WOOD RESEARCH
53 (3): 2008
121-134

SIMULATION AND DIRECTING MEASURES IN WOOD UTILIZATION

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ABSTRACT

Contemporary energy consumption cannot have a stable structure over the long term. Average energy consumption in the EU in 2002 was at a level of 3,72 tons of oil equivalent per capita. In spite of the declaration of numerous programs of energy consumption reduction, total energy consumption has been increasing in the EU since the year 1992 by 2-3% every five years. One of the development programs in the sphere of construction looks to increasing the use of wood as a construction material. This deals with a range of wood uses for higher generation as substitution for steel constructions and the replacement of constructions with high energy consumption (concrete, reinforced concrete, brick, insulation materials etc.). The article deals with the creation of a model for strategic change assessment and its evaluation. On the basis of the described model different directing measures are proposed.

KEY WORDS: energy consumption, sustainable development, simulation, wood utilization, directing measures.

INTRODUCTION

In the previous century there was a very marked increase in the use of artificial materials and goods made with oil-based products. The same tendency was evident in construction and led to the strong growth of non-renewable raw materials production and harmful substances emission.

The European Union has the aim of the increase of renewable energy from the level of 6% in the year 1997 to 20% in the year 2020 and the decrease of greenhouse gases emission (CO2, CH4, N2O etc.) by 20% in the year 2020. Although there are different programs of energy consumption reduction in existence the contemporary renewable energy level is still about 6%.

A further argument for the topicality of this problem is the world-renowned Stern Review on the Economics of Climate Change. According to the review, the artificial environment of construction objects represents about 60% of energy consumption in the EU25 countries. In the case of not taking appropriate measures, the costs of climate change will represent a five percent decrease of global GDP annually. At the same time expenditures on a necessary decrease in greenhouse gases emission are estimated at the level of 1 % of global GDP (Stern 2006).

For the declared goal achievement it is necessary to change the structure of energy consumption. One of the programs in EU countries such as Germany, Austria and Switzerland in the sphere of construction is concerned with decreasing the energy intensity of construction materials and increasing the regulated use of renewable raw products (primarily wood) (Folmer and Cornelis van Kooten 2004).

Within research on wood utilization in construction there has been developed a practical example of a Modified Dynamic Model (MDM, Beran and Dlask 2005) consisting of the interaction of several elements within the woodworking industry. This simulation allows us to evaluate internal mechanisms of wood utilization development and to suggest different variants of decision without significant expenditure.

Rationale

The construction industry is one of the largest waste-product producers and energy consumers. Building erection has a significant and evident negative influence on the environment starting with raw materials production and processing right through to buildings and structures maintenance. In addition, constructed objects are the largest consumers of energy.

According to the Amsterdam Treaty ratified in May 1999, EU members are obliged to introduce environmental criteria to economic policy. With this intention there was developed a method of Life Cycle Assessment (LCA), which is an integral part of European norms and international standards EN ISO 14040 – 14049. In the construction sphere this means the evaluation of buildings, starting with raw materials extraction and processing, materials and building equipment production, transportation, industrial and on-site assembly up to and including maintenance expenditures and dismantling with recycling of wastes.

This means that ecological building should as a priority use construction materials on the basis of renewable sources. In the Czech Republic, Russia and many other states this means more particularly with wood, which is the only completely renewable construction material with excellent bearing qualities (Backeus et al 2005).

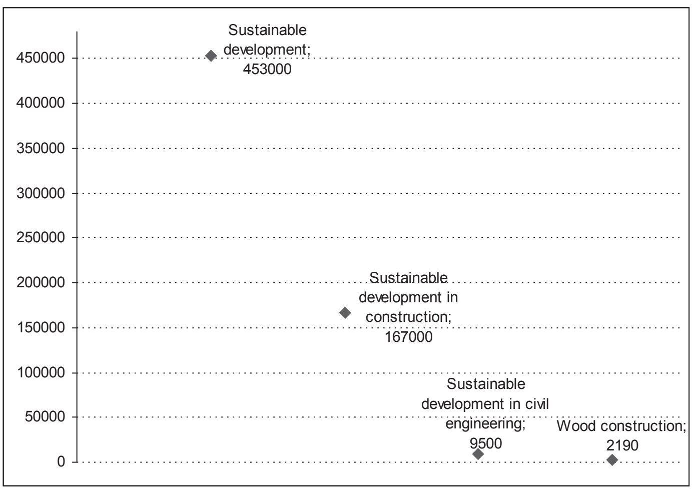

Fig. 1: Number of links in Google Scholar Search system

In spite of growing interest in wood construction and architecture, there is only a slight growth in wooden building production; wooden family and apartment houses invariably amount to 1 – 2% of total complete construction objects in the Czech Republic (Beran 2004).

