

“MULTIBAT” A NEW ARCHITECTURE FOR STAND ALONE RENEWABLE ENERGY SYSTEMS

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ABSTRACT: An innovative battery architecture and management system was developed in the course of European Research project ENK6-CT2000-00326.

The innovative system developed by EDF slows down or overcome lead acid battery “unusual” degradation process which is currently observed in the renewable energy systems (RES); this whatever uncontrolled source and demand. The general principle is to manage the battery by individual strings with advanced and innovative functions ensuring complete effective recharge every cycle and exact real time SOC and SOH control.

The main project objective is to improve batteries exploitation lifetime (by more than 50%) for every kind of renewable energy systems using lead acid batteries. This gain will present strong benefits by lowering the cost of RES exploitation without increasing installation costs. This paper describes the MULTIBAT principle and reports the development advances and results obtained during the European project.

Keywords: lead acid batteries, renewable energy systems, battery management systems

1 STAND ALONE RES STATE OF THE ART & MULTIBAT OBJECTIVES

Photovoltaic represents a very interesting and appropriate solution in many cases, especially for rural decentralised electrification. For Europe it is estimated that the total population that lives without electricity is approximately 1.2 million, mainly at isolated locations in the Mediterranean area. This number will be probably increased with the recent adhesion of east countries to the European Community.

One of the biggest handicaps for stand alone RES is that solar or wind are uncontrolled sources to supply often an uncontrolled demand and hence the need to integrate battery storage in PV system. Batteries can count for up to a third of total RES cost but they can count for more than 90% in the maintenance cost. This problem to be solved has an important impact on renewable energy final cost calculation and is limiting the process of large-scale exploitation.

From the storage technical point of view, due to uncontrolled energy generation and demand the lead acid batteries generally suffers from bad recharge conditions giving irreversible sulphating and acid stratification. This leads to fast lost of autonomy and premature battery life termination giving high exploitation cost to system. Moreover, state of charge (SOC) and state of health (SOH) of batteries are difficult to measure and no reliable system exists. This gives also to RES poor predictability, high cost and bad image for final user. However, some reasons to be optimistic exist because lead acid batteries research is in continuous progress and experience shows that some batteries in the field reach very long exploitation time, this is probably explained because such batteries meet perfect electrical management.

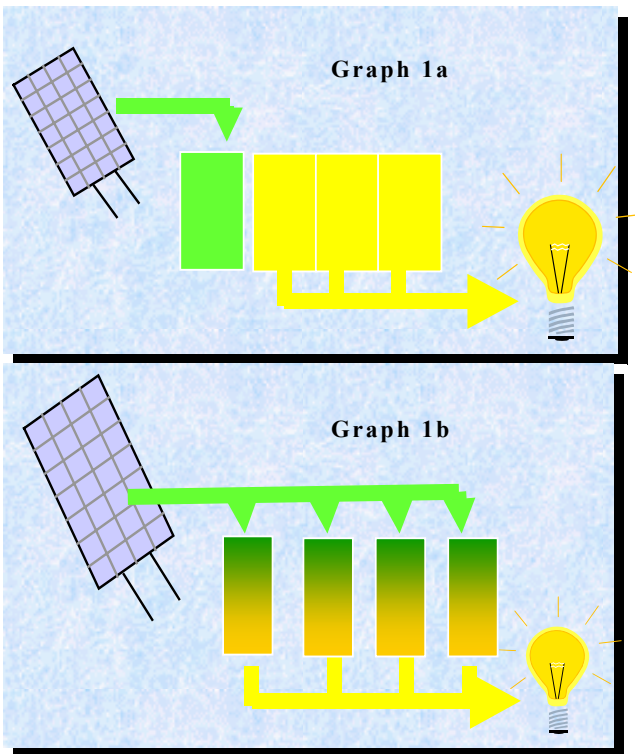
2 MULTIBAT OBJECTIVES

The MULTIBAT system developed by EDF aims at improving battery management for stand alone renewable energy systems this will lead to increase drastically lead acid battery lifetime and to reduce significantly storage over-sizing. Therefore, the final objectives with this work are to decrease by factor two the full cost of stand alone RES at medium term (2010) and to increase the penetration of renewable energies in Europe and world. The MULTIBAT system will optimise power quality for stand alone and hybrid systems and could contribute significantly to the objectives of the white paper on the RES community politic (12% RES in the energy balance for 2012).

