Review of the Dutch and European change from landfilling to more than 80 percent recycling

A practical guide to market creation for C&D waste

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ABSTRACT

The cornerstones for the creation of a sustainable market for C&D waste are:

- Production, purchase and use of certified quality products;
- Economic feasibility of the operation;
- Engagement of public bodies in lawmaking and enforcement;
- Engagement of those responsible for landfills.

Some secondary aggregates passed in Europe recently the 'end of waste' criteria, meaning they are seen as products and no longer as waste. This is a milestone that marks 25 years of development and successful re-use and recycling of C&D waste. The transfer of the underlying knowledge can speed-up development in upcoming markets like South Africa.

Following a request from the GreenCape organizatation[1] we describe what products of C&D are being used for particular applications and how the required quality is created and monitored.

Furthermore we will show under which economic conditions the market can exist and how public bodies and those responsible for landfill operation can contribute to success or failure of the market.

Waste management often starts from a technical and environmental perspective. To my experience in waste management, the economic picture is often the engine or the medium for technical and environmental changes. This makes it interesting to examine and describe the waste market from a leading economic perspective. It helps in finding fast, effective, sturdy and lean solutions.

This article is focusing on Construction and Demolition Waste: soil, aggregates, asphalt and organics.

1. Time and money

1.1. Triggers, conditions and response in the Netherlands

In the Seventies of the 20th century the GDP per capita in current prices in the Netherlands grew from $3000,- to $13000,-. By the end of the Seventies it was clear that this growth had caused some environmental problems: contamination of water, soil and air. In waste management there were some scandals (contaminated sites, illegal dumping and -export) and there was a lack of remaining landfill space. There was enough wealth to spend some money on it.

This lead to some political ideas and measurements. The waste hierarchy was developed as a mutual comparison of treatment options. This hierarchy is still important worldwide, mainly because it is easy to communicate and stimulates thinking about waste management. But more was done. In the Mid-eighties, the organisation of the waste management was concentrated at the provincial level. Some tasks, like capacity planning, were decentralized from the National Government. Some tasks –licensing

[1] http://greencape.co.za/

and enforcement- were centralized from municipalities. For the main waste categories the Provinces were ordered to be self-sufficing. This created the opportunity for an interactive multi-stakeholder interaction in the old Dutch tradition of the functional democracy of the water boards.[2] In the Province of North-Holland, where I was involved, public and private parties clotted together to manage the issue of waste management. The Province built new landfills to replace the old small dumps at the borders of municipalities. The alignment of policy making and operation made it possible to organise and finance the transition from dumping towards sustainable landfilling, recycling, composting and incineration of combustible municipal waste. A public owned private company at supra-provincial level was established. This company was and still is responsible for landfilling, soil reclamation, aftercare, and some aspects of waste management and recycling. The approach was copied in other provinces. By the end of the century the facilities and companies that were created, needed coordination at a higher level. The provincial borders were opened and the waste management policy became a national issue. In 2014 the national borders were opened and it became a regulated international market.

The emergence of a vibrant market for C&D waste the Netherlands in the late Eighties was supported by the fact that this country lacks large amounts of mineral raw materials. About 50 percent of minerals is imported.

1.2. International development

The creation of waste markets took place over the last 30 years in the whole North-West Europe. It developed from a mainly simple structure with municipal collection and landfills to a very diversified landscape.

Later in this article we will see that the market can be characterized as an artificial arena with interacting players of different kind: consumers, governments at different levels and all kind of public, semi-public and private companies

The EU adopted a national legislation and changed it into European legislation. Important here is the creation of a 'level playing field' to enhance fair international trade. This is challenged by the fact that countries of the EU have a different economic situation. The national rules of the game and quality assessment of those who were ahead, are sometimes frustrated because of more sloppy regulations of the EU.

The international situation with urbanisation, big economic differences and the fast development of African and Asian countries demands effective solutions within a short time-span. This needs coordinated action of the actors.

2. Products from C&D waste

Compared to other waste streams, C&D waste is easy to process with mechanical equipment. It is dry and contains relatively low concentrations of hazardous materials.

