

Integrating Massive Wind Power in the Electric System: ACCIONA Experience in Spain

8th Symposium on Power System Management, CIGRÉ

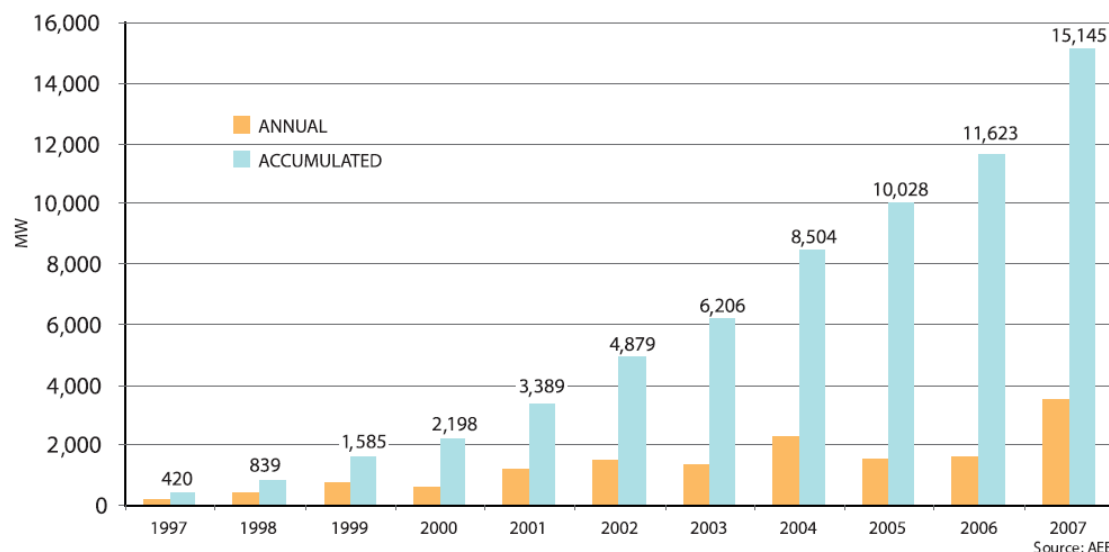
Cavtat, November 10, 2008

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- EVOLUTION OF THE SPANISH WIND SECTOR
- ACCIONA ENERGÍA
- PRODUCTION FORECASTS AND MARKET INTEGRATION
 - Forecast Models
 - Power Sales
- REMOTE CONTROL CENTER (CECOER)
 - REE Requirements
 - The CECOER
 - Main tasks of CECOER
 - Structure and operation of CECOER
 - REE Certification
- REACTIVE POWER CONTROL
- FAULT RIDE-THROUGH CAPABILITY
 - The Rules
 - The Application
- NEW CHALLENGES

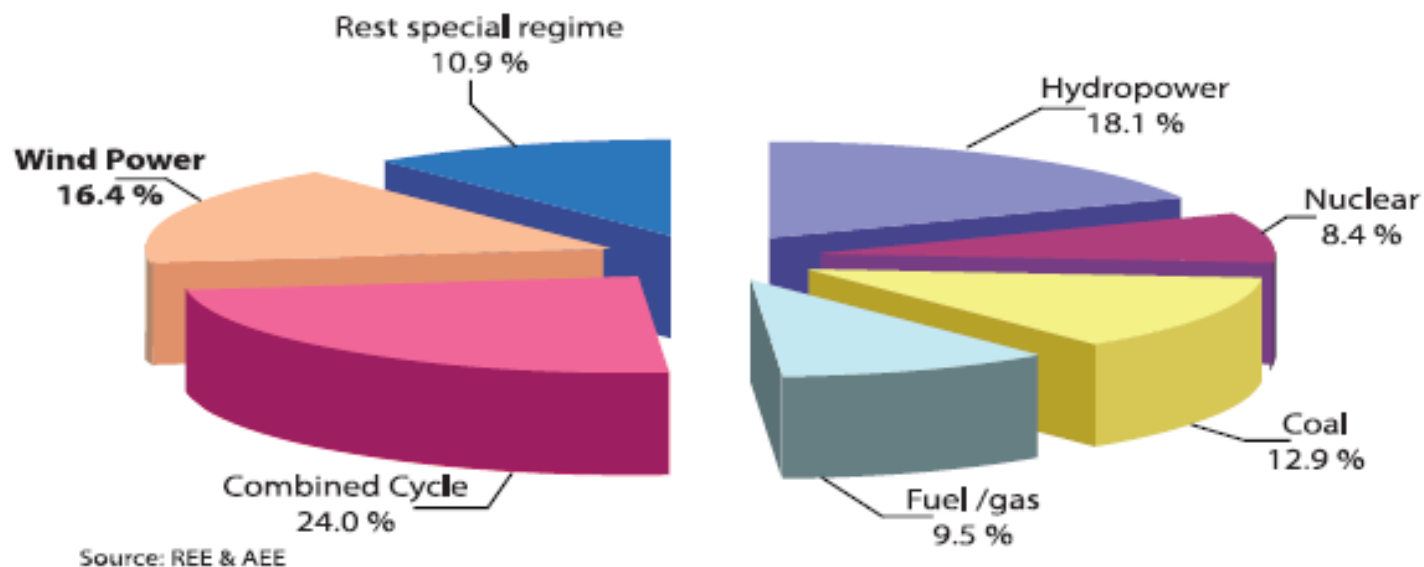
EVOLUTION OF THE SPANISH WIND SECTOR

- 15,500 MW of wind power installed
- 3rd country worldwide in installed wind capacity
- 1st WTG installed at the end of the seventies, 1st WPP in the mid eighties.
- One of the first countries to introduce massive wind power in the system, with Germany and Denmark



Yearly evolution of installed wind power capacity, 1997-2007

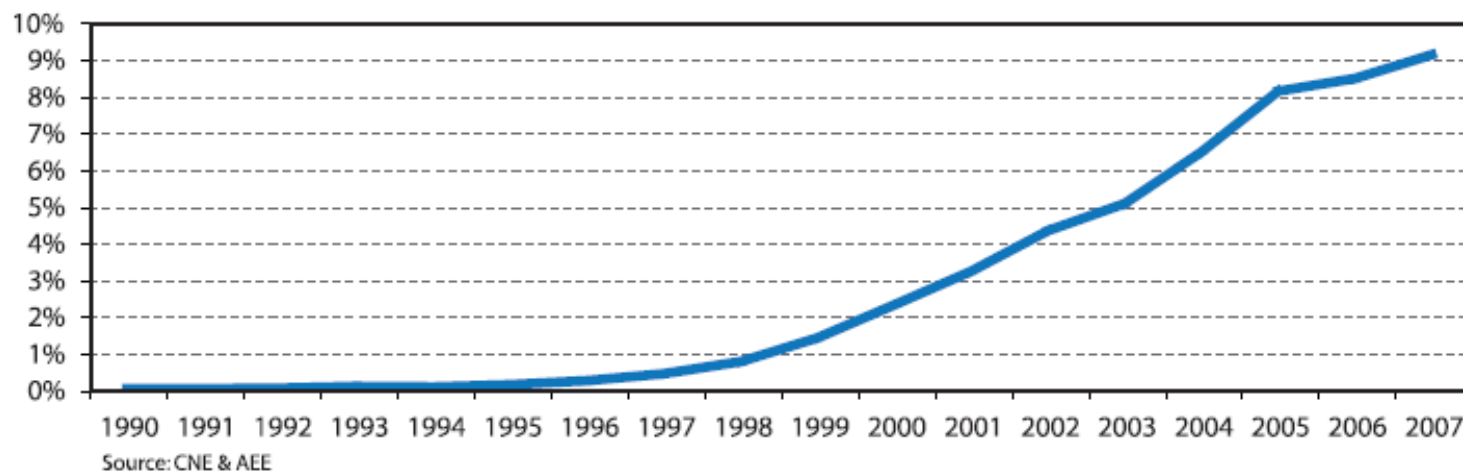
- 3rd generation technology in the country in installed power



Share of power capacity by technology.

