Coal/gas plant cycling: Costs, causes, impacts

Dr. Debra Lew, GE Energy Consulting

Harvard Electricity Policy Group

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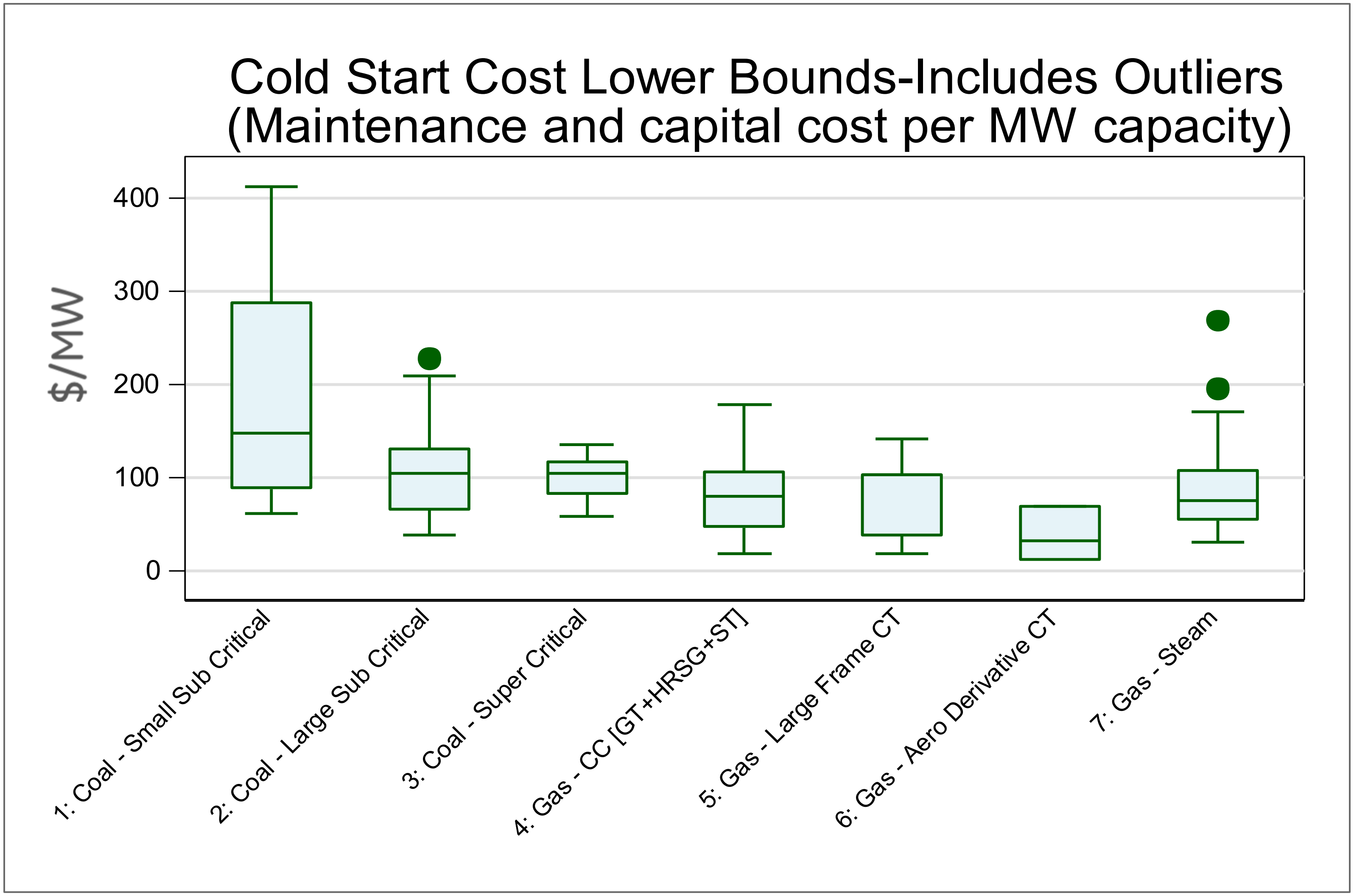
Imagination at work

