Electricity Market Design in Chile: A Vision Going Forward

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Outline

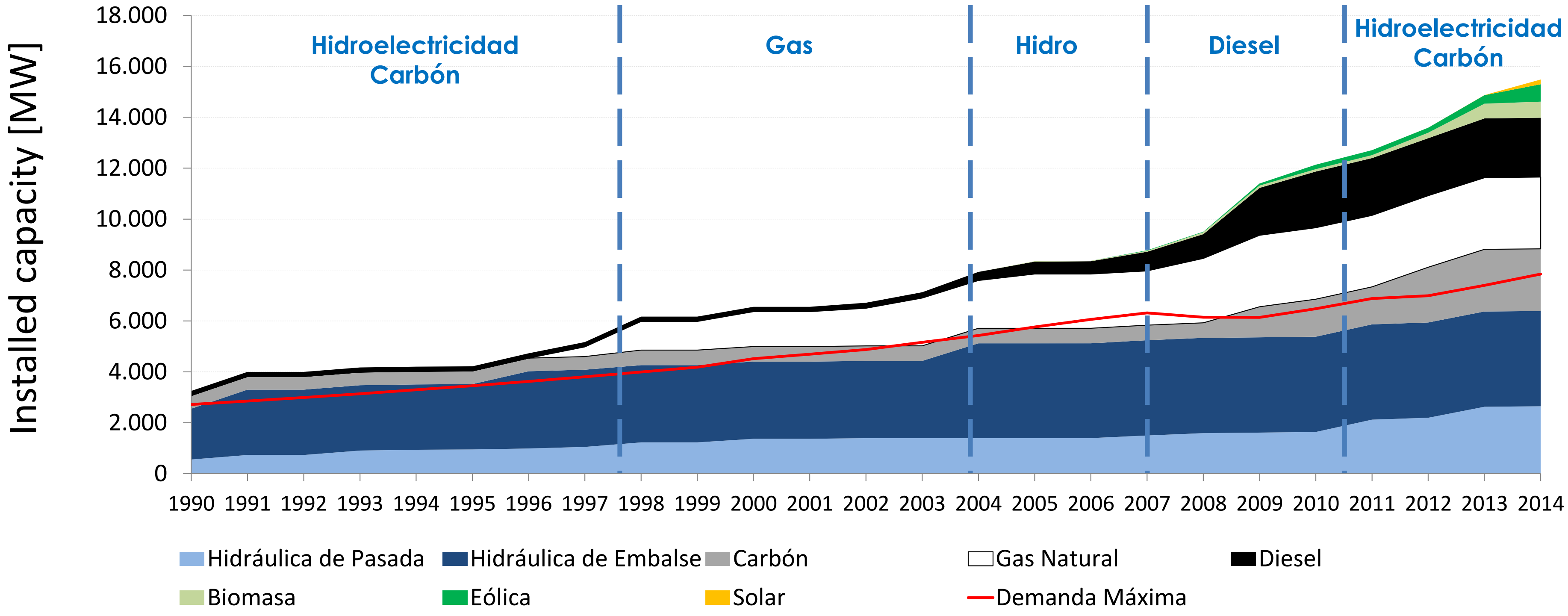
- Historical perspective
- Renewables and the need for flexibility
- Considerations going forward
  - Scarcity pricing mechanisms
  - Bid- vs cost-based wholesale electricity markets
  - The importance of forward markets for risk management
- Conclusions and perspectives

Historical perspective

- Chile was the first country that reformed its electricity sector in 1982
    - Unbundling of generation, transmission, and distribution
    - Privatization
    - Competition in the generation segment
    - Nodal pricing
- Often cited as a successful example of an electricity reform in developing countries (Pollitt, 2004)
- For different reasons, we did not follow the textbook guidelines for electricity deregulation:
    - No scarcity pricing: Price caps + capacity payments
    - Bid format: Cost- instead of bid-based dispatch and pricing
    - Forward markets: With the exception of PPAs, no forward markets

