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Waste Materials in Construction: Putting Theory into Practice

Application of waste materials a success now, a success in the future

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Summary

The recycling or reuse of secondary materials is a nowadays practice in the Netherlands. At this time more than 10% of all granular materials used in he building industry is replaced by secondary materials. Especially in infrastructurale works large quantities are being applied. The drive for he use of secondary materials is sustainable development.
Thanks to the government's policy and entrepreneurship successes have been scored.
At this time nearly all streams of granular waste streams or industrial byproducts (f.i. building and demolition waste, milled asphalt, municipal incineration bottom ash, coal fly ash, steel slag phosphorus slag, blast furnace slag) are being reused completely.
Over the years there is a perceptible change in the questions related to the use of those materials. Where in the beginning the questions were mainly technical, today they are dealing with market forces, economics etcetera.

From a governmental point of view, it is necessary to spot in time bottle necks that can be prohibitive for the successful application of those materials. The role of the government is very subtle. On the one hand in the Netherlands there is a strong believe in a free market economy, on the other hand the interests of the government are in having environmental acceptable applications and in striving for high grade use. This means that the government has to set coals and to create conditions for a free market that will achieve those coals.

In the paper the way the Directorate-General of Public Works and Watermanagement deals with this subject will be explained. A special attention is paid to the succesfactors that have been decisive for the successful introduction of the secondary materials. A study into these succesfactors has been performed in order tot enable the government to increase its efficiency in the implementation of the policy.

Also the question of sustainable use of materials will be dealt with. Not always reuse of a material is a synonym for or in line with sustainable development. Given the fact that the first use of the secondary material of course fulfils technical and environmental criteria, it is necessary to take into account the reuse and re-reuse of secondary materials. In this kind of life cycle approach not only technical or environmental conditions have to be set, bus also labor conditions, actual control of the material and other questions influence the acceptability of the first application. If these questions are not taken into account than it is possible that a solution now creates a larger problem in the future.

Application of waste materials: a success now, a success in the future.

1. Introduction

Recycling of materials in construction has been a normal matter in the Netherlands for many years. In [1], the situation in the Netherlands a number of years ago has already been examined. In recent years, a further development has taken place whereby more insight into market tendencies has arisen. The market for secondary materials has been professionalized whereby, in a number of cases, the differentiation between primary and secondary materials is beginning to fade. However, watchfulness remains the precept. Changing social, economic, scientific and technical insights can influence the current recycling possibilities. The government, with responsibility for collective standards and values, has a task to intervene and/or make adjustments where necessary.
This paper will explain factors which influence the application of secondary materials, and the manner in which the government can work as effectively as possible proceeding from policy responsibility.

2. Umbrella policy lines

In brief, the policy framework in which the recycling of secondary materials occurs will be stated.
The Netherlands is a densely populated and relatively affluent country. This means that there are many people living per surface unit who all have their requirements for space and comfort. In addition, there is a high level of activity in many economic sectors. All these factors are accompanied by a continual need for the use of the limited space available in the Netherlands.
Every year, very large quantities of land are used for dumping wastes, on the one hand, and for extracting surface minerals such as gravel, sand, clay, and limestone, on the other hand.
The realisation that this way cannot be continued any longer is deeply anchored in Dutch society. The closing of material cycles, resulting in the need to dump less, and less exhaustion of non-renewable raw materials, is a consequence of that.

The application of secondary materials derives from the national administration's policy as articulated in, among others, the National Environmental Policy Plan (NMP). [2]. The NMP states:
"This NMP contains the strategy for the environmental policy for the medium long term. The strategy was developed against the background of the wish to solve or to control environmental problems within the life of a generation."

For environmental control, striving for a sustainable development is the starting point.

A sustainable development is a development that supplies the needs of the current generation without endangering the possibilities for future generations to also supply their needs.

"Sustainable development takes shape through feedback at the sources aimed at a combination of:
- closing of cycles in the chain of raw material - production process - product - waste, and the accompanying emissions;
- saving energy, together with increasing efficiency, and the deployment of durable energy sources;
- promotion of the quality (above quantity) of products, production processes, raw materials, waste and environment, with a view to longer usage in the economic cycle."

