LOW COST PIPING: A CHALLENGE FOR FIRST AND THIRD WORLD!

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ABSTRACT

In this contribution we summarise investigations how the three sustainability areas ecology, economy and society can be converted one into the other, how they are correlated etc. Results are explained with the example of different pipe systems made from PVC and other materials. The most important economical criterion, (life cycle) cost, is a scarce resource like ecology and highly connected to ecology and social development. It can be converted into ecological criteria as follows:

Money is invested into thermal insulation of a house wall e.g., thus saving heating energy. Then primary energy resources and a lot of emissions connected to the use of these resources for heating, like CO_2, NO_x, CO, PAH, Hg etc. are saved. The saved ecological impacts are quantified and put into relation to the cost necessary to achieve these savings. The most important result is:

- Economical advantages are much more important (40 times in the case of pipe systems) than ecological advantages in the following sense: Investing 100% of the cost of a pipe system to finance ecological sensible optimisations will result in a factor of 40 higher savings of energy e.g., than is used to produce the pipe system.

From this other results can be derived:

- Cost advantages of products can be used in extended product systems to create very high ecological advantages. Such high advantages can not be achieved by only ecological optimisations. PVC pipe systems are good examples for economically advantageous products and we show quantitatively the ecological advantages possible with them.
- Decreasing life cycle cost is a very important task supporting sustainable development (SD), with huge positive potential for ecological and social development.
- One can support the goal of saving non renewable resources (NRR) and decrease the emission of greenhouse gases better with low cost plastic products based on NRR than with higher cost products made from renewable resources (RR). This is accomplished by investing part of the cost advantage in sensible ecological optimisation.
- Sustainable consumption must not violate ecological restrictions, like the limited availability of NRR connected to greenhouse gas emissions. This can be accomplished by investing a little additional cost in sensible ecological optimisation, neutralising the demand of NRR to produce the consumed products.

Cost advantage can directly be converted into social advantage: A cost advantage of 18% of a PVC pipe system allows the supply with safe drinking water of 18% more people if the money for such investments is limited.

1 INTRODUCTION

1.1 SUSTAINABLE DEVELOPMENT

Sustainable development (SD) is understood as a joint ecological, economical and social development, as shown in the “**Three Pillar Modell of SD**”. This concept is widely accepted by all societal groups like industry, politics, NGO’s etc. and does substitute the older concepts centred towards either ecological or economical or social progress alone. But in practice we still do have “eco labels” and not “sustainability labels”, “green procurement” and not “sustainable procurement” etc.. And even in important European activities like the “public procurement”, SD is mentioned as the final target at the beginning of the paper but for the rest of it “public procurement” is restricted to an ecological development. All these examples show that the concept of SD is still far from being integrated into the society. We did investigate the most important economical criteria, the (life cycle) cost of products or product systems and the relationship of cost to the three pillars of SD.

1.2 (LIFE CYCLE) COST AND SD

Low cost is positively related to all three pillars of SD:

- Ecology: With low cost products scarce monetary resources are saved and they can be used for ecological optimisations, e.g. by investing money into better thermal insulation of houses in order to save heating energy
- Society: With low cost products scarce monetary resources are saved and they can be used for social optimisations, e.g. by investing money into better medical care
- Society: Many people both in first as in third world countries can better afford low cost products than higher cost products. This does help against to big negative social differentiation.
- Economy: Low cost products do save the scarce monetary resources of the economical system

We show in this contribution that already low monetary advantages can be converted into huge ecological advantages. From this one can deduce two important tasks how to support SD:

1. Decrease of life cycle cost of products is even more important than decrease of ecological burdens from a SD-view.
2. Development of possibilities how the ecological/social potential of “saving money with low cost products” can be realised in a positive way.

1.3 NON RENEWABLE RESOURCES AND SD

Most experts believe that the demand of non renewable resources (NRR like oil) and (strongly connected to this) the emission of greenhouse gases (mainly CO_2) are important ecological criteria for SD. From this some deduce that using products made from renewable resources (RR like wood) instead products made from NRR would support SD. There are e.g. quality labels which do exclude plastic products for this argument.

