New Challenges and Trends in Electricity Markets

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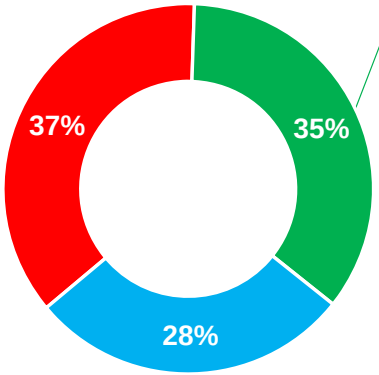
Enel Fleet for CCGTs

Enel CCGT Fleet

Key elements

Installed Capacity



Net Generation

38 TWh

Power Plants

24

	# PPs*	# BLOCK	Net Generation [TWh]
Base-load	9	10	24,8
Intermediate – Peak Load	18	28	12,9

* Plants that belong to two or more service cluster are counted one for each cluster

Enel Fleet Machines & Technologies

Country	Total CCGT Installed Capacity	Siemens/AEN	GE	MHPS
Italy	4480 MW	12 x V94.3A2		
Iberia	5460 MW	2 x V94.3A6	14 x 6FA/FA +e 2 x GT26B 4 x 9FB 3 x GT8C	1 x 701F
Russia	800 MW	1 x SGT5-4000F	1 x MS9001FB	
Chile	1512 MW		4 x PG9171E	2 x 701F
Argentina	1920 MW	1 x V94.3	2 x GT26A/B	2 x 701F
Peru	470 MW	2 x SGT6-4000F		
Brazil	300 MW		2 x GT11N2	

Market Challenges faced by Enel Thermal Generation

Enel Thermal Generation challenges worldwide

Enel Thermal Generation as a global player in Energy Production manages plants in two main geographic areas:

- **Europe**
- **South America**

Within Europe significant capacity is located in **Russia**, which has quite different rules and challenges from Western Europe

By means of:

- Matrix organization
- Strong cooperation between functions
- Open mindedness

Enel is able to manage local specificities, but keeping focus on global goals, strategies and pillars for growth.

O&M Drivers: path to Operational Excellence

- *Maintenance Technical Standards*
- *Contract management*
- *Procurement efficiency*

Cash Cost Efficiency

Performance Improvement

O&M

Capacity optimization

Best Practice Sharing

- *Efficiency and Reliability optimization*
- *Environmental improvements*
- *Flexibility*
- *Overhaul Quality Control*
- *Digital Transformation: Big Data and IoT*

- *Growth according to market opportunity*
- *BESS plant development*

- *Sharing of Significant Technical Issues*
- *Continuous improvement programs*

Western Europe

Italy, Spain and Portugal

Market Challenges:

- High penetration of RES
- Targets for Emission reduction and decarbonization
- Strongly competitive market with low prices
- Strong focus on Emission Limits by authorities
- Different regulations on Grid Service Markets (balancing & ancillary services, PFR, SFR, etc.)
  - ✓ Becoming more and more important for EBITDA and competitiveness
- Discussion on capacity market ongoing
- Local peculiarities (islands)

Country Russia

Market Challenges:

- Overall capacity close to the actual demand
- Extreme environmental conditions
- High load factors during winter
- Focus on Availability, Reliability, Efficiency, Increase of Power Output
- Very high average age of the fleet: modernization projects launched by Ministry of Energy
- Compliance with Russian Technical Requirements which are mandatory for Energy Wholesale Market Participants.

