SIEMENS

Panel A: Main Aspects of Emerging Electricity Markets

Topic: Progression towards best practice and reasons

Sankaran Rajagopal, Ph.D., E.E.

Director, Energy Market Management Systems

Siemens Smart Grid Solutions

Sankaran.Rajagopal@SIEMENS.com

+1 612 801 9909

Progression Towards Best Practice - Contents

SIEMENS

Facts and Motivation

Trends and Experience to consider

Best Practice and Review of Reasons

Conclusion

Electricity Markets Evolved

SIEMENS

- Started in Chile in the 1980's
- UK, NZ, AUS in the early 1990's
- US in the mid-1990's and subsequent evolution
  - Price spikes and gaming resulted in Two Settlement FERC mandated Standard Market Design of Nodal Market as a cure
  - Measures taken to converge forward and real time market prices
  - Renewable pentetration increased the emphasis on reliability – Look Ahed capabilities w/ contingency analysis
  - Energy Imbalance Markets between balancing areas to make use of geographic diversity of renwables

Some Facts to Remember

SIEMENS

Facts and Rules to remember while Restructuring

- competition in economic terms is very different from sports analogy
- objective of true economic competion is a “win-win” for suppliers and consumers
- suppliers compete with each other and bring prices down for the consumers
- level playing field and a fair market place
  - information and access is on equal footing to all players
  - confidentiality for suppliers’ sensitive price-data is assured

Facts of our grid - electricity markets

SIEMENS

Grid has some peculiarities to be recognized

- System balancing: Production needs to be adjusted almost constantly to match varying consumption
- Impedances of transmission determine the share of flows
- Reducing overloads is done by rescheduling injections (generations/loads) in several locations
- Voltage support has to be sufficient
- Contracts are limited by the laws of physics
- Customers consume energy without a contract in real-time
- Renewable penetration: variable energy resources on the supply side – we have to find ways to forecast and fully utilize

