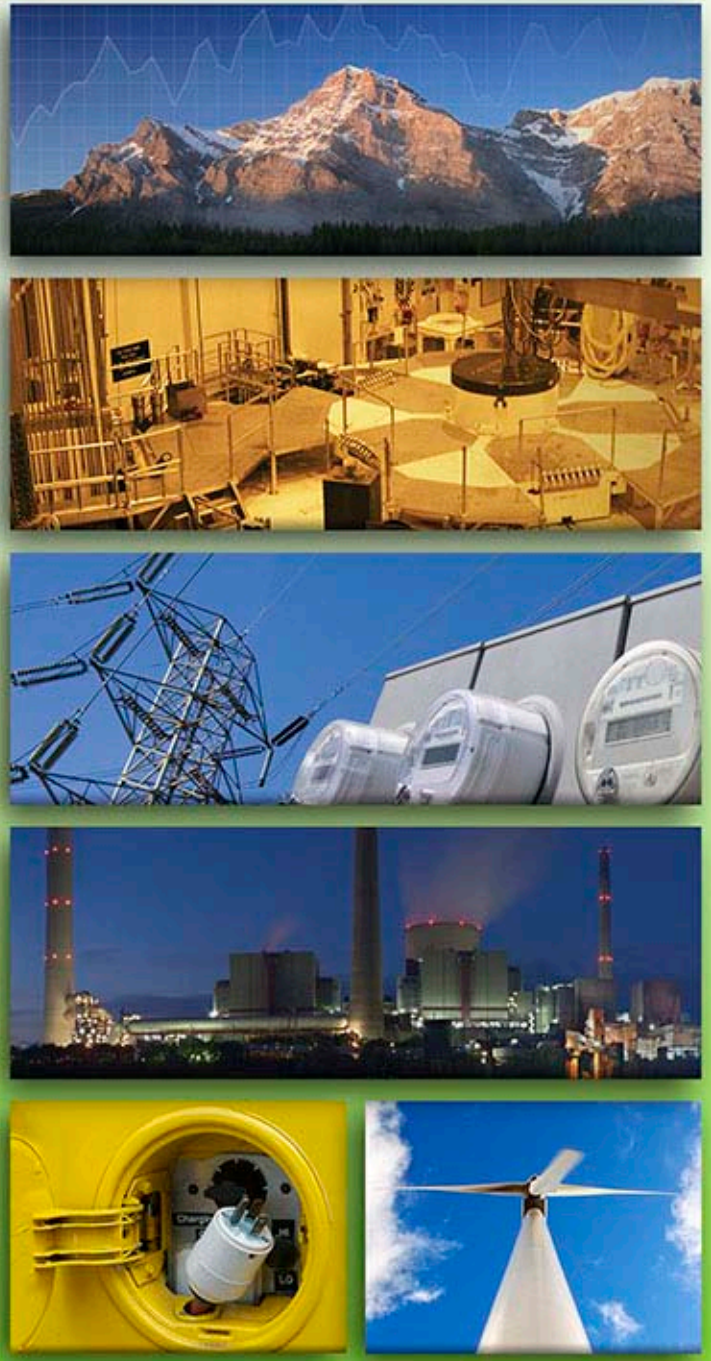

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Overview of Wholesale and Retail Electricity Markets in the U.S.

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Los Alamos, New Mexico

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Outline

I. Key events, 1990-2010

II. Two basic industry structures
   - A. Regulated Monopoly
   - B. Wholesale/retail competition

III. Key differences
   - A. Who decides and who bears risk?
   - B. How are retail prices formed?

IV. Interfaces between wholesale and retail markets
   - A. Original British idea
   - B. U.S. adaptation
   - C. Today's diverse markets
   - D. Tomorrow's challenges

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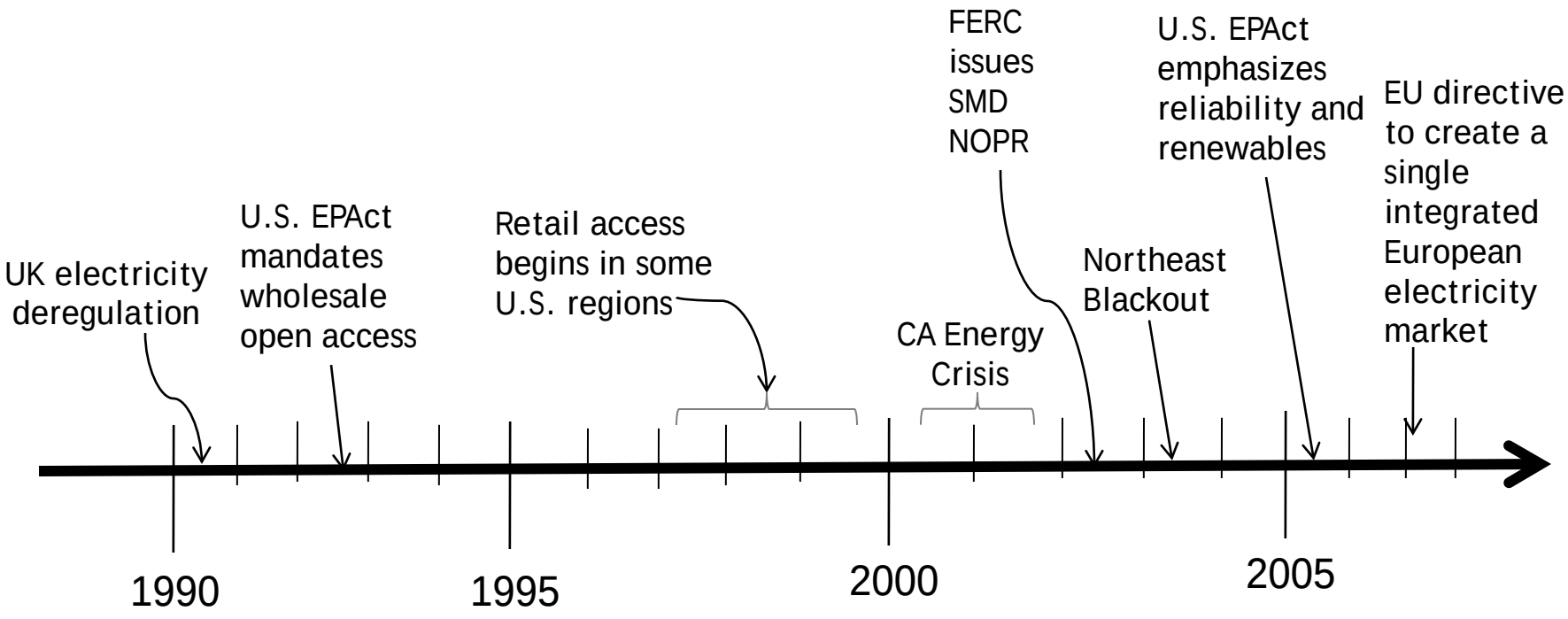
Electricity Markets – 20 years of evolution



Sources: Sally Hunt, *Making Competition Work in Electricity Work*, John Wiley & Sons, Inc., New York, NY, 2002; Georg Gebhardt and Felix Hoffler, "How to Determine Whether Regional Markets are Integrated? Theory and Evidence from European Electricity Markets," Governance and the Efficiency of Economic Systems, University of Munich, Munich, Germany, May 2008.

