EUROPEAN COMMISSION
Programme «LIFE+2007»

Developing Local Plans for Climate Change Mitigation by 2020

(CLIM-LOCAL2020)

LIFE07 ENV/GR/000282

ACTION 5

Classification of measures into priority categories

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1. General approach

The aim of action 5 is to finalise the classification of the examined GHG emission reduction options into priority categories that will be subject to public consultation (in the context of Action 6). To this end, a set of criteria to be applied in choosing the measures for incorporation in the Local Action Plan (including those calculated in Action 4) will be defined by the local decision makers/key stakeholders. Utilizing this set of criteria, the measures to be incorporated into the Local Action Plan will be selected and categorized into high, medium and low priority.

At the end of Action 4, potential measures were classified in three groups with respect to their benefit to cost (B/C) ratio. However, there are other important criteria that local decision-makers and key stakeholders may view as important and thus need to be incorporated in the decision-making process. For instance, possible financial and implementation difficulties, environmental impacts other than GHG emissions reduction etc., could be considered as additional evaluation criteria. At the same time, measures currently under implementation and/or existing priorities of the Municipality of Volos and DEYAMV, as recorded in the relevant budget and operational plans, should be included in the Local Action Plan.

In the context of this LIFE project, a methodological framework has been developed to assist the process of defining priorities for the measures to be included in the Local Action Plan. Specifically, a two step procedure has been formulated, aiming at identifying (first step) the low priority measures and then (second step) classify the rest of the measures into the high and medium priority categories while taking into account the different characteristics of the Municipality of Volos and DEYAMV as compared to the rest of the decision makers involved (residents, private sector (services – trade) and public authorities). **Figure 1** presents an overview of the framework applied for the determination of priorities.

At first measures with a B/C ratio less than 1 constitute the low priority measures for all implementing authorities/agents. Then, the process differentiates between (a) the Municipality of Volos and DEYMAV and (b) the rest of the involved authorities/agents.

- **Municipality of Volos and DEYAMV**. High priority measures are those already implemented or planned by both authorities, with a penetration rate lower than the one defined in the context of Action 4. The rest of the measures correspond to the medium priority category. The application of such a procedure, enables the utilisation of existing policies and measures of both authorities while at the same time allows for the introduction of additional elements aiming at a further reduction of GHG emissions.
- **Other involved authorities/agents**. The classification of GHG emissions reduction measures into high, medium and low priority categories is the result of the application of a multi-criteria method. Multicriteria analysis forms a very useful tool in order to take

into account simultaneously all the basic aspects of a problem that may be expressed in different units (even qualitative). It represents a sound methodology applied internationally during the last decades in several problems of environmental and energy planning. ELECTRE Tri was considered as a suitable multiple criteria method for the specific problem faced (the reasons for this selection are analysed in Section 2).

