EU PiG

EU PiG Innovation Group

Technical Report

Precision Production

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Challenge: Reducing costs

Introduction

Pig production across the EU is dominated by production at scale with the majority of pork produced, being produced as a bulk commodity with marginal profit gains. Rising prices on inputs such as feed, fuel and labour combined with pressures to keep low food prices for consumers and to take care of the environment and animal welfare has meant that the industry shows increased volatility. The pork industry whilst mainly driven by profit margins rather than lifestyle choices, is still not as practiced in driving efficiency as some other industries such as manufacturing. Systems of management that can drive efficiency savings and integrate consumer demands and pressures are vital to the survivability of the pork industry in the face of the afore mentioned volatility and consumer challenges.

1. The Background to the Challenge

Since Henry Ford devised a method of producing products in a stepped process, and later with the introduction of the 'Toyota Way', manufacturing methodologies have gained traction across multiple industries. Automotive and manufacturing are not the only industries that are looking to management methodologies such as Lean Production (Lean) and Six Sigma[1] to drive further efficiency gains. Melin and Barth (2018) describe how a multistage approach to implement Lean can change farmer behaviours to management systems that focus on efficiency rather than lifestyle as a driver for farm production.

The pig industry across much of Europe has focused on profitability rather than lifestyle. Wilson *et al* (2012) identified that this was a leading factor in the changing landscape of UK agriculture and was linked directly to scale of production and profitability. Those farms that grew specialised and focused on performance were more likely to be profitable than those that were family led and looked to maintain a lifestyle. There are also regional differences in the production chain. For example, managements practices are influenced by the farm history, thus farming practices differ between integrations versus family farmed cooperatives. Furthermore, Redman (2015) showed that it was by focusing on marginal gains not sweeping changes that made farmers more competitive and profitable. This suggests that there is a need for management methodologies such as Lean and Six Sigma in agriculture in general to provide a template or road map as to how farmers can achieve a system of marginal gains.

[1] Lean Production or Lean Manufacturing, often referred to simply as 'Lean', is a managerial philosophy intended to make companies and organisations more efficient. Six Sigma is a set of management techniques intended to improve business processes by greatly reducing the probability that an error or defect will occur.

There has been some research within the pig/swine industry across Europe and the US showing that labour efficiency does have a direct impact on productivity. Martel *et al* (2008) found that high labour productivity can lead to high reproductive productivity in the breeding herd. This is supported by Knox *et al* (2014) who showed that 70% of farms report a 'technician effect' on processes such as fertility.

Agricultural production is arguably not different in context to the production of any other good or product, meaning that producing meat fundamentally is the same as producing an electronic device or a car. To clarify: each of these requires inputs, processes or steps in production that ultimately lead to an output. Production businesses would often use a diagram called a SIPOC (Suppliers, Inputs, Processes, Outputs and Customers). Yet agricultural production is also fundamentally different from automotive or other traditional manufacturing processes.

That is largely due to our 'machinery', our 'factory' and of course our raw materials. The machinery in all agricultural processes is actually a biological organism and in the case of pig production, that machine is the sow. The sow is used to turn out piglets which are then fattened and processed to produce a finished pork product. Animals all differ from each other, change with time both on the short and long run and continuously adapt to a changing environment. Animals are Complex Individual Time varying and Dynamic systems (CITD-systems) that have been traditionally considered as too complex to be monitored and controlled by image, sound and sensors automatically (https://tice.agrocampus-ouest.fr/pluginfile.php/59209/mod_resource/content/7/co/u141.html). Automatic monitoring and controlling techniques are becoming more and more important to support the farmer in managing the production. The 'factory' is the farm, in outdoor production it is completely at the mercy of the elements and the seasons. A relative new element is the production chain where the machinery and factories are part of. In the production chain, marketing and logistics play an important role in connecting producers and consumers. It has long been held as a premise that these substantial variations make process control techniques such as Lean management or Six Sigma, unlikely to succeed in reducing the 'waste' caused by biological variation.

2. Addressing the Challenge

Increasingly we are seeing elements of 'process control', be that officially Lean management or Six sigma, creep into common practice on our pig units. This can be simple methods such as standard ways of working, checklists or visual controls that mark which equipment and personnel should enter which buildings for biosecurity. White *et al* (1996) observed that those processes that followed clear management protocols such as farrowing and weaning, led to better survivability for piglets. Some producers are trialling how the standardisation of their service groups by parity can impact the variation in performance of the litters they produce. Producers across the EU are looking at indexing and scoring sow performance based on their litter averages with outliers having additional 'maintenance' in the forms of diets or delays to re-entering service groups. This is akin to a Lean concept called Total Productive Maintenance

(TPM) in which the 'Machinery' of any process is maintained as part of the typical routine, not as an additional task.

What is missing is the use of a clear strategy such as Lean or Six Sigma that allows the 'tools' described above to be put into a coherent process. Various members of the EU-PiG consortium have reported starting projects that relate to a management cycle using Lean principles, "Plan, Do, Check and Act" (PDCA). The cyclical nature of PDCA is what creates the process of continuous improvement and provides a framework onto which the tools from the 'Lean toolkit' or Six Sigma sit. Teagasc (Ireland), AHDB (UK) and several others are looking at what value Lean management specifically can add to their pig industries. A group from Sweden has provided a comprehensive framework for Lean management implementation (Melin and Barth, 2018). The suggested framework consists of 5 phases of Lean Thinking adapted from Hines, Holweg, and Rich (2004) and Narayanamurthy and Gurumurthy (2016): a pre-implementation phase, three phases of Lean Thinking and a post-implementation phase. In the pre-implementation phase, the Lean work is a highly prescriptive and tool-based approach. The companies are not yet familiar with Lean management or work therefore, a number of Lean tools are initially introduced, usually piloted in isolated areas of production. According to Argyvris and Schon (1996), the strategic perspective on Lean Thinking can best be described as 'adaptive' or based on 'single-loop learning', which is only successful when the market is stable and the competition is low. In the next three phases of Lean Thinking, the understanding of Lean management or work increases and leads to the introduction of the five Lean principles (Womack and Jones 1996) to develop production processes and create more customer value, involving improvements in quality, cost and delivery. Ultimately, a wide range of business tools are considered as a contingent Lean approach. Overall, during these three phases, Lean Thinking in companies progresses to develop learning abilities among both employees and customers referred as triple-loop or deuteron-learning (Bateson 1972). Finally, in the post-implementation phase, evaluations of Lean outcomes are conducted from strategic and operational perspectives.

