LIFE CYCLE COST METHOD CALCULATION FOR A SMALL HYBRID SYSTEM PV-WIND

***Drd.Ing. Ionela NEGREA, **Drd.Ing. Luminita BAROTE**
* Faculty of Technological Engineering,Transilvania University of Braşov, Eroilor, 29, 500068 Brasov (Romania), email: ionela_n@unitbv.ro
****** Faculty of Electrical Engineering and Computer Science, Transilvania University of Braşov, Eroilor, 29, 500068 Braşov (Romania), email: barote@leda.unitbv.ro

Keywords: Hybrid system, Wind turbine, Photovoltaic panel, Life Cycle Cost

Abstract: The principal objectives of the article are to calculate with the method Life Cycle Cost the life cost and energy management for an independent hybrid system of type Pv-Wind of small capacity. For this calculation is made a program in Matlab where are used the Life Cycle Cost formulas. To calculate the Life Cycle Cost and the energy are need the solar radiation and the wind speed. These values are taken from a Meteo Station from TEI University of Crete, Greece.

1. Introduction

The systems of regenerating energies began to be the main activity of so many countries of the world because of decreasing of the existent sources.
By combining the solar energy and the wind energy is obtained a hybrid system. A powerful hybrid system is an electric system where are combined different sources of regenerating energy, that generate electric energy on an isolated network.

This small hybrid system is implemented in the rural areas, isolated areas, faraway from the national electric energy network, and where are such resources that can be exploited. The most used hybrid systems are systems Pv-Wind.

For this system is very important to calculate the Life Cycle Cost and the energy management.

The Life Cycle Cost (LCC) method includes every cost that is appropriate and appropriateness changes with each specific case which is tailored to fit the situation.

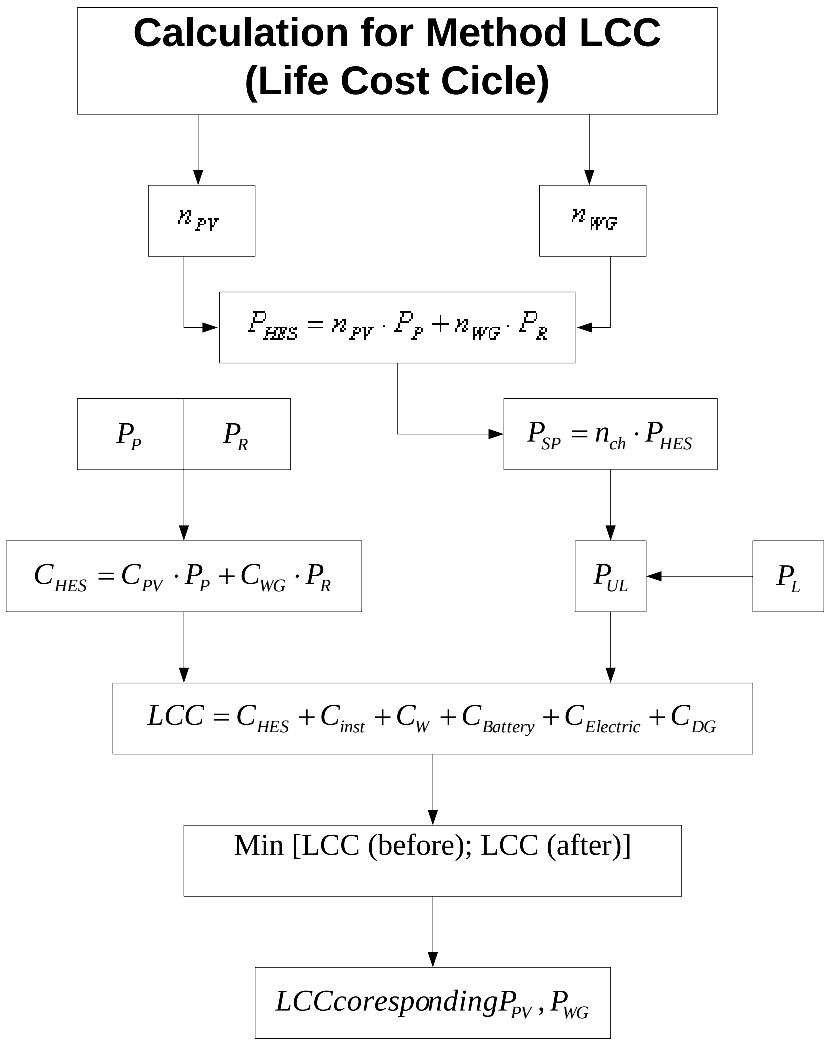
2. Life Cicle Cost method

LCC follows a process as shown the steps:

- **Step 1** - Identify what has to be analyzed and the time period for the project life study along with the appropriate financial criteria;
- **Step 2** - Focus on the features by way of the economic consequences to look for alternative solutions;
- **Step 3** - Develop the cost details by year considering memory joggers for cost structures;
- **Step 4** - Select the appropriate cost model, simple discrete, simple with some variability for repairs and replacements, complex with random variations, etc; required by project complexity;
- **Step 5** - Acquire the cost details;
- **Step 6** - Assemble the yearly cost profiles;
- **Step 7** - For key issues prepare breakeven charts to simplify the details into time and money;

- **Step 8 -** Sort the big cost items into a Pareto distribution to reconsider further study;
- **Step 9 -** Test alternatives for high cost items such as what happens if maintenance cost is ±10% than planned, etc;
- **Step 10 -** Study uncertainty/risk of errors or /alternatives for high cost items as a sanity check and provide feedback to the LCC studies in iterative fashion;
- **Step 11 -** Select the preferred course of action and plan to defend the decisions with graphics.

The Life Cycle Cost formulas are presented in the next form:



3. The Matlab program for Life Cycle Cost calculation

The program is made for the small hybrid system (HES) Pv-Wind, the wind speed and solar radiation are taken from Meteo Station from TEI University of Crete, Greece.

The Life Cycle Cost (LCC) program:

```
%LCC Methodology. The simple HES with PV and WG
%while repeating 1
clear all
%repeating=1;
PeakpowerPV= input('Give me the peak power of the PV module in Watt: ');
NPV=input('Give the number of PV modules : ')
display('PV power in KWatts')
PVpower=(PeakpowerPV*NPV)/1000
PL=input('Give me the average Load Power for selectic month in kW:')
nmet=0.7
display('The average Loat power PL to be covered from the HES in kW:')
format short
%PLaverage=PL*nmet
PLaverage=PL/nmet %in kW
%WG POWER
% Calculation the number of the WG
npv=0.21,nwg=0.09
%WGPower=input('Give me the nominal power of the used WG in kW:')
format long
%NWG=(PLaverage-npv*NPV*(PeakpowerPV/1000))/nwg*WGPower
A=(PLaverage-npv*NPV*(PeakpowerPV/1000)) %in kW the neded from PWG power
B=A/nwg  %the neded PWG power in kW
B=B/10
format short g
%C=B/nwg
%C=round(B)
NWG=1
%C1=round(C)
%Average produced power from the HES
phes=npv*NPV*PeakpowerPV+nwg*NWG*B*1000*10 %IN WATT
%Power that is given to the demand
%ptot=phes/nmet
ptot=nmet*phes %in watt
PLoss=(PLaverage*1000)-ptot %in W
%Total cost of the HES instalation
cpv=4.5,cwg=3.2
cpv=cpv*NPV*PeakpowerPV
cwg=cwg*NWG*B %*1000
%display('total cost of HES - only PV and WG :')
ches=cpv*NPV*PeakpowerPV+0
%rate of  P
Prate=PVpower/B
%Examples and graphs
%phes-PLoss
%Average produced power from the HES in Watts
phes=npv*NPV*PeakpowerPV+nwg*NWG*B*1000*10
%Power that is given to the demand
%LCC calculation
ai=0.15 %instalation factor
cinstal=ai*ches
a1=0.2 %maintnance factor
i=0.035,d=0.05 %i:inflation, d:discaunt rate
r=(d-i)/1+i
N=20 %life time
CRF=r/(1-(1+r)^-N)  %Capital recover Factor
cmaint=a1*ches/CRF
cb0=150 % initial cost of accumulator Euro/kWh
NR=10 %time of battery replace
v=N/NR
```

```
PVF=(1+r)^-NR
PVFj=trapz(PVF)
cbat=cb0*(1+PVF) % cost of the battery
aelec=0.15
celec=aelec*ches %cost of electric elements
cfuel=0.8
PLoss=(PLaverage*1000)-phes
Edg=PLoss %in Wh
cdg=(cfuel*Edg)/CRF
LCC=ches+cinstal+cmaint+cbat+celec+cdg
Ey=phes*N
N=12%number of months
COE=LCC*CRF/Ey
cfuel1=0.7
N1=5
T=24;
Edg1=PLaverage*N1*T
Cdg=Edg1*cfuel1/CRF
%YEARLY PRODUCED ENERGY
%EHESy=
%MAKE A DATA FILE
%Make a file to save data
format short g
DATA = [   ches  phes  ptot  LCC B  PVpower Ey COE PLoss Cdg ]
  name=input('What is the name of the file :   ');
  fid=fopen(name,'a');%create a new file for writing
  fprintf(fid,'%f %f\n',DATA);%write formated data in the file
  fid=fopen(name,'r');
  a = fscanf(fid,'%g %g',[1 inf]);
 disp(  'ches   phes  ptot  LCC  B  PVpower Ey COE PLoss Cdg'  )
DATA
```