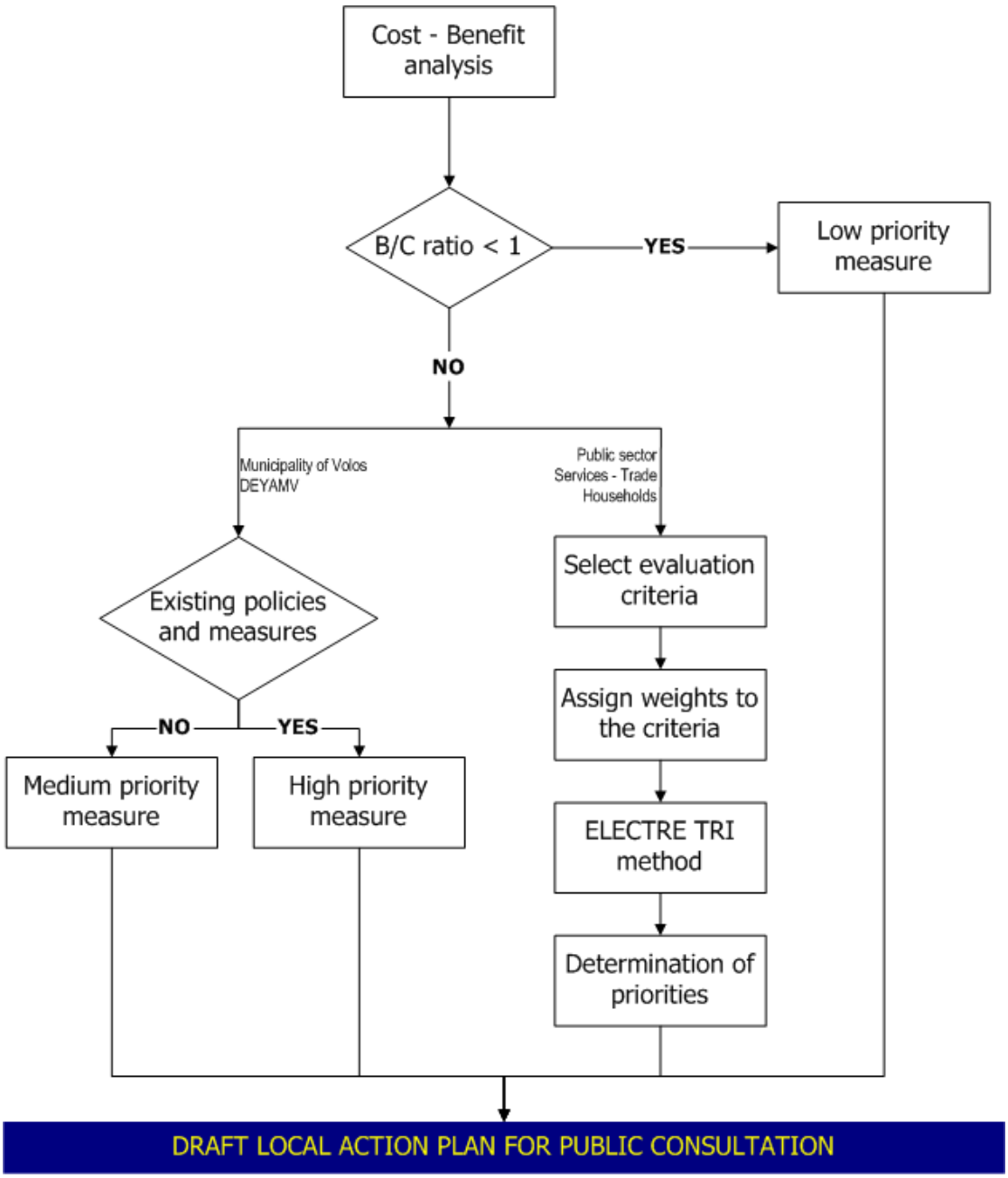

Figure 1. Methodological framework for the classification of measures into priority categories

2. Methodological framework

2.1. Selection of evaluation criteria and the associated weights

Criteria are essential components of multicriteria analysis since they are the basis for the evaluation of the different alternatives/scenarios. Therefore, a criterion can be defined as "a measurable aspect of judgment by which a dimension of the various scenarios under consideration can be characterized". It is essential that the set of criteria selected for the analysis of a problem should comply with the following disciplines:

- **Completeness**. A set of criteria is "complete" if it covers all aspects of the problem.
- **Operational**. The set of criteria selected should be meaningful and transparent for facilitating decision makers to perceive the implications of the alternatives.
- **Decomposable**. This means that the selected set of criteria is possible to be broken into smaller parts to simplify the analysis.
- **Non-redundancy**. Criteria should be defined in such a way that double counting of consequences is avoided.
- **Minimum size**. The set of criteria should be kept as small as possible.

The determination of the criteria scores can be made either on a quantitative measurement scale or on a qualitative one. In a quantitative scale, scores can be related by the four basic mathematical operations while qualitative scores can be related only by <, >, =. Quantitative criteria are measured by means of a physical unit or a proxy attribute directly related to the criterion in question, while for qualitative ones a scale from 1-10 or similar may be used.

Weights are used to introduce subjective human judgments into the decision making procedure. They express the decision maker's particular preferences over the considered criteria and reflect his overall attitude about GHG emissions reduction and the proposed measures. There are four methods that can be used for the assignment of weights to the criteria selected:

- No assignment of weights.
- Direct assignment of weights by the decision maker.
- Indirect assignment of weights, where a decision maker expresses his preferences by constructing a hierarchy of the criteria.
- Indirect assignment of weights, where a decision maker expresses his preferences by comparing a number of fictitious actions.

