Electric System Modeling to Assess Bay-Delta Flow Criteria Proposals

Joint Presentation
CEC, CPUC, ISO Technical Staffs
SWRCB Bay-Delta Workshops
November 13-14, 2012

Overview

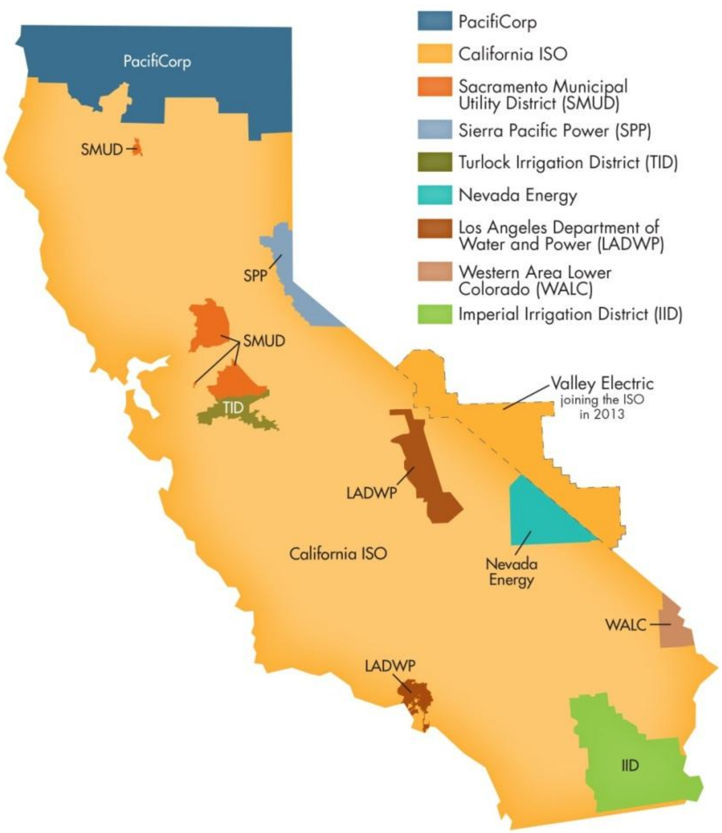
- Achieve state policy goals while ensuring electric system reliability at reasonable cost to ratepayers
- Describe analyses needed for a complete assessment
- Illustrate concerns:
  - the potential loss of capacity and flexibility of resources
  - Shift of energy production to periods of lower value
- Communicate lead time needed for some replacement resources

Key Takeaways

- California's electric grid relies on hydroelectric resources – roughly 11,000MW out of 61,000MW of instate generating capacity
- Resources are currently dispatched to accommodate existing water policies, so their operational flexibility is already constrained compared to their capabilities
- There is considerable uncertainty over the electric system impacts, but a clearly defined set of expected water flow criteria proposals will enable indepth modeling assessments

Balancing Authority Areas

- The Western interconnection is divided into manageable areas that an area operator balances supply/demand on a minute to minute basis
- Nine BAAs exist within California
  - Five wholly within California
  - Four centered outside of California serving small portions of our state



Hydro-Electric Capacity (MW) by Balancing Authority Areas

DWR River Basin	DWR Hydrologic Regions	CAISO BAA	BANC BAA	TID BAA
Upper Sacramento	Sacramento	0		
Pit /McCloud	Sacramento	757	746	
Sacramento Valley	Sacramento	20		
Butte Creek	Sacramento	9		
Stony Creek	Sacramento	4		
Feather	Sacramento	1,734		
Yuba	Sacramento	594		
American	Sacramento	257	946	
Mokelumne	San Joaquin	187		
Calaveras	San Joaquin	1		
Stanislaus	San Joaquin	459	300	
Tuolumne	San Joaquin	0	62	154
Merced	San Joaquin	70		
San Joaquin	San Joaquin	1,237		
Total for Bay-Delta		5,329	2,054	154
Other	Various	3,645	0	0
Total for BAA		8,974	2,054	154

Capacity, Energy, and Operational Flexibility

- Electricity system planning has traditionally focused on energy and capacity to meet demand
- Increasing load uncertainty combined with increased penetrations of variable renewable resources create a new need for flexible resources in addition to energy and capacity
- Flexible resources have to cover sudden production decreases from wind or solar

Modeling Approaches

- Different modeling approaches are used for specific purposes – general planning, resource adequacy, procurement authorization, etc.
- Five primary types of modeling
  - Supply/demand balances
  - Transmission system assessments
  - Local capacity assessments
  - System simulation
  - Flexibility assessment

Supply/Demand Balances

- Ensures there are sufficient resources to meet expected peak demand plus a reserve margin
  - The reserve margin is designed to account for issues such as higher loads than forecast and resource outages
- Usually conducted at state, system or zonal level

Tools: Spreadsheets and Databases

Metrics: 15-17% Planning Reserve Margin

Transmission System Assessment

- Represents the electrical connection of generation and loads via the transmission system
- Identify overloaded transmission system elements and local or regional system stability criteria
- Once problems are identified, mitigation measures (new lines, reconductoring, upgraded transformers, etc.) can be proposed

Tools: Power flow and dynamic stability analysis

Metrics: Meet NERC/WECC standards

Local Capacity Assessment

- Studies to determine whether sufficient in-area generation exists in transmission constrained local areas to satisfy NERC/WECC and ISO standards
- Ten local capacity areas in the ISO Balancing Authority Area – Greater Fresno, Stockton and Sierra areas relevant to flow criteria proposals
- CPUC imposes resource adequacy requirements based on ISO study results

Tools: Power flow and dynamic stability analysis

Metrics: Preventing load drop from contingencies

System Production Simulation

- Production cost simulations assume load patterns and non-dispatchable profiles to forecast:
  - How a given resource build-out would be operated to minimize operating costs while meeting modeled constraints
  - Optimum imports from other regions
  - GHG emissions
  - Hours of unserved load and over-generation
  - Optimum dispatch of use-limited resources
- Models incorporate resource characteristics and are run for 8,760 hour per year

