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Sustainable Management Organization With Example of Passenger Car Sustainability Assessment

Abstract: *This paper deals with sustainable management organization. In this paper we also present example of passenger car sustainability assessment. This exercise shows the example, of the multi-criteria evaluation for the selected number of car options and the data obtained from the open literature of car producer.*
Keywords: *Sustainable, management, organization*

1. INTRODUCTION

Sustainable development encompasses economic, social, and ecological perspectives of conservation and change. In correspondence with the WCED, it is generally defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”[1, 2] This definition is based on ethical imperative of equity within and between generations. Moreover, apart from meeting; basic needs of all; sustainable development implies sustaining the natural life-support systems on Earth, and extending to all the opportunity to satisfy their aspirations for a better life. Hence, sustainable development is more precisely defined as 'a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all harmony and enhance both current and future potential to meet human needs and aspiration .

This definition involves an important transformation and extension of the based concept of physical sustainability to the social and economic context of development. Thus, terms of sustainability cannot exclusively be defined from an environmental point of view or basis of attitudes. Rather, the challenge is to define operational and consistent terms of sustainability from an integrated social, ecological, and economic system perspective. This gives rise to two fundamental issues that need to be clearly distinguished before integrating normative and positive issues in an overall framework.

The first issue is concerned with the objectives of sustainable development; that is, “what should be sustained” and “what kind of development do prefer”. These are normative questions that involve value judgments about society's objectives with respect to social, economic, and ecological system goals. These value judgments are usefully expressed in terms of a social welfare function, which allows an evaluation of trade-offs among the different system goals.

The second issue deals with the positive aspect of sustainable development; that is, the feasibility problem of “what can be sustained” and “what kind of system we can get”. It requires one to understand how the different systems interact and evolve, and how they could be managed. Formally, this can be represented in a dynamic model by a set of differential equations and additional constraints. The entire set of feasible combinations of social, economic and ecological states describes the inter-temporal transformation space of the economy in the broadest sense.

Complexity is the property which

describes the state of complex system [6,7]. It is multi-criteria indicator which comprises all individual characteristics of the system. Complex system is entity which characterizes the structure with a large number of elements interacting among themselves. There is different structure of elements. Elements in biology are structured to perform specific function. Typical example is DNK molecule, comprising large number of elements interacting among themselves. In the information theory the structure of elements is described as the internet network with large number of nodes for information exchange. In energy system we can describe complex system as the system which produces, transport and utilize different energy sources. The complexity of these systems is the internal property of the system expressed as the wholeness property. This imply that the complexity describe the essential characteristic of the system. If the complexity is described in thermodynamic words, it represents the internal parameter of the system expressed by agglomerated indicators describing specific property of the system. If we take into a consideration only material system, we can take the entropy of the system as the macroscopic property of the system. These can be applied to chemically bounded molecules. Prigogine [8.9] has determined the characteristic property of these systems as the entropy generation. This means that every interaction between elements accompanying with mass, momentum and energy exchange ultimately is connected and contribute to the entropy generation in the system. It should be taken into a consideration that the entropy generation is defined per unit mass of the system and represent specific property of the system. So the entropy generation represents the complexity property of the system.

If we take into a consideration non-material system where complex properties include entities which are not defined per unit mass of the system, we have to introduce notion which represents wholeness of the system. Good example for this type of complex system Internet system. Large numbers of nodes are connected in large net serving to transfer information among nodes. If we assume that transfer of information contribute to the increase of informativity of the system, we can see that the increase of informatively is equivalent to the increase of the complexity of the system. In this respect the informativity is equivalent to complexity.

The management system is also complex system with defined functionality to produce, transfer and utilize different sources. Each of elements of the system is an open sub-system with different processes which perform its function by the exchange of capital and products. These transfer processes always include exchanges which are measuring parameters of the system.

If the multi-criteria evaluation of energy system is introduced in this analysis, indicators which are reflecting all potential interaction of the system and surrounding must be also recognized. In this respect, the indicators the integral parameters of the system, which comprise resource, economic, environment and social indicators will be used.

Since these indicators are given in different scales it is necessary to convert them into the specific quantities which are expressed in the same scale. Convolution of these indicators wills represent an integral measuring parameter which will reflect the total quality of the system. Any degradation of the system will lead to the decrease of Sustainability Index.

