RESOURCE EFFICIENCY – THE CINDERELLA OF THE EFFICIENCY DEBATE

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Summary

The environmental pollution could be reduced noticeably in the last two decades, especially through technical measures. The reports on progress both of the European Union and of the individual national governments moreover show a positive image of the productivity of resources development. With about one third of all direct and indirect material flows the building sector still contributes a great deal to the national consumption of resources in almost all European countries. In the area of the energy efficiency results have been achieved, whereas those results are not yet visible in the building sector. One reason is due to the fact that we hardly feel the “material-backpack” of 50 tons per year for each citizen, as a good deal of this weight shows up in other places (e.g. imported goods) or in the world at large (e.g. exhaust fumes). A comprehensive analysis of the whole German housing sector according to building types and construction age groups reveals that little progress has been achieved in Germany in the last century with regard to the use of resources. The investigation shows that the analyzed buildings are responsible for a consumption of approximately 4 to 6 tons of resources per square meter of the main constructed area. Although a building has a comparatively long life expectancy, this consumption will in the long run lead to supply problems of building materials. The challenge for the building sector of the 21st century therefore consists in drastically improving material efficiencies.

1 Energy – an important pillar in the necessary global resource efficiency increase

The subject of energy is nowadays again enjoying a prominent position, and rightly so, as a glance at current statistics will show. Even if the International Energy Agency assumes that we will require in the year 2030 only another 60 % of the demand for energy in the year 2002 [1], the fossil sources oil, gas and coal will be employed as primary energy sources to cover this demand. Two big disadvantages mitigate against the large-scale circulation and cost-effectiveness of these energy sources:

- Fossil fuel sources are limited (the statistical range e.g. of mineral oil and natural gas is only approx. 30-40 years according to current estimates) and
- According to the conversion process technology employed, they are associated with a high emission of climate-influencing gases (**Tab. 1**).

Tab. 1 CO_2 emissions from fuels (without conversion processes) (Source: Deutsche BP).

Fuel	**CO_2 Emission Factor**
Natural gas	0.19 kg CO_2/kWh
Liquefied gas	0.21 kg CO_2/kWh
Heating oil	0.27 kg CO_2/kWh
Coal	0.32 kg CO_2/kWh
Wood pellets*	0.00 kg CO_2/kWh
Gasoline	2.30 kg CO_2/l
Diesel	2.63 kg CO_2/l

* Wood pellets are a renewable raw material: The quantity of carbon released during the combustion corresponds approx. to the quantity of carbon which was absorbed during the growth of the plant. Small-scale CO_2 emissions result from the harvesting, the processing and the transport.

Nevertheless, even if the energy cost development does not progress independently of market-economic mechanisms, a clear increase in prices can be observed in past years (**Fig. 1**). This price increase has resulted from a combination of economic interests of the exporting countries and their interest representatives (OPEC), a significantly increased demand in particular in the BRIC states (Brazil, Russia, India, China), due to an increasing industrialization of these regions and rapid population growth, as well as growing awareness of the effective scarcity of fossil sources and the increasingly high-cost supply conditions.

