

# Andrea Scalfati

## Tutor: Maurizio Fantauzzi – Diego Iannuzzi


XXX Cycle – Ist year presentation

# Design Methodologies for DC Microgrids in Buildings

# Personal Background

Master Science Degree with honors in Electrical Engineering, with the thesis entitled "Sull'inquinamento armonico e interarmonico causato dagli azionamenti statici per motori asincroni di grande potenza", march 1997

DIETI groups:

ING-IND/32: Power electronic converters, electrical machines and drives

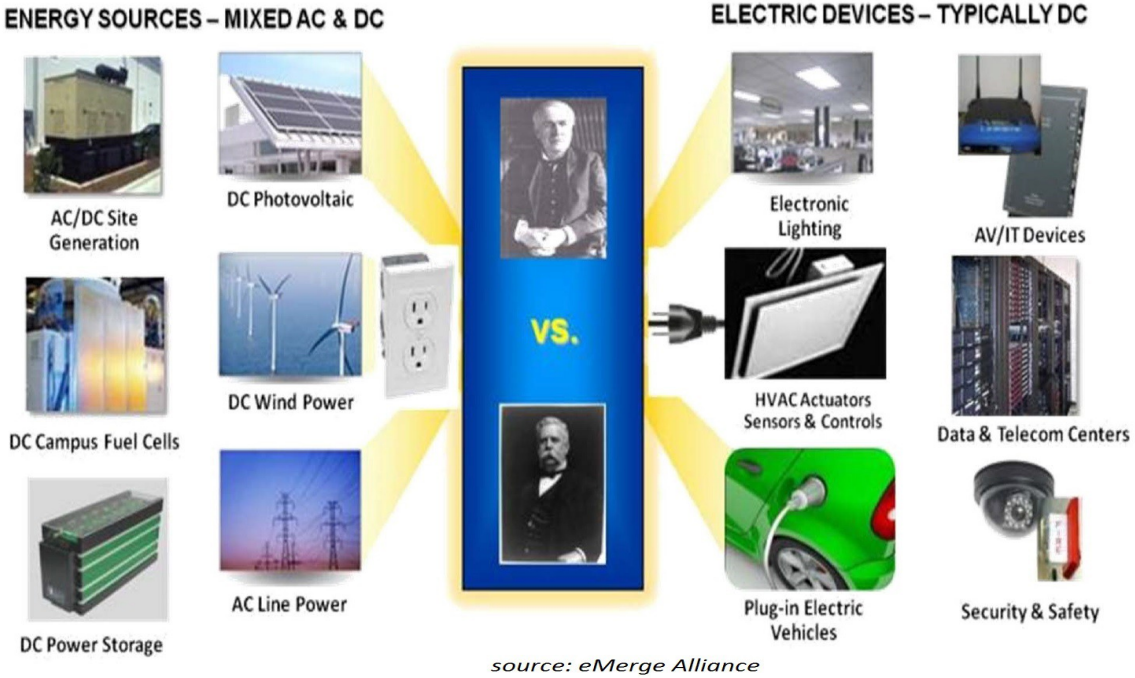
ING-IND/33: Electrical power systems

Full time worker for the Italian Ministry of Education as High School professor in electrical engineering from 2008

No Fellowship

# Problem

In modern buildings the majority of present and expected loads and distributed energy resources are natively DC.




source: eMerge Alliance

DC microgrids can give a significative contribution to increase the energy efficiency and achieve the goal of Net Zero Energy Buildings.