Both the UK and Spain have conducted research in Lean implementation specifically on the pig sector. In the UK the primary focus was on the red meat processing (post farm gate) with little review on farm (Simons and Zokaei 2005), in Spain the focus was very much on pig production in the Catalan region (Perez *et al.* 2010), both demonstrated the benefits of Lean production in a value chain analysis that responded to consumer requirements.

Funding for this type of research and on farm implementation as traditionally been funded through one of three routes:

1. EAFRD – European Agricultural fund for rural development
2. ERDF – European regional development fund
3. ESF – European Social Fund

All of these funding routes are funded by the EU yet administered nationally by national government with responsibilities devolved according to national policy.

3. EU PiG Best Practice

In order to identify the top five best practices for 'reducing costs' a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
  - Clarity of the practice being proposed;
  - Soundness of the concept;
  - Knowledge exchange potential from the proposed practice;
  - Scientific and/or technical evidence supporting the proposed practice.
- **Impact**
  - The extent to which the practice addressed the challenges pointed out by the R-Pigs (Project representatives from each country) groups;
  - Clear/obvious benefits/relevance to the industry;
  - Impact on cost of production on farm and/or provide added value to the farming business or economy;
  - The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants into the industry.
- **Exploitation/Probability of Success**
  - The relevance of the practice to each member state or pig producing region/system;
  - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
  - Level of innovation according to the Technology Readiness Level (TRL);
  - The extent to which there are clear opportunities for the industry to implement the practice/innovation;
  - Degree of development/adaptation of the practice to production systems of more than one Member State.

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.

2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 - Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five practices followed a procedure in six steps:

1. All members of the TG had the opportunity to send their scoring sheets to the TG leader.
2. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five.
3. The TG leader standardized all individual scores by calculating Z-scores.
4. The first 10 practices have been ranked according to the average Z-scores of all participants of the Thematic Group. All other lower ranked practices have been excluded.
5. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
6. In a dedicated meeting, the Thematic Group discussed the results and finally decided on the top five best practices for each challenge based on the comments provided by the group.

3.1. Validation of the top five best practices

For the challenge of reducing costs, there were 23 entries across 8 countries with a heavy bias towards countries form Western and Northern Europe. Most of the entries focus on single interventions or elements of a management toolkit such as Lean, with few specifically referring to an entire shift towards following a lean or Six Sigma type approach. It was noted that many of the challenges had entries that could have been seen as 'lean' entries including some of those for Health and Welfare.

Winning Ambassador

Best practice **'5S Lean Programme to Improve Work Efficiency'** from Teagasc in Ireland was chosen as EU PiG ambassador 2020 for the challenge 'Reduction of costs' (www.teagasc.ie/pigs). The best practice innovation lies in the implementation of a 5S Lean programme for the maintenance, mineral storage, medicine storage and weaner mixing room areas. This led to a programme of continuous improvement underpinned by Lean principles across the entire business.

How: As part of the 5S exercise, mapping of areas, training of staff, implementing a programme, monitoring progress (checklists and audits) and addressing areas for improvement. A control chart was used, numbered and colour coded: scores up to 6 (signifying substantial action needed), 7-8 (minor corrections needed) and 9-10 (acceptable). Once staff had engaged with the Lean process, a value stream mapping exercise identified areas of 'waste' on the farm and engaged staff with improvement activities to reduce or remove that waste. This included reducing breeding group numbers to remove weaned piglets as a product as the business was losing money. The increased space allowed increased stocking density in finished pigs without needing additional construction. Feed waste was reduced to just 2% of feed and further improvements were made across the business leading to an estimated reduction in labour and a saving in cost of production.

Remaining Top 5 entries

Dashboard for pig farm benchmarking

Country: Italy

The innovation is a dashboard benchmarking system to monitor different features of the pig farm. Graphs are available and function to monitor and compare productive performance across years and among a number of users (pig farmers). The system allows the user to anonymously compare the performance of its farm to those of other pig farms in other countries by using coloured indicators (e.g. green = very good; red = very bad). This system can be integrated into a number of management systems for pig farming. The system deliberately identifies the outliers of production within each process. This allows producers to identify 'waste' in the production system and direct labour in the most efficient way. The system has been developed by the company AgriSyst. https://agrisyst.com/en/products/agrisyst-solution-for-pig-farmers/agrisyst-productionmonitor/

Multi-criteria approach for successful and lasting demedication

Country: France

In 2012, all piglet feeds were medicated[2]. Farmers decided to undertake demedication. To support the change, they did the following at this specific farm:

- Vaccination with a Porcine circovirus & Mycoplasma hyopneumoniae combination vaccine
- Strong piglets at weaning: homogeneous and strong piglets at birth: gestating feed strategy based on individual performance and on previous litter size.
- Lactating feed contains palatable raw materials to maximize ingestion and additives for better feed recovery and control of digestive pathologies.
- In 2015 they built a new Post-weaning facility to reduce stocking density.

[2] Systematic in feed medication was abolished in other countries well before year 2000.

- Focus on feed quality: high inclusion of barley, feed additives claimed having natural anti-inflammatory properties, yeast extracts – reduction in protein contents to reduce gastrointestinal disease.
- Attention to hygiene, disinfection against coccidiosis, change of clothes.
- Application of improved gilt quarantine with the aim of improving health status of gilts. Consequence: more homogeneous lots, better fertility and prolificacy while maintaining very good longevity.

Production Concept Finishers

Country: Denmark

The aim was to reduce production costs by using less feed per kg daily gain. To achieve our purpose new management systems and use of Precision Production tools/equipment were introduced. The new management system was implemented with an advisory service, visits on farm, service on technical equipment and monitoring of key figures. The new management system is controlled by checklists. New key figures have been the daily gain and feed consumption from day 0 to day 28 after pigs arrival. New Precision Production equipment consisted in the use of pig scales from MS Schippers measuring daily gain of pigs. It was implemented during a 3-month start-up program. The cost is estimated at about 0,40 euro per produced pig. Feed conversion rate was 2,60 kg feed per kg of weight gain (from 30 to 110 kg of live weight). After the implementation of the new management system and the introduction of Precision Production tools, feed conversion ratio dropped down at 2,43. This has improved our profitability. By improving our management and monitoring tools we could increase our efficiency.

Lean Management - Focus on Energy Use

Country: Ireland

To reduce energy use and costs Innovation: Lean programme to focus on energy use.