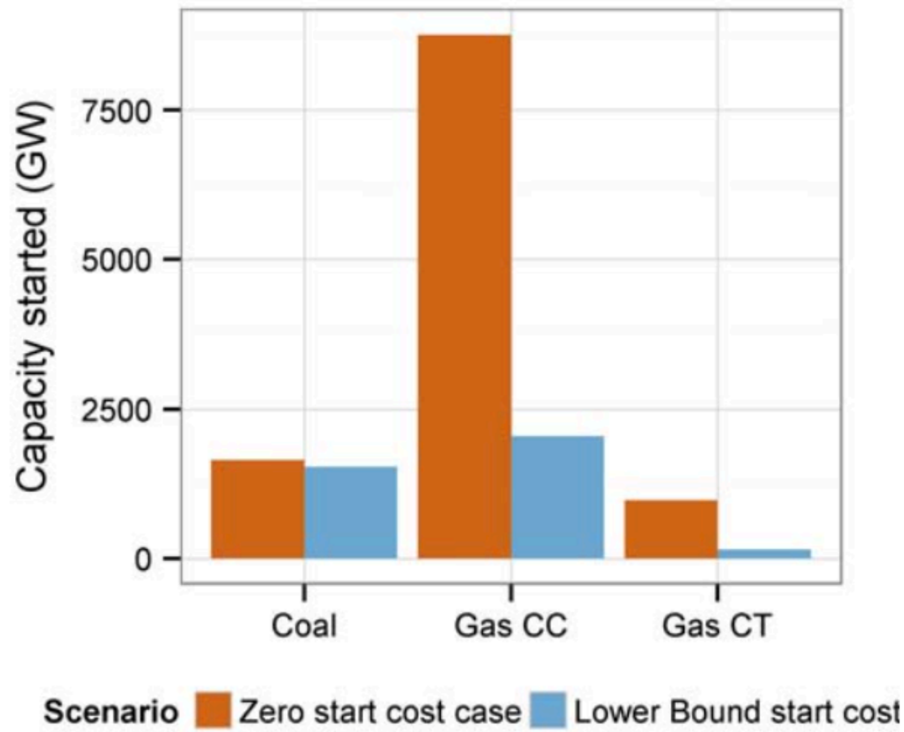
Wear-and-Tear Cycling Costs

Quantifying cycling costs is not easy



Kumar et al 2012, www.nrel.gov/docs/fy12osti/55433.pdf

Ignoring wear-and-tear costs impacts commitment and dispatch



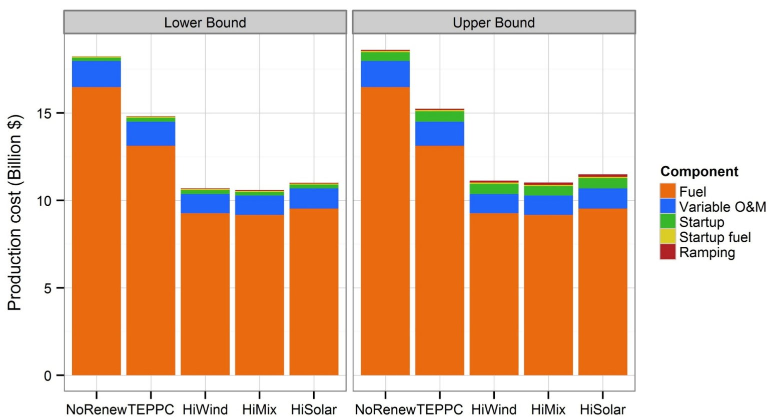
Note: start-up fuel costs are included in optimization in both scenarios

Security-constrained unit commitment and economic dispatch should include wear-and-tear cycling costs

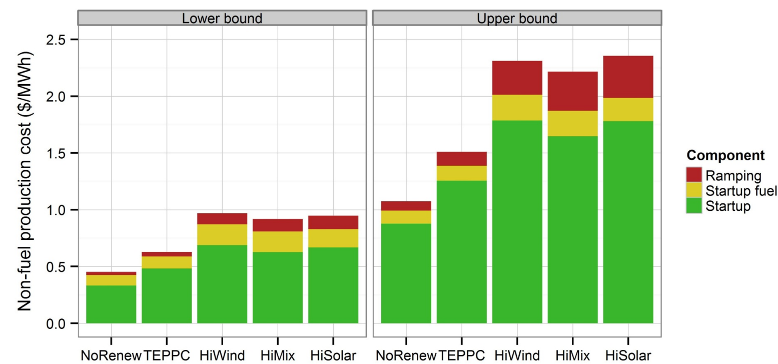
Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