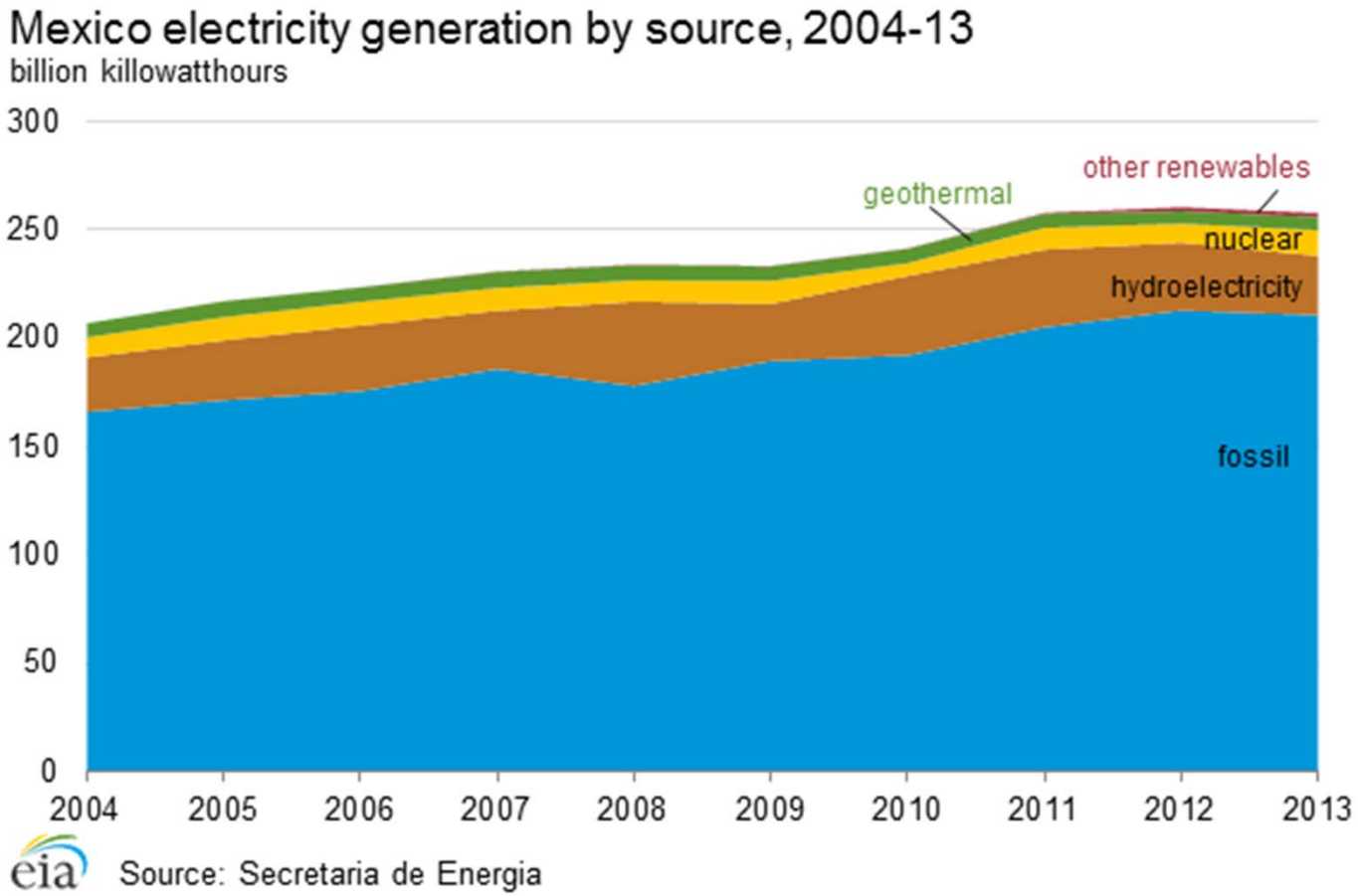
Mexico Power Grid

SIEMENS

- 4% Annual increase of demand for next 15 years is forecast by SENER
- Transmission: 27,000 miles HV, 28,00 miles MV, 370,000 Miles LV
- CFE has interties to California, Texas, Belize and Guatemala
- Mexico has the third largest solar potential in the world
- Latin America's largest solar power plant (40 MW) went on-line in 2013

