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# Analysis of Electrical Energy and Minimum Ventilation Consumption

*Analysis Of Electrical Energy And Minimum Ventilation Consumption*

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**Summary**

The project consists of altering the operating mode of the minimum ventilation system in a poultry house, with the aim of reducing electricity consumption. To achieve this, the use of *on/off* starting methods is replaced with frequency inverter starting, allowing for control of fan speed, power variation, and continuous adjustment of the system rather than time-based.
**Keywords:** power variation; poultry house fans; energy saving.

## Abstract

The project consists of changing the operating mode of the minimum ventilation system in an aviary, aiming to reduce electrical energy consumption. The traditional *on/off* starting methods are replaced by inverter-based starting, allowing speed control of the fans, power variation, and system control based on continuous adjustment rather than time-based operation.
**Keywords:** power variation; aviary fans; energy saving.

## 1 INTRODUCTION

Brazil has a large economic activity focused on poultry farming, which, through Rural production generates food for the population. However, for it to be a viable product, it is... It is necessary to take special care in the management of poultry farms in order to obtain quality and Avoid as much waste as possible at the end of each batch.

The technologies used in this field are constantly evolving, with a focus on... The well-being of the chicken is paramount, ensuring the best possible outcome at the end of the batches. Therefore... Furthermore, existing automation aims to improve environments, along with a reduction in... Energy consumption within the aviary, aiming to maintain the bird's optimal comfort.

This article aims to provide information on the electrical consumption required for minimum ventilation. in a poultry house, allowing for the analysis of this process and its efficiency in reducing electricity consumption.

In a tropical country like Brazil, with a warm climate, the ideal temperature for birds is... always below the average daily temperature, and to achieve this, ventilation systems are used inside the Poultry house. In this location, the most demanding equipment is that of the cooling system, which consists of... It consists of basically two machines: the exhaust fan, responsible for air circulation, and the evaporative panel. which lowers the temperature of this air the moment it enters the poultry house.

Currently, in Brazilian poultry farms, the ventilation used works through a... Dedicated controller, with direct starts, that controls the amount of air that needs to be exchanged. through a timed *on/off logic*. This article will present a solution that seeks to... to reduce power consumption during minimum ventilation and provide a more linear air tunnel within the Poultry house. This same ventilation will be responsible for keeping the air inside the shed always clean.

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and with a pleasant temperature.

For this proposal, a 0-10V analog output from the controller will be used, which will send the This signal is sent to an inverter. The inverter will then control, via frequency, the rotation of the ventilation exhaust fans. minimum. In this way, we had an extractor fan that operated at a fixed power and time. It's variable, but by changing the amount of air exchange, we have power that will vary accordingly. environmental needs.

This new operating principle will reduce electricity consumption, as there will be no motors starting at full speed. The moment, and because there is no longer a sudden exchange of air, but rather a continuous one, will allow for a sensation. A more comfortable temperature for the birds.

## 2 LITERATURE REVIEW

The following chapter contains a brief summary of the history of poultry farming, for better understanding. Understanding the subject that will be presented in the article. According to some historians, poultry farming It was created a long time ago. In the early days of raising chickens and roosters, these birds were domesticated. to be used as fighting animals and as ornamental objects. Only a very long time Then, their meat and eggs began to be consumed. From that moment on, the birds They began to have commercial value and became a source of income. With this market appreciation, Crossbreeding between breeds began, seeking improvement and obtaining superior birds. more resistant, and this continues to this day.

In Brazil, chickens were brought by the Portuguese in the early 1530s. During that period, they were raised free-range and ate leftover household food or insects that lived in the environment. Around the year 1900, chicken farming began on smallholdings and farms as a source of... Income. In the 1930s, there was great progress in poultry farming in Brazil, where one of the One of the pioneers was the French agricultural engineer Charles Toulin.

Currently, according to the Brazilian poultry industry association (UBABEF), Brazil is the third largest The world's leading producer of chicken meat, generating a total of 3.6 million jobs and representing almost 1.5% of the GDP (Gross International Product). Of this total produced, 69% remains in the country – which This proves the strength of this segment – where the average consumption per person reaches a total of 39 kilos. per year.

Currently, the production of this meat is concentrated in the interior of Brazil, mainly in South and Southeast, being in some places the main source of the economy.

## 3 CURRENT REFERENCE

According to the presentation, throughout history there have been great advances in poultry farming.

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Over the last three decades, technology in poultry farms has grown in the pursuit of improvements, given that... the need to achieve better efficiency at the end of the animals' lives, whether in the bird itself or in the costs incurred for their production.

When discussing improvements in the poultry industry, it's important to highlight the points that... These factors influence the bird's development, along with factors that enhance its well-being.

