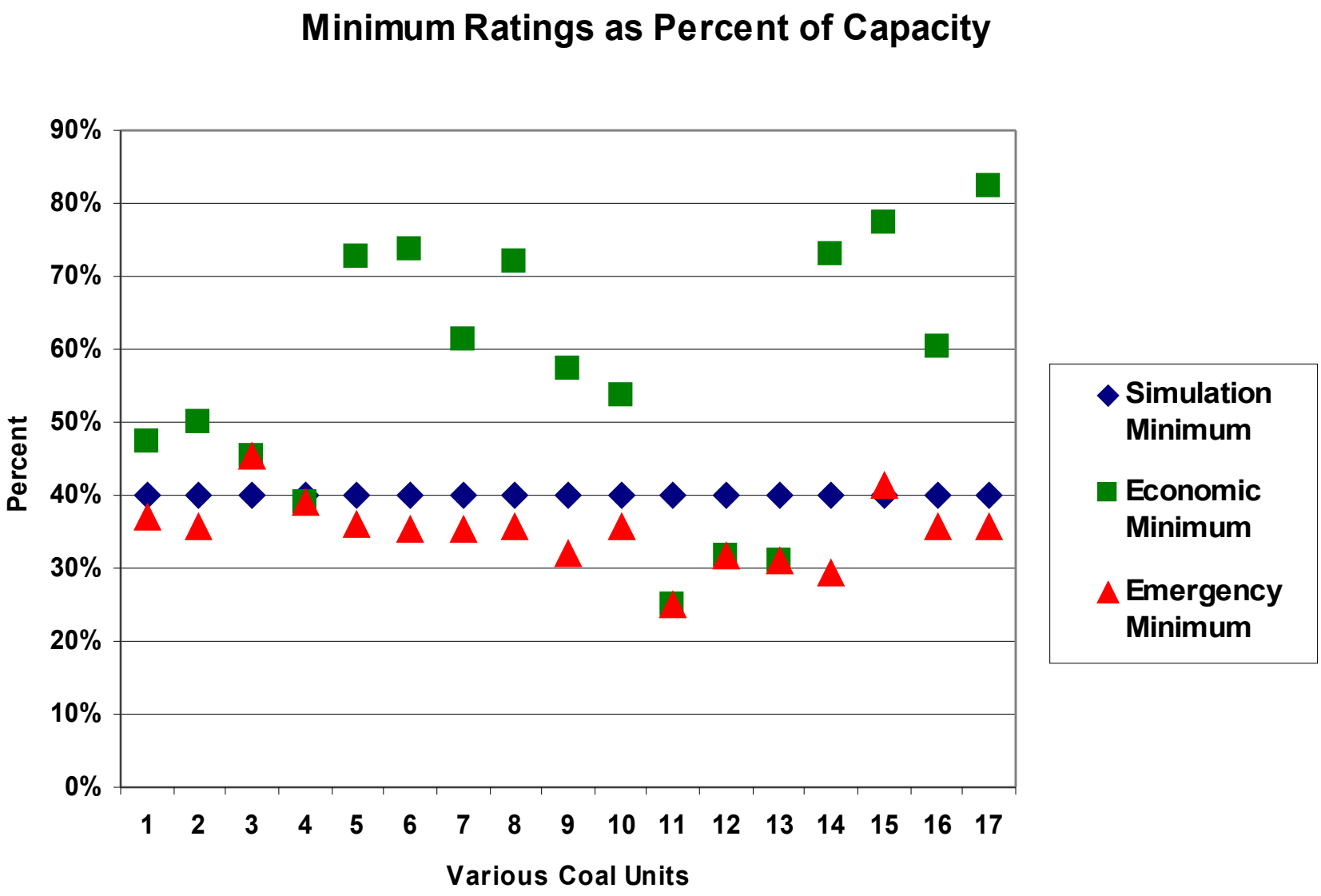
Operational Sensitivities

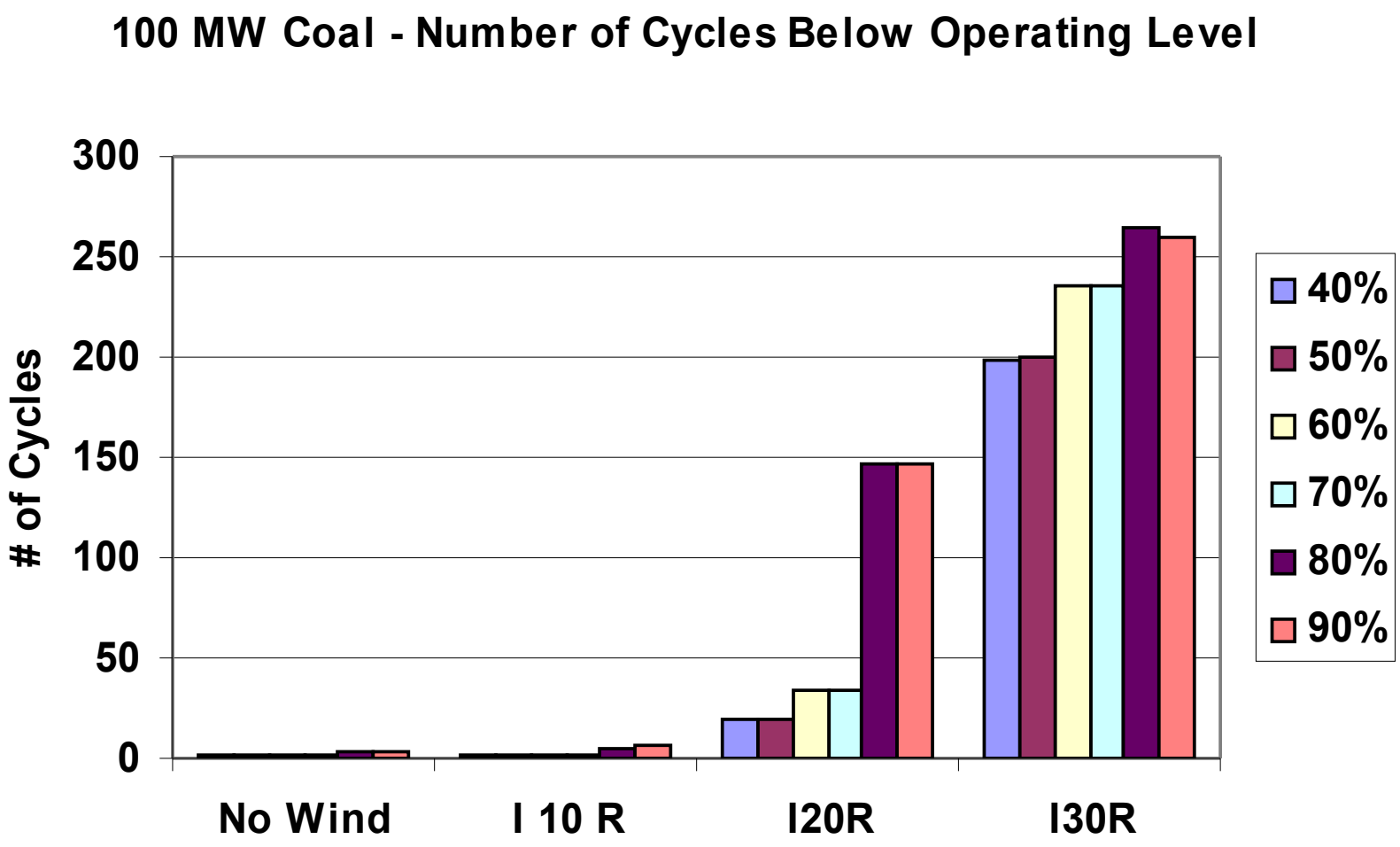
- Minimum operation of Coal plants
- Storage Operation
  - Pumped Storage Hydro
  - CSP
- Plug-in Hybrid Electric Vehicles, PHEV
- Hydro Flexibility
- Unit Expansion Plan