Cycling costs – in perspective

Cycling costs are 1-7% of overall production cost



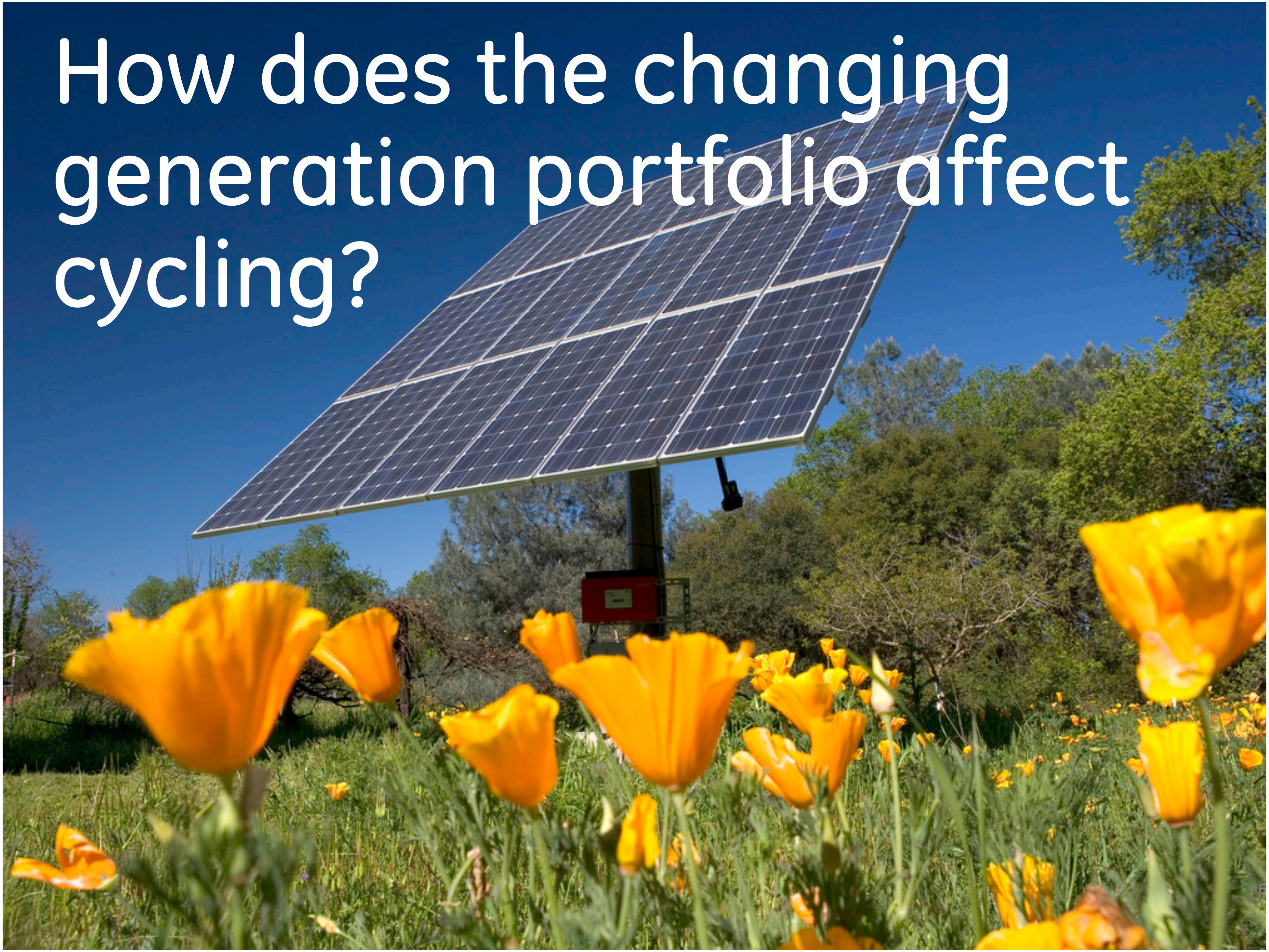
The average fossil-fueled plant sees an increase in O&M of $0.47-1.28 per MWH generation

