Optimal algorithms and non optimal outcomes: A perspective from Ontario

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Overview of the Evolving Alberta Landscape

- Challenges facing Alberta:
  - Energy transition and changing generation supply mix
    - reduced carbon-emitting sources, increased intermittent renewable sources and new technologies
  - Intermittency of renewable supply raising concerns for reliability (short-term security not long-term adequacy)
  - Transmission costs, generator market power creating affordability concern
  - Uncertainty of changes affecting investor confidence
- Conclusion:
- Policies and current electricity market structure not suitable to address current and emerging challenges
- Task:
  - Restructure market to ensure reliability, affordability, decarbonization goals met, and new market implementation in a timely and transparent manner

Recommended Path Forward

- Maintaining a competitive, market-based structure is best means of achieving objectives
  - ***Near-term*** changes to reduce effects of generator market power and to manage intermittency of supply
  - ***Medium-term*** changes such as a day-ahead market, scarcity pricing, security constrained economic dispatch with co-optimized energy and ancillary services, shorter settlement intervals with potential for negative prices, and modifying the Transmission Regulation and the tariff to send improved locational signals
  - ***Long-term*** changes to allow targeted contracts of controllable capacity on an as-needed basis

Motivation for My Talk

- Alberta's competitive wholesale electricity market is facing a potential existential moment
- Ontario faced a different but not too dissimilar moment shortly after it opened in the spring of 2002
- In this talk, I discuss:
  - key aspects of the initial Ontario wholesale market design and competitive market structure;
  - unanticipated design and structure challenges; and
  - design and policy responses and longer-term implications

The morale of my story:

- elegant algorithms cannot correct deficiencies in competitive structure
- unexpected outcomes with new design are likely
- What is root concern – bad design, bad structure?
- reducing participant risk to promote reliability may distort competition

But first……a comment on….

Why introduce markets for electricity generation?

- From a "public interest" perspective, it is to use the forces of competition to deliver efficient outcomes
- Competitive markets, which harness the self-interest of individuals through the "invisible hand," lead to the best use of society's presently available resources (Pareto efficiency)
- Requires the absence of a "***market failure***" – individual incentives for rational behavior do not lead to best use of resources for society at large

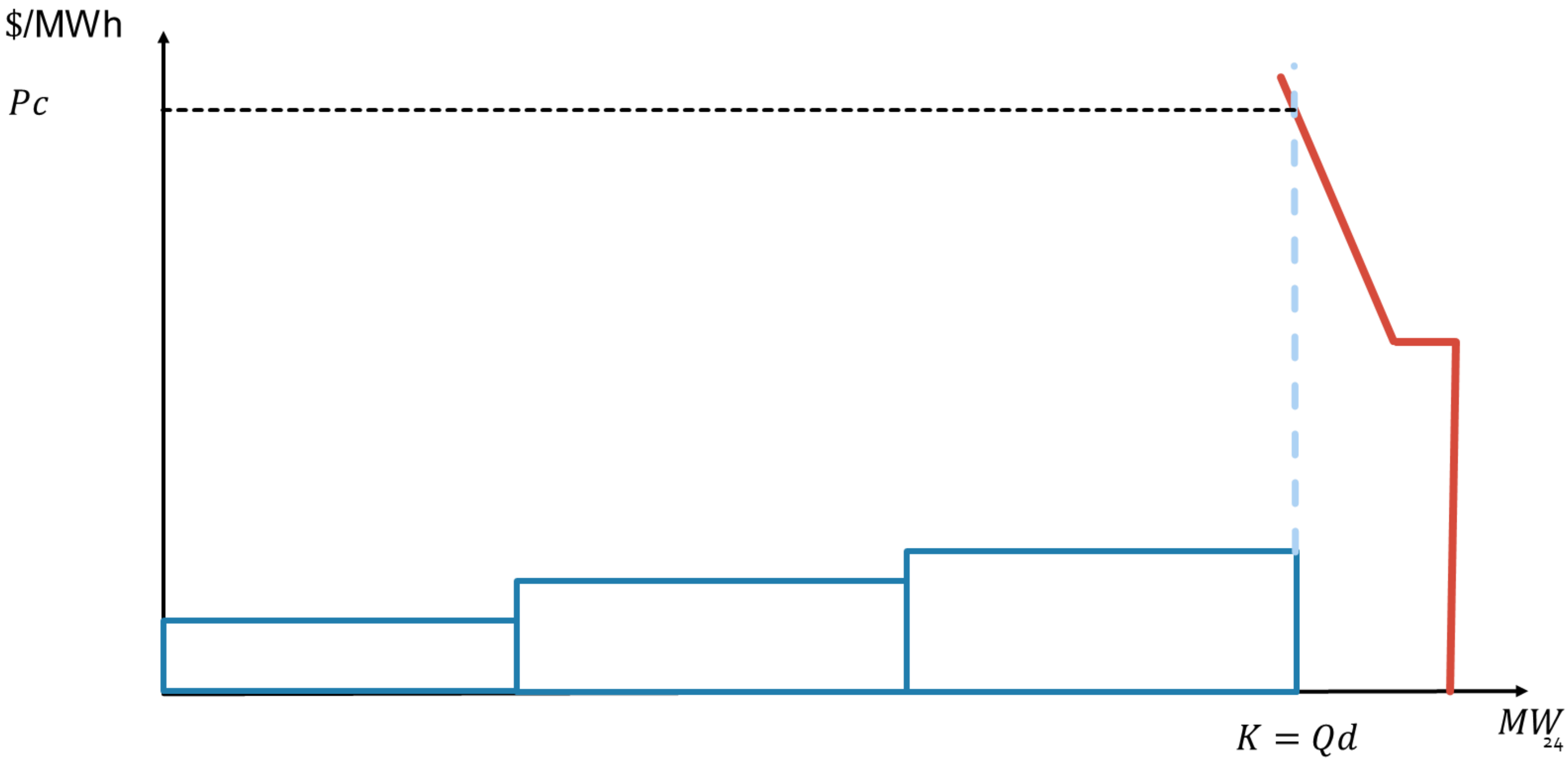
- ***Is there a market failure in electricity markets***?

