Interaction between policy measures – Analysis tool in the MURE database

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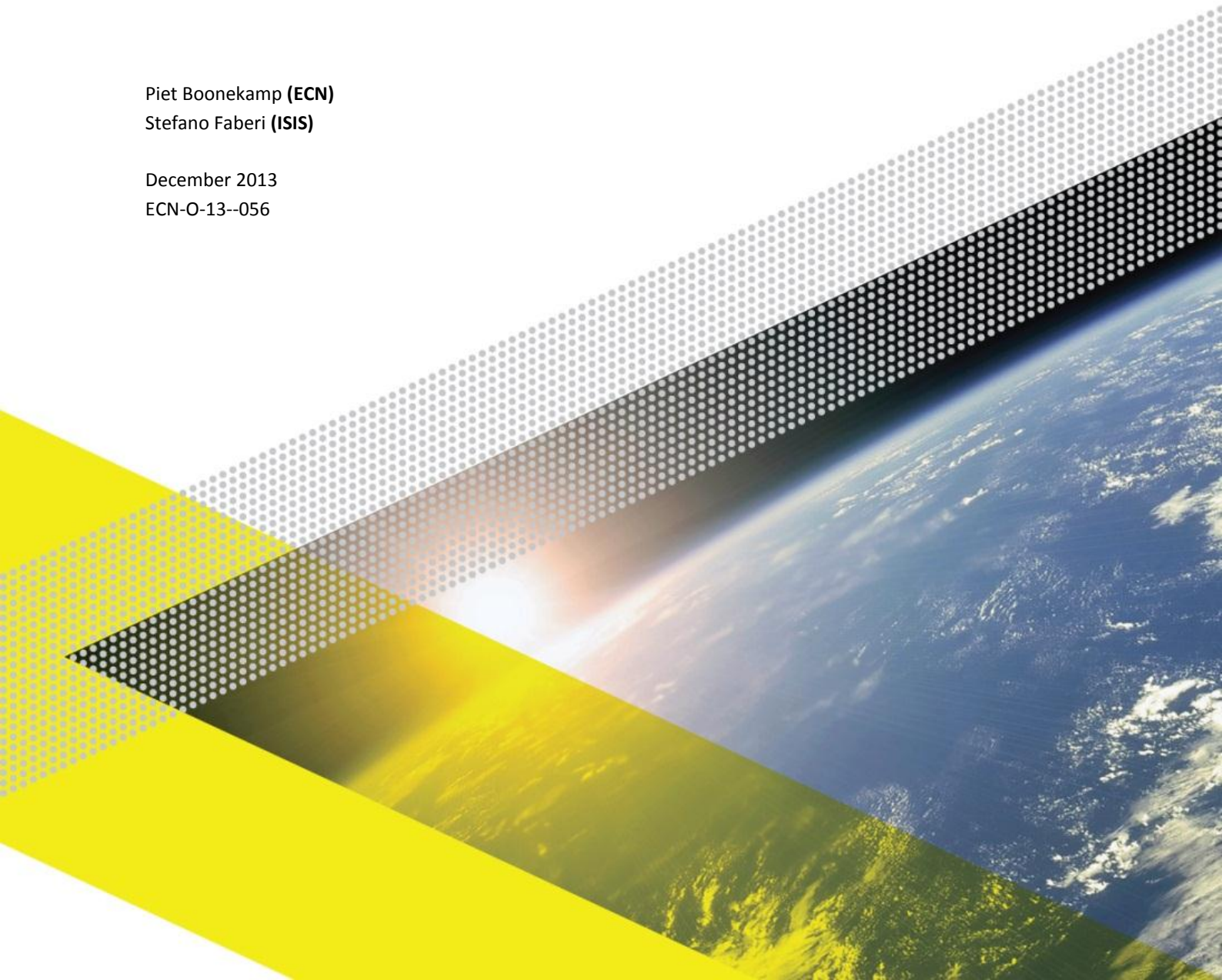

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Contents

1 Introduction

MURE policy measures
The MURE database provides information on policy measures in EU countries that focus on energy efficiency and savings. Presently MURE contains about 1600 policy measures, divided over the end-use sectors Households, Industry, Tertiary and Transport, supplemented with cross-sector policy measures. The information concerns not only the type and the active period, but also the impact as to energy savings.

Impact and interaction
In the MURE database the impact of policy measures is provided for each policy measure apart. A qualitative impact (High, Medium of Low) is provided by country experts. However, when more policy measures have influence on the same savings, the combined effect may not fit with the sum of the individually specified impacts.

For about a quarter of the policy measures quantitative impacts from evaluations are available, e.g. x PJ of savings over a period. The quantitative impacts are often calculated for a package of policy measures, but due to the MURE format must be attributed to most important measure of the package. In this case no impact can be presented for the other measures in the package, although they contribute to the total impact.

In both cases interaction between policy measures plays a role. When specifying impacts per individual measure one has to take account of interaction when summing up impacts. In case impacts for packages are given, there is a need to have impacts for all contributing policy measures, again taking account of overlap between individual effects.

This report describes how sets of mutually consistent impacts for packages as well as individual policy measures can be determined in the MURE database. The full implementation of the approach in the MURE database is not part of this study, but is planned for the next Odyssee/MURE project.

Set-up of report

The second chapter provides a short overview of the MURE database on policy measures. The next chapter focuses on interaction between policy measures and how the interaction can be rated in general. Chapter 4 describes how the rating method can be applied in the MURE set-up. Finally, chapter 5 shows how the approach will be implemented in the frame of the MURE database.

2

Overview of MURE database of policy measures

2.1 MURE database

The MURE database (www.mure2.com) provides an overview of the most important energy efficiency policy measures for EU-27, Croatia and Norway.

Per policy measure the following is specified:

- Sector: households, industry, transport, tertiary and cross-sector
- Status: completed, on-going or planned
- Period: year of introduction and (for completed policy measures) end year
- Type: e.g. standards for new dwellings), obligatory labels for appliances, subsidies.
- Impact: energy savings over a period
- Other properties: targeted end-uses, actors involved, etc.

For each policy measure a detailed description is available which contains, if available, a quantitative impact in terms of energy savings and/or CO_2 emission reduction.

The database excludes long term R&D measures, measures to improve supply side efficiency and greenhouse gas reduction measures without a direct link to energy efficiency. All policy measures from 1990 to the current year are available. Important policy measures introduced before 1990 and planned policy measures are also available.

Information about these measures is collected by national energy agencies or institutes, according to harmonised guidelines which have been established centrally.

2.2 Categories of policy measures

The policy measures are aggregated into types (see Table 2-1 that shows the list of the measures types for the household sector). At the highest level (c1, see table) seven different types are distinguished. These are split into more types at the lower levels (c2 and c3).

