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Analysis of Model Indicators in Assessment Impact of the Teleworking on Carbon Emissions Reduction Transportation Activities

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Abstract: This paper analyzes the key indicators of the impact assessment the teleworking as practice of performing regular work from home or from a location close to home, on reducing the number of travel and reduced carbon emissions transportation activities. Models and methodologies described in the literature are a good basis for a better and more comprehensive and understanding of the positives and negative effects teleworking and real opportunities of its wider application, however there is a lack of systemic analysis. Development of a set of indicators for assessing emission reduction induced by the measures to promote sustainable transport. Due to the complexity of the transport sector, a change in any indicator models have side effects on other indicators (unwanted and multiplier effects) and what is the theme of our research work.

Key words: Teleworking, ICT-EM, GHG, ASIF, BAU.

1. Introduction

The increase in the frequency of using the online activities such as online shopping, teleworking, telemedicine and other ICT solutions can significantly contribute to reducing emissions of carbon dioxide (million metric tons) and bring significant savings in energy consumption. According to rough estimates, the further development of "smart technology" and creating opportunities for substituting physical travel by electronic communications, could be by 2020 even to achieve 15 % reduction in carbon emissions and this is "business as usual - BAU" scenario. Namely information and communication technologies enable the launch of bits (information) rather than the physical launch of the atom (matter), what is the essence of the process of dematerialization. The telecommunications system, as a system for the distribution of bits, offering an alternative to today's key problems of translation points of physical distance. Teleworking as a representative of the information and communication solutions can be defined as the practice of performing regular work from home or from a location close to home, instead of commuting. The literature for this kind of " telework " and used terms tele - work and e - work. Teleworking in order to reduce the number of trips as the idea emerged from the 1970s, but the increase in this form of switching from then until now was relatively slow. Although it is estimated that, regardless of the rapid development of information and communication technologies, broader implementation teleworking continues to be a slow process, reducing the number of commuting is considered emergence that will bring social benefits, as a way of solving the problem of congestion and the reduction of carbon emissions. Provide support to the process and the different bodies that have joined efforts in finding adequate, but primarily standardized, procedures for evaluation (quantification, monitoring and reporting) emission of

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pollutants for which it is responsible sector of information and communication technologies.

The physical transport as the object of substitution, except the benefits that brings to society, causing huge social and environmental costs, such as accidents, health risks, pollution, land cut into pieces and the emission of greenhouse gases. Creating a sustainable transport system means the balance of profit versus reducing these costs and increase profits. Strategy towards less intensive transport requires consideration of potential carbon reduction related to various measures, including a measure of teleworking.

Therefore, the paper analyzes the effects that the best way to illustrate the indicators evaluate contributions of teleworking in terms of their impact on the reduction of carbon emissions of transport activities.

2. Model and methodology Impact Assessment of Teleworking to Reduce Carbon Emissions

The model for assessing the impact of teleworking to reduce carbon emissions involves two aspects: the first relates to the assessment of emissions technology teleworking directly caused (in the manufacturing process system components and functioning), and the other on the quantification and evaluation of the effects of emission reductions resulting from the application of this solution. Both effects must be taken into account to estimate the overall utility of the application of virtual mobility. Methodological assessment process in both of these domains, based on the use of life-cycle approach (LCA - eng. Life Cycle Assessment) [1]. Existing LCA standard series ISO 14040, is the basis for developing specific methodologies intended of ICT.

The methodology called ICT Enablement Methodology (hereinafter ICT-EM), which is briefly explained below, was developed under the auspices of an international strategic partnership of information and communication companies and associations-GeSI [1, 2]. It is actually a specific instruction on how to identify and evaluate the effects of the application of ICT solutions. It was created as an expression of the need to standardize procedures for quantification of effects arising from the application of ICT-EM solutions. With a focus on simplifying assessment, over-the applicable general approach, different actors of this industry, the economy and policy makers, gain practical guide to assessment procedures. ICT is based on the LCA approach to estimate the changes that occur in the system BAU, which are a result of the adoption of various ICT solutions. It consists of three main steps: (1) define the objectives and scope of the research, (2) the limitation / reduction of assessment (3) evaluation and interpretation of the overall effects. These steps are shown in Fig. 1. and briefly explained.

