IMPEL PROJECT: "*ENERGY EFFICIENCY IN PERMITTING AND INSPECTION*", EXCHANGE OF EXPERIENCES ON HOW THE ISSUES OF ENERGY EFFICIENCY AND REDUCTION OF GREENHOUSE GASES ARE DEALT WITH IN PERMIT PROCEDURES AND INSPECTIONS IN THE MEMBER STATES – DEVELOPMENT OF A TEMPLATE FOR DOCUMENTS AND DATA REQUIRED REGARDING ENERGY EFFICIENCY IN THE PERMIT APPLICATION (2011/2012)

2012/04/ANNEX 3

INTENSIVE REARING OF POULTRY AND PIGS

SUMMARY OF ENERGY-RELATED INFORMATION FOR THE INTENSIVE REARING INDUSTRY AND PROPOSAL FOR THE SECTOR SPECIFIC ANNEX TO THE DRAFT APPLICATION FORM FOR ENERGY EFFICIENCY

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IMPEL

European Union Network for the Implementation and Enforcement of Environmental Law

In cooperation with

BiPRO

Beratungsgesellschaft für integrierte Problemlösungen

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1 Summary of Energy-related Information – Intensive Rearing

In the following, energy (efficiency)-related information has been extracted from the **Draft Reference Document on Best Available Techniques for the Intensive Rearing of Poultry and Pigs (IRPP BREF; Draft 1, March 2011).** This document is a working draft of the European IPPC Bureau (BREF review) and as such still contains a number of **proposals for amendments, corrections and comments** in track-change mode (e.g. 'strikethrough': text from the previous BREF deleted; 'red text': text inserted during the review). The extracted information has been complemented with **contributions from relevant experts.** The summarised information serves as a basis for the development of a proposal for the sector specific supplements to the Draft Application form for Energy Efficiency in Chapter 2.

1.1 Intensive Rearing or Poultry and Pigs

The scope of the BREF for intensive rearing of poultry and pigs is based on Section 6.6 of Annex I of the IED 2010/75/EU of the European Parliament and of the Council of 24 November 2010, on industrial emissions (Integrated Pollution Prevention and Control) (Recast). It addresses **'Installations for the intensive rearing of poultry or pigs'** with more than:

a. 40000 places for poultry

b. 2000 places for production pigs (over 30 kg), or

c. 750 places for sows'.

The following relevant farm activities are described, although it is acknowledged that not all of the activities will be found on every farm:

- **farm management (including maintenance and the cleaning of equipment)**
- **feeding strategy (and feed preparation)**
- **rearing of animals**
- **collection and storage of manure**
- **on-site treatment of manure**
- **landspreading of manure**
- **waste water treatment**

The environmental issues associated with the above listed activities include:

- **the use of energy and water**
- **emissions to air (e.g. ammonia, dust, green house gases)**
- **emissions to soil and groundwater (e.g. nitrogen, phosphorus, metals)**
- **emissions to surface water**
- **emissions to waste other than manure and carcasses**

Environmental issues have only been on the agricultural agenda for a relatively short period of time. It was not until the 1980s that the environmental impact of intensive livestock farming really became an issue, although there was already an awareness of the contamination of soil due to excess manure application and of odour increasingly becoming an issue due to an increasing population in the rural areas. The growing concerns about climate change raised the attention of the emissions from the entire livestock sector. According to the FAO, about 12 % of greenhouse gas in the world is related to livestock production. On a global scale, the greater contributions come from enteric fermentation of ruminant animals and deforestation related to feed crops, whilst emissions from pigs and poultry contribute to a smaller extent.

Notable advances have been achieved in the relatively short period of time in pig and poultry sectors. **Environmental and welfare awareness with legal obligations have impulsed technical improvements that renewed the production means to unprecedented environmental performances.** One of the major challenges in the modernisation of poultry and pig production is the need to balance the reduction or elimination of the polluting effects on the environment with increasing animal welfare demands, while at the same time maintaining a profitable business. Food security has become a real concern in public opinion. The European agriculture operates in the global food market with technical tools that at once aim to comply with economic efficiency, animal and consumer health safeguarding and environmental protection.

The attention paid to a number of environmental aspects associated with the intensive rearing of poultry and pigs has increased. The key environmental aspect of intensive livestock production is related to the natural living processes, i.e. that the animals metabolise feed and the excreted nutrients are nearly all eliminated via manure. **The quality and composition of the manure and the way it is stored and handled are the main factors determining the emission levels of intensive livestock production.**

1.1.1 On-farm manure processing

To reduce nitrogen losses from livestock manures, it is important to manage the manure effectively so as to improve utilisation of the nutrient content, thereby reducing mineral fertiliser requirement. Currently, where farmers have insufficient land to accommodate the manure being produced they are encouraged to export manures to their neighbours or look to reduce livestock numbers. Movement of manure is an added cost and a source of problems with biosecurity, odour and road safety, whilst reduction in livestock numbers may not be economically viable.

Some countries have opted to encourage the treatment of livestock manures so as to improve their manageability and utilisation. It is important that such manure treatments do not increase losses of gaseous forms of nitrogen (N) or of other greenhouse gases. FYM is not often treated, but in some cases it is composted, dried and treated anaerobically. The treatment of slurry is of minor importance in Europe. In some southern countries (IT, CY, PT) solids separation seems of practical importance possibly because of the value ascribed to the organic matter recovered. Amongst all other treatment techniques, anaerobic and (to a lesser extent) aerobic treatments have some use. **Anaerobic digestion has increased interest due to the rewards of biogas production.**

Manure treatment prior to or instead of landspreading may be performed for the following reasons:

1. **to recover the residual energy (biogas) in the manure** (Using the energy value of manure: organic compounds are converted to methane by the anaerobic digestion of manure; methane can be recovered and used as a fuel at the farm or in the neighbourhood)
2. to reduce odour emissions during storage and/or landspreading
3. to decrease the nitrogen content of the manure to prevent groundwater and surface water pollution as a result of landspreading and to reduce odour
4. to allow easy and safe transportation to distant regions or to other sites for application in other processes

Anaerobic digestion is carried out in a biogas reactor in the absence of oxygen, and consists of the methanogenic anaerobic decomposition of organic matter. Most but not all organic matter can be decomposed via this fermentation process without chemical or physical pre-treatment. It **produces useful methane** and a stabilised residue that can be applied to land as a soil conditioner and source of nutrients. Anaerobic digestion with biogas production has benefits in terms of manure treatment as **it reduces greenhouse gas emissions**, producing a digested product with reduced pathogen levels and fewer odours on spreading, whilst the **biogas provides a source of renewable energy**. The **biogas can be used for heating or for generating electricity**.

Anaerobic lagoons can be applied for pig slurry in warmer climates. The lagoons serve as storage for waste water as well as for the biological treatment. Designs are site-specific, in Italy for example, **covers are used to collect biogas**.

1.1.2 Installations for heat and power production

On-farm solutions exist to use self produced renewable energies that can reduce the need to buy other forms of energy. Solar or wind-driven generators are more frequently installed with both the intention to cover part of the farm power need and for sale on the market.

Electricity production from photovoltaic panels is possible in pig installations because large roof surfaces are available on pig houses. Roof slopes fall in the useful range of 26 – 45 % that allows a good efficiency of the system. At the time of drafting (i.e. 2011), the cost for the purchase of equipment is high, investment returns are long (10 to 20 years) and on-farm uses of the produced energy are not economically convenient. Photovoltaic panels cost EUR 600 – 800 per m², and the installation of a small windmill, up to 12 m in height, costs around EUR 500/kWh.

Livestock production is a sector where **anaerobic gas production** might be interesting, due to the availability of organic matter. After a first wave of digesters that were built in the 80s and 90s had little real success, **anaerobic treatment is in a new phase of development in Europe**, especially due to attractive prices that have been gained by the produced electricity that is classified as renewable.

Heat production using biomass (or wood) firing requires a whole infrastructure to benefit from the produced heat. These requirements, that normally are not present in existing farms, consist of the network of heating, hot air blowers or, heating floors or fins. Boilers must be installed close to buildings, because the distribution piping net is relatively expensive.

This heating system is profitable when heat needs are large and stable, as happens with multiple houses or users. Three examples from Brittany, France, are presented for the heat requirements in mixed poultry and dairy farms combined with the farmer's house.

Workshop	Heat needs (Boilers capacity)
3000 m^2 poultry housing + 230 calf places	300 kW
1800 m^2 poultry housing + farmer's house	240 kW
600 m^2 poultry housing + farmer's house + hot water in milking room	100 kW or 60 kW + 8 infrared supplementary heaters

Table 1-1: Examples of mixed farms heating needs that can be supplied by warm water produced by wood boiler [Table 2.19; IRPP BREF Draft 1, 2011]

Strategies of energy savings from heating techniques can be put in place for the use of energy directly on farm, like heat recovery by exchangers or pumps.