- If so, there may be a need for some regulatory intervention to address market failure
- Imperfectly competitive markets can promote cost minimization and efficient pricing, and can be preferable to imperfect regulation

- ***What is the appropriate level of regulatory intervention?***

Real-time Energy Market Clearing

(with elastic demand and capacity constraints)



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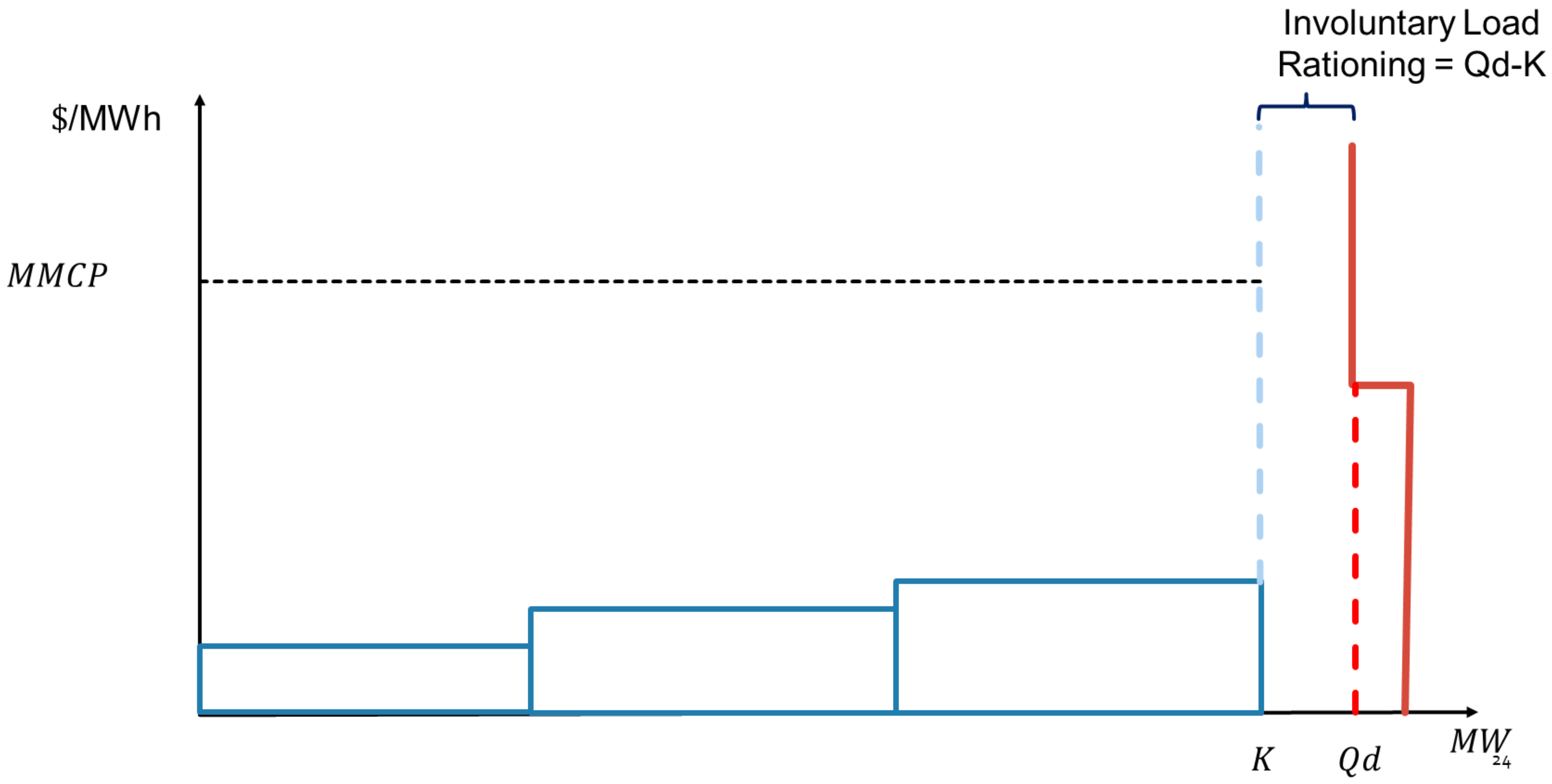


