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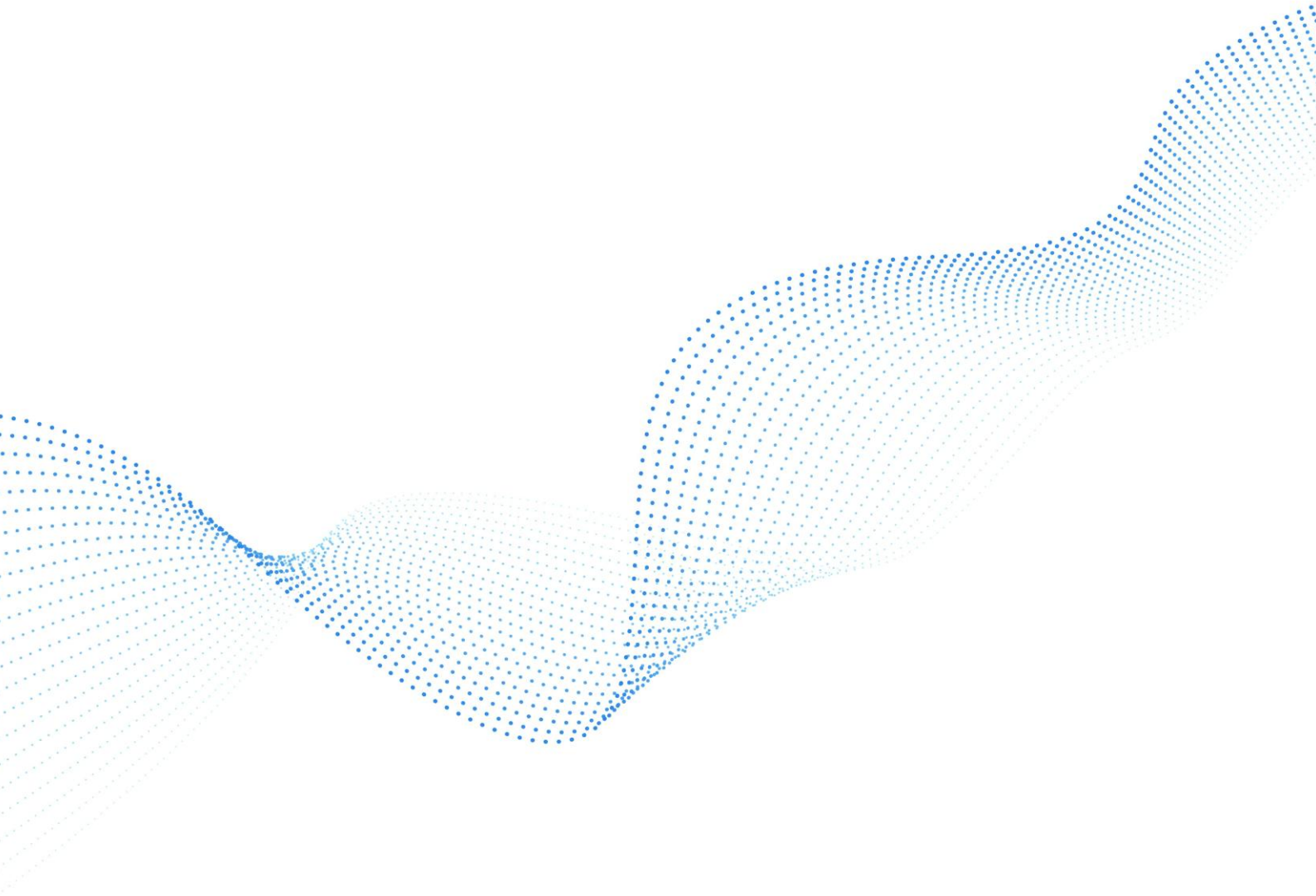
| 2025-11-01 | Energy Simulation Report | 1.0 |

# Broiler Energy Saving Report

## PROJECT NAME – LOCATION



# Contents

# Targets of the report

The present document has the aim to describe the benefits of using a ventilation solution with fans equipped with EC motor with respect to a standard ventilation solution with fans having standard AC motor.

Fans with EC motors ensure the best energy saving if operated at low propeller speed since the power consumption at a fixed static pressure scales more than proportionally with the % of nominal propeller speed.


The electrical energy saving reflects clearly into an economic saving meaning lower operative costs, this produces a saving that will cumulate over time reducing the total cost of ownership of a high-efficiency ventilation system.

