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NEW MEASUREMENT METHODOLOGY FOR THE RESOURCE VALUE OF WASTE

Abstract

Waste management is now a subject of the highest priority on the European and global agenda. The European Union's approach to waste management is based on three principles: waste prevention; recycling and reuse; and improving final disposal and monitoring.
In the introduction to the Directive 2006/12/EC of the European Parliament and of the Council on Waste it was stated that "the recovery of waste and the use of recovered materials as raw materials should be encouraged in order to conserve natural resources. It may be necessary to adopt specific rules for reusable waste". The WASTEMET concept proposes a new methodology for the measurement of waste, which replaces the current negative weight-based measure with a positive measurement of resource value. The methodology has the capability for making subtle distinctions between the resource value of different waste types, that are currently not measured. The consequence of measuring the resource value of waste will be that current weight-based waste policies will be capable of refinement, waste strategies will be more efficient, targets can be improved, product ecolabelling announcing resource values can be transformed, and communication to consumer and trade markets concerning waste can be much clearer. The WASTEMET methodology is based on a concept of substitution.

Keywords: waste management, waste recovery, waste policy, waste targets, ecolabelling

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1. Introduction – A Global Problem

The threats posed by growth in the global economy to environmental stability, especially climate change, are now well documented and recognised. The solutions are not.
It has become clear that the growth in population is threatening the carrying capacity of the planet. This was first and most famously pointed out by The Club of Rome, in *Limits to Growth*, published in 1972, which predicted that the world would run out of the resources required to support human life by 2050; then reinforced by the publication of the *Brundtland Report* in 1988, which unveiled the concept of sustainable development as a basis for seeking out a range of global solutions. The literature analysing the problem has expanded and expanded in the last decade. In recent times, one publication has both overshadowed all others, at the same time as prompting an even greater rush into print from different sectors with a point of view on the problem. This is *An Inconvenient Truth*, a lecture by Al Gore published as a book and released as a film in 2006, with such impact that the USA has subsequently softened its stance on climate change, and shows signs of positively changing its position completely.
But the world has yet to achieve a workable range of solutions. In spite of an ever-increasing number of initiatives, a growing fund of support, ever-deepening political and public commitment, experimentation and innovation, the problem is still worsening. Population continues to increase, economic activity to expand, carbon emissions grow, climate change accelerates. These problems are now the top priority for human endeavour.

2. The Role of Waste

It is also clear that waste of resources by the human race lies at the heart of the problems. Human waste has always created a problem in terms of pollution. Nearly all forms of human waste do not allow easy bio-degradation, and hence frequently degrade the environment, poisoning and polluting the area in which waste is disposed. This in itself represents a loss to the environment, both of the locality used for disposal, and also of the matter which fails to decompose organically. We accept as a given the most basic of all scientific principals, Lavoisier's Law of Conservation of Matter that states: "matter cannot be created or destroyed, only redistributed". According to the rules of this Law, waste which cannot successfully biodegrade is consequently a permanent depletion of the resources available to be used on Earth.
Throughout the history of the human race, this has not mattered, because the impression given by all significant study was that, in all meaningful senses, Earth's capacity to sustain the species is infinite. The Club of Rome changed that perspective. In what can be seen as one of the greatest changes in human thought, ranking with the most radical discoveries of Galileo, Newton and Albert Einstein, *Limits to Growth* presented an alternative proposition, whose force has become unstoppable, and whose power to change our most basic philosophical and practical relationship with our World has become all-powerful.
The World is finite.

3. Squandering Resources

There is a universal recognition that the rate and scale of the waste of resources is threatening the capacity of earth to sustain human life indefinitely. If the current rate of waste is maintained – and waste has continued to grow, in spite of the various strategies for reduction and diversion developed in the last decade – it is commonly accepted that this threat will become a reality in the foreseeable future. Domestic waste production is growing even faster in Europe than domestic consumption. Over 1.8 billion tonnes of waste are generated each year in Europe. This equates to 3.5 tonnes per person (according to the European Topic Centre on Resources and Waste Management). Referring to municipal waste only, the level of waste generation reaches just above 500 kg per capita for the EU27 average (Figure 1). It can be observed that in the countries chosen for the comparison, i.e. Germany, the Netherlands, Poland and the United Kingdom, there is a slight growth trend in municipal waste generation volume per capita. The situation is not quite the same when compared to total municipal waste generation (Figure 2). In Germany and the United Kingdom the volume of waste is growing slowly, but in the Netherlands since 2001 we can observe a decline. In Poland after slight growth in the years 1995-2002, the volume has dropped slightly. Waste management is now a subject of the highest priority on the European and global agenda.