The amount of scientific research on wood utilization in construction is also rather low: when we enter in *Google Scholar Search* the word combination *Sustainable development* we will receive 453,000 links to different scholarly works, when we enter *Sustainable development in Civil Engineering* – 9,500, and when we add *Wood construction* – just 2,190 references (Fig. 1).

MATERIAL AND METHODS

With the purpose of analyzing present and future development there were set out the initial data for a dynamic model (Beran and Dlask 2004) of the supposed development of five interrelated elements, these being: ecology, economy, construction industry, woodworking industry and sustainable utility for consumers.

The notions of basic elements and their properties are described in Fig. 2.

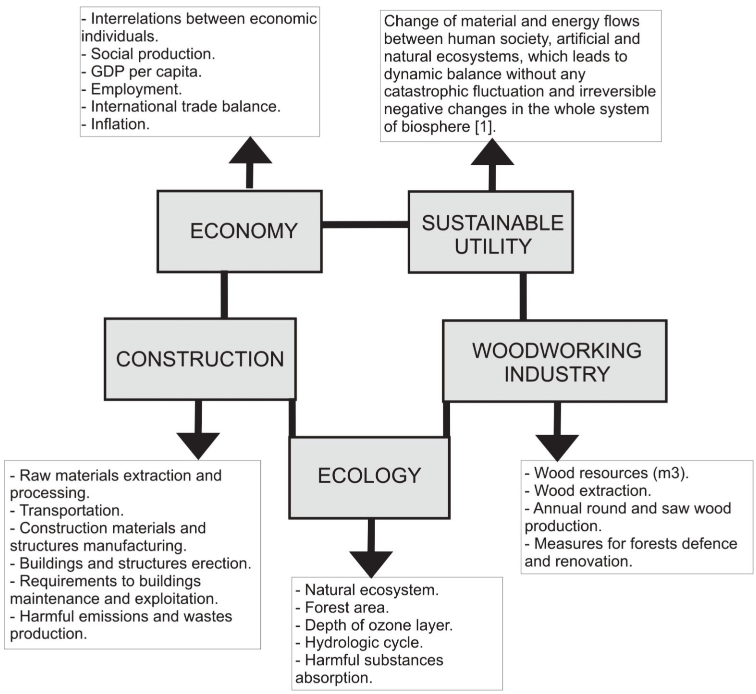

Fig. 2: Ideational scheme of relations in sustainable construction creation (mental model)

It is possible to derive information about the supposed development of wood utilization by means of a *computational simulation experiment*. Of considerable advantage is the possibility of different decision scenarios. For the development of the model, there was used the MDM (Beran and Dlask 2005). To create the structure of the applied model, we suppose that between single elements there is a certain interaction. Every element can negatively or positively influence the others. Values of interactions between certain elements x_i can be expressed by matrix symbology. Elements a_{ij} of matrix $\boldsymbol{A}$ shown in Tab. 3 are the above mentioned interactions between the elements. When evaluating an interaction it is advantageous to convert its components to a common unit of relation (volumetric, financial, material etc.). Accuracy of the assessment is determined by the level of skill and knowledge of the evaluating person. Calculation can be effective even with simplified evaluation by means of interval [-1, 1].

Tab. 1 contains a description of some interactions of the developed model (Anisimova 2007a). By the assessment it can be found that relations between the elements either don't exist or can't be determined. In the respective position of interaction matrix $\boldsymbol{A}$ zero value is set (Tab. 3).

The calculation scheme is shown in Fig. 3.