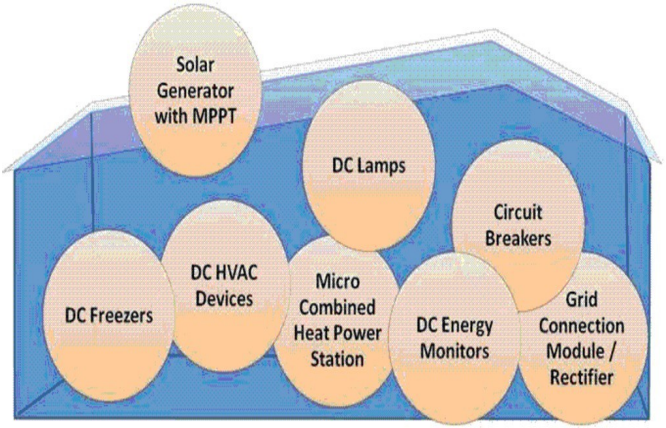
Despite promising perspectives, DC microgrids encounter various barriers, like current lack of approved standards and of familiarity with design of DC LV distribution systems.

# Research Activity - Idea

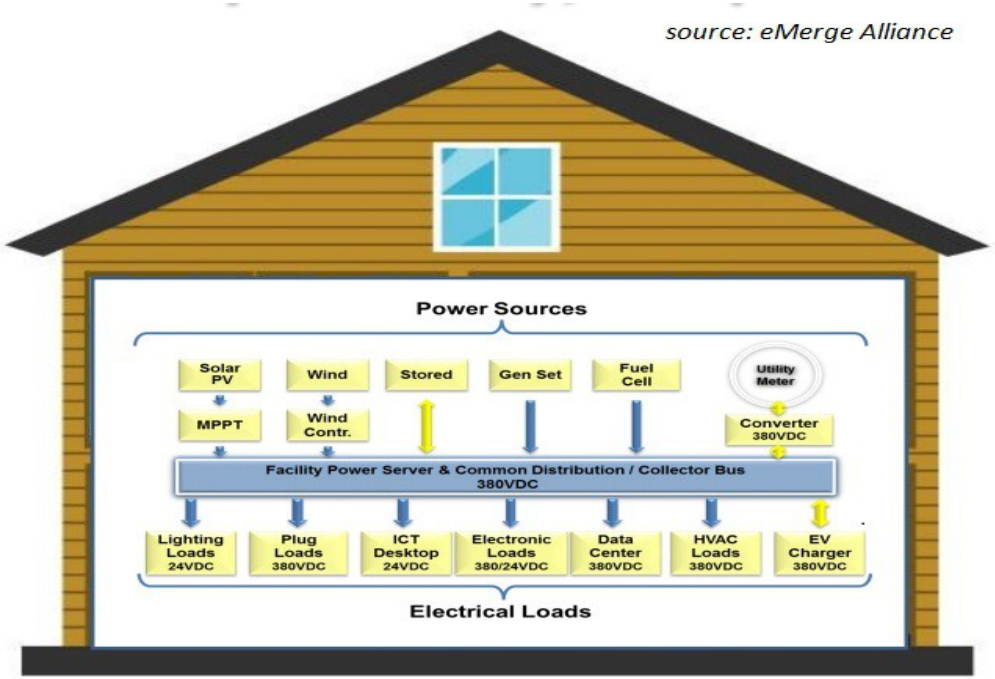
To study and develop design methodologies for Building DC microgrids

We aim to work on two paths:

- developing an experimental platform with Power Hardware In the Loop features for studies on DC microgrids
- studying the application of optimization techniques to the design of building DC microgrids



