POLICY PROCESS OF ALLOWING RESEARCH PILOTS FOR SUSTAINABLE EMISSION REDUCTION AT LANDFILLS IN THE NETHERLANDS

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SUMMARY: The Dutch Government promotes innovative techniques that stimulate natural biodegradation and immobilization processes in landfills. Examples of such measures are infiltration and recirculation of water and leachate, as well as the injection of air. Aims are to reduce the emission potential of landfills and decrease the eternal after-care effort. In 2008 the Dutch industry launched the idea to develop a full scale ten years research program to test if biological stabilisation leads to a significant reduction in emission potential. To accommodate this the government launched a project called: Introduction of Sustainable Landfill Management. The main challenge for the government is how to transform this idea into an effective research program with full public support. The main answers is to invest fully in creating a level playing field for officials, citizens and industry by providing them with accurate and timely information and independent scientific analyses of the proposed research program. This paper gives an outline of the policy process and products needed to achieve this level playing field.

1. PRELIMINARY

From the perspective of sustainability the Dutch Ministry of Infrastructure and the Environment is stimulating research in to *source-oriented* reduction measures aiming to substantially reduce the emission potential of landfills. Up till now environmental policies on landfill management were based on traditional preventive effect-oriented measures, which aim to maximize the isolation of the waste from its environment.

The Ministry wants to promote the development of innovative techniques that stimulate natural biodegradation and immobilization processes in landfills. Examples of measures to stimulate and accelerate natural processes in the waste body concern infiltration and recirculation of water and leachate, as well as the injection of air.

In 2006 the Dutch Sustainable Landfill Foundation (DSLF) completed the project 'Sustainable Landfilling at future landfills'. This project aimed at landfills *yet to be constructed*. One of the main conclusions from this research was that when natural biochemical and physical processes are allowed to complete, emission potential is reduced significantly (Mathlener et al.,

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2006a,b). In 2008 the DSLF launched the idea to develop a *follow-up* research project called 'Sustainable emission reduction at existing landfills', in order to test if biological stabilisation of the waste body by irrigation and recirculation followed by aeration will lead to a significant reduction in emission potential. The aim of these pilot projects is to provide sufficient evidence that stabilisation of waste bodies is an effective means of after-care that eventually may lead to a situation where a landfill is released from after-care because the remaining emission potential in the landfill is so low that no substantial risk to the environment remains. This project realizes a full scale (10 year program: 2013-2023) research of sustainable emission reduction at four pilot landfills. The DSLF executed feasibility studies to select suitable pilot landfills (van Vossen & Heyer, 2009).

The main questions to be answered by the research pilots are:

- does sustainable landfill management lead to a significant reduction of emission potential of the landfill to groundwater?
- Does this significant emission reduction also lead to admissible emission levels?
- By which method can the reduction of emission potential convincingly be assessed and determined?

The costs of this research are approximately € 9 million (technical measures and monitoring). The research will be funded by the landfill industry (including the DSLF).

In addition, the Technology Foundation STW recently accepted a research proposal by the Technical University of Delft (Netherlands), which involves a subsidy of around € 1.3 million for carrying out accompanying technical scientific research at the pilot landfills.

In paragraph 2 we summarize shortly what is called the traditional approach of landfilling, and in paragraph 3 we give a general outline of the sustainable landfill management approach.

Before addressing the question how to put sustainable landfill management on the Dutch political agenda, some characteristics of the Dutch landfill industry need to be explained. In paragraph 4 we will see both a negative financial development for the long-term (strong decline of waste supply and declining gate fees over the years), and a positive development (it is expected that the Dutch financial reservations for long-term after-care costs are sufficient).

Preliminary calculations show an accumulated capital for 22 landfills of approximately € 189 million, level 2009 and an estimated total target capital of approximately 500 million in 2046. Nevertheless, it is crucial to keep on searching for opportunities to reduce the costs of landfilling, including eternal after-care costs. One of the possible solutions can be found in introducing sustainable landfill management. Not as a replacement but as an addition to the traditional approach of landfill management. Before amending regulations, however, this concept has to prove it can be successful. A recent financial research calculated the total cost savings potential of the Sustainable Landfill Management concept in the Netherlands at approximately € 88 million, for 19 landfills with a total surface of 440 hectares (Hopstaken et al., 2011).

The main question for the industry is how to transform a new technological innovative idea into a cost effective operational research programme around a number of pilot projects.

