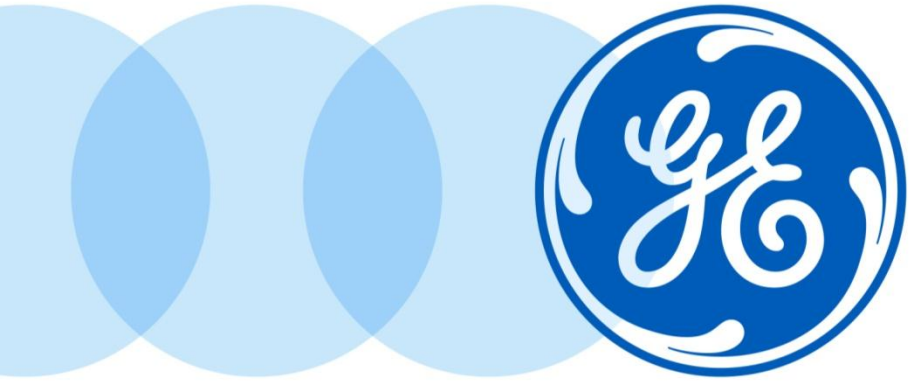


Distributed Generation and DER Management: Technical Perspective

Jovan Bebic, GE Energy Consulting

ARPA-E Workshop, Washington DC
July 31, 2014

Imagination at work

Overview

The question:

Quantify the benefits of more flexible DER management (Load, DG, ES) Concentrate on improvements to efficiency and emissions

The approach:

Study impacts at large scale, e.g. PJM (~20% of US load)

Define modeling proxies for DER technology features and quantify their value using production simulations (GE MAPS)

Acknowledgment

Thank you to the GE Energy Consulting team:

Gene Hinkle

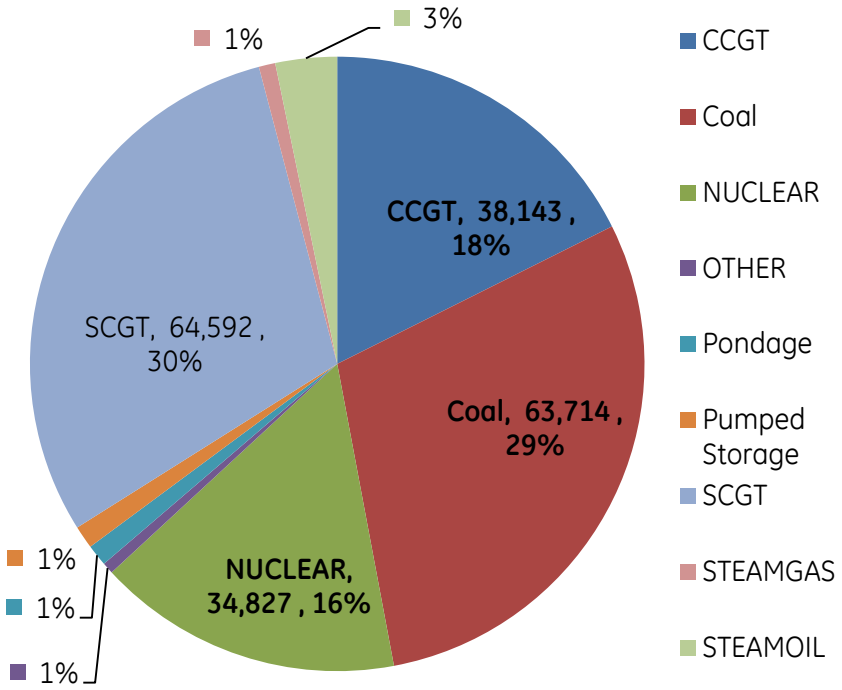
Bahman Daryanian

Derek Stenclik

Bob Woodfield

Initial Condition – PJM Non-Renewable Fleet

Markets favor low cost



Tech	Cap Cost $/kW	Var Cost $/MWh	Eff %
Nuclear	5,530	12.21	32.2
Coal	2,934	44.15	34.7
CCGT	1,023	56.22	46.8
SCGT	676	95.78	30.5