The first step (defining the goal and volume of the research) requires consideration of the entire potential of the application of information and communication systems including related adverse effects. In doing so, one should take into account all the individual components of the information and communication systems, which are necessary for its functioning.

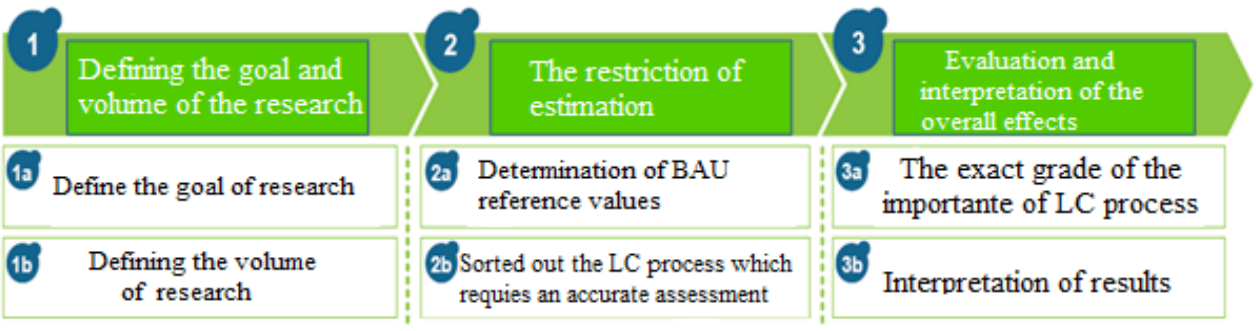

Fig. 1 Steps of ICT - EM evaluation.

In the first phase (1a) we define the purpose of the research, which requires the documentation of the purpose of the research (for example, whether it relates to the assessment of the environmental effects of a particular product or need to anticipate potential of ICT solutions to reduce carbon emissions across the country), and the users which are intended for these solutions. Defining the types of users is of importance for the assessment of greater use of a particular solution, and therefore measurable effects assessment.

In the second phase (1b), we define the scope of the research, which involves the identification of the information and communication system, BAU system and all potential positive and negative effects associated. In these effects include: direct information and communication programs, primary and secondary positive effects, and the primary and secondary backing negative effects.

The primary positive effects occur directly as a result of the introduction of ICT solutions and related to the reduction of energy consumption and reduce the number of trips. In contrast, the secondary positive effects occur after a long period of time and are usually the result of the enlargement circle of users. The primary precedes negative effects related to the increase in emissions that is usually a result of additional activities / behavior changes, which reduces the positive effects. The primary negative effects accompanying occur immediately and the result of the implementation of ICT solutions. Secondary effects occur later and are often the result of cumulative effects.

The objective of the second step (limiting assessment) is to limit the assessment of relevant effects, that is, the components of the BAU and ICT systems isolate only those processes within the life cycle of the product that significantly affect carbon emissions. In essence, the purpose of this step is to rule out processes that are estimated to significantly alter the closing marks.

In the first stage (2a) is determined by the so-called. BAU reference value which shall be the basis for the comparison of the individual contributions of the process BAU system. This value represents a change in the quantity of emissions in the life cycle of that BAU process, which is supposed to be the main driver of emissions reductions. BAU reference value may be in the form of a numeric value, or a numerical range of the order.

In the second phase (2b) for each LC process (Life cycle) determines the expected change in emissions. As for determining the baseline, quantification of impacts is a complex problem that can be solved in different ways - using existing LCA estimates for the components of information-communication solutions and BAU system, or by collecting data and using the results of small pilot studies. At the end of this phase, set aside the processes that are of influence, with the choice of threshold matter of decision - makers (for example, the decision-maker may determine to exclude all LC processes whose influence is less than 1% of baseline).

The last step (evaluation and interpretation of the effects) ICT is also composed of two phases. First made more accurate assessment of the relevant effects of the process identified in steps 1 and 2, and their aggregation (3a). Unlike the previous step, the evaluation shows the LC processes that were selected as relevant, at this stage requires reliable data. If, for example, estimate the level of scale implementation, cannot be determined reliably enough, it is necessary to consider different scenarios. Finally, in the final stage to interpret the results in the context of assumptions in terms of potential uncertainty (3b). Fig. 2 shows the concept of the overall impact of information and communication system for emissions that represents the cumulative effect of emission reduction systems BAU emissions and increasing the information and communication systems.

