

Category Selection Brief

Aim: Present validated results from the feed company perspective. Identify the categories to be assessed in the next stage and those that require scoping.

Priority opportunities integrated across the PD and VCA studies

Priority Opportunity i.e. areas of under performance	A PD	B PD	C PD	VCA Salmon	VCA Shrimp	Problem definition options
1. Lead industry change						
2. Creating a service product				1	1	
3. Input substitution				1	1	
4. Value chain cost-share partnership						
<i>5. SMART/AI forecasting/ traceability technologies</i>					2	
6. Supporting/investing in innovators						
7. Improving communication						
<i>8. Food waste use</i>					2	
9. Co-product use				1	2	
10. Partnering to improve Feed Conversion Ratio						
11. Sustainable Transport				1	1	
12. Tracking innovations						
13. Organisational process and polices						
<i>14. Wildcard – unknown</i>						
15. Waste product/sludge re-use (shrimp)					1	
16. Energy footprint reduction innovations (shrimp)					2	

Based on the highly correlated opportunities from stage 2 it was agreed that the following would be the focus of where to select categories for the next stage:

1. Input substitution
 2. Co-product use
 3. Food waste use
 4. Technologies
- Wildcard

Where value chain cost-sharing partnering will be delivered by the broader Feed X programme

Internally the priorities recommended would be:

- Creating service products
- Sustainable transport

Workshop results

Categories of input substitution with the highest votes

1. Fermented proteins (using CO₂ &/or Microbial processes)
2. Non marine Omega 3
3. Insects
3. Food waste

From the Kano diagrams the following categories were chosen that even if it were not done well it will still make Skretting customers happy, i.e. delighter. The following results were obtained for recommended categories:

- The mapping of local food waste near Skretting factories
- And the use of sludge as a co-product
- Technology was a priority opportunity that generated many ideas that delighted the group the key ones are
 - Integrated AI-digital biomass monitoring system linked to feed delivery and ordering
 - Digital health control systems for Shrimp and Salmon
 - Accurate biomass measurement systems
 - Servicing customers with aquafeed in local regions using local ingredients
- For categories in Input substitution there was a high degree of correlation between the voting and delighters; however there were interesting exceptions
 - Food waste delighted the most people
 - Fermented proteins was the next most delightful choice
 - Microbes and seaweed delighted people more than insects or non-marine omega 3

Assessment criteria for Input substitution categories recommended

Questions that all categories will need to ask:

1. Are they relevant to the aqua-industry or feed industry as a whole, or are only strong for Salmon or Shrimp
2. Do they have the ability to feed more than one species; Salmon, Shrimp, Tuna, Talapia – poultry, swine?
3. Is there a time or money aspect – are they expensive to produce/process or do they take a lot of time to produce/process?
4. What innovation level do they have – have they been pilot tested or are they **ready to scale**?
5. What are the potential volumes available?
6. Is there analysis on their energy, GHG/R&R values?
7. How complex are the logistics/transport – trucks boats?
8. Do they comply with feed/food safety regulations?
9. Do they have known or good Amino acid/nutrient digestibility properties?
10. Do they contain Omega 3 (DHA/EPA) if this is through GM ingredients it is noted?
11. Can they be adapted to be produced in multiple geographies, locally relevant and globally significant?
12. What kind of sustainability issues need to be considered?

Categories recommended from the 2nd stage analysis and workshop are as follows:

1. Input substitution category increasing sustainable performance of feed



1. Food waste (or food industry co-product) either as an ingredient substitute or processed (see the list below or used as a substrate e.g. with insects)
 2. Fermented proteins that use sustainable sources of CO2 and microbes
 3. Non-marine Omega-3 sources from microbes (including micro algae),
 4. Seaweeds either as an input substitution or processed/concentrated (e.g. with insects, but as source material that is being fed on) Category Input substitutions that incorporates food waste (food industry co-products)
- 2. Technology categories that increase the health, survival and growth performance of the fish/shrimp**
- Integrated technologies incorporating digital monitoring to increase the health, survival and growth performance of the fish/shrimp
- 3. Integrated system category that increases feed production efficiencies**
- Systems that can map local food waste streams and the nearest processing to provide local inputs into local feed plants
 - Systems that use co-products including sludge water from pens or ponds
- 4. Wild card category could include the following**
- Wild card innovations that use solar and wave power to produce/test feed and ingredients
 - Wild card innovations that move the whole farm production food print off land

OPCOs agreed the 4 priority opportunities.

