WT BREF: Proposal for definitions of resource efficiency indicators.

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1. Introduction

Reasons to include and expand Resource Efficiency indicators in the WT BREF definitions and questionnaire

In the framework of the Europe 2020 strategy, the flagship initiative for A Resource-efficient Europe supports the shift towards a resource efficient, low-carbon economy in order to achieve sustainable growth. An integral part of the flagship initiative is turning waste into a resource, as a way to mitigate primary raw material consumption (European Commission, 2011):

"If waste is to become a resource to be fed back into the economy as a raw material, then much higher priority needs to be given to re-use and recycling. A combination of policies would help create a full recycling economy, such as product design integrating a life-cycle approach, better cooperation along all market actors along the value chain, better collection processes, appropriate regulatory framework, incentives for waste prevention and recycling, as well as public investments in modern facilities for waste treatment and high quality recycling."

The scope of the IE Directive is broad and covers all industrial production sectors including the waste sector. Resource-use efficiency is a measure of performance included in the scope of the Directive and subsequent BREF documents, i.e. article 13.2.:

"(a) the performance of installations and techniques in terms of emissions, expressed as short- and long-term averages, where appropriate, and the associated reference conditions, consumption and nature of raw materials, water consumption, use of energy and generation of waste;

(b) the techniques used, associated monitoring, cross-media effects, economic and technical viability and developments therein;

(c) best available techniques and emerging techniques identified after considering the issues mentioned in points (a) and (b)."

In addition, Environmental Management Systems are already implemented in the BREF and BAT Conclusions.

Resource-use efficiency indicators and eco-efficiency indicators are well defined internationally e.g. through the EU Eco-Management and Audit Scheme (EMAS) and ISO 14045:2012 with the title "Environmental management – Eco-efficiency assessment of product systems – Principles, requirements and guidelines". Eco-efficiency indicators are used internationally at regional, national, industrial sector and company level (IEA, 2008; ESCAP, 2009). In the view of industrial production, the concept of resource efficiency can be expressed as minimizing the resources used in producing a unit of output (typically unit product output), where resources include at least energy, materials, water and land. Since the activities within most of all industrial sectors within the scope of the IE Directive, except the waste treatment sector, are to convert various forms of primary or secondary resources into material or energy products, the measures quoted in article 13 above should in principle be enough to reflect BAT based on resource-use indicators alone.

The core indicators measuring resource efficiency found in the mentioned standards and already included in the BREF documents have to be broadened in the case of waste treatment installations. The waste treatment sector has the main objective of safe treatment of the waste it receives, and this is defined typically as a service. The waste hierarchy (EU Waste Framework Directive) determines the priority of such operations ensuring reuse and recycling, followed by energy recovery, over disposal operations. Therefore, where is the case, certain technologies and installations should receive credit and should be evaluated as better performing than others in the same category if they prioritize operations according to the waste hierarchy, while achieving emissions limits and all other requirements at the same time. Indicators to measure performance of installations in this regard should be a criteria based on which BAT in the WT sector is determined. Another difference is that in this context resource efficiency cannot be measured per unit output or product but can be expressed per unit input waste to the installations, as a measure of the service provided.

If BAT is to correctly reflect the objective of waste treatment installations, the inclusion of resource efficiency indicators in the data collection needs to be comprehensively expanded. The current approach, based on the industrial production view, addresses one side of resource efficiency only, i.e. resource-use efficiency. We propose an expansion of this in the case of waste treatment. Resource efficiency can be measured in three dimensions:

- Material and energy intensity – a measure of materials and energy consumption, including from self-production, to achieve the treatment or processing of one unit input waste (i.e. one tonne waste input).
- Material and/or energy recovery efficiency – a measure of waste-derived material and/or energy products recovered from one unit input waste (i.e. one tonne waste input).
- Land occupation efficiency – a measure of space needed per unit input waste (i.e. one tonne waste input).