Table 2-1: Policy measure types defined at different levels in the MURE database

Level c1	Level c2/c3 (examples)
Legislative/Normative	Mandatory Standards for Buildings
	Regulation for Heating Systems
	Other Regulation in the Field of Buildings
	Mandatory Standards for Appliances
Legislative/Informative	Mandatory labelling
	Mandatory energy efficiency certificates
	Mandatory audits
Financial	Grants / Subsidies for investments
	Grants / Subsidies for audits
	Loans/Others
Fiscal/Tariffs	VAT Reduction
	Income tax reduction
	Linear electricity tariffs
Information/Education	Voluntary labelling
	Information campaigns
	Detailed energy/electrical bill
	Regional and local information centres
Co-operative Measures	Voluntary/Negotiated agreements
	Voluntary DSM measures of suppliers
	Technology procurement
Cross-cutting	Eco-tax on electricity/energy
	Eco-tax on CO_2 - emissions

2.3 Impact of policy measures

Policy measures are intended to stimulate energy savings. The effect of the policy measure, the impact or energy savings, is registered in the database in two ways:

- A qualitative impact, expressed as Low, Medium or High.
- A quantitative impact, expressed in PJ or another energy unit.

Qualitative impacts are provided by the country experts who are responsible for managing the MURE database. The categories Low, Medium and High each represent a given amount of savings as fraction of the relevant energy consumption (Low < 0.1%, Medium 0.1% to 0.5% and High > 0.5%).

Figure 2-1 shows the number of policy measures in all EU countries, and the division over the three impact categories.

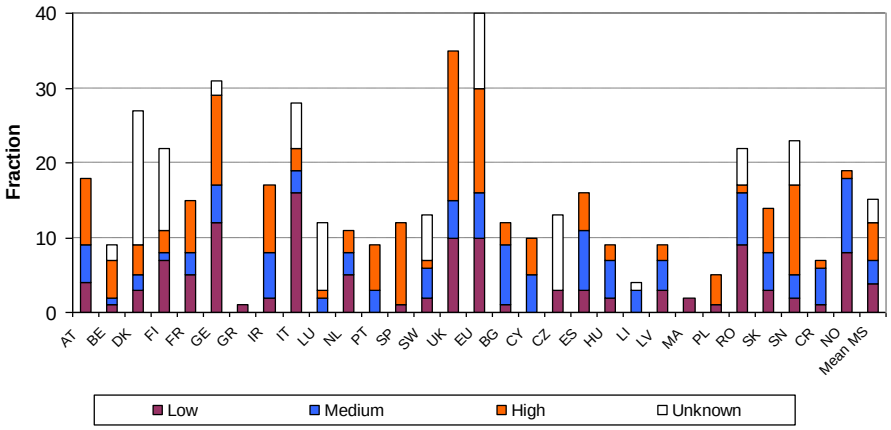


Figure 2-1: Impact of policy measures for Households in EU-countries

Quantitative impacts are based on evaluations of the effect of policy measures, and are highlighted in the database separately. These are available for about a quarter of all policy measures.

3

Rating of policy interaction with matrices

3.1 Types of interaction

The impact of a policy measure is specified for the measure as such. When two measures focus on the same targeted end-use, e.g. space heating in existing dwellings, the combined effect may take different forms:

- Mitigating
- Neutral
- Reinforcing.

If there is no interaction the combined effect is equal to the sum of the effects for both policy measures (see Figure 3-1, “neutral”). If there is overlap between the effect of the measures, the combined effect is lower than the sum. An example of a mitigating combination of a minimum efficiency standard and a subsidy for an energy using device. Finally, policy measures can reinforce each other’s effect, e.g. a combination of obligatory labels and a subsidy for A-label appliances (see “reinforcing”).

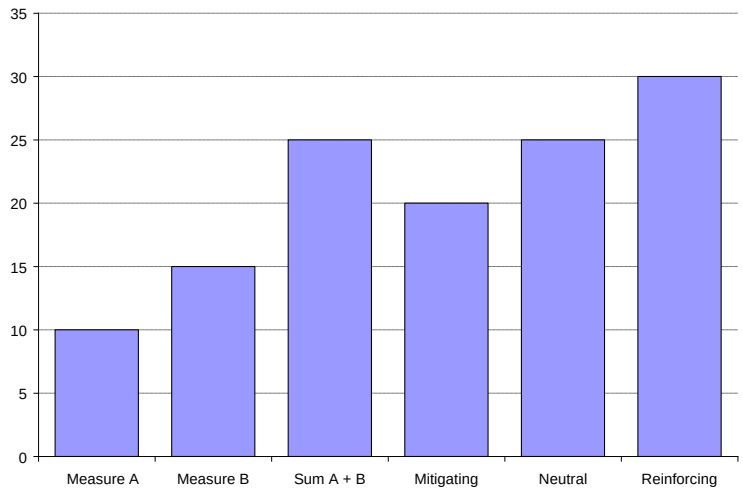


Figure 3-1: Combined effect cases for two policy measures

3.2 Rating of interaction

Conditions for implementation

Energy savings are attained by the implementation of saving options, such as insulation, highly efficient electric motors or distillate cracker in chemistry. The implementation is assumed to be dependent on the following set of conditions:

1. The saving option must be available for application.
2. The option must be sufficiently known to the appliers.
3. Restrictions that prevent a choice for the saving option must be lifted.
4. The decision maker must become motivated to take a positive investment decision.

Restrictions regard barriers such as lack of financing for a company or the split incentive for landlord and tenant, which hamper saving investments that are profitable. As illustrated in Figure 3-2, all four conditions have to be met before the saving option will actually be implemented. The conditions are highlighted into more detail in Annex A.

Figure 3-2: Conditions for a successful implementation of a saving option

Influence of policy measures on the conditions

The various policy measure types mentioned in Chapter 2 can influence the conditions for implementation and thereby stimulate energy savings. Table 3-1 summarizes how policy measure types influence the conditions for implementation (indicated with crosses). In Annex A it is explained in detail how the different policy measure types influence the conditions.

Table 3-1: Policy measure types addressing conditions for implementation and proper utilization of saving options

	Implementation				Proper utilization
	Available for application	Known to appliers	Restrictions lifted	Motivation to invest	
Measure type:					
Legislation					
- implementation	X	X	X	X	
- utilization					X
- labels		X		X	
Taxes				X	X
Support					
- financial		X		X	
- audits		X			
Information					
- options		X		X	
- utilization					X

	Implementation				Proper utilization
	Available for application	Known to appliers	Restrictions lifted	Motivation to invest	
Agreements		X	X	X	
Procurement	X	X		X	
R&D-facilities	X		X	X	
Emission-trading				X	

Looking to the rows in the table it is clear that most policy measures do not cover all conditions. The influence of taxes is limited to one of the implementation conditions only; information and subsidies cover two implementation conditions. Legislation can affect all conditions for implementation but is not always acceptable or applicable. Looking to the columns in the table, a general observation is that most policy measures types are designed to influence the motivation to invest. Few policy measure types aim at lifting restrictions or increase the availability of saving options.

Next to the implementation of saving options, mostly with investment decisions, a proper utilization of the energy using systems is also part of the savings. It is clear that there are few measures that affect both implementation (first four conditions) and utilization (fifth condition). Only energy taxes will by nature affect both. The effect of policy measures on proper utilization is also highlighted into more detail in Annex A.

Optimal combinations of policy measure types

Given the picture of policy measures and conditions, a combination of policy measures appears necessary to comply with all conditions. However, the importance of each condition differs per saving option[1]. For instance, when a saving option is available in the market and restrictions are minor, only information measures (known to appliers) and financial measures (incentive to invest) are needed. Therefore the optimal set of policy measures to be applied is dependent on the type of saving option.