OPCO suggested category priorities for input substitution were the following

North America	Asia-Africa
1. Non Marine Omega-3	1. Insects
2. Land animal protein concentrates	2. Food waste (including Cassava waste)
3. Insects	3. Omega 3 from algae
4. Fermented proteins	4. Seaweed /Algae <i>we should choose if we want to focus on red, brown or green algae.</i>
	5. Plant protein

Other categories considered by Asia-Africa were:

Co-product (consider as part of Wildcard innovations to reduce GHG emissions)

- Co-products for energy production in Skretting facilities

Technology categories

- Local regions with local ingredients
- Digital health control of shrimp
- AI biomass control

Technologies that improve recycling (consider as part of wildcard innovations to reduce GHG emissions)

- Plastic recycling

Both the energy co-product suggestion and the plastic recycling will be added to the wild card innovation category.

Technology categories suggested from Asia-Africa region will be included as part of the technology category search as its definition has been clarified by North America OPCO edits on its purpose.

Land animal proteins were considered in the workshop but did not receive sufficient interest to go forward. Insects in combination with food waste or seaweed will be put forward. However if an innovation

in this area were to be identified as part of the wildcard category, this could be considered but may be subject to specific de-risking as before it were put forward for the next phase.

The following are therefore the categories that will be de-risked in the next phase of work.

Categories to be de-risked

Must have criteria: ready to legally compliant and ready to be scaled.

All categories need to meet relevant international laws and national regulations, to cover known unknowns e.g health and safety, labour,

Need to clarify what ready to be scaled means for each category: prototype tested, operationalization?, TBD

FEED INGREDIENTS: Applicable to Salmon and Shrimp feed: avoid negative, and promote positive environmental impacts (e.g. GHG emissions and BD loss) associated with less sustainable ingredients

a) Nutritional solutions creating net positive effects using sustainable waste streams including not limited to food waste, CO2 and energy

1. Protein (processed or concentrated) or starch from locally available food waste stream (e.g. cassava)
2. Protein from Insects fed on Food waste and/or food industry co-product-list below
3. Protein from fermentation processes using waste streams
 - a. Microbial - Sustainable CO2 source, Bio-gas
 - b. Food waste or food industry co-product (sugars)
 - c. Waste product such as: Cellulose
- Unknown Protein from using energy (e.g. from the production in Skretting facilities)
- Proteins created through currently unknown innovations (cannot be de-risked in detail, but as part of the overall categories)

b) Nutritional solutions creating health effects equal to or greater than fatty acids (e.g. DHA-EPA)

4. Non-Marine oil sources of Omega-3
 - a) Microbes (inc. Micro-Algae)
 - b) Sea-weed
 - c) GM microbes or seaweeds or other Plants
- Oils created through currently unknown innovations (cannot be de-risked in detail, but as part of the overall categories)

c) Nutritional solutions using inputs that create environmentally restorative effects (e.g. ecosystem rehabilitation)

5. Protein from seaweeds (process or concentrated)
6. Protein from insects fed on **Seaweeds**

FEED PRODUCTION: Applicable to Salmon and Shrimp feed: Feed use efficiency through innovations that directly mitigate environmental impacts i.e. GHG emissions and BD loss associated with feed production processes in factories

d) Technology solutions creating net positive effects using renewable energy, packaging waste, energy waste, sustainable transport

- Use of solar and wave power to produce/test feed and ingredients
- Use of packaging waste – reduce recycling of plastic or its waste production
- Creation of co-products from energy production in Skretting facilities
- Systems that can map local food waste streams and the nearest processing to provide local inputs into local feed plants – ensuring local regions have logistical access to local food waste ingredients
- Unknown Technology innovations (cannot be de-risked in detail, but as part of the overall categories)

FEED DELIVERY SYSTEM: Applicable to Salmon and Shrimp feed: Feed use efficiency through solutions that indirectly avoid negative, and promote positive environmental impacts i.e. GHG emissions and BD loss associated with salmon and shrimp production systems

- e). Technology solutions increasing the health, survival and growth performance of the fish/shrimp
 - Integrated technologies incorporating digital monitoring to increase the health, survival and growth performance of the fish/shrimp (i. e. including digital health control, A.I. biomass control)
- f). Integrated information systems solutions increasing feed waste efficiencies
 - Systems (digital or otherwise) that use co-products including sludge water from pens or ponds
- g). Innovations moving the whole farm production food print off land
 - Unknown innovations (cannot be de-risked in detail, but as part of the overall categories)

Scoping means that the researchers identify broad issues and risks associated with the category focus (1, 2, and 3) that may need to be considered at a later stage once more detailed innovations are selected. Category de-risking assessment may need to be carried out at the solution level for the first 3 categories (a, b and c).