How: Lisavaird engaged with Teagasc and Pembroke Alliance consultants and developed a programme to focus on existing energy use. The programme identified high energy use areas on the farm and recommended changes to reduce energy use and costs. The areas identified included: 1. heating controls in the farrowing room and first stage weaner rooms; 2. Upgrading Ventilation Fan motors; and 3. Replacement of fluorescent tube lights with T8 LED tubes in the dry sow, service and farrowing rooms.

3.2. Cost and benefit analysis of the EU PiG Ambassador

Best practice '5S Lean Programme to Improve Work Efficiency' from Ireland was chosen as EU-Pig ambassador 2020 for the challenge 'Reduction of costs'. The best practice innovation lies in the implementation of a 5S Lean programme for the maintenance, mineral storage, medicine storage & weaner mixing room areas. The costs and benefits of this system have been analysed, taking into account the estimated changes in technical performance parameters being the result of introduction of the system and necessary investments on the case study farm. We included also reported costs and benefits observed by the farmer as the result of 5S Lean management implementation. Basing on the real farm data and calculations with the Interpig model the following parameters of the farm has been assumed:

Benefits:

- Decrease of labour costs due to 5% decrease of labour input per sow/fattener. The final lean report suggested a saving of 0,5 hour per person per day (5%) which caused a saving of €10,785 on a farm (farm size is 2200 sows with 2332kg of meat - cold dead weight - sold per sow) but further savings can be expected as Lean 5S is rolled out further across the farm and Waste and poor process will be more exposed in the future. Additional time for monitoring and further implementation is needed, but is rolled up into general farm management. 5S is a solution to problems, so where the farmer meets his staff and particular problems are highlighted, i.e. shortage of tool, or delay in fixing, this is then built back into the system.
- Lean project based on "Data Driven Management" resulted also in increased output of 348 finishers, generating an annual sales of €36,540 due to having more space for weaners/finishers, and savings related to slurry management (ca. €1,980), and 10% of time saving of 3 workers in weaners and farrowing house. While this is not specifically related to the Lean 5S implemented, it does show the impact of having a "Lean focus" on the farm where Lean methods are applied across the farm as a whole.

Costs:

- The implementation cost of the Lean 5S management was cheap. Approximately 6 (out of 25) of the consultancy days were spent on 5S aspects. Most of the equipment and reorganization of areas was done utilizing equipment already on farm. Training for staff was 2 hours per person in total.

Based on these assumptions fixed production costs after implementation of best practice decreased by 2% per kg, mainly due to 5% lower labour costs. In total, the entire costs of production were 0,5% lower as per kg of meat sold.

3.3. Expert Analysis

From the entries to the challenges and across the top 5, there is increasing evidence that management techniques such as Lean management and Six Sigma, not only are applicable on pig farms, but also have significant potential to increase efficiency. The increased

efficiencies as evidenced by the best practice, have the potential to save significant costs to the businesses. It was noted by the report supporting the best practice, that the labour 'savings' are often difficult to identify as labour is often reassigned to 'other tasks' that are awaiting farm workers. Marginal gains reported by Redman (2015) as the leading difference between profitable and unprofitable agricultural businesses can be difficult to identify using top level KPIs such as pigs weaned per sow per year or mortality. These tools tend to be too 'blunt' to identify the small percentage increases in efficiency. As part of the Lean methodology for example, there are tools such as value stream mapping that allow these subtle changes to be tracked at the process level.
The five best practices were all focused on farm level and management of production factors and improving KPI's. Pig farms are commonly only a part of a larger enterprise and overall profitability for the enterprise is an issue which was beyond the scope for this report.

3.4. Conclusions and advice to industry

The adoption of a management strategy needs to consider the following:

- A phased approach that builds upon accepted practices such as protocols and benchmarking into a more cyclical model of PDCA.
- An initial use of tools that have been 'proven' to work i.e. been accepted and embedded as a good practice on other farms such as 5S and process mapping.
- Review of progress with staff, it is the staff completing the tasks that are the source of both resources to address the challenges of increasing efficiency and the evaluators of change. Staff 'buy in' is key to the successful introduction of process change.
- A careful review of how to demonstrate the ROI to businesses using lean beyond estimated costs of labour savings and use of top line KPIs.

4. The Future

Further case studies in Lean management either through H2020 funding or other funding streams should be collated or produced that demonstrate clear pathways to increasing efficiency through better management techniques. In particular, translation of those techniques and implementation on farms in Eastern Europe would ensure a more balanced dissemination of the management techniques to that region.

Following from the work done by Melin and Barth (2018) a 'road map' to Leaner agriculture, supported by tools, resources and case studies showing their application could be produced to allow farmers to move through the 5 phases of Lean management and become more efficient. This would align production to the values identified by Redman (2015) in striving for marginal gains.

The challenge remains on how to increase pig farmer's uptake of principles to reduce costs using Lean and Six Sigma or other management tools. Further evidence and examples on how to better integrate Precision Livestock Farming (that make use of the core characteristics of pigs being a CITD system) and Lean and Six Sigma management tools are necessary to increase efficiency in pig and pork industry.

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Challenge: Increasing overall farm sustainability

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Introduction

Most industries are undergoing transformation towards sustainable production and the agribusiness is no exception. Sustainable production of pig meat involves many areas from selecting sustainable produced feed and feed ingredients, improving “on farm sustainable management” and continuous improvements of slaughtering, distribution and processing of meat and derived products. This transformation is driven by markets and legislators. However, the costs of the transformation demanded by legislators in western world is not necessarily covered in the price on the world market where meat is sold. Thus, there is a demand for an economically sustainable transformation in a competitive market. The present challenge was to evaluate implemented practices (best practices) aimed at “increased overall farm sustainability” for pig farms. The best practices presented in this report are economically sustainable and improve sustainability of food production, and thus may serve as inspiration for other farmers across Europe.

1. The Background to the Challenge

Increasing overall farm sustainability, the Brundtland Commission and UNs 17 Sustainable Development Goals

Back in 1987, the Brundtland Commission coined a definition of Sustainable development that is still accurate and relevant to today's challenge of "Increasing overall farm sustainability":

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs[3]".

The United Nations has set the direction for the worlds' development with 17 sustainable development goals (SDG). The 17 SDGs are a reminder that ongoing development worldwide must be made in such a manner, that it is compliant with the agenda of sustainability. The 17 SDGs are a guideline for governments, countries and companies to identify in which direction they should develop their solutions[4].