C&DW contains both inert (mineral and metal) and non-inert (organic) fractions. The inert fraction is most abundant. If it is well separated at source, the processing is simple, mainly sieving and crushing, which results in Recycled Aggregates. If the mineral fraction is mixed with other fractions, the C&DW is processed in sorting plants. Here, materials such as wood, metals, plastics and glass are recovered. The remaining organic fraction can be further processed to produce Solid Recovered Fuel (SRF), also called Refuse Derived Fuel (RDF).

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[2] See: (English), search in this article for Water Boards, history https://staticresources.rijkswaterstaat.nl/binaries/Water%20Management%20in%20the%20Netherlands_tcm224-303503_tcm21-37558.pdf

Recycled aggregates are produced in different qualities for different applications. These qualities differ in environmental impact, where leaching is the main criteria and in mechanical properties. Mechanical properties include Particle Size distribution, particle shape and crushing strength. Most common products are:

- Mixed aggregate and Recycled concrete aggregate (RCA), mainly used as road (sub-) base;
- Hydraulically bound mixed aggregate, mainly used as road (sub-) base;
- Recycled concrete aggregate for concrete;
- Recycled asphalt Pavement (RAP).

2.1. Contaminated soil separated from C&D waste

In the Netherlands and some other European countries, soil is no part of CDW, but has its own policy, legislation and application. After 40 years of policy development the quality and application of the receiving soil location now determines the quality of the soil that can be put there. Of course this is within strict boundaries. The owner/excavator needs to monitor the quality of soil before excavation. If it's clean it can be freely used for all purposes. If the soil is slightly contaminated it may be put into industrial locations. Contaminated soil must be cleaned. Cleaning is done by means of washing/wet particle size separation, biological or thermal treatment. There is also some in-situ treatment of contaminated soil. During the last decades a lot of 'soil-banks' were introduced where soil can be traded and temporary stored.

There are no or very few new contamination cases the last thirty years. Important trigger to be careful with the soil quality is the fact that anyone that wants to sell his property needs a 'clean soil declaration''. Because of the high cost of soil reclamation it's almost impossible to sell property with contaminated soil. There are also technical advantages to treat soil separate from C&D waste. The soil is not contaminated with components from the C&D waste vise-verse. The soil would get pollutants like metals and organic components. The CDW would need extra screening because of the large amount of fines. A lot of information can be found at some governmental sites.[3]

2.2. Mixed aggregates and RCA

The largest amount of recycled minerals is mixed aggregates in sizes 4-32 mm, used as road sub-base and road base. Other applications of mixed aggregates are as base course for cement pads and foundations, and as backfill material for underground pipelines and other underground utilities.

Mixed aggregates is a mixture of crushed concrete and bricks. It may hold some tiles and glass remains too. Taking into account the quality of groundwater and drinking water production, an important environmental property which is measured is Sulphate content.

There is research that proves that mixtures of secondary aggregates show a lower elasticity than mixtures of virgin material, which is an advantage. The reasoning for this is the typical particles shape, particle size distribution and the presence of non-hydrated cement past in the mix. The latter also explains why the e-modulus grows over time after the mixture was deposited.[4]

The European quality norms are laid down in EN 13242: Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction and in EN 13285: Unbound mixtures – Specifications.

[3] See (in English): http://rwsenvironment.eu/subjects/soil/policies-and/

[4] See (in Dutch): http://www.sturmendekker.nl/documents/Infoblad_toepassingsmogelijkheden_recyclinggranulaatV2.pdf

2.3. Hydraulically bound mixed aggregates.
These are mixtures that contain cementitious binders. Most common is the use of milled slags from the steel industry. Critical environmental parameters here are V, Cu, Cr, Ba and F. The leaching of these elements is restricted. It seems that the immobilization which is the result of the hydraulic reaction is responsible for decrease in leaching data.

The European quality norms are laid down in EN 14227: Hydraulically bound mixtures – Specifications.

2.4. Recycled concrete as coarse aggregate in concrete.
The recycled coarse aggregate will have a higher absorption than the virgin aggregate, due to the presence of cement paste in the recycled aggregate. This makes it necessary to change the sequence of mixing the material: first wet the aggregate, then add sand and cement. With the standard mixing sequence the porosity might cause drying of the mix before the cement reaction is finished. Research indicates some recycled mixes had higher flexural strength than the original mixes. As with compressive strength, both were well above required levels.

