 1984).

C. Household demographics and behaviour

1. Income

Income is a determinant of how large a utility bill can reasonably be afforded by a household, without detracting from the ability to purchase other goods and services. Income is also reflected in the size and the quality of the household appliance stock and the type of home. Ceteris paribus income increases should lead to higher energy consumption in the short term and the acquisition of newer and larger appliance stocks in the long run. (Warriner,1981)

Consumption of energy does rise monotonically with income level (Jaffee, 1984) High-income families have higher total energy expenditures. But low-income households spend a larger share of their income on energy. (Downs and Bradbury, 1984; Struyk, 1984)

The poor occupy less energy-efficient housing. Adjustments made by the poor are modest (Struyk, 1984) In the United States, the poor tend to live in houses that will soon be removed from the housing stock and are at the bottom of the quality distribution.

In relation to income, the pattern is systematic to each type of unit : higher income levels imply higher levels of insulation. Of course; income is correlated with other characteristics of housing - particularly the year of construction - so the relation between income and insulation may be spurious. There is evidence however that the financial ability to make the necessary capital expenditures (for insulation and equipment) is an important determinant (Jaffee,1984)

Cunningham and Brondel (1978) conclude that the price responsivesness of low and very high income groups to energy price increases is lower than of the middle - income group. The low-income group cannot reduce energy use any further [11]

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[11] in that they show an energy reducing behaviour and have already applied inexpensive conservation measures such as weather stripping, caulking and plastic covering.

the high-income group tends to buy itself out (Verhallen and Van Raaij, 1981). The disadvantages of the low-income group to accomodate price increases are definitely exacerbated by financial considerations (Tienda and Aborampah, 1981) [12]

Hausman estimated the relation between discount rates used by energy consumers and their income (Hausman, 1979) :

Table 6 : Estimated Discount Rates
(mean population estimates)

Income Class in $	Number of observations	Implied discount rate
6000	6	89 %
10000	15	39 %
15000	16	27 %
25000	17	17 %
35000	8	8.9 %
50000	3	5.1 %

Economic theory implies that the discount rate should decrease as income rises, even with perfect capital markets, since the marginal tax rate rises with income while the services of consumer durables are untaxed. Given the uncertainty of the income streams of the poor and their lack of savings, one expects a high discount rate (Hausman, 1979)

2. Homeowners vs. renters

The poor, especially in urban areas, are predominantly renters (Struyk, 1984). Further, there is a high correlation between a unit's being a single-unit structure and its being owner-occupied.

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[12] e.g. Tienda and Aborampah find upper-income households to be more likely to use alternative fuels.

Not surprisingly, home tenure affects the occupant's interest in conservation. Careless reports on a Residential Energy Survey in Cranbrook (221 households) where 43 % of the sample who had undertaken some degree of weatherisation and 82 % of these where homeowners (Careless, 1984) [13] . Data on the incidence of energy saving features show single-family (detached) units to be most weathertight among structures having up to four units. The incidence of weatherisation in single-family units rises with income (Struyk,1984)

Homeowners seem to have been reducing their energy use by increasing efficiency, but not by reducing the level of housing services they consume (Jaffee, 1984). In general, they are not willing to sacrifice assets such as floor space, aesthetics and comfort (Downs and Bradbury, 1984; Mc Donald, 1984). Owners spend much more than renters : home energy consumption increases steadily with income (Struyk, 1984)

Renters are also most likely to live in the oldest units (Jaffee,1984) Rental units are removed from the housing stock at higher rates than owner-occupied units. Many of the rental properties occupied by low-income households are in marginal areas - characterised by little (if any) appreciation in property values. Apart from renters with rent paying problems, owners are generally discouraged from investing in such structures (additionally, financial institutions are reluctant to lend money) (Struyk, 1984).

The <u>tenant - owner relationship</u> deserves special attention. While owners control design and structure of the dwelling and the main energy using equipment, energy behaviour is controlled by tenants (Downs and Bradbury, 1984). We can observe two extreme situations (apart from mixed forms) :

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[13] Renters are also considerably less likely to report relying on alternative fuels for space heating. Especially residents of apartment units are less apt to switch to alternative fuels. (Tienda and Aborampah, 1981)

On the one hand when tenants pay the energy bill, they are motivated towards energy conserving behaviour as costs rise (close windows and doors, set thermostat lower, etc.), but they cannot directly affect the physical structure of buildings or the equipment. All physical improvements become the property of the owner. Yet owner's incentives for improvements are low since he does not pay the utility bills. Only when improvements can be returned by higher rents (or selling price), there are financial incentives to invest.