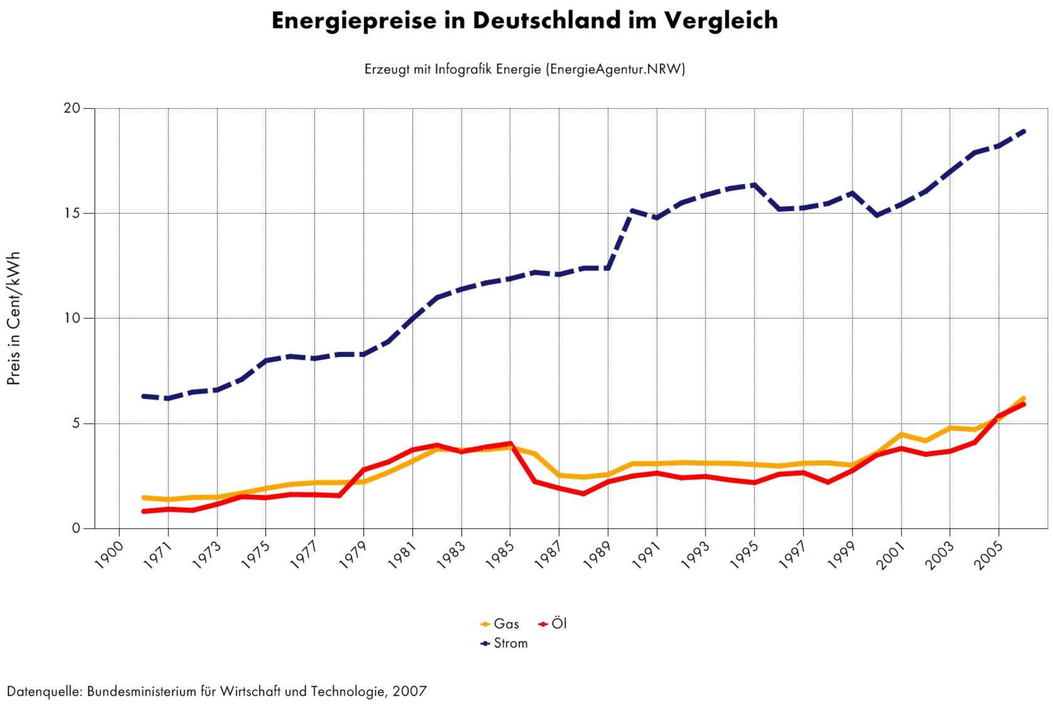

Fig. 1 Energy cost development in Germany
(Source: Federal Ministry for Economy and Technology 2007)

In addition, political uncertainties (terrorism and war), as well as politically driven price increases as a result of climate protection measures, are factors that appear appropriate according to the recent global climate reports (among others, [2], [3]) and will probably be expanded in perspective.

As well as the substitution of fossil fuels through renewable energy sources (photovoltaics, wind and water), the energy efficiency is of great importance in order to significantly lower the demand for energy per person, and to do this as rapidly as possible.

2 The importance of the construction sector in energy efficiency increases

The construction sector must be designated as one of the most important areas to be dealt with here. It uses approx. 40 % of the global primary energy and produces about a third of the entire anthropogic CO_2 emissions [4], which result from the heating, cooling and lighting of buildings. The European Commission reacted to this in the year 2002 and authorized the directive concerning the total energy efficiency of buildings (EPBD, Directive 2002/91/EC), that should be transferred into national law in January 2006. On the national level, corresponding legal and voluntary measures, which were already in existence or were also stimulated through this EU measure, such as e.g. the Energy Saving Ordinance in Germany (EnEV) and the MINERGIE Standard in Switzerland, have been in part introduced, which serve for the purpose of energy conservation.

Also in North America the subject and potentials in the building sector have been identified as very relevant and have been addressed, among others, by the U.S. Green Building Council with its Leadership in Energy and Environmental Design (LEED) System. Also interesting is the fact that, in the study "Winning the Oil Endgame" by Amory Lovins [5], the pentagon, as a political executive body, is in first place worldwide as the largest oil purchaser. As well as lowering fuel consumption in traffic and providing efficiency increases in power generation, Lovins identifies energy efficiency in building as a third important pillar for the United States. As well as ecological reasons, Lovins also deals explicitly with the value of this necessary efficiency revolution in the form of independence to be striven for in energy imports, as well as the opportunity for securing national and global peace. Furthermore, he regards as linked with these measures the opportunity to activate technical environmental innovations, which, from the American economic perspective, will be of great importance in order not to lose to an even greater degree of connection to Europe and Asia, which are leading in this market segment. As a positive result of an engaged energy remediation of the building sector, positive effects on the capacity utilization are also expected, which have already been identified in other studies [6].

In these previously issued works, however, it also becomes clear that the energy problem can be considered to a large degree as being solved. Certainly research requirement continues to exist in this area, in order to bring forward the development of more efficient power generation and conversion technologies, or also energy reservoirs. Frequently the political will is primarily missing to enforce a more future-capable energy system, a clarified characteristic of consumers, including the stimulus structures, such as e.g. the Top Runner approach in Japan or manageable and expressive building certification labels. Furthermore, there is still a deficit in transparent life-cycle-wide economical comparisons, which fairly compares the costs of conventional power generation, including the internalized external costs of ecological consequences (Stern Report) and the putatively higher costs of renewable sources. Also the regionally correct concepts are certainly still expandable (when will there be such a window of opportunity, also financial,) for renewable energies, however, in particular also national strategies for resource efficiency in the building sector. As well as an energy-related, future-capable concept, which links appropriately with each other the components of medium-term to long-term availability, the ecological sustainability, the economic compatibility and the social acceptance, the second pillar of resource efficiency (**Fig. 2**) will have to be attended to more intensively: Material efficiency.