The biggest concern for the Brazilian poultry industry is related to climatological aspects, which They are different from other countries. This generates a search for technological adaptations, which through Attempts can result in beautiful work, however, in some situations, they don't turn out as expected. as expected, causing frustration and high costs.

Due to the climate, current farming practices favor more open sheds, where This results in improved air quality, better facilities, and improved sanitation for the plots.

## 4 EQUIPMENT

Inside a poultry shed, it's necessary to control various pieces of equipment so that the bird doesn't waste energy. their energy attempts to compensate for the ideal environment, thus maintaining their full strength. geared towards increasing mass, resulting in higher profits for the producer.

Within a poultry farm, there are two topologies, the automations currently in place, which are characterized as the bird's diet and environment. Within the bird's diet we have the The following equipment:

- Silos: used for storing feed on the farm, almost always located on the side of the poultry house. They can be made of wood, metal, fiber, or masonry.
- Feeder: used to provide food for birds, its size may vary depending on the age of the bird. batch or self-adjusting, depending on the automation applied.
- Drinking fountain: a place where clean water of a pleasant temperature is consumed. The same also It is often used for administering vaccines diluted in water.

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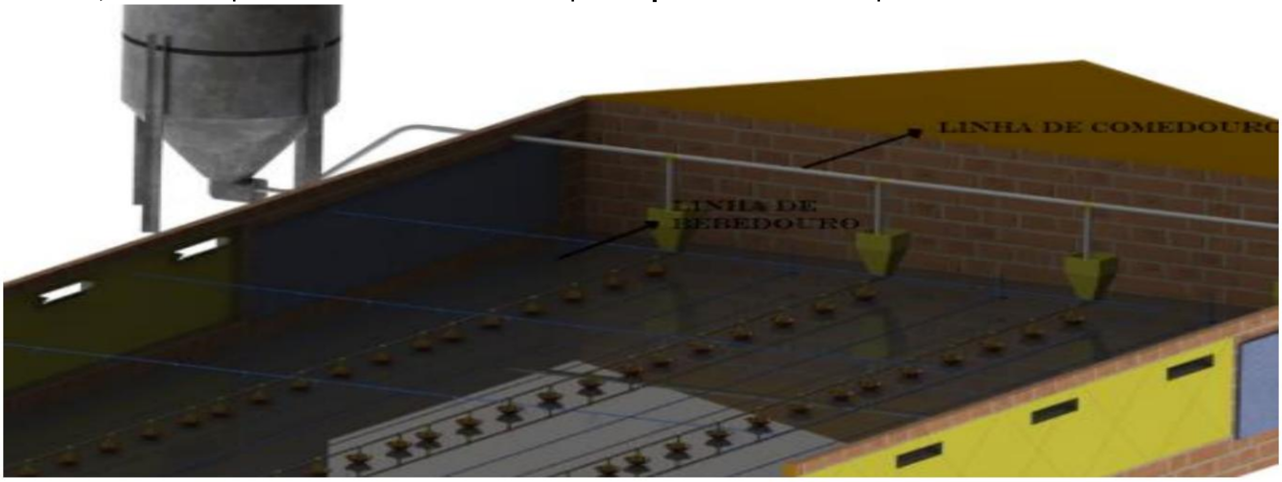


Fig. 1 – Feeding Systems

To achieve optimal feed conversion, there must be no waste.

The bird's energy needs are regulated by factors such as heat and cold. Below are the main pieces of equipment for the environment:

- Exhaust fan: it is extremely important for air renewal, as it creates an air tunnel inside the In a shed, this helps to lower the temperature, whether through negative or positive ventilation.
- Evaporative panel: allows the air entering the building to lower the temperature. through contact with fresh water, passing through constantly moistened plates.
- Nebulization: allows for a reduction in the temperature inside the shed on very hot days. through water dust, increasing air humidity.
- Curtain: its purpose is to enclose the shed on the side and in other cases that may require it. compromise the remaining equipment. It can be retracted, allowing air to enter. naturally, lowering the temperature.
- Inlet: Used in locations with higher temperatures to aid ventilation. minimal and transitional ventilation.
- Heater: when necessary, it is used to increase the internal temperature of the poultry house. It has various models, whether electric or with some type of combustion.