National total at December 2007

- 2007: Wind power covered almost 10% of demand, over 30% occasionally
- 2008: Generation record of 10,000 MW
- All historical maximums reached without incidents => Joint work of the wind sector and TSO allows for improvement on integration



Electricity demand covered by wind power, 1990-2007

- World leadership by the leading role of actors in the main world markets exporting knowledge, experience and commitment with the future of this technology
- Pioneer worldwide:
 - Remote Control Centers for Renewable Energies
 - Procedure for testing, validation and certification of the fulfillment of the requirements regarding voltage dips, with the collaboration of REE
- Effort maintained to enhance grid requirements compliance, to keep growing and to improve the operation of the electric system

ACCIONA ENERGÍA

- Key player in wind in Spain collaborating continually with the TSO to improve behavior and operation of WPP and their grid integration
- Leader in the development, construction, O&M of renewable energy facilities, present in all the main technologies
- 1st constructor and developer and 4th operator of WPP in the world
- Manufactures wind turbines: Acciona Windpower, 7th world manufacturer, 2nd in Spain
- 3rd largest owner of wind energy assets in the world, 2nd in Spain.
- Also present in solar (PV & CSP), biomass, small hydro, cogeneration plants and biofuels

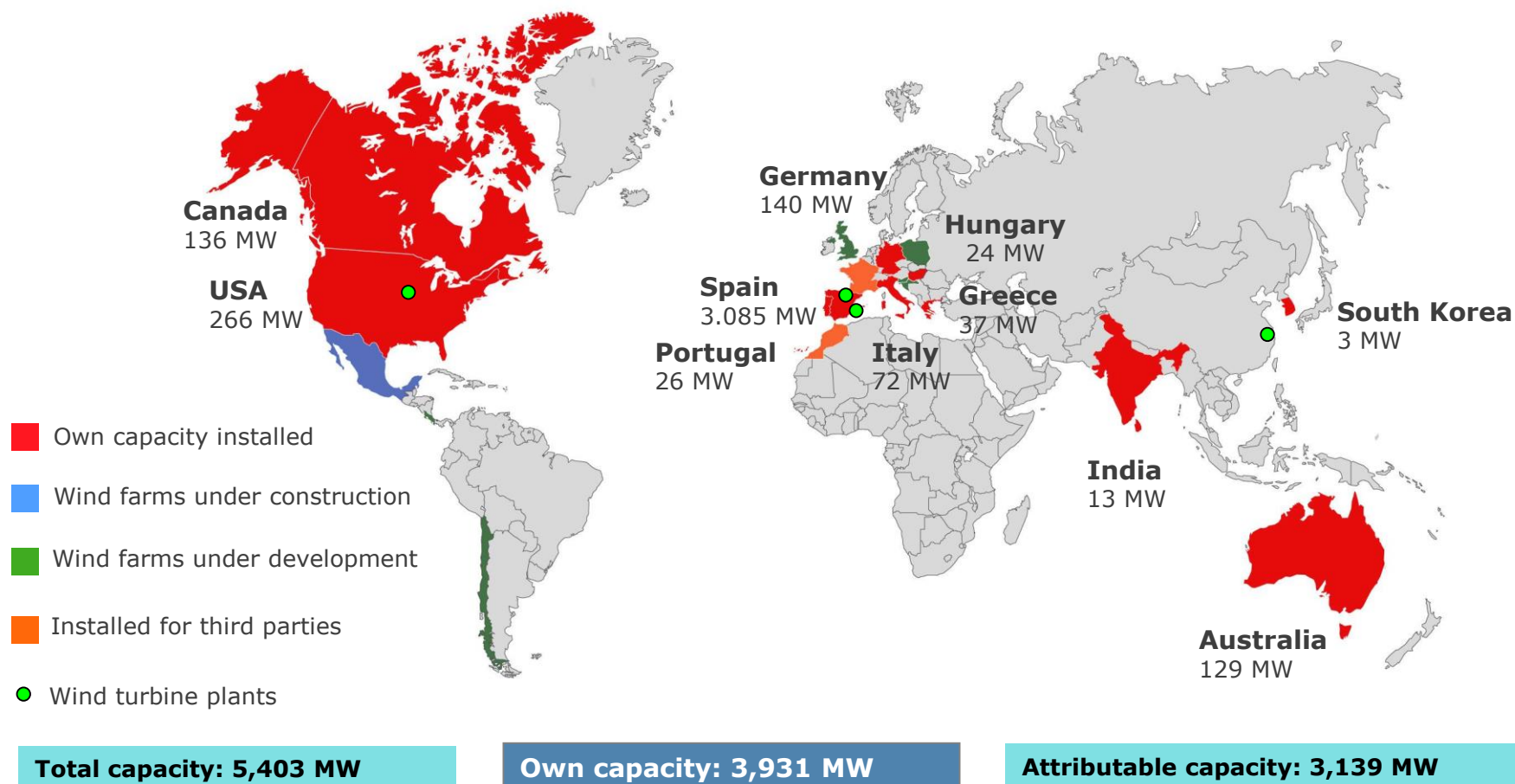


- Acciona Energía is the energy division of the ACCIONA Group, pioneer in development and sustainability
- 35,000 people in over 30 countries in 5 continents
- Other divisions:
 - Acciona Infraestructuras (Infrastructure): Design, engineering, construction, financing and maintenance
 - Acciona Trasmediterránea (Logistics and Transport Services): Passenger and good transport services by land, sea (leader in Spain) and air
 - Acciona Inmobiliaria (Real State): Development of eco-efficient residential buildings and assets management
 - Urban and Environmental Services: Water supply and treatment, solid waste disposal and city cleaning, desalination, car parking, hospitals and multi-services

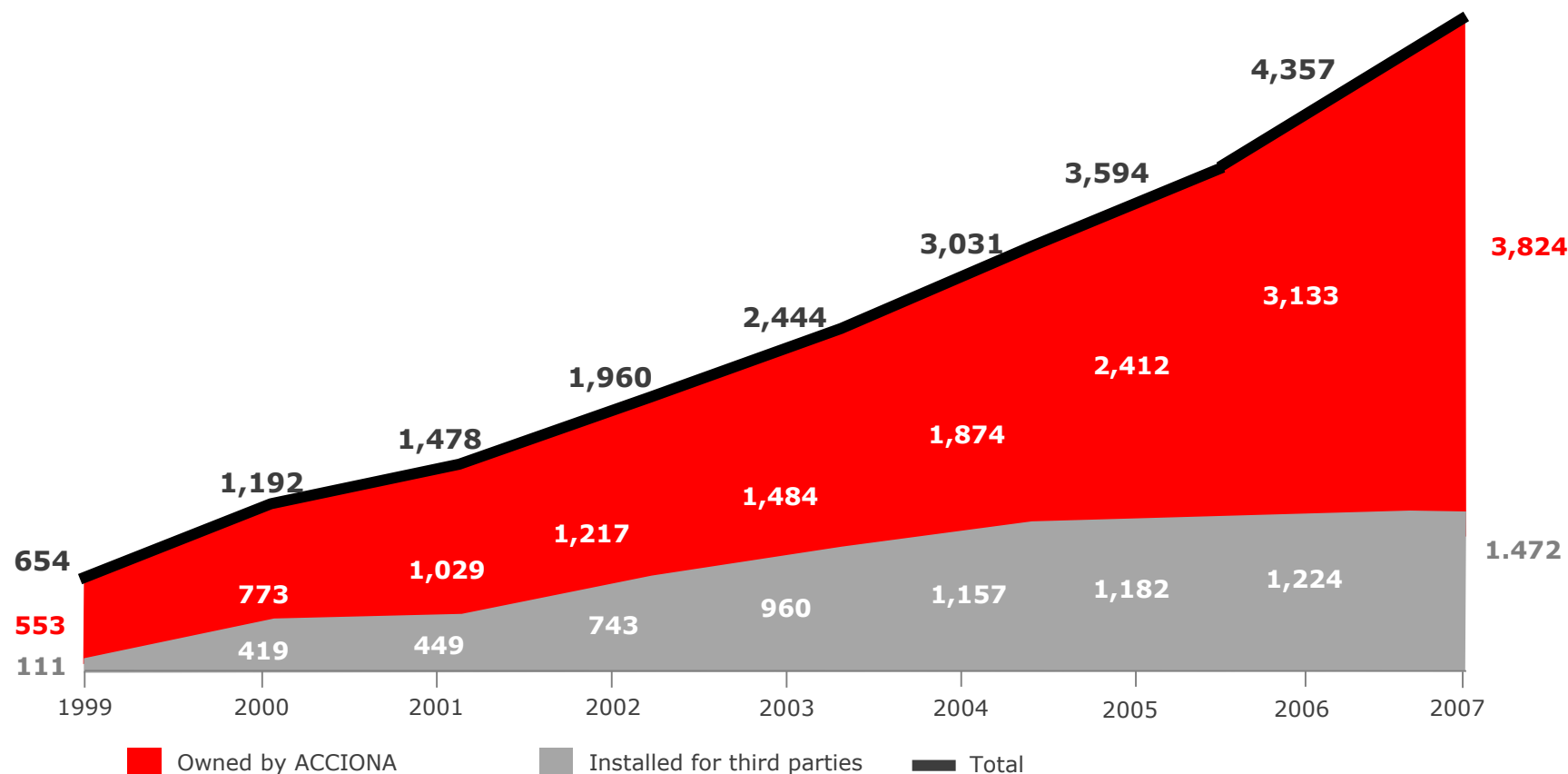




Wind energy implementation by ACCIONA (30.06.2008)

