

Rokkedahl Energi. Agro Clima Unit Heat Exchange System for reduction of ammonia emission from broiler houses.

Verification report





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1 INTRODUCTION

Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology for a specified application, under defined conditions and quality assurance.

This document is the verification report resulting from verification of the Agro Clima Unit heat exchange system applied for reduction of ammonia emission from broiler housing systems.

1.1 Name of technology

The technology verified was Agro Clima Unit 200, type 2.5.

1.2 Name and contact of proposer

Agro Clima Unit is developed by the Dutch company Agro Supply. In Denmark Agro Clima Unit is marketed and sold by Rokkedahl Energi, Nymøllevej 126B, Kølby, DK-9240 Nibe, Denmark. Website: www.rokkedahl-kylling.dk/rokkedahl-energi.aspx.

Contact at Rokkedahl Energi: Mark Rokkedahl. E-mail: adm@rokkedahl-energi.dk. Phone: +45 30 28 72 10.

1.3 Name of verification body and verification responsible

The verification was performed by DANETV, AgroTech Test Centre, Agro Food Park 15, DK-8200 Aarhus N, Denmark. Verification responsible: Amparo Gomez Cortina. Phone: +45 87 43 84 70. E-mail: aco@agrotech.dk.

1.4 Verification organisation including experts

The verification was conducted by Danish Centre for Verification of Climate and Environmental Technologies, DANETV, which performs independent tests and verifications of technologies for the reduction of climate changes and environmental pollution. The verification was planned and conducted to satisfy the requirements of the EU ETV pilot programme (EU ETV) established by the European Union.

An internal and an external technical expert provided independent reviews of the planning, conducting and reporting of the verification and tests. The technical experts assigned to this verification and responsible for review of the verification plan and report documents include:

Internal expert: Thorkild Q Frandsen, AgroTech, Agro Food Park 15, DK-8200 Aarhus N. Phone: +45 8743 8468, e-mail: tqf@agrotech.dk.

External expert: Arne Grønkjær Hansen, Gronconsult, Agro Food Park 13, DK-8200 Aarhus N, Denmark. Phone: +45 30 50 40 98. E-mail: a.gronki@gmail.com.

An overview of the organisation associated with test and verification is given in figure 1.

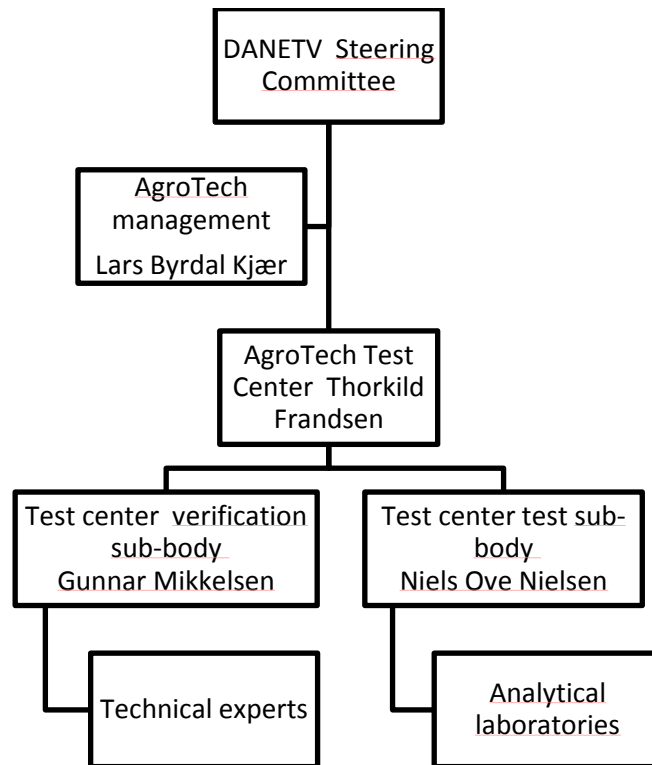


Figure 1. Organisation of test and verification

1.5 Verification process

The verification and the test were conducted in two separate steps, as required by the EU ETV pilot programme. The steps in the verification are shown in Figure 2.