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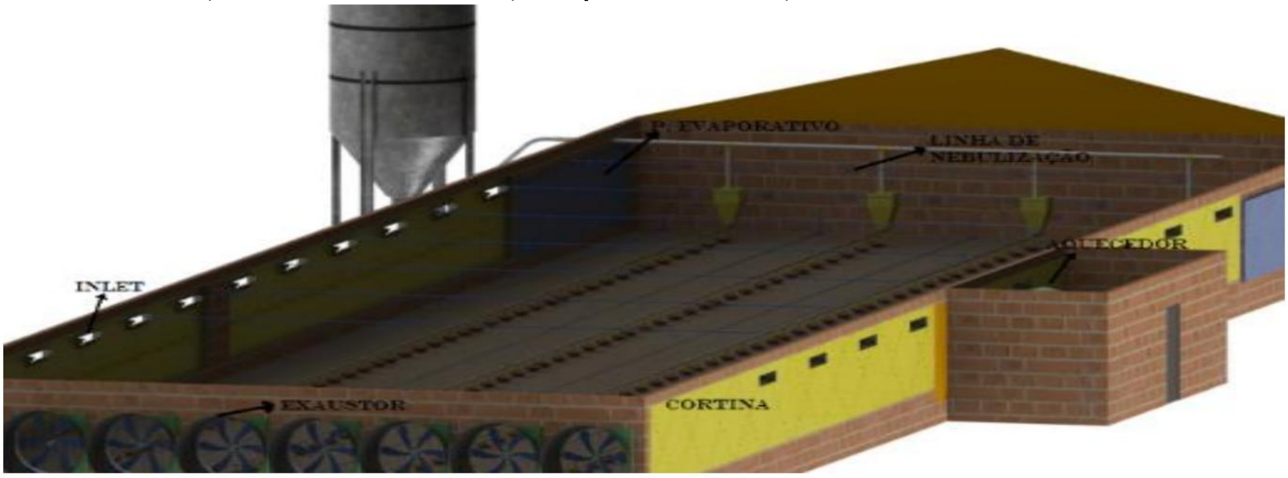


Fig. 2 – Environmental Systems

All of this existing equipment uses a central control panel, which is the responsible for starting each motor within the farm, through direct starts.

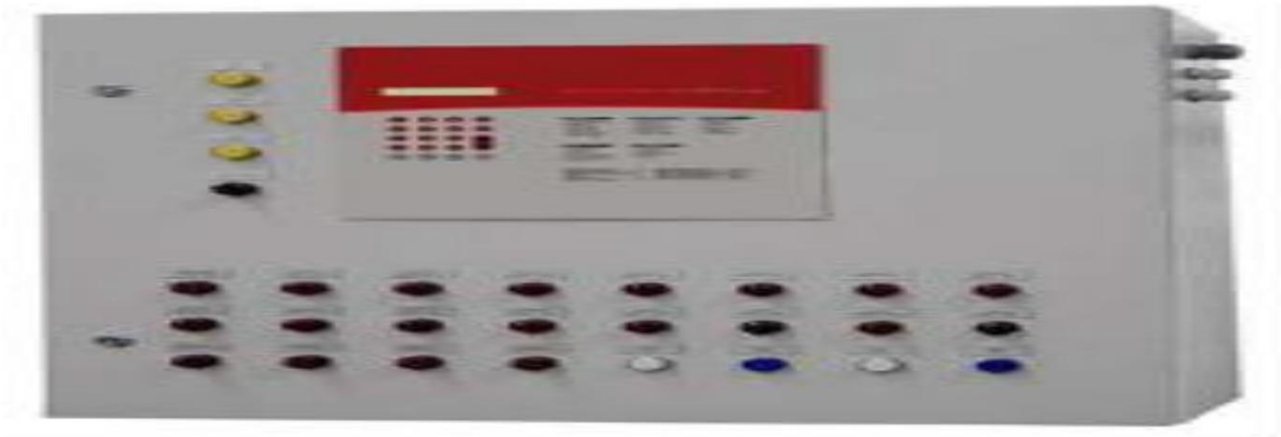

Fig. 3 – Electrical Panel

The equipment seen so far is extremely important for the operation of However, in an aviary, there is a dedicated controller for the execution of these tasks, which ensures that each The step should be processed according to the needs of the program being executed.

This set of equipment, along with the controller, uses several readers to... To define what should be turned on and what should not. The main ones are:

- Digital electrical temperature sensor, 3 to 5.5V, with an accuracy of 0.3 ºC (ROTEM P-RTS-2).
- Analog electrical humidity sensor, 0 to 10V, with a range of 0 to 100%, (ROTEM P - RHS-10PL).
- Digital CO2 sensor, 12V power supply with a range of 0 to 100%. (ROTEM P-CO2).

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## 5. FIELD APPLICATION

Having knowledge of the main equipment used in a Dark aviary

In the House (enclosed aviary), we present the table below, where it is possible to verify the total power that This is included in a standard 150x14 aviary. The power that will be applied refers to a power rating. Installation, not operation, is the key, since within the logic of the environment it is understood that all... The equipment will never be switched on at the same time. The information described in the table was... collected from an aviary located in Nova Veneza/SC, owned by XXXXXXXXXXX.