Contributing Factors to a Potential Market Failure

- The physical nature of the grid that requires supply and demand to always balance (system security)
- The lack of interval meters and other technical and social (inertia) limitations that inhibit the ability of most consumers to respond to price signals
- The technical inability of a system operator to rationally curtail individual consumer's consumption according to pre-identified price/quantity bids
- Price caps, retail price regulation, and randomized ISO curtailments in the event real-time supply shortfalls reduce the downside to consumers purchasing energy in short-term markets and increases the incentive to under-procure their expected energy needs in forward markets

▪ Can manifest into other market failure concerns such as market power and can become of greater concern with the addition of variable energy, intermittent resources

What is the appropriate regulatory intervention?

- Market failure generally discussed in terms of Resource Adequacy
  - Remedies include long-term contracts, capacity market, energy-only market with scarcity pricing, or permissive of unilateral market power
- Also relates to System Security
- Arguably, reliability concerns of intermittency of renewables is a short-term security issue not adequacy issue
  - Is this due to distortions in long-term investment incentives?
- What is appropriate remedy?
  - Additional reserve products, ramping products?
  - Should more thought be given to understand how to overcome limitations on demand side elasticity?
- Challenge is zeroing in on root of market failure issue and devising least intrusive remedial action while not distorting competitive dynamics

Ontario's Wholesale Electricity Market
A look back to the early days of market opening

MARKET SURVEILLANCE PANEL

MONITORING REPORT ON

THE IMO-ADMINISTERED ELECTRICITY MARKETS

THE FIRST EIGHTEEN MONTHS

(MAY 2002 - OCTOBER 2003)

DECEMBER 17, 2003

PUBLIC

Ontario's Market Assessment Unit Circa 2002

Market Design Features

Wholesale Market

- Real-time energy and operating reserve market - co-optimized
  - Two-schedules – security constrained schedule for dispatch and an unconstrained schedule to determine the Ontario wide prices
  - 5-minute settlement for dispatchable participants (MCP), including generators and dispatchable loads and hourly settlement for others (HOEP)
  - Maximum MCP = $2,000, Minimum MCP =-$2,000
- Contract market for Regulation Services
- 24-hour pre-dispatch schedules for informational purposes, one-hour ahead pre-dispatch selects import and export quantities, which are then fixed in real-time
  - Exports pay the 5-minute price
  - Imports receive Intertie Offer Guarantee (IOG) which ensures importer receive at least the average price of their offer across hour
- ***No day ahead market, unit commitment program, or capacity mechanism***

Retail Competition

- All consumers to be settled based on real-time prices
- Could contract with a retailer to manage price risk

Structural Features

Generation Supply

- Government-owned Ontario Power Generation (OPG) accounted for 90% of the installed capacity
  - Bruce Power 11% of the capacity (the Bruce nuclear facilities) through a long-term lease arrangement with OPG
- Great Lakes Hydro Income fund - 3% and transitional self-scheduling - 6%
- OPG was subject to a "Market Power Mitigation Agreement" which included must offer requirements and a CfD for a certain percentage of their expected production

Table 1.2: Ontario-based Generation Resource Mix, Actual (2002) and Projected (2006)[32]

	2002		2006	
Resource Type	**MW**	**Share (%)**	**MW**	**Share (%)**
Nuclear	8,748	32	12,278	33
Coal	7,553	27	7,553	20
Oil/Gas	3,662	13	9,755	26
Hydroelectric	7,522	27	7,522	20
Miscellaneous	77	0.28	77	0.21
Total	**27,562**		**37,165**	

