Scheduling and Dispatch solutions for Smarter Power Market:

Jean-Louis COULLON
Eric GOUTARD
Alstom Grid

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Tomorrow's energy: we have a responsibility …

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… and a few challenges

Oct 4, 2009: The first complete day of negative average spot prices in Germany

- The EEX spot price average on Sunday, October 4 was minus €11.59/MWh

The first complete day of negative average spot prices on Germany's EEX power exchange has set alarm bells ringing for Germany's renewables' lobby. "We are seeing a storm brewing for a **conflict** that will play out daily if **nuclear** plant and later **coal** plants are not closed step-by-step as **renewables** expand," said Rainer Baake, managing director of environment organization Deutsche Umwelt Hilfe

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We converge on the Key Drivers …

1. Maximize CO2 free energy and reduce environmental impacts

- Enable renewable grid connection and improve thermal generation flexibility
- Maximize dispatch of intermittent renewable generation (wind, solar)
- Integrate distributed generation, eco-buildings and electric vehicles
- Develop new energy storage capabilities

2. Improve energy efficiency across the value chain

- Optimize real-time CO2 free energy delivery to end-users
- Maximize energy flow in constrained and aging grids
- Enable end-users dynamic participation to the market (“prosumers”)
- Integrate smart metering and demand side information integrate

3. Increase Grid Reliability and Stability

- Estimate Grid Asset condition through real-time and react accordingly
- Prevent transmission blackouts and minimize outages in distribution
- Monitor Grid stability / oscillations and implement Defense plans/Grid self healing

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We bring smartgrid technologies in …

Generation | **Grids** | Consumption

TECHNOLOGY EVOLUTION

Smarter equipment

- HVDC
- FACTs (Flexible AC Transmission System)
- NextGen digital substations

- DC Grids
- Electric Vehicle fast charging
- Grid connected batteries
- Wide Area Controls / Protection Systems

Smarter grid management

- Grid management systems
- Renewable energy management
- Wholesale market management

- Demand Response management
- Online Asset Management
- Virtual Power Plant / Microgrid management

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… Business Models and Regulations are expanded …

Application			Av. Power (MW)	Time horizon	Reaction time	Duration
Generation	"Traditional" Peak		100 - 1,000	Hours	Minutes	Hours
	RE Peak & Base Load		< 100			
	Renewable Power Quality		< 100	Minutes	Seconds	Minutes
	Arbitrage		> 50	Weeks	Minutes	Hours
Grid	Grid security	Reserve	< 200	Hours	Minutes	Hours
		Regulation				Minutes
		Black Start	< 10	Hours		Hours
	Load Shifting		< 200	Hours		
	Power Quality		< 200	Minutes	Seconds	Minutes
Demand	Load Management		< 10	Hours	Seconds	Hours
	Power Quality	Reliability	< 10	Seconds	Minutes	Minutes
		Quality			Seconds	Seconds