**Table 1 – Total power of a poultry house.**

| Equipment | Engine Power CV | Quantity | Total KVA |
|---|---|---|---|
| Exhaust fan | 1.5 | 11 | 25.56 |
| Evaporative Panel | 0.75 | 3 | 3.48 |
| Nebulizer | 2 | 1 | 2.51 |
| Inlet | 0.33 | 1 | 0.70 |
| Curtain Machine | 0.25 | 1 | 0.51 |
| Feeder | 0.75 | 4 | 5.63 |
| Primary Line | 1 | 1 | 1.38 |
| Lighting | 9W | 120 | 1.2 |
| Heater | 5 | 1 | 6.15 |
| **Total** | | | **47.12** |

The motors used in the table can be divided into four groups: heating; lighting; power supply and ventilation, which are divided into: exhaust fans, evaporative panel, Nebulization, entrance and curtain.

By applying the engine power to a pie chart, one can clearly visualize the How much ventilation is installed in an aviary?

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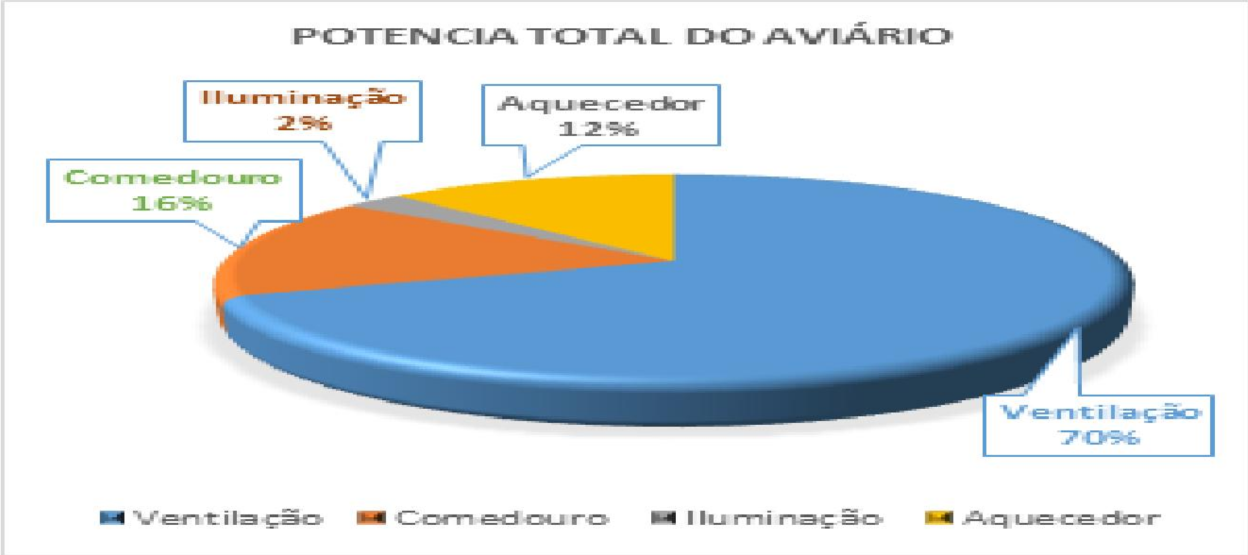


Fig. 4 – Total Power of the Poultry House.

With the consumption value of this batch, which began on 06/03/16 and ended on 02/04/16, A consumption of 8,534 kWh was obtained, considering that the value of kWh is R$ 0.30, an expense of R$ 2,560.20. Applying these values to the graph, as shown in the figure above, the result is... a considerable amount in ventilation consumption, totaling R$ 1,792.14. As already mentioned, These values were presented in an application where all motors would be operating at At the same time, however, studies already carried out have shown that this energy consumption in The ventilation generated during a batch period would be around the percentage shown in the graph. (70%), which may exceed this value depending on the climate – the hotter it is, the greater the consumption. with ventilation.

Based on this knowledge, this article aims to reduce poultry consumption. through lower power consumption during minimum ventilation and, in addition, providing better air exchange. more balanced air.

According to the definition of minimum ventilation, where "the main objective of minimum ventilation is to provide good quality air to birds" [4], it is known that it is essential that birds always have available a volume of oxygen and a small amount of carbon dioxide ($CO_2$), monoxide carbon dioxide (CO), ammonia ($NH_3$), and dust. Poor control of minimum ventilation may result in various problems, such as an increase in carbon dioxide and a decrease in oxygen. If this occurs With increased ammonia levels, birds can suffer serious consequences, such as "eye irritation, irritations "Skin and chest calluses, weight loss, poor uniformity, susceptibility to disease, and blindness."