Specifically, indicators for "Material and/or energy recovery efficiency" can be used to reflect on which type of installation and technology follows more closely the waste hierarchy.

The data collection process is a great opportunity to establish the level and understand how different installations are performing today in Europe. The development of specific requirements to be included in future permitting of installations is not the intent or the purpose of this proposal. However the process of revision of WT BREF can be used to generate benchmarks, to understand the possibilities and limitations of today's existing and emerging treatment technologies and installations.

Challenges in the measure of resource efficiency for WT installations

The following is a list of some of the challenges and also suggestions which have been discussed in the Danish group in the preparation of this document:

1. The broad scope of the WT BREF
2. Regional variation in waste composition and background conditions
3. Installations which treat hazardous substances or materials
4. What is the best way to measure material recovery efficiency?
5. Importance of value chain and economies of scale
6. The double edge of over-focusing on emissions

1. The broad scope of the WT BREF

The WT BREF covers many different types of treatment installations which receive an even wider range of waste streams. For some waste streams, such as WEEE and ELV, targets for recovery and recycling are established through specific EU Directives, while for other streams there are no specific requirements. For regulated streams the BAT-Conclusions should not overlap with existing regulations.

The broad scope of the WT BREF makes it difficult to define uniform resource efficiency indicators. Ideally, specific indicators should be defined for installations which fall in the same category: mechanical treatment, biological treatment and physic-chemical treatment, however even so, they could be too broad. In practice developed indicators should enable to compare treatment plants which process the same waste material types.

A way to mitigate this aspect is to adjust the data collection (questionnaire) to waste-specific installations (e.g. MBT plants, composting plants, shredder plants and so on). This will enable to capture unique aspects, which will better determine what is BAT. The current working structure of the WT BREF with thematic subgroups and a subgroup on the questionnaire that is composed mainly of other thematic subgroup participants supports the possibility to adjust the questionnaire to include these unique aspects.

2. Regional variation in waste composition and background conditions

Although a benchmarking should be relatively easy to establish regarding especially energy and material intensity, it will be less facile regarding energy and material recovery efficiencies. This is because waste-derived material and energy cannot everywhere in Europe be utilized locally (no markets), or it is not economic to do so. This will determine a lot of variation in the answers given by the industry to the questionnaire in preparation.

The same type of waste treated in similar facilities across Europe will have a degree of variation in characteristics. As an example, municipal solid waste contains more biodegradable materials and more moisture in southern and south-eastern Europe. A suggestion is to include in the questionnaire a description of the type of waste treated and its main characteristics (e.g. composition, energy content).

3. Waste streams containing hazardous substances or materials

Some waste treatment installations have to ensure safe handling of hazardous substances and materials and the destruction of POPs. For waste streams containing hazardous substances / materials the first priority should be of environmental protection and proper handling and second priority to waste-derived material or energy recovery. Some of these waste streams are treated only with the purpose to be decontaminated or to undergo destruction so that the hazardous substances/ materials are removed from the environmental cycle. E.g. thermal destruction of PCBs contained in concrete or stabilization of mercury from products containing mercury (flue gas treatment after thermal treatment of products containing mercury where mercury is contained in the flue gas treatment product and safely disposed of in specialized landfills).

It is for these reasons that we suggest that waste streams containing hazardous substances /materials treated only with the purpose of removing hazardous substances / materials from the environmental cycle to be excluded from a more extended definition of resource efficiency indicators.

