Departamento de Ingeniería Eléctrica

Research lines & main technology transfer projects

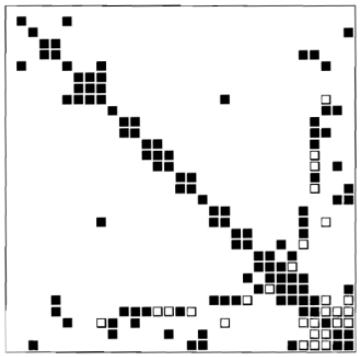
- Julio II Pope's edict in 1505
- Arts, Logic, Philosophy, Theology, Laws and Medicine (in 1508)
- Second largest in Spain:
  - Nearly 70,000 students
  - Over 4000 teaching staff
  - 32 Faculties/Colleges
  - 67 Bachelor degrees
  - 79 Master degrees
  - 31 PhD degrees (new RD)

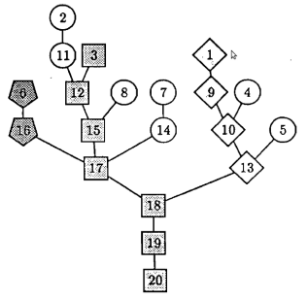
- Created in 1967 under OECD umbrella
- Currently all branches of engineering:
  - Nearly 6000 students
  - Over 400 teaching staff
- AICIA:
  - Non-profit foundation created in 1982
  - Third-party of US for management of research & technology transfer projects

- Principal investigator: Antonio Gómez-Expósito
- Steadily growing since the mid 80's
- Currently **30 members** (20 Ph.D., 4 full professors)
- Uninterrupted Postgraduate Program in Power Eng.
- Ph.D. program in cooperation with UPC-UPV/EHU-UMA
- Strong link with utilities and industry:
  - Endesa Industrial Chair
  - Over 80 R&D&T projects
- A spin-off launched in 2012: INGELECTUS - Innovative Electrical Solutions

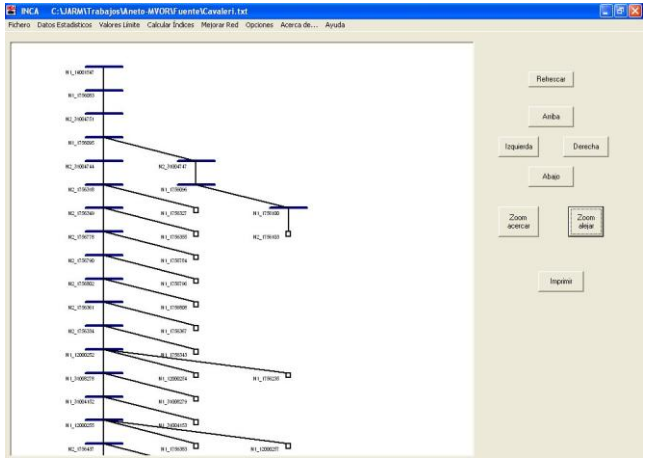
- Modeling & computational tools
- Transmission & distribution planning (with uncertainty)
- **Operation and control of T&D smart grids**
- **Integration of renewable sources**
- **Electricity markets, ancillary services & regulatory issues**
- **Monitoring & protection of smart grids**
- Energy efficiency and power quality

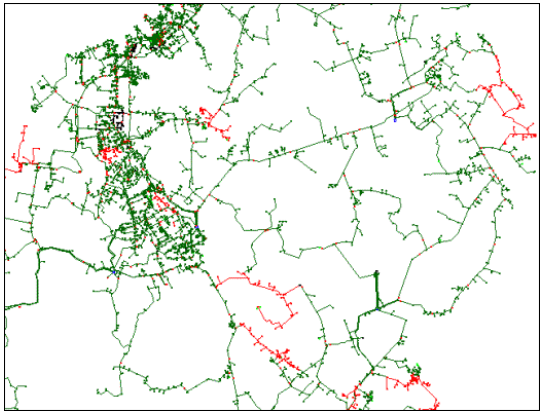
- Sparsity:
  - Large-scale systems of equations
  - Optimal node ordering
- Load flow:
  - Improved efficient formulations
  - Focus on distribution networks
- Digital signal processing:
  - Short-time discrete Fourier
  - Wavelet transform
- Modeling of renewable sources
  - PV, thermosolar
  - Wind, wave

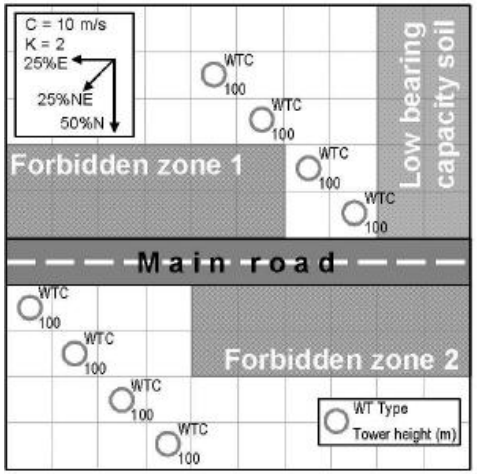




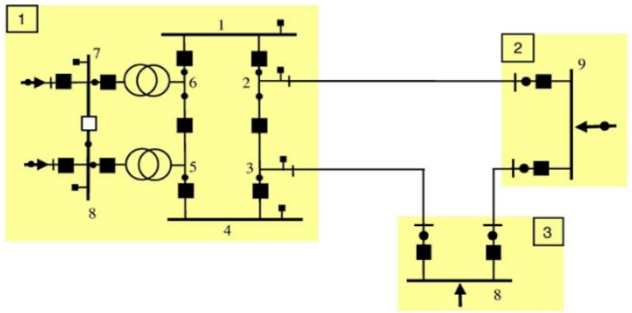
- Reliability analysis and improvement
- Right-of-way capacity upgrading:
  - HTLS
  - AC-DC conversion
  - Low reactance configurations
- Optimal configuration of feeders with embedded DG
- Wind farm planning:
  - Optimal plant layout
  - Portfolio assessment