Tool: Plexos (or other production cost models)

Metrics: Resources to cover loads and reserves in every hour while minimizing operating costs or other dispatch criteria

Flexibility Assessment

- Focus is on whether resources are sufficiently flexible to meet operating needs
- Shifts perspective from a total load basis to a net load, e.g. total load forecast minus the forecast of energy production from wind and solar resources
- Determine whether the net load shape (8760 basis) can be served with available resources
- Analytic techniques are evolving to identify metrics such as ramping requirements or increased regulation

Tool: Uses production simulation tools like Plexos

Metrics: Example – maximum continuous 3-hour ramp

Integrating Electricity Planning Tools with Water Flow Modeling

Modeling Approach	Tools	Relevance	Interaction with Flow Criteria Proposals
Supply/demand balances	spreadsheets	assess need for replacing lost capacity	determine generator head reduction and whether reduced hours requires capacity derate
Transmission system assessments	PSLF	identify overloaded transmission	identify whether lost capacity has transmission implications
Local Capacity Assessments	PSLF	identify generation needed in load pocket	identify whether lost capacity has generation implications
System simulation	Plexos	determines dispatch of generating fleet to satisfy load	indicate how revised flow patterns will influence dispatch of other generating resources
Flexibility assessment	numerous	assess capability of generating fleet to ramp up and down as intermittents fluctuate	assess importance of reduced hydro flexibility on the need for additional capacity from other dispatchable resources

General Issues for Hydro-Electric Modeling

- "Constraints" - minimum water flow, fisheries protection and linkage between facilities on the same river are well recognized by electricity modelers
- "Doing it right" - extremely challenging in production cost models which are greatly simplified compared to reality
- Assessing flow criteria proposals requires modeling greater detail than customary

Hydro-electric Capacity Modeling

- Basic Question: is sufficient capacity available to serve load under forecast conditions?
- Modeling assesses whether water is available to assure that the facility’s capacity rating can be achieved and sustained for some minimum period for the interval of interest – usually peak
- Testing whether capacity is available or constrained is different than assessing whether power will be produced

Hydro-electric Energy Modeling

- Basic Question: how much energy will be generated from a facility over a given time period?
- Monthly pattern of runoff and snow melt influences this pattern as well as the amount of storage (if any) available
- Resource classifications:
  - Run of river
  - Dispatchable from reservoir storage
  - Pumped

– Algorithms for dispatching hydro can be simple or complex to represent flow criteria and other constraints.

Modeling Dispatch of Hydro Resources for Energy and/or A/S

- Conventions for determining “average” hydro patterns and “adverse” hydro patterns have been established, and actual generating patterns from historic years are frequently forced into production cost modeling in lieu of actual dispatch algorithms
- Hydro-electric dispatch has to be understood to be in the context of many other resources with very different cost or controllability characteristics:
  - Dispatchable conventional resources have high marginal operating costs vs. hydro’s near-zero costs
  - Renewables like wind, solar, and run of river hydro also have near-zero operating costs, but cannot be dispatched and do not provide the flexibility benefits needed by the system

Consequences of Changes in the Annual Pattern of Generation

- Studies suggest climate change will modify rainfall/snowfall
- Additional changes from unimpaired flow criteria <u>will</u> shift water usage for dispatchable hydro toward spring months, but the extent and implications are uncertain
- Seasonal shifts mean energy generated has less value
  - Spring loads are lower
  - Spring is high production period for wind and Pacific Northwest hydro
  - If spring usage constrains hydro operation, this may increase the need for other flexible resources
- Any increased chance of spill means some energy value is lost

Potential Issues with Unimpaired Flow Criteria for Hydro-Electric Facilities

- Run of River facilities -- expected impact is minimal
- Pumped facilities -- expected impact is minimal
- Storage facilities -- expected impact varies:
  - Change in pattern of hydro-electric generation
  - Change in capacity rating of facilities by season
  - Expected decrease in flexibility

Change in Capacity Ratings of Facilities

- A shift of water releases from summer months to spring months **cannot** increase spring capacity, but **may** decrease summer capacity
- The summer months are traditionally the period of highest system stress, because the system has needed the most capacity. However,
  - Flexible capacity needs are different in summer vs. winter
  - The flexible capacity needs in the future may be different than those traditionally seen
- Resource adequacy requirements mean that any loss of capacity will have to be replaced, and this may increase total costs for satisfying a given customer load pattern

Issues for Replacement Options

Option	Cost Expectations	Other Issues
Natural Gas Power Plants	New capacity costs and high operating costs	Criteria pollutant and GHG emission consequences
Storage	Extremely high capital costs and net energy loss in operations	Battery technologies can have serious waste disposal issues
Demand Response	Existing DR programs are on/off so creating flexibility implies substantial control and telemetry costs in addition to payments to participants	DR typically thought of as load reduction, when at least some flexible increases in load would be required to mirror a generating resource

Preliminary Assessment of Importance of Hydro Capacity

		ISO LCTA Study for 2013		
ISO Local Capacity Area	**Hydro Capacity (MW)**	**Total Capacity (MW)**	**Category C Requirements (MW)**	**LCA Surplus/(Deficit) (MW)**
Stockton	217	620	567	(154)
Sierra	1531	2039	1930	(218)
Greater Fresno	2093	2817	1786	1031

Note: These columns are independent from each other.

