Santiago 2013 Symposium on Microgrids

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Battery Model for Microgrid Studies

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Instituto de Energía Eléctrica

- Universidad Nacional de San Juan
- Facultad de Ingeniería
  - Instituto de Energía Eléctrica (IEE)

Instituto de Energía Eléctrica

Main Activities at IEE

- **Undergraduate and graduate teaching**
- Human resource training
- Consulting and technology transferences
- **Research and technology development**

Instituto de Energía Eléctrica

Undergraduate and graduate teaching:

- Electrical Engineering Career.
- Doctorate and Master program in Electrical Engineering.
- Intelligent Power System Master (forthcoming)

Professional Staff

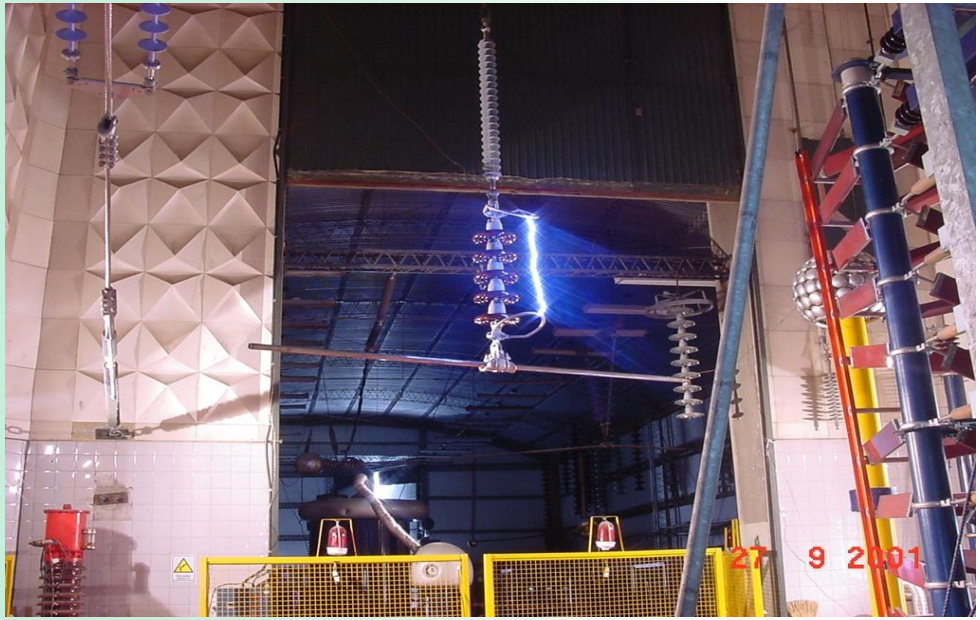
- 41 teachers and researchers
- 46 doctoral candidates.
- 10 undergraduate teaching assistants

Instituto de Energía Eléctrica

Areas of Research and Development:

- Electricity Markets
- Performance analysis of Power Systems. Steady state and dynamic studies
- Design and testing of electrical equipment and laboratories. High voltage laboratory.
- Power electronics and electrical drives. Control of alternative energy sources and energy storage.

Building and Laboratories



New H.Voltage and Renowable Energy Labs

Renewable Energy Laboratory (SEPEA)

- Weather Station
- PV Peak Power Meter
- PV Power Inverter (SMA)
- Data acquisition system (“Sunny Webbox”)
- 6x50W and 15x80W PV modules
- Wind Turbine (500W)
- Ultracapacitor

Renowable Energy Laboratory (SEPEA)

- Power inverter: to 220Volts
- Sunny Webbox: to IEE LAN and
  - To ww.SunnyPortal.com

