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Reuse and Recycling in the Rural Building Process

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Abstract: The building activity including construction, maintenance, demolition and the treatment of waste, moving and transporting large masses of materials are highly responsible for the energy and environmental problems. The communal sphere, with the building sector can have 40% share of the total national energy demand, resulting also in environmental disadvantages in similar rate. Our investigation started in the agricultural, rural fields. Based upon exact survey and calculations *on hundreds of different farm structures* the rate of estimated reusability has been nearly 50%. Extra energetic and environmental benefits can come from the local functional reuse of buildings or their materials in case of their demolition. Further even more environmental advantages are expected by a*far-seeing* conscious design.

Key words: farm structures, building materials, demolition, reuse, recycling, environmental management

1. Introduction

The overproduction may exhaust the energy sources of the Earth soon resulting in billion tons of waste as well. Also the poor hundred millions are driven to use up their own surroundings. Meanwhile environmental protection is merely subsequent, can solely not help, as the endangering is already serious.

The only sustainable activity can be the preventive environmental management. It stimulates the protection by economic benefits in which the whole society is certainly interested.

An up to date management, thinking environmentally, looks over a large scope in space and time. The technical task, specially the building process, touches the whole site, the surroundings in an interaction with the natural environment, in space and also in time. In this sense, the whole life-cycle of a building has to be considered.

The conventional programmes and calculations of constructions may regard only a few months period of the design and erection. Whilst the whole life-cycle can span over decades or even centuries, beginning with mining, transporting and processing of materials in great quantities for the building industry, disturbing the environment, the landscape (Fig. 1).

In the modern world building functions change soon as well as light structures of shorter duration, demanding continually new building up. This acceleration of the cycle needs subsequent energetic and environmental sacrifices.

Further, after a fast up to date erection, the cycle will not be finished. Maintenance will soon be necessary, later repair or reconstruction, arriving to final periods of the life-cycle: demolition of buildings, reusing, recycling of materials; and transportation, deposition again. After all, the customary building process is only a short phase in the total life-cycle. Just the rest, beginning with the mining, finally demolition and reuse can save energy and environment to a surprising extent. So, just these two ends of the life-cycle promise considerable, unexploited reserves in energy and environmental management.

2. Limiting the Scope of Research

The reuse of structural materials is already

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successful in the most industrialized countries around the world like Japan and Germany and is remarkably instructive in certain states of the USA where the most valuable structural elements are selected with a special care [1-3]. Nevertheless, these results regard only smaller part of the world, therefore these practices should be extended to the whole Earth.

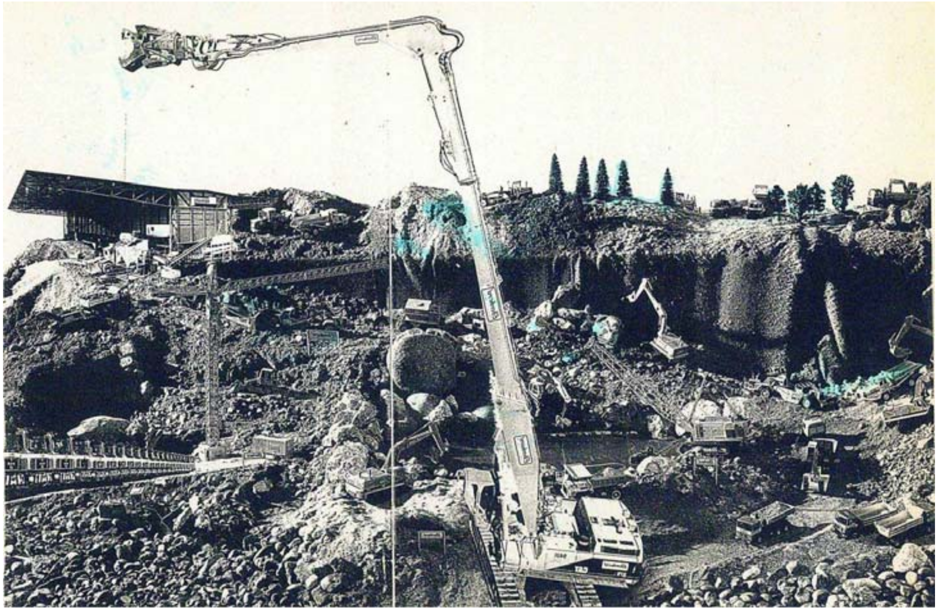

Fig. 1 Mining of building materials.