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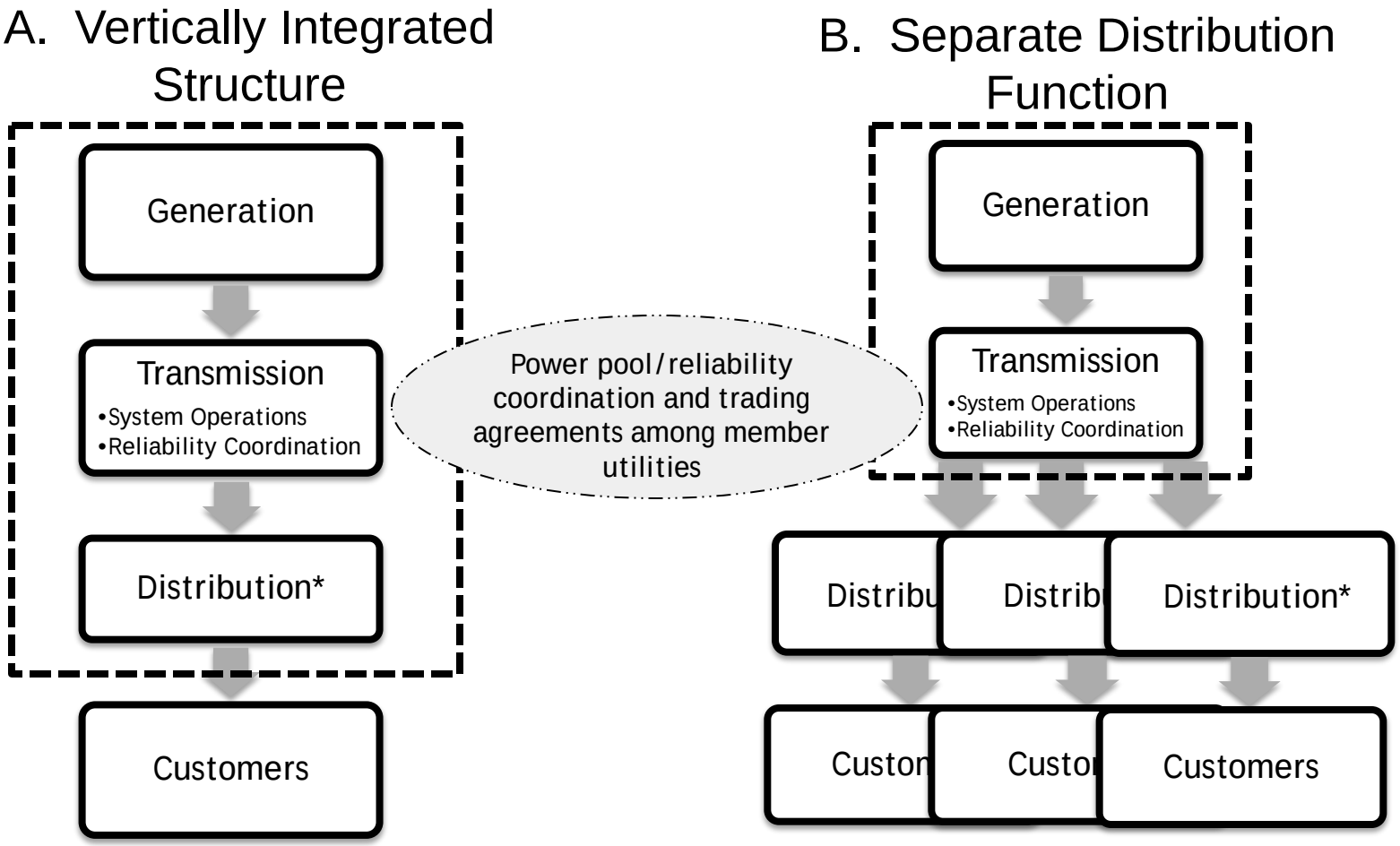
Structure 1: Regulated Monopoly Model



*Includes retailing and customer service functions.

Integrated functions

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Observations on the monopoly model

- This structure was predominant in the U.S. prior to restructuring efforts which began in the mid-1990s.
  - Most of the ***capacity*** (~75%) in the U.S. was owned by ~200 investor-owned utilities, most of whom were vertically integrated
  - Most of the ***utilities*** (~3000) were small, distribution municipal or cooperatively owned systems, many of whom who bought their generation and transmission services from cooperatively owned generation and transmission (G&T) suppliers.
- Reliability and trading agreements between monopolies were common.
  - In the Northeast, there were a number of “tight” power pools which became PJM, NYISO and NE-ISO.
  - In other regions, there were reliability and trading agreements, but not central dispatch of utility-owned systems which characterized the tight power pools.
- Both versions of the monopoly structure shown are still common in those regions of the U.S. that have not opened their markets to competition.

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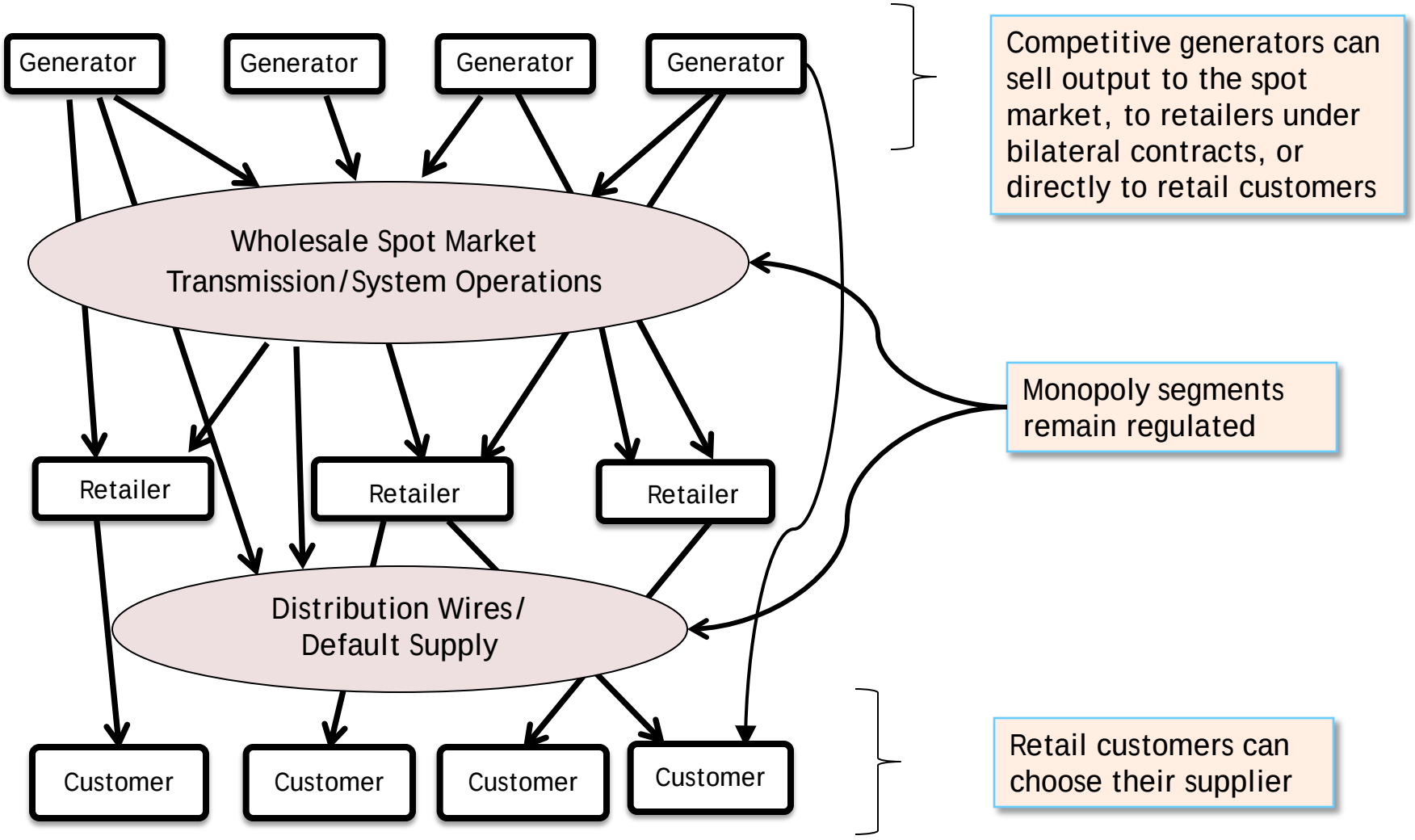
Structure 2: Wholesale & Retail Competition



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Observations on wholesale and retail competition

- This is the model that was pursued by most states in the U.S. who embraced restructuring (such as California, New York, New Jersey, Pennsylvania, Massachusetts, Illinois, Rhode Island, Maine, New Hampshire, Virginia, etc.)
- Wholesale competition is more widespread than retail competition, even in states where retail customers can choose
- Structured wholesale markets serve 66% of consumers in the United States, and more than 50% of Canada's population
- There are no credible proposals to eliminate existing ISOs/RTOs.
- In other regions, further restructuring has stalled
  - Emphasis in bilateral markets is on improving open access
  - There's no political support to introduce competition
  - Strong support in the Northwest and Southeast for state regulation over federally mandated organized markets