The quotations above from the NMP outline a policy-directed framework within which the recycling of materials takes place. The NMP-plus [3] published later does not give any change of policy, but rather a speeding up of it.

A further realisation of the general policy is taking place in about three (for this subject) relevant policy lines.

2.1 The waste materials policy [4]

The waste materials policy, for a significant part, is based on the so-called Lansink ladder. (the Dutch Lower Chamber motion from 1979). This ladder indicates a priority ranking for the waste materials problem.

Lansink Ladder:

* prevention
* recycling
* burning
* dumping

This ranking shows that prevention, or avoiding waste in accordance with policy scores highest, followed directly by recycling (in this context, by recycling is also meant the reuse of materials). In the stream of priorities, there are a number of materials which, in terms of nature and quality, are suitable for application in civil engineering.

2.2 Soil protection policy

Protection of the soil is another policy line which influences the deployment of secondary materials. In a general sense, it can be said that secondary materials, due to their composition, can have other environmental effects than conventional materials. In the framework of the Soil Protection Law, a General Administrative Order (AMvB) was published which states preconditions to the application of materials on or in the soil. The Soil and Ground Water Building Materials Degree (BSB) [5] is intended to give the environmental-hygienic preconditions proceeding from soil and ground water protection to the use of secondary and primary materials on or in the arable soil or in ground water or on or in the soil under surface water.

The BSB limits its operational sphere to granular (stony) materials applied outside.

In applying construction materials, the concept of marginal burdening of the soil is used. Marginal burdening of the soil entails:

- a very minor increase in the proportions of contaminated materials in the compact layer of the soil, and
- protection of the ground water at the level of ground water target values.

Marginal burdening of the soil is numerically filled in as: *a burdening of the soil as a result of the extraction of surface materials, which mathematically leads to an increase in the compact layer of the soil of at least 1% of the proportions of contaminated materials in comparison with the soil target values in 100 years, averaged over a meter of standard soil considered to be homogeneous.*

The BSB assumes an emissions model which can be determined based on the emission from the surface material in a specific application.

In order to continue existing recycling of materials, the maximum permitted emission level for a few materials has been increased.

The emission applies to inorganic components. NEN-standards have also been developed for this in order to be able to determine the emission. A good extraction test for organic components is still lacking; because of that, a composition requirement was assumed for organic components.

The BSB will come into effect in phases, the first for soil. Mid-1998, the BSB should be fully in effect.

2.3 Surface minerals policy [6]

In order to supply the need for raw materials for construction, a policy in this domain has been developed by the government.

Long-last development implies, among other things, integral control of the chain of raw materials. This entails closing the chain of raw materials in construction as much as possible, preventing degradation of the quality of raw materials, and limitating the production of waste. For the supply of raw materials, this particularly means the frugal use of raw materials and the responsible recycling of waste materials as secondary raw materials. This leads to, among other things, less excavation and dumping of waste.

The main objective for the supply of raw materials in construction is: "The policy of the national government with respect to the supply of raw materials for construction has as goal to supply the need of private individuals, businesses and government for construction raw materials (in a socially

responsible manner) by:

- encouraging the use of raw materials as sparingly as possible;
- stimulating the deployment of secondary raw materials in a responsible manner as often as possible;
- supporting more deployment of replaceable raw materials;
- and ensuring the timely excavation of an adequate portion of surface minerals from Dutch Soil in the total supply of construction raw materials."

The policy lines above indicate that it can be a matter of a synergy aimed at the application of secondary materials.