The methodology described is a good basis for a better and more comprehensive understanding of the positive and negative effects of teleworking and the real possibility of its wider application.

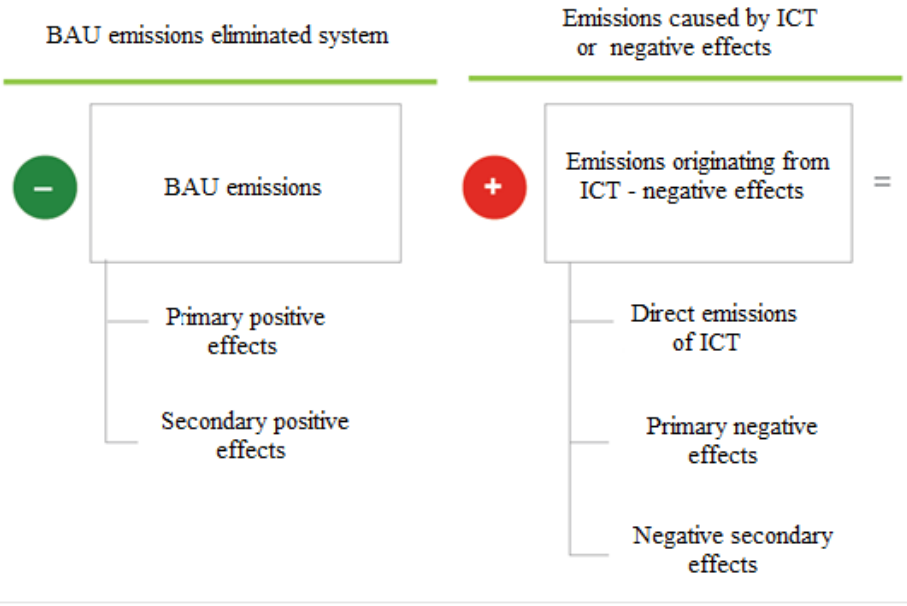

Fig. 2 The calculation of the overall positive effects.

In the first step of ICT is necessary to define the target as a basis for defining indicators, and in the case of teleworking it could be defined as research opportunities information and communication sector to reduce emissions in the transport sector, while keeping in mind the increased energy consumption in the household. Analysis can be performed at the level of the company, or employees.

The scope of the research involves defining the components of the system. This system includes a PC, printer and the necessary infrastructure such as servers and a network. BAU system components are cars, houses and structures (Table 1.)

In the next step, ICT, should we consider all positive and negative effects and isolate only those that are estimated to have a significant impact. In the case of commutation this makes the potential effects of teleworking and indicators in the analysis given in Table 2.

Table 1 System.

System	Description	The components of the system	
ICT	Teleworking	PC Printer Computerized center	4. Servers 5. Network
BAU	Commutation (relation home – job)	Private vehicle Public transportation	3. Home 4. Office

Table 2 Analysis.

Category	Identified effects
Direct emissions of ICT	Emissions equipment needed for telecommunitation
Primary positive impacts	Reducing the use of private vehicles
Secondary positive impacts	Reducing the use of public transport vehicles
	Reduced use of facilities
	Reduced construction of facilities
	The reduction of road infrastructure
The primary negative impacts	Increased energy consumption at home
The secondary negative impacts	Contribution in space
	Increasing travel by switching