We assisted initiatives for reusing the industrial waste in India where the untreated amount of waste is considerable, simultaneously with an urgent demand of mass production of new houses. For this reason helping the whole Third World should be an ultimate aim.

First however Central-Eastern Europe is more prepared for such rationalization. Here, in contrast with the most developed countries, majority of buildings are traditional in great diversity, among them with monuments. Their appearance and essential structures cannot be changed. Functions can slightly be altered, but reuse of materials are limited.

The industrial areas had become sooner arranged. In the course of large scale technology, standardization of industrial structures started already in the 19th century.

The large-scale domestic re-usage is generally still hindered in the crowded, heterogeneous urban and industrial sphere, contrary to the situation in the countryside. Following the example of some developed countries, I have demonstrated that majority of building materials can be reused in the natural, agricultural regions owing to:

- The more place, time and locally skilled labour force are available for the particular processes of constructions and repair or demolition.
- Structure of traditional farm buildings to be demolished consists of good quality conventional, durable, natural materials besides the ruined parts.
- The use of natural materials, without dangerous elements, available in site fitting into the environment, concerned also architectural, visual appearance.
- Less durable but natural materials can easily be recycled locally in the countryside, without environmental damages (wood, reed or straw) [1].
- The determinant farm building groups having simple, typical structures, are well arranged, easy to survey and select their different parts for the reuse.

- The multipurpose mobile land machines can help the process of reuse and movement of materials.
- To sum up, the local solution is the most economical: reuse in site without mass deposition or transportation.
- New structures can be built of the reusable materials possibly in the vicinity. Simple, horizontal farm buildings and linear objects, bedding of country roads can be constructed of secondary materials (even of a permissible lower quality), compared to actual building standards.

Since the 1950s in the Eastern European collectivization — as “modernisation” — an overall standardization had been introduced in farm buildings, using prefabricated elements and uniform structures. This complex simplified system (Fig. 2) made our study easier.

3. Method of Research

3.1 Analyzing the Rate of Reusability

Last decades a great part of buildings in the collective farms has become unused or out of date due to a significant depreciation in livestock. I have therefore studied the further use of various stables and storages, in particular the reuse of their structural materials, regarded also the environmental aspects.

Determined investigations started at the turn of the century to survey the farm building property of the country. Factual information was given by the statistics of the Hungarian Ministry of Agriculture (Table 1).

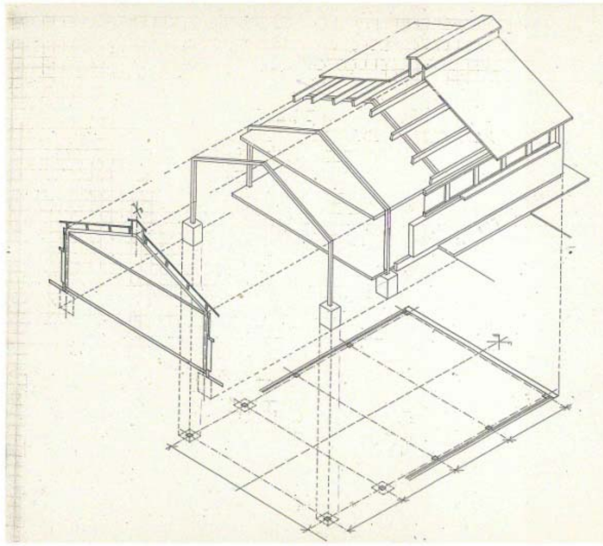

Fig. 2 Framework system of sheds.