3. General preconditions and assumptions

In order to get the application of secondary materials in civil engineering off the ground, it is necessary to satisfy a large number of preconditions and assumptions. The most elementary principle is that there should be a market; in short, a supplying party and a demanding party who can come to terms based on a transaction that is attractive for both of the parties. In the Netherlands, the principle of the free market economy rules, which is also the prevailing opinion for the application of secondary materials. This means that the government is of the opinion that a very important role has been reserved for private industry. However, only in a few instances is private industry the producer of the waste material to be recycled. In nearly all cases, the government itself is a producer of waste materials, resulting from its function or its policy. (E-fly ash as a result of the energy policy, municipal waste incineration bottom ash (AVI-bottom ash) as a result of the policy of burning waste materials, construction and demolition waste from infrastructural works, dredging spoils from maintenance of waterways, etc.). This means that if the government wants to use private industry as a resource for solving its own problems, it must be attractive for business to operate in this market. In the following section, a number of essential preconditions will be explained.

3.1 Unambiguous policy

For the application of secondary materials, it is necessary that there be an unambiguous government policy that has taken shape in unambiguous rules that are fixed for a long time.
The application of secondary materials is surrounded by risks and uncertainties.
The risks concern both material-technical risks and environmental-hygienic risks. As far as the environmental-hygienic risks are concerned, it is noted that in the past, the lack of an unambiguous frame of reference of what is permitted under which preconditions, and the various ways in which the competent authorities (particularly provinces) deal with this, have frightened off potential customers. The various ministries responsible for policy (and responsible management within ministries) have not always worked together in an exemplary way in years past.
At the same time, an application now may not lead in the future to a situation in which the current user is punished for his use.

3.2 Private Industry

To realise government objectives, an active business community is necessary. It is the business community that through investments and implementation, ultimately sees to it that the policy objectives are realised. The business community is always ready to invest if the prospects are sufficiently attractive. That means that the government must pursue an investment-friendly policy, and should be reliable as legislator and lawgiver. There are examples where the government has not appeared to be too reliable a partner. That the business community has become cautious after that should be clear. To be reliable also means that the government should be ready to take risks itself by, for example, stimulating, as a customer, the application of secondary materials in its works.

3.3 Engineering-technical parameters and rules

In a country where nearly every application is set down in standards, it is practically impossible to achieve a general application if there is not a setting down of the application of secondary materials in

a standard or a similar document in private law. The inclusion of secondary materials in standards and rules is an important precondition.
This means that in the general sense, the effects of the application of a secondary material on the engineering-technical parameters of the construction segment must be known. In sum, the price/performance ratio of a secondary material or of a product manufactured from it should be known. In general, it is a time-consuming affair. Working for years with a limited choice of primary materials has led to, on the one hand, empiricism being based completely upon it and, on the other hand, standards and the like from that empiricism being valid only for those materials. In addition, the civil sector seems to be conservative. It takes a long time before a new material has proven itself in the market.

3.4 Economics of the application
It has already been stated above that the price/performance ratio of an application should be known. One may assume from this that in the Dutch market economy, a material will only get a chance via market-conforming mechanisms. This means that the price/performance ratio of a secondary material must at least be comparable with a traditional material (and preferably, more suitable still).

In a general sense, it concerns an "artificial" market. Recycling or useful application is often not cheaper. This is partly due to the fact that not all cost factors which determine the price of primary materials are charged. That is a question of time-dependence is shown by the fact that bitumen, once a waste product, is now a raw material that has a market value of approximately ƒ 350 per ton. If many applications are looked at, then it appears that these only get off the ground if favourable measure are introduced from the government's side which influence the economics of the product. The following will make that clear.

The application of granulates in road construction has become a successs because dumping fees have increased sharply. The granulates have certain engineering-technical qualities which make application as a base course material possible. However, in order to have a chance in the marketplace, those materials should at least be cheaper than traditional materials. The application of a base course leads to a reduction in asphalt thickness. This means that the granulate base course must at least be cheaper than the price for the quantity of asphalt saved. In other words, the asphalt price determines the maximum price of the granulates. This means that a demolition waste recycling plant (because of the fixed and variable costs) must ask an acceptance-price in order to be able to sell the finished product competitively.
Only with a dumping fee higher than the acceptance-price of the plant will the flow of demolition waste be altered toward recycling.

