

Large Hydro and the Growth of Renewable Energy in Western North America

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Who is Powerex?

- Established in 1988 as wholly-owned energy marketing subsidiary of BC Hydro
- BC Hydro is a Crown Corporation, owned by the Province of British Columbia
- Gross revenues about \$1.0 billion today, ~50 000 GWh
- Staff size ~160
- ~450 wholesale natural gas, electricity & renewable customers
- Active in Western North America
- ***Most active physical marketer of electricity in the West*** - not as a function of total volume, but as measured by number of distinct transactions
- Extensive transmission portfolio allowing Powerex to access major Western markets – ability to send up to 3 000 MW/h to California

Powerex Today

Three distinct tasks today:



i) Market facing activity for BCH

- Buy or sell electricity on behalf of BCH
 - Buy market energy when BCH is deficit
 - In low water years or when capacity-deficient
 - During a system emergency
 - Market BCH surplus energy
- Use residual storage to buy when cheap/sell when more valuable
- Purchase and manage natural gas for BCH gas fired generators

...and...

Powerex Today

ii) Buy and sell electricity, natural gas and renewable products, with a focus on Western North America

iii) Market Design Advocacy

- Future market design/market structure sets the rules for future trading
- Strongly Advocate for BC Based Resources/Assets

Powerex' Business Lines

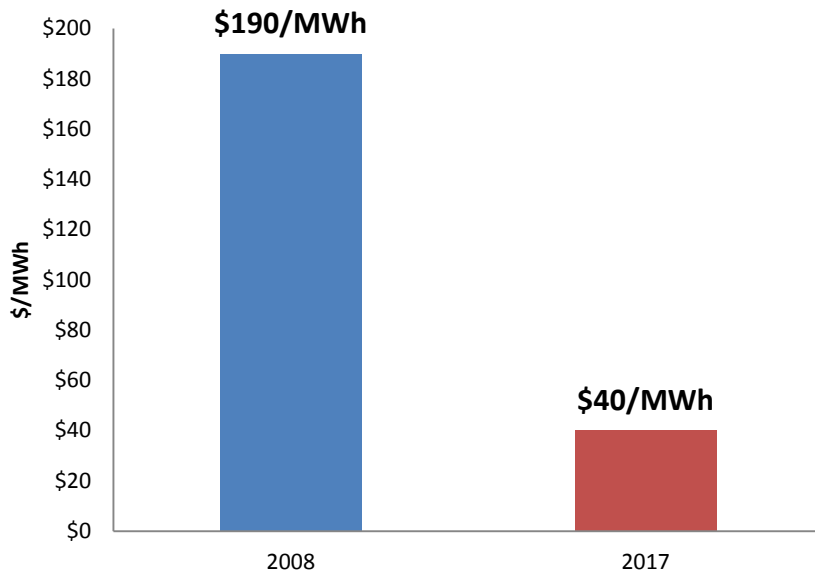
- Main wholesale product lines:
 - Electricity
 - Natural gas
 - Environmental/renewables