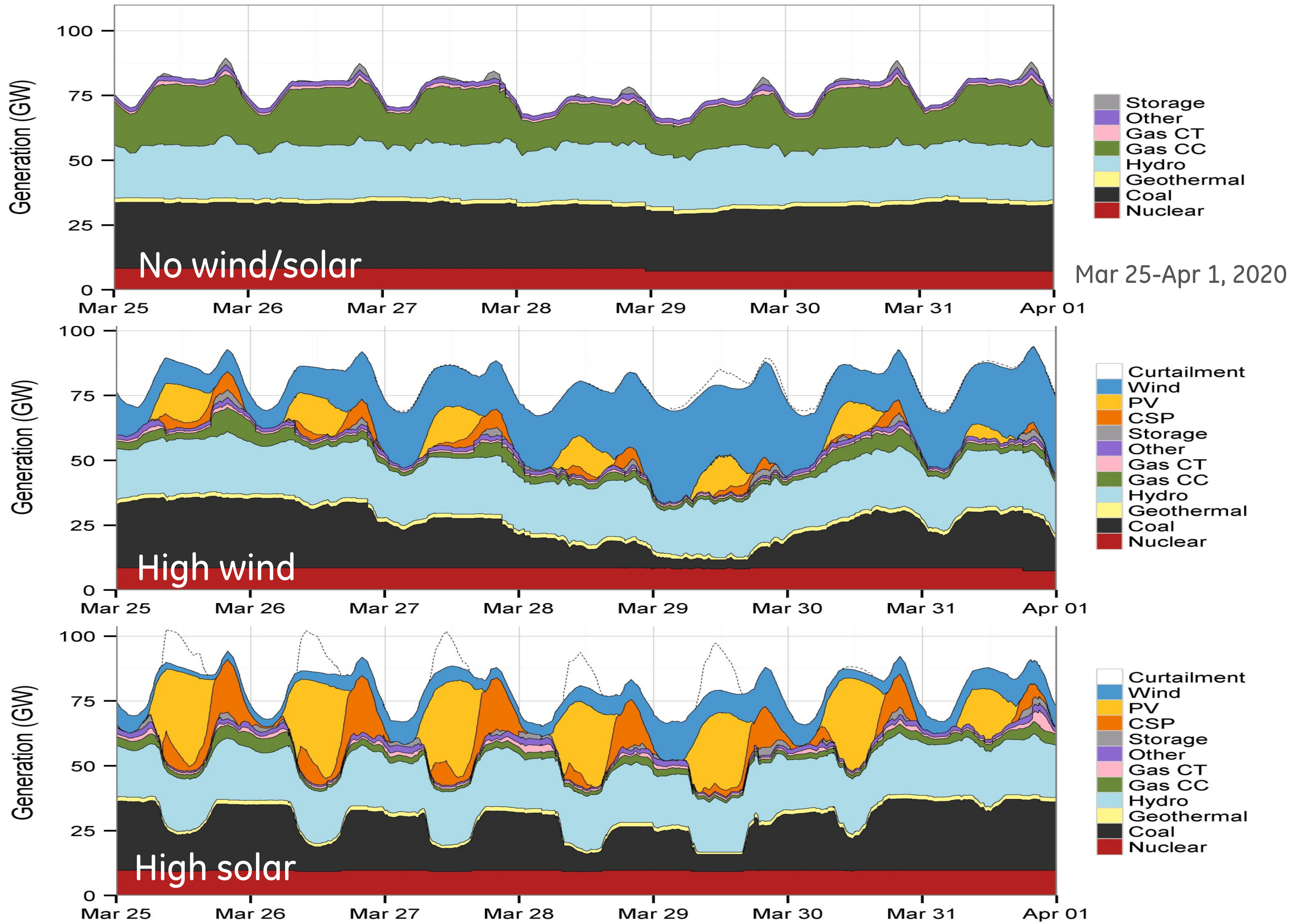


Cycling costs may impact financial viability of generators

Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

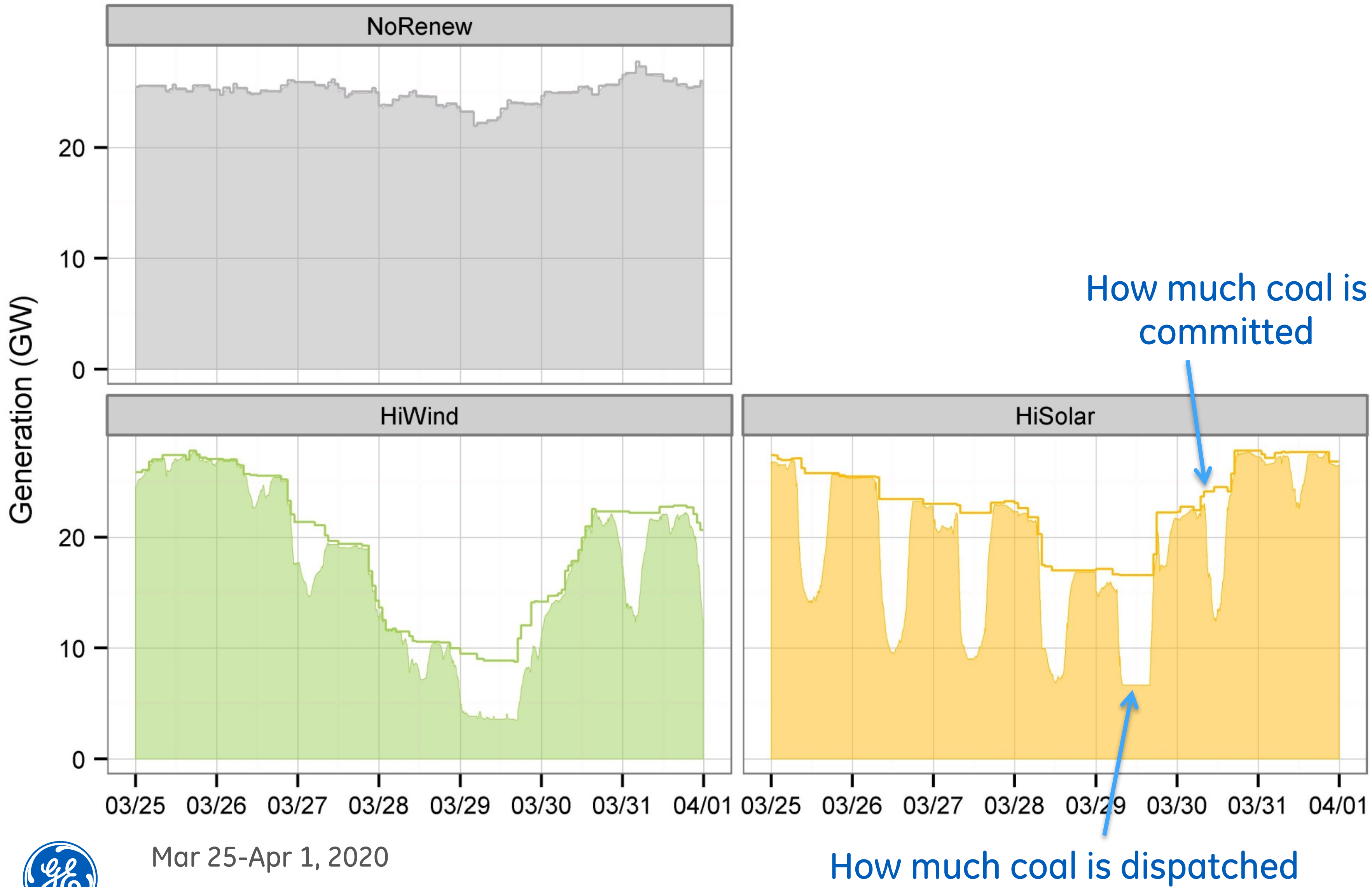
How does the changing generation portfolio affect cycling?





Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

Wind and solar have different impacts on cycling



Mar 25-Apr 1, 2020

Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

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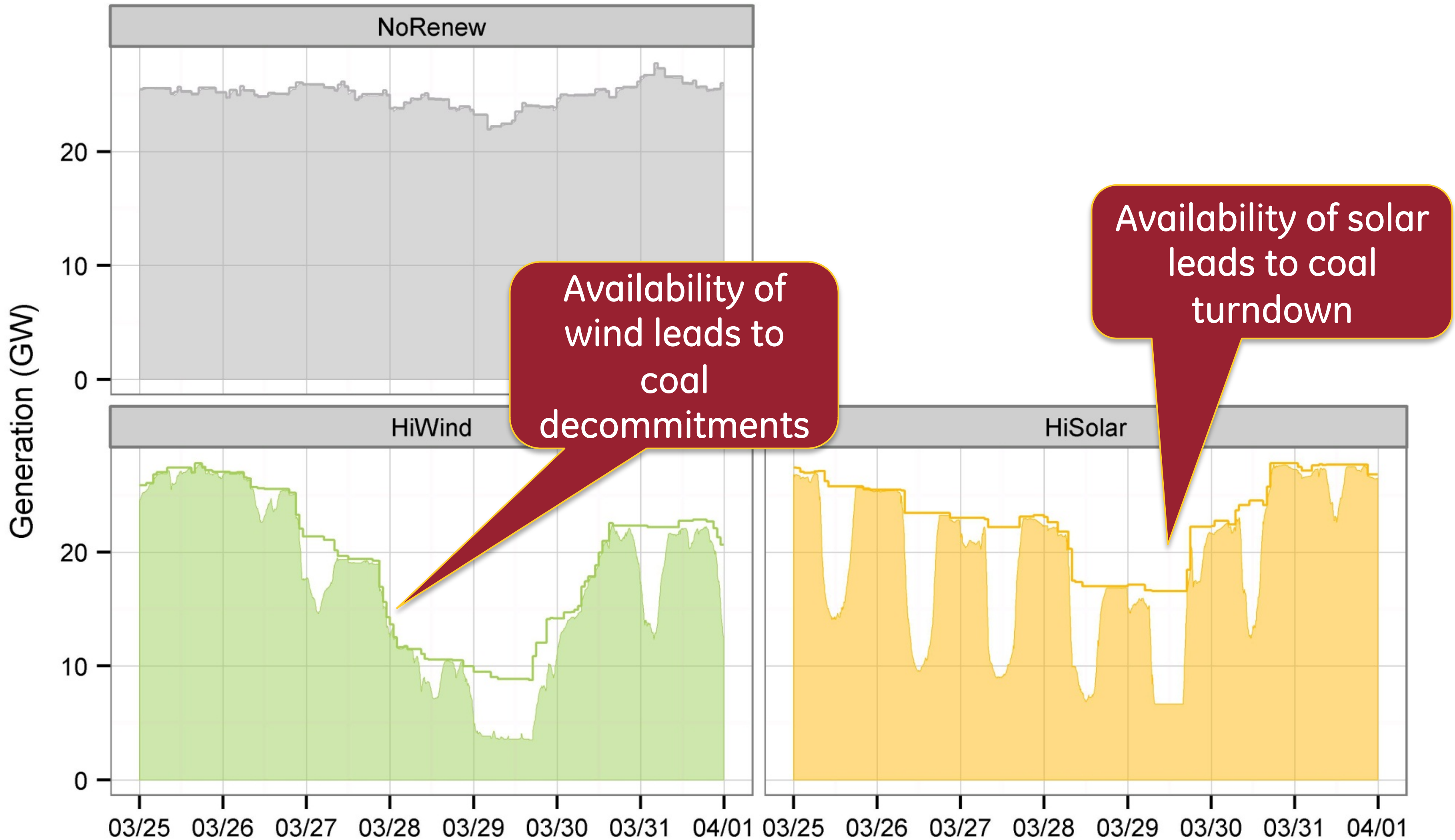

