SPIDER: Simulation Platform For The Integration Of Distributed Energy Resources

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Overview

- SmartGrids at CEA
- Modeling and simulating Smartgrids: What are the challenges?
- SPIDER: Simulation Platform for the Integration of Distributed Energy Resources
- Conclusions and next steps
SMARTGRIDS AT CEA
CEA at a glance

**Defence Security**
- Defence Applications Division

**Nuclear Energy**
- Nuclear Energy Division

**Research & Technology**
- Technological Research Division

**French strategic independance**

**French energetic independance**

**Fundamental Research**
- Material Science Division / Life Science Division

**Technological**
- 4,500 employees
- 550 M€ budget
- 500 priority patents filed / year
- 50 spin-off companies

**Science**
Mission of CEA Tech

Government & Universities

GAP

Private companies

Pump priming 25% (5 - 10 years)

Technology transfer 75% (1 - 3 years)

Technology Readiness Level

1 2 3 4 5 6 7 8 9

1. Basic Technology Research
2. Research to prove feasibility
3. Technology Development
4. Technology Demonstration
5. System/Subsystem Development
6. System Test, Launch & Operations

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Smart-grid lab

**Topics**
- Smart VE
- Smart Storage
- Smart Grid
- Smart Building/City

**LSEI**

**E-plateforme**: complex system simulation, SCADA

**P/C HIL**: Power and control hardware in the loop

**PRISMES**: experimental micro grid

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Hybrid systems

- Grid stability?
- Reserves?

Districts

- Voltage level?
- Centralized VS distributed EMS?

PV plant

- New strategies for market integration?
- Contribution to ancillary services?
MODELING AND SIMULATING SMARTGRIDS
What are the objectives associated to Smartgrid modeling and simulation?

1. Support for the development of advanced controls:
   - Energy Management Systems (EMS)

2. Optimal sizing and configuration:
   - Component sizing (PV, Storage, …)
   - Analysis of different electric architecture

3. Model delivery to partners;

   ➔ Need for a tool which covers different activities, from pre-sizing to development of advanced controls.
Model Based Design for Smartgrid modeling

Control

Planning control #1

Planning control #i

Operation control

Plant

measures

set points

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Control

User events

Planning controls

Operation control

Plant

Power

PV

GRID
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Legend:  
- **PC**: rapid prototyping  
- **micro controller**: PHIL  
- **PHIL**: real plant
Steps to smartgrid deployment

Towards smart grid deployment

Legend:
- PC
- rapid prototyping
- micro controller
- PHIL
- real plant
### Steps to smartgrid deployment

#### Towards smart grid deployment

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<td>Predictive optimal planning control (perfect predictions)</td>
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<td>Simple operational control (optional)</td>
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<td>Simple model</td>
<td>Detailed model</td>
<td>Real plant or Power-hardware-in-the-loop</td>
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#### Legend:
- PC
- rapid prototyping
- micro controller
- PHIL
- real plant
From Simulation to field tests

« Control/Power hardware-in-the loop »
Control validation, component characterisation

Experimental validation
With an adequate information system
SPIDER

Model factory

Model developpers
Experts
# 10 persons at INES

Spécifications

Simulation users
Non experts
Transfer (industrial partners)
Challenges associated to model development (1)

- Problem: develop models with different levels of precision (for different applications), and different requirements (computation time, ...)

  - Example for diesel generator models:
    - Models which informs about power limits and fuel consumption for system sizing;
    - Models which describe the eclectic behavior of the system for grid stability analysis.

- Solution: use Simulink models or Simscape PowerSystems models depending on the application
Challenges associated to model development (2)

Problem: maintain the models libraries operational, with a high level of documentation

Solution:

- Propose a model development framework, with a format for parameters and a set of validation tests for each model.
- Develop MATLAB scripts to:
  - Run non-regression tests;
  - Build automatic documentation (wiki format).
Challenges associated to model development (3)

Problem: develop component models in line with existing standards

- FMI
  - Compiled models
  - Intellectual property protection
  - Standardized format with a description of Inputs / Outputs / Parameters;

Solution:

- Use Embedded Coder + FMI export to generate FMI models;
- Proposed equivalent models for models which are not compiled.
SPIDER 1.0

Component and control models
- Simulation engine
- Simulink based

System Modeling, including GUI

Technic and economic indicators
- Simulation
- Optimization
- Sensitivity analysis

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SPIDER 1.0
Next steps

- **Model factory:**
  - Development of new control and component models, related to industrial and academic partnerships;
    - Technologies related to smart grids: Storage, Renewable generation;
    - Advanced controls, including optimal planning

- Development of specific methods and tools for defining system operation strategies;

- Deployment: model compiling and master algorithm.
Use case example:

Use cases:
- Energy Management System validation for hybrid systems
CONCLUSIONS
Conclusions

- SPIDER: an adequate tool for EMS development and evaluation

- Appropriate modeling and simulation framework for smart grid application: MATLAB–Simulink

- Possibility to develop a range of models for different applications: Simulink – Simscape PowerSystems

- Possibility to compile normalized models; MATLAB Coder – Simulink Coder – Embedded coder