Distillery by-products, livestock feed and bio-energy use in Scotland

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ABBREVIATIONS

AA	Advisory Advice
AD	Anaerobic Digestion
ADBA	Anaerobic Digestion & Bioresources Association
CHP	Combined Heat & Power (plant)
CP	Crude Protein (of animal feed)
DDGS	Distiller's Dark Grains with Solubles
DM	Dry Matter
FAS	Farm Advisory Service
FW	Fresh Weight
GJ	Giga Joules
GW	Giga Watt (1 thousand million watts)
HL	Hecto-litre (100 litres)
kW	kilo watt (1 thousand watts)
kWhr	kilo watt hour (1 thousand watts for one hour)
kW e	kilo watt electrical energy
kW TH	kilo watt thermal energy
LPA	Litres of Pure Alcohol
MAGB	Maltsters Association of Great Britain
ME	Metabolisable Energy (livestock feed)
MJ	Mega Joule (1 million joules)
MW	Mega Watt (1 million watts)

NNFCC	National Non-Food Crops Centre
PAS	Pot Ale Syrup
REA	Renewable Energy Association
RFV	Relative Feed Value
SAC	Scottish Agricultural College
SRUC	Scotland's Rural College
TH	Thermal
UK	United Kingdom
US	United States

EXECUTIVE SUMMARY

Summary

(i) Distillery by-products are an important feed for the livestock sector in Scotland. In recent years, livestock feed use has fallen due to a fall in whisky production and an increased use in bio-energy, which has in turn been driven by government carbon reduction targets and incentives. A rise in bio-ethanol by-products output in England has partly offset this on a UK wide basis. Distillery by-products had been a surplus product in Scotland and the livestock sector had benefitted from lower feed prices. This has changed due to falling supply and rising demand leading to an increase in the price of distillery by-products. Farmers have adapted by making better use of home grown forage and switching to alternative feeds. Forecasts of rising whisky production are expected to see rising distillery by-product output in the next few years.

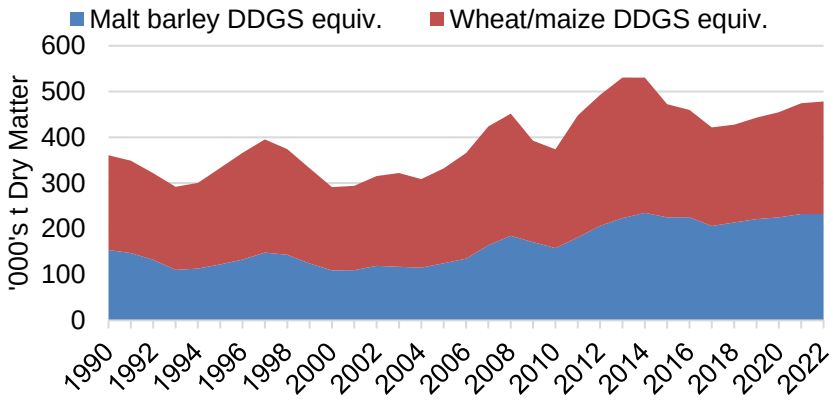
Study objectives

(ii) This report was commissioned by Scottish Government in response to concerns by livestock farmers about the impact of anaerobic digestion and bio-energy on the availability of distillery by-product in Scotland. The study aims to investigate the parameters influencing the supply of these feeds to farmers and their reactions.

Distillery by-product output

(iii) Distillery by-product output mirrors changes in Scotch whisky production. The industry is estimated to have produced a record 531,000t DM of by-product in 2013. Output then fell 20% (109,000t DM) by 2017 to a low of 422,000t DM. Output has since started to rise and is expected to increase 13% (56,000t DM) between 2017 and 2022.

Figure (i). Estimated by-product feed output from Scotch whisly distilling

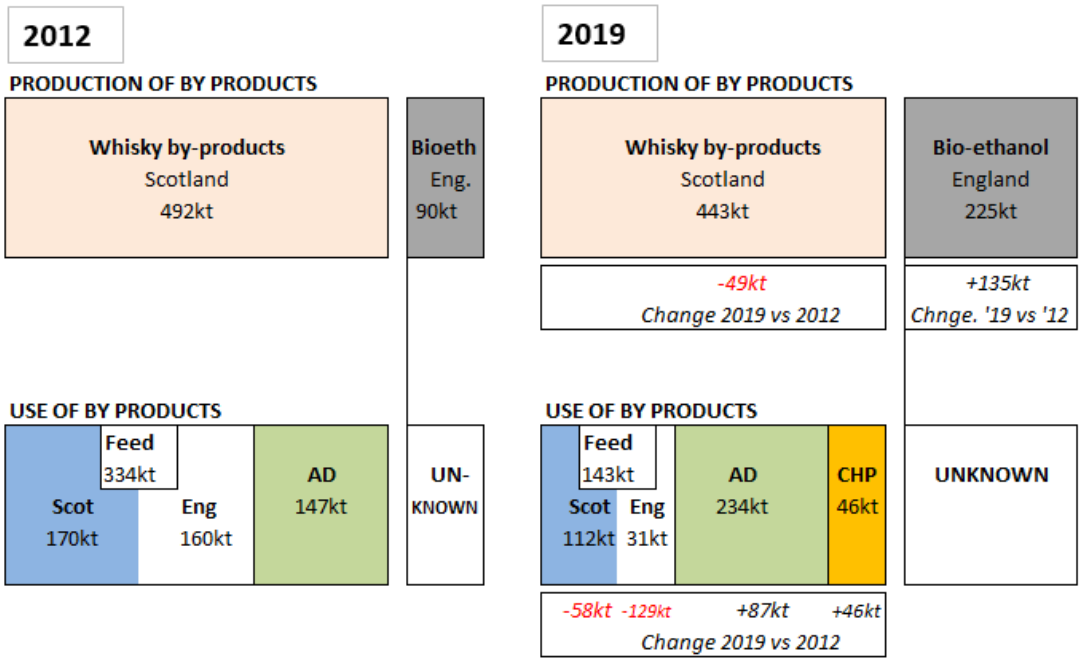


Source: SRUC

Production and use of distillery and brewery by-products in the UK and Scotland

(iv) SRUC working with the feed trade estimate that around 142,800t Dry Matter (DM) of distillery by-products from the whisky industry in Scotland will be used in UK animal feed in 2019. This represents a reduction of 57% on estimated UK feed use of 334,200t DM in 2012. Due to an increasing share of consumption occurring in Scotland, total use of distillery by-products in Scotland is expected to be 111,825t DM in 2019, down 36% from 2012 levels. Bio-energy use of distillery by-products is expected to have risen by 133,000t DM between 2012 and 2019; 87,000t DM in AD and 46,000t DM in CHP. In 2019 the quantity of distillery by-products used in animal feed in Scotland is estimated to represent for cattle (beef and dairy) around 8% of national concentrate feed requirement and 2% of total feed needs on an energy basis. By-products from breweries and maltings provide additional feed sources in Scotland equivalent to around 2% and 5% respectively of the quantity of by-product produced by the Scotch whisky distilling sector.

Figure (ii) Distillery by-product production and use by sector



Source: SRUC

Bio-energy is now the dominant use for distillery by-products in Scotland

(v) Animal feed now comprises an estimated 32% of demand for distillery by-products in Scotland down from 68% in 2012. Bio-energy in contrast is now the dominant use having risen from 30% of distillery by-product use in 2012 to an estimated 63% share in 2019.

English ethanol distillery by-product production had offset declines in Scotland

(vi) Since 2012, UK bio-ethanol production from plants in the north of England had increased sharply leading to a greater overall UK supply of distillery by-products for feeds helping offset declines in Scotch whisky distillery by-product availability for feed. In 2018 a large ethanol plant was closed (presumed permanently) and another announced a period of extended closure from December 2018 due to poor profitability. This is likely to lead to an overall reduction in UK distillery by-product availability compared to the levels seen in the last SRUC study in 2012.

Scottish AD plants use feedstock estimated at 9% of Scottish cattle feed use; split equally between agricultural and distillery run AD plants

(vii) SRUC's model of cattle feed demand and estimates of feedstock usage by agricultural and distillery AD plants and distillery CHP plants indicate that bio-energy now uses feedstock equivalent to around 9% of the total feed requirement of the Scottish cattle herd (beef and dairy). SRUC estimates suggest that both agriculture and distilling sectors now use a similar quantity of feedstock and so both may be having a similar impact on feed availability and markets.

Relative draff prices have risen sharply in the last two years, farmers are making better use of home grown feed

(viii) Price spreads indicate that fresh distillery by-products i.e. draff have become relatively more expensive since 2016 and have moved back to a comparable relative nutritional value. In response to rising feed costs, livestock farmers have taken steps to increase the value of home grown feeds. The most significant impact has been to improve the quality and feeding value of both grazed grass and grass silage.