For the food and agricultural sector, several SDGs are relevant. Multiple firms in the processing industry focuses on the SDG, e.g. Danish Crown has selected a number of goals, where they believe they have the biggest impact. Among others, they focus on zero hunger (goal no 2), responsible consumption and production (goal no 12), Climate Action (goal no 13) and Partnerships (goal no 17)[5].

But why is a large company in the processing business focusing on SDG? And why should a European pig producer also focus on SDG? There a number of reasons why farmers and stakeholders should adopt an SDG approach to increase their overall sustainability, some of them are outlined below.

Focusing on increasing overall farm sustainability to help mitigate world's emergent crises.

We are currently facing multiple emergent worldwide crises directly caused by the human action: global warming and climate change, hunger and poverty, etc. In all of them agriculture is a central part of the crisis and at the same time agriculture holds a key role in solving the crisis.

Regarding global warming and climate change, in a European context, the agricultural sectors contribution to greenhouse gas emissions was 10%[6] by 2017, meaning that the agricultural

[3] https://www.iisd.org/topic/sustainable-development
[4] https://sustainabledevelopment.un.org/?menu=1300
[5] https://www.danishcrown.com/da-dk/baeredygtighed/vores-bidrag-til-fns-verdensmaal/
[6] https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-4a.html

sector has a shared responsibility for reducing the Greenhouse Gas emissions (see the list of FAO numbers on GHG emissions by livestock).

FAO numbers on GHG emissions by livestock

- Total emissions from global livestock: 7.1 Gigatonnes of CO_2-equiv per year, representing 14.5 percent of all anthropogenic GHG emissions.
- Cattle (raised for both beef and milk, as well as for inedible outputs like manure and draft power) are the animal species responsible for the most emissions, representing about 65% of the livestock sector's emissions.
- In terms of activities, feed production and processing (this includes land use change) and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of total emissions, respectively. Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products.
- Cutting across all activities and all species, the consumption of fossil fuel along supply chains accounts for about 20 percent of the livestock sector's emissions.
- On a commodity-basis, beef and cattle milk are responsible for the most emissions, respectively, contributing 41 percent and 20 percent of the sector's overall GHG outputs. (This figure excludes emissions from cow manure and cattle used as draught power).
- They are followed by **pig meat, (9 percent of emissions**), buffalo milk and meat (8 percent), chicken meat and eggs (8 percent), and small ruminant milk and meat (6 percent). The remaining emissions are sourced to other poultry species and non-edible products.
- Emission intensities (i.e. emissions per unit of product) vary from commodity to commodity. They are highest for beef (almost 300 kg CO_2-eq per kilogram of protein produced), followed by meat and milk from small ruminants (165 and 112kg CO_2-eq.kg respectively). Cow milk, chicken products and **pork have lower global average emission intensities (below 100 CO_2-eq/kg.)** (At the sub-global level, within each commodity type there is very high variability in emission intensity's, as a result of the different practices and inputs to production used around the world.
- Enteric emissions and feed production (including manure deposition on pasture) dominate emissions from ruminant production**. In pig supply chains, the bulk of emissions are related to the feed supply and manure storage in processing,** while feed supply represents the bulk of emissions in poultry production, followed by energy consumption.
- About 44 percent of livestock emissions are in the form of methane (CH_4). The remaining part is almost equally shared between Nitrous Oxide (N_2O, 29 percent) and Carbon Dioxide (CO_2, 27 percent). This means that livestock supply chains emit:
    - Gt CO_2-eq of CO_2 per annum, or 5 percent of anthropogenic CO_2 emissions (IPCC, 2007)
    - 3.1 Gt CO_2-eq of CH_4 per annum, or 44 percent of anthropogenic CH_4 emissions (IPCC, 2007)
    - 2 Gt CO_2-eq of N2O per annum, or 53 percent of anthropogenic N_2O emissions (IPCC, 2007)

At the same time, 1 out of 9 people in the world were still undernourished in 2017[7]. Across the world there is still poverty and hunger, and a lack of access to the vital proteins necessary for an optimal nutritional diet. Combined with a projected world population around 9,7 billion in 2050, from 7,7 billion today, there is an expected increase on food demand, especially from protein of animal origin.

With an increase in world population, and the subsequent increase of food demand, more resources are needed to produce food. However, resources to produce food are limited and even scarce, the food production, and thereby the farmers, need to continue increasing their efficiency and sustainability.

[7] https://sustainabledevelopment.un.org/sdg2

Focusing on increasing overall farm sustainability to meet consumers demands

For many farmers, overall farm sustainability is becoming a parameter of competition with increasing importance. More and more consumers are buying food, with a higher perceived level of sustainability[8]. Thereby overall farm sustainability is not only about what the world needs, but it is also a way of ensuring the commercialisation of its products.

Consumers are therefore asking for a higher level of perceived animal welfare, higher level of environmental friendliness, lower use of antibiotics, higher level of locally sourced food, etc. Farmers have to adapt to changes in consumer's preferences.

Trade-offs for each farm's sustainable development

Achieving *overall farm sustainability* is complex and not without trade-offs. Often, initiatives will not only have positive effects on overall farm productivity, economy and sustainability. We can find an example in pig production regarding initiatives to increase animal welfare which, at the same time, might increase productions cost. Therefore, it is important to be aware of the consequences, and thereby outlive the *do no significant harm* (DNSH) principle, as mentioned in some EU publications[9], meaning that the consequences of initiatives should do no significant harm. Thereby farmers should adopt a holistic approach to sustainable development.

2. Addressing the Challenge

The challenge for the present section of the Technical report was "**Increasing overall farm sustainability"**. Sustainability is the focus in several EU projects. In the consortium of the EU PIG project a total of 22 good practices addressing the challenge were collected. Good practices are farmers that are using or heavily being involved in the examples addressing the challenge. From these 22 good practises the top 5 were selected and denominated as "Best Practice".

3. EU PiG Best Practice

In order to identify the top five best practices for 'increasing overall farm sustainability' a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
    - Clarity of the practice being proposed;
    - Soundness of the concept;

[8] https://www.foodbusinessnews.net/articles/15162-sustainability-leads-off-five-trends-for-2020
[9] https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

    - Knowledge exchange potential from the proposed practice;
    - Scientific and/or technical evidence supporting the proposed practice.
- **Impact**
    - The extent to which the practice addressed the challenges pointed out by the R-Pigs Groups;
    - Clear/obvious benefits/relevance to the industry;
    - Impact on cost of production on farm and/or provide added value to the farming business or economy;
    - The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants into the industry.
- **Exploitation/Probability of Success**
    - The relevance of the practice to each MS or pig producing region/system;
    - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
    - Level of innovation according to the Technology Readiness Level (TRL););
    - The extent to which there are clear opportunities for the industry to implement the practice/innovation;
    - Degree of development/adaptation of the practice to production systems of more than one Member State.