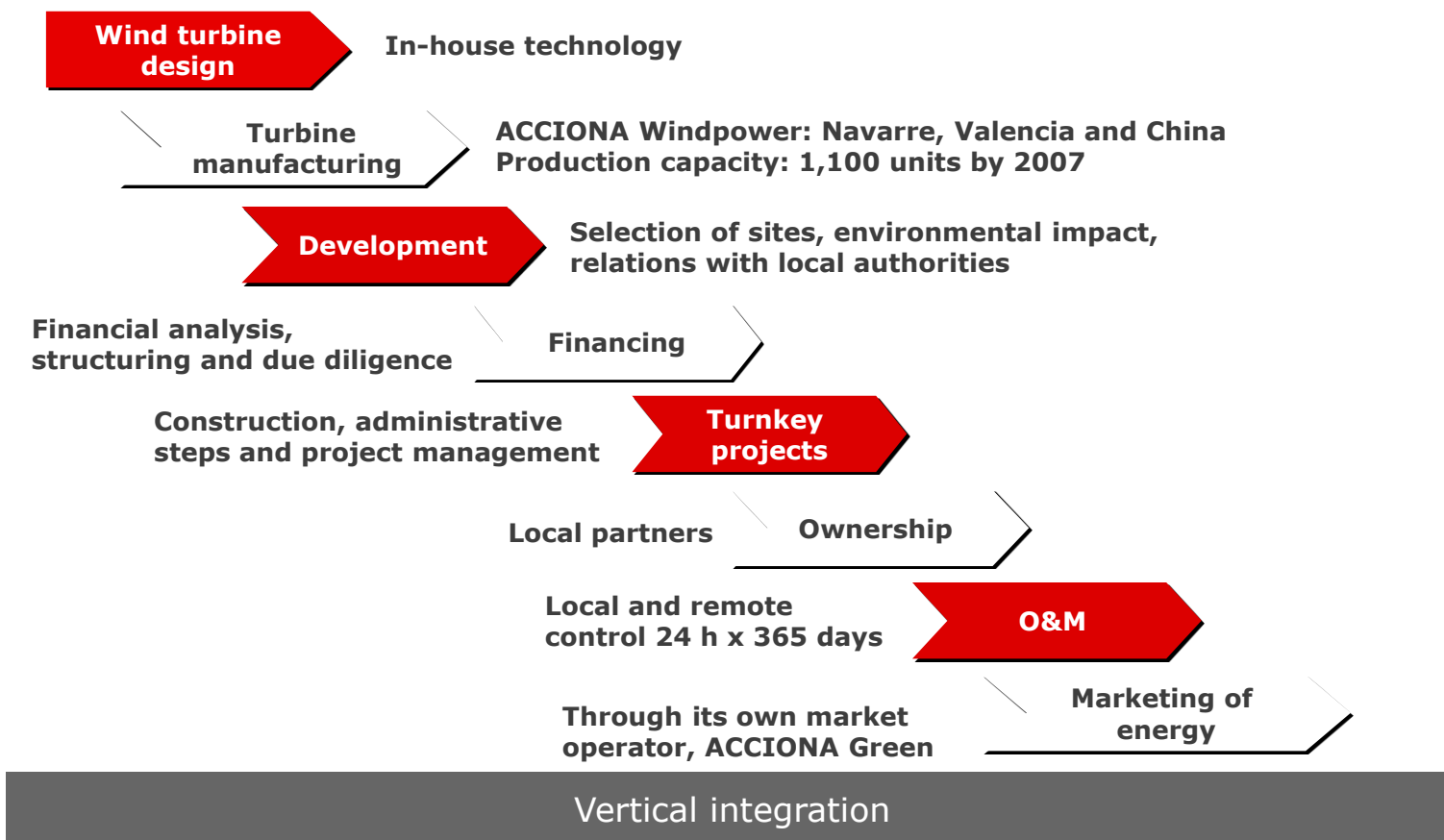


Growth (1999-2007) (MW) (1)



(1) Including annual capacity installed by companies currently belonging to Acciona Energy

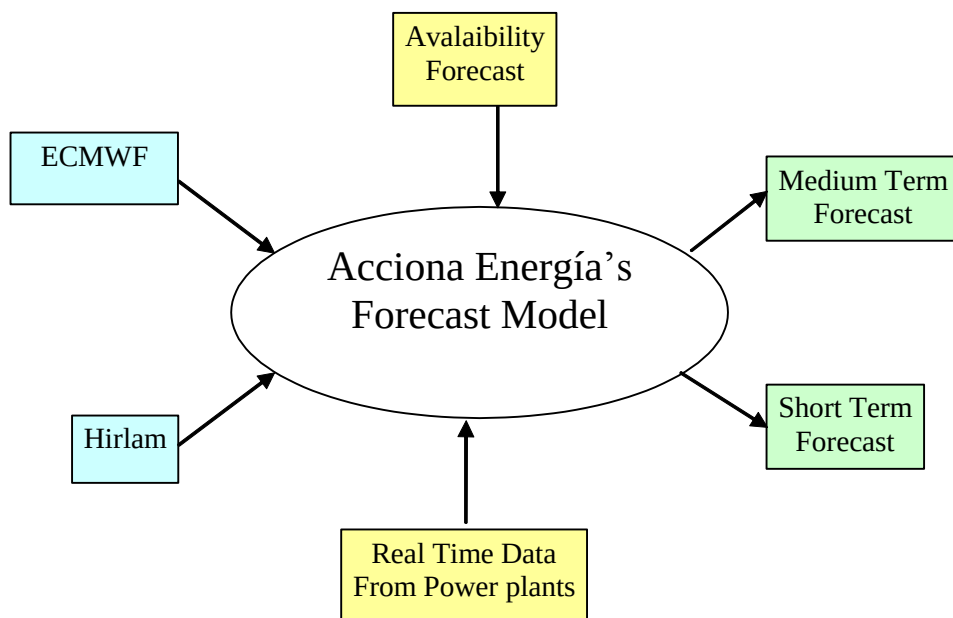
Presence in the entire value chain



- Solid R&D presence: 5 CENITS
 - EOLIA: 18.38 MM€, development of technologies for offshore wind power plants in deep waters
 - SPHERA: 11.73 MM€, search of solutions for hydrogen production from renewable energies
 - MEDIODIA: 9.3 MM€, development of new concepts of advance greenhouses
 - PIIBE: 3.068 MM€, research for promoting the use of biodiesel in Spain.
 - CETICA: 13.962 MM€, search of solutions for the construction of buildings and cities under a model of ecological energetic efficiency.