The European quality norms are laid down in EN 12620: Aggregates for concrete

2.5. Regenerated Asphalt Pavement (RAP)
Hot mix asphalt concrete (commonly abbreviated as HMAC or HMA) consists of minerals and bitumen. Often recycled asphalt, commonly known as 'RAP' for recycled or Reclaimed Asphalt Pavement, is used up to about 70% of the mix. Asphalt concrete is often said to being 100% recyclable. RAP that is removed from a pavement is usually stockpiled for later use as aggregate for new hot mix asphalt at an asphalt plant. This reclaimed material, is crushed to a consistent gradation and added to the HMA mixing process.

As thermoplastic component two main groups of materials are used: Coal tar and bitumen. Both are black, hard and sticky materials that become fluid on heating and become hard again when cooled. Coal tar is a condensation by-product stemming from high temperature carbonization of coal in the coke production process.

Refined tar-based coatings have an advantage over asphalt in that it has better chemical resistance than asphalt coatings. Another quality of refined tar-based coatings is their lower permeability to moisture. Coal tar contains hundreds of chemical compounds that will have varying amounts of polycyclic Aromatic Hydrocarbons (PAHs) depending upon the source. This is the reason that in the Netherlands and some other European countries road material, made with coal tar is not allowed in new applications. After removal this material is thermally recycled. The coal tar is used as fuel (energy recovery). The mineral components are reused in new asphalt concrete or some other application (material recovery).

The European quality norms are laid down in EN 13108-8 Bituminous mixtures - Material specifications Reclaimed asphalt.

3. Value creation and cost of C&D waste recycling: an educated guess

The added value of C&D recycling, compared to the combination of landfilling, untreated backfilling/fly tipping and use of virgin aggregates is about € 10,- per ton[5]:

- It prevents the use of scarce landfill space
- It prevents dispersal of hazardous components
- It conserves natural resources

[5] Free after FIR publication: https://brbs.webdog.nl/files/Information_document_on_C&DW_March_2005.pdf
FIR: Federation Interrnationale du Recyclage: http://www.fir-recycling.com/

One ton of recycled aggregates saves approximately 0.6 m3 of landfill space. If a m3 of landfill space is valorized at € 10,- the added value hereof is € 6,- per ton.

If only certified products from certified producers may enter the environment, the probability that unknown and unwanted dispersal of hazardous substances is minimized. Programs of soil reclamation in several European countries show that the cost of clean-up are large, in the range of 2 to 5 times landfill cost. The added value of this safety can be estimated at € 2,- per ton.

While many effects are hard to quantify, the main effect is rather well quantifiable: each ton of recycled aggregates saves approximately one ton of natural resources. Even if natural resources are abundant, the external cost of mining and transportation are present. These cost can be estimated € 2,-.

The cost of C&D recycling are about € 5,- for simple processes:

- Extra equipment and labor for separation at source and in recycling plants;
- Extra labor for policy making, administration and enforcement
- Extra costs at landfills.

Separate collection, recycling equipment, monitoring and administration costs the business owner € 9,- to € 15,- per ton. This cost estimation is based on a 'standard' recycling plant of 100.000 tons per year and the logistics involved. Such a plant would ask for an investment in the range of 3 million (real estate, licenses, machines). For more complex waste streams (containing higher percentages of non-re-usable minerals) the costs are higher.

The costs to the government are about € 0,50,- per ton for policy making, monitoring and enforcement. This would imply that for 5 million tons per year € 2,5 million is used to for civil servants and equipment. The largest component of these costs is enforcement.

The cost for landfill operators can be that they no longer have free supply of daily coverage and access road material on their landfill. Tipping fees may cover these costs.

The combined value (market prices times percentage) of the different products of recycling is moving around, but normally somewhat lower than the cost of operation.
This implies that recycling of C&D waste is impossible without:

- collection fees and gate fees for recycling;
- tipping fees at competing landfill and backfill activities;
- licensing, quality control and enforcement.