We show in this contribution that by using lower cost products even made from NRR one can save much more NRR than by using higher cost products made from RR. This is realised just by investing a small part of the cost advantage into an ecologically sensible optimisation, e.g. in improving the thermal insulation of a house wall and thus saving heating energy, which is responsible today for a big part of our demand of NRR and emission of CO_2 and other toxic substances.

1.4 ECONOMIC GROWTH AND SD

Many economists believe that economical growth is necessary for prosperous economical development, which is positive for company share holders as well as for the creation of working places, an important social criterion.

Many ecologists believe that normal economical growth has to be stopped in order to decrease the demand of NRR and the emissions of greenhouse gases; they look for a compromise in form of postulating a qualitative growth.

We show in this contribution that important negative ecological impacts of growth like demand of NRR and emissions of greenhouse gases can be neutralised by investing only few percent of the cost of products in such optimisations as given above. Since such a neutralisation of negative impacts of consumption would cost only few percent more, a consequent use of low cost products would not need higher monetary resources than we use today.

2 COMPARING ECONOMIC AND ECOLOGICAL IMPACTS OF PIPE SYSTEMS

Different pipe systems for drinking water and disposal of waste water are competing in the market, mainly pipes made from PVC, polyolefins, metal or minerals. Progress is fast in reducing the weight of such pipes, combining different materials, creating solutions for relining work etc. and this is covered in PPXII. Conventional pipe systems from PVC, PE, cast iron and concrete have been compared in a recent LCA study (1). The study did look for the ecological impact of a drinking and waste water pipe system for a small settlement of 21 houses including the digging of drenches etc., excluding the recycling of the pipes, which is possible in general but to expensive in most cases. The cost of these pipe systems were analysed parallel to this LCA study. Both ecological and economical cost are evaluated along the whole life cycle of the products.

2.1 ECONOMIC IMPACTS OF PIPE SYSTEMS

The life cycle cost analysis did take into account the different cost for different pipe materials, quite in accordance with prices found elsewhere. Cost for digging the trenches are added.
The results show differences of some 25% maximum for different pipe materials.

2.2 ECOLOGICAL IMPACTS OF PIPE SYSTEMS

The LCA study did look mainly for broadly accepted and well quantifiable criteria like energy demand, greenhouse emissions, acidic and nutrient effects. Risk topics were not discussed and are not important in this area, as we believe: There is a long and safe experience with the pipes mentioned above. Second and third order problems like the recent leaching problems of polyolefin pipes in Scandinavia can – if necessary – be solved with minor means, the Pb stabilisers in PVC pipes will be substituted in few years and have never really been a toxicity problem etc.
The results show again differences of some 25% maximum for different pipe materials.

2.3 JOINT ASSESSMENT OF ECOLOGICAL AND ECONOMICAL IMPACTS

2.3.1 MONETISING METHOD

The monetising method assigns costs to ecologically negative impacts, i.e. emissions, energy demand etc.. Cost relations are quantified by several methods, e.g., the cost to compensate for the damage caused by emissions or the cost to avoid them. The sum of the costs for all impacts is added to the life cycle cost (LCC) of a product. Then it is possible to determine whether a particular product costs more or less compared to its alternatives. This cost is now the sum of economical and ecological cost.

- Recently this methodology has been used in several studies (2), (3). The costs in such studies for emissions of CO_2, NO_x, SO_x, CH_4, etc. are shown in table 1.

