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ENERGY STORAGE AND POLLUTION CONTROL:

EXPLORING OPTIONS IN THE U.S. SOUTHWEST

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DEPARTMENT OF MECHANICAL ENGINEERING

CLEAN ENERGY RESEARCH

ENERGY AND COMPUTATIONAL MODELING LAB

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OUTLINE

- Motivation
- Regulatory framework
- Method and model setup
- Overview of results
- Summary and policy recommendations

MORE PARTICIPATORY GRID = NEW PATTERNS OF EMISSIONS

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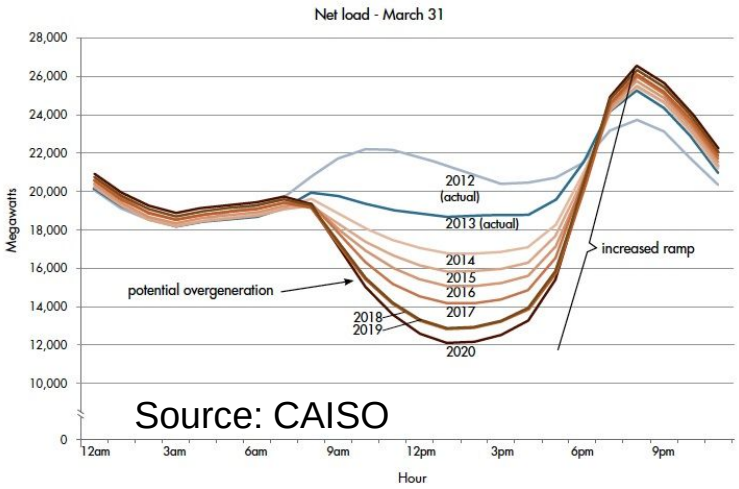
- US Southwest experiencing significant **Duck Curve** issues



Source: CAISO

- **Changing usage patterns** due to
  - residential desire to capture value of sola
  - Time-of-Use rates
  - initiatives such as OhmConnect

- Electrification of **transportation sector**

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CLEAN AIR ACT OVERVIEW

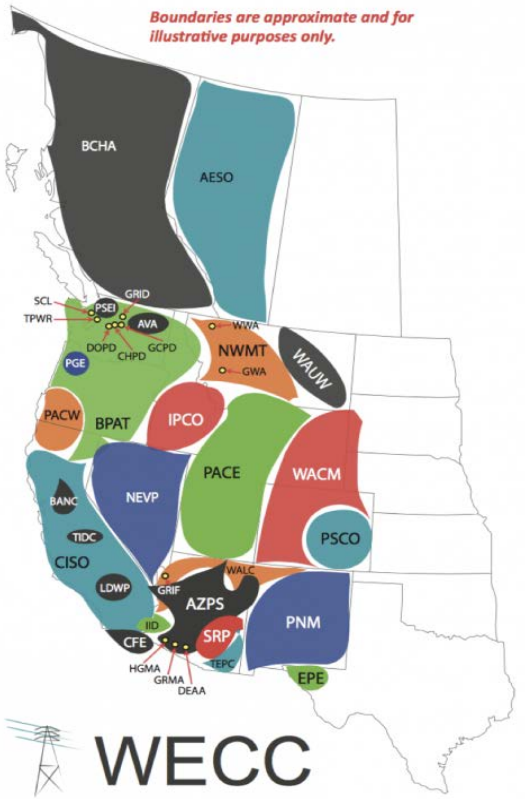
- Historical rigid approach: individual pollutants, individual facilities
- New facilities: meet pollutant limits or offset pollution entirely
- Evolution at Environmental Protection Agency:
  - Multi-pollutant approach
  - Onsite non-filtration measures (Solar at natural gas plant)
  - “Outside-the-fence” measures (offsets from other facilities)
- Increased flexibility with proposed CO_2 rule (Clean Power Plan)
  - Allowed “Best System of Emission Reductions” to include energy efficiency, renewables, etc. across entire state

RESEARCH QUESTIONS

- Can energy storage limit new natural gas peaking plant emissions?
  - Do higher levels of renewables cause increased ramping, spinning, starts/stops?
    What about increased drought due to climate change? What is the emissions impact?
  - Does storage mitigate these impacts? By how much? Under what scenarios?
- Emissions impacts:
  - Increased CO_2 from charging or system changes
  - Decrease in CO_2 due to reduction in ramping and plant starts/stops
- Additional goals:
  - Evaluate other impacts: system utilization and reliability
  - Identify potential pitfalls: "What could go wrong?"