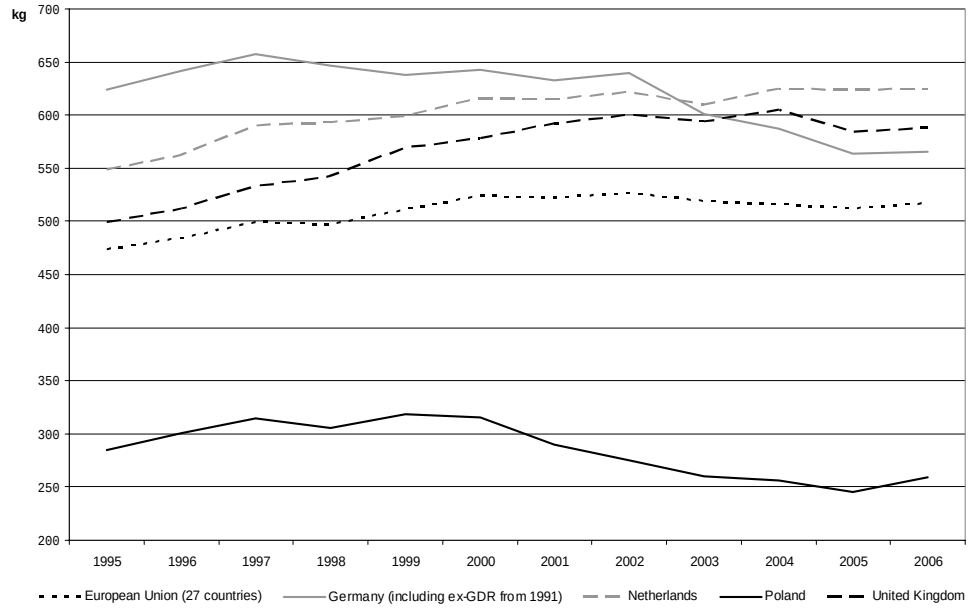

Figure 1. European municipal waste generation, 1995-2006 [kg per capita]

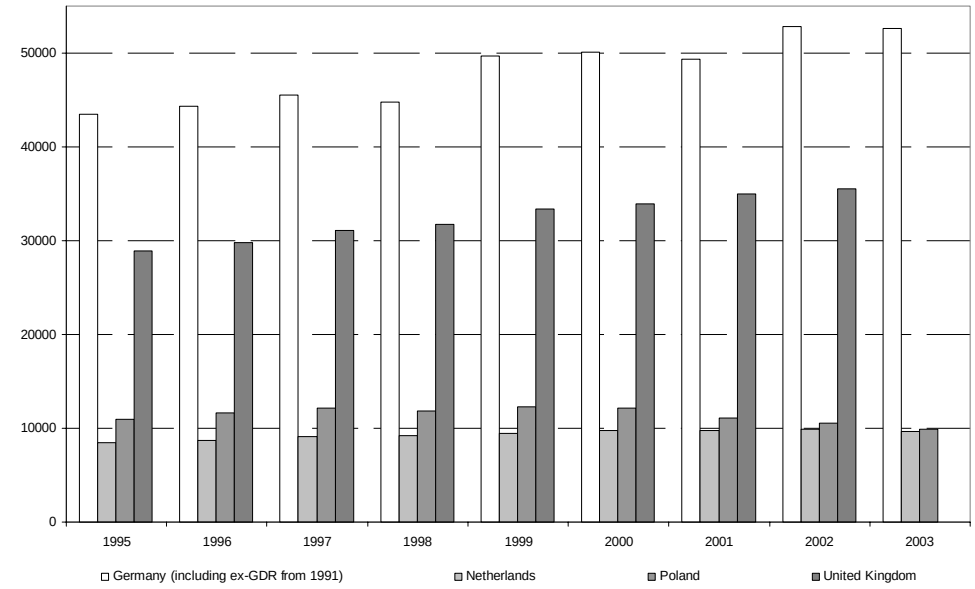

Figure 2. Municipal waste generation in chosen countries, 1995-2003 [t]

4. Waste as a Resource

There is no doubt that our society wants to treat waste as a resource. The European Parliament's latest version of the Waste Directive makes this clear: "the recovery of waste and the use of recovered materials as raw materials should be encouraged in order to conserve natural resources"[1].