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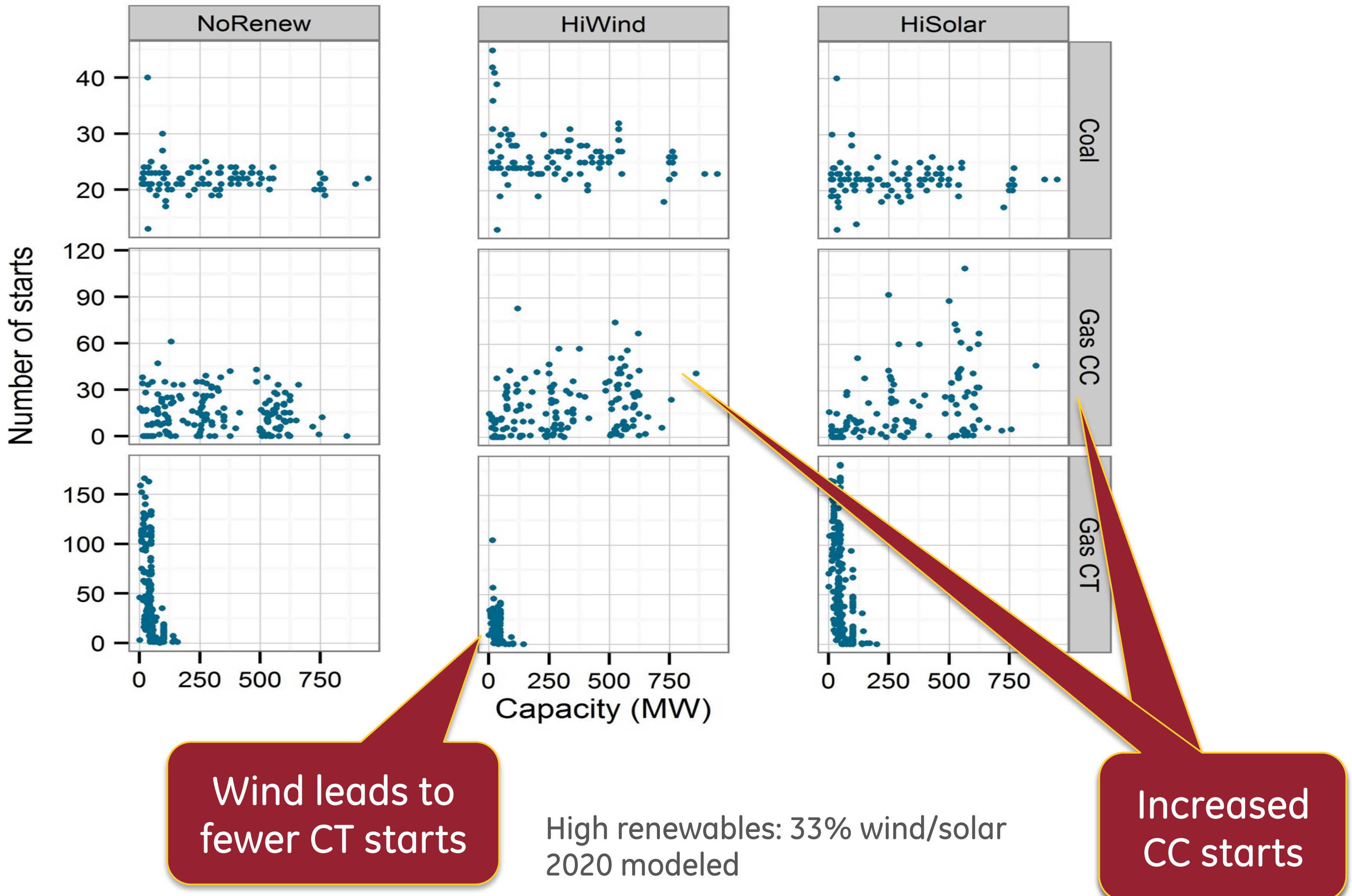
Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

Which units are being started more often?