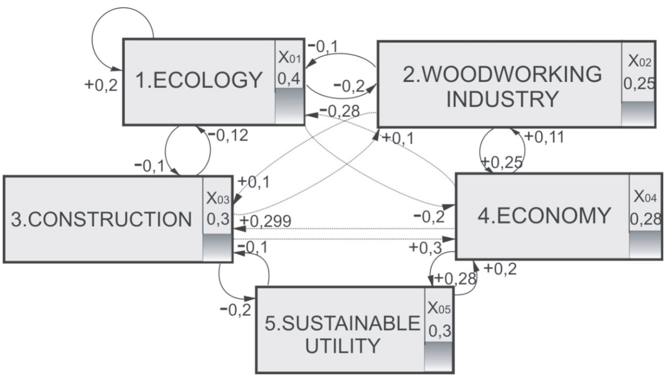

Fig. 3: Calculation scheme of interrelations in the model of wood utilization

Before the simulating calculation it is necessary to set the initial values of separate elements x_i of the model in the moment of time t = 0. Starting with the values $x_i(0)$ the calculation of model state will be made in the interval t > 0. Tab. 2 contains description of the initial values of the elements (Anisimova 2007b). Tab. 3 shows the values of matrix $\boldsymbol{A}$ elements, necessary for the calculation.

In the calculation there are used the algorithmic relations (1.1) and (1.2), see (Beran and Dlask 2005), of KSIM (Kane Simulation – Cross-Impact Simulation Method).

This method is based on the relation, in which the values are defined in the following way:

$$x_i(t+\Delta t) = x_i(t)^{\Phi i(t)} \tag{1.1}$$

The formula of exponent in the equation (1.1) is the following:

$$\Phi_{i(t)} = \frac{1+\dfrac{\Delta t}{2}\sum_{j=1}^{m}[|a_{ij}+\mathrm{B}_{ij}|-(a_{ij}+\mathrm{B}_{ij})]x_j(t)}{1+\dfrac{\Delta t}{2}\sum_{j=1}^{m}[|a_{ij}+\mathrm{B}_{ij}|+(a_{ij}+\mathrm{B}_{ij})]x_j(t)} \tag{1.2}$$

Tab. 1: Assessment of intensity of chosen interactions in the dynamic model

Intensity of interrelation a_{31}. Construction industry – ecology.	Description of intensity	Intensity of interrelation a_{41}. Economy – ecology.	Description of intensity
-1	Construction wastes at the rate of 70 mil. tons per year.	-1	Emission of harmful substances equivalent to destruction of ecological system – greenhouse gases emission at the rate of 50 tons per capita annually.
-0,12	8,26 mil. tons of construction wastes (CZ, 2004)[1].	**-0,28**	Emission of greenhouse gases at the rate of 14 tons (CO_2 equivalent) per capita (CZ, 2002, acc. Eurostat).
0		0	Zero emission.
1	Total recycling of construction wastes.	1	Maximum investments to atmosphere defense.
Intensity of interrelation a_{42}. Economy – woodworking industry.	Description of intensity	Intensity of interrelation a_{43}. Economy – construction industry	Description of intensity
-1	Liquidation of woodworking industry.	-1	Liquidation of construction industry.
0,11	Gross investment in woodworking industry of €80,8 mil. (CZ, 2003, acc. Eurostat).	**0,299**	Gross investment in construction industry of €448,3 mil. (CZ, 2003, acc. Eurostat).
1	Gross investment at the rate of €750 mil. per year.	1	Gross investment at the rate of €1,500 mil. per year.
Intensity of interrelation a_{24}. Woodworking industry – economy.	Description of intensity	Intensity of interrelation a_{34}. Construction industry - economy.	Description of intensity
-1		-1	
0	Zero production.	0	Zero production.
0,25	Production of 3,940 thousand m3 of saw wood (CZ, 2004, acc. Eurostat).	**0,29**	Gross value added per person employed - €9,9 thousand (CZ, 2003, acc. Eurostat).
1	Production of saw wood at the level of round wood production – 15,601 thousand m3 per year.	1	Gross value added per person employed at the rate of €34,6 thousand per year.
Intensity of interrelation a_{54}. Sustainable utility – economy.	Description of intensity	Intensity of interrelation a_{45}. Economy - sustainable utility.	Description of intensity
-1	Absolutely negative effect.	- 1	
-0,6 – -0,8	Extremely strong negative effect.		
-0,4 – -0,6	Strong negative effect.		
-0,2 – -0,4	Medium negative effect.	0	Zero utility.
-0,2 – 0	Gently negative effect.		
0,2	Gently positive effect.	**0,28**	GDP per capita – $10,600 (ЧР, 2004 г.).
0,2 – 0,4	Medium positive effect.		
0,4 – 0,6	Strong positive effect.		
0,6 – 0,8	Extremely strong positive effect	1	Annual GDP per capita at the level of $45,700.
1	Absolutely positive effect.		

