

▪ Objectifs généraux :

- ⇒ Concevoir des architectures, dimensionner et gérer l'énergie dans les systèmes embarqués, de transport, de production et transformation d'énergie électrique.
- ⇒ Définir des modèles, outils, méthodes favorisant une approche de conception intégrée des systèmes hétérogènes couplés dans le domaine de l'énergie électrique

▪ Composition de l'équipe :

2 chercheurs, 5 ens-chercheurs, 3 ingénieurs:

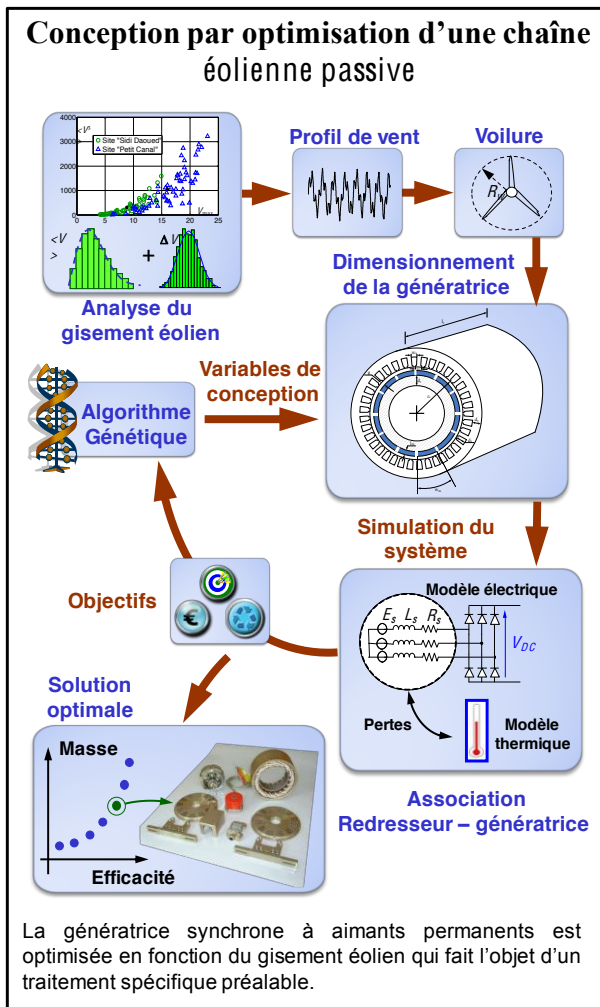
- | | |
|-------------------------|---------------------|
| S. Astier (PR) | X. Roboam (DR) |
| J.M. Blaquière (IE) 50% | N. Roux (MC) |
| E. Bru (IE)* | B. Sareni (MC) |
| F.Lacressonniere (MC) | C. Turpin (CR) |
| H. Piquet (PR) | S. Vinnac (AdT) 50% |
| O. Rallieres* (IR) | |

11 doc, 1 post doc (*) fonds propres GENESYS

▪ Thèmes de recherche :

1- Méthodologies de conception intégrées :

Mots clés : optimisation multicritère par algorithmes génétiques, conception robuste sous incertitudes, traitement et analyse des variables d'environnement et profil de missions, classification et segmentation, représentation des systèmes par bond-graph;



2- Architecture et gestion des réseaux et des systèmes :

Mots clés : Qualité, stabilité, CEM, hybridation multi-sources, gestion énergétique, systèmes embarqués, production décentralisée.

Applications : réseaux électriques pour l'aéronautique, transports ferroviaires, smart grids, réseaux hybrides.

Hybridation énergétique d'un réseau dernier secours électrique aéronautique

The schematic shows the hybridization of an aircraft emergency power network. It includes a RAT + C_{bus} (Ram Air Turbine + bus capacitor), a storage system with supercapacitors and Li-ion batteries, and various charges. Currents like I_{RAT}, I_{Cbus}, I_{SOC}, and I_{ch} are indicated. A photograph shows the physical implementation with SAFT and AIRBUS logos.

Face à des profils de charge fortement intermittents, l'hybridation d'une Ram Air Turbine (RAT) par un stockage super capacitif permet de réduire la masse du réseau dernier secours d'environ 30%.