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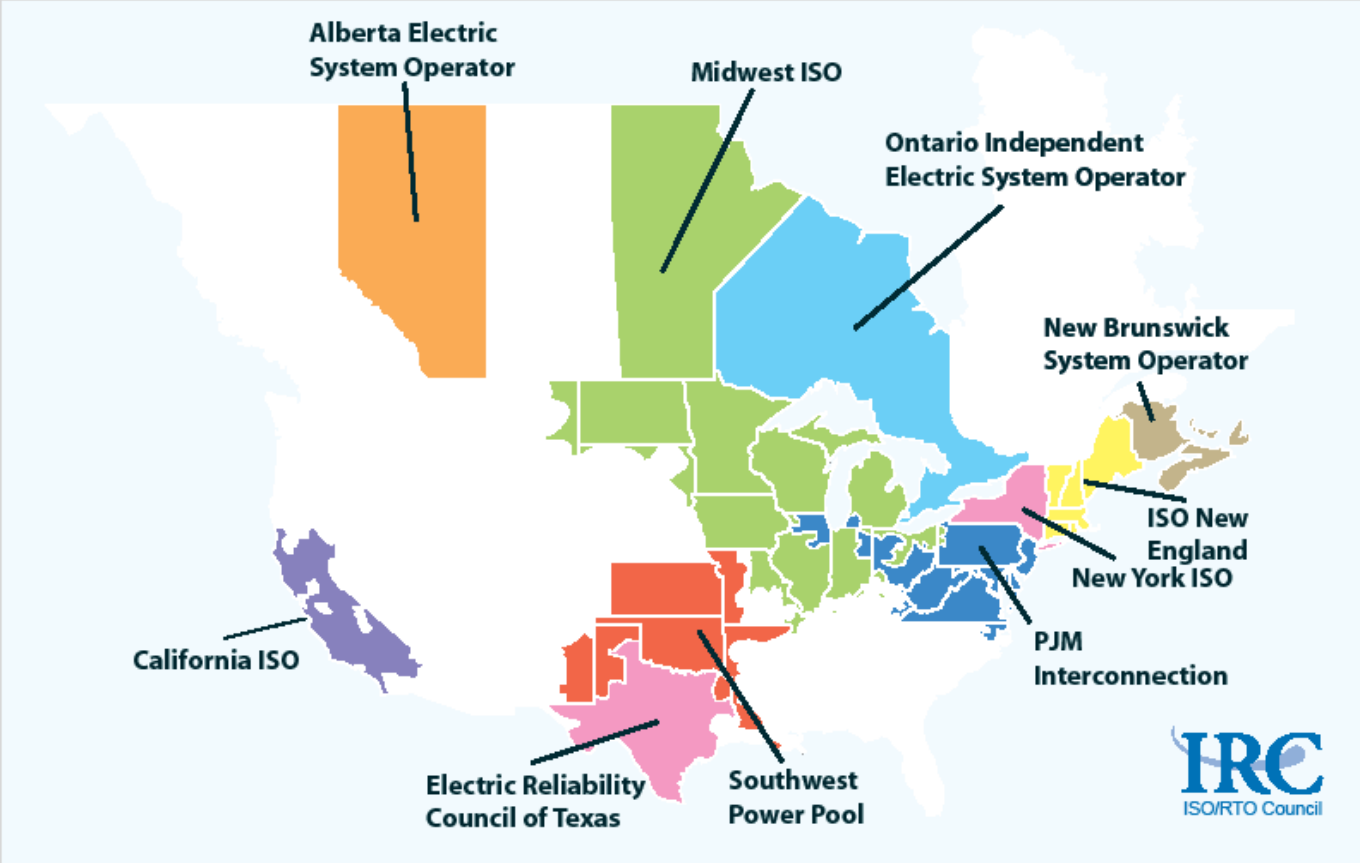
Organized electricity markets in North America

Ten Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) serve 66% of consumers in the U.S. and more than 50% of Canada's population. See the ISO/RTO Council website: www.isorto.org.



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Key differences: Who decides and who pays?

	Monopoly Model	Competitive Model
Who decides: •How much capacity? •What fuel type? •Where to site?	• Regulated utility develops subject to regulatory approval • G&T Cooperative	• Competitive supplier • Customer • Anyone with the money & inclination
Who builds or acquires supply?	• Utility under rate-base construction • G&T Cooperative	• Same as above • Utility (if default provider)

Who pays?
Who bears risk?
	• Investor-own Utilities:
	  • Customers pay for prudent investment
	  • Investors pay for imprudent investments
	• G&T Coop – customers pay
		• When market prices are low:
		  • Investors absorb costs
		  • Customers benefit
		• When market prices are high:
		  • Investors benefit
		  • Customers pay more

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Key Differences: Market vs. Regulated Pricing

- Market Prices
  - Forward-looking, based on marginal cost
  - Don't reflect sunk costs
- Regulated Prices
  - Based on average, historic costs.
  - Only reflect marginal costs to the extent they impact the average

$$\text{Regulated Price (¢/kWh)} = \frac{\text{Fixed Costs} + \text{Fuel Costs} + \text{O\&M Costs}}{\text{Energy Sales (kWh)}}$$

Fixed Costs = Depreciation of original investment & maintenance capital, fixed price contracts, financing costs, etc.

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Regulated vs. Market Prices – Mid 1990s

What happens to prices when there is:	Regulated monopoly	Competitive markets
Excess generating capacity		
Declining natural gas costs	Depreciation capacity mix & fuel contracts	↓
New capacity **cheaper** than old capacity	↓ or ↓ ↔	↓ ↓

On the eve of deregulation, average embedded generation costs were 6 ¢/kWh in upstate New York. Average market prices were 2 – 3 ¢/kWh.

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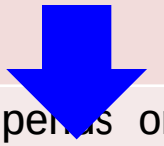
Regulated vs. Market Prices – 2008

What happens to prices when there is:	Regulated monopoly	Competitive markets
A shortage of generating capacity		
Increasing natural gas costs	Depends on capacity & contract mix	
New capacity more expensive than old capacity	 or 	

When natural gas prices are $10-15/MMBtu, electricity prices can be in the range of 10-15¢/kWh due to fuel costs alone.

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Implications for modeling

- The particular market structure determines who makes decisions, what costs are incurred, who pays and who bears risk
- In both the monopoly and competitive structures, marginal (forward-looking) costs (not historic or sunk costs) will determine real resource savings

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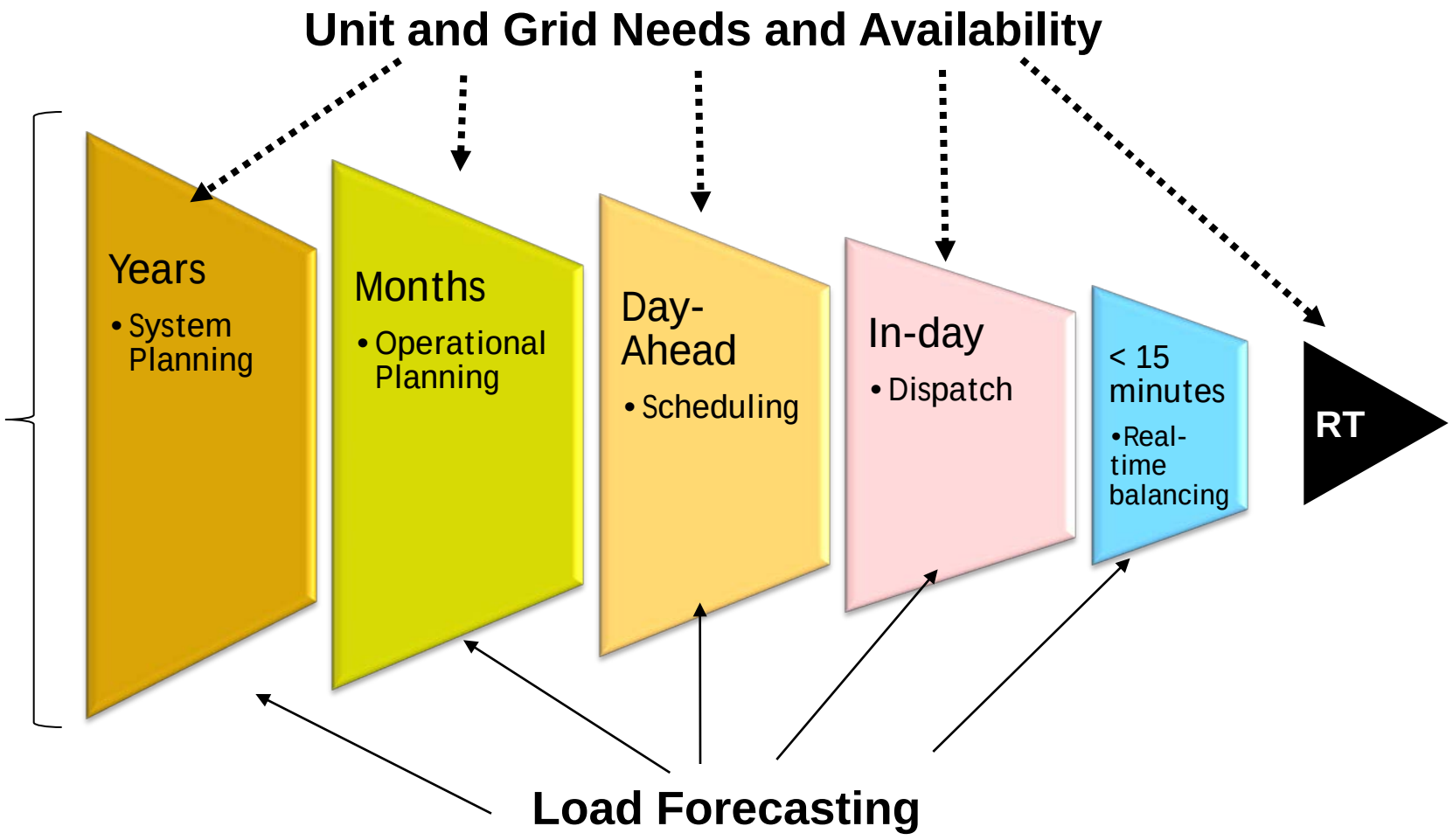
IV. Interfaces Between Wholesale and Retail Markets