Historical perspective

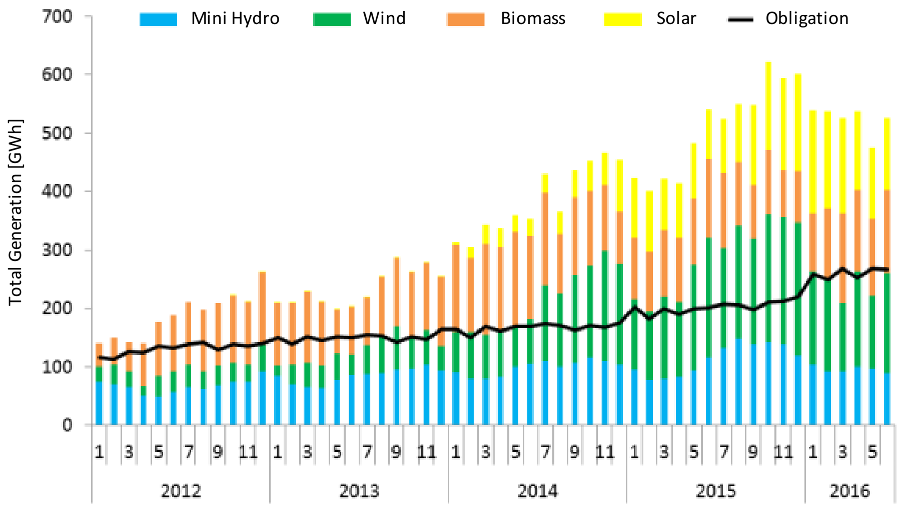
- So far so good…
  - With a few tight periods (e.g., 2008, natural gas crisis)
  - Installed capacity has increased by nearly 800% since 1990



Source: Systep

Renewables and the need for flexibility

- But the future might look quite different from the past
  - Lots of generation from renewables in the horizon



The New York Times

Chile's Energy Transformation Is Powered by Wind, Sun and Volcanoes

Leer en español

By ERNESTO LONDOÑO AUG. 12, 2017

Renewables sweep Chiles electricity market and set historic low prices

The median price for 12.4 terawatt-hours awarded is around US$47.59/MWh. Wind triumphed and solar took a minimal part of the total, but set new records at $29/MWh.