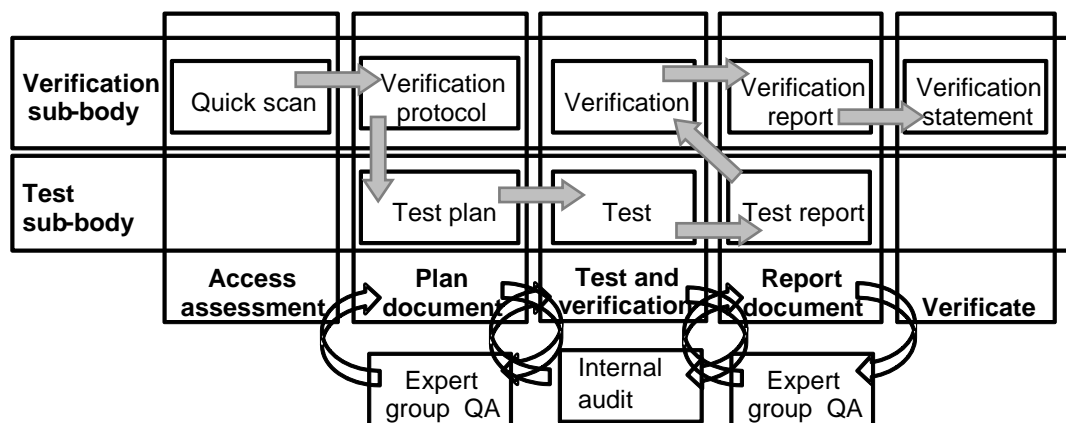


Figure 2. Verification steps.

The verification process is described in the AgroTech Test Centre Quality Manual [1].

This verification protocol, the test plan and the process document shall be seen as one consolidated verification description.

1.6 Deviations to the verification protocol

There have been no deviations to the verification protocol.

2 OVERALL DESCRIPTION OF THE TECHNOLOGY TYPE

Since the 1990s there has been increasing focus within Europe to reduce ammonia emission from livestock housing systems. In Denmark initiatives have been taken by the Environmental Protection Agency to reduce ammonia emission through regulative measures. Thus, when a livestock producer wants to expand his/her production unit requirements for reducing the ammonia emissions are included in the environmental permission. Therefore, the demand for ammonia reducing technologies has increased.

Different technologies have been developed to reduce ammonia emission from livestock housing systems. In housing systems with controlled ventilation systems one approach is to install air cleaners that remove part of the ammonia from the ventilation air and in some cases also odour and dust. However, the technology in focus for the present verification is developed with a different approach.

Generally speaking, ammonia emission is higher from materials with wet surfaces than from materials with dry surfaces. Thus, by installing a technology in the broiler house that keeps the manure layer on the floor dry ammonia emission can be reduced.

3 DESCRIPTION OF TECHNOLOGY FOR VERIFICATION

The technology evaluated was an Agro Clima Unit (ACU) Clima⁺ 200, type 2.5 developed by the company Agro Supply and sold in Denmark by Rokkedahl Energy. Broiler production in Northern Europe involves a high energy requirement due to a high temperature requirement of newly hatched chicken. The Agro Clima Unit is a heat exchange system that by a counter current heat exchange system utilizes the thermal energy of air leaving the broiler house to heat and dry incoming air.

The potential ammonia emission reducing principle of the Clima Unit is the drying of the manure layer caused by the heat exchange system and the continuously circulation ventilation in the broiler house.

The Clima Unit is normally situated next to the poultry house (Figure 3). Inlet 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 four additional in-house supporting vents. This results in an improved distribution of in-house air.