Traditional electricity system operation under a vertically integrated model



Source: USDOE, The Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them, Feb. 2006.

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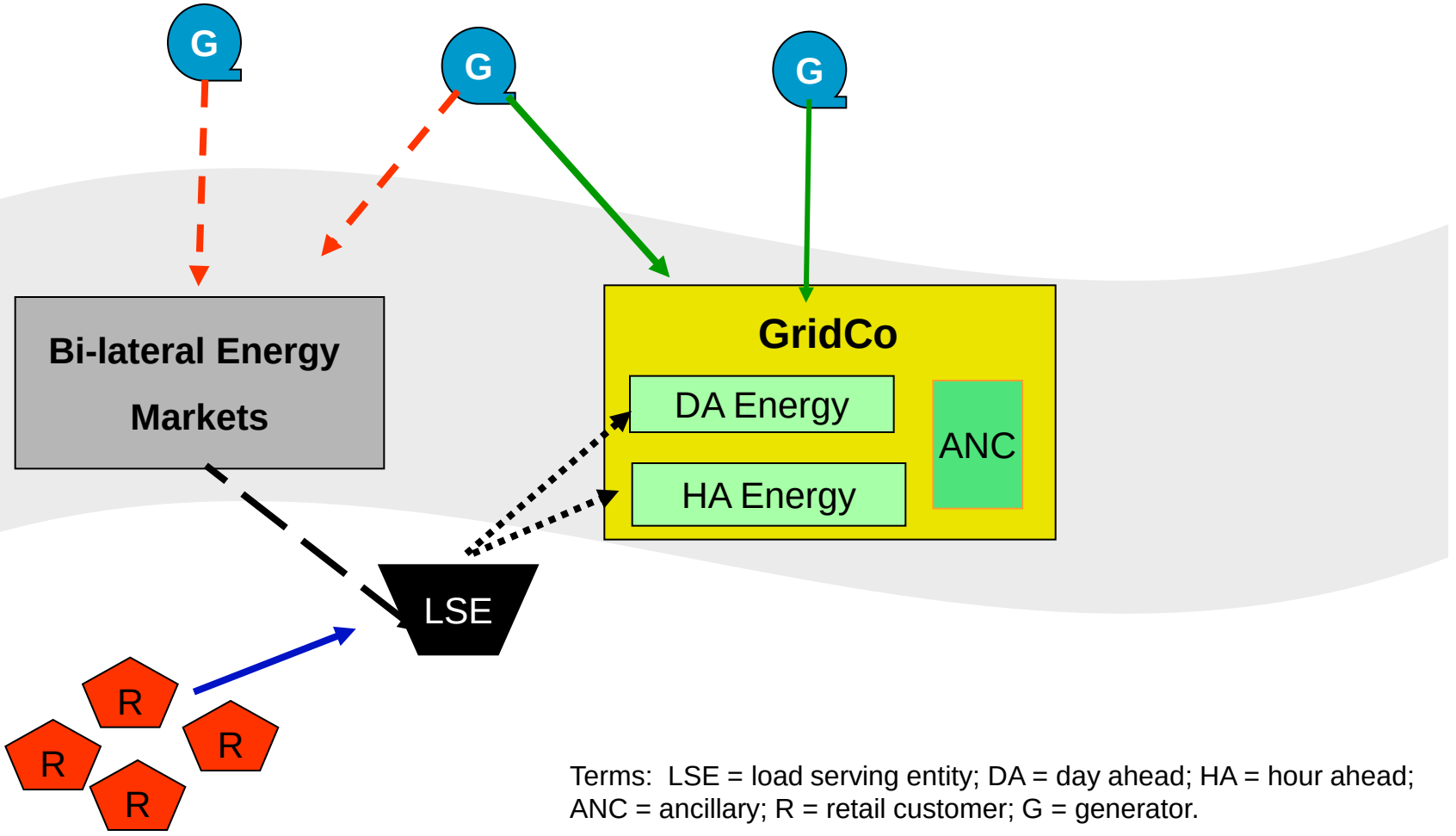
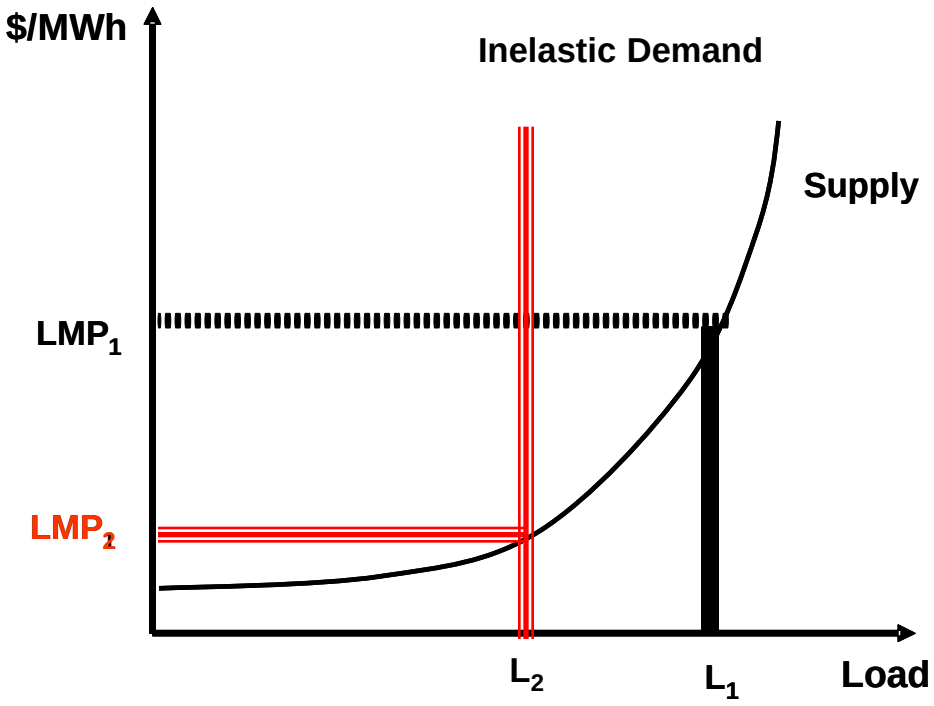
English GridCo Model



Terms: LSE = load serving entity; DA = day ahead; HA = hour ahead; ANC = ancillary; R = retail customer; G = generator.