Ratepayer Costs

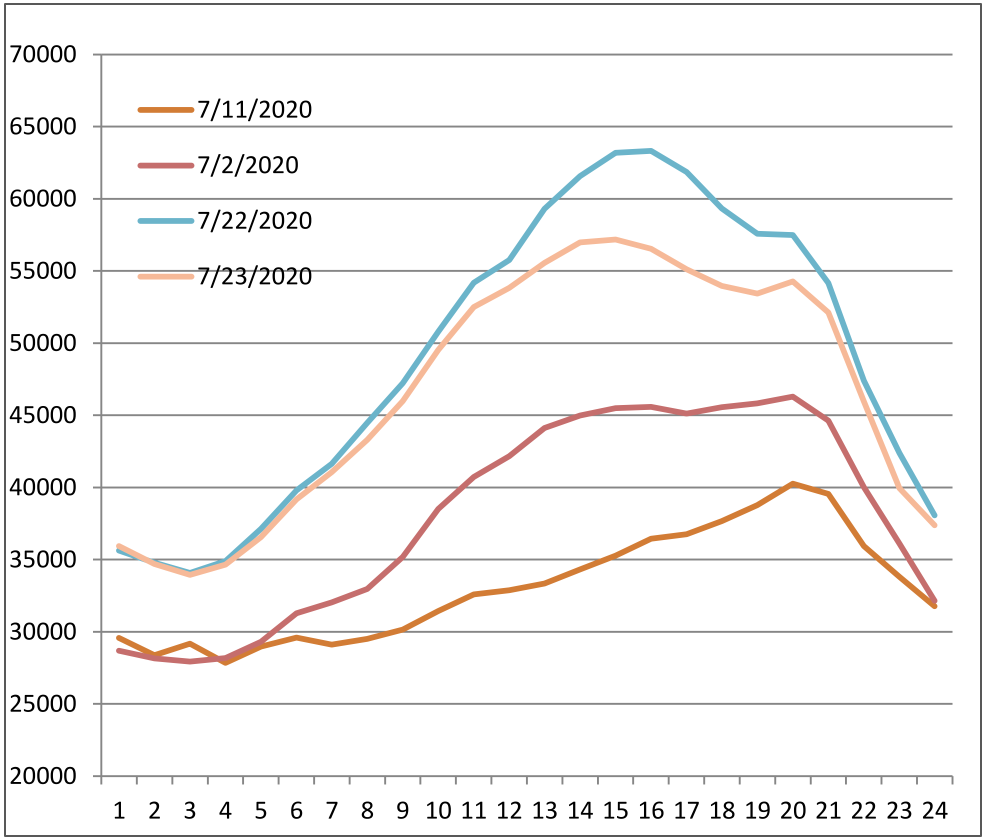
- Reducing flexibility of the hydroelectric fleet is likely to have impacts on ratepayers since capacity is in place and operating costs are low
- Each MW of lost hydroelectric flexibility will cost approximately $2 million to replace with a combined cycle or combustion turbine power plant
- Operational cost impacts are uncertain, but the replacement energy will be more expensive
- Increased GHG costs associated with the emissions from the new fossil generating facilities, if chosen

Flexibility to Integrate Renewables

- Aside from generating energy, hydro-electric facilities are dispatchable, respond quickly and can provide ancillary services:
  - Regulation
  - Load following
- Flexible alternatives to dispatchable hydro, such as natural gas power plants increase GHG, presenting challenges in meeting other State goals
- Ramping to integrate renewables is a new consideration that is still evolving

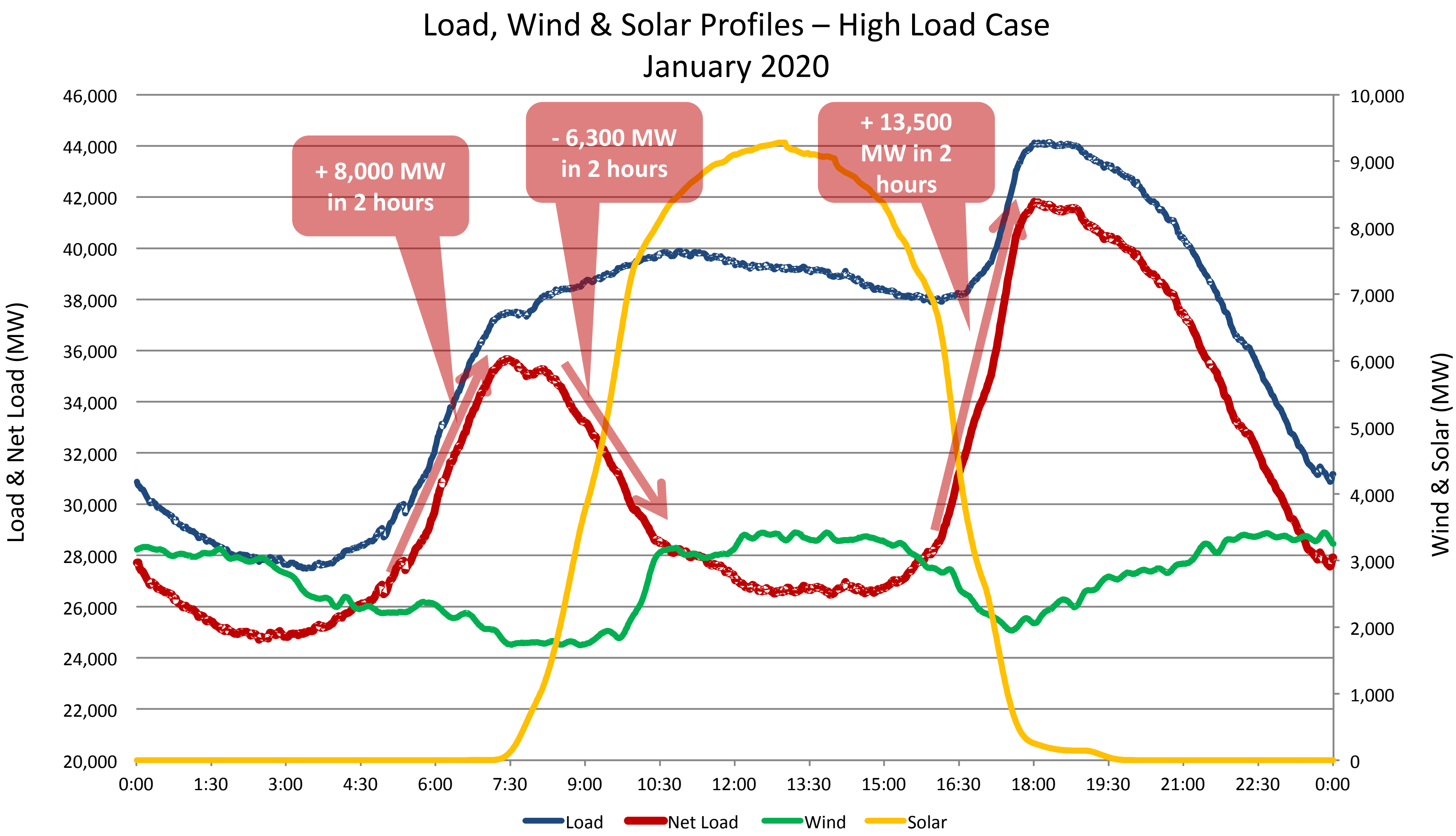
Variability in July 2020 Peak Hour Using the Net Load Perspective