Heat recovery by heat exchangers

Several solutions for the recovery of energy from various media are available that use heat exchangers based on three major principles:

- **Air/air heat exchangers**: The principle consists of warming-up the air that enters the houses by the heat of the waste air that exits the house. In poultry production, the heat is transferred through plates that separate the flows that enter and exit the house. The heat exchangers are used during the starter period when only minimum air renewal and humidity abatement (10 %) are necessary. These exchangers are similar to MCV (mechanical controlled ventilation) double-flow equipment. They allow economy of 30 – 40 %, and can only complement centralised air heating.
- **Air/water heat exchangers**: Aluminium plates (commonly called fins) are placed in the centralised extraction shaft. The heating water located in line with these fins is heated by the warm extracted air and is closed-circuit circulated to a fan-convector which returns the energy indoors. Electric consumptions only refer to the pump which ensures the circulation of the water. The maximum recorded efficiency is the increase of 12 °C of the incoming air.
- **Air/ground heat exchangers** ('Canadian well'): The exchangers use the inertia of the ground to smooth the seasonal variations of temperatures and, consequently, to improve the conditions of thermal comfort of the animals. They are used to preheat the air in winter as well as to cool it in summer, and to decrease the variations of temperature.

Heat Pumps

Heat pumps consist of two thermal exchangers, a compressor and an evaporator where a coolant liquid allows for drawing energy from a source of heat (ground, scrubber water, biological reactor) and for returning it to the building. The recovered heat can be used to produce sanitary warm water, to feed a heating circuit (warm water buckles) or to ensure the heating of the buildings by means of fan convectors. In liquid form, the fluid collects calories to evaporate from sources of energy, such as water, ground or air from a biological engine. A compressor turns the fluid into gas and circulates it to a condenser where the heat is exchanged to the fluid of the heating circuit, while cooling and returning in a liquid state. A pressure reducer then optimises the return of the fluid back to a gaseous state.

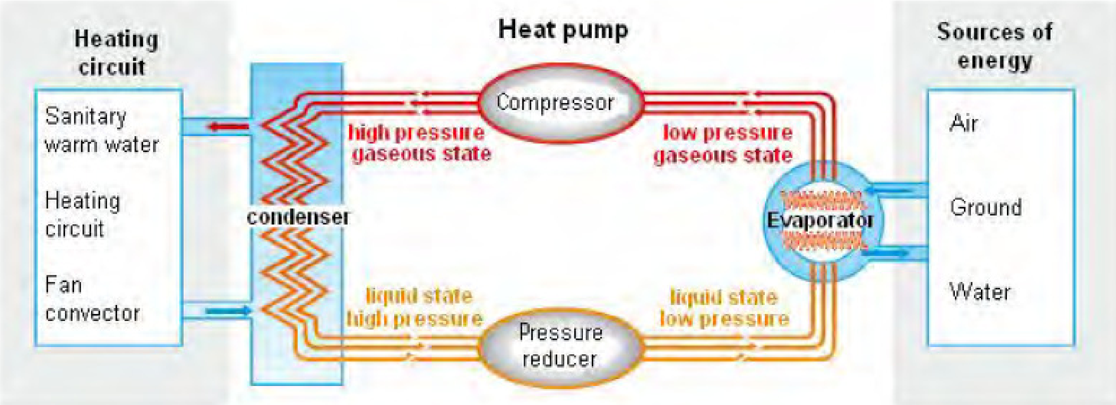

Table 1-2: Operating principles of heat pumps [Table 2.49; IRPP BREF Draft 1, 2011]

Biogas energy production

Anaerobic digestion is a process of degradation of the organic matter without oxygen that leads to the **production of biogas (mainly constituted by methane)**. **Biogas can be used as fuel** for a co-generator **to produce electricity** to sell it to the commercial network and **to produce heat**. The thermic energy that develops in the combustion is reused according to the farm's needs such as for homes, rearing houses, greenhouses and piglet heating.

1.1.3 Monitoring and control of consumption and emission

Computerised registration and the administration **of costs, inputs and outputs is increasing** and is already common on large enterprises. Where measuring is applied, water gauges, **electric meters** and computers for indoor climate control are used.

Currently, farmers do not normally monitor and control emissions to air unless specifically required to do so as a result of complaints from neighbours. These complaints are usually related to noise and odour emissions. In Ireland, monitoring of emissions and sampling points for air (odour), noise, surface water, groundwater, soil and waste are required under Integrated Pollution Control Licensing arrangements.

For further information **see Chapter 2.15 of the Draft IRPP BREF**.

1.2 Consumption levels of intensive poultry and pig farms

This chapter presents data on consumption and emission levels associated with activities on farms for the intensive rearing of poultry and pigs. It aims to give an overview of the ranges that apply to these sectors in Europe and so to serve as a benchmark for the performance levels associated with the techniques presented in Chapter 1.3.

1.2.1 Introduction

The following table summarises the **key environmental issues of the major on-farm activities**.

Major on-farm activity	**Key environmental issue**	
	Consumption	**Potential emission**
Housing of animals: - the way the animals are stocked (cages, crates, free) - the system to remove and store (internally) the manure produced	Energy, litter	Air emissions (NH3), odour, noise, manure, greenhouse gases
Housing of animals: - the equipment to control and maintain the indoor climate and - the equipment to feed and water the animals	Energy, feed, water	Noise, waste water, dust, CO2
Storage of feed and feed additives	Energy	Dust
Storage of manure in a separate facility		Air emissions (NH3), odour, emissions to soil, greenhouse gases
Storage of residues other than manure		Odour, emissions to soil, groundwater
Storage of carcasses		Odour
Unloading and loading of animals		Noise
Application of manure on land	Energy	Air emissions, odour, emissions to soil, groundwater and surface water of N, P and K, etc., greenhouse gases, noise
On-farm treatment of manure	Additives, energy, water	Air emissions, waste water, emission to soil
Milling and grinding of feed	Energy	Dust, noise
Treatment of waste water	Additives, energy	Odour, waste water
Incineration of residues (e.g. carcasses)	Energy	Air emissions, odour

Table 1-3: Key environmental issues of the major on-farm activities [Table 3.1; IRPP BREF Draft 1, 2011]

The central environmental issue for poultry and pig sector emissions is manure: the amount produced, composition, method of removal, storage, treatment and its application on land.

1.2.2 Energy consumption

The **energy consumption** of livestock farms **varies substantially** depending on the production system, as their organisation and production characteristics are not homogeneous. Another **important factor** that influences the energy consumption is the **climatic conditions**.

The collection of data on energy consumption is also difficult, as energy consumption is usually variable and generally poorly or not monitored. Units will differ depending on the type of energy carrier and will thus need converting into kWh or Wh per day to allow comparison to be made. Data can be expressed per day per head, but if calculated over a year the seasonal effects of weather on ventilation and heat inputs can be averaged out.

The **reported energy use** on poultry and pig farms and their main findings are presented in the following sections.

Poultry farms

As regards **layer farms,** artificial heating of the housing is not commonly applied, due to the low temperature needs of the birds and the relatively high stocking density. Activities requiring energy are:

- heating the water in winter;
- feed distribution;
- housing ventilation;
- lighting, this requires high consumption levels in order to artificially maintain a constant period of high illumination during the year, so as to at increase egg production during the periods of the shortest days;
- egg collection and sorting: consumption is about 1 kWh per 50 – 60 m of conveyor belt;
- operating the sorting and packaging facilities.

Estimates of **energy consumption in layer houses** are shown in Table 1-4.

Animal	**Gas**		**Electricity**	
	Cage	**Non cage**	**Cage**	**Non cage**
Pullets	1.42	1.42	0.45	0.45
Layers	Not used	3.15	Not used	2.45

Table 1-4: Estimate of consumption of energy (kWh/animal) for pullets and laying hens [Table 3.17; IRPP BREF Draft 1, 2011]

On **poultry meat farms**, the **main energy consumption** is related to the following areas:

- local or ambience heating in the initial phase of the cycle, this is effected with hot air heaters, and accounts for around 80 % of the consumptions;

- housing ventilation, which varies between the winter and summer periods from 2000 to 12000 m^3/h per 1000 heads, or 5 m^3/h per kg of LW in France and moderate climates;
- lighting;
- watering, distribution and sometimes preparation of feed.

In addition to electricity and the fuel to run tractor engines and generators, **gas propane is an important source of energy**. Propane gas is mostly used for heating houses, and accounts for approximately 2 % of the production costs in poultry meat production. Gas heating allows quick raise of temperature at the birds arrival. The big volumes of air flowing in the large poultry houses produce power requirements of about 85-100 W/m^2. Gas consumptions depend on the type of ventilation and the reared animal, and generally range from EUR 3.5 to 5.0 per m^2 per year for poultry meat species (broiler, turkey and duck).

Approximately 50-70 % of the heat losses occur from roofs that hence need to be well isolated. The following table shows the amounts of losses from roofs that occur in a building of 1200 m^2 of area. For the different levels of insulation and of outdoor temperature, the energy that is lost and the amount of propane needed to replace the losses are displayed.