Figure 3. Picture of the Agro Clima Unit situated outside a poultry house. Ventilation air to and from the poultry house are drawn through the Agro Clima Unit by a counter current principle to utilise the heat content of out flowing air to heat up inflowing air.

3.1 Application and performance parameter definitions

The intended application of Agro Clima Unit is defined in terms of the matrix, the purpose and exclusions.

The matrix is the type of material that the Agro Clima Unit is intended for during this verification. Agro Clima Unit has been tested and verified for treatment of ventilation air from a typical broiler housing system.

The purpose of a technology is defined in terms of what measurable properties that are affected by the technology and how these properties are affected. In case of Agro Clima Unit the purpose was to reduce the ammonia emission from a broiler housing system compared with a similar broiler housing system without Agro Clima Unit installed. To evaluate this, the performance parameters listed in table 1 have been defined for this verification.

Table 1. Performance parameters for the verification of Agro Clima Unit.

Parameter	Value
Reduction in ammonia emission from broiler housing systems with Agro Clima Unit installed compared with similar broiler housing systems without Agro Clima Unit installed.	Minimum 30 %
Ammonia loss from the broiler housing system with Agro Clima Unit installed based on measurements from warm, medium and cold periods of the year.	Maximum 3.50 Kg NH ₃ /1000 broilers

The verification comprises a complete and full-scale installation of the Agro Clima Unit.

The proposer claimed that Agro Clima Unit has a positive effect on energy consumption related to heating of the broiler housing systems. However, reduction of energy

requirement for heating broiler houses by use the Agro Clima Unit was not evaluated as part of this verification.

3.2 Additional parameters, including operational parameters

Apart to the performance parameter a number of additional parameters were defined as part of this verification:

- CO₂-concentration in air inlet and air outlets
- CH₄ in air inlet and air outlets
- N₂O in air inlet and air outlets
- Ventilation rate (air exchange rate)
- Temperature
- Relative humidity

Moreover, The Agro Clima Unit user manual was evaluated as part of the verification.

4 EXISTING DATA

4.1 Accepted existing data

No data from previous tests have been included in the verification of Agro Clima Unit.

5 EVALUATION

5.1 Evaluation of performance parameters

The performance parameters have been defined to be able to verify the reduction in ammonia emission from broiler housing system as a result of the Agro Clima Unit.

The overall principle for testing the performance of Agro Clima Unit (ACU) was to compare the emission of ammonia from a test section attached an Agro Clima Unit (case section) and an equal test section without an Agro Clima Unit (Control section). As broilers were housed in a mechanically ventilated housing system, the emission was measured by simultaneously measurements of ventilation rate and concentration of ammonia in ingoing and outgoing air.

Emission measurements require measurement of the air exchange (ventilation) of the housing system. The ventilation rate was continuously on-line measured by anemometers (Stienen 600) situated in ventilation ducts during the test periods.

Concentrations of ammonia in ingoing and outgoing air were continuously on-line measured by use of an on-line automatic photo-acoustic multigas analyser (INNOVA, 1412).

The ammonia emission from both case and control sections were measured over three full production cycles each lasting approximately 30 days. To incorporate the yearly climatic change, the production cycles were placed in the warm and cold seasons. One of the production cycles took place in the summer period, one took place in the autumn

period, and one was undertaken in the winter period. The three production cycles took place from August to December.

The daily ammonia emission from broilers produced in houses with or without the ACU system is shown in Figure 2. Levels of emission were found to increase during the production cycle for all three periods. In period 1 ammonia emission was found to be lower from the broilers produced in the test section attached the ACU system for the first 20 days of the production cycle. In period 2 lower emission from the test section attached the ACU was observed during the full period of measurement. In period 3 lower emissions was observed from the case section during the first 25 days.

The highest effect of the ACU system was found when ventilation of the case section was performed mainly by the ACU system. In general, it was observed that the higher proportion of the total ventilation requirement that was performed by the roof ventilation system, the closer were the emission levels of the test and case section (Figure 4, 5 and 6).

