THE MANAGEMENT OF A HYBRID RENEWABLE ENERGY PRODUCTION SYSTEM

Radu **JOIAN**, Claudiu **LUNG,** Mircea **HORGOȘ**
Electric, Electronic and Computer Engineering Department, Technical University of Cluj-Napoca, North University Center Baia Mare, Romania
yo5pcw@yahoo.com

Keywords: Energy management, Homer software, hybrid system

Abstract*: The paper focuses on the use of the Homer software on an autonomous hybrid system. The dedicated Homer software is intended for the energy management analysis of renewable electricity sources. The program simulates the operation of the systems, performing calculations on energy variations for each of the 8760 hours (specific to one year).*

1. INTRODUCTION

The best known software product specific to the design and evaluation of renewable hybrid systems is Homer software. The optimizations and the algorithms of sensitivity analysis make it easier the evaluation of many power supply system configurations.

The Homer software can also answer at the various questions about the configuration of low-capacity energy systems, questions that address various issues, including: the effectiveness of introducing an electric turbine in a system with diesel generator and batteries; the economic efficiency when using the wind turbines for the supply of electricity and heat for a system with possibility for connection at the network; how much the price of fuel must increase to make it economical the use of renewable sources etc.

For using the Homer software environment, the user must provide ton the program the input data describing the tasks, the technological options (in principle the components of the system to be simulated and analyzed), the component prices and the availability of renewable and diesel resources.

The program uses these inputs to simulate different system configurations or combinations components and it generates the results that can be viewed as a list of reliable systems, sorted by net present cost. Homer will also display the simulation results in a wide variety of tables and graphs which compare the configurations and evaluate them based on economic and technical merit.

The functions of the Homer system are:

- Simulation: for each hour specific to a year, the software compares the electricity and the heat demand for that hour with the energy that the system can deliver at that time and calculates the energy input to and from, each component of the system . The program also calculates the energy variations for each system configuration that can be considered. In this way it determines if a system is reliable, if it can cover the demand for electricity under the specified conditions and, at the same time, it estimates the cost of installing and operating a system over the entire life of the project, considering the following costs: the initial capital, the capital for replacements, the cost of operation and maintenance, the cost of fuel and the interest:
- Optimization: after simulating all possible configurations, the program displays a list of possible configurations, sorted by current net cost, which can be used to compare different constructive variants of systems. It can view all possible configurations or the Homer program, it can be left to choose only one option, the most economical, for each system.
- Sensitivity analysis: if we enter in the program, as primary data, the sensitivity variables such as the wind speed, the fuel price, etc., it will repeat the optimization process for each variable entered.

2. HYBRID ELECTRICITY PRODUCTION SYSTEM

The North University Center of Baia Mare has installed a hybrid system, photovoltaic and wind, for electricity production composed of the following equipment:

- Wind turbine AirXLand regulator included 24V - 400W;
- Current shunts;
- Battery PS PNGB 121400 - 140 Ah;
- Inverter Xantrex 3300 W with 220 V charge controller;
- 150 W photovoltaic panels;
- 30 A solar regulator;
- Digital control and acquisition devices;
- Electrical fuses;
- Cables and installation materials

The principle scheme of the system is shown in *figure 1*.