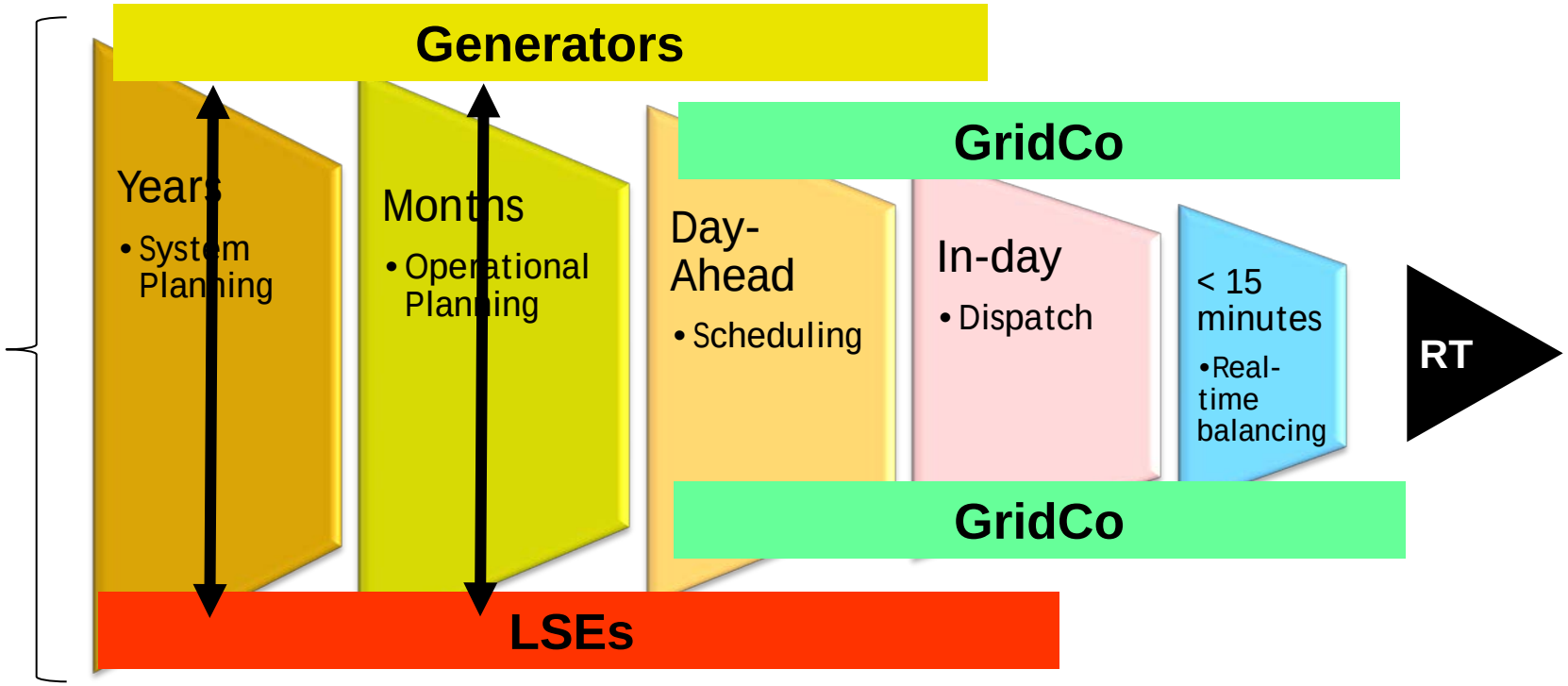
Electricity market price formation



- All generation bids into pool
- Loads are forecasted by pool
- Security constrained dispatch set schedule and price (last price auction)
- Price apply only to spot market transactions

GirdCo system interdependencies

System and Grid Needs and Availability



Load Forecast

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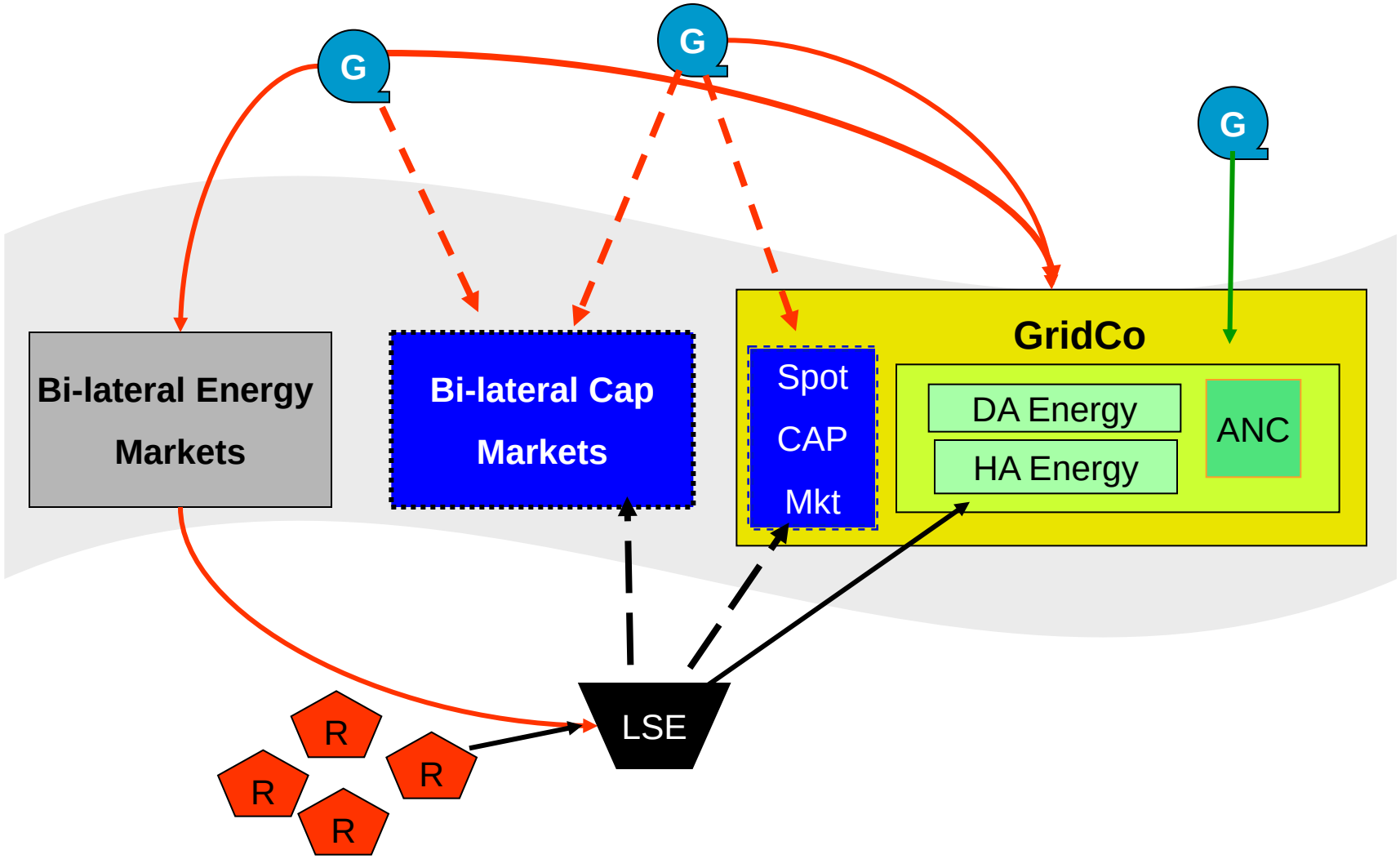
The U.S. Adaptation

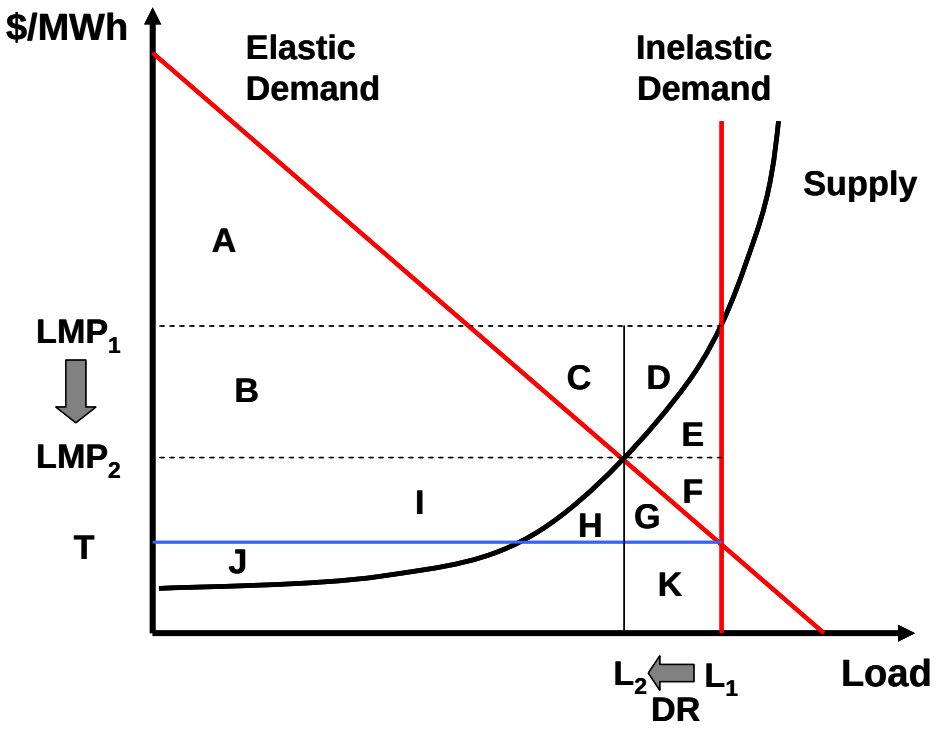
- British experience
  - Cyclical pattern to locational marginal prices (LMPs) and depth of bilateral market activity
  - No investments, excess capacity (dash for gas)
- California calamity
- Capacity requirements and markets added to assuage fears of high prices/price volatility

