Enerdata

Training Seminar

Evaluation of energy efficiency trends and potentials

Grenoble, 30 January – 10 February 2006

Costs and cost-effectiveness of policy measures

Bertrand Château

Enerdata

Agenda

Assessing cost effectiveness of energy efficiency investment

Assessing cost effectiveness of energy efficiency policy measures

Enerdata

What are the costs of energy efficiency measures?

> **Private costs are**:
Costs directly supported by the final consumers when implementing an energy efficiency equipment. They include

Investment costs (overcosts)

- Equiment costs (overcosts)
- Implementation costs (overcosts)

Maintance and operating costs

- Fuel costs
- Other operating costs
- Maintenance costs

> **Public costs are** :
Cost supported by all tax payers because of the implementation of the energy efficiency policy and measures. They include

– Current functionning costs of public administrations and agencies in charge
– Specific tax credits and public subsidies to support energy efficiency
– Transaction costs

Micro costs

Macro costs

Enerdata

How effectiveness of policy measures are measured

> **The final consumer viewpoint** :
– At a micro level, the effectiveness is measured by the reduction of the energy consumption of the final consumer due to the policy measure
– At the macro level, it is measured by the difference between the final consumption which is registered and the consumption that would have been observed without the policy measure
– Bridging micro and macro evaluations is not so simple….

> **The tax payer view point**:
– At the macro level, the effectiveness is first measured by the reduction in the energy intensity of the GDP which is due to the policy measure

Enerdata

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro-economic evaluation)

Pay-back time, gross

- Ratio between the investment cost and the yearly savings on energy expenses
- If the investment is « overnight », without loan, the pay-back time measures the number of years which are necessary to recover the money spent in the investment by the yearly savings.
- Example : if investment is 100 , electricity price 20 cents /kWh (ex Denmark, Netherlands) and electricity savings 100 kWh/an:
  - the yearly savings on energy expenses are 20
  - The gross pay-back time is 100 / 20 = 5 years

Enerdata

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro, continued)

Pay-back time, net

- Ratio between the investment cost and the yearly savings on energy expenses
- If the investment is spread over time, or financed with a loan over several years, the pay-back time measures the number of years which are necessary for the cash-flow of the action to become positive.
- Example : if the 100 investment is financed with a loan over 4 years with a total cost = 120 :
  - After 3 years the cash-flow is 20 x 3 – 30 x 3 = - 30
  - After 5 years the cash-flow is 20 x 5 – 30 x 4 = - 20
  - After 6 years the cash-flow is 20 x 6 – 30 x 4 = 0
  - The gross pay-back time is 6 years

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro, continued)

Pay-back time: criteria for decision

- An investment is considered cost effective within a maximum accepted pay-back time of N years if
  - either investment < sum of yearly savings over **N** years (gross)
  - or **N** is the first year when the cash flow of the action becomes positive (net)
- The pay-back time accepted by the final consumer depends on the type of energy efficiency investment
  - Rather low (18 months to 3 years usually) for investment on existing equipment (retrofitting)
  - Larger (up to 7 years) for investment or over-investment linked to a new eqipment

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro and macro-economic evaluation)

Discounting: principles

- Measures the preference for the present, the aversion for future uncertainties
- The higher the discouting rate, the higher the preference for the present, the higher the aversion to uncertainties; the higher the value of having one today as compared to having one tomorrow
- The lower the discounting rate, the higher the weight of future expenses and savings as compared to the initial investment in the decision process

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro and macro, continued)

Discounting: calculation

- Discouting formula: DV=1/(1+a)n
  - DV: discounted value
  - A: discouting rate
  - N: year in the future for which the discounted value is calculated

- Example 1: 1000 $ in 10 years, is the same than:
  - 1000 $ today with a = 0%
  - 905 $ today with a = 1%
  - 463 $ today with a = 8%
  - 162 $ today with a = 20%

Assessing cost-effectiveness of energy efficiency investment from the Government viewpoint (macro-economic evaluation)

