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Supplementary information files for "Embodied energy in preventable food manufacturing waste in the United Kingdom"

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Supplementary Information 2: Assessment of Embodied Energy associated with the stage of manufacture at which it arises

The waste prevention measures recommended in WRAP (2016) are the mirror of the main causes of PMW, so point us to the stage of manufacture at which the waste arises.

Waste Prevention Measures	Stage of Arising	Score	% of total	Weight	* factor	New Actual
Dairy Products						
The development of specialised processes such as ultrafiltration (UF) and modern drying processes have increased the opportunity for the recovery of milk solids from whey, which were formerly discharged as waste to sewer or fed to animals.	End	3				
In-process technologies to reduce waste: collection of solid wastes, such as curd particles, using a brush instead of directing them to the drain with a water spray.	End	3				
Further investments in Clean In Place (CIP) technologies which are calibrated to automatically control the process to an optimally efficient level.	End	3				
Reduction of waste caused by line cleaning, such as through the use of pigging systems to remove product residues from the internal surfaces of pipeline prior to cleaning.	End	3				
Ensuring that tanks, pipes and hoses are as empty as possible before cleaning is commenced.	End	3				
Reduction in waste associated with damaged final products: through packaging failure, poor handling and breakages.	End	3				
Score Max		18	10%			
Score Actual		18	13%	13%	0.95	17.15
Diff as % Max		0%				95%

17,508 MWh

Ambient Products						
Use waste monitoring data to plan corrective action and prevent waste: better prioritisation (rather than simply collect and record).	Middle	2				
Complex sites with multiple lines: focus more on waste monitoring (rather than simply hours worked / production rates) and challenge current waste levels.	Middle	2				
Value stream mapping to prioritise waste prevention.	Middle	2				
Review practice of having a ‘waste allowance’ within ‘Bill of Materials’ BOMs (whereby assumptions about quantities lost in production are built into the system).	Middle	2				
In-take/storage of ingredients: improve stock rotation, ‘first-in-first-out’, to reduce losses.	Start	1				
Better ‘line balancing’ to reduce downtime and wastage.	Middle	2				
Procurement review: minimum order quantities (MOQ) for bulk purchases, not used in time.	Start	1				
Score Max		21				
Score Actual		12	9%	17%	1.98	23.78
Diff as % Max		43%				113%
Actual as % max		57%				

24,285 MWh

13,877 MWh

Meat, Poultry & Fish						
Better data management to establish yield losses and pin-point lost value and root causes of down-grades	Middle	2				
Improvements to forecasting accuracy to reduce poor yielding ‘top-up’ production runs needed to fulfil customer orders (higher start-up and shut down losses per unit of production); also in examples linked to seasonal demands (e.g. barbecue cuts and meat products, Christmas in the poultry sector)	Middle	2				

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Better visual inspection of in-take material to reduce ‘off-spec.’ production.	Middle	2				
The need to set up tracking systems to establish yield variability on processing lines	Middle	2				
Process improvements that reduce losses (in value and waste) through more extensive adoption of lean manufacturing principles, more value stream mapping to establish where value is lost in processing/ packing lines and establish links with variability of inputs	Any (middle)	2				
Better grading of intake from abattoirs in relation to intended meat products and customers (e.g. in relation to bacon), reducing QA rejects later in production	End	3				
Investigate potential to revise specifications set by customers that can result in significant ‘down-grades’ e.g. chops needing to be equally sized, standard chicken portions	Middle	2				
Reductions in over-trimming of chicken breast fillets	Middle	2				
Improving measurement and monitoring of losses throughout processing stages, particularly to reduce rejected product due to earlier stages: poor condition of the meat/ failure to comply with specifications	End	3				
Better segregation of material in abattoirs and cutting plant to reduce the extent of edible co-products currently sent to rendering; likely to be a particular problem with smaller and medium-sized abattoirs	End	3				
Score Max		30				
Score Actual		23	17%	16%	0.93	21.43
Diff as % Max		23%				
Actual as % max		77%				

21,879 MWh

16,774 MWh

Fresh Fruit & Veg Processing						
Yield losses through process inefficiencies: excessive peeling, physical damage to the produce (poor conditioning) or premature spoiling.	Middle	2				
Reduction in grading errors where good produce ends up in out-grades.	Start	1				
Reducing the scale of out-graded materials wasted or sent to animal feed through new markets for greater range of produce (e.g. smaller potatoes that are ‘microwaveable’ and sold as a premium product).	Start	1				
Whole supply chain improved sharing of knowledge and demand forecasting to improve crop utilisation and moderate supply and demand.	Start	1				
Earlier discussion of tolerances in product specification, between retail buyers and producers, in seasons when yields are lower than expected or there are other problems with produce meeting quality standards.	Start	1				
Better monitoring of out-grades and losses on different packaging lines.	End	3				
Score Max		18				
Score Actual		9	7%	2%	0.29	2.57
Diff as % Max		50%				
Actual as % max		50%				