Coal Unit Operation

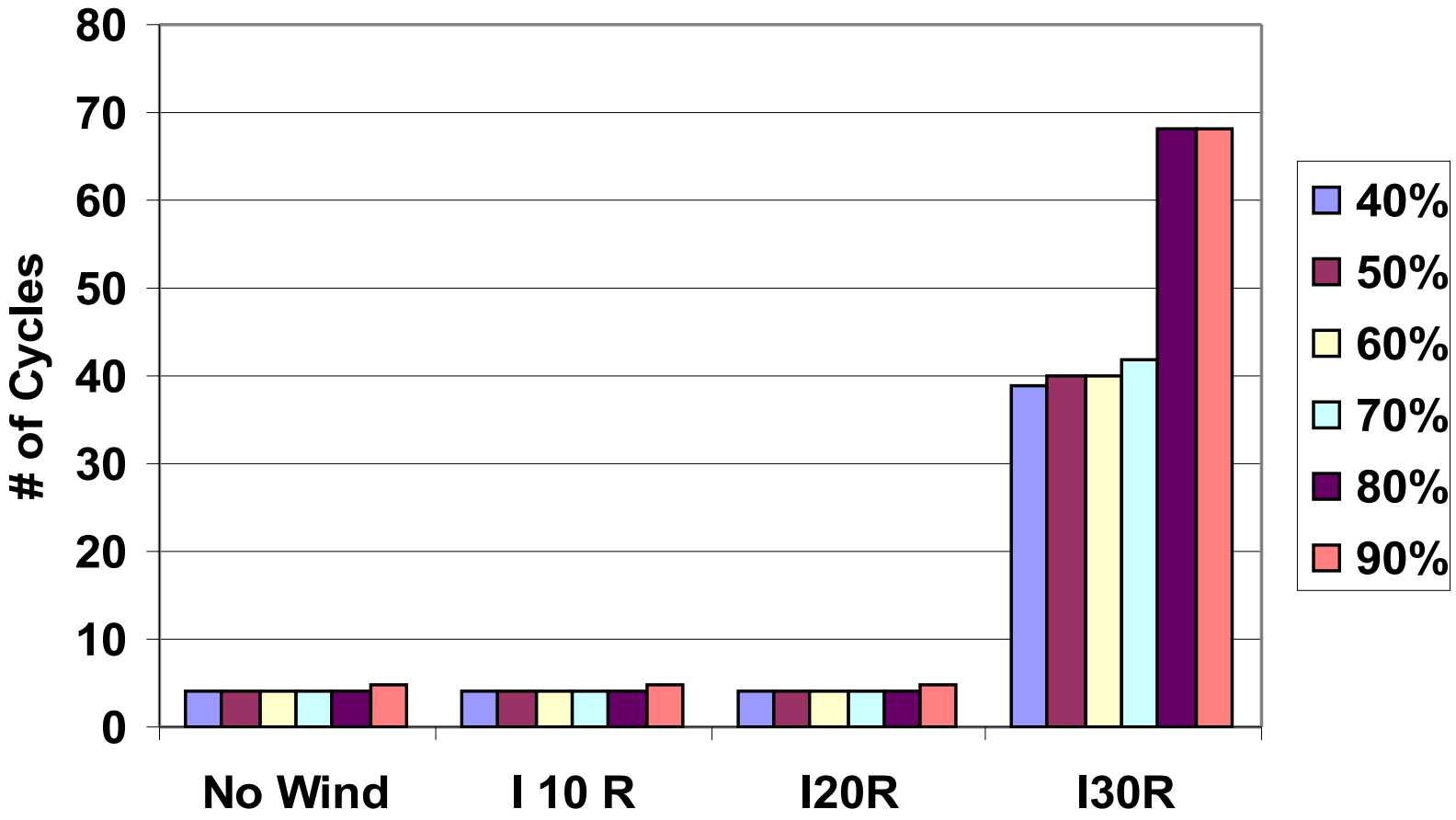
- Although modeling assumptions allowed coal units to cycle down to 40% rating only minimal cycling occurred prior to 30% wind penetration



