



Introducción

- El análisis del mecanismo de remuneración de suficiencia debe hacerse en concordancia con las otras 11 medidas establecidas en la Estrategia de Flexibilidad.
- No es recomendable modificar esta parte antes de completar el análisis integral.
- En esta presentación se efectúa primeramente un análisis integral de cómo debiera ser el mercado en su conjunto para resolver los desafíos de flexibilidad a mínimo costo global para los consumidores.
- La segunda parte plantea elementos específicos relacionados con el mecanismo de suficiencia (cargo por potencia), en el entendido que la solución global es concordante y asegure el mínimo costo a los consumidores, sin crear nuevos cargos que podrían significar sólo aumento de costos, pero no resolver los desafíos planteados.

Wholesale Market Design Features that Support Investments in Flexible Resources

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Outline of Talk

Features of wholesale market design that support investments in flexible resources

- Greater temporal granularity in energy pricing versus a designated charge to pay for flexible resources
- Multi-settlement versus single settlement energy market
 - Co-optimization of energy and reserves versus sequential procurement of energy and reserves



Temporal Granularity in Energy Pricing versus Designated Charge to Support Flexible Resources

Temporal Granularity in Energy Pricing

Economically efficient price of energy is the marginal cost of providing an additional MWh during relevant time interval

A large intermittent renewable generation share implies that economically efficient price of energy should change more frequently in response to changes in output of intermittent resources

- Shorter pricing intervals will reward investments in flexible resources
- Resources that can adjust more of their output in response to higher prices will receive higher revenues and greater wholesale energy cost savings from shorter pricing intervals

All wholesale markets in the United States set prices in real-time market every 5-minutes

- Rewards investments in fast-ramping resources on both supply and demand side of market

An efficient energy price provides the appropriate economic signal for the provision of flexibility (reward fast-ramping resources)

There is no need for and additional customer charge

The Trouble with Designated Payments for Flexibility

- Designated payment to flexible generation units does little to make these units responsive dispatch instructions
 - Simply pays units to exist, not to solve real-time reliability problem
- Recovering fixed payments to flexible generation through a charge on loads does little to make loads responsive stressed system conditions
 - Loads have little incentive to shift demand away from periods when demand for flexibility is high
- Maintaining hourly energy prices (as opposed to more frequent pricing) with an increasing share of intermittent renewable reduces incentive for investments in flexibility

Inflexible short-term prices are a higher cost solution for customers

Does not adequately reward fast-ramping resources



Multi-Settlement Markets and Flexibility

Day-Ahead Energy and Reserves Markets

- System operator minimizes cost to meet demand for energy and reserves in day-ahead market for all 24 hours of the day simultaneously
 - Co-optimize procurement of energy and reserves in day-ahead market
 - Can specify locational demands and prices for ancillary services, just like for energy
- Day-ahead market respects all transmission network and all relevant generation unit and transmission network operating constraints
 - Energy and reserves schedules that result from day-ahead market are physically feasible given transmission network and other generation operating constraints

Day-Ahead Energy and Ancillary Services Markets

- Schedules for energy that emerge from day-ahead market are purely financial
 - However, suppliers and retailers face financial consequences of real-time deviations from day-ahead schedules for energy and ancillary services capacity
- Suppliers or loads that do not follow day-ahead schedules must settle deviations at real-time price
 - Rewards suppliers and loads for following day-ahead schedules
- **Note: Both day-ahead and real-time markets can operate as cost-based**
 - Cost offers set by system operator and generation unit owners set availability offers and inelastic demand bids in day-ahead market
 - System operator solves for optimal day-ahead schedules for all (hydro, renewable and thermal) generation resources

Day-ahead and Real-time Settlement

- Supplier receives revenue from day-ahead forward market sales *regardless of real-time output of its generation unit.*
 - Sell 40 MWh at a price of \$25/MWh receive \$1,000 for sales.
 - Any deviation from day-ahead generation schedule is cleared in real-time market.
 - If supplier only produces 30 MWh, it must purchase 10 MWh of day-ahead commitment from real-time market at real-time price
- Buyer pays for day-ahead forward market purchases *regardless of real-time consumption of energy*
 - Buy 40 MWh at a price of \$25/MWh and pay \$1,000 for energy
 - Any deviation from day-ahead load schedule is cleared in real-time market
 - If buyer only consumes 30 MWh, it sells 10 MWh of day-ahead commitment in real-time market at real-time price