15x80Wp SolarTec
PV Modules

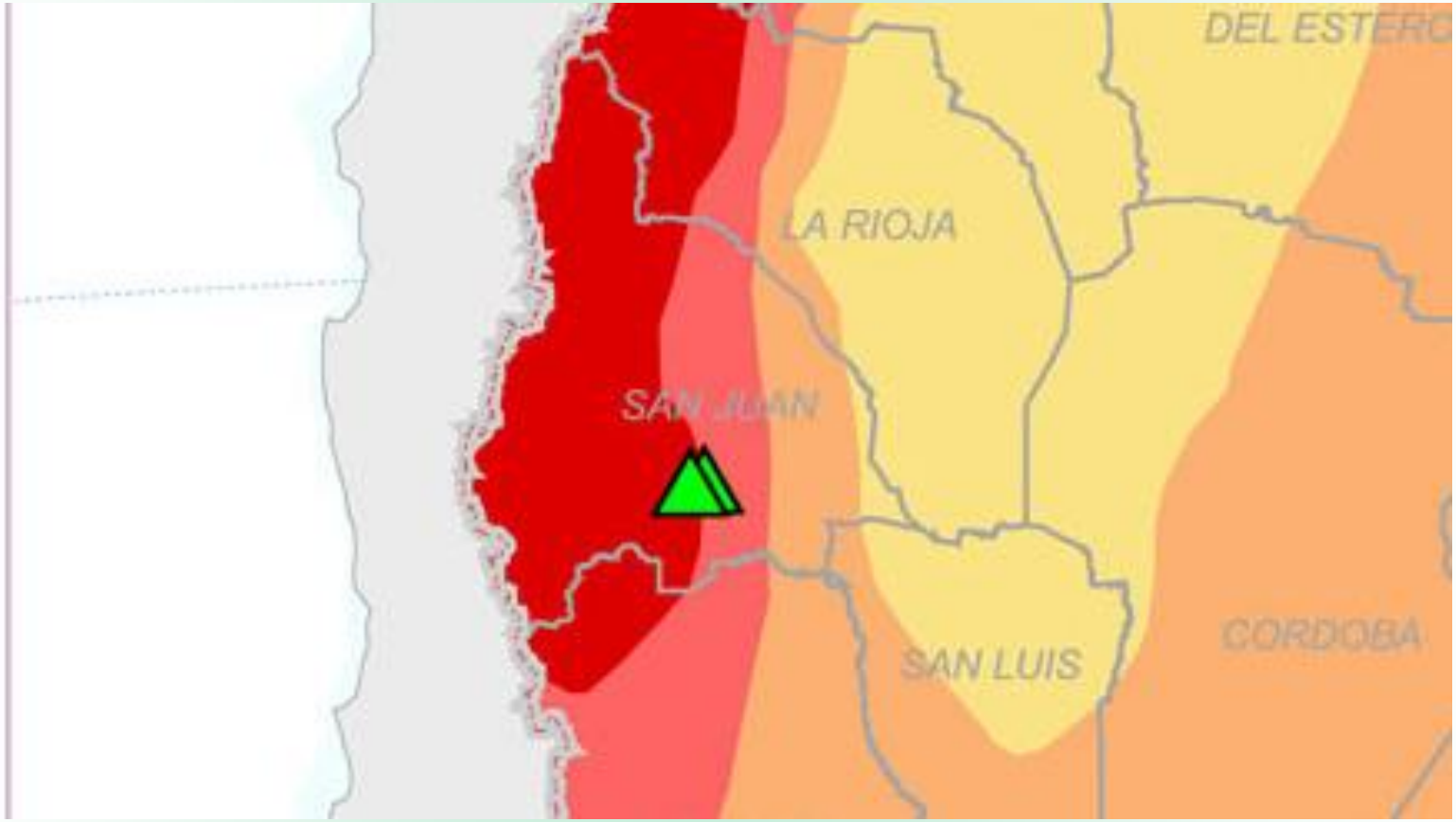
Renowable Energy Laboratory (SEPEA)

