VERA

VERA VERIFICATION STATEMENT

VERIFICATION OF ENVIRONMENTAL TECHNOLOGIES FOR AGRICULTURAL PRODUCTION

It is hereby stated that

TECHNOLOGY

Agro Clima unit (ACU) Clima+ 200, type 2.5

DELIVERED BY

Rokkedahl Energi ApS

has been tested according to the VERA Test Protocol for
Livestock Housing and Management Systems (Version 2, 2011).

The following main results have been documented through the test:

Verified environmental efficiency

A 28% reduction of ammonia emission per animal place per year can be achieved in broiler houses with the tested technology combination.

Verified operational stability

The tested technology combination has demonstrated a satisfactory operational stability.

25 november 2019

Thomas Bruun, ETA-Danmark

ETA DANMARK

EXEMPTION OF LIABILITY

The VERA Secretariat does not endorse, certify or approve technologies. VERA verifications are based on an evaluation of the technology performance under specific, predetermined criteria and the appropriate quality assurance procedures.

VERA as a representative for the Danish EPA, the German Federal Ministry of Food and Agriculture, the Dutch Ministry of Infrastructure and Environment and the Flamish Institute of Agricultural-, Fisheries- and Nutrition Research makes no expressed or implied warranties as to the performance of the technology and does not certify that a technology will always operate as verified.

The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Further the end user must be aware that the countries involved in VERA are having different legal requirements which will influence the status and use of this verification statement in each country.

THE VERA ORGANISATION

VERA – Verification of Environmental Technologies for Agricultural Production – is a multinational organisation for testing and verification of environmental technologies for agricultural production. VERA is established as a cooperation between the Danish Environmental Protection Agency, the Dutch Ministry of Infrastructure and Environment and the German Federal Ministry of Food and Agriculture.

The purpose of VERA is to enhance a well-functioning market for environmental technologies to increase the environmental protection of agricultural production by substantially accelerating the acceptance and use of improved and cost-effective environmental technologies.

VERA verifies the performance of technologies which are tested according to pre-defined test protocols. A VERA Verification Statement secures validated documentation for the environmental efficiency and operational stability of the technology and is an important step in introducing the technology to the market. Based on information from the test reports, the VERA Verification Statement gives a general and short description of the technology, its principle of operation and the main results and conclusions from the VERA test.

APPLICANT DATA

Technology type	Heat exchanger used as part of the ventilation and heating system in broiler houses
Applied for	Reduction of energy requirement for heating broiler houses and reduction of ammonia from the broiler production
Technology name	Agro Clima Unit (ACU) Clima+ 200, type 2.5 for broiler production
Company	Rokkedahl Energi ApS
Contact person	Anja Møller
Address	Nymøllevej 126, 9240 Nibe, Denmark
Website	www.rokkedahl-energi.dk
Phone	+45 30287210
E-mail	adm@rokkedahl-energi.dk
Test institute	AgroTech, Agro Food Park 15, 8200 Aarhus N, Denmark

TECHNOLOGY DESCRIPTION

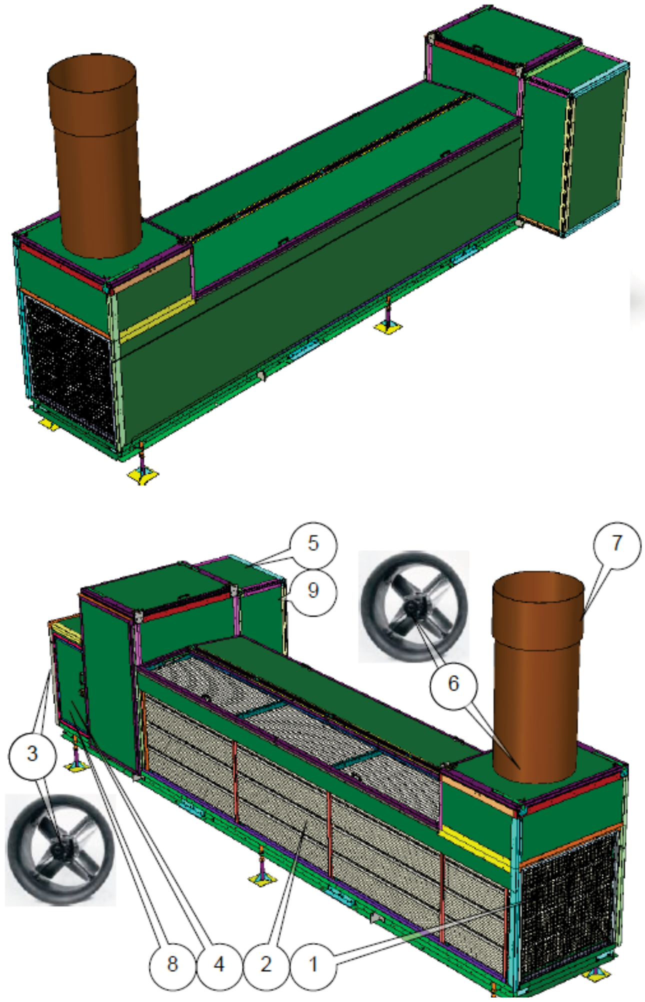
The technology evaluated was the Agro Clima Unit (ACU) Clima+ 200, type 2.5 developed by the company Agro Supply (Figure 1).

