Hybridization of electrical energy storage for intelligent integration of photovoltaics in electric networks

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KEYWORDS

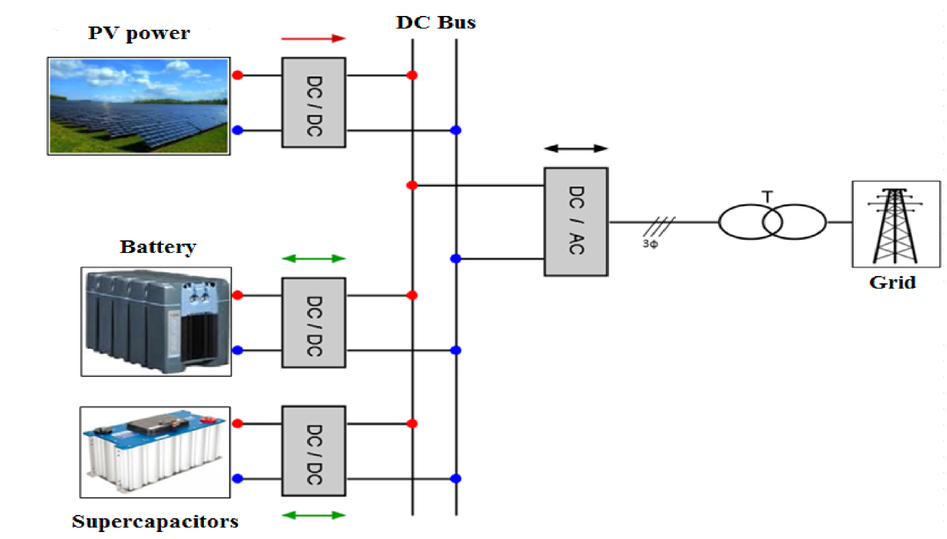
« Photovoltaic System », « Hybrid Storage », « Energy Management », « Batteries Lifespan», « Rainflow Method »

ABSTRACT

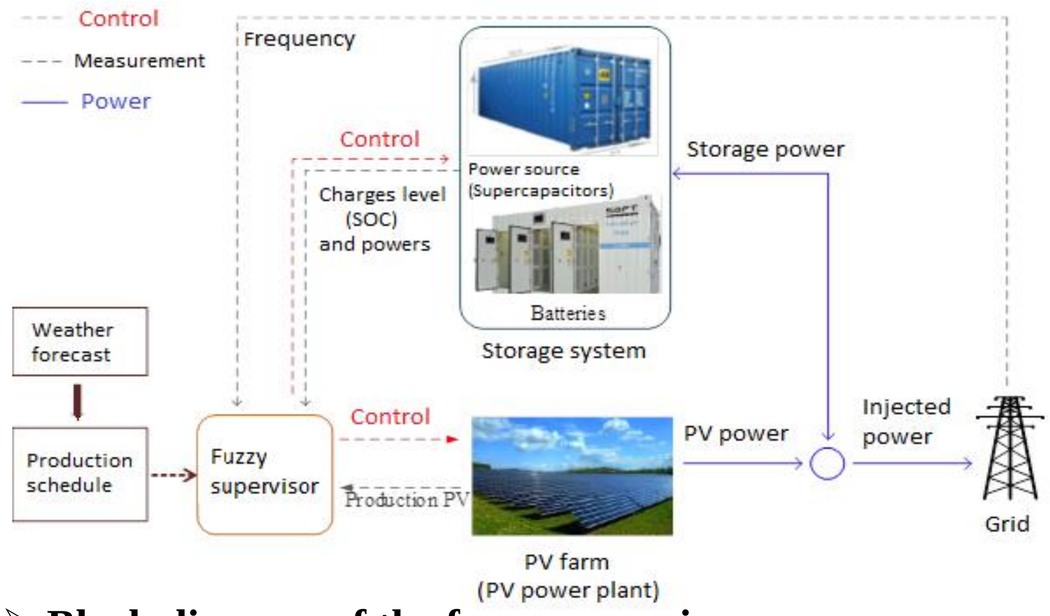
In this paper, a photovoltaic system with super capacitors and batteries hybrid storage connected to the grid has been studied. A smart supervision algorithm based on fuzzy logic has been successfully developed. In addition, contribution of storage hybridization on batteries longevity has been proved using rain-flow cumulative damage method.