See the follow appendices for examples of how some of the solutions in the first 3 categories may be assessed using the 12 criteria and against the 6 categories of risk. Food waste /food industry co-products are also listed below for clarity based on previous studies.

Project X document

2018

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Appendices

Example of what the solutions look like against the new CDR assessment criteria

Category outcome	Solutions	Substrate or condition	Industry relevance	Species applied	Time/money	Innovation level	Potential Volumes available	Energy, SGS, R&R	Logistics/transport	Feed/food safety	Other?	Amino Acid Nutrient	Oil - Omega 3	Geo-geography Local/global	Sustainability issues to consider	
Net positive effects with waste streams used	1. Food waste See list below	Processed or concentrated-	✓	✓	L	✓	✓	✓	✓?	✓?		✓	✗	✓	Landuse, water, food, fuel	
	2. Insects	Food waste	✓	?✓	M	✓	✓	✓	✓?	✓		✓	✗	✓	Transport, processing	
	3. Microbial protein from fermentation processes	Sustainable CO2 source Bio-gas	✓	✓	Hi	✓	✓?	✓?	✓	✓		✓	?✓	✓	Energy, processing	
		Food waste	✓	✓	Hi	✓	✓?	✓?	✓	✓		✓	?✓	✓	Transport, processing	
		Waste: Cellulose	✓	✓	Hi	✓	✓	✓	✓	✓		✓	?✓	✓	Landuse, transport, water, processing	
	Unknown Protein	Energy form plant	?	✓	Hi	✓	✓	✓	✓	✓		✓	?✓	✓	Transport, processing	
Health effects from fatty acids replaced	4. Non Marine-protein sources of Omega-3	Sea-weed	✓	✓	M	✓?	✓	H	✓	✓	WQ	✓	✓	✓	Transport, treatment – may need to be concentrated	
		Microbes (inc. Micro-Algae)	✓	✓	M	✓	✓	✓	✓	✓	✓	WQ	✓	✓	✓	Transport, treatment
		GM microbes or seaweeds or - Non edible	✓	✓	L	✓	✓	✓	✓	✓?	✓	GMO	✓	✓	✓	Landuse, water, processing
Environment restored	5. Seaweeds	Concentrated or processed	✓	✓	M	✓?	✓	H	✓	✓	WQ	✓	✓	✓	Transport, treatment – will need to be concentrated	
	6. Insects	Seaweeds	✓	?✓	M	✓	✓	✓	✓?	✓		✓	✗	✓	Transport, processing	
Wildcard – unknown			✓	✓	F/L	H	H	L	L	G	✗	✓	✓	✓	Few issues	

Details	Industry relevance	Species applied	Time/money	Innovation level	Potential Volumes available	Energy, SGS, R&R	Logistics/transport	Feed/food safety	Other	Amino Acid Nutrient	Oil – Omega 3	Geography Local/global	Sustainability issues to consider
Technology solutions reducing GHG emissions in feed production systems													
innovations that use solar and wave power to produce/test feed and ingredients	✓	✓	H	?	✓	✓	✓	✓		X	X	X?	Materials
Systems that can map local food waste streams and the nearest processing to provide local inputs into local feed plants	✓	✓	M	✓	X	✓	✓	✓		X	X	?	Energy, materials, IT infrastructure
Technologies reducing GHG emissions in farm production systems													
Technology/digital monitoring Integrated technologies incorporating digital monitoring to increase animal health, survival and growth performance	✓	✓	M	✓	X	✓	✓	✓		X	X	?	Energy, materials, IT infrastructure
Systems that use co-products including sludge water from pens or ponds e.g. Fish Faeces, Shrimp sludge	✓	X	L	✓	X	✓	✓	X?		✓	✓	X	Processing, transport
innovations that move the whole farm production food print off land	✓	✓	H	?	X	✓?	✓	✓	?	X	X	?	Energy, materials, IT infrastructure

Examples here were mentioned during interviews and illustrate combined categories e.g. Input substitution with Food waste, Waste Food, Local and global:
The values within this table are based on best estimates