Outside temperature	Insulation with 40 mm of foam PU (1) U= 0.780 (2)		Insulation with 50 mm of foam PU U= 0.638		Insulation with 120 mm of fibreglass + 40 mm of foam PU U= 0.241	
	kWh	Kg of propane	kWh	Kg of propane	kWh	Kg of propane
Average: 4.5 °C range: -4.1 to 21.6 °C	15931	1154	13029	944	4925	375
Average: 12.5 °C range: 3.9 to 29.6 °C	10889	789	8905	645	3366	244
Average: 16.5 °C range: 7.9 to 33.6 °C	8380	607	6853	497	2591	188
(1) PU = Polyurethane (2) U= coefficient of surface loss, in W/1000 m^2						

Table 1-5: Estimations of heat losses from roofs from a building of 1200 m^2 of area and requirements for energy replacement by level of roof insulation [Table 3.18; IRPP BREF Draft 1, 2011]

Electricity consumptions vary according to productions due to the differences in type of buildings, ventilation and heat needs. For turkey and broiler production, the average consumptions for the whole of the closed buildings is around 108 kWh/m^2 per year, which is 0.52 kWh/kg per live weight.

Animal	Gas propane		Electricity
	kg/m^2	kWh/m^2	kWh/m^2
Duck	9.3	128.1	39.5
Turkey	7.2	99.2	11.7
Chicken	6.6	90.9	15.2

Table 1-6: Average annual consumption of propane gas and electricity in meat poultry houses [Table 3.19; IRPP BREF Draft 1, 2011]

The Seasonal variability of energy consumption during the year is primarily related to the type of farm and the type of systems used. On broiler farms, the energy consumption for heat production in winter is higher than that used for ventilation in summer. On broiler farms, electrical energy consumption is at a maximum in the summer (ventilation) and thermal consumption is at a maximum in winter (ambient heating). At laying hen farms, where winter heating is not used, the peak of (electrical) energy consumption is in summer, due to the increase in ventilation rate.

The following table shows the energy requirements of some essential activities on broiler and layer farms in Italy.

Activity	Estimated energy consumption (Wh/bird/day)	
	Broilers	Laying hens
Local heating	13-20	
Feeding	0.4-0.6	0.5-0.8
Ventilation	0.10-0.14	0.13-0.45
Lighting	-	0.15-0.40
Egg preservation (Wh/egg per day)		0.30-0.35

Table 1-7: Indicative levels of daily energy consumption of activities on poultry farms in Italy [Table 3.20; IRPP BREF Draft 1, 2011]

The overall energy consumed based on the (Italian) consumption data was reported as ranging between 3.5 and 4.5 Wh per bird per day depending on the type of farm. Data from the UK confirm the data pattern and is shown below.

Type of animal	Electricity	Non-electric static equipment	Mobile machinery (fuel)
Chickens	0.66	1.10	Trace
Turkeys	4.20	7.00	Trace
Ducks	1.05	1.75	Trace
Geese	Trace	Trace	Trace
Dozen eggs	0.54	0.09	Trace

Table 1-8: Indicative levels of energy use of poultry farms in the UK (kWh/bird per year or dozen eggs), [Table 3.20; IRPP BREF Draft 1, 2011]

Apart from annual trends, daily trends in electrical energy consumption are also quite variable and related to the type of technical systems used on the farm. Often, there are two daily peaks corresponding to feed distribution.

As far as the energy use for other poultry species is concerned concerns, total energy use for turkeys was reported to be about 1.4 to 1.5 kWh per bird per year.

For further information **see Chapter 3.2.3 of the Draft IRPP BREF**.

Pig farms

Energy use on pig farms is related to illumination, heating and ventilation. Daylight is considered to be desirable, but artificial light is used in its place instead in areas where natural light intensity can be highly variable. Energy requirements for the illumination of pig housing can therefore be quite different for different areas in Europe.

Electricity is the form of energy that is consumed the most. It satisfies the needs for ventilation, feed distribution, pumps supply, etc. and for other equipment such as computers, lighting and refrigeration. Electricity is also largely used for heating. Fuel is the second most consumed type of energy, in particular for powering generators that are used in more than 60 % of the French farms, and for running warm water boilers.

The following figure represents the average electricity consumptions, where the proportion of ventilation might be highly variable depending on the characteristics of fans and management and on the animals' physiological stages.

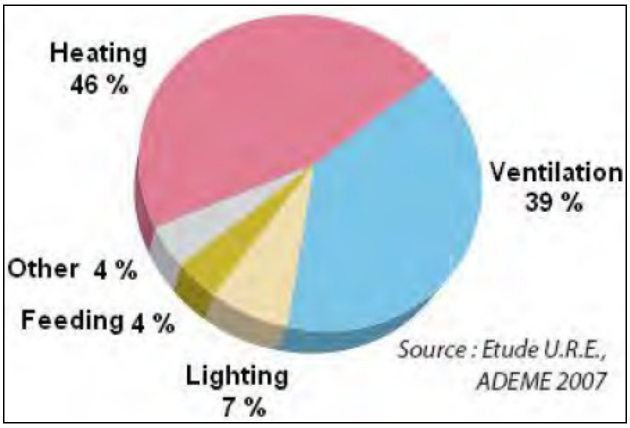

Figure 1-1: Breakdown of electric consumption on pig farms [Figure 3.1; IRPP BREF Draft 1, 2011]

Energy use for heating depends on the type of animal, the housing system and the management of air turnover in rooms. From the following table it can be deduced that increasing the ventilation flow from the minimum recommended (in France) of 3 m^3/h per animal to 5 m^3/h per animal can result in double energy consumption for heating up the mass of air.

Ventilation	Heat consumption	Heat consumption with 1cm of insulation added
m^3/h per animal	kWh per produced pig	kWh per produced pig
3	6.68	6.00
4	9.02	8.22
5	12.29	11.00
6	14.82	12.79
7	17.40	14.35

Table 1-9: Heat consumption according to ventilation flows [Table 3.22; IRPP BREF Draft 1, 2011]

For feed preparation, the total energy use is considered to be between 15 and 22 kWh/tonne of meal produced where a hammer mill with pneumatic transfer is used to mill cereals. Pelletisation or cubing of the feed on-farm will double the input, requiring about 20 kWh per tonne.

Housing type/management	Energy inputs breeder/finisher herd (kWh/finisher produced per year)	Energy inputs weaner/breeder herd (kWh/sow per year)
Heating – Farrowing house creeps		
Uncontrolled heater lamp (250 W)	15.0	
Heater lamp with 50 % dimmer (half time)	10.2	
Temperature controlled lamp in creep box	7.8	
Heating – Weaner accommodation		
Flatdeck with poor ventilation/heater control	10-15	200-330
Flatdeck with good ventilation/heater control	3-5	70-115
Automatically heated/ventilated kennels	3-6	130
Ventilation		
Dry sows/service		30-85
Farrowing		20-50
Fans – farrowing	1-2	
Fans – flatdeck	1-2.25	
Fans – rearing	2-5	
Fans – finishing	10-15	
Automatically Controlled Natural Ventilation (ACNV)	Negligible	
Lighting		
All stages of the housing	2-8	50-170
Milling and mixing		
Whole herd feed preparation	3-4.5	20-30

Table 1-10: Approximate annual energy use for typical pig housing types and systems in the UK [Table 3.23; IRPP BREF Draft 1, 2011]

With this data the total energy use on both farm types was calculated for different herd sizes.

Weaner/breeder herd farm size	Energy use (kWh/sow per year)	Breeder/finisher herd farm size	Energy use (kWh/pig sold per year)
< 265 sows	457 – 1038	< 1200 pigs	385 – 780
265 – 450 sows	498 – 914	1200 – 2100 pigs	51 – 134
> 450 sows	83 – 124	> 2100 pigs	41 – 147

Table 1-11: Total annual energy use per head on different farm types of different size in the UK [Table 3.24; IRPP BREF Draft 1, 2011]

Average daily consumption per head was calculated in Italy on different types of farms of the same size with at least 10 heads/farm. A very wide variation was observed. The finishing farms have lower energy use on average than breeding farms and integrated farms. In particular, a lower consumption of diesel fuel and electricity accounts for this.

Energy source	Energy consumption per farm type (kWh/head per day)		
	Integrated farms	Breeding	Finishing
Electrical energy consumption	0.117	0.108	0.062
Diesel fuel	0.178	0.177	0.035
Natural gas	0.013	0.017	0
Fuel oil	0.027	0.011	0.077

Liquid gas	0.026	0.065	0.001
Total thermal consumption	0.243	0.270	0.113
Total energy consumption	**0.360**	**0.378**	**0.175**

Table 1-12: Average daily energy consumption per type of pig farm and by type of energy source used in Italy [Table 3.25; IRPP BREF Draft 1, 2011]

The effect of farm size is also illustrated for farms in Italy. Here, the larger the farm, the higher the energy consumption. This was explained by the use of higher technology on larger enterprises, with an associated higher consumption of power (factor 2.5). Interestingly, this is in contrast with the experiences in the UK, where large herds have lower energy inputs per head than small herds.