## The most recurring questions are:

- Will my investment ever pay off?
- If yes, when the break-even point will be?

The Energy simulation tool provided by GRAINPROTEINTECH provides an answer to the above two questions.

On the other hand, the **maximum absolute energy saving** will be achieved **during the hot season** when all fans are running to provide tunnel ventilation. In this situation also fans with EC motors operate at propeller speed close to the maximum. Energy saving is not achieved due to a reduction of fan speed but is anyway guaranteed by the higher efficiency of an EC motor compared to AC.

The document will provide below:

- Standard calculation framework of the energy simulation (cannot be modified)
- Setup of the specific energy saving simulation scenario

# The energy simulation tool

The calculation tool developed internally by GRAINPROTEINTECH has the aim to give an indication of the energy saving that is theoretically possible to achieve.

The calculation algorithm implemented estimates the energy consumption considering a standard way to perform ventilation in broiler barns and has not the aim to reflect the climate control algorithm implemented in all the climate computers available on the market neither has the possibility to consider the setting made on top of each climate controller.

For that reason, the results of a simulation cannot be representative of all the possible scenarios and so GRAINPROTEINTECH cannot provide a range of accuracy of the results in ABSOLUTE terms.

The system calculates the ventilation profile required to fulfil the animal needs both from the Indoor Air Quality perspective (minimum ventilation) as well as for managing the thermal comfort for animals (transition and tunnel ventilation).

# Calculation of the ventilation for a winter flock

**The minimum ventilation requirement for managing indoor air quality** in the broiler barn has been calculated starting from the following external resources:

- Broiler Management Manual
- Aviagen Management Handbook

On top of these ventilation profiles can be applied a safety factor (usually around 15-20%) to increase the flowrate to achieve a further reduction of humidity or carbon dioxide and ammonia concentrations.

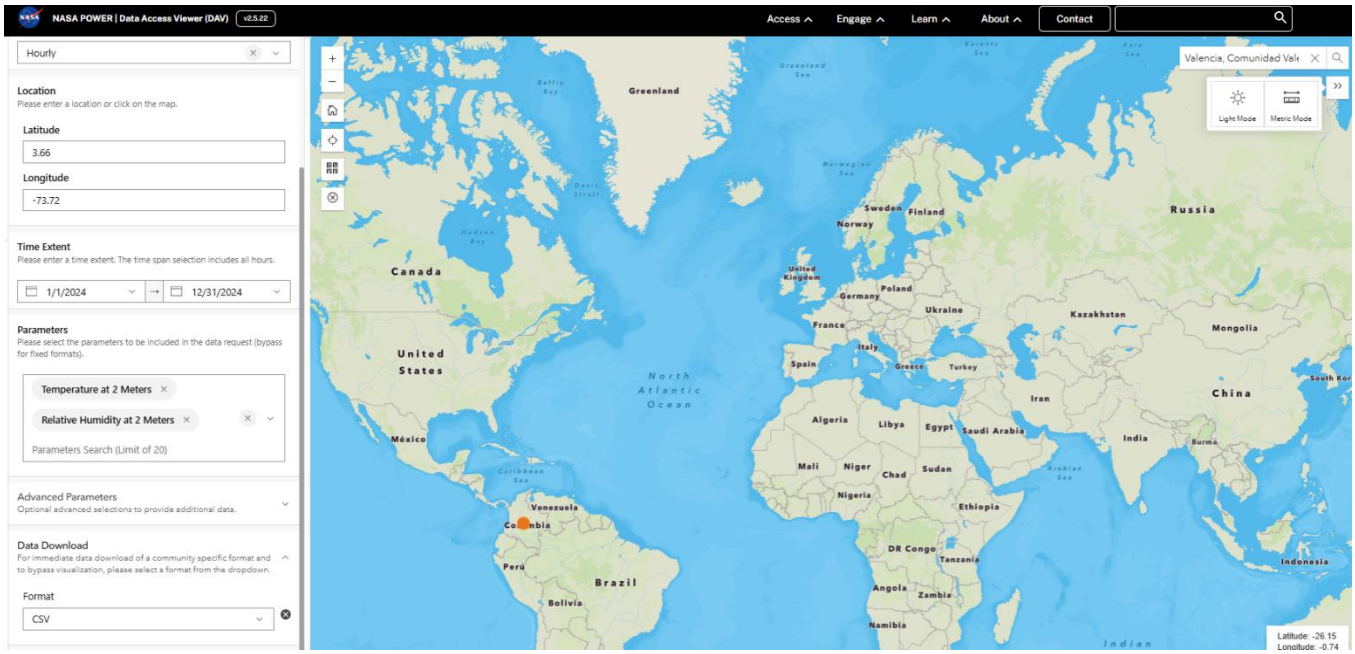
# Calculation of the ventilation for a summer flock