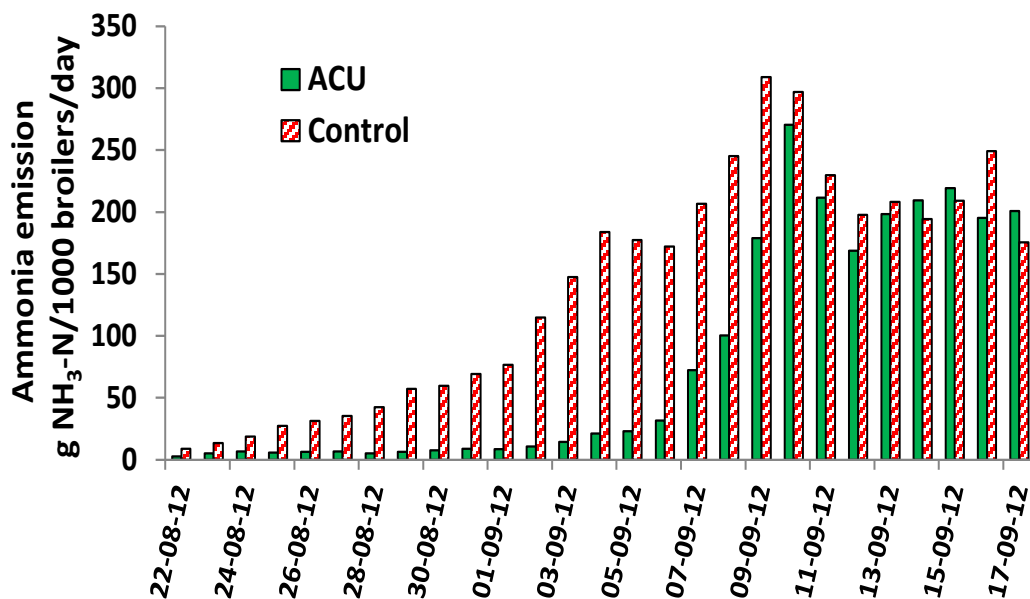


Figure 4. Measured daily emission of ammonia nitrogen (NH₃-N) from broilers produced in a test section with the Agro Clima Unit (ACU) installed and a test section without use of the ACU system (Control). Ammonia volatilization is shown in g of ammonia nitrogen (NH₃-N) per 1000 broilers per day. This diagram shows results for broilers produced during test period 1 (August and September 2012). Missing data is a consequence of malfunction of measurement equipment.