Hail Test

PV Modules for San Juan I
1,2 MWp PV field

Renewable Resources in Argentina

Solar radiation in San Juan

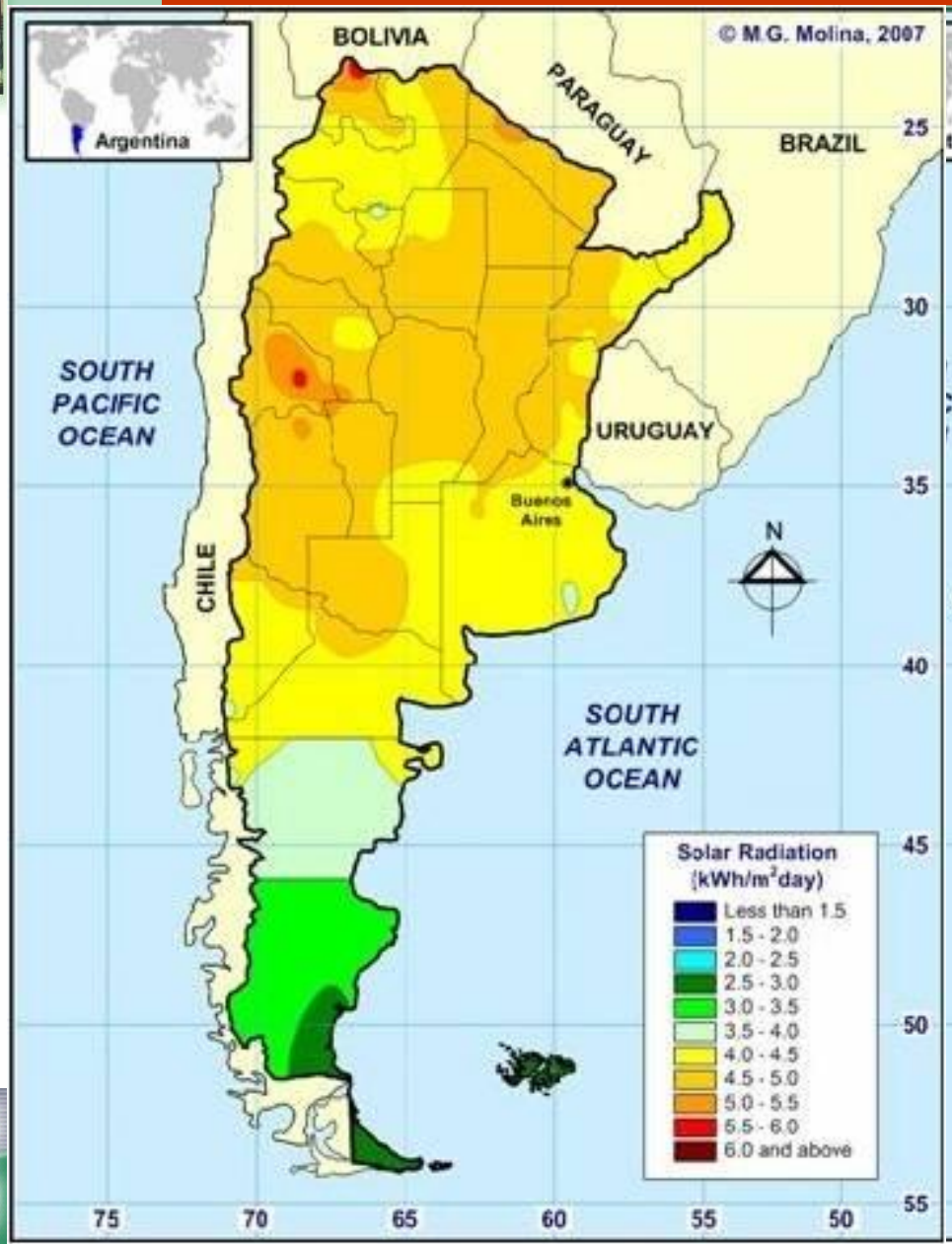


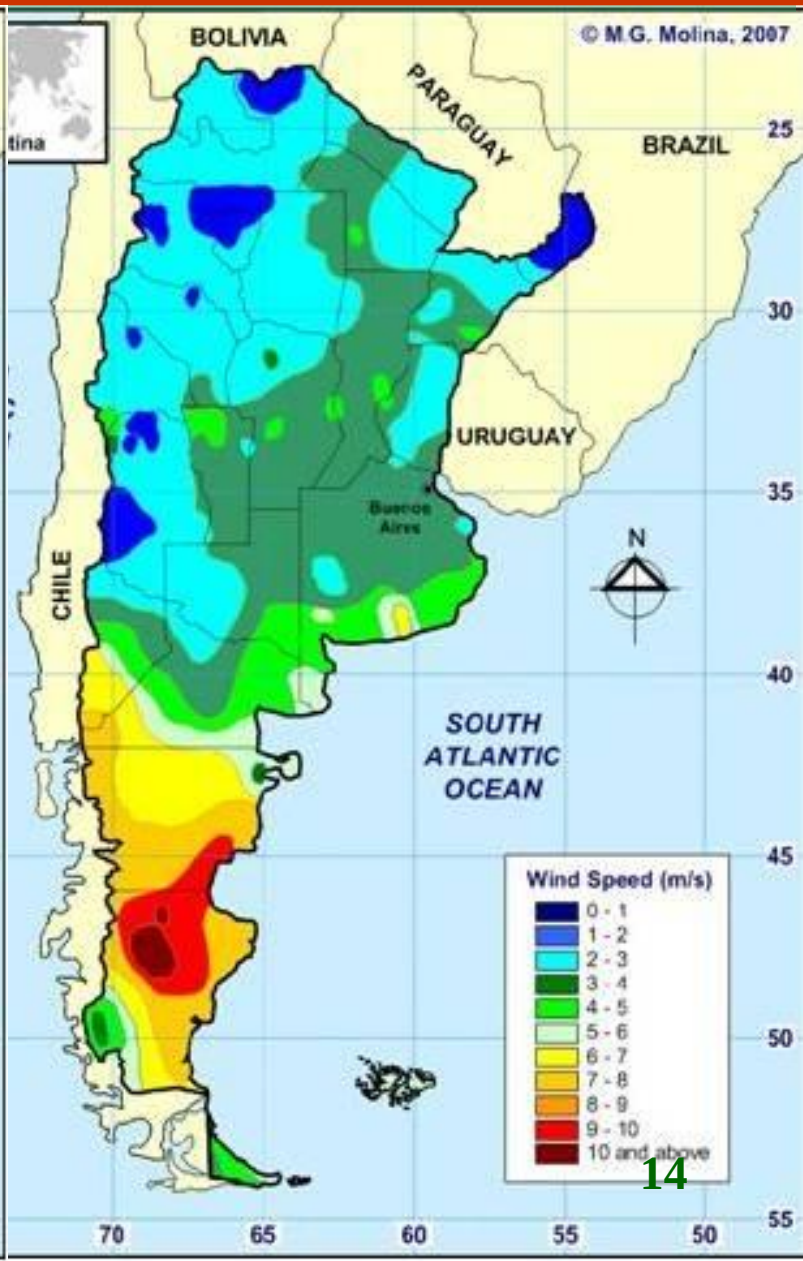
San Juan I (1,2 MWp) and Cañada Honda (5MWp to 20 MWp) PV fields