4. What is the best way to measure material recovery efficiency?

Two approaches can be suggested here:

- A <u>simple approach</u> is to include general indicators such as “total waste-derived material recovery” (measured in mass per year of products intended for reuse or recycling) and “specific waste-derived material recovery” (measured in mass recovered per tonne input waste). This approach is exemplified in the following chapters. By choosing the simple approach we cannot account for the variation of input waste to treatment installations on the one side. And we cannot account for materials or substances which should be prioritized for recovery (e.g. phosphorus, REE, precious metals) but which are not present in large quantities, on the other side.
- A <u>detailed approach</u> is to include the general indicators above and additional specific indicators, such as “material X specific recovery”. Material specific recovery measures how much of the material X present in the input composition has been recovered in the output product (e.g. how much of Cu in the input scrap is recovered in the Cu product).
  This however makes it necessary for companies to know in detail the characteristics of the waste they process. A suggestion here can be that companies are allowed to estimate such material recovery efficiencies, and that they should be required only for materials/resources of interest.

Critical materials for the EU economy have been identified, and these could be the considered in this framework (European Commission, 2010). They cover however mostly speciality metals and elements, therefore the definition of materials/ resources of interest can be extended, and discussed. As a starting point plant nutrients and the four groups of materials of focus in the Waste Framework Directive can be considered: metals, paper, plastic and glass respectively.

5. Importance of value chain and economies of scale

Typically, a specific installation is only one link in the treatment chain. The waste sector works as a network, where outputs from one plant constitute the feedstock for other plants until the material exits the network, either recycled to new products, as energy or as disposal residues. This could make it difficult for a specific company to indicate what is the destination of its outputs, depending on where in the chain it is placed. The network is a natural adaptation driven by market forces in order to fulfil criteria for economies of scale, which allows for material which cannot be economically processed in one plant to join similar material sent to other plants which need a certain capacity in order to function feasibly.
An example from the WEEE industry: pre-treatment plants recover a variety of products which have to be sent to other refining plants. A specific product are printed circuit boards, which contain precious and other scarce materials, for which the end link in the chain are only a few advanced smelters around the world. This product is funneled to these

smelters which are able do to economies of scale to apply very sophisticated technology and recover efficiently these resources.

Specific suggestions:
- A specific company/installation can control in- and outgoing materials, energy and water. It can to some extent control the purity of the outgoing materials. This suggests that the BAT-Conclusions should focus on the installation and aspects that can be controlled by the installation.
- The BAT-Conclusions may support market forces but shall not replace them. An example of supporting market forces could be a BAT Conclusion demanding the company to declare the quality such as the purity of reusable outgoing materials in order to stimulate the market to buy more recycled/reused products. Some companies do that already on a volunteer basis, eg. Komtek who publishes declarations for their ”products” made of waste: http://komtek.dk/Miljo-med-visioner/varedeklarationer/bioaske.aspx.

6. The double edge of over-focusing on emissions

BAT-Conclusions making it more difficult for recycling/reuse have been seen and should be avoided. An example is BAT-Conclusion on low concentrations of emissions to water making it difficult for companies saving water. This supports that the data collection should always include data on water consumption related to produced products in order to differentiate BAT-associated emission levels between companies working with water savings and companies not doing so. Another example is the use of RTOs – Regenerative Thermal Oxidation in MBT plants in Germany. The reason why Germany had adopted very stringent regulations for emissions for this type of plants has more to do with politics than environmental protection. The RTO system require the consumption of natural gas, landfill gas or biogas which can account for a considerable energy consumption in these plants.

To quite the opposite, a suggestion could be to accept emission in the higher end of the BAT-interval if a company can efficiently save resources.

