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POSMETRANS

POlicy measures for innovation in **TRANS**port sector with special focus on **S**mall- and **M**edium sized **E**nterprises
- factors and recommendations for success and sustainability -

Deliverable 1.4

Document describing methodology for analysis

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Content:

1. Introduction

In the present document, a methodology is described which will be used to make a ranking of innovative technologies and policy measures collected in Tasks 1.2 and 1.3 (cf. D1.2 and D1.3). The same methodology will also be used to make a ranking of keys players identified later on in Task 2.1. The ranking procedure is based on criteria defined by the consortium and used to estimate the relevance/importance of each collected data, each criteria being moreover weighted and classified in one of four categories (functional, social, economical and environmental). To take into account the complex situation of criteria of various nature and importance, a Multiple Criteria Decision Aid (MCDA) methodology was followed. The present deliverable sets the basis for the ranking, choosing the most relevant MCDA methodology and defining all criteria to be used and their respective weight.

The aim and expected benefits of such a ranking methodology for POSMETRANS is the following:

- **Innovative technologies**: identify innovation trends in the domain of surface transport in Europe. These trends will be used to establish the technological profile of people filling the questionnaires developed in Task 1.5. Technology trends will also be used in for WP3, dealing with the analysis of market adoption of innovative technologies;
- **Policy measures**: identify the most relevant policy measures that will be analysed in WP5 in which the impact of policy measures will be studied;
- **Key players in innovation**: select POSMETRANS experts for the expert panel consultation of WP3-5 among the identified key players.

2. Methodology of Multiple Criteria Decision Aid

Multiple criteria decision aid (MCDA) is a dynamically developing area which aims at giving the decision-maker some tools in order to enable an advance in solving complex decision problems, where several – often contradictory – points of view must be taken into account [18]. In contrast to the classical techniques of operations research, multicriteria methods do not yield “objectively best” solutions, because it is very difficult to generate such solutions which take into consideration all points of view [20].

The main attributes of multiple decision problems are: set of action/variants/solutions A and a consistent family of criteria F. The set of action A is a set of decision objectives, candidates, variants or actions which is put analysis and evaluation during decision procedures. The set of A can be defined directly in the form of a complete list or indirectly in the form of certain rules and formulas that determine feasible actions/variants/solutions, e.g. in the form of constraints. The consistent family of criteria F should be characterised by the

following features [9]: it should provide a comprehensive and complete evaluation of A, each criterion in F should have a specific direction of preferences (minimised –min or maximised – max) and should not be related with other criteria in F. The domain of each criterion in F should be disjoint with the domains of other criteria.

The multiobjective decision problem is a situation in which having defined a set of actions/variants/solution A and a consistent family of criteria F the decision – maker (DM) tends to [18]:

- define a subset of A which is the best with respect to F (choice problem),
- divide a set of A according to certain norms (sorting problem),
- rank action/variants/solution in A from the best to the worst, according to F (ranking problem).

The MCDA approach clearly identifies the major participants of the decision aiding process, such as: the DM and the analyst, and describes their roles in this process. The DM (an individual or a group of individuals) defines the objectives of the decision process, expresses preferences and finally evaluates the generated results. Finally one can select the best solution, the most desired variant. The analyst, who is external to the decision problem, handles the decision supporting process. His role is to construct a decision model and select the most appropriate tool to solve the decision problem. The analyst explains to the DM the consequences of certain actions and finally recommends the most desired action [21].

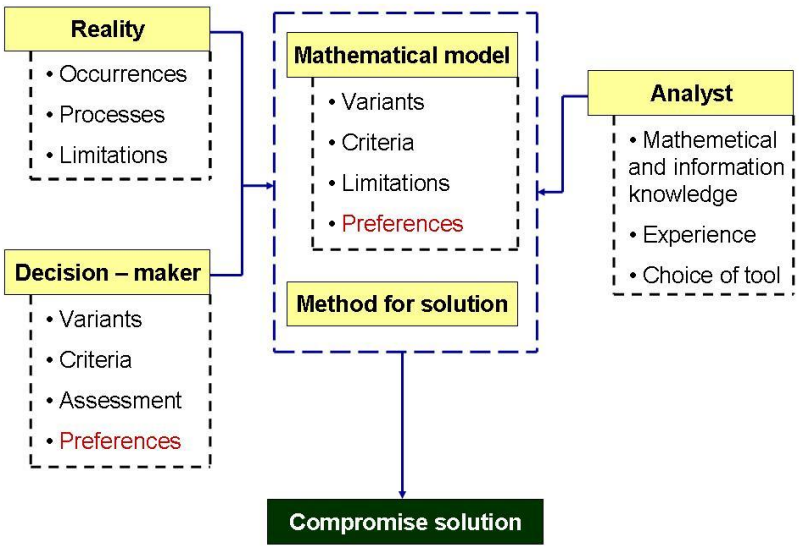
According [9],[18] MCDA methods are usually classified as:

- so called American approach, based on the utility function (e.g. AHP [11], UTA [4]), that aggregate different criteria (point of views) into one global criterion, called utility function, those methods eliminate incomparability between variants,
- so called European approach, based on the outranking relation (e.g. ELECTRE III/IV methods [1],[8], Promethee I and II [1]), Oreste ([7]), that take into account the incomparability between variants,
- interactive methods (e.g. GDF [2], SWT ([3]), Steuer ([17]), that are based on the „trial and error“ approach in each iteration of the solution search procedure; those methods are characterized by phases of computation alternating with phases of decision making.