Also, making changes in a package of products occurs only if this is economically attractive.
The demolition granulate materials for road construction are in principle also suitable for application in concrete. This, however, requires an extra treatment step (sifting and washing), whereby extra costs are incurred, but an extra waste product (silt) also remains. This silt will have to be dumped at a very high cost due to the pollution level. Despite the fact that the granulate can yield a higher price (comparable with gravel), the net result is negative due to the extra treatment and the costs of processing silt.
This means that without the creation of preconditions by the government in a market-conforming manner (e.g., a special dumping charge for silt), no altering of the stream of waste can be obtained.

3.5 Chain concept approach
An important concept connected to unambiguous policy is the chain concept approach.
In a general sense, this means that application of materials now may not stand in the way of future recycling. It is noted that the policy on that subject has not yet fully taken shape in an operational sense.
The application of the chain concept means that a designer or a materials expert should ask himself if application of a secondary material now stands in the way of future recycling. Many factors play a role in this. A number of these will be explained.
In the first place, it certainly concerns a civil engineering evaluation. If an application now leads to the

conclusion that the material soon cannot be recycled, the cart is being put before the horse. Indeed, in the application, the secondary material is often mixed with new materials, whereby the waste problem then only grows larger over time.
In addition to a civil engineering reason, the same can also apply for environmental-hygienic and labour-hygienic aspects.

Another aspect concerns enforceability. Due to preconditions, it could be necessary to allow a specific secondary material only in a specific application. One can think of the application of materials with lightly increased radioactivity only in concrete in an outside environment. (as might be the case with phosphorus slag).
Future recycling of this concrete, then, must take place in such a way that this material does not come directly into concrete that is applied in an interior environment. If this cannot be guaranteed, it should seriously be considered not trying to pursue the first application.
A careful weighing of risks and application possibilities is necessary for this. Here, an important responsibility lies with the government to make these choices and to create the necessary preconditions.

3.6 Quality

For a customer, it is important to obtain certainty about the quality of the materials to be applied. More than with primary materials, secondary materials are surrounded by a negative image. (secondary = second-hand and thus, (in the mind of some clients) inferior with respect to primary materials).
Supplying materials with a good quality guarantee (certificate) is of importance in order to get the application further off the ground. It concerns, then, a certificate which covers both the material-technical and the environmental-hygienic parameters.

3.7 Market

To sell materials, a market is needed. On a macro scale, there appears to be no problem. Every year in the Netherlands, there is a need for approximately 140 ml tons of granulated raw materials, while approximately 30 ml tons of secondary materials can be brought to the market. At this moment, some 15 ml tons of secondary materials is being sold. It appears that in some market segments, there is saturation of the market, whereby growth in sales remains behind. In the Netherlands, it seems that the market for granular (unbound) base courses is saturated, whereby substitution effects could arise by further growth in production [7].
It should be realised that the market for secondary materials is very inelastic. Indeed, the production is largely determined by the size of the flow of waste and not primarily by the demand for the product.

3.8 Market acceptance

Satisfying the conditions mentioned above is not yet sufficient for market acceptance. There appear to be multiple forces at work. The customer has an important role in this. In time it must be so that the differentiation between secondary materials and primary materials fades. Think of the example of bitumen given, but one can also think of blast-furnace cement or Portland fly ash cement.
Before it comes to that, it is necessary for customers to take their responsibility and open their works for the application of secondary materials. At this moment, it is the large authorities in particular that are fulfilling an exemplary function (Rijkswaterstaat (Directorate-General for Public Works and Watermanagement), the municipality of Rotterdam). Putting forward experiences about this is a means by which to achieve further spreading. Of importance is that managements of organisations themselves form a clear policy for deploying secondary materials. At this moment, the decision to apply secondary materials or not is often taken at a low level without clear guidelines from management at the foundation.

4. Current situation

Figure 1 shows which materials in what quantities are produced and recycled. It is good to state here that recycling has various degrees, from low-quality application such as embanking material to high-quality application such as, for example, replacement of scarce primary materials (application in

concrete or asphalt recycling). Different countries use different definitions of reuse and have different objectives. This does not mean that overall recycling figures from different countries can be compared with each other just like that. The degree of high quality and application in various market segments is a better measure for this.