2. SUSTAINABILITY DEFINITION

Lately, in a number of years "sustainability "has become a popular buzzword in the discussion of the resources use and environment policy. Before any further discussion on the subject, it is necessary to define and properly assess the term we are going to use. So, what is sustainability? Among the terms most often adapted are the following:

a.) for the World Commission on Environment and Development (Brundtland Commission) [1] "development that meets the needs of the present without compromising the ability of future generation to meet their own needs "

b.) for the Agenda 21, Chapter 35 [2] "development requires taking long-term perspectives, integrating local and regional effects of global change into the development process, and using the best scientific and traditional knowledge available "

c.) for the Council of Academies of Engineering and Technological Sciences, Declaration of the Council Engineering and

Technological Sciences, 1995 [3] “It means the balancing of economic, social, environmental and technological consideration, as well as the incorporation of a set of ethic values “
d.) for the Earth Chapter (The Earth Chapter, 1995) [4] “The protection of the environment is essential for human well-being and the enjoyment of fundamental rights, and as such requires the exercise of corresponding fundamental duties “
e.) Thomas Jefferson, Sept.6 1889 (Jenkinson C.S.,1987) [5] “Then I say the earth belongs to each generation during its course, fully and in its right no generation can contract debts greater than may be paid during the course of its existence”

2.1 General sustainability index for the system

The definition of General Sustainability Index is essential requirement for the measurement of sustainability as the property of the system [11, 12]. It implies that the system under consideration is complex system. Close link between General Sustainability Index and complexity of the system the essential property of the system. It reflects multi-dimension and multi-criteria properties as the essential parameters in the assessment and validation of the system. It has been shown [13] any complex system is in essence is composed of a number of element which are in interaction among themselves. These interactions are described as the non-linear processes imposing some chaotic behavior.

The system is entity with a number of elements devoted to the specific function of the system [14]. For the identification of system, it is of importance to clarify elements function and their contribution to the general behavior of the system. Each element is defined with respective number of indicators describing their multi-criteria attributes. Since all indicators are defined in different scale their contribution to the general property of element have to be appropriately defined , in order to meet requirement for the general scale in which the property of element is defined.

Contribution of each element to the Index is defined by the respective weighting coefficient multiplied with agglomerated indicator for the respective element.

3. PASSENGER CAR SUSTAINABILITY ASSESSMENT

The car selection procedure is very a subjective process and strongly depends on the individual knowledge of options taken into a consideration. Usually, it is done under specific constrains reflecting the availability of reliable information.

It is of great importance to introduce the objective merits in the car selection process. Sustainability multi-criteria assessment method proves to be the efficient tool in the evaluation of the potential options in the decision making process.

The paper presents an exercise in the evaluation of number of options defined with the respective indicators describing economic, environment, technological and social characteristics. Each of the indicators is divided in the sub-indicators in order to quantify different property of the car under consideration.

The results obtained shows the Car Rating List under constrain imposed in this evaluation. It is up to the decision maker to verify personal preference in of the constrain important for the finale decision.

The transport sector has become one of the milestones of modern society. In particular, the passengers car fleet represents major a part of the transport sector. In European Union in 2004 has been 15 $x10^6$ cares which produce the amount of CO_2 which makes about 50 % of total CO_2 production in Europe. The integral oil equivalent fuel consumption by passenger cars is about 350 toe in/year 2004 (Fig. 1) [1].The total European market of passengers care in 2004 was about 150 billion Euro/year [2]. With this few general figures it can be verified that the privet car transport is one of the major concern in the future European strategy development.

[×] "The views expressed are the author's own and do not necessarily reflect those of the European Commission."