In Table 1 the 1951-1975 period is remarkably striking. Thousands of sheds were built in those decades (while before and in the later periods — only hundreds). To sum up the data in the table including calves and beef cattle, the number of sheds is above ten thousand.

Moreover these sheds are large in size having usually 12.0 by 60.0-84.0 m (nearly 1.000 m^2) floor each. The industrialized standard structures could still be used, while majority of these ones are abandoned or misused. This is however a potentially great domestic value which can totally be utilised also by the reuse.

Table 1 Cattle sheds by construction date.

Function	Unit	Erection date								
		Before 1940	1941-1950	1951-1960	1961-1965	1966-1970	1971-1975	1976-1977	1978	Total
Cow shed	nr.	450	106	1509	1226	1703	904	185	87	6170
	%	7.3	1.7	24.4	19.9	27.6	14.7	3.0	1.4	100.0
Calf shed	nr.	76	41	344	879	1054	436	65	37	2932
	%	2.6	1.4	11.7	30.0	35.9	14.9	2.2	1.3	100.0
Calving shed	nr.	63	19	157	144	291	318	64	42	1098
	%	5.7	1.7	14.3	13.2	26.5	29.0	5.8	3.8	100.0
Beef cattle	nr.	331	85	689	618	419	327	83	28	2580
	%	12.8	3.3	26.7	24.0	16.2	12.7	3.2	1.1	100.0
Growing cattle	nr.	584	147	1460	1893	942	438	128	76	5668
	%	10.3	2.6	25.8	33.4	16.6	7.7	2.3	1.3	100.0

Source: Ministry of Agriculture (MEM, 1978, XII, 31)

The tabulated information on number of pig-pens are quite similar, not necessary to show here. In the same time 1951-1975 period also some ten thousand were built of these in similar structure and size.

Summarizing only this two breeding sectors therefore, the number of buildings to take into consideration, is around **twenty thousand** in the Hungarian countryside. Regarding this greatest number of uniform structures, I have focused on this remarkable period when majority of the standardized farm buildings was built during the collectivisation in the Central-Eastern European countries.

The other branches of animal breeding and storing of products were not represented in relevant number to influence our assessment.

The most detailed analysis could be carried on in a farm nearby town Kóka, also not too far from our University and was easily accessible as it had become empty in a large measure by reprivatisation. This large scale multipurpose unit has a great selection of different animal buildings and additional structures. Thus, as a representative farm, it could be a basis for the most of our examinations.

Totally I surveyed and measured some 700 stables and storages in different regions of the country. Among these I selected 50 typical buildings (including 14 ones in Kóka) for detailed analysis.

It meant the most accuracy in measurement of geometrical forms of buildings including the smallest details. The different materials, structural parts were all separately analysed, their volumes calculated and qualities tested. The rate of decay or damage in different details was also carefully controlled.

50 typical — model — buildings were therefore analysed, in such an exactitude, to calculate the rate of reusable materials. There were still uncertainties inside of covered structures and instability also could be supposed.

The doubtful parts of the structures had to be carefully controlled. The covered, hidden instabilities and damages were approached by chiselling and cutting.

In the practise different kind of old, abandoned buildings may hide eventualities, thus the final assessment of reusability can not be accurate enough. A basic scientific investigation is necessary, in another programme. Now it has been out of the sphere of this study.

Now, in our initiative examination, the survey and diagnosis of structures have been exact. The further calculations based only good estimations regarding however the great number of similar farm sheds all around the country. Accuracy of estimated values was not the main view-point. The total expected result is anyway huge, the environmental benefit still immeasurable.

Different stables and sheds of the farm Kóka (Fig. 3) are demonstrated in their neglected, deteriorated conditions. In spite of this appearance the structures are steady, made in the early 1950s of heavy, solid materials as (reinforced) concrete and traditional solid brick. There is a thought-provoking dilemma: Reuse the buildings or their demolished materials.