With respect to the application of saving options one can formulate general rules to reach an optimal set of policy measures. From the preceding analysis the following general criteria for an optimal set follow:

- The optimal set should cover all (relevant) conditions;
- Measure types should complement each other, not overlap;
- A measure type should influence more than one condition;
- Measures should be introduced in the right order.

The second criterion says that, if two measure types both focus on the same condition, e.g. high taxes and subsidies to motivate investments, this is not very effective. The last criterion says that first measure types stimulating availability of the saving option should be introduced, before measure types to motivate to invest can be applied.

[1] Here it is assumed that each saving options can be looked at in isolation, without taking into account interactions between saving options in a set for e.g. a dwelling.

Non-existing interaction
The MURE database contains hundreds of policy measures for which, in principle, interaction can exist However, it is assumed that no interaction can exist between policy measures for different sectors, such as households or industry. If a common policy measure is present, e.g. an energy tax for all end-users, the tax measure is split into one per sector (with different tax levels).

Energy consumption per sector can be divided into targeted end-uses, such as space heating for households, traveling by rail for transport or electric drives in industry. Very often policy measures focus on one targeted end-use and their effect does not interact with that of other measures focusing on different targeted end-uses.

Finally, policy measures are defined in a way that excludes interaction. For instance, a policy measure is only valid for companies that do not participate in the Emission trading System (ETS). Therefore, no interaction can exist between the ETS policy and the other measure.

Rating method
Energy consumption is split into targeted end-uses and for each targeted end-use the set of relevant policy measures is defined. The possible interaction effect for each combination of two measures is rated by taking into account the relevant conditions for successful implementation or proper utilization, the influence of both policy measures on these conditions and the overlap or synergy, the ratings of possible interaction effects in a set of policy measures can be:

- Mitigating
- Reinforcing
- Neutral
- Non-existing.

The differences between the combined effects of the first three has been explained earlier (see Figure 3-1). For the last one no combined effect is specified.

3.3 Interaction matrix for policy measure types

Possible interactions
The rating results for all combinations of two policy measure types can be presented in a standard matrix with all types both in the rows and the columns. mitigating: - - - strong/- - modest/ - marginal, reinforcing: +++ strong/++ modest/+ marginal, 0 = no interaction.

Figure 3-3 shows an example matrix of possible interaction effects for policy measure types in general.

Measure	Legislation on: applicat.	use	inform.	Taxes	Support via: finan.	audits	Information: options	use	Agree-ments	Procu-rement	R&D	Tra-ding
Legislation application												
Legislation use	-											
Legislation information	- - -	0										
Regulatory taxes	- -	- -	+									
Support (financial)	- - -	-	+++	- -								
Support (audits)	- - -	- -	- -	+	+							
Information (options)	- - -	0	- - -	+	+	- - -						
Information (use)	-	- - -	0	+++	0	-	0					
Agreements	- - -	-	-	-	+	-	-	-				
Procurement	- - -	0	+	+	+	+	-	0	-			
R & D-promotion	-	0	0	++	+++	0	+	0	0	++		
Emission trading	- -	- -	0	- - -	- -	-	+	++	-	0	+	

mitigating: - - - strong/- - modest/ - marginal, reinforcing: +++ strong/++ modest/+ marginal, 0 = no interaction.

Figure 3-3: Matrix of possible interaction effects for policy measure types

Interaction matrices in practice

In practice interaction is analysed for separate targeted end-uses per sector, e.g. new dwellings in the households sector. Not all policy measure types are applicable here (see mitigating: - - - strong/- - modest/ - marginal, reinforcing: +++ strong/++ modest/+ marginal, 0 = no interaction

Figure 3-4). For new dwellings mostly energy performance standards are applied and sometimes financial support, agreements with builders and R&D stimulation. But prescribed temperature levels (legislation use), subsidized audits, information on daily energy use, procurement or emission trading or not relevant here. Regulatory taxes influence all targeted end-uses, including (in principle) savings in new dwellings. Therefore, in practice the matrix of interaction is often much smaller in terms of rows and columns.

Measure	Legislation applicat.	Taxes	Support (financial)	Agree-ments	R&D prom.
Legislation application					
Regulatory taxes	- -				
Support (financial)	- - -	- -			
Agreements	- - -	-	+		
R & D-promotion	-	++	+++	0	

mitigating: - - - strong/- - modest/ - marginal, reinforcing: +++ strong/++ modest/+ marginal, 0 = no interaction

Figure 3-4: Practical matrix of interaction per targeted end-use (new dwellings)

4

Interaction for MURE policy measures

4.1 Overview of approach

The method of rating interaction between policy measures, as described in the previous section, is applied to the saving effects of MURE policy measures. A distinction can be made between the one-off preparatory phase and the execution phase at regular time intervals for all countries.

The preparatory phase regards the following steps:

- Define the targeted end-uses per sector
- Adapt the policy measure types to be used in interaction analysis
- Define the package of possible policy measure types for each targeted end-use
- Set-up standard interaction matrices, for possible PM-types per targeted use

The execution phase regards the steps:

- Define the actual package of policy measures for each targeted end-use
- Process policy measures for the same type and targeted end-use
- Define interaction strength for all combinations using the standard matrices
- Establish a consistent impact estimate for each measure, combination and package

The preparatory steps are described in the following sections 4.2 to 4.5 and the execution steps in sections 4.6 to 4.8. Chapter 5 describes the software implementation of the approach in the MURE database by ISIS.

4.2 Targeted end-uses per sector

The targeted end-uses in MURE (see Annex B) have been aggregated for interaction analysis.

Households:

- New dwellings
- Space heating - existing dwellings
- Hot water preparation
- Appliances and Lighting
- Renewable contribution

Services (Tertiary):

- New buildings
- Space heating existing buildings
- VAC
- Lighting
- Other electricity

Transport:

- New cars (technology)
- Existing cars (behaviour)
- Goods/road (truck, lorries)
- Persons – modal shift
- Persons – mobility

Industry:

- Process heat
- Electric drives
- Other electricity
- CHP

4.3 Adapted policy measures types for interaction

In the current MURE database the policy measures are characterized as to type. At the highest level (c1) this regards 7 main types (see level c1 in Table 2.1). At the medium (c2) and lowest (c3) level the main types are expanded in up to 40 sub-types, which can differ per sector.

For analysis of interaction the main types at c1 level are used. However, it is necessary to make a distinction between policy measures focusing on investment decisions and measures focusing on daily use. This distinction has already been made in the rating of interaction (see Table 3-1) where “implementation” and the conditions regard investments and “proper utilization” regards daily use.

Further on, for some policy measure types a split is made between focused measures and broad measures. For focused measures it is possible to restrict interaction to other measures that have the same focus. For broad measures the interaction can regard many other policy measures; therefore it is treated differently.

The two adaptation result in 12 policy measure types for interaction analysis (see Table 4-1). In Annex C it is shown how the 47 policy measure types for households are aggregated into the 12 types used in interaction analysis.