PRODUCTION FORECASTS AND MARKET INTEGRATION

- Used for O&M planning and participation in electric market, with 8 year experience
- Reduction of spinning reserve needs and improves network management
- >3000 MW covered in Spain, Ireland, Canada and USA
- Several models tested and own model created, which uses combination of different models and WPP on-line information, modular



Two types of forecasts obtained:

- Medium Term Forecast:
 - Used to enter the Spanish daily market and to prepare WPP maintenance schedule.
 - 7 forecasts a day, with horizons up to 120 hours, for daily market program and intraday markets.
 - Accuracy: 50% error when the model is fed by theoretical data, reduced to 40-35% error when fed only by real output data. Margins of error diminished by the aggregation of several WPP.
- Very-short Term Forecast:
 - Result of combining Acciona's medium-short term forecast and real-time WPP production data
 - Output: Prediction for each WPP with horizons up to 48 hours.
 - Best results first hours predicted (horizons 1-10 hours)
 - Improves accuracy up to 5% for intraday markets

- Acciona Green Energy Developments S.L. manages the sale in deregulated power markets of the power produced by renewable and cogeneration power plants (Acciona's and others)
- Most of transactions carried out in daily market, bidding the global production program to the Spanish Market Operator (OMEL) 14 hours before the real power production
- Program corrected in six additional intraday markets, using the last wind forecast prevision and the production availability data => Reduction of economical penalties applied to hourly deviations between program and real production
- Representative with the 2nd highest volume of power negotiated in the market; sales portfolio over 3.600 MW from wind (90%), biomass, hydro and cogeneration (155 facilities) => Important economical benefit in deviations reduction, due to offsets between facilities.
- 6-year experience trading in the wholesale market

Services:

- Access to Market: Advice on the management of administrative procedures (OMEL, REE, Ministry, CNE, Customs)
- Accreditation of Guarantee of Origin of electricity from renewable sources and high-efficiency cogeneration
- Settlements and advice on the management of financial guarantees to OMEL and MEFF
- Other markets: OTC (Over-The-Counter market), OMIP futures market (Portuguese Market Operator), auctions to distributors, bilateral contracts, etc.
- Operational in the wholesale market (OMEL/REE, OMIP) 365 days a year
- Participation in the Portfolio Effect, reducing cost of deviations
- Optimization of operating regimes and programmed maintenance on the basis of electricity prices
- Advice on financial hedges
- Join the Control Centre for Renewable Energies of ACCIONA Energía.
- Marketing of electricity and CO₂.

REMOTE CONTROL CENTER (CECOER)

- Equipped with the human resources and the technology needed to guarantee the operation 24h/365d/year
- Provide real time data of the plants under its supervision, and send the information to REE's Control Center
- Solve problems affecting critical functions in less than an hour
- Redundant SCADA system
- Devoted and redundant lines with a speed of at least 256 kbps
- Protocol ICCP (IEC-60870-8-503. TASE 2), blocks 1 and 2
- Guarantee the real time delivery of data: active power, reactive power, connectivity, voltage, wind speed and direction, temperature.
- Guarantee that each minute it will receive and follows the signals of maximum power output per node and type of WPP calculated by REE's Control Center

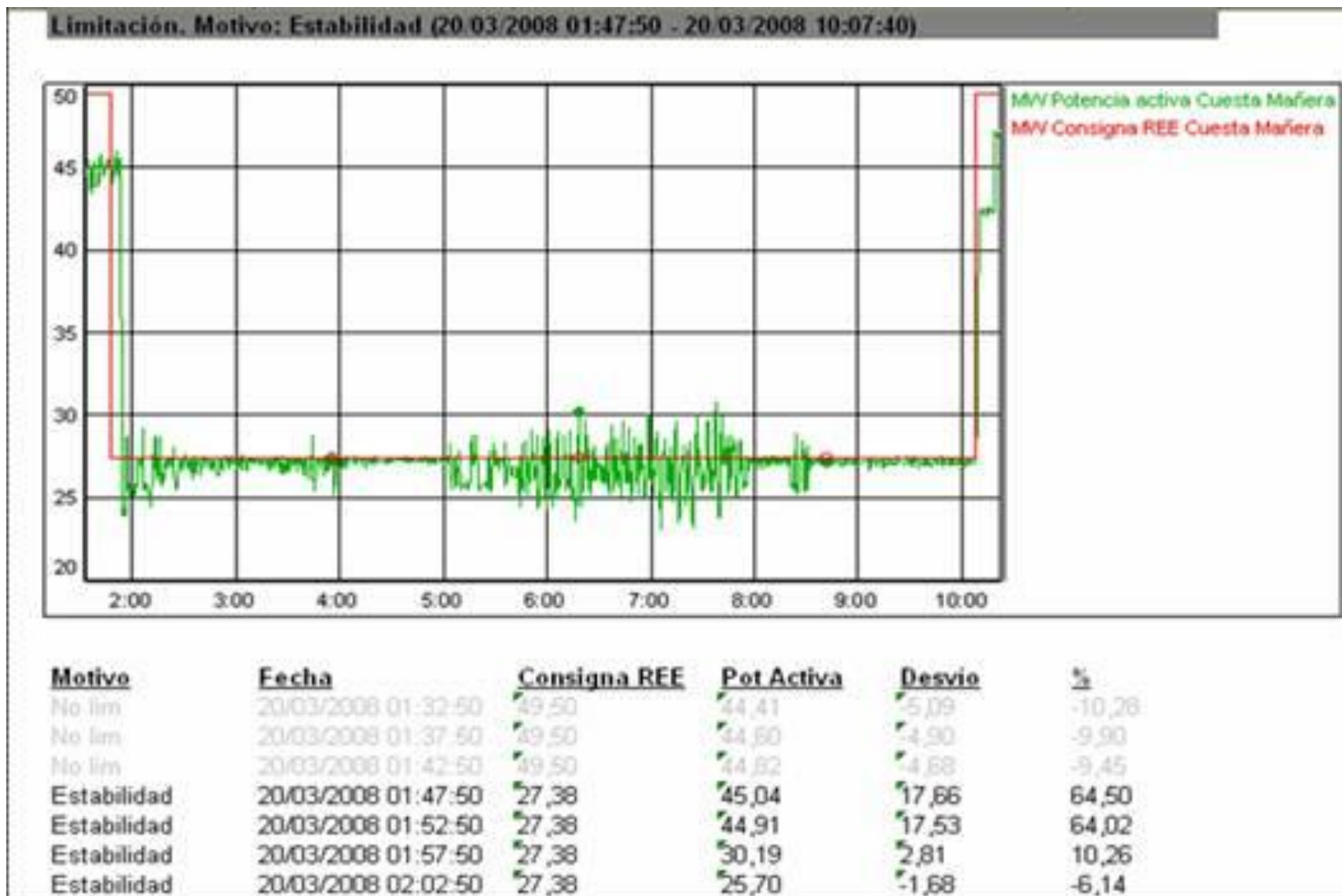


Biggest control center of renewable energies in Spain and the 2nd worldwide, with 15 years experience in control, supervision and operation of WPP, hydro and solar, substations and meteorological stations

- Control and Supervision on real time of operating parameters (wind turbines, hydro, solar plants, substations, lines, met stations, etc.)
- Operation of plants through delivery of orders and set points, solving over 60% of incidences by remote control, or coordinating with service team on site.
- Management of the electric energy:
 - Preparation and delivery of energy production plans to Acciona Green
 - Management of measurement system for settlement and invoicing processes of energy sales (controls over 300 metering devices)
- Interaction as Control Center with all control centers of REE
- Acquisition, storage and analysis of the information gathered, increasing the availability and efficiency of the power plants
- Maintenance of the high voltage substations and lines (over 80 SETS)
- Management of the maintenance works through GMAO
- Watch and ensure permanently the fulfillment of legal requirements of the electric sector for the special regime, optimizing the economic results of the energy sales

- Takes into account security and safety of people and facilities
- Takes care of the environmental impact of the facilities
- Masters the technologies operated:
 - Guarantee the life cycle of the equipment
 - Maximize the economic performance of the projects
 - Reach maximum availability of power plants networks
 - Optimization of O&M costs and energy forecast planning
- Controls WTG of Acciona Windpower, Gamesa, GEWE, Vestas, Neg Micon, Lagerwey, Enercon and Kenetech
- Controls hydro turbines type Pelton, Francis, Kaplan and SemiKaplan.
- Numbers:
 - 36 persons
 - 165 Spanish WPP, 5105 WTG and 5066.93 MW
 - 21 WPP in Germany, France, Canada and USA (327 MW)
 - Biomass 25 MW, PV 1.2 MW, 25 mini-hydro 62 MW