On the other hand when the owner pays the utility bills, he has a strong incentive to make his property more energy efficient by adding insulation, installing a better furnace, etc. But the owner cannot dictate the tenant's behaviour. Tenants have little motivation to conserve energy since they do not suffer from higher utility bills.

Additional complicating factors can be the following :

- when rent includes energy costs, tenants cannot see the direct effects of their actions on energy consumption (given that they were motivated). As a result , energy price increases do not even inspire changes in behaviour (Struyk, 1984).
- Rental buildings often operate without seperately metered units (Downs and Bradbury, 1984).
- for larger structures, the degree of uncertainty of the savings from particular improvements is much greater. Indeed, a lack of experience is often cited as a primary factor inhibiting investment in the larger properties (Struyk, 1984). Additionally, the initial cash outlay is substantial.

We can conclude that reliance on market forces to generate adjustments of the housing characteristics for the sake of conservation is proving quite effective for single-family and owner-occupied housing (Downs and Bradbury, 1984)

3. Age

Elderly are more dependent on reliable and continuous supply of energy. Their age and already frugal living conditions make it difficult for them to cut back on their energy consumption through changes in lifestyle (Warriner, 1981 [14]

The rate of homeownership by the elderly poor is higher than by other poor households (Struyk, 1984), the incidence of poverty among the elderly is higher than among the nonelderly (Downs and Bradbury, 1984; Warriner, 1981) [15]

In an analysis of electricity consumption (not for heating pruposes) in 694 homes in northeastern Wisconsin, Warriner found that the elderly (Warriner, 1981)

- use about one third less electricity
- pay proportionally more of their annual incomes for electricity
- use more electricity per capita (fewer household members)
- have fewer appliances

Additional hindering factors to energy conservation may be that elderly :
- are less able to make improvements themselves
- are hesitant to engage contractors for fear of being cheated
- are hesitant to let strangers in their homes (Struyk,1984)

There seems to be no real difference between elderly and nonelderly households of the same income level in the share of income spent for energy (Struyk, 1984). Since total energy needs for elderly are lower (fewer household members, fewer appliances, smaller size of dwelling), but efficiency tends to be lower, energy consumption may correspond between elderly and non elderly households.

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[14] Also families with very young children have constraints on their ability to adjust (Tienda and Aborampah,1981)

[15] The elderly occupy single-family units at a lower rate than do younger households (Struyk, 1984)

4. Other household demographics

Total family size exerts a substantial and significant effect on a household's propensity to invest in home retrofitting measures and to use secondary less expensive fuels. (Tienda and Aborampah, 1981).

In families with both parents working, energy consumption tends to be lower, which makes energy conservation measures less urgent (but income is higher).

When education is low barriers to implement a conservation measure will bo more effective.

Finally, occupational status is closely related to income.

5. Attitudes and behaviour and their relation to household demographics.

As consumers perceive the energy problem and its persistence as real, they are less likely to prefer a continuation of the status quo (Bennett and Klein Moore 1981). Consumers will only act accordingly to their attitudes when they feel fully responsible for energy problems and perceive that their personal contribution to energy saving is effective (DPWB, 1984; Verhallen and Van Raaij, 1981)
Most studies prove attitudes to be poor predictors of household behaviour.

Those who attribute problems, e.g. energy shortages, to a personal cause are likely to prefer personal actions toward solving the problem (conservation - eventually mandatory - is taken to be the most personal action). The others (who blame government, OPEC or the oil companies) prefer nonpersonal actions. Belk states that the failure of most consumers to see themselves and the general public as the major source of the energy problem is likely to be a substantial deterrent to energy conservation (Belk et al., 1981)

Leonard - Barton defines voluntary simplicity as the degree to which an individual selects a lifestyle intended to maximise his direct control over daily activities and to minimise his consumption and dependency (Leonard - Barton, 1981).