There is also universal acknowledgement that our society wishes to retain the value of the resource represented by waste, by means of recycling. The High Level Group (HLG) convened to advise the European Commission on issues relating to Competitiveness, Energy and the Environment made direct reference to this requirement: "the HLG calls on the EU and Member States to support the development of a raw materials policy by […] improving the EU's resource efficiency through the better use of resources embedded in waste, while ensuring optimal choices amongst intensified collection, advanced recycling technologies, minimum standards and eco-design approaches."[2]

This offers an unequivocal recognition that waste should be regarded as a resource, and that it therefore has explicit value. The significance of this assumption is spelt out in the same document, which recommends: "in particular, support mechanisms that divert resources from a high value added use to a lower one should be avoided"[2]. Thus a link is made between the value of waste as a resource, and the recognition that the value varies according to its possible use.

The question arises as to how then can this be turned into effective policy. In the European Union, this has been a matter of concern for some years. The Thematic Strategy on the Prevention and Recycling of Waste, published in 2005, introduces the concept of a

European Recycling Society: “as resources placed on the market are bound, sooner or later, to become waste and any productive activity generates some form of waste, measures to put waste back in the economic cycle are necessary”[3].

This itself echoes an action proposed in the 6th Environment Action Programme, published by the European Commission in 2001, which calls for recognition of the differential values of waste as a resource: “identify which wastes should be recycled as a priority, based on criteria which are linked to the resource management priorities, to the results of analyses that identify where recycling produces an obvious net environmental benefit, and to the ease and cost of recycling the wastes”[4]. The Thematic Strategy recognises another important strand to the problem, when it acknowledges that “prevention can only be achieved by influencing practical decisions” and “production of municipal waste is also affected by the consumer”[3].

The first and most obvious consequence of the work undertaken in these different developments of policy and direction is the universal acknowledgement of the need to treat waste as a resource and attempt to recycle as much as possible. This has led to an attitude that all recycling is good, all waste disposal is bad. Whilst this has much to commend it in terms of the impetus it gives towards changing attitudes and behaviours, which is crucial to success, it distracts attention from an issue that has been made explicit in all that has gone before.

A unilateral approach of this type may be useful for other environmental problems, but it is not useful for waste. It may be legitimate to assert that we must use less energy in all circumstances, that we must emit less CO_2, come what may, that we have to travel less, save more, use less. Of course, we have to waste less, but the decision has to be made where to concentrate. This difficulty is now being recognised, and is reflected in the Sixth Environment Action Programme, as well as the Waste Directive, and – most of all – in the Thematic Strategy, which links the two. This defines the problem: “The current definition of waste sets no clear boundaries for when a waste has been adequately treated and should be considered a product. This is problematic, as it creates legal uncertainty and administrative costs for businesses and competent authorities. It can lead to diverging views from Member State to Member State and even from region to region, which creates problems for the internal market. On top of this, poor-quality recycled material circulates on the market, generating difficulties both for potential purchasers and also for reputable sellers”[3].

At first sight, this seems to pose an obscure question of definition related to the process by which waste is treated. It seems to relate to an abstruse legal point, allowing “waste” one set of rules, and “product” another. Legislation in this regard is, of course, very important and it is affected by the distinctions in definition. However, the problem it raises is more fundamental than an issue of definition. It is the problem of measurement. Definition depends on identification, and identification depends on some kind of measure. How do we measure and define what constitutes waste? The Strategy does then propose something that could offer a radical solution. The Commission considers that further definition is required and is therefore proposing an amendment to the Waste Framework Directive which will base the definition of recovery on the concept of substitution of resources in the economy[3].

This concept is dazzling in its simplicity. But the authors of the Thematic Strategy almost throw it away by suggesting this should only be applied to Energy from Waste plants, or

incinerators. They thereby avoid tackling the problem of treating waste as a resource. If it is a resource, what value does it have? What is it worth? The failure to provide an answer to this question has been one of the most significant limiting factors in the development of radical waste management and recycling strategies. This paper offers a solution to the problem, a new methodology for measuring the resource value of waste.