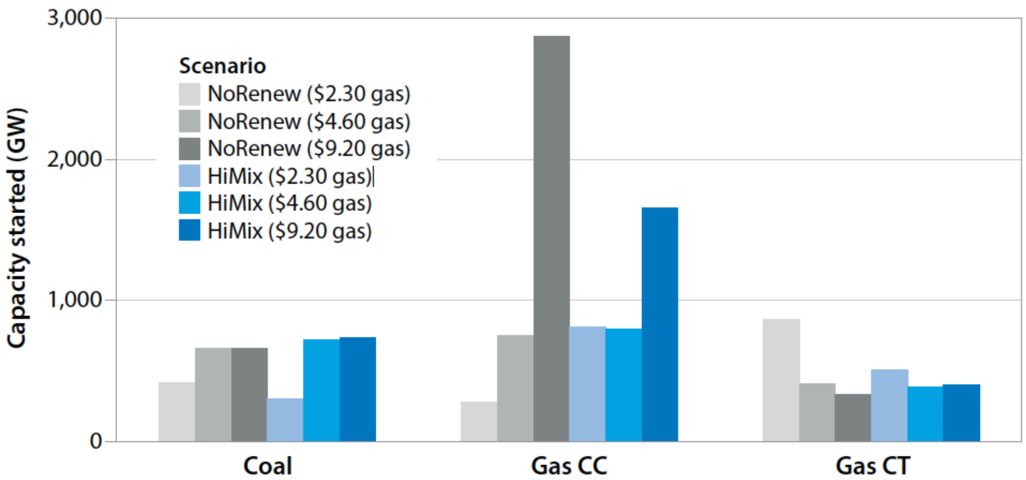


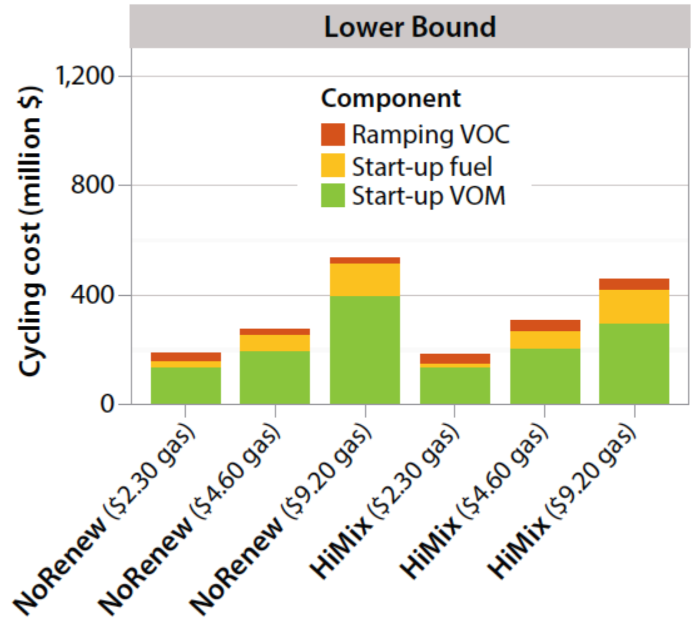
High renewables: 33% wind/solar
2020 modeled

Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf


It's not just renewables

Natural gas prices can significantly impact cycling





Wind/solar can ***reduce*** total cycling costs
for high/low gas price scenarios

Lew et al, 2013, http://www.nrel.gov/docs/fy13osti/55588.pdf

From baseload to *super peaker*

Low marginal cost energy sources can drive change

Designed as baseload coal plant

Over decades, evolved into intermediate and then superpeaker

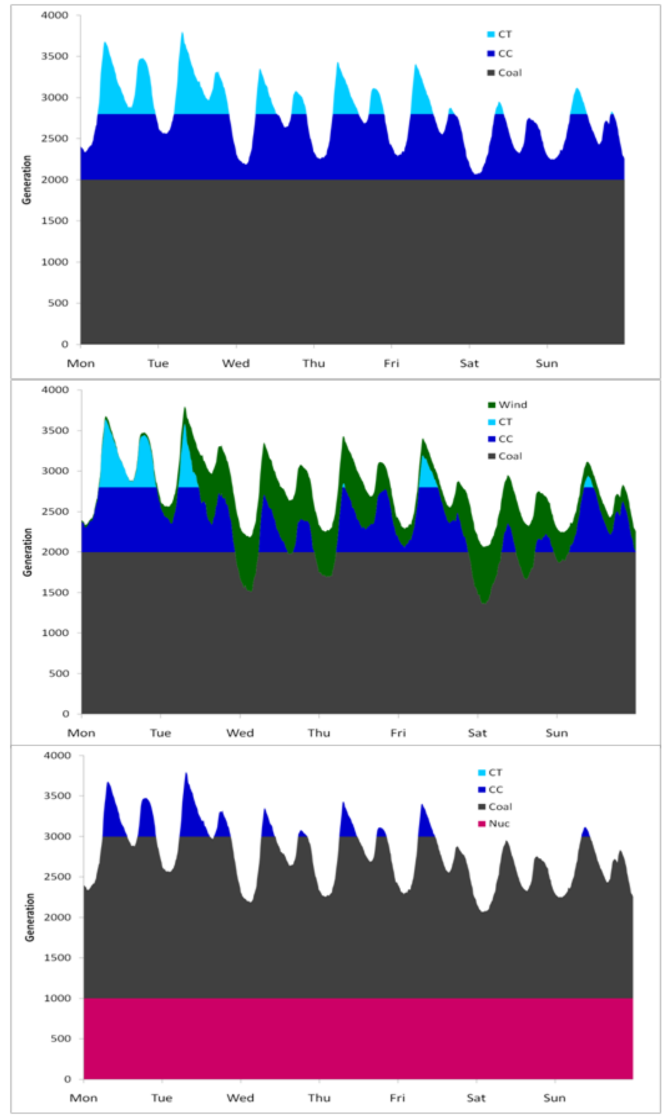
2-shifting, even 4-shifting (5-10am then 4-8pm)