MODELING

- Hourly modeling of one full year in PLEXOS
  - Production Cost Model:
    Economic dispatch of electrical system
- WECC TEPPC* 2024 dataset: Base case
  - Reduced coal generation in Arizona
  - Natural gas at $3.50/MMBTu
- Changes to dataset: Central test case
  - 30% renewable energy in AZ,
    40% renewable energy in California



Source: Western Electricity Coordinating Council

* WECC = Western Electricity Coordinating Council
* TEPPC = Transmission Expansion Planning Policy Committee

SCENARIO SETUP

- In high-renewables, low-coal, modest-gas-price future
  - Added 100 MW storage in each of 4 key Ariz. Balancing Authorities (BAs)
    - On nodes with high renewable penetration
    - 2 hours of capacity (200 MWh)
    - 4 hours of capacity (400 MWh)
  - Climate Change sensitivity
    - Extreme drought:
      - Reduced generation from, or eliminated, dams in Colorado River basin
      - Eliminated dams in select California BAs
    - Scenarios with 2-hour and 4-hour storage at 100 MW

CASE DETAILS

Scenario details	Name
2024 WECC TEPPC* dataset with $3.50/MMBTu gas and low coal	TEPPC+
TEPPC+ + Arizona at 30% renewables, California at 40% RE	AZ30
AZ30 + 100MW/200MWh of storage in 4 AZ Balancing authorities	AZST
AZ30 + 100MW/400MWh of storage in 4 AZ Balancing authorities	AZST4
AZ30 + significantly reduced AZ & CA hydroelectric capacity	AZXD
AZST + significantly reduced AZ & CA hydroelectric capacity	AZSTXD
AZST4 + significantly reduced AZ & CA hydroelectric capacity	AZST4XD

*WECC = Western Electricity Coordinating Council

* TEPPC = Transmission Expansion Planning Policy Committee

RESULTS

COSTS - GENERATION - EMISSIONS - RELIABILITY

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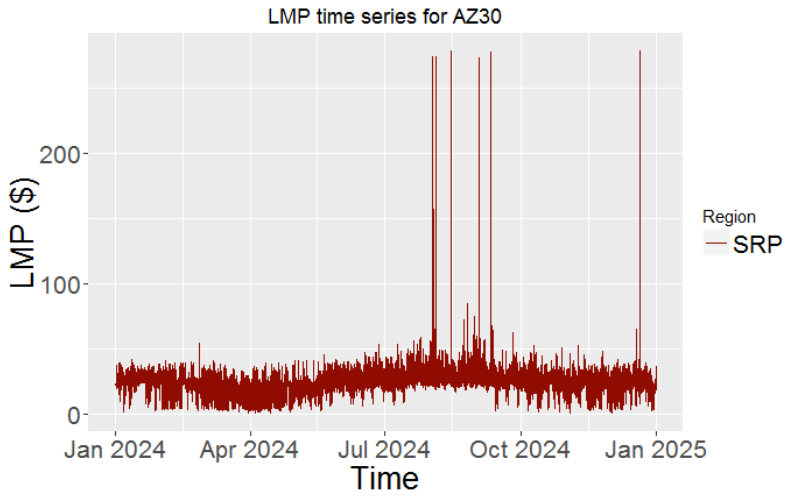
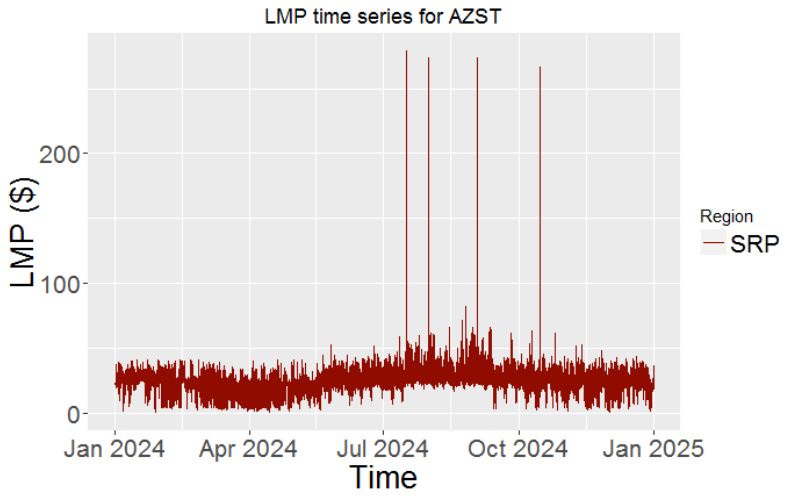
COST AND PRICE