L'accumulateur Lithium ion 28V permet d'assurer les phases plus énergivores de la mission (déploiement de la RAT, atterrissage).

The graph shows the battery voltage (V_{bat}) and current (I_{bat}) over a 40-minute mission profile. Key phases include: 1) SOC = 80%, V_{bat} = 27.05V, T_{cell} = 19°C; 2) Déploiement RAT; 3) Phase vol secours; 4) Eteinte atterrissage. SOC = 58%, V_{bat} = 25.79V, T_{cell} = 20°C.

3- Nouvelles Technologies de Production et Stockage d'énergie Electrique :

Mots clés : modélisation, caractérisation, hybridation, état de santé, 'batterie H2/O2', (pile à combustible : électrolyseur / réservoirs gaz); accumulateurs Lithium ; couplage aux énergies renouvelables.



▪ Supports, partenariats :

Supports institutionnels : ANR, ADEME, Région Midi Pyrénées, Europe, CNRS, DGAC, pole AESE

Partenariats universitaires :

- International : ENIT Tunis, Université de HCMV-Vietnam, IHCE Tomsk, Univ. Javeriana – Bogota, Univ Cocody-Abidjan, Univ of Rosario-Argentine.
- National : Univ de Corse, CEA Liten, SEEDS : G2ELab (Grenoble), AMPERE (Lyon), FEMTO-ST/FCLab (Belfort), IFSTTAR, LACCO Tours, GDR PACS.
- Régional : CIRIMAT, LGC, ICA, IMFT, association PHYRENEES, IMRCP.

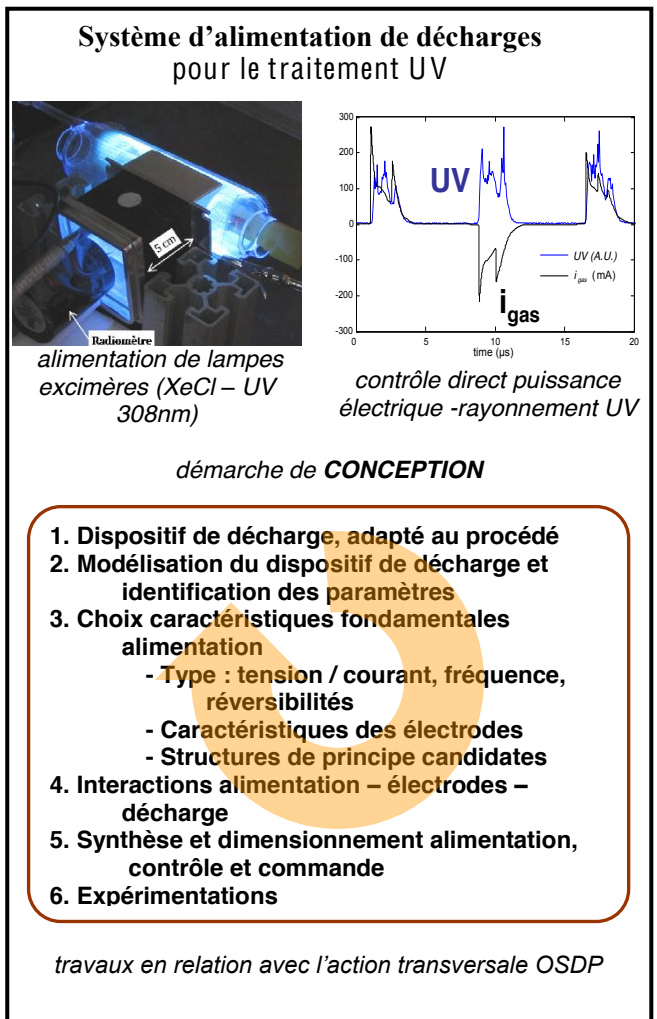
Partenariat industriel actif :

- Secteur Aéronautique & Espace : Airbus, Liebherr, Safran/Technofan-Micro Turbo, Aeroconseil, CIRTEM ;
- Transports terrestres : SNCF
- Mini réseaux, smart Grids: INEO-SCLE, LEVISYS
- Electrochimie : HELION Hydrogen Power, SAFT, SOLVAY.
- Décharges électriques : Quantel, Trojan, Cirtem, Oliscie

4- Systèmes d'alimentation de décharges électriques :

Mots clés : modélisation des dispositifs de décharges, interactions systèmes sources-plasmas, conception alimentations, contrôle des décharges.

