EIP-AGRI Focus Group

Enhancing production and use of renewable energy on the farm

MINIPAPER: “Solar and wind combined with energy storage”

Jan Reinier de Jong, Laura Garau Contreras, Marleen Gysen

funded by European Commission

1. Introduction

Content

In this paper, we discuss why the use of stationary batteries for electrical energy storage can be interesting for farms that have their own renewable energy installation. We identify different applications and describe the importance of energy production and consumption profiles when choosing and dimensioning renewable energy systems as well as energy storage systems. We also discuss some cases from different countries and the lessons that can be learned from them. Finally, we indicate where further research is needed.

Motivation

Farms can play an important role in the energy transition in rural areas and in the sustainable production of food. In contrary to other SMEs or residential houses, farms often have a lot of space to install renewable energy systems like wind or solar energy techniques. In many cases those techniques have proven to be viable technologies, due to the decrease in investment cost and the increase in efficiency and modularity. We have seen the realisation of many renewable energy projects at farm level in countries where renewable electricity has achieved grid parity. Although wind and solar energy are therefore important technologies in the energy transition, their production is unpredictable and erratic because it depends on the weather conditions. As a result, there is often a mismatch between the onsite generation curve of the solar panels or the windturbine and the energy consumption profile on the farm.

In cases where there is no net-metering[1], a farm that directly consumes its own generated electricity will save the money that it would have otherwise paid to buy electricity. If the farm has to sell its electricity to the grid – at moments when there is an excess production of renewable energy compared to the energy use at that moment on the farm– it will receive the wholesale price as revenue. The price gap between buying electricity from and selling electricity to the distribution grid is getting bigger over the years. To make renewable energy production on the farm level more cost-effective, farms have an interest in maximising the rate of self-consumption of their own produced solar or wind energy.

The main options for increasing the onsite self-consumption are energy storage and demand-side management (buffering and shifting of energy consuming processes). Energy storage systems include electric batteries (stationary as well as in electric vehicles), pumped hydro systems, power-to-heat systems such as hot water boilers or heat pumps that can convert excess electricity to heat to be stored for later use and power-to-gas systems that convert excess electricity into hydrogen. In this paper we discuss short term electrical energy storage by stationary electric batteries.

[1] Net-metering is a regulatory framework under which the excess electricity injected into the grid can be used at a later time to offset consumption during times when onsite renewable production is not sufficient. It is a simple billing arrangement that ensures consumers with own electricity production to receive one for one credit for any electricity their systems generate. Production and consumption are compensated over a larger time frame (up to one year) and the network should be regarded as a long term storage solution, with the solar or wind electricity being occasionally injected and consumed later on.

funded by European Commission

2. Dissertation

Applications

On farms, electrical energy storage in a battery can be applied for various reasons:

- Increasing self-consumption: batteries can store excess onsite renewable generation in periods of low electricity demand for use in periods when the own renewable production is absent or not sufficient. Time of generation and consumption can be more decoupled that way.
- Peak shaving: the use of a battery can possibly decrease connection costs or costs caused by occurring power peaks by lowering the demand peak of the electrical system (the stored energy is used at the moment of greater electrical power demand).
- A battery can allow farms to get off-grid, e.g. in case of a temporary power outage (as back-up or UPS – Uninterruptable Power Supply).
- Through the use of batteries, farms can offer flexibility to the wider energy system (including through aggregators) for supporting the grid.
- When farmers operate more directly in the energy market, the use of a battery can give price opportunities. Because of an increasing share of renewables, there are more price fluctuations. The farmer can respond to this by using batteries.
- For the use in mobile applications, like electrical vehicles (tractors, forklifts, …) or other electric equipment.

The importance of energy profiles

Energy-intensive agricultural sectors like livestock breeding, fruit, chicory and horticulture under glass all have specific energy demand profiles. Those energy demand profiles have a big influence on the self-consumption of the renewable energy installation and consequently on the profitability of that installation.

The energy demand profile of a traditional dairy farm without milking robots, for example, varies strongly during the day: there are large peaks due to milking and cooling in the morning and evening. However, the energy demand profile of a dairy farm varies less during the year. Whereas the energy demand profile of a fruit company with cooling cells, for example, varies strongly throughout the year because of the big peak during the picking season for the immediate cooling of the fruit. Later on, the cooling rooms will become more and more empty and the energy demand of the farm will decrease.

These energy demand profiles have a major influence on which renewable energy technology is chosen best (e.g. the self-consumption of solar panels on fruit farms is generally quite low so windmills are probably a better choice) and on the dimensioning of that technology. Secondly, these profiles also have a major impact on the choice of the energy storage system (seasonal storage, short term storage, …) and on the cost-effectiveness of the energy storage system. Simulations in the context of the SAVE project[2] show that – for comparable energy yields - the self-consumption of wind energy is higher than that for solar energy. Despite their erratic production profile, wind turbines produce energy throughout the year and also during the day and night. Moreover, short term storage batteries have a bigger influence on the self-consumption rate when combined with wind energy.

[2] The project SAVE ("Slim Aansturen Van Elektriciteit") is a research and dissemination project in the region of Flanders in Belgium. The project is about the smart use of own produced renewable electricity by SMEs. One of the target groups is the agricultural sector.
www.slimaansturenvanelektriciteit.be

funded by European Commission

Energy storage cases

Beekeeping farm, Spain

Beekeeping farm with installation of solar panels and batteries for energy storage that generates the electricity that feeds the warehouse and the pumping of water from the well. The installation power has 3,000 W of solar panels and 3,000W in batteries. The installation cost was € 9,300 and an annual saving of € 800-1,000 is estimated. Also, the farm saved the amount of money that had to be invested on the connection to the grid estimated in 60,000€ (30,000€ per km).

