WHITE PAPER

TrinaPro AGRIVOLTAIC SOLUTIONS

A Cost-Effective Total Solar Solution for Agricultural Operations



Trinasolar

Trinasolar.com/us

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EXECUTIVE **SUMMARY**

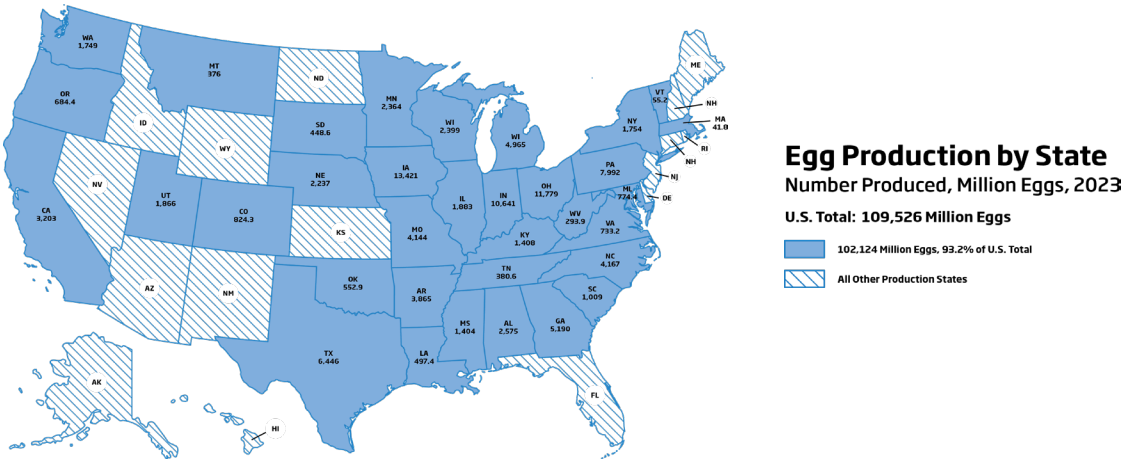
The poultry industry consumes a significant amount of energy, a crucial factor for maintaining the conditions necessary for poultry health and productivity. However, rising energy costs and environmental regulations present significant challenges for poultry farmers. Integrating solar plus storage systems can address these issues by reducing energy costs, improving reliability, and supporting sustainability goals. This white paper explores the benefits of a 250 kW solar photovoltaic (PV) system with a 200 kWh battery storage system for the poultry industry and provides a detailed return on investment (ROI) analysis (both with and without incentives) based on an electric rate of 11 cents per kilowatt-hour (kWh) (the current average rate in most of Arkansas). The paper assumes the solar system offsets approximately 91% of the facility's energy usage. This paper also provides a high-level overview of the PV and storage system's construction and installation processes, including an example wiring diagram.

PURPOSE AND SCOPE

The poultry industry relies heavily on energy to regulate environmental conditions within poultry houses, including heating, cooling, ventilation, and lighting. After property mortgages, energy costs typically constitute the second largest expense for most contract poultry producers. With increasing energy costs and regulatory pressures for sustainable practices, poultry operations would greatly benefit from cost-effective solutions to manage these challenges. A solar plus storage system offers a single solution to access financial savings, energy security, and environmental benefits.

MARKET INSIGHTS

The U.S. is home to more than 168,000 poultry farms[1], 97% of which are family-owned farms that operate in coordination with large companies such as Tyson, Georges, and Butterball, among many others. More than 30% of all poultry and egg sales originate in just three states - Arkansas, Georgia, and North Carolina. In 2023, the combined production value from all poultry operations – broilers, eggs, turkeys, and chicken sales – was $67.1 billion, with 9.93 billion broiler-type chicks hatched and 638 million egg-type chicks hatched.[2] Much of the data utilized in this paper is targeted at the Arkansas market; however, other regions should still see significant benefits from the system described below and could potentially obtain even better ROI.



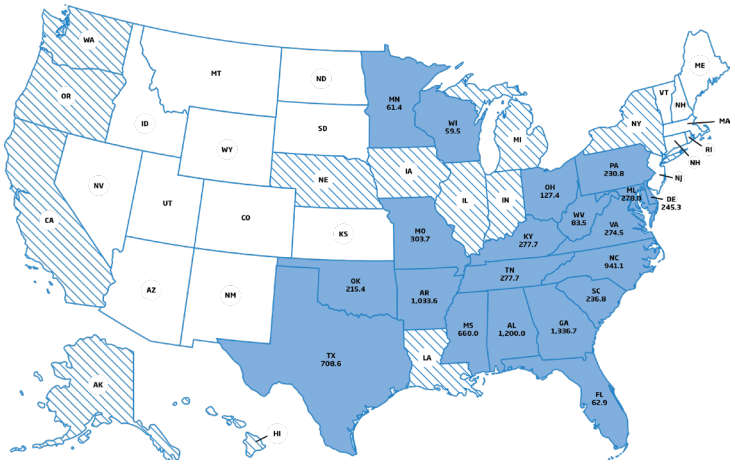
Egg Production by State

Number Produced, Million Eggs, 2023

U.S. Total: 109,526 Million Eggs

102,124 Million Eggs, 93.2% of U.S. Total

All Other Production States



Broiler Production by State

Million Head, 2023

U.S. Total: 109,526 Million Eggs

8.5 Billion Head, 93.1% of the U.S. total

Other Production States

[1] *2022 Census of Agriculture (Issued February 2024). USDA https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf*