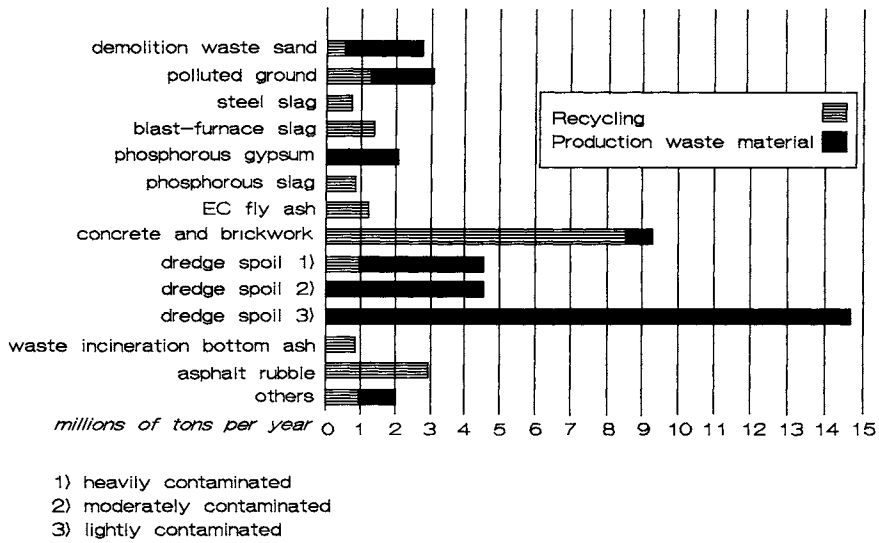

Figure 1: production and recycled amounts of waste materials

In this article, this aspect will not be explained in further detail. At this moment, suffice it to say that in the Netherlands, and particularly from the standpoint of surface minerals policy, there is an effort to apply secondary materials at as high a quality as possible.
The table shows that it is, of course, clear that recycling is successful in the Netherlands. However, circumstances can change, whereby it could be possible that a current application would come under pressure. Although the objective in the Netherlands is to reach a market-conforming sale of secondary materials and, thus, there is a very important role reserved for private market parties to anticipate developments, it may have become clear from the previous paragraphs that certainly for secondary materials, the role of the government is great. Therefore, the government deemed it necessary to find out what the success factors were in the past which saw to it that the current market situation arose, in order to learn lessons for policy to be developed in the future. In what follows, a number of important learning points from that study will be explained.

5. Definition of success

In order to recognise success factors, it is necessary to define the concept success in detail. The definition of success strongly depends on the point of view of the observer. Success for one is failure for another. From the standpoint of the government, the following definitions could be applied.

5.1 Degree of market acceptance

The national government feels the need to obtain more insight into the market acceptance of secondary raw materials.

In the last decade, partly due to an active policy of various authorities, a large number of bottlenecks were overcome in order to be able to apply secondary raw materials in construction. The market acceptance of the various secondary raw materials differs, though. Some, such as granulated blast-furnace slag, are completely established; for others, conversely, market acceptance and appreciation is (more) uncertain. (figure 2)

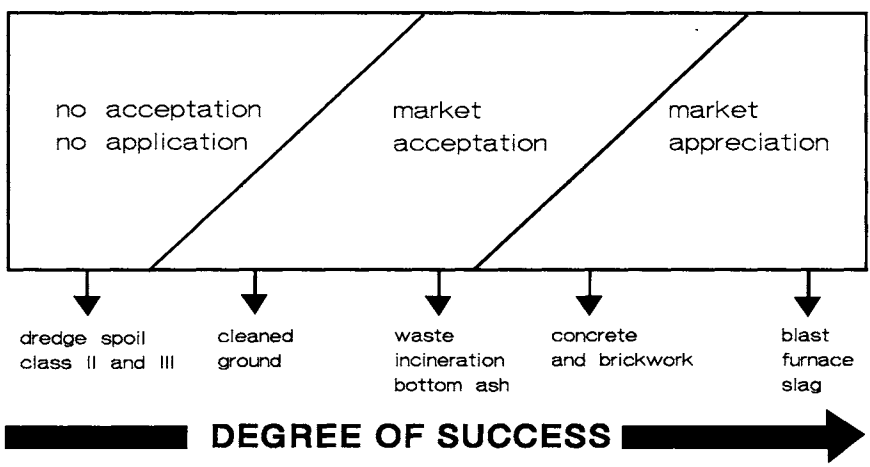

Figure 2: representation of success

Crudely put, there are three groups of materials to differentiate:

A. **Accepted and preferred:** Many secondary materials for which the (domestic) demand is greater than the supply are characterised by the fact that these materials are (often) preferred above primary materials in their specific application. Acceptance is determined by the unique quality/product characteristics, whereby price is less important.

B. **Accepted:** For many secondary materials, supply and demand are not always "in balance" (usually oversupply). Then, application often depends on the relative price ratios between the various suitable materials. The price instrument is, thus, the success factor here in terms of sales (large price sensitivity). The quality differences in the supply (differentiating capability) are minor. Demand is often stimulated directly or indirectly by government. The material does have sufficient specific characteristics that, due the influence of price, lead to application.

C. **Not yet accepted:** For the secondary materials belonging to this group, sales and application are especially a result of pressure; for example, mandatory application or the policy-driven, explicit choice for application by specific customers (e.g., Rijkswaterstaat), without leaving it to market forces. Sensitivity to policy, then, is also great. Despite pressure, it must be concluded that in a number of cases, application is still not a viable proposition (material is dumped).

It is particularly groups B and C for which it is important to have insight into the factors which determine and/or can lead to such market acceptance that in the long run, it will also be a matter of establishment (appreciation). Not all secondary raw materials, however, have the potential to become fully established (appreciation). The degree of market acceptance/appreciation, however, does indicate to what extent a market-conforming sale is achievable and has a relationship with the extent to which the government should be involved in the sale. This will be discussed further.

5.2 Percentage of utilisation

The percentage of utilisation is a simple instrument for ascertaining whether recycling of secondary materials has been realised. It gives quantitative information which can also make a development over time more visible. Figure 1 is an example. However, without testing on other objectives (e.g., prevention, market conformity, closing of the cycle chain approach), the instrument is too limited to be able to determine the degree of success.

5.3 Realisation of wishes and objectives

Here, the perception of the actor plays a very strong role. Indeed, objectives and wishes can vary greatly from actor to actor. Thus, policy authorities will often have abstract objectives (degree of building cycle closing, long-lasting development, reduced volume of dumping, etc.), and the business community, operational objectives (continuity, market volume, revenue, profit, etc.).

6. Sales of secondary materials and success factors

Because success here is a combination of these three definitions and is partly dependent on the actor, giving a formula for success is an impracticable affair. Due to the dynamics of time as stated earlier, circumstances change and other success factors are determining. The study shows that it is also possible to make this visible over time. To be emphasised is that what follows is indicative of the Dutch market and the Dutch situation. It certainly does not have to be true that in other countries with other societal, economic and social structures, the same end-evaluation needs to be reached.

6.1 Evaluation in time at the macro level

Over time, there are four periods to be differentiated at the macro level (figure 3). Each period has its own impediments, but also its own success factors. In the following diagram, the most important impediments and success factors are summarised. The last period, 1995 to 2005, is characterised by long-lasting development. In addition to sharpening standards for asbestos, dust and radiation, an expected impediment is a greater reluctance to invest in new recycling techniques; for some materials, a greater dependence on a few processors and purchasers (environmental rules too complicated) and the falling away of national boundaries.

