Computer system for the energy potential determination in pig's enterprise

Sistema informático para la determinación del potencial energético en centros porcinos

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A computer system was developed to determine the energy potential in pig's enterprise with the purpose of using the renewable energy sources. For their design, the IDE NetBeans, version 8.1 was selected as environment. A program named RESCE (renewable energy sources, clean environment) was generated to create hybrid systems, in which a priority order is establish respect to the residuals treatment. In a second phase, an estimate was made to determine the potential of electric energy generation with other sources. The use of this system allow the maximum exploitation of all natural resources, without damage the environment and it is consistent with the concept of circular economy. It is concluded that the program, in addition of allowing the computerization of the use of renewable energy sources in pig enterprise, speeds up decisions-making.

Key words: *biodigestors, eolian, pigs, photovoltaic, thermal solar*

Se desarrolló un sistema informático para la determinación del potencial energético en centros porcinos con el propósito de poder utilizar las fuentes renovables de energía. Para su diseño, se seleccionó como entorno el IDE NetBeans en su versión 8.1. Se generó un programa denominado FREAL (fuentes renovables de energía, ambiente limpio) para crear sistemas híbridos, en el cual se establece un orden de prioridad respecto al tratamiento de los residuales. En una segunda fase, se hizo una estimación para determinar el potencial de generación de energía eléctrica con otras fuentes. El uso de este sistema permite la explotación al máximo todos los recursos naturales, sin dañar al medio ambiente y es consecuente con el concepto de economía circular. Se concluye que el programa, además de que permite la informatización del uso de fuentes renovables de energía en los centros porcinos, agiliza la toma de decisiones.

Palabras clave: *biodigestores, cerdos, eólica, fotovoltaica, solar térmica*

The energy generation in the last decades is one of the main worries in the world. For their generation great amount of fossil fuels were used. The renewable energies are characterized because, in their transformation and exploitation processes in useful energy, they are not consuming or exhausted in a human scale of time (Venegas *et al.* 2017).

From the energy point of view, the agricultural sector has the capacity of generate electric and thermal energy through wastes use, some very pollutant and other alternative sources, which can constitute renewable energy sources (RES). This is: from the biomass it can produce, biofuels and biogas, which suppose important economic, social and territorial advantages (Guardado-Chacón and Arencibia 2021). For this reasons, the agriculture could be energetically self supported, since it creates sufficient surplus to achieve positive balances, as well as to stop of emit pollutant gas to the atmosphere and to avoid the pollution of hydrographic basins (Casimiro-Rodríguez *et al.* 2019).

To determine the energy potential, a computer tool that speeds up the calculation of the technologies to be used is needed and that, in turns, allowed the integration of each of them, as well as the selection of the optimum variant for each scene. Therefore, the objective of this study was to develop a computer system for the energy potential determination in pig's enterprise, in a way that the RES can be used.

The computer system was developed at Instituto de Ciencia Animal (ICA) in engineering and applied mathematics departments. The computer application was performed in the development environment open-source free IDE NetBeans, version 8.2, which provides support almost all the novelties of Java programming language (Varona 2012). It was programmed with an architecture divide into layers. The first, of interface managed with the UI Swing, in which the components and buttons are adjusted to the size of the monitor on which the computer system is running. The second has a services module, in charges of input and output of data.

In addition, the Racional Unified Process (RUP) methodology was used, it adapts to any informatic project. This methodology uses the unified modeling language (UML), that allows to perform reverse engineering. From the code of a program, it can obtain information about its design (Schmuller 2009). It was also used the Visual Paradigm tool to apply RUP, which support the complete cycle of the program development. This tool allows generating source code for several languages (Mejías *et al.* 2021), among them Java.

Figure 1 show the logical-structural diagram of the computer system where it's running is detailed. It was named RESCE, whose acronyms means: renewable energy source-clean environment. The number of the facultative register of protected works and of acts and contract regarding to the authors right was 0072-01-2023.