Multicriteria method allows take into consideration different aspects of the problem (technical, economical, social or environmental).
Multi-criteria decision is characterized by methods that support planning and decision processes through collecting, storing and processing different kinds of information and to construct a viable idea of how to solve a multi-criteria decision problem.
The decision process on a multiple criteria problem is described in the following distinct phases:

- definition and construction of the problem (variants),
- definition of a set of consistent family of criteria,
- identification of the preference system of the decision maker,
- selection of the multiple method evaluation,
- computational experiment,
- analysis and comparison of results,
- choice of the best solution and conclusion.

Methodology of the MCDA can be used almost in every field of our life for scientific, research as well as practical purposes. There are not many situations in which we have only 2 or 3 criteria and the taking a decision is quick and simple. More compound problems require application of more sophisticated approach like MCDA. Methodology of MCDA identifies the main participants of decision process - decision makers, analysts and others interesting in solving of decision problem. Decision maker (individual or group) determines the aims of decision process, presents the preferences and finally evaluates the obtained results. Analyst is responsible for the course of decision support (e.g. formulate the decision model, making a choice of methods and tools hopeful in solving a problem). Employers, clients, local community, etc. are the stakeholders in decision process (see picture 1).



Picture 1: Model of decision making process [12]

There are two suitable approaches within POSMETRANS project: **the Analytic Hierarchy Process – AHP or the Compensating – Conjunction Method** (the most popular method of MCDA).

Analytic Hierarchy Process method [11]

The AHP (Analytic Hierarchy Process) method is a multiple objective ranking procedure, proposed by T. Saaty [11], and focused on the hierarchical analysis of the decision problem. The method is based on the multiattribute utility theory [5] and allows ranking a finite set of variants *A*. Through the definition of the overall objective, evaluation criteria, subcriteria and variants the method constructs the hierarchy of the decision problem. On each level of the hierarchy, based on the pair-wise comparisons of criteria, subcriteria and variants, the DM's preferential information is defined in the form of relative weights w_a [11]. Each weight represents the relative strength of a given element against another and it is expressed as a number from 1 to 9. All weights have a compensatory character, i.e.: the value characterizing the less important element (1/2, 1/5, 1/9) is the inverse of the value characterizing the more important element in the compared pair (2, 5, 9).

The algorithm of the AHP method focuses on finding a solution for a, so called, eigenvalue problem [11] on each level of the hierarchy. As a result a set of vectors containing normalized, absolute values of weights w_a for criteria, subcriteria and variants is generated. The sum of the elements of the vector is 1 (100%). The absolute weights w_a are aggregated by an additive utility function. The utility of each variant i – U_i is calculated as a sum of products of absolute weights w_a on the path in the hierarchy tree (from the overall goal, through criteria and subcriteria) the variant is associated with. The utility U_i represents the contribution of variant i in reaching an overall goal and constitutes its aggregated evaluation that defines its position in the final ranking.

The important element of the AHP algorithm is the investigation of the consistency level of matrices of relative weights w_a on each level of hierarchy. Through the calculation of a so-called consistency index *CI* one can measure how consistent is the preferential information given by the DM. If the value of *CI* is close to 0 the preferential information given by the DM is considered to be almost perfect. The acceptable level of *CI* is below 0.1

The AHP method:

- is based on utility function,
- utilizes quantitative and qualitative criteria, which form a consistent family of criteria (see below)
- proceeds by pair comparison of criteria, subcriteria and variants; using a ranking scale from 1 to 7 (9) where:
  - 1 - equivalence
  - 3 - weak preference
  - 5 - strong preference
  - 7 - very strong preference
- enables to read off the measure of the distance between variants,
- takes into consideration the search of consistency index – CI > 0.1,
  Is mainly used for ranking set of variants (from the best to the worst)

The AHP method presents the following steps:

1. Setting of the problem (definition of possible variants).
2. Definition of a consistent family of criteria.
   The consistent family of criteria is a set of criteria that takes into consideration all possibility aspects of the problem (e.g. technical, economical, environmental, social aspects) and meets the following conditions: coherence of assessment and uniqueness of meaning scope of criteria.
3. Determination of the value of criteria for individual variants.
4. Decision about weights of criteria and minimization or maximization of criteria (taking into consideration the interests of different subjects: local authority, local community etc.
5. Carrying out of computational experiments using a professional software, including:
   - **The construction matrices of comparison** – with first the comparison of pair of criteria, and then the comparison of pair of variants with respect to each criterion (scale from 1 to 7 (9) – as mentioned above).
   - **The evaluation of the decision-maker rank consistency** – checking how consistent is the preferential information given by the decision–maker (DM) with reference to criteria, subcriteria and variants. Values of importance elements (criteria, subcriteria and variants) are more

consistent, when the value of the calculated consistency index (CI) is smaller. If the value of CI is close to 0 the preferential information given by the DM is considered to be almost perfect. The acceptable level of *CI* is below 0.1. If the *CI* > 0.1 then it is necessary to verify the preferential information given by the DM because it is too non-coherent.

- **The final ranking of variants** – it is final ordering of variants from the best to the worst, which come into based on values usefulness.

6. Analysis and comparison of obtained results.
7. Choice of the best desirable solution, conclusion.

Compensating – Conjunction Method [10]

Analysis based on Weighted Summation Methodology – proposed by Prof. Rudnicki 1999 [10]. This model expresses rule „something for something" - low weight of one criterion can be compensated by high value of another one.

Procedure of methodology

- setting of the problem (definition of possible variants).
- definition of a list of consistent family of criteria in one or multistage ordering,
- determination of the weight of criteria (threshold character),
- assessment of the fulfilment level of individual criterion for each variant,
- elimination of solutions which do not fulfil the threshold criterion,
- aggregation of partial assessments in global assessment,
- Ranking of variants as a result of values of global assessment indicators.