Each services needs to be mapped against specific market regulatory structures

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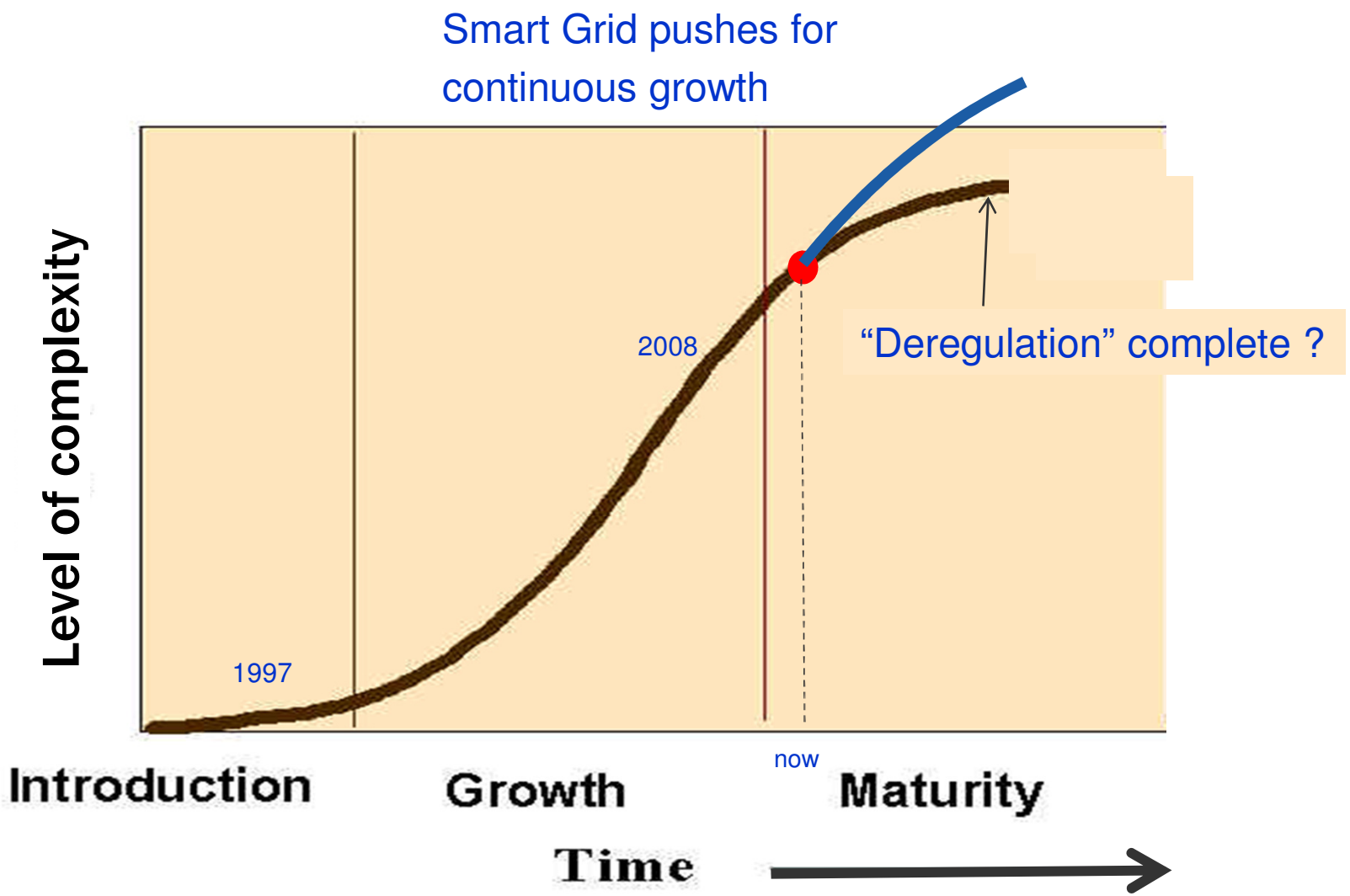
… growing the complexity of Electricity Markets



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"Smart Dispatch" vs. Classical Dispatch Comparison Summary

Classical Dispatch	Smart Dispatch
Cost-based, centralized generation	Extension for price-based, distributed, less-predictable resources
Passive, static demand	Active, dynamic demand
Inaccurate, fixed parameters	Parameter adaptation
Manual re-dispatch to relieve grid security violations	Congestion management with security constrained optimization
Ad-hoc forward scheduling disconnected from RT dispatch	Continuum from forward scheduling to real-time dispatch
Designed for normally inter-connected system operation	Extension for dynamic, multi-island operation in emergency & restoration
Limited forensic analysis	Perfect-Dispatch for root-cause impacts and process re-engineering