According to the Statistical Yearbook of the Czech Republic 2006

Tab. 2: The description of the initial elements values for the dynamic model (numerical data are listed for the Czech Republic according to the Czech Statistical Yearbook 2005)

Element of the model	Initial conditions evaluation		Element of the model	Initial conditions evaluation	
1. Ecology	1	The highest ecological system value.	2. Woodworking industry	1	Production of saw wood at the level of round wood production – 15,601 thousand m3 per year.
	0,8	High ecological system value.			
	0,6	Above the average value.		**0,25**	Production of 3,940 thousand m3 of saw wood (CZ, 2004, acc. Eurostat).
	0,4	Average value.			
	0,2	Low value.		0	Zero production.
	0	The lowest value.			
3.Construc-tion	1	High level of annual output in construction – €20,500 mil.	4. Economy	1	The highest level of GDP – €320 milliards.
	0,3	Current level of annual output in construction – €6,142 mil. (Czech republic, 2004).		**0,28**	Annual GDP – €90,93 milliards (Czech republic, 2004).
	0	Zero output.		0	Zero GDP.
5. Sustain-able utility	1	The highest value of balance between society requirements satisfaction and ecological system preservation.			
	0,6	Average value.			
	0,3	Moderate value of sustainable utility.			
	0	The lowest value.			

Tab. 3: Matrix A – values of interactions between elements of the model; initial situation is simulated for the Czech Republic, 2004 (according to the available statistical data)

	1.Ecology	2.Woodwork-ing industry	3. Construction industry	4. Economy	5. Sustain-able utility	**Initial value *X*(2004)**
1. Ecology	0,2	-0,1	-0,12	-0,28	0	**0,4**
2. Woodworking industry	-0,2	0	0,1	0,11	0	**0,25**
3. Construction industry	-0,1	0,1	0	0,299	-0,1	**0,3**
4. Economy	-0,2	0,25	0,3	0	0,2	**0,28**
5. Sustainable utility	0	0	-0,2	0,28	0	**0,3**

RESULTS AND DISCUSSION

The imitating calculation of a dynamic model of wood utilization.

The time variation of interference of the elements is calculated by means of the MDM 2004 model, developed in the VBA environment of table processor Microsoft Excel. The result of the calculation is the graph of standards (Fig. 4), which shows the development of elements in the course of time and the graph of differences (Fig. 5), which demonstrate the differences in element values and the rate of their development. The elements of economy, construction, woodworking industry and sustainable utility have a positive, growing trend of development, while ecology has negative, reducing values.

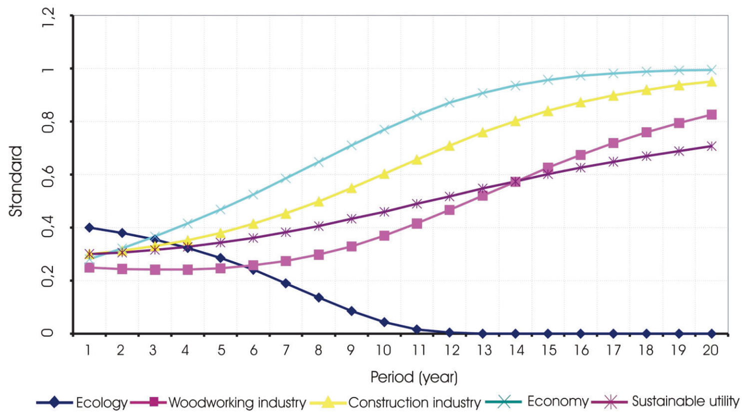

Fig. 4: Simulation of standards of the dynamic model elements

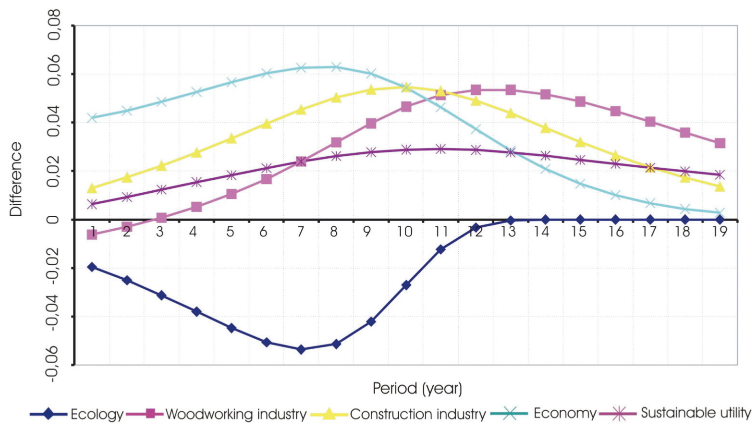

Fig. 5: Simulation of differences of dynamic model elements

Interpretation of the graph of standards is as follows:

1. The degradation of the environment can be observed in the short term (destruction of ecosystem in the 12-th year of imitation), as well as the stagnation of the woodworking industry.
2. Expansion of the woodworking industry can be seen in the long term, from 6-th and 7-th year of the development simulation. But this growth seems to be impossible

due to the degradation of the environment (state of forestry management, form of woodworking industry, need for innovation and new waste-free technologies).
3. The increase of wood utilization in construction is very slow in the short and medium term.
4. Efficiency of the sustainable utility shows just a minor growth, the results being evident only in the long term.
5. Economic growth in the utilization of wood is very low in the short to medium term.

Conclusion of the description of the model standards:

In terms of values of the elements the proposed variant of the development should be regulated by means of directing measures (management actions). By management action we understand a measure which introduces innovations and improves the structure of a development in a certain period of time.

According to rates of changes in the model development, which are shown in the Fig. 5, it can be noted that:

1. The rate of destruction of ecological parameters is rather high and reaches culmination in the 7-th year of modeling. Then the rate of destruction decreases, but there is no positive direction in ecology development.
2. The woodworking industry stagnates at the beginning of simulation, the positive growth being observed just from the third year of the model development.
3. The growth of the economy and the construction industry, which has its highest values in the 8-th and 10-th year of simulation respectively, has an average rate. Then the rate of growth declines.
4. The rate of sustainable utility increase is rather low, decreasing in the long term.

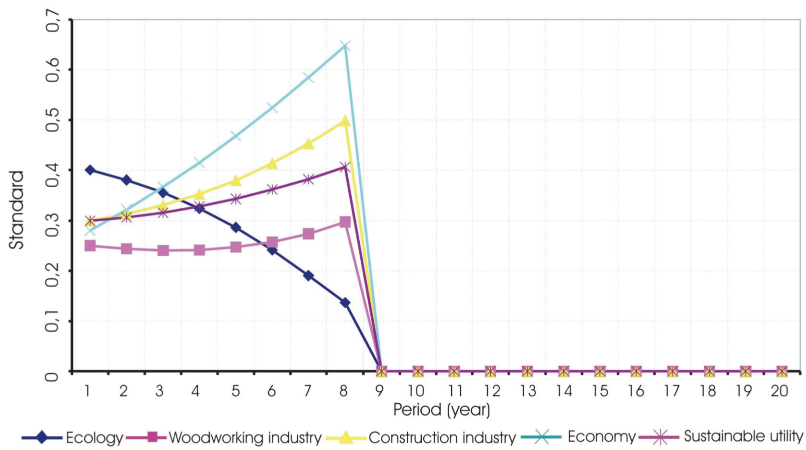

Fig. 6: Termination of elements interaction under the achievement of nonreversible negative changes in ecosystem

Conclusion of the description of the rates (differences) of model development:

The rates of growth of separate elements, which are shown in Fig. 6, are insufficient. The structure of changes in model development is rather unfavorable. The increasing destruction of ecological values will lead to a decrease in available sources of energy and raw materials; that makes further growth of economic values impossible.

With the achievement of critical values in the ecological system, which lead to nonreversible changes, the proposed model will cease to fulfill its functions and should be replaced by a model of management under critical conditions.

When we insert into the calculation system a condition of calculation termination with achievement by the ecology element of the critical value of 0,1, the model stops functioning in the medium term, that is in the 9-th year of the simulation (Fig. 6).

The state of the model shows the necessity of ecological revitalization. It seems to be necessary to decrease the negative influence of all the other elements in the ecosystem and to increase the sustainable wood utilization, as well as the sustainable utility for consumers.