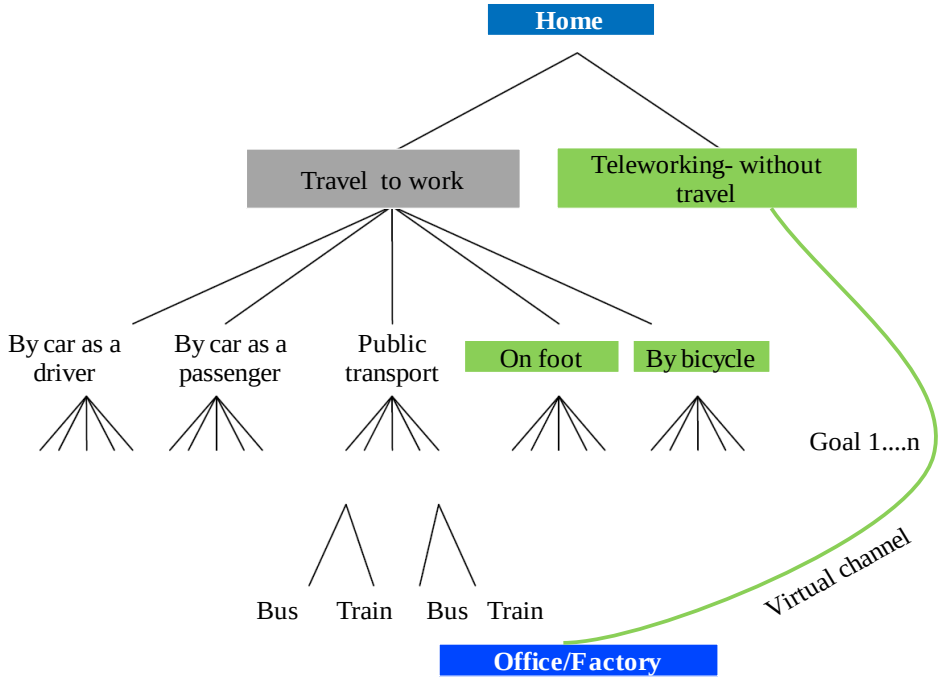

Fig. 3 The structure of regional models of physical travel and virtual channel relationships house - office / factory.

If you choose effects that are recorded in a relatively short time and at a relatively small scope of implementations (at company level), the final list of processes that require evaluation decreases. BAU reference value is determined, in this case, based on the maximum potential effect that can be achieved. This means that it is necessary to calculate the level of emissions that are transmitted using passenger cars owned by employees, public transportation per employee, etc., on the route road-job (Fig. 3.).

In doing so, they can use existing assessments and perform extrapolation of data for the number of employees in the company. Changes in emissions themselves ICT components are considered negligible, and the work of some components of the system as a server and computer centers are also not working because of the impact regardless of where they are employed. It is also assumed that employees already possess the necessary equipment (computers and printers) at home, and purchase of new equipment for teleworking is of no significance. In this case, as they identifie the following significant effects: reducing the number of trips, increasing energy consumption in the household and reduce equipment and energy use in commercial buildings. All of them are processes that need to be mathematically quantified only in the operation phase (LC process is not complete).

For further calculation is necessary to determine the mean distance to work, then determine the percentage of employees who use passenger cars those who use public transportation and use of existing emission factors for the final calculation. The actual effect of (A) is expressed in quantity (kt) of CO_2 emissions. In the same units are also expressed in CO_2 emissions, which is reduced because it saves energy in commercial buildings / offices (B), as well as emissions resulting from the additional energy consumption in households (C). The total effect (A + BC) gives a quantitative value that is the answer to question potential usefulness of teleworking on reducing carbon emissions.

To conclude, for the quantification of the overall effects of introducing teleworking in business systems is necessary, based on the life cycle, to assess environmental impacts, to the very system components services of teleworking, and reference business system. To analyze the potential effects of reducing the environmental impact of the introduction of the service teleworking, ITU recommendations include two cases

of comparative analysis, as follows:

The first case: a comparison of the reference production system service of teleworking. In this case, assessment of environmental impacts of the reference BAU ("business as usual") production systems teleworking which it replaces.

Another case: a comparison between two services or products. The objective is to determine the differences between networks, services products teleworking, usually between old new technologies.

3. General Characteristics of the Three Indicators of the Carbon Impact of Transport Activities

When we talk about the impacts of transportation activities, they can be generally classified into direct impacts resulting from the current transport activities, with the reasons effect relationship of these effects generally clear and well understood. Then the indirect effects that are secondary tertiary effects of transport activities, where the same often have more serious consequences than direct influence, but included connections relationships are often incomprehensible and difficult to pin down. The third type of impact of transport activities are the cumulative effects of having additional, multiplier or synergistic effects. Under them we understand the different effects of direct and indirect impacts on the ecosystem, and the same are generally unpredictable.

