SUSTAINABILITY OF ENERGY USES IN AGRICULTURAL AND FORESTRY SYSTEMS

ENERGY EFFICIENCY ANALYSIS OF A HYDROGEN AND GEOTHERMAL STAND-ALONE SYSTEM FOR GREENHOUSES HEATING

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Keywords: Renewable energies stand alone system, hydrogen production, ground source heat pump, greenhouses heating.

The current rise of floricultural and horticultural crops in a protected environment, mainly due to market factors and the increase in demand for biological products, is the basis of the significant increase of the energy consumption for the greenhouse climate control. Diesel, LPG and natural gas are generally used as fuel in heating greenhouses and, although the use of renewable energy can improve the sustainability of the crops in a protected environment, these still play a niche role in the energy panorama due to the non-simultaneity of the energy production during the daylight hours compared to the night energy required. For these reasons, the scientific community is aimed at testing new energy storage technologies, such as new batteries with very high efficiency, re-pumping water into elevated water storage systems, boilers powered by solar thermal systems. However, an interesting solution consists in the solar energy conversion in hydrogen(H_2) in order to implemented a totally renewable and stand-alone system for greenhouse heating.

The above mentioned system was installed at the experimental farm of the University of Bari "Aldo Moro" in order to supply the heating energy required of a experimental tunnel greenhouse of 16 m^2. The systems consist of photovoltaic panels connected to an electrolyzer, that during the daylight hours, produce hydrogen by electrolysis and then it is stored in a pressure tank. During the night, thank to a fuel-cell, the hydrogen was converted to electric energy in order to feed a ground source geothermal heat pump for greenhouse heating.

In particular, the system was composed of polycrystalline photovoltaic panels with peak power of 8.23 kWp, an alkaline electrolyzer with 2.5 kW of electric power in the absorption, an hydrogen storage tanks with a capacity of 15 Nm^3 and operating pressure of 30 bars, a PEM fuel cell with 2 kWp of peak power, buffer gel batteries with a capacity of 10.8 kWh, a heat pump with thermal power of 0.8 kW and 0.16 kW of electric absorption and vertical geothermal borehole 120 meters deep.

Considering the energy efficiency of photovoltaic panels of 13%, the energy efficiency of electrolyzer equal to 48%, the fuel-cell energy efficiency of 41% and finally, the coefficient of performance of geothermal heat pump of 5, the overall system efficiency, starting from the amount of solar energy available during the daylight hours, was of 12.8%.

GREENDRY: LOW TEMPERATURE DRIER FOR DRYING GRAINS AND OILSEEDS

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Key words: Low temperature drying, corn, energy saving, logistics, automation.

The natural air/low temperature (NA/LT) in-bin drying technology is not adopted in Italy and Europe. The lack of information and successful examples prevent the diffusion and adoption of this technology by farmers. In the last years, an in-bin drying prototype was developed by the National Institute of Agricultural Technology (INTA) in agreement with four companies in order to investigate the applications of this technology in Argentina. The core of the drying system is a model based fan and burner controller. The system was adapted by DISAFA to be used in Italian conditions and installed in two plant of capacity of 70 and 100 t in NW of Italy to dry corn. The goals of this research were: 1) test the reliability of automatic smart drying controller for low-temperature drying, 2) test the performance of a prototype in-bin drying system for drying corn to 14% final MC, 3) evaluate the energy consumption and 4) evaluate grain quality after drying. The results showed that the in-bin drying system was able to dry the grain in about 28 days from 21.5% to 13,7% MC. The individual kernel MC gradient was reduced during drying. The energy consumption was very low compared to traditional mixed flow driers, just about 4.95 L t^{-1} of dried grain, equal to 55% energy saving. Grain quality was very good with very low stress crack index compared to traditional driers. Another important aspect is the very low flow rate of the air compared to traditional driers, that imply practically no dust emissions. These results confirmed the potential of NA/LT in-bin drying systems for drying corn, rice and other special quality grains in NW of Italy.

ENERGY EVALUATION OF GRASS RESIDUES SUPPLY CHAIN FROM NON-CULTIVATED AREAS FOR BIOGAS FEEDING

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Key words: Non-cultivated green areas, anaerobic digestion, harvesting and transport systems, economic and energy analysis

The increasing demand of biomass for biogas production is arousing some concerns about the sustainability of this process. In fact, the cultivation of energy crops in farmlands is becoming more noticeable, causing a competition with food production.

The utilisation of grass from the management of territory as a feedstock for the anaerobic digestion process could contribute to reduce these problems, both on environmental and social aspects. In fact, grass exploitation, beyond minimize the competition with food, could reduce eutrophication and production of greenhouse gases, provide nutrients for the fertilization of the soils and make more profitable the management of landscape and the biogas production.