Directing measures and their modeling in MDM

The proposed goals can be achieved by means of management actions (regulation measures). Measures of revitalization in the model of wood utilization can be expressed by change in the values of interactions in the matrix $\boldsymbol{A}$ (Tab. 4) as follows:

1. Measures for the protection and renovation of forest resources – change of influence of woodworking industry on ecology, a rise of $\boldsymbol{a_{12}}$ **value** from −0,1 to −0,05.
2. Reduction of construction wastes – change of influence of construction industry on ecology, a rise of $\boldsymbol{a_{13}}$ **value** from −0,12 to −0,08.
3. Reduction of non-renewable resources use, reduction of greenhouse gases emission – change of influence of economy on ecology, a rise of $\boldsymbol{a_{14}}$ **value** from −0,28 to -0,2.
4. Increase of wood-based materials and structures utilization in construction – change of mutual influence of construction and woodworking industry, a rise of $\boldsymbol{a_{23}}$ **value** from 0,1 to 0,15, and a rise of $\boldsymbol{a_{32}}$ **value** from 0,1 to 0,15.
5. Additional investments in wooden buildings and structures technology and wood-based materials production – change of influence of economy on woodworking industry, a rise of $\boldsymbol{a_{24}}$ **value** from 0,11 to 0,18.
6. Decrease of transportation, period of construction and labor expenditures on assembling – change of influence of construction industry on sustainable utility for consumers, a rise of $\boldsymbol{a_{53}}$ **value** from – 0,2 to −0,15.
7. Reduction of energy consumption for building maintenance – change of influence of economy on sustainable utility for consumers, a rise of $\boldsymbol{a_{54}}$ **value** from 0,28 to 0,33.

Tab. 4: Matrix A – changed values of elements interactions are indicated in bold type

	1.Ecology	2.Woodworking industry	3. Construction industry	4. Economy	5. Sustainable utility	Initial value *X*(2004)
1. Ecology	0,2	**-0,05**	**-0,08**	**-0,2**	0	0,4
2. Woodworking industry	-0,2	0	**0,15**	**0,18**	0	0,25
3. Construction industry	-0,1	**0,15**	0	0,299	-0,1	0,3
4. Economy	-0,2	0,25	0,3	0	0,2	0,28
5. Sustainable utility	0	0	**-0,15**	**0,33**	0	0,3

Fig. 7 shows the difference between the values of the initial model and the model with the suggested directing measures (changes of interactions of elements x_i).

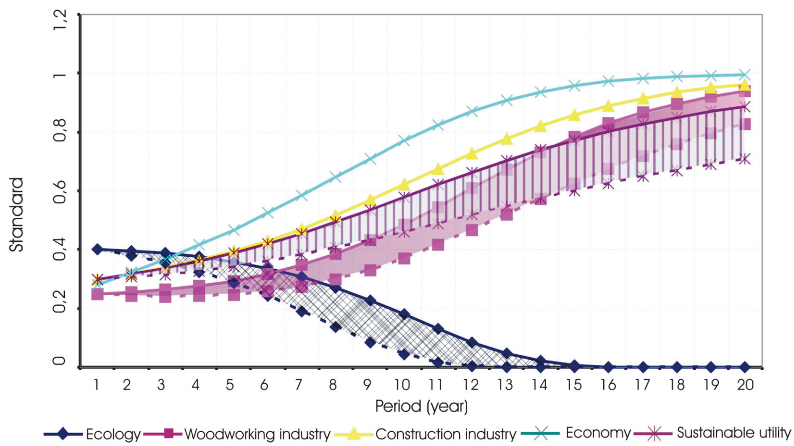

Fig. 7: Differences between initial (dotted line) and modified (solid line) model with directing measures

Efficiency of the proposed management actions can be expressed by the differences between the parameters of the initial and the modified model; that is before and after the input of changes of values of a_{ij} shown in Tab. 4.

The model with the directing measures shows:

1. A higher growth of wood utilization in the medium and long term without stagnation of the woodworking industry at the beginning of the simulation.
2. An increase in the positive development of sustainable utility values.
3. A considerably lower rate of ecological values destruction.
4. The elements of economy and construction industry preserve their positive tendency of growth and show a higher rate of increase.
5. The positive development of ecology is still not achieved, as well as the ability of the model sustainable functioning over the long term.