Renewable Resources in Argentina

San Juan I (1,2 MWp) PV field

Renewable Resources in Argentina





Microgrids

Conventional Power utilities

- **Use non-renewable energy sources**
- **Environmental hazards**
- Well-known technologies
- Low specific building costs
- **Ease resources availability and storage:**
  - ***back-up capacities help maintain spinning reserve***

Microgrids

Microgrids

- Use sustainable energy resource:
  Mainly uses Solar and Wind energy
  - plentiful availability
- Reduce environmental impacts
- Can operate isolated of the main power grid

Major drawbacks of using wind and solar:

- Unpredictability of generated power
- Constrained back-up capacities
- No spinning reserve contribution

Microgrids

Load Management and Energy Storage should be used in Microgrids

Batteries can storage energy from renewable energy sources to collaborate in spinning reserve and back-up capacities

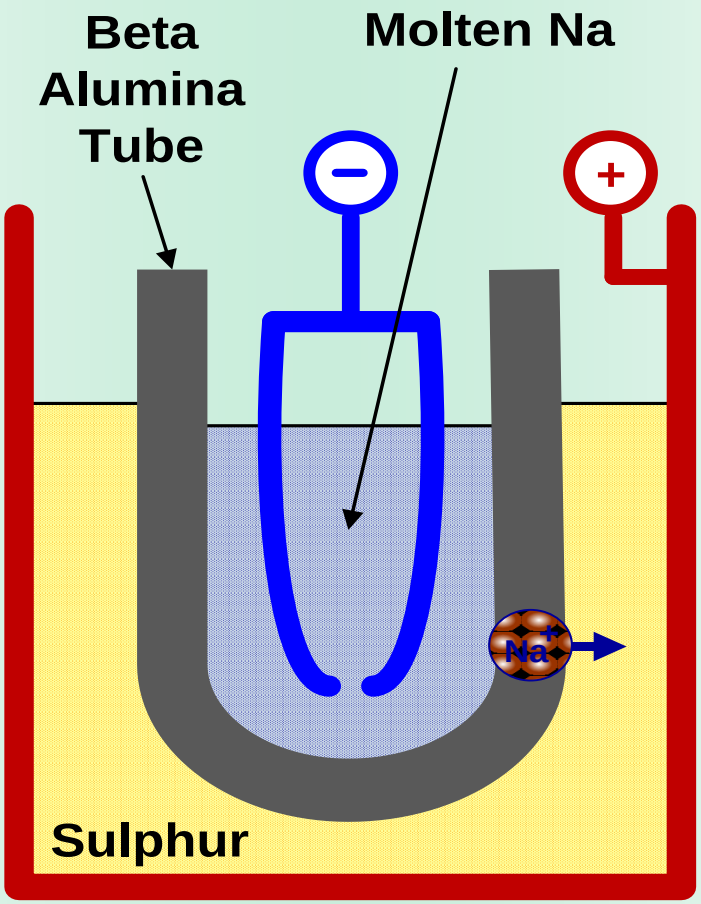
Batteries can provide: Power Quality (PQ) and Peak Saving (PS) support

Objective:

"Model a battery for PQ and PS purpose"