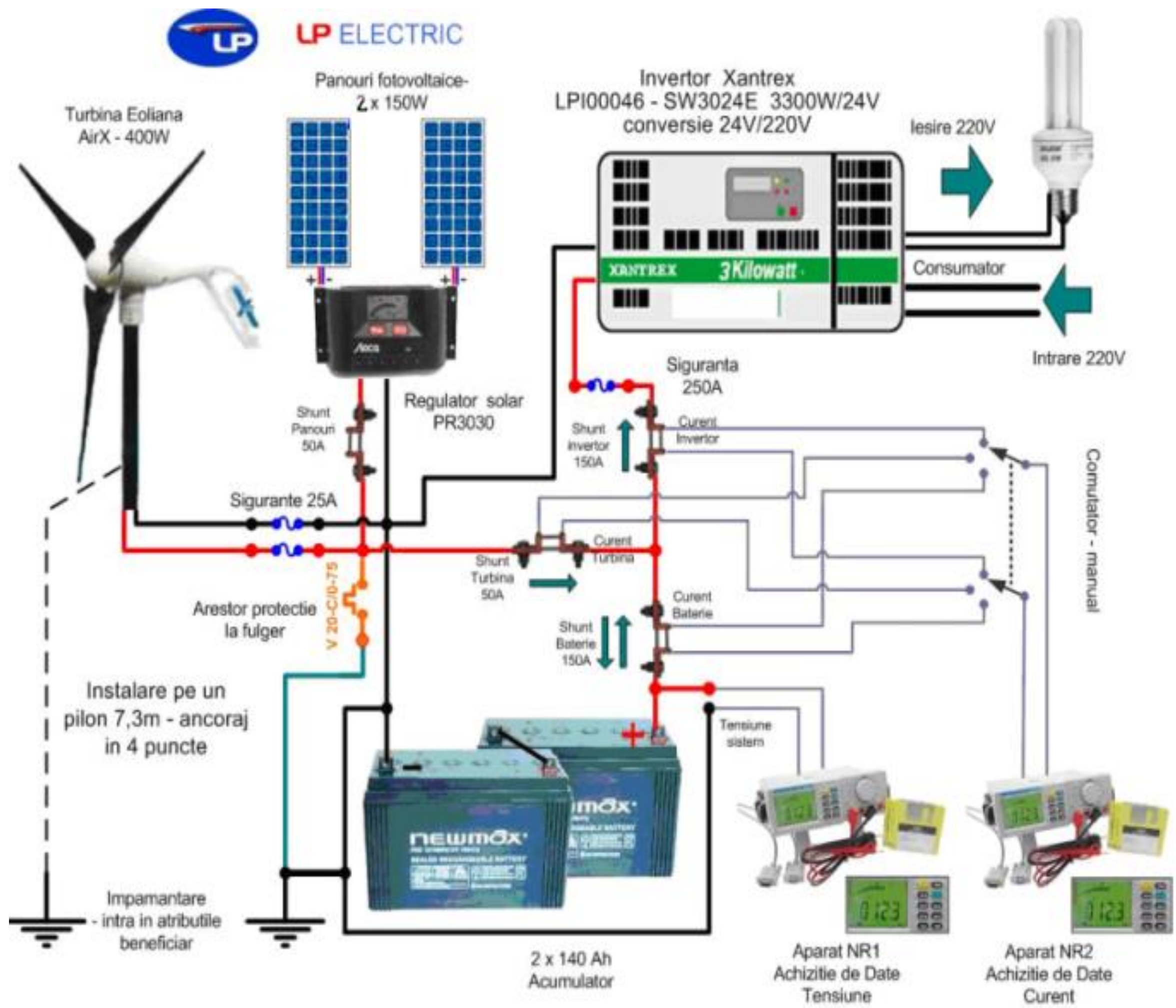

Fig. 1. The hybrid, photovoltaic and wind system for electricity production at CUNBM

The system is equipped with two meters, one for the energy produced from renewable sources and the other for the power supply option from the electricity supplier's network, in case that the discharge of the batteries cannot be compensated by the renewable sources.

The system is also connected to the Weather Station of the North University Center in Baia Mare (*fig. 2,3,4*) which was installed in 2008 and is of the Oregon Scientific Weather Station WMR 100 type. It has ten external sensors (without the internal of the console) which are grouped in the following functional units: anemometer, rain gauge and barometer. The console includes an atomic clock with autonomous and automatic adjustment.

The recorded meteorological quantities are: the indoor and outdoor temperature, the indoor and outdoor humidity, the wind speed and direction, the monthly precipitation amount, the daily and annual atmospheric pressure, the dew point temperature, the wind cooling, the temperature index etc.

The software used for data management is Weather Display.