Real-Time Market

- Real-time market utilizes same network model (updated to real-time conditions) minimizes cost to meet real-time demand for energy and reserves
- Real-time market can clear and settle more frequently
 - All United States real-time market clear every 5-minutes
 - Dispatch levels for energy and prices are set every 5 minutes
- More frequent real-time pricing rewards flexibility on both supply and demand side of market

Multi-Settlement Market

- Multi-settlement market rewards suppliers for responsiveness of supply, yet still pays same LMP to all resources at same location in both day-ahead and real-time markets
 - **Very important feature of market design for regions with ambitious intermittent renewable energy goals**
- Supply of intermittent resources typically highly correlated
 - Wolak (2016) “Level versus Variability Trade-offs in Wind and Solar Generation Investments: The Case of California,” The Energy Journal (available at <http://www.stanford.edu/~wolak>)
- Higher share of intermittent resources likely to increase revenues received by flexible resources in multi-settlement LMP market

Multi-Settlement Market

- Suppose that a dispatchable thermal unit sells 100 MWh at price of \$50/MWh in day-ahead market and intermittent resource sells 80 MWh in day-ahead market at same price
- In real-time, significantly less wind is produced than was scheduled
 - Wind produces 50 MWh, so must purchase 30 MWh from real-time imbalance market at \$90/MWh
- Thermal unit supply must maintain supply and demand balance, which explains high real-time price
 - Sells additional 30 MWh at real-time at \$90/MWh
- Average price paid to thermal and intermittent units
 - $\$59.23 = 100 \text{ MWh} * \$50/\text{MWh} + 30 \text{ MWh} * \$90/\text{MWh} / 130 \text{ MWh}$
 - $\$26 = (80 \text{ MWh} * \$50/\text{MWh} - 30 \text{ MWh} * \$90/\text{MWh}) / 50 \text{ MWh}$
 - Dispatchable unit rewarded with higher average price than intermittent unit

Multi-Settlement Market

- Case of unexpectedly high intermittent resource output yields a similar outcome of rewarding dispatchable resource with higher average price
 - Intermittent resource sells only 50/MWh in day-ahead market and thermal unit sells 130 MWh, both at \$50/MWh
 - Intermittent resource produces 80 MWh, which implies that it sells 30 MWh in real-time market at \$20/MWh
 - Low real-time price because of unexpectedly large intermittent output
 - Thermal resource buys back 30 MWh in real-time at \$20/MWh
- Average prices paid to thermal and intermittent units
 - $\$59 = (130 \text{ MWh} * \$50/\text{MWh} - 30 \text{ MWh} * \$20/\text{MWh}) / 100/\text{MWh}$
 - $\$38.75 = (50 \text{ MWh} * \$50/\text{MWh} + \$30 \text{ MWh} * \$20/\text{MWh}) / 80 \text{ MWh}$
- Multi-settlement market rewards suppliers and demanders for responsiveness
 - Responsive resource receives higher average price because of responsiveness

Benefits of Multi-Settlement Market

- Multi-settlement, LMP market rewards resources for the forecastability of their output
 - The more accurate are a participant's day-ahead energy schedules the less exposure it has to the real-time price
- Real-time price likely to be low when renewable production is high and high when renewable production is low
 - Renewable resource sells imbalance energy at low price and buys imbalance energy at high price
- Dispatchable resource typically produces when real-time price is high and produces very little when real-time price is low
 - Dispatchable resource sells imbalance energy at high price and buys imbalance energy at low price

Day-Ahead Energy and Reserves Markets

- Co-optimized day-ahead and real-time markets for energy and reserves ensures that generation unit owners never regret selling energy versus ancillary services in day-ahead market
 - If day-ahead market for energy is not firm financial commitment, supplier could be taken for 10 MW of ancillary services at \$4/MWh, because day-ahead price of energy was \$23/MWh and its marginal cost is \$20/MWh
 - In real-time, supplier could regret this decision because price of energy is \$30/MWh and per unit variable profits for 10 MW is $\$10/\text{MW} = \$30/\text{MWh} - \$20/\text{MWh}$
- Day-ahead market with firm financial commitments implies that after day-ahead market clears generation unit is happy with energy versus ancillary services schedules given day-ahead prices for energy and ancillary services