Electrochemical batteries

NAS Battery



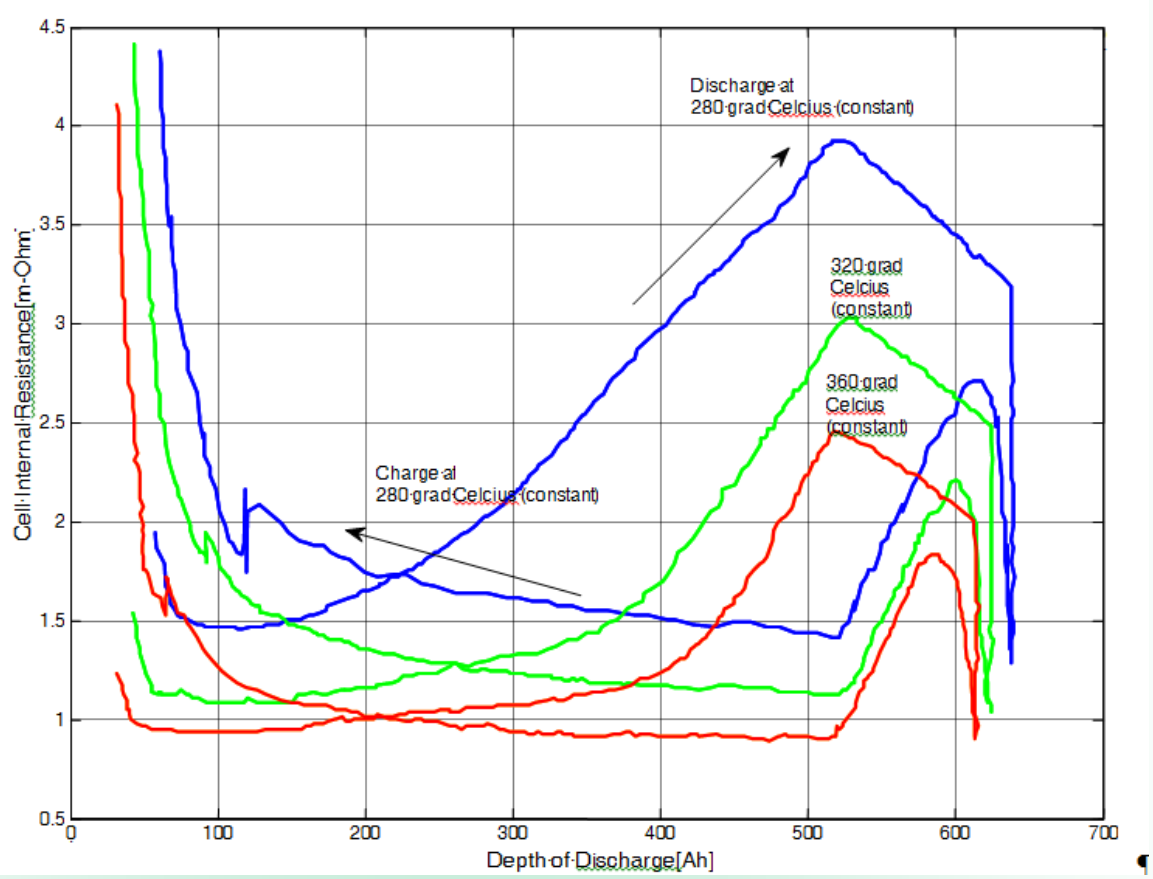
Schematic model of a sodium-sulphur battery

NAS Battery

- TEPCO and NGK developed the first commercial sodium-sulphur battery (NAS®, registered in Japan) to replace pumped hydro energy storage
- High power density
- High energy density (tree times Lead Acid)
- Can be used for peak saving (PS) or power quality (PQ) purposes
- A NAS battery module of 50kW can discharge at up to 250kW for 30 seconds.

The battery open circuit voltage (Voc) and the internal resistance depends in a non-linear way on the depth and direction of discharge (SOD)