STUDIED PHOTOVOLTAIC SYSTEM

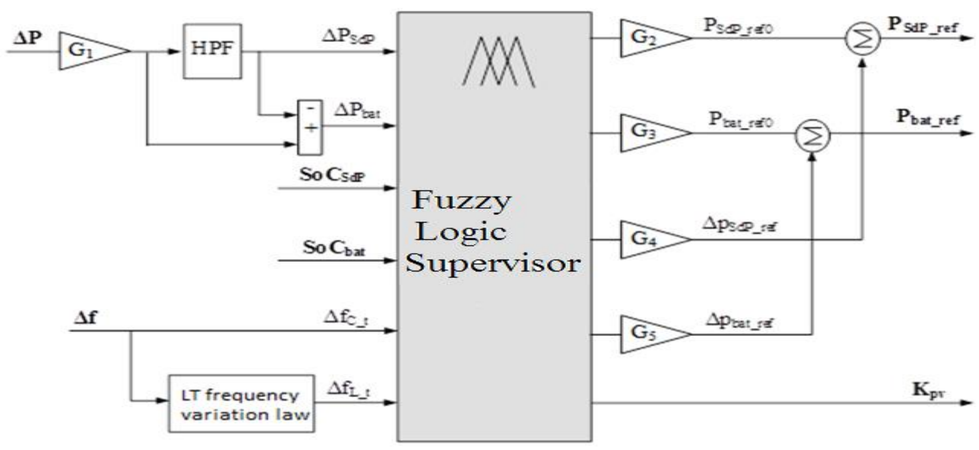
➢ Architecture



➢ Management structure



➢ Block diagram of the fuzzy supervisor



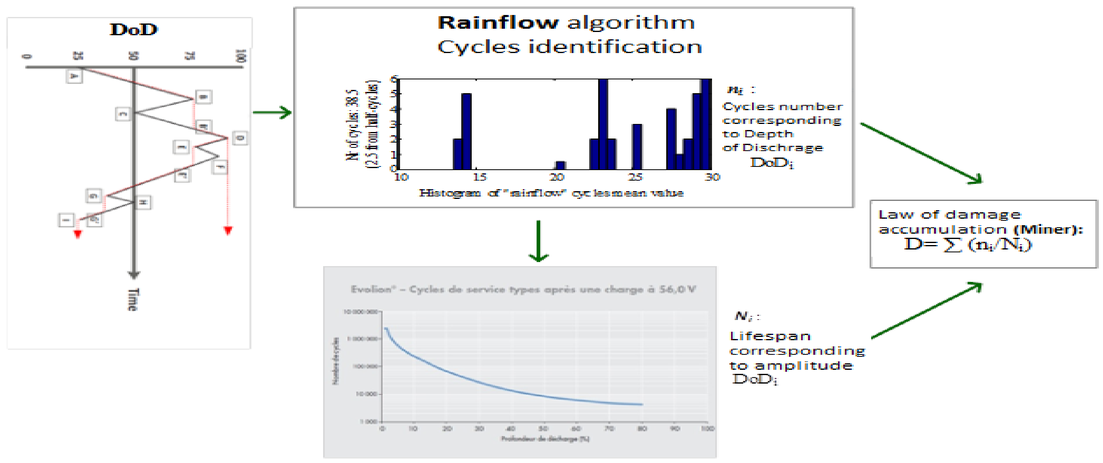
METHODOLOGY FOR PHOTOVOLTAIC SYSTEM ENERGY MANAGEMENT

- Work specifications
- Design of the supervisor
- Chart representation of operating modes -Functional graphs -
- Determination of the membership functions
- Chart representation of fuzzy operating modes - Operational graphs -
- Determination of the fuzzy rules
- Determination of indicators to measure the achievement of objectives