**The ventilation requirement for managing the animal thermal comfort** is calculated starting from the steady state energy balance equation of the poultry house (no thermal capacity effect of the shed envelope is considered). The steady state energy balance equation is derived on hourly basis with the ventilation flowrate being the unknown to get the temperature setpoint for the animals.

As soon as the maximum transition ventilation is evaluated to be no-more sufficient to achieve internal setpoint for animals, tunnel ventilation mode is activated, in such a case windchill effect is considered to reduce the animal perceived temperature.

# Evaluation of the climate data

The climate data on hourly basis to run the energy simulation are retrieved from the climate database of NASA (https://power.larc.nasa.gov/data-access-viewer/) for: LOCATION




Temperature and humidity are provided on hourly basis for the entire year to perform the evaluation of the ventilation rate needed as described above.

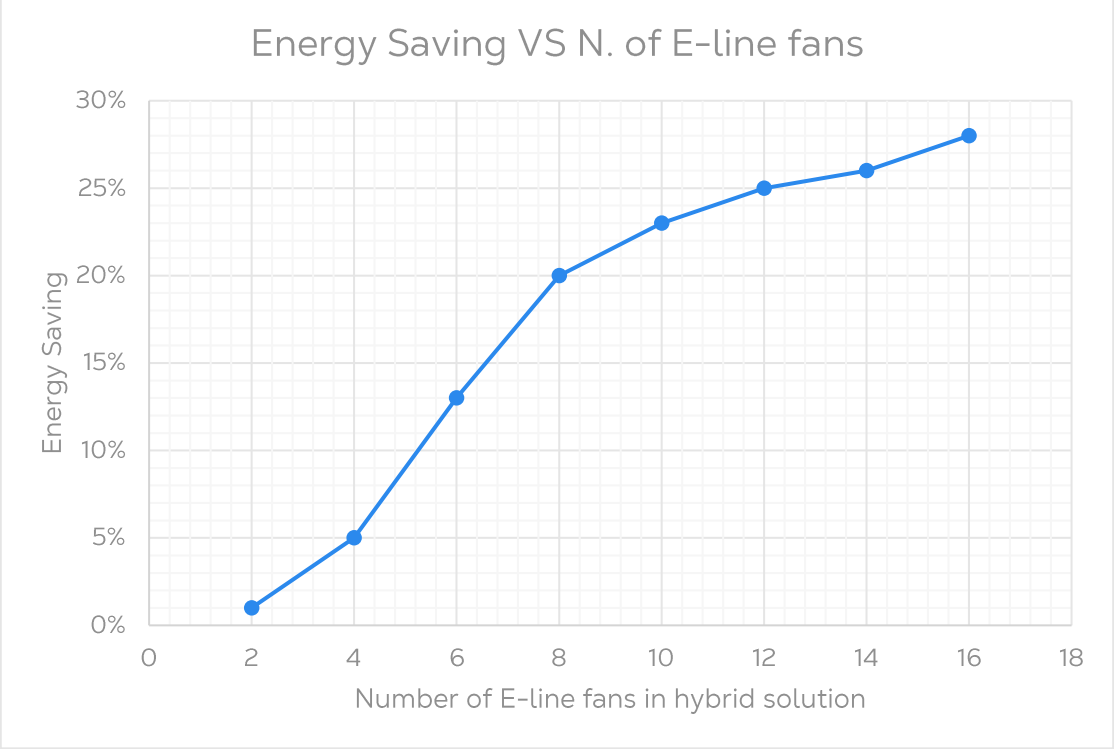
# Results of the simulation

Keeping in mind the above information the tool will provide as output the following data:

- Evaluation of the best hybrid ventilation system combining AC fans and E-line fans.
- Comparison of the electrical energy consumption of a standard ventilation system with ON-OFF fans equipped with AC motors with those of a high efficiency solution with EC E-line fans.
- Comparison of the operative cost of the two solutions considering energy consumption starting from economical information provided (cost of energy)

## Evaluation of hybrid ventilation solution

We performed a parametric analysis by adjusting the number of E-line fans in the hybrid ventilation system to find the optimal rate that maximize the ROI and minimize the PAYBACK time.