The global assessment of criterions S_j for the *j* - variant is determined as follows:

$$S_j = \sum_{i=1}^{n} w_i \cdot s_{ij}$$

Where:
s_{ij} – level of fulfilment of *i* criterion in *j* solution / for the j-variant (in % or in scale from 1 to 10),
n – number of criteria,
w_i – weight of *i* criterion (weights of partial criterion are normalized) so that:

$$\text{wi} > 0, \quad \sum_{i=1}^{n} w_i = 1$$

The higher the S_j value, the better the variant is.

Calculating S_j values for individual variants allow assessing their global quality. One dimensional assessments obtained in this way enable to explicitly compare the results (i.e. compare directly all variants).

Weights of partial criteria are normalized (their sum equals to 1.0). In the case of hierarchical structure of criteria, they are summed up in a two-step operation: 1) the weights of partial criteria are taken into account, 2) the weights of groups of criteria are considered.

Application of MCDA methods in transport field

Nowadays we can observe significant development of MCDA methods. This methodology is commonly used in solving of problems in field of transport, logistics, economics, and social science. Examples of the practical application of the MCDA methodology in transport and logistics fields are presented below:

- ***Multicriteria assessment of freight transport systems*** [14]: two kinds of methods were applied to the quality evaluation of seven alternative transport systems, where each system was operated by one transport company. All transport companies were similar in terms of their annual turnovers. They rendered domestic freight transportation services, including bulk cargo shipments primary. The MCDA methods Electre III/IV, Oreste and Mappac were applied.
- ***Multicriteria choice of the operators of logistics services*** [13] – the way of the choice was done with utilization of the ELECTRE III/IV method.
- ***The choice of route of bike paths*** [6,16] – In the framework of the Civitas II - Caravel project, the bike paths connections between campuses of Krakow University of Technology was worked out and then the choice of the best solutions (best connection) was done using the AHP and the compensating - conjunction methods.
- ***The choice of the routes of roadway*** [10] in the framework of the project concerning localization of Balicka Route in Krakow, seven variants of the roadway routes were mapped out. In the process of the choice of the best solutions (best variant of the roadway route) the compensating - conjunction method was applied.
- ***Evaluation of the integrated urban transport system*** [19,20] – five alternative variants which enable to integrate the urban transport system in Poznan were accepted. AHP and Electre III/IV methods were applied to evaluate the system.
- ***Multicriteria evaluation of the Polish urban transport system*** [15]: Six variants of urban transport systems in Polish cities were evaluated. The AHP and Electre III/IV methods were applied for conceptual experiments.
- ***A multiple Criteria Approach for the Evaluation of the Rail Transit Networks In Istanbul.*** **H. Gercek and others** [22] - three alternative rail transit network proposals were evaluated by using Analytic Hierarchy Process (AHP), a multiple criteria decision support system. The AHP facilitated decision-making by organizing perceptions, experiences, knowledge and judgments, the forced that influence the decision, into a hierarchical framework with a goal, scenarios, criteria and alternatives of choice. Based on this analysis, the decision makers have developed a new alternative as a combination of the most closely competing two alternative rail transit networks.
- ***An Assessment of Transportation Alternatives for Istanbul Metropolitan City for Year 2000.*** **Ergun M., Iyinam S., Iyinam A.** [23] - a comprehensive multicriteria assessment of transportation alternatives for Istanbul metropolitan area were carried out. Nine variants were considered. They involved the construction and extension of metro line, development of a commuter rail system and a construction of new bridges.
- ***Ranking of Suburban Line Extension Projects on the Paris Metro System by a Multicriteria Method.*** **Roy B., Huggonard J.** [24] - the evaluation of 12 suburban line extension projects on the Paris metro system was carried out with usage of specific multicriteria method, ELECTRE IV. Based on the concepts of “pseudo-criterion” and “outranking”, it led to a final partial ranking established without any kind of weighting of the criteria. After a statement of the problem, the principles and three stages of the

method were presented. A final discussion on the results established its validity in such a case, as well as for various other applications.

- ***Multicriteria Ranking of Urban Transportation System Alternatives*. Gomes L.** [25] - A method to rank urban transportation system alternatives, taking into consideration multiple criteria was presented. Those criteria can be quantifiable or not. The new method is founded on Utility Theory and it makes use of absolute weighting and pairwise comparisons. It has important practical advantages over other existing methods, the most important among those advantages being its capability to be understood and accepted by professionals and by the public.
- ***Transport Planning with Multiple Criteria: The Analytic Hierarchy Process Applications and Progress Review.* Saaty T.** [27] – Five examples of applications of the Analytic Hierarchy Process (AHP) are made to illustrate the different uses of this ratio scale multicriteria decision method in transportation. They include a commuter route selection hierarchy, a best mix of routes to Pittsburgh's new International Airport, a benefits/costs hierarchy to choose the best mode to cross a river, a planning hierarchy for a transport system and a simple dependence with feedback cycle to choose a car when criteria depend on the alternatives. For a better appreciation of the use and power of the method, the examples are followed by a resume of developments in research on the (AHP) in the last few years.
- ***A Fuzzy Multicriteria Model to Evaluate the Privatization of the Public Bus Operations*. Chang Y.-H., Shyu T.-H** [27] - A double model based on fuzzy synthetic decision and a fuzzy multicriteria decision is presented for this study. In a basic level decision, we use a fuzzy synthetic decision to reduce the sub-criteria calculation work. In a higher level decision, the approximation reasoning allows the decision maker to make his best choice. These methods are more in accordance with the thinking processes of the human mind when complex issues are involved. Therefore, this paper will use a fuzzy linguistic approach, instead of the traditional approach to avoid the interference of the numerical estimates for weight and performance of alternatives.
- ***Public Transportation System Project Evaluation: A Fuzzy Delphi AHP*. Hsu T.H.** [28] – applies a fuzzy Delphi AHP to the evaluation of the mass transit system in Kaohsiung. The author handles the multi-criteria group decision making process with uncertainly and vagueness involved in the experts opinions. Finally, the author ranks different transportation projects for mass transit system.
- ***The Strategic Evaluation of New Technologies through Multicriteria Analysis: The Advisors Case*. Macharis C, Verbeke A. and K. De Brucker** [29] – the economic experts participating in the ADVISORS project, a large scale, pan-European study co-funded by the European Union (2000–2002), have developed a strategic evaluation methodology building upon multicriteria analysis (MCA), to assess advanced driver assistance systems (ADAS). ADAS is a set of new technologies intended to fundamentally improve road safety in the European Union. This new MCA methodology is based on the analytic hierarchy process (AHP) of Saaty and synthesizes information from both stakeholder analyses and technical performance studies.
- ***A Decision Support Approach for the Evaluation of Transport Investement Alternatives*. Caliskan N.** [30] – A new decision support approach was used to evaluate potential transportation investments by using the opinions and experience of experts as its base. Modern decision-making methods such as the Cognitive Map and Analytic Hierarchy Process were used in the creation of this approach. The Cognitive Map is a process based on a chain of interviews held with transportation experts. The