Applications : décharges DBD, décharges Corona, plasmas froids, glidarc.



▪ Domaines d'applications :

- Réseaux embarqués aéronautiques et spatiaux
- Transport ferroviaire
- Production décentralisée et stockage d'énergie : éolien, solaire, vecteur hydrogène (Piles à Combustible, Electrolyseurs), stockage électrochimique (accumulateurs Lithium), smart grids.
- Décharges Electriques pour l'éclairage, les traitements de gaz, de surface ; applications santé & environnement.

▪ **Main objectives**

- ⇒ To integrate architecture, sizing and energy management of embedded and transportation systems, or of electrical energy production / and conversion.
- ⇒ To define models, tools and methodologies for an integrated design of heterogeneous systems in electrical engineering

▪ **Staff**

7 teacher-researchers, 3 engineers:

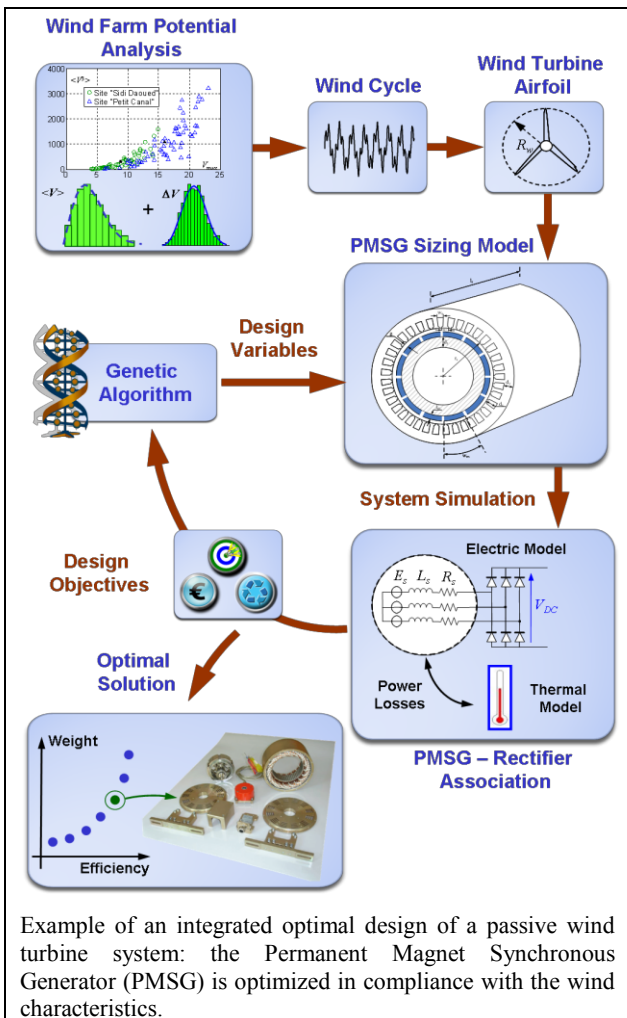
- | | |
|-------------------------|---------------------|
| S. Astier (PR) | X. Roboam (DR) |
| J.M. Blaqui re (IE) 50% | N. Roux (MC) |
| E. Bru (IE)* | B. Sareni (MC) |
| F.Lacressonniere (MC) | C. Turpin (CR) |
| H. Piquet (PR) | S. Vinnac (AdT) 50% |
| O. Rallieres* (IR) | |

11 PHD, 1 post doc (*) GENESYS funds

▪ **Research Topics :**

1- *Integrated design Methodologies:*

Keywords: multiobjective optimization with genetic algorithms, robust design under uncertainties, analysis of environmental variables(photovoltaic or wind farm potentials, driving profiles of electric vehicles...), clustering and classification, system modeling with bond-graphs.



