D6.11

Identification of food waste conversion barriers

Identification of social, economic, legislative and environmental barriers and opportunities

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1 Executive Summary

1.1 Scope

The report identifies how external conditions (legislative, environmental, social and economic) can influence development of food waste conversion options, specifically through conversion of currently wasted food to animal feed.

It was reasoned in REFRESH D6.7 that valorising wasted food for feed is possible through specialist licenced treatment plants complying with stringent biosecurity measures. Based on a risk/hazard analysis, a set of critical criteria for the processing has been formulated. It is concluded from economic and sustainability analysis that it may result in significant savings in terms of greenhouse gas (GHG) emissions and economic cost-benefits.

REFRESH D3.3 analysed the policy context, specifically current EU policies and regulations, in the field of tension between demand for sustainability, safe and healthy food supply and resource efficiency.

This report integrates the view on actual barriers and opportunities for the intended valorisation option. As concluded in D3.3, current legislation heavily limits the use of side and waste streams containing animal products, in animal feeds. This document explores how such valorisation would be possible within the intended effect of legislation (actually intending to prevent unacceptable risks). Furthermore, we elaborate which factors are dominant in the economic model, and factors that may affect stakeholders' (from consumers to producers) acceptance.

1.2 Key conclusions

It is shown that there is ample room for valorising surplus/wasted food products from the processing, retail and food service sectors. Current legislation is the main hindrance for a substantial increase of valorisation. This legislation is arranged to maximally prevent risks of feed- and foodborne animal diseases. Connected to that are high administrative and practical burdens, which not only prevent valorisation of animal by-products but also significant amounts of other food waste streams. Allowing safe pathways – that still fulfil the intended safety standards as intended with current legislation – could take away practical hindrances. The research shows that in regions with sufficiently large supply the options are economically competitive to current (generally less circular) feed supply.

2 Background

2.1 Scope

The headline aim of REFRESH WP6 is to 'increase the exploitation of *food waste' and the* title of this deliverable refers to a target for waste reduction. The reference to '*30% by 2025'* (6.5.2. task description: REFRESH Description of Actions 2015) implicitly places the scope of this deliverable title firmly within the context of the *EU food* waste policy targets expressed in the revised Waste Framework Directive (rWFD) (Box 1).

Box 1. EU Food waste targets (rWFD)

The revised Waste Framework Directive (rWFD) adopted on 30 May 2018 calls on the EU countries to reduce food waste and food losses at each stage of the food supply chain:

> *Member States should take measures to promote prevention and reduction of food waste in line with the 2030 Agenda for Sustainable Development, adopted by the United Nations (UN) General Assembly on 25 September 2015, and in particular its target of halving per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, by 2030.*
>
> *Those measures should aim to prevent and reduce food waste in primary production, in processing and manufacturing, in retail and other distribution of food, in restaurants and food services as well as in households. In order to contribute and ensure to be on track towards the attainment of the UN Sustainable Development Goal, Member States should aim to achieve an indicative Union-wide food waste reduction target of 30 % by 2025 and 50 % by 2030.*

–09 Point 31 and Article 9 (g) of EU Directive 2018/851 (EU, 2018).

Data on food waste generation in different stages along the food supply chain are given in Table 1 (estimates from the FUSIONS project).

Table 1. Estimates of food waste in EU-28 in 2012 (Stenmarck et al 2016). These data include food and inedible parts.

Sector	Food waste (million tonnes) with 95% CI*
Primary production	9.1 ± 1.5
Processing	16.9± 12.7
Wholesale and retail	4.6 ± 1.2
Food service	10.5 ± 1.5
Households	46.5 ±4.4
Total food waste	**87.6 ± 13.7**

*CI = Confidence Interval

The data in Table 1 include edible and inedible parts. To the authors' knowledge, no (scientific) data are available that distinguish the edible and inedible fraction for the food waste in the distinguished sectors. The best available estimate found is based on data from Gillick & Quested (2018), who found that about 70% of the household food waste is or was edible and 30% is inedible.

For the other post-harvest segments, we make the following estimates:

- In wholesale and retail, whole products are wasted. Since the edible fraction is largely consumed and the inedible fraction will largely remain after consumption, in household waste the inedible fraction will be relatively high compared to the edible fraction. Based on this reasoning, for the wholesale and retail sector the edible fraction is expected higher than in the household reference situation, say 90% edible and 10% inedible fraction.
- The same reasoning holds for the processing industry. However, they also emit significant inedible streams which are not sent to the consumer canal. Such side-streams, may, however be edible for specific animal categories (think of surplus bread for ruminants). Since we have no better data, we adopt the 70:30 figure for this sector.
- In food service, planning inaccuracy is expected to be a more serious reason for food waste than in households. Consequently, a relatively higher fraction of the edible part is expected for food service. We estimate it at 20%.

The total edible volume based on these estimates is given in Table 2.

Table 2. Estimates of edible and inedible food fraction in post-harvest segments, based on averages from Table 1 and fractionation in edible and inedible parts according to the reasoning in the text above.

Sector	Food waste	Edible fraction	Inedible fraction
Processing	16.9	11.8	5.1
Wholesale and retail	4.6	4.1	0.5
Food service	10.5	8.4	2.1
Total	**32.0**	**24.3**	**7.7**

As shown in Table 2 preventing and valorising food waste in the post-harvest can significantly contribute to reaching the "30% food waste reduction" goals. However, 'low-hanging fruit' has already been picked (as is expressed, amongst others, by the large fraction of processing side streams that is valorised as animal feed). As part of this 'already picked low hanging fruit', 5 million tonnes former food stuffs per year[1] are already valorised for feed (European Former Foodstuff Processors Association (EFFPA, www.effpa.eu, visited April 2019). Amongst these products are for example bakery and confectionary-type goods, fruit and vegetable goods, potato goods and other mostly well-defined stuffs that for various reasons

[1] These feed-destined are not part of the figures of Table 1.

are removed from the food supply chain. EFFPA foresees a further growth by 2 million tons per year in 2025.