- •Renewable development requires a shift from a "gross load" perspective to a "net load" perspective
- •The net load represents the remaining load after "must take" renewables have put power into the system
- •Dispatchable resources have to be sufficiently flexible to ramp up and down to this "net load" shape
- •The "net load" peak hour is frequently later in the day, and it is much less centered around hour 1500

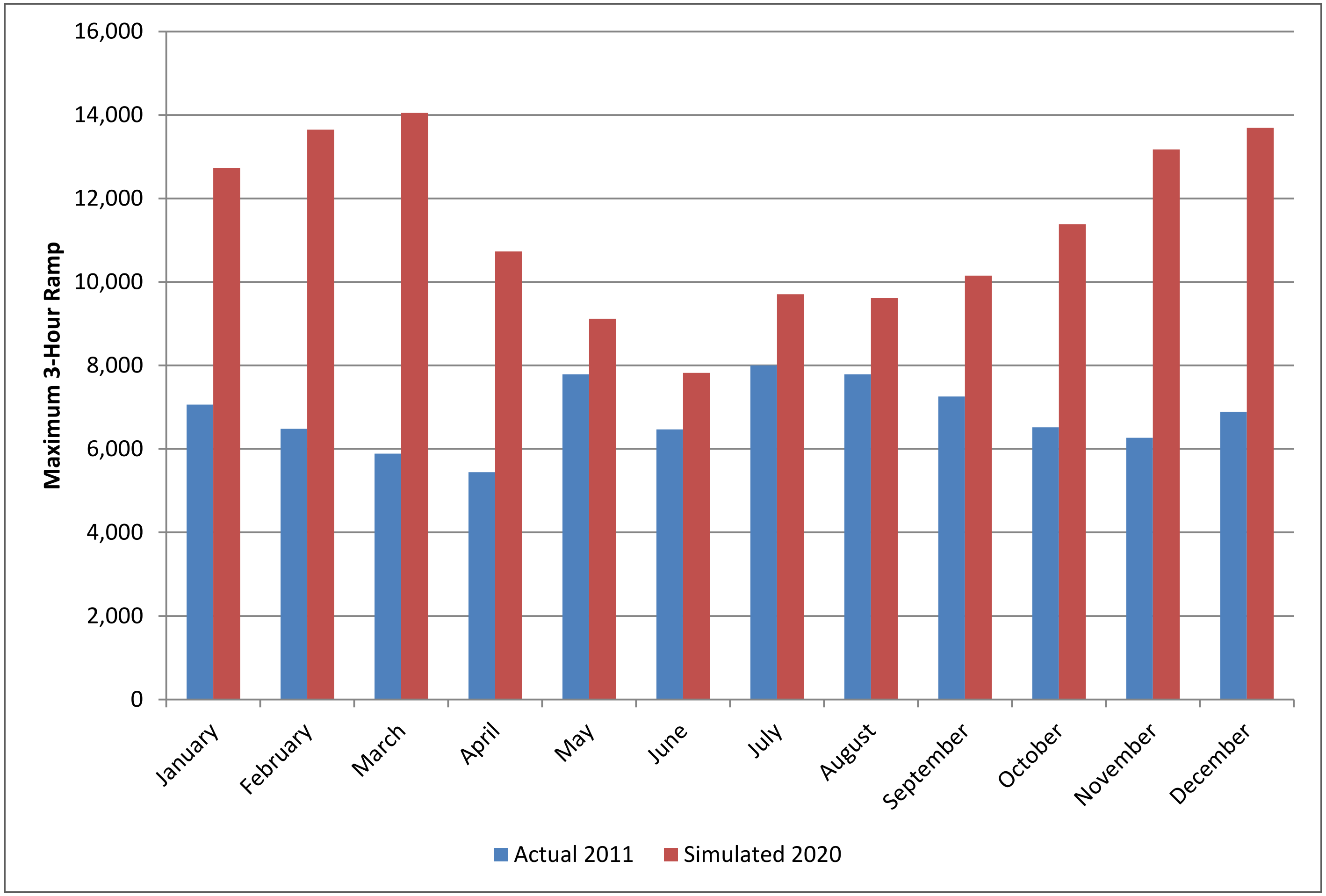


Source: CAISO July 2020 Plexos renewable integration analyses, Spring 2012

Forecast dispatch needs based on the net load demand curve – January 2020 High Load Case