Families with low income ($ 15 000 or less) and very high incomes ($ 46 000 or more) score lower on the voluntary simplicity index. It is not surprising that poorer families score low : many live in an involuntary existence of material simplicity. Further , the voluntary simplicity index is positively related to education (and mechanical ability) and negatively to age (Leonard - Barton,1981)

Labay and Kinnear studied the adoption proces of solar systems. Adopters rate such systems as greater in relative advantage over other energy sources (the degree to which the innovation is perceived as being superior to the idea or product it replaces), lower in financial and social risk (the perceived risk is the expected probability of economic or social loss resulting from innovation), lower in complexity (the extent to which the innovation appears difficult to understand and use) and more compatible with their personal values, experiences and needs (Labay and Kinnear, 1981)

As compared to nonadopters, adopters are younger, earlier in the family life cycle, more highly educated, have higher incomes and a higher occupational status. In general, the adopter and knowledgeable nonadopter appear to be demographically very similar, yet different from the general population.

IV. Proposed solutions and evaluation

A. Curing the lack of resources

1. External financing

External financing, by means of a loan, can be introduced in formula 11 by converting the borrowed sum $f_b I_o$ (where f_b is the fraction of debt in the investment) into a level repayment $\bar{R}$, using the formula :

$$\bar{R} = f_b I_o \left(\frac{r(1+r)^m}{(1+r)^m - 1}\right) \qquad (17)$$

where m = the number of periods the loan is outstanding
r = interest rate per period

Repayments are properly discounted and cause net present value to decline. usually, repayments are discounted at the interest rate of borrowing :

$$NPV = \sum_{i}^{n} \frac{S_i}{(1+d)^i} - \sum_{i}^{n} \frac{O_i}{(1+d)^i} - \sum_{i}^{m} \frac{\bar{R}}{(1+r)^i} \qquad (18)$$

where n and m must be stated in the same units (e.g. months)

In theory, in comparing several investment alternatives, the following approach can be followed (Duff, 1984) :

- rank investments starting with the one yielding the highest IRR
- invest the available capital in projects 1 to n. If there are investment capital constraints the MARR is the IRR on that increment n+1 where the investment capital runs out.
- if borrowing at an interst rate < MARR is now made part of the alternatives, those investment options for which IRR > interest rate can be added. MARR is then almost equal to the borrowing rate.

The following agents may find it difficult to raise capital for energy conservation investments :

- first time buyers tend to be fully stretched in mortgage terms with little flexibility to raise more capital for investment in energy conservation measures which would reduce operating costs. This is reflected in the tendency to prefer low capital cost / high running cost type of equipement (Beijdorff, 1979; Tienda and Aborampah, 1981)

- landlords who rent to low-income households generally find it more difficult to obtain financing (especially in deteriorating neighborhoods).

- low-income groups may have to spend all capital (available and eventually borrowed) to higher priority uses.

- many landlords originally financed their properties with fixed-payment mortgages at relatively low interest rates. The cash flows provided by these properties would be wiped out if the owners had to refinance them at much higher interest rates in order to pay for energy saving improvements (Downs and Bradbury, 1984)

- Public and private non profit sectors' energy managers (school administrators, hospital energy managers,...) often lack the possibility to implement conservation measures since they do not manage investment budgets or are not allowed a budget for that kind of investment (Johnson, 1984)

- Energy managers in industry may find it difficult to raise capital since energy conservation investments tend to be treated as discretionary investments.

2. Government aid

Downs and Bradbury mention 4 types of government aid to the poor :

- assistance tied to energy costs
- provision of funds which the poor can use at their discretion (e.g. on energy conservation)
- lending at low interest rates
- aid to the installation of energy improvements e.g. tax credits subsidies (premiums)

The first intervention reduces the incentives of the recipients to conserve energy. The measure aims to offset increases in energy costs with assistance tied to those increases. It is less equitable to provide aid in response to changes in people's conditions than in response to the levels of their conditions. Consequently, aid to the poor should be related to their general level of poverty, regardless of what caused that poverty. (Downs and Bradbury, 1984).