Tab. 5: Difference of values of the initial and the successive model and the benefit of measures taken in 5, 10 and 15 years of supposed development

Element of the model	$\Delta_{5\text{-th year}}$	$\Delta_{10\text{-th year}}$	$\Delta_{15\text{-th year}}$	Branch production, 2004[2], €mil.	Benefit of measure in 5 years, €mil.	Benefit of measure in 10 years, €mil.	Benefit of measure in 15 years, €mil.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Ecology	0,07	0,14	0,007	-	-	-	-
2. Woodworking industry	0,05	0,12	0,16	2 506,71	288,46	1394,22	3239,26
3. Construction industry	0,01	0,01	0,02	7 103,48	259,81	896,91	1559,06
4. Economy	0,003	0,009	0,008	-	-	-	-
5. Sustainable utility	0,04	0,12	0,17	-	-	-	-
Total					**548,27**	**2291,13**	**4798,32**

[2]*According to the Statistical Yearbook of the Czech Republic 2006*

The results of the above mentioned management measures are presented in Tab. 5. They consist in the difference of the state of the model before and after directing measures implementation. The numerical values of the difference Δ_i for the 5-th, 10-th and 15-th year of simulation are shown in columns 2 to 4. Column 5 contains the value of production in the corresponding branch (woodworking and construction industry) in 2004[2] (on the assumption that the production level will be preserved). The benefit of the measures taken was calculated by multiplication of each year difference Δ_i by branch production and a summarizing of the obtained values for 5, 10 and 15 years accordingly (columns 6, 7 and 8, Tab. 5).

The calculation shows the sufficiently greater effectiveness of the suggested measures according to the corresponding changes in a_{ij} values.

The values of the interactions of some elements, which were increased, are indicated with bold type in Tab. 4. The matter concerns on the whole eight interactions. Each was estimated according to its economic impact. In such a way the working hypothesis of the proposed directing measures was formed, as well as the economic assessment of expenses required for the measures implementation.

Evaluation of the expenses of measures realization was made in the following way:

1. Directing measure 1 presents the change in impact of the woodworking industry on the ecology, that is the increase of a12 from –0,1 to – 0,05, i. e. a 50% rise in the value (see column 3, Tab. 6). The output in the corresponding branch (woodworking industry) at the initial state of the model (2004) equals €2,506.71 mil. Fixed assets acquired for environmental defense in the area of landscape and biodiversity protection in the Czech Republic equaled €18,34 mil. in 2002. We suppose, that a 50% increase in this value means an increase in fixed assets of 50%, i. e. by €9,17 mil. (column (5), Tab. 6). Tab. 6 presents also a percentage of supposed expenses in the branch output and GDP of the Czech Republic (columns (6) and (7)).
2. The increase of a_{13} value (the impact of *construction on ecology*) from –0,12 to –0,08 represents an increase of 33,3%. In 2002 fixed assets acquired for environmental defense in the area of waste management equaled €44,38 mil.[5] By the management measures realization we suppose an increase in fixed assets of 33,3%, that is of €14,78 mil. (column (5), Tab. 6).
3. The directing measure 3 implies a *decrease of greenhouse gases emission*, which means an increase of a_{14} value by 28,5% (from –0,28 to -0,2). The corresponding branch in this case is the whole economic system, the output of which can be expressed by GDP. Fixed assets acquired for environmental defense in the area of air pollution control and climate protection in 2002 made €148,98 mil.[5] in the Czech Republic. The matter concerns the increase of fixed assets by 28,5%, i. e. €42,46 mil. (column (5), Tab. 6).
4. The directing measure 4 suppose *the increase of wood-based structures and materials usage in construction*, i. e. an increase of a_{23} from 0,1 to 0,15 (by 33,3%). Gross investment in tangible goods in the woodworking industry have amounted to in the Czech Republic in 2003 €80,8 mil. (according to Eurostat). The increase of investment by 33,3% means a €26,91 mil. addition.
5. Management action 5 (increase of a_{32} from 0,1 to 0,15) supposes growth of the positive influence of the *woodworking industry on construction* by 33,3%. Gross investment in tangible goods in the construction industry equaled €448,3 mil. in 2003 in the Czech Republic (according to Eurostat). The increase of 33,3% in investment results in €149,28 mil. (column (5), Tab. 6).
6. The directing measure 6, an increase of a_{24} value by 39% (from 0,11 to 0,18), implies

an additional *investment in the woodworking industry* of €31,51 mil. (39% of gross investment).