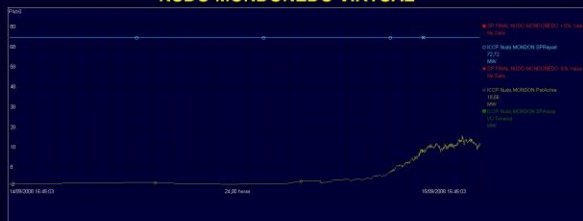
EXAMPLE OF ACTIVE CONTROL



Lunes, 15 Septiembre de 2008 6:45:03

Regulación de Potencia Activa **ACTIVADA**

NUDO MONDOÑEDO VIRTUAL



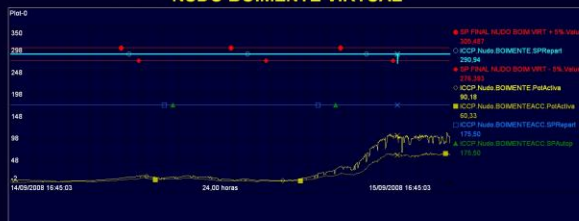
Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Mondoñedo Acc	79.5	18.7	78.0	60.6	0-NOLIM	D	OK
MONDOÑEDO VIRTUAL	113.1	18.7	78.0			D	

NUDO OLITE 220 kV



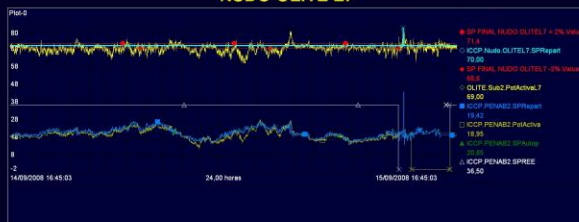
Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Alaiz	33.1	31.3	33.1	36.4	0-NOLIM	H	OK
OLITE 220	209.6	133.0	167.1	155.0		MN	

NUDO BOIMENTE VIRTUAL



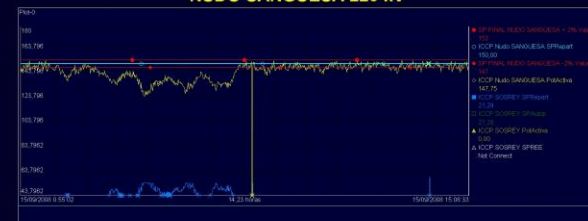
Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Boimente Acc	0.0	60.3	175.5	175.5	0-NOLIM	H	OK
BOIMENTE VIRTUAL	271.7	90.2	293.7			MP	

NUDO OLITE L7



Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Peñablanca II (L7)	36.5	18.9	36.5	19.4	0-NOLIM	H	NO
OLITE L7	209.6	68.0	69.6	70.0		MN	

NUDO SANGÜESA 220 kV



Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Sos Rey Católico	48.7	3.2	18.8	4.5	0-NOLIM	H	OK
SANGÜESA 220	226.2	148.8	162.6	150.0		MN	

NUDO ORCOYEN - LA SERNA



Parque Eólico	P Nom MW	P Act MW	SP REE MW	SP Final MW	Motivo	Reg	Autp
Caraquidoya	15.0	0.0	16.5	16.5		H	OK
Egastiaga	6.0	1.5	6.6	6.6		H	OK
ORCOYEN-LA SERNA		275.5	0.0	298.0		MN	