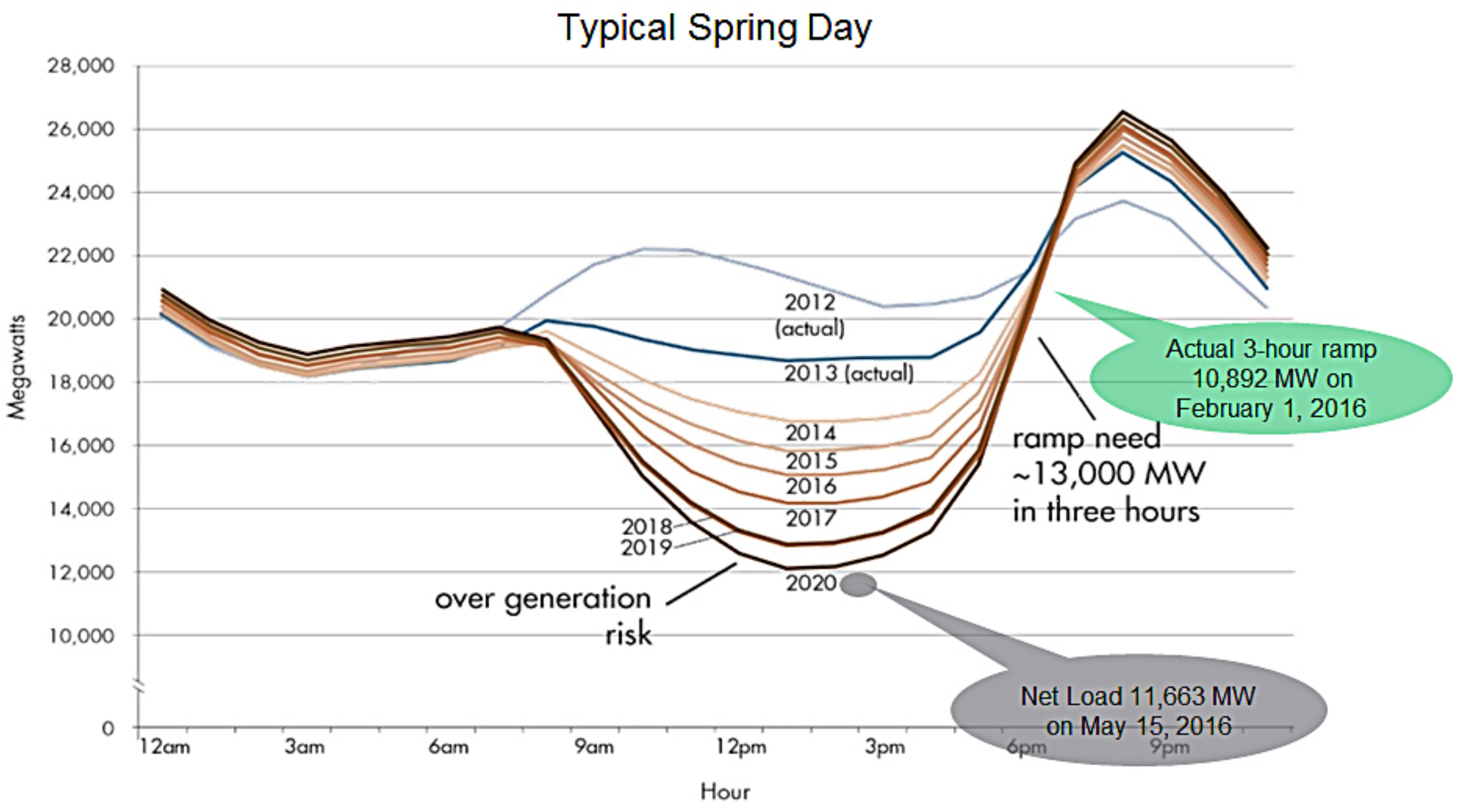
AUGUST 17, 2016 PV MAGAZINE

LA TERCERA

Renovables acaparan ofertas de última licitación eléctrica del Gobierno

Renewables and the need for flexibility

- Variability and unpredictability pose new challenges to power systems
  - Steep ramp events

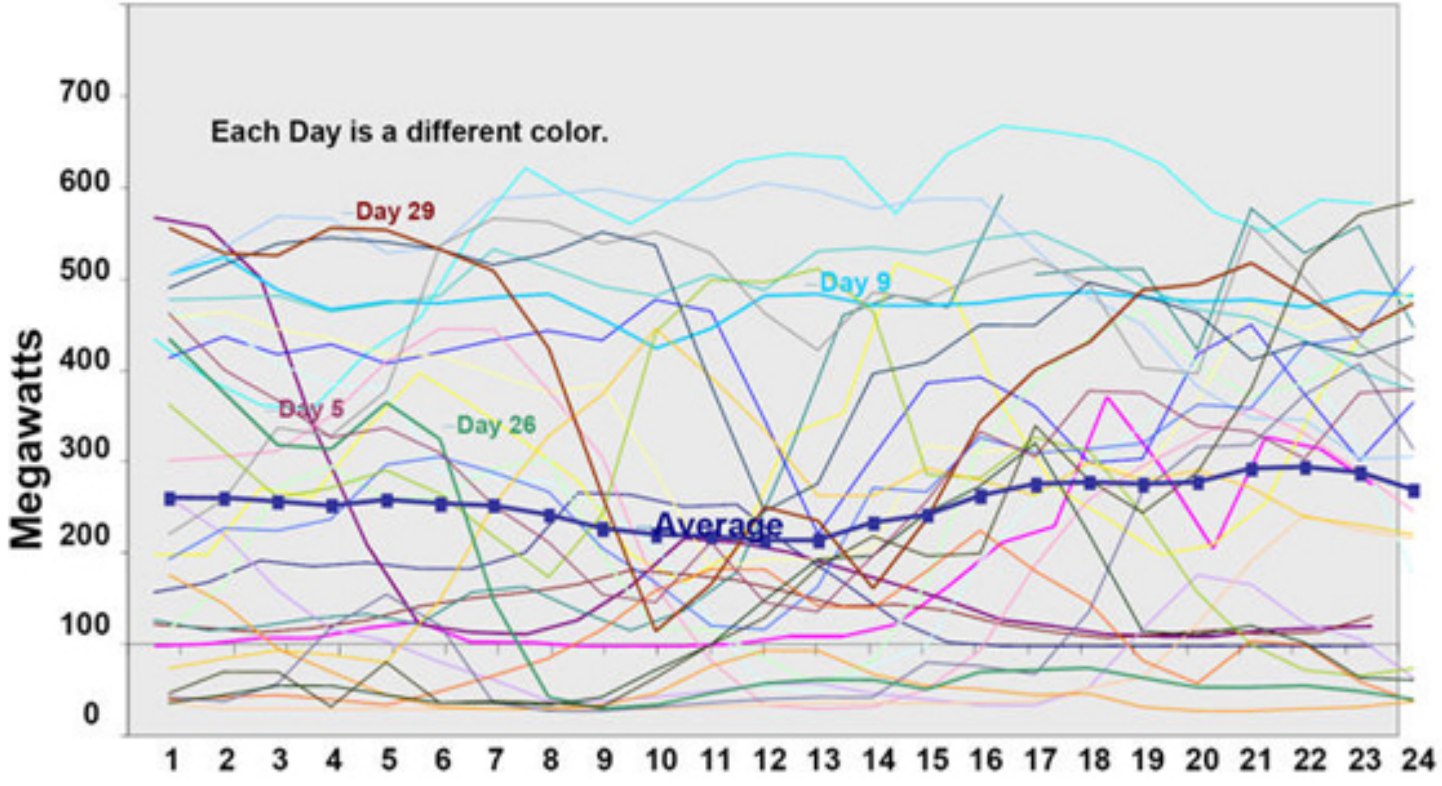


Source: California ISO

Renewables and the need for flexibility

- Variability and unpredictability pose new challenges to power systems
  - How well can you predict wind generation for tomorrow?