Broiler production has a high energy requirement for heating, especially in the first part of the production period caused by the high temperature requirement of newly hatched chickens. The in-house temperature in broiler houses follows a preset temperature schedule. The temperature of broiler houses therefore has to be regulated by heating. This heating can partly be provided by the use of a heat exchange system.

The ACU is a heat exchange system developed for broiler houses (Figure 2A. The ACU heat exchange system utilizes the thermal energy of the air drawn out of a broiler house to heat incoming air by a counterflow heat exchange system. The potential ammonia emission reducing principle of the ACU is the drying of the litter mat caused by the heat exchanger and the additional in-house air distribution and circulation which is a part of the ACU system.

The heated incoming air that has passed through the ACU is blown to the ridge of the broiler house (Figure 2B). The system includes an internal mixing of in house air which potentially results in homogenization of in-house temperatures and improved drying of the broiler litter (Figure 3).

HEAT EXCHANGER



Use:
The heat exchanger is designed to exhaust warm air from a house while and at the same time blowing fresh air into a house. The warm air preheats the fresh air inside the heat exchanger.

Construction:
The heat exchanger consists of:

1. Filters
2. Air tubes
3. Intake ventilator
4. Intake ventilator box
5. Air return box
6. Extraction ventilator
7. Exhaust chimney

Attached to the heat exchanger are:

8. Electrical cabinet
9. Air measuring unit

The heat exchanger has standard dimensions (l x h = 9 meter x 2.3 meter) except for the width. The width of the heat exchanger determines its maximum capacity. The heat exchanger is available in 4 widths:

ACU 1,0 m	9.400 m³/hour
ACU 1,5 m	13.700 m³/hour
ACU 2,0 m	18.400 m³/hour
ACU 2,5 m	22.300 m³/hour

Process:
The extraction ventilator exhausts warm air

Figure 1. Description of the Agro Clima Unit (ACU) and its main components.

The ACU Clima+ 200, type 2.5 has a max air capacity of 22300 m3 air h-1. In the first weeks of the production cycle, when the need for heating is high and the need for air exchange (ventilation) is low, the air flow through the ACU is normally gradually increased from ca. 10 to 100 % of its max air capacity. In the last part of the production cycle, when the need for ventilation is higher than the max capacity of the ACU system, the ventilation of the houses is performed by both; the ACU system and the ridge ventilation system. In warm periods the ventilation could be supplemented by gable ventilation.

The ACU units were situated next to the broiler house (Figure 2A).

A

B

Figure 2 (A and B). The Agro Clima Unit situated outside a broiler house (A). Ventilation air to and from the broiler house are drawn through the Agro Clima Unit by a countercurrent principle to utilize the heat content of out flowing air to heat up inflowing air. Figure 2 B shows the tube transporting the heated air to the ridge of the broiler house in test farm 1.

Air drawn through the ACU was transported to the ridge of the house (Figure 2B). At the ridge the air was distributed to the front and back side of the building by means of additional in-house circulation fans (Figure 3) to improve the distribution of the fresh and heated air inside the broiler house. The mixed air was drawn by the circulation fans towards both ends of the building at the ridge of the broiler house. The mixed air was then drawn towards the centre of the broiler house above the chicken and the litter layer when drawn out by the ACU unit. Exhaust air was taken trough the side wall and the air flow was measured by measuring fan.