(1) Evidently, the further, improved proper use of buildings would be most economical. Only surfaces, plaster works, doors, windows and smaller damages (Fig. 4) should be repaired. It would share only few percentage of the total new investment costs.

(2) As second solution, if there is no functional claim to maintain a building, demolition and reuse of materials will be reasonable, to save extra energy and environment.

After this traditional unification in the beginning of our chosen period standardization was on the increase. Later in this period the use of prefabricated concrete and steel frames spread, supporting also the solid brick walls (Fig. 4).

Finally light structures also appeared as wall and ceiling elements, thus our representative period became rather diversified.

Fig. 3 Buildings from the beginning of period studied.

Among the 50 selected model buildings, a few are demonstrated in Table 2 with exactly calculated volumes of their materials. The unusable parts are neglected, the usable ones accounted in proportion (%) of their usability.

Further 10 different structures of the Kóka farm were also surveyed and calculated as it is shown in Table 2. Therefore, totally 14 structures were finally summarized

Fig. 4 Local damages.

in this farm, supposing demolition and reuse of the main building materials (Table 2).

With a careful separation, the concrete and brick can be potentially reused in 100% by crushing. What is more, the traditional standard brick is coherent, long-lasting, can be demolished in wholeness. The reusability of the steel, wood and tile is only 60-70% because of corrosion, decay, breaking. These damages were carefully revealed controlled but evidently could not be exactly calculated. So thus, the last column of the table can also not demonstrate absolute numbers, these are valid only in given cases. The primary energy content can be different worldwide regarding variable technologies during the whole production cycle, mining, transport included and to build new structures. Materials can be local or transported from distances of thousand miles.

Thus, the quantities of energy are only good estimations. It is practically just enough, but also necessary in this case, when tremendous unknown volumes of buildings are going to be wasted. As first step, at least a rough estimation of these values and the solution of this problem is urgent.

In case of the reinforced concrete demolition is not easy, steel bars may be usable only secondary purpose.

Table 2 Reusable building materials of Kóka farm.

Function of building	Erection year (value %)	Basic area (m^2)	Materials and amounts of structural parts						
			Foundation	Floor	Wall structure	Dividing walls	Doors, windows	Roof structure	Cover
Grain store	1958 (50)	198,0	Brick unusable	Concrete 23, 8, 0 m^3	Brick 55,0 m^3	Brick unusable	Pine wood unusable	Pine 6.5 m^3	Slate 200,0 m^3
Grain stores	1967-68 (30)		Concrete	Concrete	Wooden log unusable	Reed board unusable	Pine unusable	Log unusable	Tile 1500,0 m^2
		495.0	38.0 m^3	59.5 m^3					
		495.0	38.0 m^3	59.5 m^3					
		195.0	38.0 m^3	59.5 m^3					
Store	1975 (80)	1843.0	Concrete 145 m^3	Concrete e21.5 m^3	Brick 204.0 m^3	Brick unusable	Steel unusable	Steel 2.5 tons)	Slate unusable
Young cattle	1969 (70)	561.6	Concrete 33.0 m^3	Concrete 55.0 m^3	Brick 60.0 m^3		Steel unusable	Pine (12.5 m^3)	Tile 600.0 m^3

In Table 3, all of 14 buildings in Kóka farm are summarized with all of their main reusable materials.

In Hungary there are at least 1.000 similar or larger farms as in Kóka, therefore the total saving of energy can be estimated as 298.400 kWh, that is nearly 300 GWh.

This is a remarkable potential value, therefore it was worth analysing 50 representative buildings, in all, in different parts of the country, after the example of examinations in Kóka.

This simple statistical treatment helps to find the best phase in the tested period.

It is demonstrated that reusability of the structural materials changed during the former ages: Building materials of traditional farm structures built till the mid of the last century are natural and durable; their reusability approaches the 60% (Figs. 5-6). This ratio decreased roughly to 50% between 1951 and 1975, followed by a consistent declining tendency as the structures became lighter and more complicated, e.g., the sandwich layers are heterogeneous and hardly selectable.