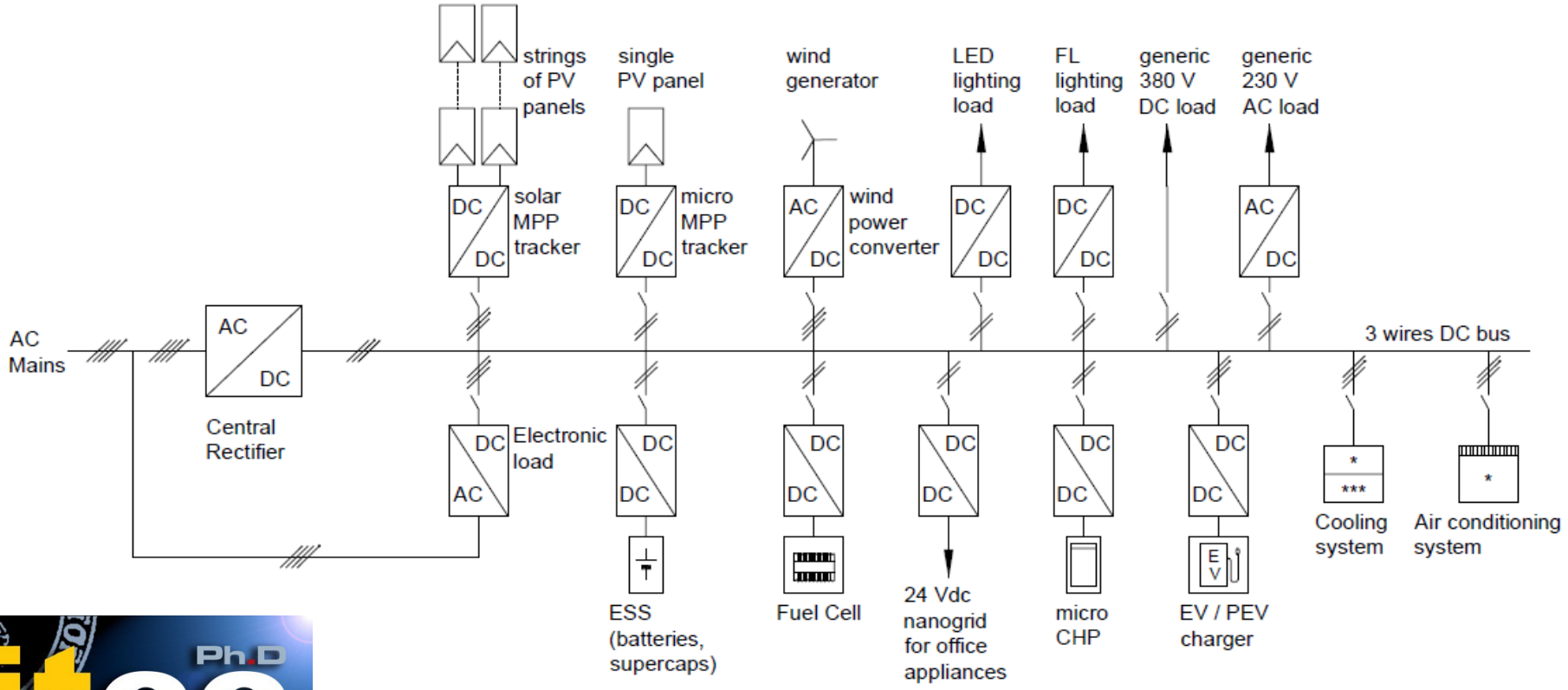

source: DCC+G Consortium




source: eMerge Alliance

# Research Activity - Developments (1)

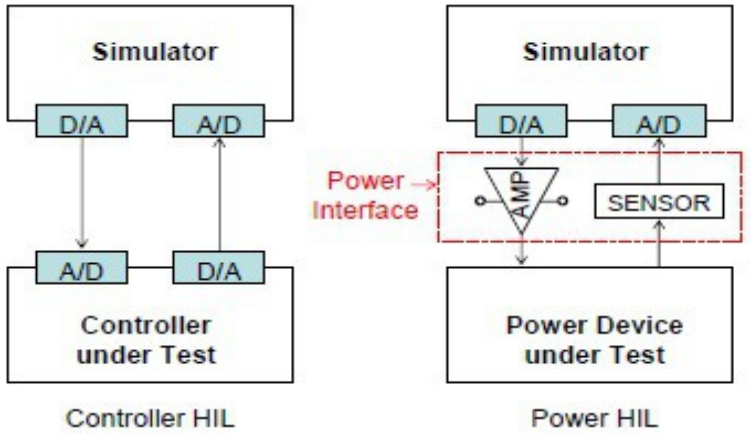
Defining a reference architecture for an experimental platform for studies on Building DC Microgrids (ref. paper “Building DC Microgrids, Planning of an Experimental Platform with P-HIL Features”, accepted for ICRERA 2015 conference).