Feedlot farm, Spain

Feedlot farm that was previously supplied with energy from a generator that provided electrical energy based on the burning of diesel fuel, with the consequent emissions to the atmosphere. It is an off-grid farm. The company made the investment, and now, it is supplied exclusively by an autonomous photovoltaic solar installation, which production is consumed instantly by the farm's own consumption, and stores the surplus production in “OPZS” batteries, which are able to provide an added energy to a consumption punctually high, at the time of solar production, and, additionally they are able to supply consumptions outside of solar time.

The consumptions that it supplies are:

- Feeder engines
- Ventilation window engines, controlled by an internal temperature sensor.
- Illumination.
- Little consumption of force of the farm.

Project “Energy Storage on the Farm”, The Netherlands

In 2016, the project "Energy Storage on the Farm" started in the Netherlands. The goal of this project was to realize added value for renewable energy. This way, green energy can be produced in the long run without a subsidy. The idea was to temporarily store solar energy in a battery and sell the electricity when the prize is high. By means of a battery you would be able to play on peaks in the electricity market. Meanwhile, there are four Dutch farmers that have bought a battery of 300 kWh. There has been trade in various energy markets for example the APX and the Intraday. Unfortunately, after 2 years we see that the return on investment is too low. The technical lifetime of the battery is shorter than the payback time. Currently the batteries are used to keep the grid on voltage (the FCR market). The national network company Tennet pays a one-week fee for the service provided. This is separate from the solar power production. We see that electricity has been very cheap in recent years, while batteries are still expensive.

Thanks to this project, we know where the opportunities lie and what the weak points are. In the long run, the expectation is that energy storage will become profitable. We can’t do it without using more and more renewable energy. Conclusion, there will be plenty of opportunities for farmers in the long term.

Technical data project De Jong Odoorn, The Netherlands

- 20-feet container with:
  - 300 kWh battery storage (126 lithium ion cells)
  - 2x bi-directional converters of 125kW and 225kW
  - ATEPS Energy Management System
  - Integrated climate system
- Solar installation:
  - 1057 polycristalline solar panels
  - 300 Wp per panel, size 1.99x0.99
  - Production: 240.000 kWh/year
  - East-west set up, curve 22% and 25%

funded by European Commission

SAVE - Inagro, Belgium

The project SAVE ("Slim Aansturen Van Elektriciteit") is a research and dissemination project in the region of Flanders in Belgium. The project is about the smart use of own produced renewable electricity by SMEs. The energy-intensive agricultural subsectors are amongst the target groups. Besides simulations on the choice and dimensioning of renewable energy systems and the implementation of demand-side management measures and battery systems and advising farms on those technologies, another goal of the project is to demonstrate those smart solutions in a working context. One of the demonstration sites of the project is the research farm of Inagro, where the largest part of the energy consumption comes from the cooling cells and the washing installation. The farm already had a PV installation (18 kW) and in 2017 was a Lithium-Ion battery with an energy content of 20.7 kWh also installed. Of this total energy content, about 3 kWh is reserved for back-up (UPS) in case of a net failure. That means that 17.7 kWh can be used for increasing the self-consumption of the PV installation.

The biggest problem that the test farm Inagro is currently struggling with to get the battery cost-effective is the high internal consumption of the inverters. This high self-consumption was estimated much lower on the technical specifications of the technology provider. The project also experienced that – although electric batteries are not a "new" technology – providers encounter problems in meeting all the requirements of the end customer. The case also shows that is important to involve the distribution grid operator in the process from the beginning of a battery project.

3.Research needs

In addition to a general need for further research into the performance and the affordability of electrical energy storage by batteries, more specifically for farms is needed:

- An assessment of the impact of behind-the-meter storage at farms: business models for the farmer, grid opportunities.
- An assessment of the most appropriate energy storage techniques for different types of farms and/or generation and consumption profiles.

4.Conclusions and recommendations

There are great opportunities for farmers who opt for the combination of renewable energy production like wind or solar with electrical energy storage by stationary batteries on their farm: increasing the self-consumption rate of the onsite produced renewable energy and providing an UPS in case of a power outage are the most obvious ones. Moreover, farmers can support the grid by managing the peak power of the decentralized renewable energy installations by using batteries.

However, although stationary batteries are becoming increasingly cheap, they are still far too expensive if their only goal is to increase the self-consumption of the renewable energy installation like solar or wind energy. When providing grid services, the case of the Netherlands shows that there are also a lot of unnecessary network costs when loading and unloading and a high energy tax when balancing.

When assessing batteries for their technical performance, the Belgian case shows that there are still problems with reliability and the high internal consumption of the inverters. Also, suppliers are not always familiar with the specific requirements of a farming business. There are few specialized companies with experience. Electrical energy storage by stationary batteries is still in the pioneering phase.

funded by European Commission

To fully realise the potential of energy storage, regulatory actions are also needed: simplified and clear procedures for small-scale renewable energy projects, in consultation with grid managers and other actors in the local, regional and national energy system. The government and network regulators must encourage entrepreneurs who want to store energy (e.g. energy tax on energy storage must stop as well as the extra costs charged by the network regulator).

Finally, much research is still needed on the use of battery systems on farms, especially on finding and defining interesting business models.

5.References

- Project SAVE: www.slimaansturenvanelektriciteit.be
- Project Energy Storage on the farm:
  http://www.dejongodoorn.nl/energieopslag/
  http://julesenergy.nl/case/zonnepanelen/

funded by European Commission