	Current categories					FEED INGREDIENTS: Applicable to Salmon and Shrimp: avoid negative, and promote positive environmental impacts (e.g. GHG emissions and BD loss) associated with less sustainable ingredients					
	Marine animal protein		Plant based protein		LAP	Cat 1: create net positive effects using waste streams			<i>Cat 2: create the health effects equal to or greater than fatty acids</i>	<i>Cat 3: use inputs that create environmentally restorative effects</i>	
Category Type	Wild caught fish	Fish By-product	SPC	Legume	Poultry By-product	1. Food waste &/or waste food co-product	2. Insects; BSF, MW, Cricket	3. Microbes fermentation – bacteria meal yeast meal	4. Non Marine oils with O-3	5. macro algae, <i>Staurosira sp</i> etc	2. Insects; BSF, MW, Cricket
Examples	sand eel, Anchovy NEW: Krill, Calanus	Tuna, blue whiting, sprats, etc NEW: Capelin	Soy from Mato grosso (cerrado)	Peas, beans, peanuts	By-product, feather, bones etc	Coffee, potato peelings, wheat mash Cassava	Substrate: food waste	CO2 waste, Bio-gas from food waste, Waste stream - trees	<i>microbes, Substrates of GM plants/sea weeds/microbes, micro-algae</i>	Light, CO2, N2, WQ ecosystem	Seaweed
1.Environment lens	IUU By-catch	IUU By-catch Transport	LU impact High Energy	LU impact Energy	Low LU impact	Transport Land Fill saved	Location LU impact	P.Plant LU impact	LU impact low	Water quality	Location LU impact
C1. Landuse & biodiversity	By-catch	By Catch	Cerrado, Forest code	Land use	Disease transfer	None known	Yes food crop	None known	Land use	None known	None known
C2.GHG emissions	fishing	Processing Transport	Processing, transport	LU	Processing, transport	Transport Avoided	Processing, transport	Processing, transport	Land use processing	Processing transport	Processing, Transport
C3.by-products-inedible crops	NA	YES	NO	NO	YES	YES	Possibly	YES	possibly	NO	Possibly
C4.Pollution	Bilge water	Waste water	Waste water	Waste water	Waste water	Not known	Waste water	Waste water	Waste water	None known	Waste water
C5. Fresh water use	NA	NA	Yes	Yes	Yes	Not known	Yes food crop	Yes depends on substrate	Yes	Yes, minimal	Yes ,minimal
C6. Depletion of fisheries	Yes	Yes	No	No	No	No	No	No	No	No	No
2.Nutrition	High	High	Medium	Low	Medium	Low data?	Potential	Potential no data	Low data?	Potential	Potential

lens	Data	Data	Data	Data?	Data?		No data			No data	No data
C7. Animal health – FCR, mortality	Good	Good	Low digestibility	Low digestibility	OK	NA	Not known	Not known	potential digestibility	Not known	Not known
3.Policy/ Regulation lens	IUU - TAC	IUU –TAC PCBs	Forest code, CM	certification	LAP	Food waste	PAP No meat substrate	GMO on substrate?	GMO, Certification on substrate	Not known	PAP No meat substrate
4.Social acceptability lens	Concern	OK	Concern	OK	Not clear	OK, but not confirmed	Not clear	Not clear	OK	Not clear	Not clear
5.Ethical lens Social trade off Labour/HR Animal welfare	Slavery Social trade off, Fish welfare	Slavery potential	Labour potential Social trade off	Labour potential	Animal welfare	Labour conditions Jobs	Labour conditions Jobs	Labour conditions Jobs	Labour potential Social trade off good	Labour conditions jobs	Labour conditions Jobs
C8.Human rights and welfare	Potential	Potential	Potential	Potential	Health and safety	Health and safety	Health and safety	Health and safety	Potential	Health and safety	Health and safety
6.Economics lens Price /volume	Price	Price	Low cost	Low cost	Low cost	Low cost	Not known	High	Low cost	Not known	Not known
C9. Financially viable	Yes	Yes	Yes	Poss	Yes	Yes	Possibly	Not known	Not known	Possibly	Possibly
7.Investment feasibility lens– relative cost, Bus plan	NA	NA	NA	NA	NA	Probably	Not known	Not known	Not known	Not known	Not known

Feed compass criteria (1 to 9) are incorporated here to ensure that FEED X contributes to the testing of the KPIs and therefore enabling transferability of the risk assessments into broader feed industry programmes.