These costs vary considerably, depending on the methods used by which they were calculated: For example, CO_2 cost varies from 3.9 to 139 Euro/t of CO_2 (4) - cost to repair damage by climate change - up to 190 Euro/t of CO_2 (5) – limit cost to half CO_2 emissions to a world-wide acceptable value. Therefor the monetising method still can not be applied easily. One can nevertheless derive two interesting results from such studies:

- Even the highest CO_2 cost of 190 Euro/t (5) does not significantly influence the LCC results quantified in chapter 2.4. The 27,4 t CO_2, which is emitted to produce an average pipe system cost 5205 Euro/pipe system or 3.2% of the pipe system cost. Since these costs are avoidance costs, demand of NRR, emissions of CO, NO_x, etc. are included.
- Taking average cost numbers it was shown that classical risk topics (dioxins, heavy metals etc.) do not play a significant role compared to the classical emissions (CO_2, NO_x, SO_x etc.) (2).

Table 1: Monetising ecological cost: Cost sets in Euro/t for some emissions to atmosphere.

Emissions to Atmosph.	ExternE (4)			UBA (5)
	Best estimate	Lowest estimate	Highest estimate	
CO_2	19	4	139	190
SO_2	9 200	1 300	27 000	
NO_x	10 000	1 100	30 000	8 700
PM_{10}	17 000	1 900	50 000	
Cd	67 000	6 700	120 000	
Pb	10 000	6 700	15 000	
Dioxin	290 000 000	29 000 000	520 000 000	
CH_4	210	43	1 600	

2.3.2 VINNOLIT OPTIMISATION METHOD

In contrast to convert ecological impacts into cost the “Vinnolit Optimisation Method” does convert economical advantages into ecological advantages (8). Money is converted in ecological advantages by investing this money into an ecologically sensible optimisation. E.g. a thermal insulation of a house wall is financed, thus saving heating energy and related energy resources and emissions (CO_2, NO_x, SO_x etc.). Table 2 shows results from a specific example of a well known sanitation project of a quarter at Ludwigshafen, Germany (6). Negative, red numbers in table 2 indicate used items like used money = cost; positive, green numbers indicate saved items like saved energy and saved/avoided CO_2-emissions.

Table 2: Relationship of economical and ecological cost: Costs and the related ecological savings of energy and CO_2 for 1 m^2 of thermal insulation or for 1 €.

	Cost (€)	**Energy saved (MJ)**	**CO_2-emissions saved (kg)**
Savings by investing for 1 m^2 thermal insulation	**- 44.5**	**+ 11 900**	**+ 680**
Savings by investing 1 € in thermal insulation	**- 1**	**+ 267**	**+ 15.3**

2.4 RESULTS COMMON TO ALL PIPE SYSTEMS

From (1) we calculate average economical and ecological results for all possible combinations of pipe materials to realise a drinking and waste water system. Average numbers for cost, energy demand, CO_2 emissions are shown in the 2nd line of table 3. The 3rd line shows saved energy etc. if one would invest the same amount of money into thermal insulation. Negative numbers indicate used items like cost, energy and emissions in the second row and positive numbers indicate saved items like saved energy and saved CO_2-emissions in the third row.

Table 3: Relationship of cost, energy demand/savings end CO_2 emissions/savings for producing an average pipe system (2nd row) and for investing this money into sensible optimisation (3rd row).

	Cost (€)	Energy used/ saved (MJ)	CO_2 emissions/ savings (t)
Ecol. impacts from a pipe system	**- 82 163**	**- 569.3**	**- 27.4**
Ecol. savings from investing this money into thermal insulation	**- 82 163**	+ 22 000	+ 1 250

One first result: Investing some 82 000 € into a thermal insulation would save some 40 times more energy, CO_2 emissions than would be used/emitted producing a pipe system worth this same amount of money. Or: The intended saving of greenhouse gases is 40 times more efficient than the unintended negative impact of "consuming" a pipe system.
Two other results are derived from this, one valid for all and one for plastic pipe systems:

2.4.1 CONSUMPTION WITHOUT NEGATIVE ECOLOGICAL IMPACTS

From this result above on can conclude: Important (negative) ecological impacts of a pipe system can be balanced investing only 2.5% of the pipe system cost into thermal insulation.
In this way consumption at only slightly increased prices would not contribute to some major ecological negative impacts. This holds of course not only for pipe systems but for all kind of product systems.