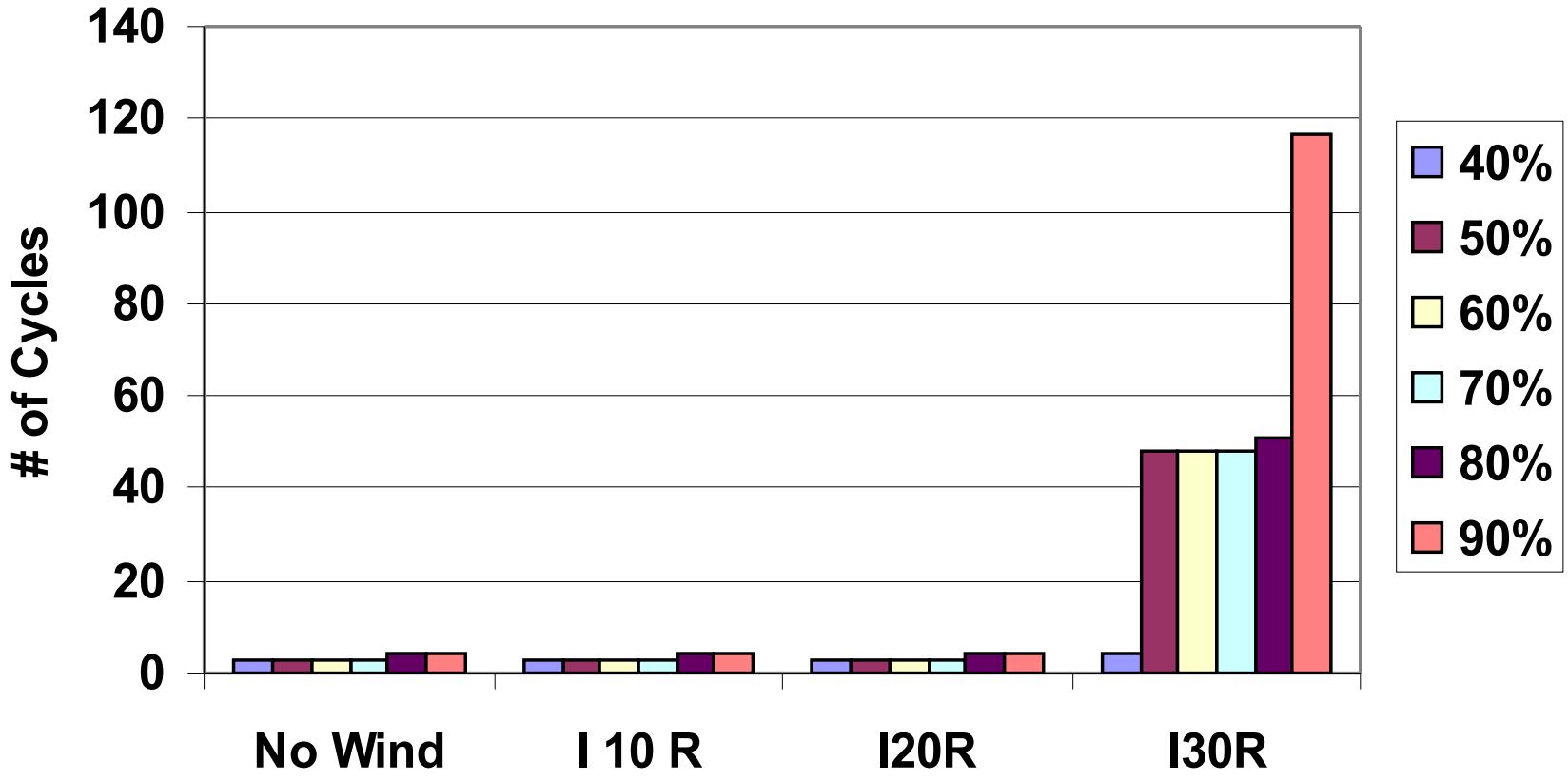
imagination at work

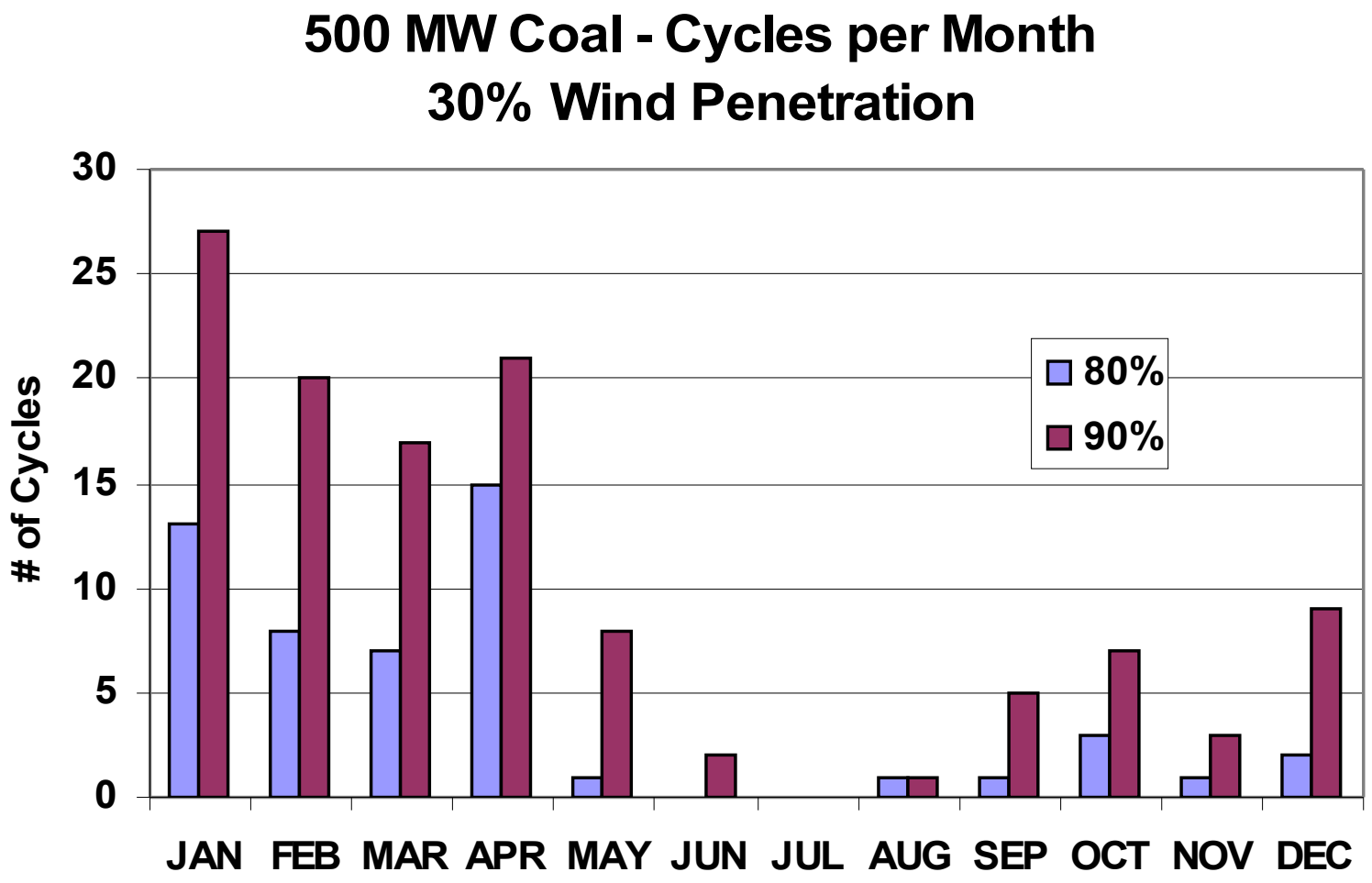

100 MW Coal - Number of Cycles Below Operating Level
# of Cycles
300
250
200
150
100
50
0
No Wind
I 10 R
I20R
I30R
40%
50%
60%
70%
80%
90%

350 MW Coal - Number of Cycles Below Operating Level



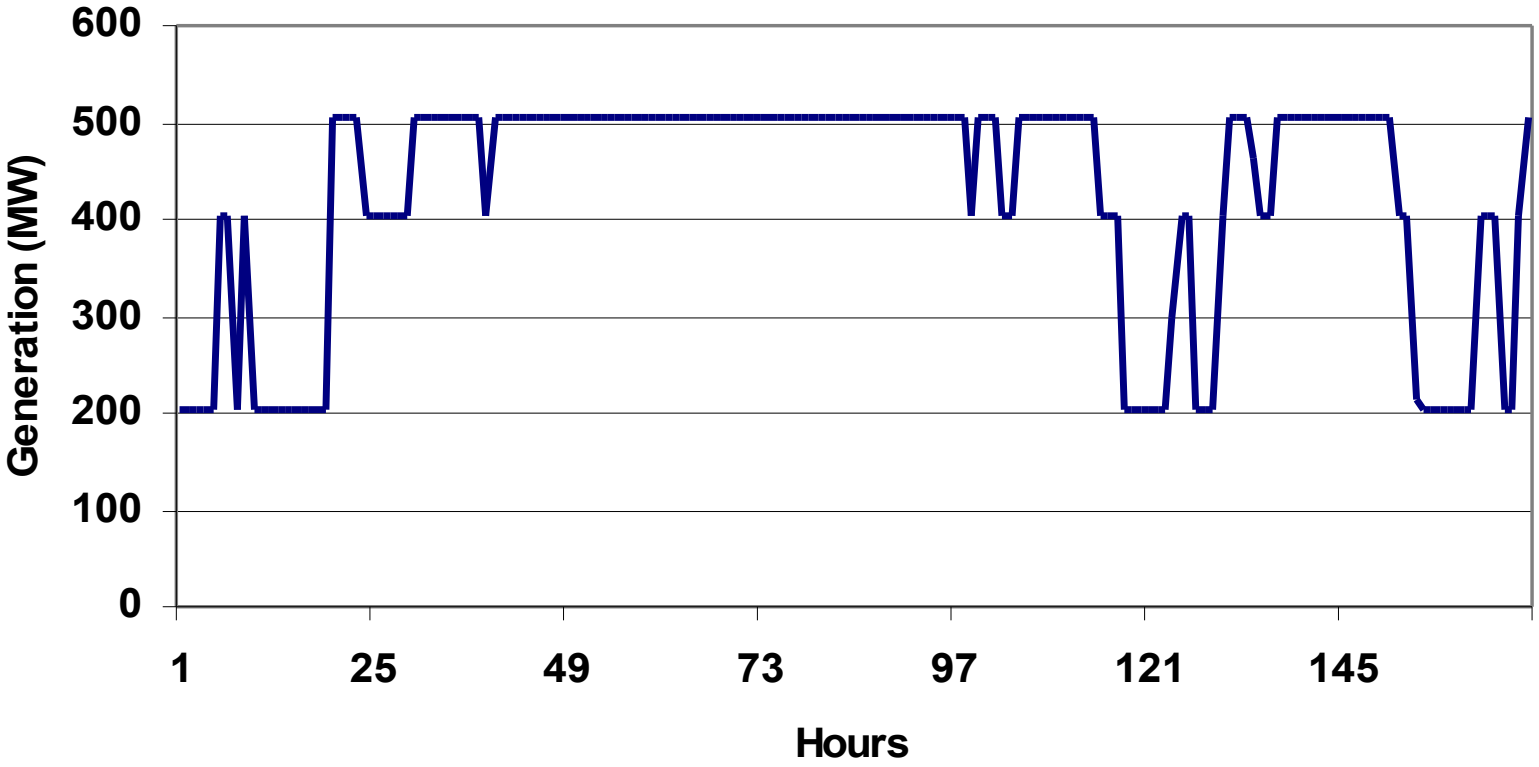
500 MW Coal - Number of Cycles Below Operating Level