4. The results

The Life Cycle Cost (LCC) values calculate in Matlab is presented in table 1. We have the cost of hybrid energy system (C_{hes}), Power hybrid system (P_{hes}), Power Loads (PL), Wind generator power (WG_{power}), Power of Pv ($P_{Pvpower}$), Energy (E_y), The Cost of Energy (COE) and Power losses (P_{loss}) for 20 years.

Table 1.The Life Cycle Cost

C_{hes} [Euro]	P_{hes} [W]	PL[W]	LCC [Euro]	E_y	COE [Euro]	P_{loss}	Pv Modules	Wind Turbine
25313	142.86	179	95999	28571	0.26961	0	5at150W	1
12251	214.29	154	46486	42857	0.087038	-3.6	3 at 55W	1
14608	285.71	172	17478	57143	0.24543	0	4 at 80W	1
17500	350	172	27308	62053	0.21913	0	4 at 100W	1
11250	642.86	167	42667	12857	0.26629	0	4 at 125W	1
19602	785.71	146	74342	15714	0.37962	-1.4	4 at 165W	1
20808	857.14	146	78916	17143	0.36939	-1.4	4 at 170W	1
22050	714.29	146	83626	14286	0.46972	1.4	4 at 175W	1
10368	142.86	167	39322	28571	1.1044	0	4 at 120W	1

Table 2. The WG_{power} and $P_{Pvpower}$

WG_{power} [W]	$P_{Pvpower}$ [W]
0.96079	0.1
0.85111	0.4
0.74	1
0.61312	1.3
0.5231	1.5
0.4101	1.6
0.3	1.85
0.291	1.96
0.1854	2.5