# Research Activity - Developments (2)

Identifying technical requirements for the Power Amplifier to be used in the Power Interface of a P-HIL platform.

*Hardware in the loop (HIL) is a technique in which a part of actual hardware is tested using computer based real time simulation to reproduce the behavior of the system interacting with it. If the hardware is a power device, a Power Interface is needed. The Power Interface can seriously affect stability and accuracy of the simulation.*




*source: "Accuracy Evaluation of P_HIL Simulation"*

We identified technical requirements for the Power Amplifier included in the PI (results have been included in the paper "Building DC Microgrids, Planning of an Experimental Platform with P-HIL Features" accepted for the presentation at ICRERA 2015).

# Research Activity - Developments (3)

Requirements for the Power Amplifier to be used in the Power Interface of the P-HIL platform:

General requirements

- fast response time
- high precision with a large bandwidth
- low output impedance

Use case dependant specifications:

- power rating: 100 kVA
- Vripple_out_peak < 0.15 % Vin
- THD < 0.15%
- Step Response (10%-90%) < 100µsec
- Signal bandwidth 10kHz (3dB)
- Bidirectional energy flow

DC operation mode:

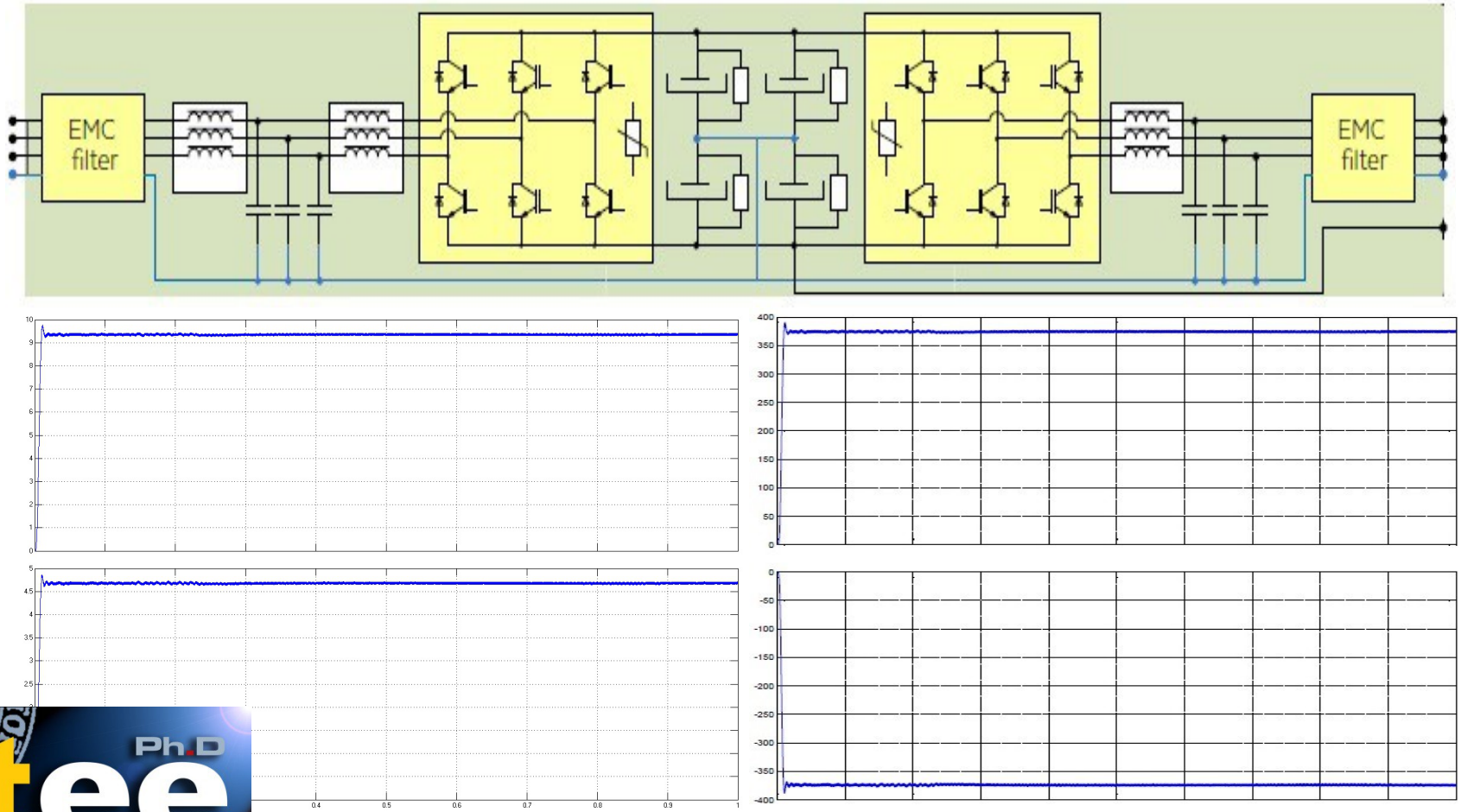
- three poles output (positive L+, neutral M, negative L-)
- variable output voltage from 0 to 450 V between L+ and M and from 0 to -450 V between L- and M
- voltage and current source operation
- photovoltaic generator simulator