South America

Argentina, Brazil, Chile, Perú

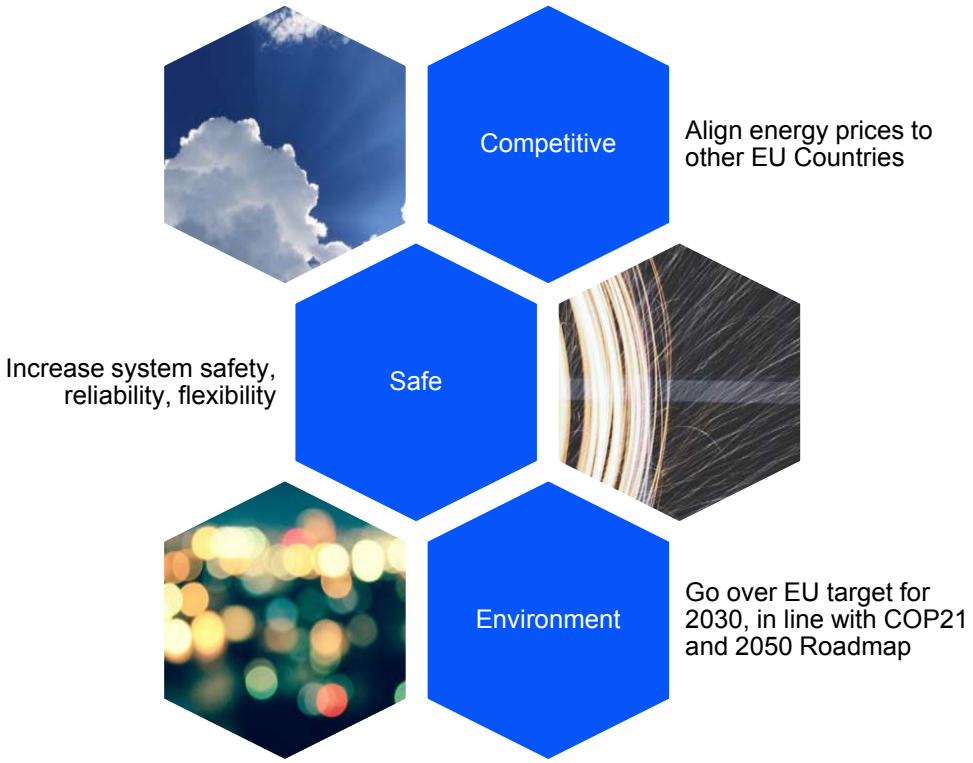
Market Challenges:

- Different level of development of Electricity markets across the countries
- In some case Grid Service Markets are developing and now growing, having as model western countries
- Different levels of regulation in Markets
- Overall capacity often close to the actual demand
- In several cases high average age of generating units
- For most of units, focus is on availability, reliability, efficiency

Focus: New Italian Strategic Plan for Energy

New Italian Strategic Plan for Energy (SEN)

Key Pillars



Main Targets

- Wind and Sun will drive transition
- Hydro capacity: preserve the efficiency with the support from small hydro

Increase of RES

- Reduction of primary energy consumption
- Occasion for innovative production systems

Energy Efficiency

- Current plan will significantly reduce coal in the mix.
- Investments and new capacity to handle the transition

Coal Phase Out

- Capacity Market
- Investments in network development

Better System Resiliency

CCGTs as possible key technology to handle transition

- New Capacity
- Capacity Market
- Increased flexibility
- New Grid Market Opportunities
- Higher service factors

Enel approach to capture market opportunities

Key elements

Operating Flexibility increase

- Improved ramp rates
- Increased participation to SFR
- Lowering of Minimum Environmental Load

Reduction of Planned Unavailability

Reduction of Unplanned Unavailability

Increase or Recover Maximum Load

Improvement of Start-up time

- Cold Start-up
- Hot Start-up

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Enhancement of flexible operation

Ramp rates

Target

- Improve participation to PFR
- Enhance participation to SFR
- Increase opportunities in Grid Services

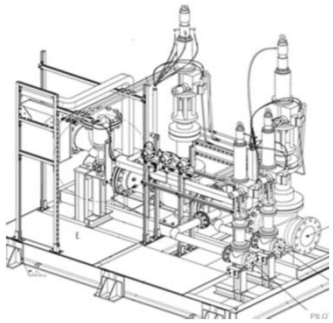
Expected Benefits

- Allow fast transient states without impacting on flame stability
- Keep emissions within the limits also during transient states

Required Activities

Depend on OEM but typically implies:

- Burner Upgrades
- Fuel Systems Upgrades
- Fuel Control system Upgrades
- Recommissioning & Tuning



Minimum Environmental Load (MEL) reduction

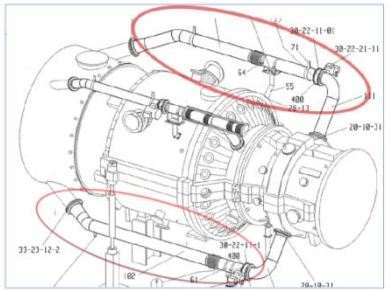
Combustion improvements

Target

- Enhance market positioning of the unit
- Increase chances of being called to production by bidding a wider operating range