Nevertheless, there seems to be a strong tendency towards aid tied to the consumption of specific goods or services. There are clearly more opportunities for politicians to make publicity than if antipoverty aid is consolidated in general income assistance. Aid towards e.g. energy conservation also enables to make producers of such items benefit. Finally, it provides a way of coping with the general fear of the taxpayer that aid is not well spent if not restricted to specific types of consumption (Downs and Bradbury,1984)

Special attention is paid to tax credits. First, consumers must be informed on the existence of tax credits and must perceive them as a means of price reduction. In fact, they must be able to assess their advantages. Secondly, credits are available only to taxpayers whose tax liabilities are sufficient to cover the credit claim. Finally, the after-the-fact nature of the credit requires that recipients prefinance the entire initial cost (Pitts and Wittenbach, 1981).

In a survey on 146 respondents who had been offered tax credits, Pitts found not one individual that considered the tax credit so important that the purchase would not have been made without it. Moreover only 61 % had prior information [16], which means that at least for the rest, the credit proves to be a windfall.

Tax credits are of little help to consumers least able to afford conservation measures (Pitts and Wittenbach, 1981). The fiscal deduction for insulation investments on 1982 incomes were carried out by 15 163 Belgian households (almost 1 %) for a total amount of 1175 million francs - i.e. an average investment of 77 491 francs per household. The following table presents the average benefits according to income class (Allé) [17]

Table 7 : Average benfit from tax deduction on insulation investment for fiscal year 1982

income class (in 1000 francs)	average benefit
- 250	3070
250 - 500	5930
500 - 750	7460
750 - 1000	9550
1000 - 1500	13650
1500 -	20000

We add the possibility of subsidising firms [18] for implementing energy conservation investments. Jacques mentions firms waiting for subsidies (caused by massive bureaucracy), while the lack of actual conservation is undermining the supposed economic benefits of the subsidy.

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[16] College-educated respondents were more likely to have obtained prior information. In general, the majority of those receiving the credit tended to be college-educated and to hold white-collar jobs

[17] Unfortunately, average investment per income class was not mentioned, nor was the number of households that invested in each income class

[18] Mutatis muntandis, tax credits favor firms that make profits.

Jacques also argues that subsidies tend to concentrate on large organisations who already possess adequate skills and have more access to capital markets (they are even more likely to achieve good value from external private consultants)(Jacques, 1984).

3. Creative Financing

A. utilities as participants

Many authors search for alternative ways of financing energy conservation and attribute an important role to utilities (e.g. by providing loans (Downs and Bradbury, 1984) or by buying high-efficiency appliances and leasing them to customers (Hausman, 1979). Utilities should particularly be interested whenever they operate close to maximum capacity to help their customers reduce energy use (Downs and Bradbury, 1984)

Evidently, this also reduces demand for the product utilities sell. Consequently, utilities might prefer trying to spread demand loads [19] since this results in lower capital expenditures because of reduced capacity requirements and lower operating costs. If peak / off-peak users are charged prices related to the cost of serving them, synchronisation efforts will lead to a more efficient allocation of resources (Kasulis et al., 1981)

One such action of creative financing is the RECAP-Program (Residential Energy Conservation Action Program) described by Esteves (Esteves,1984). It is creative in that it introduces a third party : the Energy Conserving Company (ECCO).

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[19] E.g. electricity consumption not only has seasonal cycles, but also weekly and time-of-day (TOD) peak and off-peak periods. To the extent that limited storage facilities (pumped storage) are not available, production capacity must correspond to the maximum load demanded, even if that demand is for short periods of time.

The principles of RECAP are :

- a contract to provide conservation retrofits for the utility's customers is agreed upon by the utility company and the ECCO
- ECCO installs free to the owner or occupant where there is a need for conservation retrofits, if they are cost effective
- the utility does not pay either for installation
- the utility does pay ECCO on the basis of projected savings (that consequently must be measured) [20]
- payments are made and savings monitored over a period of several years (3 - 5 years)

The success of the formula lies in the continuing interest of the ECCO, that therefore provides high quanlity workmanship and materials (eventually warranted) and that in some cases directs educational programs towards users. If during the guarantee period savings do not exceed payments, ECCO will refund the difference.