Period in the recycling industry	Most important impediments	Most important success factors
1. Trade in valuable secondary raw materials to 1970	• lack of good reference projects • unknown reprocessing technology + application • dumping and discharging cheap	• utilising unique product characteristics • saving transport costs • little thought for environmental risks
2. Trade + (threatening) scarcity of primary raw materials 1970-1985	• insufficient processing capacity/infrastructure • suppliers split • specifications, rules and regulations, product requirements not adjusted • sharpened environmental policy (various compartments sometimes inconsistent) • cost/return ratio	• technology development, incl. improved construction • adjustment of product rules/specification standards • threatened shortage of primary raw materials • building up of (logistical) infrastructure
3. Trade + control of waste flow 1985-1995	• poor management of quality/ quality systems (to about 1990) • authorities reticent as customer (to about 1990) • unclear/environmental policy/ enforcement/provincial borders • no continuity of supply and/or balance of supply and demand in the short term	• high dumping charges • quality improvement + certification • suppliers bundle together • consistent market policy • authorities (RWS) serve as example
4. Sustainable development (closing of cycle + functional utilisation or fitting in) 1995-2005	• sharpening standards, Occupa- tional Health & Safety, radiation, asbestos • (competent) authorities more decentralised • harmonisation supply + demand middle long term • falling away of national borders	• ban on dumping + charges • clarity as to what is allowed (environmental-hygienic/long-lasting context) • (special) large-scale projects + multi-year planning projects • long-last designs e.g. material decision lists, new technologies

Figure 3: Overview of bottlenecks and success factors, 1970-2005

6.2 Evaluation at the meso level

In practice, in addition to influence from social groups and attitudes of the end users/consumers, there are three groups of actors to be differentiated:

- government as lawgiver
- suppliers of secondary raw materials
- users of secondary raw materials.

These actors are initiators of success factors and/or take measures aimed at sales promotion/improvement of secondary raw materials. Government measures again influence the activity of suppliers or users and thus, indirectly, sales (see paragraph 3).

It appears that just as for "ordinary products", secondary raw materials also have a Product Life Cycle (see figure 4).

Some secondary raw materials that are not saleable now or difficult to sell were previously sold without problems; e.g., dredging spoils and AVI-bottom ashes.