Figure 1: Administrative regions of the CFE

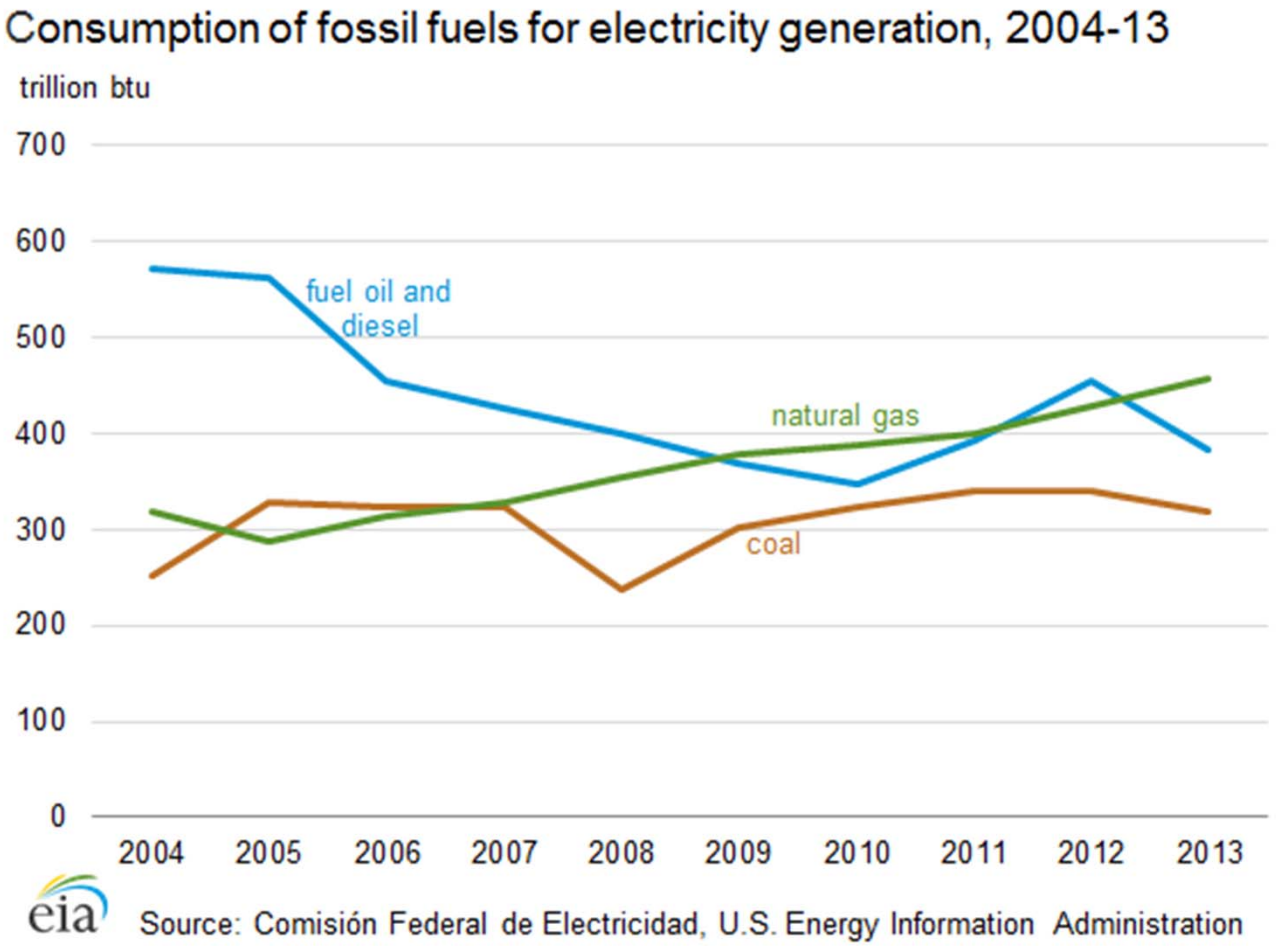
Mexico Fuel Mix



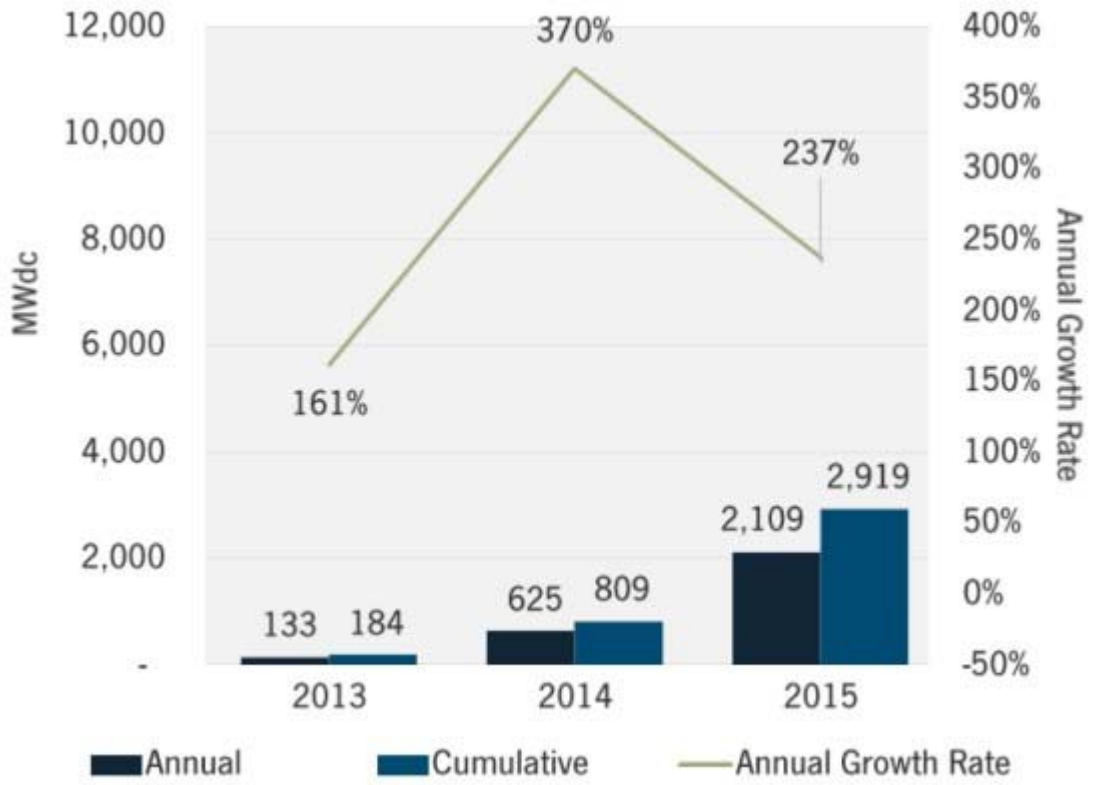
- 60,000 MW of installed Generation capacity
- 12,000 MW capacity from IPP's(20% capacity)
- Fossil: 75%, Hydro and other renewable 20%, Nuclear: 5%
- Combined cycle plants as a strong trend coming from the IPP's