This implies that the material stream is economically to be seen as waste, because of the negative value of the waste. It needs some kind of governmental intervention. Herewith the market of C&D waste can be called 'artificial'. Without governmental intervention the waste will be found anywhere around the country.

4. Some Economic remarks

4.1. Waste as good with a negative value

According to economic rules, waste is a strange good. Economics normally don't recognise goods with value below zero, the so-called "free goods". Nevertheless, from an economic point of view, waste can best be seen as a good with a negative value, being traded with the inclusion to handle it properly downstream. How is a negative value possible?

This negative value is based on public awareness and political choice, maintained with legislation and enforcement. The knowledge of the negative value is a practical tool for the market to cope with the responsibility of the producer, which is, in the end, the consumer of all the services that are needed to treat the waste properly. The negative value is thus a measurement of all the cost of goods and services downstream.

Instead of a service chain with positive values, a chain of products with negative value is created. In such a chain, together with the waste, the responsibility for further treatment in a legal and environmentally-friendly way is the service-part of the product which is more expensive than the value of the physical product itself.

4.2. Consequences of a value chain of goods with negative value.

Two stocks
Imagine yourself as a link in this value chain. From your client you receive goods with a negative value. This means that you create two stocks at the same time. On one hand you have a stock with collected waste. On the other hand you have a stock with money. This creates for you a situation which is unique compared to all other production processes where products are made of supplies with a positive value.

Cash flow
In a normal production process it is important to have as little stock as possible because there is a lot of value in the stock that costs money. In the case of waste management, the money comes in on the moment the waste comes in and the costs of processing come at a later time. This means that there is a cash-flow reward for the storage. This can be a large advantage when you start the business. Suppose you want to invest in a recycling plant. From the moment you have your license it will take maybe one year to have the plant in operation. If you have enough storage capacity you could start collecting waste and store it during that year. When your plant is coming into operation you will have collected a nice starting capital for your business. It could mean that you don’t need an expensive loan. In conclusion, storage capacity in front of processing capacity pays off. It creates an initial sum and extra yearly revenue.

Risks
Big stocks are a large cash-flow generator but they also contain risk. The risks for a recycler with stock are multiple.

Technically seen, there is a possibility of quality loss or the material can catch fire. As a result of these technical problems the stock loses its value because the products that the recycler will make will have a much lower quality than previously planned.

Changes in legislation might make the recovery process more expensive. Large stocks create risk for the environment and for the governmental organizations too. One risk is that stocks themselves create emissions. Another risk is that a recycler, confronted with a change in legislation might not be able to pay the enlarged process cost of the materials. This can result in stagnation of development***.*** ***G***overnmental bodies may be taken hostage because of the threat of bankruptcy. Bankruptcy creates an environmental problem. The risk for the government is that they end up with a big stock of polluted material with a negative value and there is no one responsible any more for cleaning up the mess. For this reason often maximum storage capacity is mentioned in the license.

Revenues
For the well informed entrepreneurs, calculated risk and revenues might occur in the future.

If an entrepreneur is able to predict future legislation, especially when he is able to predict a “laisser-faire” trend in legislation he can earn a lot of money. The waste comes in for the actual prices and will be processed in a cheaper way.

If a recycling company takes in waste that contains humid organic material it can possibly lose 50% of the waste within a year. What happens during that year is that half of the organic material is composted away. Storage becomes part of the recovery process. A lot of people in recycling say, "you earn the most with the work you don't do."

4.3. The waste hierarchy

On the macro-level some development stages can be depicted. These stages were developed in the western world around a waste hierarchy: prevention, product and material recovery, energy recovery and land filling. In Western Europe incineration with energy recovery was seen as an improvement compared to landfills and therefore became higher in hierarchy. Material recovery rates grew further when more expensive incineration became the core treatment option, which meant that new break evens for material recovery were set at a higher level. With flue gas treatment and bottom ash cleaned or land filled as technical standard the cost per ton are at least in the range of € 60,-. These costs are being paid by waste and energy clients, but still mainly by waste clients.

The waste hierarchy can be seen as a political statement based on the situation in a high income country with the knowledge of 1979. Its main purposes were that it tried to prevent:

- spillage of resources
- dumping
- incineration without energy recovery

All these were the case when the hierarchy was developed.