Feed remains an important end use for distillery products

(ix) Feed remains an important end user for distillery products and farmers have responded to rising prices and lack of availability by placing greater value on the supplies available. The dairy sector is taking a greater share of what is available and through its year round feed requirement is well placed to ensure consistent off-take of moist distillery feeds. In the Highlands and Islands beef producers are becoming more pro-active in securing and storing supplies of draff and offer a valuable market for the expanding malt distilling sector where lack of scale and distance from alternative markets limit options. Equally, local farmers gain a valuable and cost effective feed supply in areas where high transport costs make bought in feed particularly expensive

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CONTENTS

1. Introduction – objectives and approach

1. In response to the growth in Anaerobic Digestion and other forms of bio-energy production in Scotland supported by government targets and issues around rising feed prices following the drought in 2018 the Scottish Government has commissioned SRUC to conduct a study into the quantities of feed stocks being used (such as distillery by-products, energy crops) and the potential impact on the livestock feed situation.

2. UK and Scottish Government carbon reduction targets have led to incentives for renewable energy which in turn have spurred investment in energy efficiency and renewable energy across different sectors of industry. The distilling industry has invested in a range of renewable energy technologies to tackle climate change. The Scottish Government's proposed Climate Change Bill appears likely to increase Scotland's carbon reductions since 1990 greenhouse gas emission reduction ambitions by tightening from the current target for 2050 from 80% target to 90% target by 2050 for reducing greenhouse gas emissions with an aspiration to move towards net zero emissions.

Objectives

(i) Distillery by-products supply and demand balances

Building on the previous SRUC research in 2012, undertake a further piece of work to take stock of the current position and any changes that may have occurred in the supply of feed by-product from distilleries and breweries in Scotland and use by farmers against a backdrop of an increased number of AD plants and distilleries in 2018.

(ii) Distillery by products pricing and livestock feeds

Determine changes in the pricing of distillery feed by-products relative to other feeds and how this may have affected use in the livestock sector and any alternative feeds or crops that livestock farmers may have turned to in response.

(iii) Anaerobic digestion and energy crops

Assess the quantities of feedstock and the area of crops being grown for AD plants in Scotland and the potential scale of impact on feed output.

(iv) Feed market factors

Undertake qualitative research, drawing on feedback from SRUC offices, to determine whether there are any other barriers to farmers and crofters accessing distillery by-product markets e.g. possible reluctance amongst farmers/crofters entering into medium/long-term contracts with merchants; availability of other alternative feedstuffs etc.

2. Distillery by-products output

Introduction to distillery by-products

3. There are two main types of Scotch whisky produced; malt whisky and grain whisky. Malt whisky is produced from malted barley while grain whisky is produced using grain (wheat or maize) and a small quantity (~10%) of malting barley.

4. A range of by-products are produced from the Scotch malt and grain distilling processes as outlined in the following table. These by-products have differing characteristics which determine their suitability for different end uses. The two predominant uses are; livestock feed and bio-energy production. Bio-energy production is principally achieved using Anaerobic Digestion but there are also a small number of Combined Heat and Power plants using draff as a feedstock in the combustion process.

5. Distillery by-product can be wet, liquid or pelletised. Some are utilised in their raw or minimally processed form straight out of the distillery; draff and grain moist feed. Other products undergo further processing. Distiller's Dark Grains with Solubles are formed by combining, drying and pelletising in the case of malt whisky; draff and pot ale syrup and in the case of grain whisky; grain moist feed and spent wash syrup. Both pot ale and spent wash syrup are produced by concentrating the very dilute liquids from the malt and grain distilling processes respectively to form a thick syrup. Details of the typical processes involved in whisky production are detailed in Appendix 1. Bioethanol plants produce similar by-products. Actual processes vary widely from distillery to distillery.

Table 1. Summary of distillery feed by-products and use

Spirit	Product	Type	Dry Matter (typical) (%)
Malt	Draff	Wet	23%
Malt	Pot ale syrup	Liquid	45%
Malt	Malt DDGS	Pellet	90%
Grain	Grain moist feeds	Wet	23%
Grain	Spent wash syrup	Liquid	45%
Grain	Wheat/Maize DDGS	Pellet	90%

Source: SRUC. Note - * Distiller's Dark Grains with Solubles (DDGS)

Appendix 1 outlines the inputs, process flows and product outputs involved in malt and grain Scotch whisky production.

Estimated output of Scotch whisky distillery by-products

6. Estimates of total output of Scotch whisky distillery by-products were calculated for the period 2000 to 2017 based on available industry data. Projections were also made from 2017 to 2022.

7. These estimates were calculated using the following data:
   - Spirit production (in million of Litres of Pure Alcohol (m LPA) and spirit yields (LPA per tonne of malt and grain) (Gray, AS, 2017)[1] and based on the Scotch Whisky Association Databank.
   - Conversion factors in distilling from malt/grain to feed by-product obtained from industry experts Pass et al (2003)[2].
   - Full details of the calculations are given in Appendix 2 and results displayed in Figure 1 overleaf.

Results

8. Based on these methods the production of Scotch whisky distillery by products in Scotland in 2019 is estimated to be 443,000t of Dry Matter (DM) equivalent (Figure 1, Table 2 following). This comprises the total output (on a

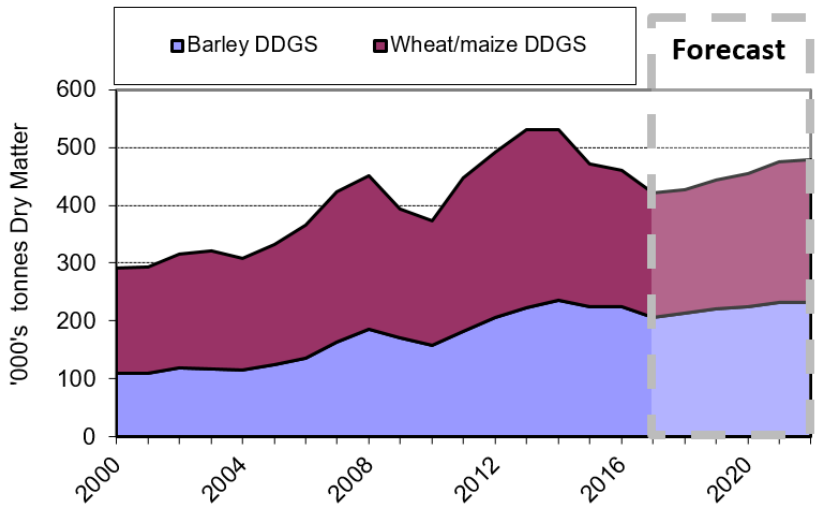
[1] Gray, A.S., (2017) The Scotch Whisky Industry Review 2017, Pagoda Scotland, Edinburgh
[2] Pass, B and Lambart, I, (2003) Whisky: Technology, Production and Marketing, Elsevier

100 % dry matter basis) of distilling by-products for both malt and grain distilling. In practice, as well as dried and pelletised product (at around 10% dry matter) much of this feed is produced in a wet form with dry matter in the 20% to 30% range for draff and substantially lower for other by-product streams such as pot ale. Therefore on a wet basis a much greater overall tonnage is produced.

9. The level of distillery by-product output mirrors changes in Scotch whisky production. The industry is estimated to have produced a record 531,000t DM of by-product in 2013. Output then fell 20% (109,000t DM) by 2017 to a low of 422,000t DM. Output has since started to rise and is expected to increase by 13% (56,000t DM) between the low of 2017 up until the forecasted values in 2022. This suggests that overall availability of distillery by-product will increase but it is not known in which sectors (livestock feed, bio-energy) this increased supply will be utilised.

10. Given the uncertainties outlined above these estimates should only be taken as a starting point for the potential availability of feed by-products from the distilling sector.

Figure 1: Estimated by-product feed output from Scotch whisky distilling



Source: SRUC

Table 2: Estimated by-product feed output from Scotch whisky distilling in Scotland

	'000's t Dry Matter												
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Distillery by-products	374	448	493	531	530	472	460	422	427	443	455	474	478

Source: SRUC

UK production of bio-ethanol by-products

11. The output of bio-ethanol plants in England has been extremely variable, responding to volatile conditions in global grain and ethanol markets. In September 2018 the large Vivergo ethanol plant (1.1mt of grain, 0.35mt of by-product) on the Humber was closed (it is assumed permanently) due to lack of profitability. The estimates above assume continuation of production at the remaining Ensus ethanol plant on Teeside (1.0mt of wheat, 0.30mt of by-product). However, in October 2018 it was announced this plant would close for extended maintenance from December 2018 for an unknown period. In summary, the recent growth of UK bio-ethanol production has helped counter the fall in feed by-product availability from the Scotch whisky distilling sector (see Table 8). This has helped to maintain or increase overall UK supply of distillery by-products. However, the current lack of profitability in the ethanol market is leading to closure and extended maintenance of these bio-ethanol plants curtailing by-product output.