Energy source	**Estimated energy consumption per farm size (kWh/head per day)**			
	Up to 500 pigs	**501 to 1000 pigs**	**1001 to 3000 pigs**	**Over 3000 pigs**
Electrical energy consumption	0.061	0.098	0.093	0.150
Diesel fuel	0.084	0.107	0.169	0.208
Natural gas	0.002	0.012	0.023	0.010
Fuel oil	0.048	0.029	0.011	0.049
Liquid gas	0.042	0.048	0.018	0.026
Total thermal consumption	0.176	0.196	0.221	0.293
Total energy consumption	**0.237**	**0.294**	**0.314**	**0.443**

Table 1-13: Average daily energy consumption for farms in Italy by farm size and energy source [Table 3.26; IRPP BREF Draft 1, 2011]

Energy sources are used in variable ways across Europe. In Italy, about 70 % of pig farming supplies are from fuel, whilst in the UK more than 57 % of the energy use is electricity.

Pig rearing on litter is associated to little energy use because dynamic ventilation and heating are only provided to farrowing stages, and fuel energy is only used for the operations of litter spreading and cleaning out. Hence, as reported from France, average consumptions are 206 kWh/sow per year (10.8 kWh per produced pig), and of 11.1 kWh/produced pig for the post-weaning and fattening stages.

1.3 Techniques to consider in the determination of BAT (energy-related)

Measures to improve the efficiency in the use of energy involve good farming practice as well as the selection and application of proper equipment and proper design of the animals' housing. Measures taken to reduce the level of energy usage also contribute to a reduction of the annual operating costs. In this section, a number of general measures are described followed by a few specific examples of reduction techniques. **Energy saving methods are also closely related to the ventilation** of livestock housing.

Control of ventilation rates is the simplest method of controlling the internal temperature of animal housing. Factors that affect the house temperature are:

- heat output from the pigs, according to their weight and density
- any heat supply (e.g. gas heater or heat pads for newborn pigs, or lamps for piglets, input from lighting and sun radiation)
- ventilation rate
- heat absorbed by the air in the house
- heat used to evaporate water from drinkers, feed troughs, spilt water and urine
- heat loss through walls, roof and floor
- external temperature.

The ventilation system **should be designed to evacuate the extra heat** in the building so that it has sufficient capacity to **control the house temperature in the warm summer months** when the animal stock is at full capacity it is fully stocked with the heaviest animals, and to also have sufficient control to **provide a minimum ventilation rate with the lightest stocking rate in colder winter months** when the house is stocked with the lightest animals. For animal welfare reasons, **minimum ventilation rates should be sufficient** to provide fresh air, oxygen and sufficient humidity and to remove unwanted gases.

Energy demand can be significantly reduced if houses are equipped with **natural ventilation rather than with forced ventilation systems**. **However, this is not always possible or desirable** for every livestock type and for all farming objectives. In fact in France, buildings with natural ventilation used for broiler production record higher energy demands for heating than mechanically ventilated houses. The most significant energy savings are obtained by good management of air circulation to minimal flows. Energy savings are allowed by high efficiency motors that cost no more than standard motors, and should be considered when specifying or upgrading motors on feed or waste handling systems.

Many electrical heating and lighting installations in the livestock sector are manually controlled. The **adoption of simple thermostatic control with 'dimmers' returns considerable energy savings**, and the **use of electronic systems** that are now also widely available yields further energy savings. Investment costs and cultural resistance to the use of such equipment (which is often viewed as complex and difficult to operate) are inhibiting uptake.

Solar radiation can easily be converted into heat, but the technology is **not yet cost-effective**. Both techniques, the 'indirect' (panels contain hot water that transfers heat through a coil to the fluid to be heated) and the 'direct' (the hot water from the panel is directly used) have potential for their use in agriculture, but at the moment, the benefits do not justify the capital expenditure. However, this technology is unsuitable for use in areas with very hard water.

Energy management approach

Establishing an energy action plan is an essential foundation for the reduction of energy waste. Energy plans consider all of the information available to operators. Simple planned rules, a comparison of performances to benchmark figures and a selection of measures and actions are the elements of plans. A well-timed correction of the problem will lead to energy savings.

Basic elements of an action plan are given below:

- To take regular meter reading and to record results in systematic way. For what is possible, readings need to be related to processes, production phases, houses, etc. Collected information need to be related to production levels and external influences (e.g. weather).
- Carry out maintenance and repairs. Dust and corrosion are major problems for heaters, ventilation components and controllers. All components must be cleaned at the 'end of batch'.
- To check the accuracy of temperature sensors.
- To use information from control system. Modern controllers store temperatures and ventilation settings that can be used at a later date.
- To use improved controlling devices, like dimmers, thermostatic controls.
- To install efficient fans and ducts.

Complete reference to efficient use of energy is given in the BREF for Energy Efficiency: ftp://ftp.jrc.es/pub/eippcb/doc/ENE_Adopted_02-2009.pdf

For further information see **Chapter 4.5.1.1 of the IRPP BREF**.

1.3.1 Insulation

Description

Thermic losses occur through stable walls and are **reduced by the interposition of insulating materials between the internal and external environment**. Insulation materials that are in use for livestock housing are displayed in the following, along with the average U coefficient.

Insulation type	U (W/m^2 per °C)
Fiber glass or batt	0.56
Loose-fill fibreglass	0.44
Loose-fill rock wool	0.49
Loose-fill cellulose	0.61
Perlite/vermiculite	0.47
Expanded polystyrene board	0.67
Extruded polystyrene board	0.84
Polyisocyanurate board, unfaced	1.02

Spray polyurethane foam	1.04

Table 1-14: U-values for different insulation materials used in poultry houses [Table 4.21; IRPP BREF Draft 1, 2011]

For north-western Europe, U-values of 0.4 W/m^2 per °C or better are recommended for building insulation where new poultry houses are planned, which approximates to about 50 mm of extruded polyurethane. In France, the suggested coefficient for vertical walls of insulation is around 0.6 W/m^2 per °C.

In some countries, as the UK, buildings are mainly made of timber framed construction and their average age is estimated as at least 15 to 20 years. Fibre wool insulation materials were widely used in the recent past because of their low cost, but damage caused by vermin and moisture is very common, greatly reducing its efficiency. Blown fibre and slab insulation products are used to substitute older materials.

Achieved environmental benefits

A good insulation limits excessive cooling and heating through walls, roof and floor.

Operational data

Insulation material should repel moisture and should be dry when being installed, because water is a major factor of deterioration of insulating materials. Water may fill the voids that characterise the product thermal quality. Insulation material should also be wild bird-, rodent and insect-proof.

From Finland, an example of insulation for broiler houses has been reported as 140 mm of mineral wool on vertical walls and 300 mm of cellulose mineral wool applied under the roof.

Composite panels containing solid polyurethane insulation produce good results. These panels can be bought with plastic-coated steel cladding for durability and cleanliness and can also be used as effective structural components (e.g. kennel construction).

In a well-insulated poultry building, gas consumption savings of 30 to 50 % compared to average-insulated buildings are possible. Approximately, 2 to 4 kg of gas propane/m^2 per year is saved.

Up to 218 kWh/sow per year can be saved compared to average buildings. Savings can be expressed also as about 19 % of the energy consumption, or approximately 10.4 kWh per produced pig. Insufficiently insulated fattening pig houses require up to around 45 % of energy compared to well insulated houses, as can be seen in the following table, where consumptions for buildings with insulation are shown.

Thickness of insulation	8 cm	6 cm	4 cm	2 cm	0 cm
Heat consumption (kWh/place)	64.5	66.8	71.0	80.7	121.0
Heat consumption (kWh/produced pig)	9.9	10.3	10.9	12.4	18.6
Difference ([1]) (%)	Reference	3.4	9.1	20.1	46.6
([1]) The difference in percentage is given as a ratio to the reference of 8 cm					

Table 1-15: Effect of insulation level on heat consumption in post-weaning houses [Table 4.22; IRPP BREF Draft 1, 2011]

For further information see **Chapter 4.5.1.1 of the IRPP BREF**.

Economics

The application of a layer of 3-5 cm of standard polyurethane foam for a renovation of a pig stable might cost EUR 18-35/m^2. This would allow savings of EUR 0.01 per kg of produced pig for slaughter.

Heat-reflecting membranes

Description

Walls and ceiling are lined in the indoor side with laminated plastic foils to seal off poultry housings from air leakage and humidity. More than 96 % of the infrared energy can be blocked from the outside hence the indoor climate is better kept under control. Indoor energy is reflected back or is not radiated away from the membranes surface. Where lighting programmes are used, due to the reflective property of the material, the electrical power required for lighting the interior can be reduced.

Achieved environmental benefits

A better control on indoor temperature and air flow reflects in heating power savings.

Operational data

Manufacturers claim energy (gas) savings of up to 34 %.

Applicability

This solution can be fitted in new or existing sheds.

For further information see Chapter **4.5.1.1.1 of the IRPP BREF**.

1.3.2 Low-energy illumination

Savings in lighting consumption can be programmed at planning stables, by simply allowing more natural light to enter, though avoiding direct radiation (by placement of films or sun visors).

General measures applicable to save energy for lighting are:

- to apply fluorescent lights instead of conventional tungsten glowing bulbs (although note that their 'biological' suitability is reported to be uncertain);
- to apply sodium lights;
- to use dimmers for adjusting electrical lighting;
- to adopt lighting controls using proximity sensors or room entry switches;
- to apply lighting schemes programmes, for example, using a variable lighting period such as an intermittent illumination of 1 period of light to 3 periods of darkness instead of 24 hours light per day reduces the amount of electricity to one third;
- to improve the use of natural light, also by the installation of vents or roof-lights;
- to adopt photoelectric cells to turn artificial lights on.