In this way already over 1000 homes in the region New Jersey - Pennsylvania are retrofitted in cooperation with General Public Utilities. Esteves reports that interest by other utilities is lively (Esteves, 1984)

b. shared savings

As the participation of utilities in demand reduction is not evident, other creative financing methods are searched for. In "shared savings" three parties are involved :
- owner of the building
- energy service company ESCO
- investor

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[20] The ECCO has to be aware of "phantom conservation" since in recent years energy use is partly decreasing because of changes in energy behaviour that do not involve capital outlays.

The ESCO plays the pivotal role. It identifies buildings where cost effective ways of reducing energy use and monitoring are possible (by conservative estimates) and also implements these measures. The ESCO is paid for the analysis and implementation and also obtains a portion of the "shared savings". This system helps the company to establish credibility (they are risk sharing) and to attract projects that otherwise would never have happened. On the other hand, the company agrees upon a long term involvement with unpredictable tenant situations, possible changes in ownership, character of the building, price and availability of energy and equipment.

The investor has a central function since he purchases the equipment and pays for installation. The investor must be comfortable with the basic principles involved (some technical engineering knowledge is required). To the investor's advantage we can mention substantial ROI while the risks are controlled by the ESCO. In this kind of experiments most investors will not consider projects with an IRR of less than 25 %. The complexity of this investment may be a hindrance : it is time consuming to set up and the investor must still to a great extent trust the evaluations and predictions of the ESCO. His profit is dependent on the ESCO's ability to implement and monitor the project.

The owner obtains a positive cash flow (saving) with no initial capital investment required and runs a small risk. The reduction of building operating costs he gains is of course substantially less than if he directly made the investment. The only risk is that the ESCO may be wrong in predictions, may install bad equipment or go out of business (but this can also happen with a regular contractor who was paid properly). Finally, the owner undergoes reduced control on the building [21]

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[21] The owner can use a "buy out clause".

This comment on energy shared savings is entirely based on a demonstration project Morrisania II (which is a rental housing building in the Bronx (New York)), described by Benjamin (Benjamin 1984) Banks, institutional investors and insurance companies were reluctant to invest given their unfamiliarity with the technique and the absence of tangible collateral. A new project in 30 to 60 city-owned buildings is now initiated.

Remark : both ECCO and ESCO spread over a large number of projects the risk that an improvement would not work (Downs and Bradbury, 1984)

B. Information initiatives

Government may launch educational campaigns to help consumers better understand the tradeoff between capital outlays and reduced energy use, by means of advertising, booklets, pamphlets, etc.

In the meantime, it has become clear that increasing the information flow towards consumers does not necessarily cause changes in energy behaviour or even in attitudes (Leroy, 1984). As a general rule, campaigns become more efficient as they get personal (which usually implies material stimuli).

Or as Lim (Lim, 1984) puts it : "It appears that, while there is some value in energy campaigns, ... there is a general unwillingness to let go modern conveniences made available by electrical appliances which are both time-saving and prestigious. The dependence on energy intensive appliances is a way of life, and the possession of these appliances has become the yardstick of success."

Utilities may also provide information (e.g. enclosed in utility bills) (Mc Dougall et al., 1981)

2. Demonstration programs

Demonstration programs help reduce the application time of technologies by assisting individuals and companies with their new energy saving ideas and by widely promoting the promising ones (Tremblay, 1984).

3. Energy audits

We already pointed out that audits are often based on very simplistic models. It is important that the auditing agent is independent and really searches for the best conservation solution (Douthitt and Moss, 1984)

4. Energy workshops

Scott Geller conducted an experiment by means of community energy workshops. The test group really did undergo a major change in attitudes :

- More concern about the energy crisis
- increase in perception of personal control over the energy crisis
- decrease in the amount of money estimated to be required in order to implement energy conservation measures
- increased realisation that personal efforts to insulate homes had not been sufficient
- decreased belief that a fireplace conserves heat energy
- increased awareness that simple changes in lifestyle can save substantial amounts of energy
- increased commitment in changing residential lifestyle for energy conservation.

However, the follow-up home surveys (one visit at home) of the workshop attendees showed very few applications of the energy conservation strategies emphasized at the workshops (Scott Geller,1981)

5. Labeling

Many authors favor labeling of homes and appliances for energy characteristics. The label on a particular appliance should include a scale showing annual running costs, compared to the model with the lowest and highest energy costs (Henion, 1981).