Tehachapi (CA) wind generation



Source: California ISO

Renewables and the need for flexibility

- And new technologies

Considerations going forward

- How do we incentivize efficient investments and operations of these resources in a deregulated market?

Optimization	Market design
Harness the power of algorithms and computers to reach an objective	Harness the power of markets to reach an objective
Challenge: logic	Challenge: asymmetric information

Optimization versus Market Design

- **Example:** How can a mother divide a cake between two daughters and make sure that each of them sees it as a fair division?

Optimization approach

Mother splits the cake in two parts such that they have equal:

- Weight
- Volume
- Number of colors/flavors

Market design approach

Mother lets her daughters figure it out through a splitting rule:

- Ana cuts the cake first
- Marcela picks her piece first
- Ana takes the remaining cake

Considerations going forward

- How do we incentivize efficient investments and operations of these resources in a deregulated market?

Optimization	Market design
Harness the power of algorithms and computers to reach an objective	Harness the power of markets to reach an objective
Challenge: logic	Challenge: asymmetric information
• More detailed dispatch software • Stochastic or robust planning • Co-optimization of resources	• Improved bidding format • Market clearing rules • Product definitions

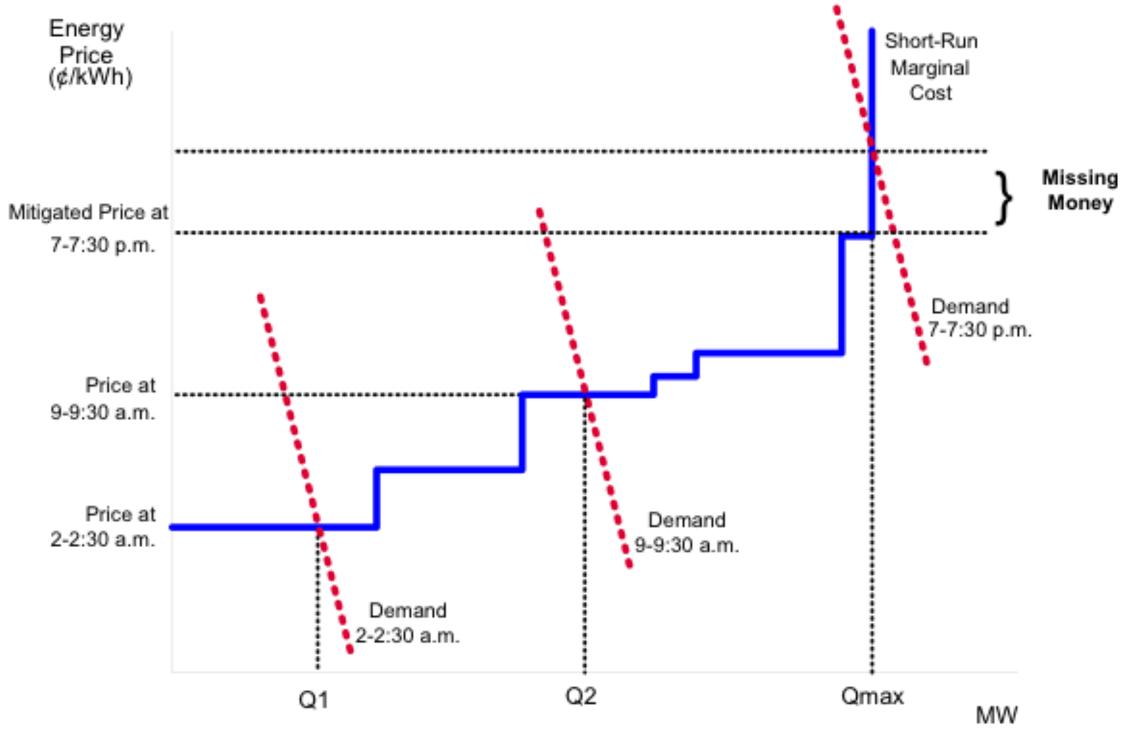
- Three important market design features that improve price signals:
  - Scarcity pricing mechanisms
  - Bidding format: Cost- vs bid-based
  - Forward markets for risk