2,624 MWh

1,312 MWh

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Pre-Prepared Meals

More effective line balancing in ready-meal and sandwich making: ensuring that batch-sizes for different ingredients match up with product recipe.	Middle	2					
Improved depositor design in sandwich and pizza making: better changeover and fewer residues.	Middle	2					
Dedicated waste capture on individual production lines.	Middle	2					
Skills audit: manual processes on wraps production line.	Middle	2					
MOQ: challenge company procurement policies on grounds of waste caused by bulk ordered ingredients that are not used in time.	Start	1					
Reduction in ingredient losses through improved stock control and ordering systems.	Start	1					
Reduced trimming of salad, tomato, find uses for cucumber cores.	Start	1					
Avoidance of short batch-runs in ready meal production, as wastage from start-up and shut-down times greater as proportion of finished product.	Middle	2					
Address barriers to redistribution: perceived risks to the integrity of branded products	End	3					
Score Max		27					
Score Actual		16	12%	11%	0.97	15.57	
Diff as % Max		41%					
Actual as % max		59%					

15,900 MWh

9,422 MWh

Bakery, Cake & Cereals

Collection of data relating to losses to be given greater priority tracking/ reducing waste and looking at the operational aspects rather than just the commercial aspects.	Middle	2					
Need for closer monitoring of waste levels caused by over-baked/ off-spec production.	End	3					
Closer monitoring of surplus to animal feed and the need for inclusion within waste KPIs.	End	3					
Review of ingredients purchasing policies: bulk purchase of ingredients can cause issues with shelf life especially where minimum order quantities (MOQs) are high.	Start	1					
Address barriers to redistribution: perceived risks to the integrity of branded products	End	3					
Score Max		15					
Score Actual		12	9%	10%	1.17	14.00	
Diff as % Max		20%					
Actual as % max		80%					

14,292 MWh

11,433 MWh

Alcoholic Drinks

More effective calibration of filling heads to reduce over- and under-fill: reduction in filling inefficiencies, regular test calibrations of weight accuracy.	End	3					
Reduction in ingredient and product waste through addressing misalignment on filling lines and product falling off lines.	End	3					
Elimination of damaged cans before filling lines.	End	3					
Reduction in filtration losses in wine making.	Middle	2					
For shorter shelf-life ales, demand prediction and innovations to extend shelf-life.	End	3					

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Potential to find alternate uses for ullage/ beer keg residues/ spoilt beer. (as a waste reduction measure)	End	3				
Score Max		18				
Score Actual		17	13%	6%	0.51	8.63
Diff as % Max		6%				
Actual as % max		94%				
						8,808 MWh
						8,319 MWh
Soft Drinks & Fruit Juices						
More efficient wash-down procedures, less syrup/ ingredient lost to waste water.	End	3				
Minimisation of set-up losses and run-down losses through larger batches.	Middle	2				
Reduction in losses associated with 'push water' used to move product through production process.	Middle	2				
Over-production of soft drinks: improvements to demand prediction, review of promotional offers and surpluses generated.	End	3				
Improvements in juice extraction efficiencies within fruit juice manufacture.	Start	1				
Continuous improvement approach to reduction in rejects, caused by under-fill and over-fill in packaging formats - maintain optimal setting on filling machines.	End	3				
Review line run rates and economics of higher wastage rates relative to value of sales and customer order fulfilment.	Middle	2				
Overcoming barriers to switching from AD to animal feed due to perceived difficulties of compliance with the regulatory requirements	NA					
Score Max		21				
Score Actual		16	12%	1%	0.09	1.41
Diff as % Max		24%				
Actual as % max		76%				
						1,436 MWh
						1,094 MWh
Confectionery						
Improvements to re-work to reduce surplus to animal feed.	End	3				
Provide better buffering capacity to ingredient feeds on line, when shut-downs occur.	Middle	2				
Waste reduction potential from CIP cleaning sludges, evaporation unit.	End	3				
Reduction in floor waste through better belt alignment and more regular monitoring.	Middle	2				
Address barriers to redistribution: perceived risks to the integrity of branded products	End	3				
Score Max		15				
Score Actual		13	10%	10%	1.09	14.12
Diff as % Max		13%				
Actual as % max		87%				
						14,414 MWh
						12,492 MWh
TOTAL						
Score Max		183				
Score Actual		136			118.65	
Diff as % Max		26%				
Applied to total consumption (GWh)		78.8				
Total weighted GWh consumption						92.23
% of total consumption (GWh)		13%				