Secondly, we know that the indicator symbol or variable focused on the state of specific measures or development, and the same communicated complex information in a simplified understandable way. International Institute for Sustainable Development defines indicators as follows: "The indicator quantifies and simplifies the appearance and helps us to understand the complex reality. Indicators were collected from the raw processed data, but they can still muster in the form of a complex mark." In our case the indicators used as a "pointer" as a factor of mathematical determination of carbon reduction. The indicator can also be defined as "a parameter or a value derived on the basis of parameters, which indicates, provides information and describes the state of occurrence (environment, space) has a significant impact beyond the range of the parameter values."

Because of its importance, the four variables / variable, A (total transport activity in tone or vehicle miles), S (participation mode of transport in the road), and (energy intensity) F (CO_2 content of fuels), are called indicators of transport activities, while the variable making up these indicators called factors / actors.

The general set of indicators for the carbon impact of transport activities is an asset that can contribute to the identification of potential applications for carbon reduction sectors. Carbon indicators can be used in ex-ante assessment, for example, for planning future measures, including research and development. After the introduction of transport measures, policies or programs, indicators can be used for their assessment. Indicators for the carbon impact can be used for surveillance / control objectives in carbonic reduction, to construct forecasting models or field comparisons development of low-carbon transport.

To determine the savings in CO_2 emissions from transport activities are not only significant estimated CO_2 emissions after the measurement, but also the "business as usual" (BAU) or baseline projections of the expected emissions without measurements. For budget savings in the program appropriate to use ASIF method, since this method provides a "quick and easy" way of quantifying carbon emissions [3-6]. This is the procedure below for calculating CO_2 emissions in any form of transportation. CO_2 emissions are presented as a product of four factors: activity (A), division (S), intensity (I) and fuel (F), which are essential for assessing the transport sector the potential impacts. The formula for CO_2 transport system is [6]:

$$CO_2 = \sum_{i=1}^{n} G_i = \sum_{i=1}^{n} A_i S_i I_i \sum_{j=1}^{k_j} \lambda_j F_{ij}$$

where:

CO_2 - total emissions of all forms of transportation used by the user on his way from home to work;

G_i - CO_2 emissions of the transport vision used by the user;

n - the number of types of transport;

k_i - number of fuel in the form of transport;

A_i - total transport activity in vehicle-km per transport form;

λ_j - participation of k_i fuel in the form of transport of i(%);

j - participation of k_i fuel in the form of transport of i(%);

S_i - participation of transport forms of i;

I_i - energy intensity of transport vision of i (MJ/km);

F_{ij} - CO_2 emissions from fuels of j in transport forms of i (g / MJ).

According ASIF model, emission saving transport activity m is calculated as [6]:

$$\Delta CO_2 = A_{BAU} * S_{BAU} * I_{BAU} * F_{BAU} - A_m * S_m * I_m * F_m$$

Here, A_{BAU} represents the transport activity under the BAU scenario and A_m is the transport activity if the measures are undertaken (by analogy to other variable).

CO_2 reduction of impact on the transport activity after t years is calculated as the difference between the annual core values of CO_2 emissions per year (project) values of CO_2 emissions in the event in which it was undertaken example teleworking realization in a particular area. Alternatively, the value of emission savings for the least the transport vision can be processed using the following formula:

$$\Delta C0_2 = t * (CO_{2\,old} - CO_{2\,new}) - D = \sum_{i=1}^{n} \Delta G_i - D$$

For each of the components of A (activity), S (division by aspects), and (energy intensity) F (fuel), a single set of factors is needed to determine the carbon impact of transport measures. In addition, D as constant emissions from transport measures (for example, to build a new tram tracks) are taken into account. When you combine various ASIF measures, emission savings can be easily handled due to a possible increase in undesirable effects of any measures it has on other measures. This is because the interaction of elasticity measures with all kinds of other measures must be taken into account with the inclusion of effects, such as unwanted induced transport effects.