3 MULTIBAT PRINCIPLE

The innovative MULTIBAT system will be able to slow down or overcome lead acid battery degradation process which is currently observed; no matter how variable the energy source or demand.

The general principle is to manage the battery by individual strings with advanced and innovative functions. Graph 1a shows a standard system where batteries are all working together. This configuration gives most of the time insufficient recharge period (mainly in winter for PV) and battery degradation processes occur. The graph 1b shows the Multibat architecture, the whole battery is divided by strings which are independent; therefore, each battery part is managed separately and can be fully charged one by one before to be authorized to discharge, this even during underproduction period.



A complete power full algorithm using PWM charges with advanced battery state detection and innovative de-sulphating strategies are used. This allows:

- Effective and controlled full battery charges every cycles;
- Charge by string at high current giving higher active materials reversibility and an efficient acid de-stratification;
- Extension of battery lifetime to maximum battery manufacturing ability;
- No premature lost of autonomy giving lower battery sizing for system

Moreover, using this innovative architecture, RES storage function becomes predictable and maintenance operations are simplified:

- Every battery string state by master controller giving exact real time SOC and SOH measurements
- The summation of all strings gives the complete system SOC and real autonomy
- The last batteries string capacity is recorded and gives accurate SOH
- The system remains operational during maintenance or a battery string replacement
- Each string can be made of different battery kind...

4 "MULTIBAT" EUROPEAN RESEARCH PROJECT STATUS

In order to fulfil these objectives, MULTIBAT European project is running (ENK6-CT2000-00326)

since January 2001 in the course of 5th PCRD. The project technical objectives are:

- Development of MULTIBAT equipment using several innovative strategies;
- Demonstration on several sites or laboratories with the purpose to validate good operations and to quantify the MULTIBAT impact on true systems.
- Analysis results and conclusions.

Development and laboratory tests are carried out by EDF, ECN and CEAC, while demonstrations on real sites were done by ATERSA, Arsenal Research and CRES.

During the first project phase switches (photo 1) and master controller (photo 2) were developed by EDF.

Second part of project were devoted to lab test in EDF, CEAC and ECN. Tests on individual components were made (EMC, thermal, electrical tests). Complete systems were manufactured (photo 3) in two voltage categories (24V & 48V), these systems are operating in 4 tests platforms. Finally comparative battery tests with or without MULTIBAT using same simulated PV irradiation and load profiles are running in the purpose to quantify the exact benefit of MULTIBAT on battery lifetime.

The last part of project concerns demonstration in real sites:

- the lightning of ATERSA factory in Spain with a PV system;
- the electricity supply for a Greek farm house, using an hybrid system PV / diesel (by CRES);
- the lightning of a temple in Austria, using a PV system (by Arsenal Research);
- the demonstration of a PV/wind installation by ECN in the Netherlands.



Photo 1



Photo 2

The MULTIBAT systems (pilots) were manufactured and installed in these real sites for field tests.