imagination at work

Week of April 10th - 500 MW Coal Unit
30% Wind Penetration

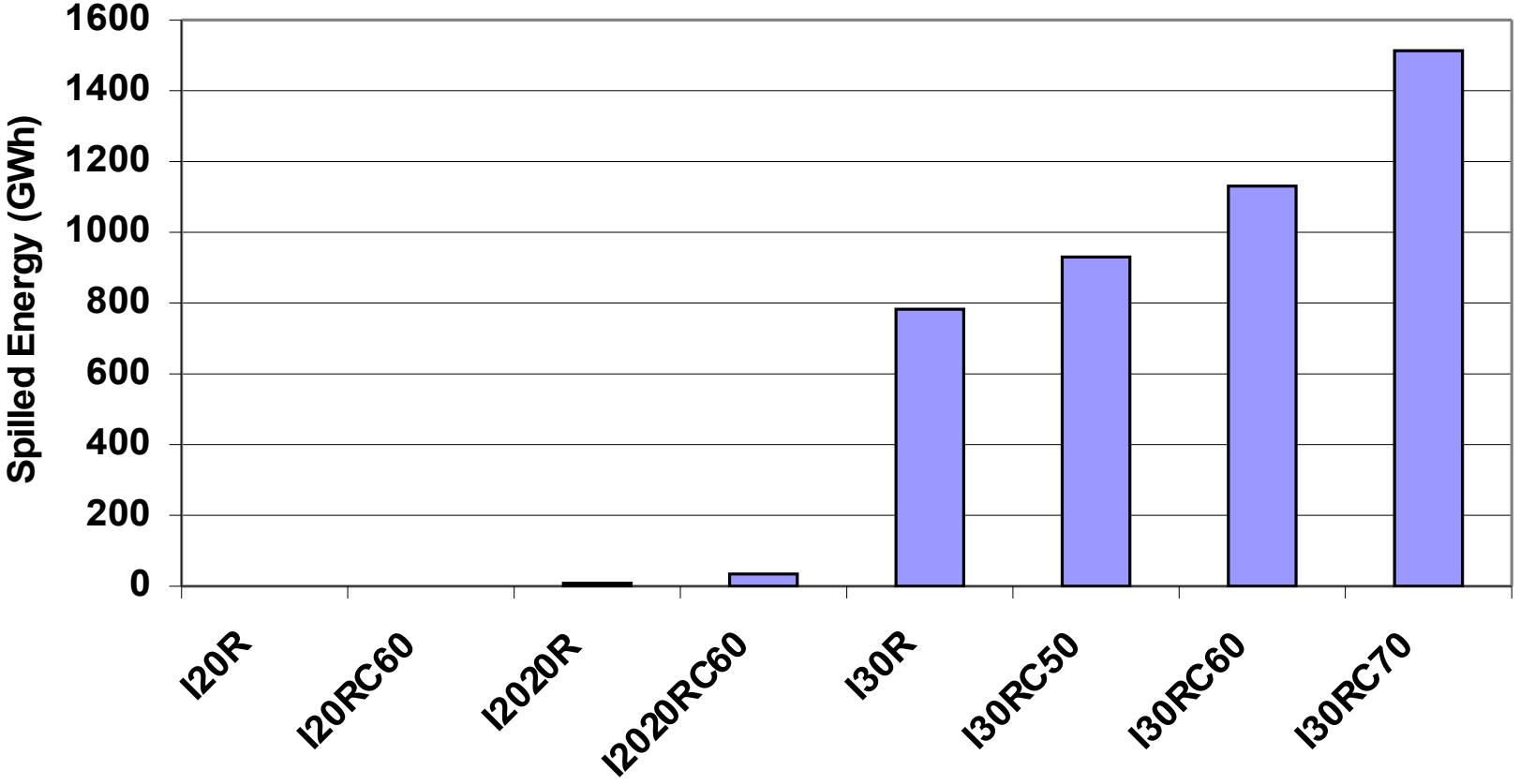


imagination at work

Variation of Coal Unit Minimums

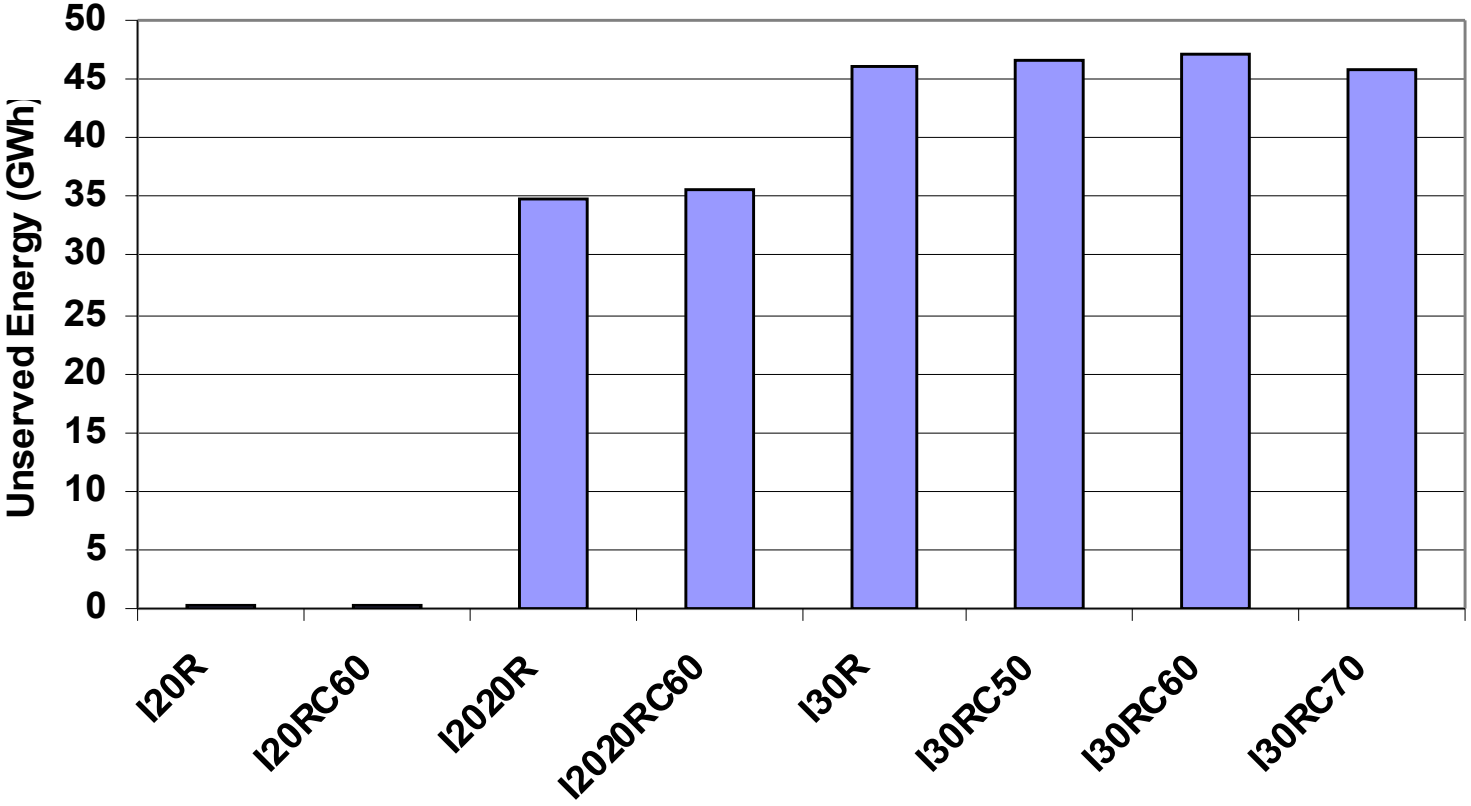
- Base scenarios assumed 40% minimums.
- Sensitivity cases examined minimums at 50% to 70%
  - I30RC50 = I30R scenario with coal plants set to 50% minimum