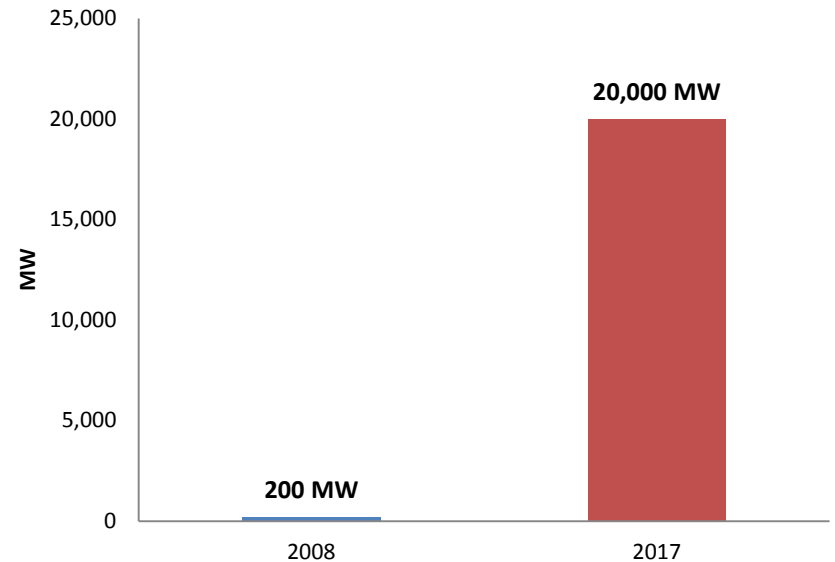


Growth of Solar Generation in US Desert SW & California

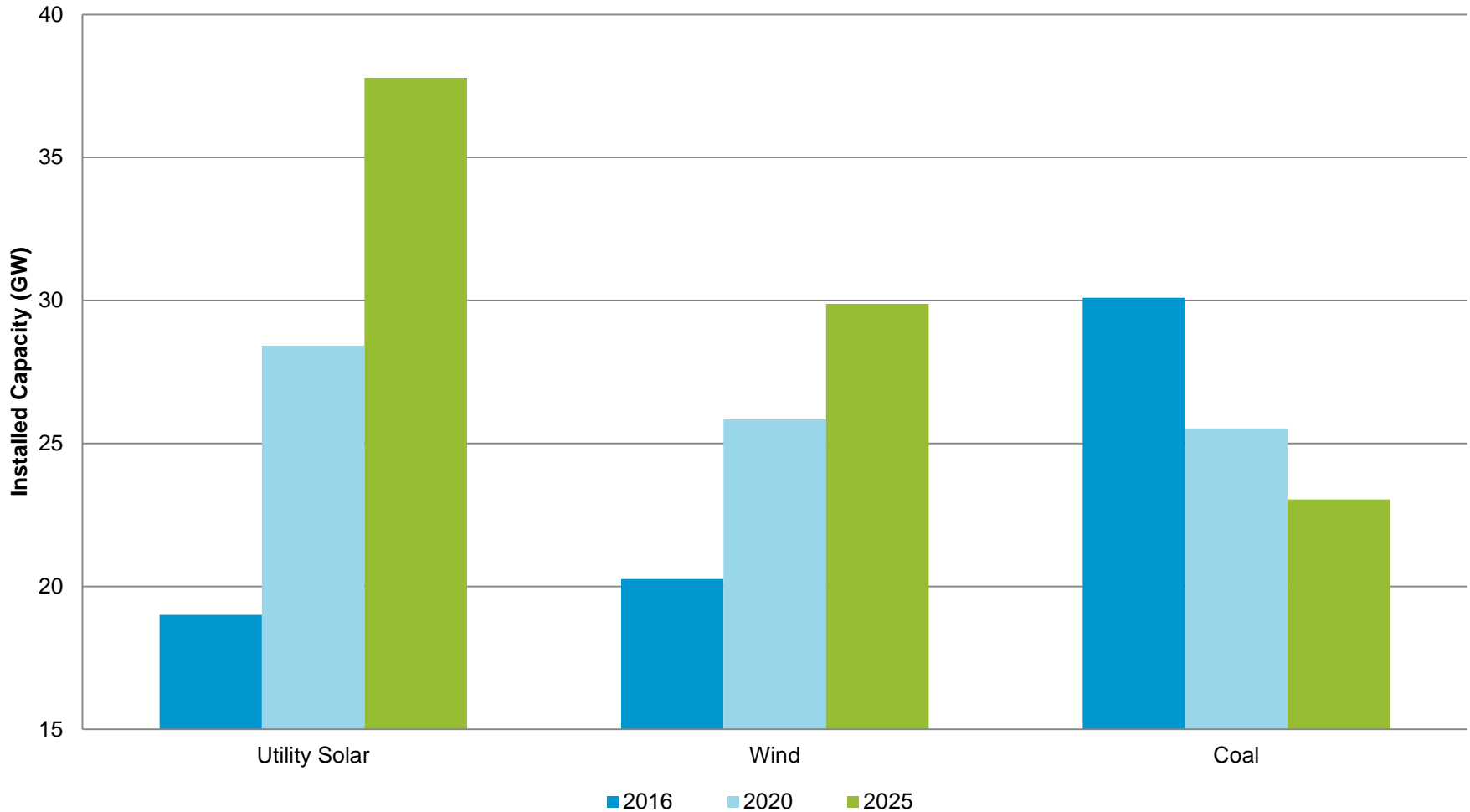
Cost of Solar Generation (20 year Power Purchase Agreement)



Solar Generation Capacity in California & Desert SW (Utility Scale & Rooftop)

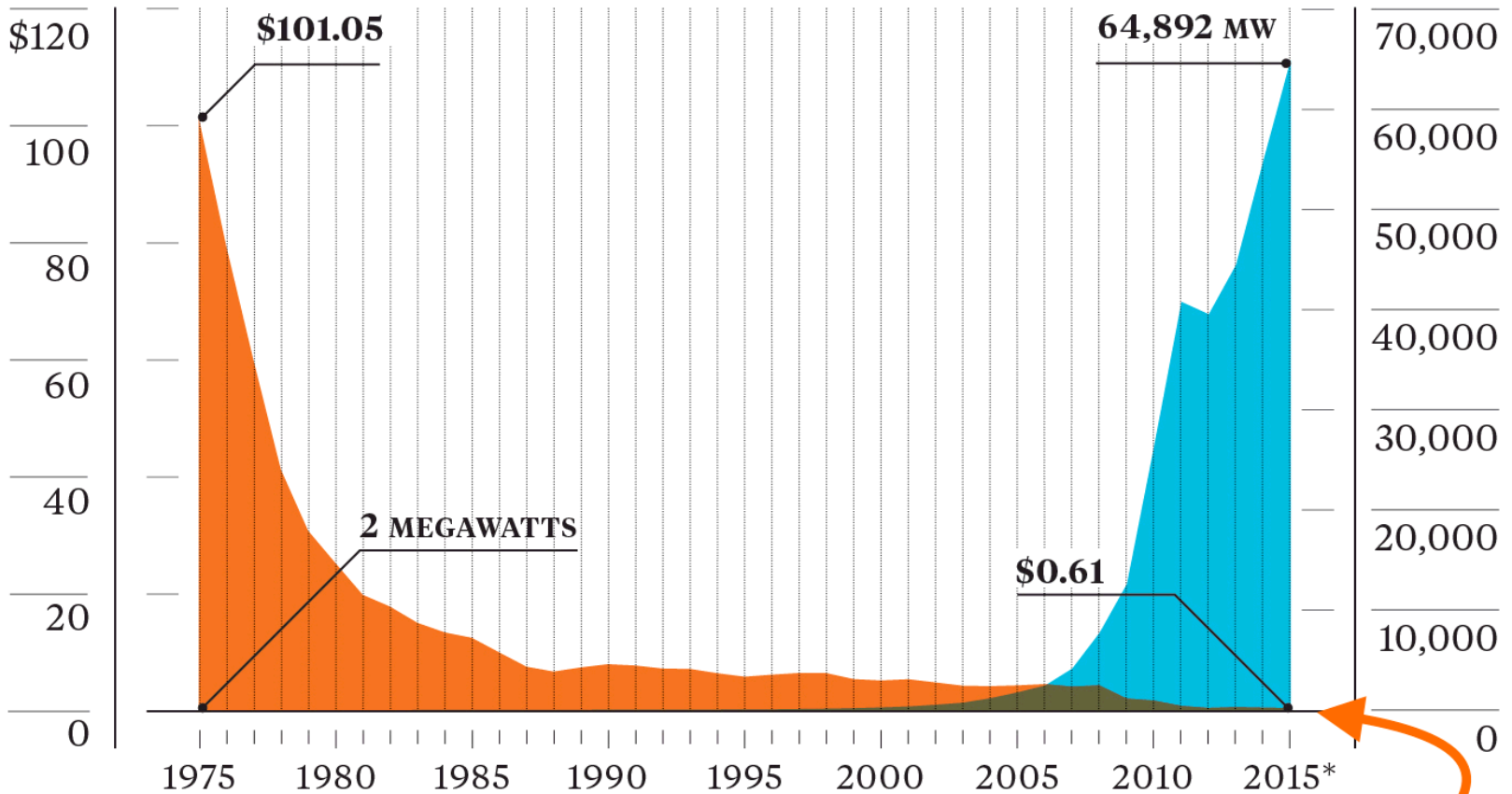


Solar, Wind and Coal Installed Capacity (California, Rockies, Desert SW)