Definitions

Priority opportunity: A change at a specific point in the feed value chain offering the potential for improved sustainability. For example, a change in the protein or Omega 3 inputs (input substitution), or a change in forecasting technologies.

Category: A specific type of product or technology representing sustainable innovation within the feed production core value chain for the priority opportunities e.g. insects as a protein input substitution, algae as an Omega 3 input substitution, Artificial Intelligence as better forecasting technology.

Food waste Definition used here – plant based.

Food waste recovery innovations (Plant based: coffee granules, olive mill wastewater, wine lees, grape marc, coffee husk, coffee silverskin, polyphenol-rich substrates, wheat bran, tea-bags)

- 1) Top 20 food waste streams in EU (WRAP – H2020) excluding Animal protein waste streams because this was a choice (i.e. LAP) not selected
 1. Spent grains, distillers dark grain & draff (ales, largers & spirits)
 2. Pomace (apples)
 3. Whey, whey concentrate and whey permeate (cheese)
 4. Pomace (cider)
 5. Egg shell waste (shell)
 6. Pomace (skin and seeds) (light wines)
 7. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)
 8. Fibre, concentrated fruit juice & protein from potato starch production (potatoes)
 9. Peelings (potatoes)
 10. Organic wastes, mash from grain, fruit or potato (spirits)
 11. Sugar beet pulp
 12. Pomace (skin, pulp & seeds) (tomatões)
 13. Crude & extracted press cake or spent meal (vegetable oils/margarines)
 14. Olive stones (vegetable oil)
 15. Wheatfeed / wheat middlings (wheat milling products)
 16. Other innovations
- 2) Excluded here because they are classified as LAP – land animal protein
 1. LAPs -were not selected by sufficient number of participants
 - a. Blood
 - b. Bones
 - c. Hair, feathers, hooves & feet
 - d. White and red offal incl guts & giblets
 - e. Proteinaceous matter incl. Category 3 material from slaughter plus carcass fat

Waste (plant based co-products) from the food industry

- 15 co-products from the food industry: The food industry produces a wide variety of products. This makes the variety of co-products even bigger.
 - [French fries industry](#)
 - [Sugar industry](#)
 - [Grain industry](#)
 - [Corn industry](#)
 - [Chips industry](#)
 - [Dairy industry](#)
 - [Bread and confectionery industry](#)
 - [Potato starch industry](#)
 - [Sweets industry](#)
 - [Fruit and vegetables industry](#)
 - [Pea protein and starch industry](#)
 - [Inuline industry](#)
 - [Consumer oil industry](#)
 - [Beverages industries](#)
 - [BioFuel industries](#)

These may be defined by local industrial food processes like Cassava.

Objectives of the workshop

- Agree on the most important 3 to 4 priority opportunities for Category De-risking.
- Select the categories of innovation opportunity for each of the chosen opportunities that can deliver the greatest sustainability gains for Skretting and for the feed industry.

Workshop process

STEPS

1. The priority opportunities resulting from the combined Problem Definition (PD) and Value Chain Analyses (VCA) assessments were presented and the most significant 3 to 4 agreed to take forward for Category De-Risking (CDR).
2. Within each agreed opportunity for salmon and shrimp, participants brainstormed and then selected the most important innovation categories for input substitution.
 - Voting individually for the most important placing a number from 1 to 5 on the post-it notes, where 1 was least important and 5 most important
 - Adding any missing criteria that should be used to assess input substitution categories in the CDR
3. Participants used “Kano” to prioritize the suggested categories in each priority opportunity. Participants chose their priority category example across all 4 priority opportunities and decided whether they were a delighter, linear and or taken for granted. The letter D, L or T was written on the post-it for the categories chosen

Validation of the workshop process with the OPCOs

A summary report of the workshop process and results was shared with the Feed company offices in several regions globally, and were asked to contribute their votes on the priority options, the category choices to be sent forward into the next stage. Only three regions gave feedback within the timeframe given, two of these, North America and Africa and Asia were able to provide inputs and suggestions. They confirmed the priority opportunities identified and suggested categories that should be explored in the next stage from their perspective. These were considered with the other votes and were choices overlapped these were included or moved the category further up the priority list. The suggestions not on the list will be considered strongly if they emerge as part of the wildcard category.

Produced by Project X, October 2018