Non-efficient light bulbs are going to be progressively removed from the market. From September 2011 onwards, bright bulbs of over 60 watts will all be out of the market. By 1 September 2012, all light bulbs over 7 watts will be withdrawn, including 25 and 40 watt bulbs.

Fluorescent lights (TL-lamps) can be applied in combination with a device to adjust the frequency of microflashes (>280 000), so the animals will not be able to register the rapid fluctuations typical for this light.

Achieved environmental benefits

Fluorescent lights have a higher light capacity per energy unit (lumen/watt) than conventional bulbs. Power rating and the number of hours used will determine the annual energy use. The replacement of filament bulbs by compact fluorescent lights could save up to 75 % of the energy used. The replacement of 38 mm fluorescent with 26 mm tubes of lower wattage could save up to 8 % of energy used.

Lighting type	Efficiency characteristics	Energy use (kWh/pig place)
Tungsten bulbs	Cheap but very inefficient. Can be dimmed for dual stockman/stock use	2 to 4
Compact fluorescent bulbs	Often used as a direct replacement for tungsten lights but cannot be dimmed	0.4 to 0.8
Fluorescent strip lighting	T8 (11/4 inch) tubes are more efficient than T12 (11/2 inch) tubes; Electronic control gear give a 20 % energy saving over conventional ballasts; Extend lamp life by 50 %; Electronic dimmable types are available	0.4 to 0.8

Table 1-16: Typical lighting equipment for livestock stables [Table 4.24; IRPP BREF Draft 1, 2011]

Driving force for implementation

Savings on the electrical bill are often significant

For further information see Chapter **4.5.1.2 of the IRPP BREF**.

1.3.3 Fuels for heating

Gas-fired infrared heaters and air blowers

Description

The gas-fired infrared heating system generates radiant energy that is converted into heat when absorbed by objects in its path. Eventually, the infrared energy is absorbed by floors and then heat is re-radiated upward to the surrounding air. State-of-the-art heaters are preferred to non progressive gas infrared heater. In sealed and isolated buildings, warm air generators might be effective, but also require electricity to induce the air movement.

Achieved environmental benefits

Radiant heaters are useful since they allow house temperature to be reduced and to provide concentrated heat where needed.

Operational data

State-of-the-art heaters allow gas savings higher than 20 to 40 % compared to older apparatuses, that is to say 1.4 to 3.1 kg of gas/m^2 per year.

Driving force for implementation

The difference in prices for electricity and gas can play a role in choosing this technique. Gas heating may be the alternative for installations that are not connected to the electrical network.

For further information see **Chapter 4.5.1.3.1 of the IRPP BREF**.

Wood and biomass fired boilers

Description

Standard boilers or combined heat and power systems (CHP) are fuelled with wood and other biomass for heating up water to warm up animal houses. Heating exchangers serve the heating circuit. Straw, poultry litter and peat, where convenient, are used to replace oil for combustion.

Achieved environmental benefits

Wood use has a neutral impact on the greenhouse effect. The economical value is given by adding value to copses and secondary materials that are not fully exploited.

Cross-media effects

This system allows for efficient heating and a good temperature control. Heat is well distributed in all the building.

Operational data

This heating system is profitable when heat needs are large and stable, as happens with multiple houses or users. An example is reported of a mixed poultry and dairy farm combined with the farmer's house.

Heated houses	Boiler power
3000 m^2 poultry housing + 230 calf places	300 kW
1800 m^2 poultry housing + house	240 kW
600 m^2 poultry housing + house + heated water in the milking room	100 kW or 60 kW + 8 infrared supplement heaters

Table 1-17: Example of mixed farm benefitting from warm water heating served by a wood boiler [Table 4.26; IRPP BREF Draft 1, 2011]

Economics

Wood is less expensive than fossil fuels and its price is more stable. The investment in France for a boiler is around EUR 90 000. The investment may be subsidised for about 40 – 50 %, in which case the return on investment is around 7 years. For a pig installation of about 3300 m^2 (approximately 220 sows), 85 kW of power are needed at a total cost of EUR 400 per installed kW. Requirement of wood would be around 45 tonne per year, which is obtainable by utilisation of 9 – 14 km of copse hedges.

For further information see **Chapter 4.5.1.3.2 of the IRPP BREF**.

1.3.4 Heat recovery

Heat exchangers

Description

There are three major types of heat exchangers that exploit different principles:

- air-air heat exchangers
- air-water heat exchangers
- air-ground heat exchangers.

The fundamental principle of both air-air and air-water systems is to recover heat from the exhaust air extracted by houses, that otherwise is lost in the outdoor environment. Air-ground exchangers can take advantage of the combination of the two characteristics of heat variation in soils. From one side, the thermal variations of soil horizons decrease with the depth and on another side, the deep soil average temperatures are negatively correlated to the seasonal temperatures. This means that these exchangers can produce heat in the cold season and keep relatively cool in summer.

Achieved environmental benefits

Heat recover allows reductions in energy consumption for heating by providing adjustable support. In buildings with mechanical ventilation (dynamic buildings), heat exchangers might replace the ventilation system. In buildings with natural ventilation (static buildings) heat exchangers aid ventilation.

Reduction in energy expenses is obtainable as a result of the following:

- shorter heating periods
- reduced total energy consumption for heating.

Operational data

For air-air and air-water systems, the theoretical maximal yield of an annual cycle ranges from 50 to 55 %, meaning that from exhaust air at 24 °C, the entering air can be heated up to +12 °C (starting from 0 °C). This means that the higher temperatures that are needed in post-weaning need to be reached with a complementary heating system.

Heat exchangers allow for a recovery of 4 – 7 kWh per produced pig for slaughter. They are considered to work better in the cold season when heat is required the most.

Outdoor temperature (°C)	Incoming air temperature (°C)	Indoor warmed air (°C)	Recovered energy (W/pig)
-9.4	2.6	12.0	97
-4.9	6.4	11.3	89
0.0	9.2	9.2	69
4.4	11.6	7.2	46
7.8	13.9	6.1	41

Table 1-18: Working features of Air-Air heat exchanger [Table 4.27; IRPP BREF Draft 1, 2011]

Economics

In a standard poultry building of 1200 m^2, two heat exchangers of capacity 5000 m^3/h are needed. This implies an investment of about EUR 8.3 – 10/m² and additional running costs for electricity of about EUR 0.13/m² per year. In this case, the monetary savings for the propane that is not consumed sums to around EUR 1/m^2 per year, for a total return of the investment in the range of 9.5 – 11.4 years. The price of air-ground systems vary depending on the method of drilling the soil, the type of tubes and fans, surface necessary, etc. Pipes must be buried at approximately 2 metres depth.

For further details see Chapter 4.5.1.4.1 of the FDM BREF document.

Heat pumps

Description

The principle of this technique is based on the recovery of heat from various environmental media (water, slurry, ground, air, etc.) and its use on-farm, usually in buildings.

A fluid is used in the sealed circuit of the pump to transfer the heat from one medium to another, transforming in turn from a liquid to a gaseous state. Fluids used in other functional circuits are preheated with the energy that is recovered, to produce sanitary water, or to feed a heating system and even be used in cooling systems.

Geothermal energy

Calories are transferred from underground soil level or from shallow aquifers (less than 100 m).

Scrubbing water recovery

Heat is recovered from washing waters of end-of-pipe treatment that must be collected in sufficiently large basins.

Biological reactors

They can provide working temperatures as high as 25 °C.

Engines exhaust

Heat is recovered from the gas exiting biogas engines to heat up piglet areas.

Achieved environmental benefits

Every thermal calorie that is recovered is deducted from the farm’s economical balance related to energy.

Operational data

Compared to classic heating, with geothermal recovery, savings of about 50 % (4.4 kWh/piglet per year) are possible, and up to 69 % (6.21 kWh/pig per year) can be recovered from a biological reactor or from scrubbing water.

Systems based on biological reactors and water of scrubber systems are more stable and efficient than those based on geothermal energy. The efficiency coefficient of a heat pump is the proportion of the recovered heat with the energy that is needed to run the pump (recovered kW/consumed kW). The efficiency of a geothermic pump is about 2 – 3 (1 kWh electric consumed, 2 – 3 kWh recovered), the same as that related to biological reactors. Scrubbing waters are provided at about 20 °C and the heat pump efficiency is up to 4.

Economics

The indicative investment cost for a geothermal heat pump is EUR 45 – 55 (taxes excluded) per post-weaning place, which must be compared to the standard heating investment of around EUR 35 per place.

The reductions of energy consumption allow savings that are estimated about EUR 0.01 per kg of pig produced for slaughter.

Heat recovery in broiler housing with heated and cooled littered floor (combideck system)

Description

Two closed water circuits are connected by a heat pump. A water circuit is installed below the floor where broilers are housed. The water in the underground circuit is used to heat the floor at the expenses of heat exchanged with the other circuit or alternatively to cool down the floor and simultaneously heat up the other circuit. The second circuit is built at a deeper level and is used to store the excess heat or to return it to the house when needed. The heat pump serves the connection between the two water circuits.