The main challenge for a government policy maker is to get full public support. In other words, what is needed to convince society, politicians, government and citizens that this idea is worth the investment of public time and money (see paragraph 5)?

To accommodate this initiative of the Dutch landfill industry the Ministry launched in 2010 a project called: Introduction of Sustainable Landfill Management (ISL, see paragraph 5 and 6). This voluntary project aims to shape the cooperation between the landfill industry, the competent authorities (provinces) and the Ministry, that ultimately should lead to a signed covenant.

2. TRADITIONAL APPROACH OF LANDFILL MANAGEMENT

Sanitary landfills are reactive systems, the waste in a landfill body is a heterogeneous mixture of a wide range of materials, contains high levels of organic matter, high amounts of salts and has a wide range of different organic and inorganic substances such as heavy metals and organic solvents. Bio-geochemical processes in a landfill body lead to the development of landfill gas, a mixture of predominantly methane (CH_4) and carbon dioxide (CO_2). The precipitation surplus will leach through the landfill and finally be captured in the drainage system of the landfill as leachate.

Emissions of potentially contaminating substances, present in the waste body, to the surroundings takes place via the landfill gas to the atmosphere and via the leachate to surface and groundwater. In order to prevent such emissions, modern sanitary landfills are equipped with a range of barrier systems to limit these emission routes as much as possible. A sanitary landfill is equipped with an impermeable bottom liner to prevent leachate from migrating to the groundwater. A drainage system is installed above the bottom liner to control the water level in the landfill and to capture the produced leachate in order to treat it before discharging it in the environment. Landfill gas is captured and treated or burned, sometimes in combination with energy production. After operational life of the landfill, a surface sealing is applied to the surface of the landfill.

In the Netherlands this surface sealing is required to limit infiltration of precipitation as much as possible. As a result, leachate production will be minimized. The idea behind this concept is that when the bottom liner fails, the presence of the surface sealing will limit leachate production to such an extent that no bottom liner is required.

3. SUSTAINABLE LANDFILL MANAGEMENT APPROACH

Although the traditional approach is a robust approach to protect the environment, one major issue is not addressed: the contamination potential of the waste body remains. The reason for this lies in the lack of water flow in the waste body.

Research in to landfill processes in the last two decades clearly show that biological and geochemical processes occurring the waste body lead to a stabilization of the waste and as such the contamination potential decreases (Bareither et al., 2010; Barlaz et al., 2010; Reinhart, 1996; Rich et al., 2008). Availability of water is a requirement for these processes.

Reducing the water flow through the landfill by a water tight surface sealing will therefore significantly slow down the stabilisation of the waste, and as such the contaminating life span of a landfill will be prolonged for a significant amount of time, up to several centuries (Huber et al., 2004). The threat associated with the presence of the landfill therefore remains and as a result eternal after-care is required to ensure the integrity of the surface sealing.

Though the environment is adequately protected, eternal after-care cannot be considered a sustainable approach. The responsibility for the management of present day waste is transferred to a number of future generations. In addition, the protection of the environment is based on the integrity of the installed barriers, calamities can occur such as earthquakes, floods, etc. during which it is likely that the barriers will be compromised thus leading to emissions to the environment.

Nowadays alternative after-care concepts are being developed which are based on a different approach. Instead of only placing our trust in the presence of adequate barrier technology, attempts are being made to actively enhance the natural stabilization of the waste in the landfill. The ambition is to reduce the contaminating potential of the waste to such a level that the resulting emission levels are such that no threat occurs to the environment (Bareither et al., 2010;

Barlaz et al., 2010; Cossu et al., 2003; Mathlener et al., 2006b; Reinhart et al., 2002; Ritzkowski et al., 2006; Valencia et al., 2009).

The principle of waste stabilisation is based on the degradation of organic matter present in the landfill by increasing the local water content. The approach is based on a combination of irrigation (adding extra water) and recirculation of the captured leachate in order to reduce the heterogeneity in water distribution within the waste body. If necessary, the leachate can be treated before recirculation.

Irrigation and recirculation enhances the methanogenic degradation of organic matter by micro-organisms present in the landfill. This type of operation is also called a bioreactor. An efficiently operating bioreactor can produce landfill gas at such rates and with such a quality that energy production is an economical option. Eventually energy production is no longer economic due to the depletion of organic matter.

In order to further reduce the amount of organic matter present it is an option to aerate the waste body. The idea is that the amount of organic matter and the rate of methane production after these stabilisation measures is so low that the corresponding emissions are low enough to pose not a threat to the environment when the installed barrier systems fail.