7. Directing measure 7, an increase of a_{53} from − 0,2 to −0,15 (by 25%), supposes a decrease in the negative impact of *construction on the sustainable utility for consumers*. For the assessment of expenses, the data of fixed assets acquired for soil protection and decontamination, groundwater and surface water protection, noise and vibration abatement, radiological protection, environmental protection research and development, and other environmental protection activities, were used. These assets amounted to €71,42 mil. in the Czech Republic in 2002. The increase in assets by 25% means a €17,85 mil. investment (Tab. 6).
8. The directing measure 8, an increase of a_{54} by 15% (from 0,28 to 0,33), supposes a decrease in the negative impact of the *economy on sustainable utility*. The assumed expenses represent 15% of the total expenditures on environmental protection, which amount to €810,56 mil., that is €121,58 mil. (Tab. 6).

Tab. 6: The changes of the values of elements interactions and expenses for proposed measures realization

Rise of the value		Difference in percentage terms	Output in corresponding branch (2004)[3], €mil.	Expenses of measure, €mil. (preliminary estimate)	Rate of expenses (5) in branch output (4),%	Rate of expenses (5) in GDP[4],%
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	a_{12} from –0,1 to –0,05	50,0	2 506,71	9,17	0,37	0,01
2.	a_{13} from –0,12 to –0,08	33,3	7 103,48	14,78	0,21	0,01
3.	a_{14} from –0,28 to -0,2	28,5	90 930, 00	42,46	0,04	0,04
4.	a_{23} from 0,1 to 0,15	33,3	7 103,48	26,91	0,38	0,03
5.	a_{32} from 0,1 to 0,15	33,3	2 506,71	149,28	5,96	0,16
6.	a_{24} from 0,11 to 0,18	39,0	2 506,71	31,51	1,26	0,03
7.	a_{53} from – 0,2 to –0,15	25,0	7 103,48	17,85	0,25	0,02
8.	a_{54} from 0,28 to 0,33	15,0	90 930, 00	121,58	0,12	0,12
	Total			**413,54**		**0,43**

According to the Statistical Yearbook of the Czech Republic 2005
Equals €90,93 milliards in CZ in 2004

Tab. 7 presents the analysis of the efficiency of proposed regulations. We suppose that 70% of the estimated expenses are the investment outlay, and the remaining 30% are for operating costs in the simulated development.

Tab. 7: Efficiency of the measures proposed

Year of simulation	Benefit P, €mil.	Expenses (€413,54 mil.)		Total expense C, €mil.	Investment efficiency I_e= P/C.
		Investment outlay, 70%, €mil.	Operating costs, 30%, €mil.		
(1)	(2)	(3)	(4)	(5)	(6)
5-th	548,27	289,48	124,06 × 4 = 496,24	785,72	**0,70**
10-th	2291,13		124,06 × 9 = 1116,54	1406,02	**1,63**
15-th	4798,32		124,06×14 = 1736,84	2026,32	**2,37**

From comparison of the costs and benefits we can see the effectiveness of the proposed management actions (Prostějovská and Beran 2006). The efficiency ranges from 0,7 in the short term of five years and 1,63 in the medium term to 2,63 in the long term. The returns on investments are expected at the point of 6,62 years (Interpolated between 0,7 and 1,63; Tab. 7).

CONCLUSION

The structure of development of wood utilization was simulated by means of the Modified Dynamic Model in the example described. MDM represents a device to formalize a view of the future situation, as well as giving the possibility to compare different decisions proposed.

The analyzed model suggested in Fig. 2 and analyzed in Tab. 4 is not sustainable in the long term due to ecological degradation. The proposed directing measures are sufficiently effective, although they cannot positively change the development of the ecosystem concerning renewable recourses. The possibility and efficiency of an increase in wood utilization in construction and the economy can be observed from the model development, as well as the necessity of a decrease in negative influence on the environment in the Czech Republic and EU.

The suggested controlling measures have an increasing effectiveness in terms of time. Payback on the expenses required for the realization of management actions is less than 7 years. Knowledge of standards development and their differences gives the opportunity of further elaboration and suggestions for even more effective decisions. The given model is a tool of management which allows the simulation of further strategies and the opportunity to change the current situation which is unsatisfactory from the view of long term sustainability.

ACKNOWLEDGMENT

This paper originated as part of a CTU in Prague, Faculty of Civil Engineering research project on The Management of Sustainable Development in the Life Cycle of Buildings, Building Enterprises and Territories (MSM: 6840770006), financed by the Ministry of Education, Youth and Sports of the Czech Republic.

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