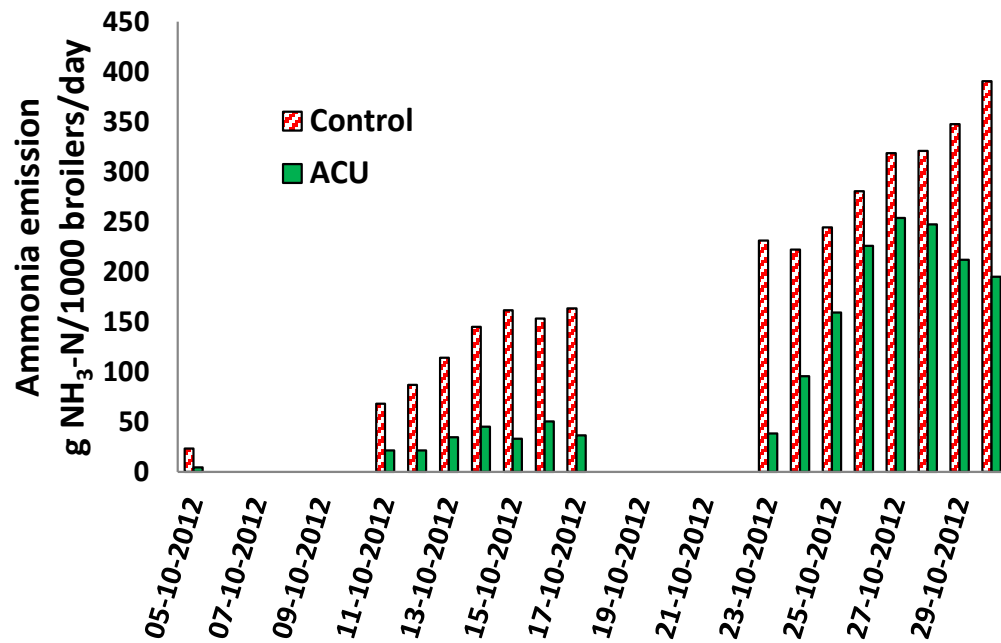


Figure 5. Measured daily emission of ammonia nitrogen (NH₃-N) from broilers produced in a test section with the Agro Clima Unit (ACU) installed and a test section without use of the ACU system (Control). Ammonia volatilization is shown in g of ammonia nitrogen (NH₃-N) per 1000 broilers per day. This diagram shows results for broilers produced during test period 2 (October 2012). Missing data is a consequence of malfunction of measurement equipment.

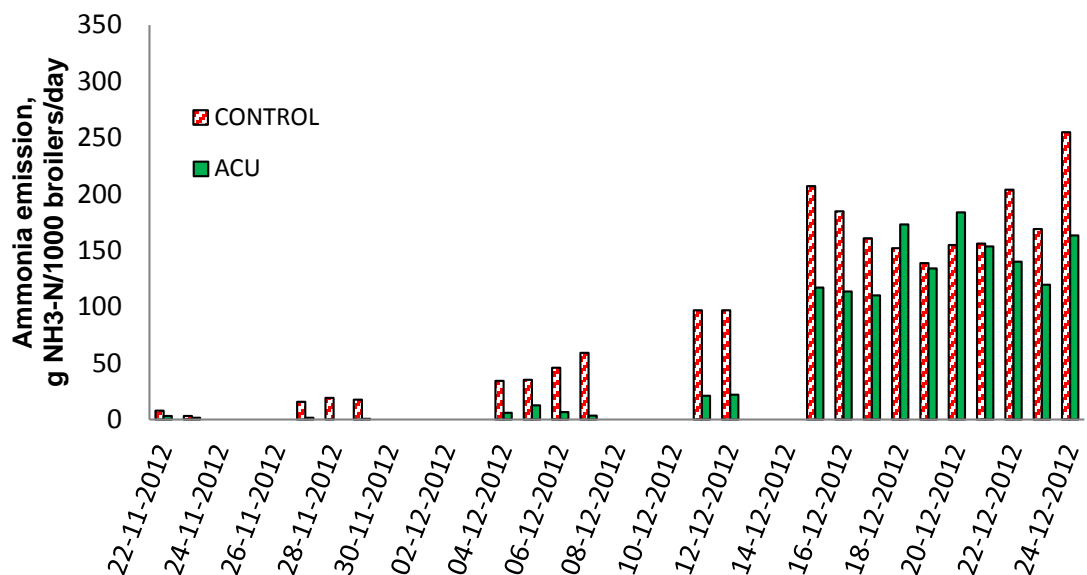


Figure 6. Measured daily emission of ammonia nitrogen (NH₃-N) from broilers produced in a test section with the Agro Clima Unit (ACU) installed and a test section without use of the ACU system (Control). Ammonia volatilization is shown in g of ammonia nitrogen (NH₃-N) per 1000 broilers per day. This diagram shows results for broilers produced during test period 3 (November and December 2012). Missing data is a consequence of malfunction of measurement equipment.

The total ammonia emission per 1000 broilers produced in a housing system with and without use of the ACU system can be seen in Table 2. The ACU system was found to

reduce ammonia emission from broilers by 42 % in period 1, by 49 % in period 2 and by 33 % in period 3. In average the ammonia emission reduction is found to be 41 %.