Trend in Fossil Fuel in Mexico

SIEMENS



PV Growth in Latin America

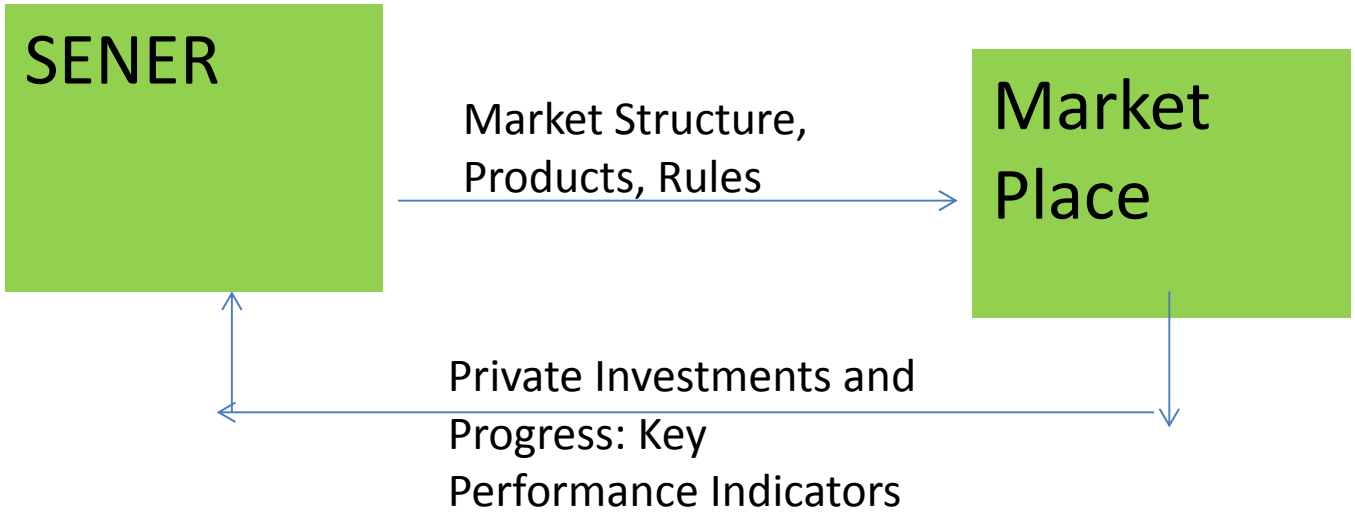


Source: *GTM Research Latin America PV Playbook*

PV growth in Latin America is led by Chile, Mexico & Brazil

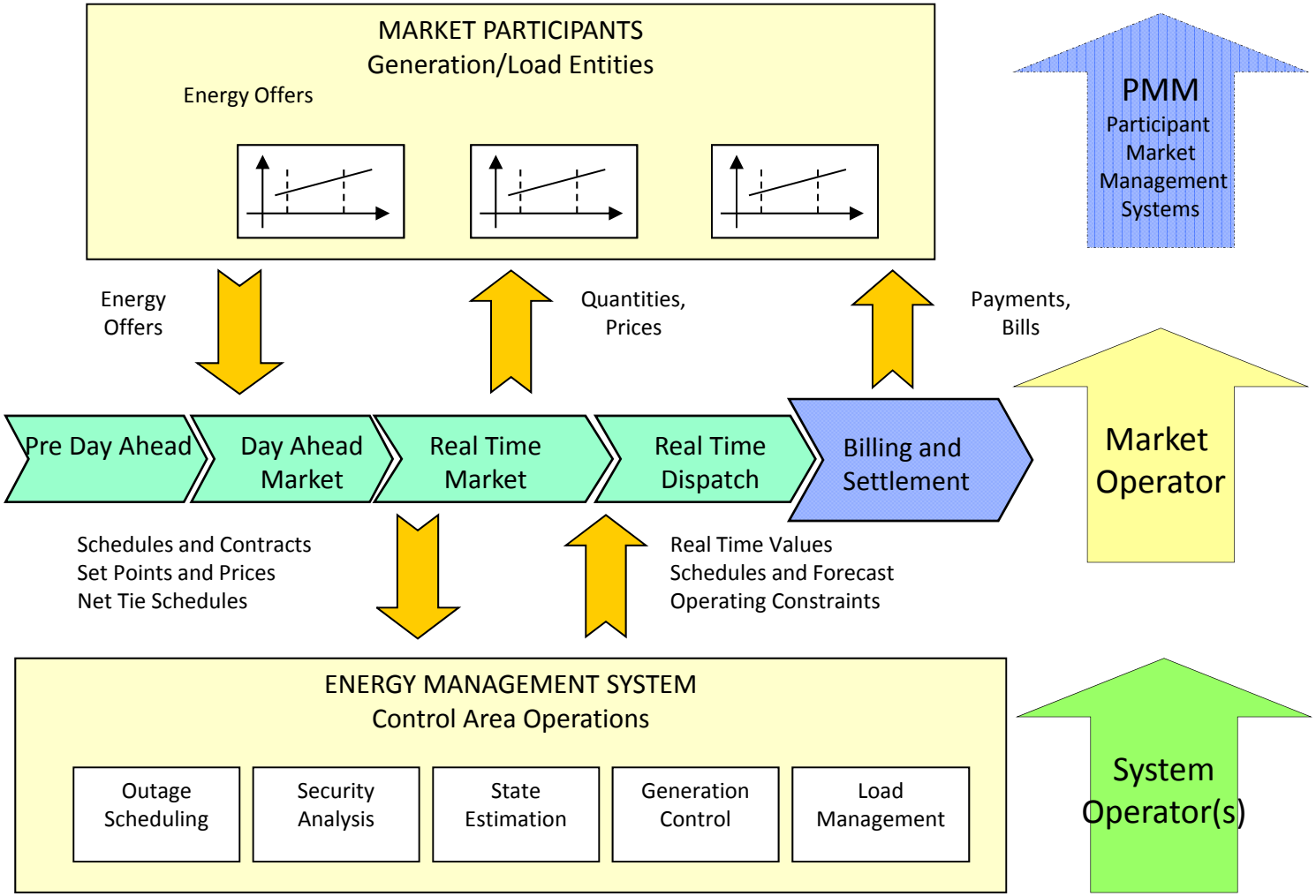
Review Changes in Progress

- SENER establishing/improving market structure
- CENANCE as Market Operator
- CFE as Transmission and Load Serving Entity
- Generation providers bid in to the Market