Minimum ventilation varies depending on the number of animals inside the barn and their Age is a factor, as each bird needs an average of 0.0024 m³ of air. Therefore, the volume of the shed must be determined. and establish a minimum time for air exchange, considering that each exhaust fan has a power. As an example, a 1.5 HP three-phase 380V exhaust fan was considered, and in this case, that

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The exchange rate would reach 550 m³ of air per minute when switched on, at 100% of its capacity.


Fig. 5 – Cubic area

As shown in the figure above, a shed measuring 20 m ***x*** 12 m ***x*** 2.4 m will be dimensioned. equivalent to 576 m³ of air. For a poultry house of this size, the configurations for air exchange are as follows: considering an ideal temperature of 23°C. It is important to emphasize that this sizing of A poultry house is only suitable for the studies and tests developed for this article.

The controller used for the tests includes up to six minimum ventilation stages:

- **First stage:** will always function to maintain air exchange, regardless of the drop in temperature. temperature. Its configuration is: 1 minute on and 4 minutes off, exchanging 550 m³ of air every 5 minutes.

- **Second stage:** the process changes to 1.5 minutes on and 3.5 minutes off, switching 825 m³ of air. Therefore, from this stage onward, the temperature will influence the exchange of levels.

Third **stage:** in this condition, it will be on for 2 minutes and off for 3 minutes, exchanging 1,100 m³ of air.

- **Fourth stage:** the controller will be on for 3 minutes and off for 2 minutes, for a total of 1,650 m³ of air exchange.

Fifth **stage:** will alternate between 4 minutes on and 1 minute off, with a total switching time of air 2,200 m³.

Sixth **stage:** the configuration will finish in 1 minute and will not turn off, causing the Minimum ventilation should operate continuously. If you are unable to lower the temperature... Inside the poultry house, the ventilation will switch to the standard system that makes up the rest of the exhaust fans.

Each of the six levels specified above has a difference of 0.5 ºC to transition to Next stage, remembering that in the first stage the minimum temperature level is chosen. by the product and the age of the batch.

The data in the table below will be used for comparison with the solution that will be presented.

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further on, they demonstrate the electrical consumption of minimum ventilation for five days in a poultry house. with the same dimensions as the previous example. The gauge used to extract the data was the KOMPACT model - DRT-301D, three-phase energy meter, with a minimum resolution of 0.1 kW/h. and a digital output with pulses every 25w/h. The exhaust fan model used for the tests was a three-phase 380v model with a power of 1.5hp. It is important to emphasize that, as the objective is to demonstrate the The difference between ventilation consumption and frequency variation will be used in the matches. The frequency inverter is *switched on/ off* . This results in a difference in power consumption between the two logic settings. ignoring the starting ramp.

**Table 2 – Fuel consumption of a poultry house measuring 20m x 12m x 2.4m**

| Date | kW/h consumption | Average daily temperature (°C) |
|---|---|---|
| 05-06/05/2016 | 11.70 | 15.9 |
| 07-08/05/2016 | 13.4 | 17 |
| 09-10/05/2016 | 15.2 | 18 |
| 11-12/05/2016 | 9.2 | 9.5 |
| 13-14/05/2016 | 10.5 | 11.3 |

Given that the cost of energy is R$ 0.30, the cost per kWh is R$ 18.00 for 5 Operating days. Below, the graph shows the consumption for this period.


Fig. 6 – Consumption *On/ Off Method.*

**6. APPLICATION OF THE IMPROVEMENT**

In order to improve the values presented, an analog output was used from The AC_2000 controller performs the same functions as the previously mentioned model, however, with the variation of the ventilation power unit instead of time, where that was the variable that was... It modulated according to the need for ambient air exchange.

It is extremely important to mention that within these programming parameters, there is no... Turning off the minimum ventilation exhaust fans, only reducing ventilation to the point where

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by working with reduced power, already resulting in some savings in final electrical consumption.

The following equipment will be used for this implementation:

**1st - WEG CFW 300/04P2 Inverter:**

- Rated output current: 4.2 A;
- Power supply voltage: 200-240V single-phase and 380V three-phase output;
- Simple installation, contactor style;
- Built-in operator interface (HMI);
- Operating ambient temperature 0 °C to 50 °C.

**2nd - Dedicated AC_2000 POR Rotem Controller**

- Single-phase power supply voltage 220 V;
- It has 12 normally open (NO) relays for its ON/OFF logic, one of which is dedicated to alarms, with the possibility of... expansion;
- Digital inputs used for temperature, humidity, and weighing scale sensors;
- 2 analog outputs, one dedicated to the dimmer, water meter, and ventilation.