Considering the volumes available in the remaining food waste and side streams (see e.g. REFRESH deliverables D6.5), the valorisation routes of such streams is essential to attain high impacts. Consequently, new routes must be explored, and because market potency for food application is often limited, the options for animal feed should be further exploited in order to get the 30% food waste reduction goal in reach.

In this deliverable we analyse barriers for valorising food surpluses (from retail, processing and catering) as pig feed through specialist licensed treatment plants as described in REFRESH deliverable D6.7 and specified in deliverable D5.5. As described in D6.7, when implemented adequately such system can provide safe animal feed and contribute to sustainable production (D5.5).

2.2 Current valorisation approaches

Refresh deliverable D6.3 (Metcalfe *et al.*, 2017) projected the current disposal and valorisation routes on the Food & Drink material hierarchy (Figure 1, Table 3)

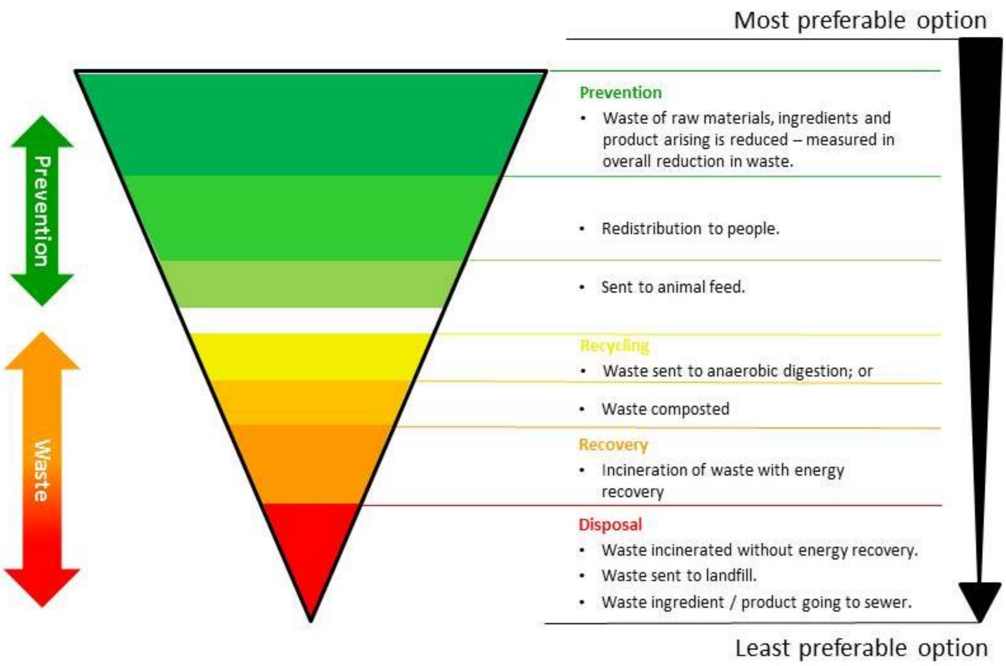

Figure 1. Food & drink material hierarchy (Parfitt et al., 2016)

Table 3 How the Waste Hierarchy relates to REFRESH situations

Waste Hierarchy level	Description

1.	Waste Prevention	Waste reduction at source through improving processing and planning efficiencies and effectiveness.
		Waste reduction at source through further reuse
		Material is used directly/with certain use/lawfully (either for food or animal feed) and becomes a by-product
2.	Waste recovery by recycling	Recycling: Waste is principally recovered by reprocessing waste into new materials (food or feed ingredient) replacing other materials.
3.	Waste recovery by other means	Waste is principally recovered for biobased application (including fuels), fertilizer production, possibly including energy production.
4.	Disposal	End of life treatment with limited recovery.

Food waste at consumption level (Households, Food service) and from Retail and wholesale ends largely at the levels of 'Waste recovery by other means' and 'Disposal' (Table 3), which is outside food and animal feed domain, consequently considered 'food waste'.

Side streams from food processing, though, are largely used for generating food ingredients and for animal feeds (REFRESH deliverable D6.3, Metcalfe *et al.*, 2017). Remaining fraction (with indicative volume given in Table 1) ends at the levels of 'Waste recovery by other means' and 'Disposal' (Table 3). Some potential reasons for that:

- the product may be unsuitable for feed or food application or (nutritional) quality may not be of sufficient interest;
- quality issues (related to composition, safety or others);
- costs of processing and logistics may be higher than the actual benefit of upgrading from 'waste' to food or feed product;
- legislation may prevent the use, specifically for waste streams containing animal proteins.

The latter reason is addressed through the potential solution of valorising food surpluses (from retail, processing and catering) as pig feed through specialist licensed treatment plants. This process is characterised as follows (based on REFRESH deliverable D6.7, Luyckx *et al.*, 2019):

- sourcing of residual food from a manufacturing, retail and catering (with appropriate measures for safety and traceability),
- transporting the material to central location
- treatment at the plant, including:

    - sorting, cutting/grinding/shedding, …
    - preservation process (heat treatment and/or acidification)
    - dewatering (optional)
    - monitoring/control of toxin loads and microbial inactivation parameters
    - biosecurity and safety measures will need to comply with those for the treatment of Category 3 Animal-By Products as set out in Commission Regulation 142/2011, Annex IV, Chapter 1 "Requirements for Processing Plants and Certain Other Plants and Establishments, as applicable to Category 3 materials. (pp. 27 – 29).
- transport to either feed manufacturer or farm
- feeding at farm level

As shown in D6.7, through appropriate measures a processing and supply chain can be set up that fulfils the society demands for safe and sustainable products, meanwhile contributing to significant reduction of food waste. Barriers for the proposed solution are addressed in this report.

3 Social, safety and legislative barriers analysis

3.1 Analysis of legal barriers

Legislative barriers

Using products containing unspecified animal (by-)products in feed is generally not allowed in current legislation, but D6.7 shows that through appropriate measures the intended effect of legislation (i.e. enforcing safe product) the intended effects of the legislation – adequate safety levels – can be achieved.