Expected Benefits

- MEL Reduction
- Flexible operation



Required Activities

Depend on OEM but typically implies:

- Burner Upgrades
- New combustion logics
- Active combustion systems
- Excess air control

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Operating Flexibility increase

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Planned Unavailability Reduction

Reduction of Unplanned Unavailability

Increase or Recover Maximum Load

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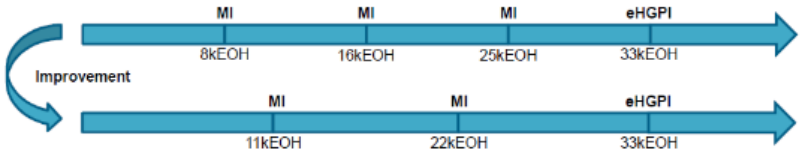
Reduction of Planned unavailability

Enhancement of maintenance cycles

Target

- Reduce planned maintenance unavailability
- Reduce Total Cost of Ownership



Expected Benefits

- Longer service Intervals
- Lower wear & tear of parts
- Avoidance of costs related to Major Overhaul, included in the packages

Required Activities

Depend on OEM but typically implies:

- New Hot Gas Parts
- Several improvements in cooling and combustion system
- Normally it requires outages with rotor extraction

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Operating Flexibility increase

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Reduction of Planned Unavailability

Reduction of Unplanned Unavailability

Increase or Recover Maximum Load

Improvement of Start-up time

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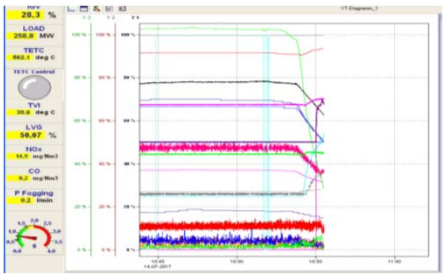
Reduction of unplanned unavailability

Active combustion monitoring systems

Target

- Reduce unplanned maintenance unavailability
- Improve overall machine performances without “touching” the iron



Expected Benefits

- Reduction of trips for severe humming events
- Increase of generale machine performances (if combined with other improvements)
- Where necessary, reduction of Short/Minor inspections after such events

Required Activities

Depend on each OEM, but normally requires:

- Active monitoring of combustion
- Potential need for additional sensors
- Commissioning & Tuning

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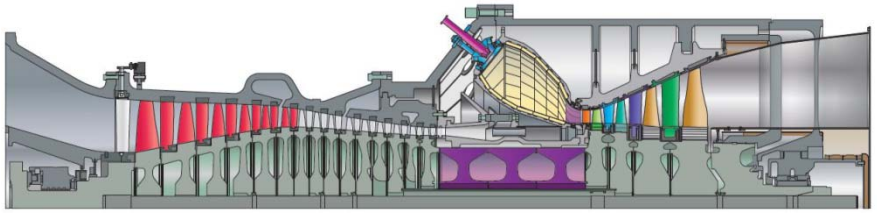
- Operating Flexibility increase
  - Improved ramp rates
  - Increased participation to SFR
  - Lowering of Minimum Environmental Load
- Reduction of Planned Unavailability
- Reduction of Unplanned Unavailability
- **Increase or Recovery of Maximum Load**
- Improvement of Start-up time
  - Cold Start-up
  - Hot Start-up

Maximum Load increase

Mass flow and TIT improvements

Target

- Where availlable, increase of revenues from capacity market
- In baseload scenarios, increase of gross output



Expected Benefits

- Increase of maximum load
- Longer service intervals
- Increase of efficiency
- Benefits on bottoming cycle
- The improvements can allow to save overhaul costs

Required Activities

Depend on OEM but can imply:

- Compressor upgrade for improved mass flow
- Turbine B&V substitution with higher ratings for higher TIT

Indice

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Increase or Recover Maximum Load

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Reduction of start up time

Group of actions for BOP

Cold Start-up

Activity

- Purge Credit
- Fuel Gas Electric Heater
- Final Desuperheater

Benefits

- Avoidance of Purge before start-up
- Avoidance of aux boiler pressurization time
- GT/ST Dynamics decoupling