Scottish production of draff alternatives - brewery by-products

12. When considering distillery by-products as feed it is useful to consider the supply of alternative sources of similar feeds. Beer production results in output of a similar by-product to distillery draff with very similar feeding values known as brewer's grains.

13. Beer production in Scotland was estimated at 2,435,000 hecto-litres (HL) in 2013 according to the Scottish Government[3] though this is an approximate value as no official estimates of beer production in Scotland are available. Total UK beer production has declined from 55 million HL in 2000 to 39 million HL in 2016 according to the British Beer and Pub Association. In the absence of production data for Scotland it is not known how beer production in Scotland may have changed in recent years.

14. Based on typical levels of by-product production per unit of beer produced, this is estimated to have resulted in the production of 48,700t of brewer's grains in Scotland in 2013. At 23% dry matter this would equate to 11,201 t of dry matter. This was equivalent to 2% of the 529,000t DM of distillery by-products estimated to have been produced by the Scotch whisky industry in that year (2013). Therefore, while locally significant, the production of feed by-products from the brewing sector in Scotland is a relatively minor component of national feed supply.

Scottish production of malt feed by-products

15. Scotch whisky production is based on the use of malting barley. The malting process generates a range of by-products that can serve as feed for livestock or other sectors including bio-energy. The primary malting by-product is malt culms; the sprouted shoots of barley. Other by-products include malt corns, barley dust and malt dust. These by-products are usually blended with a binder and pelletised to produce a feed product known as malt residual pellets.

16. No official figures are available for the annual quantity of barley malted in Scotland nor the level of malt feed by-product generated. However, Scottish Government produce estimates of the quantity of Scottish barley used for human and industrial uses[4] which in 2017 was estimated to total 949,000 t.

[3] Sector study on Beer, Whisky and Fish, June 2015, circular economy report, Scottish government.
[4] Economic report on Scottish agriculture, 2018, Scottish Government

The Scottish Government do not give a breakdown of actual end uses within this category, but based on industry knowledge, SRUC understand that almost all of this is used for malting apart from a relatively small and undisclosed quantity for milling and pearl barley production.

17. The MAGB estimate[5] that the GB malting industry is capable of producing around 50,000t of feed by-products from a GB malting usage of approximately 2,000,000t of malting barley. Given likely malting barley use in Scotland of over 900,000t in 2017 this is expected to result in approximately 22,500t of malt feed by-products being produced in Scotland. At 90% dry matter this would equate to approximately 20,000 t of dry matter. This would be equivalent to around 5% of the 422,000t DM of distillery by-products estimated to have been produced by the Scotch whisky industry in that year (2017). Therefore, while locally significant, the production of feed by-products from the malting sector in Scotland is a relatively minor component of national feed supply.

[5] MAGB Malting co-products - http://www.ukmalt.com/malting-co-products

3. Use of Scotch whisky distillery by-products in livestock feed

Overview of distillery by-products as livestock feed

18. A range of by-products suitable for livestock feed are produced from the malt and grain distilling processes as outlined in the following table. These by-products have differing characteristics which determine their suitability in the feed rations of different species and classes of livestock. In general, cattle are the most suitable target for these feeds with some limited use in sheep and pigs. Any feeds which have originated in a copper malt still (pot ale syrup, Barley DDGS) cannot be used for sheep feed due to the high levels of copper which sheep are particularly sensitive to.

Table 3. Summary of distillery feed by-products and use

Spirit	Product	Type	Livestock
Malt	Draff	Wet	Cattle, sheep
Malt	Pot ale syrup	Liquid	Cattle, pigs
Malt	Malt DDGS	Pellet	Cattle
Grain	Grain moist feeds	Wet	Cattle
Grain	Spent wash syrup	Liquid	Cattle, sheep
Grain	Wheat/Maize DDGS	Pellet	Cattle, sheep

Source: SRUC. Note - * Distiller's Dark Grains with Solubles (DDGS)

Appendix 1 outlines the inputs, process flows and product outputs involved in malt and grain spirit production.

Appendix 3 details the nutritional value of distillery feedstocks.

19. Unprocessed feeds (draff, moist grain feeds) have a high water content (70-80%) which raises transport costs per unit of dry matter and makes storage more difficult. Draff can be stored by ensiling in clamps alongside silage during the summer months. In practice the quantity of surplus draff which can be preserved in this way is restricted by the availability of clamp space and the

limited duration of the grass silage harvest. Effective storage requires experience and losses can be high if not undertaken with care.

20. Pot ale syrup is a liquid by-product, it is a palatable medium to dark brown, viscous syrup that resembles molasses in appearance. The dry matter content is variable depending on the producer. A range of 30-50% dry matter is common. This can make it difficult for handling and storage.

21. Dried and pelletised feeds (barley, wheat and maize dark grains) have a low moisture content (<10%) and can be readily stored and transported economically.

22. Demand for draff from farms in the vicinity of each distillery can at times be insufficient particularly in the summer when grass growth is strongest and the need for feed purchases is reduced. At these times draff might be hauled by road from the North of Scotland to the Central Belt and into the North of England to find demand. This raises the cost of draff to the farmer in these more distant regions. Conversely in winter, local feed demand for draff increases and the draff may be utilised by farms closer to the distillery. It is estimated that around (78%) of distillery by-products used in feed are consumed in Scotland and (22%) (Table 7b) are exported mainly to the north of England.

Estimated quantities of Scotch whisky distillery by-products used in livestock feed

23. Given estimates of the total potential output of distillery by-products (Figure 1, Table 2), further work is then required to determine the quantity that was actually used for animal feed. Given the lack of official statistics in this area SRUC prepared estimates based on discussions with the livestock feed supply trade. These indicate that total usage of Scotch whisky distillery by-products used for animal feed in the UK in 2019 is likely to be around 142,800t of dry matter equivalent or 405,000t on a fresh weight basis. These figures encompass a wide range of feed types and moisture contents as detailed in Table 4.

Table 4. Estimated quantities of Scotch whisky distillery by-products used in UK animal feed in 2019

	Fresh weight	Dry matter	Dry matter equivalent
	(t)	(%)	(t)
Draff	270,000	22%	59,400
Pot Ale Syrup	35,000	42%	14,700
Malt DDGS	-	90%	-
	305,000		**74,100**
Grain moist feeds	20,000	30%	6,000
Spent wash syrup	15,000	28%	4,200
Grain DDGS	65,000	90%	58,500
	100,000		**68,700**
TOTAL	**405,000**		**142,800**

Source: SRUC and trade sources.

24. Trade estimates (feed compounders and brokers) of actual usage in feed are lower than estimates of total distillery by-product output prepared by SRUC (based on spirit production and grain use – Figure 1, Table 2, Appendix 2).

25. For malt whisky, trade estimates indicate that 74,100t DM of by products will be used for animal feed in 2019 compared to SRUC estimated total malt whisky by-product output of 221,370 t DM. This equates to 33% utilisation in feed. For grain whisky (produced from wheat and maize) trade estimates indicate usage in feed of 68,700t DM compared to SRUC estimated total grain whisky by-product output of 221,640t DM. This equates to 31% utilisation in feed. The average across all distillery by-products is 32% utilisation in feeds.

26. The difference between the potential output of distillery by-products and the actual use in feed is due to a range of factors:

- Collection of draff by farmers straight from distilleries (small scale only)
- Non-feed uses (such as bio-energy)
- Spreading to land as a soil improver and disposal to sea

27. A comparison of historic trade estimates of the quantities of Scotch whisky distillery by-products used for animal feed (Table 5) in the UK indicates there is expected to have been a 57% reduction in feed use over the seven year period from 2012 to 2019.

Table 5. UK feed use of Scotch whisky distillery by-products 2012 to 2019

		Dry Matter Equivalent		
	2012 (t DM)	2019 (t DM)	Change (t DM)	Change (%)
MALT DISTILLING				
Draff	75,000	59,400	- 15,600	-21%
Pot Ale Syrup	25,200	14,700	- 10,500	-42%
Malt DDGS	67,500	-	- 67,500	-100%
Sub total	167,700	74,100	- 93,600	-56%
GRAIN DISTILLING				
Grain moist feeds	45,000	6,000	- 39,000	-87%
Spent wash syrup	22,500	4,200	- 18,300	-81%
Grain DDGS	99,000	58,500	- 40,500	-41%
Sub total	166,500	68,700	- 97,800	-59%
All whisky by-products	**334,200**	**142,800**	**-191,400**	**-57%**

Source: SRUC and trade sources.

28. The largest falls in by-product use in feed have been in grain distilling by-products. There are a number of explanations for this:

- Between 2012 and 2019 it is expected that grain whisky output will have fallen 22% while malt whisky output will have risen by 8% - as a result total grain distillery by-product availability has fallen, irrespective of its use[6].
- In addition there has been a greater uptake of bio-energy production at grain whisky distilleries aided by their larger scale. There are only seven Scotch grain whisky distilleries in Scotland and at an average

[6] Changes in whisky output – see Appendix 3 - In 2012 Scotch grain whisky production was 337 million LPA and is expected to be 275 million LPA by 2019 a fall of 62 million LPA or -18%. In 2012 Scotch malt whisky production was 272.8 million LPA and is expected to be 295 million LPA by 2019 a rise of 22.2 million LPA or +8%.

capacity of 59 million Litres of Pure Alcohol (LPA) they are significantly larger than the average malt distillery of 3 million LPA capacity[7]. This increased scale makes investment in bio-energy production more feasible at grain distilleries as they can access a greater quantity of by-product at the one site.