REFRESH Deliverable D3.3 gives an overview of legal barriers for the proposed solution:

> Risk management of prion and other foodborne animal diseases is a central aspect of the legislative framework regulating the use of 'former foodstuffs' in animal feed. According to Regulation 68/2013 (EU, 2013a), Catalogue of Feed Materials, 'former foodstuffs' are defined as "foodstuffs, other than catering reflux (catering waste), which were manufactured for human consumption in full compliance with the EU food law (Regulation 178/2002) (EC, 2002) but which are no longer intended for human consumption for practical or logistical reasons or due to problems of manufacturing or packaging defects or other defects and which do not present any health risks when used as feed". The concept of "former foodstuffs" in this document follows the legal definition. When we refer to surplus, we mean other types of food produced for human consumption but which are currently not permissible in animal feed. It is also important to note that the legal definition does not consider the fact that many "former foodstuffs" may well be suitable for redistribution for human consumption. The European Association of Former Foodstuff Processors (EFFPA, 2018) states that "EFFPA fully supports the responsibility of food producers to consider the donation of foodstuffs to people in need first."

The Waste Framework Directive states that former foodstuffs (FFs) are automatically classified as waste unless the responsible business operator makes clear that it intends the former foodstuff to be used as feed. "Food which has passed its 'best before' date can be used as a feed provided that those products are safe for the animals. Highly perishable food where the 'use by' date has expired can only be marketed and used as a feed material if no risk to public or animal health has arisen from a risk assessment" (EU, 2018). Belgium and Germany have an arrangement that allows waste to be upgraded back to feed. The main problem arises in countries where former foodstuffs are placed on the market as feed and then environmental authorities judge it as waste. A solution to this problem would be to stop challenging the feed status of former foodstuffs in member states. The Commission Guidelines for the feed use of food no longer intended for human consumption, published in April 2018, attempt to further resolve confusion on the status of former foodstuffs (EU, 2018a). The Guidelines confirm that the burden to prove to the competent authority that the criteria for a non-waste classification are met is on the food business operator (section 3.1 (a)). However, the Guidelines also point to the superfluous nature of the requirement by some national waste authorities for a certificate containing a detailed justification of non-waste classification. The Guidelines say that such certificate is superfluous since a food establishment must be registered as a feed business operator under Commission Reg 183 and is thus under control of the feed authorities.
Regulation 999/2001 (EC, 2001) prohibits the feeding to ruminants of most types of animal protein. This prohibition was first temporarily extended to non-ruminants in countries considered to have a high risk of Transmissible Spongiform Encephalopathy (TSE) / prion disease, and later made permanent EU wide by amendments 1923/2006 (EC, 2006) and 56/2013 (EU, 2013). Put simply, farmed animals, whether they are ruminant or non-ruminant, herbivore or omnivore, are not allowed to eat meat, ruminant collagen and gelatine, or any products containing these. Low risk animal by-products (ABPs) such as processed milk or eggs are allowed, and later amendments include exceptions allowing pigs and poultry to eat fish meal, and fish to eat non-ruminant ABPs[2]. Additionally, it is permitted to feed blood products and di-calcium and tri-calcium phosphate of animal origin to non-ruminant livestock.

[2] ABP = animal by-products

Regulation 1069/2009 (EC, 2009) (laying down health rules on ABPs not intended for human consumption) enshrines the ban on using kitchen left-overs and catering waste, and the ban on intra-species recycling, and defines categories of ABPs according to their level of risk. For instance, "a former food contaminated by pathogen bacteria is considered as category 2 material and shall not be used for feeding farmed animals". Regulation 142/2011 (EU, 2011) implementing Regulation 1069/2009 specifies how low-risk category 3 ABPs that have not been prohibited need to be processed before they can be fed to farm animals (for example, heat raw milk to 72ºC for at least 15 seconds).
Permissible ABPs (including products processed as food) intended for feed use are not considered waste and fall under animal health and feed legislation. These products must comply with the feed safety requirements according to Regulation 767/2009 (EC, 2009a) ("Placing on the market and the use of feed") and Regulation 1069/2009. Regulation 1069/2009 also "establishes a general registration duty for operators active at any stage of the generation, transport, handling, processing, storage, placing on the market, distribution, use or disposal of ABPs, including former food with animal products". Food businesses wishing to supply FFs for feed must ensure that these foodstuffs do not contain any prohibited ABPs such as meat or ruminant gelatine and meet strict segregation requirements to avoid cross-contamination with prohibited ABPs. Most of the above restrictions do not apply to pet food.
Regulation 183/2005 (EC, 2005) (laying down requirements for feed hygiene), requires registration as Feed Business Operator with the competent authority for all food and feed businesses that produce, use, retail or market feed or feed ingredients. For example, in the UK and the Netherlands a bakery wishing to supply surplus bread to a former food processor must go through the full registration process, while in Belgium and Italy a bakery does not need registration, as long as they deliver their bread to registered distribution centre. The Commission Guidelines for the feed use of food no longer intended for human consumption, published in April 2018, state that a food retailer registered according to Regulation 852/2004 (EC, 2004) (hygiene of foodstuffs), can place food on the market within the provisions of the food law, and without registering as a feed business operator under Reg 183/2005. A feed business operator can then collect this food, and from this moment the food enters the feed chain. This puts full responsibility for compliance with feed legislation on the feed business operator. Such food from a food business not also registered as a feed business operator cannot be directly delivered to farmers as it should first be processed by a registered feed operator to ensure compliance as feed.

In the current legal system, former foodstuffs, excluding streams containing or derived from impermissible animal by-products, may be destined to feed if appropriate measures are taken, including appropriate quality and safety control. Extending this solution to more wasted food products is possible within the current legal system. EFFPA foresees a further growth by 2 million tons per year in 2025. This growth is small compared to the theoretical potential – 24 million tons according to Table 2.