2. Proposal for definition of Energy efficiency indicators

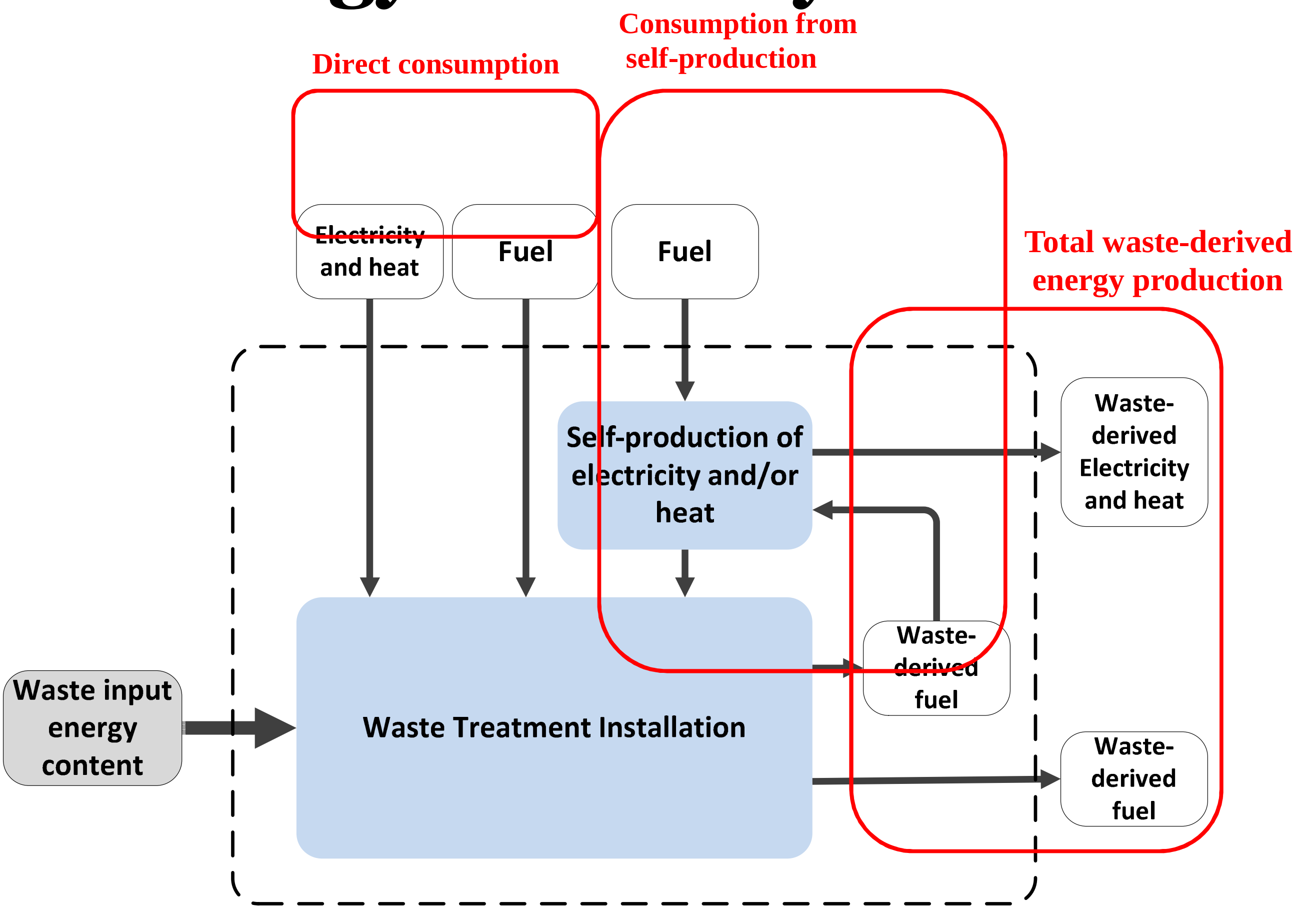

FIGURE 1: ENERGY FLOWS WITHIN A WT INSTALLATION, DOTTET LINE DELINIATES THE INSTALLATION SYSTEM

The figure above illustrates energy flows in and out of a typical waste treatment plant. First, the waste itself can have an energy content, measured by its calorific value. Different forms of energy are then used in order to operate the treatment process or in conversion processes. These can be imported from the national, regional or local grid (i.e. electricity and thermal energy) or can be imported in the form of fuels which are converted internally in electricity or thermal energy or used as such (e.g. diesel for internal transport). Some form of waste-derived fuel could be produced in the treatment process and internally converted to electricity and heat. This waste-derived energy could be totally or partially used in the same installation or could be exported. Lastly, waste-derived fuels could be one of the products of the installation, and they are exported as such to be used for energy production outside the treatment plant.