[2] *USDA National Agricultural Statistics Survey. https://www.nass.usda.gov/Statistics_by_State/Regional_Office/Southern/includes/Publications/Livestock_Releases/Poultry_PDI/HatchandPoultryPDI2024.pdf*

BENEFITS OF SOLAR PLUS STORAGE FOR THE POULTRY INDUSTRY

This section covers how solar plus storage systems can provide commercial poultry farms a single solution for cost savings, energy security, and environmental benefits.

1

COST SAVINGS

a Reduction in Electricity Bills

A solar PV system can significantly reduce the amount of electricity purchased from the grid. Coupling solar PV with a battery storage system enables storage of the excess solar energy to use when solar production is unavailable, further enhancing cost savings. In particular, a poultry facility adding a 250-kW solar PV system and a 200-kWh battery storage system would see substantial financial benefits.

Consider the following breakdown of the potential savings for a sample solar PV plus storage system in Southern Arkansas.

Annual Solar Energy Production

- **System Size:** 250 kW
- **Average Solar Production:** Assuming 5 hours of adequate daily sunlight
- **System Efficiency Due to Weather Conditions and Efficiency Losses: 75%**

Annual Energy Production: 250 kW × 5 hours a day × 365 days = 456,250 kWh x 0.75 (to accommodate efficiency losses) = **342,187 kWh annual energy production**[3]

Energy Offset

- **Offset Percentage:** 91.2%
- **Annual Energy Offset:** 342,187 kWh per year / 375,060 kWh = 91.2%

Annual Electricity Cost without Solar

Annual Consumption: 375,060 kWh per year
Cost: 375,060 kWh per year × $0.11 per kWh = $41,256.60

Annual Electricity Cost with Solar and Storage

- **Grid Electricity Needed**

Annual Energy Offset: 342,187 kWh
Grid Electricity Used: 375,060 kWh – 342,187 kWh = 32,873 kWh
Cost: 32,873 kWh per year × $0.11 per kWh = $3,616.03[4]
Annual Savings: $41,256.60 – $3,616.03 = **$37,640.57 per year**

[3] *According to the National Renewable Energy Laboratory's (NREL) PVWatts calculator, the system output for a 250 KW installation in Southern Arkansas ranges from 332,487 kWh per year to 363,580 kWh per year. https://pvwatts.nrel.gov/pvwatts.php. Accessed October 7, 2024.*

[4] *This figure does not include any financing costs.*

b Stable Energy Costs

Although the short-term forecast for electricity costs has been moderate, the overall trend continues to be rising prices. Between 2012 to 2022, nominal bundled electricity prices for industrial customers, which includes the agricultural sector, increased 31.6%, or 4.4% on an inflation-adjusted basis.[5] Additionally, analysts do not anticipate any near-term relief due to rapidly growing demand from industrial onshoring and the proliferation of power-hungry Artificial Intelligence (AI) platforms, which are pressuring the supply and likely to contribute to rising energy prices.

At the same time, the average chicken size has grown larger, meaning a corresponding uptick in electricity costs for more ventilation and cooling with exhaust fans.

Solar plus storage systems help stabilize energy costs by providing a fixed cost for energy production and reducing exposure to fluctuating electricity prices. This predictability aids in budgeting and financial planning.

c Peak Shaving

Storing excess solar energy and using it during peak demand periods can lower peak demand charges. This capability reduces the reliance on grid electricity during expensive peak hours, leading to additional cost savings.[6]

d Selling Excess Energy Between Flocks

For poultry operations that produce multiple flocks per year, it can take up to two weeks to clean and reset a house between flocks. During this period, poultry houses consume minimal power. With a solar plus storage system, the panels keep producing energy during this time. In areas where the local utility offers net metering, system owners can sell this excess energy back to the grid and further reduce the farm's energy cost.

[5] *"US Retail Electric Prices Likely Moderate in 2024, Continuing 2023 Trend." SP Global, https://www.spglobal.com/marketintelligence/en/news-insights/research/us-retail-electric-prices-likely-moderate-in-2024-continuing-2023-trend*

[6] *At the time of publication, most regions producing the bulk of the U.S. poultry supply do not yet have peak energy rates; those states that do are generally seeing prices double during peak windows. This trend is expected to change over time and will only improve the system's ROI.*

2

ENERGY SECURITY

A Growing Risk of Power Outages

An enclosed poultry house with a controlled environment experiencing a power outage can encounter several catastrophic scenarios and result in massive bird losses within minutes.