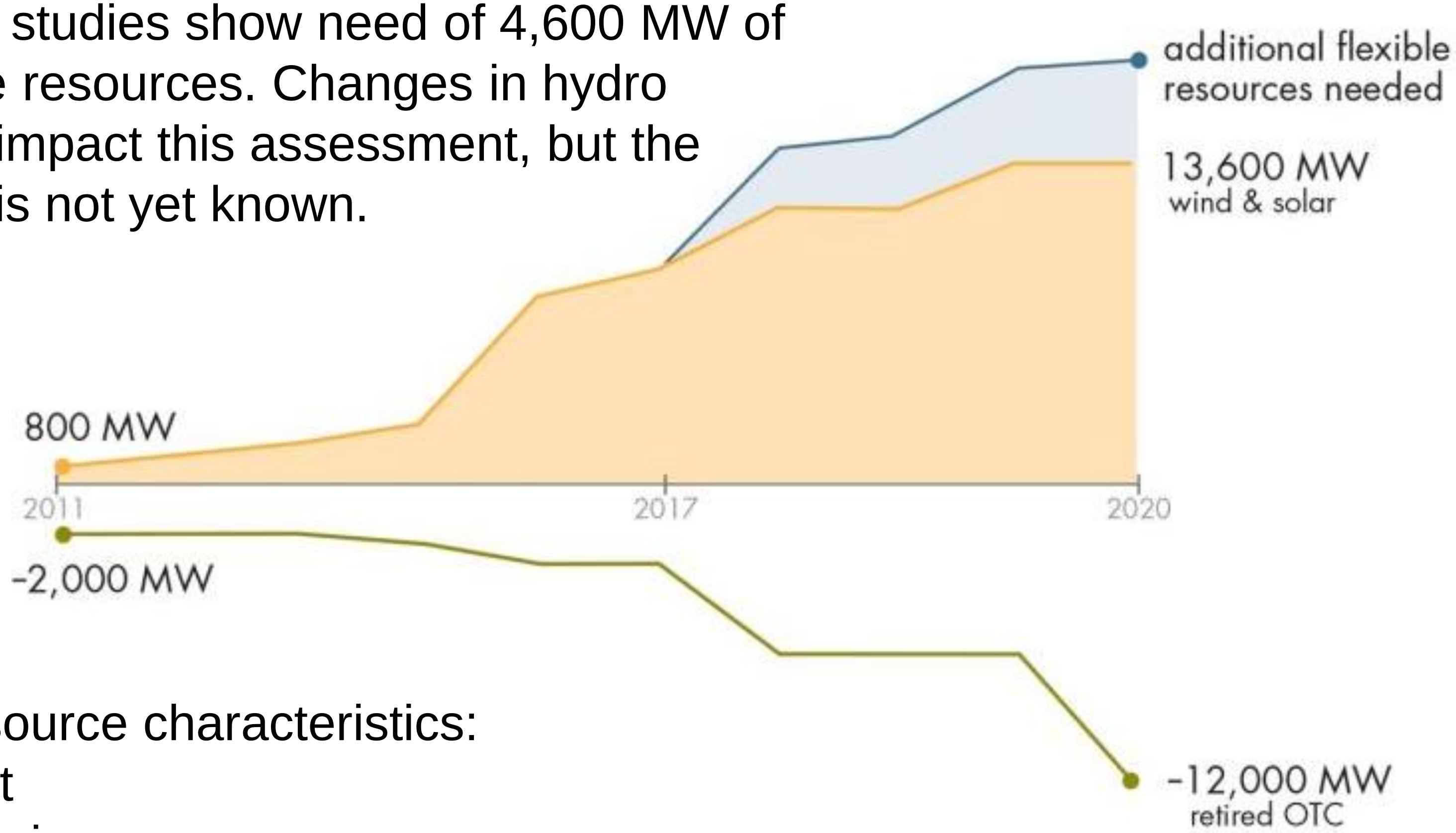


Increase in Monthly Maximum Net Load Ramp from 2011 to 2020



Supply variability is increasing while the flexible capability of the fleet is decreasing

Preliminary studies show need of 4,600 MW of new flexible resources. Changes in hydro production impact this assessment, but the magnitude is not yet known.