29. The changes in malt distilling include the cessation of all malt Distiller's Dark Grains with Solubles (DDGS) production following the closure of the last remaining malt dark grains plant in early 2018.

30. The feed usage figures given in Table 5 are for the whole of the UK as some Scotch whisky distillery by-product is sold elsewhere in the UK. To allow consideration of how these changes have affected feed use in Scotland directly, a further breakdown has been made to show how feed use of whisky distillery by-products has changed in Scotland alone, Table 6. With greater retention of what is available for feed, the impact on Scottish feed availability has been less than the overall UK impact. Further details of the change in use by country are given in the following section.

[7] Alan S Gray, (2018) 2017 Scotch whisky industry review, Pagoda Scotland.

Table 6. Scottish feed use of Scotch whisky distillery by-products 2012 to 2019* [8]

	2012	2019		
	Use in Scotland (t DM)	Use in Scotland (t DM)	Change (t DM)	Change (%)
MALT DISTILLING				
Draff	45,000	44,550	-450	-1%
Pot Ale Syrup	10,080	7,350	-2,730	-27%
Malt DDGS	33,750	-	-33,750	
Sub total	88,830	51,900	-36,930	-42%
GRAIN DISTILLING				
Grain moist feeds	27,000	6,000	-21,000	-78%
Spent wash syrup	9,000	4,200	-4,800	-53%
Grain DDGS	49,500	49,725	225	0%
	85,500	59,925	-25,575	-30%
	0	0		
All whisky by-products	**174,330**	**111,825**	**-62,505**	**-36%**

Source: SRUC and trade sources.

Rising proportion of distillery by-products used for feed in Scotland

31. Since 2012 there have been changes in destination country for Scotch whisky distillery feed by-products. The overall split currently expected for 2019 is that 78% of Scotch distillery by-products will be used in Scotland up from 52% in 2012. Greater retention of Scotch whisky distillery by-product feeds within Scotland and reduced exports to England has meant that local by-product availability for feed within Scotland has not declined as much (-36%) as the fall in overall Scotch whisky distillery by-product output (-57%) would suggest (Tables 7a & 7b). These figures do not include bio-ethanol by-products.

[8] NB - * no estimates are available for use of English bioethanol by-products in Scotland.

Table 7a. Changes in Scottish use of Scotch whisky distillery by-products 2012 to 2019 (tonnes)

	2012		2019	
	Sales in Scotland	**Sales in England**	**Sales in Scotland**	**Sales in England**
By-product	(t DM)	(t DM)	(t DM)	(t DM)
Malt distilling	88,830	78,870	51,900	22,200
Grain distilling	85,500	81,000	59,925	8,775
All whisky by-products	**174,330**	**159,870**	**111,825**	**30,975**
Change '12 - '19 (t DM)			**- 62,505**	**-128,895**
Change '12 - '19 (%)			**-36%**	**-81%**

Source: SRUC and trade sources.

Table 7b. Changes in Scottish use of Scotch whisky distillery by-products 2012 to 2019 (%)

	2012		2019	
	Sales in Scotland	**Sales in England**	**Sales in Scotland**	**Sales in England**
By-product	(%)	(%)	(%)	(%)
Malt distilling	53%	47%	70%	30%
Grain distilling	51%	49%	87%	13%
All whisky by-products	**52%**	**48%**	**78%**	**22%**

Source: SRUC and trade sources.

Bio-ethanol feed by-product output in England

32. When consideration of distillery by-products from bio-ethanol plants in the north of England is included, current estimates indicate a 150% increase in supply between 2012 and 2019. This increase helps partly offset the fall in Scotch whisky by-product use in animal feed and when taken together these changes suggest a 13% fall in total UK availability of distillery by-products between 2012 and 2019 (Table 8).

Table 8. Changes in UK wide use of UK distillery by-products 2012 to 2019 (tonnes)

Origin			Dry Matter Equivalent			
			2012 (t DM)	2019 (t DM)	Change (t DM)	Change (%)
Scotland	Scotch whisky	Scotch whisky by-products	334,200	142,800	- 191,400	-57%
England	Grain bio-ethanol	England grain bio-ethanol	90,000	225,000	135,000	150%
UK		**Total**	**424,200**	**367,800**	**- 56,400**	**-13%**

Source: SRUC and trade sources.

Estimated feed requirement of the Scottish cattle sector

33. In 2017 the livestock sector in Scotland generated output of £1,835m[9] representing 57% of the total output of Scottish agriculture. The Gross Value Added of the individual sectors within Scottish agriculture is not known, as a breakdown is not prepared by Scottish Government. Cattle (beef and dairy) are the most important livestock class within Scottish agriculture and accounted for 40% of total agricultural output and 70% of livestock output in 2017.

34. The beef and dairy sectors in Scotland combined are the livestock sectors most reliant on the types of feed stock typically being used in agricultural and distillery AD plants; e.g. distillery by-products, energy forage crops and other crop by-products. Therefore, it is valid to compare the feed requirement of the Scottish cattle herd with the feedstock requirements of the agricultural and distillery by-product fed AD sector as they are broadly competing for the same feed materials.

[9] Scottish Government, Economic Report on Scottish Agriculture 2018

35. SRUC has developed a model to estimate the feed requirement of the Scottish livestock sector[10]. The model is based on livestock numbers adapted from the Scottish Government's June 2018 Agricultural Census and SRUC estimates of feed consumption by animal age and type. These feed estimates are derived from models of energy requirement by livestock class and SRUC estimates of typical feed rations across Scottish farm types. From this model SRUC estimate that in 2018 Scottish beef and dairy cattle are expected to consume around 1.38m t Dry Matter (DM) of concentrate feed, 1.80m t DM of preserved forage and 2.80mt DM of grazed grass (Table 9). These estimates are indicative only.

Table 9. Estimated feed requirement of the Scottish cattle herd 2018

	Dairy	**Beef**		**All cattle**	
Concentrates		(t fresh weight)	(t fresh weight)	% DM	(t DM)
Total	**471,000**	**1,095,000**	**1,566,000**	**88%**	**1,378,000**
Forage					
Silage	2,055,000	4,218,000	6,274,000	23%	1,443,000
Hay		90,000	90,000	87%	78,000
Straw		323,000	323,000	87%	281,000
Grazing	1,870,000	10,301,000	12,172,000	23%	2,799,000
Total	**3,926,000**	**14,932,000**	**18,858,000**		**4,601,00**
Total feed					**5,980,000**

Source: SRUC, note totals may not add due to rounding

36. When comparing total annual cattle feed demand in Scotland of 5.98 million t DM, then the estimated supply of distillery products in Scotland for feed of 142,800t DM in 2019 represents around 2.4% of estimated total feed requirement and 10% of concentrate feed requirement. However, given the high protein content of distillery feeds, the importance to the livestock sector of this feed source is greater since it represents a valuable protein supplement to lower protein forages and grains.

[10] Heyhoe, P, Bell, J, Morgan, C, Livestock feed use in Scotland, AA211 Special Economic Study for Scottish Government, 2015

4. Feedstock use in the Scottish AD and bio-energy sectors

37. AD plants in the agricultural and distilling sectors utilise a range of feedstocks which vary depending on technology, availability and pricing. The table below lists the most common feedstock types by sector. There are no official data sets detailing actual usage of different feed stocks in AD plants in Scotland. Therefore, it is not possible to categorically define the quantities of distillery by-products used by AD plants. The approach taken has instead been to estimate the quantity of feedstock needed to operate the plants by sector (agricultural, distillery) as a proxy for actual usage. An explanation of these calculations is given in Appendix 4.

Table 10. AD plant feedstock types

Sector	Feedstock
Agricultural	Energy crops - grass silage, rye and cereal whole crop, energy beet
	Out-graded potatoes and vegetables
	Distillery by-products
	Slurries and manures, poultry manure
Distillery	Distillery by-products

Source: SRUC, AD Portal

38. Based on estimated bio-energy plant capacity (AD and CHP combustion), SRUC has estimated their likely feedstock requirement (in tonnes of dry matter equivalent). Using this approach it is estimated that between them the agricultural and distillery bio-energy sectors utilise an estimated 533,000 t DM of feedstock in dry matter terms, of which 268,000t DM is used in the agricultural AD sector and 278,000t DM is used by AD and CHP plants in the distillery sector (Table 11. overleaf).