The strength of the waste hierarchy is that it is easy to understand and to communicate. Ends become means and therefore it is relatively easy to manage and enforce.

There are two types of criticisms regarding the waste hierarchy possible:

- It does not apply to low income situations;
- It disregards inter-linkage between technical options, which might lead to inefficient options.

4.4. The hierarchy and income

GDP or PPP is a leading factor for the affordable cost of waste. Socio-economical factors such as the division of wealth are also very important. One percent of income is seen as the maximum for collection and treatment of all types of waste including C&D waste. The World Bank comes to a comparable amount. A politician should be able to defend such a rate to the electorate. For poorer people, the amount should be no more than 0,5%, as resources like water and food are more important. Because of the annoyance and the possible health problems, the 0,5% is politically defensible. How much can we pay for waste treatment <u>per ton</u> in various wealth situations? Here we have to take into account:

- The total amount we can spend on waste management (0,5 to 1%);
- The amount of waste generated per capita per year (0,1 to 1,2 ton);
- The division of the costs between collection and treatment.

If there are large differences in income of the people it can be a problem to establish a waste policy that counts for all. Wealth influences the waste amount and composition:

- How much and what people throw away;
- How much and what people take out of the waste.

It can be expected that as long as there are people living in urban areas with less than $ 2,- per day to spend, there will be rag picking and scavenging, simply because it pays.

Rag picking and scavenging are also of great influence on the physical properties of the waste. Metals, wood, recognizable plastics and stone elements are taken out at the demolition site. The result is that C&D waste generates less value for the recycling company.

With growing wealth:

- less organic waste is thrown away, because of refrigerators, packaging and people starting to show their wealth with means other than food.
- more inorganic waste is generated as a percentage of its consumption.
- less inorganic waste is pre-collected by rag pickers and scavenged at disposal sites.
- less waste is burned at the curb side or at home for heating or fly chasing.
- the need will grow to sanitise formerly polluted sites.

Growing wealth thus will gradually create more waste per inhabitant, which makes affordable waste treatment cost (per ton!) grow slower than the growth of PPP. A calculated estimate is that the treatment cost per ton may grow from $ 10,- to $ 40,- , still in the range where land filling is the main treatment option. A boost of quantity and a dramatic change in composition will occur when the income exceeds €10,000,-. Countries with strong economic growth and a PPP around $ 8.000,- per capita can easily expect a doubling of the waste amount within a short period.

4.5. The hierarchy and integrated system thinking

To make choices between treatment chains instead of only mutual comparison, one needs sophisticated cost accounting that takes into account external costs. This creates so called "Full Cost Accounting" or "Total Cost Assessment". Costs include internal costs, such as process cost and product costs and revenues as well as external costs also seen as public or "community" cost.

The external costs are a calculation of the generation of pollution, deterioration of renewables exceeding natural absorption level and the depletion of natural resources.
Some characteristics of external costs show that they are:

- Difficult to count and might change with wealth
- Difficult to address: locally, regionally or globally
- Applicable to someone else or the next generation

The external costs partly contain the results of political choices. For the calculations, LCA's and the like are used, but to my opinion these are not free of subjectivity too. There have been a variety of models and computer programs made, like IWM-2, for decision making in this field.

To simplify, for the design of treatment chain it can be investigated:

- What is scarce and what could be recovered?
- How many resources (mainly energy) does it take to reproduce new materials from recycling compared with production from raw materials?

5. Market as a dynamic arena of interacting parties

The waste market is like an arena with many players, each with their own role. In this arena the waste has its own characteristics as a good with negative value. Consequences of this negative value are that waste treatment shows positive cash flows. This also includes risks for the owner and society.

The price of disposal influences the economic feasibility of materials- or energy recovery. Roughly a higher disposal price enables recycling, but can frustrate it when the price for residues is high.

The choice of products to be made and technology to make it, influences the economy of scale of the recovery facility and thus the risk for the owner in case of political or economic changes. This influences market dynamics.