Market based Control Centers

SIEMENS



Trends to consider

SIEMENS

- Ideally, we are driving the prices to the marginal cost by competition – incenting innovation of distributed generation and cogeneration as example – healthy diversity of energy types to emerge
- Right products and competition also incents investment and efficiency improvements in power plants for ROI and profitability
- Local Market Power – generators crucial for system operation have extreme market power - declared as “Must Run” for example (California example)
- Global and Local Market Power Mitigation is essential by market rules and agreed-to reference bids as the mitigation basis from the suppliers
- Price caps and ceilings in the beginning and relaxed over time based on Market’s performance

Trends to consider

SIEMENS

- Bilaterals, Day Ahead and Real Time markets coexist – High share of bilaterals in the beginning
- Hedging the Market power during transition: Divested generation to have vesting contracts (indexed to the fuel prices) to sell back part generation for an extended period of time
- Unit Commitment by MO to increase savings (5% to 10% typical)
- Coal-gas-oil share of generation will oscillate based on fuel prices – assistance from optimization techniques such as Mixed Integer Programming (MIP)
- Solar and wind energy penetration increase – Reliability focus is necessary (10 minute and 30 minute return-to-normal standards for example, for generation and transmission outages) considered by Market dispatch
- Connections to Texas and California – utilize geographic diversity of renewables and price diversity – powerful choices

Market Products - Motivation

SIEMENS

Optimization Technique (e.g., MIP)

Security Constraints

Generator constraints

→ Minimize Operating Cost

Achieve sufficient reliability

Realistic dispatch

Incentives for investment by market structure

Products (Energy, types of Ancillary Service)