Spilled Energy vs Coal Minimums



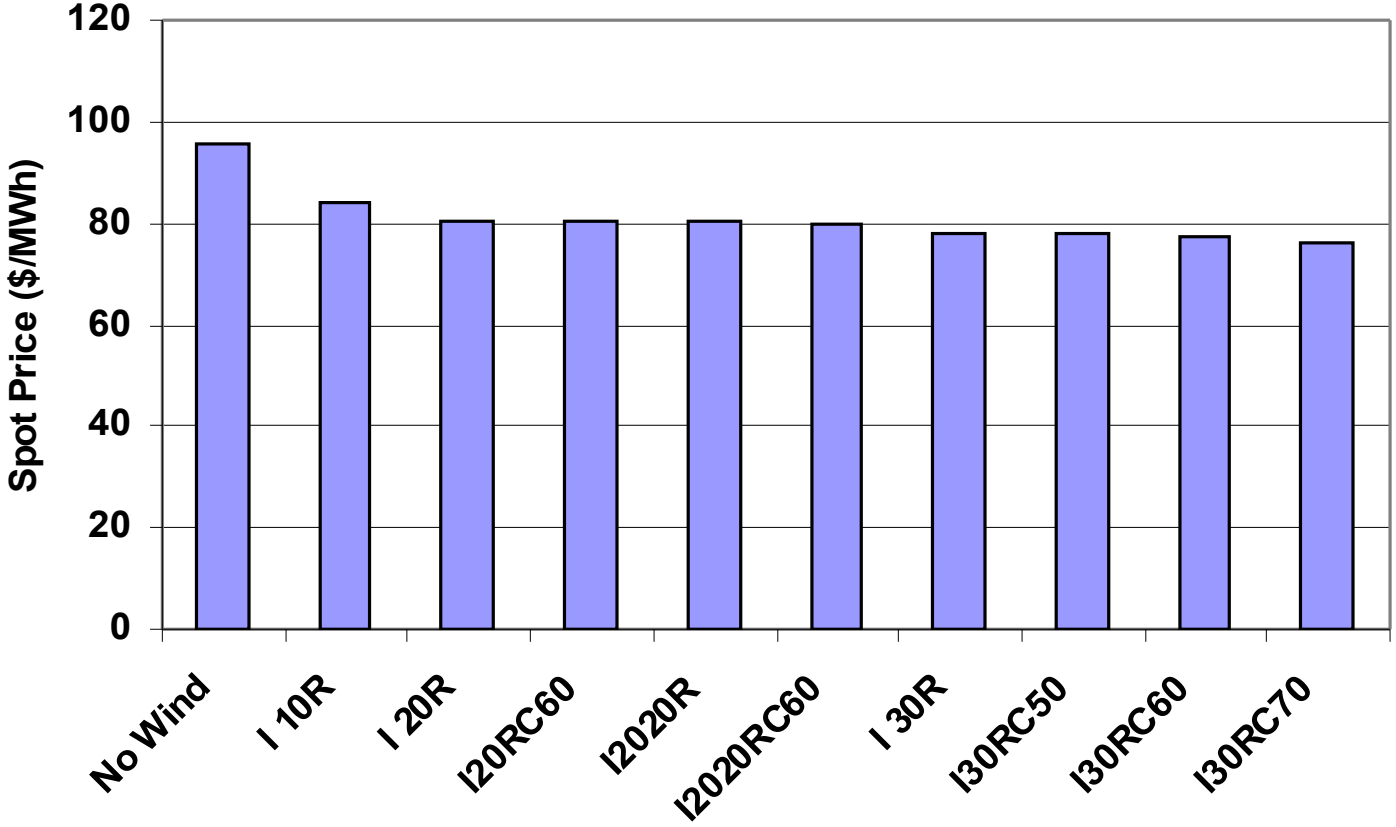
imagination at work

Unserved Energy vs Coal Minimums



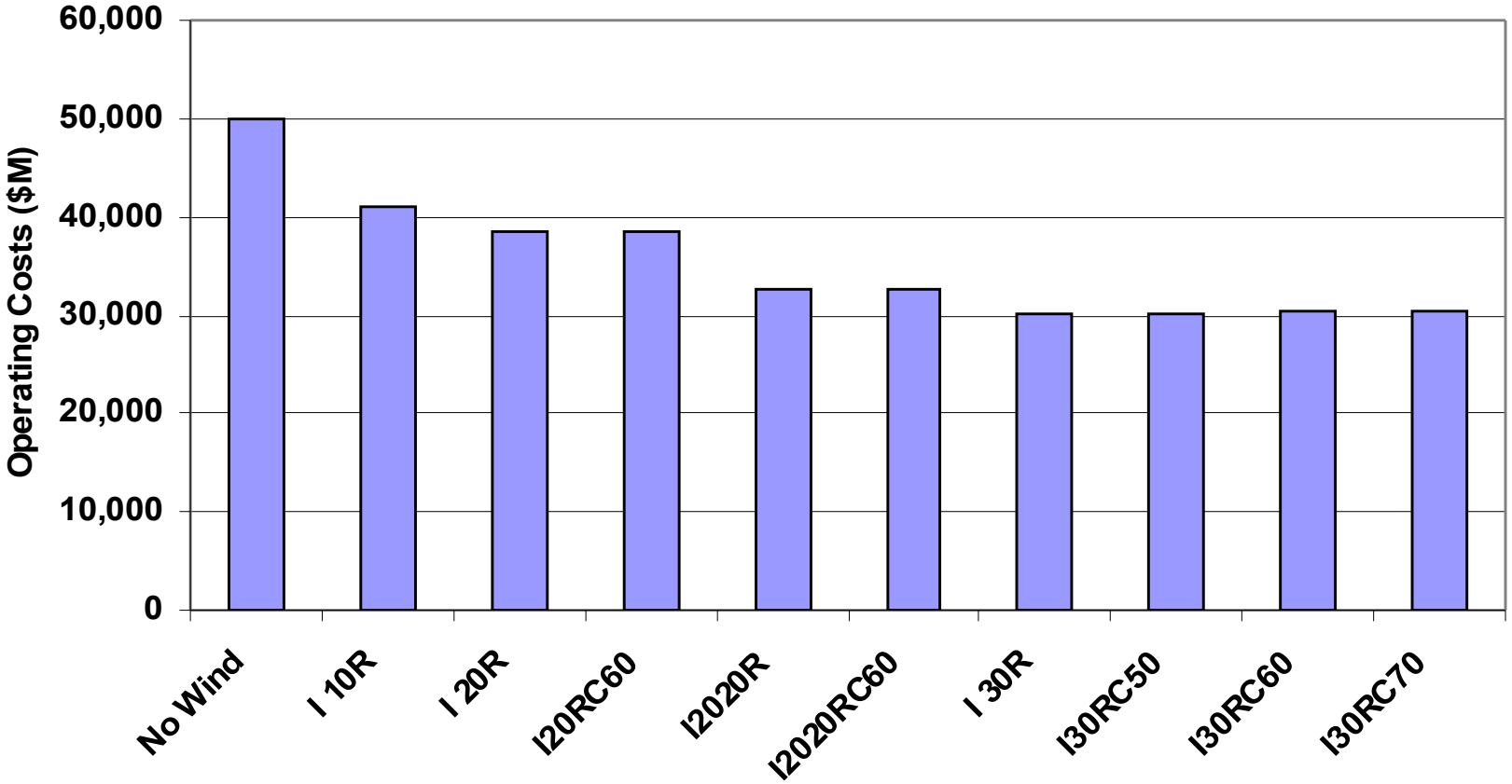
imagination at work

Average System Spot Prices vs Coal Minimums



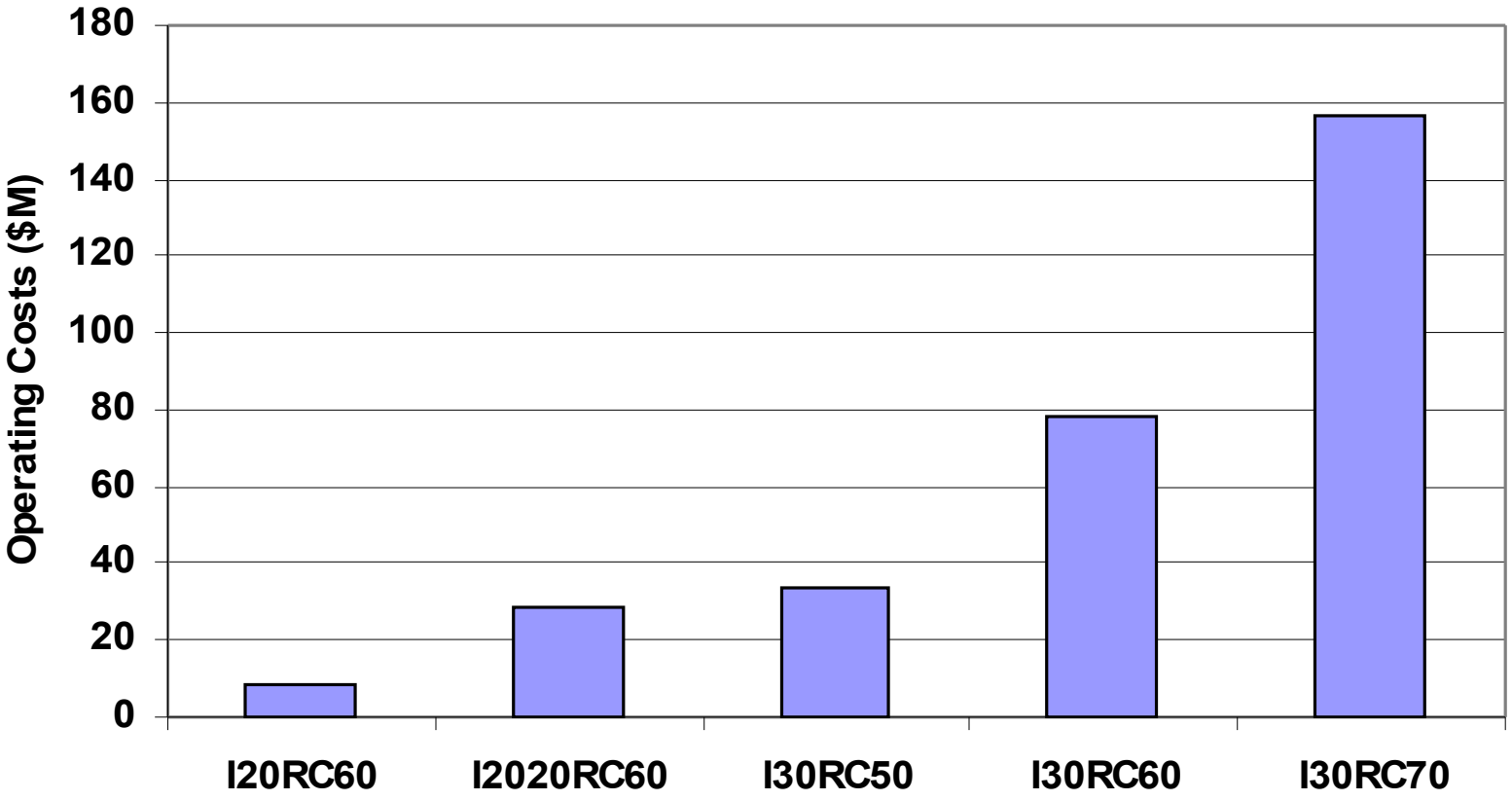
imagination at work