5.1. Viewpoints of Actors

In the arena there are different actors in the waste chain. This chain consists of consumers, also called "primary disposers", those who deal with logistics: the ones who are busy with collection, storage and shipping and in some cases, rag picking, those who are in material recovery, owners of incinerators and owners of landfills.

We can also find two influential other actors aside of the: public authorities and investors.

We have to know what is important for the various actors from an economical viewpoint. If we don't understand what influences the decisions made by the individual actors it is impossible predict the future as a result of changes in economic or legislative developments.

5.2. Public authorities regulating waste management

Some public authorities represent the client in a municipal cooperative client situation. Here the public authorities negotiate with the actors in the chain. Furthermore they regulate the activities in the chain. Between the public policymakers and the lobby of the waste management actors exists a kind of love-hate relationship. Without public authorities there would be no chain of added value considering waste treatment. People would still throw their waste on the street for free. After regulations are made, a market for waste treatment occurs and the play starts. On behalf of and with the aid of these regulations private parties start to invest in waste treatment and logistics. From that moment on, they want to be protected by the governmental authorities.

The ideal situation for a waste company would be if the development of regulation would completely be in line with its own development. This means:

- No new regulations during the entire depreciation period of the treatment facility.
- Protection against "wild riders" who don't stick to the rules because they can act cheaper than our entrepreneur because of new technology.
- After a treatment plant is completely depreciated a new public policy is made to support his new investments.

It would be a big coincidence if the timing of the one entrepreneur would be completely synchronised with the timing of another. This results in countervailing lobbying. These dynamics make it difficult for the individual entrepreneur to find the right timing and the right level for investments. For the public authorities it is also difficult to have the right timing and to decide how much they want to be involved in the technology discussion.

5.3. Instruments of policy makers

Since waste has a negative value, without public policymaking everybody would get rid of it for free, because the people could leave their waste wherever they liked. So the role of public policymakers is to create an artificial market that first may feel like hindering the people but is meant to support the people's welfare.

The different instruments for influencing waste management action are:

- Technical regulations: License constrain the hindrance a technology may cause.
- The choice of technology: BAT (Stands for Best Available Technology).
- Treatment regulations: Economic measurements: subsidies, grants, taxes and tradeable options.
- Economic actors: client, supplier, manager.

All these instruments may be powerful to change market behaviour.

The effect of technical regulations in fact decreases the external cost and turns it into a part of the production cost. These regulations increase the prices of products and in the end consumers will have to pay for this increase. Setting technical regulations with licenses is often the first stage of the process of influencing the waste management chains by policymakers.

With treatment regulations, bans and setting constraints on products that are leaving the facility, policymakers influence the waste chain downstream.

Taxing increases the cost of a process or a product. It can be an instrument to include remaining external cost that must be taken care of by public bodies. In that case it is a part of 'full pricing'. Taxing can be a forceful instrument, even more when it is combined with subsidizing the treatment options that are favoured by the policymakers. A negative result of this kind of taxing and subsidizing is that treatment solutions might occur that cannot hold when the financial measurement is taken away. So, in fact, a kind of mutual or interactive hostage-taking is the effect between the policymakers and the industry. Once a tax or subsidy is created it is difficult to withdraw this measurement.

It becomes even more complicated when policymakers are directly influencing the industry structure by creating organizational units apart from their own organization that have to regulate waste streams. A forceful example of this kind of policy is the German DSD system that was created in the early 1990's.

The role of Landfill organizations

Landfill facilities have a special role in waste chains.

- They are necessary as backstop and last resort for the chains.
- They may not acquire actively for waste if 'better options' are available.
- They might even collect (tax-) money for alternative options.
- They should create new projects for backstop capacity, even if it is economically uninteresting.
- They should take care of the payment for capping and aftercare.

These characteristics block a normal business approach. This makes it obvious that public bodies are involved in the management of these facilities, at least at distance to decide on issues like tariffs and capacity building.

Landfill owners can contribute to a transition process by providing landfill space for those waste activities that need surface area, such as for storage of soil or CDW treatment plants.

The landfills have liners, water treatment plants etc. that can be used for multiple use awaiting the filling of the landfill-cells or on top of the waste.

From here landfills can grow towards facilitators of new business in waste treatment.