U.S. Capacity Requirements Model



Electricity Market Savings of Price Response

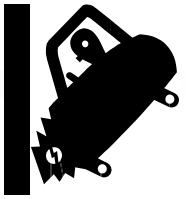
3.0



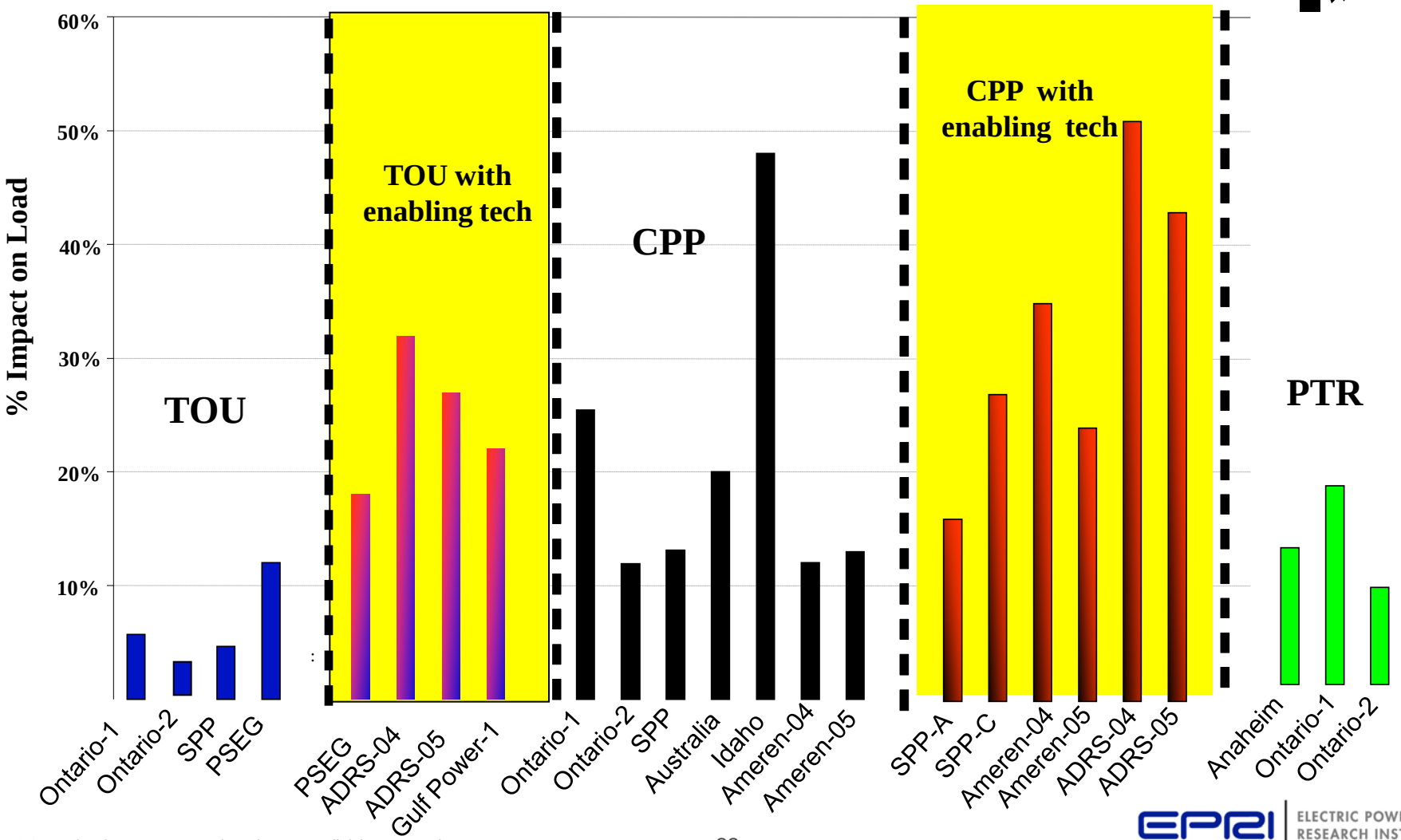
- Customers facing flat-rate tariff (T) would consume at load L_1
- Generators meet this level of demand with electricity at a price of LMP_1
- Customers facing market prices see LMP_1 and respond by reducing load to L_2
- Load demands of L_2 causes the market to clear at $LMP_2 < LMP_1$
- Assuming 100% of load is bought in market, LSEs save & Generators lose