The method used in the context of the present analysis is the direct assignment of weights by the decision maker, due to the simplicity of the method.

2.2. ELECTRE-TRI method

The translation of the preferences expressed on the criteria by means of the weights determined into a global preference upon the examined alternatives is made by using a method of multicriteria analysis (MCA). The different MCA methods available in the literature can be categorised as follows:

- **Value and utility theory approach**. Relevant methods are based either on utility theory or on a rating procedure, where partial utilities or ratings with respect to an -implicitly or explicitly defined- goal, are determined for each separate criterion. These partial functions are then aggregated in a unique (usually additive) function which measures the overall performance of each alternative and allows for ranking the examined alternatives. The basic assumptions related to these approaches are (a) there is a need for compensation between the criteria and (b) there is a "true" ordering of the scenarios representative of the decision maker's preferences which needs to be discovered.
- **Outranking approaches**. This category of approaches attempts to avoid assumptions (a) and (b) of the utility approach. They are based on the pairwise comparison of the considered alternatives with respect to each separate criterion using a binary, so-called outranking relation. Contrary to approaches based on utility functions which assume only two states in the underlying model of preferences (the decision maker either prefers an action to another or he is indifferent between the two actions) outranking approaches recognise hesitations in the decision maker's mind which prevent him from clearly adopting one of these two states.

Out of the various outranking MCA methods available the ELECTRE Tri method was selected. It is the most recent out of the methods of the ELECTRE family – was developed in 1992 – and has been applied in problems related to environmental planning, business risk, etc. The method was considered appropriate for application in the specific problem faced as:

(a) This method, as well as some other outranking methods, comprises the concept of pseudocriterion. In the case of a real-criterion, action *a* and *a'* are indifferent according to this criterion only if their performance is equal, otherwise *a* is preferred to *a'* or vice versa. In the case of pseudo-criterion, indifference is extended to a zone where the difference between *a* and *a'* is small, while between the zone of indifference and the zone of strict preference there is a zone of weak preference, which indicates a hesitation between indifference and strict preference. For the definition of these zones two thresholds per criterion, the indifference threshold and the strict preference threshold, must be defined. The possibility of introducing thresholds makes ELECTRE Tri a suitable method for the particular problem examined, as it can better approximate the attitude of decision-makers, which is usually characterised by a gradual transition from the

indifference to the preference state. Furthermore, the introduction of thresholds provides a sound way to deal with the unavoidable uncertainties in the evaluation of the various reduction measures according to the criteria selected.

(b) A particular characteristic of the ELECTRE Tri method is that it provides the possibility of assigning potential actions into pre-defined categories and thus it is suitable for exploring which reduction measures can be considered as of high, medium and low priority.

The ELECTRE Tri method is basically a two stage process. In the **first stage**, the outranking hypothesis ‘‘action a is at least as good as the reference action of a pre-defined category’’ is tested. Testing is performed through a comparison between the performances of action a according to the evaluation criteria selected and the relevant performance of reference actions (defining the upper and lower limits of the pre-defined categories). The hypothesis is tested through the conditions of concordance (there is a majority of criteria in favor of a) and discordance (there is no criterion too much in favor of the reference action). For the examination of the latter condition, a veto threshold can be introduced. Furthermore, the outranking hypothesis is not completely accepted or rejected: a credibility index of this hypothesis varying from 0 to 1 is calculated. In the **second stage**, the outranking relations established in the previous step are exploited in order to classify potential actions in the various pre-defined categories. This classification is performed through two processes, the "optimistic" classification (where the action is classified to the highest possible category) and the "pessimistic" classification (where the action is classified to the lowest possible category). Differences that may occur between these two classifications for a specific action are due to the smaller or higher incomparability between this action and the reference actions of the pre-defined categories.

3. Results

3.1 Priorities for the Municipality of Volos and DEYAMV

The classification of measures attributed (on the basis of the responsibility for the implementation of a measure) to the Municipality of Volos and DEYAMV is presented in **Table 1**.