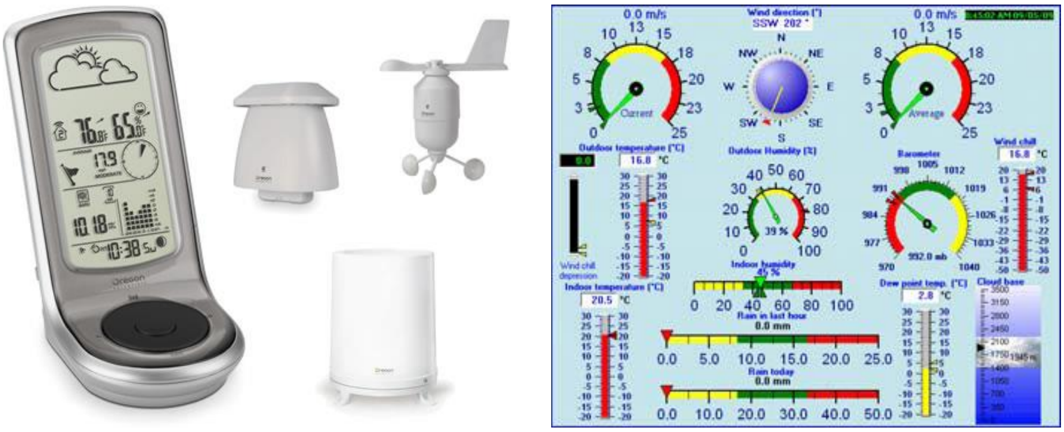

Fig. 2. Oregon Scientific WMR weather station and weather display interface

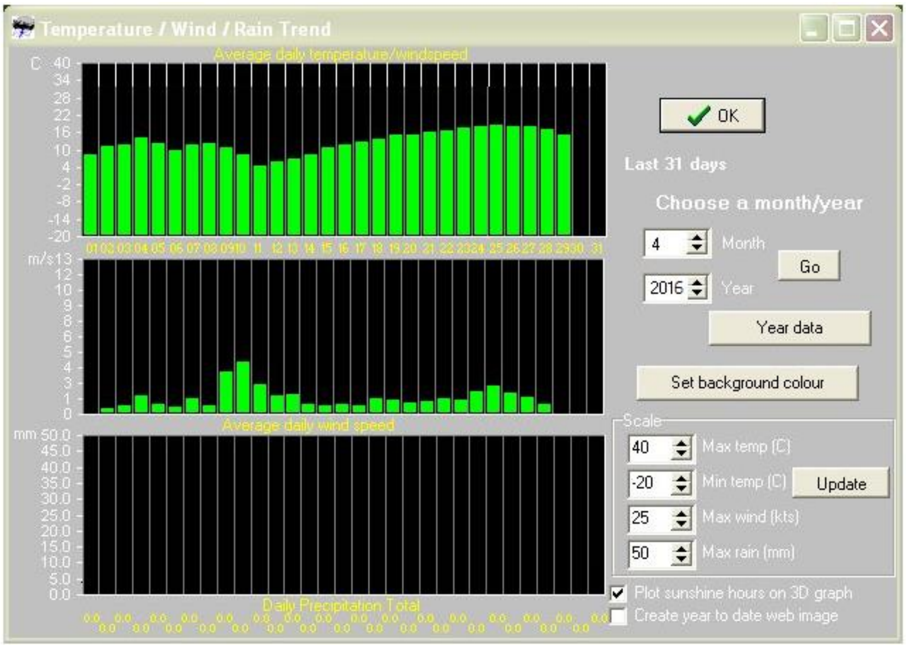

Fig. 3. The variation temperature and the wind speed in April 2016

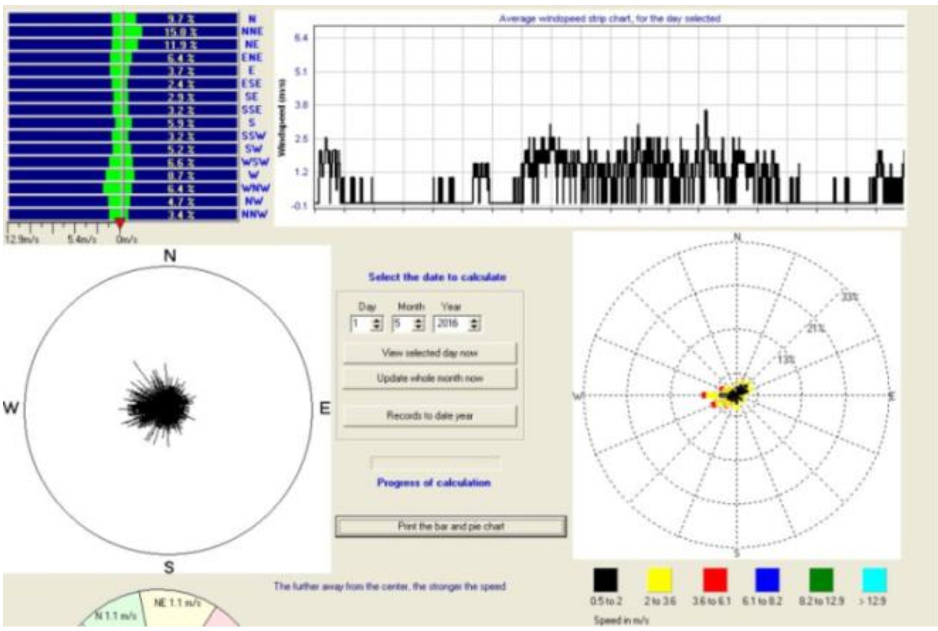

Fig. 4. Graphic report in CUNBM weather station, May 2016

3. EXPERIMENTAL DETERMINATIONS

The 400W wind turbine and the 300W solar module, component parts of the hybrid system within the CUNBM are installed on the roof of the Faculty of Engineering.

The equipments considered for optimization is shown in *figure 5*.

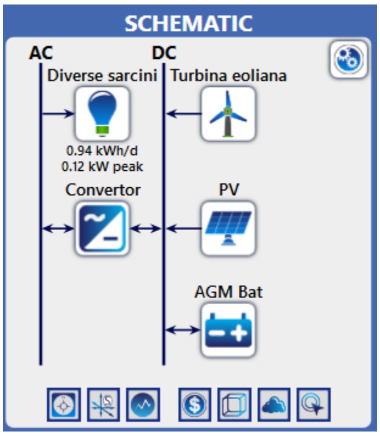

Fig. 5. The equipment considered in optimization

The profile of solar radiation is presented in *figure 6*. According to the Maramureș Energy Management Agency, the solar radiation corresponding