



*The Business Case for Integrating Clean
Energy Resources to Replace Coal*

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* This work is sponsored by the American Clean Skies Foundation

The Business Case for Integrating Clean Energy Resources to Replace Coal

- The electric power generation industry is confronted with the confluence of three powerful, game-changing forces:
 - Environmental regulation increasing the cost of legacy coal-fired generation plants
 - Availability of under-utilized gas-fired generation capacity
 - Mandated expansion of renewable generation, requiring more flexibility in the generation fleet
- These forces create a historic opportunity to replace obsolete coal-fired generation fleet with a portfolio of:
 - Flexible, natural gas-fired generation, mostly existing
 - Variable renewable generation, mostly mandated
 - A range of demand-side energy and peak-capacity resources, mostly less expensive than any new generation source



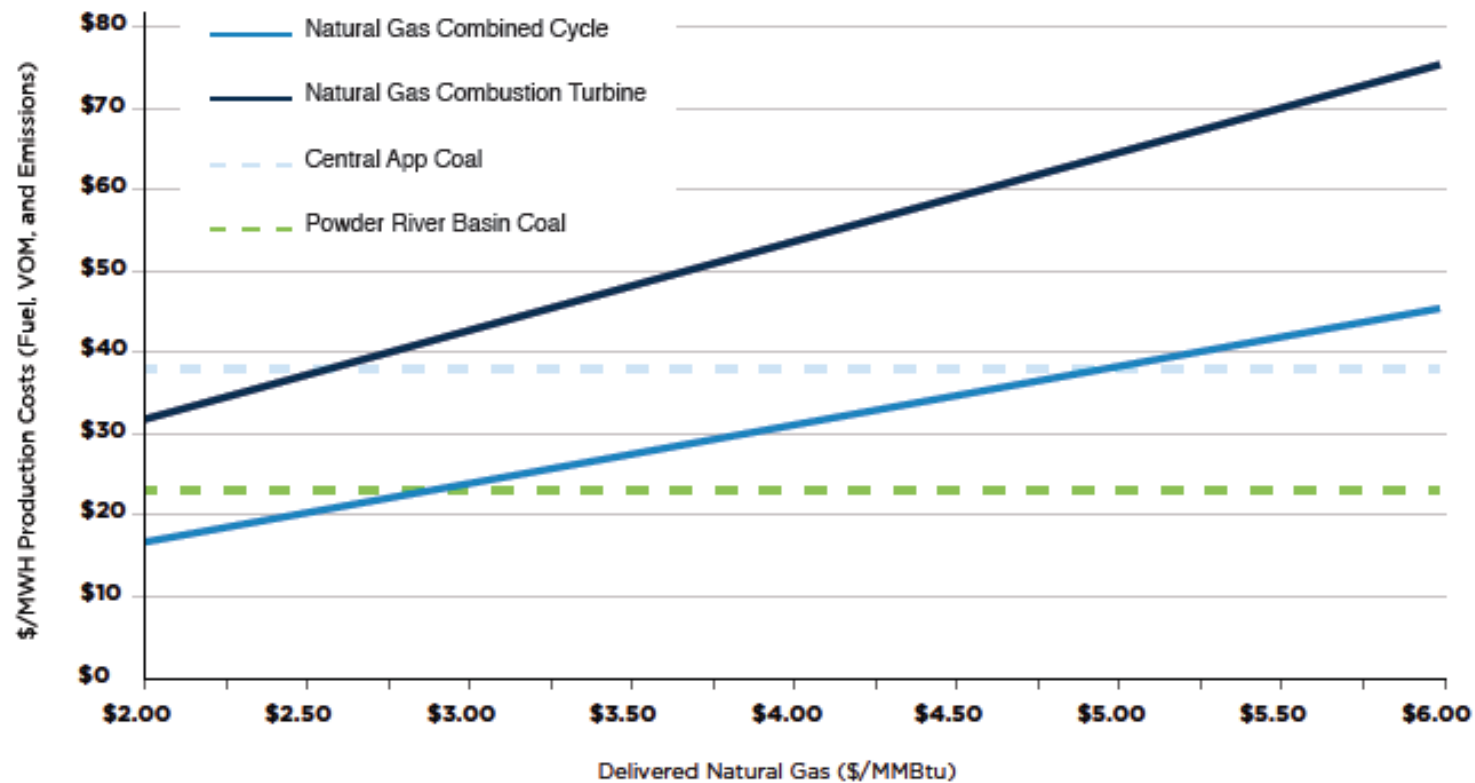
Managing grid reliability with the retirement of coal-fired generation