Moreover the frequency distribution (Fig. 6) indicates that the average (~55%) reusability is the most recurrent. It is also clear that most of the analysed buildings fell within the 45-65% phase. That is, in our investigations, among the great number of buildings this average reusability is very likely. Roughly, in large scale, nearly 50% reusability can be expected in such agricultural areas.

Secondary use of the utilizable materials would save potentially more hundred GWh energy according to my analysis. Some 50% of this estimated value can be realized within reasonable time regarding the simple material demand of the numerous small farm buildings and reconstructions.

Table 3 Total potential energy saving in Kóka farm.

Structural materials	Amount m^3 (x value)	Primary energy content	
		(kWh/m^3)	Total kWh
Total concrete	2165.8 (1.0)	45	97.800
Reinforced concrete	253.0 (0.5)	150	19.000
Brick	860.0 (0.95)	140	114.000
Steel	12.5 (0.6)	600	4.500
Wood	77.5 (0.65)	60	3.000
Tile	4293 m^2 (0.7)	20 (kWh/m^2)	60.100
Total			298.400

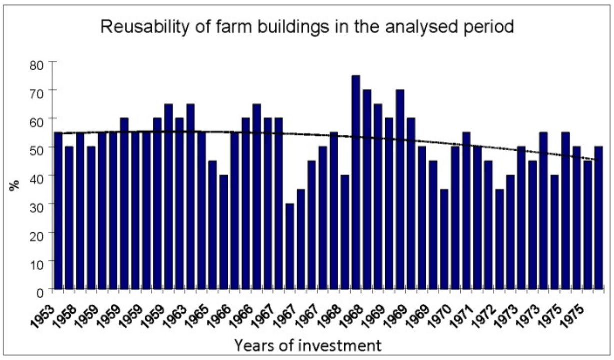

Fig. 5 Reusability of structures in the analyzed period.

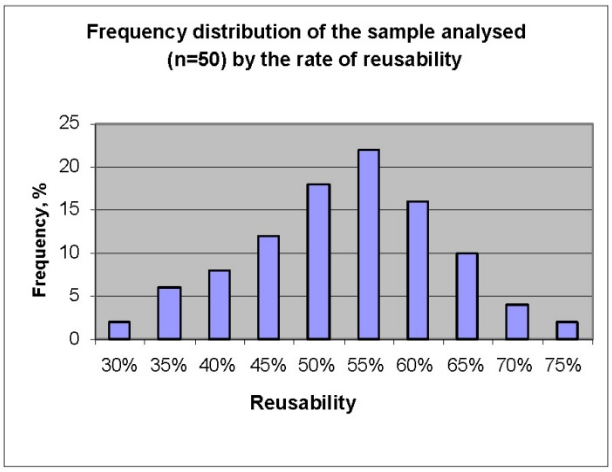

Fig. 6 Frequency distribution of the sample analysed (n = 50) by the rate of reusability.

3.2 Environmentally Conscious Design and Realization

The above analysed period has proved that reusability of standardised structures can be at least 50%. It means a great benefit but the rest half is also worth for attention: Further selection of locally recyclable materials and the final rest of artificial parts (metallic, synthetic ones and glass). Reusability of these is uncertain, uncontrolled also in the countryside. The whole architectural solution and execution have to be designed beforehand.

Traditional rural examples [4] for the contemporary creative design can be found just in the agricultural background.

On this basis, an up to date environmental attitude looks far beyond the recent energetic and economic problems. The whole production system has to be sustainable for long, which is impossible without saving the values of the natural environment in its wholeness. The nature is already in danger beside the modern technical development.

The industrialized mass building production, as analyzed in this study above cannot mean a 100% protection from pollution and contamination. According to our results reusability of materials could be 70% or with special care may still be more but not in the practice. The rest is always waste of different kind and dangerous parts can usually not be excluded.