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.
2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 - Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five practices followed a procedure in six steps:

1. All members of the TG had the opportunity to send their scoring sheets to the TG leader.
2. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five.
3. The TG leader standardized all individual scores by calculating Z-scores.

4. The first 10 practices have been ranked according to the average Z-scores of all participants of the Thematic Group. All other lower ranked practices have been excluded.
5. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
6. In a dedicated meeting, the Thematic Group discussed the results and finally decided on the top five best practices for each challenge based on the comments provided by the group.

3.1. Validation of the top five best practices

Winning Ambassador:

Best practice **'Sustainable produced ABF Rypsiporsas'** from Finland was selected as EU-Pig ambassador 2020 for the challenge 'Increasing overall Farm Sustainability'. (https://www.hk.fi/tuotteet/rypsiporsas/)

Rypsiporsas® pigs are fed with an optimised mixture of close-to-the-farm harvested crops that makes the meat more delicious and is rich in omega-3-fatty acids. The pigs are raised completely without antibiotics. The next goal of the farm is to make its production carbon-neutral.

*The calculated carbon footprint for Rypsiporsas is on our farm 2.5 and on average 3.3 kg CO2/kg (*the authors were not able to find any reference*). This is lower than that of pigs raised in other European regions, using mainly soybean-based feeds. To calculate our carbon footprint, we use the Biocode tool, which is based on ISO-standards and IPCC-recommendations.*

We have solar panels to increase our energy production. Feedstuffs make the biggest share of the farm's footprint, so we participate in a project to optimize the input/output-ratio of feed. The project studies conservation agriculture in terms of fertilization and soil cultivation methods. Effects of conservation agriculture on greenhouse gas emissions is shown by several studies, and it also reduces the risk of soil runoff.

Rypsiporsas, meaning Rapeseed Pork, is a concept developed and owned by HKScan Corporations (HK), in Finland[10]. The concept incorporates several elements of sustainability:

- Reducing the carbon footprint of the pigs;
- Nutritional features that are healthier;
- Upbringing without antibiotics;

[10] https://www.hkscan.com/en/market-areas/hkscan-in-finland/

- A greater extent of local sourced feed.

The main feature of Rypsiporsas is the relatively low carbon footprint, and the focus on bringing it even further down. With help from the VTT Technical Research Centre of Finland (Teknologian tutkimuskeskus VTT[11]) and the Biocode tool, they have measured the carbon footprint for pigs throughout the value-chain[12]. According to HK, the Biocode tool incorporates IPCC-recommendations, which should be praised. In general, the ability to accurately measure, identify the sources of greenhouse gas emissions and document the carbon footprint is essential, in order to bring down the carbon footprint. It should be noted that the authors are not experts on Life Cycle Analysis, and tools like Biocode. Therefore, the claim is not thoroughly tested.

There are also several features of the best practice that should appeal to more certain consumer groups. According to HK, the meat is also healthier and tastier, due to the mixture of feed, which the pigs are fed with[13]. Especially, Rapeseed seems to be central in that context, which is claimed to be a good source of omega-3 fatty-acids[14]. Rapeseed meal use has recently increased in EU as an alternative to soybean meal as the main dietary protein ingredient in pig diets. From a recent meta-analysis study, it was identified that in a nutritionally balanced diet, up to 30% rapeseed meal in growing-finishing pig diets, compared to a soybean meal-based diet, did not compromise growth performance (Hansen et al., 2020). Although rapeseed meal has been associated with increased levels of polyunsaturated fatty acids (PUFA), among them omega-3 and omega-6, evidence from literature does not clearly show the actual extend or magnitude of its effect (Grabez et al., 2020). It should be noted however, that the authors are not experts in nutrition, and it is beyond the scope of the report to validate this detail further.

As we have seen, only up to 30% rapeseed meal inclusion as a sole substitute of soybean meal has been identified for diets nutritionally balanced. However, the specific nutritional plan of the animals is not stated in the best practice. To properly assess whether the nutritional requirements of the animals are being sufficiently fulfilled and to identify any potential issues connected to the health of the pigs associated to eating a high levels of rapeseed meal, we should know the other feedstuffs used in the diet and the diet's specific nutritional composition, such as essential amino acids, minerals and vitamins.

Similarly, the pigs are raised without antibiotics. There is a growing concern of antimicrobial resistant bacteria and a need to reduce the use of antibiotics in pig production in particular and in livestock production in general. While producing without antibiotics will appeal to consumers, benefit commercialisation and reduce the cost of the drugs; it requires the

[11] https://www.vttresearch.com/en/about-us/what-vtt
[12] https://www.hkscan.com/fi/uutishuone/press-releases/2019/09/vtt-laski-rypsiporsas-elaimen-hiilijalanjaljen-c3407183/
[13] https://www.hk.fi/tuotteet/rypsiporsas/
[14] https://www.hk.fi/tuotteet/rypsiporsas/ruokavalio/

implementation of other measures that might increase production costs (e.g., change in diet nutritional characteristics, use of additives, biosecurity management, stock density, increased labour, etc.) and close attention must be paid to the health of the animals to prevent disease outbreaks.

In addition, pigs' diets are, to a great extent, locally sourced and based on alternatives to the conventional soya-based diet. Many consumers are worried about the large import of soya from South America and should therefore be pleased to know that soya is not a part of the feed for Rypsiporsas. The production of soya is known to be linked to deforestation of rainforests in South America, which has detrimental effects on climate change. Thus, decreasing, or in this case, eliminating the import of soya, will decrease the impact on climate change of pig production and thereby the carbon footprint of the meat (Morton et al., 2006).

Overall, the current best practice should be appraised for its holistic approach to a sustainable production of pigs. There are several aspects of the best practice incorporating different features of sustainability, especially when it comes to the preferences of the consumers. Furthermore, HK have with Rypsiporsas gone far in order to measure and document the carbon footprint of the pigs. And the ability to measure and document, is a key aspect in the development of sustainable production.

The following practices complete the EU-Pig top five best practices for increasing overall farm sustainability.