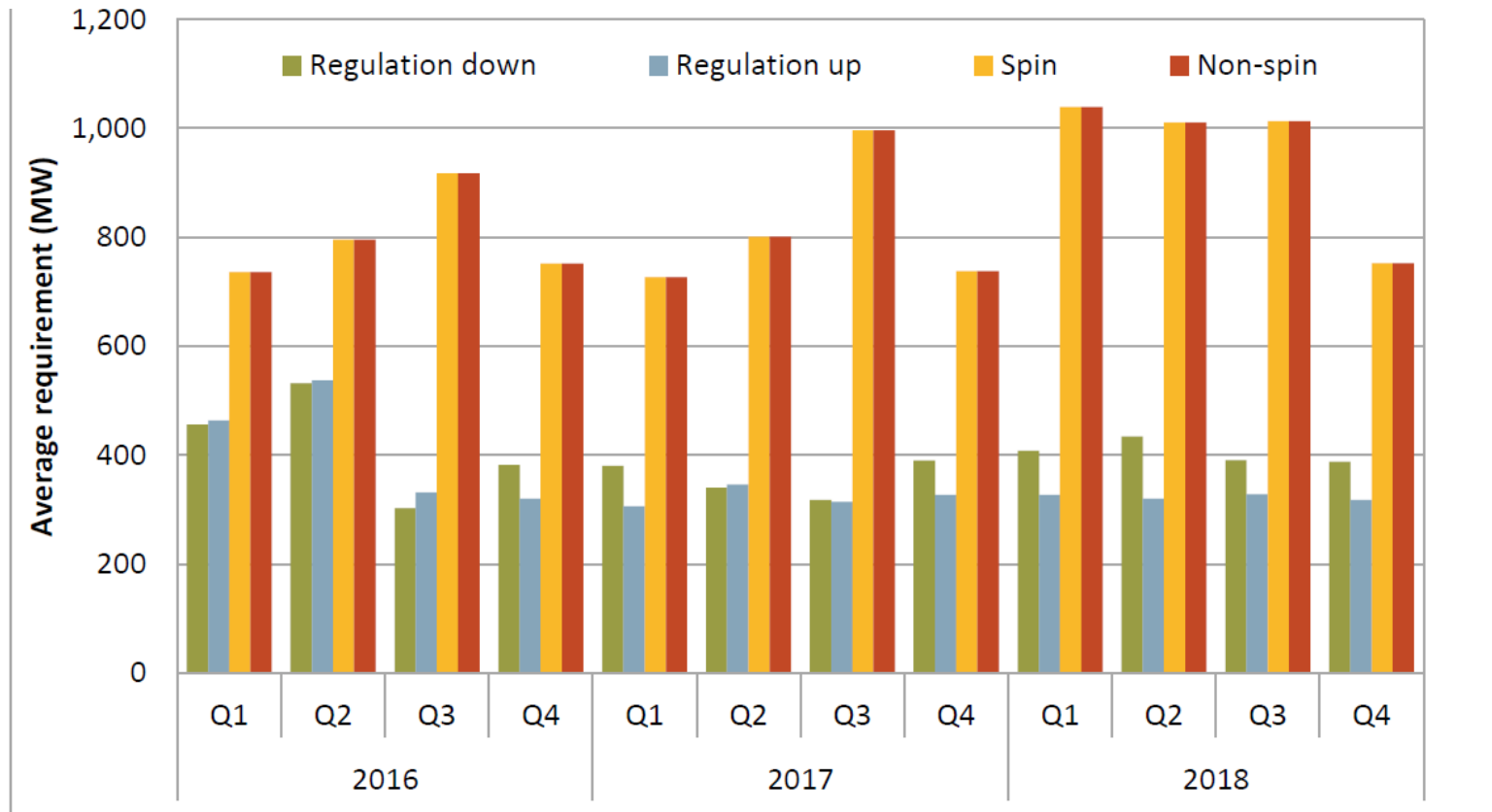
Downside of Sequential Markets

- Sequential clearing of energy and ancillary services markets introduces market inefficiencies
 - Suppliers receive “stale prices” for ancillary services relative to energy prices
- Early in California, the ancillary services market cleared before real-time energy market and after day-ahead energy market (not co-optimized with day-ahead market)
 - During this time period ancillary services costs were 13% of annual energy costs in 1998, 5.7% in 1999 and 6.8% in 2000
 - During last three years of multi-settlement LMP market in California with approximately 30% renewables, ancillary services costs were between 1.6% of annual energy costs in 2017, 2% in 2018 and 1.7% in 2019
- Conclusion—Day-ahead market that sets firm financial schedules for energy and reserves can reduce costs relative to sequential market clearing of energy and reserves