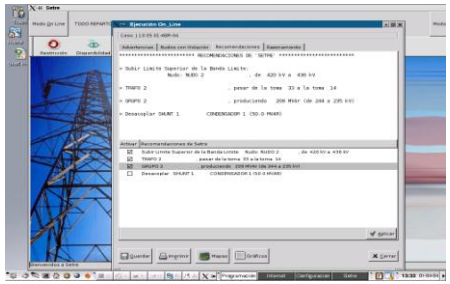






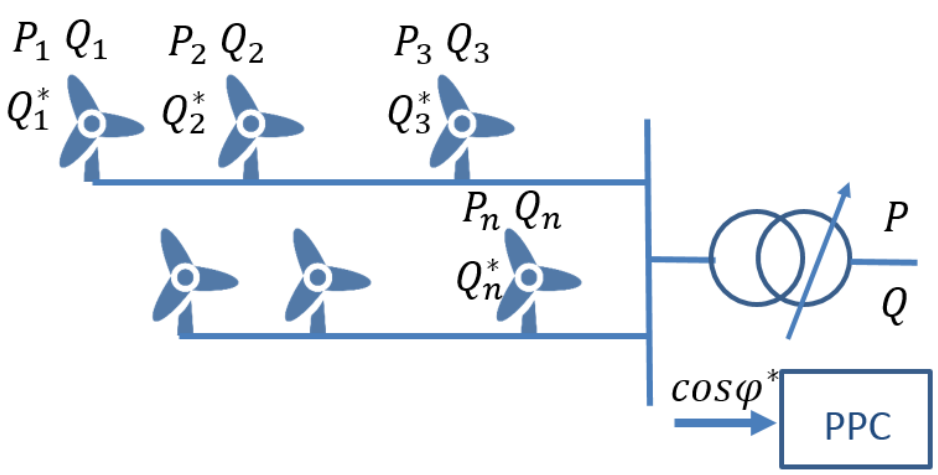
- State estimation:
  - Solution breakthroughs (PEGASE)
  - Multi-area applications (PMUs)
  - Substations and distribution feeders
- OPF tools in restructured systems
  - SETRE Expert System (Spain, Algeria)
  - PEGASE (large-scale SC-OPF)
  - Operation of wind & PV plants
- Security assessment:
  - Contingency analysis
  - Feeder congestion removal
- Service restoration

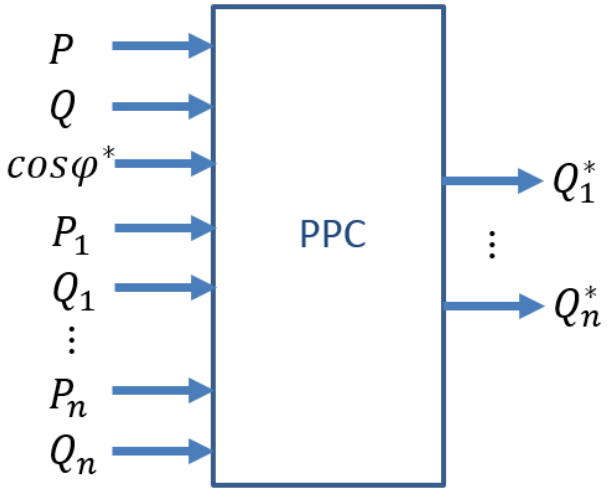




WINDOPF project

- Potencia reactiva en los parques eólicos y fotovoltaicos:
  - Factor de potencia constante (España)
  - Tensión de referencia (Puerto Rico)
- Necesidad de un controlador de planta (PPC)