3.1.1 Administrative and logistical requirements related to current legislation

- As concluded in D6.7, the current requirements (for setting up a watertight system) are considered too burdensome by many food business operators and retailers. The obligations – registration and compliance with near-zero tolerance for contaminants, such as traces of packaging, in feed auditing and certification of Good Manufacturing Practice, labelling, and segregated storage and transportation - are considered too burdensome by many food business operators and retailers to justify sending "former food stuffs" to feed (REFRESH D3.3).
- REFRESH D3.1: In the retail and logistics stage for dairy, it is generally corporate policy to send surplus products to AD rather than animal feed or other channels due to the perception of a limited redistribution sector (unviable channels) and due to the perceived brand risks. "There is a perception among site operators that the legislative framework is complex surrounding diversion of food surplus to animal feed and there is a lack of understanding relating to diversion to animal feed (REFRESH D3.1).
- To our knowledge only a handful of retailers – eg Colruyt, Tesco in the UK, Sainsburys, Spar Austria - invest in the staff training and logistical requirements that ensure the extremely strict segregation standards required during storage and transport to allow for their unsold bread products to be used in animal feed.
  REFRESH has not been able to research whether the introduction of the new guidelines on the use of former food in feed have helped solve some of these administrative and logistical hurdles.

3.1.2 Prohibition of the use of ruminant gelatine

Ruminant gelatine is explicitly excluded for feeding farmed animals (except for fur animals) because it is considered potential pathway for transferring TSE/prions. Scientific findings, however, indicate that this threat is negligible for non-ruminant animals:

- EFSA (2006) deduced that ruminant derived gelatine is considered sufficiently safe for human consumption. They conclude that - even in worst case situation - the relative human exposures due to gelatine sourced from cattle are very low compared to the 1990s.

- Wells et al. (2003) concluded that feeding with BSE contaminated feed did not result in BSE development in pigs.

Other studies did show transmission of TSE, but these studies applied different pathways than through feed. For instance, Hedman et al. (2016) concluded that through intravenous and other direct injection of BSE material, BSE/prion material development in pigs was induced. These pathways, however, are different from the feed route and are highly unlikely to occur naturally in farm environments.

The combination of these findings leads to the conclusion that the threat of TSE/prions transmission to non-ruminants is negligible in the current system.

3.1.3 Application of TSE legislation to non-ruminants

A significant part of the theoretical potential volume of 24 million tons contains animal by-products that are not accepted in animal feed according to current legislation. The EU is unusual in that its TSE legislation extends to all types of farmed livestock, whereas elsewhere in the world, including in New Zealand, the United States, Japan and Australia, TSE legislation and feed controls only cover ruminant livestock.

Regulating for the safe processing of meat-containing side and waste streams in specialist treatment plants would remove a significant obstacle to keeping unavoidable surplus in the food supply chain as non-ruminant feed.

Conclusion: within the current legal system a further increase of 'former food stuffs' valorisation for animal feed is foreseen, but because of the burden and expected costs, as well as limitations with respect to animal by-products, only about 10% of the foreseen potential is used. Adequate reformulation of legislation, offering space for business within boundaries of safety, could largely increase the potential.

3.2 Non-ruminant feed safety

It was concluded in REFRESH D6.7 that from a technical point of view it is possible to produce safe non-ruminant feed from surplus food through heat treatment, potentially complemented with acidification (for example through fermentation or adding lactic acid). When adequately applied to food surpluses that were appropriately (with an eye on safety) managed, such treatment would inactivate pathogens.

Note that the intensities of the treatments are not yet predefined in REFRESH. As D6.7 explains the levels of inactivation largely depend on material properties and the intensity of the applied conditions; which levels would be acceptable is subject of further analysis by the authorities. As in any risk assessment, even for pathogens in food, in general certain risk levels (sufficiently small) are considered acceptable. For example, for most foodborne pathogens, a 6-log reduction (in other words 99.9999% of pathogenic micro-organisms destroyed) is standard practice.

One of the fundamental principles under the current legislation is to prevent intra-species recycling, aimed at preventing Transmissible Spongiform Encephalopathy (TSE). Various studies (amongst others by EFSA in 2007, stating 'no naturally occurring TSE, including BSE, have been detected so far in pigs') and the continued use of porcine material in pigfeed in countries such as Australia, New Zealand, the US and various Asian countries, show that such a ban on intraspecies recycling in pigs is unnecessary. The issue of intraspecies recycling is further discussed in sections 3.4 (safety perspective), 5.1.1 (nutrition perspective) and 8.5.1 (welfare perspective) of REFRESH report D6.7.

3.3 Environmental effectiveness

As concluded in D5.5 and D6.7 per million tons 'former food waste' about 3 million rearing pigs can be fed (average value for the UK and France cases considered). Taking into consideration feed need by sows and piglets, altogether about 1.5 million pigs can be produced per million tons 'former food waste'.

We assume the same valorisation potential as in Japan, 52% of the total available volume of 37 million tonnes wastes plus already utilised streams (Table 1 and D6.7): 19 million tonnes, of which 14 million is not yet used. This 14 million could feed 21 million pigs: about 7.5% of the current pig production in the EU. Van Hal et al. (2019) compared different livestock farming systems in terms of their effectiveness at converting low cost feeds, including food waste and found that low-productive pig systems are best at converting mixed food waste streams. They calculated that a total of 56 million low-productive pigs could be kept in the EU on a diet of food waste combined with a large proportion of available oil-seed by-products. This can accordingly significantly contribute to reducing dependency on imported animal feed ingredients.

3.4 Social acceptance

Acceptance by consumers, pig farmers, meat processing industry and food industry stakeholders was assessed in D6.7. From this inventory, it was concluded that concerns about safety are the main obstacle; adequate implementation safe procedures and substantial cost price advantage will be essential for successful acceptance.