data obtained from the Cognitive Map were utilized to determine the fundamental and sub-criteria. Then, an Analytic Hierarchy model was established and this model was used to determine the most suitable investment choice for the Third Bosphorus crossing. The implementations of the approach and findings are summarized in this paper.

- ***Multiple Criteria and Fuzzy Based Evaluation of Logistics Performance for Intermodal Transportation*. Hanaoka Shinya, Kunadhamraks Pichet** [31] – Fuzzy set techniques were applied to assess the logistics performance within the decision process of freight operators. Using a fuzzy-based approach, fuzzy-AHP was applied to assess the criteria by different judgment procedures. Consequently, fuzzy-MCDM was used to assess operators' perception of the logistics performance via proper assignment of numerical scores. The subjective judgments for hierarchical criteria were transformed into fuzzy degrees of score. The methodology provided an alternative approach to facilitate the importance of a set of performance criteria. It can also entail use of improved corresponding parameters to develop a better freight transport system.
- ***The Multi-Actor Multi-Criteria Analysis (MAMCA) application in the Flemish long-term decision making process on mobility and logistics***. **Cathy Macharis, Astrid De Witte, Laurence Turcksin** [32] - The Multi-Actor Multi-Criteria Analysis (MAMCA) is a methodology to evaluate different policy measures whereby different stakeholders' opinions are explicitly taken into account. The MAMCA methodology has been used in the "Flanders in Action Process". One of the objectives of this process was to turn Flanders into a top region in terms of mobility and logistics by attracting logistic activities with a large added value, realizing fluent and widely accessible mobility, a huge increase in traffic safety and a decrease of the environmental impact of transport. As there were a wide range of actors with different interests involved in this process, the MAMCA methodology was applied to evaluate a set of possible policy measures being proposed to reach this objective. An important advantage of this methodology is that it is able to support the decision maker in his final decision as the inclusion of different points of view leads to a general prioritization of the proposed policy measures.

The MCDA methodology is the most real, natural and the human nearest concept of the decision making. It exist everywhere we take into consideration several factors (criteria), interests of different stakeholders (people who are interested in selected solutions).

Taking into consideration the character of the POSMETRANS project, the Compensating – Conjunction Method is more appropriate then AHP Method regarding the following issues:

- the Compensating – Conjunction Method:
  - Is intuitively convincing and clear,
  - Allow to split global assessment into the sequence of partial assessments taking into account factors (criteria) with different meaning.
- AHP Method has some weakness:
  - The process of generation of matrix, where we are comparing in pairs, is based on subjective decision-makers' opinions. The higher the number of these subjective comparisons, the higher the risk of loss of consistency in sequences of comparison is.
  - This method is highly time-consuming. In the POSMETRANS project we would have to take into consideration a high number of matrixes of pair comparison

(for each group - policy measures, innovative technologies and key players - pair comparisons of all criteria with each other as well as pair comparisons of all variants with respect to each criterion should be performed, which would correspond to about 9 matrixes 10x10 per group).

The idea of POSMETRANS project is that all partners should have an impact on the final ranking of policy measures, innovative technologies and key players. This would be difficult using the AHP Method because it requires all partners to follow the entire AHP procedure of comparison in order to have an influence on the final ranking. Comparatively, the Compensating – Conjunction method can be easily implemented when many partners should have an impact on the final decision.

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3. Definition of the consistent family of criteria for the POSMETRANS project

A consistent family of criteria is a set of criteria meeting the following conditions:

- it takes into consideration all possibility aspects of the considered problem: technical, economical, environmental and social aspects,
- coherence of assessment,
- non-redundancy (it means uniqueness of meaning scope of criteria).

