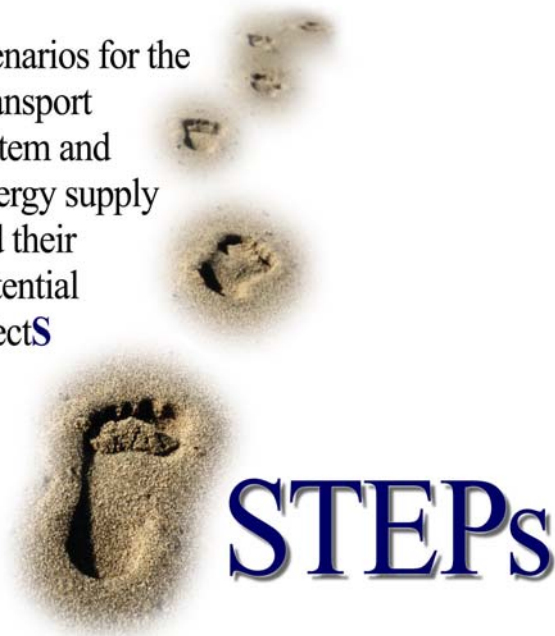


Scenarios for the
Transport
system and
Energy supply
and their
Potential
effectS



Framework Programme 6, Call 1A
Thematic Priority 1.6.2, Area 3.1.2, Task 1.10
Co-ordination Action + Additional Research

WorkPackage 5

Methodology for the assessment of transport and energy supply scenarios

Deliverable 5.1

List of project partners

- | | | | |
|---|---|----|--|
| 1 | Buck Consultants International (BCI), The Netherlands (Project Coordinator) | 8 | Spiekermann und Wegener (S&W), Germany |
| 2 | AUEB, Greece | 9 | Stratec, Belgium |
| 3 | ITS, United Kingdom | 10 | TIS, Portugal |
| 4 | JRC IPTS, Spain / EU | 11 | TRL, United Kingdom |
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| 6 | LT, Finland | 13 | TTR, United Kingdom |
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Chapter 1 Introduction

This deliverable describes in detail the proposed methodology for the assessment of the scenarios developed in WP3, based on the model outputs included in WP4. Figure 1 includes a scheme with the relations between WP5 and the rest of WPs.

Stemming from the overall structure of STEPs, the design of the assessment methodology is closely related with the work developed in other WPs and will have a strong influence in the final conclusions of the project. On the one hand, this selection was carried out in coordination with the two previous WPs (WP3 & WP4). On the other, the outcome of the scenario assessment will be used as the main input for WP6.

These relationships have been reflected in Figure 1. The dotted line represents a co-operation link between WPs to ensure coherence between them, while the wider arrows represent in each case the WP from which the following receives its inputs. These relationships are further detailed in next sections.

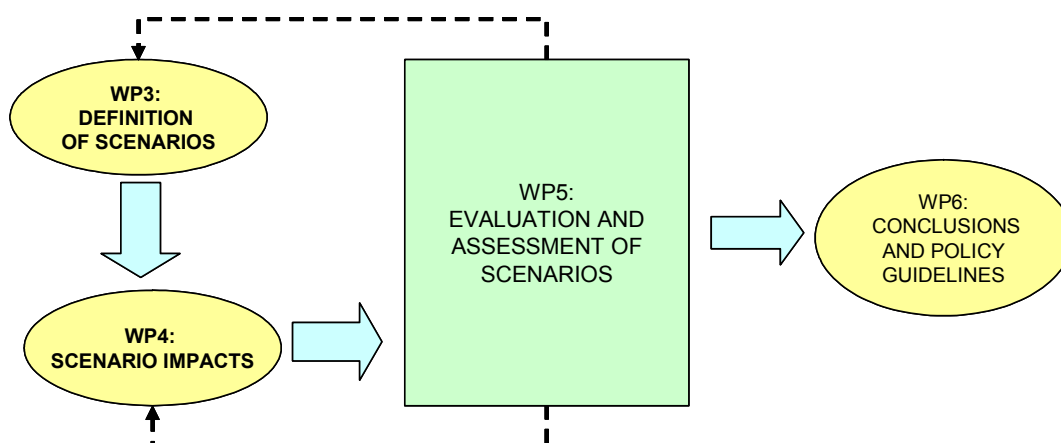


Figure 1 Links with other WPs

This objective of Deliverable 5.1 is to describe the assessment methodology, which is based on a classic multicriteria analysis (MCA). The assessment results will be subsequently analysed in Deliverable 5.2, in which we will draw conclusions on the best scenario. The proposed methodology is outlined in Figure 2. The procedure constitutes a discrete utility-based multicriteria method (see e.g. (Nijkamp et al., 1990) for a review of MCA literature).