# Ventilation systems compared

The EXAMPLE solutions compared are the following:

- Solution 1 (full AC fans) with:
  - 16 x Saturn Five direct-drive 3-blades 60Hz with AC motor
- Solution 2 (hybrid) with:
  - 8 x Saturn Five direct-drive 3-blades 60Hz with AC motor
  - 8 x Saturn Five direct-drive 3-blades E-line
- Solution 3 (100% variable speed) with:
  - 16 x Saturn Five direct-drive 3-blades E-line
- Solution 4 (hybrid) with:
  - 8 x Saturn Five direct-drive 3-blades 60Hz with AC motor
  - 9 x Saturn Five direct-drive 3-blades E-line (maximum speed 93%)

Here below we provide the estimated energy consumption of the 6 yearly flocks assuming the 1st is starting 1st of January.

| | Solution 1 | Solution 2 | Solution 3 | Solution 4 |
|---|---|---|---|---|
| Flock 1 [kWh] | 10800 | 8560 | 7900 | 8,083 |
| Flock 2 [kWh] | 13150 | 11070 | 10080 | 10,451 |
| Flock 3 [kWh] | 12430 | 10390 | 9390 | 9,778 |
| Flock 4 [kWh] | 11000 | 8830 | 7840 | 8,264 |
| Flock 5 [kWh] | 10260 | 7960 | 7060 | 7,433 |
| Flock 6 [kWh] | 10000 | 7900 | 6910 | 7,380 |
| Flock 7 [kWh] | 9730 | 7540 | 6780 | 7,061 |

Considering an energy price of 0.20 USD/kWh the expected cost for ventilation for the 7 flocks are the following:

| | Solution 1 | Solution 2 | Solution 3 | Solution 4 |
|---|---|---|---|---|
| Flock 1 [kWh] | 2160 | 1712 | 1580 | 1620 |
| Flock 2 [kWh] | 2630 | 2214 | 2016 | 2090 |
| Flock 3 [kWh] | 2486 | 2078 | 1878 | 1960 |
| Flock 4 [kWh] | 2200 | 1766 | 1568 | 1650 |
| Flock 5 [kWh] | 2052 | 1592 | 1412 | 1490 |
| Flock 6 [kWh] | 2000 | 1580 | 1382 | 1480 |
| Flock 7 [kWh] | 1946 | 1508 | 1356 | 1420 |

On yearly base the estimated results of energy saving are the following:

| | Solution 1 | Solution 2 | Solution 3 | Solution 4 |
|---|---|---|---|---|
| Yearly energy consumption [kWh] | 77370 | 62250 | 55960 | 58450 |
| Cost for electrical energy consumption [USD] | 15474 | 12450 | 11192 | 11690 |
| Relative energy / economical saving [%] | - | 20% | 28% | 24% |
| Yearly saving [kWh] | - | 15120 | 21410 | 18915 |
| Yearly saving [USD] | - | 3020 | 4280 | 3780 |