Benefits of Multi-Settlement Markets

- **Day-ahead market makes supply equal demand at all locations in grid for energy and reserves**
 - In real-time supply equals demand at all locations in grid
 - Multi-settlement market zero-sum between generators and active loads
- **Efficient assignment of costs and benefits of energy, flexibility and reserves cost between different players**
- **The generators would translate these costs to the customer through price of energy in power supply agreement**

Quarterly Average Ancillary Services Demand in California



Benefits of Multi-Settlement Markets

- Reserves demand
 - California sets SFU = 300 - 400 MW and SFD = 350 – 400 MW for an average hourly demand of ~30,000 MWh
 - Markets without multi-settlement mechanism like Chile, Colombia and Peru have 12%, 48% and 96% more SF requirements per MWh of average hourly than California
 - Co-optimized multi-settlement market with frequent (every 5-minutes) settlement in real-time allows market operator to purchase significantly less reserves

Benefits of Multi-Settlement Markets

- For same level of output produced by thermal units in California, both total BTUs of fossil fuel energy used and total operating costs of thermal generation units fell after implementation of multi-settlement LMP market
 - Total fossil fuel energy used each hour to dispatch system fell by 2.5 %
 - Total cost of dispatching system fell by 2.1%
 - Wolak, F.A. (2011) “Measuring the Benefits of Greater Spatial Granularity in Short-Term Pricing in Wholesale Electricity Markets,” *available on web-site*
- Estimated reduction in annual total cost of operating thermal units of more than \$100 million from transition to LMP market
- Even larger savings from transition to multi-settlement market design in ERCOT market
 - Triolo, R. and Wolak, F.A. (2020) “Measuring the Market Efficiency Benefit of the Transition to a Multi-settlement LMP market in ERCOT,”

Concluding Comments

- More frequent real-time market prices far more economically efficient approach to paying for flexibility than fixed payment to flexible resources
- Multi-settlement market supports flexibility investments relative to single settlement energy market
- Co-optimization of energy and reserves versus sequential procurement of energy and reserves support investments in flexible resources

Thank you

Papers cited available at:
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Un Nuevo Mecanismo de Remuneración de la Potencia Firme

Propuesta en desarrollo
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Noviembre 5, 2020