ERII heating system: Individualized intelligent regulation equipment, Spain
(http://www.empresasnuevas.es/es/directory/details/porcibalsa-sl.html)

Heating during first days of piglet life is crucial for survival and future performance. Heating plates used in conventional farms usually work all the time depending only on room temperature and not taking into account each litter's needs (e.g., age, health status, presence of animals using it or temperature).

Our system aims at reducing heating costs as well as increasing productivity, with an individual heating system (ERII) for new-born piglets. We use ERII (designed by Lamapor) that reduces energy costs and provides the best conditions to each litter, according to real litter needs. The heating plates are turned on/off depending on the presence/absence of animals on them and, thanks to the presence of probes, the plates automatically adjust its temperature according to the litter's specific needs. The farmer can control it from his mobile (Android/iOS) and rapidly modify the temperature when there are problems within a litter. Farmers can receive notifications when problems/issues occur.

The system installation is easy and fast. Compared with the conventional heating plates' installation, the ERII system needs one extra day of work. The price per site is about €100, with approximately a 4–year return (only taking into account the energy). The return on investment is even better once the improvement in production (less mortality rate) is counted.

The ERII Heating System: Individualized Intelligent Regulation equipment, is a system for heating plates for new-born piglets. The system is characterized by its ability to function in accordance to the presence/absence of piglet on them as well as its ability to adjust the temperature according to the litters' specific needs. The farmer can control the system from an Android/iOS unit. There are several aspects in terms of sustainability in this case:

- Productivity and thereby resource efficiency;
- Animal welfare;
- Energy savings.

As mentioned, proper heating is essential during the piglets first days of life. Due to their lack of body fat reserves and high body surface per body volume ratio at birth, piglets are highly susceptible to hypothermia. Hypothermia in new-born piglets can lead to death within the first three days of live, in less extreme cases it can lead to impaired colostrum and milk intake which will have negative consequences throughout the piglet's upbringing. With the claim, that the heating plates are able to increase productivity (e.g., reduce piglet mortality, increase growth), the heating plates contributes to a sustainable development by ultimately increasing the kg of meat produced by a sow.

Furthermore, the best practice also includes an animal welfare aspect. Pre-weaning mortality in pig farms is not only a production issue, is also considered a welfare concern. Therefore, any practice that contributes to increase piglet early survival is also raising herd's animal welfare level. Nonetheless, management of pen temperature in the farrowing room is a complex aspect of pig production. While piglets' requirements are above 33ºC at birth, sows have a comfort temperature range of 18-20ºC, above which start displaying thermoregulatory behaviour and above 25ºC can start showing heat stress symptoms (Herpin et al., 2002; Muns et al., 2016). With the information provided we can't assess the impact of the heating system might have on sows and we can only discuss its benefits in theory.

Last, the best practice is providing the farmer with savings in energy. According to the best practice description, there is a reduction in the heating cost, up to 40 %. Therefore, the payback period, is also stated to be only 4 years. By reducing heating energy requirements, there is an improvement of sustainable on farm production, especially if the heating is being produced using fossil energy.

Overall, the best practice is a fine example of innovations in equipment that are necessary for a sustainable development. The best practice, according to the provided description, is able to increase productivity for a relatively low investment, and it has the potential to increase herd's welfare while it's able to save energy. In large scale, at multiple farms, there could be considerable sustainable gains, both considering animal welfare and climate.

Micro scale digester, Belgium
(https://www.innovatiesteunpunt.be/en)

Faeces and urine are separated under the slatted floor. The sloped floor makes sure the urine is collected in a urine gutter, while the faeces are scraped with a newly developed scraper towards a collection pit. The immediate separation and the frequent removal results in the prevention of production of ammonia emission. So, this is not an end-of-the-line technique.

The air inside the stable is better than on the average farm, so the health for farmers and pigs is improved. The fresh faeces are digested in an on farm small scale mono-digester that produces heat and electricity. First Bart reconverted a small existing building in order to experience the technique in practice. He was satisfied with the excellent in-house conditions both for farmers and pigs and the practicability of the technique. This gave him confidence to plan and construct a new and bigger building.

The idea of the best practice, and the micro scale digester, is to immediately separate the faeces and urine in the stables, which give a better input to a farm micro scale digestor, which in return produces heat and electricity. According to desk-research, and thereby not validated, the separation happens every 6 hours[15]. There are therefore several positive consequences and overall farm sustainability aspects in this relation:

- Better animal welfare and performance;
- Better working conditions for staff and less odour and ammonia for environment;
- Production of heat and energy based on circular resources;
- Decreased methane emissions from manure storage and handling.

The separation of faeces and urine and its frequent removal from the pen should contribute to a proper pig health and increase the animal welfare and performance. Slurry, usually stored in manure pits located underneath the pens, is a source of gas and emissions that can reduce pig and staff's welfare and, in some cases, also reduce health. Ammonia is arguably the most relevant but not the only gas produced by slurry (e.g., CH4, H2S, CO2, etc.). In addition, specific pathogens present in slurry can contribute to disease transmission across production batches. Although in the literature there are very limited evidence of the potential benefits of this novel slurry management system (due to its limited implementation in the sector), it has potential to facilitate improvements in farm's productivity (e.g., pigs growth efficiency) and overall welfare (for both pigs and staff).

The 'cleaner' air should furthermore improve the working conditions for the staff at the farm. According to Bart Vanackere it is "*more comfortable to be inside his stable, than a stable where*

[15] https://www.vilt.be/schonere-stallucht-op-vlaams-varkensbedrijf

the manure is being stored below the slatted floor"[16]. Likewise, its claimed that the surrounding environment to the farm and stables, should have less odour nuisances.

By separating the faeces and urine, it is possible to use the fresh faeces in a small farm scale mono-digester, and thereby produce heat and electricity. The farm is utilizing already existing resources in a circular manner, and they should therefore be able to make some savings on heat and electricity – in terms of costs and resources. By using the manure for the production of biogas, greenhouse gas emissions and emission to the environment while stored and when being spread on fields will also be lower (Monteny et al., 2006). Presumably, by separating urine from faeces at the collection point, ammonia emissions can be reduced significantly. Ammonia emissions have been identified as a threat to biodiversity in different areas across EU. At the same time, the loss of nitrogen via ammonia also reduces the fertilising value of the slurry. The current best practice has the potential to reduce environmental impact of farm's activity while improving nitrogen use efficiency of the system.