Other potentially contaminating substances are also present in landfills in addition to organic matter such as heavy metals and salts. Recent research provides evidence that as the bio-geochemical processes responsible for the degradation of organic matter also lead to a condition in the waste body in which the mobility of heavy metals is reduced to more or less minimal values (Dijkstra et al., 2002 & 2009). This is caused by the fact that the remaining organic matter and metal oxides in the waste body have a high sorption capacity for a wide range of compounds. In addition, the biological processes buffer the pH and the redox potential in the waste body to such levels that solubility of heavy metals is minimal.

4. ECONOMICAL CHARACTERISTICS OF THE DUTCH LANDFILL INDUSTRY

The general Dutch policy on waste management aims at limiting the generation of waste and reducing the environmental pressure through waste management. The landfill policy aims to not deposit reusable and non combustible waste into landfills. For this purpose various instruments have been implemented in recent decades, including deposit bans and taxes. The Dutch landfill sector in recent years faced a reduced input of waste and lower landfill gate fees. The amount of landfilled waste has decreased from nearly 13 million tonnes in 1993 to just over 2 million tonnes in 2009. This decline is a direct result of Dutch waste management policy that focuses on prevention, reuse or incineration instead of landfilling. The prevailing opinion is that this decline is a direct result of the success of the Dutch waste management policy.

The Ministry of Infrastructure and the Environment is responsible for determination of environmental conditions in legislation and has a special responsibility towards the preservation of landfill capacity in the longer term. Provinces are responsible for licensing, care of landfills and for the management of the provincial (site specific) aftercare funds for landfills.

The provinces own (directly or indirectly) over 40% of the landfills in the Netherlands. The municipalities own over 40% and the remaining 20 % is owned by the private sector.

The landfill sector is characterized by concentration of market players (landfill operators). The total number of market players has significantly decreased. The market in 2010 includes 22 landfill sites in operation (2000:39 and 1991: 79).

The Dutch landfill market in economic terms can be characterized as a exceptional market. An important feature is that every landfill operator has access to seemingly infinite capacity in the short term. That basically means that any operator is able to absorb at any time the currently existing amount of waste to be landfilled, often in one landfill. With a limited number of landfill

operators, each operator is able at any time to set the market to his own terms.

In economic sense there are significant entry and exit barriers. Entry to the market is limited and there exists a government moratorium on new landfills. The landfill operator is required to ensure the application of a surface sealing no later than 30 years after construction of the bottom liner. The cost of surface sealing shall be borne by the owner, who for that purpose in most cases reserves and manages the resources during the operating period. An operator can only exit if sufficient capital has been accumulated, or when the operator is willing to take a loss. The transfer of the after-care from the operator to the province is carried out after the province issues a closure certificate. The closure statement in conjunction with the cost of capping is also an important exit barrier. The operator is also required to draft an aftercare plan. According to the law after-care consists of conservation, improvement and replacement of soil protection measures, inspection, soil investigation, contained in after-care plans, which require the approval of provinces. The after-care is carried out or commissioned by provinces.

An after-care fund must have been built to finance the future ('eternal') after-care costs. The management of the after-care funds lies with the province. To be able to fill the after-care funds the provinces impose during the operational period a levy at the operator on each ton of material deposited at the landfill. A financial research (Hopstaken et al, 2011) stated that the estimated accumulated capital (in 2009) in the after-care funds for the current 22 operational landfills are approximately € 93 million (target capital for 2046: € 315 million) and the facility operators themselves have a total accumulated capital (2009) of approximately € 96 million as provision for future costs of for instance the construction of surface sealing (target capital: € 185 million).

The expectation of the industry is that the current income (lower waste input combined with lower gate fees), now has fallen below the cost for the sector as a whole. That is the price at which all costs for the sector, including long-term costs (capping, aftercare) are covered. The question is whether the landfill operation on such a basis is viable as an independent activity in the longer term. The Ministry of Infrastructure and the Environment commissioned a study into the future of the landfill sector: It is expected that the report will be finalized in the coming months. It is expected that the report will be finalized in the coming months.

5. PUTTING SUSTAINABLE LANDFILL MANAGEMENT ON POLITICAL AGENDA

The main question for the industry was how to transform a new technological innovative idea into a cost effective operational research programme around a number of pilot projects. In this case a complicating factor was the fact that Dutch legislation had to be changed. Approval of the Dutch government and the local authorities was needed.