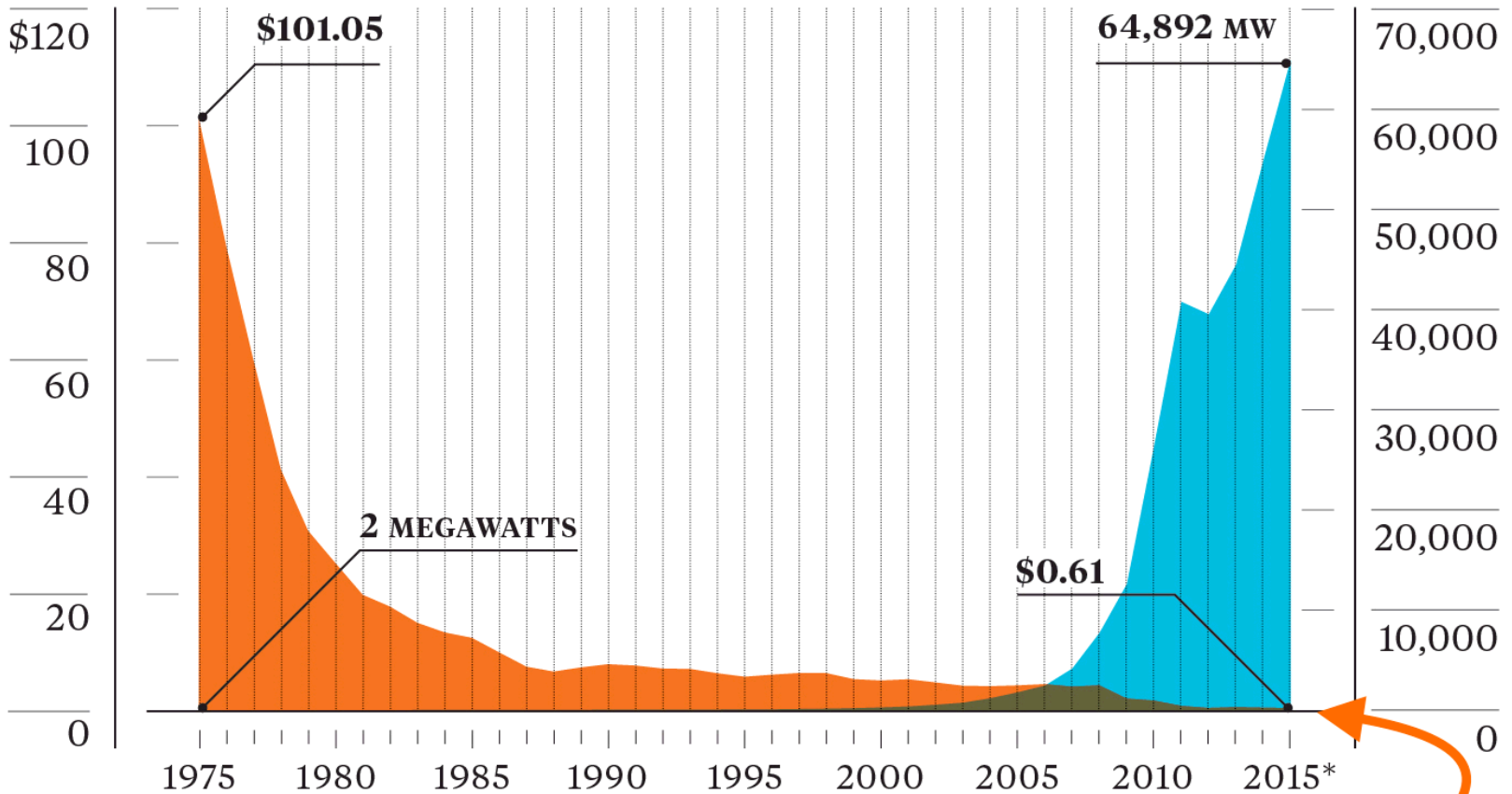


Source – IHS CERA April 2017

Price of a solar panel per watt



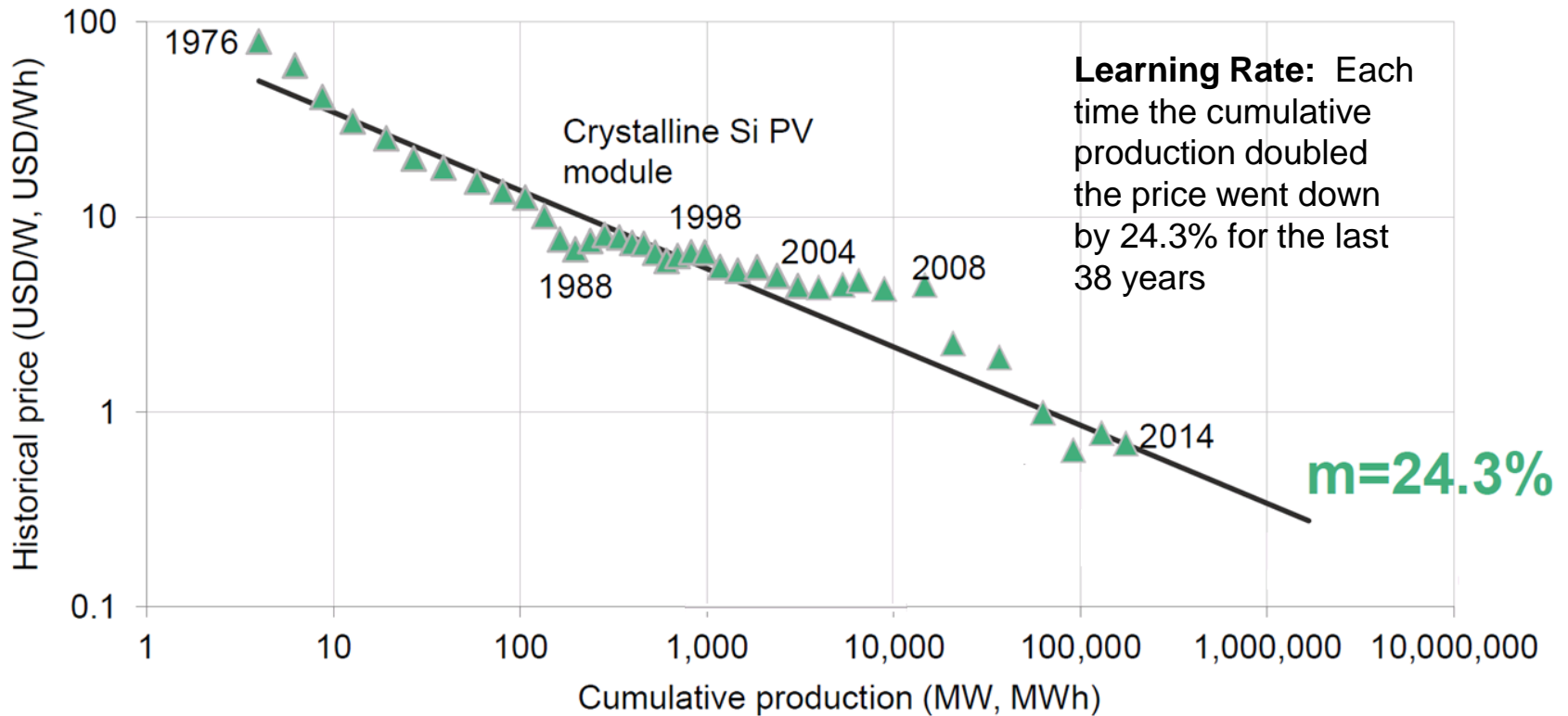
Global solar panel installations



*Estimate. Sources: Bloomberg, Earth Policy Institute, www.earth-policy.org

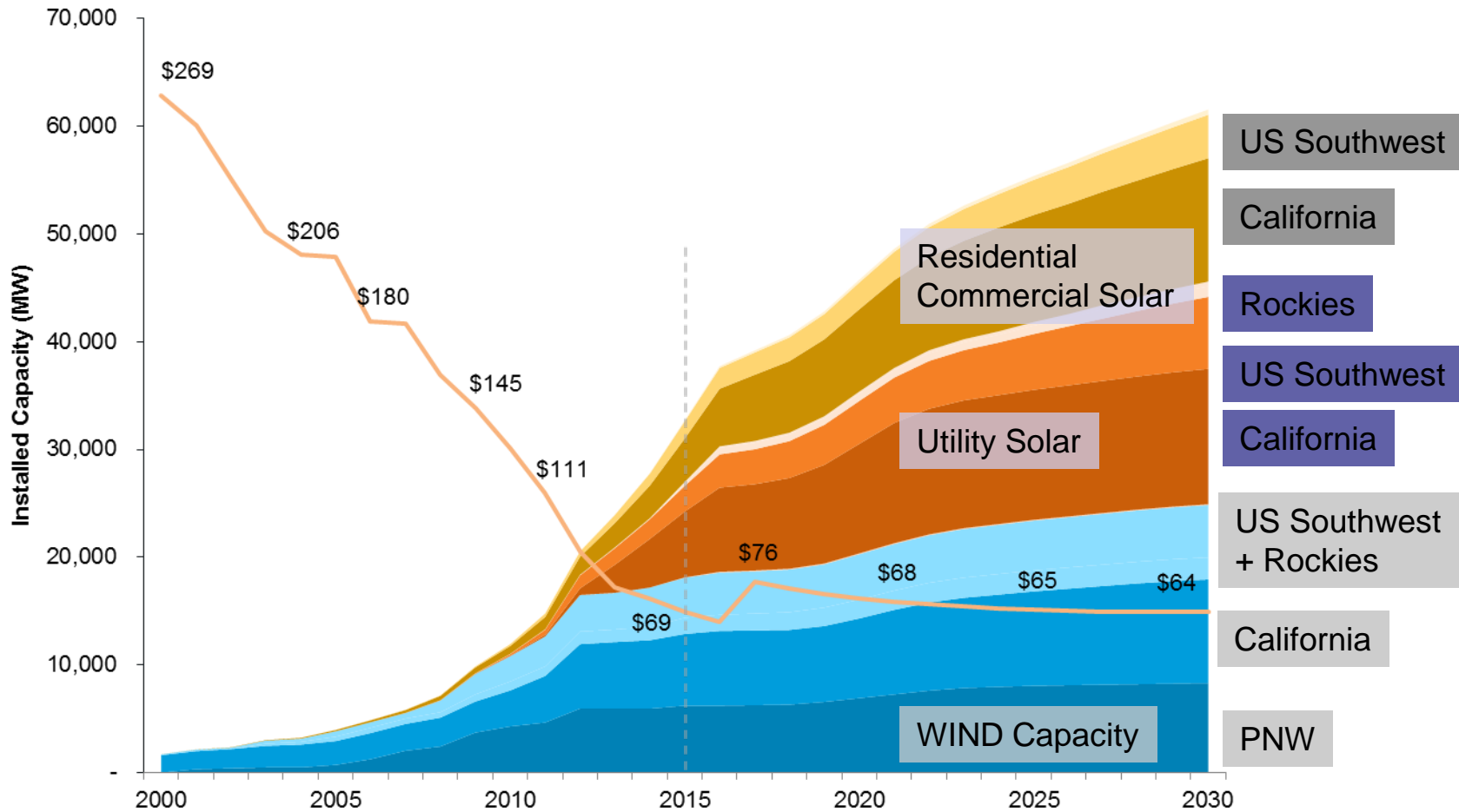
Down to \$0.447 in August 2016

Solar PV Experience Curve



Bloomberg New Energy Finance

Future Outlook: Technology Revolution



Source: IHS CERA: "Breakeven" price is based on 20 year fixed notional power purchase agreement price required for utility scale solar in California/Desert SW. US Dept of Energy – 2013 Wind Technologies Report; based on weighted average of levelized actual western grid Power Purchase Agreements (shifted to reflect build time)

Key Renewable Integration Challenges

- Periods of Oversupply
 - Too much “must run generation” results in renewable curtailment
 - BC Hydro has this problem from time to time in the spring – overnight when demand is low
- Sufficient Flexible generation to respond to **variability**
 - Variability in California solar is dramatic
- Sufficient Flexible generation to respond to supply **uncertainty**
 - Particularly for wind resources