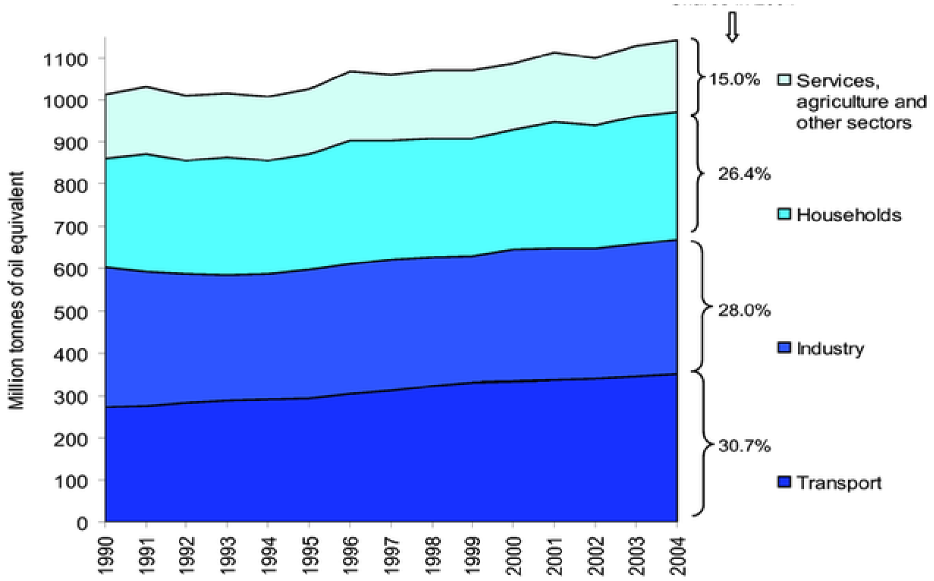

Fig.1 Equivalent oil consumption by sectors

Within the transport sector the passenger cars contribute with …% of total transport sector oil equivalent consumption. 2002 European market of passenger car was distributed among different car producers as shown on Fig. 2.

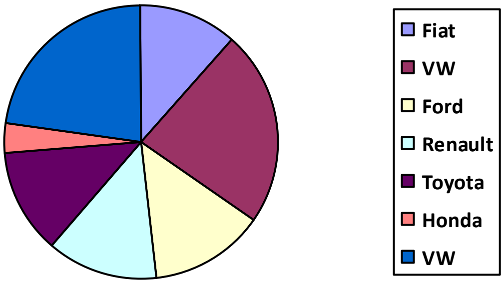

Fig.2 2002 Market share of passenger cars in Europe

It is of interest to investigate passenger cars which are available on European market in order to make classification among them.

3.1 CAR OPTIONS SELECTION

It is estimated that every year 15 millions car is sold in Europe [3]. Selection of the cars is subject to the individual choice and is mainly reflecting the tacit knowledge of the buyers. In order to assist buyers in the selection of cars it is of interest to introduce approach which is based on the objective merits composed of the different indicators reflecting objective criteria and respective indicators. This approach is aimed to promote the evaluation of car quality based on the multi-criteria assessment of individual car.

Among options under consideration are following cars: Ford Fiesta [4], Honda Jazz [5], Toyota Echo [6], VW Golf [7], Peugeot 206 [8], Renault Clio [9] and Fiat Punta [10] It is anticipated that all cars belong to the same class of passenger car.

The evaluation of selected options of

passenger car is based on a number of criteria, including Economic priority, Environment priority, Technical priority and Social priority. This will allow us to define the Rating List of the selected car sunder constrain with the different priority.
In this evaluation a following indicators are taken into a consideration: Economic Indicator with Consumption and Price sub-indicators, Environment Indicator with CO emission and NO emission sub-indicators, Technical Indicator with Acceleration and Maximum speed sub-indicators and Social Indicator with Comfort rating and Euro Market sub-indicators. Numerical values of sub-indicators is given in Table 1.

TABLE 1

INDICATORS									
	Options	Economic Indicators		Environmnet Indicators		Technical Indicators		Social Indicators	
		Consumption	Price	CO_2 emission	NO_x emission	Aceleration 0 – 60 km/h	Max. Velocity	Confort Rating	European Market
		l/100 km	Euro	g/km	mg/km	sec	km/h	Rating number	%
1	Ford Fiesta	9.51	7005	147	27	13.6	166	2	11.1
2	Honda Jazz	10.36	7500	136	43	13.3	160	3	6.4
3	Toyota Echo	9.504	11580	130	10	11.5	175	5	10.4
4	VW Golf	8.89	11950	119	16	12.2	185	4	18.8
5	Peugoue 206	8.90	11800	152	67	14.4	170	5	12.4
6	Renoult Clio	8.90	10730	159	18	13.4	183	4	10.6
7	Fiat Punto	9.05	13550	139	14	14.5	180	3	9.8