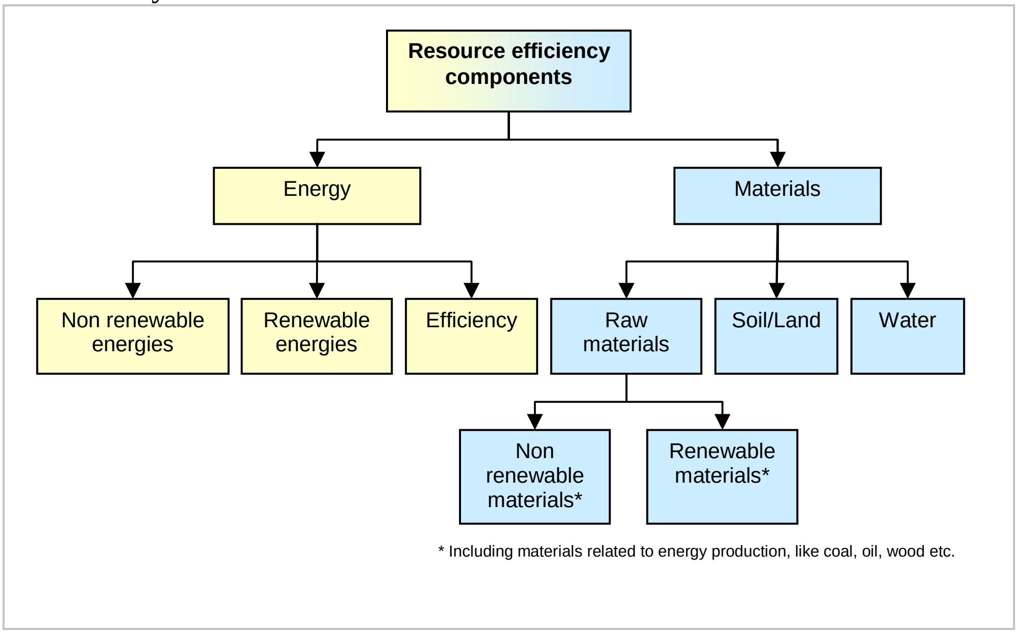

Fig. 2 Representation of the resource efficiency components

3 The importance of the construction sector in material efficiency increases

Natural resources are the basis of all economical activities. Increases in human welfare can be achieved by an optimal and efficient use of resources. The management of natural resources has become the challenge in past years, however. The continued growth of world population, the increase of global production and price increases on the energy and raw material markets, increase the long-term adaptation pressure to efficiency increases with the employment of natural resources. With approximately one third of all direct and indirect material flows, the construction sector contributes a large part, in almost all European countries, to the respective national resource consumption. The "material rucksack", e.g. of every German citizen, of approximately 50 tons per annum is hardly felt, since a large part of this weight does not result domestically any longer, but is included in imported raw materials, as well as semi-finished and finished products (**Fig. 3**).