Groups of criteria were set for three variant groups which are: key players in innovation, policy measures and innovative technologies. The definitions of each criterion as proposed by project partners are presented below:

Definitions of the consistent family of criteria for **Policy Measures**:

- **C1: Geographical area of enforcement -** This criterion indicates on what geographical area policy measure is/can be enforced: local, national or EU.
- **C2: Time of enforcement -** In the case of EU funding programme this criterion makes reference to the average length of the projects funded. When considering regulations in general, it refers to the time length passing from their approval to the time when they are actually put in force. For a guideline/action plan: time-scale concerned by the paper.
- **C3: Ease of enforcement/bureaucracy burden -** This criterion indicates the level of complexity in implementing a policy measure / accessing a funding programme. Is the process easy to understand and follow, transparent, time-consuming or not, requires taking into account many non-technical aspects such as social and environmental aspects, requires specifically trained personal.
- **C4: Mandatory level -** Level of obligatory nature of policy measures. For example, recommendations, opinions, communications (low level); regulations, decisions or directives (high level).
- **C5: Part of comprehensive and holistic strategy/approach** - The criterion means the policy measure is integral to a long-term and comprehensive strategy / vision which aims at considering the most facets of a problem / situation.
- **C6**: **Dissemination extent -** Existence of weak/strong information channel between policy maker and policy target (weak: communication only through a website - Middle: info disseminated at local contact points, or through cluster/networks - strong: direct contact between policy maker and policy target (visit/mailing...).
- **C7**: **Level of support to R&D activities -** The criterion means the policy measure (both EU funding programme and regulations) supports R&D activities (the biggest the support is - for example grants allocated to R&D activities- the highest the rank is) in different ways.
- **C8**: **Consistency with EU standards -** Criterion indicates if the policy measure is in compliance with EU standards, and if it is consistent with EU standards, or results from them.
- **C9**: **Safety and security aspects -** Are safety and security aspects taken into account in the policy measure? (High rank: it is clearly defined what must be taken into account and/or it is actually the theme of the policy - low rank: not even mentioned).
- **C10**: **Consumer oriented -** This criterion indicates in which extent the interest of consumers / end-users of a technology is taken into account (high: policy directly intended at improving the consumer well-being - low: consumer well-being not considered or only indirectly).

- **C11**: **Total allocated budget -** High of the total allocated budget (only applicable to funding programmes).
- **C12**: **Industry participation -** Percentage of funding allocated to industry partners (Rank 1: 0-10%, 2: 11-20%, 3: 21-30%, 4: 31-40%, 5: 41-50%, 6: >51%).
- **C13**: **SME participation -** Percentage of funding allocated to SME partners (Rank 1: 0-10%, 2: 11-20%, 3: 21-30%, 4: 31-40%, 5: 41-50%, 6: >51%).
- **C14**: **Incentive taxes system -** This criterion indicates if the use of incentive taxes is planned either to penalize those who do not follow a policy measure (e.g. CO2 tax) or to help/simplify/encourage investments/the implementation of policy measures.
- **C15**: **Environmental commitment -** Criterion indicates the degree of commitment with environmental sustainability of policy measure.

Definitions of the consistent family of criteria for **Innovative Technologies**:

- **C1: Reliability -** Criterion indicates whether or not the technology works correctly and fulfils its functions in expected time and in specified conditions of exploitation.
- **C2: Implementation flexibility -** Criterion indicates whether or not the technology is easy to implementation in specific (local) circumstances**.**
- **C3: Transferability -** Criterion indicates whether or not technology can be transferable and implemented in different conditions e.g. in different country.
- **C4: Level of competition -** This criterion indicates how many actors are (potentially) active in a given technological field and how far they already are in the implementation of this technology. The level of competition also depends on the market extent: e.g. 10 actors in a niche market might already mean a high level of competition whereas 100 enterprises in Europe for a market where the consumers are the whole population of Europe might correspond to a very low level of competition.
- **C5: Position of SMEs -** This criterion is an estimation of the amount of SMEs (percentage of the total number of enterprises in the field) involved in the industrialization of an innovative technology.
- **C6: Existence of networks/associations supporting this technology -** Existence and size of networks/clusters/associations supporting a given innovative technology.
- **C7: Job creation -** Thanks to the introduction of the innovative technology the rate of employment has increased (think for example of the jobs created through by the Green economy).
- **C8: Life quality improvement -** Thanks to the introduction of the innovative technology citizens' and /or workers' life has become better (time saving, reduced physical efforts, reduction of traffic problems).
- **C9: Accessibility -** Degree to which a technology (product, device, service) is accessible by as many people as possible**.**
- **C10: Customers' acceptance -** It means the innovative technologies are well perceived and thought as valuable, useful and efficient by the end-users.
- **C11: Risk management -** Criterion indicates how high is the identification, assessment and prioritization of risk followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events concerning innovative technology.
- **C12: Cost of the implementation -** Criterion indicates the costs related to necessary personal and equipment investments related to the implementation of a new technology (from R&D to production).

- **C13: Added value -** Criterion indicates how high is the difference between the sale price of a technology and the cost of its production.
- **C14: Time to market -** Time to market is the length of time it takes from a product being conceived until its being available for sale.
- **C15: Market position -** How far is the innovative technology developed: is it to date only existing at R&D level or is the technology already available on the market (Rank 1: technology invention -> 2: laboratory prototype -> 3: Industrial demonstrator -> 4: industrialisation -> 5: market entry).
- **C16: Environmental friendly -** Criterion indicates whether or not the technology inflicts minimal or do not harm on the environment, e.g. concerns renewable energies commitment and CO2 reduction commitment.