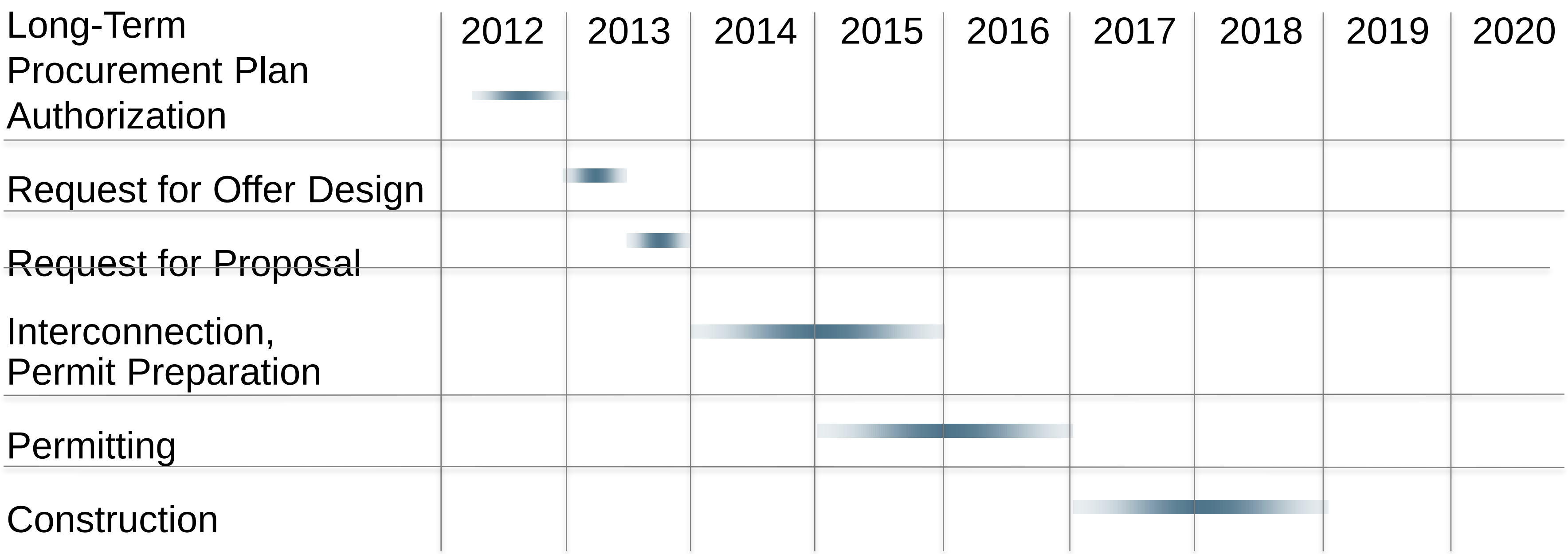


Flexible resource characteristics:

- fast start
- fast ramping

Source: ISO Briefing on Renewable Integration Memorandum (Aug 2011)

Illustrative example of conventional generation development timeline



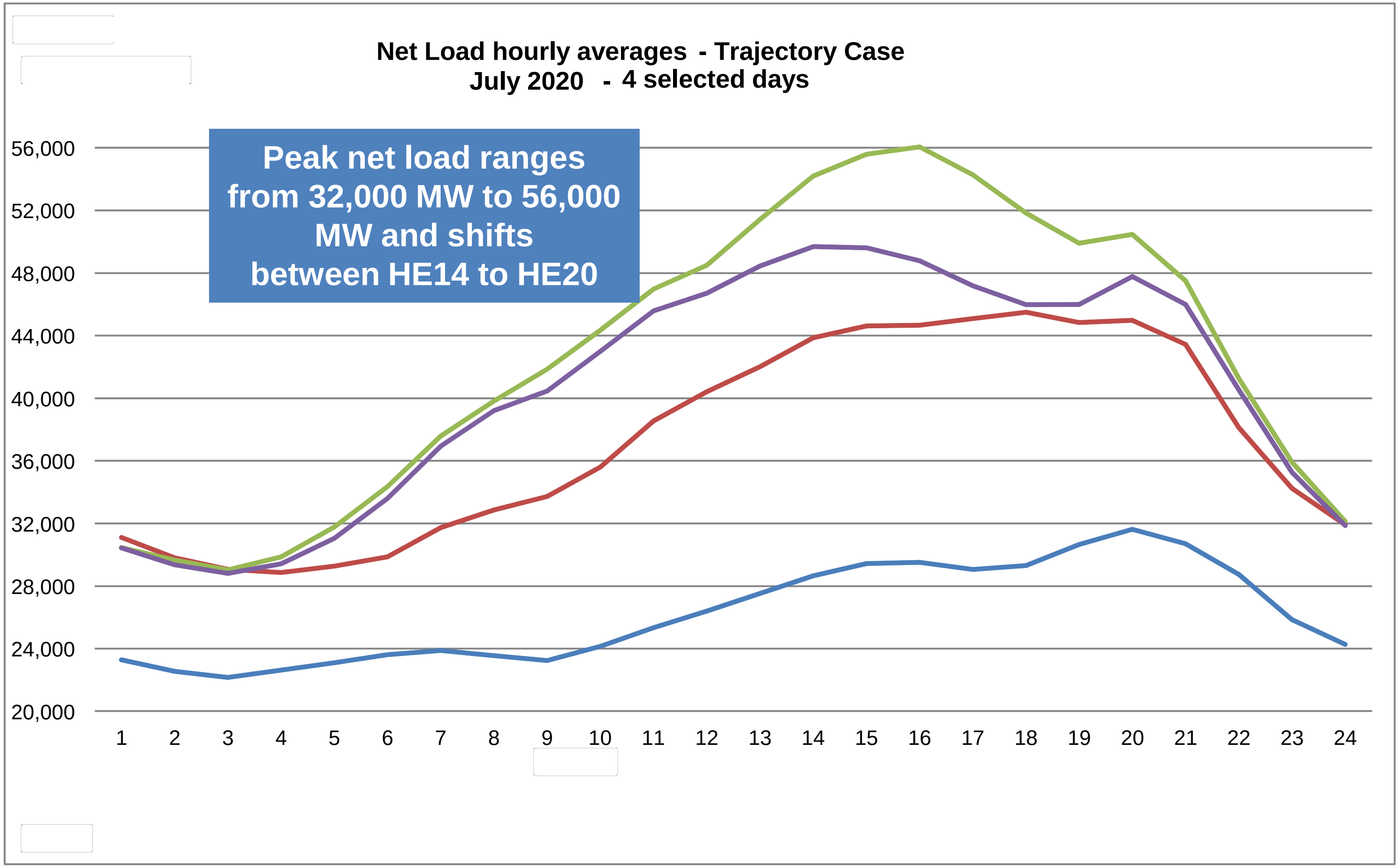
- This timeline presents a nominal development timeframe
- Other resources may have shorter or much, much longer development times depending upon the issues in the permitting process