2- *Architectures and energy management of networks & systems:*

Keywords: Quality, stability, EMC, multi-sources hybridization, energy management, embedded systems, sustainable energy systems.

Applications: electrical network for aerospace, railway transports, smart grids, hybrid systems with storage.

Power Hybridization of an electrical network for aircraft in emergency mode

To face strongly intermittent load profiles, hybridization of a Ram Air Turbine (RAT) by a super capacitor storage allows decreasing the whole weight of the emergency network approximately by 30%.

The Lithium ion accumulator allows facing high energy phases of the flight cycle:

- RAT power on,
- landing.

SOC control during flight

SOC= 80%
Vbat= 27.05V
Tcell= 19°C

SOC= 50%
Vbat= 25.79V
Tcell= 20°C

3- New Technologies for electrical energy production and Storage:

Keywords: modeling, characterization, hybridization, State of Health, 'H₂/O₂ battery' (fuel cell – electrolyzer gas storage); Lithium Ion accumulator; coupling with renewable energy.

Modelling and characterization of fuel cells and electrolyzer

Complementary approaches are used to characterize and analyze the involved physical & chemical phenomena in order to set a dynamic model of the device.

The diagram illustrates a modeling framework. At the top is the 'Quasi-static approach'. Below it are three interconnected components: 'Small signal dynamic' (left), 'Dynamic model' (center), and 'Full signal dynamic' (right). Arrows indicate bidirectional relationships between these components. The 'Dynamic model' is represented by a circuit diagram.

To apply this process, test facilities have been implemented for medium power device tests. The example below shows a 800 cm (P_{rated} = 6kW) PEM fuelcell designed by HELION Hydrogen Power.

HELION Hydrogen Power

Supports, partnerships:

Institutional supports: ANR, ADEME, Région Midi Pyrénées, Europe, CNRS, DGAC, AESE pole

University Partnership:

- International : ENIT Tunis, University of HCMV-Vietnam, IHCE Tomsk, Univ. Javeriana – Bogota, Univ of Cocody-Abidjan, Univ of Rosario-Argentina
- National: Univ of Corsica, CEA Liten, SEEDS: G2ELab (Grenoble), AMPERE (Lyon), FEMTO-ST/FCLab (Belfort), IFSTTAR, LACCO Tours, GDR PACS.
- Regional: CIRIMAT, LGC, ICA, IMFT, association PHYRENEES, IMRCP.

Current industrial partnership:

- Aerospace: Airbus, Liebherr, Safran/Technofan-Micro Turbo, Aeroconseil, CIRTEM;
- Railway Transport: SNCF
- Stand alone networks, smart Grids: INEO-SCLE, LEVISYS/SEVIL
- Electrochemical systems: HELION Hydrogen Power, SAFT, SOLVAY.
- Electrical discharges: Quantel, Trojan, Cirtem, Oliscie

4- Power supply for electrical discharges systems:

Keywords: modeling of discharge device, sources-plasmas interactions, power supply design, control of discharges.

Applications: DBD discharges, Corona discharges, cold plasmas, glidarc.

Power supply of electrical discharges for UV process

power supply for excimer lamps (XeCl – UV 308nm)

Direct electrical power control UV radiance

DESIGN METHODOLOGY

1. To characterize the electrical system dedicated to the discharge process
2. To develop device model and parameter identification of the discharge process
3. To choose the main characteristics of the power supply
 - Electrical characteristics: voltage / current, frequency, reversibility
 - Electrode characteristics
 - Candidate structures
4. Supply – electrodes – discharge interactions
5. Synthesis and sizing of supply and control
6. Experiments
7. Process performance analysis

Studies involved in the framework of OSDP (Optimization, Sources Discharges & Process) transversal action

Application fields:

- Embedded electrical networks in aerospace
- Railway transport
- Renewable energy and storage: wind turbines, solar PV, hydrogen power (fuel cell, electrolyzer), electrochemical storage (Lithium Ion), smart grids.
- Electrical discharges for lighting, gas and surface processing, health & environment applications.