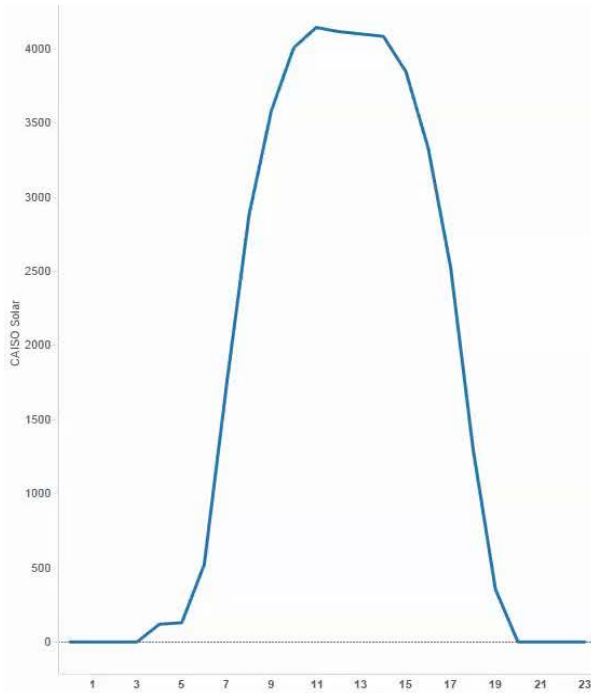
Value Proposition of Large Hydro

- **Energy**
 - The quantity of energy produced over a defined time period
 - i.e. BC Hydro produced 53 000 GWh in 2013
- **Capacity**
 - The quantity of energy that can be produced at a moment in time
 - i.e. BC Hydro is able to produce 10 500 MW at 12.00 on December 18th
- **Flexibility**
 - The *ability to change* generation production from one level to another level over a defined period of time
 - i.e. BC Hydro is able to increase its energy production from 8 000MW at 12.00 to 10 000MW at 13.00

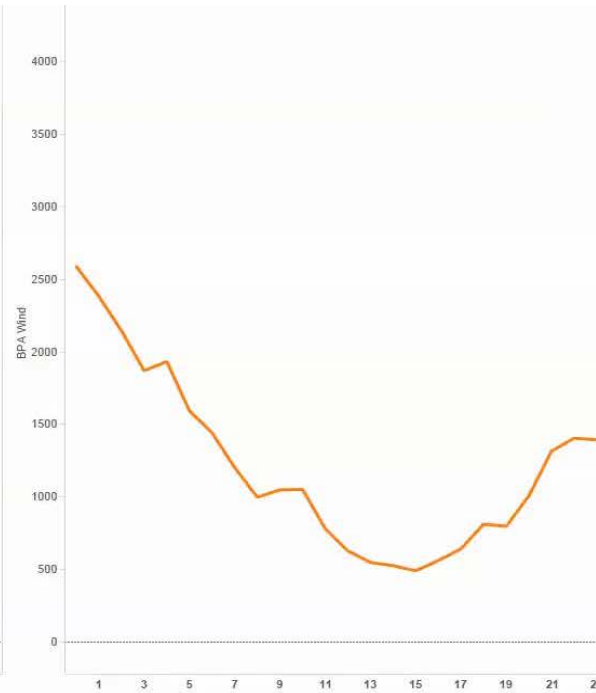
Renewable Resource Comparison

(June 1, 2014 – July 31, 2014 - Video)