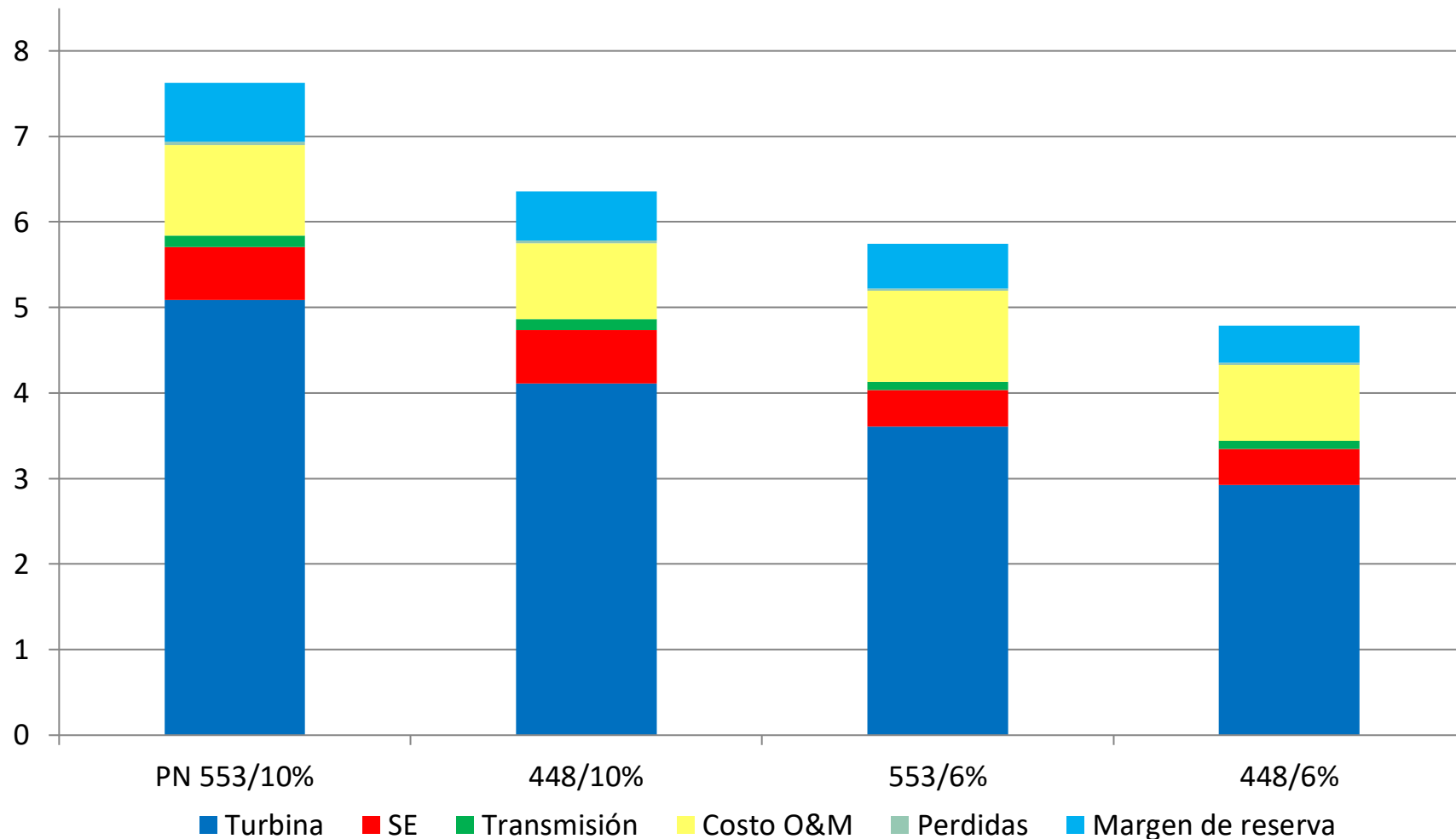
Flexibilidad no requiere cargo adicional

- Razón de fondo: flexibilidad es la capacidad de responder a fluctuaciones de la demanda y de la oferta en plazos muy breves.
- Eso se logra haciendo que:
 - Cada cual se haga cargo de su cantidad ofrecida y demandada;
 - Quien aporte flexibilidad sea remunerado en el momento en que la aporta;
 - Costos de la flexibilidad sean parte del costo de la energía y traspasados eficientemente a clientes mediante contratos.
- Cargos y pagos fijos son la antítesis de la flexibilidad.