Internacional

Nacional

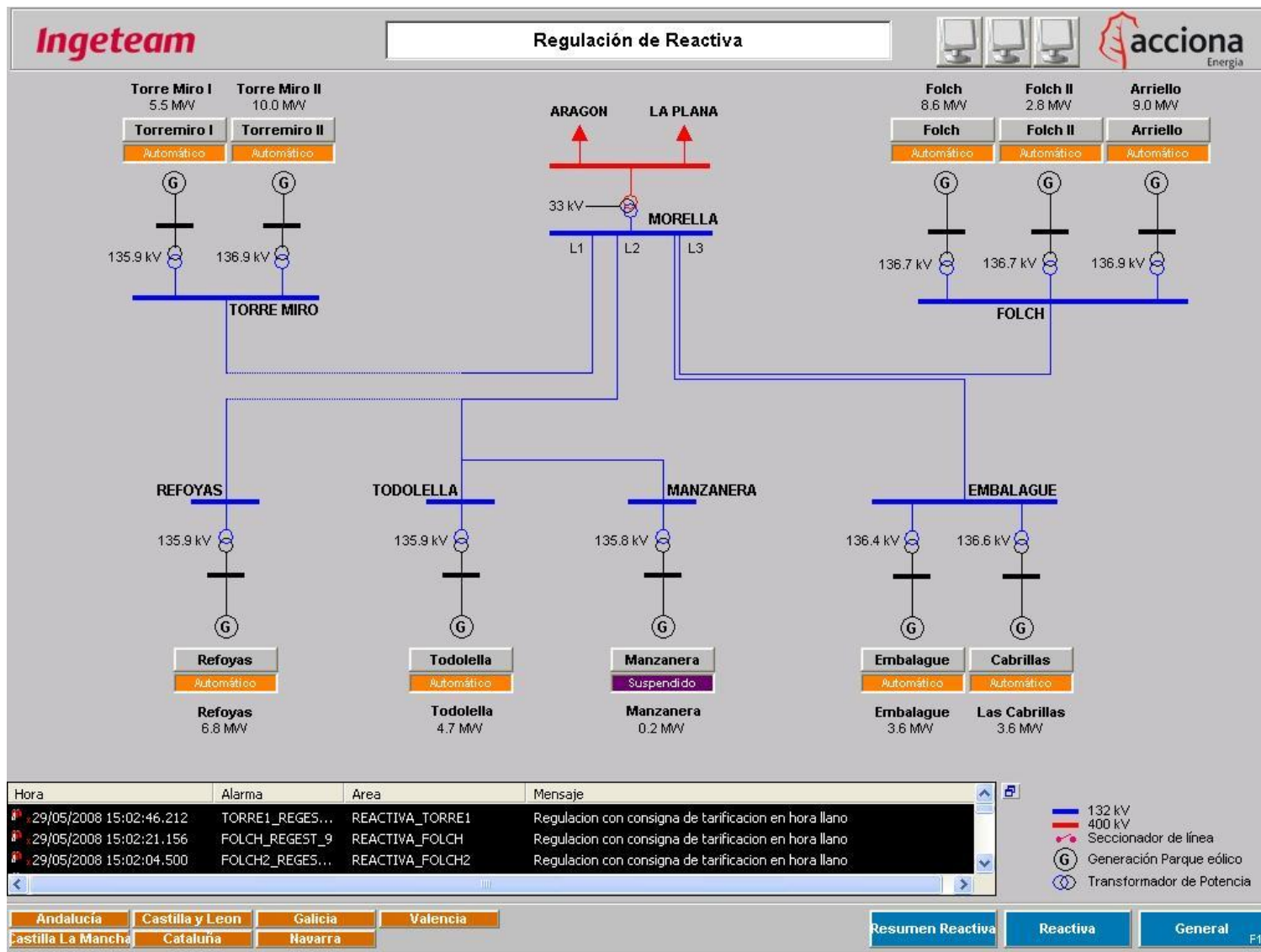
Unifilares

Esquema General

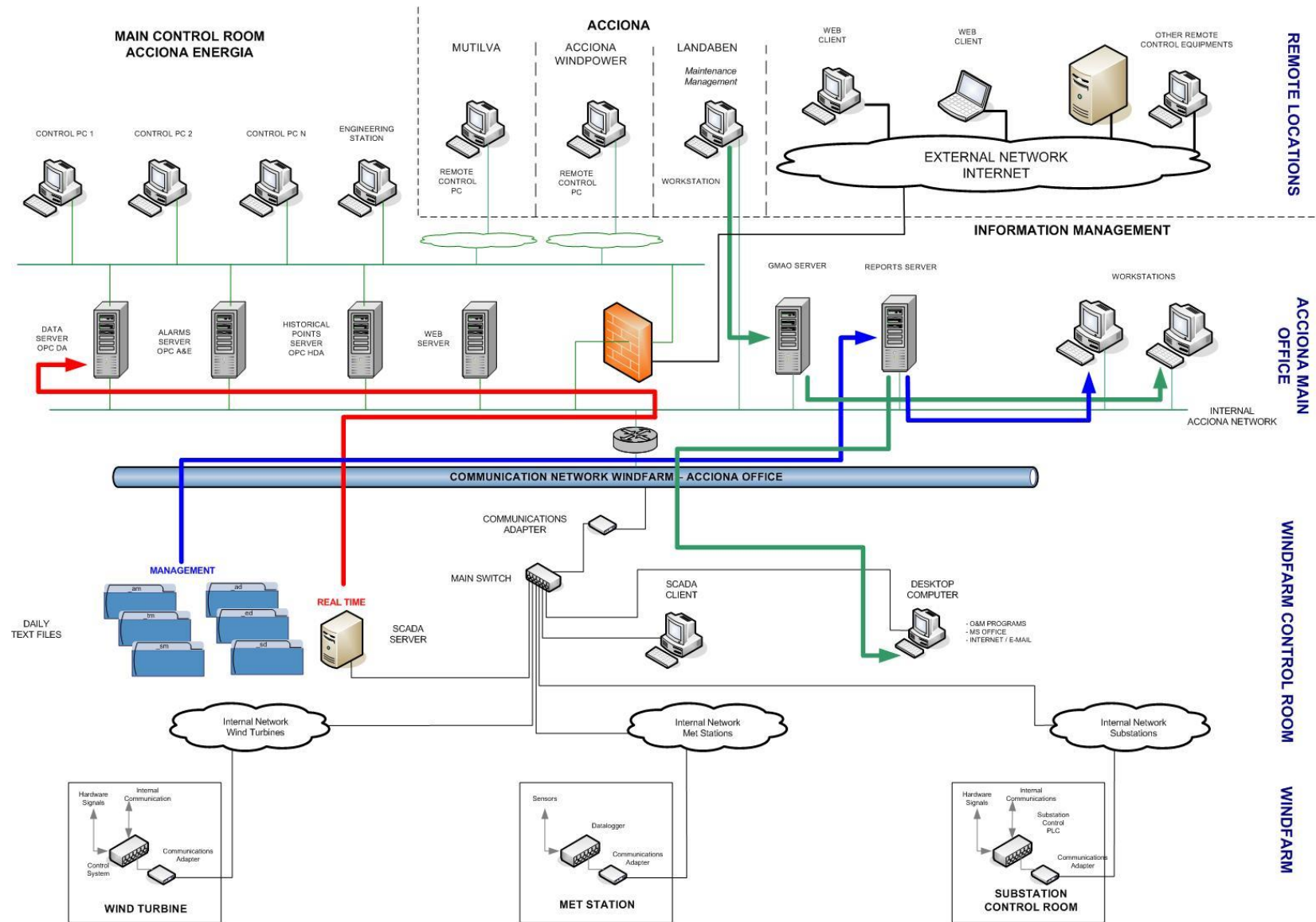
Resumen REE 1

Resumen REE 2

Potencia Activa



STRUCTURE OF CECOER





Madrid, 2 de febrero de 2007

César Sola Ayape
Acciona Energía
Avda. Ciudad de la Innovación 5
31621 Sarriguren (Navarra)
Ref: DO-CE/07-003

Una vez realizadas por nuestra parte las comprobaciones pertinentes de los siguientes extremos:

- Disponibilidad y operatividad de un sistema de control, así como sus comunicaciones, adecuado y suficiente para suministrar en tiempo real a los centros de control de Red Eléctrica la información establecida en los procedimientos de operación vigente.
- Disponibilidad de un turno de operación 24 horas con los recursos, tanto humanos como materiales, suficientes para realizar la función de interlocución con los centros de control de Red Eléctrica con el fin de poder seguir y ejecutar sobre las instalaciones bajo su control las instrucciones recibidas de éstos en su calidad de Operador de Sistema.

Red Eléctrica estima que el Centro de Control CECOER de Acciona Energía cuyos datos básicos de contacto son:

Dirección: Avda. Ciudad de la Innovación 5
Teléfonos de contacto: 948006315
Fax: 948006451
Correo electrónico: cecoer@acciona.es

Cumple en el momento de emitir esta carta con las condiciones mínimas exigibles a un centro de control de acuerdo con la normativa vigente. Cualquier modificación de los puntos arriba indicados, incluidos en el alcance de esta certificación, deberá ser comunicada al Operador del Sistema en el menor plazo posible.

Adjuntamos anexo con la organización y datos de contacto de los centros de control de Red Eléctrica. Por otra parte les informamos para su conocimiento y efectos que, como es norma habitual en el sector eléctrico, Red Eléctrica graba todas las conversaciones telefónicas que efectúan sus centros de control.

Finalmente le comunicamos que de no recibir instrucción en contra por su parte incluiremos en un plazo de 15 días su centro de control dentro de la lista de centros de control habilitados que Red Eléctrica mantiene en su página Web (www.ree.es).

Atentamente,



Fdo.: Tomás Domínguez Atrán
Jefe del Centro de Control Eléctrico

REE Certifies:

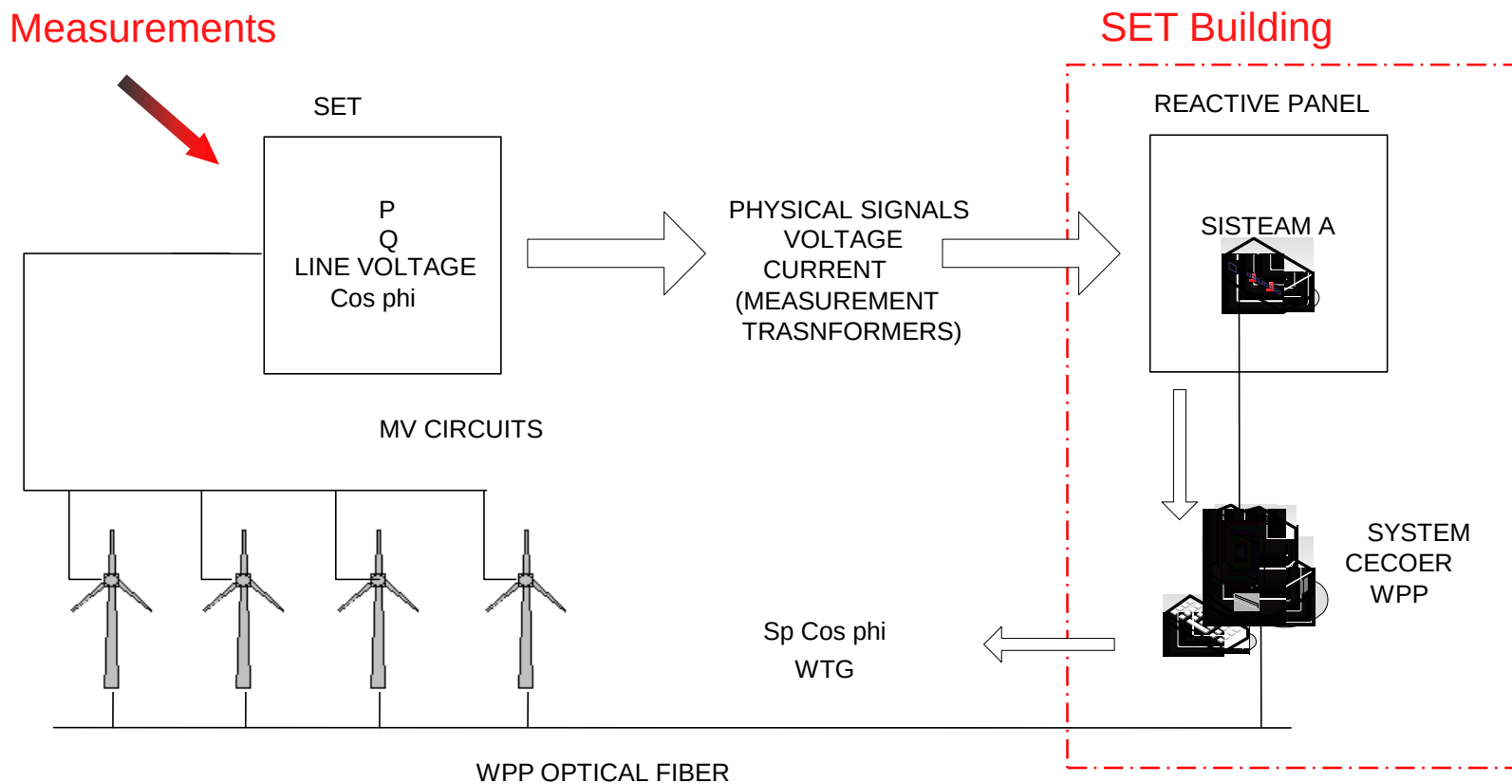
- Compliance with the regulation in force applicable to RCC
- Availability, adequacy, sufficiency and operability of the control and communication systems and real-time the information exchange
- Availability of operation shift 24h (human and material resources), to follow and execute REE instructions

