Food Waste on the Agenda

Key factors to be considered

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Abstract—**Huge amounts of food waste are generated worldwide. Efficient valorisation strategies ensure that embedded energy and resources are at least partially recuperated. Food waste is a highly biodegradable material with high water content, and as such well destined for biogas production through anaerobic digestion. In order to ensure successful implementation of food waste valorisation via anaerobic digestion, a range of key factors related to the characteristics of the material as well as to more general frameworks need to be considered.**

Keywords- food waste management; biogas; anaerobic digestion; bioenergy

I. INTRODUCTION

Occurrence of food waste is a factor that significantly decreases efficiency of a food system. Along with reduction of wastage, valorisation of not avoided food waste is at the heart of the challenge to establish a more sustainable food system.

Despite the fact that bioenergy production, and in particular biogas production, has been and is further studied by many research groups worldwide, it requires increased commitment from stakeholders and availability of key knowledge to encourage more widespread and successful uptake in practice. This publication aims at compiling key factors to be considered when looking at possible valorisation of food waste.

II. WASTE IN THE FOOD SYSTEM

There is no consensus what the term food waste comprises. The term may refer to lost or degraded material which was originally destined for human consumption, or might include edible material intentionally fed to animals or by-products of food processing diverted away from human consumption, or might even refer to over-nutrition as the gap between consumed and needed per capita food energy [1]. In the following, food waste refers to all losses and inedible by-products in the food supply chain (FSC) after that material was designated to human consumption purpose (including potentially consumable material left on field), which is in line with the majority of literature in the area.

Food waste is generated at all stages of the food supply chain (Figure 1). So-called post-consumer waste comprises food wastage which occurs at the point at which food is consumed, e.g. meal preparation waste, left-over and discarded food, while food occurring during earlier stages of the supply chain can be summarized with the term pre-consumer waste. Nevertheless, the characteristics of the waste at each single step of the FSC can significantly differ from the next step, and might among others depend on the individual food type, management, preferences and engineered infrastructures.

At all stages, not all food losses would potentially be avoidable. Food is a biological material susceptible to degradation and which requires processing before it can be consumed, so occurrence of material which cannot be served as food is to some extent unavoidable.

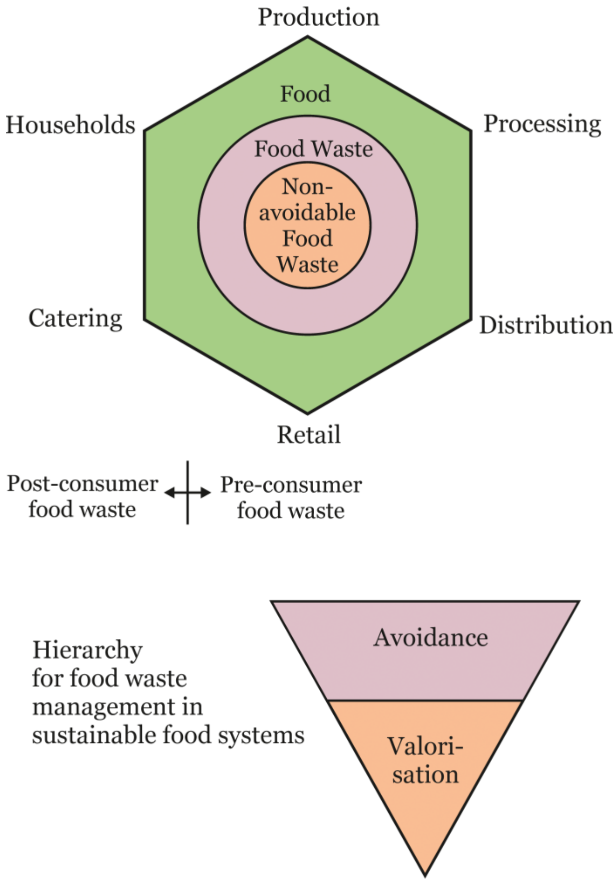

Figure 1. Food waste in the food supply chain

Amounts and characteristics of food wastes are highly related to the economic development stage of a country. Financial, managerial and technical limitations in harvesting techniques, in storage and cooling facilities, in transport infrastructures, and in packaging and marking systems are most relevant in low-income countries, while in medium and high income countries consumer behaviour and a lack of coordination between different actors in the chain have decisive influence [2] [3]. In industrialized countries, substantial food losses occur as post-consumer waste, mainly in households after purchase, but retail, distribution and processing remain responsible for significant amounts of wastage [4].