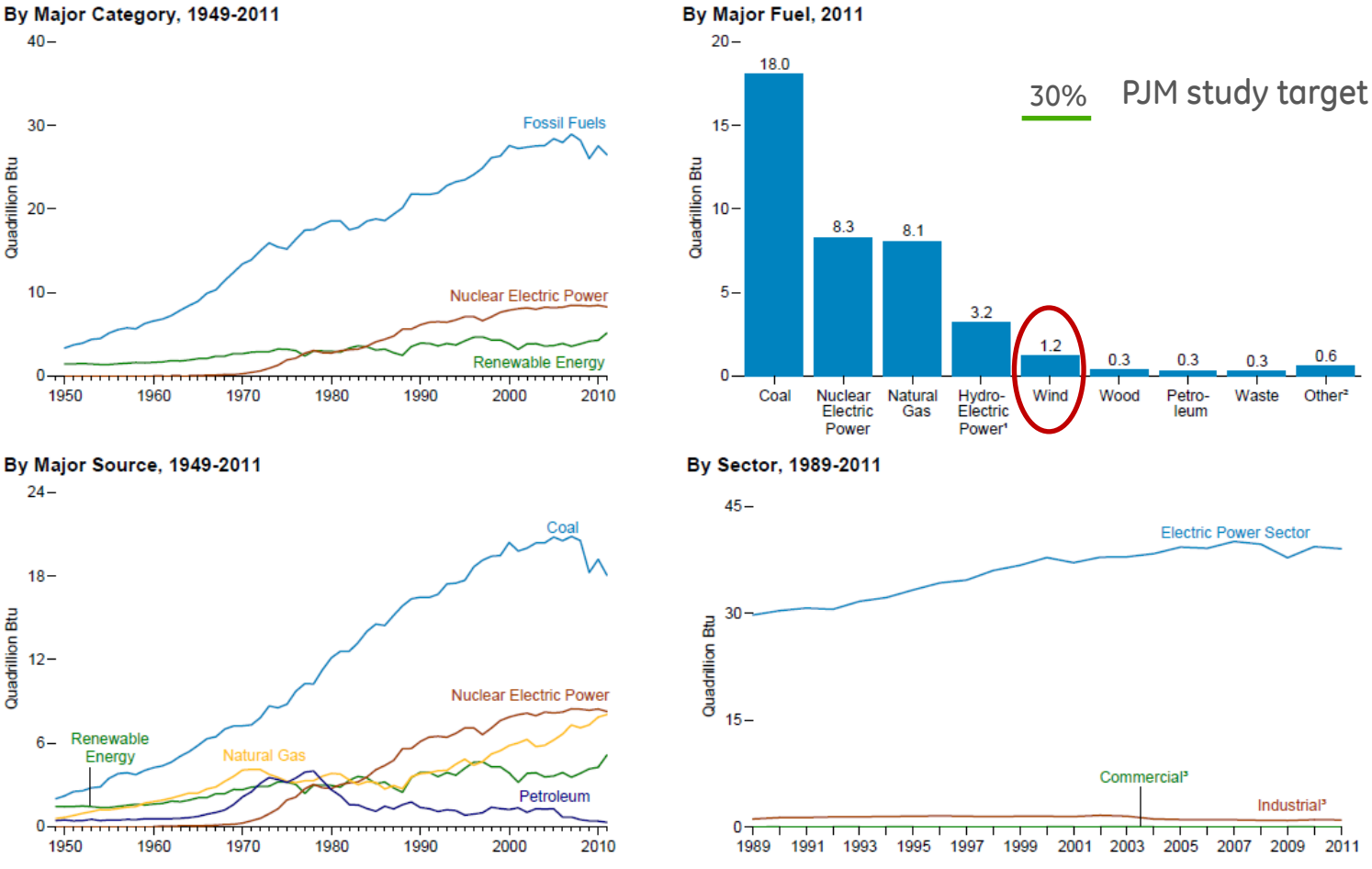
Tech	CO2 t/GWh	SOX t/GWh	NOX t/GWh
Nuclear	--	--	--
Coal	1007.3	1.014	0.869
CCGT	433.5	0.071	0.003
SCGT	666.1	0.339	0.040

183GW Gen Capacity, 165GW Peak Load, 794GWh Annual Energy, 61M People
Source: PJM 2013 Annual Report

Primary fuels consumption for generation

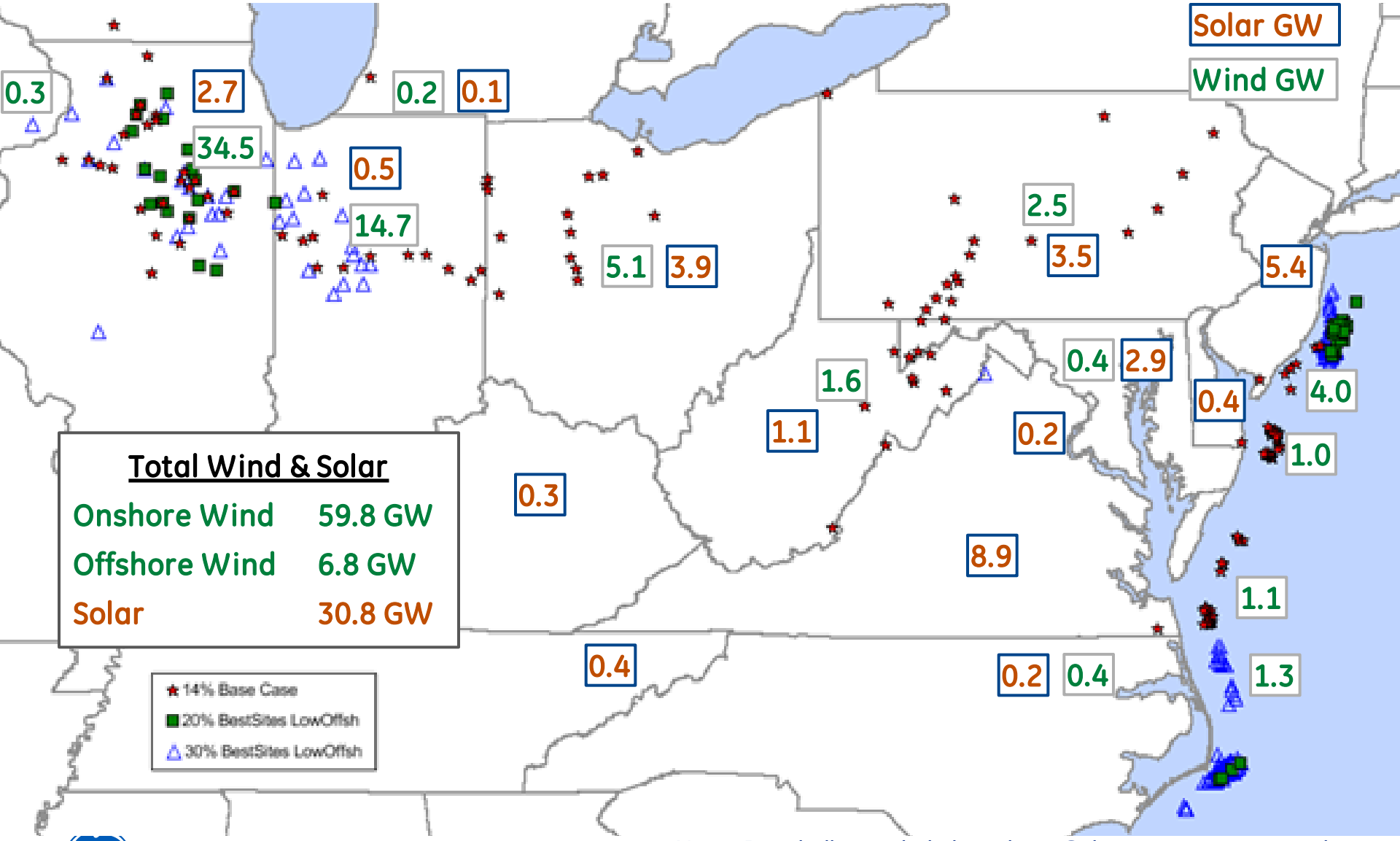
Increase in renewable production can lower energy output of thermal fleet