To be reliable and cost-effective, the evolving gas-plus-renewable generation portfolio must succeed across the following metrics:

- Energy
 - *Existing natural gas-fired CCGT generation can produce more than enough energy to replace the vulnerable coal-fired capacity*
 - *This incremental gas-fired production more than compensates marginal generation displaced by increasing renewables*
- Capacity
 - *In the few regions where reserve margins may be in jeopardy, incentives exist to encourage timely construction of new generation*
- Flexibility
 - *The new generation fleet will need sufficient flexibility to respond to the variations and uncertainties of both load and variable generation*
 - *This flexibility is similar but not identical to existing ancillary services*
- Revenue
 - *Conventional wisdom is that renewable production mostly replaces gas at the margin, but coal retirements should increase gas-fired generation*

At moderate natural gas prices, gas-fired generation will remain competitive, even against existing coal-fired steam plants

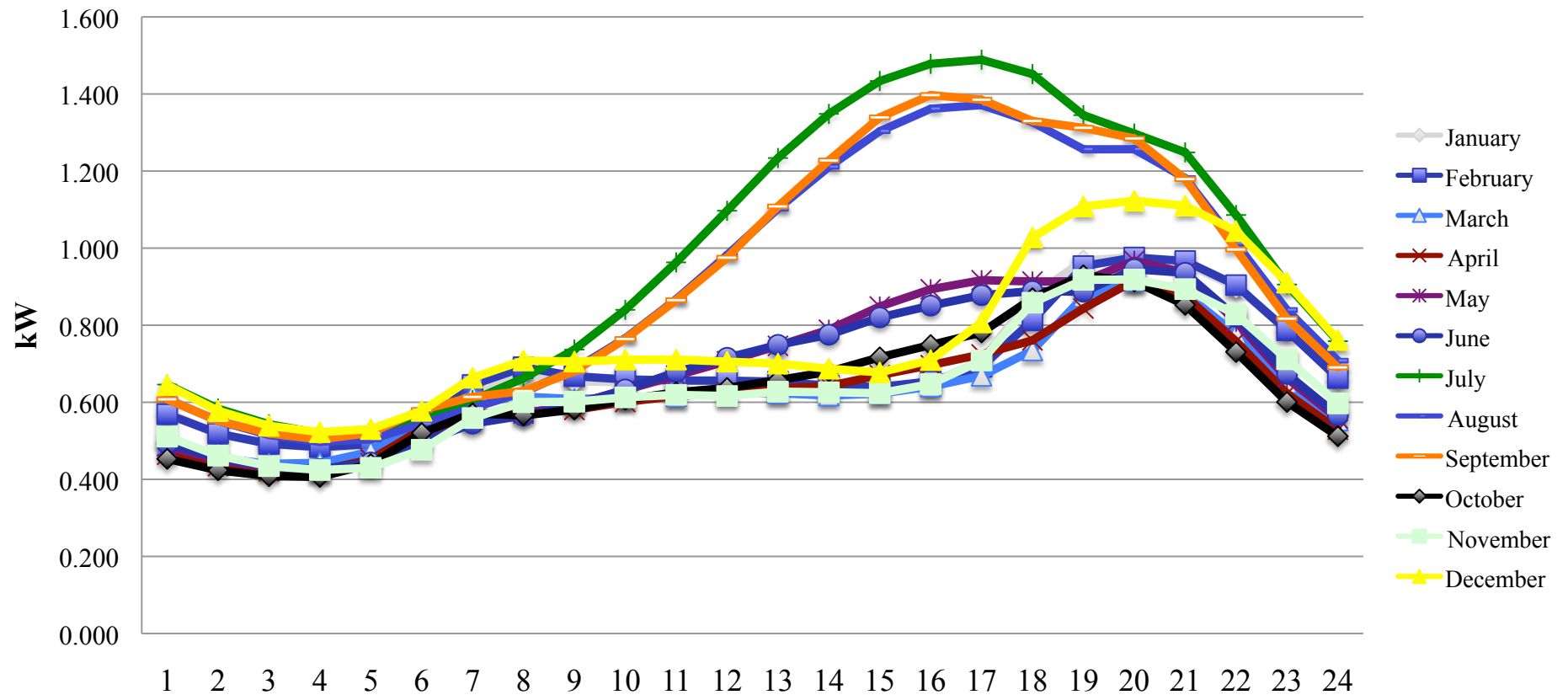
Power plant break-even production costs: natural gas v. coal