Definitions of the consistent family of criteria for **Key Players**:

- **C1: Territorial coverage in which they operate -** This criterion means how wide spread (f.i. regional, national, European, world-wide scale) is the territory where the key player works / can have influence on.
- **C2: Influence in sector -** Criterion indicates the access to decision making on trends or policies, by market power (big companies) or political power (government institutions).
- **C3: Membership in networks -** Is the person/entity member in a cluster/network and how many of them (high number of membership = high ranking) - criterion intended for enterprises and research institutes.
- **C4: Direct communication channel with innovation actors from the industry -** Criterion intended for policy makers and networks: do they have a direct and regular contact with innovation actors in the research and industry (especially SMEs) - this should indicate how well a key player is effectively informed about the current technological and economical situation (and if he/she is entitled to become a POSMETRANS expert).
- **C5: Number of patents -** Criterion indicates how many patents have been/are created by key player.
- **C6: Number of implemented technologies -** Criterion indicates how many technologies have been/are implemented by key player.
- **C7: Involvement in training sector -** This criterion indicates how deeply involved and committed the key player is, with regards to carrying out training activities (both targeted to their members and to a broader audience).
- **C8: Capacity of know-how transfer -** This criterion means the key player is able to make the know-how accessible and usable by third parties.
- **C9: Number of employees/members -** Criterion indicates how many people are employed in key player enterprise / how many members are registered in the key player network.
- **C10: Contribution to the Municipality -** Criterion indicates how the company can support and guide municipalities on transport matters.
- **C11: Awareness of the brand -** Criterion indicates whether or not the society is aware of the key player existing on the market and know his products.
- **C12: % of the turnover invested in R&D activities –**This criterion indicates which percentage of the annual turnover is spent on R%D activities (both internally and given in outsourcing).
- **C13: The new technologies/the action undertaken respect the new targets set by the European Agenda 20-20-20 -** In the Europe 2020 Strategy, the Commission

identifies three key drivers for growth: smart growth (fostering knowledge, innovation, education and digital society), sustainable growth (making our production more resource efficient while boosting our competitiveness) and inclusive growth (raising participation in the labour market, the acquisition of skills and the fight against poverty). Progress towards these objectives will be measured against five representative headline EU-level targets: 1)75 % of the population aged 20-64 should be employed. 2) 3% of the EU's GDP should be invested in R&D. 3) The "20/20/20" climate/energy targets should be met. 4) The share of early school leavers should be under 10% and at least 40% of the younger generation should have a degree or diploma.5) 20 million less people should be at risk of poverty.

Criteria for policy measures, innovative technologies and key players were then divided in four groups of criteria: functional, economical, social and environmental. Within each group, criteria were given weights from 1 to 5 by each project partner, where 1 means the lowest weight (rank) - unimportant criterion, 5 means the highest weight (rank) - very important criterion. Weights of criteria for policy measures, innovative technologies and key players were presented below in tables 1, 2 and 3.

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Table 1: Criteria and weights of criteria for policy measures

Criterion		Group of criteria	Criteria proposed by						Weight of criteria (1: lowest rank, 5: highest rank)								Weight of group of criteria: functional, social, economical, environmental (1: lowest rank, 5: highest rank)							
			SEZ	ACCIONA	EGE	IVT	CUT	URCC	SEZ 1	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *	SEZ 1	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *
C1	Geographical area of enforcement	Functional					✓		4	4	4	3	4	3	3	3	3,3	4	4	4	4	4	3	4	4	3,8
C2	Time of enforcement		✓					✓	3	5	3	4	3	3	3	5	3,6									
C3	Ease of enforcement/ bureaucracy burden						✓		3	4	4	5	5	5	5	5	4,8									
C4	Mandatory level			✓					5	3	5	5	4	2	4	5	4,1									
C5	Part of comprehensive and holistic strategy/ approach							✓	2	3	2	3	4	2	2	4	2,9									
C6	Dissemination extent		✓						2	3	4	3	4	4	4	3	3,5									
C7	Level of support to R&D activities							✓	4	2	3	4	4	4	4	5	4,0									
C8	Consistency with EU standards						✓		1	1	1	3	4	2	3	4	2,8									
C9	Safety and security aspects	Social	✓						3	4	3	3	4	4	4	4	3,7	3	4	3	3	4	4	3	4	3,6
C10	Consumer oriented		✓						3	4	3	5	5	3	5	5	4,4									
C11	Total allocated budget	Economical	✓						4	4	4	5	5	4	5	5	4,7	5	4	5	5	5	3	5	4	4,4
C12	Industry participation		✓						5	4	5	5	4	3	3	3	3,8									
C13	SME participation		✓						5	5	5	5	5	4	5	5	4,8									
C14	Incentive taxes system		✓						3	3	4	4	5	4	4	4	4,1									
C15	Environmental commitment	Environmental		✓					2	4	4	2	4	5	4	4	3,7	3	4	3	2	4	4	3	4	3,4

Table 2: Criteria and weights of criteria for innovative technologies

Criterion		Group of criteria	Criteria proposed by						Weight of criteria (1: lowest rank, 5: highest rank)								Weight of group of criteria: functional, social, economical, environmental (1: lowest rank, 5: highest rank)								
			SEZ	ACCIONA	EGE	IVT	CUT	URCC	SEZ 1	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *	SEZ 1	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *
C1	Reliability	Functional					✓		2	3	2	3	3	2	4	5	3,2	5	3	5	4	5	3	5	4	4,2
C2	Implementation flexibility				✓		✓		1	3	4	3	5	4	4	4	3,8									
C3	Transferability						✓		3	3	4	5	4	4	3	5	4,1									
C4	Level of competition		✓						2	3	2	4	4	3	3	3	3,2									
C5	Position of SMEs		✓						3	3	5	5	5	5	5	5	4,8									
C6	Existence of networks/ associations supporting this technology		✓						5	4	5	5	4	4	3	3	3,9									
C7	Job creation	Social						✓	3	4	5	4	4	3	3	5	3,8	4	4	4	3	4	4	3	5	3,8
C8	Life quality improvement							✓	3	5	4	3	4	3	2	4	3,3									
C9	Accessibility			✓					2	4	4	3	4	2	3	4	3,2									
C10	Customers' acceptance						✓	✓	3	5	3	5	4	3	4	5	4,1									
C11	Risk management	Economical			✓		✓		4	3	4	4	5	4	5	4	4,3	4	4	4	4	4	3	4	4	3,8
C12	Cost of the implementation						✓		4	3	4	3	4	5	4	4	3,9									
C13	Added value						✓		2	4	3	3	4	3	3	3	3,2									
C14	Time to market							✓	3	4	5	3	4	4	2	5	3,7									
C15	Market position		✓						5	4	5	5	4	2	3	5	3,9									
C16	Environmental friendly	Environmental					✓		4	4	4	3	5	4	4	3	3,8	3	4	3	3	4	4	2	3	3,2