Discounting: a criteria for macro decision

- An investment is considered cost effective with the discounting rate a over n years if

  investment < sum of yearly discounted savings over n years (i.e. their overal value today)

  i.e. overall discounted cost : I- Δq*p *(Σ1/(1+a)^n) < 0

  Where :

  I: investment

  Δq: yearly energy savings (toe/year ou kWh/year)

  p: energy price

  Σ1/(1+a)^n= K: aggregated discounted factor, function of the discounted rate (a) and the number of years (n); provided by appropriate discounted tables

  n, number of years taken for the calculation, is

  - either the life time expected for the energy saving device
  - or the maximum time span admitted for cost-effectiveness demonstration

  a, discounting rate, is fixed by the national authorities

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro-economic evaluation)

Rate of return : a criteria for micro decision

- An investment is considered cost effective with a required rate of return R over n years if

    investment <= sum of yearly discounted savings with R as discouting rate over n years

    i.e. overall discounted cost : **I**- Δq*p *(Σ1/(1+R)^n) < = 0

  Where :

  I: investment

  Δq: yearly energy savings (toe/year ou kWh/year)

  p: energy price

  Σ1/(1+R)^n= K: aggregated discounted factor, function of the required rate of return (K) and the number of years (n); provided by appropriate discounted tables

  n, number of years taken for the calculation, is

    - either the life time expected for the energy saving device
    - or the maximum time span admitted for cost-effectiveness demonstration

  R, rate of return, is fixed by the final consumer

Assessing cost-effectiveness of energy efficiency investment from the consumer viewpoint (micro and macro-economic evaluation, continued)

Discouting : examples

- Example 1: discounting value of a macro-investment in thermal insulation
  - Investment = 1 billion , gas price 100 /toe, gas savings = 0.1 Mtoe/year, discounting rate 8% over 40years
  - Discouted value = 1 billion - 10 M x Σ1/(1+0.08)^n

- Example 2: rate of return of an micro investment
  - Investment = 100 , electricity price 20 c /kWh, electricity savings 100 kWh/year over 8 years
  - K= 100/(0,20*100)= 5 Ł R= 12 %

Assessing cost-effectiveness of energy efficiency investment: the cost of discounted energy savings (macro-evaluation)

Cost of energy savings: principles

- Cost of energy savings (« negawatt-hour »)= investment in energy savings per unit of discounted energy savings (per saved kWh or per saved toe)

- Calculation = investisment I divided by the aggregation of discounted energy savings accross time

$$PN = I / \Delta q^* (\Sigma 1/(1+a)^n))$$

Where :

PN: cost of « Negawatt-hour »

I: investment

Δq: yearly energy savings (toe/year ou kWh/year)

p: energy price

$\Sigma 1/(1+a)^n$= K: aggregated discounted factor, function of the discounted rate (a) and the number of years (n); provided by appropriate discounted tables

n, number of years taken for the calculation, is

- either the life time expected for the energy saving device
- or the maximum time span admitted for cost-effectiveness demonstration

a, discounting rate, is fixed by the national authorities

Assessing cost-effectiveness of energy efficiency investment: the cost of discounted energy savings (macro-evaluation)

Cost of energy savings: example

- Over-investment ΔI =50 , savings: Δq = 100 kWh/an; Life time:15 years, discounting rate 8%

- Cost of « NegakWh » for the whole society:

  $PR= \Delta I / (\Delta q^* *(\Sigma 1/(1+a)^n)) = \Delta I / k^*\Delta q$

  With k= 8.5 (from discounting table)