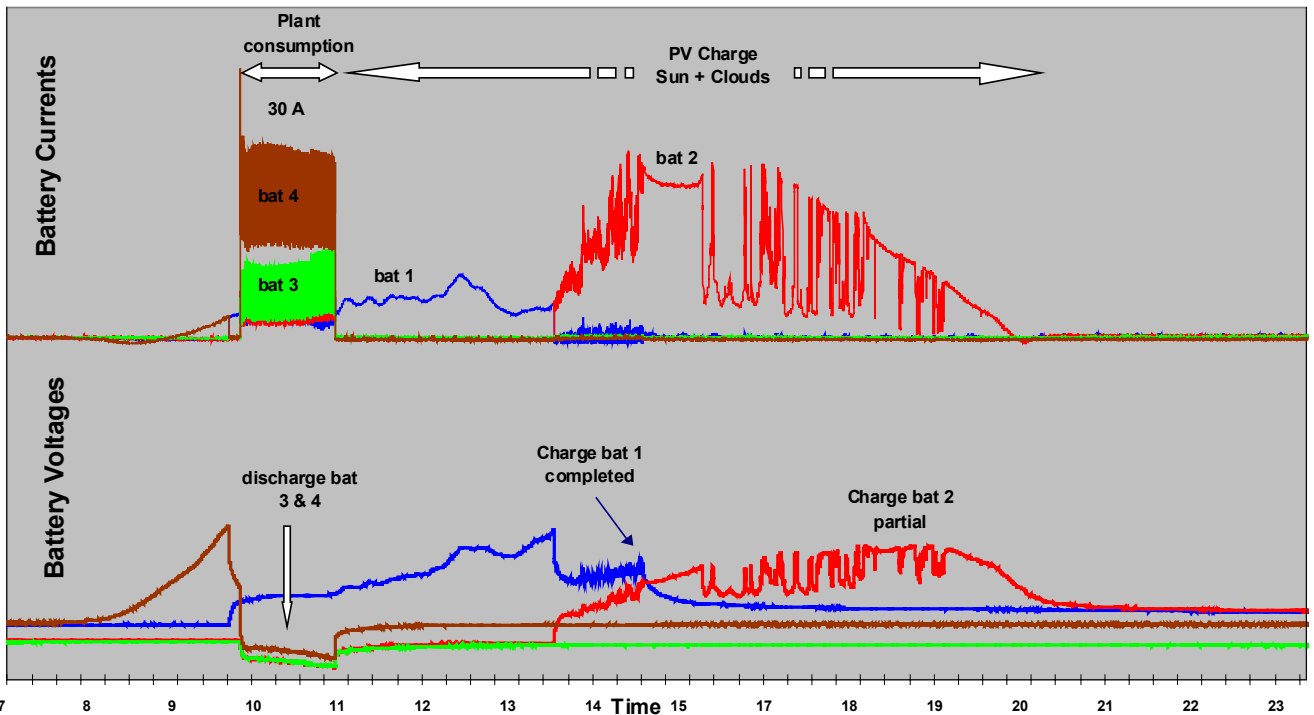
As result example, the graph 2 presents the data obtained with MULTIBAT system for lightning demonstration.

These data show good operations with systems. During this day a lightning current consumption is observed between 10 and 11 o'clock. This current is provided by batteries 2, 3 & 4 whereas battery 1 remains in charging status. When this battery reaches predetermined high charging voltage a charge complement procedure starts and battery 2 begins charging process. During this time other batteries are kept in discharge status waiting for charge authorization.



Photo 3

04th May 2004 - ATERSA's Plant - SPAIN



Graph 2

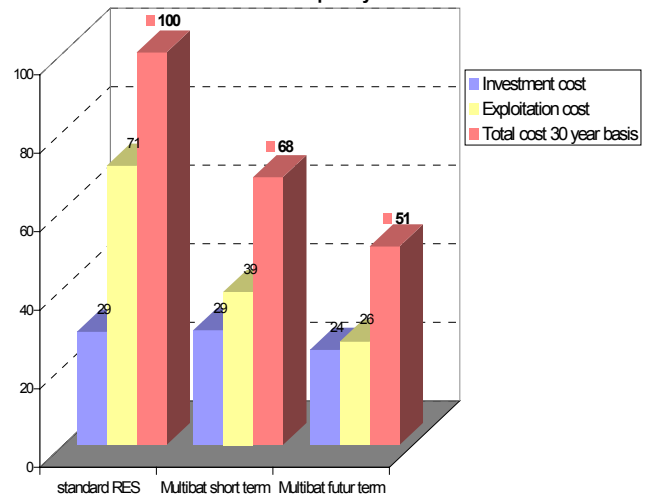
5 MULTIBAT VALUE ANALYSIS

In order to better quantify the MULTIBAT system value, the graph 2 shows the normalised cost figure for a RES 48V/1500Wp. The calculation made takes into account with MULTIBAT, the improvement of exploitation battery lifetime, the simplification of maintenance procedures and the decrease of RES sizing keeping same system autonomy. The MULTIBAT short term figure show cost reduction about 30% and for the longer term figure (2010) a 50% cost reduction is obtained. These results are mainly linked to important reduction of exploitation RES costs, the over investment due to MULTIBAT system hardware is compensated by lower sizing of storage system for same real autonomy.

6 CONCLUSIONS & PERSPECTIVES

The innovative battery manager system MULTIBAT developed and patented by EDF should bring a significant contribution for renewable energy penetration in Europe and World. Using MULTIBAT, full cost reduction of RES by 50% in 2010 is expected, leading to better stand alone RES market acceptance.

Stand alone RES full Costs figures (base 100)
48V/1500Wp PV system



Graph 3

The next project phases are:

- ✓ Results monitoring continuation during 2004;
- ✓ Preparation of new projects for new installation and applications.
- ✓ Industrial take off is expected in 2005.

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