Considerations going forward

Scarcity pricing mechanisms

- Scarcity price: reflects the marginal willingness to pay for one more unit of energy when capacity is limited
- Difficult if demand is perfectly inelastic
- Most markets use price caps + capacity mechanisms for adequacy requirements

SHORT-RUN ELECTRICITY MARKET



- Capacity payment = CC of peaking technology * firm capacity
- Firm capacity = Administrative definition (e.g., availability during peak)

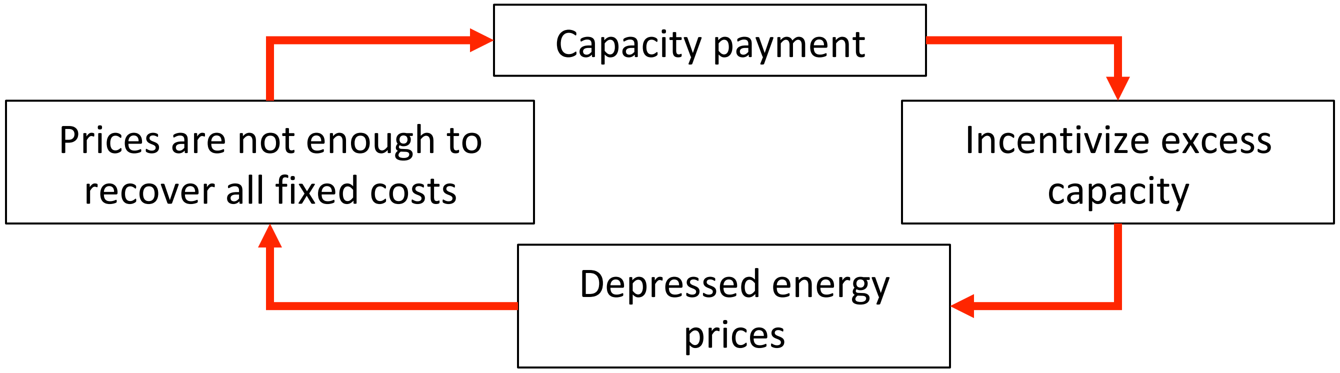
Considerations going forward

Scarcity pricing mechanisms

- Capacity payments do encourage *some* investments, but we don't know if they incentivize *efficient* investments (Bushnell et al., 2017)

- Main challenges of capacity payments going forward

  - Arbitrary rules to define firm capacity for renewables and energy storage
  - Poor incentives for generation and demand response during peak periods
  - Hard to price energy when trading with neighboring countries
  - Risk double payment to generators: adequacy or security?
  - Self perpetuating