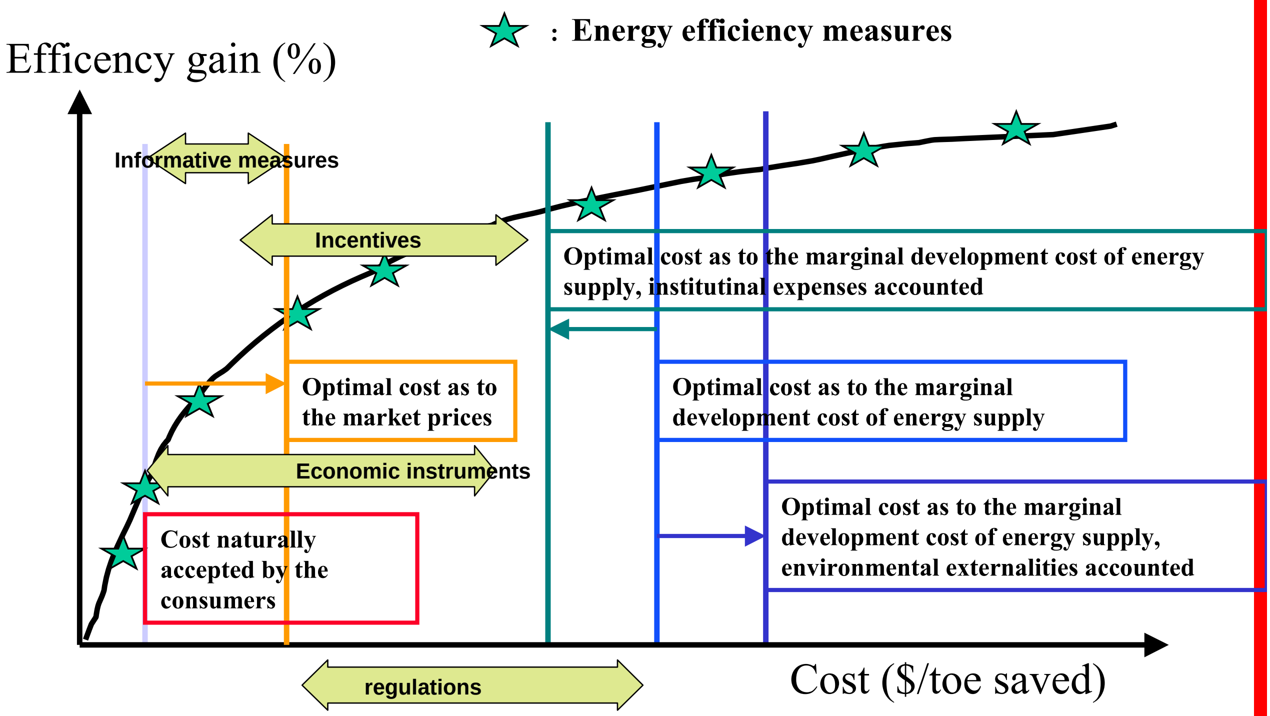
  PR =50/ (100*8.5) =0.06 / kWh

- This cost of the energy savings (6c / NegakWh) is to be compared to the price of electricity (either actual market price or long term marginal development cost) to decide if the investment worth while or not from the society point of view

Cost-effectiveness of energy efficiency investment: a summary

- For micro decision makers, final consumers:
  - investment paid back within a maximum time period (for example < 3 years)
  - Investment with a minimum rate of return (for example 12%)
- For public authorities
  - Investment lower than the agregated discounted savings on energy
  - Investment with a resulting cost of the energy saved lower than either the market price or the long run marginal development cost

Cost-effectiveness and design of policy objectives and measures in energy efficiency