The transport sector is a very complex system small changes within a single field can have great effect on the whole system. In this way, one, individual transport measures cannot be estimated with the exception of the interaction. If you take the measure of reducing CO2, there are always side effects that affect the result of the measurement. This can be done in the same procedure as the original effect and thus increasing the impact (they are called multiplied effects) or working in the reverse procedure dilute the original effect (they are called undesirable effects).

An example of undesirable effects is "induced traffic" that can be seen with infrastructure measures to increase travel capacity to reduce congestion - due to better road conditions, the people next to teleworking want to run more, determination of cars increases, the induced traffic problems congestion is not resolved. If several measures undertaken at the same time, estimates about the overall impact on emissions become very difficult or even impossible. The interactions between different measures are very general character of these interactions can be positive or negative.

Example for a multifunctional effect is the interaction between measures for public transport infrastructure and price measures for individual, motorized transport, which can lead to multiplication versus collecting these effects. Another example could be the impact of measures to increase urban population densities, which will reduce transport demand due to shorter distances and thus induce a change mode of transport.

4. Analysis of the Model Evaluation Indicators

Indicators to evaluate contributions of teleworking can be developed at the international, national or

regional and local level. Monitoring indicators of assessment at the local level (or project level) is most appropriate. Monitoring at this level can bring real benefits so as to make decisions based on the monitoring and measurement. Since one of the objectives of the methodology is based on indicators comparability of indicators at different levels, some indicators should be available to all interested parties. Indicators, which are derived from the data, the basic tool for analyzing changes and trends. They are better analytical tools of data for several reasons. First, they can serve as a basis for the evaluation by providing information on the status and trends of development solutions. Secondly, as the basis of these assessments, indicators provide input for policy formulation teleworking. Third, presenting more data a number that is easier to interpret than complex statistics, already providing easier communication between the different groups.

4.1 The Goals of Teleworking

The goals application teleworking includes a description of what should be achieved in order to achieve the desired look of the new state of emissions, or operational goals of reducing emissions in the transport sector (reducing the number of trips, reduction kilometers per vehicle, reduction of transport emissions, etc.). The goals should be defined for each individual problem, which is marked as important in the projection of future conditions. For teleworking defined objectives, determine the possible indicators to measure the performance of sustainability solutions.

4.2 Developing and Defining a Set of Indicators Teleworking Impact on Reducing Carbon Emissions Transport Activities

In the accordance with established goals to reduce emissions by applying solutions of teleworking, develop define performance indicators solutions. These indicators should be related to performance that indicate the degree of compliance with the established emission reduction targets. Developing and defining indicators should be made through the following steps:

- defining the criteria for the selection of indicators assessment,
- identifying potential indicators,
- evaluation of potential indicators,
- the final selection of indicators.

4.2.1 Defining the Criteria for Selecting Indicators of Estimation

Criteria for the selection of indicators estimated are defined in accordance with the circumstances, that the priorities identified in the strategies of reducing carbon emissions. Criteria for the selection of indicators that have been proposed are:

- scientific / theoretical acceptance indicator estimates,
- representativity indicators for concrete problem teleworking,
- the ability of indicators to show the connection between cause and effect,
- the ability of indicators to show the change of values performance,
- the importance of user - friendliness indicators for the service user,
- comparison between indicators with the objectives, standards tolerance limits,
- compatibility with indicators of other solutions,
- adequacy indicators in relation to the size of the area of application solutions teleworking,
- adequacy indicators in relation to the accuracy, type, extent, and time availability of data,
- cost acceptability of indicators.

4.2.2 Identifying potential indicators of assessment

In the accordance with one or more of the adopted criteria are determined by the set of all potential indicators of impact assessment teleworking to reduce emissions. By the set of potential indicators leads the overall research literature available that can be applied in the field of application teleworking on reducing carbon emissions transport activities. Examples of possible indicators teleworking are shown in Table 3.

Table 3 Examples.