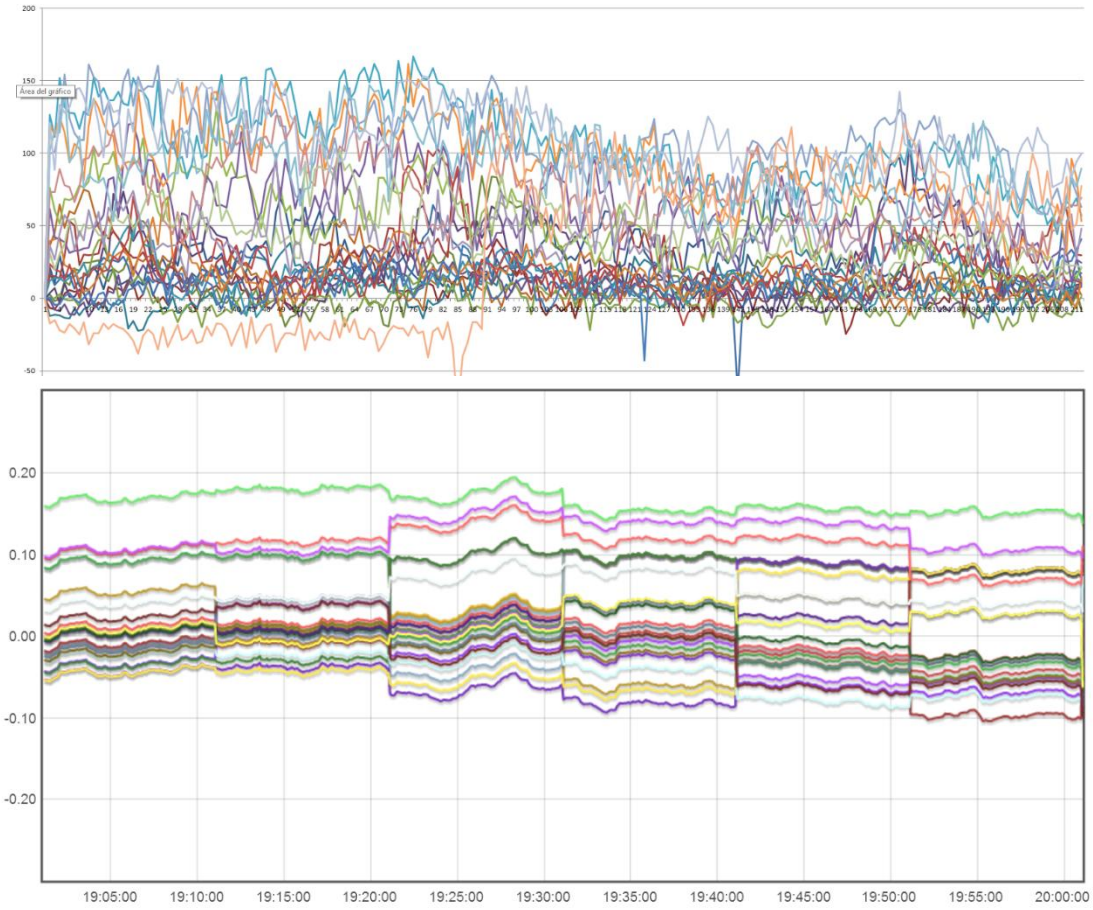




WINDOPF project

Característica	PPC convencional	PPC WindOPF
Cumplimiento requerimiento punto frontera	✓	✓
Variables de control	*Q* generadores	*Q* generadores Toma trafo cabecera
Criterio de asignación	Proporcional	OPF
Minimización de pérdidas internas	✗	✓
Cumplimiento límites operacionales internos	✗	✓

WINDOPF project



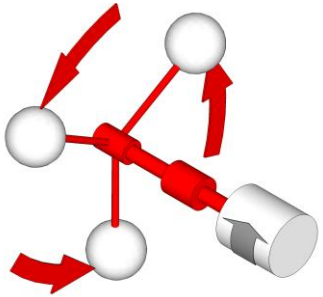
PPC convencional

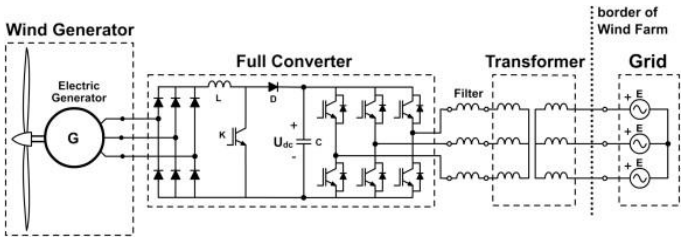
(2-3% pérdidas)

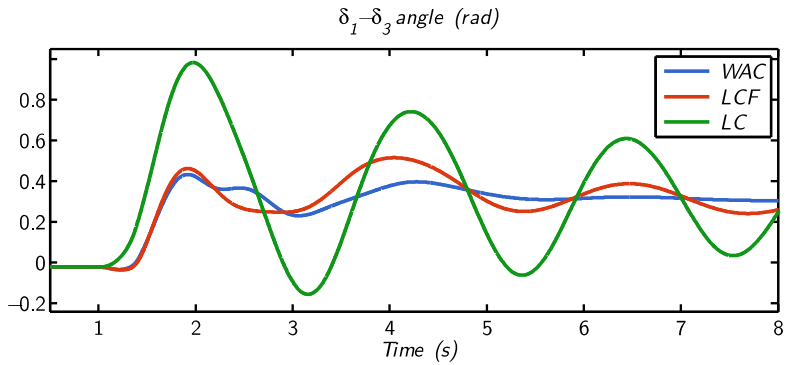
PPC WindOPF

(5-10% reducción)

- Wind turbine control:
  - Mechanical stress mitigation
  - Contribution to voltage stability, frequency regulation and oscillation damping
- Control of renewables with storage
- Wide-area control (WAC) using PMUs
- Application of power electronics:
  - Shunt-series AC-DC links
  - Tap changers