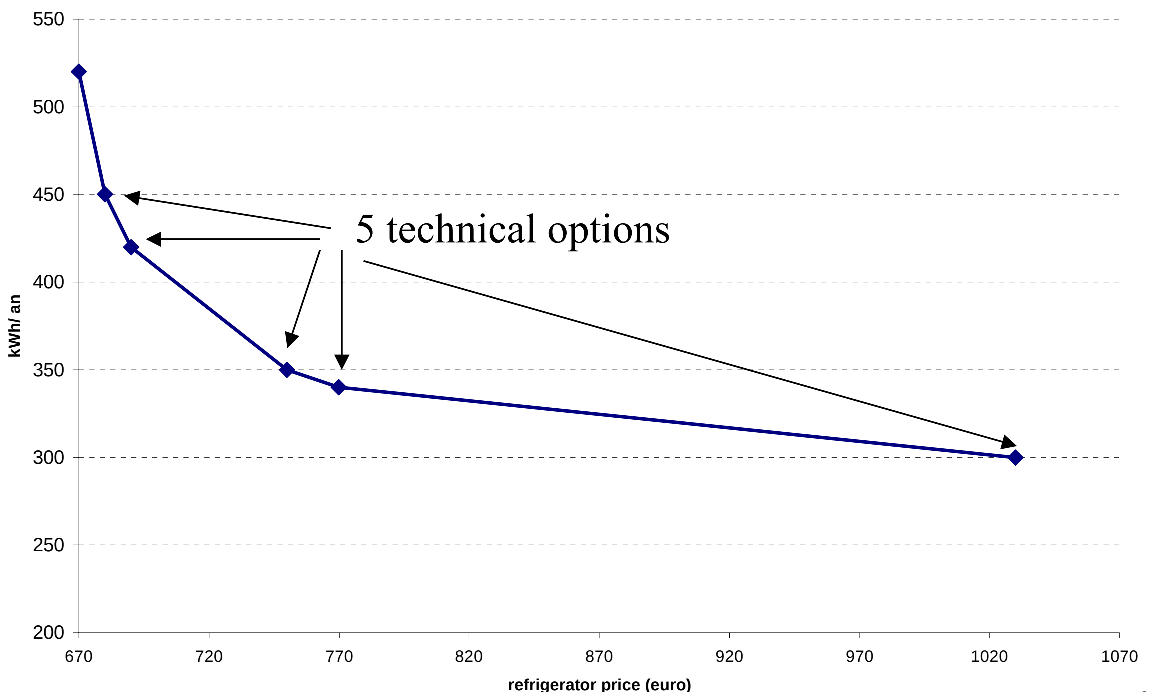
Enerdata

Cost-effectiveness of energy efficiency investment : example of refrigerators

- Several technical possibilities available to reduce the unit consumption of refrigerators (5 considered in the example)
- Each possibility has an extra purchasing cost
- Cost-effectiveness is assessed from the macro-economic point of view, with the discounted value: I + q*(Σ1/(1+a)^n)