Source: Bean & Staple, ACSF, 2012

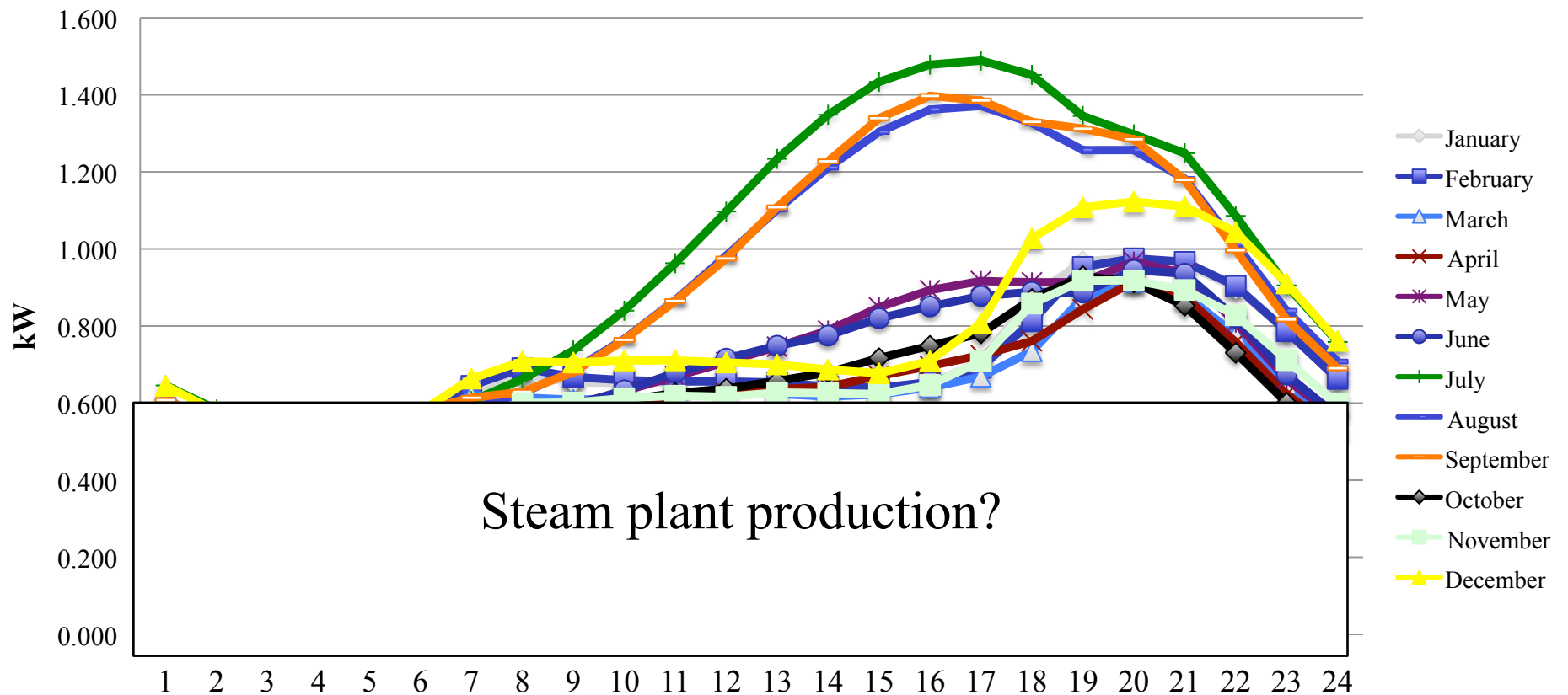
Variations in utility demand over time

SoCal Edison residential load profile (max load 1.5 kW July 5pm)