The GHG emissions reduction potential (for 2020) of *High* and *Medium* priority measures is estimated at 23,000 t CO_2 eq approximately. Interventions in the street lighting system (automation and replacement of low efficiency bulbs), utilization of water potential for electricity generation by DEYAMV and additional solid waste management options (focusing on residents' contribution) account for about 65% of the above-mentioned potential.

Table 1. Priority categories for measures implemented by the Municipality of Volos and DEYAMV

	Municipality of Volos		DEYAMV
	Municipal	Schools	
A. BUILDINGS			
Insulation of roof & external walls	HIGH	HIGH	
Green roofs			
Replacement of window/door frames & glazing	HIGH	LOW	
Replacement of low efficiency A/C units	LOW		LOW
External shading	HIGH		MEDIUM
Ceiling fans	LOW		LOW
Replacement of low efficiency diesel boilers	MEDIUM	MEDIUM	
Regular maintenance of boilers			
Intelligent indoor temperature management system			
Solar collectors for space & water heating			
Increased penetration of natural gas use			
Thermosiphonic solar systems			
Solar cooling			HIGH
Photovoltaics	LOW	LOW	MEDIUM
Energy efficient office and home electrical appliances	LOW	LOW	LOW
Replacement of low efficiency bulbs	MEDIUM	MEDIUM	MEDIUM
Light control automation systems	LOW	LOW	LOW
Non-technical energy conservation measures	HIGH	HIGH	
Cogeneration			
Installation of Building Management Systems (BMS) - new construction	LOW		
Bioclimatic buildings - new construction	MEDIUM		
B. TRANSPORT			
Replacement of old municipal passenger cars with hybrid ones	HIGH		
Renewal of heavy duty vehicles fleet	LOW		
Renewal of garbage truck fleet	HIGH		
Renewal of DEYAMV vehicle fleet			LOW
Municipal bicycle rental system	HIGH		
Extension of bicycle lane network	HIGH		
Extension of the pedestrian walkways	HIGH		
New car parking stations	HIGH		
Urban buses - new low emissions compact buses			
Urban buses - redesign of bus lines			

	Municipality of Volos		DEYAMV
	Municipal	Schools	
Tram construction			
Eco-driving	HIGH		MEDIUM
Car pooling			
C. WATER SUPPLY AND SANITATION			
Reduction of water consumption through advertising campaigns and/or billing policy. which will result in energy demand reduction of the following services: (a) exploitation of water resources (water wells) & operation of water distribution network and (b) operation of sewage conveyance and pumping system & operation of sewage treatment plant			HIGH
Leakage minimization in water distribution network and residential connections			No quantification
Reduction of water supply share coming from water wells (especially deep wells) by the utilization of surface water resources			No quantification
Optimization of water supply system through the installation of "smart" valves. division of water network into additional distribution zones. etc.			HIGH
Installation of electromagnetic water meters of direct reading to improve leakage monitoring			
Changes in the electromechanical equipment (pumps. etc) and generally upgrading of the water pumping stations to increase operating equipment efficiency			HIGH
Minimization of parasitic inflow into the sewer system that causes operational problems in transporting and treating sewage			MEDIUM
Upgrading of the electromechanical equipment of sewage treatment plant with the aim of reducing local and linear losses			MEDIUM
Changes in the electromechanical equipment (pumps. etc) and generally upgrading of the sewage pumping stations to increase operating equipment efficiency			LOW
Optimization of sewage treatment plant (STP); the measures to be specified by energy audit (resetting of control system. put switch 'off' when not in operation. leakage repair. reprogramming of load/consumption)			No quantification
Shift electrical load to off-peak. improve power factor (STP)			No quantification
Simple control systems (STP)			No quantification
Further sludge treatment – possible further energy recovery (STP)			HIGH
Utilization of potential energy in surface waters to produce electricity– application of renewable energy systems. autonomous and interconnected			HIGH
D. MUNICIPAL WASTE MANAGEMENT			
Paper recycling	HIGH		
Biodegradable waste recycling	HIGH		
E. CITY OPERATION			
Replacement of low efficiency bulbs in street lighting	HIGH		
Automation in street lighting	HIGH		
Tree planting/ green areas	HIGH		

