

FOSSIL FUEL POWER PLANTS: SOLUTIONS TO IMPROVE FLEXIBILITY

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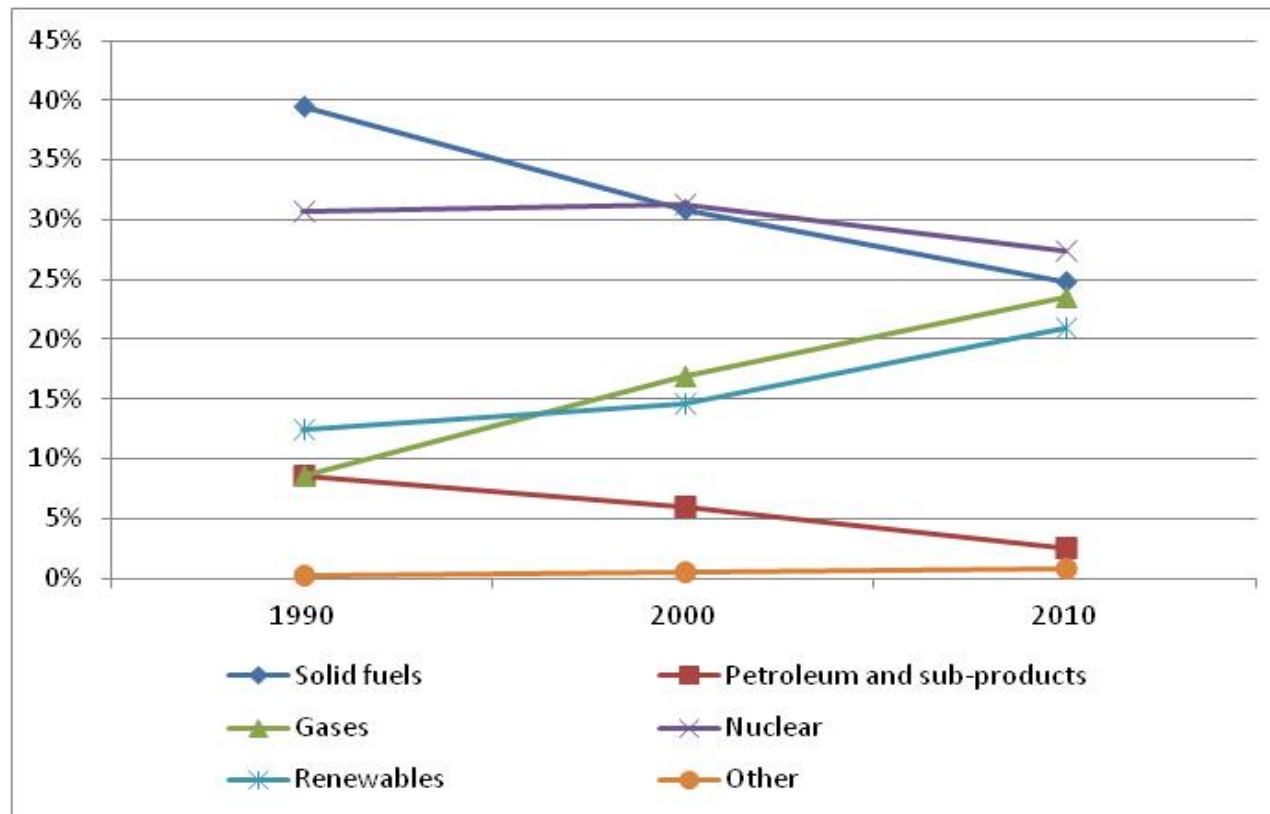
Enel - Engineering & Research Division

Outline

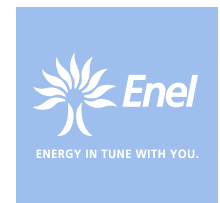
- ❑ Evolution of power generation markets in EU, Italy, Spain
- ❑ Enel plants in the current production scenario
- ❑ Enel's actions to increase competitiveness of CCGT plants
- ❑ Power generation on islands
- ❑ Remarks

EU power generation structure evolution

EU-27 electricity generation (1990-2000-2010)
(Gross electricity generation by fuel)