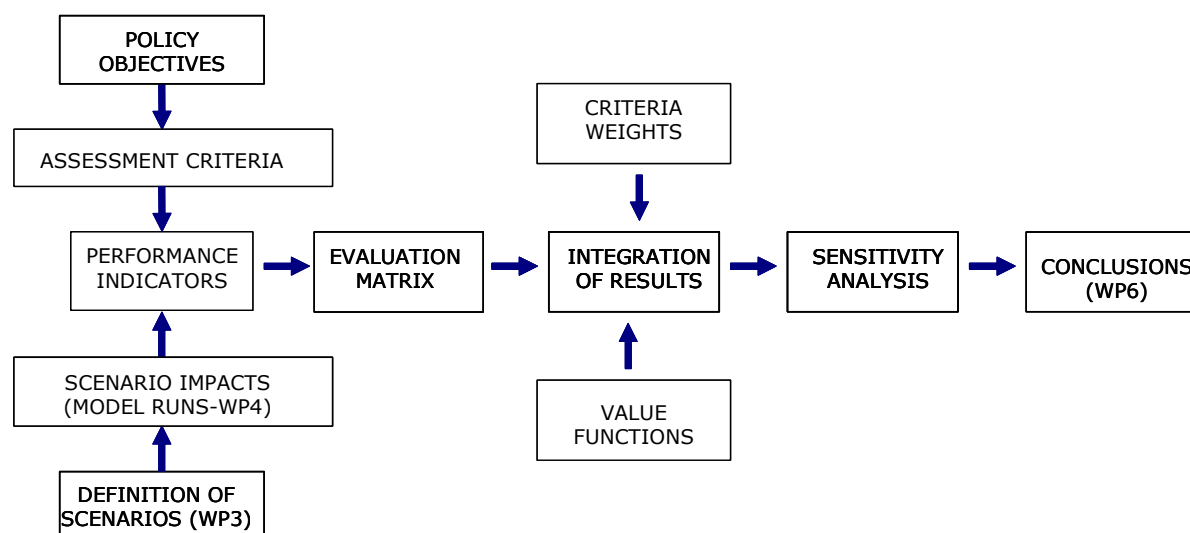


Figure 2 Outline of the MCA methodology

Chapter 2 describes the process followed in order to select the assessment criteria, from the review of existing policy documents to the selection of the indicators to measure the performance of each scenario in each criterion.

Chapter 3 describes the procedure for the integration of results. The assessment is carried out on the basis of an evaluation matrix (sometimes called impact matrix or project effect matrix). Its elements (i.e. performance indicators) represent a measure of the quality of each scenario in each criterion.

Four main criteria categories have been defined, namely efficiency and security of energy supply, environmental, social and competitiveness criteria. Subsequently, a score representing the performance of each scenario in each of these four categories has been computed. This transformation requires the definition of criteria weights and value functions. No aggregation of the corresponding four scores has been made in STEPS, mainly for two reasons. The first is that none of the models provides performance indicators for all the indicators, and therefore it is not possible to compute a strict 'global social utility value' for each scenario. The second is to intentionally leave the decision maker with the final decision on the best scenario, depending on his/her trade-offs between the –often conflicting- scores obtained in each of the aforementioned four criteria groups.

Finally, a sensitivity analysis of the results to key parameters of the methodology is carried out before extracting conclusions on the best scenario and giving policy recommendations.

Chapter 2 **Selection of assessment criteria and indicators**

2.1 Policy background

2.1.1 Introduction

The starting point for the selection of the criteria to assess STEPs **transport** and **energy** scenarios is the identification of the main concerns and policy targets of the European Union related to the aforementioned sectors.

The growing importance of Energy and Transport sectors in the EU became clear in 1999, when the Commission created a specific Directorate-General for the management of Energy and Transport Policy. These two sectors share a number of fundamental characteristics (EC, 2004a):

- they are essential to **economic competitiveness**;
- they contribute to **social and territorial cohesion**;
- each is the subject of important **public service** missions guaranteeing all users and consumers, wherever they may be on the territory of the Union, equal access, on equitable conditions, to quality services at affordable prices;
- they require substantial infrastructure with quality, inter-connected networks and the question of **investments** is vital to each;
- often organized in a monopolistic basis, they face similar problems when confronted with the **integration of national markets and regulatory changes**;
- both have a major influence in the quality of our **environment** and are subject to the same requirements in terms of **safety** and **security**;
- they each have a major **international dimension**.

In summary, the main objective is that energy and transport contribute to **sustainable development**: making Europe both a homogenous area of economic development and an area where the environment in the broadest sense of the term is conserved.

The following sections review the main concerns and policy targets of the European Union in terms of transport and energy related to the objectives of STEPs, which will constitute the main input for the selection of the assessment criteria. A complete list on EU's legislative

Acts on transport and energy sectors can be found in (EC, 2004a). It is beyond of the scope of this task to include them in this Deliverable.

2.1.2 Common Energy and Transport Policy

The Common **Transport Policy** (CTP) has two basic goals: **efficient**, **accessible** and **competitive** transport systems - essential to growth and employment and to keep EU businesses competitive - and a high level of **safety** and **environmental protection**. Therefore the CTP Action Programme seeks:

- better integration of transport modes and greater use of environmentally friendly and energy-saving modes;
- stimulation of new technologies;
- promotion of a 'Citizens' Network' to provide high-quality collective transport of all kinds;
- fair competition between the different modes;
- improvement of road safety.

EU's main **Energy Policy** targets have been recently summarized in the Treaty establishing a Constitution for Europe Official Journal of the European Union, 310/01 of 16 December 2004 (EU, 2004).

'In the context of the establishment and functioning of the internal market and with regard to the need to preserve and improve the environment, Union policy on energy shall:

- a. ensure the functioning of the energy market,*
- b. ensure security of energy supply in the Union,*
- c. promote energy efficiency and energy saving and the promotion of new and renewable forms of energy'*

(Article III-256, Section 10: Energy, Title III, Part III)

Current activity in the fields of transport and energy is based on two major Policy documents: the White and the Green Papers:

White Paper: European Transport Policy for 2010: time to decide (EC, 2001). It proposed four main priorities:

- adjusting the **balance** between the different modes of transport;
- implementing the **trans-European transport network**;
- placing the **user** at the heart of transport policy;
- managing the effects of **transport globalisation**.

Green Paper: *Towards a European strategy for the security of energy supply* (EC, 2000). It established three major strategic priorities:

- controlling the **increase in demand**, identifying two priority sectors : transport and construction;
- managing **dependence on supply**, not to maximise the Union's autonomy on energy, but to reduce the risks involved in dependence;
- ensuring that **the internal energy market** works well.

Finally, the recently adapted *Community Guidelines for the development of the **trans-european transport networks*** (EC, 2004b) include essential EU transport policy objectives. The following list constitutes a selection of the relevant objectives in the context of the STEPs project:

- ensure the **sustainable mobility** of persons and goods (...) under the best possible social and safety conditions, while helping to achieve the Community's objectives, particularly in regard to the **environment** and **competition**, and contribute to strengthening **economic and social cohesion**;
- be, insofar as possible, **interoperable** within modes of transport and encourage **intermodality** between the different modes of transport;
- cover the whole territory of the Member States of the Community so as to facilitate **access in general**, link island, landlocked and peripheral regions to the central regions and interlink without bottlenecks the major conurbations and regions of the Community.