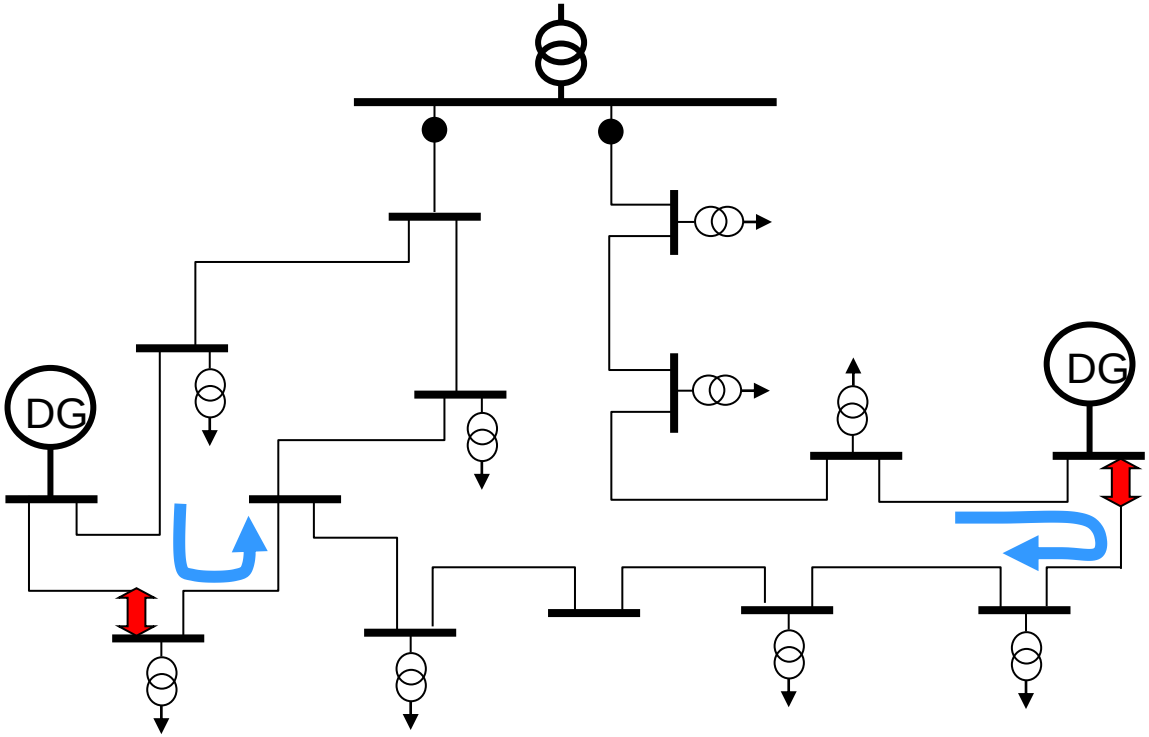






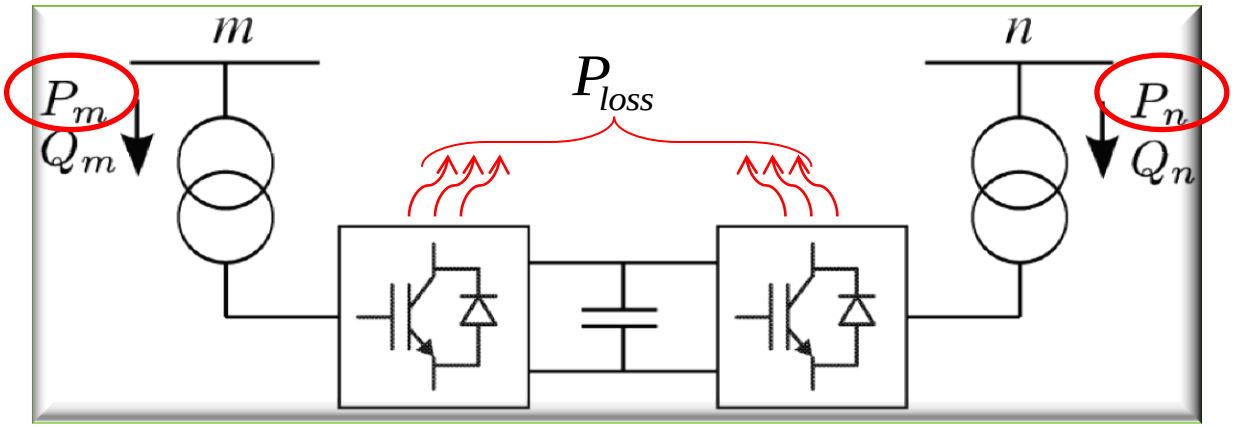
SMARTIE project

Smart links: Replace (normally open) mechanical switches by fully controllable electronic switches



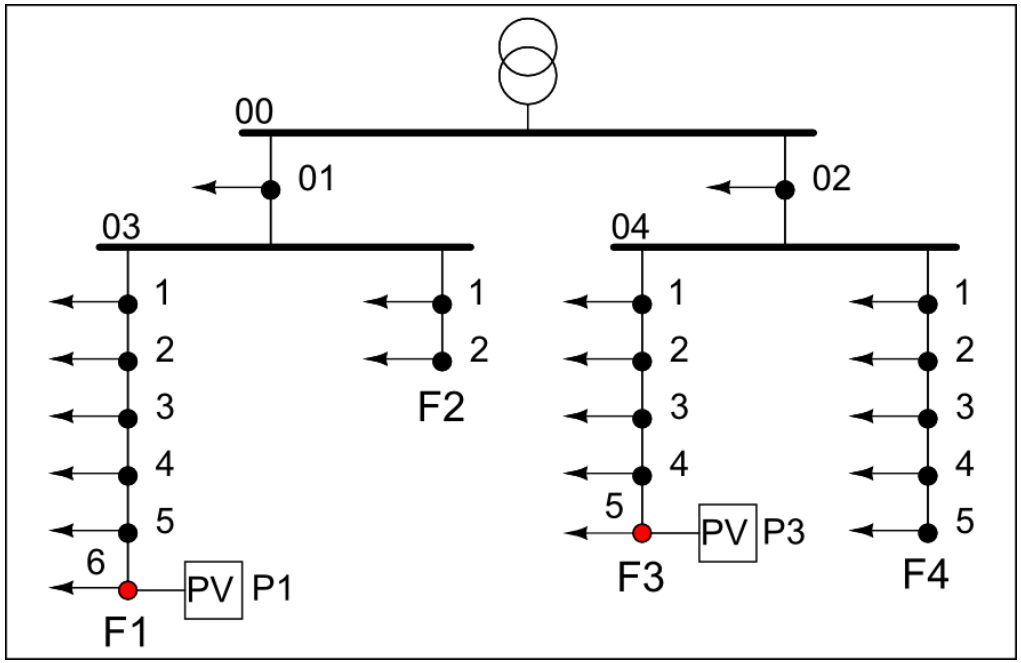
SMARTIE project

Back-to-back PWM **Voltage Source Converters** (VSC)