Figure 8.4 Consumption for Electricity Generation



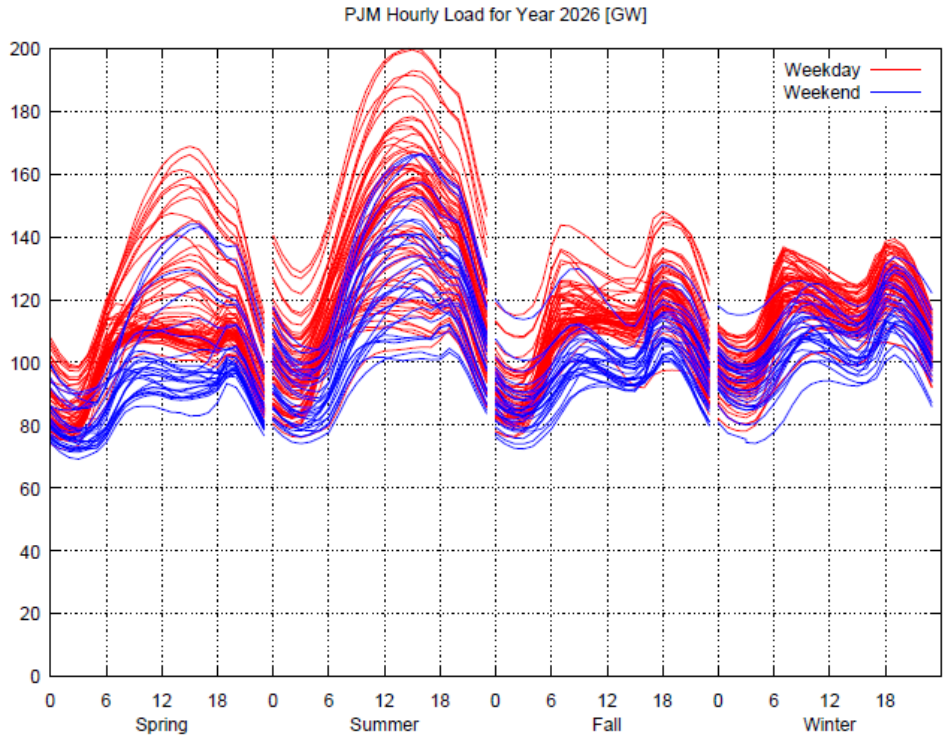
¹ Conventional hydroelectric power.
² Geothermal, other gases, electricity net imports, solar thermal and photovoltaic energy, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, miscellaneous technologies, and non-renewable waste (municipal solid waste from non-biogenic sources, and tire-derived fuels).
³ Combined-heat-and-power plants and a small number of electricity-only plants.
Sources: Tables 8.4a-8.4c.

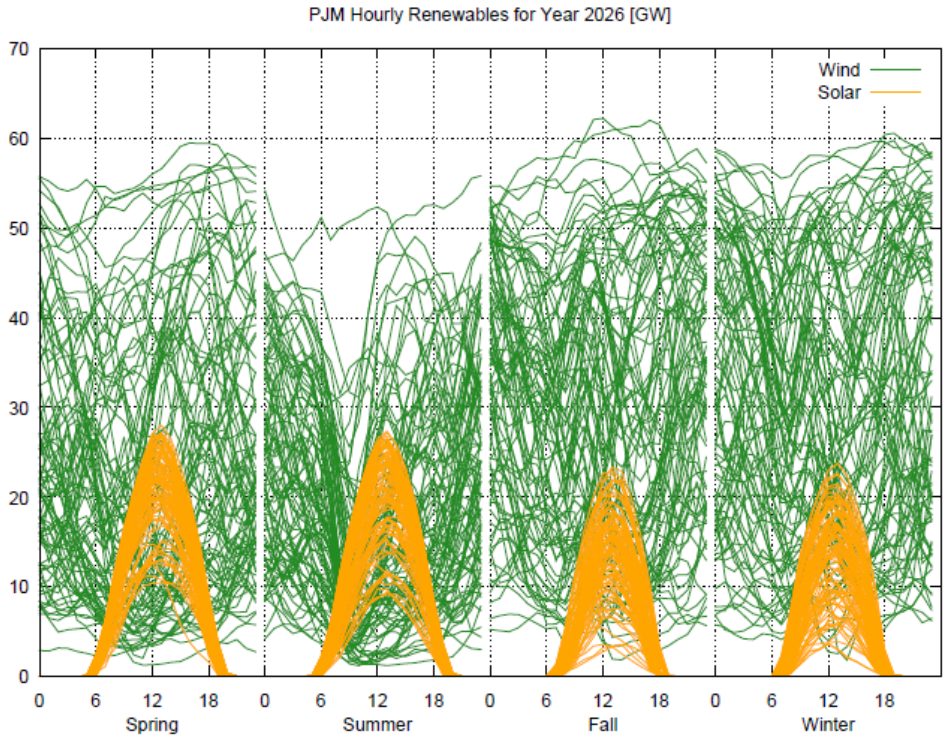
The 2026 Base Case (30% renewables)



Note: Dots indicate wind plant sites; Solar resources are not shown.