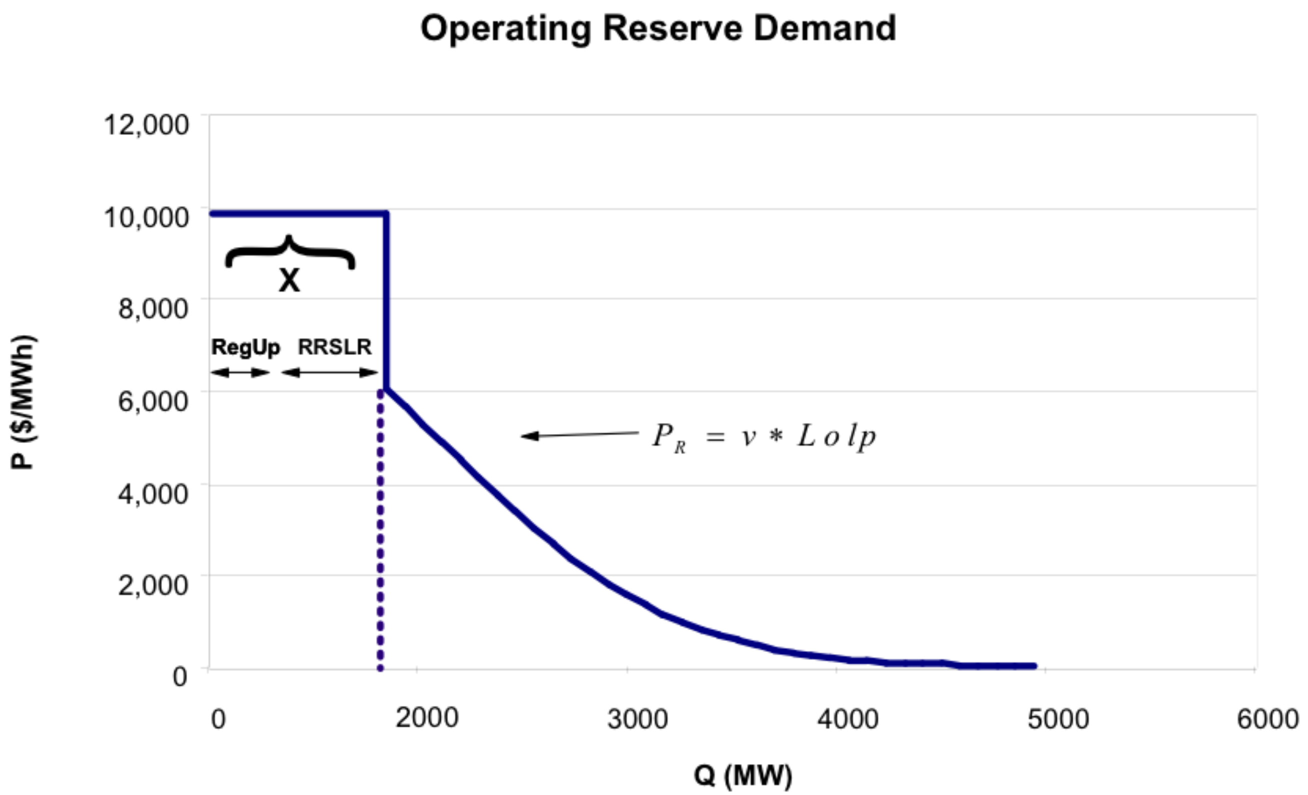


Considerations going forward

Scarcity pricing mechanisms

- Any potential solution in the short term?
- Operating Reserve Demand Curves (ORDC)
- Use Loss of Load Probability (LOLP) and Value of Lost Load (VOLL) to create a demand curve for reliability

  -> first economic principles!



- Different versions applied in ERCOT, New York ISO, PJM, Midcontinent ISO, ISO New England and now in the Mexican electricity market (Hogan, 2014)
- Recently tested in Belgian market: ORDC restores economic viability for flexible CCGTs under high penetration of wind and solar (Papavasiliou & Smeers, 2017)

Considerations going forward

Scarcity pricing mechanisms

Scarcity prices are an important ingredient to the market design

Jean-François CONIL-LACOSTE
Chairman of the Management Board, EPEX SPOT

The European electricity market is transforming together with the way we produce power across the continent. Only a free price formation, accurately reflecting scarcity, will provide the necessary flexibility to power this transformation.

Considerations going forward

Scarcity pricing mechanisms

European Commission

NEW ELECTRICITY MARKET DESIGN: A FAIR DEAL FOR CONSUMERS

What role will storage play?

Storage is one amongst several fast-advancing technologies whose contribution to the efficient working of our electricity system cannot be underestimated. From
a system-wide perspective, storage is one amongst key technologies that enable the grid to be more flexible, as they can counter-balance peaks and drops in demand and supply – provided the remuneration gives an incentive to do so.
Storage will therefore need to benefit from appropriate pricing to have its flexibility and usage adequately remunerated. By introducing scarcity pricing, the current initiative wants to give due credit to such technology. By strengthening the price signal, we are in practice allowing storage technologies to take advantage of instantaneous market remuneration, whilst creating a case for longer-term investment in the technology.

Considerations going forward

Cost- vs bid-based electricity market designs

- Original “textbook” implementation of deregulated electricity markets considered bids from market participants

- Reasons not to use bids and rely on audited cost information (Wolak, 2003):

  - Too much hydropower, firms could allocate water strategically
  - Few generation firms, prone to the exercise of market power
  - Weak transmission systems (i.e., too much congestion)
  - Too costly to implement a trading floor

- It turns out that cost-based markets are more prone to other sources of inefficiencies (Munoz et al., 2017)

  - Market power exercised differently
  - Almost impossible to audit all opportunity costs

Considerations going forward

Cost- vs bid-based electricity market designs

- Market power in cost- vs bid-based markets: Market rules affect behavior

	Cost-based market	Bid-based market	Central planner
Investments per firm [MW]	504	603	904
p_{peak} [$/MWh]	124.0	99.4	24.0
p_{base} [$/MWh]	56.0	74.5	11.8
Consumer surplus [Billion $]	0.6	0.617	1.38
Total profits [Billion $]	0.6	0.617	0
Total welfare [Billion $]	1.21	1.23	1.38