3.2 MULTI-CRITERIA CAR EVALUATION

Multi-criteria evaluation method is based on the agglomeration of normalized values of individual quality indicators multiplied by the respective weighting coefficient [11,12]. This will lead to the formation of General Index for quality assessment of each option under consideration. Normalization procedure implies selecting Minimum and Maximum value for each indicator and use following equation for normalization.

$$q_i(x_i) = \begin{cases} 1, \quad if \quad x_i \le MIN(i), \\ \left(\dfrac{MAX(i) x_i - x_i}{MAX(i) - MIN(i)} \right)^{\lambda}, \quad if \quad MIN(i) < x_i \le MAX(i), \\ 0, \quad if \quad x_i > MAX(i) \end{cases}$$

Second step in multi-criteria evaluation procedure is formation of aggregation function of sub-indicators for every indicator. It is designed as the additive function of the weighted quality sub-indicators for all criteria expressed the respective indicator.

$$I_{agg} = \sum_{i=1}^{m} w_i q_i$$

Where

I_{agg} - Aggregated indicator

w_i - weighting coefficient for sub-indicator i

q_i - normalized value of sub-indicator i

It is of interest to recognize that this will be the first level of agglomeration comprising the effect of sub-indicators to the respective indicator value. It becomes obvious that the indicator values will be depend on the weighting coefficient attached to the respective sub-indicator. This will lead us to the specific value of indicator strongly depending on the selection of procedure for the determination of weighting coefficients. There are several methods used in the decision making procedure for the determination of weighting coefficients. The most popular method is the expert procedure. It imply selection of the number of experts and ask them to justify priority of the individual option with the specific weighting coefficient for the individual sub-indicator and expressing decision in the predefined scale. The next step in this procedure is averaging weighting coefficients of all experts participating in the evaluation procedure.

This will lead us to the formation of the agglomerated indicators for all criteria so we can use agglomerated indicators for the formation of the General Index for every option under consideration.

3.3 INDICATORS

In the assessment of passenger cars a following indicators are taken into a consideration:

1. **Economic Indicator**
Within the economic indicator are following sub-indicators: Fuel Consumption and Car Price sub-indicators. The fuel consumption is expressed in liters per 100 kilometers. For each car this sub-indicator is selected from the respective information presented by car producer standard test. The car price is determined from the producer price list for the specific type of the car. In the car price is not included the taxation in the country[13].

2. **Environment Indicator**
The environment indicators comprise the CO_2 emission sub-indicator and NO_x emission sub-indicator. The data for all passengers car under consideration are taken from the Vehicle Certificate Agency, The Society of Motor Manufacturers and Traders Ltd. All cars are in the agreement with Euro 4 standard [14].

3. **Technical Indicator**
The technical indicator is defined within the scope of two sub-indicators, namely: Acceleration and Maximum speed sub-indicators. The acceleration sub-indicator is defined as the time required to reach from 0 to 60 km/h. The maximum velocity sub-indicator is taken as the velocity declared by car producers.

4. **Social Indicator**
In the car assessment the important aspect is validation of the social characteristic of passenger cars. Among the social indicators are: comfort and market sub-indicators. Comfort sub-indicator is author's assessment of all cars under consideration, taking into a consideration internal and external features of the car. The market sub-indicators expressed as the partition of every car in West European market. From the available literature it was estimated that the total market of passenger cars in 2004 was 15 million cars. The market sub-indicator is defined as the percentage participation of individual cal in the west European market. [15]

3.4 AGGLOMERATION OF SUB-INDICATORS

The first step in multi-criteria procedure is to determine the agglomerated values of the indicators to be used in the evaluation process. This requires the definition of constrains to be used in calculation the agglomerated indicators. In this exercise it will be used following constrains: equal weight for sub-indicators and weight priority to one sub-indicator. The definitions of individual indicators are

Economic Indicator

$$I_{EcI} = \sum_{i=1}^{2} w_i q_i$$

Environment Indicator

$$I_{EnI} = \sum_{i=1}^{2} w_i q_i$$

Technical Indicator

$$I_{TeI} = \sum_{i=1}^{2} w_i q_i$$

Social Indicator

$$I_{SoI} = \sum_{i=1}^{2} w_i q_i$$

In Table 2 are presented agglomerated Indicators with constrain as defined.