**Reverse** **Controller**


Fig. 7 – Inverter/Controller

In this way, the two pieces of equipment were combined to gain greater control over the Minimum ventilation.

With the controller set with the information that an exhaust fan has the ability to change 550 m³ of air per minute, it will convert m³ of air into a 0 to 10 V signal at its output. Analog, where this output voltage will modulate the frequency at which the exhaust fan should operate.

The calculation performed to obtain the same air exchange values is then demonstrated. The method without analog output.

825 m³ of air are needed, so the following logic applies;

550m³/60s = **9.16 m³ per second;**

9.16 m³ * 90 s *(time it was on, previous method, stage* 2) = **825 m³ exchanged in total;**

825m³/5min *(total cycle time)* = **165m³ of air every 1 minute;**

550m³/10v = **55m³ per 1** V;

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165m³/55m³= **3V;**

60hz/10 V = **6hz for every 1** V;

3V*6hz= **18hz applied to the motor;**

100% of the voltage / 10V total voltage = **10% per 1V;**

**3V * 10% = 30% that the controller should release;**

Thus, the controller will send 3V so that the reverse side enables the exhaust fan to work at 18Hz. using only 30% of its maximum capacity.

It is important to point out that the parameters used in this process were the same as those used in [previous process]. The previous process, which was based on controlling air exchange over time with the logic of switching on... and turn off the exhaust fans. Only the time variable was transferred, where it will now be fixed and, Therefore, the power of the exhaust fans will vary according to need.

Below is a description of the six parameters considered for the test, based on a Aviary measuring 20m x 12m x 2.4m:

- **First stage:** The previous method required 550m³ of air for minimum ventilation of the The first stage lasts for 5 minutes; now it will be continuously running, with an exhaust fan. Operating at 12Hz with 20% of its capacity.

- **Second stage:** The controller will apply 30% voltage to the output, thus releasing 3V, so that The motor operates at 18Hz.

Third **stage:** It will apply 40% voltage to the output, thus releasing 4V for the motor to work. with 24hz.

- **Fourth stage:** The controller will apply 60% of the voltage to the output, thus applying 6V, to that the motor operates at 36 Hz.

Fifth **stage:** 80% of the voltage will be applied to the output, thus releasing 8V for the motor. Work with 48Hz.

Sixth **stage:** Although the controller uses the analog output, it ends up using the The exhaust fan is operating at 100% capacity, with a total frequency of 60Hz and a 10V output.

In a poultry house, minimum ventilation is used most frequently until the chicks are 25 days old. batch and after that, if you are using the *on/off method,* it will basically work with the last stage. That is, turning it off every 4 minutes and turning it on again after the first minute. In the analog method, it will remain... When switched on at 100% capacity, this frees up the operation of the other standard exhaust fans. Therefore, it can be concluded that the use of this programming has been effective up to this date, since they worked with 100% load, except for the inverter ramp gain. (Information obtained from the field).

Each of the six levels specified above has a difference of 0.5°C to be passing through. for a new stage, and the controller always respects a 1-minute time limit before moving to the next one. Internship, if necessary.

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With the aim of demonstrating the gains in electrical energy, using the parameters of Frequency modulation in minimum ventilation exhaust fans will be presented in the next table. Calculate the electricity consumption values for a poultry farm using this segment.

**Table 3 – Fuel consumption of a poultry house measuring 20m x 12m x 2.4m**

| Date | kW/h consumption | Average daily temperature (°C) |
|---|---|---|
| 04-05/05/2016 | 12.8 | 17 |
| 06-07/05/2016 | 14.5 | 19 |
| 08-09/05/2016 | 12.2 | 14.4 |
| 10-11/05/2016 | 14.2 | 16 |
| 12-13/05/2016 | 12.9 | 18.5 |

The graph below, with the same objective of demonstrating the consumption of minimum ventilation in The readings were taken over five days and the daily consumption is presented, based on the value of... R$ 0.30 per kWh, resulting in a total of R$ 19.98.