At the beginning of the growth cycle, chicks are heated for 24 days with the stored heat (about 28 °C). Then, 6 days follow in thermal balance, and in the following final 16 days of growth, broilers produce an excess of heat that is preserved in the storing circuit while cooling down the floor at about 25 °C.

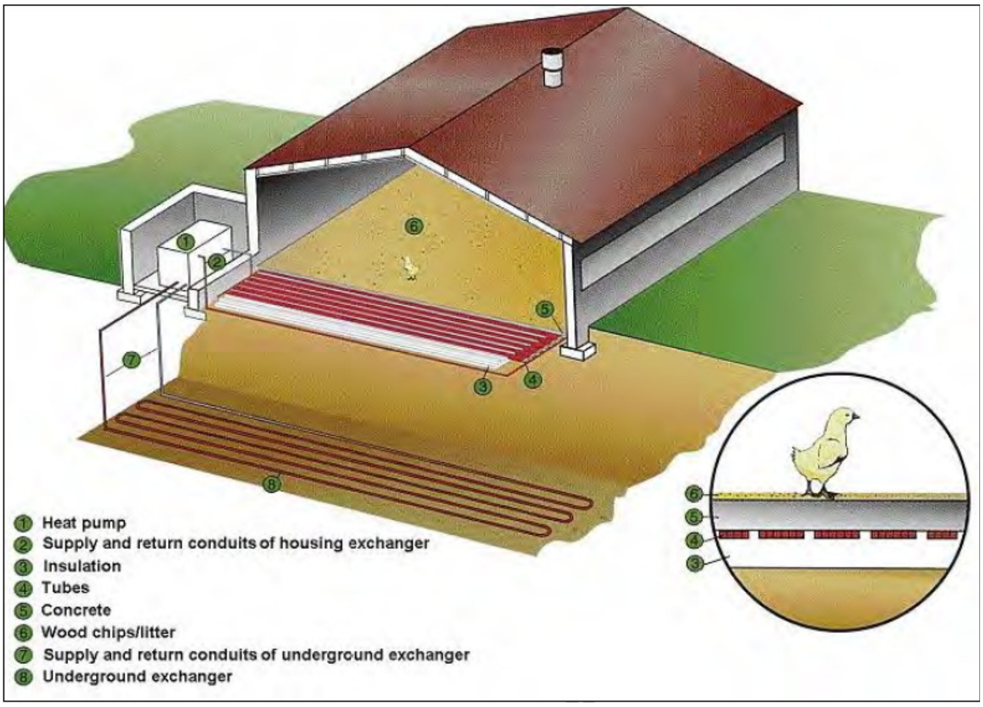

Figure 1-2: Schematic representation of the installation of the heat recovery system in a broiler house [Figure 4.7; IRPP BREF Draft 1, 2011]

Achieved environmental benefits

The reduction of energy use is the main achieved benefit. Also, preheating the floor prior to littering and introducing poultry prevents humidity from moistening the litter.

	Fuel type/ fuel use	Input	Energy equivalent (MWh/yr)	Costs([2]) (Euros)	CO_2 (tonne)([3])
Reference situation	Fuel oil	49.5 m3	549	6273	65.0
	Natural gas	36.1 m3	321	9277	158
	Electricity	40 MWh	40	3757	14.8
		Total	**910**	**19307**	**237**
Combideck system applied	Heating	63.6 MWh	63.6		23.5
	Ventilation	34.4 MWh	34.4		12.7
	Heat pump ([1])	189 MWh	189		44.4
		Total	**287**	**9194**	**80.6**
Reduction (as percentage of reference)			**623 (70 %)**	**10113 (52 %)**	**156.4 (66 %)**

(1) coefficient of performance heat pump: 4.4
(2) reference year 1999, corrected for low and peak tariffs on electricity prices in the Netherlands
(3) CO2-equivalents: oil 3.2, gas 1.8, electricity 0.37

Table 1-19: Results of the application of the combideck system [Table 4.28; IRPP BREF Draft 1, 2011]

Economics

Investment costs are EUR 2 per broiler place with 20 broilers per m^2. Operational costs (depreciation, interest and maintenance) are EUR 0.20 per broiler place year. The annual increased yields reportedly outweighed the yearly operational costs by a factor of about 3. For instance, veterinarian costs were reduced by about 30 %. Energy costs were reduced by about 52 %. The payback time is about 4 – 6 years.

For further information see **Chapter 4.5.1.4.3 of the IRPP BREF**.

1.3.5 Good practice for the efficient use of energy on poultry farms

A considerable reduction in energy consumption for heating can be achieved by paying attention to the points given below:

- Energy consumption can be reduced by separating heated spaces from other spaces, and by limiting their size and by optimising heating considering the necessary volume
- In the heated space, energy use can be reduced by correct regulation of the equipment and by an even distribution of warm air through the housing, i.e. by spatially distributing the heating equipment adequately. An equal distribution would also mean not placing sensors in spots that are too cold or too warm in the housing, which would unnecessarily activate heating or ventilation.
- Control sensors need to be regularly checked regularly and kept clean to correctly detect the temperature at the stock level (1 metre high).

- Regular maintenance (with each batch) of heating devices and substitution of worn out parts (full replacement every 5 – 6 years) allows for better combustion and savings in energy.
- The quantity of heating equipment must correctly be determined. Equipment must be run at correct (full) power, since the reduction of temperature is not proportional to the reduction of power.
- Warm air from just below the roof level can be circulated down to floor level. Air flows directed to animals must not have excessive speeds not to affect the thermal comfort and eventually origin sanitary problems.
- Minimising the ventilation rates, as far as the indoor climate requirements allow, further reduces heat losses.
- Placing ventilation vents low down on the walls (as heat tends to rise) will reduce heat losses.
- Further insulation with loose material (e.g. sand) on the floor or on top of the built-in insulation will reduce heat losses and therefore fuel input (especially with high groundwater levels).
- Cracks and open seams in the housing construction should be repaired.
- In a layer house, heat may be recovered with a calorifier between the incoming and outgoing air. This type of system is used to warm the air to dry the manure on the belts under the cages to reduce the emissions of ammonia.
- Control of minimum ventilation also requires well-sealed buildings. If heating is required to maintain the moisture content of litter, all sources of unnecessary wetness should be rectified (e.g. spillage from drinkers).
- Fans that operate intermittently should be fitted with back-draught shutters to reduce heat loss.
- The most significant energy savings are obtained by good management of minimum flows.

Savings have been reported of up to 0.9 kWh per bird sold per year accommodating the where ventilation that was 10 % higher than necessary.

For further information see **Chapter 4.5.2 of the IRPP BREF**.

Management of ventilation in poultry houses

General measures to reduce electricity for ventilation use are:

- to select the correct type of fans and to consider their position in the building;
- to install fans with a low energy use per m^3 of air;
- to use the fans efficiently, e.g. operating one fan on full capacity is more economical than operating two on half their capacity;
- to maintain and keep clean ducts, fans and controlling apparatuses.

Optimisation of energy consumption can be pursued by the use of single-speed fans that are adequately organised in space. Additional regulation cases give this type of equipment the possibility to obtain flows and speeds that match the variable needs for age, species, animal load and climatic conditions.

Energy-saving fans can reduce power consumption by up to 70 %.

Fan efficiency generally increases with the impeller diameter. Efficiency is obtained by adequate sizing of ventilation inlet and outlet and by providing smooth and clean internal surfaces with slight bends.

Circulating fans

Description

Circulating fans generate air flows that are homogeneous in speed. Several types of circulating fans can be placed: horizontal, vertical, with scavenging etc.

Achieved environmental benefits

Circulating fans homogenise the air flows at the animals level without increasing the volume of air supply by the central ventilation.

Fans are mainly used in finishers during summer. The air flows that are created allow poultry for a better thermal comfort by increasing the heat losses by convection.

Operational data

Fans are held approximately at 1 m over the litter and provide air speeds of at least 0.8 m/s to every point of the living area, since 1 m/s is the advised air speed. According to the climatic conditions, 8 to 12 circulating fans of 15 000 – 20 000 m^3/h of capacity are needed for every 1000 square metres.

Driving force for implementation

Where the electrical market is favourable such as in France, the electrical consumption for circulating fans make even more economic savings in heating that are favoured.

For further information see **Chapter 4.5.2.1.1 of the IRPP BREF**.

1.3.6 Good practice for the efficient use of energy on pig farms

The greatest biggest opportunities for savings in energy use can be ranked in priority order as:

1. heating

2. ventilation

3. lighting

4. feed preparation.

General operational measures to reduce the energy consumption in pig farms are:

- better use of the available housing capacity

- optimising animal density
- lowering the temperature as far as animal welfare and production allow.

Some possibilities for reducing energy consumption are:

- reducing ventilation, taking into account the minimum levels required for animal welfare reasons
- insulating the building, particularly lagging the heating pipes
- optimising the position and adjustment of heating equipment
- considering heat recovery
- considering using high-efficiency boilers in new housing systems.

Energy use in feed preparation can be reduced by about 50 % when meal is transferred mechanically, rather than pneumatically (blown) from the mill to mixing or meal storage.