2.1.3 Current European Commission concerns

The main concerns from the EC on energy and transport issues have recently been stated in a Report from the Directorate of Energy and Transport (EC, 2004a). This document constitutes a starting point to structure the set of criteria to be included in the STEPs methodology.

Europe's transport system is dealing with important issues, such as:

- **Traffic congestion** reaching disturbing levels, with the existence of certain bottlenecks on the major intra-Community routes and its negative economic impacts;
- **Lack of interoperability** between modes and systems;
- **Growing imbalance** between different modes: growing air and road market shares and decreasing rail and sea modes;
- **Traffic safety**: although the situation in the EU-15 has improved in recent years, the new Member States show alarming results.

However, as the development of passenger and goods transportation is directly linked to **economic growth**, **decoupling** transport and GDP growth, while dealing with increasing mobility needs, is essential. In addition, enlargement and more intensive trade relations with neighbouring countries will both contribute to an intensification of trade flows.

The rights of users and passengers are also of vital importance: European citizens should benefit from equal access to transport services under acceptable conditions. In this sense, the influence of the transport system on socio-economic disparities among regions is not clear and it can either reduce differences or introduce further spatial polarisation, i.e. increase or reduce **cohesion**.

Regarding the energy sector many warnings have been issued, not only concerning the **long-term** decline in world hydrocarbon reserves, but also the more **intermediate threat** of a reduction in the availability of crude oil on the markets - with the resulting pressure on prices- resulting in particular from the emergence of very substantial new consumers, such as China. Extensive oil consumption, combined with the expected growth in demand for natural gas, will increase the Union's **dependence on imports** from non-member countries.

Apart from the question of **physical supply**, the **price of energy**, and more particularly of oil, will be another serious cause of concern for the EU, for its implications in terms of GDP growth reduction.

It is also important to mention the international dimension of the transport and energy sectors in a growing **globalisation** and unstable geopolitical context. Given the current dependence on imports, the EU needs to strengthen its relations with the producing countries – in which the key element in energy cooperation is Russia-, and to play a more active role in certain international organizations.

Finally, there is the fact that transport is a fundamental element of the problem of **climate change** and its consequences on the deterioration of the environment. In this sense, it is urgent to take proactive measures to reverse the growing trend in GHG emissions to comply with the Kyoto Protocol agreed in 1997.

All the above mentioned concerns have been translated into three essential dimensions: safety, security and protection of the environment (EC, 2004a):

1. **Safety and security of transport and energy supply systems:** reducing the risks inherent in systems of mobility or supply, which have been increased by the globalisation of trade. These include:
 - **Safety in the mobility of goods and persons:** in the last four years there have been important developments in transport policy standards, as well as the establishment of three European Agencies set up for the maritime, aviation and railway fields, and the set up of a group of experts to advise the Commission on the development of a European policy for the prevention of accidents in all modes of transport, including the transport of energy (oil and gas pipelines).
 - **Ensuring transport security:** in response to the terrorist attacks of 11 September, a policy on security in the aviation and maritime fields has also been initiated, as they have been selected as potential targets of malicious action.
 - **Ensuring the reliability of the nuclear sector:** dealing with all the risks, whether damages to human health (radiation protection), misappropriation and misuse of nuclear materials (security), or malfunctioning of installations (safety), as well as the environmental risks stemming from the disposal of radioactive waste.

- 2. Making energy and transport a part of sustainable development:** making Europe both a homogenous area of economic development and an area where the environment in the broadest sense of the term is conserved. The achievement of this overall objective entails:
- **Preventing breaks in the energy system:** this include the regulations needed for the completion of the internal market, the development of trans-European networks (mainly in terms of improving cross-border gas and electricity connections as well as transport), but also the reduction of the heavy structural dependence of EU on energy imports, by means of diversification of energy sources, promotion of energy efficiency and re-balancing between modes of transport to promote the least energy-consuming and emission-contributing.
 - **Controlling demand for energy:** including measures such as energy labelling, rationalising the cycle of production, distribution and use of energy, increasing energy efficiency at the stage of the final use of energy.
 - **Diversifying supply of energy:** raising the share of new and renewable energy sources, promoting the use of substitute fuels (mainly biofuels), and financing the research and promotion of 'more intelligent' energy, with policy packages intended to encourage greater demand management.
 - **Combating imbalances in the transport system:** revitalizing rail transport, short sea shipping and inland navigation, supporting the progress of intermodality (e.g. MARCO POLO programme), creating essential infrastructures and technologies to make transport more efficient and fluid (e.g. GALILEO and ERTMS systems), or introducing pricing measures and infrastructure charging for a fair competition between modes.
 - **The rights of users and passengers:** European citizens should benefit from equal access to energy products and transport services under acceptable conditions.

2.2 Definition of assessment criteria and corresponding indicators

2.2.1 Introduction

The objective of this Chapter is the development of a first list of assessment criteria. These criteria will be measured from a combination of output indicators from WP4 model results. The initial selection of criteria/indicators for STEPs has been designed according to their:

- relevance in regard to Community transport and energy objectives and targets;
- applicability on the different spatial scales (UE and regional/local).

There have been some recent attempts to derive a set of measurement indicators. Starting in 1993, the OECD defined the following issues as criteria for indicator selection: policy relevance and utility for users, analytical soundness, and measurability (OECD, 1993). However, as stated in this report, these criteria correspond to an 'ideal indicator', and they may not be completely fulfilled in practice. The concept of sustainability and its three dimensions have also been widely used to structure the set of measurement indicators (Serageldin, 1996).

Another relevant reference is the list included in the TERM indicators (EEA, 2002), covering the most important aspects of the transport and environment system, in which each indicator is assigned to a corresponding policy issue. Finally, in a broader context, the Commission recently proposed a shortlist of only 14 structural indicators (EC, 2003), related to employment, innovation, economic reform and social cohesion.