3.2 Priorities for the rest implementing authorities/agents

3.2.1 Evaluation criteria and weights

The following evaluation criteria, associated with the introduction and implementation of GHG emissions reduction measures, were identified:

(1) **Total cost**. This criterion includes investment cost as well as operational cost throughout the lifetime of the examined measure. It is measured in *€/ton CO_2 eq avoided* by the implementation of the measure. It is assumed that the smaller this cost is, the easier the implementation of the measure is and thus the implementation of the latter should be prioritized. Cost figures derived from the results of Action 4.

(2) **GHG emissions reduction**. This criterion expresses the contribution of each measure to the GHG emissions reduction. It is measured in comparison with 2007 total GHG emissions (*%*).It is assumed that higher priority will be given to measures with a high reduction potential.

(3) **Ancillary benefits**. This criterion expresses the degree to which a specific measure complements other policies and measures having as an objective the improvement of life quality. This criterion is of a particular importance, as the implementation of the measure may not only lead to a reduction of GHG emissions, but also to the reduction of other environmental burdens (e.g. SO_2 or NOx emissions) which have negative impacts on health (e.g. increased mortality and morbidity), on ecosystems, etc. For the measurement of this criterion, an indirect index was used, namely the externalities of the measure expressed in *€/t CO_2 eq avoided*. In order to avoid double-counting externalities associated with climate change are not included. It is assumed that decision-makers will favor the implementation of measures accompanied by high externalities, as in this way environmental problems related not only to climate change, but also to other factors, can be reduced.

(4) **Necessary preparatory actions**. This criterion expresses the extent of preparatory actions required prior to the implementation of the measure. It is assumed that higher priority will be given to measures that require lesser preparatory actions. It is measured on a 1 – 10 qualitative scale with 1 being the worst performance (more preparatory actions) and 10 the best performance.

(5) **Technical issues**. This criterion expresses the technical complexity associated with the implementation of a measure. It is measured on a 1 – 10 qualitative scale with 1 being the worst performance and 10 the best performance.

(6) **Financing**. The implementation of measures is closely related to the availability of the

necessary economic resources and the availability/accessibility of relevant financial instruments (e.g. subsidies). It is measured on a 1 – 10 qualitative scale with 1 being the worst performance (difficulties in financing) and 10 the best performance.

The weights assigned to the selected evaluation criteria are presented in **Table 2**, while **Table 3** presents the performances of the examined measures with regard to the selected criteria.

Table 2. Evaluation criteria and weights

Criteria	Weights
Investment cost	20%
GHG emissions reduction	35%
Ancillary benefits	15%
Necessary preparatory actions	5%
Technical issues	5%
Financing	20%

Table 3. Performances of the examined measures with regard to the selected evaluation criteria

Sector	Measure	Investment cost	GHG emissions reduction	Ancillary benefits	Preparatory actions	Techncal issues	Financing
		(€/t CO_2 eq)	(%)	(€/t CO_2 eq)	(Qualitative scale 1 - 10)		
Public	Insulation of roof & external walls	143.24	0.0123	4.708	5	6	7
Public	Ceiling fans	79.21	0.0266	6.686	9	9	4
Public	Replacement of low efficiency diesel boilers	112.64	0.0004	10.360	5	7	7
Public	Increased penetration of natural gas use	144.23	0.0006	10.360	7	7	6
Public	Thermosiphonic solar systems	187.60	0.0131	3.714	7	7	6
Public	Photovoltaics	597.02	0.0441	7.166	3	4	8
Public	Replacement of low efficiency bulbs	55.50	0.0683	6.467	9	9	6
Public	Light control automation systems	66.35	0.0191	6.686	6	6	5
Public	Cogeneration	47.74	0.3513	13.132	5	6	7
Public	Urban buses - redesign of bus lines	413.88	0.0799	-7.629	5	6	3
Public	Eco-driving	110.17	0.0090	16.560	8	8	3
Private	Insulation of roof & external walls	153.48	0.4515	8.468	6	3	5
Private	External shading	108.93	0.0950	7.166	8	7	5
Private	Replacement of low efficiency diesel boilers	268.71	0.0395	10.360	6	7	5
Private	Increased penetration of natural gas use	491.42	0.1335	10.360	7	7	6
Private	Thermosiphonic solar systems	163.25	0.0114	7.699	8	8	5
Private	Photovoltaics	597.02	0.0943	7.166	4	6	7
Private	Replacement of low efficiency bulbs	26.98	0.2764	6.467	10	10	5
Private	Light control automation systems	124.86	0.0109	6.686	8	7	5
Private	Bioclimatic buildings - new construction	277.46	0.0258	4.680	5	6	6