5. The Need for New Waste Metrics

A new perspective such as this extraordinary shift in our world understanding requires new understanding; new understanding requires new value sets; new value sets require new means of measurement. We need new metrics, because the old metrics merely confirm the set of value judgements that characterised our old world order, an order which we now see to be set on a fatal trajectory towards self-destruction.

6. Existing Waste Measurement Methods

At present, waste is measured by weight, and diverted waste is measured by market value. Both of these have problems. The composition of waste is not measured in a manner that permits differentiation between the different components of the waste, unless a compositional analysis is undertaken. This then produces another weight-based measure by waste stream. A more severe consequence of the weight-based measure is that it provides no possible understanding of the potential value being lost by disposal. Weight is a negative measure, which assumes that a high number is bad, and a higher number is worse. In the campaign to treat waste as a resource, this means of measuring waste is not only unhelpful, it actually stands in the way of any knowledge or understanding of the nature and significance of the resource value of waste. We cannot truly understand why we should treat waste as a resource if we cannot define what that resource represents. In order to define it, we must measure it in a manner that has depth and meaning as well as relevance and accuracy.

Diverted waste is not only measured by weight, but also by reference to its market value. Diverted waste (for the purposes of this discussion, we exclude the “reuse” category) is either used for recycling or for energy recovery. In these circumstances, some monetary value is attached to the waste. This is arrived at by means of market forces, combined with public sector price support schemes designed to incentivise diversion of waste from landfill and increase recycling markets. But this, too, is an unhelpful and unsatisfactory means of measuring waste.

Perhaps the most telling piece of research into the subject carried out to date was published by the OECD in 2006, entitled *Improving Recycling Markets*. This document sets out to analyse non-environmental (i.e. economic and commercial) market failures in markets for secondary materials (e.g. wastepaper, plastic bottles, metal scrap, textiles). It sounds a warning note: “in many cases, environmental policies are introduced and evaluated with the assumption that all other aspects of the market are functioning efficiently. This may well not be the case.” The analysis then reveals that, not only are recycling markets not working efficiently (which means that supply, distribution, product consistency, pricing and

performance are all relatively stable and predictable), but that, in many cases they are not working at all.
It sets out evidence that demonstrates:
1. how small the markets are – total turnover for material recovery facilities in the US in 2001 was $1.3 billion, or 0.01% of US GDP; the Bureau of Industrial Recycling estimates "that the recycling industry employs more than 1.5 million people worldwide, with an annual turnover of $160 billion" which may seem to be large numbers, but in reality represent no more than 0.004% of estimated world GDP;
2. how they are linked to the waste process, not the manufacturing process – we measure recycling performance as a percentage of waste generation, which is the input data, and have no measure of output resulting from this;
3. but most of all, how they are characterised by their pioneering, or frontier, qualities. The OECD report tells us how "a study conducted for the European Commission (RDC/PIRA 2003) found that contamination was a significant problem in glass, plastics and paper/board markets, and somewhat less of a problem for metals. There are many documented cases in which contaminated wastes have been sold on secondary markets for recovery. Clearly, in some cases the financial incentives are such as to encourage sellers to put "lemons" (of whatever kind) onto the market." Here we have the principles of trade in the Wild West, with all the quality control and integrity of Snake Oil sold by the itinerant charlatan. Product quality or integrity does not matter in markets that are too diffuse for word of mouth to spread, and too irregular for any repeat purchase. You just keep moving and the customer never catches up with you.

Recycling markets are not robust enough to be real, they are not sufficiently connected to the mainstream of economic life to be relevant, and they are not appealing enough to catch consumer attention or producer investment. The value placed by such markets on the feedstock has no relationship to the wider economics that legitimise pricing scales in the context of social circumstances. Instead, price is placed according to value relative to an unreliable set of variables. This means of measurement is worse than unhelpful, it is dangerous if it is given credence, and even worse if it is proposed as a means of addressing the core problem – that of defining the resource value of waste. The values suggested will always be misleading. We need new metrics to support the new means of understanding our world in the shadow of the huge environmental threat to sustained human life.