All the above references have been used as a starting point to structure STEPs assessment methodology. Next subsection includes the draft list of criteria and their corresponding indicators.

2.2.2 Selection of criteria

The assessment criteria need to be selected in such a way that they reflect to which extent each scenario meets the four overall evaluation objectives defined in the STEPs proposal: social and environmental sustainability, technical efficiency, geographical equity and cohesion, and efficiency and security of energy supply

Based on the review of EU transport and energy policy documents, a list of criteria and the corresponding base indicators to measure the performance of each **transport and energy** scenario are defined in Table 1. The rationale behind this proposed structure comes from the intention to assess both the performance of the transport and energy system, and its consequences in terms of social, environmental and economic perspective.

Some of the indicators may influence more than one criterion, e.g. the % of renewables in each scenario has an influence both on the security of energy supply -it changes the import dependence on oil- and on the environmental consequences of transport activity-it changes GHG emissions and air quality-. However, this type of 'double counting' in the overall assessment score will be dealt with in the next phase of the definition of the assessment methodology.

Table 1 Evaluation criteria and indicators

Criteria	Sub-Criteria	Base indicator
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)
	Reducing import dependence	% of energy from imports
	Increasing % of renewables	% of energy from renewable sources
	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP
Environmental	Global warming	CO ₂ /pers-km, t-km total CO ₂
	Emissions of PM/NO _x	PM/NO _x emissions (urban/rural area)
	Emissions of traffic noise	Noise emitted (urban/rural area)
Social	Increasing transport safety	Total Deaths/Injuries
	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment
Competitiveness	Changes in accessibility	% change (each mode)
	Increasing regional GDP	% change GDP
	Increasing employment rates	% change unemployment rates
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)

It is intended to use the same criteria and indicators in the evaluation and assessment of the scenarios on the European and local level. But it has to be considered that no model is capable of calculating all indicators suggested. It is therefore necessary that results from the models of the other spatial level will be used as exogenous scenario parameters. The

capability of the models at European and regional level and whether an indicator has also a spatial dimension is summarised in Table 2 and Table 3.

Table 2 Criteria at the European level

Criteria	Sub-Criteria	Base indicator	Modelled	Spatial
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)	X	No
	Reducing import dependence	% of energy from imports	X	No
	Increasing % of renewables	% of energy from renewable sources	X	No
	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP	X X	No No
Environmental	Global warming	CO ₂ /pers-km, t-km	X	No
		total CO ₂	X	No
	Emissions of PM/NO _x	PM/NO _x emissions (urban/rural area)	X	Yes
	Emissions of traffic noise	Noise emitted (urban/rural area)	X	Yes
Social	Increasing transport safety	Total Deaths/Injuries	X	No
	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	X	Yes
Competitiveness	Changes in accessibility	% change (each mode)	X	Yes
	Increasing regional GDP	% change GDP	X	Yes
	Increasing employment rates	% change unemployment rates	X	Yes
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)	X	No

Table 3 Criteria at the local (regional) level

Criteria	Sub-Criteria	Base indicator	Modelled	Spatial
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)	-	-
	Reducing import dependence	% of energy from imports	-	-
	Increasing % of renewables	% of energy from renewable sources	-	-
	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP	X X (-) ¹	No No
Environmental	Global warming	CO ₂ /pers-km, t-km total CO ₂	X X	No No
	Emissions of PM/NO _x	PM/NO _x emissions (urban/rural area)	X	Yes
	Emissions of traffic noise	Noise emitted (urban/rural area)	X	Yes
	Increasing transport safety	Total Deaths/Injuries	X	No
Social	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	X (-) ¹	Yes
Competitiveness	Changes in accessibility	% change (each mode)	X	Yes
	Increasing regional GDP	% change GDP	-	-
	Increasing employment rates	% change unemployment rates	-	-
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)	X (-) ¹	No

Legend:

X The models (or a combination of them) are able to compute the indicator

-..... The models are not able to compute the indicator. The indicator is an exogenous parameter in the scenario and is passed over from the over level of modelling.

1) GDP cannot be calculated at the local level.

2.3 Definition of process indicators

To be able to track the overall performance of the transport system the use of the following process indicators is suggested in Table 4.

Table 4 *List of potential process indicators*

PROCESS INDICATOR	UNIT
Average trip length/mode	Km/trip
Average travel speed/mode	Km/h
Average travel costs/mode	€/trip
Balanced transport system	% each mode
Revenue generated by tax increases	mio. Euros
Revenue generated by road charging	mio. Euros

Estimates of the costs of the different scenarios generated in WP4 should be used to calculate efficiency.

Chapter 3 **Integration of results**

3.1 Description of the MCA procedure

The multi criteria analysis as developed for the projects STEPs follows closely the guidance as given by the 'Multi-Criteria Analysis Manual' of the Office of the Deputy Prime Minister, UK (Dodgson et al. 2000).

The stages of a multi criteria analysis

According to (Dodgson et al. 2000) a multi criteria analysis is made up by eight steps Table 5.

Table 5 *Steps in a multi-criteria analysis (Dodgson et al. 2000) section 5.1*

-
1. Establish the decision context. What are the aims of the MCA, and who are the decision makers and other key players?
 2. Identify the options.
 3. Identify the objectives and criteria that reflect the value associated with the consequences of each option.
 4. Describe the expected performance of each option against the criteria. (If the analysis is to include steps 5 and 6, also 'score' the options, i.e. assess the value associated with the consequences of each option.)
 5. 'Weighting'. Assign weights for each of the criteria to reflect their relative importance to the decision.
 6. Combine the weights and scores for each of the options to derive an overall value.
 7. Examine the results.
 8. Conduct a sensitivity analysis of the results to changes in scores or weights.
-

- Step 1: The decision context

The decision context has been established in task 5.1 'Evaluation framework' and is described in the technical note 'Interrelation between WPs 3-4-6 and Evaluation framework'.