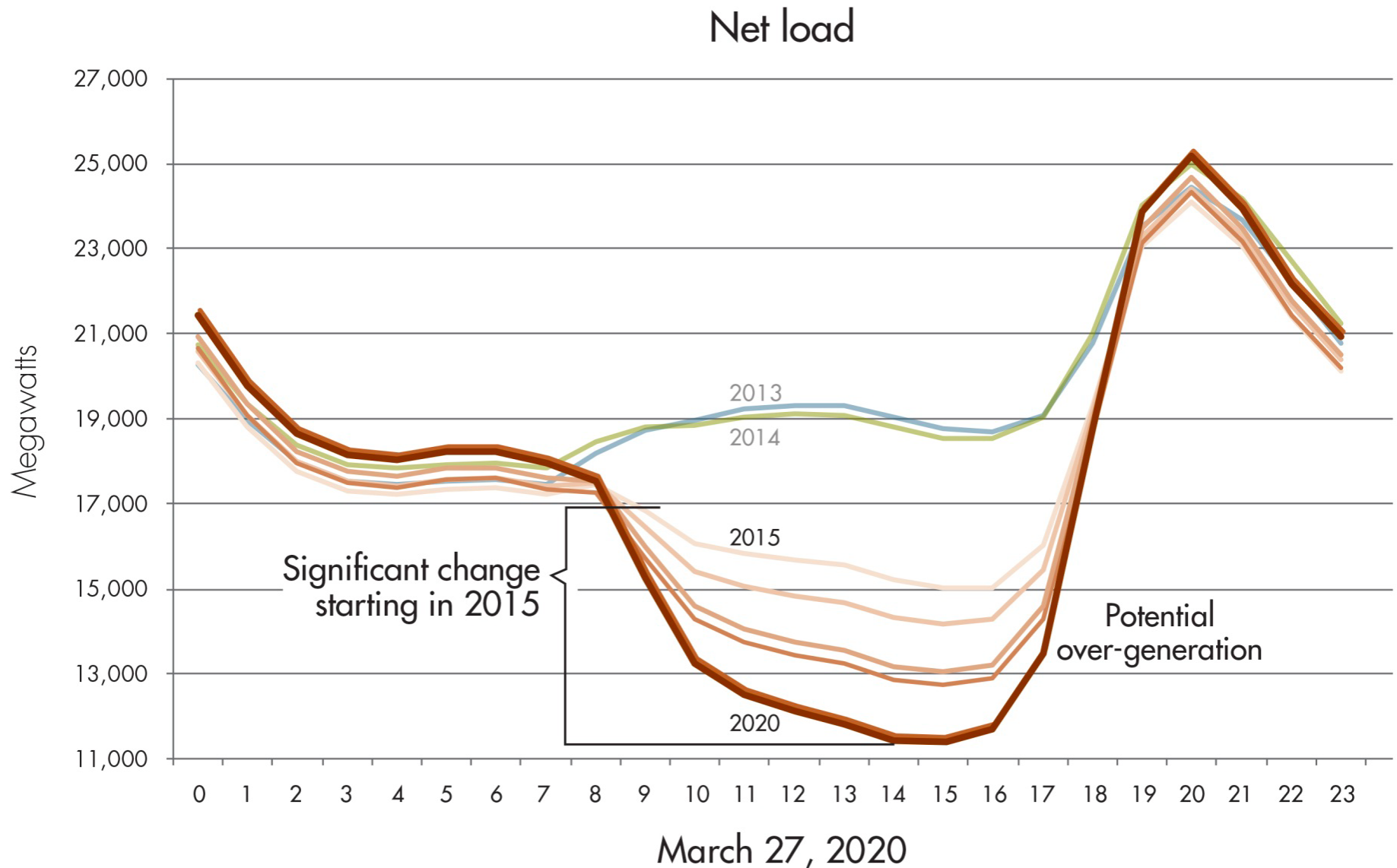


Variations in utility demand over time - load net of steam plant output