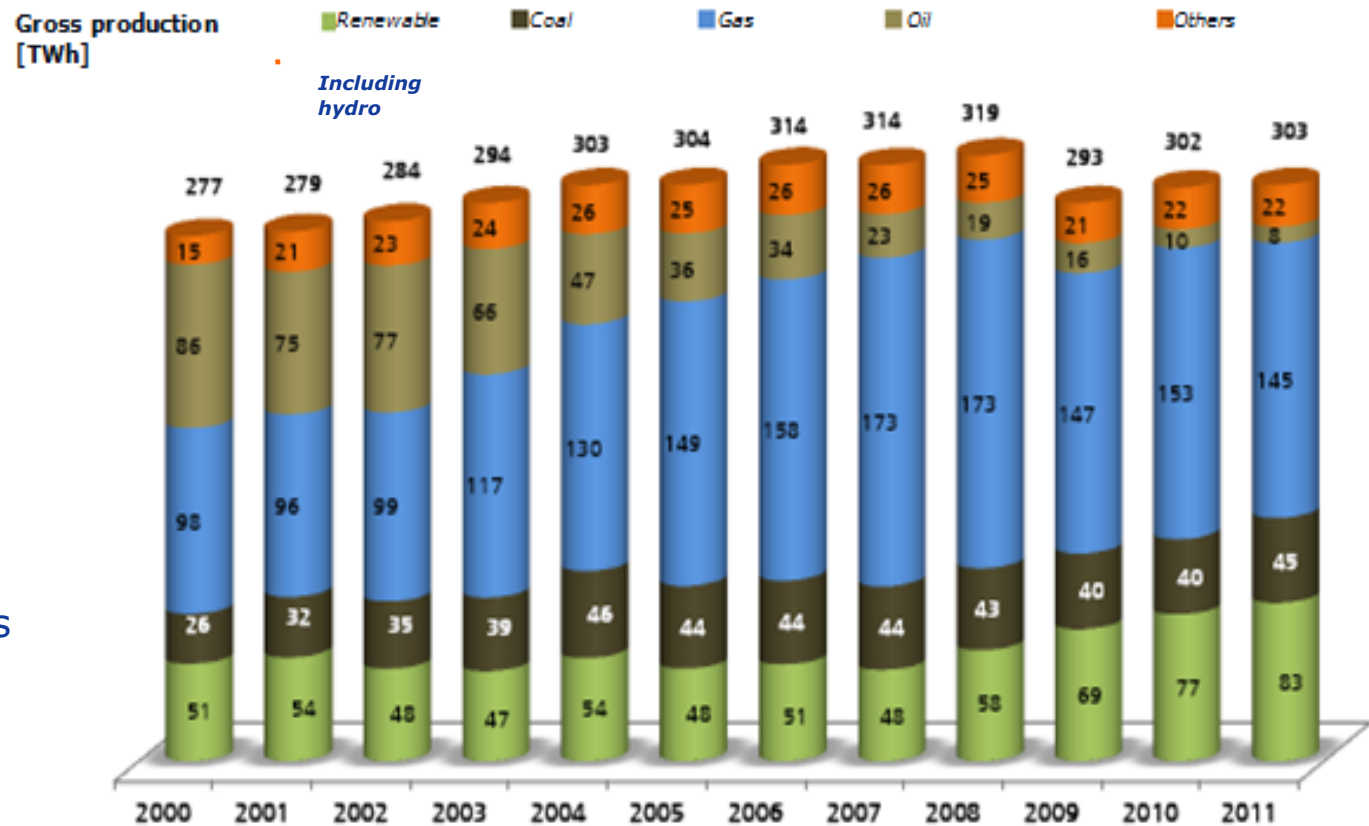
Note: Hydro is considered within RES



Italian power generation sector

Evolution of the generation mix

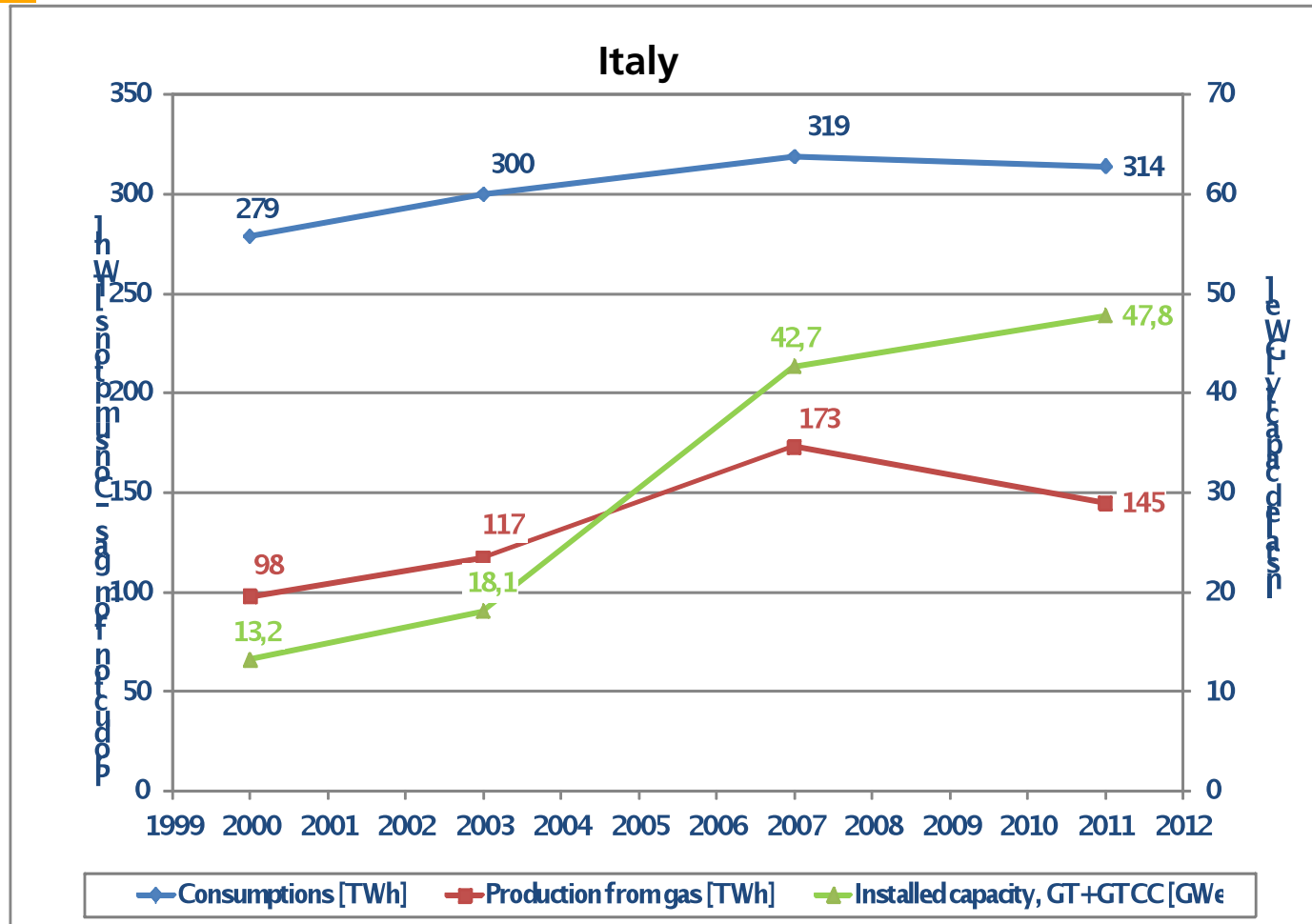
- ❑ Disappearance of oil generation
- ❑ Strong increase in RENEWABLES
- ❑ Slight decrease in gas