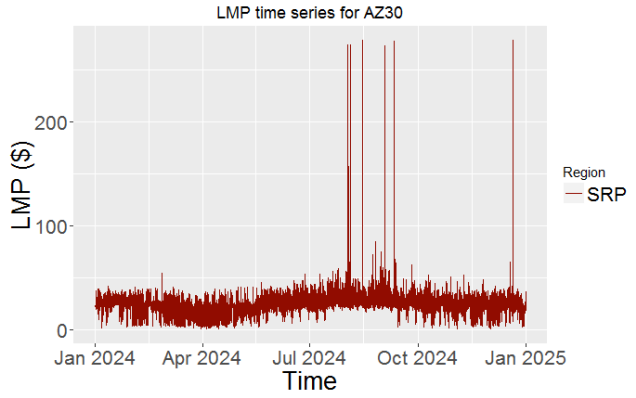
	TEPPC+	AZ30	AZST	AZST4	AZXD	AZSTXD	AZST4XD
Cost (Billion $)	18.273	17.579	17.584	17.568	18.328	18.334	18.332
Mean AZ LMP*($)	26.83	24.39	24.33	24.61	25.42	24.96	25.24





* LMP: Locational Marginal

LMP DETAILS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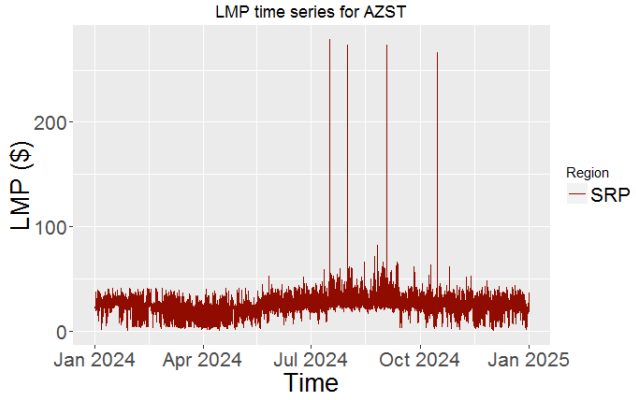
Oct 2024
Jan 2025
Time
Region