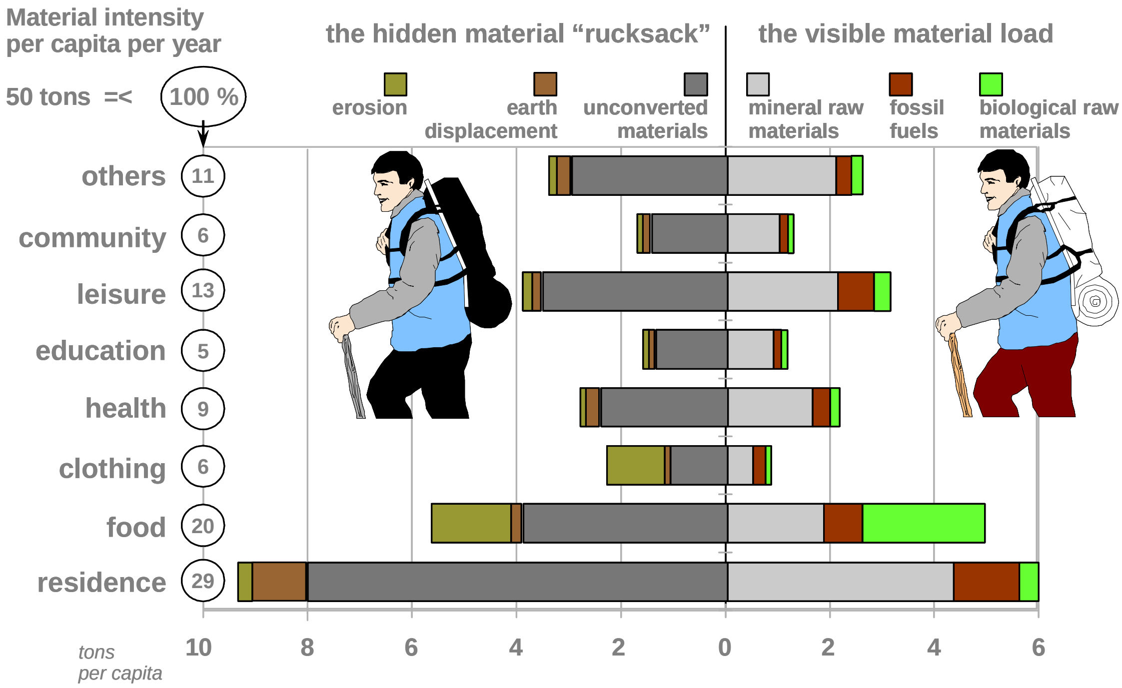

Fig. 3 The weight of lifestyles - 50 tons of materials per capita and year in Germany (own update of data from [7])

Production in Germany with a monetary value of 1000 Euro has been associated with a sinking resource consumption from 2 tons to 1.5 tons between the years 1991 and 2000 (**Tab. 2**). This has resulted, on the one hand, through the reduction of the macroeconomic global material expenditure by 9 % and, on the other hand, through the increase of the macroeconomic production value by 22 %. In this table, however, it is also clear that, in the area of stones and soil, and with that centrally the building industry, between 1991 and 2000 there has been no decoupling of material consumption from economic growth (+8 %). (Here indicated as total material requirement [TMR]) by main material categories (fossil fuels, minerals, biomass))

Tab. 2 Direct and indirect TMR per 1000 Euro final demand production – Germany [8]

NACE Rev.1 sect.	Direct and indirect global material expenditure intensity	1991	2000	Change
		in tons per 1000 Euro		in %
10	Coal, peat	213.48	387.25	81
14	Stones and soil, other mining industry products	172.65	187.17	8
02	Forestry, generation and DL	23.55	30.49	29
11	Mineral oil, natural gas	14.40	21.99	53
23	Coking plant, petroleum products, fission, breeder materials	22.81	19.85	-13
40	Energy & DL of the energy supply	36.40	18.45	-49
27	Metals & semi-finished product from this	16.45	16.38	0
26	Glass, ceramics, processed stones and soil	15.96	16.05	1
01	Agriculture, hunting	12.06	11.34	-6
21	Paper, cartons, pasteboard	6.33	5.71	-10
45	Construction work performances	5.53	5.31	-4
15	Foods, drinks	5.46	5.16	-6
28	Metal products	4.90	4.10	-16

05	Fish and fishery products	2.72	3.73	37
24	Chemical products	4.30	3.47	-19
20	Wood, wood goods (without furniture)	3.31	3.25	-2
34	Motor vehicles and motor vehicle parts	2.84	2.33	-18
55	DL of accommodation and restaurants	2.71	2.16	-20
17	Textiles	2.71	2.10	-22
29	Machines	2.38	1.95	-18
31	Equipment used in electricity generation and distribution	2.17	1.91	-12
35	Other vehicles	2.46	1.49	-39
25	Rubber and plastic goods	2.37	1.44	-39
	Remaining production trade	1.78	1.31	-27
75	DL of public administration, defense, social security	1.15	0.93	-19
52	DL of retail, otherwise Rep.	1.11	0.69	-38
85	DL of health, veterinarian and social sectors	0.93	0.56	-40
	Remaining non-market-economic DL	0.74	0.53	-29
	Remaining market-economic DL	0.87	0.48	-45
70	DL of ground site and apartment sector	0.52	0.47	-10
	All production sectors in total	**2.00**	**1.48**	**-26**