Perspectives on Bay-Delta Flow Criteria Proposals

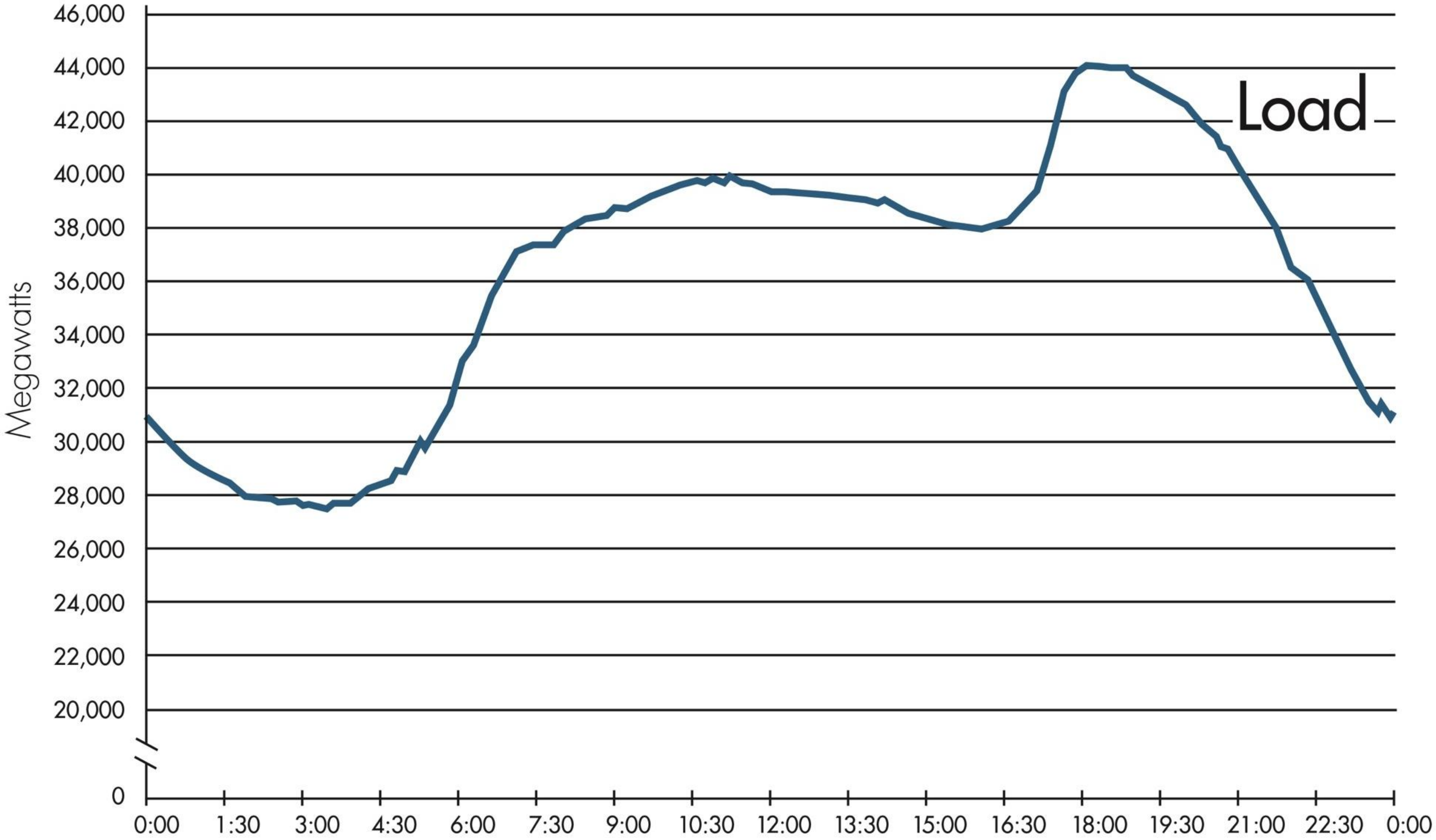
- It is critical to understand the full implications of alternative proposals on the use/capabilities of hydro-electric facilities
- Energy policies mandating renewable generation will increase the need for flexibility characteristics of storage hydro-electric facilities just as Bay-Delta flow criteria proposals may reduce this flexibility
- Energy agencies need a sufficient implementation time horizon to enable the electricity infrastructure planning process to identify, procure, and construct replacement options

Supplemental Materials

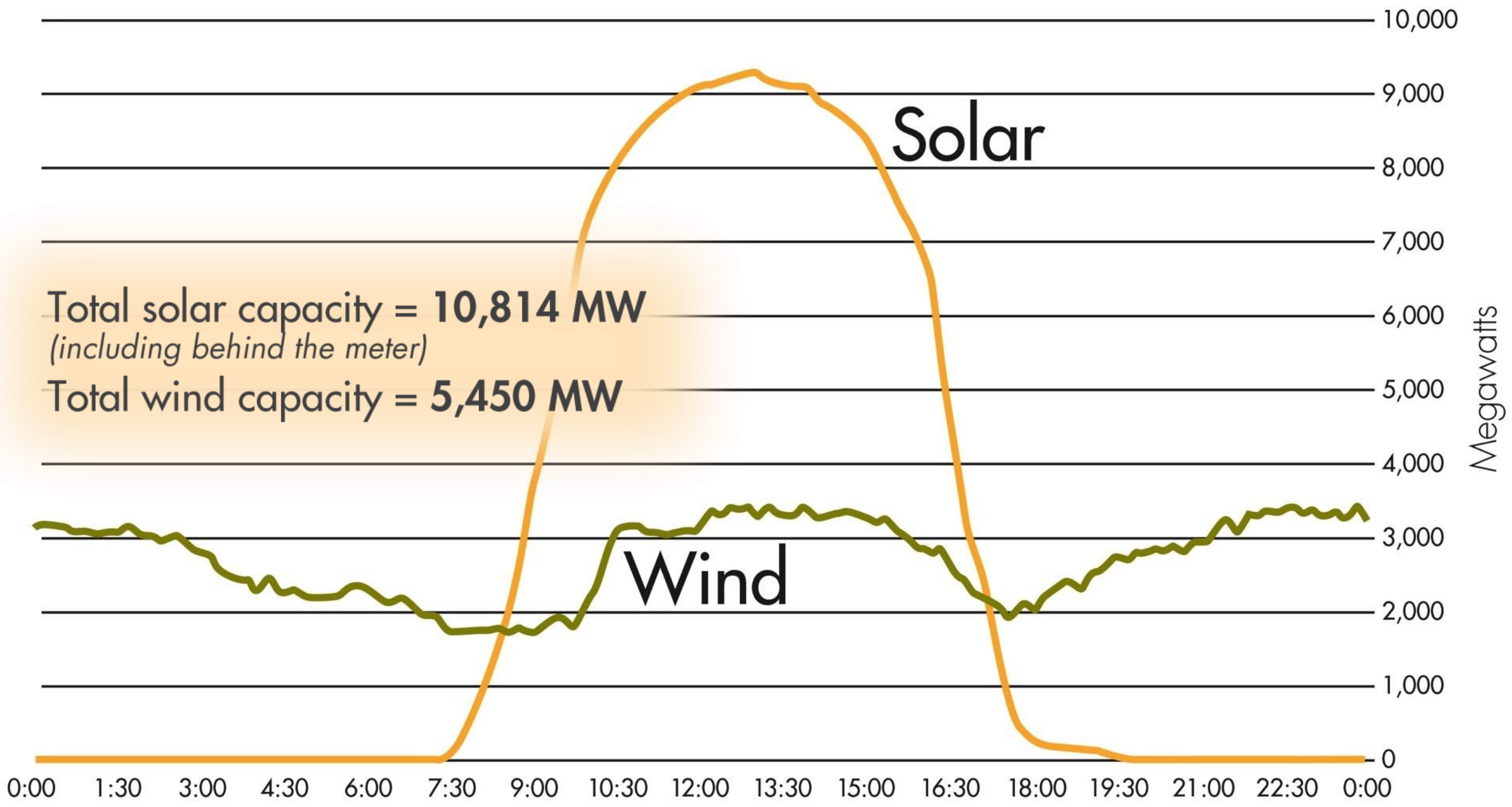
Large range of net load in summer period requires flexible capacity commitment capability