Examples show that the use of improved heater lamps in farrowing houses could reduce energy use from 330 kWh per sow per year down to 200 kWh per sow per year.

In the operation of biogas facilities, the energy generated (power and heat) from the biogas produced can be used (recovered) to replace that generated by from fossil fuels. However, it is reported that only swine nurseries and agricultural distilleries are capable of utilising the heating energy throughout the year.

For further information see **Chapter 4.5.3 of the IRPP BREF**.

Heating and ventilation optimisation in pig houses

Description

Thermal losses are minimised by an optimised ventilation management that balances heating and ventilation. This is obtained by optimising the minimum rates of air flows (manual or automated management) and installing energy-saving fans or equipment.

Dynamic ventilation systems are designed, built and operated so that the flow resistance of the ventilation system is kept as low as possible, e.g.:

- having short air ducts
- incorporating no sudden changes into air duct cross-sections
- limiting the changes in duct direction, or application obstructions (e.g. baffles)
- removing any dust deposits in the ventilation systems and on the fans
- avoiding having rain protection covers above the discharge points.

Fans with the lowest possible power specific consumption of power (W/m^3 of extracted air at 40 Pa) for a given air rate and air pressure rise should be selected. Fans with low-rated rpm (low speed units) use less energy than those that operate at high rpm (high-speed units). Low-speed fans can, however, only be used if the ventilation system exhibits a low flow resistance (<60 Pa).

Fans designed on the basis of EC (electronic commutation) technology exhibit a significantly lower power requirement, particularly over the regulated speed range, compared with than transformer-regulated or electronically regulated fans. Slightly higher purchase prices are justified by significant consumption reductions.

Frequency converter

In practice, most of the ventilators are powered by a 230 Volt triac controller benefits of the system is include less energy consumption and less fan wearout for less heat produced. Above all, that all the compartments can be adjusted between 5 % and 100 % ventilation, regardless of the influences of the weather (e.g. even in windy weather). The system works with the aid of measuring fans installed in the shed compartments that measure the need for ventilation. In connection to the main frequency controller, each compartments' ventilating fans are run at reduced speeds to produce the volume of air that is detected by the measuring fans.

End-of pipe air cleaning systems

These for exhaust air cleaning can significantly increase the flow resistance of forced ventilation systems. In order to deliver the requisite air rates, particularly in summer, higher-capacity fans with a higher specific power requirement may be necessary. In addition, power is required to operate the pumps for water circulation in bioscrubbers and for humidifying operations in biofilters.

Other general measures for optimising heating and ventilation are given below.

- To design the system well. Centralised extraction is possible in new buildings. The waste air is extracted from the building by only one turbine whose specific consumption (W/m3 of extracted air) is definitely lower than the sum of the consumptions of single fans required in a room-by-room dynamic ventilation. Reductions are possible opf up to 60 % by centralised ventilation.
- To yearly monitor fan clogging before the warm season. Wastes of consumption and equipment life span are improved.
- To regularly check the calibration of the thermal sensors that, if not working correctly, can generate heat over-consumption.

Achieved environmental benefits

The optimisation of the balance of heating and ventilation adapting it to the animal needs may reduce energy consumptions by up to 50 %.

With a minimised ventilation at the beginning of the post-weaning cycle (3 m^3/h per pig), the energy consumption per produced pig is 6.7 kWh, in comparison with 12.3 kWh needed by the standard ventilation (5 m^3/h per pig).

Operational data

In sow keeping, a zone heating system is installed for heating the piglet creep area. Hot water floor heating is more energy efficient than an electric floor heating system or the use of infrared radiators. For houses with natural ventilation, the lying area is located in heat-insulated boxes ('box and bed stalls') to avoid the need for additional heating.

Electric floor heating allows for a reduction in the consumption by 30 % compared to over-floor heating.

With the use of kennels for piglets, the different thermal needs of sows and newborn piglets can be matched simultaneously that are around 30 °C for piglets and not over 24 °C for sows.

Economics

The investments required for costs of the frequency converter system are quite similar to a conventional system.

Energy-saving fans are still quite expensive and their lifespan is short as well.

Indicative costs are reported below in relation to an integrated farm with 200 sows for installing new material with fans with 100 000 m^3/h of capacity that is paid off over 10 years. The general potential saving of energy-saving measures is EUR 1650 per year. The indicative costs for the purchase of large dimension fans is estimated between EUR 0.03 and 0.04/produced pig, or in other words, less than EUR 0.001 per kg of fattened pig produced.

Driving force for implementation

Even though centralised ventilation appears to be 5 to 10 % more expensive than conventional ventilation, it allows for the installation of end-of-pipe treatments and of heat exchanging equipments (Air-Air and Air-Water).

1.3.7 Techniques for the on-farm processing of manure

Anaerobic treatment of manure in a biogas installation

Description

Anaerobic microorganisms decompose the organic matter contained in slurry, in a closed reactor in the absence of oxygen. Methane is produced and collected to serve a heat generating system. A stabilised residue is also produced that can be applied to land as a soil conditioner and source of nutrients.

Figure 1-3: Example of a 335 m^3 capacity digester [Figure 4.56; IRPP BREF Draft 1, 2011]

Achieved environmental benefits

All emissions are reduced (NH_3, CH_4, N_2O and odour) by means of the production of a valuable product, whose benefits can be expressed in terms of a reduced organic dry matter (to 30-40 % of the original amount), biogas production (25 m^3 per m^3 of slurry) and methane concentration (65 %).

With pig slurry, it is common to calculate a specific methane production of about 200 litres per kg of dry matter (or about 6.5 kWh). The primary effect is therefore a reduction of fossil fuel use and of CH_4 emissions that the co-generation of electricity and heat makes possible. The resource efficiency of a combined heat and power (CHP) system is about 35 % for the electrical production, and is about 85 % if all the produced heat is recovered.

Additionally, the application of anaerobic fermentation in a biogas installation has a number of other effects:

- a reduction of pathogen in digested manure
- a reduction of odour emission
- transformation of N into NH_3
- improved fertilising characteristics of the digested manure
- improved characteristics for separation and further treatment or application
- a reduction of greenhouse gas emissions.

Operational data

To get the required temperature, manure can be warmed up by using part of the produced biogas or by heat exchange with the water cooling the gas engines. In farm-scale applications, heating of the manure is not always applied. The required amount of heat for the mixers and pumps to run the equipment in subsistence is estimated to be about 10 – 20 % of the gross energy production of the installation.

The gas is stored in a gas buffer before being used in a heater or a gas engine. Before the gas can be used, sulphur must be removed by a biological, adsorptive (active coal or ferro-chloride) or chemical technique (quenching) in larger installations.

Due to the general manure management induced by the anaerobic digester, it is estimated that the global farm emissions in Finland, are reduced by 40 % for ammonia, while odour, methane and N_2O are reduced by 80 %.

Applicability

There are no technical restrictions to the on-farm application. The cost efficiency is likely to increase with an increasing volume of fermented slurry. The minimum farm size according to the literature is 50 LU. In France and Denmark, biogas production is not considered technically and economically viable with only slurry as a substrate. Slurry provides a good quantity of microbes to run the process but a relatively reduced amount of digestible matter that is what methane is produced from. Hence it is necessary to co-supply the process with other raw materials having a stronger biogas production capacity.

Driving force for implementation

The high prices for energy and the availability of financial support schemes for sustainable energy production were responsible for the application of this technique. In some Member States the use of biogas in connection with the covering of the pig slurry storage store is stimulated by financial incentives (e.g. Italy). In France, economic bonuses are provided for the installation of equipment according to the size of the system, and other bonuses for up to EUR 30/MWh are available where energy is valorised with efficiencies over 40 %.

Farms can reach electrical self-sufficiency and have significant heat production for free.

For further information see **Chapter 4.12.5 of the IRPP BREF**.

Evaporation and drying of manure

Description

The manure is ground and mixed first. Using a heat exchanger the manure is heated to 100 °C by means of warm condensate and kept at this temperature for about 4 hours, while degassing occurs. Any foam that has been formed is degraded. The gases are processed into by-products.

In the next step the manure is brought into a drying machine and compressed (1.4 bar). Any water vapour that is formed is compressed, which raises its temperature to 110 °C. This hot vapour is then used in a heat exchanger, thereby drying the manure using the sensitive heat of the vapour. There is a thin tube wall between the manure and the vapour on which the vapour condenses before being discharged.

Achieved environmental benefits

This technique allows the drying of pig manure with only a low energy level and with reduced emissions to air and water.

For further information see **Chapter 4.12.7 of the IRPP BREF**.

Slurry belt dryer

Description

This technique is mostly used to dry the free-flowing solid fraction that is obtained in slurry separation processes. Belt dryers use heath convection for drying the slurry. Warm air flows through the belts where the manure to be dried is transported, absorbing and removing moisture.

The transport belts are made of wire tissue or perforated steel plates, and heated air flows through them. In drying chambers one or several transport belts are arranged one above the other downloading matter each one to the one below.