in Baia Mare is 1450 kWh /m2/year. Thus, the coordinates corresponding to the location were entered, as well as the annual average of the local temperatures. *Figure 7* shows the profile of the solar panels.

a) The solar radiation profile

a) The temperature variations

Fig. 6. The solar radiation profile and the temperature variation

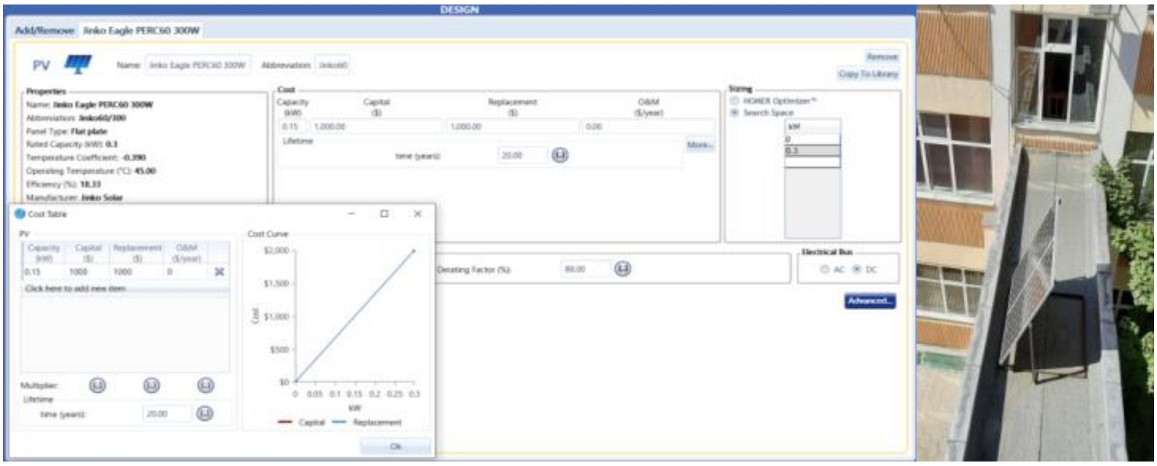

Fig. 7. The photovoltaic panels properties and mounting location

Based on the data obtained from the weather station, *figure 8* shows the profile of the wind speed during 2016. The average daily speed is 2.2 m/s, measured with the help of the weather station located at a height of 17.2 meters above the soil. In *figure 9* it can see the profile of the wind system for which we used the results obtained from the experimental measurements.