Structural Features

Demand

- Roughly 90 consumers (industrial) were connected to the grid with interval meters (15% of total demand) and 5 participated as dispatchable loads with 5-minute dispatch and settlement (250 MW)
- Remaining consumers connected to the market through local distribution companies
- Electricity rates had been frozen at 4.3 cents per kWh since 1993

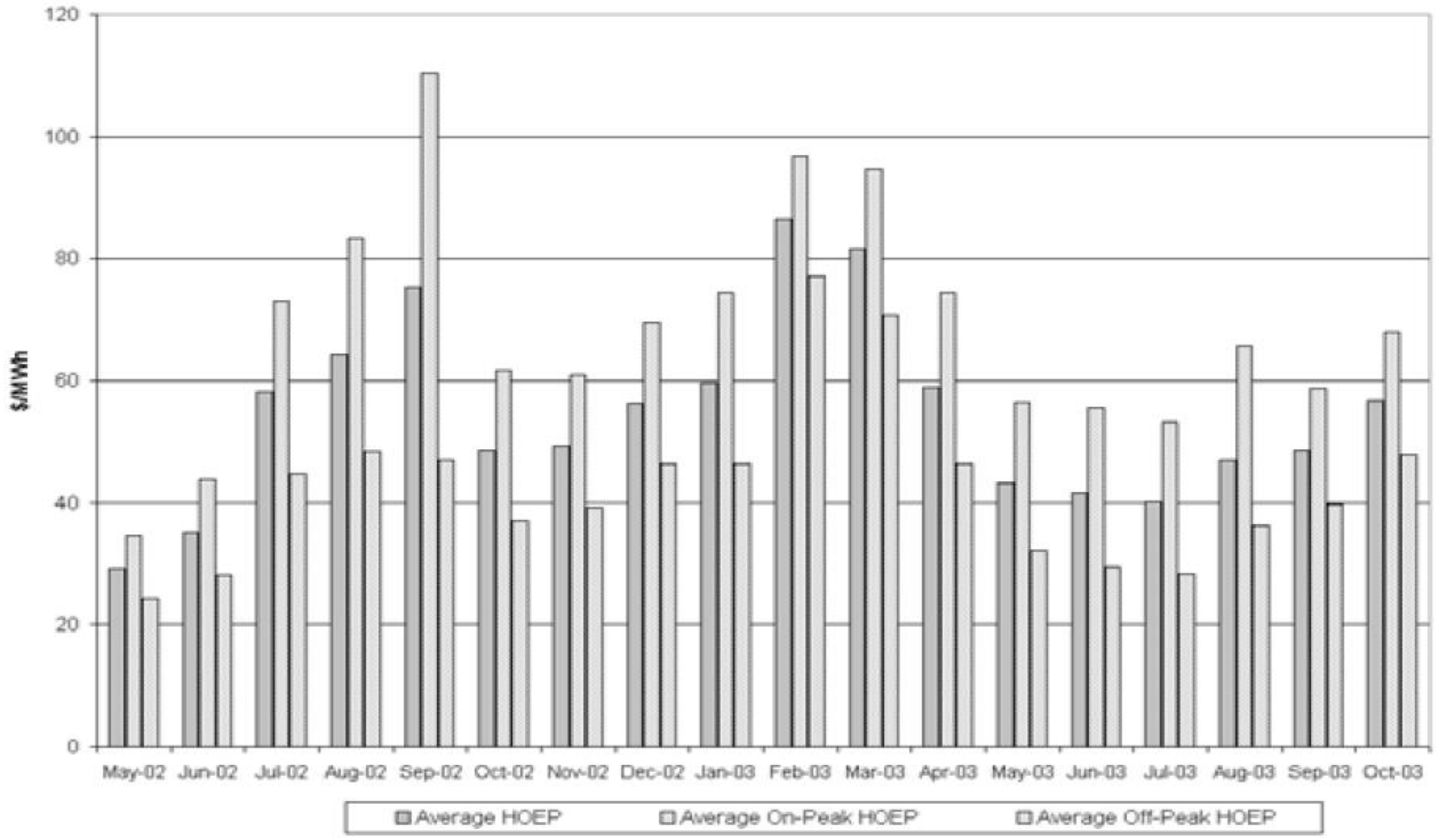
Imports and Exports

Table 1.3: Intertie Flow Limits

Interconnection	Limit – Flow Out of Ontario (MW)		Limit – Flow Into Ontario (MW)	
	Summer	Winter	Summer	Winter
Manitoba	287	287	336	336
Minnesota	140	140	90	90
Quebec North	95	115	65	84
Quebec South (East and Ottawa)	740	760	1452	1452
New York St. Lawrence	400	400	400	400
New York Niagara (60 Hz & 25 Hz)	1990	2285	1444	1656
Michigan	2350	2400	1500	1600