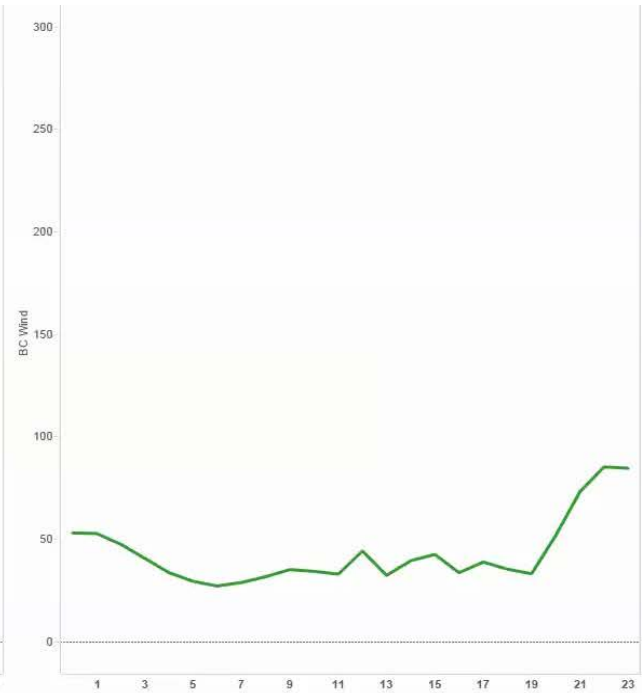
CAISO Solar



BPA Wind



BC Wind



CAISO Solar Time - June 1, 2014



BPA Wind Time - June 1, 2014



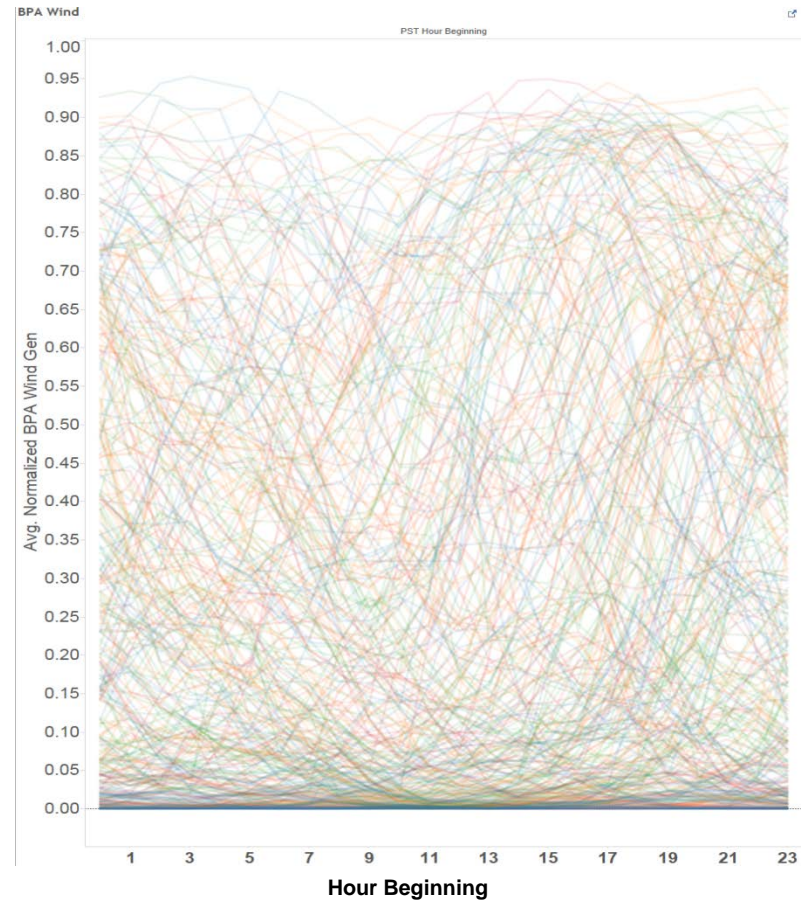
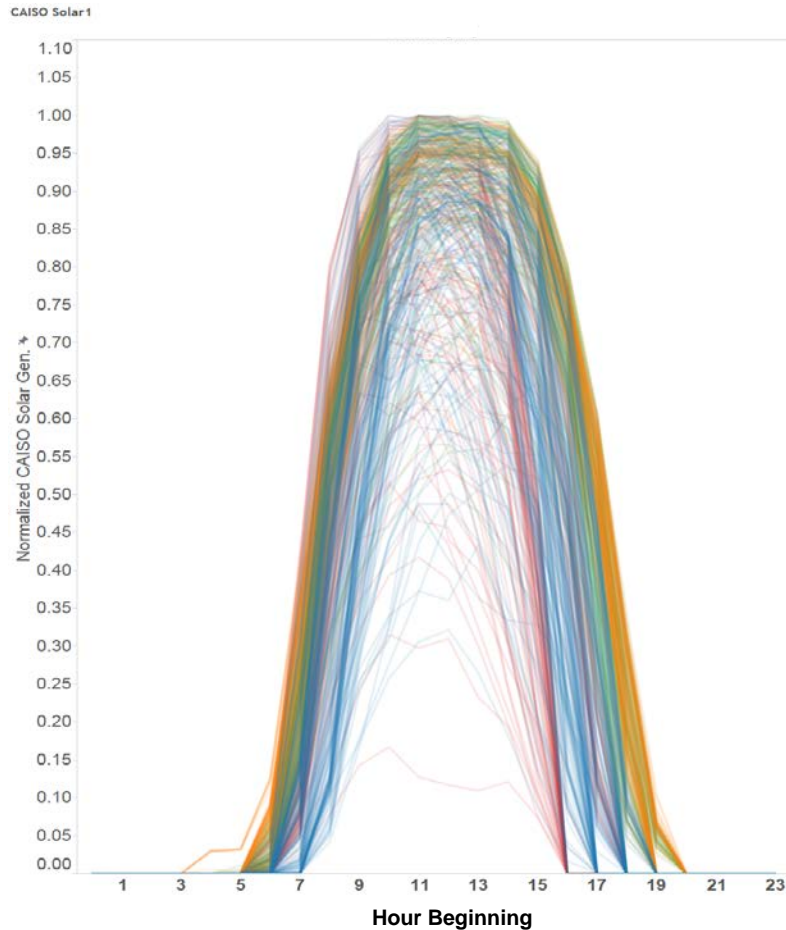
BC Wind Time - June 1, 2014



Solar vs. Wind Generation – One Year

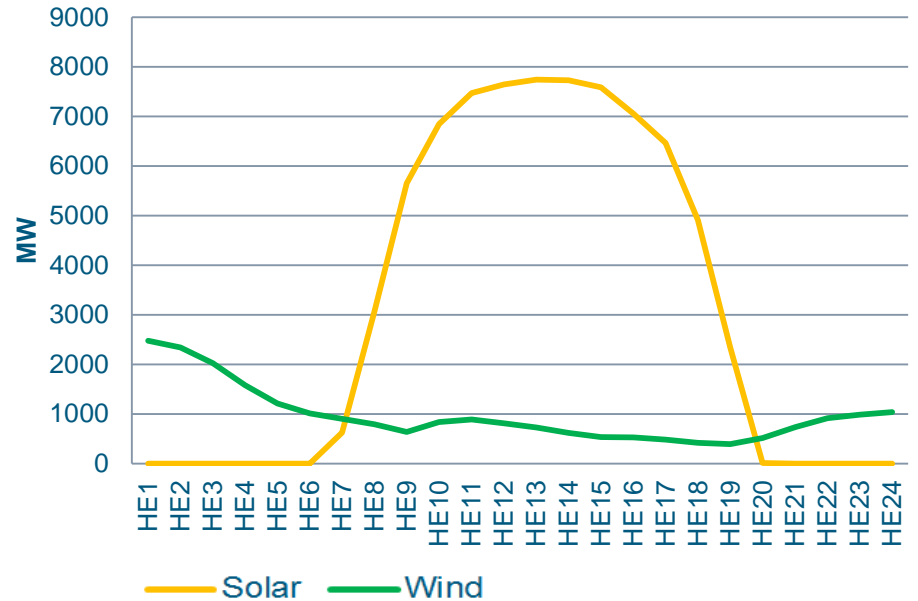
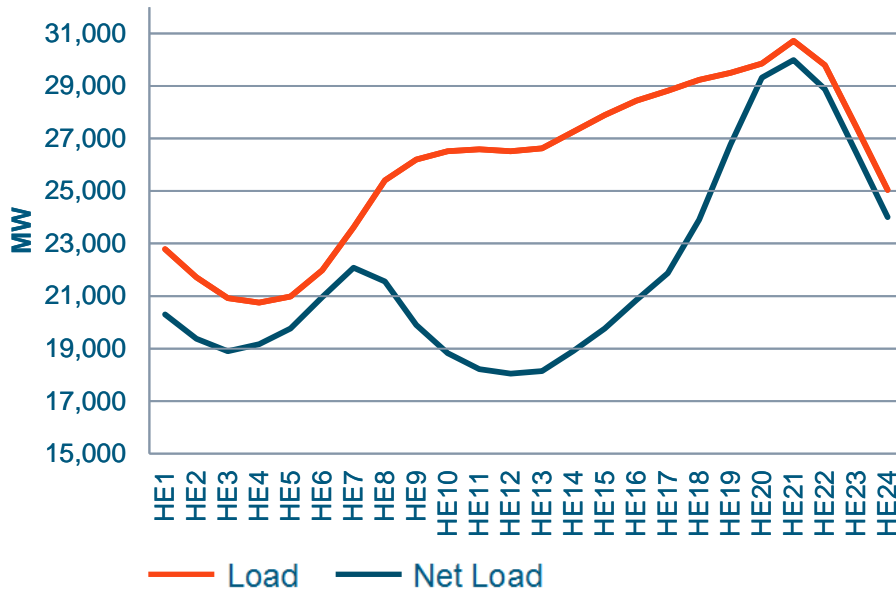
California Solar