Waste-derived fuel is here defined as treatment outputs, solid, liquid or gas, which have calorific value suitable and are in fact intended for energy production. Examples are: biogas, recovered oil and such, Refuse Derived Fuels (RDFs) etc.

Example: Anaerobic digestion plants treating organic waste collected separately from households.
The waste input has an energy content of 2-5 MJ/kg. Mostly electricity is imported from the national grid, and fuels for internal transport (e.g. diesel). The main output of the installation is biogas, with an energy content of 15-25 MJ/kg. Biogas can be upgraded and sent outside the plant to be used as a fuel or is combusted on site and converted to electricity

and heat. Part of the electricity can be used internally and the rest can be delivered to the national grid. Heat can be used internally for the digestion process or could be delivered to a district heating network.

2.1 Energy intensity

Definition: The amount of energy used in producing a given level of output or activity. It is measured by the quantity of energy required to perform a particular activity (service), expressed as energy per unit of input or activity measure of service. Adapted from US Department of Energy (2014).
We propose two measures for energy intensity, in order to verify the accuracy of the industry answers to the questionnaire.

- **Total yearly consumption (MWh/yr)** – measures total energy consumption from any sources, including self-produced and waste derived energy.

TABLE 1: PROPOSED QUESTIONNAIRE SECTION

Total yearly consumption	Unit	Answer
Thermal energy consumption	MWh/yr	
Electrical energy consumption	MWh/yr	
Petrol	L/yr	
Diesel	L/yr	
Fuel oil	L/yr	
Natural Gas	m^3/yr	
Biogas	m^3/yr	
Methane content of the consumed Biogas	%	
Others		

Detailed description of self-produced energy, allowing to calculate the conversion efficiency.

TABLE 2: PROPOSED SECTION

Self-generated energy	Electricity		Thermal energy	
Fuel type	Produced energy (MWh/yr)	Quantity fuel used (kg, m^3)	Produced energy (MWh/yr)	Quantity fuel used (kg, m^3)
Coal				
Fuel oil				
Natural Gas				
Biogas				
Other				

- **Specific consumption (MWh/Mg Input)** – measures the amount of energy consumption per unit of waste treated. Energy from any sources, including self-produced and waste derived energy.

TABLE 3: PROPOSED QUESTIONNAIRE SECTION

Specific consumption	**Unit**	**Answer**
Thermal energy consumption	MWh/Mg	
Electrical energy consumption	MWh/Mg	
Petrol	L/Mg	
Diesel	L/Mg	
Fuel oil	L/Mg	
Natural Gas	m^3/Mg	
Biogas	m^3/Mg	
Methane content of the consumed Biogas	%	
Others		

2.2 Energy recovery efficiency (waste-derived energy)

Definition: It is a measure of the quantity of energy recovered from performing a particular activity (service), here expressed as energy per unit of input waste to the treatment plant. It refers to produced energy which is consumed internally, energy which is delivered to the national or local grid and energy carrier products which are intended to be used for energy production outside the treatment plant (e.g. RDF, biogas).

- **Total yearly production (MWh/yr)** - measures total waste-derived energy, including self-use, exported and waste-derived fuels.

Destination options: self-consumption, put on national grid, sent Waste-to-Energy plants, cement production etc.

TABLE 4: PROPOSED SECTION

Total yearly production	**Unit**	**Amount**	**Destination**
Calorific value of the input waste	KJ/kg		
Thermal energy production	MWh/yr		
Thermal energy exported	MWh/yr		
Electrical energy production	MWh/yr		
Electrical energy exported	MWh/yr		
Biogas production	m^3/yr		
Methane content of the produced Biogas	%		
Other waste derived fuel	Mg/yr		
Calorific value of the waste derived fuel	KJ/kg		

➢ **Specific production (MWh/Mg Input)** - measures the amount of energy produced per unit of waste treated, including self-use, exported and waste-derived fuels.