2.4.2 USE Of PLASTIC PIPES CAN SAVE NON RENEWABLE RESOURCES

During last years some activities arose which support the use of products from renewable resources (RR, like wood) or minerals and try to avoid products made from non renewable resources (NRR, like oil) in order to save NRR. Reasons for this are the limited availability of NRR and the emission of greenhouse gases, connected to the incineration of these NRR.
One example for such activities is the Natureplus quality label (7), which gets active and monetary support by green politicians in more and more European countries. The monetary support is necessary since most of these Natureplus products are considerably more expensive compared to alternatives from plastics.
The energy saved by thermal insulation comes mostly from NRR. Therefor it is clear from above results, that by using low cost products even if made from NRR and investing only a fraction of the cost advantage into thermal insulation on can save more NRR than by using higher cost products even if made from RR. From discussions with local politicians we know that this is a good argument. Quite often active saving of NRR and lowering the CO_2 emissions is high on their agenda.

2.5 RESULTS SPECIAL FOR LOW COST (PVC) PIPE SYSTEMS

In figure 1 we now compare different pipe systems. Cost and two important ecological criteria are quantified for a pipe system with PVC (A) and with alternatives (B). The cost advantage of A to the lowest cost solution in B (i.e. 15 100 €) is invested into thermal insulation forming the extended pipe system A'. A' costs the same as the lowest cost solution of B. LCA results for A' are calculated and also shown in table 4. A' is by far the best system ecologically. The positive, green number for energy for system A' indicates that much more energy is saved than used to produce systems A, A' and B. Same with CO_2.
The important result from this is evident and equivalent to proceeding statements:
Already with very low economical advantages of some 18% very high ecological advantages can be realised. In this sense economy is some factor of 40 more important than ecology in our example. This shows the extremely high importance of low cost products for a sustainable development.

Table 4: Conversion of economical advantage of lowest cost PVC pipe system A into thermal insulation together forming system A'. Comparison with alternative pipe systems B.

	Product A	Product A'	Product B
	PVC pipe system		non PVC pipe systems
		+ 340 m^2 therm. insulation	**(stoneware, iron, PE)**
Energy demand (GJ) *)	**- 508**	**+ 3 530**	**- 523, .., 676**
Greenhouse (t CO_2) *)	**- 24**	**+ 206**	**- 24, ..., 34**
Cost (Euro) **)	**- 68 000**	**- 83 100**	**- 83 100, ..., 91 000**

What to do with 15 100 €?

Thermal insulation of 340 m^2 house wall (= 11.9 GJ/m^2, 0.68 t CO_2/m^2 and 44.5 €/m^2)

3 LOW COST (PVC) PIPE SYSTEMS AND SD

3.1 ECOLOGICAL IMPORTANCE

In first world countries safe water is normal due to a high quality of supply, therefor investment of saved cost from using low cost pipe systems to improve the pipe system is perhaps not of primary importance. In these countries one can decrease the ecological impacts from producing these pipes with the money saved. This is an example for an ecological optimisation.

3.2 SOCIAL IMPORTANCE

In third world countries, where save water and economical resources are rare, one should just use the lowest cost piping systems to supply as many people and as fast as possible with safe drinking water. In our example we have a 18% cost advantage of the PVC pipe system. Then 18% more dwellings and houses could be equipped with save drinking water and waste water disposal pipe system, an example for an social optimisation.

3.3 "ENERGY NEUTRAL" PIPES, A SUSTAINABLE MARKETING CONCEPT

It has been shown in chapter 2.4.1 that investing only some 2.5% of the cost of a pipe system, the energy demand and CO_2 emissions resulting from producing it can be neutralised. Therefor we propose that products can be bought in the future at two slightly differing prices, the lower one as today, the higher one with an additional price to balance the energy demand etc. caused by the production of these products. Decision between both prices is voluntary, the additional price is managed by an independent organisation and used to finance such ecologically sensible optimisations as discussed above.