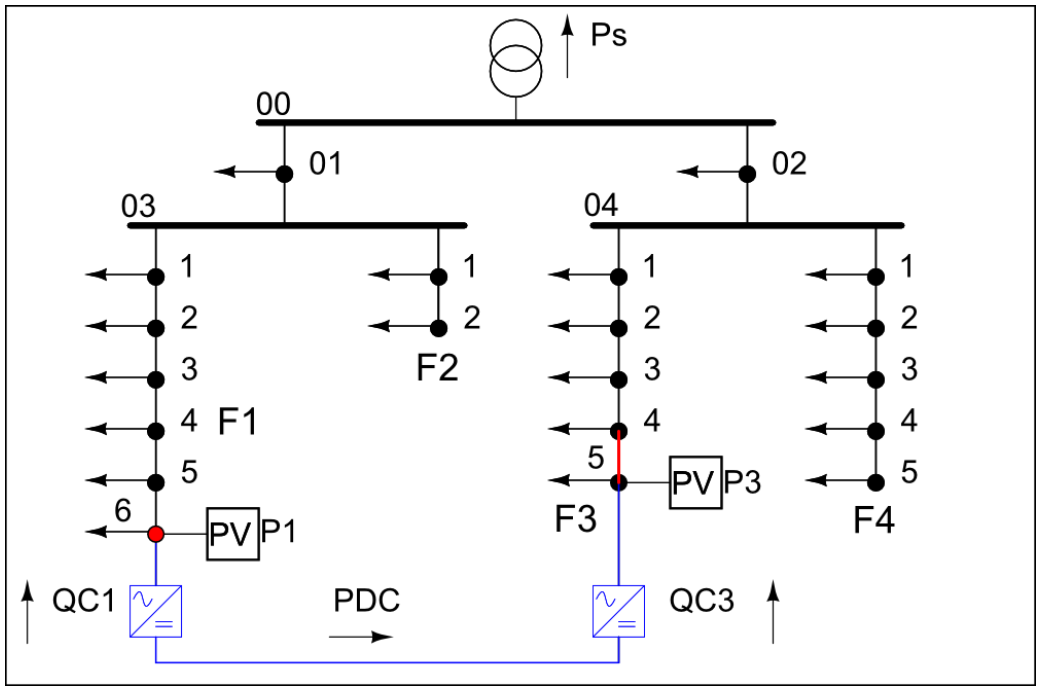
- Three degrees of freedom: P, Qm, Qn
- Short-circuit levels not affected (fast response)
- Same frequency, small voltage drop

Case study: integration of PV in rural feeders



Base case	P1 + P3 = 8.2 MW

Case study: integration of PV in rural feeders



3 control variables

DC link rated power: 3 MVA

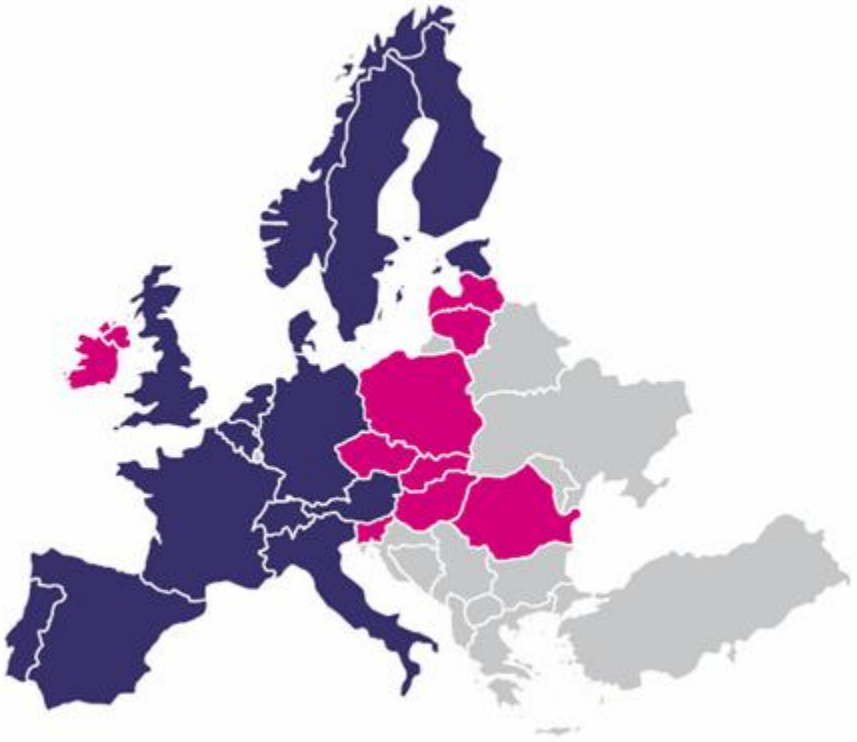
Base case	P1 + P3 = 8.2 MW
Smart link added	P1 + P3 = 9.8 MW

+ 19.9 %

- Wholesale market modeling and simulation
- Local markets (new business models):
  - Prosumer aggregators
  - Microgrids
  - Optimal dispatch with storage (EVs)
- Forecasting tools for optimal bidding
  - Demand
  - Electricity prices
  - Intermittent resources
- Demand-side management & curtailment:
  - Residential
  - Industrial
- Remuneration of distribution activity

GEMS project

The newly interconnected European electricity market is based on the creation of a single-priced region, implicit auctions for interconnections rights and the utilization of a unique algorithm to be implemented in the integrated market.



GEMS project

New European matching algorithm (Euphemia) differs significantly from the algorithm currently implemented in MIBEL market:

- Performs a **simultaneous matching** of bids of purchase and sale for a period of 24 hours.
- Uses the **maximization of social welfare** as the objective function.
- Employs a combinatorial optimization system.
- Enables the use of a hybrid representation of interconnections through the simultaneous use of ATC (with ramping) and network flow models.
- Allows the use of different types of bids to buy/sell energy, in linear or step mode and in several kinds of blocks.
- Allows the inclusion of different types of constraints, e.g. minimum income condition, ramps and linked blocks.