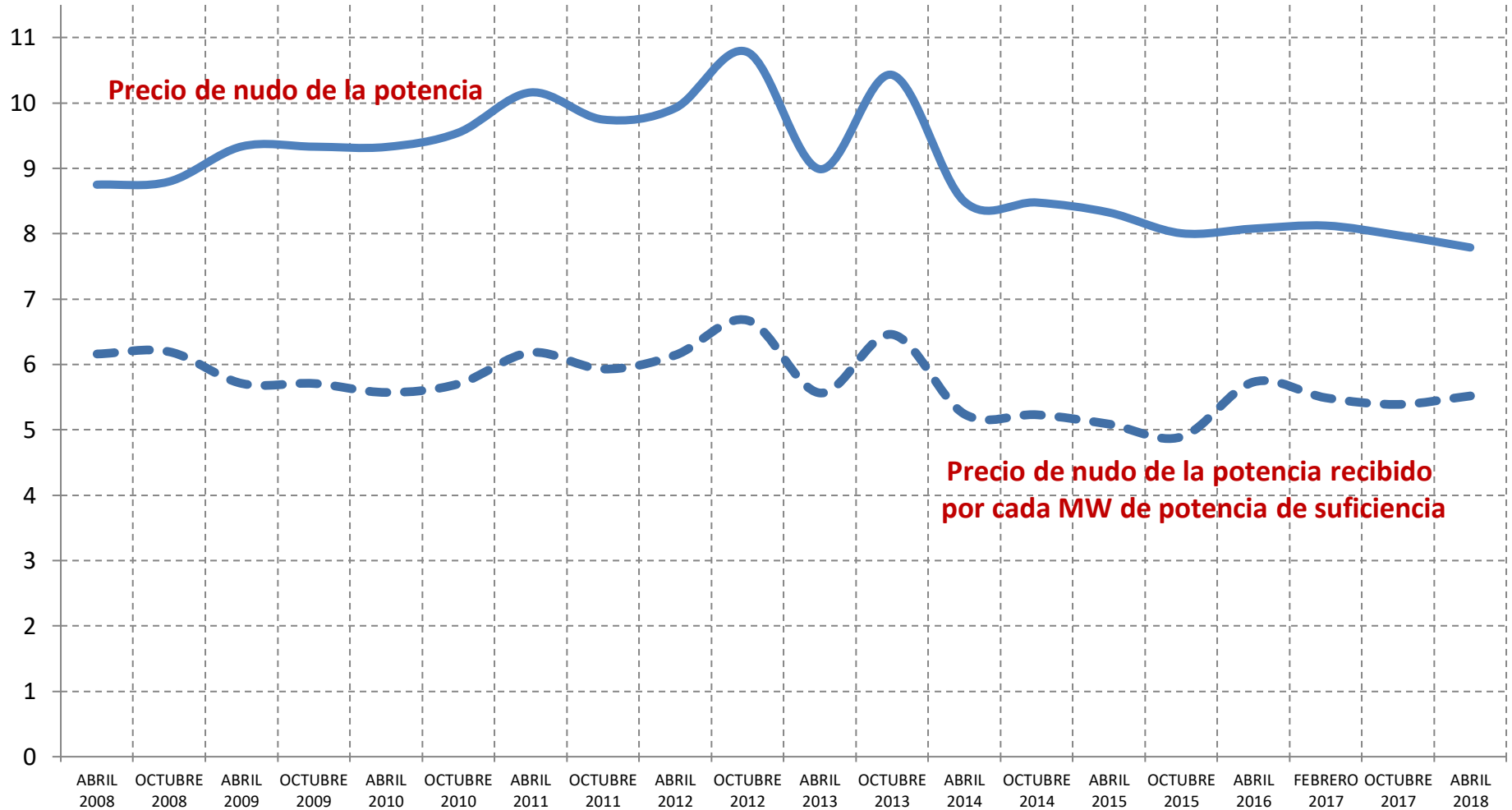
El precio spot de la potencia está mal medido

- ¿Para qué es el cargo por potencia?
 - **Oferta:** remunerar la expansión de potencia durante las horas de carga residual máxima.
 - **Demanda:** indicarle el costo marginal de la potencia a quienes consumen potencia en las horas de carga residual máxima.
- Precio de Nudo de la Potencia no conversa con el costo de instalar la turbina diésel (datos CNE).

Nivel y composición del Precio de Nudo de la Potencia (en USD/kW-mes)