Nonworking fans cannot cool broiler houses in the summer or maintain ventilation to circulate air and mitigate the risk of airborne diseases. Lights suddenly losing power can cause a flock to go into shock, resulting in mortalities or poor layer performance. Meanwhile, nonfunctioning automated feeding systems mean hungry chickens or feed waste, and nonfunctioning automated monitoring leads to data loss that can negatively impact farm management and decision making.

The devastation from Hurricane Helene created widespread power outages across Georgia and South Carolina, causing some of the nation's largest poultry companies to suspend operations at their local facilities.[7] As meteorologists forecast increasing risks of more extreme and more frequent hurricanes and weather-related power outages, poultry producers in these regions must identify ways to strengthen energy resilience and reliability.

B Uninterrupted Power Supply

Solar PV modules are designed to withstand intense wind speeds and continue generating electricity even if the main grid is down. For example, in extreme wind tunnel testing, **Trinasolar's Vertex modules remained intact** at wind speeds up to 140mph, equivalent to the low end of a Category 4 hurricane on the Saffir-Simpson scale.

An **energy storage system** (ESS) can ensure an uninterrupted power supply (UPS) even during grid outages and can play a critical role in maintaining optimal conditions within poultry houses. This reliability is essential for preventing cooling, ventilation, and lighting disruptions that can impact poultry health and productivity.

With the proper controller, a solar plus storage system can prepare for forecasted extreme weather by fully charging the batteries and then disconnecting from the main grid in a process called islanding to strengthen resilience and maintain a continuous power supply.

Battery systems can also supplement and, in some cases, replace backup generators in many applications, further reducing operation and maintenance (O&M) costs, which typically average over $1,000 per year per generator and are expected to continue to rise.

[7] *Torrella, Kenny. "Helene just pummeled America's chicken farming capital." October 1, 2024, Vox. https://www.vox.com/future-perfect/374940/hurricane-helene-georgia-chicken-poultry-farms*



3 ENVIRONMENTAL IMPACT

Most poultry operations have houses or sheds spaced sufficiently to allow for installation between house rows. The spacing can speed up installation and reduce or eliminate the need to conduct site environmental studies, a requirement for receiving Rural Energy for America Program (REAP) loans and grants.

a Carbon Footprint Reduction

Solar energy significantly reduces greenhouse gas (GHG) emissions compared to traditional fossil fuel-based electricity. Reducing carbon footprints supports environmental sustainability goals and aligns with increasing regulatory pressures for greener practices.

b Support for Renewable Energy Growth

Investing in solar energy contributes to the growth of renewable energy infrastructure, promoting a cleaner and more sustainable energy grid.

4 CORPORATE SOCIAL RESPONSIBILITY

Corporate Social Responsibility

Adopting solar plus storage technology showcases a commitment to environmental stewardship, which can enhance the company's public image and appeal to environmentally conscious consumers.

EXAMPLE OF SYSTEM **INSTALLATION AND DESIGN CONSIDERATIONS**

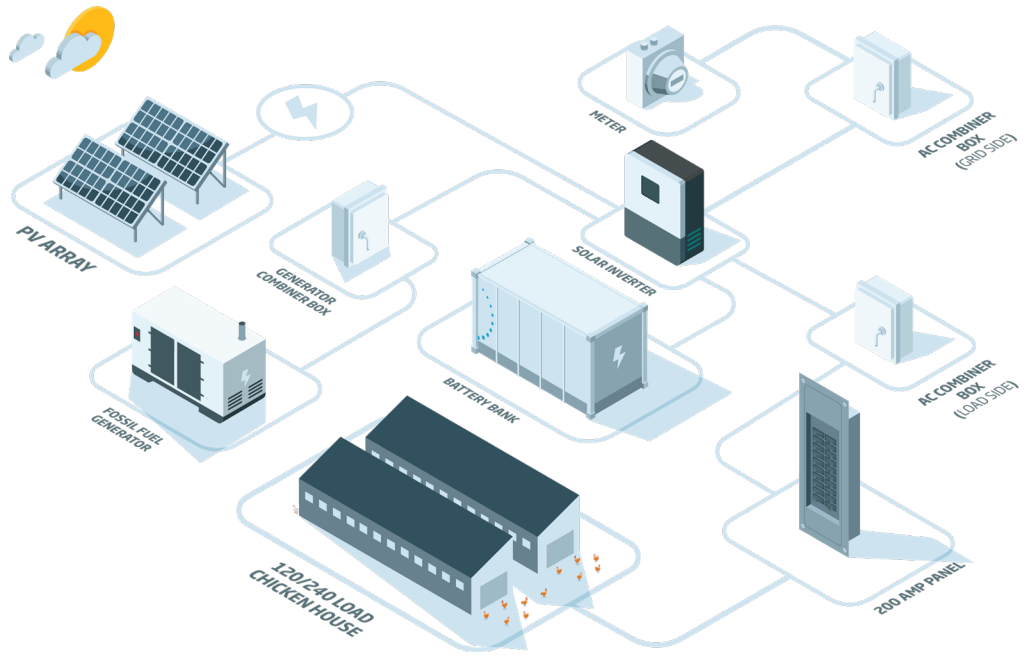
4

SITE CONSIDERATIONS

Most poultry houses operate in underdeveloped rural areas without access to three-phase power. Generally, a transformer providing residential 120/240 "split phase" power supplies energy for each house, constraining system design. However, setting up array/inverter/battery systems individually for each house dramatically simplifies the systems' wiring and construction while increasing redundancy and reliability.