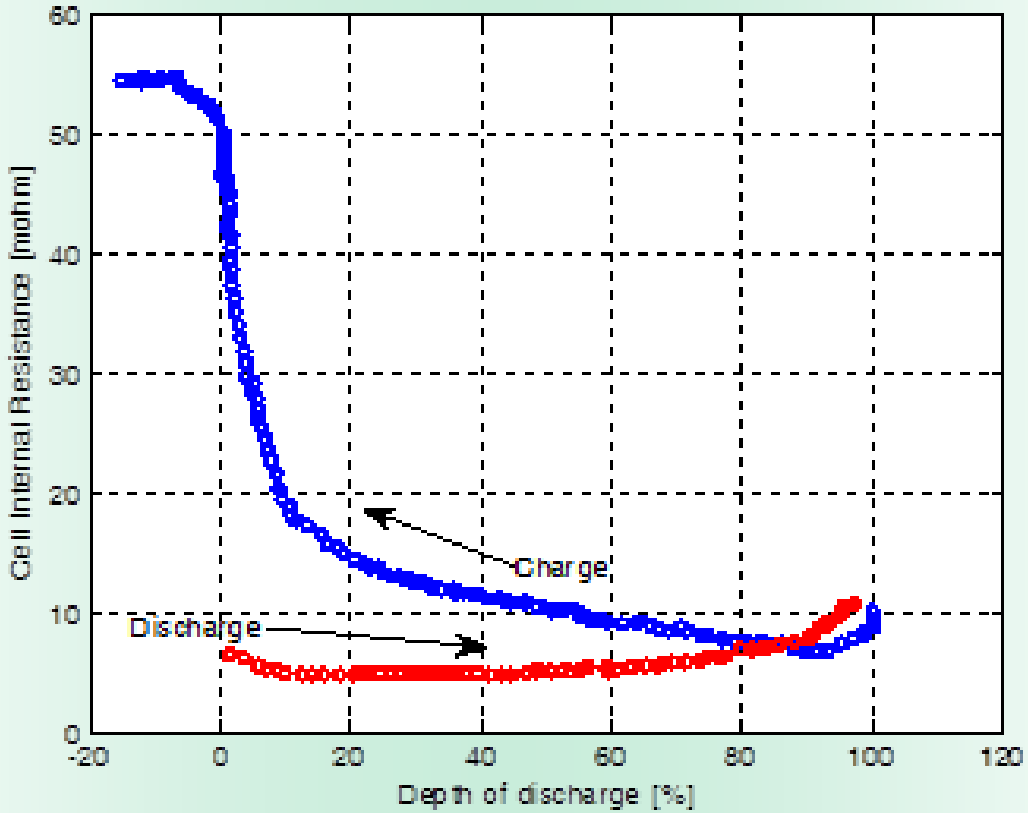
NAS Battery



Internal resistance variation depending on the state of charge/discharge for various temperatures in a NAS-type battery cell (Hussien 2007)