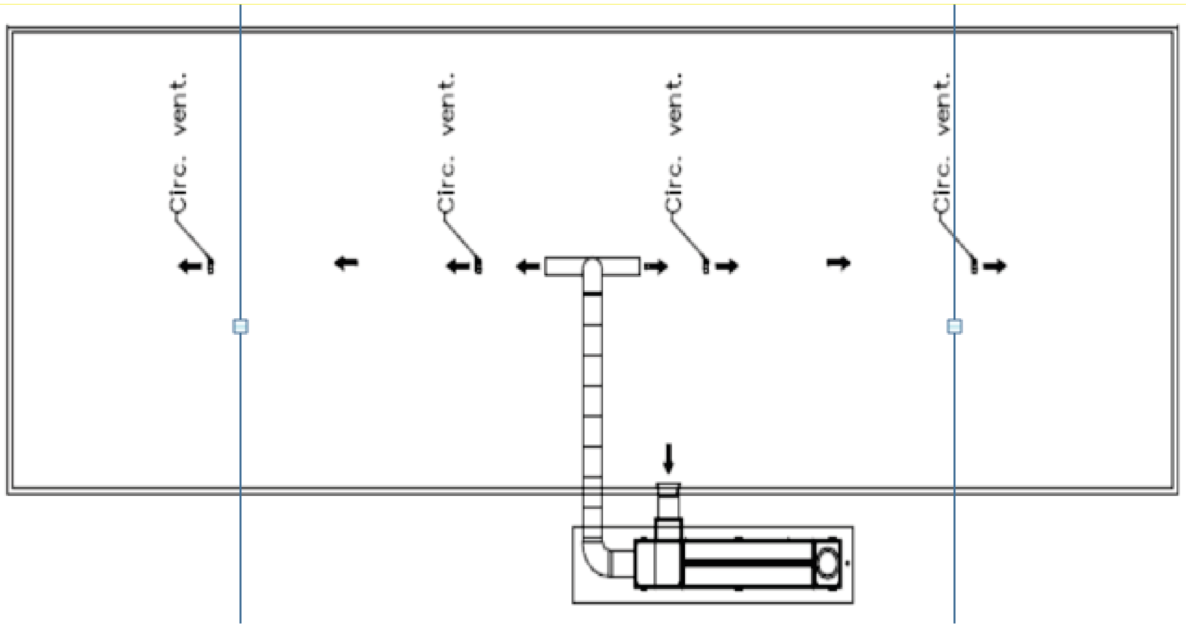


Figure 3. The air circulation system inside the broiler house. Air is drawn through the Agro Clima Unit to the ridge of the broiler house and distributed to the front and back side of the building by means of additional inhouse supporting circulation fans (Circ. vents).

TEST DESIGN

The technology combination was tested in Denmark by AgroTech (Agro Food Park 15, DK-8200 Aarhus N) in accordance with the VERA test protocol for Housing systems at two commercial broiler farms. The measurements were executed from August 2014 until September 2015.

The overall principle for testing the ACU performance was to compare the emission of ammonia and odour from test broiler houses with the ACU heat exchange system (ACU) and the emission of ammonia and odour from an equal test section without the ACU technology (Control). As broilers are housed in mechanically ventilated housing systems, the emissions were quantified by simultaneously on-line measurements of air exchange rate (ventilation) and concentrations of gases in ingoing and outgoing air.

Test setup

According to the so-called "case-control approach", 6 measurement periods of at least 24 hours for ammonia and 9 measurement periods (min. 6 during the summer period) of at least 30 minutes for odour were performed at each of the two test locations, equally distributed over the year and with all animals inside the house during measurements.