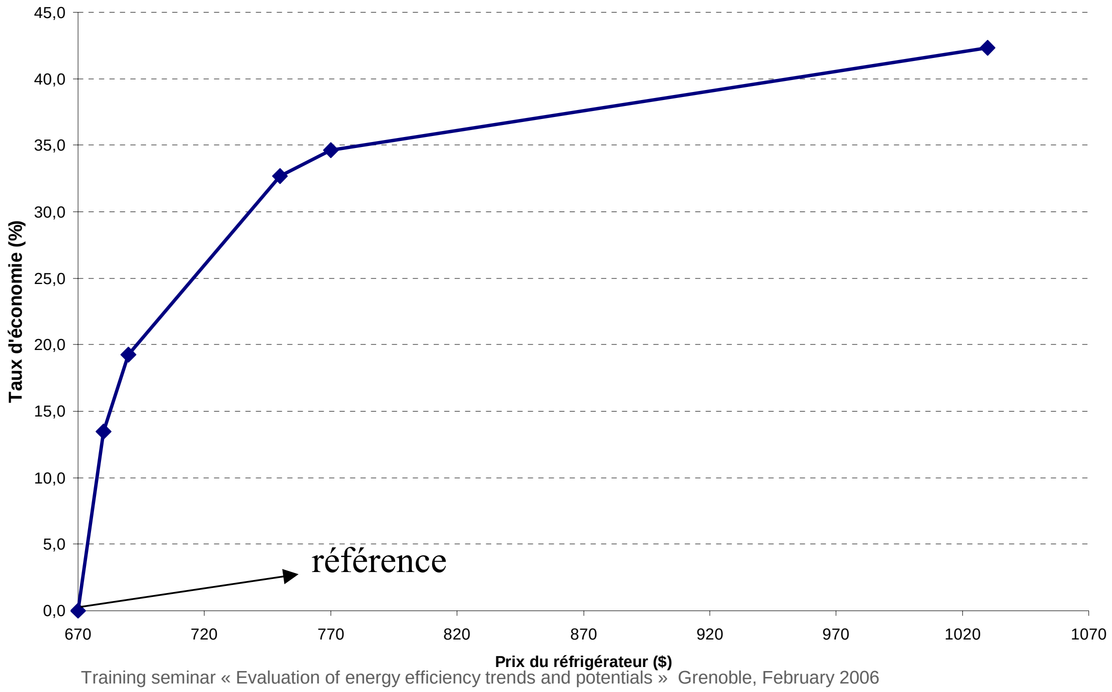
Enerdata

Price of refrigerators according to their specific consumption



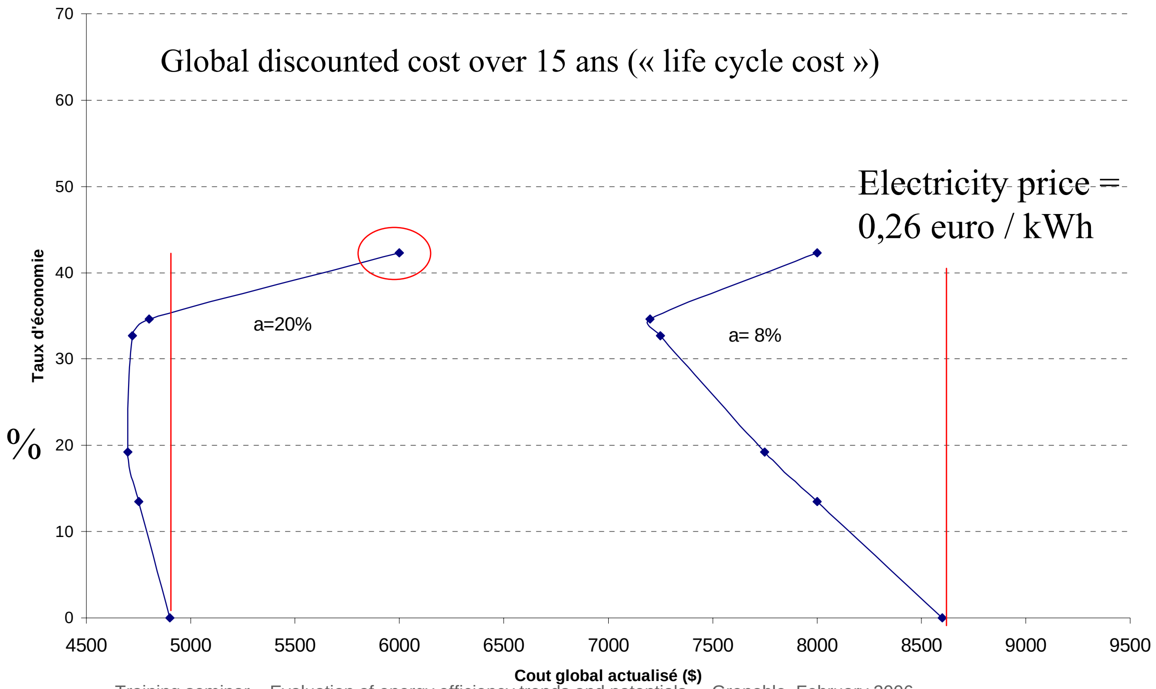
Enerdata

Efficiency rate according to the price of the refrigerator : an energy efficiency cost curve