6. Data collection

Better information gathering and data sources on energy conservation and its benefits will accelerate acceptance of the argument that energy conservation should be recognised as a genuine supply option, contributing to a higher standard of living through increased efficiency of energy use (Dyke and Chan,1984; Gates, 1983).

By means of illustration : in the United States, the Industrial Energy Efficiency Improvement Program (Department of Energy) since 1976 gathers each year approximately 600 manufacturing companies' data on efficiency improvements. This is the basis for an Annual Report on energy conservation in US-Industry, which is submitted to Congress and the President.

C. Tariff policies

- tariffs should reflect true social costs. Utilities should apply marginal cost pricing, instead of determining energy price as an average cost over all existing capacity (cf. Part I).
- the relation between tariffs of different fuel types should not be altered by taxation (e.g. oil taxation in Belgium) or government regulation (e.g. US Gas Industry). A higher free market price would have led to greater conservation (Henion,1981)
- no discounts should be allowed for greater quantity orders when a comparable entity (in a same subsector) clearly uses less energy (Lim, 1984)
- peak-off tariffs enable consumers to lower energy costs (this may reduce the return on energy conservation investment).

D. Efficiency standards

Energy efficiency standards may be imposed on buildings and appliances. This of course reduces the flexibility in design options (Gately,1979)

Setting efficiency standards places an implicit tax on those individuals who have the highest discount rates, which comes down to creating an adverse income distribution effect (Hausman, 1979) at least in the short run.

An advantage is that energy efficiency standards may be enforced at levels higher than the market participants would otherwise set (Jaffee, 1984).

E. Emergence of an energy efficiency industry

It is essential that energy conservation be recognised as a business opportunity for it to become really effective. The private sector could develop a professional conservation service industry that can work through the decentralised drive of the profit motive (Beijdorff, 1979)

At the same time, professional standards for conservation specialists should be worked out since they often are at the same time consultants and contractors. Since their jobs require both managerial and technological engineering skills, constant courses are vital to the development of the profession. Jacques proposes the installation of an independent energy conservation council funded jointly by Industry and the DOE and allowing membership by researchers (Jacques,1984)

Ideally, contractors should not be tied to any type or brand of equipment or any particular conservation activity. ESCOs and ECCOs might be better placed to search in an unbiased way for the best conservation solution (Benjamin, 1984).

In addition, Henion recommends that organisations should offer conservation packages or systems rather than a series of seperate products or services requiring consumers to piece them together (Henion, 1981).

V. Actions undertaken by Belgian government

The following actions were undertaken by the Belgian government (Allé)

towards public users : national government

- direct investments in public buildings (since 1982)
- no schools on saturday, action to lower thermostats, consumption labels for public buildings

regional government (Wallonia)

- partial subsidies of community investments (opération AGEBA + collection of consumption data). These subsidies amounted to about 30 % of total investments
- financial aid for universities being advances that can be reclaimed

towards industry :

- for the fiscal year 1981 : amortisation ad libitum
- since the fiscal year 1982 : tax deduction on taxable benefits of the amount of the investment. (In May 1984 719 cases were approved upon for a total investment sum of 735 million Belgian francs, which yielded a supplementary advantage to industry of about 30 million francs only)
- subsidies for energy auditing : intervention for 50 % of the cost with a maximum of 50 000 BF (measure not once applied)
- demonstration projects : development and commercialisation of new technologies of energy conservation (started in 1984)
- publication of an energy guide (1980)
- free audits by means of two energy busses (200 audits executed at beginning of 1984).

towards agriculture :
- subsidies for investment in classic technologies
- intervention for 35 % of investment costs plus 100 % of scientific costs for demonstration projects on new technologies (heat pumps, bio-methanisation,...)

towards residential users :
- 1976-81 Insulation premium on the national level, followed by a double glazing premium by the Flemish government and an insulation premium by both other regional governments
- 1982 : tax deduction on insulation projects up to 300 000 BF (cancelled on 1/1/1985)
- information campaigns
- 1985 Wallonia : efficiency standard K70

concerning energy supply :
- regional government (Wallonia) financed 5 district heating networks (2 were abandonned)

Financial impact of these measures can be found on the next page. Although in recent years more efforts have been made, the overall picture remains rather weak.