GEMS project

Countries: 8

Bidding Types	Consumer	Producer
Linear	1738	2065
Stepwise	132	669
Fixed Block	64	60
Variable Block	25	30

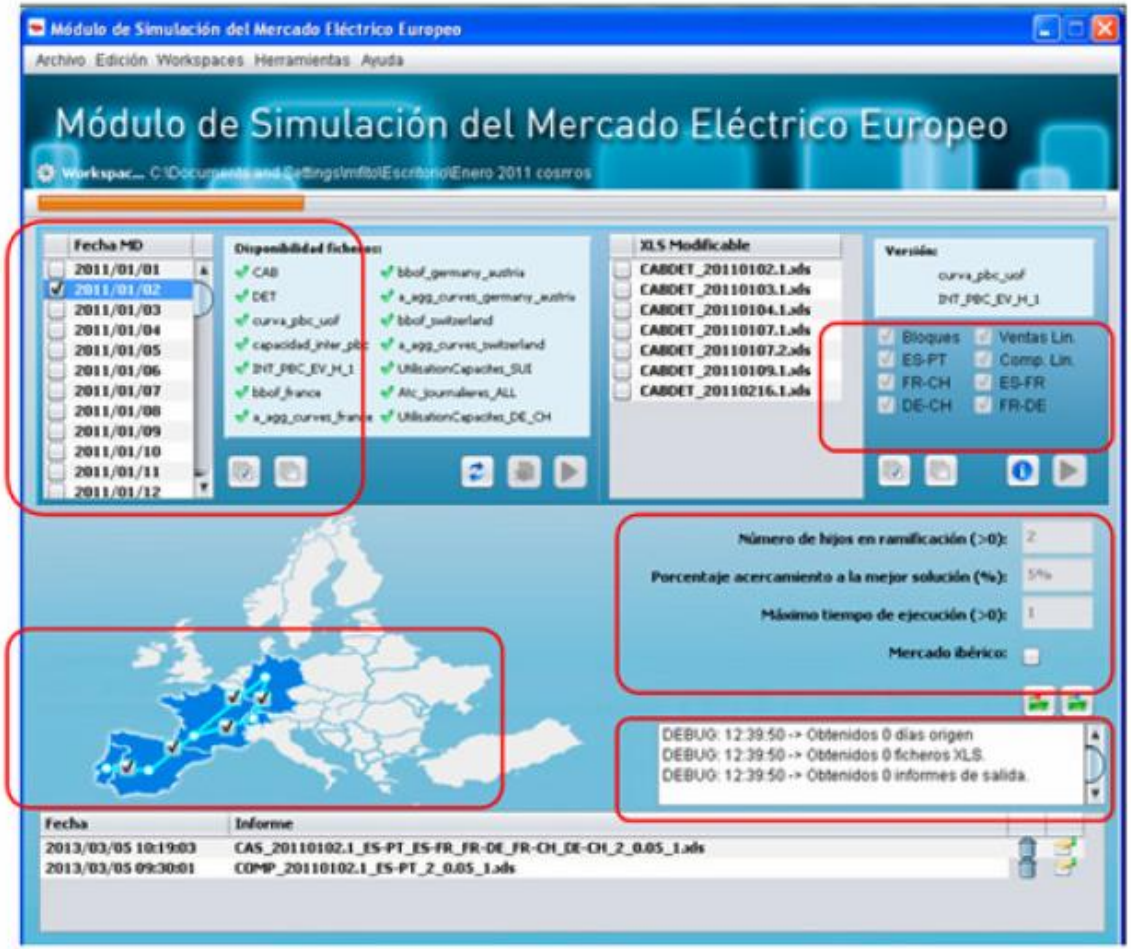
Nº Variables: 150.000 ÷ 300.000

Execution times:

simple matching: 3-5 secs.
complex matching: 5m

GEMS project

Interface by ISOTROL



Historical and modified data available to user

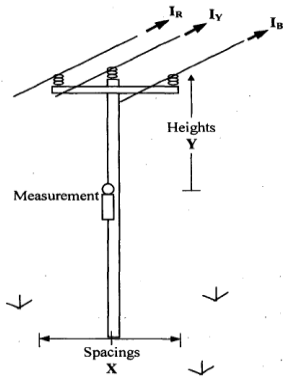
Configurable simulation: Markets and Interconnections

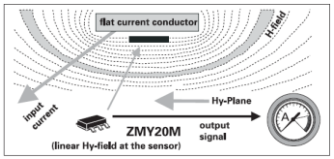
Different simulation options

Algorithm parameters, user configurable

Execution viewer and progress bar

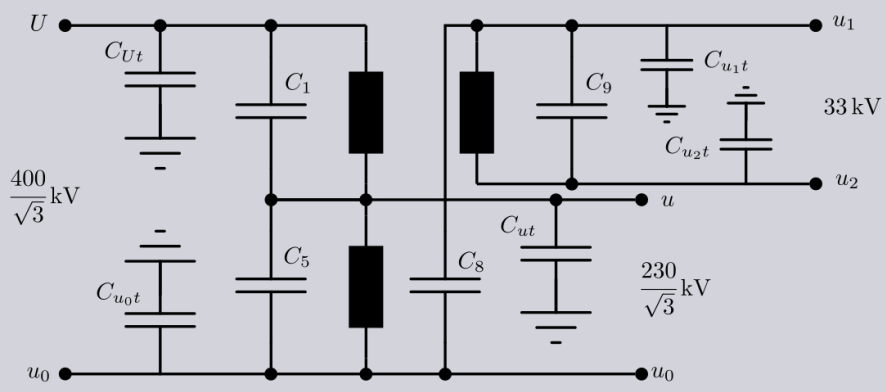
- Electromagnetic transients:
  - FDNE
  - Inrush mitigation
- Insulation coordination
- Fault detection & isolation
- Grounding arrangements
- Wireless sensors