4.4 Policy measure types per targeted end-use

The MURE policy measure types at the detailed level c3 are attributed to one or more of the targeted end-uses specified in section 4.2 (for Households see columns in Table 4-1). The attribution results in subsets of c3 measure types per targeted end-use. For each subset the adjacent adapted c1 policy measure types are registered. Results for the 12 policy measure types and targeted end-uses are presented in Table 4 1 for the sector Households.

Table 4-1: Policy measure types per targeted end-use (Households)

Policy measure type (c1-adapted)	Space heating	New dwelling	Hot water	Appliances	Renewable energy
Legislative/normative - invest	x	x	x	x	x
Legislative/normative – use	x		x		
Legislative/informative - focused	x	x	x	x	
Legislative/informative - broad	x		x		x
Financial/fiscal – invest	x	x	x	x	x
Financial/fiscal – use	(x)				
Financial/fiscal – info	x		x		x
Information/education - focused	x		x	x	x
Information/education - broad	x	x	x	x	
Co-operative – focused					
Co-operative – broad	x	x	x	x	
Cross-cutting/taxes	x	x	x	x	x

The table shows that almost all policy measure types are valid for space heating in existing dwellings; on the other hand only half are relevant for electricity use (appliances and lighting) and renewable energy production. An overview of policy measure types per targeted end-use, for all sectors, is presented in Annex D (as part of interaction matrices).

4.5 Standard matrices per targeted end-use

For each sector and targeted end-use an interaction matrix is constructed, according to the method described in chapter 3. The matrix contains the rated interactions between the relevant policy measure types. The matrix is called “standard” because it regards all relevant policy measure types that can be present for a targeted end-use. In reality this will not be the case mostly (see also actual matrices in section 4.6).

Results for space heating in existing households are shown in Figure 4-1. The 11 relevant policy measure types, as shown earlier in Table 4-1, lead to a 10 x 10 matrix of interactions (one less than number of measure types because policy measure type "Financial/fiscal – use" is not relevant in practice).

	Legislation on:		Leg-inform		Support via:		Information:		Coop	Taxes
Measure	invest	use	label	audit	invest	audits	invest	use	VA	
Leg-norm-invest										
Leg-norm-use	-									
Leg-inform-focus (label)	- - -	0								
Leg-inform-broad(audit)	- - -	0	- - -							
Fin/fiscal-invest	- - -	-	+++	++						
Fin/fiscal-info (audits)	- - -	- -	- -	- - -	+					
Inform-focused-invest	- - -	0	- - -	- - -	+	- - -				
Inform-broad-use	-	- - -	0	-	0	-	0			
Coop-broad (VA)	- - -	-	-	0	+	-	-	-		
Taxes	- -	- -	+	+	- -	+	+	+++	-	

Figure 4-1: Standard interaction matrix for space heating in existing dwellings

4.6 Actual matrices per targeted end-use

Until now all analysis regarded a situation where all policy measure types, relevant for a targeted end-use, are present. However, in reality this is not the case; generally countries deploy only 10-50% of the possible policy measure types.

For space heating in existing dwellings Figure 4-1 showed the standard matrix. The actual matrix, for households in the Netherlands, is much smaller (see Appendix E). Because several policy measures types are absent, only a 5 x 5 matrix remains compared to the 10 x 10 standard matrix.

	Support via:		Information	Coop-broad	Taxes
Measure	invest	audits	use	VA	
Fin/fiscal-invest					
Fin/fiscal-info (audits)	+				
Inform-broad-use	0	-			
Coop-broad (VA)	+	-	-		
Taxes	- -	+	+++	-	

Figure 4-2: Actual interaction matrix for space heating existing dwellings (Netherlands)

Sometimes very few policy measures types are valid for a targeted end-use. In that case the actual matrix can shrink to a 2 x 2 matrix, with only interaction rating, or even an empty 1 x
1 matrix (no interaction at all). In Annex E the actual matrices for targeted end-use for the sector Households in the Netherlands are presented.

4.7 Determination of separate and combined impacts

As described in chapter 1 there is a need to sum up impacts per individual measure, taking account of interaction, and there is a need to split the impact of a policy package into impacts for all contributing policy measures, again taking account of overlap between individual effects.

Quantitative matrix

In order to determine mutually consistent individual and combined impacts the qualitative interaction ratings presented thus far must be converted to quantitative figures. The preliminary conversion uses the following values:

+++ = strong reinforcing => 2.0
++ = reinforcing => 1.4
+ = some reinforcing => 1.1
0 = not interacting => 1.0
- = some overlap => 0.9
- - = overlap => 0.5
- - - = strong overlap => 0.1

Figure 4-3 provides the quantitative interaction figures for the standard matrix that was presented earlier with qualitative ratings (for space heating, households, see Figure 4-1).

	Legislation on:		Leg-inform		Support via:		Information:		Coop	Taxes
Measure	invest	use	label	audit	invest	audits	invest	use	VA-DSM	
Leg-norm-invest										
Leg-norm-use	0.9									
Leg-inform-focus (la	0.1	1								
Leg-inform-broad(au	0.1	1	0.1							
Fin/fiscal-invest	0.1	0.9	2.0	1.4						
Fin/fiscal-info (audit	0.1	0.5	0.5	0.1	1.1					
Inform-focused-inve	0.1	1	0.1	0.1	1.1	0.1				
Inform-broad-use	0.9	0.1	1	0.9	1	0.9	1			
Coop (VA-DSM)	0.1	0.9	0.9	1	1.1	0.9	0.9	0.9		
Taxes	0.5	0.5	1.1	1.1	0.5	1.1	1.1	2.0	0.9	

Figure 4-3: Standard matrix on quantitative interaction (space heating in households)

The preliminary figures in the standard matrix are only default values in case no other information is available. The figures can be adapted in the actual matrices for concrete sets of policy measures, to take account of the situation in the various countries.

4.8 Use of matrices

Interaction matrix needed or not

In section 4.6 it has already been highlighted that in reality matrices are not always needed. Depending on the number of policy measures (per country, sector and targeted end-use) the following cases are possible:

A. One policy measure > no interaction possible > no matrix
B. Two policy measures > only one interaction possible > no matrix
C. Three or more policy measures and only one or two types > no matrix
D. Three or more policy measures and three or more types > matrix to be used.

Thus only for case D matrices are to be used.

EU and cross-sector policy measures

Most EU policy measures are transposed into national legislation; therefore, they are part of the set of policy measures per country. In other cases it is assumed that the EU measures are copied into the set of policy measures per country.

Cross-sector policy measures regard more than one sector, e.g. a broad saving program or an energy tax. However, in MURE the concrete consequences per sector are shown in the form of specific policy measures per sector.

Given this approach the interaction approach has only to deal with policy measures per sector.

Matrix defined per year or period

For most countries and sectors the set of policy measures changes every year due to the introduction of new measures or ending existing measures. Thus, every year the interaction regards different policy measures. In principle the interaction matrices should be set up for each separate year. However, this should lead to a very complicated analysis.

In reality the changes for concrete policy measures do not influence the situation for each sector and targeted end-use. Some changes regard a more stringent version of an existing policy measure, where the type does not change. Moreover, the interaction approach is in its initial phase and has to prove its usefulness first. Therefore, the interaction analysis is restricted to a chosen period, e.g. 2000-2011, and the matrices represent interaction for all policy measures active in the period. The consequence is that all resulting impacts regard the chosen period.