SUPERVISOR OPERATING SPECIFICATIONS

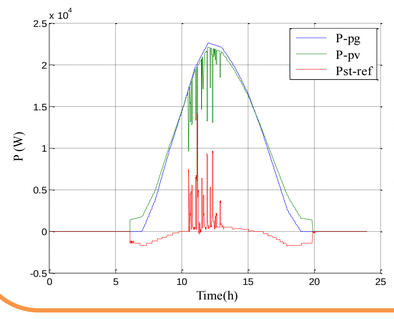
Objectives	Constraints	Actions
. Meet a production schedule ensuring injected power smoothness. . Participate in frequency support (primary and secondary Supports). . Improve storage elements life by optimizing their management.	.PV production intermittency (amplitude and duration variations). . Storage elements size. Primary support in less than 500sec for 15 minutes. Response in less than 15 minutes for 30 minutes in case of secondary support. . The error on the production schedule : - Error margin on the production schedule : - Less than 10 % in middle hourly energy of the power plant compared with production program. Beyond this constraint, there is a risk that the photovoltaic producer loses his hour of production. - In case of excess or lack of energy injected according to that suited to Day-1 with the network administrator, the hour of production is lost.	. Two power storage references: - long-term (batteries), - short-term (power source: super-capacitors). . Degradation factor of photovoltaic production.

PRINCIPLE OF BATTERIES DETERIORATION CALCULATING

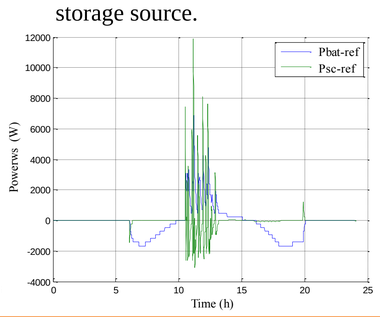


RESULTS (1) : SUPERVISOR VALIDATION

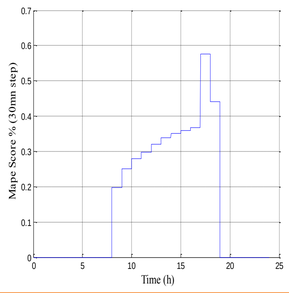
➢ **Evolution of PV power plant powers on a day**



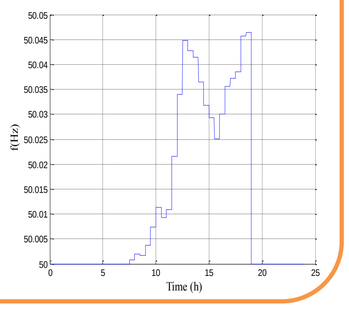
➢ Complementary operation between NCA lithium batteries and super-capacitors power storage source.



➢ Percentage of error on production program satisfaction (MAPE score evaluated every 30 minutes).



➢ Evolution of frequency every 15 minutes.



RESULTS (2) : STORAGE ELEMENTS LIFESPAN ASSESSMENT

➢ **Comparison of storage elements Lifespan for different without and with super-capacitors**

			Lifetime (years)	Lifetime (number of cycles)
Only energy storage source	Batteries Lithium NCA (6 kW)		12.5	3825
Hybrid storage (Energy and power sources)	Energy source : Batteries Lithium NCA (6 kW)		25	6750
	Power source : SuperCaps Maxwells (5kW)	Batteries NCA 6 kW	> 25	>10^6 for a DoD of 80% [13]

CONCLUSION

This work concerns the development of a management algorithm for a photovoltaic system that combines two storage technologies (NCA Lithium batteries and super-capacitors). Simulations show that developed algorithm achieves the desired objectives in terms of compliance with production program while respecting the various constraints of network manager. Furthermore, analysis of batteries lifespan proves that combination of batteries with super-capacitors enables to increase their longevity.

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