REACTIVE POWER CONTROL

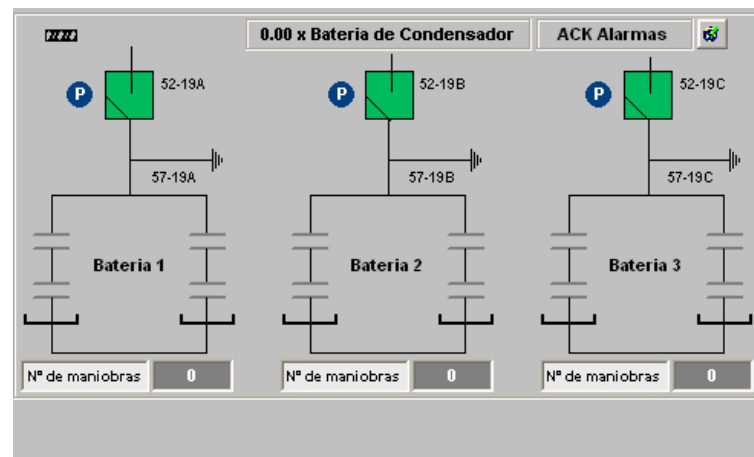
POWER FACTOR	COS ϕ	% Q/P	% OF THE MEAN REFERENCE TARIFF (Aplied to the cosPhi measured every 15-min)		
	Range		PEAK (4 hours)	OTHER (12 hours)	OFF-PEAK (8 hours)
Inductive	<0.95	> 33 %	-4	-4	8
	<0.96 y ? 0.95	29 % - 33 %	-3	0	6
	<0.97 y ? 0.96	25 % -29 %	-2	0	4
	<0.98 y ? 0.97	15 %- 25 %	-1	0	2
	<1.00 y ? 0.98	> 15 %	0	2	0
Unit	1	0	0	4	0
Capacitive	<1.00 y ? 0.98	> 15 %	0	2	0
	<0.98 y ? 0.97	15 % - 25 %	2	0	-1
	<0.97 y ? 0.96	25 % -29 %	4	0	-2
	<0.96 y ? 0.95	29 %- 33 %	6	0	-3
	<0.95	> 33 %	8	-4	-4

Following signals from REE = Maximum bonus

CONTROL LOOP OF REACTIVE ENERGY



- Automatic (maintaining WTG operating securely inside V margins):
 - Following Q signal of SET
 - Following Q signal sent by CECOER
 - Following PF values of bonus table
 - Following V signal of SET
- Manual: Following PF signal set on WTG
- Also control cap banks



SUMMARY SCREEN

Ingeteam

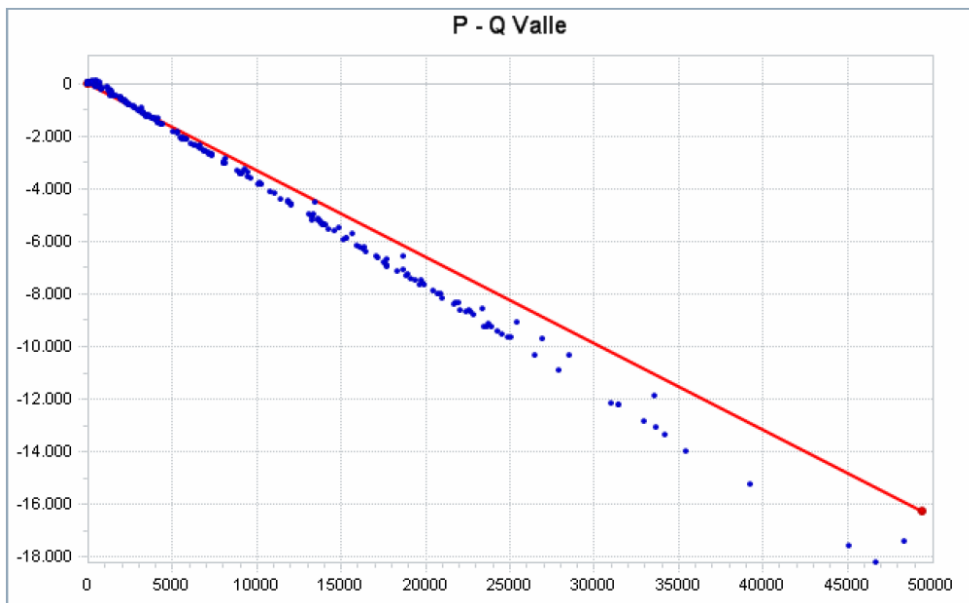
Regulación de Reactiva

acciona

Energía

Nombre Parque	Incid	Sisteam A	Reactiva.exe	Estado	Intervalo de tarificación	Potencia Reactiva	Cos phi	Potencia Activa	Tensión de línea		
NUDO CORDOVILLA 13											
AIZKIBEL	0	OK		Automático	Hora Llano	0.4 MVar	Cap	971	1.8 MW	13 %	66.2 kV
VILLANUEVA	0	OK		Automático	Hora Llano	0.0 MVar	Ind	1000	2.0 MW	12 %	66.1 kV
PERDON	0			Automático	Hora Llano	0.2 MVar	Cap	1000	5.4 MW	25 %	66.1 kV
NUDO LAGUARDIA 13											
ARAS	0	OK	OK	Suspendido	Hora Llano	0.5 MVar	Cap	353	0.0 MW	0 %	228.0 kV
NUDO OLITE 220 kV											
ALAIZ	1	OK		Automático	Hora Llano	-0.0 MVar	Ind	1000	5.3 MW	16 %	67.9 kV
MONCAYUELO	0	OK	NO COM	Saturado	Hora Llano	0.1 MVar	Cap	973	0.4 MW	1 %	66.9 kV
PEÑABLANCA II	0	OK		Automático	Hora Llano	-0.0 MVar	Ind	1000	4.4 MW	13 %	67.3 kV
VEDADILLO	1	NO COM	OK	Automático	Hora Llano	-0.0 MVar	Ind	991	0.5 MW	2 %	66.8 kV
NUDO SANGÜESA 220 kV											
AIBAR	2	OK		Suspendido	Hora Llano	0.1 MVar	Cap	886	-0.1 MW	1 %	68.7 kV
SALINAS DE IBARGOITI	0	OK		Automático	Hora Llano	0.0 MVar	Cap	1000	1.1 MW	5 %	68.8 kV
IZCO	1	OK		Suspendido	Hora Llano	0.1 MVar	Cap	733	-0.1 MW	0 %	68.7 kV
SALAJONES	29	OK		Suspendido	Hora Llano	-0.1 MVar	Ind	599	-0.0 MW	0 %	68.8 kV
SIERRA SELVA	3	OK		Automático	Hora Llano	-0.1 MVar	Ind	1000	3.6 MW	11 %	68.6 kV
NUDO TAFALLA 13											
ETXAGUE	2	OK		Automático	Hora Llano	-0.1 MVar	Ind	1000	3.3 MW	13 %	68.4 kV
PEÑABLANCA	0	OK		Suspendido	Hora Llano	-0.1 MVar	Cap	1000	2.3 MW	16 %	66.8 kV
NUDO TAFALLA 33											
LERGA	2			Habilitado	Hora Llano	0.1 MVar	Cap	80	-0.1 MW	0 %	67.3 kV
SAN MARTIN	1			Habilitado	Hora Llano	0.1 MVar	Cap	-224	-0.0 MW	0 %	67.0 kV
Andalucía Castilla y león Navarra Castilla La Mancha Cataluña Valencia Resumen Reactiva Reactiva General											