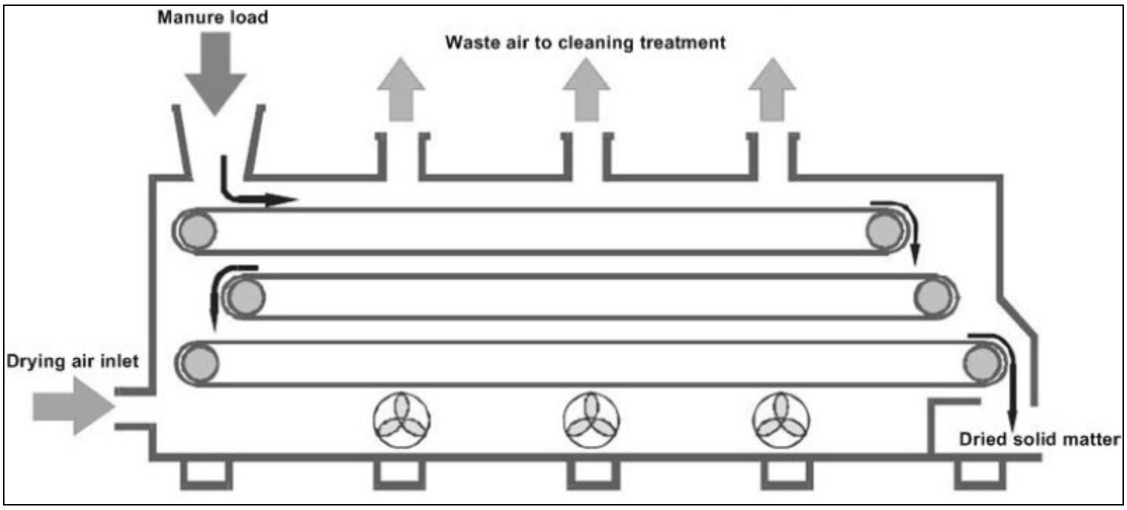

Figure 1-4: Scheme of a manure belt dryer [Figure 4.57 of the IRPP BREF Draft 1, 2011]

Achieved environmental benefits

Relatively solid matter is processed into a dry, stable product that is suitable for storage and transportation and that develops no or only slight odour. **It is assumed that the technique is used in combination with the biogas production and its parallel utilisation in a combined heat and power (CHP) production system**.

For further information see **Chapter 4.12.8 of the IRPP BREF**.

Incineration of poultry manure

Description

Broiler manure is automatically fed from manure storage into a first combustion chamber at a temperature of 400 °C. From this chamber the gas/ash mixture enters a second combustion chamber. In this chamber the mixture is rapidly heated, i.e. within three seconds, up to a temperature of 1000 to 1200 °C under controlled oxygen supply. As a result of the high temperature all the odorous components are eliminated. The hot flue-gases leaving the second chamber go through a heat exchanger, in which water is heated to a temperature of about 70 °C. The heated water is used for the floor heating of two broiler houses with a total surface of about 5000 m^2.

Achieved environmental benefits

The benefit of this technique is the production of an ash that can be used as a fertiliser and of hot water which is used for heating the housing, and which therefore saves fossil fuel use.

Applicability

The installation can be applied on new and existing farms. The capacity can be adjusted to the available manure production. There were no technical limitations reported to its application on a farm scale.

A known example was reported from the UK where 12.7 MW are produced by using approximately 140 000 tonnes of manure per year. In France, companies attempted to set up systems of smaller dimensions but for technical and legislative problems, no installation of this kind has been successful.

For further information see **Chapter 4.12.10 of the IRPP BREF**.

In this context it is important to inform about the fact that in many countries manure as fuel for incineration is considered as waste and the process is regarded as waste incineration with all consequences.

1.4 Expert Contributions (energy-related information)

A member of the project team took up contact with representatives of the Landwirtschaftskammer Schleswig-Holstein (Chamber of Agriculture). This is an administrative body (public cooperation for agriculture) giving advice to administration and to farmers. The organisation operates different installations and carries out studies for being able to offer trainings and advice concerning innovative technologies to farmers. After an on site visit the sector specific supplement on intensive rearing of pigs was filled in and the following comments were submitted:

The sector specific supplement provides a summary with the main points on the item and can be used as reference book. Detailed information about costs per product unit is missing. International data are not so very interesting for the operator. Data from regions with similar climate conditions would be better. The chapter on incineration of manure should reflect the fact that manure as fuel for incineration is considered as waste in many countries. It is necessary to develop benchmarks related to production numbers.

The check list reflects the items that are considered during the planning process for new installations. It can be used by operators to become aware of the relevant points he has to cover with the experts writing the permit application for him.

Landwirtschaftskammer proposed to carry out a project together with the authority to develop guidance on energy efficiency for pig farms in northern countries that is more specific than the proposed supplement and the draft BREF document are in that point.

2 Proposal for the Sector Specific Supplement – IRPP

2.1 Techniques to reduce specific energy consumption (entire IRPP sector)

Are the following techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification*):
Energy Management Approach		
Take regular meter reading and record results in a systematic way *(relate readings to processes, production phases, houses, etc.)* and relate collected information to production levels and external influences *(e.g. weather)*		
Carry out maintenance and repairs *(cleaning of all components to avoid dust and corrosion which are major problems for heaters, ventilation components and controllers)*		
Check the accuracy of temperature sensors		
Use information from the control system *(modern controllers store temperatures and ventilation settings)*		
Use improved controlling devices, like dimmers, thermostatic controls		
Install efficient fans and ducts		

Are the following techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification*):
Ventilation		
Control ventilation rates *(internal temperature of animal housing)*		
If possible, use natural ventilation		
Use of electronic systems instead of manually controlled systems for heating *(thermostatic controls)*		
Insulation		
Use proper insulation to limit excessive cooling/heating through walls, roof and floor *(insulation thickness; rec. U-values)*		
Use heat-reflecting membranes *(lining of walls and ceiling on the indoor side with laminated plastic foils)*		
Low-energy illumination		
Apply fluorescent lights instead of conventional tungsten glowing bulbs		

Apply sodium lights		
Use dimmers for adjusting electrical lighting		
Adopt lighting controls using proximity sensors or room entry switches		
Apply lighting schemes programmes *(e.g. using a variable lighting period such as an intermittent illumination of 1 period of light to 3 periods of darkness instead of 24 hours light per day)*		
Use natural light *(also by the installation of vents or roof-lights)*		
Adopt photoelectric cells to turn artificial lights on		
Fuels for heating		
Use gas-fired infrared heaters and air blowers		
Use wood and biomass fired boilers		
Heat recovery		
Use heat exchangers (air-air/water/ground)		
Use heat pumps to recover heat (e.g from water, slurry, ground, air, etc.)		

2.2 Additional techniques for the efficient use of energy on poultry farms

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** *(provide brief explanation)*:	**No** *(provide brief justification)*:
Separate heated spaces from other spaces, and limit their size and necessary volume		
Correct regulation of the heating equipment and even distribution of warm air through the housing *(e.g. avoid placing sensors in spots that are too cold or too warm in the housing, which would unnecessarily activate heating or ventilation)*		
Regularly check and clean control sensors to correctly detect the temperature at the stock level *(1 metre high)*.		
Regular maintenance *(with each batch)* of heating devices and substitution of worn out parts *(full replacement every 5 – 6 years)*		
Correctly determine the quantity of heating equipment *(equipment must be run at correct (full) power, since the reduction of temperature is not proportional to the reduction of power)*		
Circulate warm air from just below the roof		

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
level down to floor level		
Minimise ventilation rates, as far as the indoor climate requirements allow		
Place ventilation vents low down on the walls (as heat tends to rise)		
Further insulation with loose material (e.g. sand) on the floor or on top of the built-in insulation		
Repair cracks and open seams in the housing construction		
Recover heat in a layer house with a calorifier between the incoming and outgoing air		
Ensure minimum ventilation with well-sealed buildings		
Use fans fitted with back-draught shutters to reduce heat losses		
Good management of minimum flows		
Ventilation		
Select the correct type of fans and consider their position in the building		
Install fans with a low energy use per m^3 of air		
Use fans efficiently *(e.g. operating one fan on full capacity is more economical than operating two on half their capacity)*		
Maintain and keep clean ducts, fans and controlling apparatuses		
Use circulating fans		

2.3 Additional techniques for the efficient use of energy on pig farms

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Better use the available housing capacity		
Optimise animal density		
Lower the temperature as far as animal welfare and production allow		
Reducing ventilation *(taking into account the minimum levels required for animal welfare)*		
Insulate the building *(particularly lagging the heating pipes)*		
Optimise the position and adjustment of heating equipment		

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Consider heat recovery		
Consider using high-efficiency boilers in new housing systems		
Transfer meal mechanically rather than pneumatically (blown) from the mill to mixing or meal storage		
Use improved heater lamps farrowing houses		
Heating and Ventilation		
Optimise ventilation management that balances heating and ventilation *(optimise the minimum rates of air flows) and install energy-saving fans or equipment*		

2.4 Techniques for the on-farm processing of manure (energy related)

Are the following techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Anaerobic treatment of manure in a biogas installation		
Evaporation and drying of manure		
Slurry belt dryer		
Incineration of poultry manure		

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