Source: GSE 2011 report

Italian market

Installed gas capacity vs. production

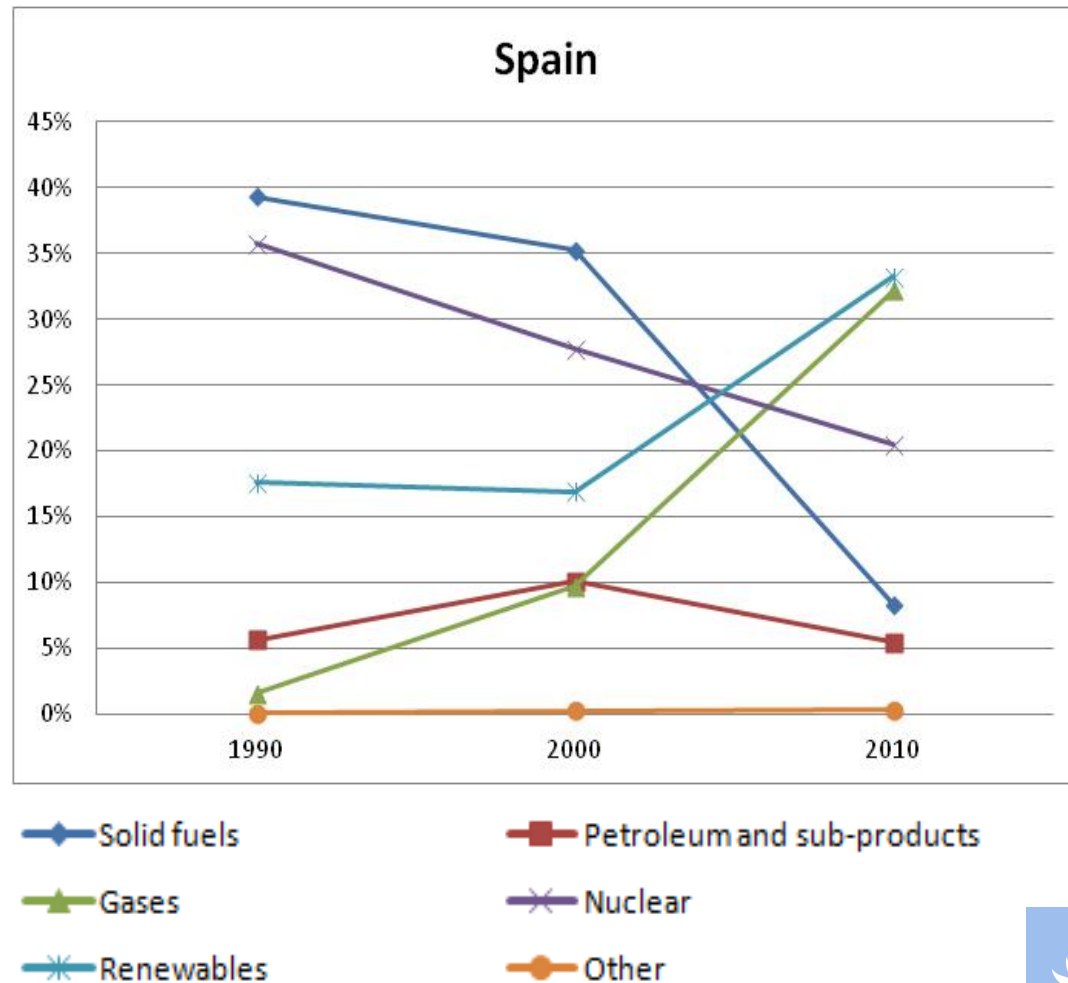


2007-2011: installed gas capacity has increased, but in the last years an important reduction in generation has occurred and this trend is not changing

Spanish power generation sector

Evolution of the generation mix

- ❑ Strong reduction of coal generation
- ❑ Reduction of nuclear generation
- ❑ Strong increase in gas and renewable generation