An example wiring diagram of a popular U.S.-based inverter company is shown below, demonstrating how such a system would be installed.

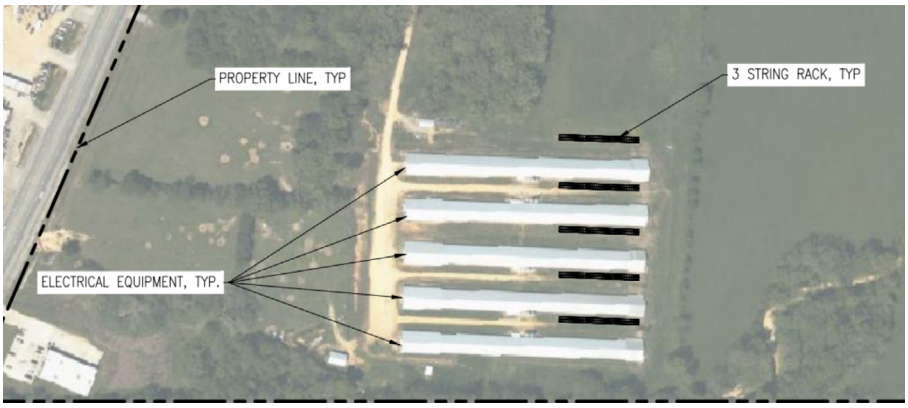
Multiple inverters would connect to the same battery bank and another set of multiple inverters would connect to the three combiner boxes as depicted in the diagram.



Three Phase Options

Even though most poultry operations are 120/240, the three-phase 208 system can also be installed with minimal changes to equipment.







System Installation

Most poultry houses have insufficient structural capacity to support roof-mounted solar modules. With that in mind, a fixed ground mount utilizing driven piles offers the most cost-effective mounting solution. Wire management and equipment location will vary with code considerations, but houses typically have adequate space between them to enable quick and straightforward installation.

ROI ANALYSIS

1 INITIAL INVESTMENT WITHOUT FEDERAL INCENTIVES

The initial cost range for installing a 250 kW solar PV system and a 200 kWh battery storage system includes the purchase and installation of equipment:

- **Solar PV System Cost:**
  $2.50 - $3.50 per W
- **Battery Storage System Cost:**
  $400 - $700 per kWh

Cost Breakdown

Solar PV System Installed Cost:

250 kW × $3.00 per W = $750,000

Battery Storage System Cost:

200 kWh × $550 per kWh = $110,000

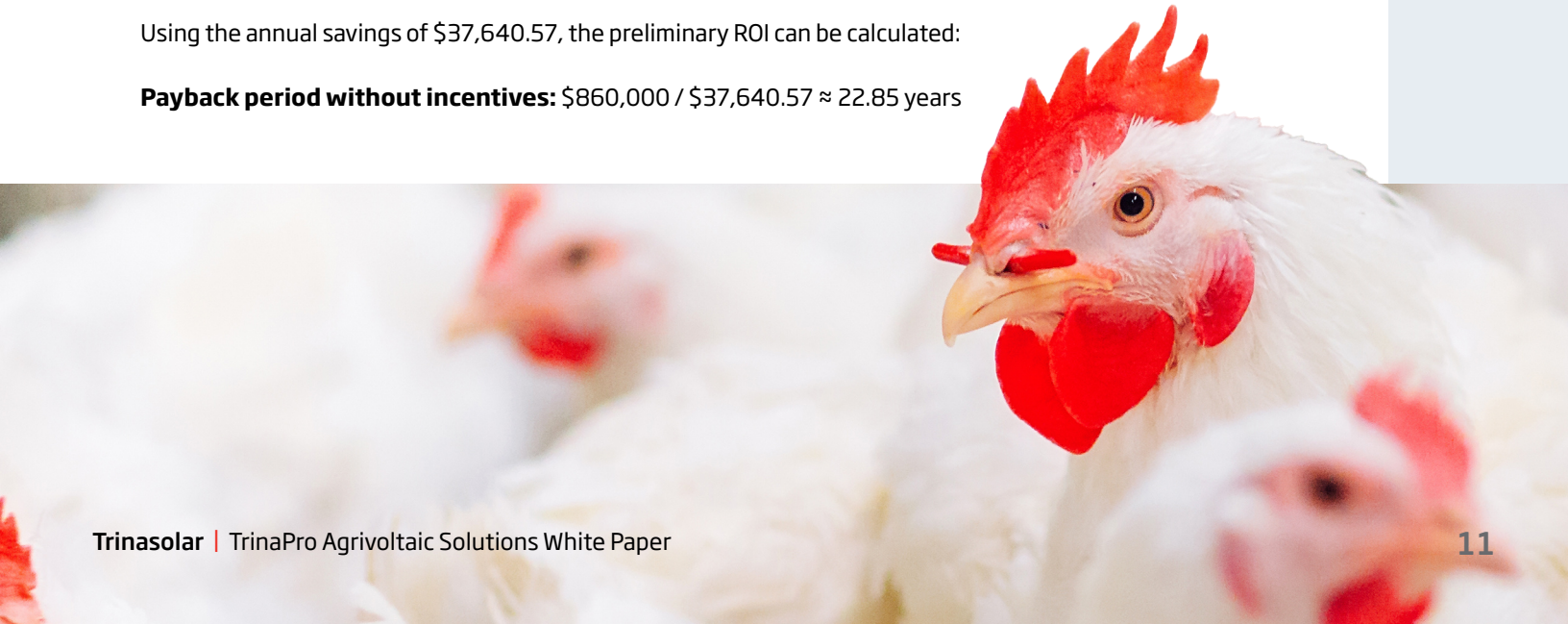
Total Initial Investment:

$750,000 + $110,000 = $860,000

2 OPERATIONAL SAVINGS

Using the annual savings of $37,640.57, the preliminary ROI can be calculated:

Payback period without incentives: $860,000 / $37,640.57 ≈ 22.85 years



3

INITIAL INVESTMENT WITH FEDERAL INCENTIVES AND TAX CREDITS

Traditionally, commercial broilers and egg producers were often unable to access federal incentives that would have significantly lowered the system's initial investment. The Inflation Reduction Act (IRA) now allows for marketable tax credits that significantly reduce system costs. Systems that qualify for REAP grants can also access cost deductions.

- **Federal Investment Tax Credit (ITC):** Up to 30% of the solar system cost[8]
- **Federal REAP Grants:** Up to 50% of system cost
- **State and Local Incentives:** Varies by location

Initial Investment with maximum REAP grant of 50%:

$860,000/2 = $430,000

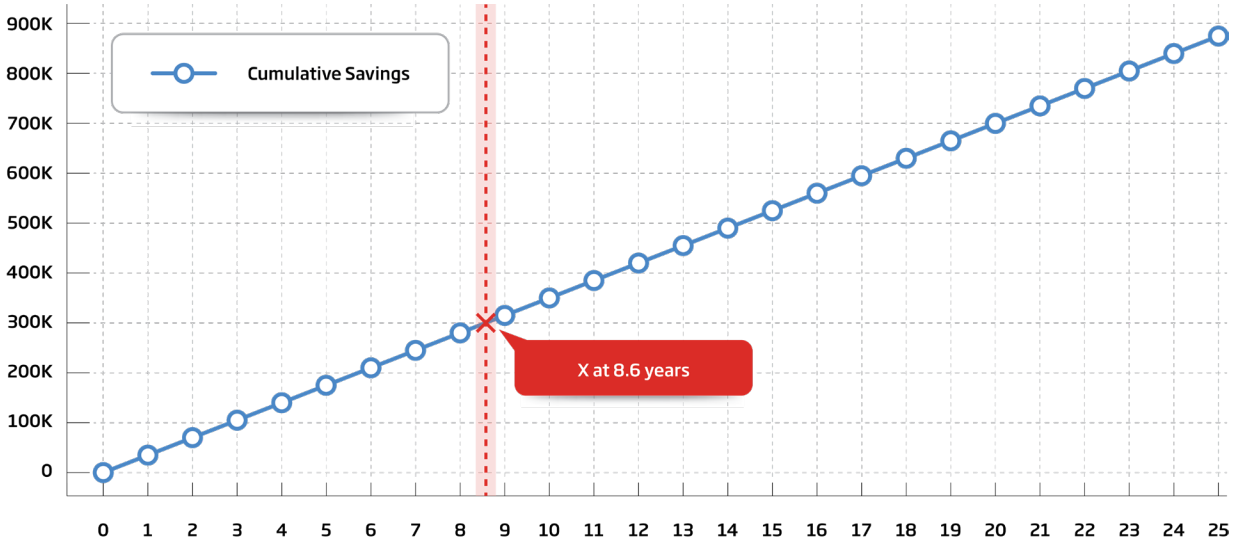
System cost after selling federal tax credit (assuming a 5% discount for marketability):

$430,000 x 0.25 = $107,500

$430,000 - $107,500 = $322,500 Final System Cost

Payback period with maximum federal incentives utilized:

$322,500 / $37,640.57 ≈ 8.6 Years (before O&M costs)



The chart above shows the solar system's payback over the warranty period and cumulative savings in energy costs over the system's lifespan. The dotted red line denotes the payoff point.