Overall, the system holds several aspects worth considering in terms of increasing the overall farm sustainability. The system has several sustainable outputs, for both the animals, the working staff and the surrounding environment. Despite the high investment required to change the slurry collection method and to install a mono-digester, it is a system worth considering for many farmers, especially for new build farms.

NatureLine low-emission label pig production finisher barn, Austria
(https://nature-line.com/index.php & http://www.hofkultur.at/familie-pamminger/)

The opportunity to increase farm sustainability arose to fulfil requirements of pork label program "Hütthaler" and "FAIR HOF" issued by HOFER in Austria. Requirements were: construction of new finisher house, low-Emission, Welfare Pig house ensuring fresh air, labour efficiency and higher performances. The pig house provides 1,4 m^2 per pig including a warm resting area, an outdoor area covered by a roof with solid flooring at the feeding area and slatted floor at the front with drinkers to encourage pigs to defecate there. Spotmix Multiphase Feeding system and natural ventilation were installed. Straw for resting area is placed manually and used for enrichment of pigs to improve the thermic micro conditions and the welfare of pigs.

NatureLine concept saves energy, reduces environmental impact including odour and ammonia emissions and improves pig welfare. The system requires more intense management due to functional separation of resting, activity and manure area.

The best practice is a combination of concepts and systems:

[16] Translated from https://www.vilt.be/schonere-stallucht-op-vlaams-varkensbedrijf

- A production and marketing concept called FAIR HOFF, between Hütthaler (a processing company[17]) and HOFER (a supermarket chain in Austria[18]).
- A production and inventory system, called “NatureLine – low emission stables”[19]
- The Pamminger-Family is a producer in Austria, who produces pigs for the FAIR HOFF concept, some of them in the NatureLine low emissions stables[20].

There are several aspects of overall farm sustainability in the combination, some of them outlined below:

- Consumer driven sustainable development;
- Improved animal welfare;
- Reductions in emissions and odour.

The farm is operating and producing under a brand and a concept, which are driven by a retailer company and ultimately, by the consumers. The FAIR HOFF provides a minimum fixed price.

The concept FAIR HOFF and the NatureLine stables claim to improve animal welfare. There are minimum requirements to the amount of space per pig and time used in managing the pigs[21]. Animal welfare can be difficult to assess in farm animals, it usually requires recording a combination of behaviour and physiologic parameters to properly assess welfare. Therefore, it is difficult to properly assess the best practice impact on welfare. Nonetheless, it is known that welfare will increase with increasing the amount of space per animal and providing the animals with straw. The welfare benefits of using straw as enrichment material are well known (Van de Weerd et al., 2009; Buijs & Muns, 2019), The description of the best practice does not provide comprehensive data for all aspects of the production. Hence, it is not possible to assess a more complete evaluation of animal welfare. Obviously, enrichment material should be provided in all parts of the production cycle for all groups of animals to obtain the best possible welfare.

Furthermore, it is claimed that there are lower emissions and less odour produced thanks to the NatureLine concept[22]. It has been highlighted in a previous best practice the importance of reducing gas emissions and its impact on farm sustainability. However, no detail is presented explaining how such improvement is achieved.

Overall, the current best practice has potential to increase overall farm sustainability through welfare, performance and commercial improvements.

[17] https://huetthaler.at/unternehmen/
[18] https://www.hofer.at/de/ueber-hofer/unternehmen.html
[19] https://nature-line.com/en/natureline-low-emission-animal-welfare-stable
[20] http://www.hofkultur.at/familie-pamminger/
[21] https://www.hofkultur.at/hofkultur-grundsaetze-schwein/.
[22] https://nature-line.com/en/natureline-low-emission-animal-welfare-stable

Sustainable sow farm, Denmark
(https://pigresearchcentre.dk/)

The slurry is used on the farm's biogas plant and from there back as fertilizer to the fields. It is also a goal to reduce spraying against pests. The following strategic projects were introduced:

- *Biogas based on slurry combined with food waste from households as well as cut straw.*
- *Introduction of Agriculture cultivation methods based on the principles of circular economy.*
- *Cultivation of horse beans to replace soya beans.*
- *Cultivation of willow for energy purpose.*
- *A biogas plant was built. At the same time, methods of storing and handling biological waste and straw (which in cut condition should be added to the slurry coming from pig production) were implemented.*
- *Introduction of Agriculture cultivation methods based on the principles of circular economy: production system where you sow directly on top of the stub field (a special sowing machine had to be purchased). "Plough free Plant production" provides much more life in the soil surface of worms and mites*.

The best practice is displaying a range of different initiatives aimed to increase overall farm sustainability. The initiatives range from different production methods in the fields, e.g. Plough-free cultivation to initiatives regarding biogas. The ability to utilize all the benefits of manure is key to increase farm's sustainability, and thereby realizing the value in manure.

The best practice mentions conservation agriculture as one of the initiatives. Conservation agriculture has recognised benefits such as increasing the value and life in the soil. However, it also has potential such as greater use of pesticides since you cannot plough.

The best practice also lists an initiative to cultivate horse beans (assumed locally) instead of soybeans (assumed imported). As discussed in a previous best practice, sourcing feed ingredients for animal production locally, have positive climate effects such as reduced emissions and carbon footprint of the farm due to transport and indirect land usage.

Building of a biogas plant, including storage, handling of biological waste etc., which is the major initiative of the best practice, has several positive effects. For example, it is claimed that all electricity and heat at the farm is produced at the biogas plant, and that the only fossil energy used is for the machines. It should be noted however, that documentation was not provided. Furthermore, the methane emissions from storing and spreading the manure will be significantly lower once the manure has been digested in the biogas plant first (Monteny et al., 2006).

Overall, the range and amount of initiatives are ambitious and have the potential to increase farm's overall sustainability. The best practice can be a good example for pig farmers willing to advance in their land and manure management.