- Cost-based markets do not eliminate market power, firms have incentives to exercise it differently
- With more technologies, firms overinvest in peaking technology (Arellano & Serra, 2007)
- How to mitigate market power effectively in bid-based markets?
  - Market monitoring units at ISOs
  - Long-term financial contracts (PPAs) (Bushnell et al., 2008)
  - Offer a level playing field that fosters competition

Considerations going forward

Cost- vs bid-based electricity market designs

- The challenge of auditing or capturing all opportunity costs
- True cost of generation composed of:
  - Directly attributable expenses (i.e., fuel, O&M, wear & tear, etc.)
  - Opportunity costs

- What opportunity costs?
  - Inflexible fuel contracts (e.g., natural gas)
  - Hydro units with reservoirs
  - Energy storage units
  - Ramping constraints
  - Maximum limits on number of starts per year
  - Participating in the energy or reserves market
  - Environmental regulation (e.g., CO_2 tax)
  - Parallel markets for renewable certificates or emissions permits

If not considered, dispatch and prices are inefficient!

Considerations going forward

Cost- vs bid-based electricity market designs

- The *engineering* approach to address the problem of opportunity costs
  - Add all constraints and variables that create opportunity costs, including parallel markets
  - Make assumptions about future system conditions on behalf of all firms
  - **Challenges:** Tedious, asymmetric information, optimization is only as good as input parameters (GIGO), and potentially confiscatory

- The *economic* approach to address the problem of opportunity costs
  - Only consider constraints for which there is good information (e.g., transmission and generators' characteristics)

ISO:
Transmission services + dispatch

↔

Price mechanism (bids)

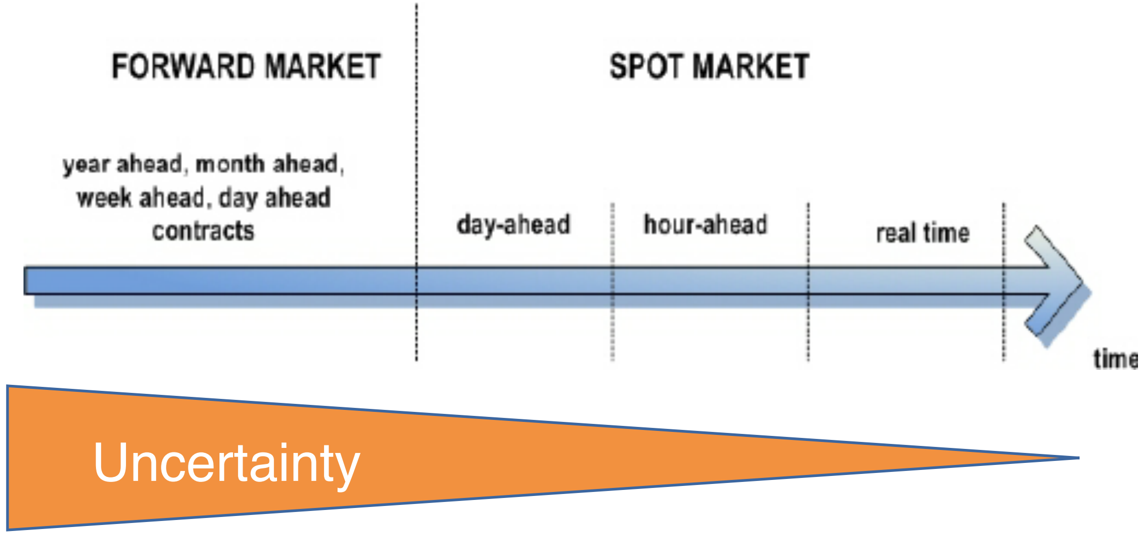
- Inflexible fuel contracts
- Maximum number of starts
- Environmental regulation
- Parallel markets
- Assumptions about future prices
- Risk tolerance
- Etc.

Private information

Considerations going forward

The importance of forward markets for risk management

- Many different types of forward markets available in deregulated electricity markets



- A series of sequential markets approximate a complete market for risk (Kreps, 1979)

- It means that firms can manage most risks by trading financial positions in forward markets (PPAs, FTRs, day ahead, hour ahead, etc.)