Nevertheless conservation remains interesting for national policy :
- reduction of deficits on the commercial balance
- stimulation of economic activity (manufacturing and installation of energy saving equipment)
- amelioration of competitivity of firms
- reduction of energy dependency
- social policy (alleviating budget burdens)

...

Table 8 : Budgets spent on energy conservation measures by Belgian national and regional governments

	1974-1980	1981-1983	TOTAL(1974-1983)
Etat central (en millions de FB)			
-URE dans les bâtiment publics (tranches sélectives, universités)	-	1.600	1.600
- Incitants à l'URE dans les secteurs industriel et tertiaire	-	1.250	1.250
- Incitants à l'URE dans l'agriculture			
- Incitants à l'URE des particuliers	300	-	300
- Recherche- développement	500	500	1.000
Total	800	3.350	5.150
Région wallonne			
- URE dans les bâtiments publics	-	250	250
- Incitants à l'URE des particuliers(1)	-	250	250
- Chauffage urbain et récupération de chaleur	440	1.110	1.550
- Recherche-développement-études-vulgarisation	40	75	115
Total	480	1.685	2.065
Région flamande (p.m.)			
Région bruxelloise		5	
Total général	1.280	5.040	6.320

Source : Allé

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(1) Il ne s'agit pas de budgets consacrés explicitement à l'URE, mais bien à la réhabilitation des logements. La Région estime qu'1/3 de ces budgets sont consacrés aux économies d'énergie.

Conclusion

When measured with expert's methodology, energy conservation shows to be a better buy than energy consumption. Thus a private investor should have to prefer energy savings to energy purchases. In practice, however, one observes the amount of realised conservation to be much lower than the amount of potential conservation.

In this paper the dominant causes of this divergence are discussed to belong to three main categories. First, proper estimation of conservation opportunities is hindered through high subjective discount rates, short required payback periods, parameter uncertainty and folk quantification in general. Secondly, a number of characteristics of energy conservation investment have serious consequences on implementation : liquidity, length and size of the investment, investment information and rise, tax and inflation effects. Finally, we considered the influence of household demographics (income, ownership, age, etc.)

Solutions for bridging the gap between realised and economical conservation are provision of resources (external financing, tariff policies, efficiency standards and the emergence of an energy efficiency industry.

Finally, the rather weak interest by Belgian government is demonstrated.

Appendix 1 : HEATING DEGREE DAYS

Because every year is characterized by a meteorological course of its own, space heating use is not directly comparable from year to year. The notion of degree days is intended to overcome this difficulty.

The number of degree days of a day is estimated by the formula :

$$T_i - \bar{\bar{T}}$$

where T_i = the desired inside temperature
$\bar{\bar{T}}$ = the average outside temperature
subject to $\bar{\bar{T}} \leq T_c$

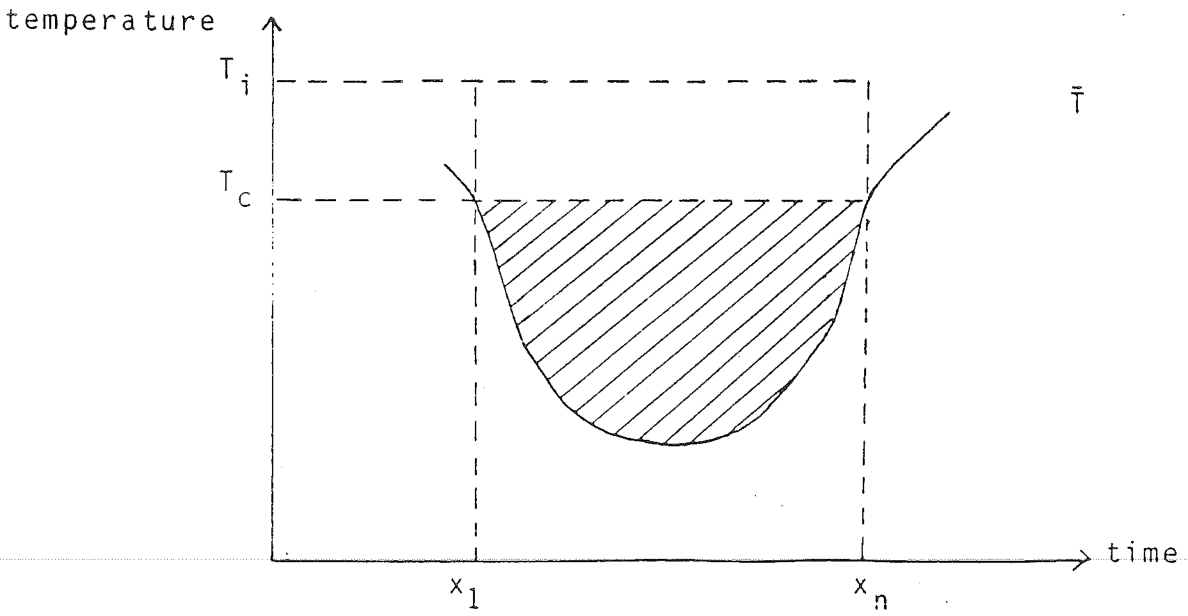
where T_c stands for critical temperature (above which heating is not required).