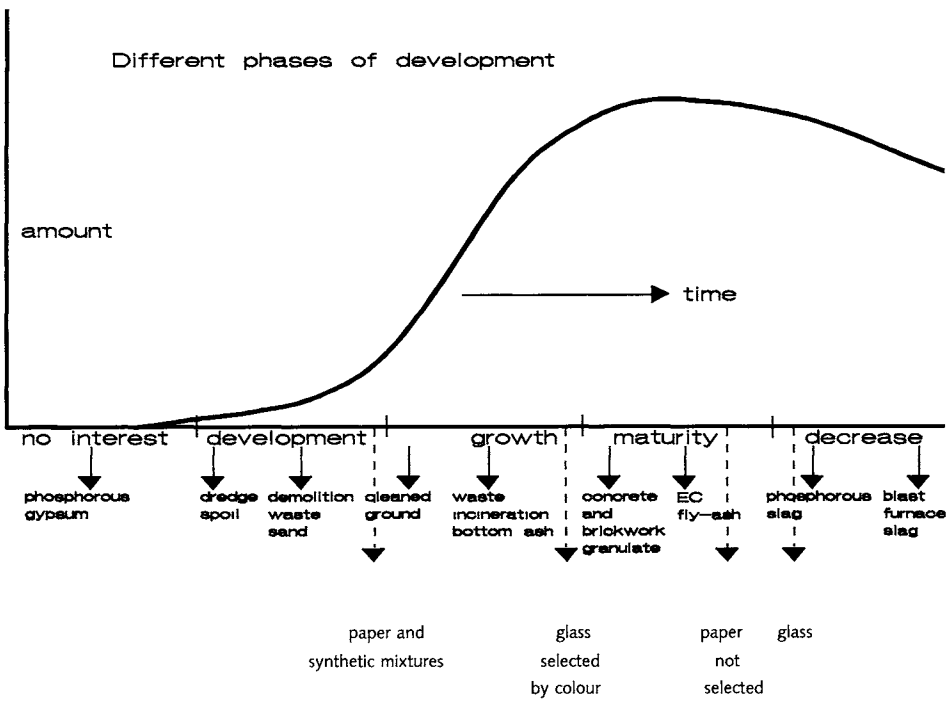

Figure 4: Product Life Cycle

In the market dynamics, we a see a large number of products, each in its own phase of the Product Life. Social, economic and technical developments (both national and international) are making the PLC shorter, in general. In addition to the business community, the government should also have insight into this dynamic, both from the quantitative and the qualitative aspect. Indeed, it could be necessary to influence the market if, due to autonomous market tendencies, undesirable movements from a policy standpoint arise (for example, substitution or product development which is less desirable from the standpoint of chain control). It may be stated that due to the dynamic in policy, the market is still turbulent at this moment.

In table 1 are the most important impediments mentioned in the study [8]

Table 1 : The 7 most frequent* impediments
1. No quality control, know-how (insight into composition)
2. No economic basis/dumping cheaper or (international) competitive position too weak
3. Demand fitful, sometimes saturated market
4. Poor image, acceptance
5. Product standards/requirements not adjusted
6. Insufficient (treatment) processing capacity
7. Problems with radiation

The success factors are given for these seven most important impediments.

The five most important success factors for the business community were:
1. Active selling/consistent selling policy
2. Investments in reprocessing capacity
3. Readiness to solve the social problem
4. Quality improvement and certification
5. Seek high-value market-technical

The five most important success factors for the government were:
1. Helping with development of recycling technology
2. Exemplary function of government
3. Clarity created as to what is allowed
4. Dumping policy (dumping charges, bans)
5. Authorities were also problem-owners (road construction, AVI-bottom ash, polluted soil)

It clearly follows from this that the market is directed more towards the operational aspects, and the government clearly must be active in the preconditions domain. For that matter, for the government in the Netherlands, a bundling of market forces by acting together with the business community and thus, being a good (and reliable) partner both at the policy level and the technical level (standards, certification, price setting, etc.) may not go unmentioned.

7. Looking ahead

On the basis of the aforementioned, recommendations for future policy are to be drawn up. Knowledge of the market is an essential condition for acting with initiative and stimulation in the correct manner with a policy framework.

- The future policy of the government could be directed toward:
  - unique applications — follow the market
  - specific applications — direct/expand the market
  - amorphous applications — influence the market directly

  With respect to the first two applications, the government should determine the preconditions in particular. For unique applications, the material itself already has an adequate price/performance ratio. The preconditions, then, will often only be set at the environmental-technical and labour-hygienic level. For the specific applications, it is often necessary that economic preconditions also be influenced if the material is to be sold in conformity with the market. Dumping policy can give a clear stimulus here, but certainly deviant behaviour should

also be counteracted through enforcement. As far as the "amorphous applications" are concerned, for example, moderately polluted soil and poorer qualities of secondary raw materials, applications undesirable from a policy standpoint should be avoided by playing a more active role. For these applications, in a number of cases, the government will itself have to act imperiously for recycling by consciously creating market demand and favouring these materials with respect to others in the application. If there is no clear policy being pursued, these materials will come off worst with respect to other materials, or the price should be so low (pay a lot for sales) that undesirable side effects can arise. These types of side effects will work negatively on the desired environmental quality and other policy objectives.

- In a general sense, for both the government and the business community, it is important to have insight into which phase of the Product Life Cycle the product is in. Depending on the bottlenecks with which the product is faced, it can be ascertained based on experiences from the past which success factors are suitable for removing the impediments. In figure 3, all of this is shown. The basis in all cases is a clear answer to the question "what do I want".

8. Conclusions

- The market for secondary materials is influenced to an important extent by the government which, in order to realise policy objectives, should be active in terms of preconditions.
- Due to the importance of the government for a good application of waste products as secondary raw materials, it is necessary that the government have knowledge of the market conditions and the market dynamic and act accordingly and take its responsibility.
- Through good interaction between the government and the business community based on common interests, a successful selling of secondary materials can also be ensured in the future based on knowledge of the market dynamic (Product Life Cycle) and knowledge of the nature of the application (unique, specific or more amorphous).

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