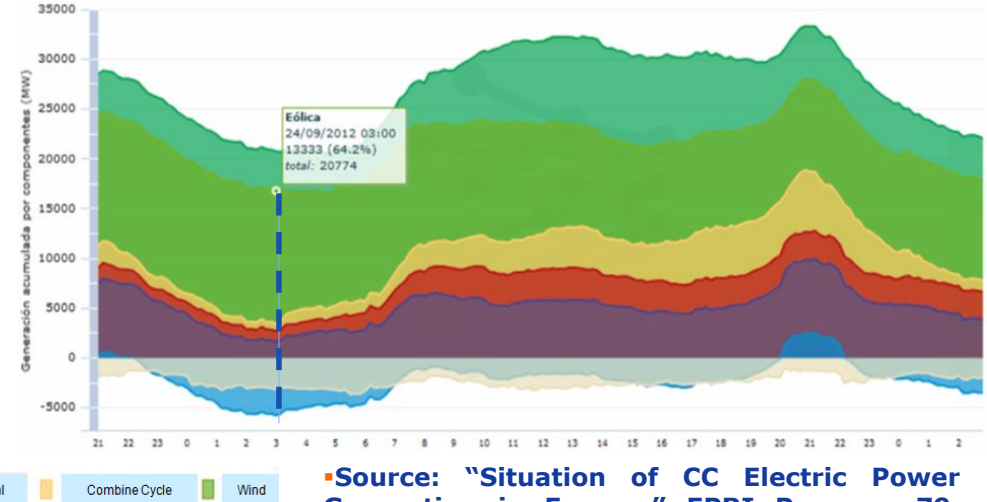
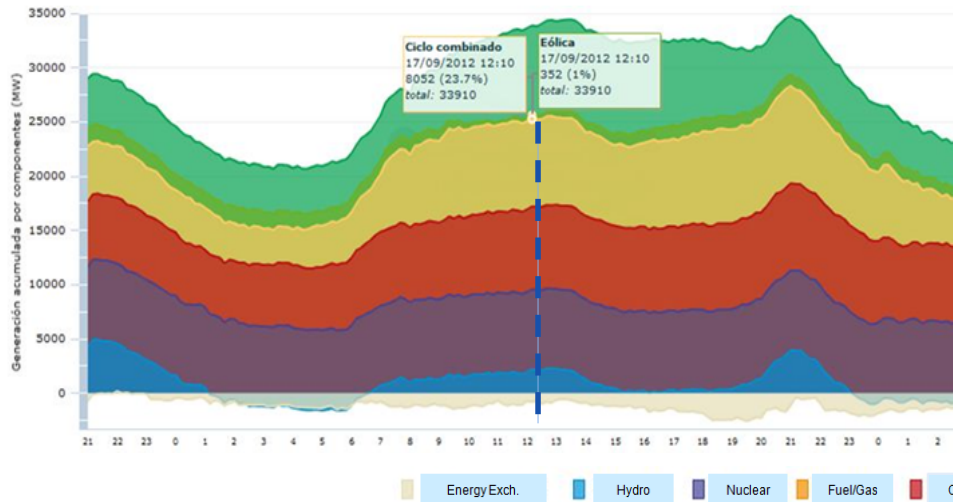


Spanish market

Backing up renewable production

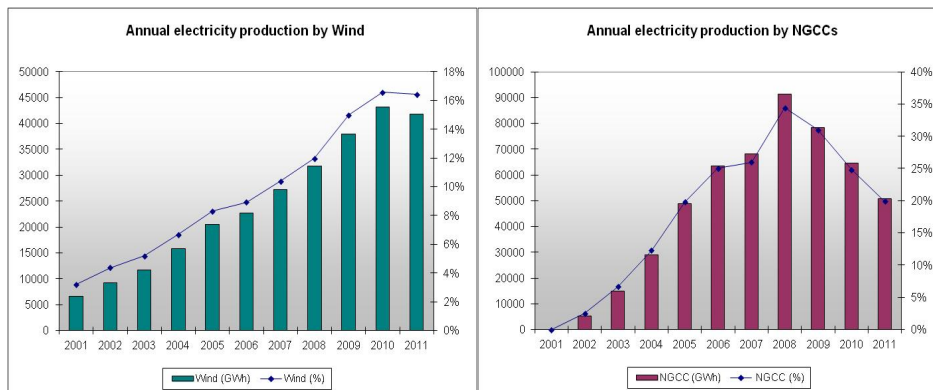
Sep the 17th : Wind covers 1% of the demand

Sep the 24th : Wind covers 64% of the demand



Source: "Situation of CC Electric Power Generation in Europe." EPRI Program 79. Nashville October 2nd 2012

Annual production: wind vs CCGT



Source: REE annual reports

- Strong increase of wind installations in the last decade led to CCGT production reduction
- CCGT fleet used to compensate wind production variations