  B + C + D + E + F + G + K
- Wealth is transferred from producers to consumers

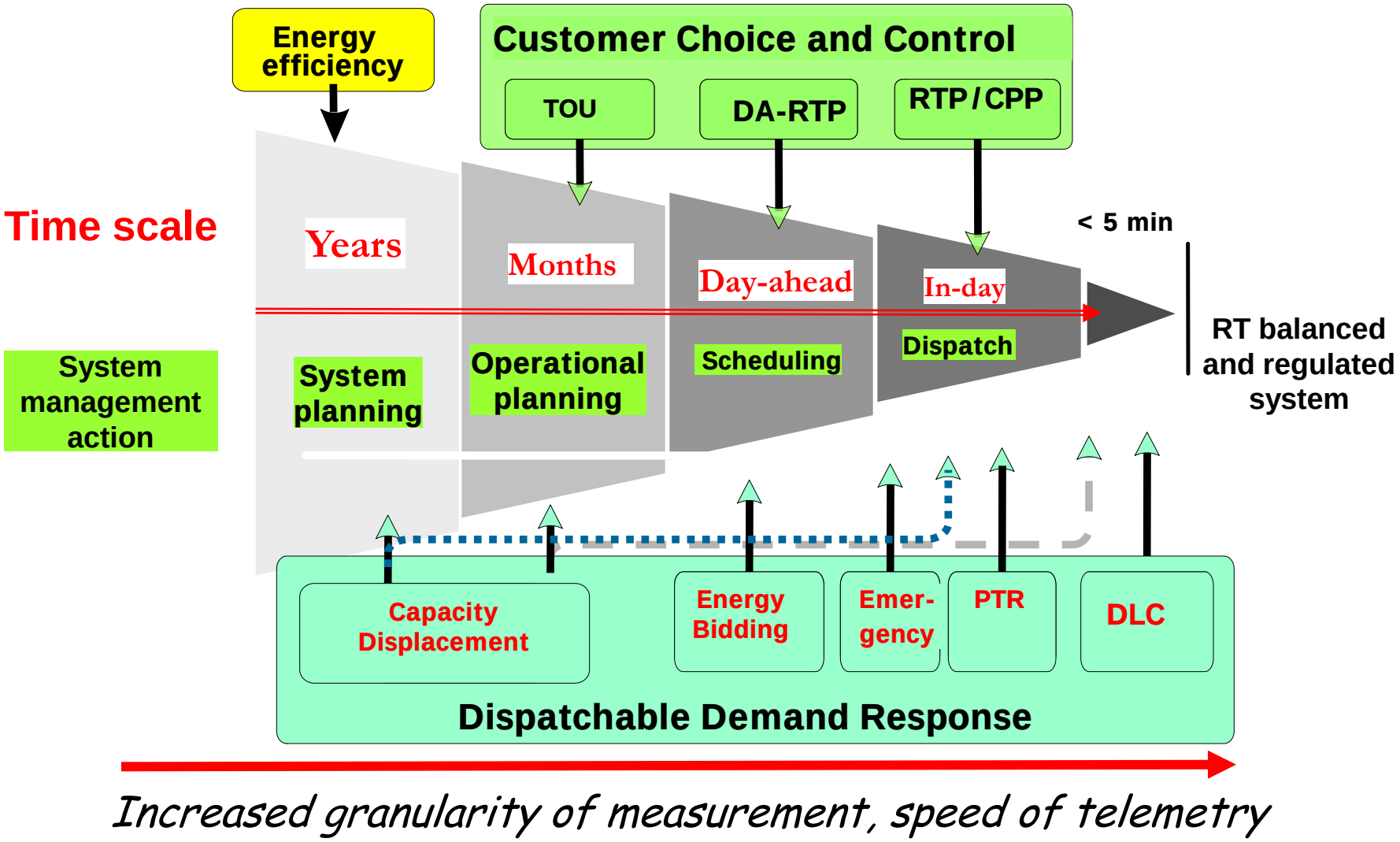
Comparison of Demand Response Impacts



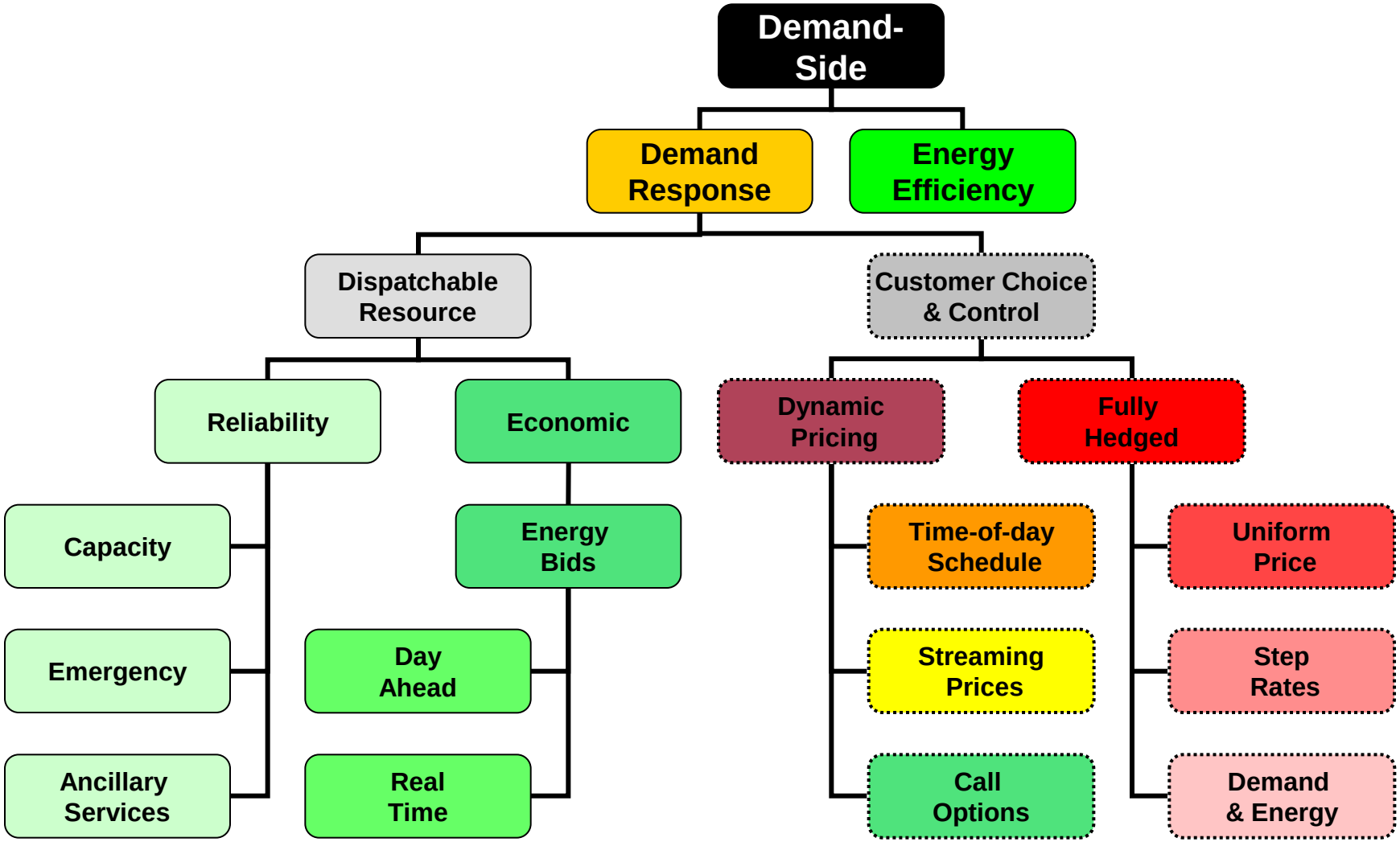
(Source: Faruqui, April 2008)



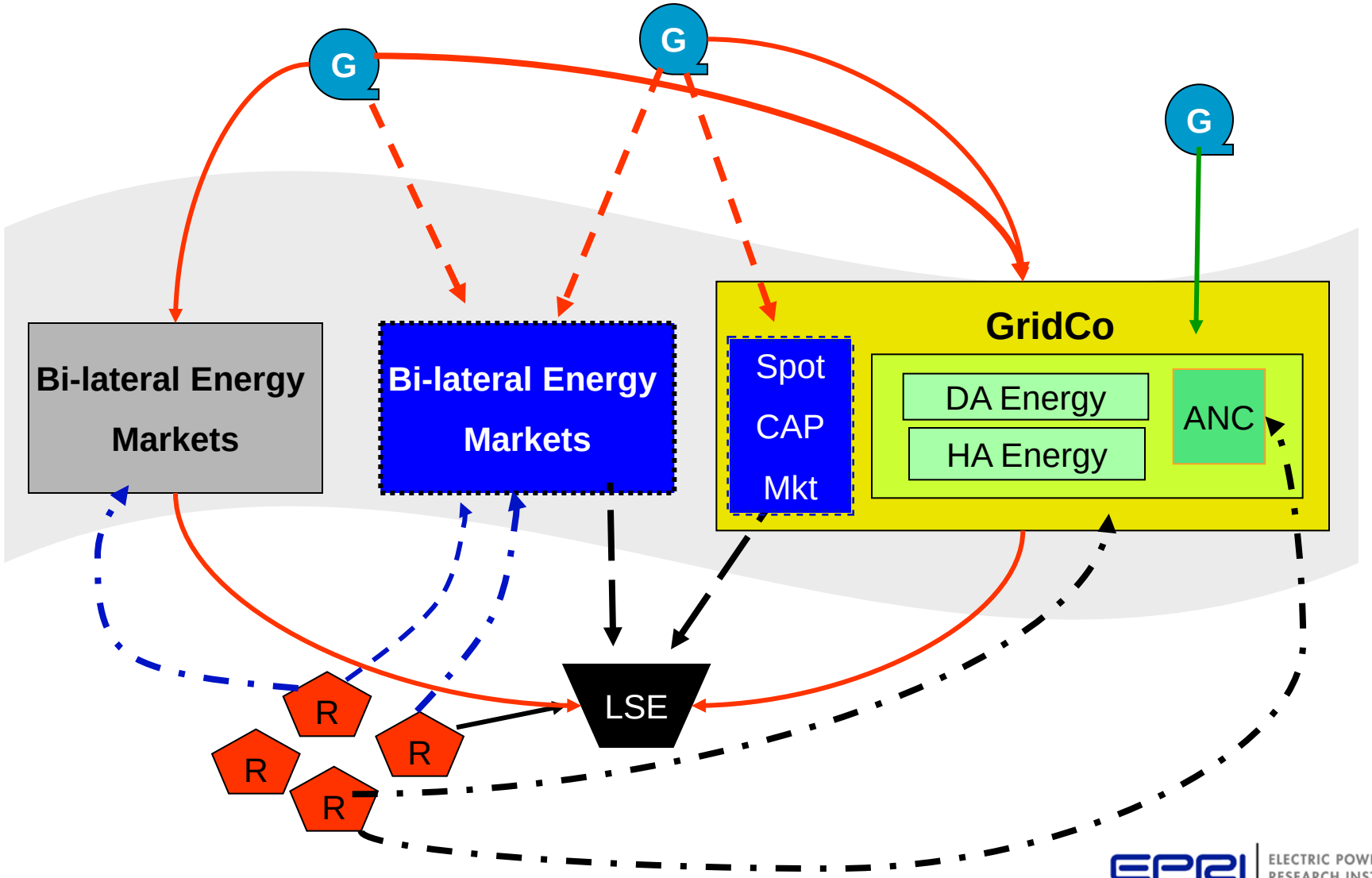
Integrating EE and DR into electricity markets



Demand Response Categorization



Added complexity with demand as a resource



EPRI Smart Grid Demonstrations

Leveraging Today's Technology to Advance the Industry

- Deploying the Virtual Power Plant
- Demonstrate Integration and Interoperability
- Leverage information & Communication Technologies
- Integration of Multiple Types of Distributed Energy Resources (DER):
  - Distributed Generation
  - Renewable Generation
  - Storage
  - Demand Response