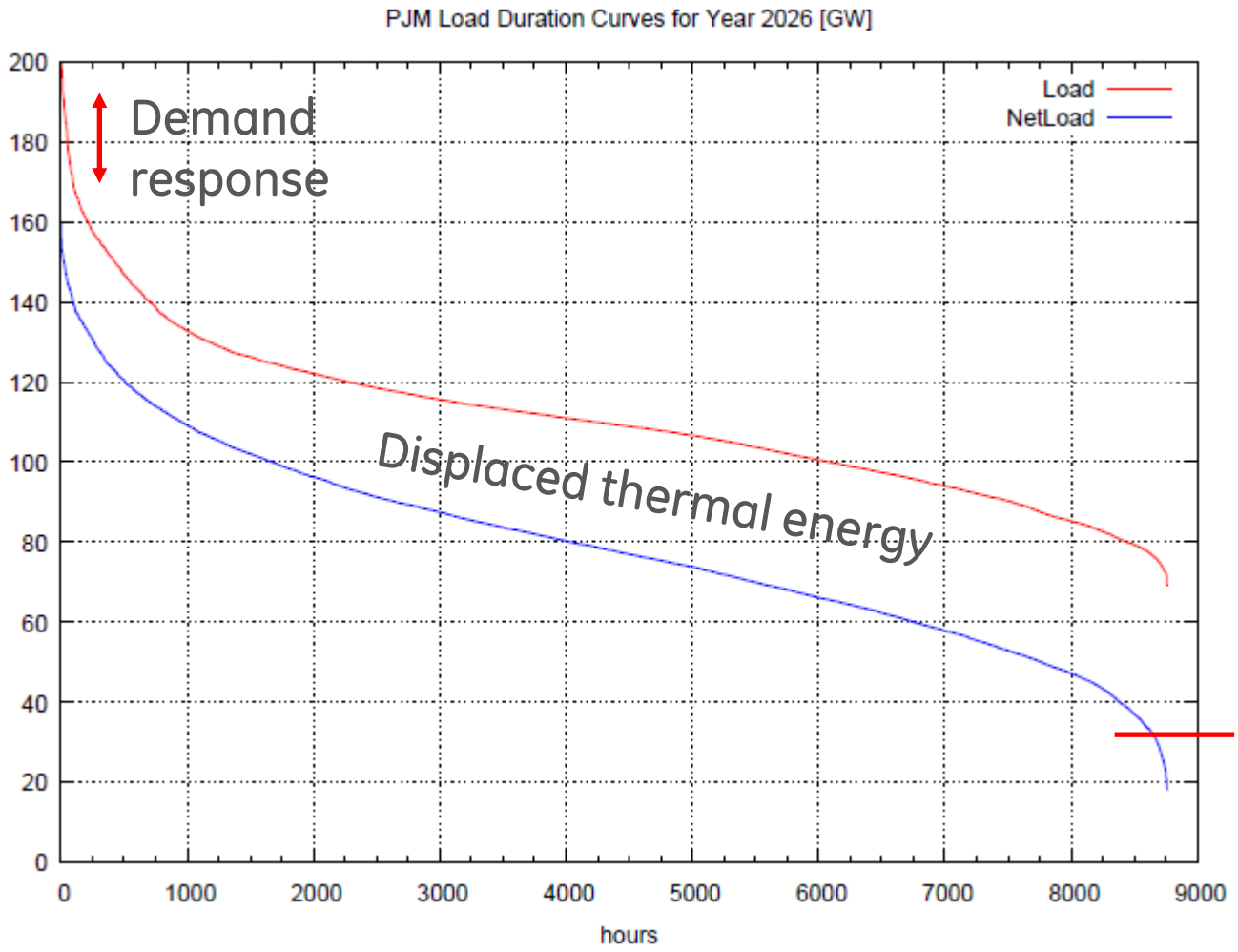
Supply/Demand Balance



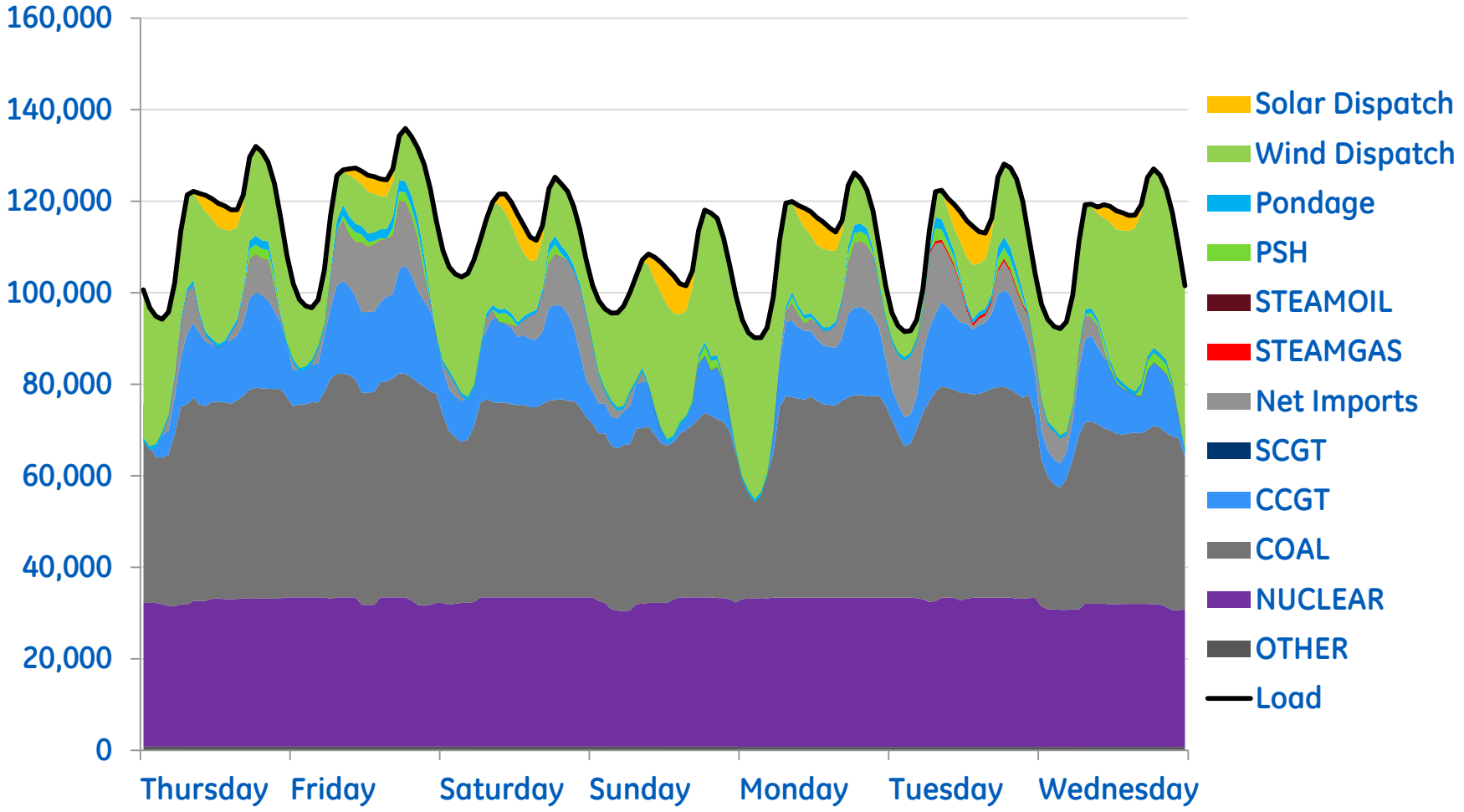


Wind forecasting will be a key challenge beyond 30% penetration

Change in net load and its impact



The Impact to the Power System



A more controllable DER…
… How does it impact system operation?

The load can act dynamically:

a. operating reserves can be reduced => operating costs lower