For any given period (a year, a winter-season) beginning at day x_1 and ending at day x_n, the number of degree days equals :

$$^{o}d(T_c/T_i) = \sum_{j=1}^{n} T_i - \bar{T}_{x_j}$$

The principle is illustrated in Figure :

Figure



For period $x_1 - x_n$ (a winter-season), a daily comparison is made between $\bar{T}$ and T_i, subject to $T \leqq T_c$, resulting in the shaded area as the number of degree days.

Observing that about 3°C of the required temperature gradient is supplied freely by household appliances, persons, living-beings, illumination and passive solar energy, T_c is lower than T_i. For Belgian households $T_c = 15°C$ and $T_i = 18°C$ is used traditionally, i.e. °d (15/15) are calculated (because of the constraint).

Each year carries a particular number of degree days that can be compared with a selected historical average number of degree days, viz the average over the period 1901 - 30, which is called the normal. Heat consumptions in various periods are adjusted by reference to these normals :

$$HC^c_{x_j} = \frac{HC_{x_j}}{°d_{x_j}} * °d_n$$

where $HC^c_{x_j}$ = corrected heat consumption in period x_j

HC_{x_j} = actual heat consumption in period x_j

$°d_{x_j}$ = number of degree days in period x_j

$°d_n$ = normal

Other periods or yeard could also be used as references.

Appendix 2

Expert Payback Model

By definition one has to find n such that

Q_t = quantity consumed in period t
P_t = price of fuel in t
I = investment

$$I = (Q_o - Q_1)\ (P_1 + P_2 + \dots + P_n)$$

Assuming that $P_{i+1} = P_1(1+f)^i$

i.e. a constant price gradient of f/year

$$I = (Q_o - Q_1)\ P_1 \left[1 + (1+f) + \dots (1+f)^{n-1}\right]$$

using the sum of finite series

$$I = (Q_o - Q_1)\ P_1 \frac{\left[1-(1+f)^n\right]}{1-(1+f)}$$

Solving for n results in

$$(1+f)^n = 1 + \frac{fI}{(Q_o - Q_1)P_1}$$

Taking logarithms of both sides

$$n = \ln\left[1 + \frac{fI}{(Q_o - Q_1)P_1}\right] \Big/ \ln(1+f)$$

We rewrite the expression $\frac{fI}{(Q_o - Q_1)P_1}$ by substituting

following indentities : $\frac{I}{C_o} = i$ investment as proportion of fuel cost

$\frac{Q_1}{Q_o} = r$ energy change ratio

$C_o = Q_o P_o$ fuel cost

$$\boxed{n = \frac{\ln\left[1 + \dfrac{fi}{(1+f)\ (1 + r)}\right]}{\ln\ (1 + f)}}$$

Folk Payback Model

$$n = \frac{I}{MS}_1$$

MS = Monetary Savings

$$n = \frac{iC_o}{P_oQ_o - P_1Q_1}$$

$$n = \frac{i}{1 - \dfrac{P_1Q_1}{P_oQ_0}}$$

where $\frac{P_1}{P_o} = 1 + f$

$$\frac{Q_1}{Q_o} = r$$

$$\boxed{n = \frac{i}{1 - (1 + f)r}}$$

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