3.2. Cost and benefit analysis of the EU PiG Ambassador

Best practice 'Sustainable produced ABF Rypsiporsas' from Finland was chosen as EU-Pig ambassador 2020 for the challenge 'Overall farm sustainability'. Rypsiporsas® pigs are fed with an optimised mixture of close-to-the-farm harvested crops and are raised completely without antibiotics. The farm invested in two feed storage tanks (for own-produced feed) and solar panels to decrease energy costs and increase environmental sustainability of the farm. The costs and benefits of this system have been analysed taken into account the estimated changes in performance parameters being the result of introducing the system and the necessary investments on the farm. We also included the reported costs and benefits observed by the farmer. Based on the real farm data and calculations with the Interpig model the following parameters of the farm have been assumed:

Benefits:

- Due to antibiotic-free production the number of medicated pigs has clearly decreased. The net effect of medical costs is quite difficult to calculate because by using antibiotics the farm could possibly save some pigs, which might have died. However, the finishing mortality parameter is low – 1.2% to 1.4% depending on the cycle. The net cost saving of medicine costs is estimated as €1000/year that is €0.27 per pig sold.
- The farm uses optimised mixture of close-to-the-farm harvested crops. The production technical efficiency parameters have remained roughly unchanged. In the case of purchased protein concentrate feed, savings were about 35% lower compared to before, which is over €20,000/year. Thus, the total costs of feeding decreased by 8.8% and are on the level of €0,64/kg cold weight. Addition of beans improved crop rotation dominated by barley.
- The farm invested also in solar panels to increase energy production. In a pig farm, the panels can be utilized quite efficiently, as energy consumption is highest in midsummer when the ventilation is running at full capacity. In mid-winter, electricity consumption is the lowest. The costs of energy decreased by 17%.

Costs:

- Investment in two new storage tanks: one for oatmeal-based protein food and a second one for rapeseed oil, cost about €15,000.
- The farm invested also in solar panels to increase energy production. Nominal power of solar panels is 16 kW. The investment costs were €18,000 euro (tax 0%).

Based on these assumptions **variable production costs** after implementation of best-practice **decreased by 7.4% per kg of meat**, mainly due to lower feeding costs (by 8.8%), vet+med costs (by 7%) and energy costs (by 17%). On the other hand, an increase was observed in case of **fixed costs of depreciation 3,6% per kg**, as a result of investments. In total, the entire costs of meat production were **5.1% lower as per kg of meat.**

Rypsiporsas® pigs produced in the sustainable farming system are better priced than the conventional pigs and have less fluctuating demand. Prices can be ca. 15-20% higher than the average price for pork, which significantly improves farm profitability.

3.3. Expert Analysis

First of all, it should be acknowledged that the ambassador best practice "Sustainable produced ABF Rypsiporsas", and the other four best practices were among many qualified candidates.

In the process of writing this technical report, it became clear that the cases varied to a great extent. Among the candidates there were concrete innovative solutions and technologies, such as the *ERII Heating system* which presented a solution to a very specific problem but with important repercussions. Also, among the candidates there were best practices more comprehensive and holistic in their approach, e.g. the case *NatureLine low-emission label pig production finisher barn*, which combined a production system with a marketing concept based on sustainability.

It is no surprise that the best practices are quite different from one to another and represent a broad spectre of sustainability. Sustainability is broad, complex and an all-including topic.

It should be noted that the cases represent different settings and contexts. What might work efficiently in Denmark at *Sustainable sow farm* and their plough-free cultivation method*,* might not work as efficiently in other countries.

It should be stressed that it was outside the scope of this report to follow up with each supplier regarding comprehensive documentation regarding claims. Thus, mainly the initially submitted documentation was included in this analysis. For each best practice, a limited further inquiry and online review of the best practice has been performed.

Documentation was not dealing with the trade-offs between different aspects. For sure farmers were dealing with these trade-offs, but they found their way in building the story and integrated the solutions into their farming systems.

The ambassador best practice "Sustainable produced ABF Rypsiporsas", demonstrated a comprehensive holistic approach towards increasing overall farm sustainability, in their:

- Reduction of carbon footprint
- Incorporation of nutritional features that is healthier
- Upbringing of the pigs without antibiotics
- Increase in locally sourced feed
- Etc.

Likewise, should the ambassadors' efforts to measure and document the carbon footprint be acknowledged. Measurement and documentation are central in the endeavours to improve sustainability.

3.4. Conclusions and advice to industry

Based on the five best practices presented, the following conclusions and advice can be made:

- Focus on specific parts of sustainability and implement those solutions that are practical or feasible, followed by demonstrating the story of the complex nature of sustainability and the added value of your solution(s).).
- Measuring and documenting the effects of implemented actions should be done to track the sustainable development and to further develop appropriate actions to increase farm sustainability. It would be helpful if there is a sustainability benchmark available for pig farms in Europe.
- Communicate to consumers as well as the industry, how the implemented actions increase sustainability.

To increase overall farm sustainability, some farm practices have been listed below. It should be noted that this is not a complete list of farm practices to increase sustainability – the list includes actions from the five best practices presented in this report.

The farm practices listed are farm practices that pig producers can implement to increase their overall farm sustainability. However, not all the practices will be relevant for all producers – this will depend on their specific production system and context. Nevertheless, the list can act as inspiration for all producers.

- Delivering manure and slurry to a biogas plant to decrease methane emissions and obtain energy.
- Decreasing ammonia levels in the pig houses. E.g. by using a urine faeces separation method and removing slurry from the pig house frequently.
- Using locally sourced feed, e.g. to decrease import of soybeans.
- Decreasing usage of antibiotics.
- Increasing animal welfare, e.g. by installing appropriate heating systems for the piglets and by providing the animals with straw for enrichment.

4. The Future

Farm sustainability encompasses many aspects, as can be seen from the five best practices presented in this report. Therefore, increasing overall farm sustainability should focus on implementing specific solutions and actions that fit in a holistic view, so that one part of farm sustainability is not becoming the only focus point. More insight in practical trade-offs are needed. In recent years there has been an enormous focus on climate change and decreasing the carbon footprint from all parts of society, including the agricultural production.

The focus on climate is completely justified, however, for people who do not have insight into the complexity of sustainability, sustainability has become synonymous with “climate change”

and for some “environment”. But very few understand the complexity of sustainable production. Therefore, communicating sustainability in all aspects of farming is important, whether it is animal welfare, biodiversity, nutrient management or climate change. Coming back to the four stated SDG goals, it is clear that farmers primarily deal with climate change. However, we expect that partnerships and responsible consumption will also be addressed in the near future to contribute to the SDG goal of zero hunger.

One key point in increasing overall farm sustainability is that the producers can access counselling on which practices will be feasible on their farm and which practices will increase sustainability the most. To ensure this, it is also important that counsellors are informed about farm practices for increasing farm sustainability, and that they are continuously informed about the development of farm practices and new knowledge within this area.

Sustainability is really a “hot topic”, therefore, there is a lot of research going on, on how to increase sustainability and documenting how specific actions contribute to farm sustainability. Hence, collecting knowledge on sustainability and actions related to sustainability, should be an ongoing process, to ensure that new knowledge is made available to consultants and farmers.

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