b. transmission constraints can be relaxed => energy supplied by thermal plants with lower var. costs => system-wide price drop

c. can compensate for renewable forecast errors => reduced operating reserves (same as a.)

The load can be scheduled:

d. the peaks are lower => SCGTs (peakers) run less

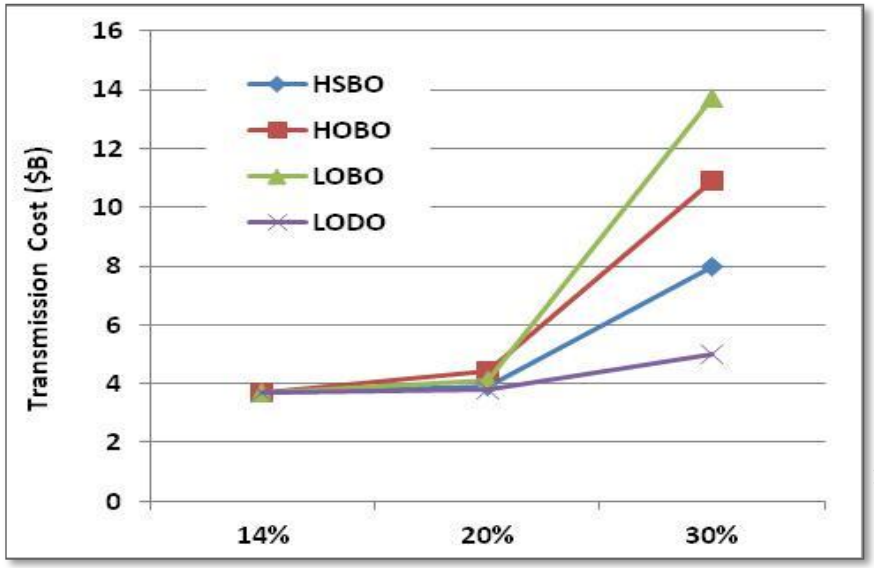
e. the daily profiles are flatter => alters dispatch of CCGTs & Coal

Distribution circuit impacts:

integration convenience, but insignificant economics…

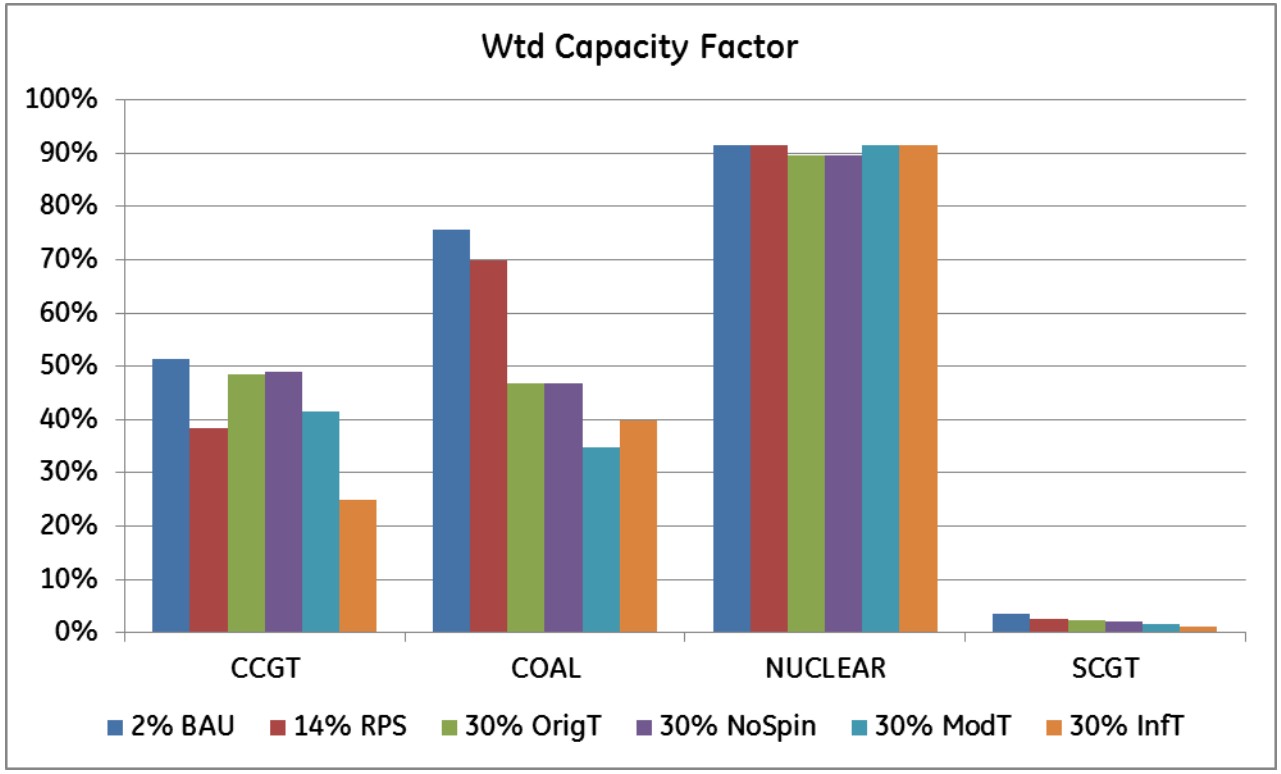
Studied sensitivities

Code	Description
2%BAU	2% Renewable energy, business as usual
14%RPS	14% Renewable portfolio standard
30%OrigT	30% Renewable: Low Off-shore, Best On-shore; 2017 transmission
30%NoSpin	30%OrigT + no operating reserves (~4.5GW reduction)
30%ModT	30% Renewable; transmission reduced to ensure <$5 LMP diffs
30%InfT	30% Renewable; infinite transmission



The results

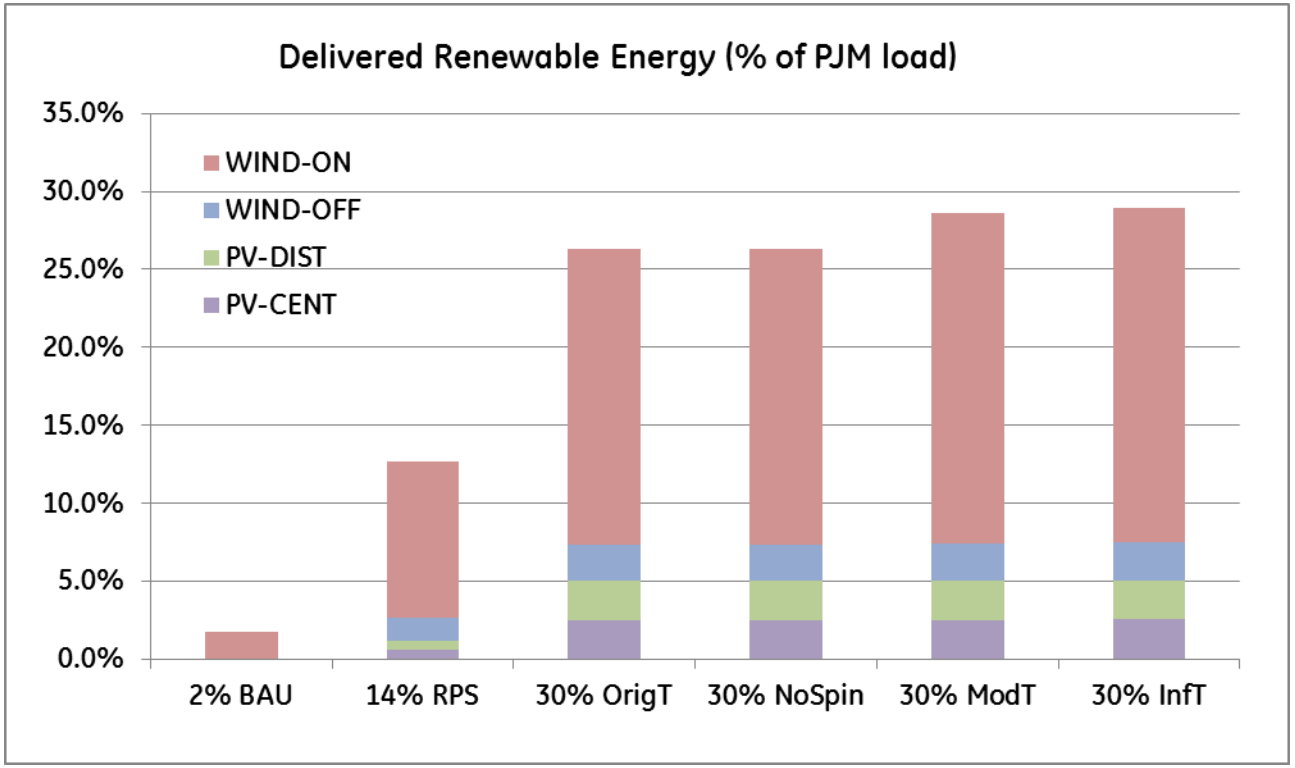
Weighted capacity factors



Coal falls-off nonlinearly with renewables increase from 14 to 30%, CCGTs go up.