Hot Startup

Activity

- Oversized Steam Drains
- Rotor Stress Evaluator

Benefits

- Faster Piping heating
- Benefits on all kind of start ups

Battery Energy Storage Systems

Battery ESS

- Over the last decade, the energy storage system (ESS) has become one of the more attractive element to boost power system performance and grid reliability
- The Battery ESS can be used to mitigate the voltage unbalance of the electrical networks, for frequency control, to complement spinning reserves, peak demand shaving, reducing operating costs.
- A widespread application of BESS is driven by CAPEX decrease and system performance improvements: now BESS does represent a remunerative investment for many applications
- To take opportunity to develop BESS applications along the three main business models: on-plant on network, stand alone and in isolated system

Opportunities from Digital Tools

Strategic Vision and Rationales

Foreword

THERMAL GEN MARKET CONTEXT

- Current scenario puts Thermal Generation under high pressure
- Future chances may arise
- Thus keeping plants up & running is necessary, but with lesser and lesser resources

WHY DIGITAL DEVELOPMENT

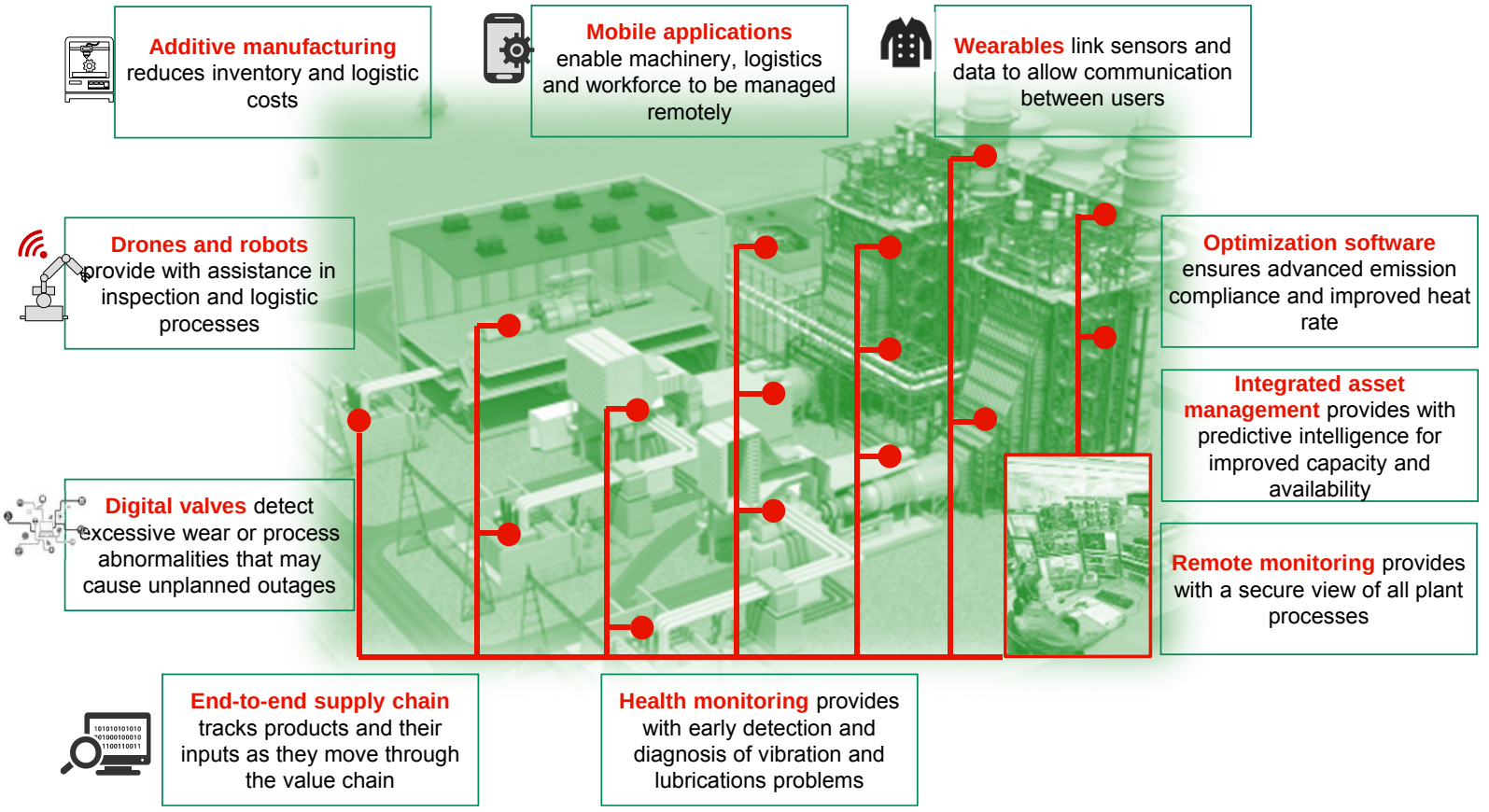
- Thermal Generation is sometime managed as a traditional business, not getting complete benefit from new technologies
- Suitable innovation programs for the business
- Digital is and will be a **major business disruptor** within the energy sector