500 MW gross units: 480 MW net running at 90 MW net, even down to 60 MW net with gas support

Automatic Generation Control (AGC)

Sliding pressure (increases efficiency and flexibility at part load)

Suffered high Equivalent Forced Outage Rates (EFOR)



Graphic: Milligan, et al, 2011, http://www.nrel.gov/docs/fy11osti/51860.pdf

Enabling Cycling

Operating procedural changes

Layup procedures

Natural cooling

Temperature monitoring of economizer inlet headers, boilers, etc

Pressure management

Inspection and repairs for thermal/ cycle fatigue, DMW, corrosion, boiler tubes

Water chemistry maintenance

Breaker maintenance

Physical changes

Boiler

- Modified buckstays
- Replace DMW
- Strategic replacement of tubes

Pulverizers – from water deluge system to steam inert

Turbines – added drains

Rotors – insulated key parts

Condenser – plugged tubes at top of condenser

Significant plant savings came from operating procedure changes

Cochran et al 2013, http://www.nrel.gov/docs/fy14osti/60575.pdf

Does it make sense to retrofit my plant?

Coal/gas retrofit study – costs and benefits

- Examined retrofits for coal and gas plants in a high renewables scenario for the Rocky Mountain region
- Retrofits to improve turndown had system-level net benefits
- Benefits were individualized for each plant

Retrofit Options	Cost to Install in Millions			Expected Benefit:		
	Small Sub Critical Coal 200MW	Large Subcritical Coal 500MW	Supercritical Coal 750MW	Ramp Rate	Turndown	Startup/ Shutdown
Improved and automated boiler drains	$ 3.00	$ 5.00	$ 5.00		50%	50%
Steam flow redistribution and metallurgy improvements in in SH/RH	$ 2.50	$ 5.00	$ 7.00	33%	33%	33%
Steam coil air heater to pre warm boiler and airheater	$ 0.50	$ 1.00	$ 2.00	33%	33%	33%
Gas bypass to keep air heater warm	$ 0.70	$ 1.50	$ 3.00		50%	50%
Improved APH basket life when cycling in or through the wet flue gas temperature region by installing traveling APH blowers to remove deposits prior to cycling down in load	$ 0.75	$ 1.00	$ 1.00		50%	50%
Improved APH basket life with improved materials when cycling in or through the wet flue gas temperature region	$ 1.20	$ 2.00	$ 2.00		50%	50%
Improved selected expansion joints. This is not a complete replacement of all expansion joints.	$ 1.50	$ 2.00	$ 3.00			100%
Add steam cooled enclosure min flow protection for balanced flow with blow down or dump to LP turbine	$ 0.30	$ 0.50	$ -		50%	50%

Venkataraman et al 2013, http://www.nrel.gov/docs/fy14osti/60862.pdf

Conclusions

- Wear-and-tear cycling costs can increase with the changing power portfolio or fuel prices.
- These costs are generator-specific. They can impact financial viability of generators.
- Incorporating cycling costs into commitment and dispatch decisions can change these decisions.
- Solar and wind have different impacts on cycling.
- Operational and/or physical changes to coal/gas plants can increase flexibility. Retrofits have the potential to increase overall profitability.

References

Western Wind and Solar Integration Study Phase 2: http://www.nrel.gov/docs/fy13osti/55588.pdf

Cycling costs: www.nrel.gov/docs/fy12osti/55433.pdf

Cost/Benefit Analysis of Retrofits: http://www.nrel.gov/docs/fy14osti/60862.pdf

Coal cycling case study: http://www.nrel.gov/docs/fy14osti/60575.pdf

Contact Debbie at
debra.lew@ge.com
303-819-3470