[8]*Systems installed in a historically low-income area may qualify for an additional 10% credit.*

4

LONG-TERM BENEFITS

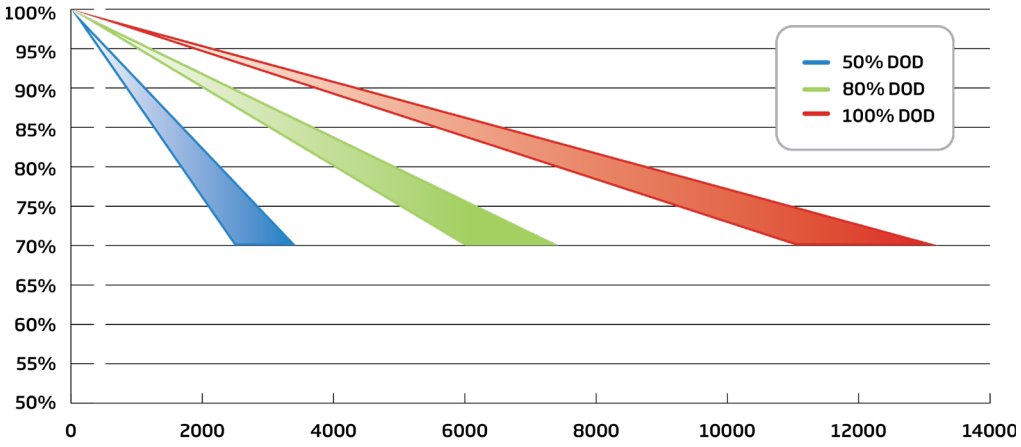
Levelized Cost of Energy (LCOE)

You can calculate the 250 KW system's LCOE for a 25-year period as:

Total Electricity Production: 342,187.5 kWh per year × 25 years = 8,554,687.5 kWh
$322,500 (system cost with incentives) / 8,554,687.5 kWh = **$0.0377 per kWh**

Beyond the payback period, continued savings from reduced electricity rates and enhanced energy reliability contribute to the financial benefits. Solar PV systems typically have a lifespan of 30-plus years, and battery systems generally last 7,000-10,000 cycles (19-27 years), providing long-term economic and operational advantages.

Cycle Life in Relation to Depth of Discharge (DOD) @ 0.5C charge/discharge



	Cycle Life	
	3000 Cycles	**6000 Cycles**
Depth of Discharge	**90%**	**80%**

Depth of Discharge represents the amount of energy drained from the battery before fully charging it. This battery charge/discharge cycle degrades the battery over time and reduces its energy capacity. The chart above shows the inverse relationship between the Depth of Discharge and Cycle Life, wherein the higher the battery's depth of discharge and the more frequently it's discharged, the fewer cycles available.