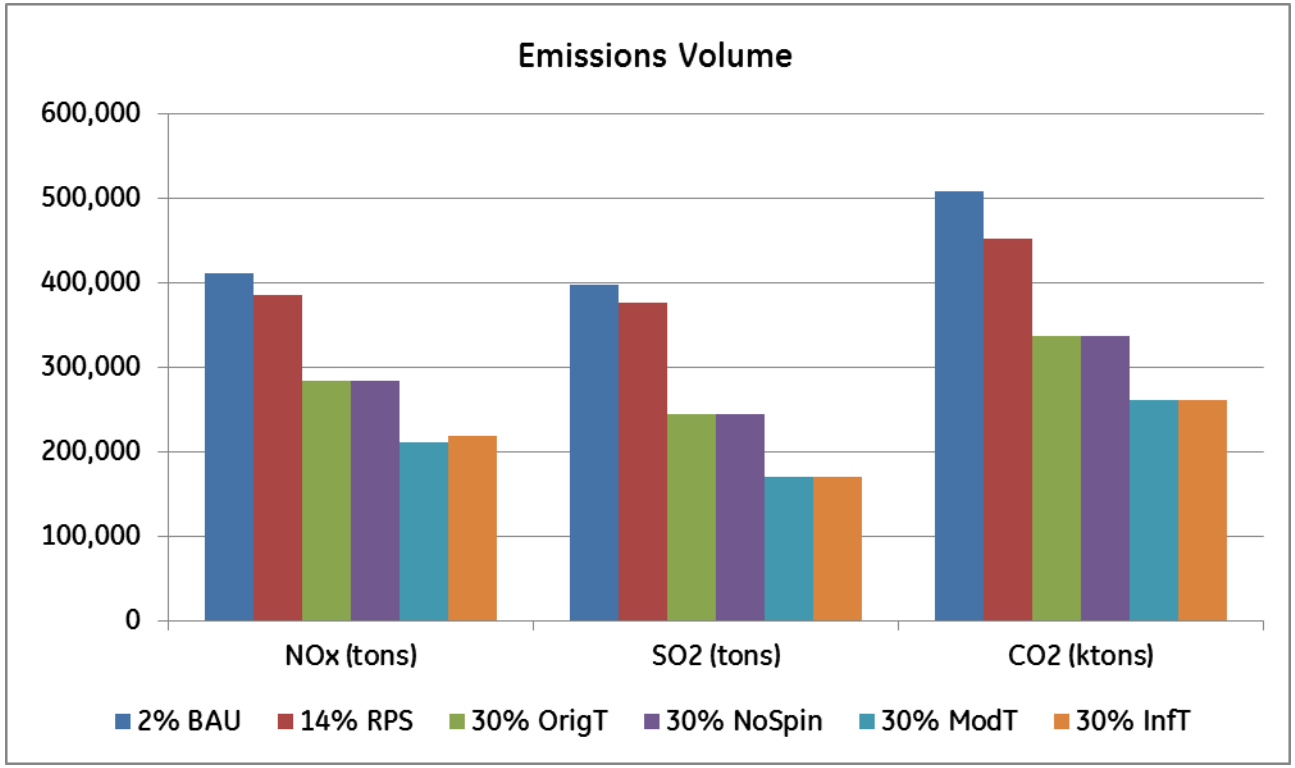
Peakers in trouble – 0.6% capacity factor (down from 2% in BAU)

Delivered renewable energy



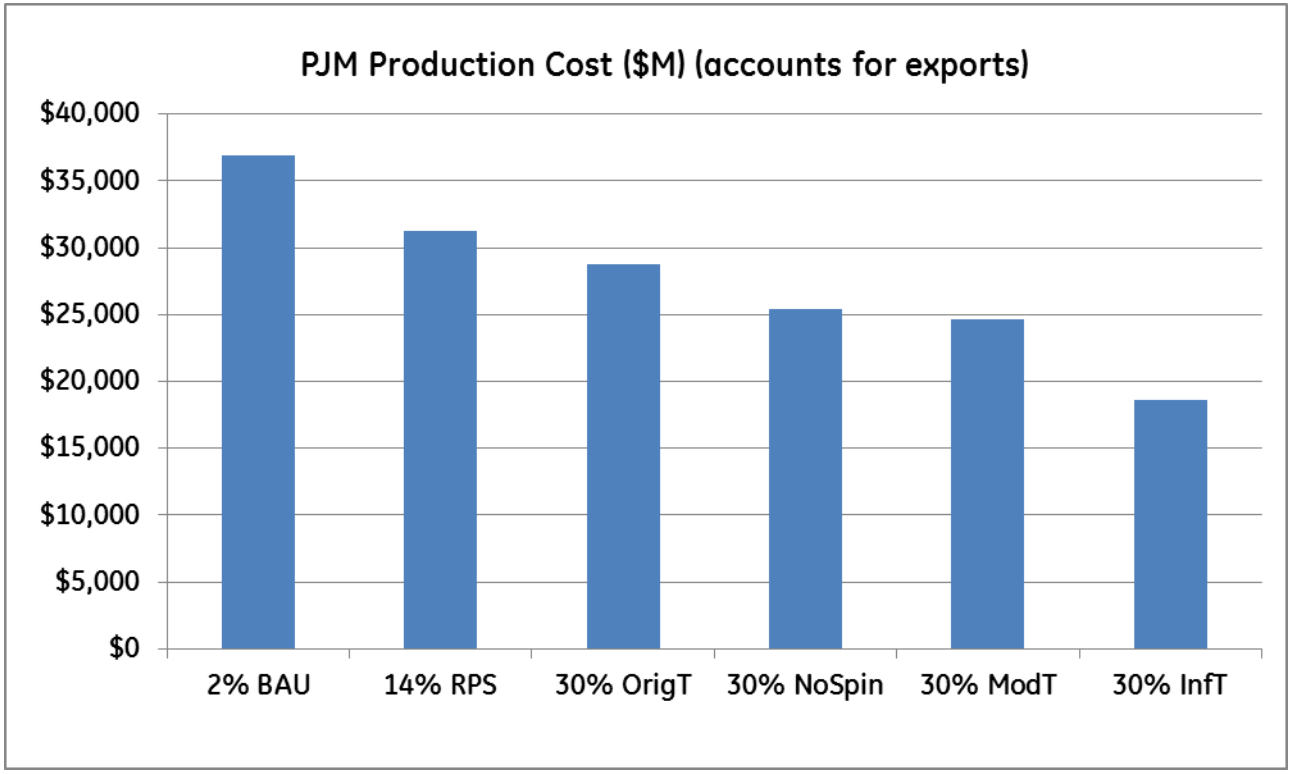
Transmission constraints have the dominant impact on renewable curtailments