SRP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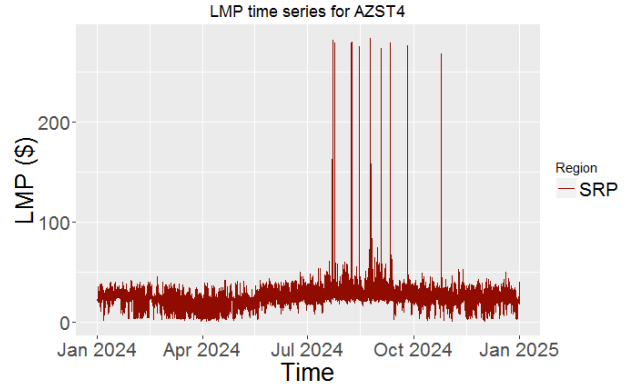
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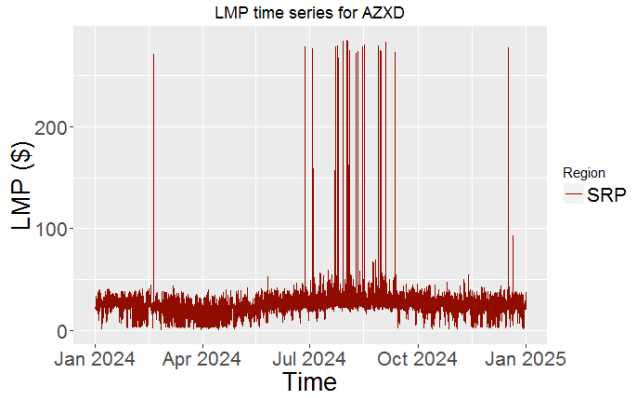
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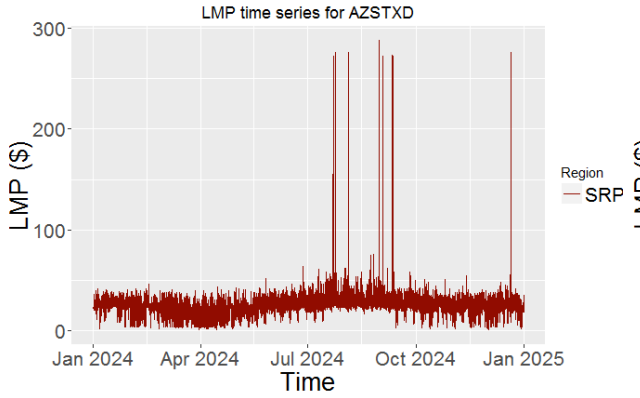
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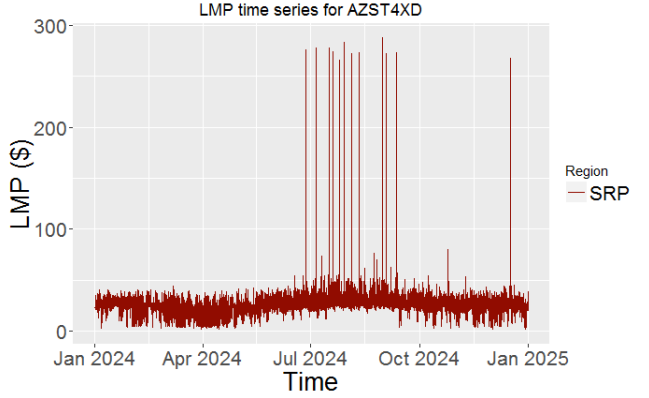
LMP time series for AZST4XD