Product configuration

TEST FARM CHARACTERISTICS		
Parameter	**Farm 1**	**Farm 2**
Farm owner Address Contact info CHR no.	Rokkedahl Landbrug Løgstørvej 113, 9600, Haubro, Aars Else Olesen, phone: +45 2272 4650 71589	Rokkedahl Landbrug Nymøllevej 161, Kølby 9240 Nibe Michael Christensen, phone: +45 20411262 71589
Number of broilers per test unit Weight range (g) broilers	Ca. 31000 Newly hatched (45 g), 34/35 days old (ca. 2000 g)	Ca. 37000
Bedding material Area of test houses Dimension test houses (w, l, h (ridge), m)	Sawdust (25 g/head) 1500 m3 19.6, 77, 6.1	Sawdust (25 g/head) 1812 m3 19.6, 96, 6.1
Floor space per animal Air volume test houses	0.05 5961 m3	0.05 7432 m3
Air volume per animal, m3 Floor system Manure removal system	0.19 Solid floor All litter is removed at the end of each production period	0.20
Feed composition Feeding system Feed analysis	Wheat, proteins (soya), essential amino acids, minerals and vitamins Four lines of dry food feeding system Table of content	
Water system	Four lines of height adjustable and pressure regulated nipple drinking system with drip cups	

Ventilation	Mechanical negative pressure ventilations system (Ziehl-Abegg, Ø = 630, Microfan Argos	
Ventilation capacity (max) (20 Pa)	Ridge: 12x12000=144000m3 h-1, Ø = 630	Roof ventilation: 13x12000=156000 m3 h-1, Ø = 630
	Gable fan: 2 x 35000 m3 h-1 ACU (test section): 22.300 m3 h-1, Ø = 160	
ACU capacity per bird	22.300 / 31.000 = 0,72 m3/h per bird	22.300 / 37.000 = 0,60 m3/h per bird
Circulation fans (only test sections)	6 Multifan vertical fans, Ø = 500, 7060 m3 h-1	6 Multifan vertical fans, Ø = 720, 14600 m3 h-1
Heating system	In house natural gas burner	Straw heated calorifiers

The test sections were equipped with six vertical circulation fans. The circulation fan system is an integrated part of the ACU system to ensure that air drawn through the ACU system is distributed to the entire broiler house. The circulation fans were vertically situated below the ridge in a way that best possible allowed that incoming ACU heated air were drawn to the front and back of the broiler house (Figure 3). The circulation fans could be regulated both automatically and manually to give between 0 and 100% of maximal air capacity. To ensure optimal in-house climatic conditions, the air capacity of the circulation fans was kept low above newly hatched broilers, and gradually increased to 100% as broilers grew up. A more detailed description of the regulation of the vertical circulation fans can be seen in the user manual (Test Report, Appendix 9.9, page 78).

The number of newly hatched broilers introduced to the test houses, daily number of sick and dead broilers taken out of the houses, on/off periods of use of gable ventilators, on/off periods of the ACU system, air temperature of test sections, and the daily consumption of feed and water were recorded daily by the test site responsible in prepared log books (Test Report, Appendix 9.1).

Test methods and test conditions

Odour and ammonia were the primary performance test parameters (Table 1). In addition, a number of conditional parameters were measured throughout the test periods (Table 2).

Primary parameters

The primary analytical parameters are presented in Table 1. The primary measurement parameters are the primary environmental pollutants emitted from broiler housing unit. These were therefore considered the primary target of the environmental technology.

Dust was not included as a primary parameter. This decision was based on the assumption that the vast majority of the dust produced in broiler houses originates from feathers and the activity of the broilers (Elvstrøm. Pers. com.. 2014), and that a previous preliminary dust study performed by the test institute LUFA NordWest had found reduced levels of dust from broiler houses attached a heat exchange system This study which was performed on behalf of the technology producer Big Dutchman, found that the use of the heat exchange system (Earny) reduced the dust emission from broiler houses by between 11 to 28% (Big Dutchman, 2014). Therefore, as the dust emission was judged to be unaffected or reduced by use of the technology tested, dust was not included as a parameter in the test.

Table 1. Primary test parameters and corresponding analytical methods and detection limits
Conditional parameters

Parameter	Analytical method	Number of samples	Sampling time/period	Limit of detection	Uncertainty
Ammonia	Photo accustic mulitgas analyzer (Innova 1412)	6 measuring periods evenly distributed over one year	Min/24 hours	0.14 mg/m3	15 % RSD
Odour	Olfactometric analyses. (DS EN ISO/IEC 17025 EN 13725 (71M549500) DANAK Test reg. nr. 522)	9 measuring periods (of which mini-mum 6 were performed during summer period (May to September)	30 minutes	100 OUE/m3	±2 x RSD

The conditional parameters are listed in Table 2. The conditional parameters are parameters which may influence the emission level of the primary environmental pollutants. In addition, the table includes additional secondary environmental pollutants.