Obs.: The first question, requesting the calorific value of the input waste allows to calculate the energy content recovery ratio.

TABLE 5: PROPOSED SECTION

Specific production	**Unit**	**Amount**	**Destination**
Calorific value of the input waste	KJ/kg		
Thermal energy production	MWh/Mg		
Thermal energy exported	MWh/Mg		
Electrical energy production	MWh/Mg		
Electrical energy exported	MWh/Mg		
Biogas production	m^3/Mg		
Methane content of the produced Biogas	%		
Other waste derived fuel	Mg/Mg		
Calorific value of the waste derived fuel	KJ/kg		

3. Proposal for definition of Material efficiency indicators

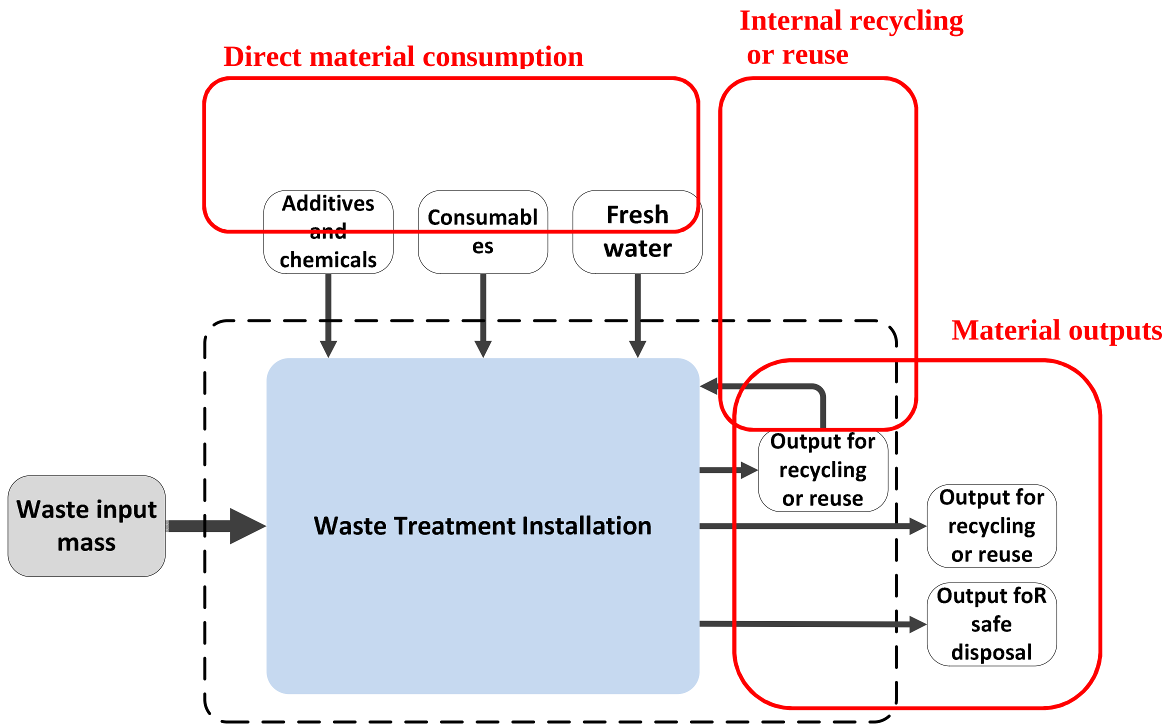

FIGURE 2: MATERIAL FLOWS WITHIN A WT INSTALLATION, DOTTET LINE DELINIATES THE INSTALLATION SYSTEM

The figure above illustrates material flows in and out of a typical waste treatment plant. Except the waste itself, the process typically requires other materials, chemicals and water to be consumed. The inputs above are not exhaustive, meaning that depending on installation and waste stream other inputs could be required. As an example, for anaerobic digestion plants an additional input could be a substrate such as straw which is used to together with the waste. Similarly, composting plants use straw in the process as well.