BPA Wind

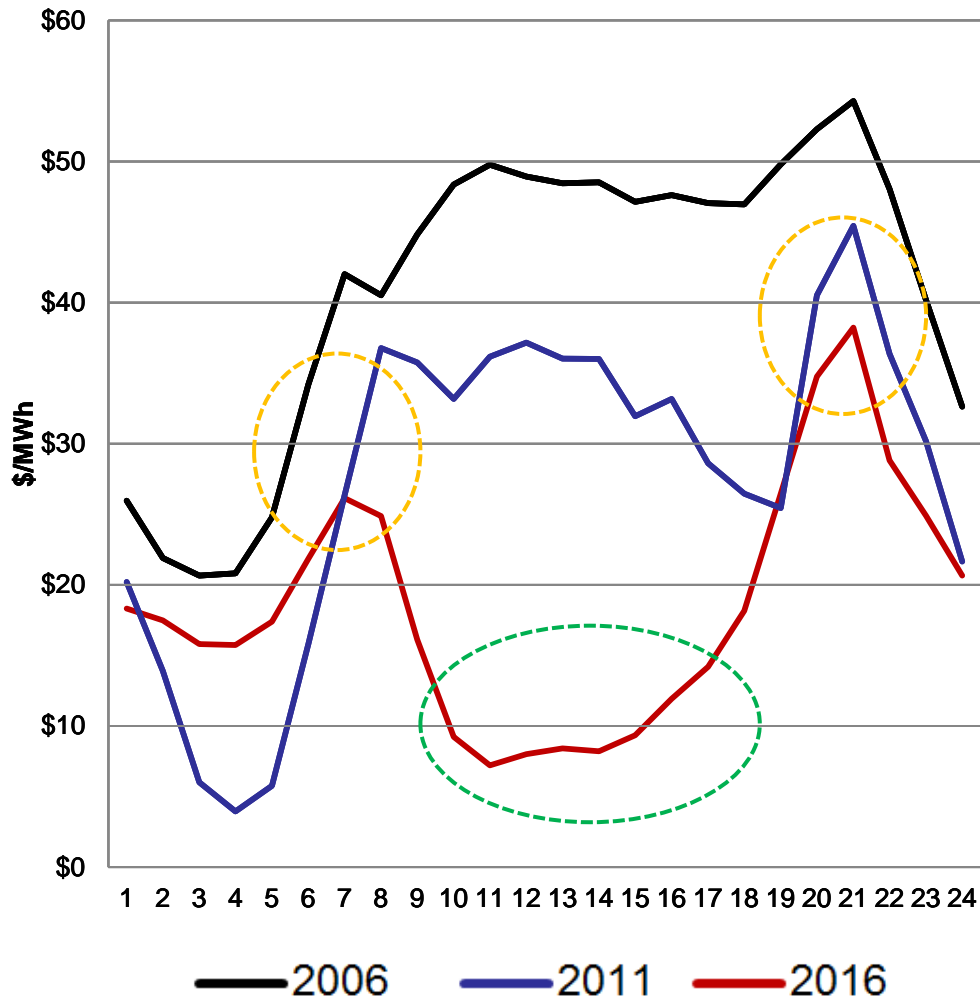


Each line represents one day, line colors by quarter, normalized to account for new facilities
April 5 2014 – April 6 2015

California's biggest challenge



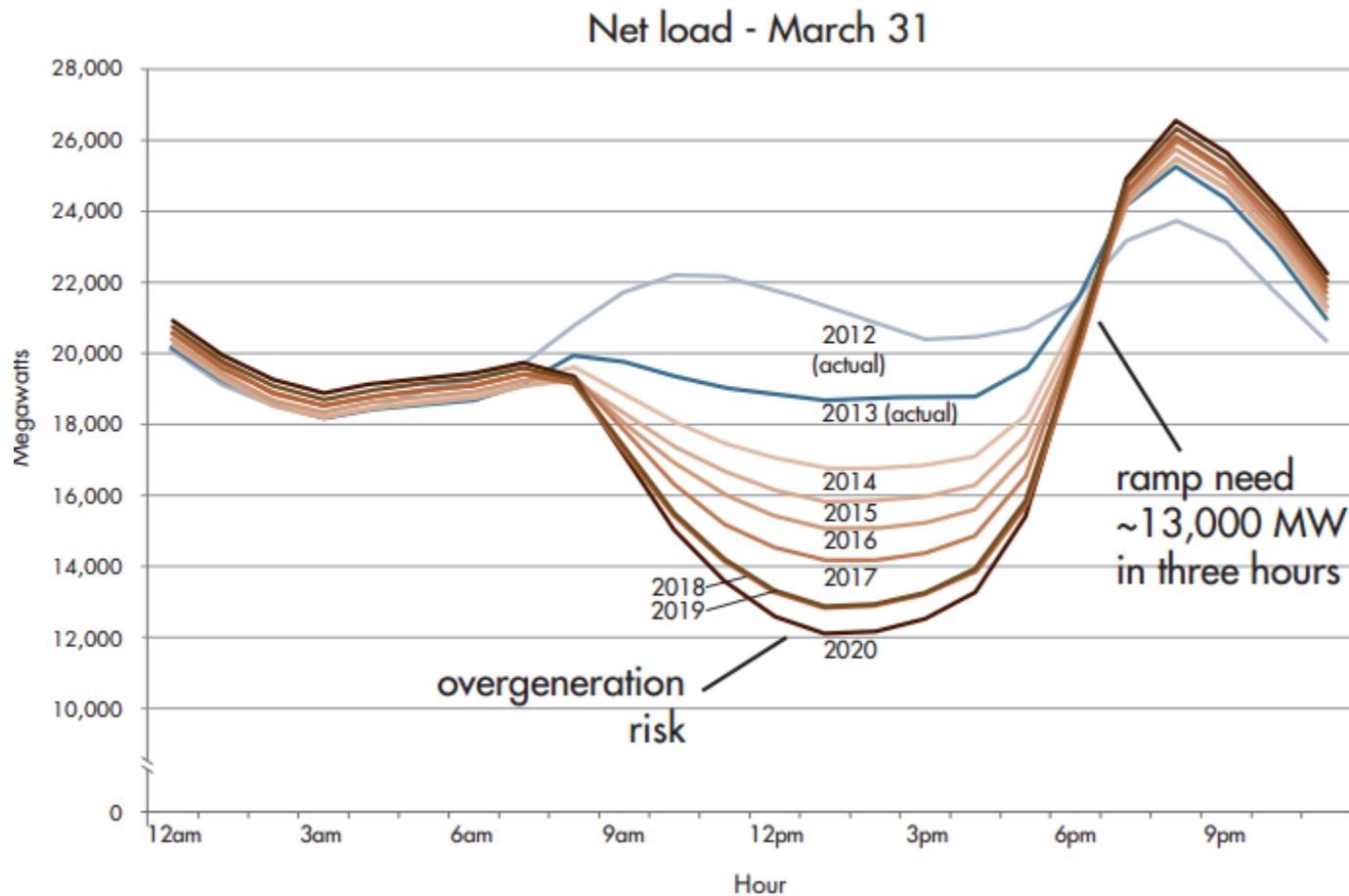
California Hourly Prices – Average April Day