LMP ($)
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0
Jan 2024
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Region
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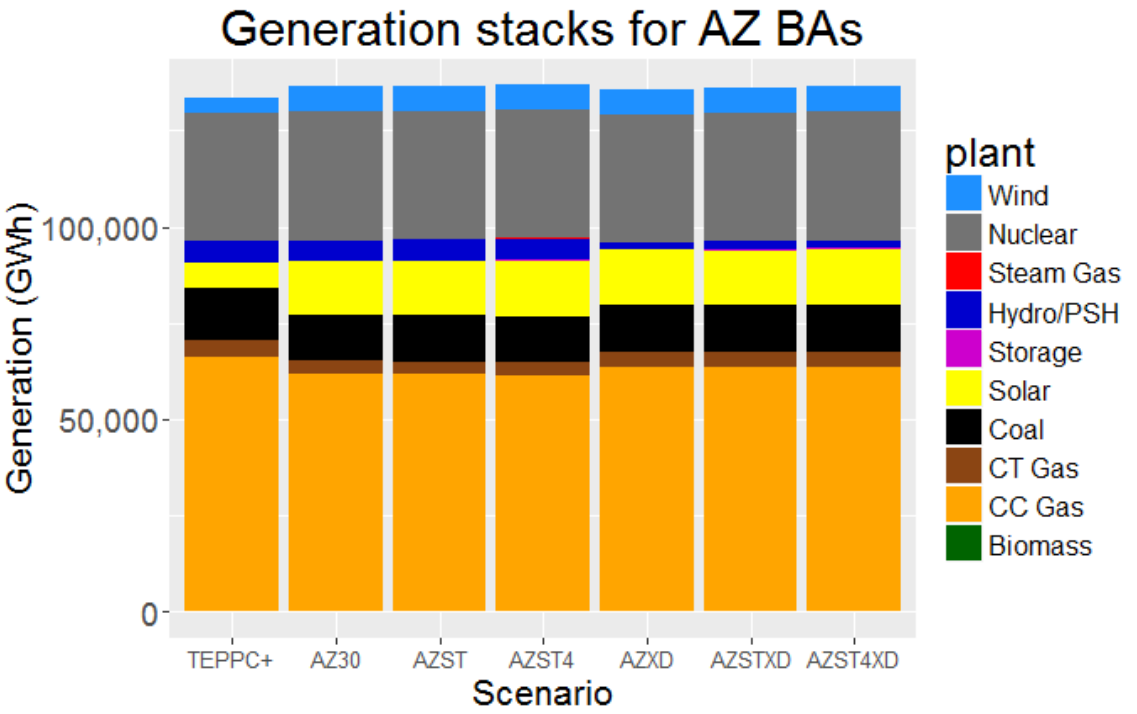
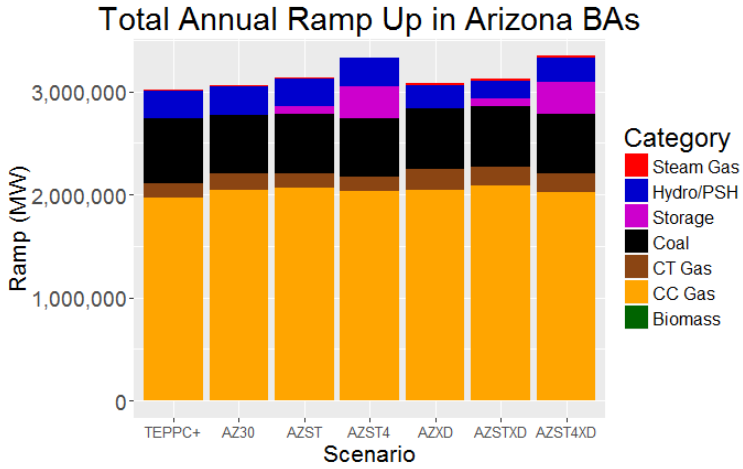
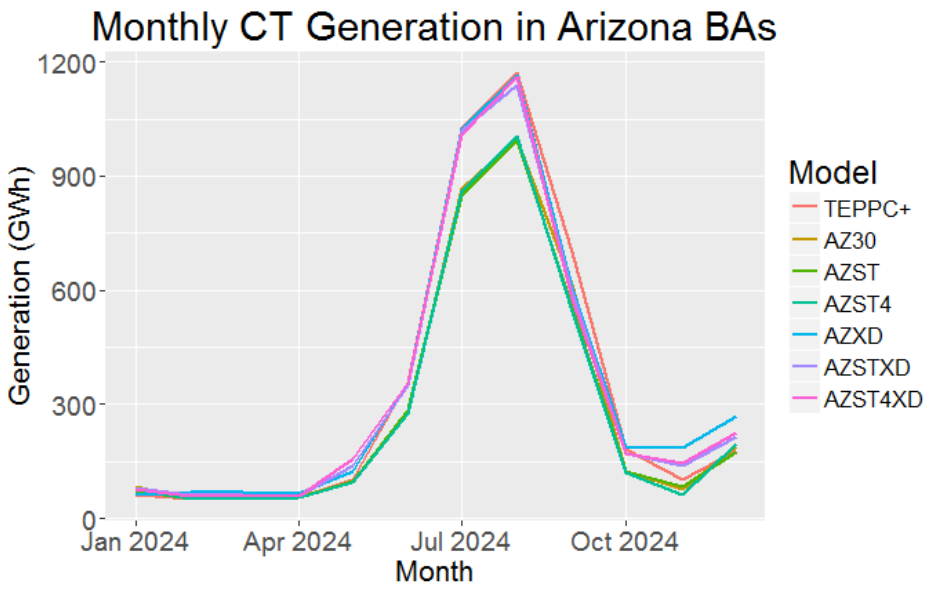
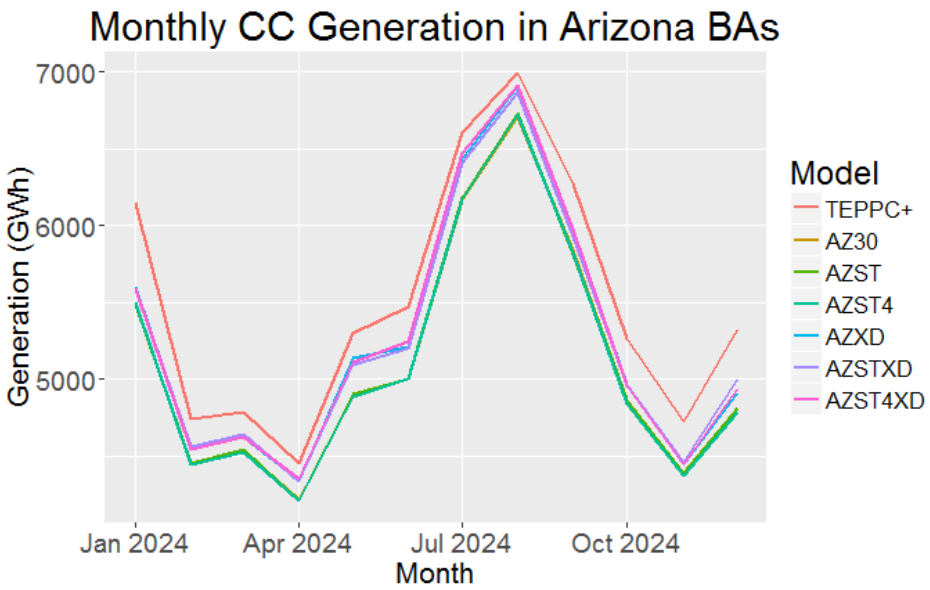
GENERATION & RAMPING