PJM emissions



PJM emissions dropping – renewable energy substitutes thermal energy

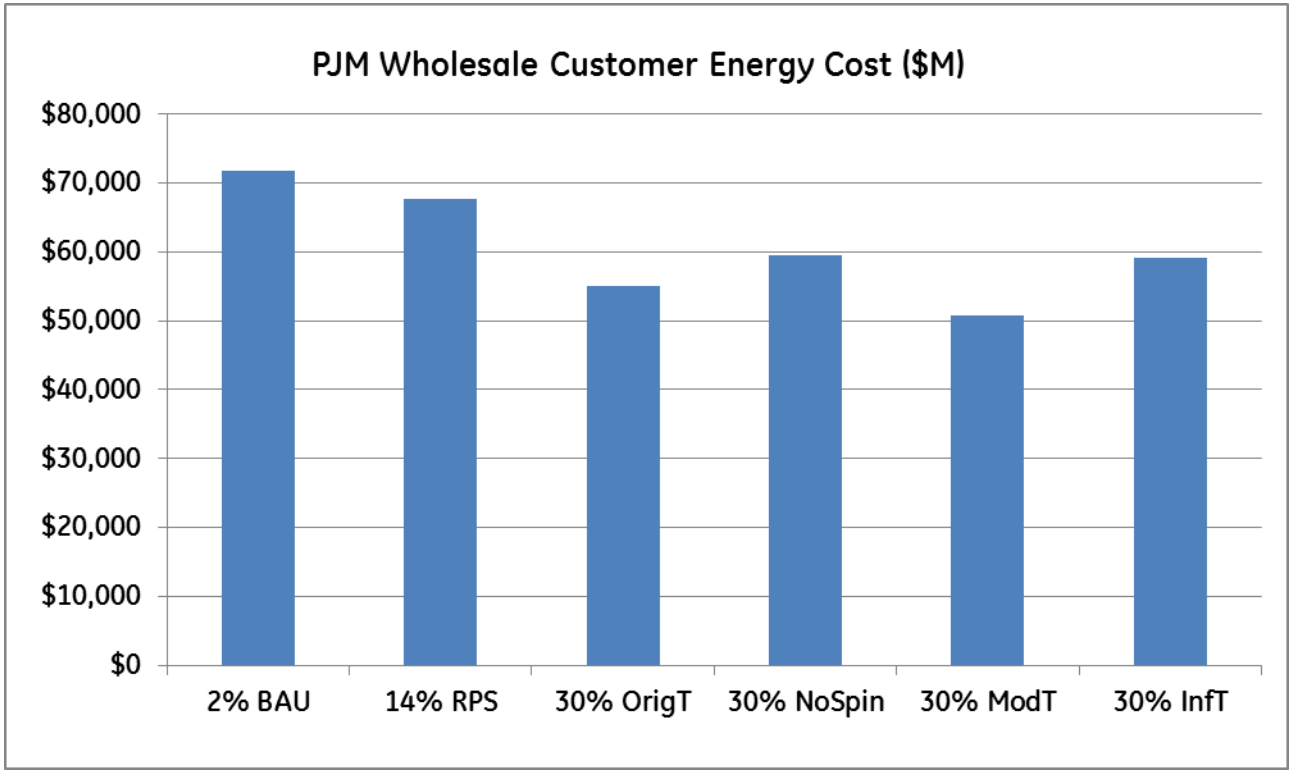
Production costs



OrigT - NoSpin: $3.3bn/year savings in production costs

OrigT – InfT: $10.1bn/year savings in production costs

Wholesale energy costs



Customer energy costs do not have a uniform trend!

Exports to more expensive regions elevate average prices in PJM

Summary

- The most impactful role of flexible DER is to alleviate transmission congestion (worth up to $10bn/year)
- The easiest to implement is substitution of operating reserves (worth up to $3bn/year)
- The markets are structured to yield lowest operating costs, so any flexibility plays first in favor of renewables, then coal
- Efficiency and emissions can be driven by energy policy to desired levels, but not without an impact to the cost of energy
- Future market and policy design should account for consumer choice that can be explicitly enabled by DER