In the same way one can imagine "carbon neutral products" (or products neutralising other points), according to the important demand of "carbon neutrality" of The Natural Step (TNS). Since the energy resources saved by investing into thermal insulation are mainly from NRR, a slightly higher additional price than for "energy neutral" products would also balance the non renewable carbon demand. This point is more important for plastic products than for products made from RR.

The idea of these higher price products is somewhat similar to the higher prices of "green electricity" (ecological reasons) or of "fair trade" products (social reasons). It facilitates consumption, taking scarcity of NRR, problems of greenhouse gases etc. into account (see also chapter 2.4.1).

4 PVC PIPING SYSTEMS AND SD

In this chapter we mention some recent developments which are important for the SD of the PVC industry.

4.1 VOLUNTARY COMMITMENT OF EUROPEAN PVC INDUSTRY

R. van't Veer (TEPPFA) is concentrating inhis contribution of on this topic (9). Therefore we just shortly mention the two most important parts of the Voluntary Commitment regarding PVC pipes:

- Substitution of Pb-stabilisers (disregarding that all existing risk assessments do not show higher risks) in all PVC products until 2015.
- Increase of recycling activities of PVC-pipes like in other PVC applications.

4.2 TECHNOLOGY CHANGE AND SD

Technology improvements will favour PVC, because PVC is the plastic with lowest percentage of feedstock and highest percentage of process energy, and this last one is affected by technology improvements mainly. Some examples of change which will reduce the process energy in addition to the normal energy saving activities:

- Already today "gas and steam plants" have been built in many chemical factories, producing three times more electricity with the same primary energy (because of higher efficiency). This process goes on.
- All new electrolysis plants to produce chlorine will use the more electricity efficient, Hg-free membrane technology.

There are also possibilities to change the feedstock production routes:

- "Renewable resources to VCM" processes can be used if a change to RR would be necessary. A "bioalcohole to VCM process" is already used in India (11) e.g.. Please do remind that with low cost PVC applications one can better save non renewable resources than by using them (see chapter 2.4.2) and increasing the cost of the product, and the cost side is not known. On the other hand PVC with it's low ethylene demand of 44% is perhaps better suited for such a change than other polymers.

4.3 POLITICAL ASSESSMENT OF PVC-PRODUCTS

4.3.1 EUROPEAN REVIEW ON LCA RESULTS

The European Commission has ordered in 2002/3 a review on comparative studies on PVC products and alternatives. The review is centred on life cycle analysis work, with only little emphasis on economical and social sustainable development; in this way it is also not integrating the idea of SD, see chapter 1. The review has still not been finalised (January 2004).

4.3.2 TODAY'S VIEW OF THE GERMAN EPA

The German EPA (Environmental Protection Agency, UBA) was strongly arguing against PVC during the last 20 years. Only since around 1998 did the German EPA edit it's first papers with differentiated arguments (10). The German EPA still does promote substitution of plastisised PVC-applications by ecologically safe plastisisers or by PVC-alternatives. But EPA also is more and more accepting unplastisised PVC-applications like PVC-windows, PVC-packaging foils and PVC-pipes.

This change in assessment was supported by many LCA studies (also some of the EPA itself) showing PVC-products quite acceptable compared to alternatives; other studies showed that alternatives do also have risk problems or that these risk problems are not important; some problems with PVC are well solved; recycling possibilities have been worked out and brought to industrial scale during last years.

PS: In order to contribute to sustainable development - our common task - we all will further improve our materials and processes regarding the ecological and economical criteria. We have the chance to use the cost advantage of lower cost products to strongly support a ecologically positive development. Reducing cost as a prime sustainability task should not damage in an unacceptable way important social criteria, like working places; other social criteria are positively affected by decreasing cost, like availability for not so rich people. Promoting this along the whole product chain will be an important, continuous task of the PVC industry like of all competing industries.

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