In the process of passenger car evaluation a following procedure is adapted. Beside collection of the numerical data of all sub-indictor as shown in the Table 1, there is a need to adapt the formatting procedure of the aggregated indicator. In the aggregation of sub-indicators for each indicator it is adapted two constrains, namely: first, equal value for the weighting coefficients for all sub-indicators and second, priority is given to one of the weight coefficient to selected sub-indicator. In Table 2 are show aggregated values of Economic Indicator, Environment indicator , Technical Indicator and Social Indicator with respective constrains.

TABLE 2 AGGLOMERATED INDICATORS

Options	**Economic Agglomerated Indicator**		**Environmment Agglomerated Indicator**		**Technical Agglomerated Indicator**		**Social Agglomerated Indicator**	
	Constrain	Constrain	Constrain	Constrain	Constrain	Constrain	Constrain	Constrain
	Fuel Consumtion = Price	Price > Fuel Consumtion	CO_2 Emission = NO_x Emission	CO_2 Emission > NO_x Emission	Aceleration= Maximum speed	Aceleratin >Maximum speed	Confor = Market	Market > Confor
Ford Fiesta	0.340	0.169	0.610	0.693	0.356	0.178	0.233	0.352
Honda Jazz	0.250	0.230	0.610	0.465	0.052	0.123	0.076	0.037
Toyota Echo	0.270	0.718	0.048	0.073	0.713	0.418	0.682	0.517
VW Golf	0.500	0.626	0.083	0.044	0.442	0.76	0.820	0.913
Peugoue 206	0.620	0.612	0.980	0.972	0.434	0.435	0.820	0.734
Renoult Clio	0780	0.423	0.603	0.812	0.313	0.895	0.522	0.450
Fiat Punto	0.922	0.821	0.334	0.394	0.624	0.878	0/223	0.247

3.5 EVALUATION OF THE PASAGER CARS

In order to obtain thee numerical justification of the passenger cars' rating is necessary to determine the cases to be analyzed. The first group of cases of interest are those which are based on the constrains with equal weight coefficients for the sub-indicators in the determination of the agglomerated indicators. In this group there are five options lists corresponding to the following constrain:

1. EcI=EnI=TeI=SoI

2. EcI>EnI=TeI=SoI

3. EnI>EcI= TeI=SoI

4. TeI>EcI=EnI= SoI

5. SoI>TeI=EcI=EnI

The Car Option Rating Lists with equal weight coefficients are shown in Table 3 .

The same procedure for the formation of the option rating list is presented in Table 4 for the option rating with the priority of weight coefficients in determination of of aggregated indicators. In the formation of General Car Option Ratinng List the same constrains are used.

TABLE 3 CAR OPTION RATING WITH EQUAL WEIGHT COEFFICIENTS

OPTION RATING with = weight coefficients for Indicator agglomeration					
	EcI=EnI=TeI=SoI	EcI>EnI=TeI=SoI	EnI>EcI= TeI=SoI	TeI>EcI=EnI= SoI	SoI>TeI=EcI=EnI
Ford Fiesta	0.357	0.676	0.294	0.161	0.298
Honda Jazz	0.199	0.329	0.237	0.143	0.090
Toyota Echo	0.489	0.200	0.769	0.740	0.219
VW Golf	0.955	0.881	0.981	0.980	0.980
Peugoue 206	0.406	0.534	0.183	0.183	0.724
Renoult Clio	0.723	0.875	0.468	0.796	0.753
Fiat Punto	0.340	0.156	0.589	0.365	0.275

TABLE 4 CAR OPTION RATING WITH PRIORITY WEIGHT COEFFICIENTS

OPTION RATING with priority of weight coefficients for Indicators agglomeration					
	EcI=EnI=TeI=SoI	EcI>EnI=TeI=SoI	EnI>EcI= TeI=SoI	TeI>EcI=EnI= SoI	SoI>TeI=EcI=EnI
Ford Fiesta	0.538	0.702	0.237	0.241	0.152
Honda Jazz	0.720	0.874	0.623	0.529	0.874
Toyota Echo	0.567	0.270	0.805	0.805	0.300
VW Golf	0.850	0.601	0.932	0.932	0.932
Peugoue 206	0.247	0.243	0.111	0.111	0.523
Renoult Clio	0.351	0.522	0.163	0.501	0.203
Fiat Punto	0.223	0.10	0.471	0.144	0.172