Although post-consumer waste is in general the most visible part of all waste, it is an essential prerequisite of more sustainable food systems to address the losses along the whole FSC (also see [5]).

There is limited availability of reliable data on generation of food waste at the different FSC stages on a global scale [1]. Updated assumptions indicate wastage in the range of a quarter to a third of all food grown [1] [6]. Changing economies and societies influence the situation. Dietary transition related to growth in household incomes results in less consumption of starchy food and increased demand for fresh fruit and vegetables, dairy, meat and fish, which means a shift towards vulnerable, shorter shelf-life items [1]. Urbanization trends, globalization of trade, aging population profiles, reduced numbers of individuals per households, and mobility patterns are further central factors in this dynamic field.

Food wastage is not only relevant with view to the reduced amount of available food, which threatens food security. In addition, it represents a loss of embedded energy and other resources such as water and fertilizer. Moreover, food which is lost, at the same time means occupation of arable land that could have been used for other purposes, e.g. for cultivation of energy crops. It is therefore evident, that avoidance is on top of hierarchy when looking at food waste. It has been assessed that by more efficient utilization of already available systems and technologies around half of the global food losses could be prevented [6].

Valorisation of not avoided food waste contributes to improved overall energy balance of food systems and holds potential to be highly beneficial towards maintenance of productivity of agricultural soils.

III. VALORISATION OF FOOD WASTE

Transition towards sustainability will require changing to systemic perspectives. When adopting such an attitude, understanding the means to reduce food waste would be the most efficient food waste valorisation strategy.

Reduction of food wastage is a multi-facetted challenge that requires interdisciplinary cooperation and multi-stakeholder engagement. In order to be successful, initiatives should aim at involving governments, farmers, academics, NGOs and food business, and need to ensure that each of the actors is able and willing to provide complementary skills, approaches and networks under consideration of the type of food chain [7].

As mentioned previously, not all food waste is potentially avoidable and it is not realistic that all potentially avoidable waste will actually be prevented. It is therefore essential to establish reliable and efficient valorisation pathways for generated wastes.

When considering the factors described in section II above, it is evident that characteristics of food waste can vary within wide ranges, depending among others on the geographical region and the FSC stage of its occurrence. Seasonal variations might change key parameters for bioenergy production [8], and the chosen waste collection scheme can influence quality of the material [9]. A detailed analysis of available materials is therefore a prerequisite for all further assessment. If not yet in place, establishment of separate collection is an essential step, either aiming solely at food waste or at several organic fractions.

Despite the variations of the material, food waste is typically to be classified as highly biodegradable biomass with in general high water content. It is therefore well suited for biogas production through anaerobic digestion (AD), provided that favourable process conditions are enabled. The resulting biogas is a versatile energy carrier, while digestate (effluent of the reactor containing liquefied or solid material) is a valuable fertilizer and soil amendment when spread to agricultural land.

Food waste digestion is not a new idea, and experiences are available both from laboratory research and from full-scale practical implementation. However, successful implementation of food waste AD requires specific knowledge and attention, and key factors to be considered are specified in the following. Alternative food waste valorisation strategies (e.g. biohydrogen production) are subject to on-going research and development, but at present AD represents the only established state-of-the art technology well beyond pilot stage.

Digestion of food waste is susceptible to occurrence of both high concentrations of volatile fatty acids (VFA) and of ammonia [10] [11]. The thermophilic process increases the risk of digester failure due to VFA and/ or ammonia inhibition [10]. While ammonia remains a critical issue in AD [12] [13], it is well documented in literature that addition of trace elements stabilizes a food waste digestion process showing VFA accumulation [14] [15] [16]. Co-digestion of food waste and of organic fractions with high carbon to nitrogen ratio is an efficient strategy to limit ammonia concentration during the process [17]. Prior to looking at AD technology and the suitable specific process to be implemented, availability of co-substrates should be assessed.

Co-digestion of food waste in agricultural AD plants operated on the basis of animal slurry is one possible and promising option to be considered. This has potential to improve economic viability of a rural facility, but requires a detailed and site-specific-assessment [18]. The decision to take in food waste does not only alter the whole AD concept on farm, but entails detailed consideration of the resulting necessary handling and management requirements, e.g. with view to hygenisation.

In many countries, co-digestion of sewage sludge and food waste is common. This option is often particularly attractive in urban settings, and despite the fact that handling of food waste requires additional equipment. However, in the UK sewage sludge and food waste are subject to different regulatory systems, which results into very complex scenarios in what concerns both the actual processing for biogas production and management of resulting residues [18]. This example indicates that transfer of successful technical concepts from one country to another might not be suitable due to existing individual regulations.