OPPORTUNITIES AND RISK FROM THE DIGITAL PLAN

- **Worldwide fleet** with different cultures is at the same time a richness and an additional difficulty for deployment
- Key objective should be to **evolve operating and cultural model** while
- Key **issues / elements** need to be addressed:
  - **Roles and responsibilities**
  - **Approach**
  - **Timing**

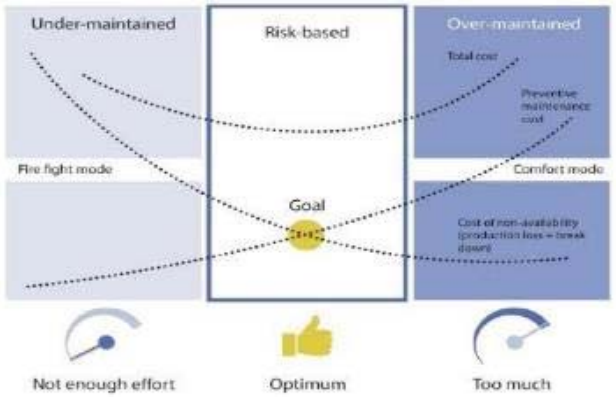
Integrated end-to-end digitalized processes

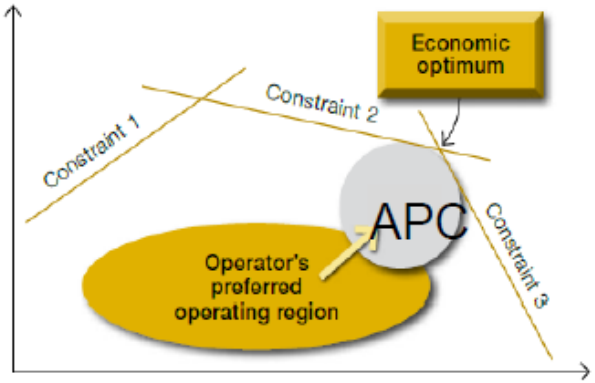
DIGITALLY INTEGRATED "SMART PLANT"



Example of Applications in O&M

	Advanced Predictive Diagnostics	Advanced Process Control
Initiatives description	• System of **Remote Predictive Diagnostic** to **switch from** an **accident/engineering-based** to a **data-driven/business approach** • The system is based on basic and **machine-learning algorithms** for **progressive performance improvement** based on historical series analysis of plant operational data (i.e. heat rate, downtime, vibration)	Installation of different APC to optimize the performances under interest: • **Steam temperature** max value and heat rate • Primary Frequency Response • **Humming** (combustion noise) • **Ammonia quantity** for Nitrogen reduction
Expected benefits	• **Reduce maintenance costs**, performing maintenance operations just in time, when necessary, **avoiding fixed scheduled maintenance** • **Reduce plant outage time**, **preventing unexpected equipment failures** through remote predictive diagnostics	• Optimization of **Net Heat Rate** • **Reliability improvement** and reduction of plant unavailability, due to maintenance operations. • Reduction of **minimum load**





Conclusions

Conclusions

- Electricity markets are facing **big changes** around the world
- Traditional Thermal generation is under pressure, but CCGTs are recognized to be a bridge technology that should last for many years
- To keep the fleet competitive, it is very important to know the market opportunities and translate them into technological improvements
- A good relationship with OEMs can help identify the most promising/adequate technologies
- A modern utility, however, must be able, by means of internal know-how, to **optimize all the aspect of O&M**, starting from conceptual design of a plant up to the decommissioning
- Leveraging on new **Digital Technologies,** quality and quantity of information will improve, while optimizing the OpEX

Thank you