Although currently grass is not used in the biogas production chain, it is a widely available biomass within the territory. Its anaerobic digestion appears feasible from a functional point of view; nevertheless, there are still few studies related to economic, energy and environmental recovery of this biomass, considering non-cultivated green areas.

The PhD project will investigate about the feasibility of exploitation

of grass collected in non-cultivated areas for biogas production, examining:
- the available biomass of grass for the anaerobic digestion according to the Veneto region territory;
- the best systems for the supply of anaerobic digestion plants;
- the biochemical methane potential of grass from non-cultivated areas;
- the economic, energetic and environmental advantages or disadvantages of its exploitation.

The results obtained until now reveal different solutions for the cutting, harvesting, transport and storing of grass collected along watercourses. From an economic and energy point of view, the costs are relatively high and variable depending on the organization of the harvesting system, the distances and the transport density. However, several environmental, social advantages, and a better hydraulic safety that the grass harvesting encompasses may be able to compensate the weaknesses encountered.

DEVELOPMENT AND APPLICATION OF A MATHEMATICAL MODEL FOR ENERGY CONSUMPTION OPTIMIZATION IN INTENSIVE SWINE FARMING

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Key words: Swine farming, Energy consumption, Sustainability, Device optimization, Algorithm.

Energy saving is a key objective to reduce environmental impact of pig production and to ensure economical sustainability in swine farming. Other than feed consumed by pigs, operating energy includes electricity needed to maintain the pig rearing environment. Copious efforts have been carried out to develop methods for energy system optimization, including the application of newly developed mathematical models. Energy consumption analysis and optimization in animal farming is widespread, but mostly focused on feed rations and recipes. However, electrical energy use in the farm should always be taken into account for economical considerations regarding cost minimization and consequent profit maximization. This work focuses on the optimization of operating electrical energy consumption.

In this study, a mathematical model based on the algorithm principles recently established for a semiconductors manufacturing industry was developed and validated employing the optimization modeling software Lingo 15.0. The model involves three general equations (decisional, calculation, constraints). Experimental data were collected in an energy-intensive swine farm located in Northern Sardinia (Italy) within Sassari province. The main technical features and use time of all equipment involved in the cycle of production were preliminary surveyed, and then the associated monthly and daily energy consumption was determined distinguishing among systems for feeding, lighting, air-conditioning, ventilation, heating, sewage sludge spreading, submerged pump system, and high-pressure jet cleaning. After monitoring all energy-demanding equipment and facilities, the "typical daily consumption", including energy use levels associated with each hour, was defined. Because in our case lighting, air-conditioning, ventilation and heating, represented the majority of swine farming energy consumption costs, only these items were taken into consideration to develop and apply our mathematical model.

Through this application more energy efficient alternatives were identified. Following the results of software analyses, significant savings are achievable for lighting, ventilation, air-conditioning and heating systems. More in detail, in the study farm lighting is based on the use of neon light that can be replaced with led light; air-conditioning system including pad cooling can be improved associating an inverter which allows to achieve around 30% energy savings; on-off ventilation system can be similarly improved integrating a variable-frequency drive; heating system relies on traditional heat lamps that can be replaced by variable heat lamps whose heat output and consequent consumption are adjusted by a variable voltage controller depending on environmental parameters. These replacements allow significant cost savings (around Euro 8,500.00 annually). Amortization costs of necessary investments, calculated on a 5-year basis, have also been considered to adequately reduce annual savings. Further improvements of this model will provide additional information on its applicability to other kinds of animal farms.

BIOCHAR OBTAINED FROM PELLET OF BIOMASS RESIDUAL BY PYROLYTIC PROCESS IN BATCH

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Key words: Characterization, biochar, biomass residual, pyrolysis process.

Biochars produced from pellet obtained from grape vine (GV) and sun flower husk (SFH) at different temperature (400 and 500°C) were studied after pyrolysis in batch reactor at Bioenergy 2020 Institute in Graz (AU) under the BRISK project.

Chemical and physical evolution of biomass under pyrolysis conditions was determinate and products characterization was evaluated including main organic components in gaseous stream. The objective of this work is to improve the knowledge for alternative use of the biochar obtained from agro-forestry biomass residuals, particularly grape vine and sun flower husks, by means of modern chemical and physical characterization tools.

ENERGY RECOVERY OF HAZELNUT'S PRUNING USING AN IMBERT GASIFIER PROTOTYPE

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Key words: Energy recovery, Pruning, Gasification process, Hazelnut, Downdraft gasifier.

Aim of this work is to evaluate the possibilities of use of hazelnut pruning as biomass to be used in an Imbert downdraft prototype for gasification with air. Biomass gasification is one of the most used techniques to obtain power from biomass and generally energy crops are used for this scope. In our case is important to stress that hazelnut pruning is a waste management problem and this work highlights that is possible to use pruning for obtaining syngas to power production and a solid residue that could be used as soil improver. In this study bio-