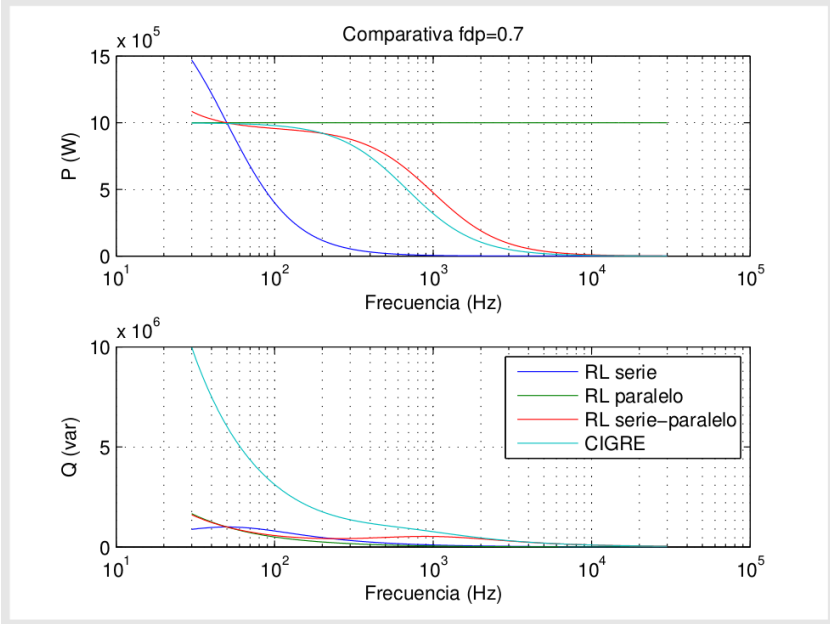


Simulation and mitigation of transients

- **Tools for EMTP simulation of large-scale systems**
  - Accurate component modeling



Autotransformer model

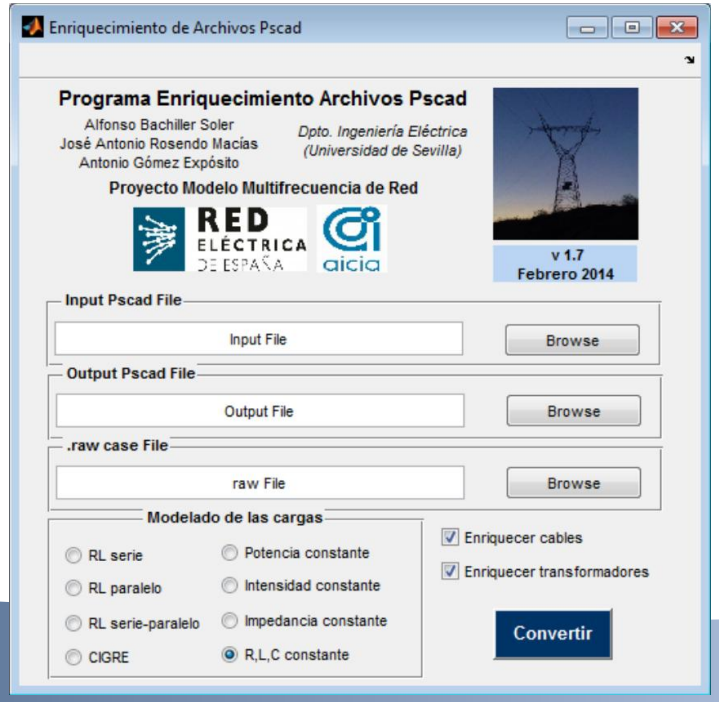


Frequency-domain load models

Simulation and mitigation of transients

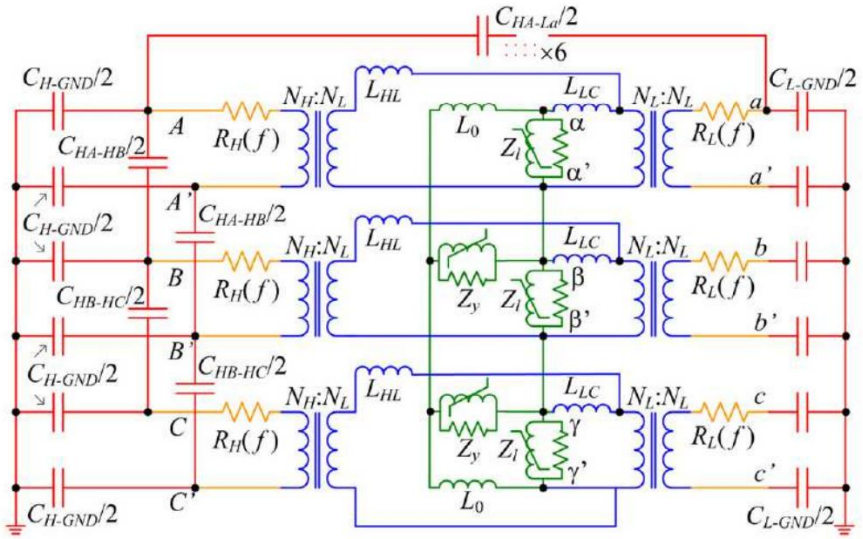
- **Tools for EMTP simulation of large-scale systems**
  - Accurate component modeling
  - Automatic creation of frequency-domain network equivalents (FDNE)

Case study: Spain-France HVDC interconnection (1400 MW)



Simulation and mitigation of transients

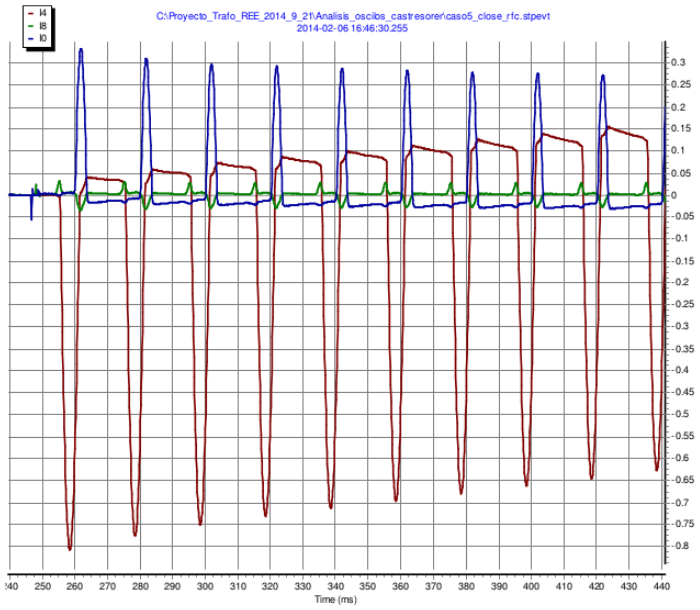
- **Analysis and mitigation of switching transients**
  - Inrush studies: detailed models