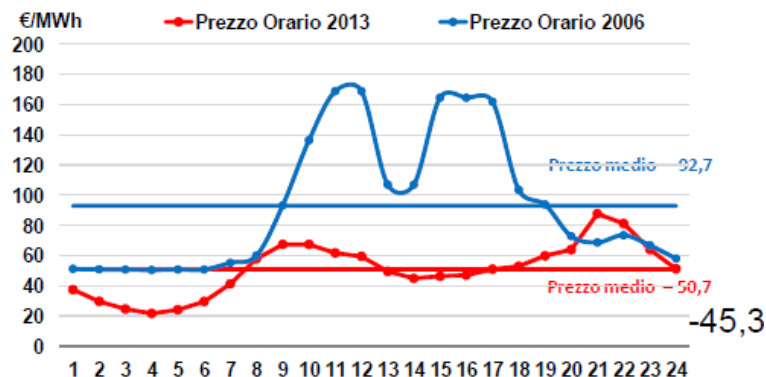
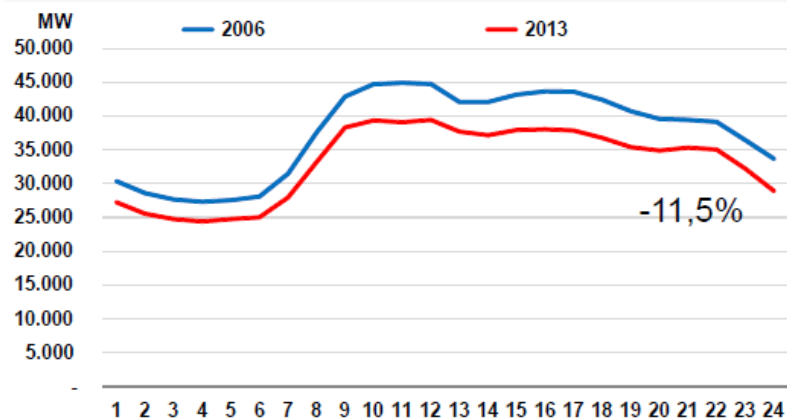
Energy offered by GSE on energy market

2006-2013: Hourly cost comparison

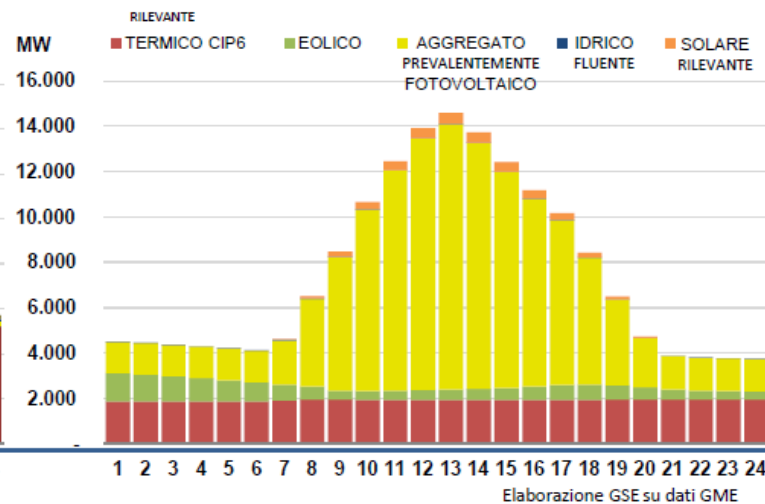
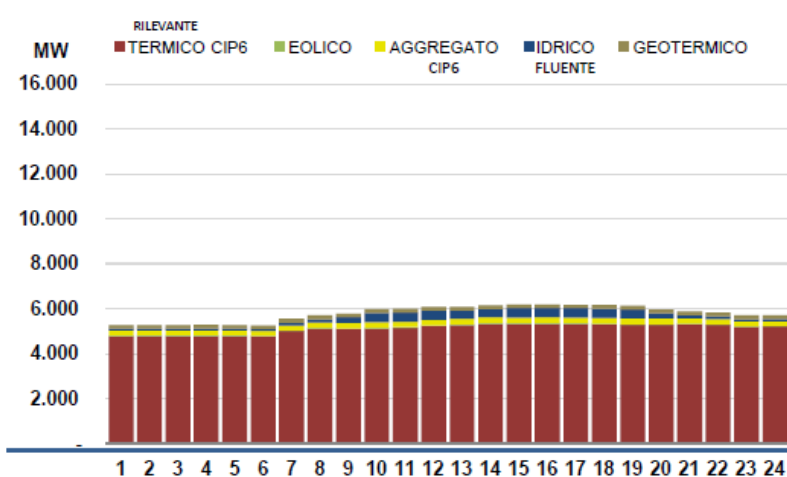
Energia scambiata in borsa

Curva oraria del prezzo dell'energia scambiata in borsa

confronto martedì 23 maggio 2006 e giovedì 23 maggio 2013



Volumi di energia elettrica offerti in borsa dal GSE
confronto martedì 23 maggio 2006 e giovedì 23 maggio 2013



Elaborazione GSE su dati GME



Power generation

New paradigms: low carbon ,flexibility, efficiency

- ❑ Increase of power ratios: RENEWABLES/fossil based;
- ❑ Priority dispatching of renewables “imposed by law” and increase of cycling duty;
- ❑ Requirement of back-up capacity and Conventional Power Plants are required to take on “auxiliary services”;
- ❑ Increasing environmental constraints;
- ❑ Volatility of grid capacity;
- ❑ Increase of electric consumption trends;
- ❑ Hourly based tariffs for electricity sale;
- ❑ Social acceptance difficulties for new power sites as well as new power grids.