Table 11. Feedstock requirement of Scottish agricultural and distillery AD and bio-energy plants

Sector and energy technology	Feedstock requirement at capacity (t DM)
Agricultural AD – grass silage equiv.	**268,492**
Distillery	
Distillery AD – draff equiv.	232,847
Distillery CHP – draff equiv.	46,125
Distillery total	**278,972**
Total	**547,464**

Source: SRUC

Bio-energy feedstock use compared to cattle feed requirements

39. The 547,000t DM of feedstocks estimated to be used in AD and CHP plants in Scotland are equivalent to 8.9% of the 5.98 million t estimated feed requirement of the Scottish cattle sector. Broadly speaking both the agricultural and distilling sectors are estimated to contribute approximately half each to this feedstock demand.

40. It must be stressed that it is difficult to make direct comparisons between the feed requirements of such different processes. While the agricultural and distillery energy plants utilise feedstocks that are suitable for feeding cattle, they also utilise other products that are not suitable nor economically feasible to feed cattle. These include dilute distillery washings, livestock manures and slurries and other wastes. Therefore, it is likely that the 8.9% figure is a modest overestimate since a small proportion by energy value of the feedstock used by AD plants would not be utilisable as cattle feed (washings etc). It is beyond the scope of the study to fully quantify this or to make an estimate of the breakdown of feedstocks used for each AD sector.

5. Supply and demand of distillery by-products

Introduction

41. In previous sections of the report estimates of distillery by-product production and use in livestock feed and bio-energy have been prepared. This section now brings these figures together to generate estimates of overall distillery by-product supply and demand.

42. Distillery by-products have traditionally been used as livestock feed. In recent years there have been concerns about the availability of co-products to Scottish farmers, due to increase in prices, export to England and use of co-products for renewables generation by distilleries. This concern has been heightened by shortfalls in traditional feed production due to adverse weather; notably the drought of 2018. In order to determine the availability supply and demand of distillery by-product the following data has been used as follows:

(i) The level of distillery by-product produced:

See details in Section 2 and Appendix 2.

(ii) The amount of distilling by-product used in livestock feed:

See details in Section 3.

(iii) The amount of distilling by-product used in bio-energy production[11]:

See Section 4.

(iv) The amount of by-product disposed as waste:

No information available, this figure has been determined as the residual of other uses.

[11] Assumed to be operating at capacity for 8,500 out of 8,760 hours per year

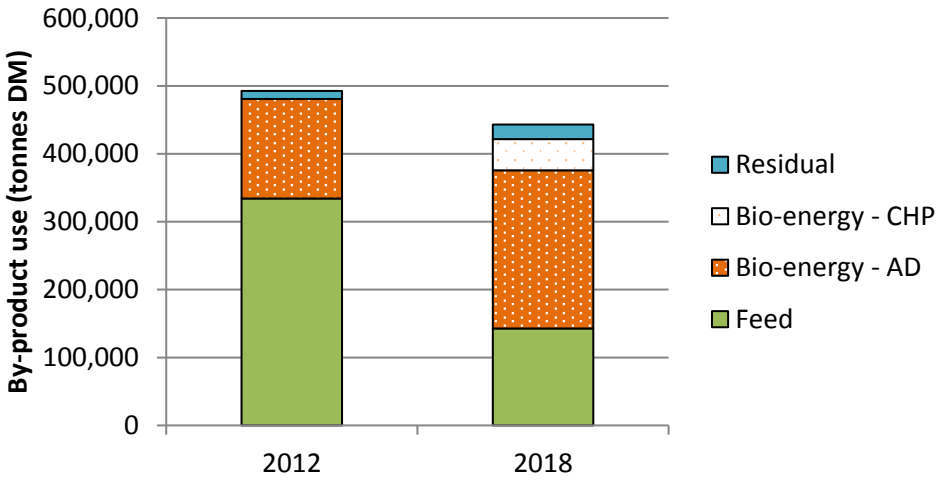
(v) Local use of distillery by-products in animal feeds:

No information available.

Distillery by-product use by sector

43. SRUC have combined available data sources to produce estimates of the balance in distillery by-product use between different sectors as detailed in Figure 2. These estimates are indicative only, however, they illustrate that there has been a large shift in end use for distillery by-products. In 2012, animal feed was the dominant use at 68% of utilisation and bio energy was estimated at 30%. Move forward seven years to 2019 and it is estimated that animal feed will constitute 32% and bio-energy a total of 63% of distillery by-product use.

Figure 2. Estimated use of Scotch whisky distillery by-product by sector across the UK*



Source: SRUC, * UK usage but mainly used in Scotland except some feed exports to England detailed in Table 7a.

Table 12 - Estimated use of Scotch whisky distillery by-product by sector across the UK*

Year	Feed	Bio-energy - AD	Bio-energy - CHP	Residual (tonnes DM)
2012	334,200	146,694	0	11,751
2018	142,800	232,847	46,125	21,236
				%
2012	68%	30%	0%	2%
2018	32%	53%	10%	5%

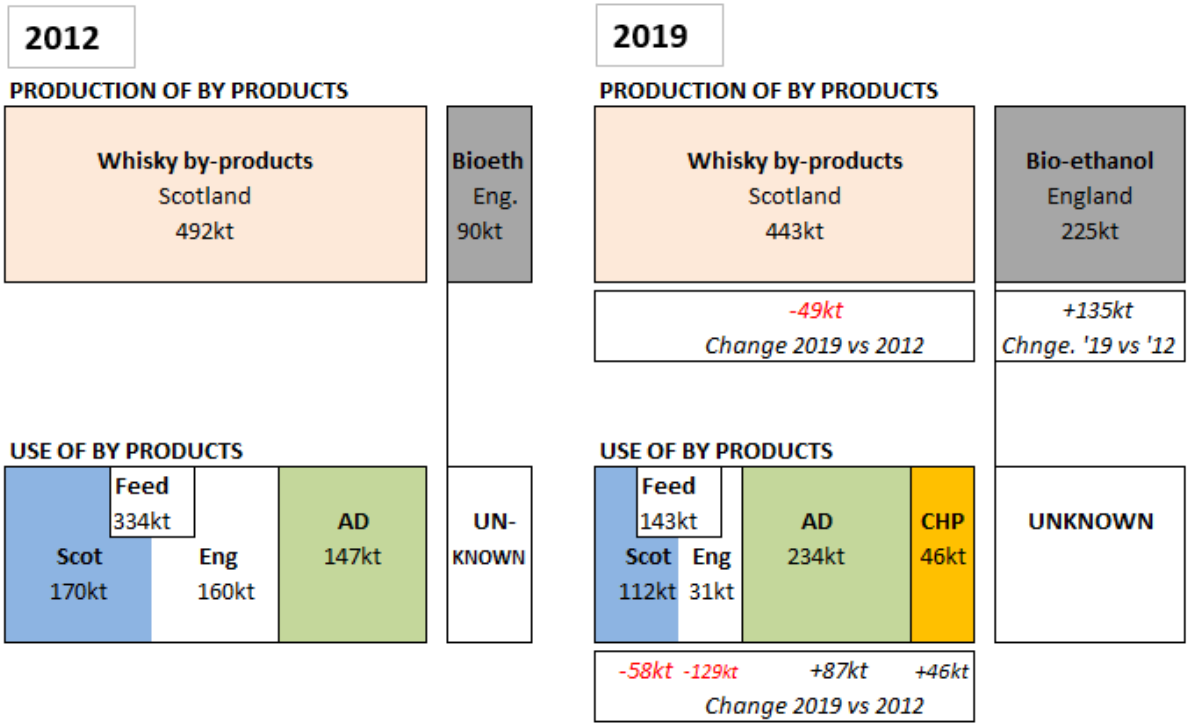
Source: SRUC, * UK usage but mainly used in Scotland except some feed exports to England detailed in Table 7a.

Summary of distillery by-product supply and demand

44. SRUC have combined all of its estimates of distillery by-product output (whisky) and use (livestock feed and bio-energy) in Figure 3 comparing estimates from the previous study in 2012 with those estimated for 2019. These figures also includes estimates of bio-ethanol by-product output from plants in England but not use of this by-product as no figures are available.

45. Figure 3 reveals that since the previous estimate in 2012, the supply of whisky by-products in Scotland is estimated to have fallen by 49,000t DM while the supply of bio-ethanol by-products in England to have risen by 135,000t. At the same time use of Scotch whisky by-products in animal feed in the UK is estimated to have fallen by 187,000t DM of which; 58,000t DM less in Scotland and 129,000t DM less in England. At the same time use of Scotch whisky distillery by-products in bio-energy is estimated to have risen by 133,000t DM of which; 87,000t DM more in AD and 46,000t DM more in CHP.

Figure 3. Production and use of distillery by-products in the UK and Scotland



Source: SRUC and trade sources

6. Distillery by-product price, availability and livestock feed trends in Scotland

Feed value of distillery by-products

46. Given nutritional information on distillery by-products (as detailed in Appendix 3) it is possible to determine the financial value of different feeds relative to one another. For ruminants the dominant feeds used by SRUC to set the base line are barley as an energy source and rapeseed meal as a protein source. Table 13 contains relative feed values for distillery by-products which are also compared to market prices for the different feeds in October 2018.