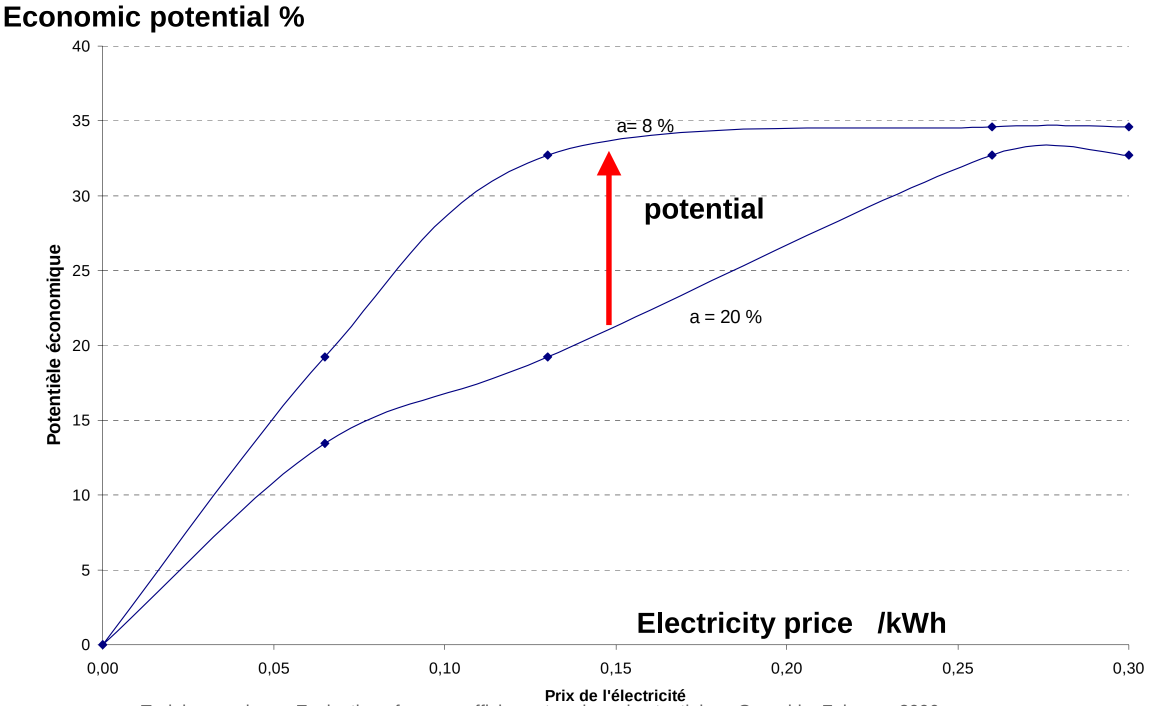
Enerdata

Cost effectiveness of technical options for refrigerators according to discount rates



Enerdata

Economic potential for energy efficiency in refrigerators according to discount rates and electricity prices



Enerdata

Agenda

Assessing cost effectiveness of energy efficiency investment

Assessing cost effectiveness of energy efficiency policy measures

Enerdata

From private energy efficiency costs to overall costs of policy measures : methodology for costs evaluation

Evaluate public costs generated by energy efficiency policies and allocate them to individual measures

- First step: evaluate current functionning costs of public administrations and agencies speifically related to energy efficiency policy on a yearly basis, and allocate them to individual measures (challenging…)
- Second step: account for specific tax credits and public subsidies according to policy meaures on a yarly basis (usually rather simple)
- Third step: evaluate transaction costs induced by individual policy measures on a yearly basis (very challenging…)

Link properly private costs et public costs involved by an individual measure

- First step: relate properly energy efficiency policy measures and related investment decision by final consumers
- Second step: build cost curves of individual equipment corresponding to technical options related to the policy measure
- Third step: link the (over)costs of individual energy efficiency equipment to the overall macro private investment related to the measure

Evaluate separately « overnight » costs and global costs

- First step: distribute over time the yearly macro investment generated by the policy measure
- Second step: distribute over time the yearly savings resulting from the yearly investment
- Third step: distribute over time the public costs of the measure
- Fourth step: agregate over time all costs related to an individual measure

Enerdata

which costs are generated by policy measures?