Available impact figures

The following cases are possible:

1. only qualitative impacts per individual PM
2. qualitative impacts per measure / quantitative combined impact for a set
3. qualitative impacts per measure / quantitative impact for the major measure in set
4. only combined quantitative impact for the set of measures.

It is assumed that always individual qualitative impacts are available; therefore case 4 is not relevant. For case 3 it is assumed that the impact for the major measure is the total impact of the set of measures.

If only individual impacts are available the total impact is calculated based on the interaction factors in table 3, thus taking into account interaction.

If qualitative impacts per measure and the total impact for the set are given, the individual impacts are derived by calculating total impact using the interaction factors scale the individual impacts in conformity with the difference between calculated and given total impact.

5

Implementation of interaction in MURE

5.1 Status and aim of the tool

This chapter describes the possible implementation of the interaction tool in the MURE database, on the basis of an experimental application developed for the household sector. The actual implementation of the interaction procedure and the reporting on individual and combined impacts of measure (package) is planned for the next Odyssee/MURE project.

The aim of the interaction application is to support the user of the MURE database to better evaluate the policy measure interaction.

5.2 Role of MURE user

The tool interface is totally transparent and allows the user to either accept or modify both the measures interaction levels and the corresponding quantitative parameters.

To calculate the energy savings of policy measures, taking into account interaction, the tool starts from the qualitative evaluation of the MURE measures (levels High, Medium or Low, supplied by the country expert). These inputs are converted into quantitative impact for individual policy measures and combinations thereof by applying the scheme outlined in this paper. Nonetheless, if the user knows the actual energy saving impacts of the analysed measures, he/she is allowed to replace these amounts with those provisionally provided by the tool. In the case of the default figures based on the qualitative impact levels, the tool just shows the interaction effect, without having the ambition to provide “proven” impacts. In the second case, when the user inserts own data, it might be assumed that the interaction calculation is much more accurate as to impacts.

5.3 Procedure and results

The operational sequences follow by close the methodology outlined in this paper, in particular the execution steps outlined in paragraph 4.1 and the interaction matrices shown in Figure 4-1, in turn translated into the corresponding quantitative parameters of Figure 4-3. The following figures show the interaction analysis procedure as it has been so far experimentally developed. The entire procedure entails three main steps. In the first step the user is asked to select the country and the targeted end-use for which he wants to evaluate the measures impact. As example Figure 5-1 shows “Germany” as country and “Space heating” as targeted end-use for the household sector.

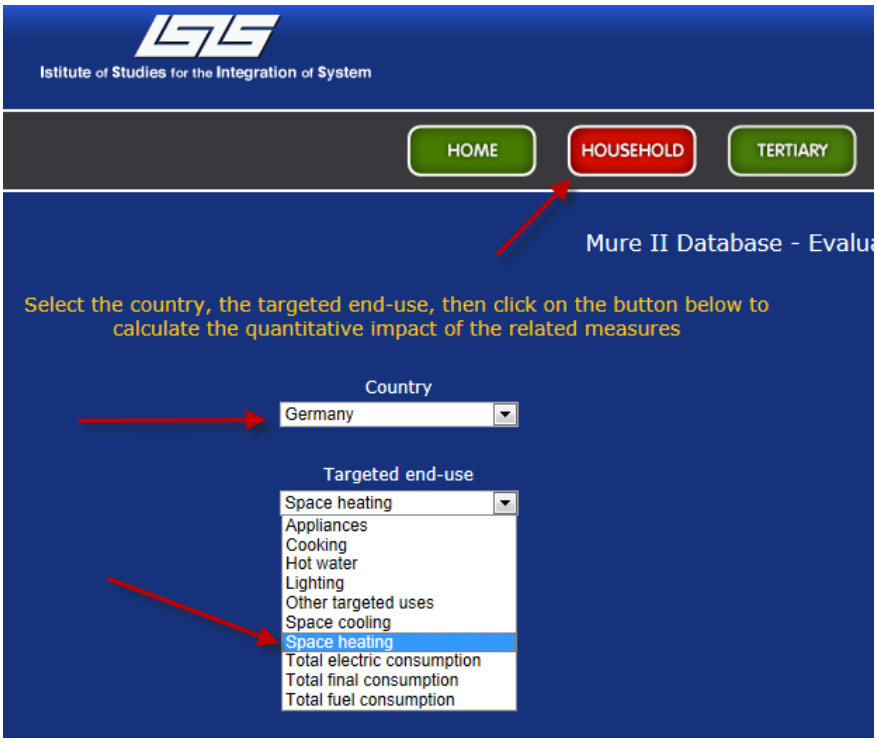
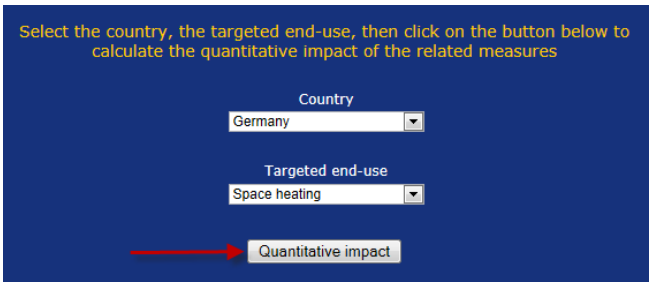


Figure 5-1: Step 1 - selection of Country and Targeted end-use

Once selected these two main options by clicking on the “Quantitative impact” button the system provides the calculation table shown in Figure 5-2. This table is divided in three columns. The first column provides the policy measures that have the same targeted end-use (in this case “space heating”). The second column shows the measures types to which they belong (opportunely “adapted”, see paragraph 4.3). The third column shows the impact evaluation. As outlined before this impact evaluation is simply the rough translation of the estimated qualitative impact of the measures into the corresponding quantitative parameters,



calculated as a percentage of the electric and thermal energy consumption of the analysed sector. To better calculate the impact the user is then allowed to put the actual impact by measure in the light blue cells of the table.

The results of the calculation are provided in the rows “Simple Sum”, that shows the arithmetic sum of the impact of each policy measure, and “Measures Interaction”, that just shows the effect of the interaction matrix.

Figure 5-2: Step 2 – Impact calculation for Country and Targeted end-use

As outlined before, it is possible to analyse and even change this interaction matrix. Actually by clicking on the “Measure types groups interaction management” button, the tool provides the table shown in Figure 5-3.

Figure 5-3: Step 3 – Checking the interaction matrix

This matrix is exactly that described in paragraph 4.5 and the “green” cells show which are the measures types involved by the five German measures shown in Figure 5-2.

By clicking on each of the green cells the user can change the interaction level of the involved measure types and in this way change the entire interaction scheme suggested by the tool (see Figure 5-4).