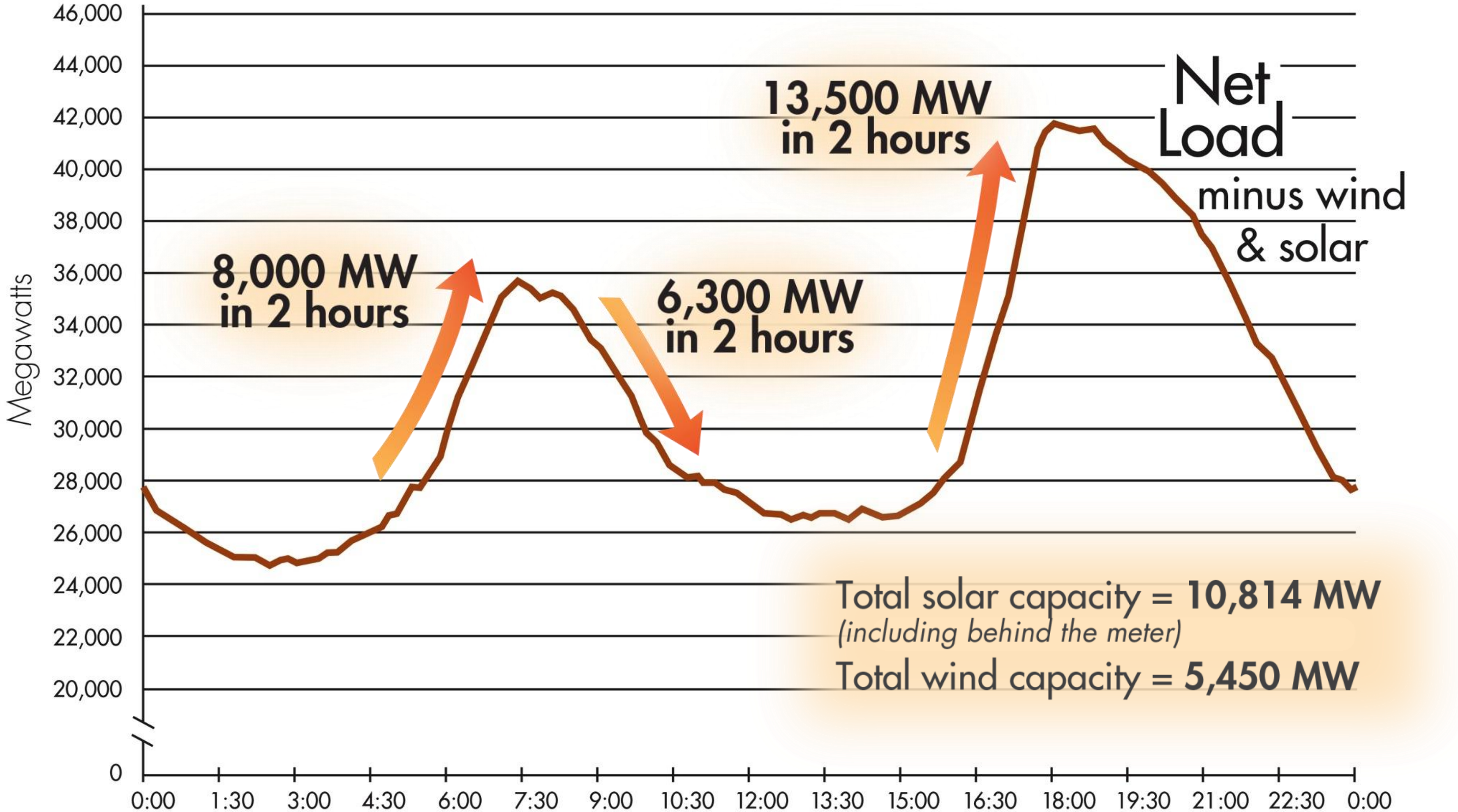
Load profile — sample winter day in 2020



Wind & solar profiles — sample winter day in 2020



Flexible resources will be essential to meeting the net load demand curve



Sample winter day in 2020

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