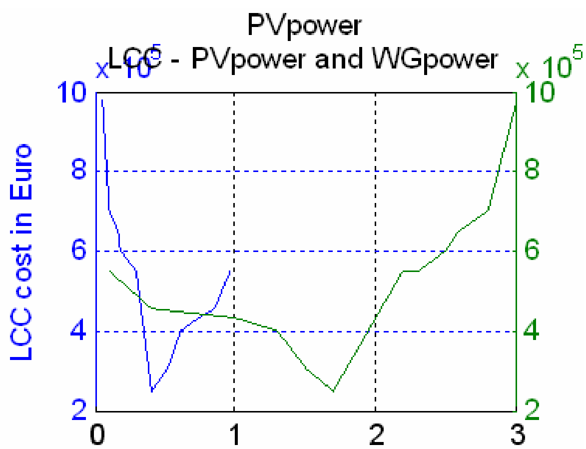


Figure 1. LCC Diagram with PV_{power} and WG_{power}

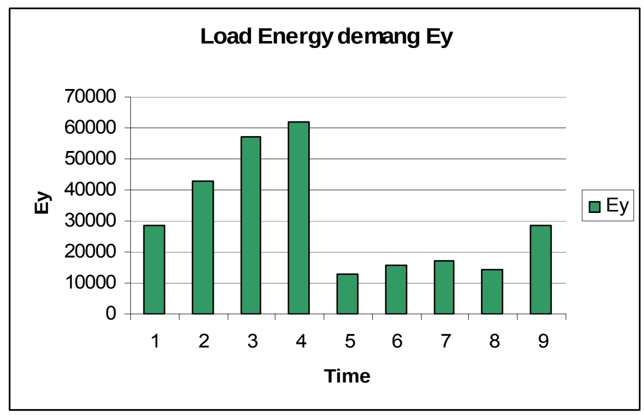


Figure 2. Energy Loads

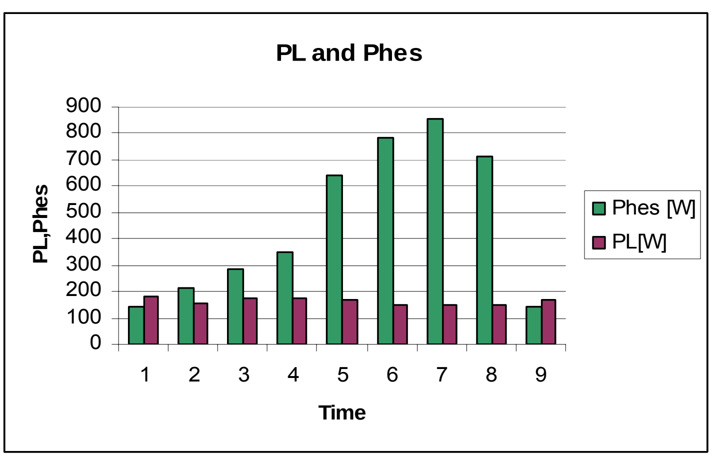


Figure 3. The diagram for Power loads and Power hes

Figure 4. The small hybrid system

The benefits of such system are exceptional. Beside the fact that such system supply ecologic energy, they also provide total energetic independence. This is the solution to get electric energy for free.

6. Conclusions

The energy management in hybrid systems for houses consist to determine the optim combination between sources of energy, batteries, wind turbine and panels, allow the necessyties fulfilment at the lowest cost of posible.

7. References:

[1] Badea, M.I.Voinea, Gh.Coman, L.Dumitrescu, C.Drăghici, Pollutants detection using hapten derivatization, Environmental Engineering and Management Journal, (in press), ISSN: 1582-9596, 2005.

[2] Bent Sorensen, Renewable Energy, Third edition, Editat de Elsevier inc., UK, 2004, ISBN 0-12-656153-2.

[3] Eduard Muljadi, IEEE, Jan T. Bialasiewicz, Hybrid Power System with a Controlled Energy Storage, National Renewable Energy Laboratory, November 2003.

[4] Godfrey Boyle , Renewable Energy.Power for a sustainabel future,ISBN 0-19-926178-4, OXFORD University Press, Oxford 2004.

[5] J.G.Manwell, J.G.McGowan, Wind Power Modelling and Impact on Power System Dynamics, 2003, ISBN 90-9017239-4.

[6] J.Larminie, A. Dicks, Fuel Cell Systems Explained, Editat de Wiley, UK, 2003, ISBN 047084857;

[7] Martin A. Green, Third Generation Photovoltaics : Advanced Solar Energy Conversion, Publisher: Springer, 2003, ISBN: 3540401377.

[8] Timur Gül, Integrated Analysis of Hybrid Systems for Rural Electrification in Developing Countries, Stockholm 2004, ISSN 1651-064X.

[9] T.Markvart,L. Costanur, Solar Cell, Matearials, Manufacture and Operation, Edited by Elsevier, Olanda, 2005, ISBN 1856174

[10] Paule Gipe, Wind Energy Basics. A guide to small and micro wind systems, Edited by Chelsea green publishing company, Vermont,U.S., 1999, ISBN 1-890132-07-1.

[11] Peny L. Jones,Herbert J. Sutherland and Byron A. Neal Sandia Report,LIST/BMI, Turbines Instrumentation and Infrastructure.

[12] P. Konor, Publisher: Universe, Renewable Energy Policy, 2004, ISBN: 0595312187.

[13] Visa, I., Duta, A., Renewable Energy Systems, Basics, Ed. Univ. Transilvania, 2005, ISBN 973- 635-541-1, pp.351.

[14] Visa, I., Duta, A., Renewable Energy Systems, Applications, Ed. Univ. Transilvania, 2006, ISBN 973-635-657-4 , pp.109.