Once having set the interaction matrix, the user can confirm the changes (or reset everything and thus come back to the initial setting) and return to the calculation table to see the new interaction calculation. In the future release of this tool it will be also

possible to change and customize the quantitative parameters of the interaction levels (see paragraph 4.7)

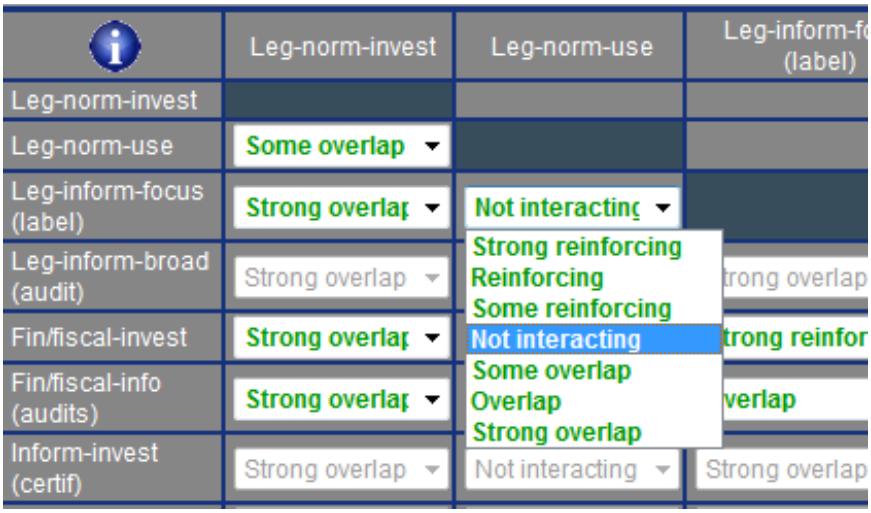


Figure 5-4: Step 3 – Modifying the interaction matrix settings

Appendix A. Details on the rating of interaction effects

Conditions for implementation

For proven saving options **availability** is hardly an issue; however, when demand is growing very fast the supply of the efficient systems can pose a (temporally) problem. For new options 'availability' can have different meanings. The first one, the proof of the concept after fundamental research, is not what is meant here. The saving option should be technically grown up and provide the energy-function in (almost) the same manner as the reference system it replaces. However, it need not serve all applications from the start. Often it suffices to supply a niche market; for instance, in case of an electrical heat pump, only new dwellings which have no connection to the gas grid. Thus availability of new saving options regards market ready saving options, at least for some applications.

Sufficient **knowledge** of the existence and properties of a saving option normally is a prerequisite to make a choice for a more efficient energy system. Only when the choice is obligatory, because of legislation, this knowledge is not essential. In other cases an important issue concerns who must obtain the knowledge: the user of the more efficient system, the investor in the system, the decision maker, the fitter/installer of the system, the architect or all parties involved? Insulation of rented houses asks for a co-ordinated information process towards all parties involved. In small enterprises the technical staff and management have to be informed both. In large energy-intensive enterprises an organisational structure will be available to continuously obtain, disseminate and evaluate the information on saving options. The same holds for a well-functioning energy service market where experts decide on the options to choose.

An important **restriction** for current energy applications is the remaining lifetime of the existing energy using systems. Normally decisions on implementing a more energy efficient system are taken at the 'natural moment' only, when old equipment must be replaced. But retrofit-options can be installed at any time. Another restriction can be the split between ownership/investment and utilization/benefits. In the case with rented office buildings or shop malls this hinders costly investments in energy savings. Finally a number of specific restrictions can be present, such as lack of space for the system, scarcity of investment money or lack of personnel resources (see Velthuijsen[2]).

Unless legal pressure forces the implementation of saving options, the decision maker should become **motivated** to choose the more efficient system. The most cited motivation is the financial benefit resulting from the implementation of the saving option. This motivation can be enhanced by introducing a tax on energy consumption; the higher financial value of energy saved shortens the pay-back time. Another possibility is lowering the investment costs by providing investment subsidies. However, enhancing non-economic motivation to invest is possible too, for instance by increasing the general awareness of the greenhouse problem and its relation with energy use. Another way is the creation of social pressure by public campaigns. Hennicke and Ramesohl[3] mention the role of regional networks and the behaviour of the peer group.

[2] Velthuijsen JW. Determinants of investment in energy conservation, PhD thesis, report SEO-R-357. Amsterdam, The Netherlands: Stichting voor Economisch Onderzoek, 1995.

[3] Hennicke P, Ramesohl S. Interdisciplinary analysis of successful implementation of energy efficiency in the industrial, commercial and service sector. JOULE III- JOS3-CT95-0009. Wuppertal, Germany: Wuppertal Institute, 1998.

Sometimes a saving option creates its own investment motive, as is the case with the extra living comfort that is achieved by installing double-glazing.

Next to the four conditions for implementation, the **proper utilization** of installed energy systems forms a fifth condition for realising energy savings. This regards use as meant in the system design, without sacrificing the energy services needed. Meeting this condition is especially important in case of new saving options because it makes sure that the promised saving effect is realised. For instance, regular maintenance of heat recovery systems is needed to keep the savings at the original level. Proper utilization asks for continued action, from a yearly inspection to a weekly feedback on energy consumption. Actually this condition can be translated into the same conditions as used with implementation: knowledge, restrictions and motivation (availability is not relevant here). However, due to the limited importance of proper utilization in this interaction analysis, this has been omitted.

Influence of policy measures on the conditions

The availability of new market ready saving options often is dependent on additional R&D to deliver a marketable option. In the latter stages of development, legislation (e.g. standards) can speed up the development process too according to Newell[4]. Financial measures can stimulate the creation of marketable options too, provided that they are considered to last over a long period. With the exception of high taxes on transport fuels, sustained for decades in various countries, this has not been the case for energy taxes in general. As Newell shows, even the very high energy prices due to the oil crises were only partly responsible for increased energy efficiency. Finally procurement can speed up actual availability.

The knowledge as to saving options, not only about the concept but also about the actual performance, is most effectively increased by dedicated information, such as mandatory labels. Other possibilities are free information on specific saving options. Audits, agreements and procurement combine the search for saving opportunities with the provision of information on saving options. Blok[5] states that subsidies often focus attention of energy users to saving options and thus serve as an information source too. Regional and branch networks of entrepreneurs are a means to provide knowledge as well, as parties often imitate each other's decisions. The level of implementation already achieved contributes to knowledge of other users too. Actually all measures that stimulate the take-off of a new saving option contribute to it becoming more widely known. Finally, as stated earlier, legislation on the implementation of the saving option is an alternative because it cancels the need for information.

Restrictions that hamper the implementation of saving options often are of a non-economic nature; therefore they cannot be lifted easily by financial measures according to Vermeulen[6]. Restrictions on performance can be overcome partly by adaptations to the saving option with additional R&D. For instance the development of a high-efficiency boiler with 'closed air circulation' has diminished the problems of placement to a great extent. Restrictions with respect to the decision making process sometimes can be circumvented with tailored policy measures. For rented dwellings this can be an agreement between housing associations, representatives of occupants and the government on the division of costs and benefits. But hardly any measure is able to influence the replacement moment when there is an opportunity to realise energy

[4] Newell RG, Jaffe AB, Stavins RN. The induced innovation hypothesis and energy saving technological change, Discussion Paper 98-12. Washington, USA: Resources For the Future, 1998.

[5] Blok K., de Groot H, Luiten E, Rietbergen M. The effectiveness of policy instruments for energy efficiency improvement in firms, report E-NWS-2002-02. Dept. of Science, Technology and Society, Utrecht University, 2002.