Table 2. Conditional parameters, involved analytic methods and detection limits

Parameter	Analytical method	No of measuring periods	Sampling time/period	Limit of detection	Uncertainty
CO2	Photo acoustic multigas analyzer (INNOVA, 1412)	6	Continuous	2.5 mg/m3	15 % RSD1
Air Temperature	Motron, Smart sence 3000 coupled to VE10A VENG universal input system	6	Continuous	-40 - +60˚C	±0,5˚C (0-40˚C)
Relative air humidity	Motron, Smart sence 3000 coupled to VE14 universal VENG system	6	Continuous	0,1% RH	±2% (10-90% RH)
Ventilation	Air anemometers, Steinen AQC-630	6	Continuous	2 m3 s-1	
H2S (odour sampling)	Jerome 631-XTM	9	10 min	3 ppb	0.003-2 ppm2
NH3 (odour sampling)	Kitagawa gas detection tubes, 0.2 – 20 ppm	9	2 min	0.1 ppm	5% RSD
Air Temperature (odour sampling)	Testo 174H	9	60 min	0.1 °C	±0.5 °C (-20 to +70 °C)
Relative air humidity (odour sampling)	Testo 174H	9	60 min	0.1 %	±3 %RH (2 to 98 %RH)
Manure parameters	Accredited standard laboratorie analyses DIN EN 12880	6			

- DM (%)	DIN 19684-4	6		
- Total N (kg/ton)	DIN 38406-5-2	6		
- NH4-N (kg/ton)		6		
Wind direction (°) and speed (m/s)	UTM based climatic data service developed by the Danish Meteorological Institute (DMI)	9	24 h	

TEST RESULTS

ENVIRONMENTAL EFFICIENCY

ODOUR

The odour emission varied considerable between the different test periods. The variation is considered to be caused by differences in climatic condition and size of broilers. The mean odour emission per growth stage 1 (broiler age 1-11 days), growth stage 2 (broiler age 12-23 days), and growth stage 3 (broiler age 24-34 days) was therefore calculated (Figure 4).

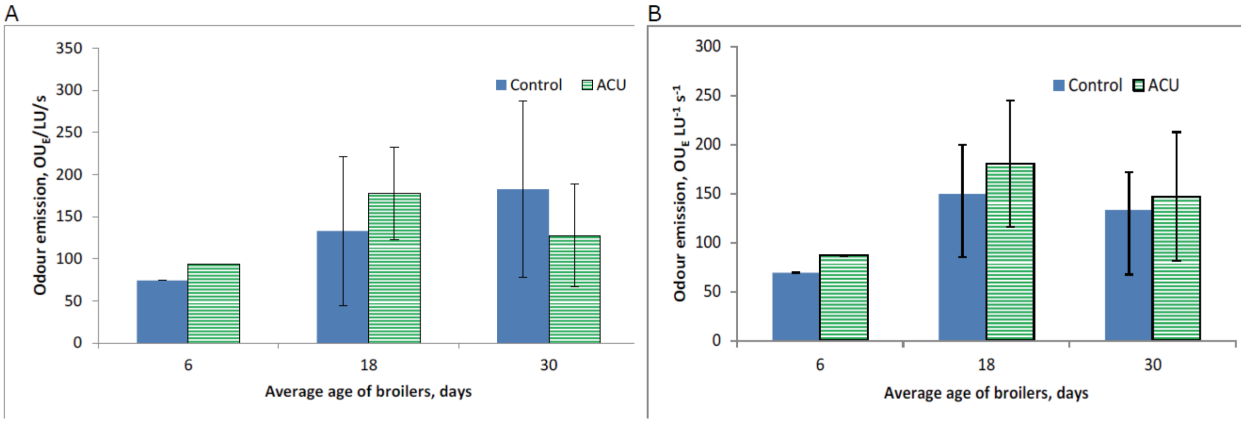


Figure 4. Mean odour emission from broilers produced in broiler houses with the heat exchange system (ACU) and without use of heat exchange system (control). The emission is shown at broiler age 6, 18 and 30 days measured at farm 1 (A) and farm 2 (B). The emission is shown as odour emission in odour units (OUE) per livestock unit (LU=500 kg broiler) per second. Error bars indicate standard deviation.