Sector	Measure	Investment cost	GHG emissions reduction	Ancillary benefits	Preparatory actions	Technical issues	Financing
		(€/t CO_2 eq)	(%)	(€/t CO_2 eq)	(Qualitative scale 1 - 10)		
Private	Eco-driving	196.00	0.0614	1.210	8	8	1
Residents	Insulation of roof & external walls	290.67	1.0810	6.006	6	3	5
Residents	Green roofs	248.03	0.0224	6.446	3	3	1
Residents	Replacement of low efficiency diesel boilers	412.59	0.0467	10.360	6	7	1
Residents	Regular maintenance of boilers	276.48	0.1564	16.694	8	9	10
Residents	Increased penetration of natural gas use	723.64	0.1740	10.360	6	6	5
Residents	Thermosiphonic solar systems	98.39	1.8565	6.969	8	8	6
Residents	Photovoltaics	597.02	0.4864	7.166	4	6	5
Residents	Replacement of low efficiency bulbs	27.77	0.2919	6.467	10	10	8
Residents	Non-technical energy conservation measures	17.70	0.3110	4.479	6	10	10
Residents	Eco-driving	237.00	0.2812	9.210	8	8	1
Residents	Car pooling	143.23	0.1116	1.224	8	4	1

3.2.2 Application of the ELECTRE-TRI method

The results of the application of the ELECTRE-Tri method for determining priorities for measures to be implemented by the public sector, private sector (services-trade) and residents are presented in **Table 4**. It should be mentioned that low priority measures include not only those assigned to this category by the application of the method but also those measures with a B/C ratio less than 1 (that were excluded from the multi-criteria analysis).

Table 4. Priority categories for measures implemented by the public sector, private sector and residents

MEASURES	Public sector	Private sector	Residents
Insulation of roof & external walls	LOW	HIGH	MEDIUM
Replacement of window/door frames & glazing	LOW	LOW	LOW
Green roofs			LOW
Replacement of low efficiency A/C units	LOW		LOW
External shading	LOW	HIGH	
Ceiling fans	MEDIUM		LOW
Solar cooling			
Replacement of low efficiency diesel boilers	LOW	MEDIUM	MEDIUM
Increased penetration of natural gas use	LOW	HIGH	MEDIUM
Regular maintenance of boilers			HIGH
Solar collectors for space & water heating		LOW	LOW
Thermosiphonic solar systems	LOW	LOW	HIGH
Photovoltaics	LOW	MEDIUM	MEDIUM
Cogeneration	HIGH		
Intelligent indoor temperature management system			LOW
Replacement of low efficiency bulbs	MEDIUM	HIGH	HIGH
Light control automation systems	MEDIUM	LOW	LOW
Energy efficient office and home electrical appliances	LOW	LOW	LOW
Non-technical energy conservation measures			HIGH
Installation of Building Management Systems (BMS) - new construction	LOW		
Bioclimatic buildings - new construction		MEDIUM	LOW
Urban buses - new low emissions compact buses	LOW		
Urban buses - redesign of bus lines	MEDIUM		
Tram construction	LOW		
Eco-driving	LOW	LOW	MEDIUM
Car pooling			LOW

The GHG emissions reduction potential (for 2020) of *High* and *Medium* priority measures is estimated at 47,000 t CO_2 eq approximately. Solar collectors for water heating in the residential sector, insulation of roof and external walls, replacement of low efficiency lighting bulbs account for about 73% of the above-mentioned potential.