Mobility	**Indicator of reduction**
Quantity of trip	kilometers per day teleworking
	kilometers per week teleworking
	number of trips per person
	vehicle-kilometer
Type of transportation means	kilometers per week teleworking for car users
	kilometers per week teleworking for rail users
Accessibility (km)	small, medium and large working distance place
Time	**Indicator of assessment**
Temporal classification teleworking	full time teleworking
	lots outside working hours teleworking
	part time teleworking
	"ad hoc" teleworking at a distance

4.2.3 Evaluation of Potential Indicators

For each of the identified potential indicators, it is necessary to carry out the evaluation in relation to the criteria adopted for the selection of indicators. The evaluation should also be carried out in accordance with the relevance of performance to which the indicator relates to the goals established.

4.2.4 Final Selection of Indicators

At the basis of the type of evaluation of potential indicators shall be final choice of indicators. Final selection of indicators leads to a set of indicators whose values will be monitored measured in the context of reducing emissions in a particular area under consideration.

4.3 Data Acquisition and Processing

At this stage it is necessary to collect, process and interpret the data so that it allows the identification of effects spotting trends in the field of application teleworking contributions. Data collection can be performed in two ways:

1. passive collection - collection of existing data relating to obtaining data from other database sources

2. active collection - collection of new data relating to the generation of data necessary for determining the value of the adopted indicators, which cannot be obtained from other sources base.

Collection and processing of data usually includes the following phases:

1. accurately identify specific needs for data on which it is based reporting,

2. identifying reliable sources from which it is possible to get information passively,

3. determine the data that is necessary to provide active collection,

4. establishing a process of passive active data collection,

5. establish the procedure of processing the collected data.

It is recommended that at this stage of documented procedures for data collection and data processing with defined responsibilities, scope, frequency other relevant factors in relation to the collection and processing of data. Rating carbon efficiency teleworking evaluation measures for the critically depend on the carbon footprint of the data collected. Obtaining data is particularly difficult for the transport sector, because it is composed of many small mobile units. Harmonization of statistical standards is extremely important for the assessment of the system, especially in terms of sustainability carbon emissions. In the final version of the report shows the table of data quality for the relevant indicators. Data quality is significantly changed by the indicators because of the importance the fact that they are not required by all countries at the same time. Further efforts are necessary to improve

data quality, because large errors in the overall budget may happen if only one variable only with large errors.

4.4 Analysis of Research Results

After processing the "raw" data, should perform their analysis in terms of value trend observed indicators. Results of the analysis must be sufficiently representative to enable discussion comparability with previous periods (for example, if the air quality deteriorated compared to the previous period or not). In order representativeness of the data should take into account the following principles:

- always be based on the same definitions and units of measure,
- use the same method in determining the value of the indicator,
- track the movement of the indicators in the same time period,
- use the same procedures for the budget, as well as methods of controlling the site.

Particular attention should be paid to possible trends of the observed indicators (How to move? Whether how changes in one indicator affect others?) for the cases of the existence of data over a longer period of time past. This will allow you to understand what is happening what can be expected in any future period. Maybe you will discover connection between the apparently unconnected group of factors.

5. Conclusion

Based on results of analysis and research teleworking parameters, which define the combination of characteristics of the system sufficient to determine teleworking positive impact on reducing carbon emissions transport activities, it can be concluded that the current model of indicators assessment methodologies, as a set of parameters or values derived on the basis of the positive effects teleworking partially describes the situation, and does not include impacts that go beyond the range of the values of the parameters of the carbon impact of transport activities.

The analysis showed that in addition to the lack of adequate models of indicators that take into account the analysis of national mobility, an additional problem created by the lack of models to collect data on the effects teleworking. Parameters indicators proposed in the literature can only be an initial impact assessment indicators teleworking to reduce emissions of transport operations. For a more comprehensive and detailed approach to this issue are necessary wider availability of research field data. Also, the paper presents two domain approach, which represent a good starting point, but whose application is still far from routine. Complexity themselves assessment procedure the required level of data base (the necessary data their quality) to make a commitment of a regular assessment of the environmental impact teleworking still only part of the individual projects. In order to preserve the overall positive environmental impact of teleworking on reducing carbon emissions transport activities is essential that there is an integrated and standardized process for its evaluation.

Like in any research, given in terms of time and space, here opened up a number of additional issues that need to be further processed, such as the evaluation ranking of the indicators, selection of appropriate methods for estimating effects and define the model of collecting data on the effects of teleworking.

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