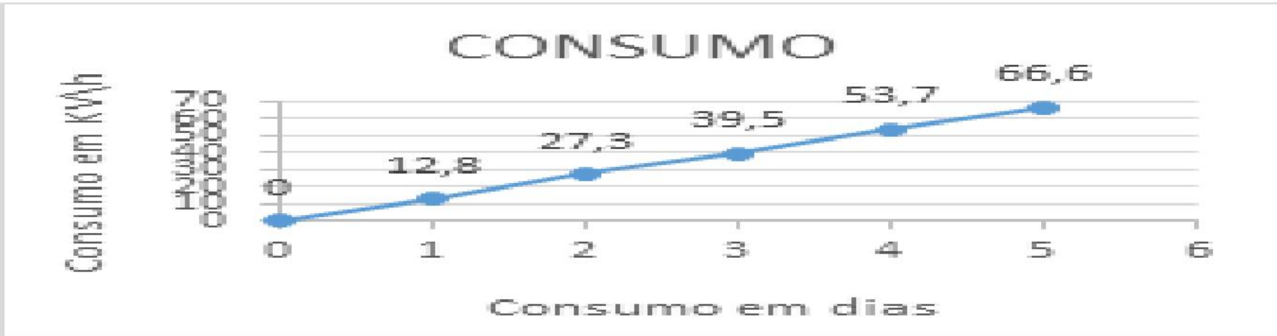

Fig. 8 – Analog method consumption

Comparing the two results presented in the article, where initially it was used a direct match, costing R$ 18.00, and in the second stage using an analog output. Along with a CFW300 inverter, the cost was R$19.80, resulting in a difference of R$ 1.80. The average temperature on the days the tests were conducted fluctuated, not showing a The actual value of consumption in both comparison scenarios. Analyzing the two graphs, On the surface, it appears that the logic using the inverter consumed more power than expected. The temperature was lower with the use of the inverter. However, the graph shows that the temperature peaks were higher. back in the days when logic was used with the inverter.

## 7 MEASUREMENT TEST BETWEEN LEVELS

In order to obtain a real comparison to analyze whether the inverter implementation is feasible, it was observed that measurements should be taken between ventilation levels. The logic without The inverter, and with the inverter that each level operates, is the same to lower the temperature and do the... Air exchange, however, only the time and power variables change.

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Considering that, regardless of which logics are implemented, the

The controller will always make the same decision, and what should really be compared are the levels of ventilation. With this, a second test was carried out where the ventilation levels were fixed and the Readings of consumption data were collected by levels over a 24-hour period, with the goal of... demonstrate the maximum reduction in consumption.

Readings were taken using the *on/ off* method with and without the inverter to create the ramp. starting point. Just to clarify, the purpose of using the inverter to create the ramp in the *on/ off* method is... to demonstrate the real reduction in logic and also to make the value of the final gain fairer, because, if If the client wanted to use other resources to reduce this initial ramp-up, there would be cheaper methods available.

The two readings will be presented in the table below, for comparison with the analog method:

**Table 4 – Consumption reading without and with on/off starting ramp method**

| DIRECT MATCH 24h | | | |
|---|---|---|---|
| **Level** | **Date** | **Consumption with ramp kW/h** | **Consumption without ramp kW/h** |
| 1 | 23/05/16 | 5.4 | 5.85 |
| 2 | 25/05/16 | 8 | 8.68 |
| 3 | 27/05/16 | 10.7 | 11.61 |
| 4 | 29/05/16 | 16.6 | 18.01 |
| 5 | 31/05/16 | 24.57 | 26.66 |
| 6 | 02/06/16 | 28 | 30.38 |

**Table 5 – Comparison of consumption with analog vs. without and with starting ramp using the on/off method**

| 24-hour inverter start | | | | |
|---|---|---|---|---|
| **Level** | **Date** | **Power consumption with inverter kW/h** | **Gain with ramp (%)** | **Gain without ramp (%)** |
| 1 | 24/05/16 | 5.1 | **5.55** | **12.82** |
| 2 | 26/05/16 | 7.7 | **3.75** | **11.29** |
| 3 | 28/05/16 | 9.6 | **10.28** | **17.31** |
| 4 | 30/05/16 | 12.9 | **22.28** | **28.37** |
| 5 | 01/06/16 | 17.2 | **29.99** | **34.48** |
| 6 | 03/06/16 | 27.6 | **1.42** | **9.15** |
| **AVERAGE CONSUMPTION** | | | **12.21** | **19.07** |

The graph below provides a better visualization of the difference in power consumption between one automation system and another, considering both the *on/ off* start system with and without the assistance of an inverter to create the starting ramp.