The odour emission per 500 kg body mass of broilers was found to vary between 74 and 182 odour units per second. The odour emission was slightly higher from broiler houses attached the ACU heat exchange system when broilers were 6 and 18 days old and only on farm 1 slightly lower when broilers were 30 days old. However significant differences between the average odour emission from broiler houses with and without attachment of the ACU unit were not found (Table 3).

Table 3. Mean odour emission per LU per second from control and ACU test sections at test farm 1 and 2 at the different growth stages, and weighted median and mean ±95% confidence intervals (CI). The odour emission is given as OUE per LU (LU=500 kg broiler) per second. Means followed by same letter do not differ significantly.

Broiler growth stage	Farm 1, $OU_E\ LU^{-1}\ s^{-1}$		Farm 2, $OU_E\ LU^{-1}\ s^{-1}$	
	Control	ACU	Control	ACU
1	74.0	93.4	69.4	87.1
2	132.8	177.5	149.6	180.4
3	182.6	127.4	133.4	147.0
Median	123.7	137.4	120.7	126.9
Mean±95% CI	$150.3^{a}\pm77.1$	$142.0^{a}\pm49.0$	$123.3^{a}\pm34.5$	$145.6^{a}\pm49.4$

Test for difference between Farm 1 con and Farm 1 ACU, $p=0.83$
Test for difference between Farm 2 con and Farm 2 ACU $p=0.16$
Test for difference between control Farm 1 and control farm 2 $p=0.44$
Test for difference between ACU Farm 1 and ACU farm 2 $p=0.90$

The average odour emission per livestock unit (LU=500 kg) for the control and ACU test houses were calculated for both test farms. As the odour emissions measured at the two test farms were not found to be statistically different, the odour emission data from the two farms were pooled before further analysed. The average odour emission from broiler houses with the heat exchange system (ACU) and without the heat exchange system (Control) can be seen in Table 4.

Table 4. Median and mean odour emission from broiler houses with (ACU) and without (control) a heat exchange system when all sampling periods were included and growth stages are included. The odour emission is given as OUE per LU (LU=500 kg broiler) per second. Mean values are given as mean ± 95% confidence intervals (CI). Means followed by same letter do not differ significantly (p=0.73)

Technology	No of sampling periods	Median odour emission, $OU_E\ LU^{-1}\ s^{-1}$	Odour emission, $OU_E\ LU^{-1}\ s^{-1}$
Control	17	122.7	$136.0^{a}\pm36{,}1$
ACU	17	132.0	$143.9^{a}\pm30.7$
Technology effect, %			-5.8

The odour emission from the control and ACU broiler houses did not differ significantly; however, a slightly higher odour emission was observed from the broiler houses attached the ACU unit. This may be due the higher internal ventilation in the ACU broiler houses causing a higher transport of odour from the litter mat to air outlets.

AMMONIA

The total ammonia emission from broilers produced in broiler houses with and without use of the ACU heat exchange system can be seen in Table 5. Given a broiler production period of 34 days the use of the heat exchange system was found to reduce the ammonia emission by 28 percent. Assuming a cleaning/preparation period of eight days between production periods, a production period of 34 days allows 8.7 production periods per year.

Table 5. Total ammonia emission from broilers produced in broiler houses with (ACU) and without (Control) use of the ACU heat exchange system. The total ammonia emission was calculated for a broiler production with a production period of 34 days. Means followed by different letter in the same line differ significantly (p<0.05). Standard deviation is shown in brackets.

Total ammonia emission	Length of production period, days	Total ammonia emission			Ammonia reduction efficiency of the ACU system, %
		Control	ACU	P value	
Per production period, g NH_3 broiler^{-1}	34	3.78^{a} (2.7)	2.74^{b} (2.6)	0.04	27.5
Per animal place, g NH_3 animal place^{-1} year^{-1} (8.7 production periods year^{-1})	34	32.9^{a} (23.9)	23.8^{b} (22.2)	0.04	27.5

The average ammonia emission from broiler houses attached the ACU system was found to be 23.8 g NH3 year-1 animal place-1. This is in accordance to results found by Hensen et al. (2010) who found an annual loss of 20 g NH3 per animal place in a Dutch study performed at four broiler houses attached ACU systems. The ammonia emission in another Dutch study found average ammonia emission equal to 35 g NH3 animal place-1 year-1 from broilers brought up in broiler houses without attachment of the ACU unit (RAV list, 2013). Comparing the ammonia emission from broilers brought up in broiler houses with and without attachment of ACU heat exchange system in Holland gave technology efficiency equal to levels found by the present study.