Table 13. Relative nutritional and financial values for distillery by-products versus other feeds for use in cattle feeding

Feed	Relative Feed Value (£/t)	Average market values* for feeds (£/t),	Difference with RFV (£/t)	Difference with RFV (%)
Brewers grains or draff (23% DM)	47	45	- 2.00	-4.3
Wheat Distiller's Dark Grains	269	270	1.00	0.4
Pot Ale Syrup (PAS)	144	77	-67	-46.53
Base (i) – barley	189	189	0	0
Base (ii) - rape-meal	259	259	0	0

Notes	**Source**
Relative Feed Value (RFV)	SAC Consulting Feed Byte October 2018
Average Market values for Feeds	Scotland delivered values October 2018

Explanation – a ruminant feed ration could be prepared using barley and rape-meal. Alternatively the nutritional requirements of the animal could be met with other feeds. The Relative Feed Value is an indication of the maximum equivalent monetary value that the producer should be prepared to pay for these alternative feeds to deliver feed of a comparable nutritional status and costs to using barley and rape-meal

47. Table 13 illustrates that at recent market values the competitiveness of distillery by-products relative to other comparable feeds varies as follows; draff is 4% cheaper, Pot Ale Syrup (PAS) is 47% cheaper, while wheat distiller's dark grains is 0.4% more expensive. Price spreads indicate that distiller's dark grains are currently close to competitive with alternative feeds of equivalent nutritional value. However, there is low availability for both draff and PAS, the majority of draff is on contract. It is worth noting that in some remote areas on the islands with a distillery, draff is being sold at £21/t, however, this is only in localised areas. Based on the Relative Feed Value (RFV) in Table 13 draff in these areas is 55% cheaper than its Relative Feed Values suggests. In addition, feed costs are higher in remote areas and the islands and if these values were used in the relative feed calculations this would make draff even better value.

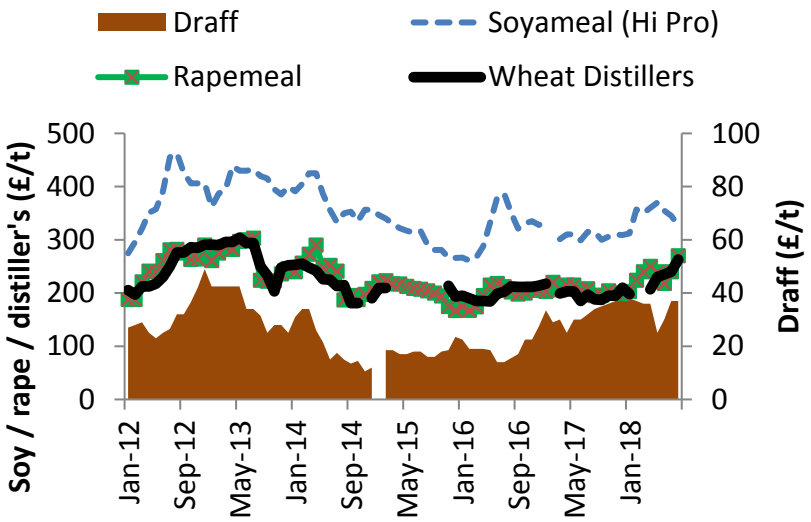
48. The apparently low value of pot-ale reflects the difficulties end users face in transporting, handling and storage due to its high water content. Livestock producers often need purpose designed feeders and handling systems to manage it effectively and not all producers are prepared to use it.

Historic price trends

49. The price of distillery by-products varies significantly across the season in response to local supply and demand issues (see Figure 4. overleaf). The most pronounced price swings are seen in draff due to the high cost of transport, difficulties in storage and the seasonal nature of production and demand. In the vicinity of distilleries in the more remote locations in the Highlands and Islands the price of draff can range between £20 and £40 per tonne delivered farm within a season. In the main agricultural regions in the east, south and south west draff prices are more stable typically in the £30 to £40/t delivered farm range in recent year and respond more to relative pricing of alternative feeds. Feed demand is higher in the winter and early spring and then declines as grass growth resumes in late spring. This can lead to an oversupply of distillery by-products in early summer and lower prices.

50. Dried by-product prices are more stable reflecting their ease of storage and greater portability enabling supply to a wider area. Price swings are mainly influenced by the global price of competing feeds and grain crops on the European and global markets particularly soya-meal and rape-meal.

Figure 4. Monthly feed prices, delivered Scotland



Source: SRUC and trade sources.

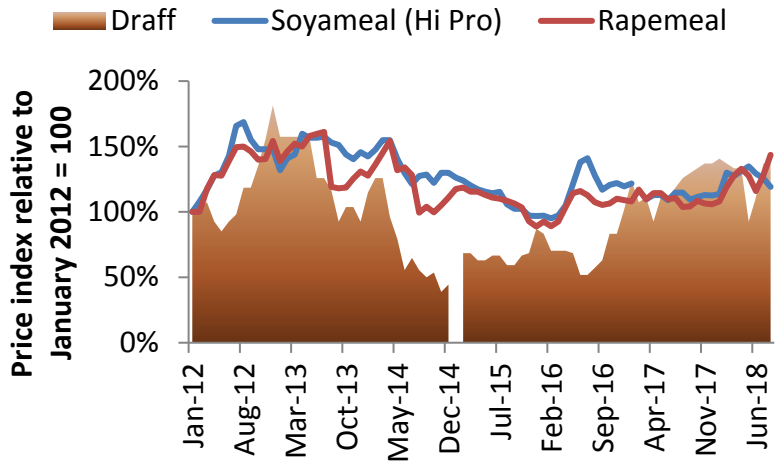
Table 14. Feed and distillery by-product price ranges 2012-2018

Price range	£ per tonne delivered			
	Soyameal (Hi Pro)	Rapemeal	Wheat Distiller's	Draff
Mean	349.29	226.54	226.78	26.99
Median	345.75	218.00	212.75	27.00
High	463.00	303.00	304.00	49.00
Low	261.00	167.00	181.00	10.50

Source: SRUC and trade sources.

51. To consider how the relative price of distillery by-products has changed since 2012, SRUC has compared historic prices with a base period of January 2012 in Figure 5 below. What is clear is that draff prices weakened significantly more than other protein feeds in the period between 2014 and 2016 suggesting oversupply. Since then draff prices have recovered to their earlier higher levels suggesting greater competition for their use. These prices reflect the increasing difficulty livestock farmers have faced in securing the same quantities of draff that they have traditionally done. These prices also support the estimates of decreased draff availability detailed in Sections 2 and 3. From a period of relative oversupply in the period 2014-2016, it appears that supplies of draff are now more restricted and prices have risen as a result.

Figure 5 – Changes in the price of individual feeds relative to their value in 2012 (2012=100)



Source: SRUC and trade sources.

Distillery by-products feed usage patterns in Scotland

52. The experience of SRUC consultants is that many beef and dairy farms in Scotland will utilise distillery by-products whenever they are priced competitively. The decline in availability in recent years has tended to increase the price of distillery by-products relative to alternatives and has encouraged changes in feeding practices. Distillery by-products are a significant source of energy but are a more important protein source due to their typically high protein content. The pattern of use varies widely by farm type and geographical area:

Draff and grain moist feeds – are widely used in the feeding of suckler cows and store cattle are often mixed with silage and stored in clamps for winter feeding. Use of draff has declined on many beef units due to reduction in availability and higher prices. As by-product prices have risen it is reported that dairy farms have taken an increasing share of what is available due to their higher ability (or willingness) to pay closer to their relative energy and protein value for feed. Dairy farms including those in the South West use draff and grain moist feeds on a regular basis. Usage of draff is more common in the north and north east of Scotland due to greater availability, lower pricing and generally closer proximity to distilleries. Despite higher prices usage of

draff remains important across the south of Scotland with use restricted more by shortage of supply than the level of demand for these feeds.

Pot ale syrup – is a particularly good value feed at present but its usage is less widespread on farm due to difficulties in handling and storage. Farmers are currently taking greater interest in the feeding of pot ale syrup as a good value feed but availability is reported as limited or not available.

Distiller's Dark Grains – these are widely used in the finishing of beef cattle as a protein source added to barley. They are also regularly used in a range of compound and straight feeds for all types of cattle. The closure of the last barley dark grains plant in early 2018 means that only wheat or maize distiller's grains are now available.

Farmer's response to reduced distillery feed availability

53. The following comments are based on feedback from SRUC nutritionists, farmers and feed industry contacts.

Feed replacement for Scotch whisky distiller's draff/DDGS

54. Until recently any shortfall in Scotch whisky draff and distiller's grains availability in Scotland was being met in part by distiller's grains from the bio-ethanol plants in the north of England. This production from England has been more significant to livestock producers in the south of Scotland due to proximity and transport costs benefits. Further north in Scotland accessing these feeds has been more expensive due to additional transport costs. Given the recent closures and extended maintenance period of the two main English bio-ethanol plants, supplies of these feeds has fallen sharply. As a result overseas imported distiller's grains have become increasingly competitive, first from continental European plants, but now increasingly from the large US bio-ethanol industry.