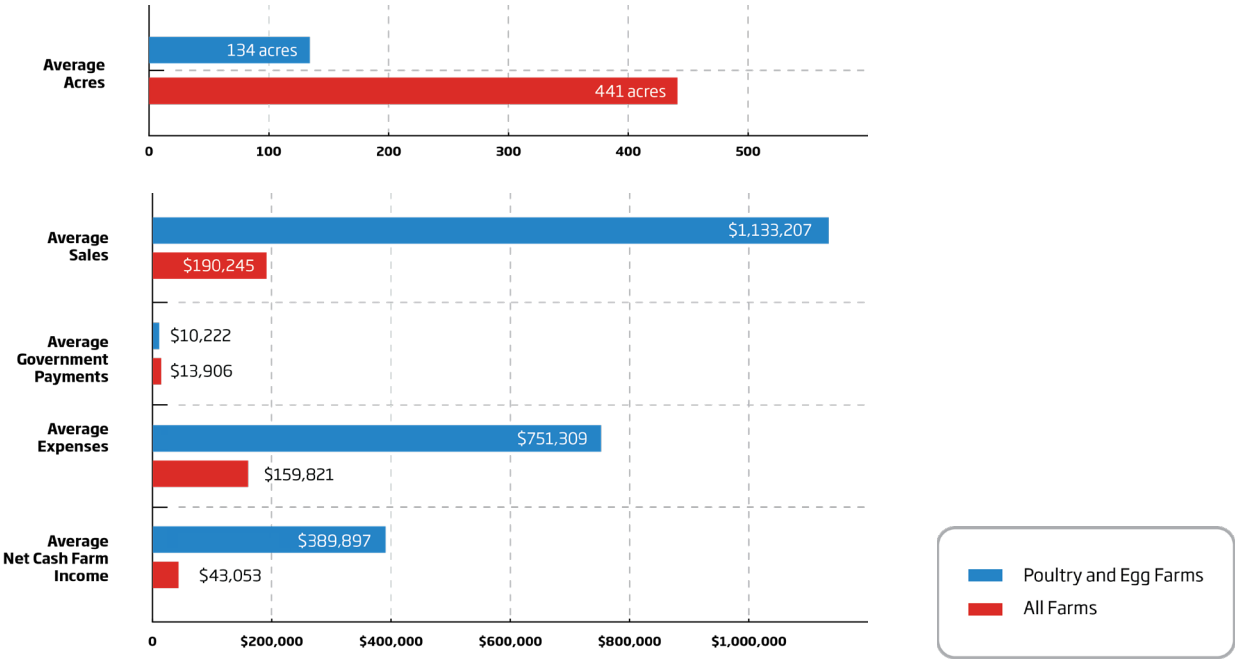
CHALLENGES AND SOLUTIONS

The greatest challenge to implementing a system like this is financial, as the cost of a solar plus storage system is close to a year's net income for a farm. However, financial solutions exist from companies like Trinasolar US, with its TrinaPro total solar solution. TrinaPro leverages Trina's capacity as an established OEM and its vast network of connections in the solar and financing sectors to identify investment and installation partners for end users.

Other challenges involve component procurement and compatibility and optimizing system performance to reach forecasted ROI milestones on schedule. As a one-stop shop for all major system components, the TrinaPro total solar solution delivers streamlined procurement, component compatibility, faster installations, optimized system performance, and maximum solar plus storage system value.



Comparison of Poultry and Egg Farms vs All Farms



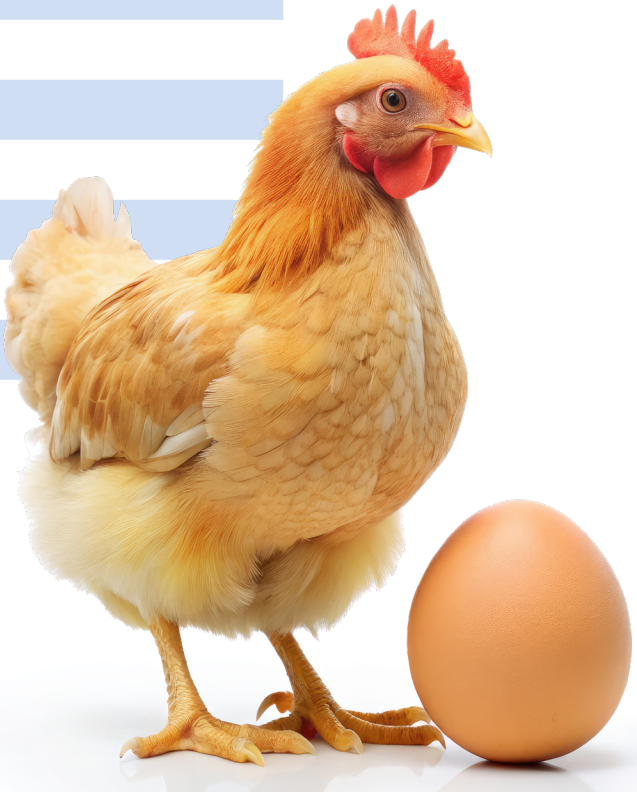
On average, farms specializing in poultry and egg production have a smaller land area, higher levels of sales, greater production expenses, and higher net income than all U.S. farms.

CONCLUSION

Integrating solar PV with a battery energy storage system offers substantial benefits for poultry operations, including significant cost savings, improved energy reliability, and positive environmental impacts. Despite the initial investment, the long-term financial savings, coupled with potential incentives, makes solar plus storage a viable and strategic investment for poultry operations.

This paper's calculations rely on the mean average of the houses surveyed. Depending on the farm size and number of houses, the sample calculations can be easily adjusted but would provide similar ROI periods. A smaller 150-175KW system would be more appropriate for smaller producers while a 500 KW+ system size would better suit larger farms.

Type of Farm	Total kWh Used
Egg Farm 1	277,076
Broiler/Some row crop 1	533,916
Broiler 2	284,796
Broiler 3	234,880
Broiler 4	375,060
Broiler 5	143,826
Broiler 6	433,629
Broiler 7	182,111
Broiler 8	317,244
Broiler 9	220,663
Broiler 10	234,953
Broiler 11	522,709