7. WASTEMET – A New Concept

This paper proposes the design of a new measurement methodology to establish the resource value of all kinds of waste, which is based on real and relevant commercial benchmarks, and which is also accessible, relevant and sustainable. The new departure in Waste Metrics is called, for these purposes, WASTEMET. WASTEMET can be applied to all waste streams, and uses a simple design for the measurement methodology.
It is based on a simple premise. The value of the matter lost in waste, especially that which cannot successfully biodegrade, can be seen to be the value of the matter into which it could be transformed by other processes. For example, 10 plastic milk bottles might be capable of transformation into a quantity of re-moulded plastic sufficient for the production of 1 new plastic milk bottle. Its value can be seen to be the price paid for the raw materials required

to make 1 new milk bottle. In other words, the value of waste is defined by market prices, but the markets in question are the markets for raw material, not the markets for recycled material. This then provides the waste material with a value related to the resource it has the capability of providing to society within the context of a finite pool of resources. It opens up the specific reference to the concept of what is lost if the material is removed from the human resource pool.
It can easily be expressed in financial terms, indeed, a monetary expression of the concept is much the best form that can be used. It is capable of applying to all forms of waste, even those for which there is no apparent transformation process. In these instances, the resource value of the waste will either be based on a transformation into energy through incineration, or may even be zero. There will be waste that is worthless, and there will be waste for which disposal to landfill is the most economic option. WASTEMET can respect the complete spectrum of differences.

8. WASTEMET – A New Methodology

The proposed methodology for WASTEMET uses the principle, embedded in the design concept, that the value of the waste relates to its capacity for transformation. The methodology starts with the calculation of the scale and difficulties of transformation. This relates to bulk, especially bulk of unit size. For example, the waste generated by cigarette packaging includes the thick cardboard outer case, the thin board carton, and finally the box of 20 or 10 cigarettes. The transformable material in each of these units is radically different. Obviously the box, which is the main end-user packaging, yields very little material, because it is so small. The carton yields more. The outer case yields most. This impacts on the cost of collection in a critical manner. The volume of material that can be collected in relation to the number of units required to achieve that volume, and hence the collection cost per unit, in the case of one type is very much more favourable than in the case of another type. In the WASTEMET methodology for the valuation of waste, especially packing materials, there is a correlation with the price of virgin materials. As a result, the price of waste changes with the rules of demand and supply – in the same way as the value of any natural resource. This point is actually a benefit not a fault, because we want the value of waste to change to reflect the relation of supply and demand. It would not be good to propose a waste value as a constant, permanently fixed, since it would prevent the use of the waste value in any meaningful way, such as a policy tool. A constant value of waste would turn the value into an artificial fee, because the price should be bigger than the costs in order to be economically viable for producers. The WASTEMET concept plots the relationship by comparing the Size of Waste Package with the Cost of Collection. The larger the size, the lower the cost. The volume of material that can be collected in relation to the number of units required to achieve that volume, and hence the collection cost per unit, in the case of one type is very much more favourable than in the case of another type. The aim of WASTEMET is to build a methodology that has the capability for making subtle distinctions between the resource value of different waste types, that are currently not measured. The consequence of measuring the resource value of waste will be that current weight-based waste policies will be capable of refinement, waste strategies will be more efficient, targets can be improved, product ecolabelling announcing resource values

can be transformed, and communication to consumer and trade markets concerning waste can be much clearer. It will concentrate initially on packaging waste and post-use materials, landfilling of which should be avoided/minimised. In the case of Poland product and deposit fees were introduced in 2002 and a significant reduction of landfilled material (large size waste) was achieved (figure 3).

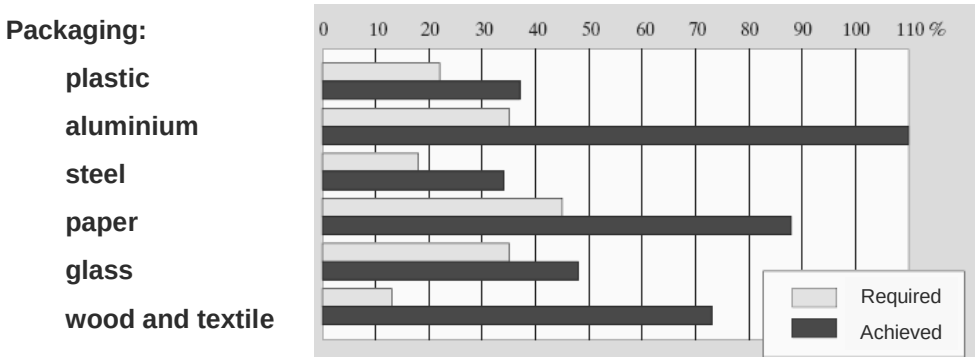

Figure 3. Level of recycling – packaging wastes in Poland 2006 (source: Ministry of the Environment).