Modern power plants

Starting and stopping time

Type of Plants Operation parameters	Nuclear	Thermal power	Gas Turbine Combine d Cycle	Heavy Duty Gas Turbine	Areod. Gas Turbine	Electrochemical batteries utility scale	Smart Power Gen.	Hydro power	Pump Hydro
Start up to synchronization (minutes)	>1400	>50	6-13	6	6	Instantaneous	0,5	<1	<1
Start to full load (minutes)	>2000	>180	50-90	13-30	8	-	3-5	<2	<2
Stop from full load (minutes)	30-60	10	5	1	<1	-	<1	-	-
Ramp – up rate (%/minutes)	3	3	2	3-5	3 - 5	-	>20	>50	>50

Sources:

- Golinelli: Smart power cogeneration-*Quarta conferenza nazionale sull'efficienza energetica-Rome-November 21-2012*
- Jacob klimstra -Markus Hotakainen – Smart power generation

Thermoelectric Power Plants

Enel efforts to optimization and flexibility

Main problems

- Difficulties in compensating the fast variations using conventional steam based power plants
- CO₂ /Kwh and (CAPEX + OPEX) per kWh increasing due to lower utilization factors of power plants.

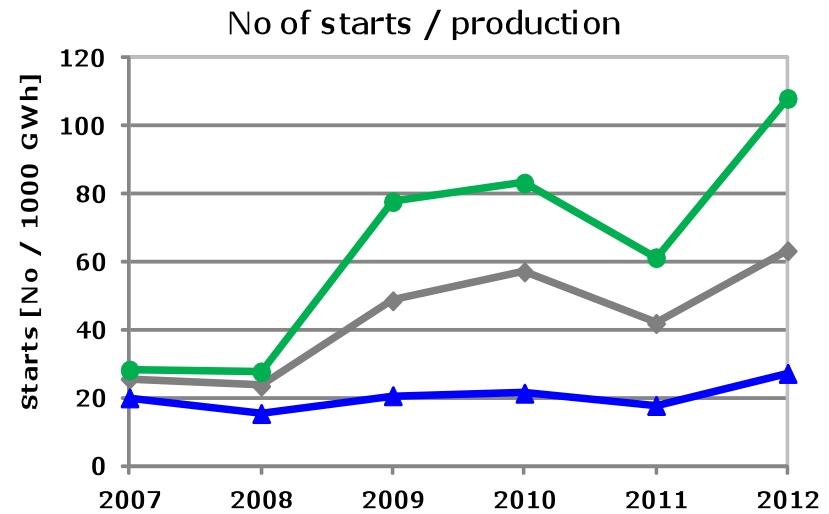
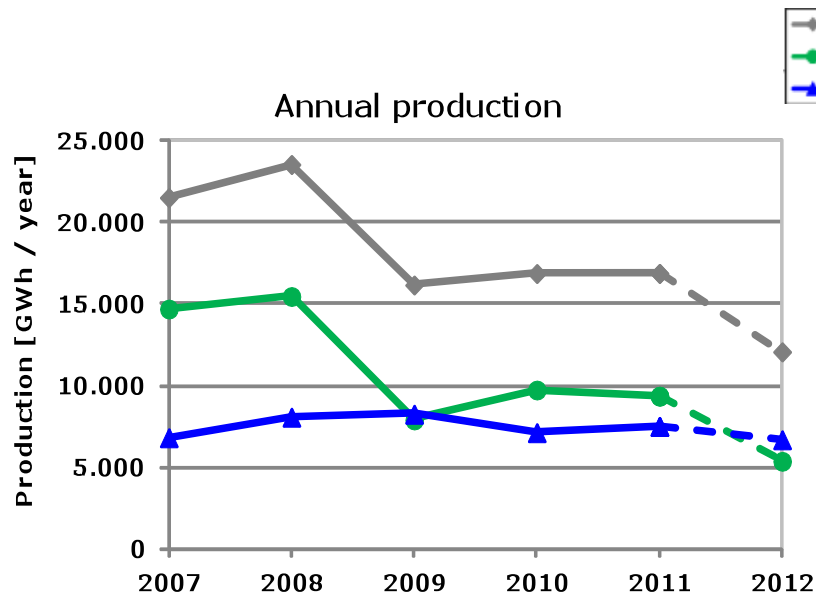
The efforts to balance renewable energy fluctuations

Enel efforts are focused to create better conditions to deliver competitive and clean energy by improving operation flexibility and modifying the technology mix of power generation park:

- obtaining a wider operation field by reducing minimum loads;
- optimizing power plant performances at lower loads;
- introducing operation procedures for faster starts and stopping without impacting on reliability and environment ;
- optimizing fuel flexibility (coal ,natural gas and bio-fuels).