- **Step 2: Identify options**
The options identified in the context of the project STEPs are the six scenarios as defined in work package 3, task 3.4 'Building and formulation of the scenarios'.
- **Step 3: Identify objectives and criteria**
The objectives and criteria have been defined in task 5.1 'Evaluation framework' and are described in the technical note 'Interrelation between WPs 3-4-6 and Evaluation framework'. Section 3.2 of the technical note gives a detailed description of the criteria.
- **Step 4: Describe the expected performance**
The description of the expected performance of each option is the result of the modelling work performed in work package 4 'Scenario Impacts'.
- **Step 5: Weighting**
A specific targeted survey will be performed among partners and decision makers of each country to weight the identified criteria.
- **Step 6: Combine the weights and scores**
In step 6 a linear additive model will be used in STEPs. The level of integration will be that of the four subcriteria groups: energy, environment, social and competitiveness. No 'global social utility value' will be computed, as justified in the Introduction of this Deliverable. A description of linear additive models is given in (Dodgson et al. 2000) section 4.7, section 6 and appendix 4. The linear additive model as applied in STEPs is described in the section 'Linear additive model' below.
- **Step 7: Examine the results**
The examination of the results will be carried out in task 5.4 'Assessment and comparison of scenarios'.
- **Step 8: Conduct a sensitivity analysis**
A sensitivity analysis of the results to changes in scores or weights is part of the work of task 5.4 'Assessment and comparison of scenarios'.

Mutual independence of preferences

Mutual independence of preferences means that the judged strength of preference for an option on one criterion will be independent of its judged strength of preference on another (Dodgson et al. 2000) section 4.3.3. In (Dodgson et al. 2000) section 5.4.4.4 mutual independence of preferences is described in more detail. The key question to test mutual independence of preferences is: can you assign preference scores for the options on one criterion without knowing what the options' preference scores are on any other criteria? If the answer is yes, the criterion tested is preference independent from the others. (Dodgson et al. 2000) uses the example of a trifle to illustrate this. The ingredients forming a trifle are not mutually preference independent. To achieve the preferred result the quantity of custard depends on the amount of jelly, sponge, etc.

The selection of the criteria set has been aimed at, -as explained in previous sections-, translating main EU policy objectives into a set of assessment criteria. This may entail a certain degree of preference interdependence between criteria, which can be handled by a linear additive model; therefore its use is justified for the purpose of the assessment to be carried out in STEPS.

3.2 Definition of weights

Once the general MCA procedure has been detailed, it is necessary to explain how the different criteria are to be taken into account; in other words, which is the weight assigned to each criterion when they are going to be integrated.

There are several methods to obtain the criteria weights (see Nijkamp et al. (1990) for a comprehensive review on existing techniques). STEPS has chosen a direct estimating method: the rating method, in which the decision-maker is asked to distribute a constant number of points (in our case 100) among the objectives distinguished in such a way that the number of points allocated to an objective reflects its relative importance.

Therefore, each of those criteria has been weighted through a specific targeted survey performed among the different partners of the project and decision makers of several European countries. The results presented below are provisional; as the survey is still being distributed among stakeholders. The definitive values will be detailed in Deliverable 5.2, together with a sensitivity analysis of the results to different weight profiles.

The results obtained so far have been summarized in Table 6. The survey results have been disaggregated according to the different roles of the respondents in the decision-making process.

CRITERIA	SUB-CRITERIA	BASE INDICATOR	POLITICIAN	PLANNER	SCIENTIST	ADMINISTR.	OTHER	AGGREGATED	
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)	10,00	7,87	9,04	8,17	6,17	8,25	25,96
	Reducing import dependence	% of energy from imports	8,00	3,63	1,10	5,38	4,33	4,49	
	Increasing % of renewables	% of energy from renewable sources	7,00	5,88	4,99	8,29	6,88	6,61	
	Reducing energy consumption	Energy/trip (toE/mio. trips) Energy/GDP (toE/Euro)	10,00	4,63	4,20	6,42	7,83	6,62	
Environmental	Global warming	CO2/pers-km, t-km (g/km) Total CO2 (t)	7,00	10,62	12,85	9,88	15,92	11,25	27,59
	Emissions of PM/NOx	PM/NOx emissions (t)	8,00	9,87	10,32	12,46	11,38	10,41	
	Emissions of traffic noise	Noise emitted	8,00	7,13	4,77	5,71	4,04	5,93	
Social	Increasing transport safety	Total Deaths/Injuries	7,00	14,12	13,59	10,53	7,88	10,62	20,18
	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	9,00	9,12	12,45	4,38	12,83	9,56	
Competitive-ness	Changes in accessibility	% change (each mode)	8,00	15,87	15,55	6,58	15,28	12,26	26,27
	Increasing regional GDP	% change GDP	6,00	3,75	2,41	4,71	1,5	3,67	
	Increasing employment	% change unemployment rates	5,00	3,13	5,07	13,24	1,67	5,62	
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)	7,00	4,38	3,69	4,25	4,29	4,72	
100,00									

Table 6 Draft criteria weights

3.3 Definition of value functions

Scores

A score between 0 and 100 on an interval scale is used in the STEPs MCA. To be able to translate the indicator values into scores it is necessary to define two reference points. There are two principle possibilities to define the reference points: global scaling and local scaling (Dodgson et al. 2000). See Table 7.

Table 7 *Scaling possibilities*

Global scaling	<ul style="list-style-type: none"> • A score of 0 represents the worst level of performance that is likely • A score of 100 represents the best level of performance that is likely
Local scaling	<ul style="list-style-type: none"> • A score of 0 represents the worst level of performance in the currently considered set of options • A score of 100 represents the best level of performance in the currently considered set of options

The choice between global and local scaling should make no difference to the ranking of the options (Dodgson et al. 2000). An advantage of the global scaling is that it is easier to include new options in a later stage if this lie outside the current range of measure achievement.

A linear value function is used to translate the measure of achievement into a value score on the 0-100 scale.