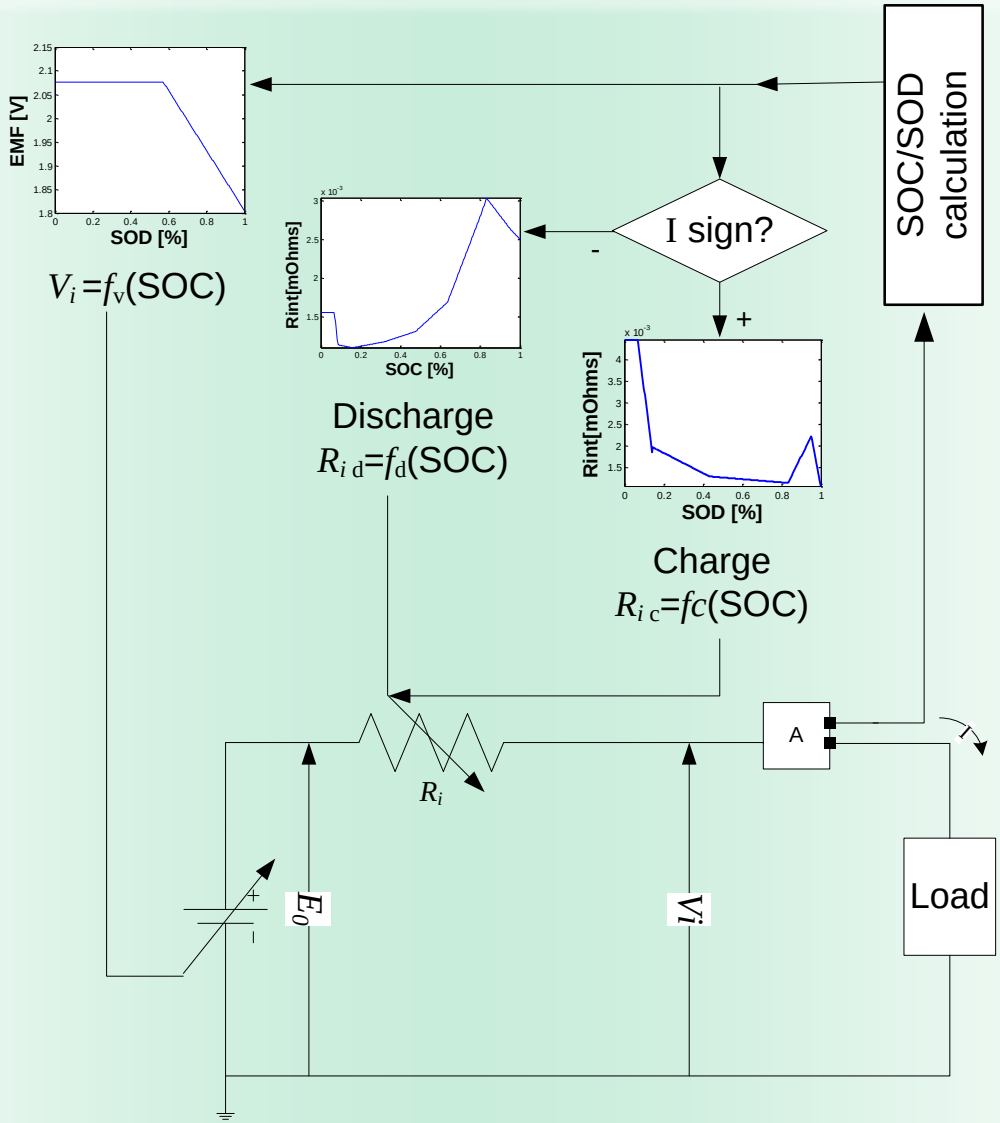
Electrochemical batteries

Pb-Acid Batteries



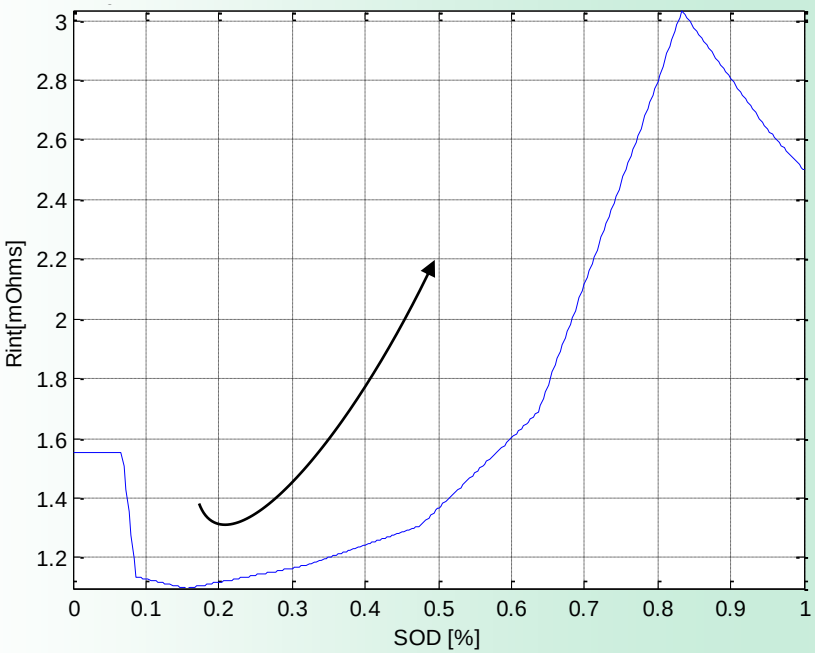
Internal resistance in charging or discharging state as a function of SOD for a Pb-acid battery at 25°C (CIEMAT 1992)