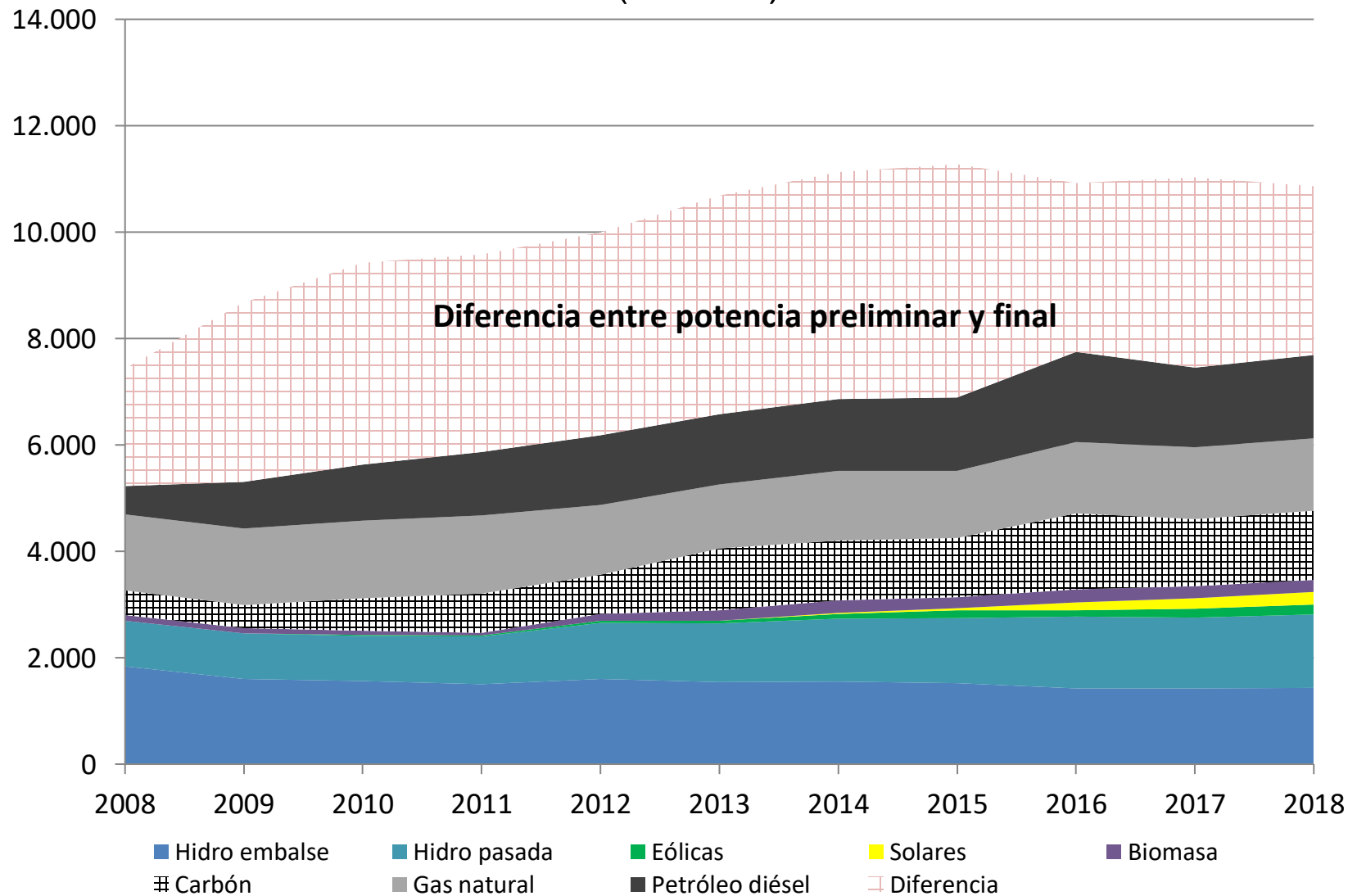
Precio de Nudo de la Potencia en barra Alto Jahuel abril de 2008 - abril de 2018 (en USD/kw-mes)



El q : el aporte de cada tecnología está mal medido

- Asignación de potencia sin una meta de confiabilidad paga por lo instalado y sobrevalora potencia firme de algunas tecnologías
- Sobreinstalación (Sub) prorrateada hace que haya reconocimiento de potencia a unidades que no son necesarias
- El aporte de potencia se determina de distinta forma para distintas tecnologías
- No se efectúa un análisis sistémico del real aporte de cada unidad a la suficiencia en horas de carga residual máxima
- No se asegura una correcta asignación de potencia firme a cada tecnología
- **Resultado:**
 - **Se sigue invirtiendo en diésel: 375 MW diésel en construcción**

Evolución de la potencia firme en el SIC 2008-2018 (en MW)



Hora de medición de consumo y de retiro no coinciden

- Consumidores que pagan el cargo por potencia no son los mismos que consumen la potencia remunerada
- Hay clientes que pagan potencia pero no la consumen (prenden motores durante las horas de carga máxima)
- Se remunera a la hora de carga máxima, no de carga residual máxima
- Períodos de control diferentes para distintos clientes y que no coinciden con las horas de carga residual máxima
 - No existe una señal eficiente para los clientes