In developing the WASTMET methodology, we propose a new way of thinking about waste and the ways to deal with it. Everywhere in Europe, the cost of recycling and reuse of small amounts of waste is high and therefore not economically viable. As a result it should receive special attention. To overcome the flaws of the current system that prefers the higher volumes of waste it is planned to develop a resource valuemeasurement that will be used instead of the weight unit. It is also important to consider the potential to introduce a life cycle perspective into the project.

Figure 4. Relation of unit collection cost and volume of waste

The graph on figure 4 showing the collection cost per unit suggests that a further adjustment is required. The resource value per unit should vary. A natural assumption is that a cigarette box will represent a fixed resource value as waste. But the value it represents fluctuates in relation to the quantity being collected. One cigarette box has almost no value, because it is impossible to collect economically on its own and has almost no transformative potential on its own. 100 cigarette boxes have high average value per unit, and 1,000 have a higher still average value per unit. In other words, we can see the value in this relationship shifts in relation to the value of the total waste of the same type, which is in direct relation to the average cost of collection per unit. The relationship of these variables makes possible the calculation of a minimum level of profitability.

Average cost of collection = Minimum resource value

Minimum resource value = Secondary Material Price

Secondary Material Price = Minimum level of profitability

The secondary material price is a direct comparator to the primary (raw) material price. This treats the waste as a viable material within an established market, the market for the raw materials that are currently in use within the existing market sectors. If the secondary material price is higher than the raw material price, the value of the waste is hard if not impossible to realise. In this case, it is overstated, and therefore another component must be taken into account. Minimum resource value is also affected by the variable price of raw material in its sector. Thus:

Minimum resource value = (Raw material market price)v = Secondary Material Price

where v is the set of variables accommodating the differences in price dictated by using recycled materials instead of virgin materials. These will vary up or down according to acceptability, perceptions, availability and environmental impacts. v is expected to be less than 1, but may well end up by being more than 1 in the majority of cases . v must be assessed individually for each market.

Therefore minimum resource value is used as the reference for calculation of a new waste value formula which is also affected by waste collection cost, capacity for transformation and the environmental impact of the specified waste. Thus:

WASTEMET waste value = f(waste i collection cost, waste i capacity for transformation, LCA of waste i)

where f is the function of waste collection cost and its LCA (Life Cycle Assessment) results. In that way the function accommodates the differences in price dictated by economic and environmental aspects as well as using recycled materials instead of virgin materials. These will vary up or down according to acceptability, perceptions, availability and environmental impacts.

The calculations above then lend themselves to restore a form of standardisation. Although they recognise that each cigarette box has a different resource value according to the size of collection in which it is contained, the definition of a minimum resource value permits the application of one standard value to every box produced. This, in turn, can be aggregated with related materials (box, carton, outer case) in which the different types are given a different minimum resource value and WASTEMET value, which can then be plotted against the average market price for raw material. As this will fluctuate, the accuracy of the aggregations will be vital to the working of WASTEMET.

9. Conclusions

It can be seen from the description of the methodology above that WASTMET is sensitive to changes in market conditions for recycled and virgin materials, as well as variations in collection costs. These are factored into the equations used in the methodology. The accuracy with which they reflect changing circumstances due to technology changes or market fluctuations is crucial to the success of the methodology. But is it important to note at this point that WASTEMET does not seek to keep up, but to anticipate changing conditions, and depends on the skill of its assessment of the impact of such changes. The aim of WASTEMET is to build a methodology that has the capability for making subtle distinctions between the resource value of different waste types, that are currently not measured. The consequence of measuring the resource value of waste will be that current weight-based waste policies will be capable of refinement, waste strategies will be more efficient, targets can be improved, product ecolabelling announcing resource values can be transformed, and communication to consumer and trade markets concerning waste can be much clearer. Based on experience, the new solution is the new way of thinking about waste and the ways to deal with it.

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