From D6.7 conclusions: Regarding consumer acceptance in Japan, pork from pigs fed on surplus food evolved from "garbage pork" into a luxury product sold at a premium based on its environmental credentials. Japanese consumer research also found that those most knowledgeable about the pig industry are more likely to value pork from pigs fed on surplus. REFRESH research with consumers in Spain and the UK, shows that while information and awareness raising work will be important to build acceptance, there is already an important niche market with consumers whose choices are influenced by broader environmental concerns. This chimes with the findings of the recent report by the European Commission (2018) on the development of plant proteins which notes that:

> *Consumers in the EU have become increasingly conscious about the way animal products are produced. They demand higher standards as regards animal welfare, environmental impact*

> *(climate change/deforestation), type of production (based on organic or non-genetically modified (non-GM) feed, regional supply chains). In response, different premium market segments for feed have emerged in the EU.*

Both the Japanese experience and the UK consumer survey show that the establishment of an independent, credible certification and labelling scheme will be paramount.

As was suggested in REFRESH D3.3, for low-risk products such as bakery goods, part of the solution lies in minimising registration requirements for former foodstuff suppliers to former food processors. Hazard Analysis and Critical Control Points (HACCP) measures to ensure compliance with feed safety legislation could be handled through the contract between the FF supplier and processor, possibly in combination with adequate labelling food products.

4 Environmental and economic barriers analysis

4.1 Environmental barriers

Environmental pressure from utilising the surplus foods is largely related to transport (REFRESH D5.5). Utilisation of the food surpluses for feed will, on the other hand, also reduce transport of imported feed stuffs (which because of their low water content can be transported more efficiently but require much longer supply chains). Current waste management practices also require significant transportation. Through organising the chains at regional scale, transportation can be limited.

4.2 Economic barriers analysis

D6.7 presented a techno-economic analysis for the proposed solution, based on average data (for UK situation). Cost-benefit results are quite promising, but appeared largely dependent on logistics (collection and distribution costs,) and on scale size (economies of scale for equipment and development costs as well as for personnel costs). For situations where food surpluses were uniformly distributed over UK, the costs and benefits were analysed for different spatial configurations. This analysis shows trade-offs between logistic efficiency (small-size processing can collect food surpluses in a small area) and economies of scale (large-scale processing has lower costs).

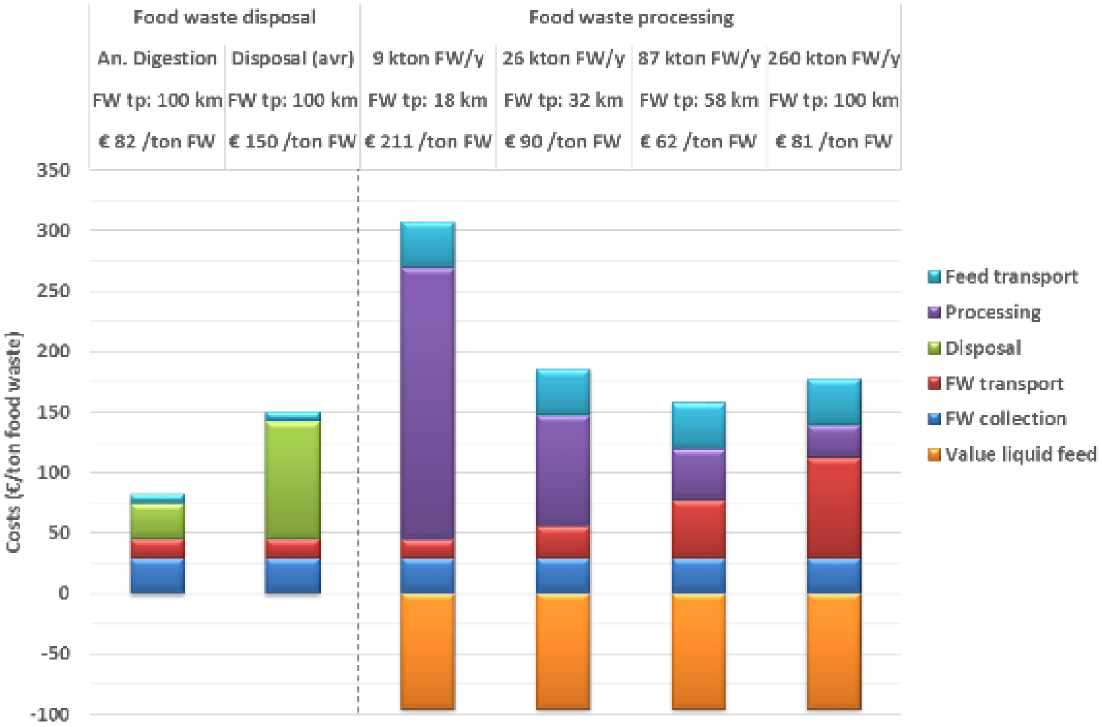

Figure 2. Estimated total costs of food waste disposal (AD and weighted average of current disposal processes) and for food-waste-to-animal-feed-processing scenarios with different scale sizes. Values expressed in Euro per ton food waste. (source: REFRESH D6.7)

Below we analyse the effects of situational conditions (density of available food waste streams in the region and distance to pig farmers) on cost-benefits. We place this in a number of regional configurations (all assuming that 50% of the food surpluses can be contracted; using the same cost model as in D6.7):

1. average UK (scenario name UK-AV)

   (relatively high mutual distances)

2. average NL (scenario name NL-AV)

   (higher population and pig density than in UK)

3. collecting food surpluses from Greater London; selling liquid feed to pig farmers in East of England (scenario name GL-EE)

   (high volumes food surpluses in small area; remote market)

4. collecting food surpluses from Rotterdam (NL); selling liquid feed to pig farmers in North-Brabant (scenario name RO-NB)

   (lower volumes, but also smaller distances than in GL-EE scenario)

5. collecting food surpluses from the "Randstad" (urban agglomeration in the Netherlands bounded by Amsterdam, Utrecht Rotterdam and the Hague); selling liquid feed to pig farmers in North-Brabant (scenario name RS-ENB)

   (higher volumes than in RO-NB scenario, but with significantly larger distances, especially for food surplus collection)

6. collecting food surpluses in North-Limburg; selling liquid feed to pig farmers in North-Limburg (scenario name (NLi-NLi)

   (Relatively small concentration area of pig farmers)

7. collecting food surpluses in the area of North-East-North-Brabant, South-East-North-Brabant, North-Limburg and Middle Limburg; selling liquid feed to pig farmers in that area (scenario name (NBLi-NBLi)

   (Larger concentration area)

Assumptions in all scenarios:

- The amount of food surpluses is assumed proportional to the number of inhabitants.
- Total available food waste in UK: 2.5 million tons.
- For the non-UK cases, the available food waste is derived from the total at EU level: 37 million tons.
- Prevention of waste processing costs (assume 50% composting and 50% anaerobic digestion; average price €62.50 per ton).