Table 2. Measured ammonia volatilization and the ammonia reduction effect of the Agro Clima Unit (ACU) system per 1000 broilers produced in a 30 days production period.

Test period	Ammonia loss	Unit	Control	ACU	Difference, kg	Difference, %
1	Ammonia loss	Kg NH ₃ /1000 broilers	5.07	2.96	2.11	41.6
	Ammonia-N loss	Kg NH ₃ -N/1000 broilers	4.18	2.44	1.74	41.6
2	Ammonia loss	Kg NH ₃ /1000 broilers	7.01	3.59	3.41	48.7
	Ammonia-N loss	Kg NH ₃ -N/1000 broilers	5.77	2.96	2.81	48.7
3	Ammonia loss	Kg NH ₃ /1000 broilers	3.84	2.58	1.26	32.7
	Ammonia-N loss	Kg NH ₃ -N/1000 broilers	3.16	2.12	1.04	32.7
Mean of the periods	Ammonia loss	Kg NH₃/1000 broilers	5.30	3.04	2.26	41.0
	Ammonia-N loss	Kg NH₃-N/1000 broilers	4.37	2.50	1.87	41.0

5.2 Performance parameter summary

An overview of the evaluated performance parameter is given in table 3 below.

Table 3. Results from evaluation of performance parameters for Agro Clima Unit.

Parameter	Verified value
Reduction in ammonia emission from broiler housing systems with Agro Clima Unit installed compared with similar broiler housing systems without Agro Clima Unit installed.	41 %
Ammonia loss from the broiler housing system with Agro Clima Unit installed based on measurements from both warm, medium and cold periods of the year.	3.04 Kg NH ₃ /1000 broilers

5.3 Evaluation of test quality

5.3.1 Control data

During the test period the data sampled by the online multigas analyser (Innova) was checked by manual sampled gas sampling equipment (Kitagawa ammonia and carbon dioxide gas detection sampler). The gas samples were pulled with a hand pump through a glass tube giving a colour reaction. The concentration of ammonia and carbon dioxide is visually read on the tube.

Online measurement of in-house air temperature and humidity were checked with mini data logger (Testo, 174 H) situated in control and case sections.

Furthermore, the stability of the test equipment was controlled continuously by daily supervision and recording of data. Procedures ensuring that test facilities and equip-

ment are calibrated and fit for the purposes are described in the Quality Manual for the Laboratories of AgroTech. These procedures are subject to internal audits by the AgroTech Management.

5.3.2 Audits

No audit was undertaken for this specific verification task.

5.3.3 Summary of amendment and deviations

Due to problems with the measuring equipment and the continuous measurement of ventilation rate, it was not possible to calculate a continuous emission profile for the full length of the production cycles.

To avoid that the periodic malfunction of measuring systems influenced the calculation of technology effect, data was excluded from both the case and control sections when a measuring problem was observed in one of the test sections. Therefore, the ammonia emission could not be calculated for all days in the production cycles. The measurement period was scheduled to last approximately 30 days per production cycle.

Due to malfunction of measurement equipment the number of measurement days was reduced by 5, 13, and 12 days for period 1, 2, and 3 respectively. It is judged that the reduction in measurement days did not have a significant influence on the verified performance of the Agro Clima Unit.

5.4 Additional parameter summary

Based on a review it is concluded, that the user manual of Agro Clima Unit contains full information and it is clearly formulated.

5.5 Operational parameters

The test activities included measurement of the following operational parameters:

- Ventilation rate of the broiler houses (m^3/hour)
- Air temperature ($^{\circ}\text{C}$) inside and outside broiler houses.
- Relative air humidity (%) inside and outside broiler houses.
- CO_2 -concentration in air inlet and air outlets
- CH_4 in air inlet and air outlets
- N_2O in air inlet and air outlets

The data from these measurements are included in the test report.