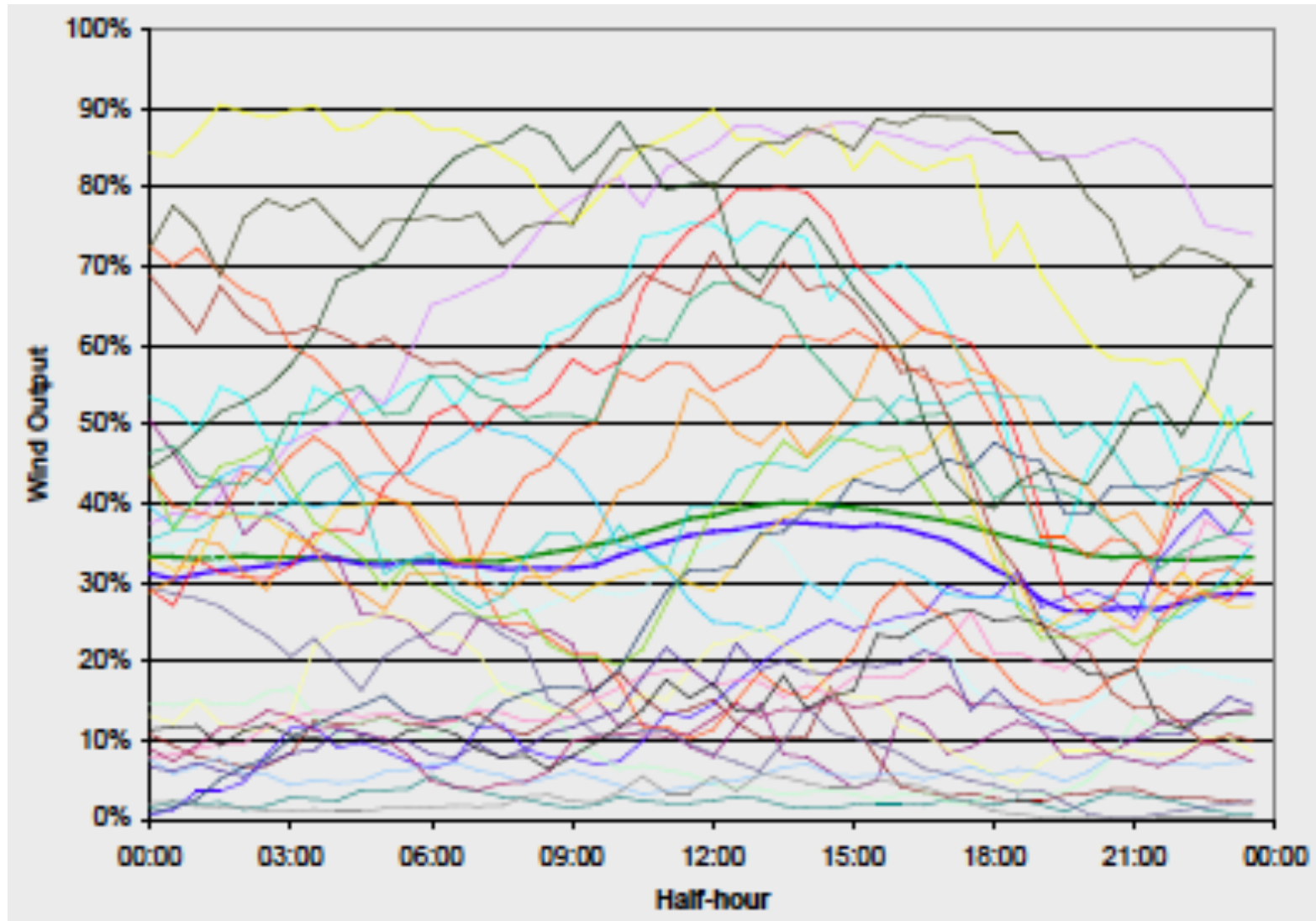
SoCal Edison residential load profile (max load 1.5 kW July 5pm)