Characteristics of these scenarios are summarized in below table.

Table 4. Quantification of characteristics/assumptions per scenario.

	UK-AV	NL-AV	GL-EE	RO-NB	RS-NB	NLi-NLi	NBLi-NBLi
Area (x1000 km^2)	240	41.5	5.52	0.325	8.2	2.20	4.40
Population density (#/km^2)	275	410	5,517	1,846	950	121	441
Contracted food surpluses (kton/year)	1250	615	150	22	282	10	70
Typical collection transport distance (km)	variable	variable	15	10	50	26	37
Typical slurry feed distribution distance	50	50	150	100	130	20	30
Number of pigs (places) that can be fed with the feed (x 1000)	1390	680	170	24	313	11	78
Number of pigs in projected market (x 1000) (excluding young piglets)	4000	10,000	1000	5000	5000	700	3700

Obviously, for each of the scenarios the regional/national market can easily take the amount of feed.

For average UK and NL conditions various cost and benefits, dependent on the scale size of a factory are given in Figure 3 and Figure 4 respectively. From these figures it is clear that processing costs drop with increasing plant scale size. On the other hand, however, collection transport costs go up with increasing scale size.

In the UK situation, with lower population density (and consequentially lower average volume of food surplus per km^2) than in NL, the transport costs are higher than for the NL situation. Consequently economic feasibility is significantly higher in NL than in UK (Figure 5).

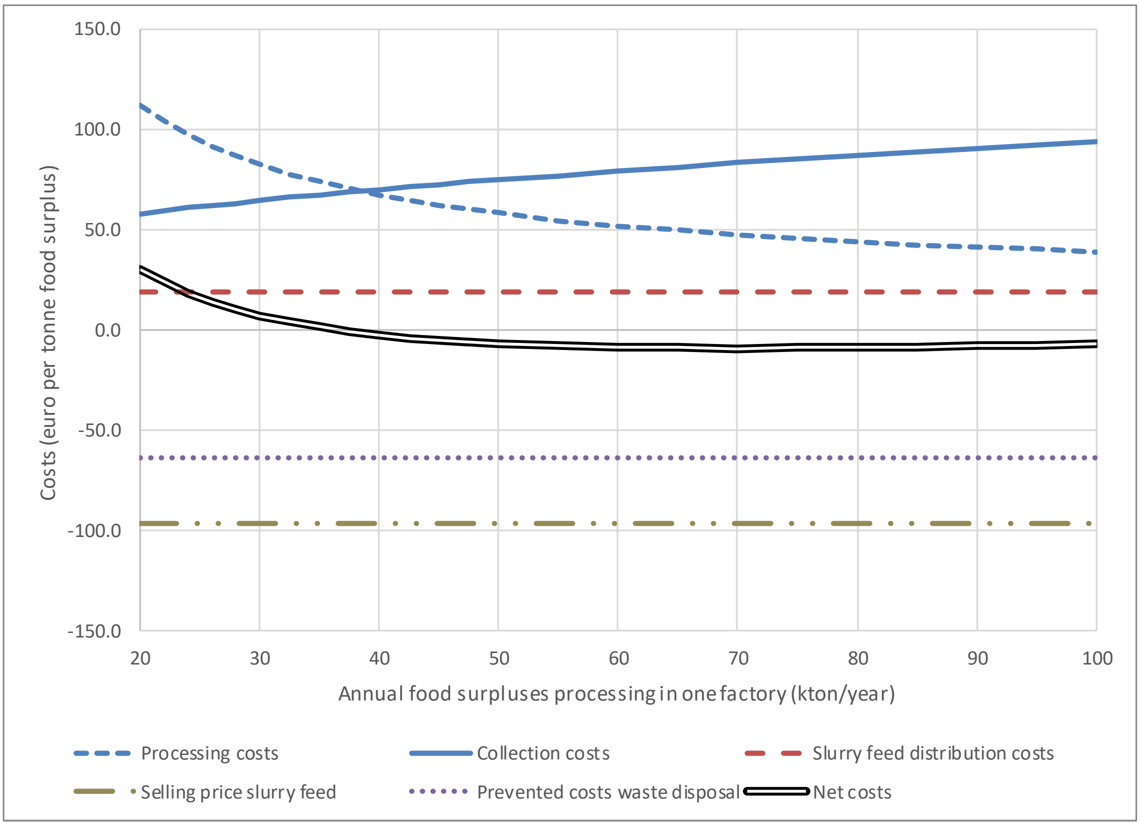

Figure 3. Cost (processing fixed + variable costs, food surplus collection costs, slurry feed distribution costs) and benefits (selling price of the slurry feet, prevented waste disposal costs) and net costs (negative = positive return) as a function of scale size of a food-residues-to-feed factory for average UK conditions.