General battery model

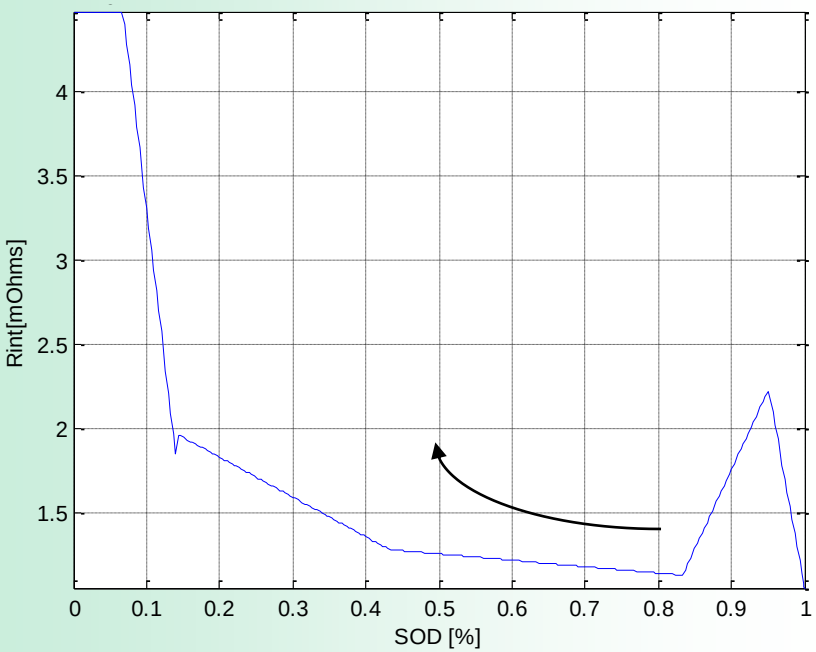


Proposed general model of the Battery Storage Systems for MGs

Battery Model Test

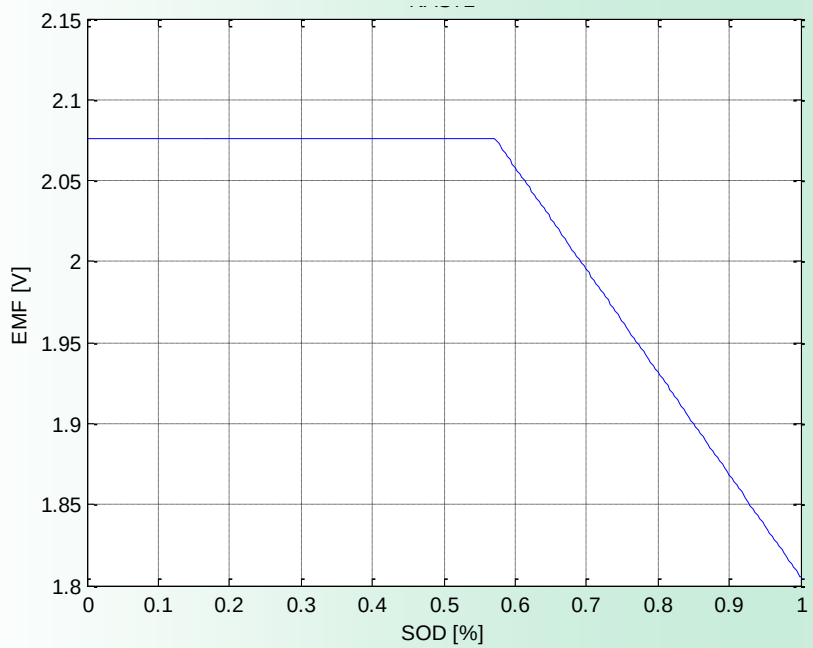


Internal cell resistance vs. SOD at 320°C for discharge (Simulated)

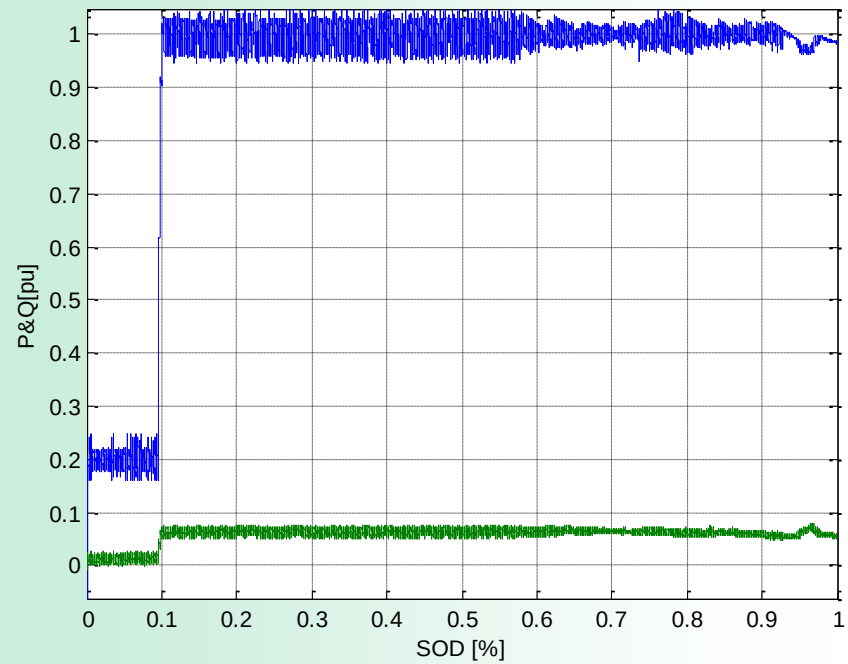


Internal cell resistance vs. SOD at 320°C for charge (Simulated)

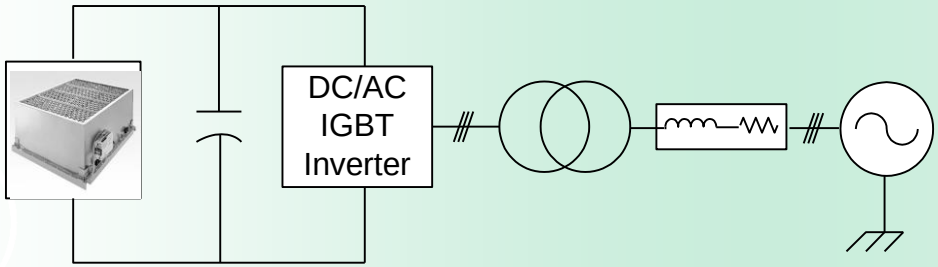
Battery Model Test



Cell Voc vs. SOD
(Simulated)



Variation of P and Q power
from the Battery module (AC side)



NAS module connected
to a testing power system

Final Remarks

- Sodium–sulphur battery presents interesting opportunities for energy storage in power systems. Are much smaller and lighter than other classical batteries and they have neither memory effects nor toxic materials.
- Authors have developed a new NAS model suitable to study the insertion of NAS batteries modules into MGs.
- Dynamic system simulation studies demonstrate the effectiveness of the developed model that can be used for other batteries types

More information on the Instituto de Energía Electrica at:

www.iee-unsj.org

Further information about the battery model can be found in the Chapter 12. of the book "Energy Storage" at:
www.intechopen.com - http://dx.doi.org/10.5772/52219

Thanks for your attention!

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