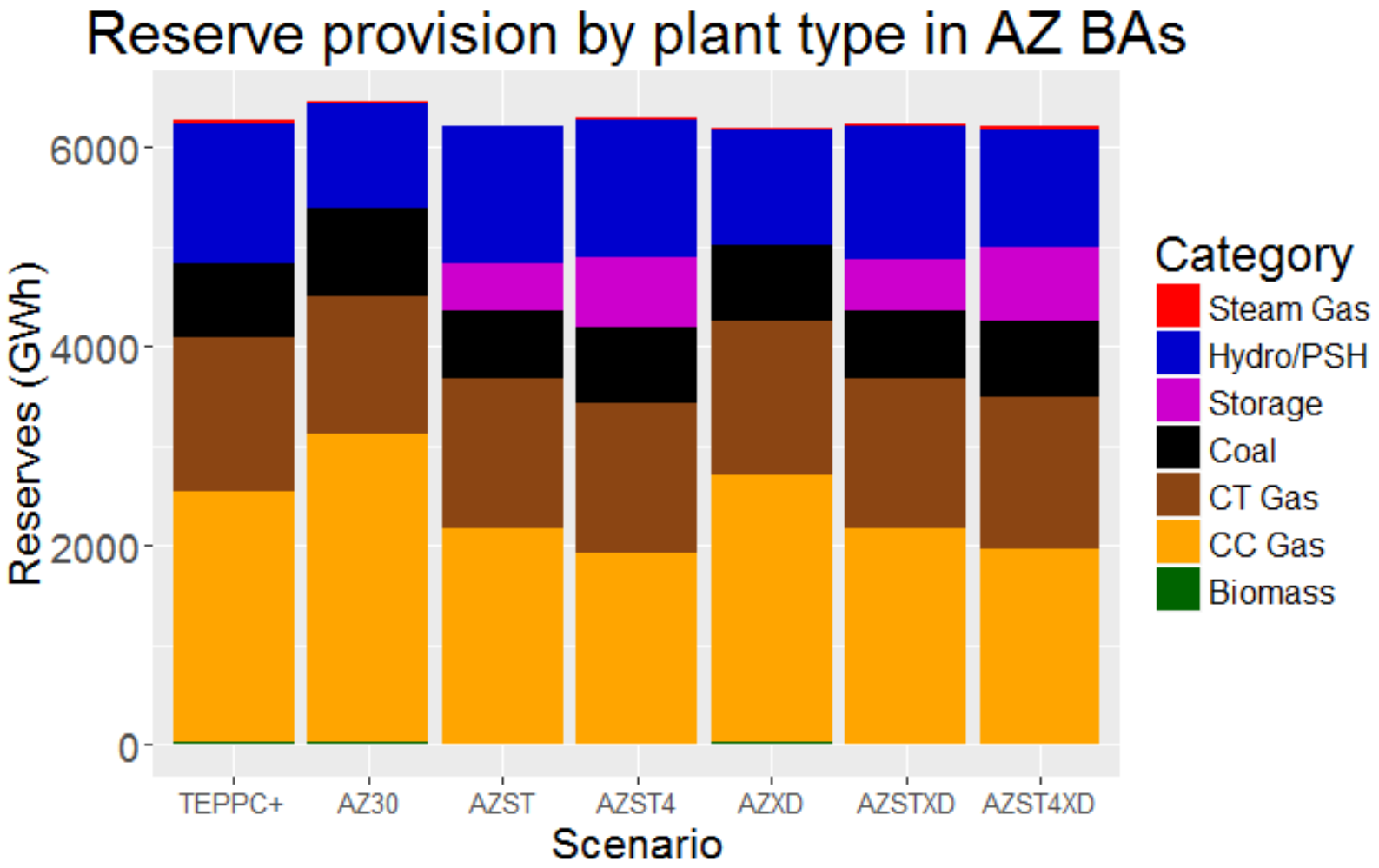


GENERATION BY MONTH





RESERVES PROVISION

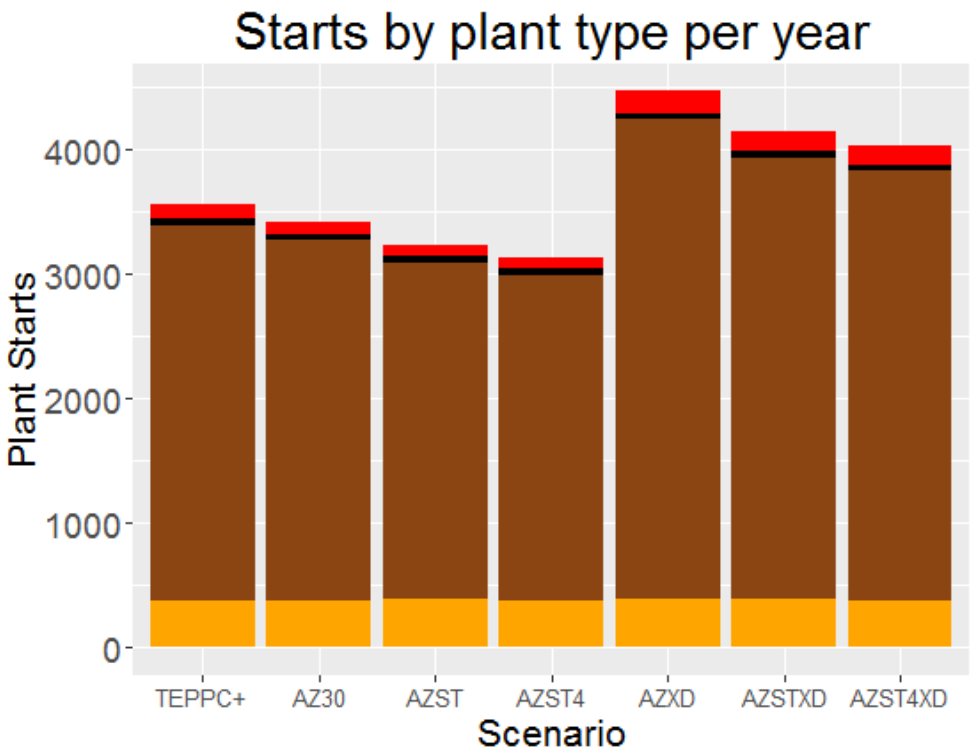


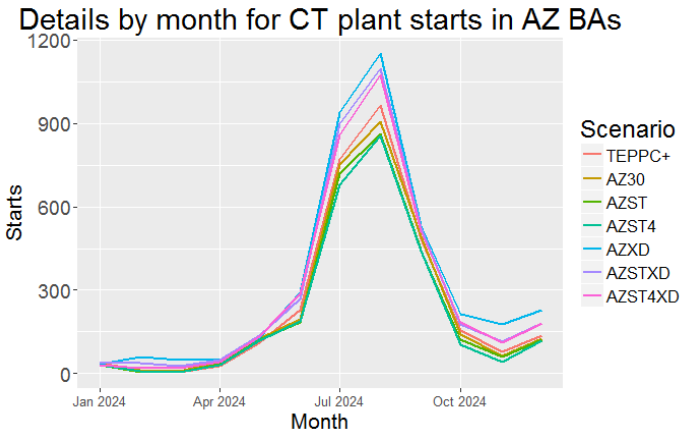
CO_2 EMISSIONS

	TEPPC+	AZ30	AZST	AZST4	AZXD	AZSTXD	AZST4XD
AZBAs	46.85	42.86	42.93	42.80	44.65	44.50	44.55
California	69.01	65.27	65.25	65.16	71.15	71.21	71.1
Other	240.4	235.4	235.7	235.7	239.1	239.0	239.4
Total (Million tons)	356.3	343.56	343.9	343.65	354.9	354.7	355.0

* Does not include plant starts/stops

PLANT STARTS





SUMMARY – STORAGE SCENARIOS

- Reduces plant starts and provides significant reserves
- CC reserves provision decreases; Hydro reserves increase
- Short-term storage reduces price spikes; eliminates reserve shortage entirely – not the case for 4-hr storage
- Impacts on operational CO_2 emissions depend on storage duration in BAU; decrease in drought scenario
- Decreases plant start emissions in all future scenarios

- Takeaway: Storage is providing needed flexibility/reliability, but may reduce other emissions more than GHGs in BAU future;