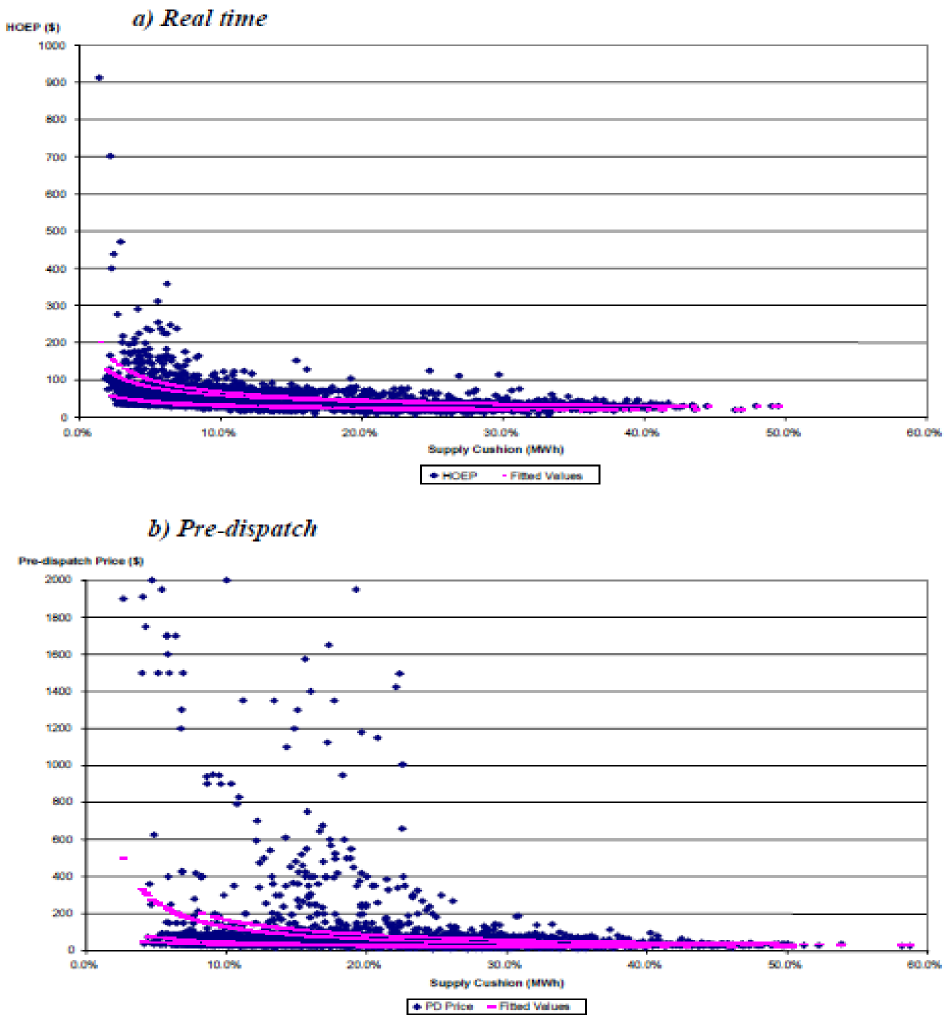
Market Outcomes – Hourly Ontario Energy Price

Figure 1-4: Average HOEP for May 2002–October 2003



Market Outcomes – Supply Cushion and Price

Figure 2.3: Relationship between Price and the Supply Cushion



- Very little investment in new capacity had been made over previous 10 years such that reserve margins were low
- OPG was the dominant supplier but generally offered energy and reserve reflective of cost
- The summer of 2002 was unusually hot and dry which affected both demand and hydroelectric supply

Chronology of Unanticipated Design Challenges

Ramp Effects on Prices

- Pre-market testing indicated that large changes in supply at the start of a new dispatch hour could lead to considerable real-time price volatility and excess ramping of generators

Contributing factors:

- Hourly offer requirements
- Dispatch algorithm minimize the cost of energy and reserve to meet demand and reserve requirements on a 5-minute basis with each 5-minute interval solved independently (i.e., no intertemporal optimization)
- OPG offering large amounts of energy limited hydroelectric facilities in the peak demand hours at low prices to run and then remove large amounts in hours that it did not want to run (Market Structure)

Market Design Response:

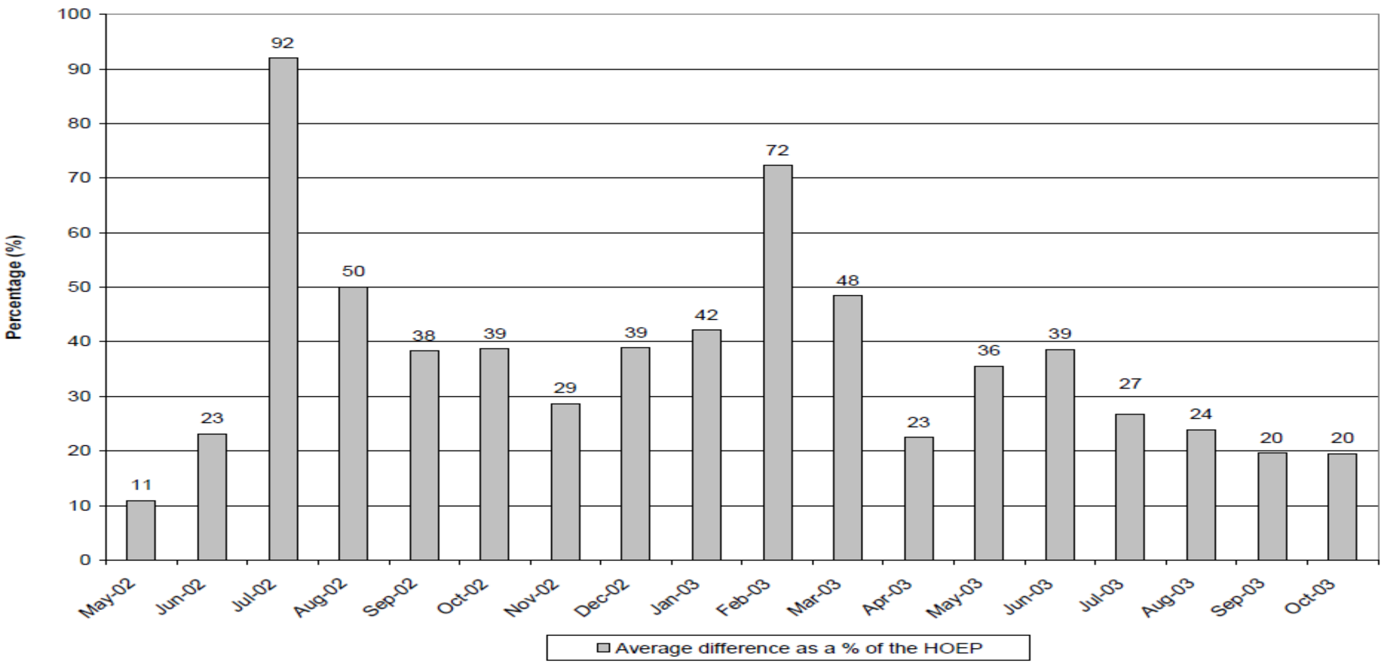
- 12-times ramp rate assumed in unconstrained price setting algorithm
  - Created a disconnect between actual system costs and marginal prices
  - Did not address real issues just masked price effect
  - Issue could be aggravated with large changes in net imports

Chronology of Unanticipated Design Challenges

Pre-dispatch to Real-time Price Differences

- There was a persistent positive difference between the hour-ahead pre-dispatch price and the hourly real-time prices that led to inefficient scheduling of imports/exports and "gaming"

Figure 1-10: Average Difference between One-Hour Ahead Pre-dispatch and Real-time as a Percentage of HOEP



Chronology of Unanticipated Design Challenges

Contributing factors:

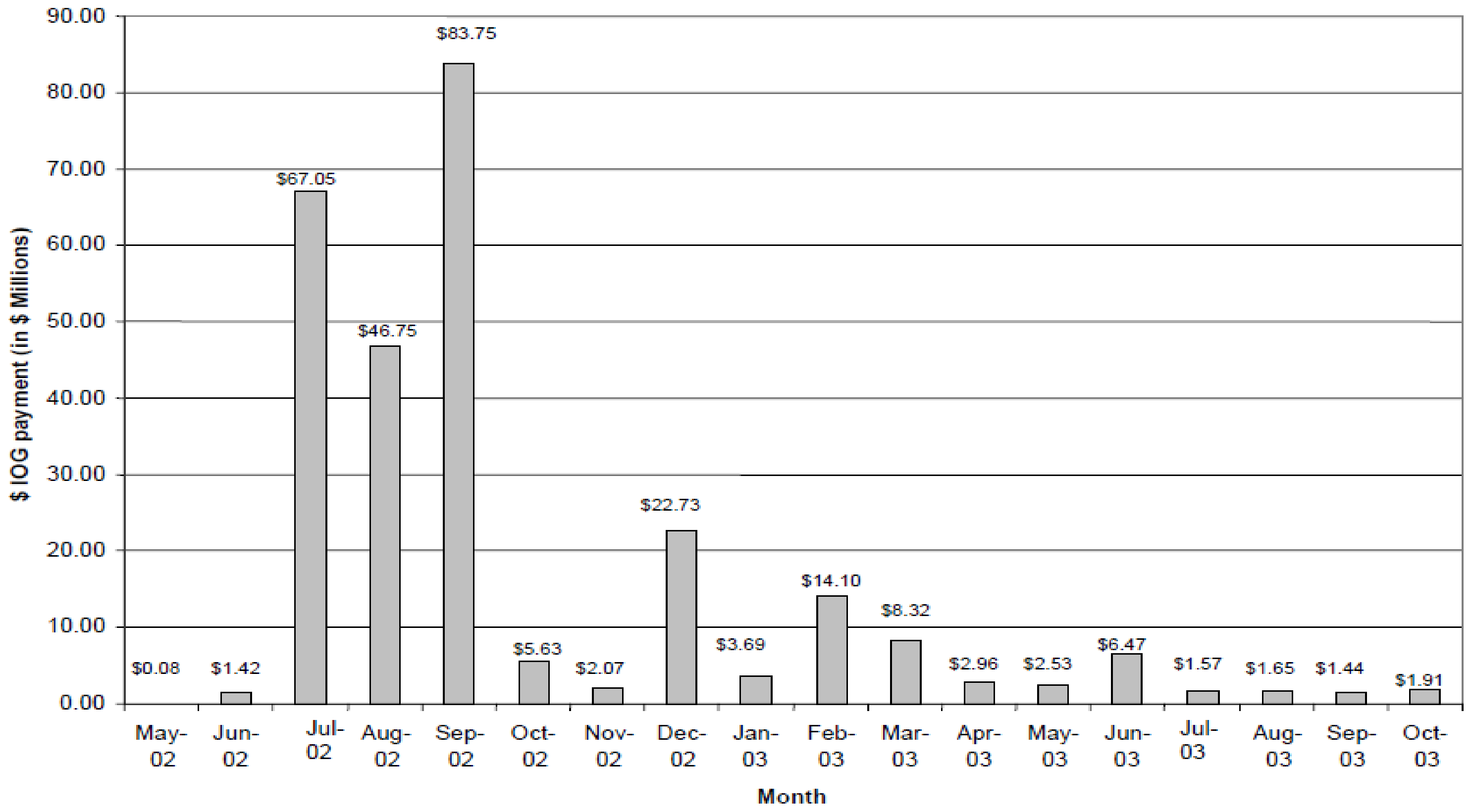
- Over-forecast of demand in hour-ahead pre-dispatch (peak demand forecast)
- Failed intertie transactions – predominately exports

Consequences:

- Positive differences between pre-dispatch and real-time prices became predictable
- Imports attracted to pre-dispatch by relatively high pre-dispatch price and IOG, exports target real-time prices
- Implied wheels matching imports and exports emerged – “gaming” price arbitrage
- Low real-time prices lead to OPG raising offer prices on peaking unit to avoid start
  - Could contribute to loss of ramp in real-time
- Control room would
  - activate 30-minute reserve and reduce reserve requirement
  - constrain on (out-of-merit) OPG’s peaking unit to gain ramp
  - implement voltage cuts
- Control room actions contributed to lower rea-time prices - aggravated issue
- Instances of pay-as-bid activity emerged due to two-schedule system (non-competitive interties)