California ISO worries about “over-generation” of solar & wind in worst case scenario by 2015!



Windpower output is unpredictable far ahead of time, but more predictable hours ahead
(each line is one day, blue & green are averages)



Options for balancing high renewable production

- System operations
 - Fast (sub-hourly) scheduling
 - Improving forecasts of load and resource variations
 - Enlarged balancing areas with combined dispatch
 - Expanded transmission
- Supply-side
 - Flexible thermal generation (generally natural gas-fired)

Existing

Emerging

- Geographic distribution of renewable sources (& operations above)
 - Concentrating solar power with thermal storage
- Demand-side
 - Demand response / load control
 - Load-side thermal storage (ice cooling)
 - New flexible loads (plug-in vehicles)
- Electricity storage?

⇒ Key options today: system operations & flexible generation

Financial incentives for flexible generation

- The good news: Fast markets and combined balancing areas make it *less* necessary to use expensive regulation to balance variable RE
- The bad news: This means that revenues to generators providing flexibility services will be reduced to levels similar to contingency reserves or lower, which may not justify build/operating capacity
 - Real-time market payments may be enough to cover operating costs for existing, depreciated assets, but not to cover debt service on new resources
 - Even forward capacity market payments are an (uncertain) annual revenue stream, which adds uncertainty and risk to recovery of capital investment
 - While gas-fired CCGT capacity costs far less than coal-fired capacity, flexibility (fast start, ramping) adds cost; *owners need compensating revenue*
- Without sufficient capacity-based payments, there is little incentive to develop flexible resources; existing units could become unviable
- New types of long-term capacity contracts may be needed to cover the fixed costs and provide incentives for flexible generation

In theory, gas and renewables are complementary - in practice...

- The more steam plants that are online, instead of more flexible gas:
 - the harder it is to ramp down when RE increases at low load, which leads to spilling a clean, free resource and unnecessary fuel use, emissions
 - the harder it is to ramp up when RE decreases at high load, which leads to reliability problems and doubts about the "capacity value" of renewables
- Keeping steam capacity (which tends to get dispatched ahead of gas) makes the renewables-integration problem worse by
 - Crowding out more flexible (i.e., gas-fired) capacity from being dispatched
 - Reducing capacity factor (i.e., revenues) of gas plants needed for flexibility
- Thus, coal retirements enable renewables by admitting flexible gas
 - Provides needed capacity for reliability and ramping capability
 - Allow higher capacity factors (revenue) for gas, even as renewables grow

But, are flexible gas-fired plants capable of fast ramping to balance renewables worth building and owning?

- Yes, because they run at high capacity factor with less steam capacity in the dispatch stack, and greater revenues can enable:
 - Long-term natural gas contracting vehicles for utilities to mitigate gas price risk
 - Firm gas supply capacity and better alignment of gas and power generation scheduling
- If they receive explicit payments for capacity, ideally for ramping capacity:
 - “Ramping” capacity product payments can reward gas-fired generators for enhancing fast-ramping capability using state-of-the-art technology (including retrofits)
- Other needed developments in power system planning and operation to facilitate flexible, gas-fired generation, to balance renewables
 - Fast scheduling, improved forecasts, enlarged balancing areas with combined dispatch, expanded transmission
 - Flexible load that allows ramping up/down when needed to balance time variations (not just simple demand response)