Italy: CCGT power generation

The new role of GTCCs: the Enel case

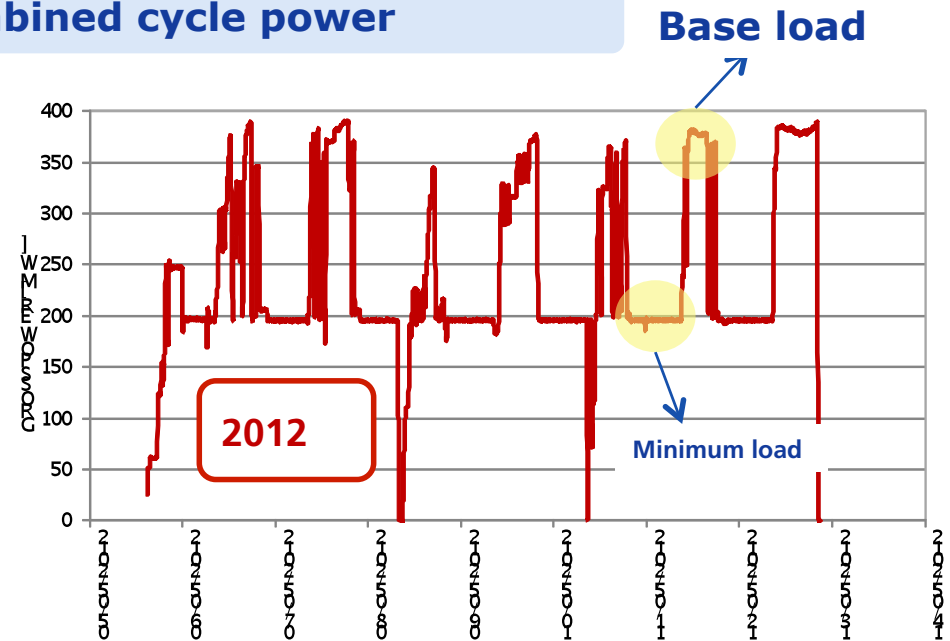
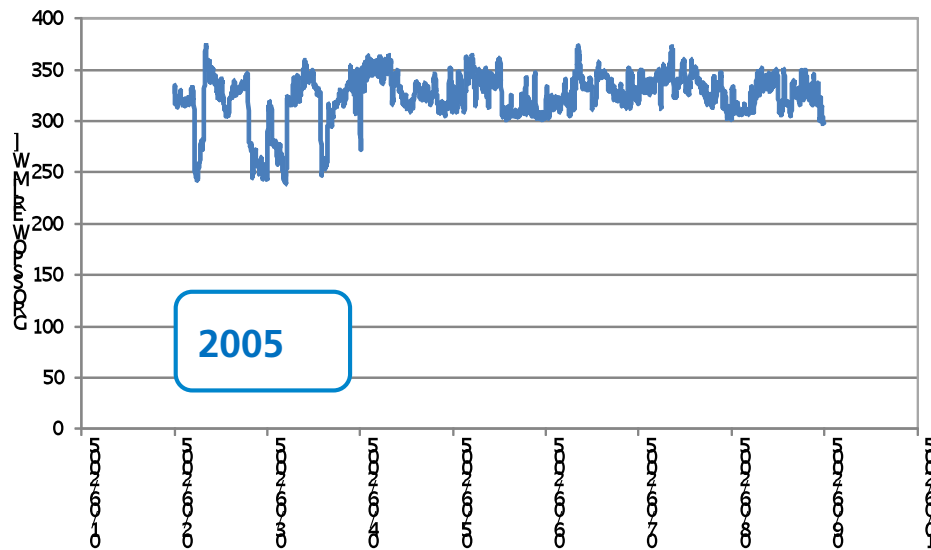


- ❑ Strong contraction of CCGT production in the last five years, especially in 2012 because of the installation of about 10GW of PV power
- ❑ Increase of the annual startups per unit of produced power

Italy: CCGT power generation

The new role of GTCCs: the Enel's case

Typical weekly trend of combined cycle power



- ❑ Increased number of startup / shut down cycles
- ❑ Reduced operation at base load
- ❑ Operation at minimum environmental load during nights

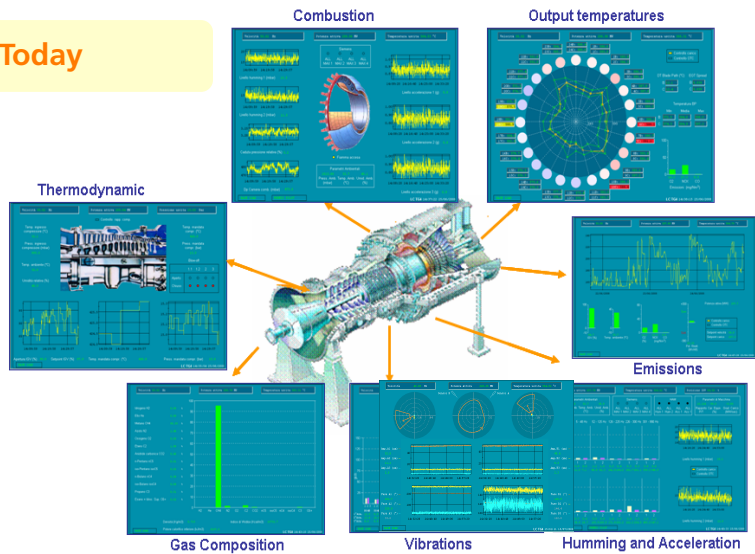
Enel's actions to increase competitiveness of CCGTs