  storage duration matters

SUMMARY – CLIMATE CHANGE

- Gas CC and CT generation increases
- CT starts increase considerably
- Coal, CTs and storage provide (slightly) more reserves
- Hydro plants provide reserves but less generation
- **Storage decreases plant starts AND operational CO_2 emissions in region**

- Takeaway: Expected climate change impacts in SW will reduce system flexibility, increase operational and start/spin emissions
  - This increases the value of other non-hydro sources for these services

RECOMMENDATIONS: STORAGE POLICY

- Consider storage in CC/CT environmental permitting decisions
- Model to quantify benefits across pollutants; may increase value to air regulators
- Work across power sector and collaborate with other states
- Compare storage to other emerging options:
  - Increased demand response
  - Distributed storage, particularly through EVs
  - Rate structures incentivizing user flexibility

THANK YOU FOR YOUR ATTENTION

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RESERVES SHORTAGE

Scenario	Hours Shortage in AZ BAs	MWH short in AZ BAs	APS Spin	SRP Spin	TEP Spin	WALC Spin	SW FlexUp	NVE FlexUp
TEPPC	5	405.9	34.3	354.4	17.1	0	0	0
AZ30	1	23.9	0	0	23.9	0	0	0
AZST	0	0.0	0	0	0	0	0	0
AZXD	12	453.7	153.1	211.1	0	47.1	0	42.4
AZSTXD	4	152.5	77.1	0	75.4	0	0	0
AZST4	1	29.3	0	29.3	0	0	0	0
AZST4XD	4	248.3	114.5	34.8	0	0	0	99

GENERATION DETAILS

Plant Type (ALL ENERGY IN GWH)	TEPPC +	AZ30	AZST	AZST4	AZ30XD	AZSTXD	AZST4XD
Biomass	263	246	246	247	250	250	252
Combined Cycle gas	66,089	61,378	61,397	61,281	63,085	63,065	63,172
Combustion Turbine gas	4,039	3,515	3,392	3,383	4,173	4,023	4,046
Coal	13,606	11,808	11,869	11,796	12,376	12,315	12,323
Solar PV	4,607	12,017	12,042	12,096	12,121	12,118	12,197
Solar CSP	2,232	2,120	2,127	2,145	2,192	2,147	2,208
Energy Storage	0	0	112	590	0	112	562
Hydro and PSH	5,315	5,366	5,388	5,389	1,576	2,112	1,603
Steam gas	97	70	68	85	129	123	117
Nuclear	33,409	33,409	33,409	33,409	33,409	33,409	33,409
Wind	3,785	6,484	6,485	6,494	6,499	6,498	6,507