5.6 Recommendations for verification statement

It is recommended to issue a verification statement based on the verified performance described in section 5.1, 5.2 and 5.4.

6 *QUALITY ASSURANCE*

Internal review of the verification protocol, verification report, test plan and test report was done by Thorkild Q Frandsen, AgroTech. No system audit was done for this verification.

External review of the test report and verification report was done by Arne Grønkjær Hansen, Gronconsult.

7 *REFERENCES*

- [1] AgroTech (2009): AgroTech Test Centre Quality Manual. Not published.
- [2] Agro Supply (2010): User Manual Agro Clima Manager for Broilers. UM-ACM-1.1-GB/11-2010. 66 pages.
- [3] VERA Secretariat (2011): Test Protocol for Livestock Housing and Management Systems. Version 2. 29-08-2011. 55 pages.



A P P E N D I X A

Terms and definitions

Word	DANETV
Analytical laboratory	Independent analytical laboratory used to analyse test samples
Application	The use of a product specified with respect to matrix, target, effect and limitations
DANETV	Danish center for verification of environmental technologies
DANETV test center	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body
Effect	The way the target is affected
Environmental product	Ready to market or prototype stage product, process, system or service based upon an environmental technology
Environmental technology	The practical application of knowledge in the environmental area
Evaluation	Evaluation of test data for a technology product for performance and data quality
Experts	Independent persons qualified on a technology in verification
Matrix	The type of material that the product is intended for
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis
Liquid fraction	Liquid or thin fraction derived from the separation of slurry.
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product
Procedure	Detailed description of the use of a standard or a method within one body
Producer	The party producing the product
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis
Target	The property that is affected by the product
Test center, test	Sub-body of the test center that plans and performs test

Word	DANETV
sub-body	
Test center, verification sub-body	Sub-body of the test center that plans and performs the verification
Test/testing	Determination of the performance of a product for parameters defined for the application
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance



A P P E N D I X B

Quick scan

QUICK SCAN REPORT

Product name:	Agro Clima Unit
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Test center		Proposer	
Name:	AgroTech A/S	Name:	Rokkedahl Energi Aps
Contact:	Thorkild Frandsen	Contact:	Mark Rokkedahl
Address:	Agro Food Park 15	Address:	Nymøllevej 126B
	DK-8200 Aarhus N		DK-9240 Nibe
	Denmark		Denmark
Telephone:	+45 87 43 84 68	Telephone:	+45 30 28 72 10
E-mail:	tqf@agrotech.dk	E-mail:	adm@rokkedahl-energi.dk

Quick scan		Previous quick scan					
Date:	21-06-2012	Yes		Date:		No	X

Product description							
<p>The Agro Clima Unit is a heat exchange system that by a counter current heat exchange system utilizes the thermal energy of air leaving the broiler house to heat and dry incoming air. The potential ammonia emission reducing principle of the Clima Unit is the drying of the manure layer caused by the heat exchange system and the continuously circulation ventilation in the broiler house. The Clima Unit is normally situated next to the poultry house. Inlet 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 four additional in-house supporting vents.</p>							
Product ready to market				Product in last development phase			
Yes	X	No		Yes	X	No	
Performance claims							
Matrices:	Exhaust air from ventilation of poultry housing systems.						
Purpose:	Reduced ammonia emission from poultry housing systems.						