Changes in on-farm feed and forage production

55. As draff has become less available in some areas of the country farmers have looked to increase the supply of home-grown alternatives. Improvements in

silage have been notable, particularly in the dairy sector where steady improvements in silage quality have been achieved. More farmers are now adopting multi-cut systems where the focus is more on quality as the majority move to earlier cutting dates. Multi-cut systems involve a reduction in the time between silage cuts down to 4 or 5 weeks. Multi-cut systems produce silage with a higher energy density (Metabolisable Energy) and higher Crude Protein levels which is particularly beneficial in dairy production or beef finishing.

56. This has also been a strong message carried over to the sheep sector, with many farmers now starting to feed just high quality silage and soya to their ewes throughout pregnancy, providing a huge cost saving. A high quality silage is that of 11+ MJ ME/kg DM. In a similar way to dairy this has been achieved by earlier cutting and management of grassland through reseeding, liming etc.

57. Weather conditions have a large effect on both quality and quantity of silage. In 2017/18 there was a shortage of silage cut due to wet conditions at harvest. In 2018/19 there was a concern of there being a shortage of forage due to the drought like conditions, however when rain did come there was a late flush of grass and farmers were able to get another cut of grass. This may have given the bulk farmers require but will be of lower quality (lower energy, higher fibre) due to the delay in cutting. This compounds the issue as draff would have eased the pressure on forage stocks.

Farmer's ability to meet the year round output of distillery by-products

58. Traditionally the whisky sector has faced issues in finding a market for draff produced during the summer months as cattle were out at grass. This has been more of a problem historically and there are reasons to that this has become less of a concern. The reduction in the surplus of distillery by-products has increased the capacity of farmers to accept what is available. The higher price of distillery by-products has concentrated their use with the more intensive livestock producers; particularly dairy farms. Dairy cattle have a more consistent concentrate requirement all year round and take less of their feed requirement from forage than beef herds.

59. Farmers have also adapted to taking draff in the summer if it is available (and at a lower price) and ensiling it for use in the winter. However, this practice has a significant cash-flow impact on a farm business as it involves them paying for it at that time i.e. if they are taking 100t of draff at £40/t that's £4,000 to lay out in one go, months ahead of the feeding period.

Feed use of draff in remote locations

60. Malt whisky production has been increasingly driven by the demand for single malts particularly the premium kind. This has resulted in a growth in demand for whisky from some of the smaller and remote distilleries in the Highlands and Islands. Due to the relatively small scale of these plants, investment in Anaerobic Digestion plants is not generally economically feasible. Haulage of by-products out of the region to meet livestock feed demand in the central belt of Scotland is prohibitively expensive. At the same time livestock producers in these areas face greatly increased transport costs for bringing feed in and often a shorter growing season and increased reliance on bought in feed. For these reasons distilleries and local farmers have a lot to gain from local use of draff in feed. There are several good examples where these arrangements have grown and strengthened in recent years on several of the islands such as Skye, Orkney and remote parts of the mainland. Farmers in these areas have adapted their feeding systems including increased use of pit storage to help ensure they meet the needs of the distilleries by accepting draff all year round.

Appendix 1 - Introduction to distillery feed products

Figure A1: Malt distilling by-products - typical process

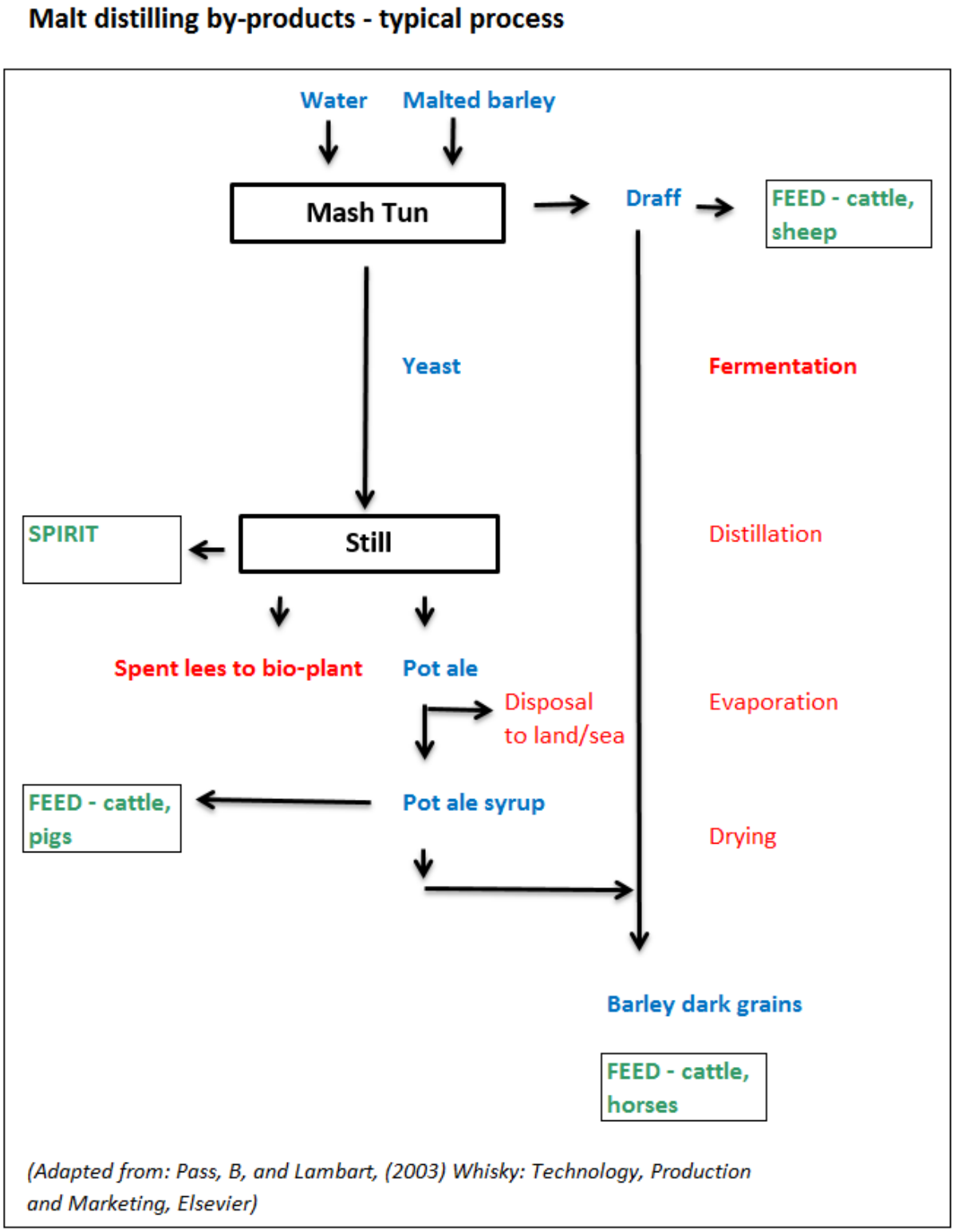
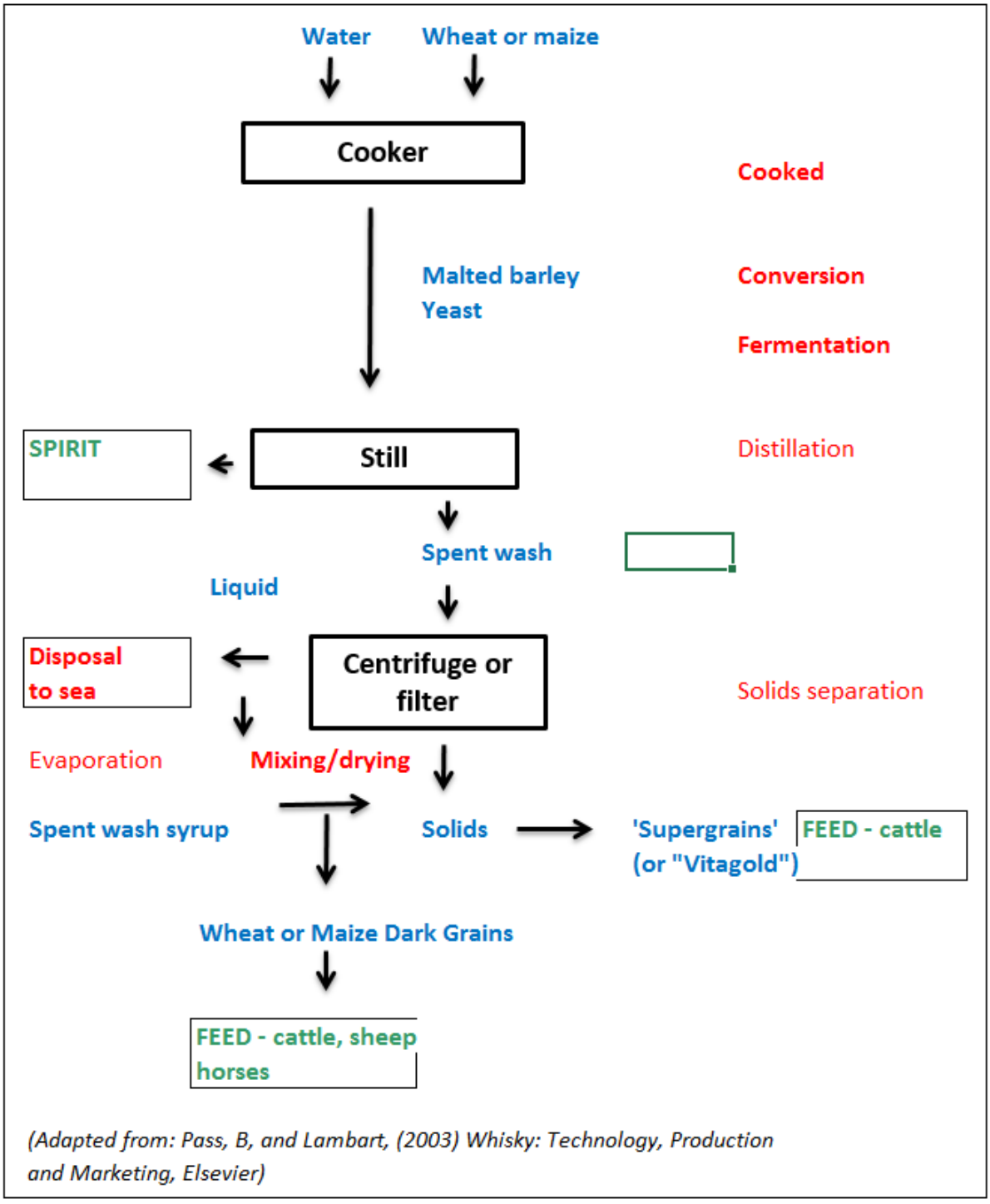