Fig. 8. The wind speed profile

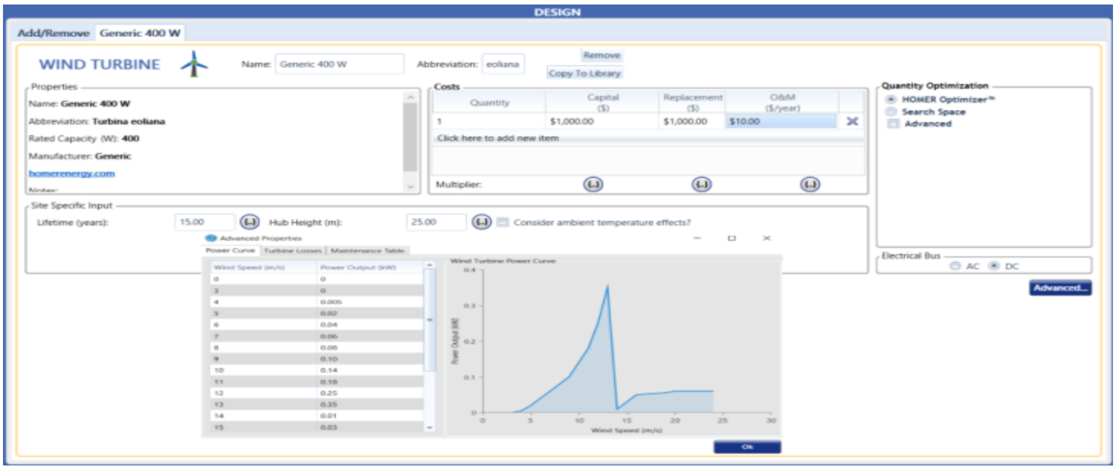

Fig. 9. The profile of wind system

The battery is a 6FM200D model. It has a rated voltage of 12 volts and a rated capacity of 200Ah (2.4 kWh). In the simulation, 2 batteries were considering, the profile of the batteries being the one in *figure 10*.

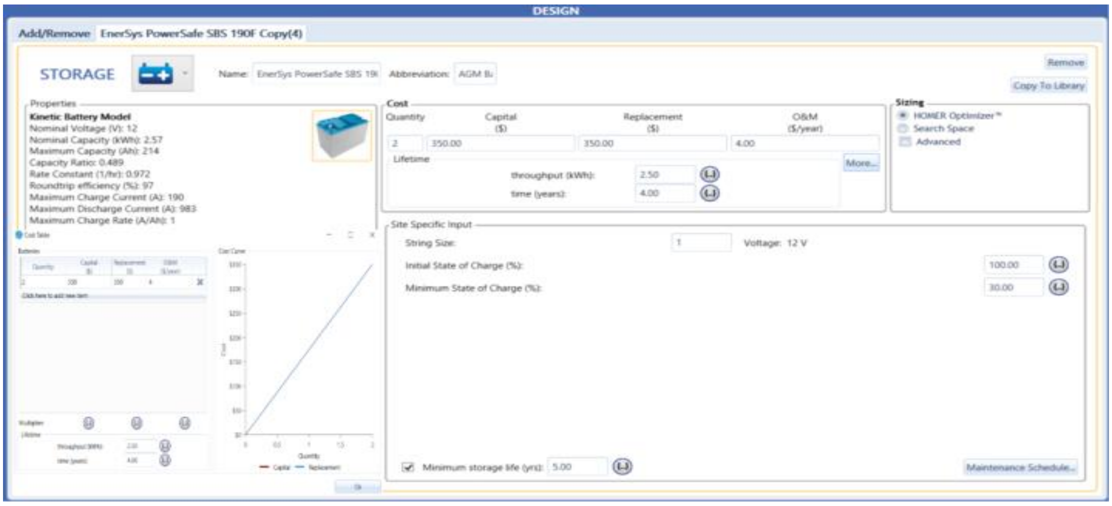

Figure 10. The battery profile

The conversion system is shown in *figure 11*.