[6] Vermeulen WJV, Das, BWJ, Meyer LA. Policy measures for energy savings in practice (in Dutch), report STB/94/006. Apeldoorn, The Netherlands: TNO-Beleidsstudies, 1994.

savings. Even legislation on more efficient systems does not influence directly the actual lifetime of the old systems (see policy measure descriptions in MURE).

Almost all measures can contribute to the motivation to invest in new saving options. Some provide an economic motivation, such as subsidies or taxes. Other measures, such as information campaigns and voluntary agreements, can create a social motivation. Legislation creates by definition the strongest "motivation". In the longer run this can be accomplished too in an indirect way, by some other measures mentioned that lead to the disappearance of less efficient options altogether.

Influencing the proper utilization of energy systems asks for continuous action, as opposed to the one-time investment decision. Moreover, the users of the systems are more difficult to reach. In practice relatively few measures are available to ensure a proper utilization, for instance legislation on maintenance and monitoring of performance. Regular feedback can lead to avoiding unnecessary energy use for space heating according to Jensen[7], but for practical applications feedback costs have to be low. Groot[8] states that energy taxes lead to limited energy savings on daily energy use given the rather low short term price elasticities.

As Sorrell[9] shows, it must be pointed out that the influence of policy measures does not only regard government and the energy users, but other actors in an implementation network as well. Shop owners that are pressed to sell more efficient appliances to their customers form an example of these other actors. The network of researchers, suppliers of technologies, energy advisers, user associations, public interest groups and subsidizing agencies, each with their own interests, defines the relationship between policy measures and implementation too. This means that the different conditions for realising saving options are not tied to the same actor. For instance the condition 'availability' often will be associated with the manufacturing of new appliances or systems, while the condition 'motivation' mostly regards the energy user. In this analysis the role of these other parties is taken into account when analysing possible interaction between policy measures.

Optimal combination of different measure types

The following general criteria for an optimal set follow:

- The optimal set should cover all (relevant) conditions;
- Measure types should complement each other, not overlap;
- A measure type should influence more than one condition;
- Measures should be introduced in the right order.

An optimal combination of different measure types meets all conditions for a successful implementation of saving options. Preferably it enhances the proper utilization of the energy systems as well. The policy measures in an optimal combination complement each other with respect to meeting the five conditions. Because the conditions often are coupled to different actors, an optimal set should regard all relevant actors as well. To limit the number of policy measure types deployed, it is important that the measures influence more conditions at the same time. The last criterion concerns the timing of various measures; it has obviously no use to increase the motivation to buy a saving option at a time when the option is not yet market ready. This last criterion is not elaborated on further as it does not play a role in the following analysis.

[7] Jensen OM. Visualisation turns down energy demand. Proceedings ECEEE Summer Study 2003. p. 451-454.

[8] Groot A et al. The price elasticity of energy demand – State of affairs 1998 (in Dutch), report no. 483. Amsterdam, The Netherlands: Stichting voor Economisch Onderzoek, 1998.

[9] Sorrell, S. Interaction in EU Climate Policy – Policy design and policy interaction: literature review and methodological issues. A report to DG Research. Brighton, UK: Science & Technology Policy Research, University of Sussex, 2001.

In practice the overall optimality of a combination of policy measures will depend on other factors too. Not all types of policy measures present are applicable to every saving option. In energy policy formulation many other factors play a role when choosing a policy measure type. For instance, legislation demands extensive ex-ante knowledge about the appropriateness of the regulated saving option; this knowledge is not always easy to provide. Subsidies often affect actors not belonging to the target group; too much free riders diminish the effectiveness of the measure (see Blok and Vermeulen)

Qualitative rating of the possible interaction effect

In this analysis the interaction effect regards the direct influence of one policy measure on the saving effect of another measure. Measures from an earlier period, such as R&D-programmes, can influence the effect of present policy measures but are not taken into account. Second order effects, such as the past agreement on industrial energy efficiency in the Netherlands which has provided for a structure that was beneficial to the new measure benchmarking, are not taken into account either.

The qualitative rating of the possible interaction effect proceeds as follows. The more two measures exert influence at the same condition(s) for implementation, the more they mitigate each other's effect. Depending on the specific situation this results in a relative rating: marginal-, modest- or strong mitigating ('-', '- -' or '- - - '). The last rating can be characterised as 'too much of the same kind'. An example is the combination 'standards and subsidies' which provides more motivation to invest into a saving option than is actually needed. Their combined effect is less than the sum of the separate effects of both measures apart. These cases are also called 'overlapping' or, as in Braathen and Serret[10], 'counterproductive'. In the extreme opposite case two measures complement each other in such a way that the combined effect is much greater than the total effect of both measures apart. This synergetic combination is rated as strong reinforcing ('+++'). A Dutch example is the label system for appliances and the energy premium scheme. The evaluation in Belastingdienst[11] shows that this combination has led, in a few years only, to people purchasing efficient or very efficient appliances only. If the mutual reinforcement of two measures is less optimal the rating is modest or marginally reinforcing ('++'or '+'). In cases where it can be reasoned that one measure does not affect the saving effect of the other the rating '0' is given.

It must be stressed that the interaction analysis regards the common scope of two measures, e.g. in case of appliance standards and subsidies only the part of the subsidy scheme that is devoted to appliances. Because the quantification of interaction effects in literature often gives rise to confusion, the outcomes of interaction analysis for two measures A and B are illustrated in **Table 3-1**. For the mitigating combination the total saving effect is less than the sum of both effects; for the reinforcing combination this is the other way around. A neutral combination provides (almost) the same total savings as the sum of both measures. The figure shows that an increase in total savings due to a second measure is valid for all combinations, even the mitigating one. The point is: how relates the combined effect to the sum of the effects of both measures on their own?

[10] Braathen NA, Serret Y. Instrument mixes used for environmental policy; Further analysis and additional case studies, report ENV/EPOC /WPNEP(2004). Paris, France: IEA, May 2005.

[11] Belastingdienst. Report on research findings with respect to the evaluation of the Energy Premium Scheme (in Dutch), Den Haag, The Netherlands: Belastingdienst/Centrum voor proces- en produktontwikkeling, June 2002.

Appendix B. Targeted end-uses per sector

One of the themes in the current Odyssee/MURE project is the specification of targeted end-uses, in order to facilitate the analysis of savings policy. The following targeted end-uses have been chosen.

Households

- Space heating - existing dwellings (insulation and boiler)
- Space heating - new dwellings
- Space cooling (electric devices, or cooling/ventilation)
- Hot water preparation
- Large appliances by type and by labelling class (diffusion indicator)
- Information & Communication appliances
- Lighting
- All electricity – own supply (Photovoltaic, diffusion indicator)

Tertiary

- Space heating –existing buildings
- Space heating – new buildings
- Ventilation, Air-conditioning & Cooling
- Lighting
- Office appliances
- Special applications (street lighting, product cooling/storage)

Transport

- Persons - new cars (technology)
- Persons - existing cars (behaviour)
- Goods/road - truck, lorries
- Persons - public transport (train, buses) (technology)
- Persons -modal shift
- Goods – modal shift/logistics
- Persons – mobility

Industry

- Space heating
- Process heat: Specific process technologies;
- Electric drives
- Other electricity (electrochemical, lighting, ventilation,….)
- CHP

For the analysis of interaction with standard interaction matrices some targeted end-uses have been aggregated.