Multiple Levels of Integration - Interoperability

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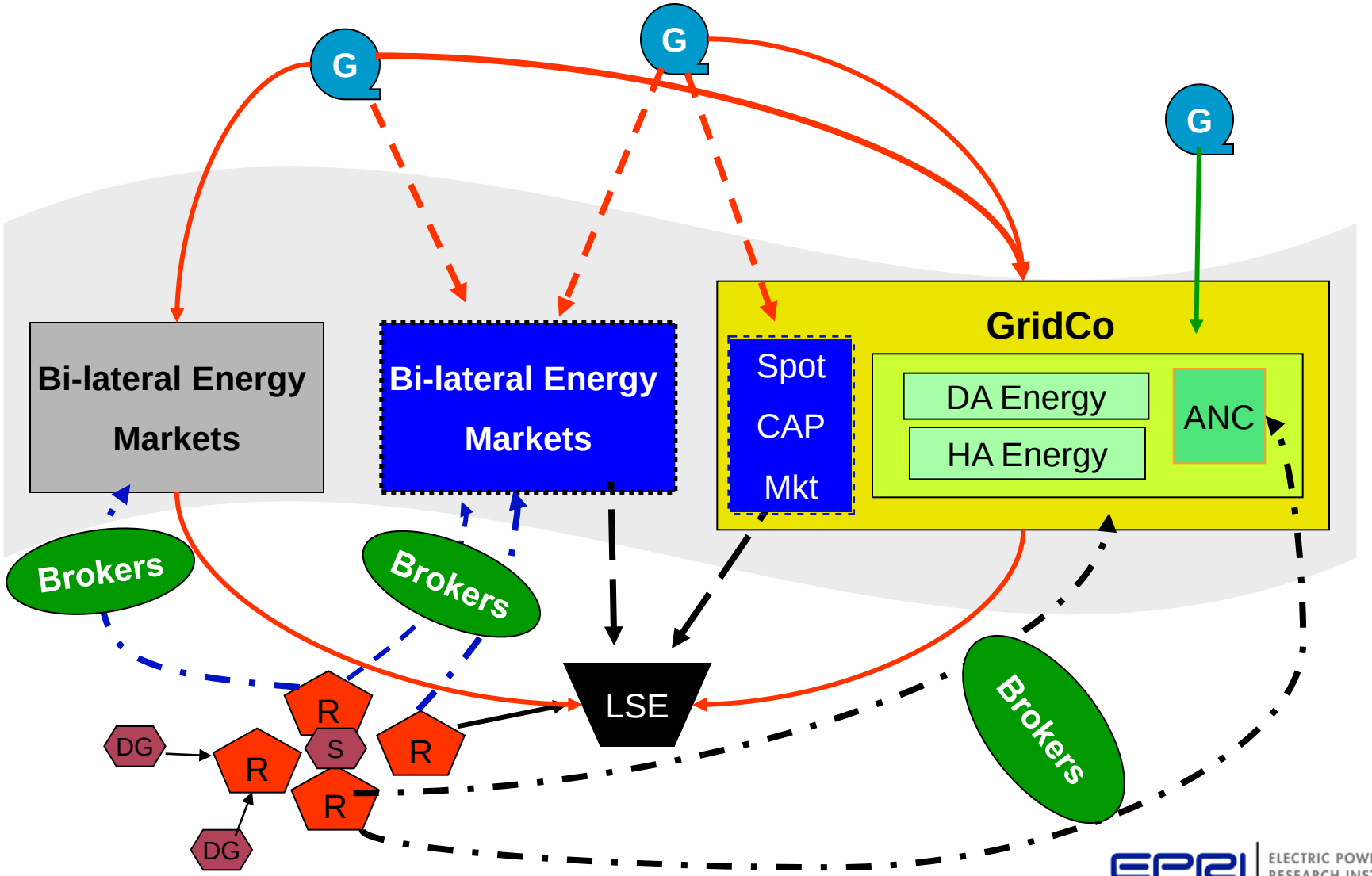
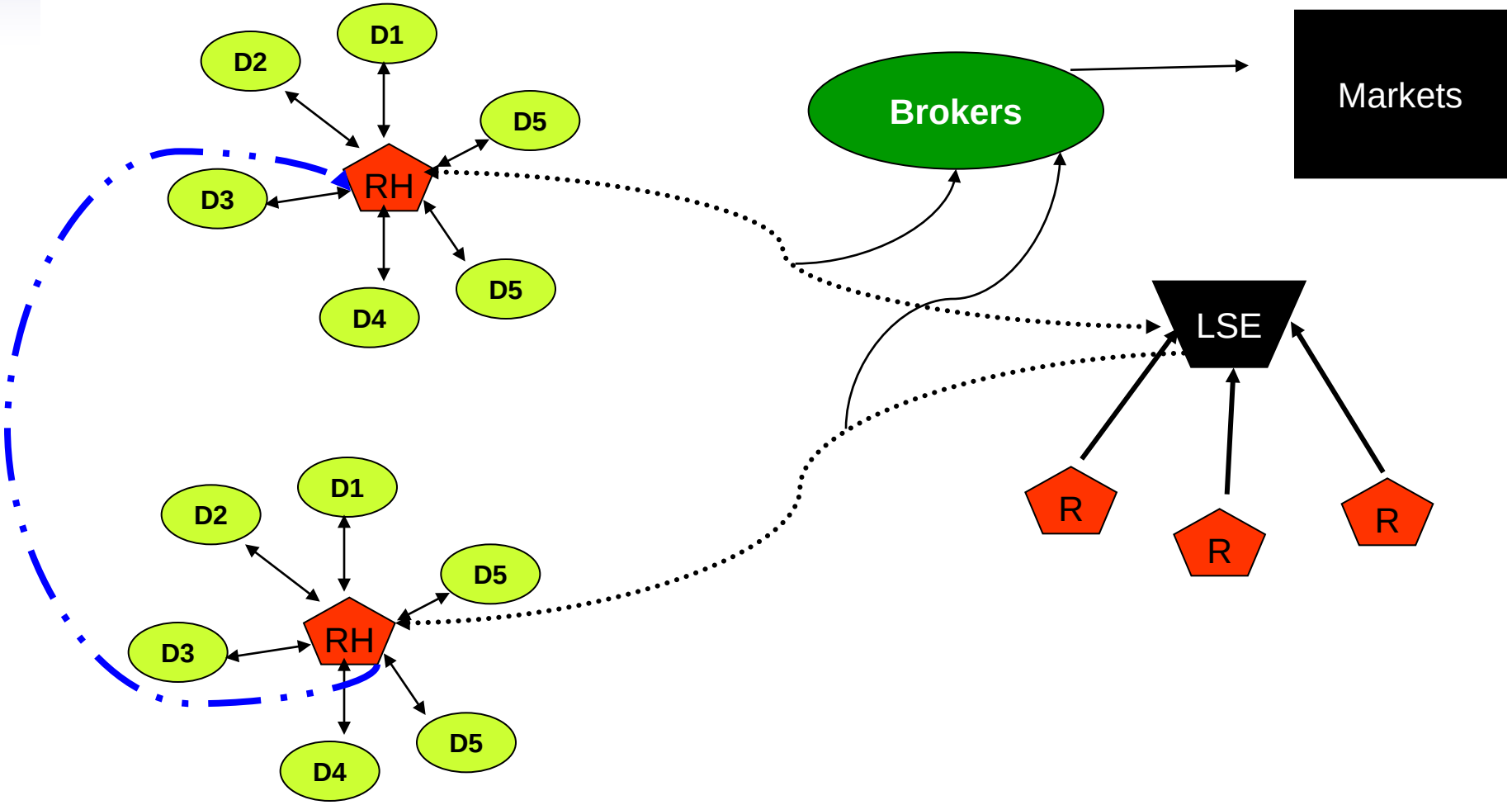
Smart Grid adds even more actors



Transactional demands - electric devices negotiating for power to provide services

- Households
  - Most devices are equipped with a chip to accept state-specific instructions
  - A central hub
    - negotiates among devices
    - Between home and agents
    - Among agents and the market
    - executes price response
    - Fulfills curtailment instruction
- Businesses
  - Execute forward position to match supply with needs
  - Trade on assets to lower costs



Tomorrow's electricity markets

- Large number of traders (maybe millions)
- Some with a physical position as suppler and consumer
- Making lots of transactions (several times a minute)
- Over the entire supply time scale (long, years-out to real-time)
- Across the entire network (generator bus to end-use device)

Questions

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