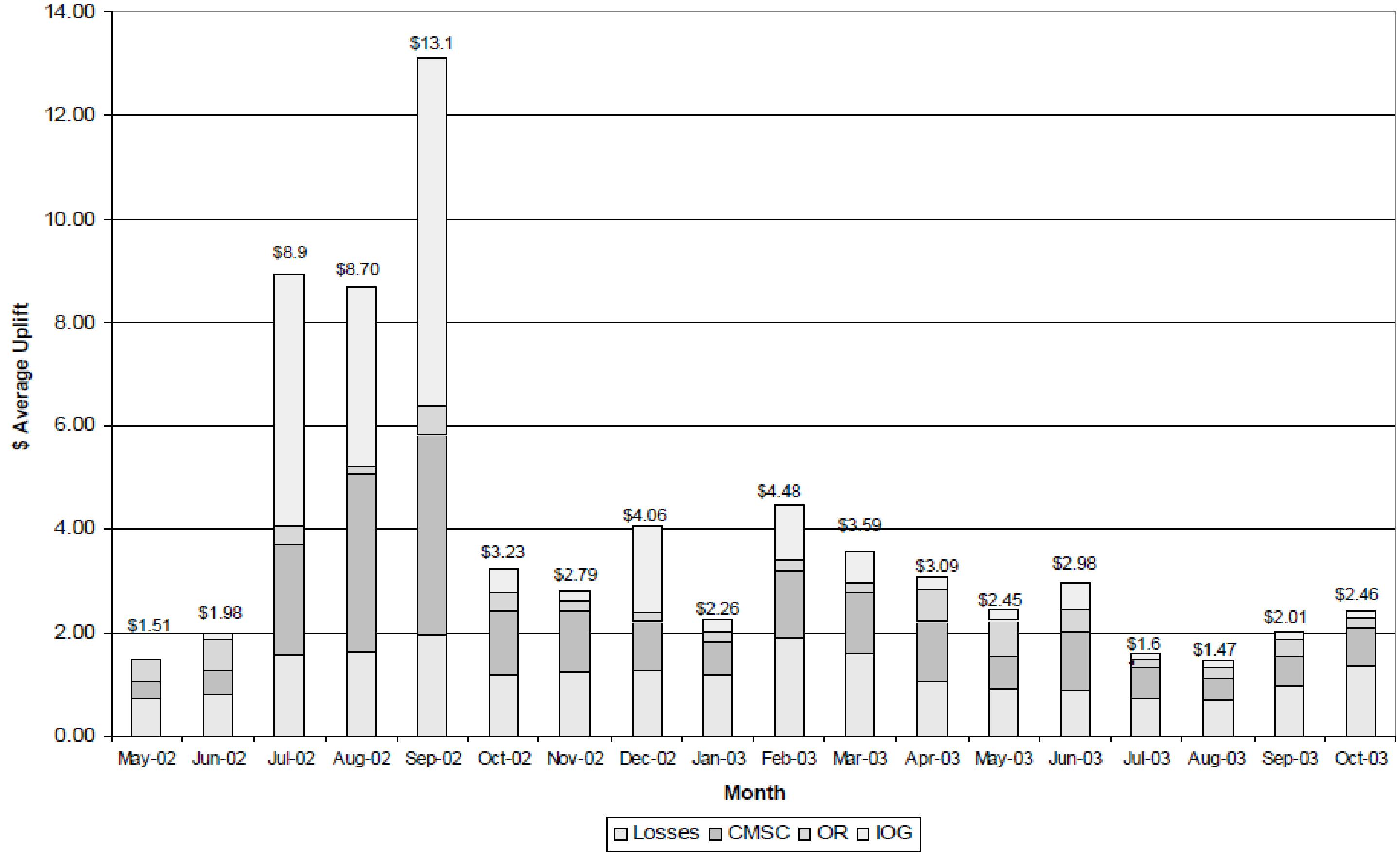
Market Outcomes - IOG

Figure 1-7: IOG Payments by Month, May 2002-October 2003



Market Outcomes - Uplift

Figure 1-6: Average Hourly Uplift, by Month, by Component



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Chronology of Unanticipated Design Challenges

Market Design Response:

- Implemented urgent market rule amendment eliminating the IOG payment on imports with matching exports in an hour – paid only on incremental imports
- Created “Spare Generation Online” program that provided start-up related cost recovery guarantees to non-quick start generators scheduled in pre-dispatch
  - optimization did not consider start-up related cost
- Implemented Control Actions Operating Reserve – placed price on control actions such as 30-minute reserve reductions and voltage reduction
- Implemented new scheduling protocol to reduce failed import/exports
- Implemented an hour-ahead demand program with guarantees

- Changes may have ameliorated pre-dispatch to real-time price differences and reduced IOG and CMSC payments but distorted efficient dispatch and created “gaming” opportunity around start-up cost payments

Closing Thoughts (in hindsight)

- Good design does not correct the effects of deficiencies in market structure, but bad design can undermine the benefits of an effectively competitive market structure
- Issue that arose at start of market and subsequent actions to address concerns was the beginning of the end of the promise of competition
  - Initial attempts to modify design were tweaks that did not properly address issues and often reduced dispatch efficiency
    - frequent rule changes and further greater uncertainty
  - Abandoned requirement for OPG to divest to 35% ownership of capacity and regulated OPG rates
  - Adopted a command-and-control approach by implemented a tapestry of regulatory incentive mechanisms, including long-term contracts, price floors for renewables and nuclear, limits on congestion related payments and start-up cost guarantees
  - Transferred risk from participants to Ontario consumers
- Created a complicated mix of incentive mechanisms and greater role for political involvement in sector

Fast forward……

Figure 3 – Generation Unit-Costs, 2004-2022