OPERATIONAL STABILITY

The ACU unit is delivered with a complete user manual, which describes relevant directions for system operation, maintenance and safety (See Test Report, Appendix 9.9).

To maintain a fully functioning technology regularly cleaning is needed. During the test the heat exchanger was thoroughly cleaned between broiler production cycles. During the production cycles the ACU unit was set to a pre-programed washing/cleaning system. The washing program was depending on the outdoor climatic conditions and normally started when the broilers were about two to three weeks old. Thereafter, the heat exchange system was set to run an automatic washing program once or twice daily.

Rokkedahl Energi advise that the customer run the rinsing program in the computer every 10 days, since this is when the air channels starts to get dusty. The rinsing system is running 3 minutes a day until end of flock. Capacity 300 L times 25 days equals 7,5 m3 water per flock.

After every flock, Rokkedahl Energi advise to soak the unit and clean it properly (not with rinsing) and to change/clean the filter at the fresh air intake.

No down-time periods of the Agro Clima unit (ACU) Clima+ 200, type 2.5 was registered during the test period. Based on that it is concluded that the technology has satisfying operational stability if it is cleaned according to the directions.

IDENTIFIED SIDE EFFECTS

None

ADDITIONAL RESULTS

None

ADDITIONAL INFORMATION

Animal welfare

The technology effect on animal welfare was not part of the test. However, the less humid litter observed in the broiler houses attached the heat exchange system is known to reduce problems with paw ammonia burns (pododermatitis) which is expected to reduce the animal welfare (Weaver and Meijerhof, 1991). A positive animal welfare effect of the heat exchange system is therefore expected.

Occupational health and safety

The tested technology was not found to have any occupational health and safety effects.

Total external environmental impact

Reduced ammonia emission from broiler houses attached a heat exchange system reduces the ammonia emission from the broiler production and thereby the impact of the production to ammonia sensitive natural habitats like forests, heathlands and water habitat. The reduced ammonia emission will increase the nitrogen level in broiler manure by nearly the same amount and thereby it's fertilizing value when used in plant production. This has be considered when fertilising.

Food safety and chemical regulation

The technology was not found to have any impact on food safety and chemical regulation.

TEST INSTITUTE

AgroTech, Agro Food Park 15, DK-8200 Aarhus N, Denmark. From 1st of January 2016, AgroTech has been part of Danish Technological Institute (www.dti.dk).

VALIDITY AND TERMS OF USE

VALIDITY

This VERA Verification Statement is only valid for the specific verified product / technology and the tested animal category. There is no time limit for the validity of this VERA Verification Statement as long as the product / technology stays unmodified.

The International VERA Secretariat can, however, at any time invalidate the VERA Verification Statement if it is found to be misused or if significant modifications have been made to the product / technology that are estimated to have a negative effect on the environmental efficiency or operational stability. In regard to the latter the International VERA Secretariat can require that a new VERA test should be performed.

TERMS OF USE

The use of this VERA Verification Statement must be in compliance with these terms:

- Rokkedahl Energi must inform the International VERA Secretariat if any modifications are applied to the technology that can significantly influence the environmental efficiency and / or the operational stability.
- This verification cannot be considered as an endorsement, approval, authorization or warranty of any kind, and the performance parameters provided cannot be extended to other applications or to other technologies.
- Rokkedahl Energi agrees not to use this VERA Verification Statement, the test reports, or to refer to those, for any other technology than the one specified in the statement.
- The VERA Verification Statement will be made available for public access at the VERA website: www.vera-verification.eu .
- All other information obtained or produced during the verification process is considered confidential and will not be made available for others than the part owning the intellectual property rights.

CONTACT INFORMATION

This VERA Verification Statement is issued by the:

ETA-Danmark A/S

Göteborg Plads 1

DK-2150 Nordhavn

Email: eta@etadanmark.dk

Website: www.etadanmark.dk/en