The outputs of the plants refer to only waste-derived outputs intended for reuse or recycling and outputs intended for disposal (i.e. incineration, deposit or other). Outputs such as waste-derived fuels are covered by the section on energy efficiency.

Some of the outputs of the installation could be used internally and this has to be specified. Typically both recycling, reuse and disposal operations are performed outside the installation system.

<u>Example:</u> Anaerobic digestion plants treating organic waste collected separately from households (continuation)
The organic waste input is typically first pre-treated in order to remove contamination and miss-sorted materials. This process could consume water and generates a residue stream which is sent for disposal. The pre-treated biomass is next transferred to the digestion reactors. At this point some chemicals and substrates could be added. The main outputs for recycling in this case are liquid or solid digestion residues which can be used as bio-fertilizers in agriculture for example.

3.1 Material intensity

<u>Definition:</u> The amount of materials used in producing a given level of output or activity. It is measured by the quantity of materials required to perform a particular activity (service), expressed as mass/volume per unit of input or activity measure of service.

- **Total yearly consumption (Mg, L, m3/yr)** – measures total material consumption, excluding the waste itself.

TABLE 6: PROPOSED SECTION

Total yearly consumption	Unit	Amount	Type	Purpose
Additives	Mg/yr			
Other chemicals	Mg/yr			
Other consumables	Mg/yr			
Fresh water	L/yr			

- **Specific consumption (Mg, L, m3/Mg Input)** – measures material consumption per unit waste input to the treatment process, excluding the waste itself.

TABLE 7: PROPOSED SECTION

Specific consumption	Unit	Amount	Type	Purpose
Additives	Mg/Mg			
Other chemicals	Mg/Mg			
Other consumables	Mg/Mg			
Fresh water	L/Mg			

3.2 Material recovery efficiency

<u>Definition:</u> Defined as the amount of waste-derived material products, reclaimed during the treatment process in materials/substances or material streams in a form that is suited for recycling applications.
Through the questionnaire we intend to establish all material outputs of the plants and their destination. The destination itself can then be assessed with regard to being reuse, recycling or disposal, thus allowing to calculate how much of the input waste stream is recycled and so on.

Outstanding question: How do we measure if a product is suited for recycling and to what quality of recycling? The simple way is to ask the industry what the material is used for.

- **Total yearly production (Mg, L, m3/yr)** – refers to total waste-derived material products.

Destination here refers mainly to either recycling applications (to be detailed) or different types of disposal.

TABLE 8: PROPOSED SECTION

Total yearly production	**Amount**	**Main parameters**	**Destination**
Main product outflows			
By-products			
Residue streams			

- **Specific production (Mg, L, m3/Mg Input)** – refers to waste-derived material products generated per unit of waste input.

Destination here refers mainly to either recycling applications (to be detailed) or different types of disposal.

TABLE 9: PROPOSED SECTION

Specific production	**Amount**	**Main parameters**	**Destination**
Main product outflows			
By-products			
Residue streams			

4. Proposal for definition of Land occupation efficiency

Land occupation is placed under the core indicator "Biodiversity" in both the EMAS scheme and the new EUROSTAT resource efficiency scoreboard[1]. The indicator measures the 'use of land', expressed in m^2 of built-up area.

This indicator is added in order to measure efficient use of space and thus impact on the surrounding environment. It is simple to measure as land area used per unit capacity (m^2/Mg), and it will reveal, when looking at specific types of plants, what is the typical area footprint, and also which are the best achievable area footprints.

[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/europe_2020_indicators/ree_scoreboard

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