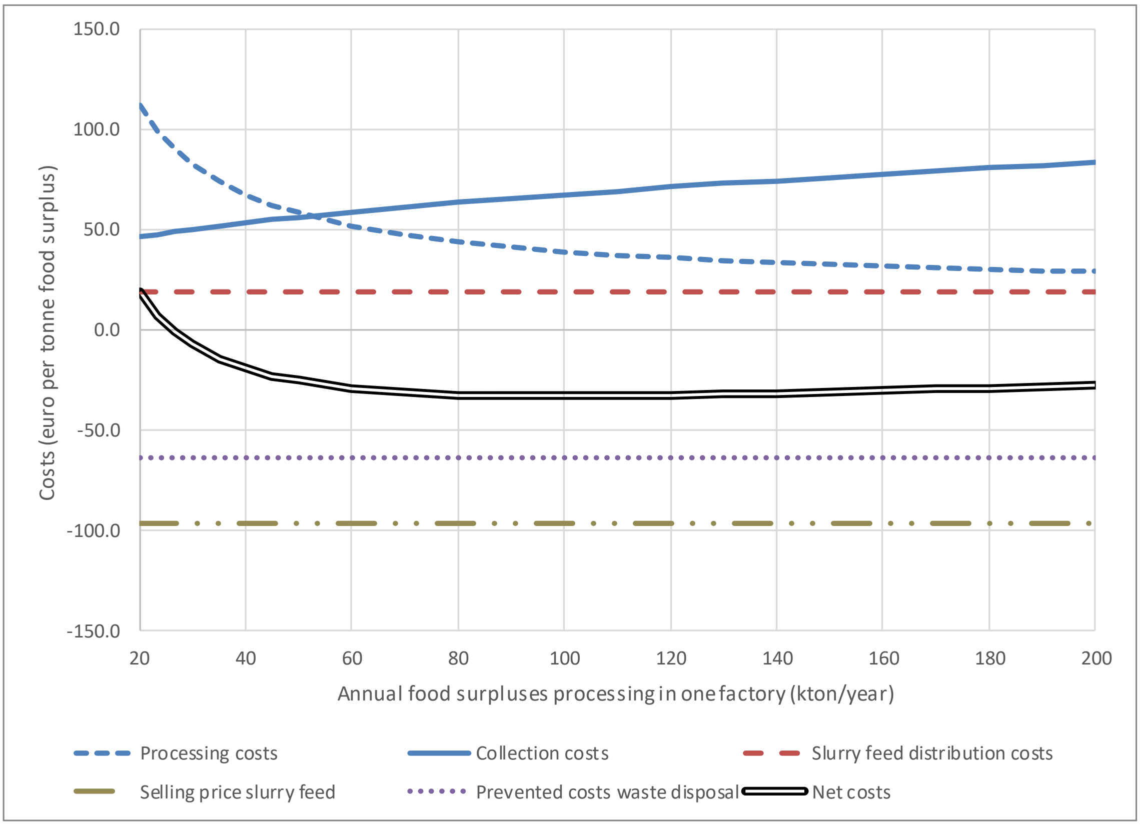

Figure 4. Cost (processing fixed + variable costs, food surplus collection costs, slurry feed distribution costs) and benefits (selling price of the slurry feed, prevented waste disposal costs) and net costs (negative = positive return) as a function of scale size of a food-residues-to-feed factory for average NL conditions.

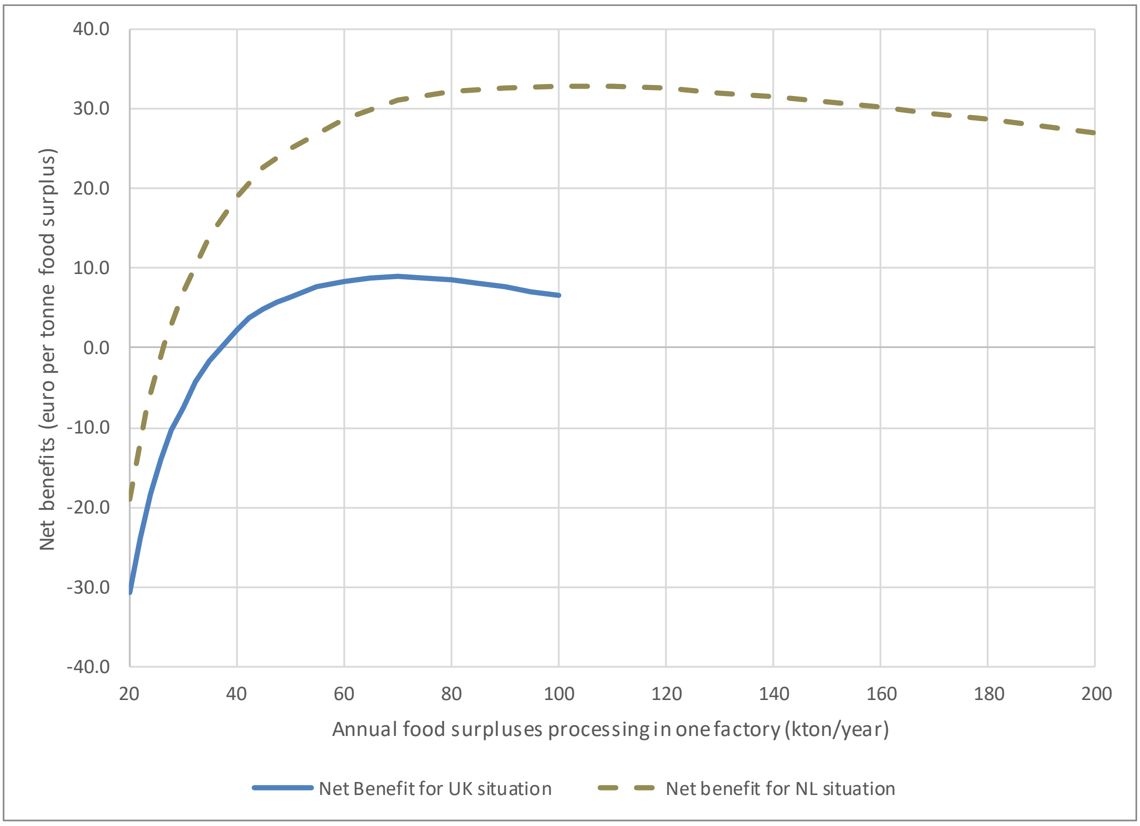

Figure 5. Comparison of net benefits per ton food residue for UK and NL average situation (as function of factory scale size).

The advantage of scale size and vicinity to food surplus areas (sourcing areas) is further clarified in comparison of the different regional scenario's (Table 4). In the results (Figure 6) we see:

- In scenario's with relatively small amount of food residues (scenario NLi-NLi and to a less extent RO-NB) costs of processing are relatively high and prevent a feasible business case.
- In highly urbanized regions with sufficient scale size (GL-EE and RS-NB) processing can be cost-efficient in large-scale facilities, whereas food surplus collection costs are also limited. If a selling market is available at reduced distance, the business case is very attractive.
- The business case is most attractive in regions with relatively high population concentration and local (pig farming) market (scenario NBLi-NBLi).