Product description clear				Performance claims clear			
Yes	X	No		Yes	X	No	

Existing test data							
Tests performed				Test body qualified: Not relevant			
Yes		No	X	Yes		No	
Test report available				Test report qualified: Not relevant			
Yes		No	X	Yes		No	
Test methods available				Test methods adequate: Not relevant			
Yes		No	X	Yes		No	
Raw data available				QA of raw data adequate: Not relevant			
Yes		No	X	Yes		No	
Performance claims sustained				Performance claims relevant: Not relevant			
Yes		No	X	Yes		No	

Conclusions quick scan	
<p>The Agro Clima Unit is judged to be relevant and ready for environmental technology verification under the DANETV-programme. Since there are no data available on performance of the technology a test has to be performed to generate the data necessary for the verification.</p>	

Date	Name	Signature
21-06-2012	Thorkild Q Frandsen	Original signed 21-06-2012



A P P E N D I X C

Proposal

VERIFICATION PROPOSAL

Verification body		Proposer	
Name:	AgroTech A/S	Name:	Rokkedahl Energi Aps
Contact person:	Amparo G. Cortina	Contact person:	Mark Rokkedahl
Address:	Agro Food Park 15	Address:	Nymøllevej 126B
	8200 Aarhus N		DK-9240 Nibe
	Denmark		Denmark
Telephone:	+45 87 43 84 70	Telephone:	+45 30 28 72 10
Telefax:	+45 87 43 84 10	E-mail:	adm@rokkedah-energi.dk
E-mail:	aco@agrotech.dk		
Date quick scan	21-06-2012		

Previous verification performed

Yes, date		No	X
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Description of technology – technical documentation

Agro Clima Unit (ACU) Clima⁺ 200, type 2.5 is developed by the Dutch company Agro Supply. Chicken production in areas with climate like Northern Europe has a high energy requirement, especially in the first part of the production period due to the high temperature requirement of newly hatched chicken. The in-house temperature in broiler houses follows a preset temperature schedule. The temperature is normally regulated by use of in-house gas burners and/or preheating of inflowing air.

The Agro Clima Unit is a heat exchange system that utilizes the thermal energy of the air leaving the chicken house to heat and dry incoming air by a countercurrent heat exchange system. The potential ammonia emission reducing principle of the Agro Clima Unit is the drying of the manure layer caused by the heat exchanger and the in-house air circulation that is included in the system. The heated incoming air that has passed through the Agro Clima Unit is blown into the house at the top of the building.

The system includes an internal mixing of in-house air which potentially results in homogenization of in-house temperatures and improved drying of the manure layer. The ACU Clima⁺ 200, type 2.5 has a max air capacity of 22,300 m³ air h⁻¹.

Intended application of the technology

The intended application of Agro Clima Unit is defined in terms of the matrix, the purpose and exclusions. The matrix is the type of material that the Agro Clima Unit is intended for during this verification. Agro Clima Unit has been tested and verified for treatment of ventilation air from a typical broiler housing system.

The purpose of a technology is defined in terms of what measurable properties that are affected by the technology and how these properties are affected. In case of Agro Clima Unit the purpose was to reduce the ammonia emission from a broiler housing system with 30 % compared with a similar broiler housing system without Agro Clima Unit installed.

The proposer claimed that Agro Clima Unit has a positive effect on energy consumption related to heating of the broiler housing systems. However, reduction of energy requirement for heating broiler houses by use the Agro Clima Unit was not evaluated as part of this verification.

Initial performance claim:				
Description/principles clear?	Yes	X	No	
Declared performances described?	Yes	X	No	
Innovative technology?	Yes	X	No	
Ready to market?	Yes	X	No	
Prototype in advanced stage of development?	Yes	X	No	

Remarks out of quick scan to be considered:
The Agro Clima Unit is judged to be relevant and ready for environmental technology verification under the DANETV-programme. Since there are no data available on performance of the technology a test has to be performed to generate the data necessary for the verification.

Verification body:		
Date	Name	Signature
03-07-2012	Amparo Gomez Cortina	Original signed 03-07-2012



A P P E N D I X D

Specific verification protocol



The specific verification protocol is attached to the verification report as a separate document.



A P P E N D I X E

Amendment and deviation report for verification



See description of deviations in chapter 5 of the verification report.



A P P E N D I X F

Test report



The test report (with the test plan included as appendix) is attached to this verification report as a separate document.