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# STATE OF THE ART OF THE OPTIMISATION OF THE SELECTION AND USE OF RENEWABLE ENERGIES FOR THE AGRICULTURAL ENVIRONMENT

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## INTRODUCTION

A combination of different energy generation sources, together with the possibility of installing batteries or other forms of energy storage systems, can enable the adaptation of the generated electricity to the needs of the farming sector. From optimal irrigation schedules for crops, to taking advantage of pruning waste to generate electricity at times when other sources are not able to generate it, this fitting can allow the farmers to focus solely on the wellbeing of the plants, without worrying about energy prices. On the other hand, it also provides the possibility of maximising energy production on days where the crop health is already ensured.

This study presents aspects missing for the adaptation and integration of hybrid renewable energy systems into de agricultural sector. These can improve the wellbeing of isolated areas, such as islands, industrial sites, or villages, helping the owners provide benefits for themselves and their communities.

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|---|---|
| **Economic Benefit** | • Reduce demand on the grid<br>• Sell surplus generation |
| **Crops benefit** | • Reduce water demand<br>• Protection from the weather |
| **Solar panels** | • Reduce module temperature |
| **Social Benefit** | • Provide shade to workers |

## OBJECTIVE

The objective of this paper is to study the state of the art regarding different hybrid energy systems with their optimisation methodologies and limitations. In addition, this paper analyses the economic and environmental benefits, as well as gaps in the agricultural sector.

## ENERGY USES IN AGRICULTURAL PRODUCTION

Many of the energy uses in agricultural production rely on diesel or gasoline, especially those related to the transport of personnel or product. Electricity is usually in the background, although for irrigated crops it gains more weight with the power of hydraulic pumps for the irrigation system.

Farm machinery and small vehicles | Deliveries and purchases | Irrigation equipment | Post production processing | Greenhouses | Lighting | Other

Nonetheless, the push for net zero emissions forces a shift regarding our actual energy sources. This can be seen with the search for alternate fuels for vehicles, with options such as electric or hydrogen cells.

Another future use of energy for this sector is the implementation of the Internet of Things to the crops. This Agriculture 4.0 revolution not only focuses on the vigilance of the status of plants and soil. Drones can synergise with the sensors installed.

Automation of actuators | Disease and plague detection | Irrigation management | Fertilizer management | Maturity identification | Marketing and supply chain | Soild fertility | Weather patterns

These new implementations seem to be moving toward the use of electricity as the main power source. The increasing number of elements that need to be connected to the power grid, either to operate or to recharge batteries, can increase the costs of production. For this reason, an energy source inside the cultivation terrains could be beneficiary to reduce the costs named before.

## ENERGY SYSTEMS

### Solar photovoltaic

- One of the renewable energy systems with most installed capacity in Spain
- Most Agrivoltaic studies use flat monofacial plate PV devices as the standard and focus on the position of the solar panels, either in the open air or greenhouses
- Different new elements are being studied, such as organic photovoltaic modules, bifacial panels and the uses of beam splitting

### Eolic

- Most of the time the symbiosis with the cultivation terrain is non-existent
- Energy wind harvesters can be used to power Smart agricultura applications such as sensing nodes

### Bioenergy

- Agricultural residue can be transformed into bioenergy, such as biodiesel and biofuels
- Wastewater can be employed to obtain different bioenergy and biochemicals by making use of several biological processing strategies

### Batteries

- They provide energy flexibility by not binding certain energy-dependant procedures to the time nor weather
- There are different types of batteries, such as electrical and gravitational

## ENERGY OPTIMISATION METHODS

The methodologies identified focus on their applicability to the agricultural environment.

### HOMER

- Hybrid Optimisation of Multiple Energy Resources
- This software program can model entire hybrid microgrid and grid-connected systems combining generated power (traditionally and renewable), storage and load management

### HOGA

- Hybrid Optimisation by Genetic Algorithms
- Use of genetic algorithms to obtain the optimisation model

### Machine Learning algorithms

- Markov Chain Monte Carlo algorithms due to their probabilistic nature can be applied to generate Models of wind and solar generation
- Bin packing algorithms for managing Smart grids, predicting the client's energye usage behaviour
- Machine Learning model including nonlinear autoregressive model, lineal model using stepwise regression and random forest approavhes to predict energy usage
- Hybridisation of an artificial neural network and chaotic search, harmony search and simulated annealing algorithms to size a stand-alone energy system using weather forecasting

## CONCLUSION

Hybrid energy systems suffer from different challenges, which can be compiled in 4 big groups: energy management, unit sizing, demand response and energy storage management. To those challenges, we have to add the challenges regarding the agricultural sector and the ones created by the combination of both worlds.

All these installations must take into account the regulations and laws of the country where it would be installed. We cannot forget that the main objective of the agricultural sector is to produce high-quality crops at the highest possible profit. Energy is secondary, reducing costs and acting as a secondary source of income but it can never be the main source.

Most methodologies do not take into account the global needs of a farm, focusing most of the time in the irrigation aspect or greenhouse necessities, over areas such as post-production processing or transport. New studies could focus on those areas, searching new ways to create biodiesel to power the actual vehicles or pushing towards electric charged ones. Also, most of the methodologies focus on self-consumption, not taking into account the prosumer aspect and benefits (economic and social) that comes with it.

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