Total, 100% protection should be proposed and designed specially. The natural traditional structures (Figs. 7-10) are predecessors of the contemporary ecological structural ideas. These can be realized absolutely without waste, following their whole lifecycle:

- Natural, durable materials can be reused locally in most different ways.
- The "useless" rest can be recycled.

The result will be no waste, no harm and load on the environment.

Examples for the contemporary creative design can be found among traditional structures in the agricultural background. Just the most developed countries do not forget certain ancient sustainable systems. There has been a German proposal [1] for a hundred percent natural, recyclable structure (Fig. 7). All of the materials are local environmental: stone

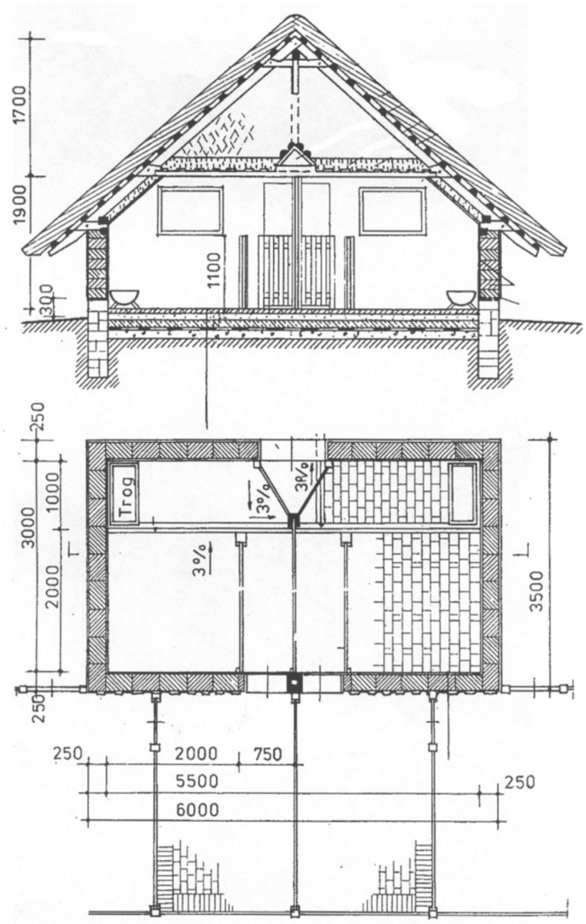

Fig. 7 Traditional stable in Germany.

foundation, adobe or clay walls and floor, hard-wooden frame and thatched roof. The adobe wall and wooden framework systems are still existing in historical town districts in Germany, are still used and sustainable even in modern urbanizations.

Even larger ecological farms are maintained in the USA (Utah near Logan) (Fig. 8) as best examples of sustainability with all conditions of total reuse or recycling of materials, even in the future of the modern world.

Within my actual activity in technical development I also proposed and designed "hundred percent" ecological farm structures where all of their materials are natural, reusable or recyclable. Otherwise comfort of animals is also optimal here.

Living houses, are even more important as these, represent the greatest number. An aesthetical and practical, well oriented and tempered country house can be seen here (Fig. 10). Its foundation and columns made of stone, walls are adobe, whitewashed, the roof thatched (with up to date fire protection).

Fig. 8 Traditional farm (USA).