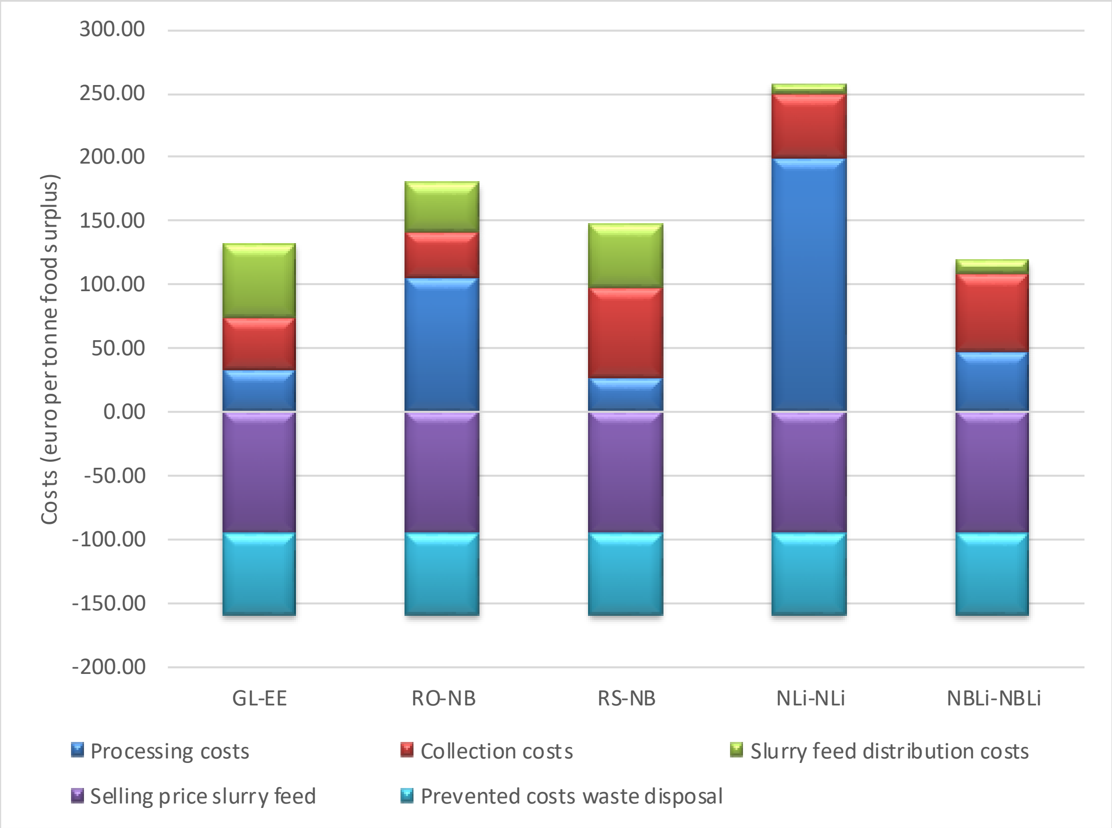

Figure 6. Results of costs-benefit analysis for the region-scenarios.

It is concluded that the food-surpluses-to-feed-slurry option is most attractive in regions that combine high population concentration with substantial demand for pig feed in the region.

5 Conclusions and recommendations

Large volumes of side streams are generated in food industries, food service and retail. Significant part of this is already valorised, largely as animal feed. However, also sizable volumes (estimated at 37 million tons per year in the EU) of these food residues are currently treated as food waste.

Further increasing the valorisation rate is hindered by legislation that intends to prevent unsafe practices related to microbial and viral hazards, toxins, contaminants, such as traces of packaging, and prions and other feed- and foodborne animal diseases.

Current legal restrictions on feeding products that (potentially) contain animal products hinder a large increase of this valorisation route. If the EU wants to achieve the intended major reduction of this food wastage, the (legal) barriers must be liberated somehow. The most significant missed potential relates to the prohibition of animal proteins and ruminant gelatine in non-ruminant feed. Changing legislation for omnivorous non-ruminant animals would harmonise the EU with Australia, Japan, the US and New Zealand.

With regard to the use of low-risk products (those that do not contain prohibited animal proteins) in livestock feed, administrative and practical burdens also prevent valorisation of significant volumes of former food stuffs within the current legal framework.

The above work (in combination with other deliverables from REFRESH, including D3.3. D5.5 and D6.7) shows that, when taking appropriate safety measures along the chain and in processing – and creating separate provisions for non-ruminant livestock, feed can be produced from surplus food streams additional to those currently processed as former foodstuffs, but which fulfil the safety standards intended with current 'feed ban' legislation. It furthermore shows that, when introduced at a large scale, a significant volume of pig feed, much of which is imported, can be replaced, contributing to circularity goals of current EU policy.

Because of the relatively high moisture content of food products, the product is relatively transport-intensive. Cost-benefit analysis has shown that in areas of high population density and substantial presence of the pig sector the intended process can be successful. In rural areas, however, because of long collection transport distances or small-scale processing (with associated high processing costs per ton), the concept can poorly compete with existing feed supply. REFRESH has not researched whether for situations with a large distance between the waste generating human food chain and pig farms, the production of dehydrated feed from food side and waste streams may be viable and environmentally desirable. The production of dehydrated feed is viable in Japan either through direct drying or through oil-frying and removal of oil for use as fuel.

In summary the research shows that from a techno-economic perspective there is ample room for valorising surplus/wasted food products from food industries, food service and retail. Current legislation is the main hindrance for a substantial increase of valorisation. Allowing safe pathways – that still fulfil the intended safety as intended with current legislation – could take away practical hindrances. The research shows that in regions with sufficiently large supply the options are economically competitive to the current (generally less circular) feed supply.

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