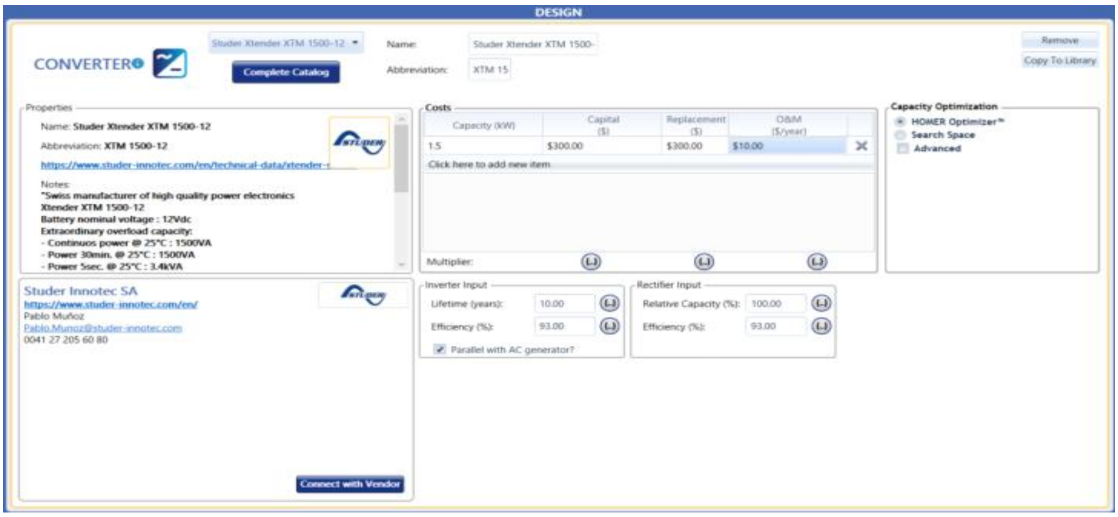

Fig.11. The profile of converter and inverter

We considered a task composed of several components such as: workbenches, projectors, PC stations etc. as in *figure 12.*

Fig. 12. The task of the considered system

The result obtained from the optimization (*figure 13*) gives the initial capital cost of $ 3,425 while the operating cost is $ 69 / year. The total net cost is $ 4259 and the energy cost (COE) is $ 1.74 / kWh.

The cost-benefit analysis of the hybrid system, compared to the tariff of energy supplied from the national grid, showed that the hybrid system is not economically cheap and must have a payback period of thirty-five years.

A hybrid energy system with solar cells, wind turbines would be cost effective if there were a reduction in component costs by installing more components, thus reducing the cost of investment per kW, the availability and the sustainability.

Fig. 13. The System Optimization

4. CONCLUSION

The use of this software is very useful, because you can analyze some constructive types of systems and their operation in conditions imposed by the user.

Simulating the variants of the energy system with such a program, can be useful in establishing the possibility of placing a hybrid system for converting the wind energy, in a place about which the data on average wind speed are known.

The program can also answer at the various questions related to the configuration of the low-capacity of energy systems, questions that address various issues, such as the economic efficiency of using the wind turbines for providing electricity for a system with the possibility of connection to the grid. After the simulation, the user can view detailed information about the chosen system and can analyze the system for several reasons: cost, electrical and components.

The program uses a relatively poor initial information on the wind potential of the area: monthly average wind speed values, possibly Weibull distribution parameters. Some problems that the Homer software has are related to the consideration of energy transfer through the battery, in the case of relatively short periods of the excess wind energy or considerating the situation when the charging controller works on *dump load* etc.

REFERENCES

[1] A. I. Goveas, *Simulation of a Wind Powered Freshwater and Electricity Production System: Numerical Modeling and Optimization*, Delft University of Technology, 2020.

[2] C. Zhang, *Modelling and Simulation of Energy Storage System for Frequency Stability Studies*, Delft University of Technology, 2020.

[3] I. Ciocan, *Theoretical and experimental researches regarding the methods of energy production and storage in photovoltaic systems*, Doctoral thesis elaborated within the UT Doctoral School Cluj-Napoca, 2015.

[4] A. Leca, V. Mușatescu, ș.a., *Energy management. Principles, concepts, policies, tools*, Agir publishing house, Bucharest, 2008.

[5] E. Lazar, *Software development for the design and control of microgrids with renewable energies*, Doctoral thesis, Cluj – Napoca, 2018.

[6] A. B. T. Attya, *Wind energy penetration impact on grid frequency during normal operation on frequency deviations*, Doctoral thesis, Darmstadt, 2014.

[7] N. Bizon, *Optimized systems for clean energy conversion*, MatrixRom, Bucharest, 2008.