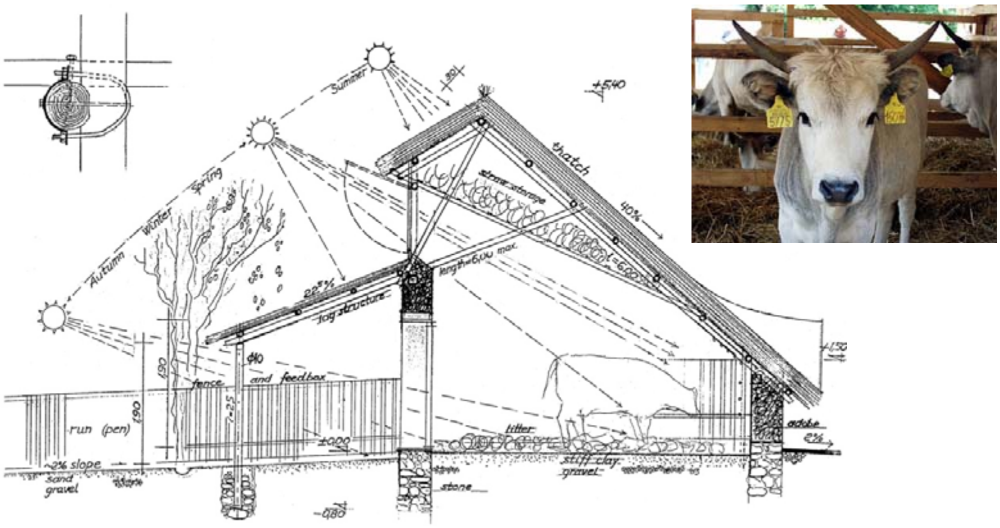

Fig. 9 Ecological shed.

Fig. 10 Rural living house.

The whole life-cycle of these model structures is totally environment friendly. All building processes and materials are local including construction and labour.

There are enough such functioning ecological systems therefore in the rural building practice but all of these are almost forgotten in the high-technical world, mainly in the mind of the society. Thus, the attention has to be called on the dangers and environmental disadvantages.

Unfortunately the environmental thinking is pressed down in large parts of the world. In this case, new mass constructions and imported materials are preferred, instead of renovation or reuse – in site.

The most developed states, mentioned above, have been saving and reusing their valuable materials since already the end of the last century. On the contrary, worldwide there has still not been a positive change. According to technical references, instead of general large scale reuse, rather partial solutions are reported. [5, 6]. These have up to date ideas about the reuse of modern artificial (metallic, synthetic) materials which are really useful and necessary.

Our approach however covers a larger field, all of the natural, rural areas have been involved where the environmental management can fundamentally carried on — for the benefit of the world.

4. Conclusions

Finally, future selectivity, reusability of the new buildings should be kept in mind already in the planning stage. In my technical development program I have therefore improved the design method for environment- and energy saving solutions covering the whole building cycle including renovation, demolition, selection and reuse of materials. Recent buildings constructed accordingly to my designs have demonstrated that efficiency of reuse can also be predicted by a planning aware of environment.

Suchlike environment-friendly planning and implementation will contribute to the sustainable development.

Besides the analyzed structures, in farms and in villages there are also living houses for the farmers, becoming abandoned and deteriorated too. The demand of man-power decreased by the larger scale cultivation and the decline of stock resulting in depopulation in remote regions. The number of living houses getting empty in the whole countryside can even be a few hundred thousand. This number can therefore be tenfold compared to the 20.000 animal sheds which are larger in size, otherwise the living houses have more valuable materials. In the long run, as a rough estimation the potential reuse of their materials would result in approximately even a TWh energy saving.

On the other hand, revitalizing the countryside, reviving its many-sided, coloured activity increases the employment and the population again. Then, more flats will again be necessary. Instead of demolition the living function will have to be modernized. The majority of the traditional farm and village houses have durable structures, these may need a careful repair. A creative renovation keeps traditional system and appearance, without unnecessary changes, saves material, energy and environment.

Finally the potential value of these innumerable living houses is high also in Eastern Europe but their investigation would require a more detailed study as these structures are less standardised as the farm sheds. Nevertheless, generally the countryside with the farms is the best practical field of environmental management — in this case — of the reuse.

Extending my estimations to other fields of building activity in urban and industrial areas over the whole country (of ten million people) the energy saving could amount even more TWh.

It is a relevant economical gain — in a small country — but much greater environmental benefit. After this, a world scale extension of this kind of environmental thinking and management would be resulting in hundredfold advantages.

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