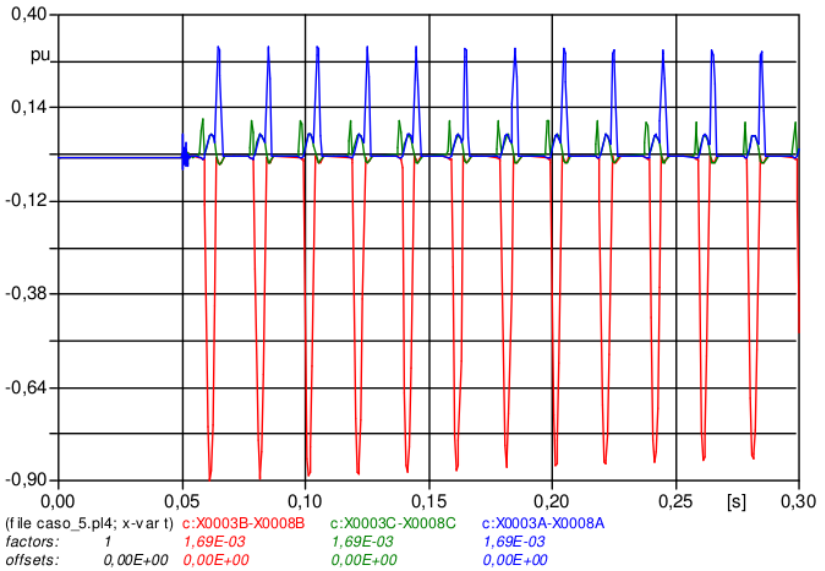


Three-column transformer model

Simulation and mitigation of transients

- **Analysis and mitigation of switching transients**
  - Inrush studies: detailed models

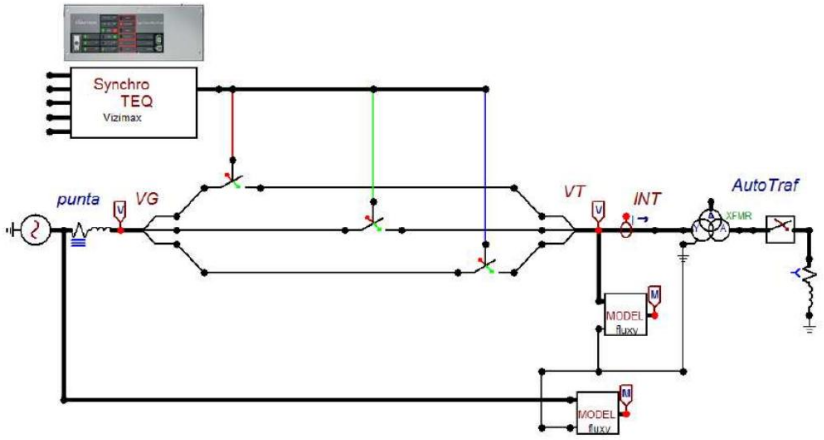




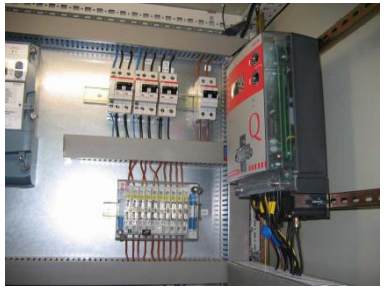
Real (left) and simulated (right) current waveforms

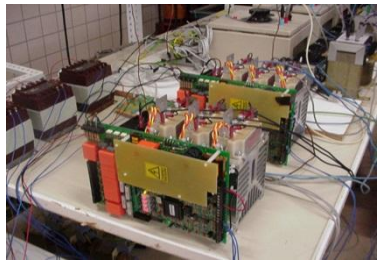
Simulation and mitigation of transients

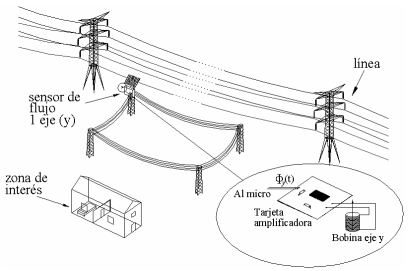
- **Analysis and mitigation of switching transients**
  - Inrush studies: detailed models
  - Mitigation strategies
  - Controlled switching: smart relays
    - Residual flux, CB dynamics

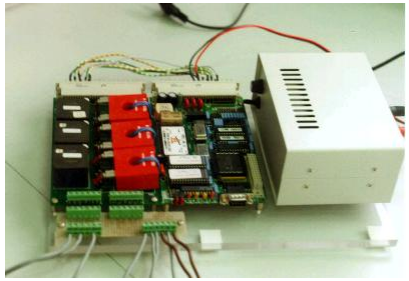


- Waveform monitoring:
  - Public utilities
  - Private customers
- Harmonic mitigation:
  - Passive filters
  - Active filters
  - Hybrid filters
- Mitigation of electromagnetic fields
- Energy efficiency advising for industrial systems and public buildings









Last five years in numbers

- 60 papers indexed in JCR
- 74 international conference papers
- 10 research and educational books
- 8 PhD Thesis
- 35 MSc Thesis
- 4 patents
- 70 R&D&T Projects