→ Influence private investment

Innovative energy sources

Markets reducing generation costs…

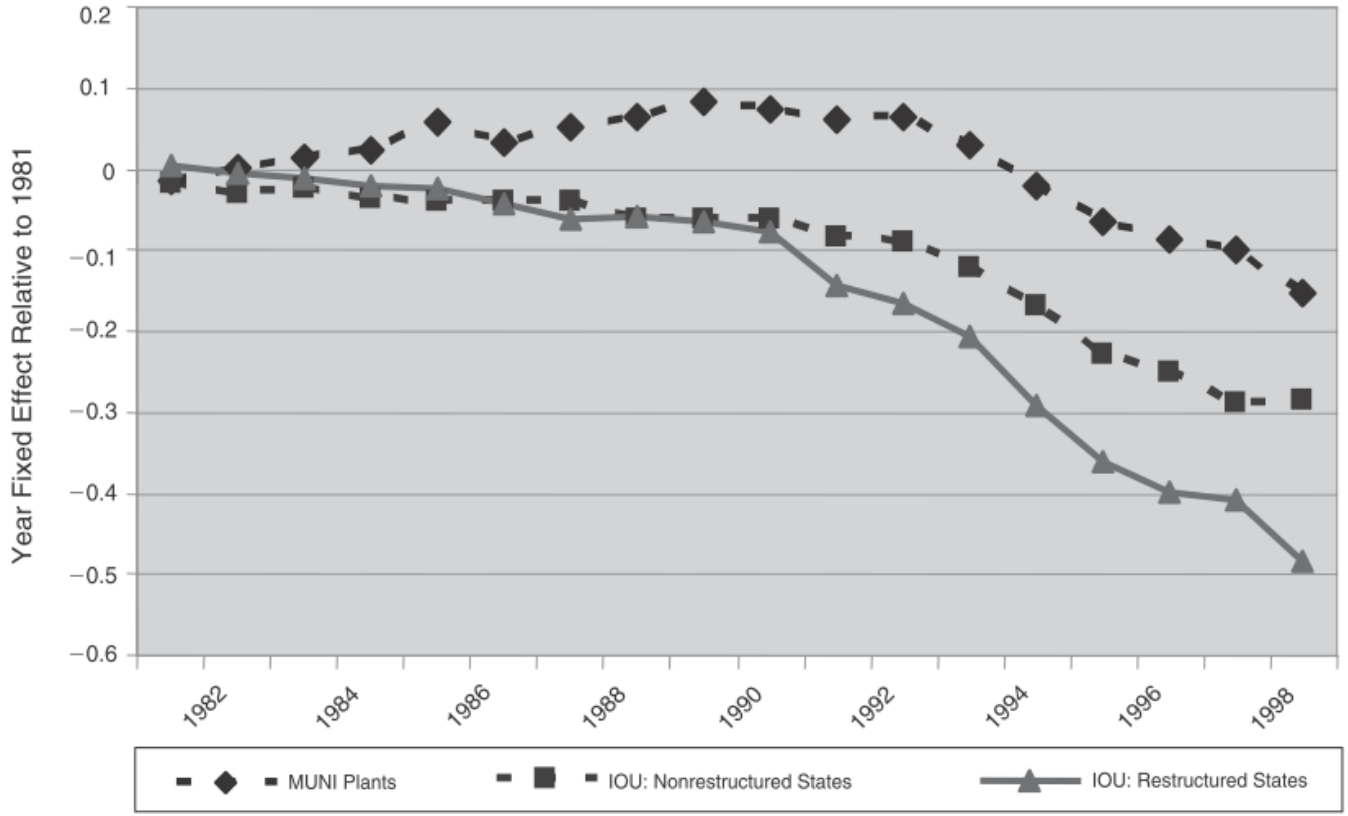


FIGURE 2. NONFUEL EXPENSE INPUT DEMAND YEAR-EFFECTS BY REGULATORY STATUS
(BASIC GLS-IV SPECIFICATION)

American Economic Review 2007: Do Markets reduce costs…, Fabrizio, Rose and Wolfram

Established US Markets Practice

SIEMENS

Wholesale Market in the US :

- Electric Energy
- Ancillary Services
  (Reg Up and Reg Down, Spinning and Non-spinning Reserve)
- Supplemental Services (Fast response, Flexible Ramping)
- Electric Power Capacity (Resource Adequacy)
- Financial Transmission Rights

Generation typically covers two thirds of the cost of power (generation operational cost, fixed and maintenance cost recovery) and hence focused the most.

Electricity Market Overview

SIEMENS

Retail Market

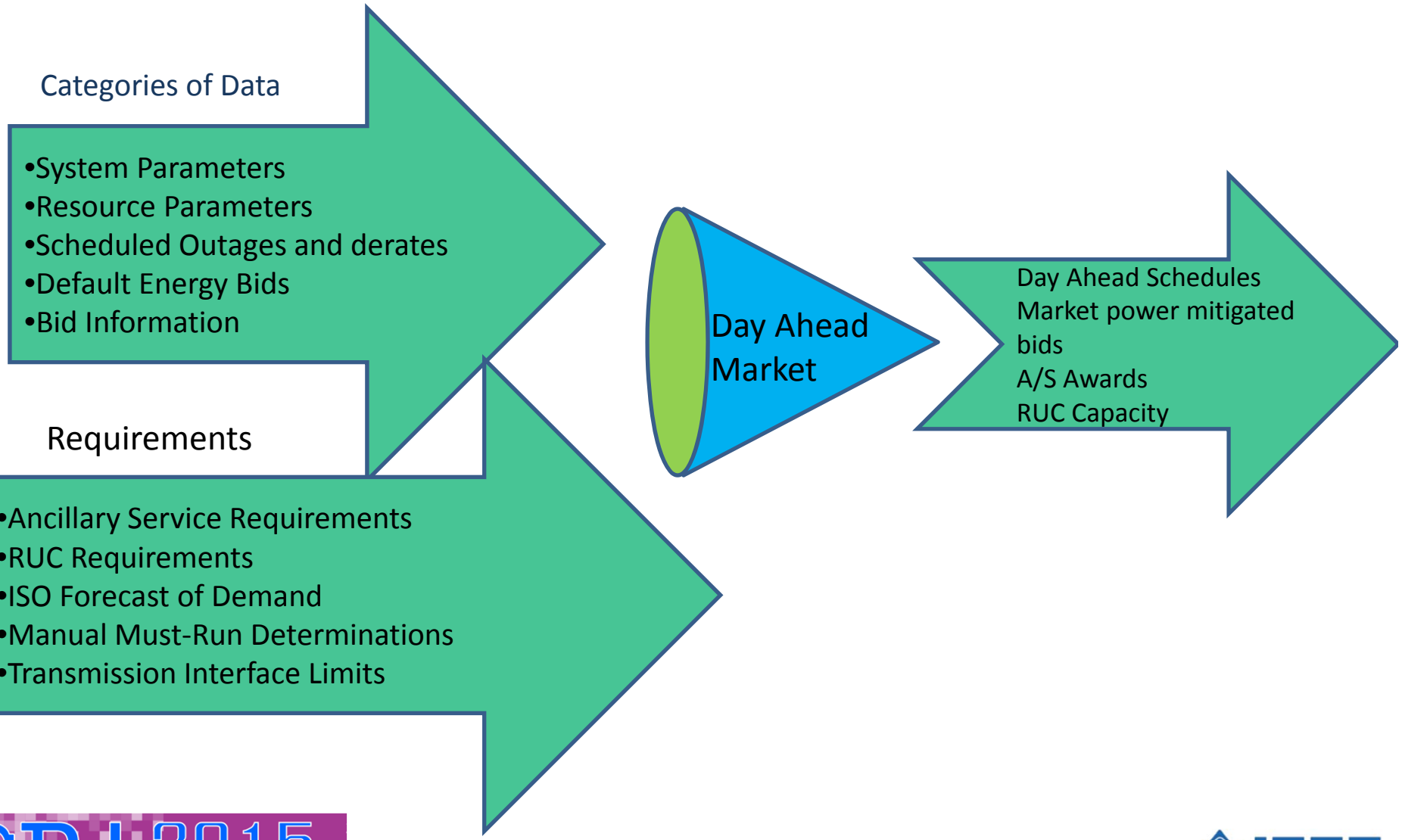
- Retail Demand Response (automatic switching where possible being done by utilities during the peak)
- Real Time Rates programs (Base versus deviations calculated and incented for avoidance of peak use)
- Green energy premiums paid by Customers, but difficult to audit
- Choice of supplier is still rare