Linear additive model

In a linear additive model the value score of each criterion is multiplied by the weight of that criterion and all those weighted scores are added together to one overall value (Dodgson et al. 2000). In STEPS, four utility values U_{ic} will be computed for each of the four criteria groups: energy, environment, social, and competitiveness.

$$U_{ic} = \sum_k s_i^k * w^k \quad (1)$$

where U_{ic} is the utility value of scenario i in criteria group c , s_i^k is the score of criteria k in scenario i and w^k is the weight of criteria k .

$$s_i^k = \frac{x_i^k - l^k}{m^k - l^k} * 100 \quad (2)$$

where s_i^k is the score of criteria k in scenario i , x_i^k is the value of criteria k in scenario i , l^k is the least preferred option of criteria k and m^k is most preferred option of criteria k .

3.4 The Excel® spreadsheet model

Partial utility values are calculated making use of the spreadsheet program Microsoft Excel. The file name of the actual version is 'STEPS Task 5_3 MCA v2.xls'. The file consists of six worksheets. Three of them require user input ('Performance Matrix', 'Weights', 'Preferred options' and 'Utility Value') while the others ('Scores' and 'Weighted Scores') contain only intermediate results and therefore need no user input. 'Utility Value' contains the result of the multi criteria analysis and, as a user input, the modelling results for the process indicators. In general user input is only possible in cells highlighted in grey. All other cells are write protected. We have used draft results of the Edinburgh case study as an example in the attached file 'STEPS Task 5_3 MCA v2.xls'.

Sheet 'Performance Matrix'

The model output for the indicators as agreed in task 5.1 for the scenarios A0 to B2 has to be written into the cells F2 to K40.

Criteria	Sub-Criteria	Base indicator	Indicator	Detail, unit	Time	A-1	A0	A1	A2	B-1	
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)		(toE)	Aggregated		1.19E+04	1.13E+04	1.18E+04		
	Reducing import dependence	% of energy from imports									
	Increasing % of renewables	% of energy from renewable sources									
	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP		(toE/trip)	2030		0.28	0.22	0.27		
Environmental	Global warming	CO ₂ /pers-km, t-km total CO ₂		(t/km) (t)	2030 Aggregated		79.64 3.36E+07	63.90 3.16E+07	69.68 2.96E+07		
	Emissions of PM/NO _x	Atmospheric emissions	PM NO _x	(t) (t)	Aggregated		2.85E+03 5.19E+04	2.68E+03 4.95E+04	2.55E+03 4.76E+04		
	Emissions of traffic noise	Noise emitted		Noise costs (mio. €)	Aggregated		32.85	32.71	29.81		
	Increasing transport safety	Total Deaths/Injuries	# Deaths # Injuries	(# injured persons)	Aggregated		6.01E+04	5.98E+04	5.43E+04		
Social	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	GDP	Variation coefficient	2030		0.45	0.44	0.36		
				Gini index							
				Spearman's rank correlation coeff.							
				Corr. coeff. relative change vs. level	2030		0.16	0.01	-0.61		
				Corr. coeff. absolute change vs. level							
	Employment	Variation coefficient									
		Gini index									
		Spearman's rank correlation coeff.									
		Corr. coeff. relative change vs. level									
		Corr. coeff. absolute change vs. level									
Competitiveness	Changes in accessibility	% change (each mode)	Slow		2030		24%	23%	24%		
			Bus		2030		18%	57%	40%		
			Train								
			Car								
			Water								
	Air										
	Increasing regional GDP	% change GDP									
Increasing employment rates	% change unemployment rates										
Decoupling transport and GDP growth	(%GDP growth-%transport growth)										

Figure 3 Spreadsheet 'Performance Matrix'

Sheet 'Weights'

The weights of the different indicators can be defined in the cells F2 to F40. In cell G1 the number of indicators with a weight different than zero is calculated. In cell H1 the average weight if evenly distributed is calculated. This is meant as an orientation to help deciding on the relative importance of the weights.

If the input cells for an indicator in the sheet 'Performance Matrix' are empty for all six scenarios then the cells G2 to G40 show the text 'No values!' and change their background colour to orange. This is meant to indicate that no weight should be allocated to this indicator.

In the columns H to J the weights for the different sub-criteria and criteria are summarised. If the sum of the allocated weights is more than 100 then column K changes its colour to red.

Criteria	Sub-Criteria	Base indicator	Indicator	Detail, unit	Time	Weights	13	7.7		
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)	(toE)		Aggregated	8		8		
	Reducing import dependence	% of energy from imports				0	No values!	0		
	Increasing % of renewables	% of energy from renewable sources				0	No values!	0		
Environmental	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP	(toE/million trips)		2030	7		7		
	Global warming	CO ₂ /pers-km, t-km	(g/km)		2030	5		20		
		total CO ₂	(t)		Aggregated	15				
	Emissions of PM/NO _x	Atmospheric emissions	PM NO _x	(t)	Aggregated	5		5		
Social	Emissions of traffic noise	Noise emitted	Noise costs (mio. €)		Aggregated	5		5		
	Increasing transport safety	Total Deaths/Injuries	# Deaths # Injuries	(# injured persons)	Aggregated	0 15	No values!	15		
	Accessibility					2030	10			
							0	No values!		
							0	No values!	20	
						2030	10			
	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	GDP	Variation coefficient			0	No values!		
				Gini index			0	No values!		
				Spearman's rank correlation coeff.			0	No values!	0	20
				Corr. coeff. relative change vs. level			0	No values!		
Employment		GDP	GDP	Corr. coeff. absolute change vs. level			0	No values!		
				Variation coefficient			0	No values!		
				Gini index			0	No values!		
				Spearman's rank correlation coeff.			0	No values!	0	20
				Corr. coeff. relative change vs. level			0	No values!		
				Corr. coeff. absolute change vs. level			0	No values!		
Competitiveness	Changes in accessibility	% change (each mode)	Slow		2030	5				
			Bus		2030	5				
			Train			0	No values!			
			Car		2030	5		15		
			Water			0	No values!			
			Air			0	No values!			
						0	No values!			
Increasing regional GDP	% change GDP				0		0			
Increasing employment rates	% change unemployment rates				0		0			
Decoupling transport and GDP growth	(%GDP growth-%transport growth)				0	No values!	0			

Figure 4 Spreadsheet 'Weights'

Sheet 'Preferred options'

The least and most preferred option for each indicator should be defined in the columns F and G respectively.