Conclusiones finales: lo que los clientes debieran pagar

Señales de energía y flexibilidad bien definidas y correctamente asignadas en los mercados spot de energía y reservas



Traspasados a través de los precios de energía en competencia de los PPA's

- Cargo de potencia correctamente asignado de acuerdo a la presencia de los clientes en las horas de carga residual
- Potencia firme total determinada por una métrica y no la instalada
- Asignada a cada tecnología de acuerdo a su contribución marginal a ella
- El margen de reserva debiera estar contemplado en la métrica anterior y no ser parte del precio
- El margen de reserva fría es parte de los SSCC y no debe ser parte del precio de potencia
- Redefinir períodos de control



Cargo de potencia en PPA's

Establecer una correcta verificación y penalización de los productos por los cuales pagan los consumidores



Accountability

Minimizar los cargos laterales o explícitos (transmisión, SSCC) a lo mínimo estrictamente eficiente y necesario



Minimizar señales ineficientes de precio

Ejemplos

Mercado	Análisis sistémico	Métrica	Cargo por Capacidad	Método	Horizonte
Perú, Bolivia	Si. Se realiza un despacho simulado para determinar la colocación hidráulica en condiciones extremas. Además, el proceso de ajuste a la demanda, se realiza mediante un despacho simulado.	No existe	Precio y Cantidad Reguladas	Potencia Firme para cada tecnología y ajuste final a la demanda no a prorrata, sino que mediante un despacho conjunto. Retiro a la hora de demanda máxima anual para Bolivia y mensual para Perú	1 año
El Salvador	No	No existe	Precio y Cantidad Reguladas	Potencia Firme para cada tecnología y prorrata de ajuste final a la demanda. Retiro a la hora de demanda máxima anual	1 año
Suecia, Finlandia	No	No existe	Subastas de Reserva Estratégica	El TSO (Svenska Kraftnät en Suecia y la Energy Authority en Finlandia) define los requerimientos de reserva estratégica y determina si cada tecnología aporta a dicha reserva o no, normalmente basándose en la producción con probabilidad de excedencia 90%. Precios horarios	Suecia: 1 año Finlandia: 3 años
Bélgica	Si	LOLE. 3 horas/año y 20 horas en 20 años	Subastas de Reserva Estratégica	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	1 año

Ejemplos (2)

Mercado	Análisis sistémico	Métrica	Cargo por Capacidad	Método	Horizonte
Reino Unido	Si	LOLE. 3 horas/año	Subastas cantidad y precio	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	Dos subastas: a 4 años y a un año
Irlanda	Si	LOLE. 8 horas/año	Subastas cantidad y precio. Pay as clear para las ofertas no capeadas y pay as bid cuando opera el cap.	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	Dos subastas: a 4 años y a un año
Francia	No	LOLE. 3 horas/año	Descentralizado (obligación recae sobre comercializadores)	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	Licitaciones a 4 años plazo
Italia	Si	LOLE. Definido por el Ministro de Desarrollo económico	Mecanismo de opciones de capacidad	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	1 año con detalle mensual

Ejemplos (3)

Mercado	Análisis sistémico	Métrica	Cargo por Capacidad	Método	Horizonte
Italia	Si	LOLE. Definido por el Ministro de Desarrollo económico	Mecanismo de opciones de capacidad	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida (ELCC). Precios horarios	1 año con detalle mensual
España	No	110% de la demanda	Precio y Cantidad Reguladas	Potencia Firme para cada tecnología basada en probabilidad de excedencia 95% Precios horarios	10 años y anual
Portugal	No	LOLE. 5 horas/año	Subastas de Reserva Estratégica	Se determina mediante la contribución marginal de cada planta (con y sin), a la calidad de servicio predefinida. Para las energías solares y eólicas es una combinación entre: i) 95% a 99% de probabilidad de excedencia ii) Aporte de la metodología al LOLE, calculada mediante series de tiempo. Precios horarios	Largo Plazo y a 1 año
PJM	No	1 día promedio cada 10 años	Mercado de capacidad centralizado	Promedio de producción en horas de punta de los últimos 3 años Retiro promedio 5 horas máxima demanda	Una licitación base por año y 3 subastas incrementales durante el año