Total WECC Variable Cost vs Coal Minimums



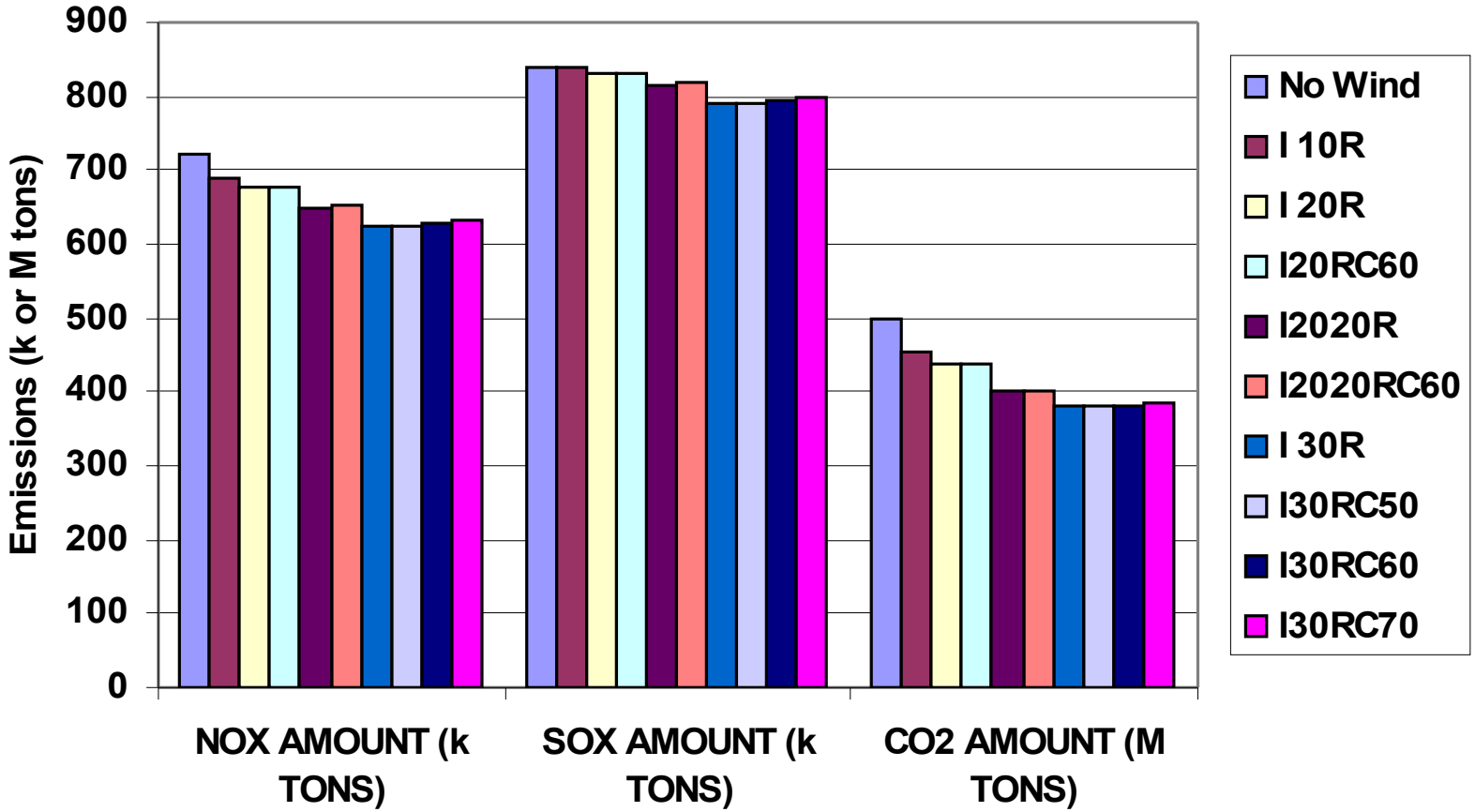
imagination at work

Increased Cost over Coal Minimums at 40%



imagination at work

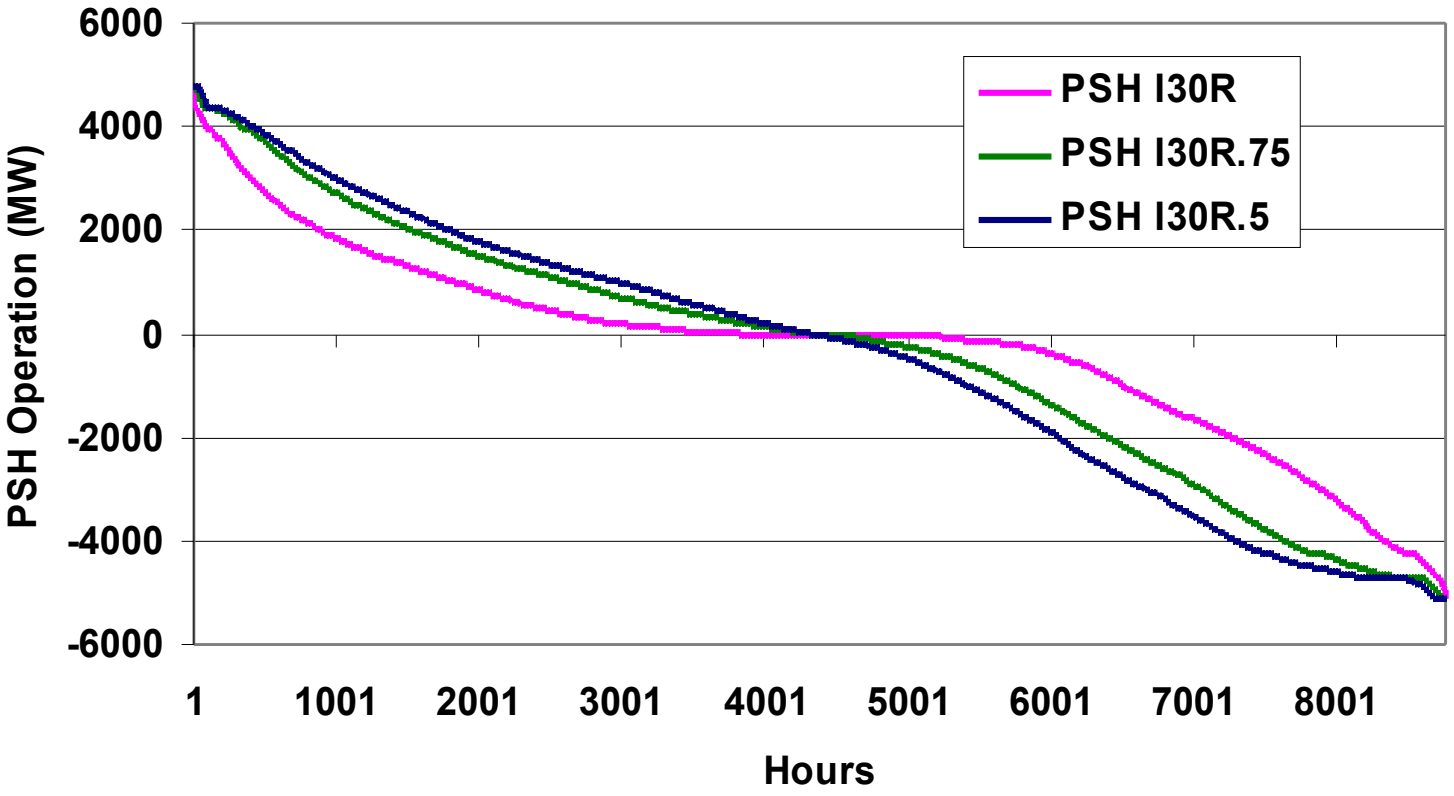
Impact of Coal Minimums on Emissions



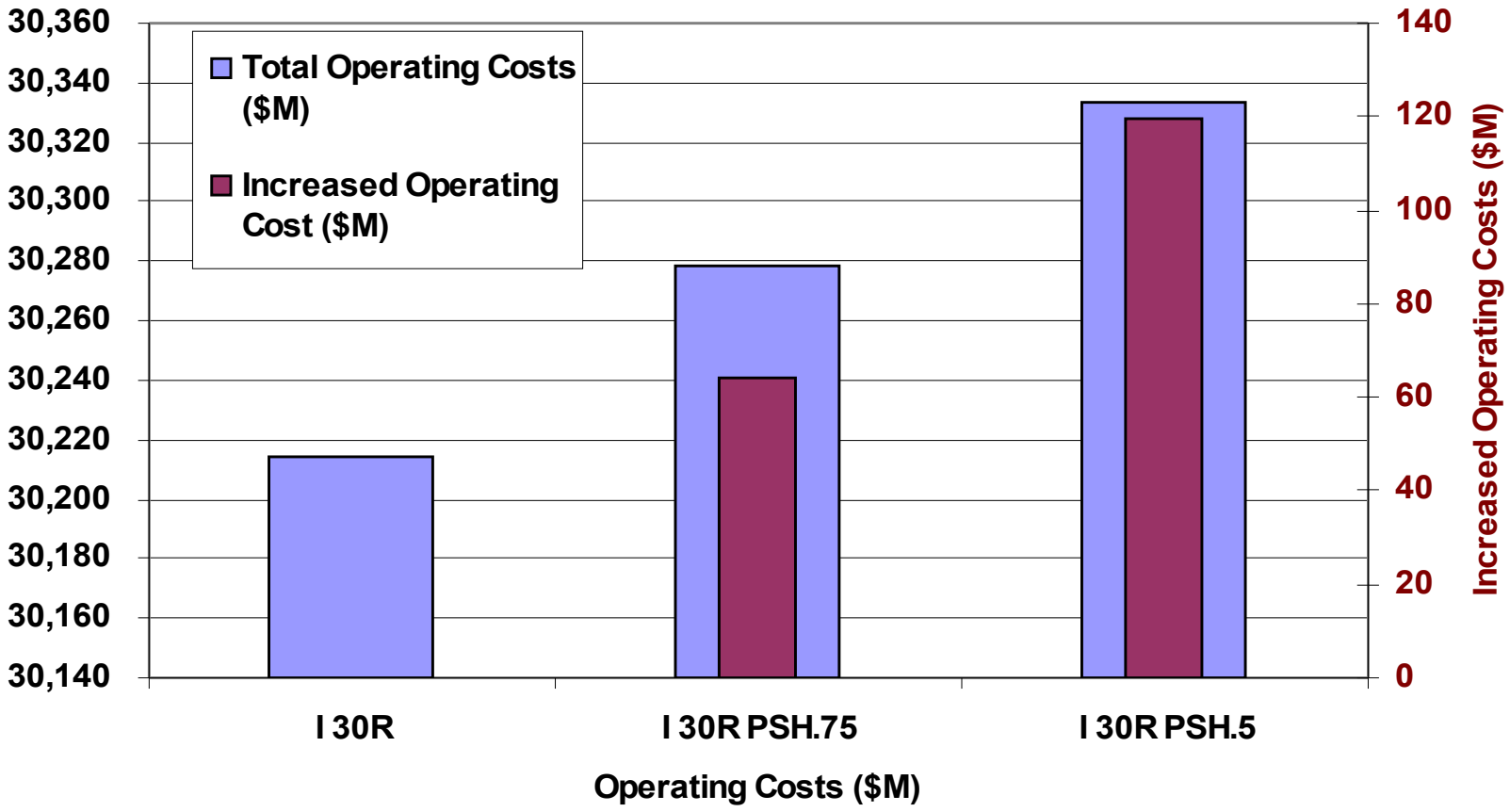
Storage Operation

- Forced the PSH to run more even if it appeared uneconomic.
- Examined the operation of 100 MW new Pumped Storage Hydro in Arizona assuming perfect knowledge of the spot price.
- Examined the value of operating the Concentrating Solar Plants, CSP, to maximize benefit rather than just hold operation at maximum until energy ran out.