Criteria	Sub-Criteria	Base indicator	Indicator	Detail, unit	Time	Least preferred option	Most preferred option	
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)	(toE)		Aggregated	1.50E+04	0	
	Reducing import dependence	% of energy from imports				100%	0%	
	Increasing % of renewables	% of energy from renewable sources				0%	100%	
Environmental	Reducing energy consumption per unit of transport/economic activity	toE/trip toE/GDP	(toE/million trips)		2030	0.5	0	
	Global warming	CO ₂ /pers-km, t-km	(g/km)		2030	100	0	
		total CO ₂	(t)		Aggregated	1.00E+08	0	
	Emissions of PM/NO _x	Atmospheric emissions	PM NO _x	(t)	Aggregated	1.00E+04	0	
Social	Emissions of traffic noise	Noise emitted	Noise costs (mio. €)		Aggregated	100	0	
	Increasing transport safety	Total Deaths/Injuries	# Deaths # Injuries	(# injured persons)	Aggregated	1000 1.00E+05	0 0	
	Accessibility	Territorial cohesion indicators of accessibility, GDP & employment	GDP	Variation coefficient		2030	100	0
				Gini index			1	0
				Spearman's rank correlation coeff.			1	-1
				Corr. coeff. relative change vs. level		2030	1	-1
	Employment	GDP	GDP	Corr. coeff. absolute change vs. level			1	-1
				Variation coefficient			1	0
				Gini index			1	0
				Spearman's rank correlation coeff.			1	-1
Corr. coeff. relative change vs. level						1	-1	
Corr. coeff. absolute change vs. level						1	-1	
Competitiveness	Changes in accessibility	% change (each mode)	Slow		2030	-100%	100%	
			Bus		2030	-100%	100%	
			Train			-100%	100%	
			Car		2030	-100%	100%	
			Water			-100%	100%	
			Air			-100%	100%	
						-100%	100%	
Increasing regional GDP	% change GDP				-100%	100%		
Increasing employment rates	% change unemployment rates				100%	-100%		
Decoupling transport and GDP growth	(%GDP growth-%transport growth)				0	2		

Figure 5 Spreadsheet 'Preferred options'

Sheet 'Scores'

As an intermediate result the scores for each indicator and scenario are calculated in this sheet.

Criteria	Sub-Criteria	Base indicator	Indicator	Detail. unit	Time	A-1	A0	A1	A2	B-1	B0	B1	B2	
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)		(toE)	Aggregated	33.8	33.8	37.0	35.3	34.4	34.4	38.4	35.8	
	Reducing import dependence	% of energy from imports				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Increasing % of renewables	% of energy from renewable sources				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Reducing energy consumption per unit of	toE/trip		(toE/million trips)	2030	34.9	35.4	38.9	40.2	35.7	36.2	40.4	41.0	
Environmental	Global warming	CO ₂ /pers-km, t-km	total CO ₂	(g/km)	2030	17.2	17.4	29.7	28.6	20.7	20.8	36.7	31.6	
				(t)	Aggregated	71.6	71.5	72.8	75.5	71.0	71.0	72.8	75.4	
	Emissions of PM/NO _x	Atmospheric emissions	PM	(t)	Aggregated	76.6	76.6	77.8	79.7	77.2	77.2	78.9	80.3	
			NO _x	(t)	Aggregated	63.3	63.3	65.1	67.6	64.3	64.3	66.6	68.6	
	Emissions of traffic noise	Noise emitted	Noise costs (mio. €)		Aggregated	72.5	72.5	72.3	75.4	72.7	72.7	72.4	75.8	
	Increasing transport safety	Total Deaths/Injuries	# Deaths			Aggregated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			# Injuries	(# injured persons)		Aggregated	49.6	49.5	49.1	55.1	49.9	49.8	49.3	55.9
	Social	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	GDP	Variation coefficient	2030	45.9	46.3	48.9	67.9	46.5	46.9	49.3	67.8
					Gini index	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
					Spearman's rank correlation coeff.	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Corr. coeff. relative change vs. level					2030	30.5	30.3	32.1	88.9	30.5	30.2	32.1	90.0	
Corr. coeff. absolute change vs. level					0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Employment				Variation coefficient	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
				Gini index	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
				Spearman's rank correlation coeff.	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
				Corr. coeff. relative change vs. level	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
				Corr. coeff. absolute change vs. level	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Changes in accessibility	% change (each mode)	Slow	2030	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0		
		Bus	2030	48.5	52.8	64.4	60.8	49.4	53.7	65.1	62.0			
		Train	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
		Car	2030	44.9	45.0	45.0	56.9	46.3	46.2	45.7	58.3			
		Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
		Air	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Competitiveness	Increasing regional GDP	% change GDP				0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Increasing employment rates	% change unemployment rates				0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)				0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Figure 6 Spreadsheet 'Scores'

Sheet 'Weighted scores'

As an intermediate result the weighted scores for each indicator and scenario are calculated in this sheet.