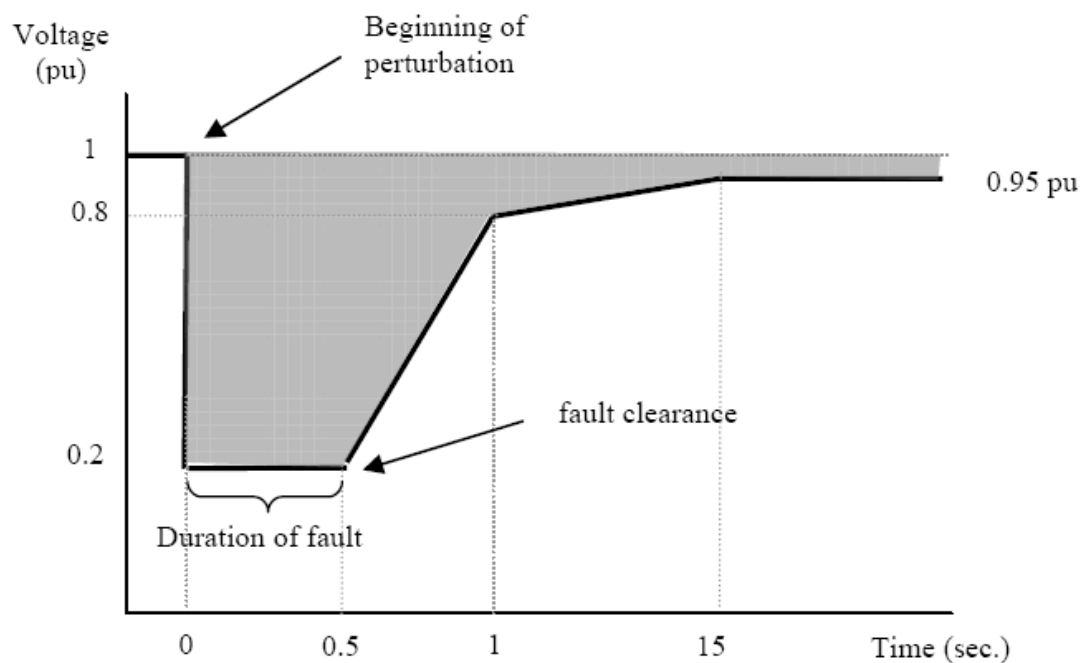
EXAMPLE OF REACTIVE CONTROL



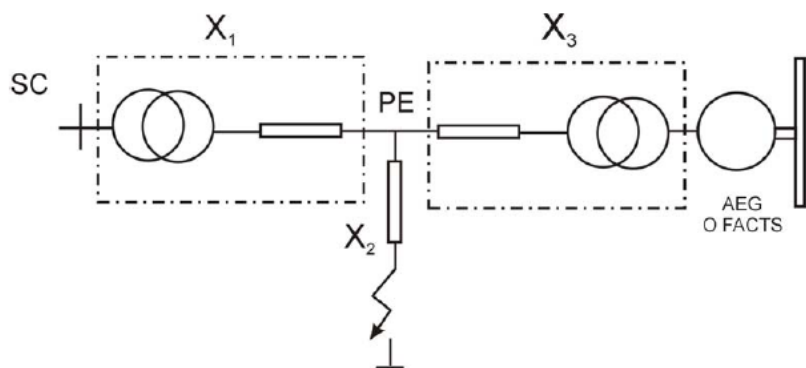
Valle			Cos Phi			CER %
P %	Nº Datos	Éxito %	Maximo	Medio	Mínimo	
0 - 10	117	14,53	1,00	0,76	0,00	5,91
10 - 20	39	100,00	0,94	0,94	0,93	8,00
20 - 30	26	96,15	0,95	0,93	0,93	7,92
30 - 40	26	100,00	0,94	0,93	0,93	8,00
40 - 50	21	100,00	0,94	0,93	0,93	8,00
50 - 60	7	100,00	0,94	0,93	0,93	8,00
60 - 70	7	100,00	0,94	0,93	0,93	8,00
70 - 80	2	100,00	0,93	0,93	0,93	8,00
80 - 90	0					
90 - 100	3	100,00	0,94	0,93	0,93	8,00
TOTAL	248	90,08				7,83

FAULT RIDE-THROUGH CAPABILITY

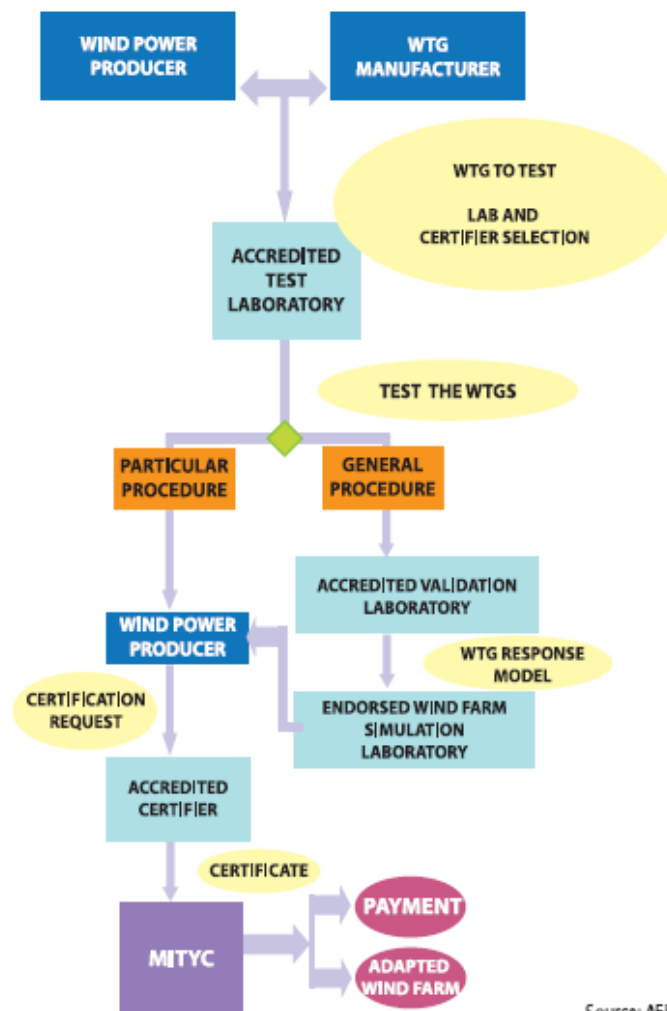
- WPP could disconnect below 85% U_n
- WPP concentrated on transmission nodes => Risk of voltage dip extension and of loosing several hundreds MW
- Stability study (using detailed models) performed jointly by Iberian TSOs and Spanish wind sector lead to PO 12.3



- Procedure for verification and certification developed by wind sector+REE+CNE+AENOR (CTV)
- Testing for complying WTG (particular process)
- Simulation for WPP (general process), when WTG need external device to fulfill requirements
- Very detailed standard



General design for PVVC compliance



Source: AEE

- WTG from 2007 installed complying (crowbars, FACTS or new converters)
- 2 generations of older WTG
 - 1995-2000: Fixed speed SFIG and 1st designs of DFIG & FC
 - 2000-2006: Variable speed SFIG and evolved designs of DFIG & FC
- Retrofit at machine level for 2nd generation, adapting existing solutions
 - Challenge: Test in field, installing in operating WPP, lack of materials and human resources
 - Ongoing in 2007-2008, over 7000 MW certified, 50% WPP
- 1st generation still a huge challenge
 - Old WPP and WTG, possible repowering
 - Manufacturers don't provide solutions => New solutions developed from FACTS
 - Parallel or series solutions, at WTG or SET
 - Difficulties in testing, industrialization, production (lack of resources)
 - Delays in planned schedule, still over 7200 WTG to retrofit

=> REQUIREMENTS MUST BE PLANNED IN ADVANCE!

NEW CHALLENGES

- New regulation on voltage dips and voltage control expected, as well as other enhancements, **but only in new WPP**
- Lesson learned: very convenient that **new regulation is discussed with the sector with enough anticipation** (around two years) as to permit adequate development of new technologies and improve grid integration
- Very active participation of Acciona in all process in Spain => exportable experience in collaborating with TSO and in ruling development
- High skilled team devoted to required improvements, AW WTG and CECOER enhancement, weak grids, storage, power quality, offshore WPP, hydrogen, desalinization, etc.

Thank you for your attention

8th Symposium on Power System Management, CIGRÉ

Cavtat, November 10, 2008

Elizabeth Giraut Ruso
Responsible for Grid Integration
Grid Interconnection Department
Contact: egiraut@acciona.es