Table 3: Criteria and weights of criteria for key players

Criterion		Group of criteria	Criteria proposed by						Weight of criteria (1: lowest rank, 5: highest rank)								Weight of group of criteria: functional, social, economical, environmental (1: lowest rank, 5: highest rank)								
			SEZ	ACCIONA	EGE	IVT	CUT	URCC	SEZ 1	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *	SEZ	SEZ 2	SEZ 3	ACCIONA	EGE	IVT	CUT	URCC	Average *
C1	Territorial coverage in which they operate	Functional						✓	4	4	4	3	4	4	4	5	4,0	5	4	5	4	5	5	5	4	4,6
C2	Influence in sector			✓					3	4	5	3	5	3	4	5	4,0									
C3	Membership in networks		✓						5	3	4	5	5	5	4	4	4,5									
C4	Direct communication channel with innovation actors from the industry		✓						4	5	4	4	4	2	5	4	3,9									
C5	Number of patents						✓		3	2	2	2	3	2	3	3	2,6									
C6	Number of implemented technologies						✓		2	4	2	5	4	2	5	4	3,8									
C7	Involvement in training sector	Social						✓	4	2	4	4	4	5	4	4	4,1	3	3	4	3	4	3	3	4	3,4
C8	Capacity of know-how transfer							✓	4	3	4	4	5	3	4	5	4,1									
C9	Number of employees/ members						✓		3	3	3	2	3	2	3	2	2,5									
C10	Contribution to the Municipality				✓				2	3	5	4	5	3	3	3	3,6									
C11	Awareness of the brand						✓		3	4	2	2	4	3	3	4	3,2									
C12	% of the turnover invested in R&D activities	Economical						✓	5	4	4	5	4	2	4	4	3,9	5	4	4	5	4	4	3	4	4,1
C13	The new technologies/ the action undertaken respect the new targets set by the European Agenda 20-20-20	Environmental						✓	3	5	3	3	4	3	2	3	3,1	3	5	3	3	4	3	3	3	3,3

* The way of average calculation = ((SEZ 1 + SEZ 2 +SEZ 3)/3 +ACCIONA + EGE + IVT +CUT + URCC)/6

From list of criteria showed in tables 1-3, about four to seven criteria should be chosen for policy measures, innovative technologies and key players. For future analysis criteria which received the highest weight were chosen, according to the following rule:

- Criteria which has weight : <5,4> - green colour - were accepted
- Criteria which has weight : (4,3> - yellow colour – to the question
- Criteria which has weight : (3,0> – red colour – were rejected

As a result, the following criteria were chosen:

1. For the policy measures
   - Ease of enforcement/bureaucracy burden
   - Mandatory level
   - Level of support to R&D activities
   - Consumer oriented
   - Total allocated budget
   - SME participation
   - Incentive taxes system
   - Environmental commitment (although this criterion got low weight 3,7 – it should be taken into account to the future analysis because of necessity of fulfilment of first condition of consistent family of criteria (exhausting of assessment).
2. For the innovative technologies
   - Transferability
   - Position of SMEs
   - Customers' acceptance
   - Risk management
   - Environmental friendly (although this criterion got low weight 3,8 – it should be taken into account to the future analysis because of necessity of fulfilment of first condition of consistent family of criteria (exhausting of assessment)).
3. For the key players
   - Territorial coverage in which they operate
   - Influence in sector
   - Membership in networks
   - Involvement in training sector
   - Capacity of know-how transfer
   - % of the turnover invested in R&D activities (although this criterion got low weight 3,9 – it should be taken into account to the future analysis because of necessity of fulfilment of first condition of consistent family of criteria (exhausting of assessment).
   - The new technologies/the action undertaken respect the new targets set by the European Agenda 20-20-20 (although this criterion got low weight 3,1 – it should be taken into account to the future analysis because of necessity of fulfilment of first condition of consistent family of criteria (exhausting of assessment).

Accepted criteria were weighted a second time from 1 to 5 (where 1 means the lowest weight - unimportant criterion, 5 means the highest weight - very important criterion) by each project

partner. Final values of weights of accepted criteria (average values form values proposed by all partners) are presented in tables 4, 5 and 6.