Sizable investment on real-time metering is needed to achieve savings

Definition of Locational Marginal Pricing

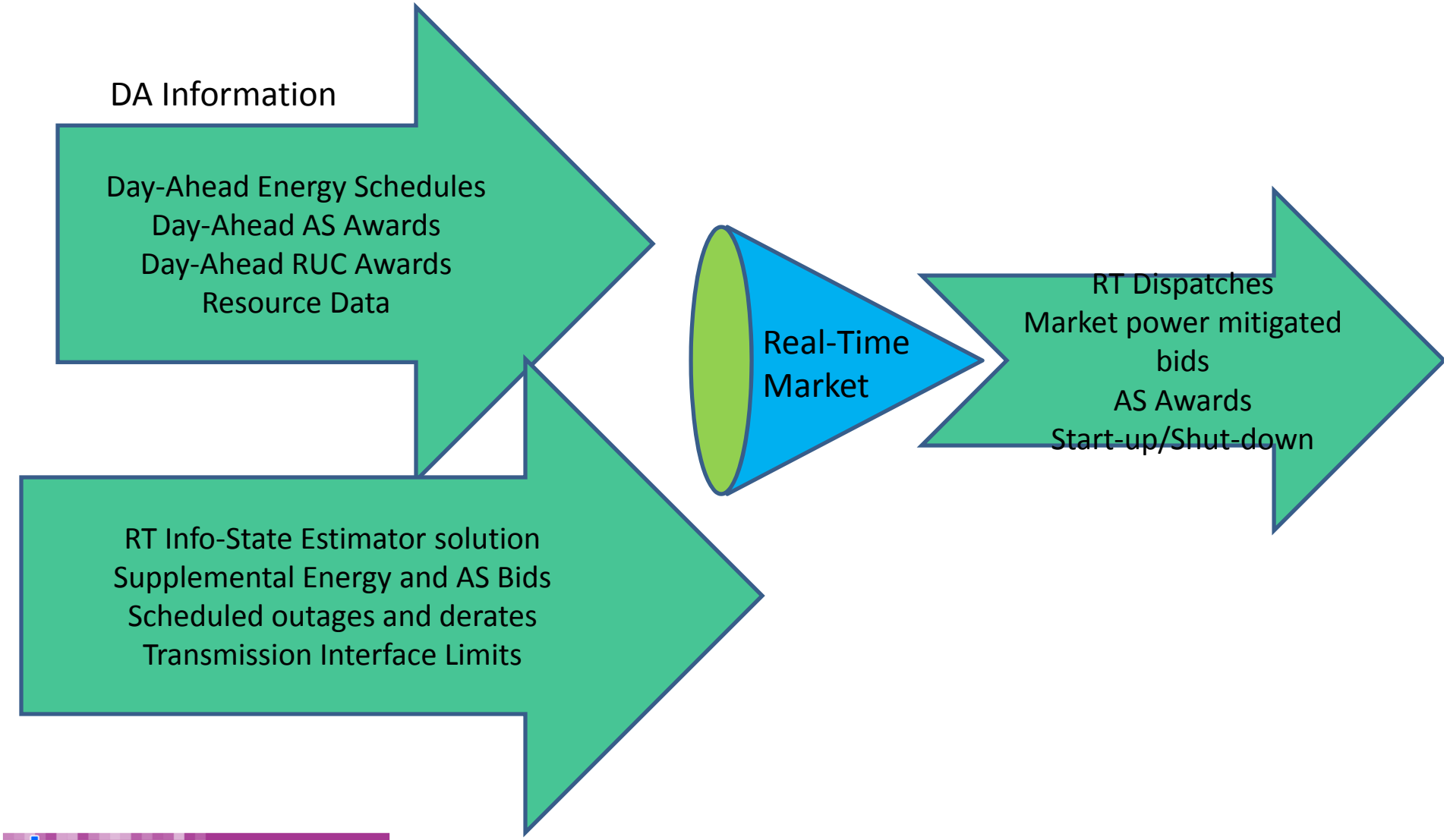
Definition: The marginal cost of supplying the next increment of electric demand at a specific location (node) on the electric power network, taking into account both generation marginal cost and the physical aspects of the transmission system.