Although the potential benefits for the environment as well as for reduction of eternal after care costs are substantial when sustainable landfill management has been proven to work (see paragraph 1), a good outcome of the approval process is not always obvious. At the start of a project like this there are limited guarantees, and many challenges and uncertainties.

An environmental precondition was that the deployment of technology must not lead to uncontrollable situations or additional environmental pressure, for example due to imperfections in the infiltration of leachate or aerating of the waste body. For this reason, the Dutch government demands that the bottom liner must be fully functional for at least the duration of the pilots (2013-2023).

Key players in this approval process are the provinces in their role as competent authorities. They must be fully convinced that the environmental and financial risks are marginal during the period of the research program, and that the potential benefits are substantial, otherwise they will not allow the research program to proceed. The provinces are also the future risks carriers of the cost of after-care of landfills. Careful scientifically based risk analysis of the sustainable landfill

management approach are therefore crucial for them.

For the landfill owners a long-term commitment of central government and local authorities is important. Another important precondition for them is that prior to the start of the pilots absolute clarity is given by the authorities about the final result to be achieved by the pilots in 2023, how this result is measured, and how and when structural change of legislation takes place when the final results of the pilots prove to be successful. The landfill owners also stated that the above-mentioned clarity can be achieved by the development and determination by the government of Emission Test Values (ETV's) in the Dutch Landfill legislation before the start of the execution of the pilots.

To summarize, the execution of the pilots in 2013 can only take place as soon as the research costs are fully financed by the industry in advance, the competent authorities support and agree upon the proposed research approach, the Ministry has adjusted the Dutch landfill legislation and directives, and finally a covenant between all related organizations has been signed.

The main challenge for a government policy maker is to attain full public support. In other words, what is needed to convince society, politicians, governmental and local officials, and citizens that this idea is worthwhile investing public time and money in? The main answer is to invest fully in communication and in *creating a level playing field* by providing officials and citizens with accurate and timely information about the advantages and disadvantages, risk analyses and independent scientific analyses of the proposed research program.

In order to create a level playing field for all parties involved, the Ministry launched the ISL-project wherein several products have to be developed and completed before the start of the execution of the research program (see paragraph 6). Because of the voluntary character of the project the main focus of the ISL-project was to optimize the cooperation between the industry, the competent authorities (provinces) and the Ministry. Ultimately, it is this cooperation that will make this research program financially, technically as well as legislatively possible, so that finally a covenant between all related organizations can be signed.

6. THE MAIN PRODUCTS OF THE ISL-PROJECT

The ISL-project provides the following products in the period 2011-2012:

1. National Institute for Public Health and the Environment (RIVM): Report phase 1, Establishing a framework for developing Emission Test Values (ETV) to evaluate the effectiveness of the pilots at the end of research period (Versluijs et al, 2011).
2. Erasmus university: Economic Outlook on the effects of ISL (Hopstaken et al, 2011).
3. Ministry: Draft of change of legislation, part 1: framework.
4. University of Delft: Literature review on sustainable landfill management.
5. Landfill industry: Integral Action Plan for execution of the pilots.
6. Research company Ecofys: Report on effects of ISL on landfill gas emissions.
7. Expertise Network Landfill: Technical advice on functional lifespan of bottom liners.
8. National Institute for Public Health and the Environment (RIVM): Report phase 2, determination of a mathematical model and lists of ETV’s per pilot location.
9. Independent International Scientific Committee: Feasibility overview report.
10. Dutch Technical Committee Soil Protection (TCB): Advice Technical and environmental advice on implementation of ISL products.
11. Guideline for usage of Emission Test Values.
12. Industry: Baseline research on pilot locations.
13. Landfill industry: Sub action plans for execution per pilot.
14. Ministry: change legislation allowing research on pilot locations, part 2: technical details.

15.Industry, Provinces and Ministry: Covenant ISL, securing long-term commitment.

Products 1 and 2 have been finalized. The draft of the change of legislation (product 3) has been presented to the Cabinet for approval in June 2011. The products 4, 5 and 6 are now (June 2011) almost completed. The products 7 to 15 will be finalized in the next 12 months.

The Ministry has requested the National Institute for Public Health and the Environment (RIVM), to develop a set of criteria that will serve as a reference framework against which the emissions from the experimental landfills can be compared at the end of the research period in 2023 (see products 1 and 8). The aim of this framework is to determine whether the emissions from the landfill are sufficiently reduced. A two-phase research approach has been decided upon. Phase 1 report (Versluijs et al, 2011) provided an inventory of possible starting points for the derivation of testing values (reference framework). Based on the Dutch Landfill Directive and the Soil Quality Directive a preliminary assessment of possible testing values has been performed. This report also describes the basis for the approach of phase 2 of this research. Phase 2 report will provide a determination of a mathematical model and lists of ETV's per pilot location.