Catégorie	**Mesures informatives**		**Mesures financières incitatives**		**Mesures économiques**		**Mesures réglementaires**		**Autres mesures**	
Description	Information sur les opportunités d'investissement	Information sur les enjeux	Subvention	Réduction d'impôt	Mesures non taxes (de marché)	Taxes	Changement de réglementation / normes	Accords Volontaires / mesures	**Investissements (R&D, …)**	**Contrôle, sanction, autre**
Objectif	Rendre les mécanismes de marché plus fluides	Inciter au changement Comportemental	Susciter le déclenchement d'investissement par les consommateurs			Accroître l'offre de solutions efficaces en énergie, amener le déclenchement d'investissements par les consommateurs et les institutions publiques				
Coûts privés	Oui	Non	Oui	Oui	Oui	Oui	Oui	Oui	Non	Non
Coûts publics d'intervention	+	+	++	++	-	-	-	-	+++	++
Coûts de Transaction	+	+	++	++	++	+	+++	++	+	+++
Lien coûts privés-publics	+	-	+++	++	+	+	+++	++	-	-
Certitude sur l'impact	+	+	++	++	++	++	+++	+++	+++	++

At the heart of the cost evaluation methodology, an evaluation framework

	Coûts privés		Coûts publics		
	ménage	**entreprise**	**transaction**	**Fonction-nement**	**Marginal CT**
Information					
Investissement	+	0	0	+	++
Comportement	0	0	0	+	++
Incit. Financières					
Subvention	++	++	+	++	+++
Déductions fiscales	++	0	+	+	+++
Inst. Eco					
Taxe	+	+	+	+	0/-
Non taxe	0	++	++	++	0/-
Réglement					
Normes	+++	+++	+++	+	+
Accords	+++	++	++	+	0
Autres					
Investissement	0	0	+++	++	+++
Autres	0	0	0	+	0

How to use the framework ? Example of the evaluation of private costs for households

- **0** : no private cost associated to the measure
- **+** : the measure has a very general impact on households investment decisions, but not specifically measurable
  - Costs estimated on the basis of general ratios private/ public for informatives measures
  - Marginal cost curves for taxes
  - cost curves needs speciifc surveys
- ++ : the measure has a specific impact on households investment decisions ;
  - Private investment cost is proportionnal to tax credit and subsidies.
  - Information on public costs inform on private costs associated
- +++ : the measure imposes households investment decisions ;
  - Private investment (macro) is the product of individual investment (micro) by the number of households concerned
  - Surveys inform on the observed individual investment cost.

Enerdata

How effective are policy measures ? The issue of interactions among measures

> **Main issues** :
- The effectiveness of a measure to improve energy efficiency depends on the other measures taken at the same time
- Interaction can be negative (the combined effect of interacting measures is lower than the sum of individual impacts) or positive (combined effect higher than the sum of individual measures)
- Interaction among measures can modify the costs

> **4 main types of interactions**:
- Alternative measures aiming at reducing transaction costs
- Push/pull measures aiming at maximising the overall effectiveness
- Complementary measures aiming at reducing the rebound effects and maximising the effectiveness of technical measures
- Conditional measures aiming at securing a minimum effectiveness of each individual measure

> **Accounting for interactions is crucial in the cost-effectiveness evaluation** :
- Evaluation of impacts on public costs (including transaction costs)
- Evaluation of impacts on decisions made by private consumers
- Evaluation of impacts on energy efficiency

Enerdata

Free-rider and Multiplicator Effects (Free Drivers) Autonomous Savings

Free-rider effects: Measure that would have been taken anyhow, even in the absence of a policy measure. No policy no free-rider, only autonomous savings !

Multiplicator effects: Imitators inspired by the policy measure but not benefitting from it

Often for subsidy programmes (Free riders) or educational measures (Multiplicator effects)

Effects have to be included in the net assessment of a measure

Source: W. Eichhammer, FhG-ISI

Non-compliance

In general for regulations

Effects depend directly on the relevant measures (e.g. degree of compliance with thermal insulation ordinances, non-compliance with energy labelling ordinances etc.).

Effects have to be included in the net assessment of a measure

Source: W. Eichhammer, FhG-ISI

Direct Rebound Effects

Certain energy-saving measures lead directly to changes in behaviour, which in turn consume some of the energy saving targeted.

This effect is clearest in energy-saving lamps and, although this was partly due to the fact that the constant switching on and off of the lamps was bad for them in the early days of this technology. Also observed for better insulated homes.

Rebound due to weather variations (problematic for the correction of annual variations in temperature)

Source: W. Eichhammer, FhG-ISI