Advanced diagnostic tools for lifetime monitoring & management

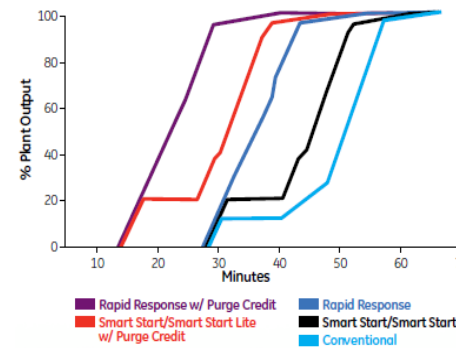
Enel's Gas Turbine Diagnostic System

Lifetime monitoring & management

Today



Target



Source: GE FlexEfficiency 50

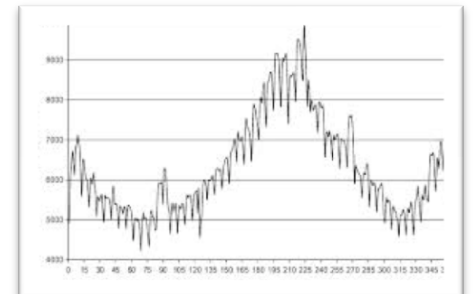
- 15 GT and 12 coal power plants monitored
- Supporting the operation through statistics rules for anomaly prediction and analysis

- Life & maintenance models: tracking history of each GT component
- On-line lifetime calculation
- Choosing start-up curve for optimizing lifetime and/or market request

Power generation on Island

Main peculiarities

- ❑ Even bigger islands are often not connected to the mainland, hence self-reliability is a must
- ❑ Power generation has costs that can reach 3 times mainland plants
- ❑ Even small quantity of renewable generation can lead to grid instability (lower grid inertia due to small size)
- ❑ Very high seasonal load variation possible (summer tourism)
- ❑ Strong constraints for new buildings/plants
- ❑ High incentives for renewable in some countries



Storage systems on islands

Main drivers

Support renewable integration

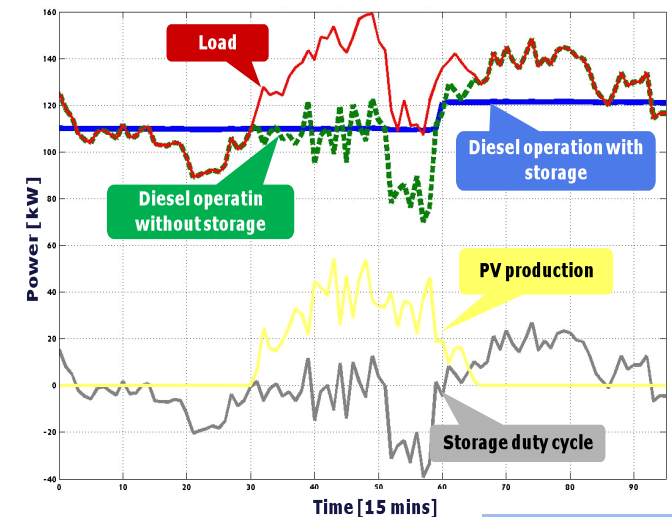
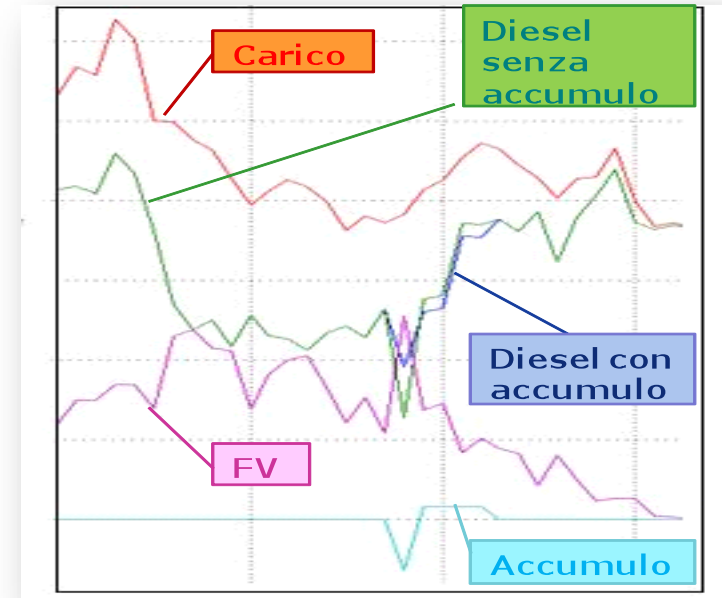
- ❑ Increase of renewable hosting capacity
- ❑ Optimization of electric supply
- ❑ Decrease of average cost of electricity

Grid stability support

- ❑ Increase of grid self-reliability
- ❑ Frequency regulation
- ❑ Voltage support
- ❑ Outages prevention and response

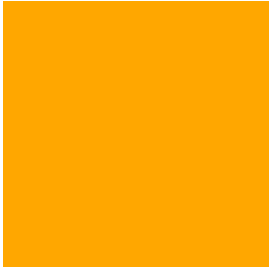
Conventional generation optimization

- ❑ Optimize conventional generation operation for fuel saving and emission abatement
- ❑ Life extension of conventional assets
- ❑ Optimization of reserve assets



Remarks

- ❑ Large scale integration on grid of renewable and their stochastic availability forces other power plants to frequent loadings and unloading to balance energy system.
- ❑ Compensating for the fast variations lowers the utilization factor of the steam power plants and the utility companies are forced to study specific innovation to be introduced in order to increase flexibility as well as to improve efficiency at reduced load; lower utilization factors of power plants increases the specific capital costs per kWh but also maintenance costs per kWh.
- ❑ Energy storage technologies are still expensive even though would be useful their integration on the grid for conjugating flexibility, efficiency, environment and prompt fluctuation of renewable.



Thank you for your attention