AC operation mode:

- output: 3P+N+PE, adjustable line to line voltage from 0 to 400 V
- one, two and three-phase operation, with and without PE and N
- variable output frequency between 0 and 400 Hz
- independent voltage specification for each line
- emulation of harmonics, inter-harmonics and voltage variations;
- bidirectional energy flow
- arbitrary waveform generator;
- grid fault and transients simulations (e.g. LVRT and HVRT test sequence, frequency drift etc.)
- virtual AC load
- grid impedance emulation

# Research Activity - Developments (4)

Study and simulation (Matlab-Simulink) of a possible architecture for the Central Rectifier/Power Amplifier of the P-HIL platform.



# Products

- Conference Paper “Building DC Microgrids, Planning of an Experimental Platform with P-HIL Features”, accepted for oral presentation at the 4th International Conference on Renewable Energy Research and Applications, to be held in Palermo (Italy) from 22 to 25 November 2015.

# Next Years

| | Credits year 1 | | | | | | | | | Credits year 2 | | | | | | | | Credits year 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated | 1 bimonth | 2 bimonth | 3 bimonth | 4 bimonth | 5 bimonth | 6 bimonth | Summary | Check | Estimated | Check | | | | | | Summary | Estimated | 1 bimonth | 2 bimonth | 3 bimonth | 4 bimonth | 5 bimonth | 6 bimonth |
| Modules | 24 | | 3 | 3 | 3 | 12 | | 21 | 20-40 | 15 | 10-20 | | | | | | 0 | 3 | | | | | | |
| Seminars | 6 | | 0,4 | 0,8 | | | 1,8 | 3 | 5-10 | 8 | 5-10 | | | | | | 0 | 3 | | | | | | |
| Research | 30 | 10 | 4 | 4 | 4 | 4 | 6 | 32 | 10-35 | 40 | 30-45 | | | | | | 0 | 60 | | | | | | |
| | 60 | 10 | 7,4 | 7,8 | 7 | 16 | 7,8 | 56 | 60 | 63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 0 | 0 | 0 |

Objectives:

Study and application of constrained optimization techniques to the design of Building DC Microgrids

(e.g. sizing and positioning of storage devices in presence of stochastic behaviour of loads and distributed generation)

Application of HIL / P-HIL techniques to the validation of controllers and electrical components