Final step in this evaluation is the formation of the Car Rating List which will comprise all Cases shown in the Table 3 and 4.For this evaluation it is adapted that the rating of every car option is defined by points 1 – 7 depending on the position on respective Option Rating list. Making sum of points for all cases defined by sub 1 = sub 2, the general Car Rating list is obtained as shown on Table 5

The same procedure is used for the evaluation of all cases defined with the priority of sub 1 > sub 2 . Table 6 shows the Car Rating List for all cases defined with sub 1> sub 2

TABLE 5: CAR RATING WITH THE SUME OF ALL CASES DEFINED BY SUB1 = SUB 2

Rating	Option	Points
1	VW Golf	6
2	Reanault Clio	12
3	Toyota Echo	22
4	Peugeot 206	23
5	Fiat Punto	24
6	Ford Fiesta	25
7	Honda Jazz	32

TABLE 6: CAR RATING WITH THE SUM OF CASES DEFINED BY SUB 1> SUB 2

Rating	Option	Points
1	VW Golf	7
2	Honda Jazz	13
3	Toyota Echo	16
4	Ford Fiesta	23
5	Renoult Clio	24
6	Fiat Punto	28
7	Peugeot 206	29

4. DISCUSSION

It is obvious that any of this type of the analysis strongly depend on the available data. As it was emphasized the main source of the date is taken from the car producers. Multi-criteria evaluation has proved to be the challenging method for the decision making process. In this respect the selection of passenger car is an exercise to show the immanent characteristic of the multi-criteria assessment in the decision process. It is important to emphasize that the non-numeric, in-exact, and in-complete data used in this method is the base in the mathematical tool and probabilistic weighting coefficients

As it is shown in this analysis two constrains have been imposed in the determination of Car Rating List for the selected option of the cars. The formation of the Car Rating List which comprises all Cases is shown in the Table 3 and 4. For this evaluation it is adapted that the rating of every car option in the Car Rating List is defined by points 1 – 7 depending on the position on respective position on the Rating list. Making the sum of points for all cases defined by sub 1 = sub 2, the General Car Rating list is obtained as shown on Table 5. The same procedure was adapted for the cases with defined by sub 1 > sub 2 and results are shown in Table 6.

It is of interest to notice that in both General Car Rating Lists the VW Golf car option is on the first place of the General Rating List. Even there are the substantial changes in the constrains among the sub-indicators and indicators for both General Car Rating Lists, the results obtained are imposing priority to the VW Golf option. Also, it could be noticed the there is the substantional change in the position of the other car options. Namely, in the General Car Rating List shown in Table 5 the other options have completely different position on the Car Rating list.

It is of interest to draw attention to the results obtained by the priority given to Economic indicators which are usually taken as the main criteria in the assessment of passenger car selection. In this case VW Golf option is having priority on the General Car Rating list.

If we take into a consideration the priority given to Environmental indicator the Honda Jazz option will gain first place on the General Car Rating List.

In the case if the priority is given to the Technology Indicator then the first place on the General Car Rating List will be obtained by the VW option.

Finally, if the priority will be given to the social Indicator the first place on the General Car Rating list will taken by the VW Golf option.

5. CONCLUSIONS

The selection of passenger car is the subject to subjective constrain. Namely, this process may impose an individual priority in the selection of the car and it will be under constrain of the human knowledge about different characteristics of the car to be taken into a consideration. For this reason the need for the objective assessment is of the great importance in order to overcome the human deficiency in the decision making process.

The multi-criteria evaluation process in the decision making adds a new quality in the decision making procedure. It does not depend on the human preference and expert deficiency. With non- numerical, in-exact, and non-complete, human perception in the decision process is eliminated and the decision making procedure is left to the judgment of the decision maker.

This exercise shows the example, of the multi-criteria evaluation for the selected number of car options and the data obtained from the open literature of car producer.

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