# Table energy consumption per week

| *Week* | Solution 1 [kWh] | Solution 2 [kWh] | Solution 3 [kWh] | Solution 4 [kWh] | Saving with solution 2 | Saving with solution 3 | Saving with solution 4 |
|---|---|---|---|---|---|---|---|
| *1* | 686 | 392 | 365 | 354 | 41% | 45% | 47% |
| *2* | 1051 | 590 | 552 | 535 | 42% | 46% | 47% |
| *3* | 1753 | 1128 | 1041 | 1037 | 35% | 40% | 40% |
| *4* | 2868 | 2504 | 2352 | 2402 | 13% | 18% | 16% |
| *5* | 3024 | 2666 | 2468 | 2554 | 12% | 18% | 16% |
| *6* | 1417 | 1271 | 1121 | 1201 | 10% | 21% | 15% |
| *7* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *8* | 319 | 184 | 170 | 167 | 41% | 46% | 47% |
| *9* | 972 | 555 | 514 | 504 | 42% | 46% | 47% |
| *10* | 1470 | 847 | 779 | 770 | 42% | 46% | 47% |
| *11* | 2657 | 2184 | 2025 | 2074 | 18% | 24% | 22% |
| *12* | 3785 | 3561 | 3180 | 3379 | 6% | 16% | 11% |
| *13* | 3939 | 3732 | 3406 | 3558 | 5% | 14% | 10% |
| *14* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *15* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *16* | 722 | 414 | 383 | 377 | 42% | 46% | 47% |
| *17* | 1013 | 567 | 532 | 513 | 42% | 46% | 48% |
| *18* | 1601 | 931 | 850 | 844 | 41% | 47% | 47% |
| *19* | 2795 | 2423 | 2209 | 2314 | 13% | 21% | 17% |
| *20* | 4039 | 3879 | 3445 | 3677 | 4% | 15% | 9% |
| *21* | 2251 | 2174 | 1869 | 2052 | 3% | 17% | 9% |
| *22* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *23* | 218 | 127 | 117 | 113 | 41% | 45% | 47% |
| *24* | 772 | 434 | 407 | 391 | 41% | 45% | 47% |
| *25* | 1318 | 748 | 695 | 676 | 42% | 46% | 47% |
| *26* | 1934 | 1348 | 1199 | 1250 | 30% | 38% | 35% |
| *27* | 2313 | 1919 | 1707 | 1827 | 17% | 26% | 21% |
| *28* | 3846 | 3667 | 3194 | 3459 | 5% | 17% | 10% |
| *29* | 597 | 578 | 514 | 548 | 3% | 14% | 8% |
| *30* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *31* | 451 | 255 | 240 | 225 | 40% | 43% | 47% |
| *32* | 914 | 509 | 478 | 462 | 42% | 46% | 48% |
| *33* | 1549 | 895 | 822 | 808 | 41% | 46% | 47% |
| *34* | 1867 | 1406 | 1175 | 1312 | 25% | 37% | 30% |
| *35* | 2927 | 2541 | 2281 | 2409 | 13% | 22% | 18% |
| *36* | 2544 | 2351 | 2063 | 2216 | 8% | 19% | 13% |
| *37* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *38* | 17 | 9 | 9 | 8 | 36% | 36% | 46% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *39* | 591 | 332 | 313 | 294 | 40% | 44% | 47% |
| *40* | 1110 | 623 | 585 | 567 | 42% | 46% | 47% |
| *41* | 1772 | 1163 | 1033 | 1070 | 34% | 41% | 39% |
| *42* | 2325 | 1918 | 1679 | 1818 | 18% | 28% | 22% |
| *43* | 3040 | 2730 | 2347 | 2575 | 10% | 23% | 15% |
| *44* | 1140 | 1118 | 940 | 1048 | 2% | 18% | 8% |
| *45* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *46* | 161 | 89 | 85 | 77 | 39% | 42% | 47% |
| *47* | 782 | 438 | 411 | 397 | 42% | 45% | 47% |
| *48* | 1345 | 765 | 712 | 693 | 42% | 46% | 47% |
| *49* | 2045 | 1495 | 1332 | 1396 | 27% | 35% | 32% |
| *50* | 2553 | 2172 | 2017 | 2085 | 15% | 21% | 18% |
| *51* | 2834 | 2573 | 2220 | 2412 | 9% | 22% | 15% |
| *52* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |
| *53* | 0 | 0 | 0 | 0 | 0% | 0% | 0% |

These table with weekly energy consumption for the 4 solutions is only an indication since the calculation algorithm implemented estimates the energy consumption considering a standard way to perform ventilation in broiler barns and has not the aim to reflect exactly the climate control algorithm implemented in all the climate computers available on the market neither has the possibility to consider the setting made on top of each climate controller.

# Boundary conditions of the simulation

General information:

- Application: Broiler
- Shed length: 180
- Shed width: 18
- Shed side height: 3
- Shed center height: 3
- Heigh of baffles: No baffles
- Shed insulation level: Roof:50mm / Wall:50mm / Pad opening:curtain / Fans:shutters
- Number of animals: 60000
- Flock length: 37 days

Geographical information:

- Reference location: EXAMPLE LOCATION

Minimum ventilation:

- Reference ventilation profile: Aviagen
- Minimum ventilation pressure: 25 pa

Tunnel ventilation:

- Maximum tunnel ventilation: 4.4 m/s
- Light filters on fans: No
- Tunnel ventilation pressure: 69 pa

Ventilation solution compared:

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Economical parameters:

- Electrical energy cost: 0.20 USD/kWh