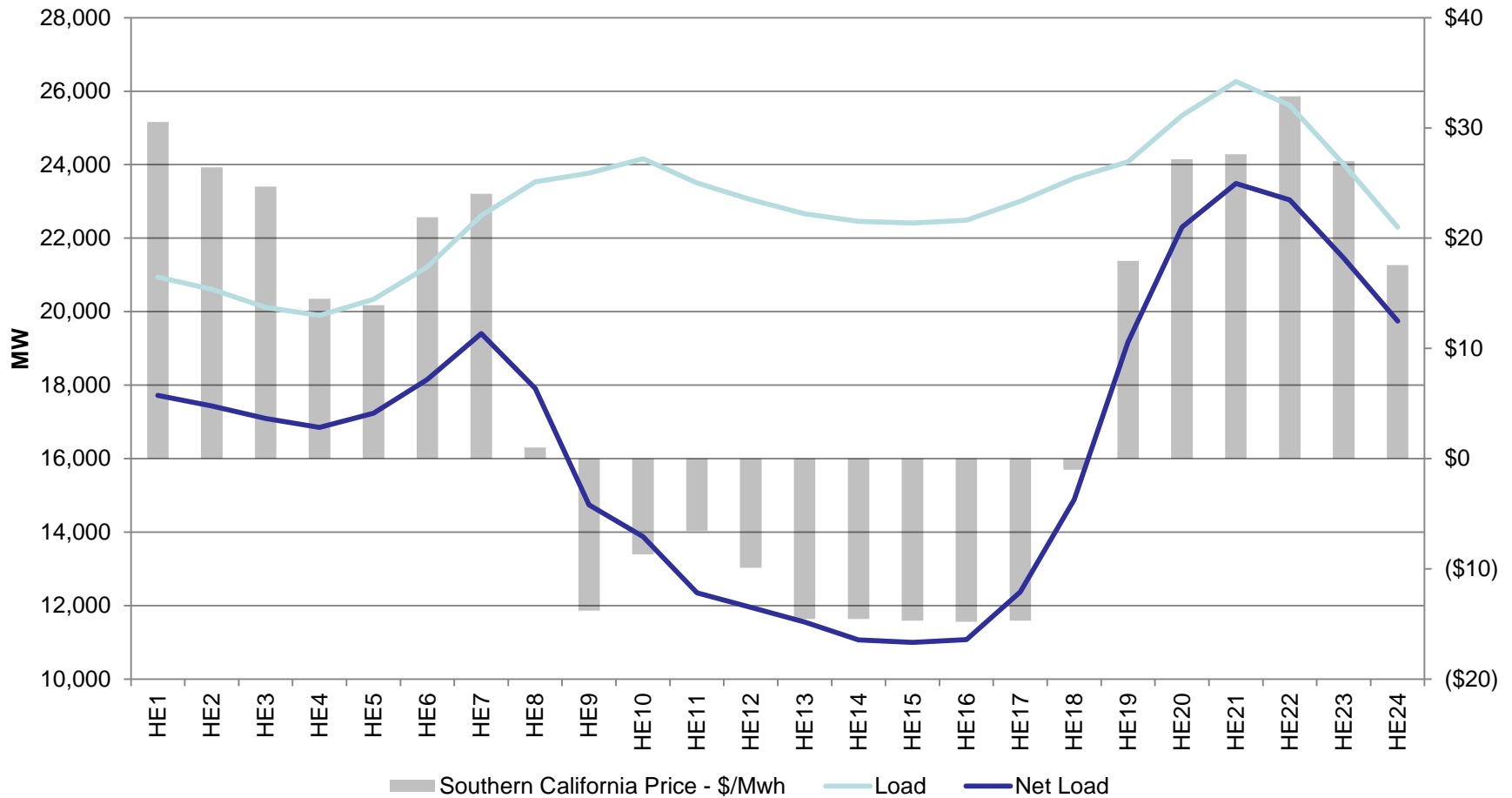
- Middle of day sales opportunities are beginning to evaporate in most months (except June-Sept)
- Middle of day purchase opportunities will arise in coming years
 - Oversupply of renewables
- Eventually opportunity will be for “battery like” trade
 - i.e. **Sell** 12 highest priced hours, **purchase** 6 lowest priced hours

California and the “Duck” Curve

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



California "Duck" Curve – April 14th 2017 (Load & Net Load)



Source – CAISO

California Legislation Evolution

Current RPS Legislation:

- RPS Program established under SB 1078 (2001) and set a target of **20%** of load served by eligible renewable energy resources by **December 31, 2017**
- RPS Program was accelerated by SB 107 (2006), which moved up the 20% target to December 31, 2010
- RPS Program was expanded by SB 2 (2011) and set a 33% target by December 31, 2020
- RPS Program was further expanded by SB 350 (2015), which set a **50% target by December 31, 2030**

California Legislation Evolution

Currently ***under debate*** in the California Legislature:

- SB 100 would set a RPS target of **45% by December 31, 2023, 50% by December 31, 2026, and 60% by December 31, 2030**
 - SB would set a goal of 100% from eligible renewable energy resources and “zero-carbon resources” by 2045
 - Definition of “zero carbon resources” still under debate, but would probably include large hydro but not nuclear resource
 - SB 100 is introduced by the Democratic leader in the Senate, Kevin de Leon
- AB 1405 and SB 338 would require the California energy commission to set targets and requirements to meet “net-load *peak* energy” with clean energy technology, demand response, and energy efficiency while reducing the need for new generation and transmission