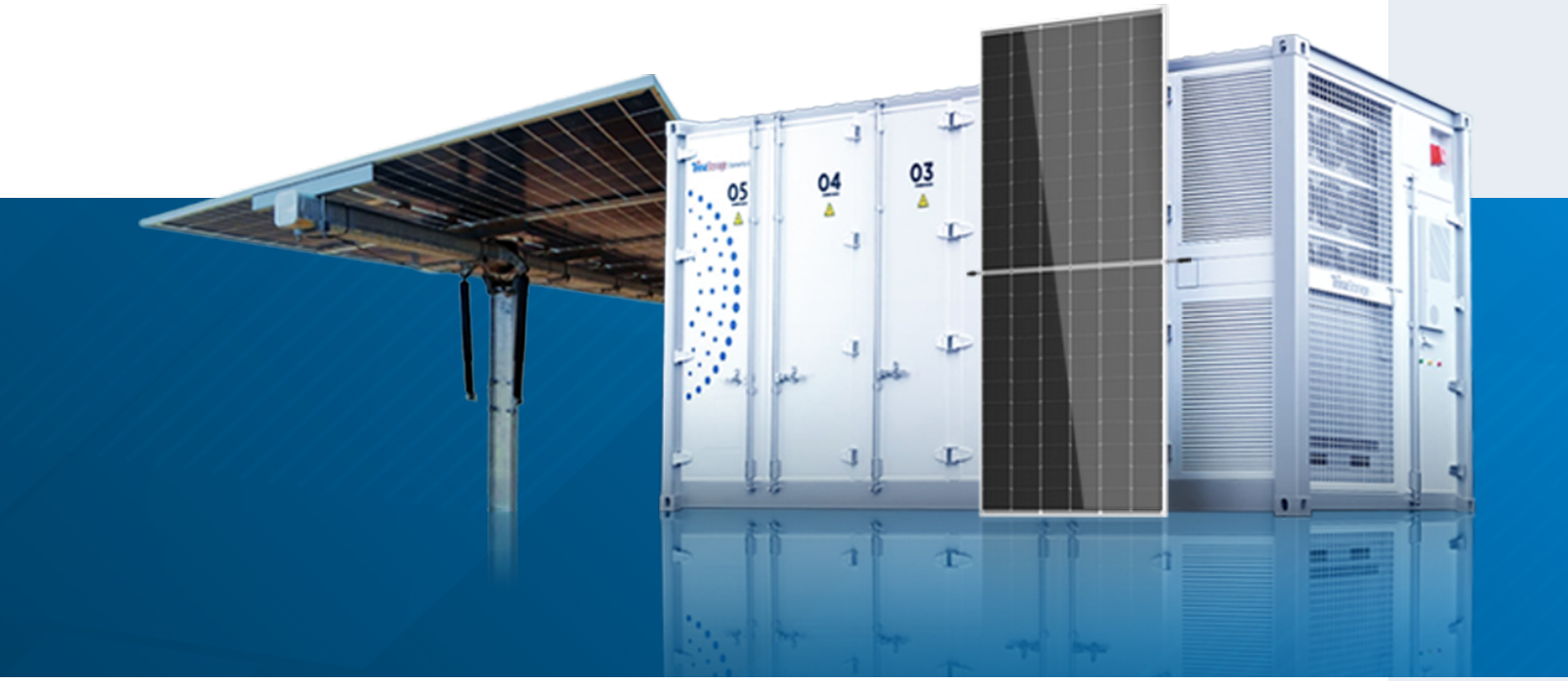
TRINAPRO, THE SINGULAR SOLUTION FOR SOLAR

TrinaPro is a breakthrough smart PV solution for C&I and utility-scale solar installations that will only improve over time as new features and services are integrated into its platform. Focusing on enhancing customer ease-of-use, Trinasolar has long distinguished itself from the competition by taking innovative steps such as integrating PV trackers into the Trinasolar portfolio. That move and others illustrate its commitment to building highly integrated solutions that streamline the otherwise complex operations associated with utility solar projects world-wide.

As EPCs and project developers continue to seek out ways to lower LCOE, boost energy generation, and speed up ROI, TrinaPro provides the one-stop solar solution they need to succeed.

Trinasolar is excited to show our customers the value of TrinaPro. **Visit our site** or **subscribe** to our newsletters to stay up-to-date on our latest production and solution announcements.

TrinaPro



ABOUT TRINASOLAR

Trinasolar is a solar pioneer with deep technology roots. Founded in 1997, the company rapidly expanded beyond its origins in China to become a global leader in the renewable energy industry.

Through global growth, Trinasolar achieved its first major milestone of 1GW of quarterly shipped capacity in 2015. It maintains a major commitment to innovative energy applications within the IoT as well as smart PV solution segments. From its manufacturing bases in Vietnam and Malaysia, Trinasolar continues to produce high-quality and responsibly sourced PV modules to help deliver renewable energy solutions to North America. Trinasolar employs a diverse team at customer service centers and warehouses across the country, with a presence in the U.S. going back more than a decade. Our dedicated team of experts working in engineering, sales, finance, value-added marketing, operations, and more have been helping U.S. solar installers and developers deliver project success for years.

Via TrinaPro, which Trinasolar introduced in 2018, the company became the first module manufacturer to bundle a module, inverter, and single axis-tracker paired solution. TrinaPro is a one-stop shop for utility solar, capable of delivering value efficiency with powerful, reliable, and scalable infrastructure.

Trinasolar

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Sources

Appendix of Terms

BESS – Battery Energy Storage System
ESS – Energy Storage System
GHG – Greenhouse Gas
IRA – Inflation Reduction Act
ITC – Investment Tax Credit
kWh – Kilowatt-Hour(s)
REAP – Renewable Energy For America Program
ROI – Return on Investment
LCOE – Levelized Cost Of Energy
PV – Photovoltaic
O&M – Operations and Maintenance
UPS - Uninterrupted Power Supply
USDA – U.S. Department of Agriculture
W – Watt(s)