Figure A2: Grain distilling by-products - typical process



Appendix 2 - Estimated Scotch whisky by-product output

Table A1 – Scotch whisky by-product estimates

	GRAIN & MALT USE IN SCOTCH WHISKY PRODUCTION		CONVERSION of BY-PRODUCTS		OUTPUT of BY PRODUCTS		
	000's t FW	000's t FW	t DM by-product/t FW of grain/malt	t DM by-product/t FW of grain/malt	000's t DM	000's t DM	000's t DM
	Malt	Grain (wheat or maize)	Malt spirit	Grain spirit	Barley DDGS equiv.	Wheat/maize DDGS equiv.	TOTAL
	e	h	i	j	(e* i)	(h * j)	(sum)
1990	494	633	0.311	0.327	154	207	361
1991	473	616	0.311	0.327	147	201	349
1992	425	579	0.311	0.327	132	189	322
1993	355	554	0.311	0.327	111	181	292
1994	364	572	0.311	0.327	113	187	300
1995	392	645	0.311	0.327	122	211	333
1996	427	712	0.311	0.327	133	233	366
1997	476	756	0.311	0.327	148	247	395
1998	460	706	0.311	0.327	143	231	374
1999	399	637	0.311	0.327	124	208	333
2000	350	557	0.311	0.327	109	182	291
2001	352	563	0.311	0.327	110	184	294
2002	383	600	0.311	0.327	119	196	315
2003	375	627	0.311	0.327	117	205	322
2004	370	591	0.311	0.327	115	193	308
2005	401	633	0.311	0.327	125	207	332
2006	433	706	0.311	0.327	135	231	366

2007	527	793	0.311	0.327	164	259	423
2008	594	815	0.311	0.327	185	267	451
2009	548	678	0.311	0.327	171	222	392
2010	507	660	0.311	0.327	158	216	374
2011	582	815	0.311	0.327	181	267	448
2012	664	874	0.311	0.327	207	286	492
2013	718	938	0.311	0.327	224	307	531
2014	755	902	0.311	0.327	235	295	530
2015	723	756	0.311	0.327	225	247	472
2016	724	716	0.311	0.327	225	234	460
2017	663	658	0.311	0.327	206	215	422
2018	687	653	0.311	0.327	214	214	427
2019	711	677	0.311	0.327	221	221	443
2020	723	702	0.311	0.327	225	230	455
2021	747	739	0.311	0.327	233	242	474
2022	747	751	0.311	0.327	233	246	478

Source and references:

SRUC calculations and estimates, Alan S Gray (2018), The Scotch Whisky Industry Review 2018, Pagoda Scotland and Bringhurst et al, (2003), Whisky: Technology, Production and Marketing, Elsevier.

Appendix 3 - Nutritional value of distillery by-products

61. The feed value of distillery feed by-products are well documented12. The FAS SAC Farm Management Handbook 2018/19 contains a list of the relative feed values of the main by distillery feed by-products. The nutritional value of feeds varies by animal species. In Scotland ruminant livestock (cattle and sheep) are the main consumers of distillery feed by products. A summary of the key nutritional values of these feeds for ruminants is given in Table A2 below.

Table A2 – Nutritive value of feeding stuffs – ruminants

Feed	Dry Matter (DM) (g/kg)	Metabolisable Energy (ME) (MJ/kg DM	Crude Protein (CP) (g/kg DM
Brewers grains or draff (23% DM)	230	11.1	200
Wheat Distiller's Dark Grains	900	13.5	340
Malt Distiller's Dark Grains	900	12.2	265
Pot Ale Syrup	450	14.2	360

Source: FAS SAC Farm Management Handbook and SAC Consulting

62. Distillery by-products are best suited for use in ruminant diets (beef, dairy and sheep) where they provide good quality protein and digestible fibre. These feeds are highly palatable with few limiting factors to feeding in ruminants though high levels of copper may limit use in some sheep diets. In contrast these feeds are of limited use in pig and poultry rations due to the high level of fibre and low energy density. Table A3 overleaf details recommended maximum inclusion rates in different species.

[12]Ewing, W.N. (1997), The Feeds Directory – commodity products, CONTEXT

Table A3 – Maximum inclusion rates by species (%)

	Brewers Grains (draff)	Distiller's Dark Grains (Barley)	Distiller's Dark Grains (wheat)	Pot Ale Syrup (PAS)
Dairy	30	30	40	25
Beef	40	30	40	20
Ewe	5	10	0	10
Sow	0	0	5	10
Broiler	0	0	5	0

Source: The Feeds Directory, Dr W.N. Ewing (1997)

Appendix 4 - Feedstock requirement of Anaerobic Digestion plants in Scotland

63. Anaerobic Digestion plants use a range of feedstocks including wastes and also potential animal feeds such as distillery by-products, rejected potatoes and vegetables and purpose grown energy crops. There is a lack of comprehensive official usage data for AD feedstock usage in Scotland which meant it was not possible to determine usage quantities through official data sources. Instead SRUC has prepared estimates of plant capacity based on a range of industry data sources such as; ADBA, NNFCC, REA and others.

64. SRUC has used these information sources coupled to existing industry knowledge to estimate the potential capacity of AD plants in Scotland by sector. These are not official statistics (of which there are none) and should only be considered as indicative estimates.

65. There are a wide range of AD plant types and final uses for the energy produced. Energy can be in the form of; heat, electricity or bio-methane (~96% methane). End uses can be as part of the operation of the AD plant, in an adjoining process (such as a distillery) or exported off-site onto the national electricity or gas network.

66. Making direct comparisons between different types of plants and end uses is not straightforward. SRUC has instead attempted to convert the available information on capacity into a single estimate of bio-methane output capacity per hour since all AD plants produce methane. SRUC estimates indicate that the total bio-methane capacity of Scottish AD plants in 2018 was equivalent to 21,545m^3 per hour of which the largest sector was agricultural at 36.6% of capacity and distilling at 31.5% of capacity.

Table A4. Estimates of Scottish AD plant capacity by sector in m^3 bio-methane

Sector	Capacity	
	Bio-Methane (m^3/hr)	(%)
Agricultural	7,878	36.6%
Distillery	6,780	31.5%
Municipal/Commercial	4,810	22.3%
Industrial	261	1.2%
Sewage	1,815	8.4%
Total	**21,545**	**100%**

Source: SRUC

67. Capacity does not equal output as plants are not always running at full capacity. In general AD plant operators will seek to maximise running time (to improve payback on capital investment) and it has been assumed for these estimates that AD plants will run for 8,500 hours on average per year (out of 8,760 hrs available). On that basis, energy value of feedstock required to run these plants for the entire year can be calculated. SRUC estimate this as 4,771,013 GJ of energy.

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