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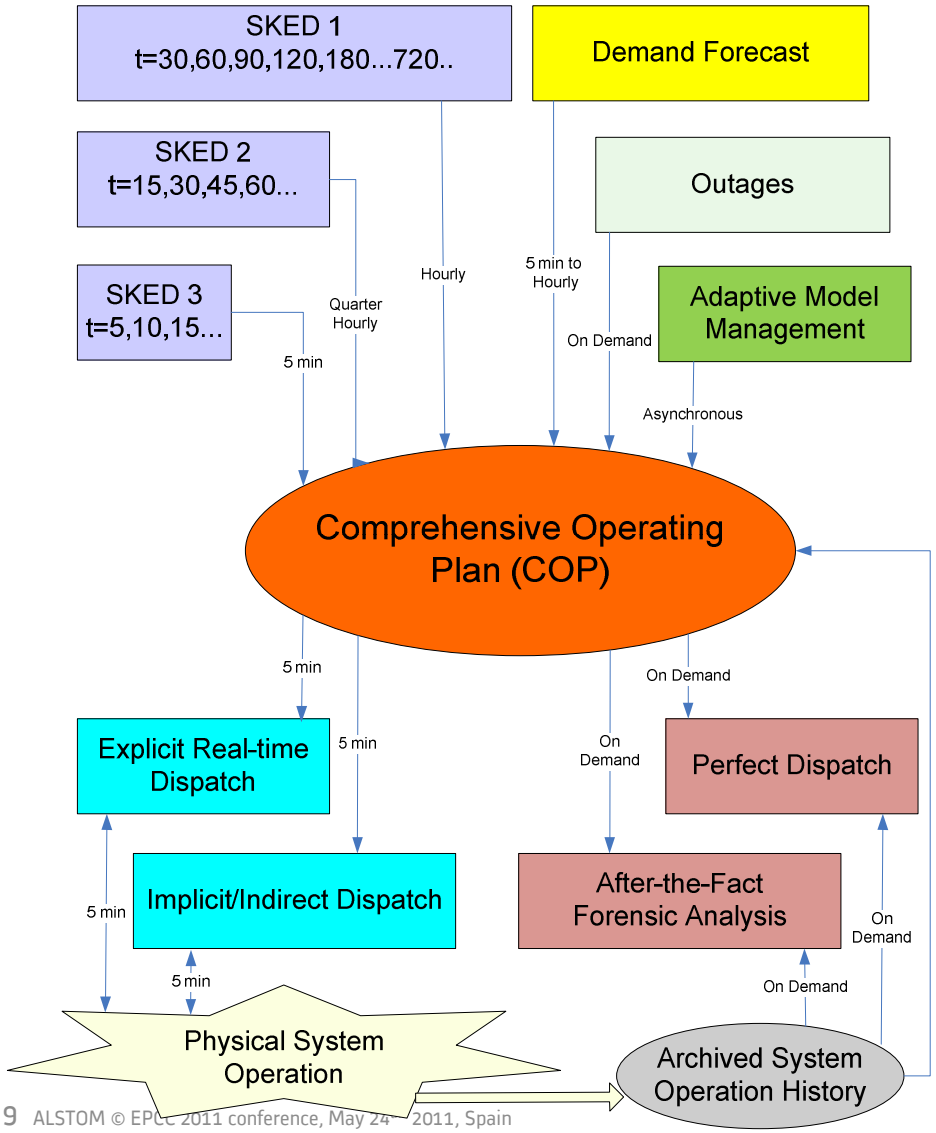
Smart Dispatch Solution Overview



Generation Control Applications (GCA)

- Multi-stage (SKEDs) robust dispatch, scheduling and commitment coordinated via COP
- Holistic forward-looking view of system conditions

After-the-fact Analysis (AFA)

- Performance benchmarking against Perfect Dispatch (PD)
- Root-cause analysis
- Simulation & impact analysis

Net Demand Forecast

- More accurate forecasting and uncertainty modeling of load, renewable generations and demand response.
- Integration of multiple forecasts

Adaptive Model Management

- Constraint management
- Generator Performance

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Conclusion

- Electricity Markets are also exposed to the “Smarter Grids” drivers:
  - CO2 Free
  - Energy Efficiency
  - Reliability
- New market places/products/actors brings more flexibility (e.g. Demand Response) … but more complexity
- “Smarter” Markets Systems available now to deal optimally with:
  - DR & end user empowerment
  - Volatility of renewables
  - Security constraints

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