REFERENCES

Bareither, C.; Benson, C.; Barlaz, M.; Edil, T. & Tolaymat, T. (2010). {Performance of North American Bioreactor Landfills. I: Leachate Hydrology and Waste Settlement}, Journal of Environmental Engineering 136 : 824.

Barlaz, M.; Bareither, C.; Hossain, A.; Saquing, J.; Mezzari, I.; Benson, C.; Tolaymat, T. & Yazdani, R. (2010). {Performance of North American Bioreactor Landfills. II: Chemical and Biological Characteristics}, Journal of Environmental Engineering 136 : 839.

Cossu, R.; Raga, R. & Rossetti, D. (2003). {The PAF model: an integrated approach for landfill sustainability.}, Waste management (New York, N.Y.) 23 : 37-44.

Dijkstra, J. J.; Meeussen, J. C. L. & Comans, R. N. J. (2009). {Evaluation of a generic multisurface sorption model for inorganic soil contaminants.}, Environmental science & technology 43 : 6196-201.

Dijkstra, J. J.; van der Sloot, H. a. & Comans, R. N. J. (2002). {Process identification and model development of contaminant transport in MSWI bottom ash.}, Waste management (New York, N.Y.) 22 : 531-41.

Hopstaken, C.F.; Van der Maesen, M.; Van der Schalk, A; Van der Zee, F.A.; De Jong, J.M. (2011); (Economische verkenning duurzaam stortbeheer. Inzicht in de economische effecten en het besparingspotentieel). Rotterdam/Delft, 17 januari 2011. Report of FFact and Erasmus University-SEOR. Rotterdam/Delft, 17 januari 2011.

Huber, R.; Fellner, J.; Doeberl, G. & Brunner, P. (2004). {Water Flows of MSW Landfills and Implications for Long-Term Emissions}, Journal of Environmental Science and Health, Part A 39 : 885-900.

Mathlener, R.; Heimovaara, T.; Oonk, H.; Luning, L.; van der Sloot, H. & van Zomeren, A. (2006a). Opening the Black Box; SUMMARY of the Sustainable Landfill project, Report for the Dutch Sustainable Landfill Foundation, http://duurzaamstorten.nl/wawcs0122289/ln-home-en.html.

Mathlener, R.; Heimovaara, T.; Oonk, H.; Luning, L.; van der Sloot, H. & van Zomeren, A. (2006b). Report for the Dutch Sustainable Landfill Foundation, http://duurzaamstorten.nl/ wawcs0122289/ln-home-en.html

Reinhart, D. (1996). {Full-Scale Experiences With Leachate Recirculating Landfills: Case Studies}, Waste Management & Research 14 : 347-365.

Reinhart, D. R.; McCreanor, P. T. & Townsend, T. (2002). {The bioreactor landfill: Its status and future}, Waste Management & Research 20 : 172-186.

Rich, C.; Gronow, J. & Voulvoulis, N. (2008). {The potential for aeration of MSW landfills to accelerate completion.}, Waste management (New York, N.Y.) 28 : 1039-48.

Ritzkowski, M.; Heyer, K.-U. & Stegmann, R. (2006). {Fundamental processes and implications during in situ aeration of old landfills.}, Waste management (New York, N.Y.) 26 : 356-72.

Valencia, R.; van der Zon, W.; Woelders, H.; Lubberding, H. J. & Gijzen, H. J. (2009). {Achieving "Final Storage Quality" of municipal solid waste in pilot scale bioreactor landfills.}, Waste management (New York, N.Y.) 29 : 78-85.

van Vossen, W. & Heyer, K. (2009). {Feasibility study sustainable emission reduction at the existing landfills Kragge and Wieringermeer in the Netherlands}, Report for the Dutch Sustainable Landfill Foundation, http://duurzaamstorten.nl/wawcs0122289/ln-home-en.html

Versluijs, C.W., Brand, E, Claessens, J.W., Wezenbeek, J (2011).: (Ontwikkeling toetswaarden voor pilotstortplaatsen duurzaam stortbeheer, Fase 1: Een inventarisatie. Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Public Health and the Environment; Grontmij). Bilthoven, april 2011.