A study by Moll and Acosta [8], 36f. underlines the importance of the "Construction" sector, where this is assigned first place in the 10 most important final-demand product groups, followed by food, motor vehicles, basic metals, and electricity. This study has primarily indicated that the top-ranking product groups score high both on resource inputs (energy use, TMR, land) and on emissions and waste outputs. This may indicate that, at least for these product groups, a close relationship exists between resource inputs and residual outputs [8], 38f.

As well as these ecological reasons, which indicate the necessity of a material efficiency increase in the construction sector, initial scarcities are also becoming noticeable in building materials on the demand side. As with energy costs, price increases can also be observed in different building materials, such as e.g. steel and copper. For this reason, different agencies have been involved for several years in investigating the possibilities of increasing the recycling content for the substitution from primary materials [9].

Increasing disposal costs are also an indication here, e.g. due to the prohibition introduced in some countries on the deposition of untreated residues in landfills. Recycling concrete from demolition projects can result in considerable savings, since it saves the costs of transporting concrete to the landfill (as much as $ .25 per ton/mile), and eliminates the cost of disposal (as high as $100 per ton). As landfill costs for construction, demolition, and land-clearing debris continue to rise and the landfills become more heavily regulated, it makes economic sense to seek alternative means of disposal of concrete from construction and demolition operations. More disposal sites are opening up and contractors are incorporating recycling into their operations to decrease disposal costs.

4 Conclusions

If material usage in the construction sector should now be reduced in order to reduce the life-cycle-wide costs and to simultaneously induce ecological relief, one of the greatest potentials is in the reduction of primary material usage through a stronger promotion of old buildings. Per cubic meter of enclosed space, these are generally less building material-intensive than respective new buildings per building type (**Tab. 3** as well as [6]).

Tab. 3 Specific building material employment in new and old construction (cubic meter of building material per 1,000 cubic meters enclosed space per building type) (Source: [10])

	Freehold dwelling		Multi-family house		Non residential construction (residential-similar)		Non residential construction (Business bldg.)	
Building material	Old building m^3/ 1,000m^3	New building m^3/ 1,000m^3	Old building m^3/ 1,000m^3	New building m^3/ 1,000m^3	Old building m^3/ 1,000m^3	New building m^3/ 1,000m^3	Old building m^3/ 1,000m^3	New building m^3/ 1,000m^3
Calcareous sandstone	19.6	22.0	7.3	18.8	9.5	25.4	7.6	18.1
Brick	17.1	19.7	9.6	12.8	10.5	7.7	13.2	13.8
Aerated concrete	9.7	11.3	2.5	5.1	6.6	14.0	9.1	22.8
Cast concrete block	3.4	11.5	2.0	2.6	2.0	2.1	2.3	0.6
Cast-in-place concrete	34.6	41.6	27.6	36.6	36.5	129.9	26.1	110.2
Prefab concrete element	4.4	14.4	5.5	9.2	11.3	54.0	16.5	53.8
Wood	12.0	7.9	11.0	3.3	6.3	2.9	7.2	7.9

In addition, the basics of the ecological product design are also to be followed in the area of new buildings, such as e.g. the avoidance of composites, modularity of component parts and application in practice. Further investigations about this are needed here, to indicate which regionally adapted and absolutely different strategies can lead to a life-cycle comprehensive optimization in the entire building sector. A balanced consideration of the two pillars, energy and material efficiency, however, is necessary for a resource efficiency increase in the construction sector. A pure energy-related optimization, as is discussed today in many countries, has inherent in it the danger of a lack of optimization, which we cannot afford, either ecologically or economically. Only with inclusion of the material component can concepts be developed which combine building remediation, replacement of new buildings and new buildings in future-capable implementation.

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