Day Ahead Market Example (CAISO)



Real Time Market Example (CAISO)

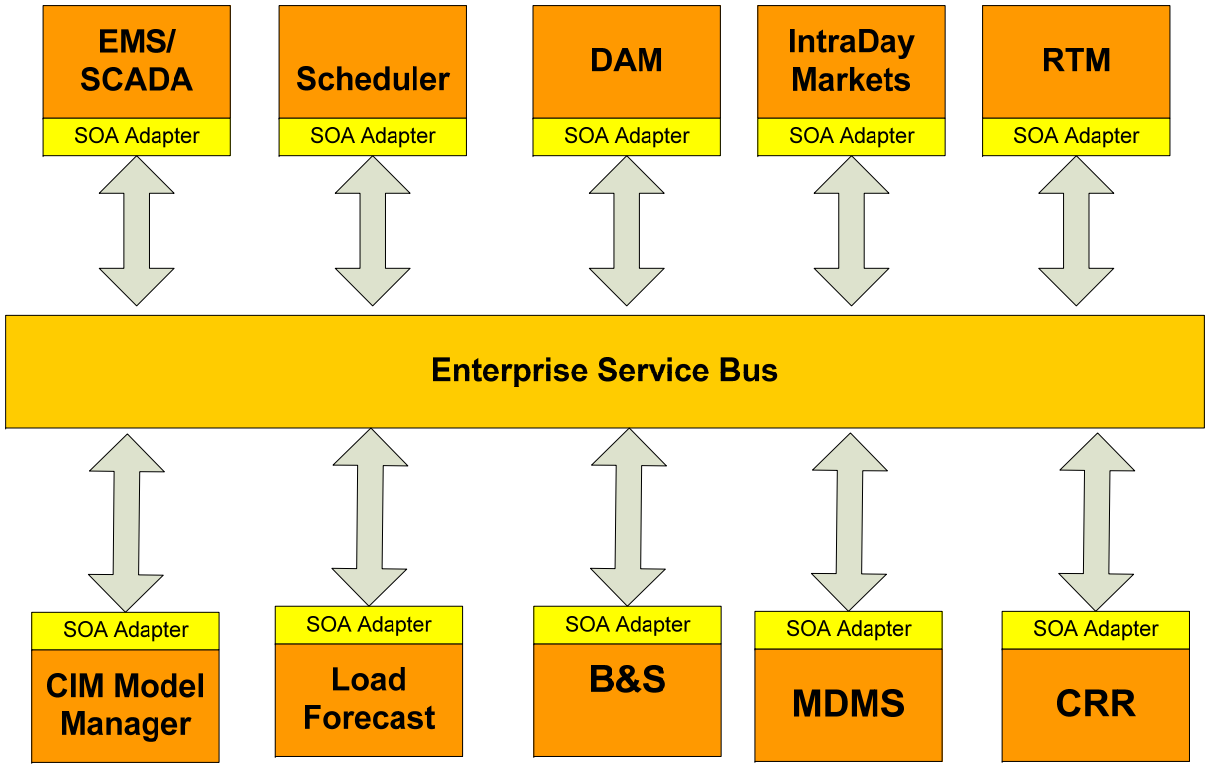
SIEMENS



Advancements in Optimization and Reliability

SIEMENS

- Co-optimization of En and AS
- AS Cascading from higher to lower quality
- Detailed Combined cycle plants dispatch
- Dynamic ramp functions in SCDD
- AS Ramping
- Minimum on-line capacity
- Flexible ramping requirements in AS
- Look Ahead - longer horizon and more frequent - Dispatch
- Preventive-corrective dynamic dispatch
- Fifteen minute market for renewables
- Energy Imbalance Market



IEC standard 62325-301: Framework for Deregulated Energy Market Communications: Common Information Model

Established Aspects - Market System

SIEMENS

- Configurable rule based system for managing bid submission: workflows, bid validation, approval, time line
- Significant amount of Real-Time metering for billing and to influence demand elasticity
- Billing ready energy calculations (after-the-fact-energy accounting) with ability to make manual corrections for errors and disputes
- Billing and Settlement: configurable architecture, managing versions and sandboxes, reports, dashboards, participant support
- Common Information Model (CIM) standards based data modeling for static and dynamic data
- Enterprise Integration and SOA governance

Conclusion

SIEMENS

Emerging Markets readily gain from the best practice resulted from two decades of evolution - US Markets have matured the Market Design and Systems to address:

- Various products (En and AS) needed for stable operation of the grid
- Configurable systems to enable only needed functionality
- Design system to avoid price spikes
- Prevent gaming and mitigate market power
- Price convergence between Forward and Real Time markets
- Renewable penetration and reliability assurance
- Fair methods of access and information to market place

ACKNOWLEDGEMT

SIEMENS

We acknowledge

California Independent System Operator

Subject-Matter-Experts and

Siemens Market Application Experts

who have proactively contributed to maturing the solution domain of market systems.

Questions and Discussions