Criteria	Sub-Criteria	Base indicator	Indicator	Detail. unit	Time	A-1	A0	A1	A2	B-1	B0	B1	B2	
Efficiency and security of energy supply	Reducing total energy consumption	Total energy consumption (toE)		(toE)	Aggregated	2.7054218	2.7069063	2.9607026	2.8232888	2.7496615	2.7505957	3.0721241	2.86748	
	Reducing import dependence	% of energy from imports				0	0	0	0	0	0	0	0	
	Increasing % of renewables	% of energy from renewable sources				0	0	0	0	0	0	0	0	
	Reducing energy consumption per unit of	toE/trip		(toE/million trips)	2030	2.4436682	2.4784341	2.7217929	2.8160829	2.4981943	2.5318958	2.8268095	2.8669268	
Environmental	Global warming	CO ₂ /pers-km, t-km	total CO ₂	(g/km)	2030	0.8617161	0.8695419	1.4872227	1.4311451	1.0350033	1.0393726	1.8356045	1.5799778	
				(t)	Aggregated	10.734129	10.728644	10.918886	11.330993	10.65109	10.643774	10.915825	11.305558	
	Emissions of PM/NO _x	Atmospheric emissions	PM	(t)	Aggregated	3.8292493	3.8286095	3.8895418	3.9855143	3.862342	3.8615619	3.9456851	4.0153549	
			NO _x	(t)	Aggregated	3.1665147	3.1666684	3.2525311	3.3821986	3.2145793	3.2145206	3.3307453	3.4293552	
	Emissions of traffic noise	Noise emitted	Noise costs (mio. €)		Aggregated	3.6271302	3.6244986	3.6145435	3.7690062	3.6356403	3.6328041	3.6205405	3.7906755	
	Increasing transport safety	Total Deaths/Injuries	# Deaths			Aggregated	0	0	0	0	0	0	0	0
			# Injuries	(# injured persons)		Aggregated	7.4330509	7.418592	7.3642942	8.2581471	7.4826393	7.4670814	7.3997294	8.3796619
	Social	Improving equity	Territorial cohesion indicators of accessibility, GDP & employment	GDP	Variation coefficient	2030	4.5889013	4.6311489	4.8945821	6.7896588	4.6539031	4.6924632	4.9301902	6.7829063
					Gini index	0	0	0	0	0	0	0		
					Spearman's rank correlation coeff.	0	0	0	0	0	0	0		
Corr. coeff. relative change vs. level					2030	3.0511203	3.0322763	3.2114177	8.8862459	3.0467341	3.0247589	3.2097696	9.0015967	
Corr. coeff. absolute change vs. level					0	0	0	0	0	0	0			
Employment				Variation coefficient	0	0	0	0	0	0	0	0		
				Gini index	0	0	0	0	0	0	0	0		
				Spearman's rank correlation coeff.	0	0	0	0	0	0	0			
				Corr. coeff. relative change vs. level	0	0	0	0	0	0	0			
				Corr. coeff. absolute change vs. level	0	0	0	0	0	0	0			
Changes in accessibility	% change (each mode)	Slow	2030	2.9999868	2.9999868	2.9999868	2.9999868	2.9999868	2.9999868	2.9999868	2.9999868	2.9999868		
		Bus	2030	2.4244209	2.6387935	3.2224403	3.0392976	2.4709669	2.686527	3.2540025	3.1006634			
		Train	0	0	0	0	0	0	0	0				
		Car	2030	2.2473705	2.2487364	2.2494125	2.8463602	2.3131931	2.3107203	2.2858236	2.9159419			
		Water	0	0	0	0	0	0	0	0				
		Air	0	0	0	0	0	0	0	0				
Competitiveness	Increasing regional GDP	% change GDP				0	0	0	0	0	0	0		
	Increasing employment rates	% change unemployment rates				0	0	0	0	0	0	0		
	Decoupling transport and GDP growth	(%GDP growth-%transport growth)				0	0	0	0	0	0	0		

Figure 7 Spreadsheet 'Weighted scores'

Sheet 'Utility Values'

The utility values in each of the four criteria groups: energy, environment, social and competitiveness, in each scenario, is shown in the cells B2 to I5. Below it is possible to input the different process indicators as agreed in task 5.1.

	A-1	A0	A1	A2	B-1	B0	B1	B2	
Energy	37	38	57	55	40	42	65	58	
Environment	31	31	45	67	35	35	54	72	
Social	22	22	24	81	24	24	25	84	
Competitiveness	18	26	47	68	23	31	50	73	

Process indicators	A0	A0	A1	A2	B-1	B0	B1	B2	Unit	Time
Average trip length/mode										
									Km/trip	2030
Slow	1.80	1.80	1.80	1.60	1.80	1.81	1.80	1.61		
Bus	14.24	14.27	14.29	12.81	14.26	14.29	14.29	12.75		
Train										
Car	14.62	14.56	14.63	13.08	14.49	14.45	14.57	13.01		
Water										
Air										
Average travel speed/mode										
									Km/h	2030
Slow										
Bus	17.46	18.27	20.68	21.40	17.75	18.55	20.85	21.62		
Train										
Car	20.37	20.30	20.30	26.99	20.81	20.71	20.53	27.46		
Water										
Air										
Average travel costs/mode										
									€/trip	2030
Slow										
Bus	2.58	3.11	3.09	1.61	2.58	3.11	3.09	1.61		
Train										
Car	2.60	2.84	2.60	4.92	3.02	3.23	2.79	5.16		
Water										
Air										
Balanced transport system										
									% each mode	trips
Slow	22.8%	23.2%	22.9%	31.3%	23.2%	23.6%	23.1%	31.8%		2030
Bus	13.0%	12.7%	12.7%	17.2%	13.3%	13.1%	12.9%	17.8%		
Train										
Car	64.3%	64.1%	64.4%	51.5%	63.4%	63.3%	64.0%	50.4%		
Water										
Air										
Slow	3.5%	3.6%	3.5%	5.3%	3.6%	3.7%	3.6%	5.4%	pkm, tkm	2030
Bus	16.1%	15.9%	15.8%	23.6%	16.8%	16.6%	16.2%	24.5%		
Train										
Car	80.4%	80.5%	80.7%	71.1%	79.6%	79.7%	80.3%	70.0%		
Water										
Air										
Revenues										
Generated by tax increases	8,136	9,231	8,718	14,054	7,939	8,987	8,261	13,499	mio. Euros	Aggregated
Generated by road charging	1,805	1,808	1,818	9,190	1,794	1,798	1,811	9,003	mio. Euros	Aggregated

Figure 8 Spreadsheet 'Utility Values'

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