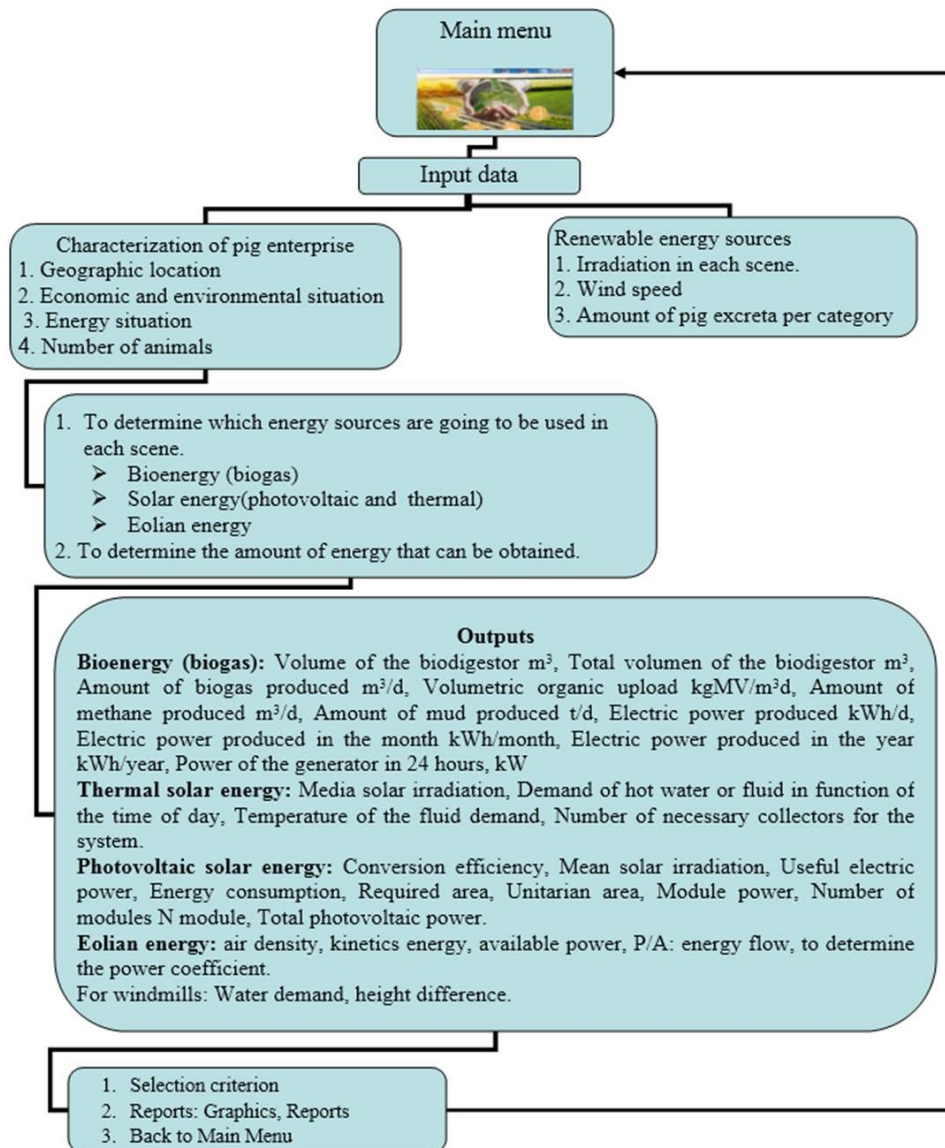In the input data was considered the information corresponded to the climatic, geographic, socioeconomic,

Figure 1. Logical-structural diagram of the computer system RESCE

productive, technological and environmental conditions. A priority order regarding the wastes treatment was established. First of all, the biodigestors design for each scene was performed, where the policies established by the Ministerio de Ciencia, Tecnología y Medio Ambiente in Cuba (CITMA) were considered. For this, the amount of biogas and mud which are obtained for the production of energy and fertilizer were considered. In the second phase, an estimate was made to determine the potential of electric energy generation with other renewable sources: solar photovoltaic, thermal solar and eolian.

RESCE provides a nice visual sight and has good functional quality. When the system starts, a welcome screen is showed, with four analysis options (biodigestor, photovoltaic panels, solar heaters and eolian energy). Figure 2 show two of these windows of the RESCE program.

In the photovoltaic panels (figure 2a) when click on the start screen on the bottom which makes reference to this technology, a window that has in its left the input fields of the information is showed, corresponding to the climatic conditions, energy demand to be supplied and common characteristics of the panels that are going to put up. To the right it showed the output fields relative to photovoltaic efficiency, number of panels and substitute demand of electric energy.

Similar to this window is those of the biodigestors, where it is introducing the information corresponding to the climatic, geographic, socioeconomic, productive, technological and environmental conditions of the pig unit. When filling this data, the program determine the potential of electric or thermal energy generation that can be used and show, in the right part of the window, reports of the amount of liquid and solid biofertilizers and cubic meters of methane that are not emit in the atmosphere.

The solar heaters window (figure 2b) has as input data the solar irradiation, the number of workers and temperature, according to the type of heater. This window was design with equal characteristics to the eolian energy, which has the

input fields in the upper part and the outputs in the lower one. For this reason, they differ from the above mentioned.

As general results, the tons equivalent to the saving petroleum and those of the CO_2 that is not emit to the atmosphere are calculated. An economic valuation is performed, when considering the incomes which are generate by this way and the expenses in which are not incurred.

With the use of the computer system RESCE, it is achieved the implementation of hybrid systems of RES in each pig enterprise and the maximum exploitation of all natural resources, without damage the environment. The computer application is created in a friendly environment, in which not only the professionals or specialists in the topic can interact, also the farmers that know the potentialities of their farms. The previous allows an approximation to the named circular economic, since can close cycles in this production systems, from the collection, recycling and the reuse of the generated wastes. In this way, there is not output flows as reject, as Oliva and Pereda (2022) described it.

It concluded that the RESCE program allows the determination of the energy potential in pig units, in a way that the RES can be used more efficient for the introduction of hybrid systems and contribute, also, to the decision-making.

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Figure 2. Calculation windows: a) photovoltaic panels and b) solar heaters

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