Appendix C. Aggregation of policy measure types for interaction analysis (households)

Aggregation as discussed in section 4.3.

	Policy measure types (level c3)	Interaction types
1	Energy Performance Standards	Legislative/normative - invest
2	Minimum thermal insulation standards	Legislative/normative - invest
3	Minimum efficiency standards for boilers	Legislative/normative - invest
4	Compulsory replacement of old boilers above a certain age	Legislative/normative - invest
5	Thermostatic zone control	Legislative/normative - use
6	Control systems for heating (Regulation)	Legislative/normative - use
7	Mandatory heating pipe insulation	Legislative/normative - invest
8	Periodic mandatory inspection of boilers	Legislative/normative - use
9	Periodic mandatory inspection of Heating/Ventilation/AC (HVAC)	Legislative/normative - use
10	Mandatory use of solar thermal energy in buildings	Legislative/normative - invest
11	Individual billing (multi-family houses)	Legislative/normative - use
12	Maximum indoor temperature limit(s)/limitation heating period	Legislative/normative - use
13	Minimum efficiency standards for electrical appliances	Legislative/normative - invest
14	Mandatory measures for efficient lighting	Legislative/normative - invest
15	Mandatory labelling of heating equipment	Legislative/informative - focused
16	Mandatory energy labelling of electrical appliances	Legislative/informative - focused
17	Mandatory energy efficiency certificates for existing buildings	Legislative/informative - focused
18	Mandatory energy efficiency certificates for new buildings	Legislative/informative - focused
19	Mandatory audits in large residential buildings	Legislative/informative - broad
20	Mandatory audits in small residential buildings	Legislative/informative - broad
21	For investments in new buildings exceeding building regulation	Financial/fiscal – invest
22	For investments in energy efficient building renovation	Financial/fiscal – invest
23	For the purchase of more efficient boilers	Financial/fiscal – invest
24	For the purchase of highly efficient electrical appliances	Financial/fiscal – invest
25	For other energy efficiency investments	Financial/fiscal – invest
26	For investment in renewables	Financial/fiscal – invest
27	For CHP investments	Financial/fiscal – invest
28	For energy audits	Financial/fiscal – info
29	Reduced interest rates (soft loans)	Financial/fiscal – invest
30	Leasing of energy efficient equipment	Financial/fiscal – invest
31	VAT reduction on retrofitting investment	Financial/fiscal – invest
32	VAT reduction on equipment	Financial/fiscal – invest
33	Income tax reduction	Financial/fiscal – invest
34	Income tax credit	Financial/fiscal – invest
35	Linear electricity tariffs	Financial/fiscal – use
36	Voluntary labelling of buildings/components (existent and new)	Information/education - focused
37	Information campaigns (by energy agencies, energy suppliers etc)	Information/education - broad
38	Detailed energy/electrical bill aiming at EE improvement	Information/education - broad
39	Regional and local information centre on energy efficiency	Information/education - broad
40	Vol./Negot. agreements with producers of White / Brown Goods	Co-operative – focused
41	Vol./Negot. agreements with producers of ICT (e.g. on stand-by)	Co-operative – focused
42	Voluntary DSM measures of energy suppliers and distributors	Co-operative – broad
43	Technology procurement for en. efficient appliances and buildings	Co-operative – focused
44	Eco-tax on electricity/energy cons./CO2 - emissions	Cross-cutting - taxes
45	Eco-tax with income (mainly) recycled to EE/RES	Cross-cutting - taxes
46	Eco-tax with income recycled to indirect labour cost	Cross-cutting - taxes
47	Eco-tax with reduced rates for the industrial sector	Cross-cutting - taxes

Appendix D. Standard interaction matrices per targeted end-use for households

Interaction matrices as discussed in section 4.5.

Space heating existing dwellings											
		Legislation on:		Leg-inform		Support via:		Information:		Coop	Taxes
Measure		invest	use	label	audit	invest	audits	invest	use	VA	
Leg-norm-invest											
Leg-norm-use		-									
Leg-inform-focus (label)		- - -	0								
Leg-inform-broad(audit)		- - -	0	- - -							
Fin/fiscal-invest		- - -	-	+++	++						
Fin/fiscal-info (audits)		- - -	- -	- -	- - -	+					
Inform-focused-invest		- - -	0	- - -	- - -	+	- - -				
Inform-broad-use		-	- - -	0	-	0	-	0			
Coop-broad (VA)		- - -	-	-	0	+	-	-	-		
Taxes		- -	- -	+	+	- -	+	+	+++	-	

New dwellings matrix							
		Leg-norr	Leg-inf	Suppor	Inform	Coop	Taxes
Measure		invest	label	invest	certif.	VA-	
Leg-norm-invest							
Leg-inform-focus (label)		- - -					
Fin/fiscal-invest		- - -	+++				
Inform-invest(certif)		- - -	- - -	+			
Coop-broad (VA)		- - -	-	+	-		
Taxes		- -	+	- -	+	-	

Hot water matrix											
		Legislation on:				Support via:		Information:		Coop	Taxes
Measure type		invest	use	label	audit	invest	audits	invest	use	VA-DSM	
Leg-norm-invest											
Leg-norm-use		-									
Leg-inform-focus (label)		- - -	0								
Leg-inform-broad(audit)		- - -	0	- -							
Fin/fiscal-invest		- - -	-	+++	++						
Fin/fiscal-info (audits)		- - -	- -	- -	- - -	+					
Inform-invest(certif)		- - -	0	- - -	- - -	+	- - -				
Inform-broad-use		-	- - -	0	-	0	-	0			
Coop-broad (VA)		- - -	-	-	0	+	-	-	-		
Taxes		- -	- -	+	+	- -	+	+	+++	-	

Appendix E. Actual interaction matrices per targeted end-use for households

Cases for the Netherlands as discussed in section 4.6,

Space heating existing dwellings					
	Support via:		Information	Coop-broad	Taxes
Measure	invest	audits	use	VA	
Fin/fiscal-invest					
Fin/fiscal-info (audits)	+				
Inform-broad-use	0	-			
Coop-broad (VA)	+	-	-		
Taxes	- -	+	+++	-	

New dwellings matrix				
	Leg-norm	Leg-inforr	Coop	Taxes
Measure	invest	label	VA-DSM	
Leg-norm-invest				
Leg-inform-focus (label)	- - -			
Coop-broad (VA)	- - -	-		
Taxes	- -	+	-	

Hot water matrix					
	Support via:			Coop	Taxes
Measure type	invest	audits	use	VA-DSM	
Fin/fiscal-info (audits)	+				
Inform-broad-use	0	-			
Coop-broad (VA)	+	-	-		
Taxes	- -	+	+++	-	

Appliances matrix					
	Legisl	Support		Coop (VA)	Taxes
Measure type	label	invest	use	Manuf.	
Leg-inform-focus (label)					
Fin/fiscal-invest	+++				
Inform-broad-use	0	0			
Coop (VA manuf.)	- -				
Taxes	+	- -	+++		

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