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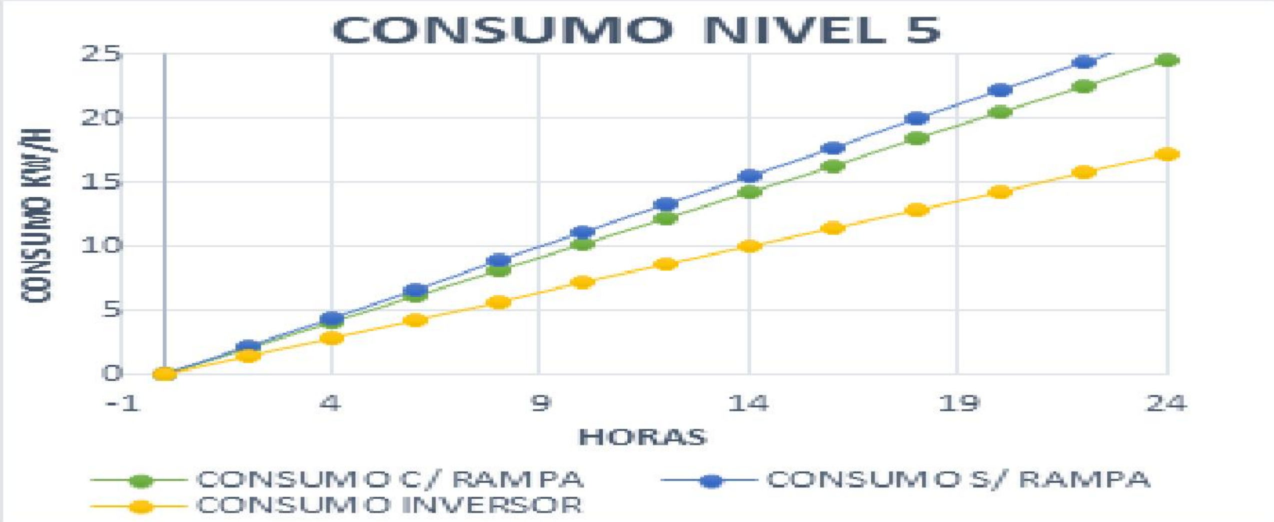


Fig. 9 – Fuel Consumption Comparison.

## 8. ANALYSIS OF RESULTS

With the real objective of reducing the electricity consumption of a poultry farm, focusing on Improved automation in minimum ventilation was achieved through testing, resulting in an average gain of 19.07% across all levels (values comparing *"consumption without ramp x inverter consumption").* Therefore, Considering that the average consumption of an exhaust fan in a lot is 619.59 kW/h, we arrive at a With a reduction value of 118.15 kW/h, considering an average value of R$ 0.30, the kW/h reaches a... Total cost of R$ 35.44 per exhaust fan. Working with this logic over a 38-day period, the costs To apply this automation to an exhaust fan of up to 6A, the cost is R$ 813.00 per inverter, subtracting- If the amount of R$ 193.00 from the match is withdrawn, if it is done at the beginning when the panel is made, the The actual cost is R$ 620.00. If an inverter for two motors is used, it will be a model that... Support up to 10A at a cost of R$ 1160.13, less two installments of R$ 193.00, resulting in a total of R$ 774.13, based on a logic of two exhaust fans.

Considering an average of 8 lots per year, this investment will pay for itself in 2 years and 5 months. If the producer uses the second option, which is closer to reality, it will pay for itself in 1 year and 6 months. month. After this period, the producer will have this amount as profit.

It is important to emphasize that the other gains are fundamental, as they directly impact... The benefit to the producer's pocket, such as the reduction of stress for the bird, which, although not the focus of the article, It is important to include this in the gains of the process. As mentioned, the lower the stress of The better the bird, the better its final performance will be. No longer having the on/off cycle at the beginning of the batch, this way... Aside from the abrupt temperature changes and the excessive airflow inside the shed, generating a better feeling for the developing chicks. This gain ends up being More important than the energy consumption itself, which is saved through this process.

Another extremely important factor is the lifespan of the exhaust fan itself, which, because it does not have

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Studies in this area do not reveal its true durability. However, it can be stated that, due to... If exhaust fans no longer have the traction factor required for such effort, there is a high chance that... Minimum ventilation exhaust fans last longer than other exhaust fans that do not use this logic. presented.

**9 CONCLUSIONS**

The main results obtained with the use of a frequency inverter in ventilation. The minimum evidence demonstrated that including this automation makes its cost-benefit ratio entirely viable. It can pay for itself in up to 2 years and 5 months. It's worth noting that its results include: a decrease of electricity consumption and a uniform minimum ventilation tunnel inside the poultry house.

To obtain the results presented in the article, some difficulties were encountered. with the reading of energy consumption, due to the temperature never being the same from one day to the next. Therefore, to make the comparisons as realistic as possible, ventilation levels were compared individually, generating a real difference in consumption. It is important to conclude that the The real objective of this article is to demonstrate to poultry farmers that, with a small modification in With minimal ventilation and the use of a CFW300 inverter, a great tool can be obtained. to help achieve a higher profit at the end of the batch.

**10 FUTURE JOBS**

For future work, here are two suggestions to consider. In pursuit of further gains... With higher electricity consumption, the use of an inverter for all exhaust fans can be analyzed, making it possible to... that everyone works collectively, on a single frequency, varying according to the needs of the temperature. Another important point would be to collect the positive data that minimum ventilation with The inverter brings improvements to chicken performance.

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