Determination of available organic materials, consideration of already existing relevant infrastructures, precise knowledge of all relevant regulations, and a detailed assessment of technologies are central when choosing the AD concept (see Figure 2). The technology assessment needs to include pre-treatment equipment, which has a decisive influence on overall-efficiency of the AD process [19]. Among others, particle size distribution influences performance of anaerobic digesters [20] [21].

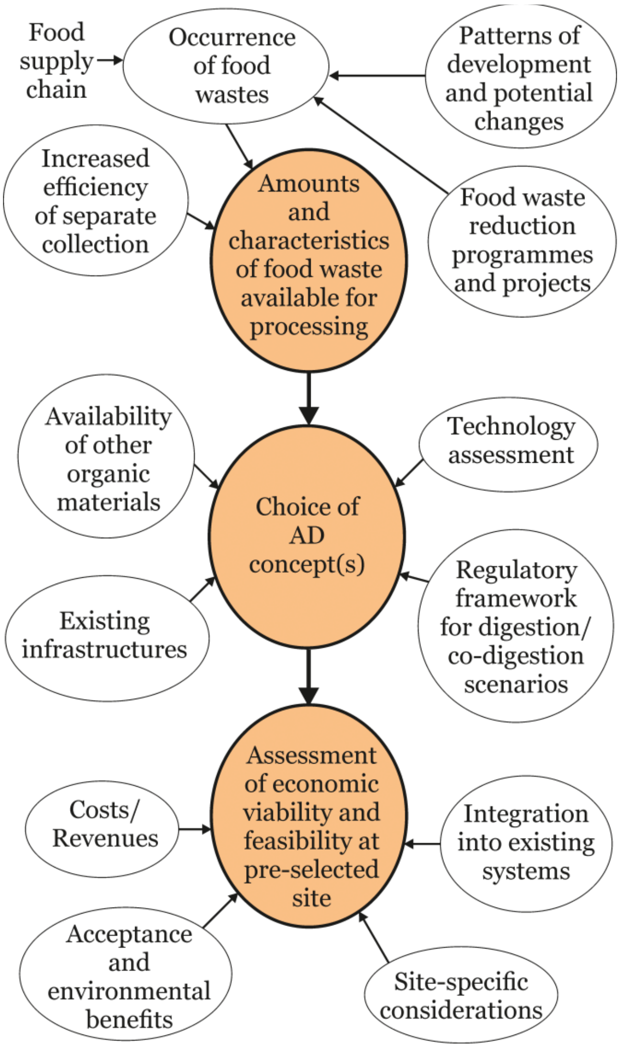

Figure 2. Food waste valorisation: decision making strategy prior to the project implementation phase

Decision in favour or against food waste digestion should be based on a detailed economic assessment of the AD concept, and should in addition consider environmental benefits, acceptance of the project by the population, the degree of complexity of integration into existing or planned systems (e.g. waste management schemes and practices), and relevant site-specific factors.

IV. Conclusions

Significant amounts of biodegradable waste, including food, still go to landfill sites worldwide. Avoidance of food wastage needs to be put on top of the agendas in order to advance progress towards more sustainable food systems. In this context, the technology and engineering perspective is important, but is by itself insufficient for solving the problems [5]. It is furthermore essential to look at all stages of the food supply chain and to assume responsibility for the complex system. In particular in industrialized countries post-consumer food waste represents the most visible proportion of food losses. Nevertheless, simply addressing the final consumer with awareness raising campaigns risks to not achieve any long-term commitment if responsibility along the whole food supply chain is missing.

The lack of precise data on food losses needs to be addressed with priority. This includes a precise overview of the amounts of food wastages, but moreover requires determination of how much of these would potentially be avoidable. There seems to be a particular lack of data at the interfaces of stages, e.g. the supplier-retailer interface [22], which needs to be understood as a special challenge. It is further essential to quantify the embedded resources, including energy, which are lost with the wasted food at each stage of the food supply chain. Consumption of resources accumulates with different patterns when moving food along the supply chain, which, among others, is of decisive influence on the percentage of potentially recoverable resources through valorisation strategies.

There is full consensus that not avoided food waste is a potential source for bioenergy generation. Anaerobic digestion with biogas production is an already well-known and in practice adopted technology for valorisation of food waste. This pathway holds huge potential for more widespread implementation throughout the world. Consideration of the key factors which are presented in this publication in a short overview, shapes the initial stages of a food waste valorisation project into the form which enables a well-founded decision making process.

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