Table 4: Weights of accepted criteria for policy measures

Criterion		Description	Group of criteria	Weight of criteria (1: lowest rank, 5: highest rank)						
				SEZ	ACCIONA	EGE	IVT	CUT	URCC	average
C1	Ease of enforcement/bureaucracy burden	This criterion indicates the level of complexity in implementing a policy measure / accessing a funding programme. Is the process easy to understand and follow, transparent, time-consuming or not, requires taking into account many non-technical aspects such as social and environmental aspects, requires specifically trained personal...	Functional	4	4	4	4	5	5	4,3
C2	Mandatory level	Level of obligatory nature of policy measures. For example, recommendations, opinions, communications (low level); regulations, decisions or directives (high level).		3,5	3	4	4	4	4	3,8
C3	Level of support to R&D activities	The criterion means the policy measure (both EU funding programmes and regulations) supports R&D activities (the biggest the support is - for example grants allocated to R&D activities- the highest the rank is) in different ways.		4,5	4	5	3	4	5	4,3
C4	Consumer oriented	This criterion indicates in which extent the interest of consumers / end-users of a technology is taken into account (high: policy directly intended at improving the consumer well-being - low: consumer well-being not considered or only indirectly).	Social	3	4	3	4	3	5	3,7
C5	Total allocated budget	High of the total allocated budget (only applicable to funding programmes).	Economical	3	4	5	4	3	4	3,8
C6	SME participation	Percentage of funding allocated to SME partners (Rank 1: 0-10%, 2: 11-20%, 3: 21-30%, 4: 31-40%, 5: 41-50%, 6: >51%).		5	5	5	5	5	4	4,8
C7	Incentive taxes system	This criterion indicates if the use of incentive taxes is planned either to penalise those who do not follow a policy measure (e.g. CO2 tax) or to help/simplify/encourage investments/the implementation of policy measures.		3,5	4	4	5	4	3	3,9
C8	Environmental commitment	Criterion indicates the degree of commitment with environmental sustainability of policy measure.	Environmental	3	4	4	5	4	4	4,0

Table 5: Weights of accepted criteria innovative technologies

Criterion		Description	Group of criteria	Weight of criteria (1: lowest rank, 5: highest rank)						
				SEZ	ACCIONA	EGE	IVT	CUT	URCC	average
C1	Transferability	Criterion indicates whether or not technology can be transferable and implemented in different conditions e.g. in different country.	Functional	4	5	5	5	5	5	4,8
C2	Position of SMEs	This criterion is an estimation of the amount of SMEs (percentage of the total number of enterprises in the field) involved in the industrialization of an innovative technology.		4	4	5	4	4	5	4,3
C3	Customers' acceptance	It means the innovative technologies are well perceived and thought as valuable, useful and efficient by the end-users.	Social	3,5	4	3	5	4	4	3,9
C4	Risk management	Criterion indicates how high is the identification, assessment and prioritization of risk followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events concerning innovative technology.	Economical	4	5	5	5	4	3	4,3
C5	Environmental friendly	Criterion indicates whether or not the technology inflicts minimal or do not harm on the environment, e.g. concerns renewable energies commitment and CO2 reduction commitment.	Environmental	2,5	4	4	5	3,5	4	3,8

Table 6: Weights of accepted criteria for key players

Criterion		Description	Group of criteria	Weight of criteria (1: lowest rank, 5: highest rank)						
				SEZ	ACCIONA	EGE	IVT	CUT	URCC	average
C1	Territorial coverage in which they operate	This criterion means how wide spread (f.i. regional, national, European, world-wide scale) is the territory where the key player works / can have influence on.	Functional	5	3	4	2	3,5	3	3,4
C2	Influence in sector	Criterion indicates the access to decision making on trends or policies, by market power (big companies) or political power (government institutions).		4	4	5	3	5	4	4,2
C3	Membership in networks	Is the person/entity member in a cluster/network and how many of them (high number of membership = high ranking) - criterion intended for enterprises and research institutes.		4	4	4	4	4	4	4,0

C4	Involvement in training sector	This criterion indicates how deeply involved and committed the key player is, with regards to carrying out training activities (both targeted to their members and to a broader audience).	Social	2	3	4	4	3	3	3,2
C5	Capacity of know-how transfer	This criterion means the key player is able to make the know-how accessible and usable by third parties.		3,5	4	5	4	5	5	4,4
C6	% of the turnover invested in R&D activities	This criterion indicates which percentage of the annual turnover is spent on R%D activities (both internally and given in outsourcing).	Economical	3,5	4	5	5	5	4	4,4
C7	The new technologies/the action undertaken respect the new targets set by the European Agenda 20-20-20	In the Europe 2020 Strategy, the Commission identifies three key drivers for growth: smart growth (fostering knowledge, innovation, education and digital society), sustainable growth (making our production more resource efficient while boosting our competitiveness) and inclusive growth (raising participation in the labour market, the acquisition of skills and the fight against poverty). Progress towards these objectives will be measured against five representative headline EU-level targets:*75 % of the population aged 20-64 should be employed.* 3% of the EU's GDP should be invested in R&D.*The "20/20/20" climate/energy targets should be met. *The share of early school leavers should be under 10% and at least 40% of the younger generation should have a degree or diploma.* 20 million less people should be at risk of poverty.	Environmental	3	3	4	4	2	3	3,2

Correction concerning the environmental criterion for key players (C7)

Because of difficulty in identification of objective parameters for evaluation of environmental criterion for key players: “The new technologies/the action undertaken respect the new targets set by the European Agenda 20-20-20” (C7), it was exchanged for criterion making reference to ISO 14 000 certifications.
The ISO 14000 is a family of internationally recognized standards for environmental management systems that is applicable to any business or organization, regardless of size, location or income. The Eco-Management and Audit Scheme (EMAS) is the EU voluntary instrument which acknowledges organizations that improve their environmental performance on a continuous basis which is based on the norm ISO 14001:2004.

The new C7 criterion is: „An ISO 14 000 certification ownership”.

The next steps in MCDA procedure for POSMETRANS project

The next steps in the chosen MCDA procedure are:

- The evaluation of level of fulfilment of criteria for each variant (innovative technologies, policy measure, and key players)
- The determination of a final ranking (for policy measures, innovative technologies, key players) following the procedure of the Compensating – Conjunction Method.