Considerations going forward

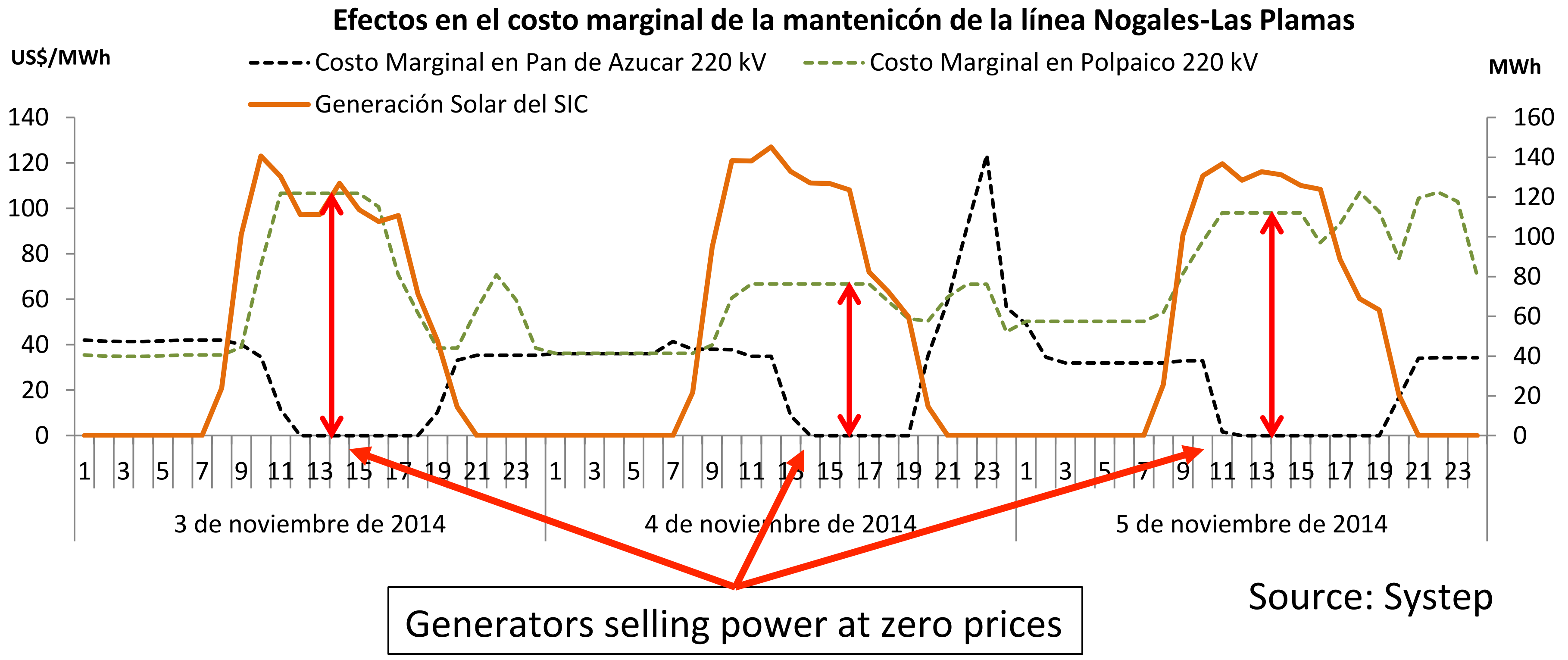
The importance of forward markets for risk management

- In Chile we only have a formal market for PPAs and spot transactions
  - No FTRs or day-ahead markets
  - If possible, forward contracts have to be arranged bilaterally, with high transaction costs
- Possible consequences of missing forward markets?
  - Lots of risk when signing PPAs and choosing investments
  - Most risks can only be managed physically
    - Portfolio of technologies
    - Portfolio of locations
  - Unlevel playing field: It implies that risks faced by small firms could be much larger than the ones faced by large firms

Considerations going forward

The importance of forward markets for risk management

- Congestion risk



Source: Systep

- With FTRs, generators could *choose to buy* insurance to get prices on the other side of the congested line

Considerations going forward

The importance of forward markets for risk management

- Cost-allocation of deviations with respect to an offer (ancillary services)

Day-ahead → Real time

Day-ahead

- Demand bids
- Generation bids
- ISO procures reserves

Results

- Demand and generation schedules
- Day-ahead prices

Real time

- Real time demand
- Security-constrained economic dispatch

Results

- Real-time prices and generation schedules

=> Deviations are paid for by those who cause them

Conclusions

- Current market design has served its purpose up to this point

- Future looks quite different

  - Lots of variable an intermittent generation
  - Smart metering and demand response
  - Energy storage units
  - Electric transportation
  - Interconnections with other countries

Prices play an important role in resource allocation problems

- Market design considerations going forward:

  - Pricing flexibility and reliability: Scarcity pricing
  - Dealing with asymmetric information: Bid-based markets
  - Instruments to manage risks efficiently: Forward markets

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Questions?

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