PSH Operation with discounted Pumping Costs

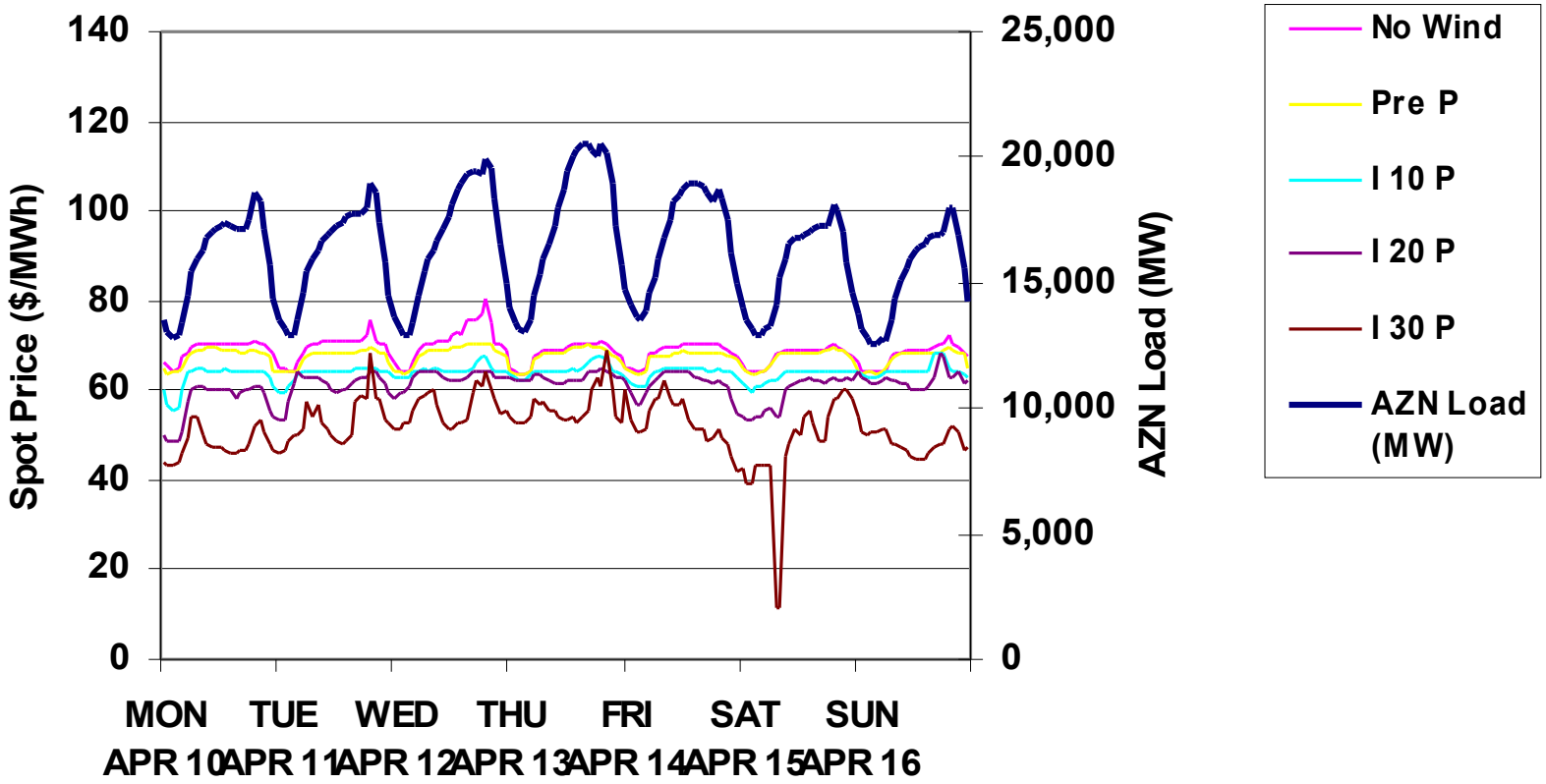


WECC Operational Impact of forcing PSH

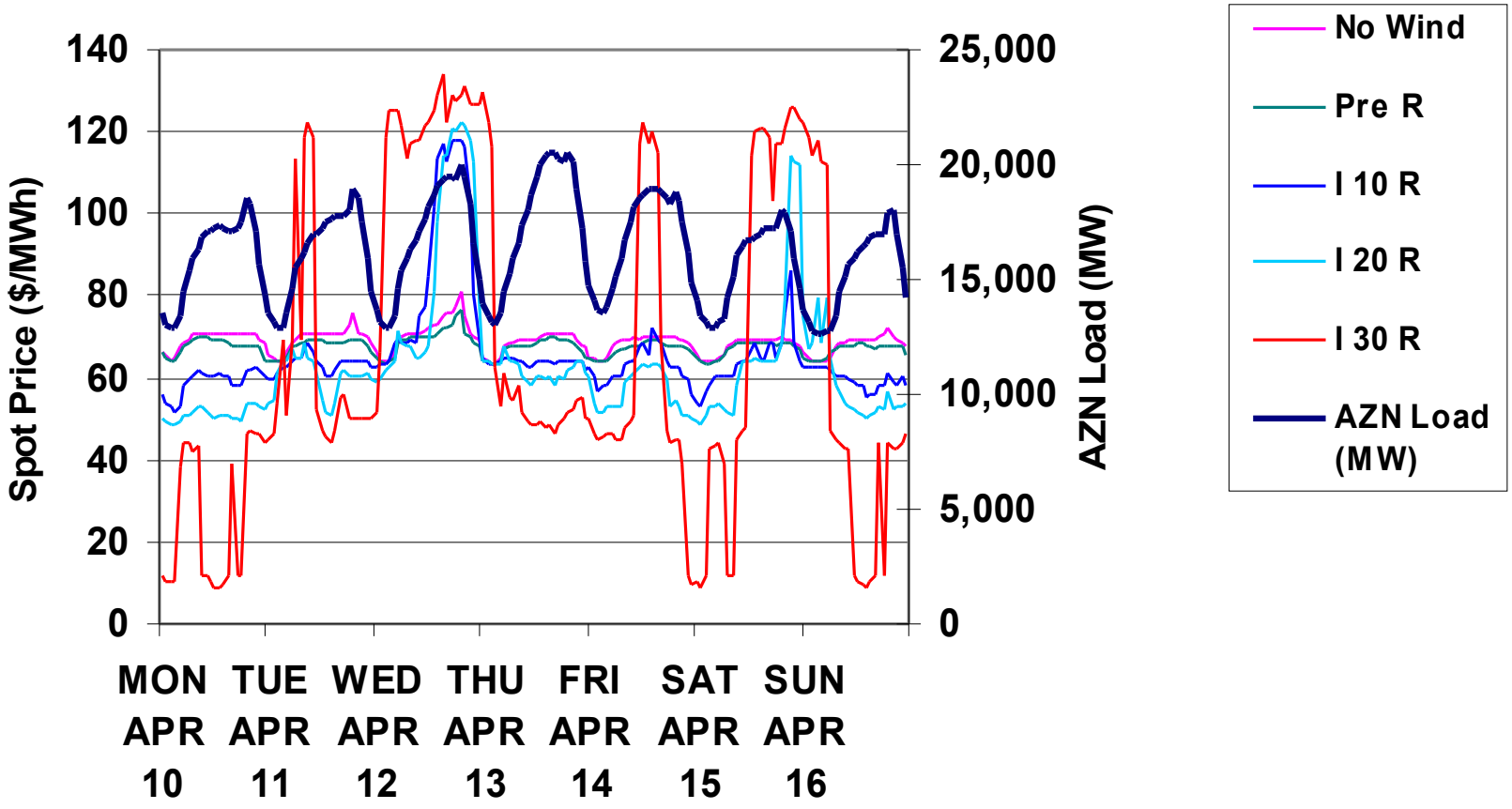


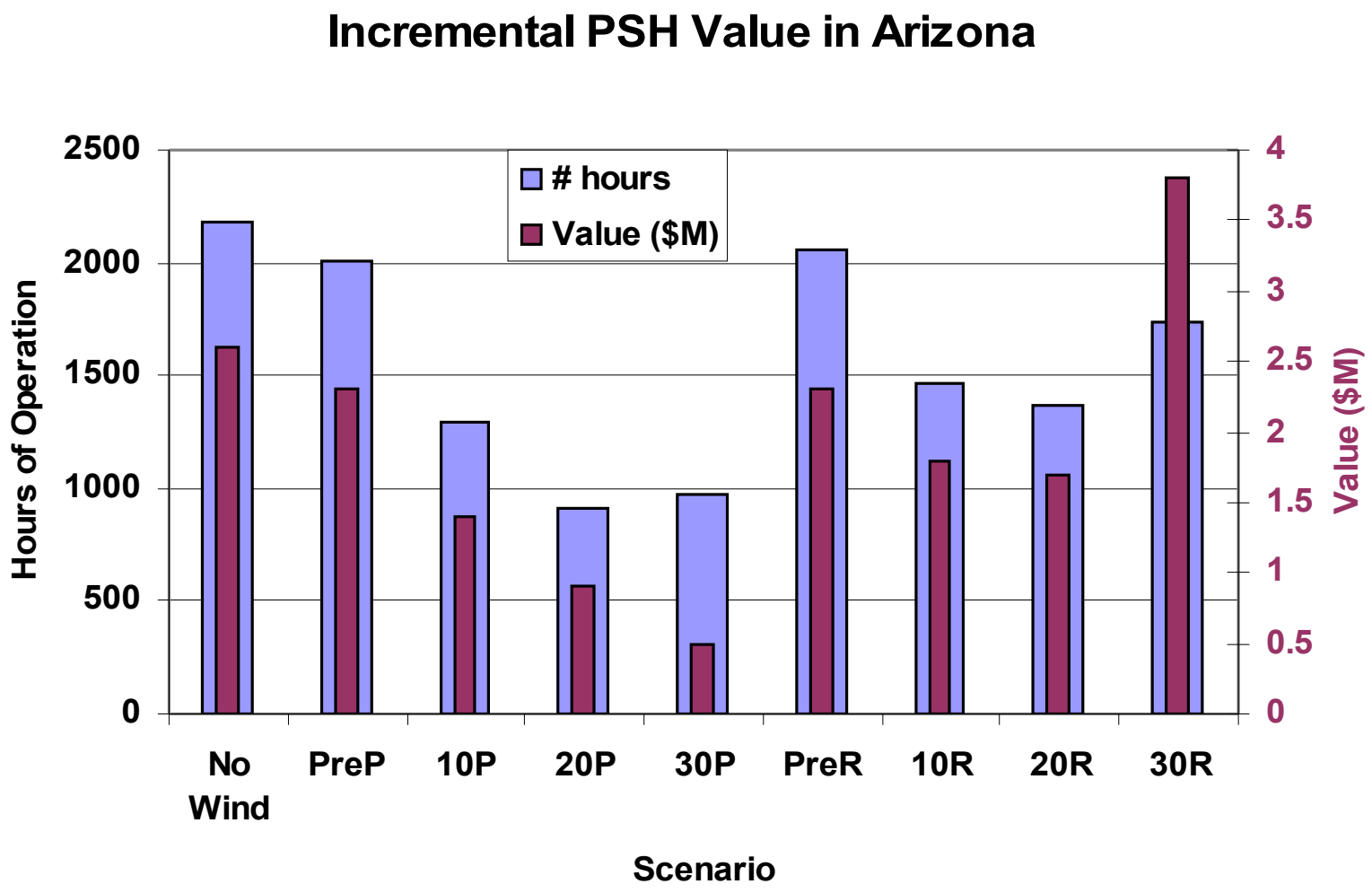
imagination at work

AZN Spot Prices - Wk of April 10th



AZN Spot Prices - Wk of April 10th





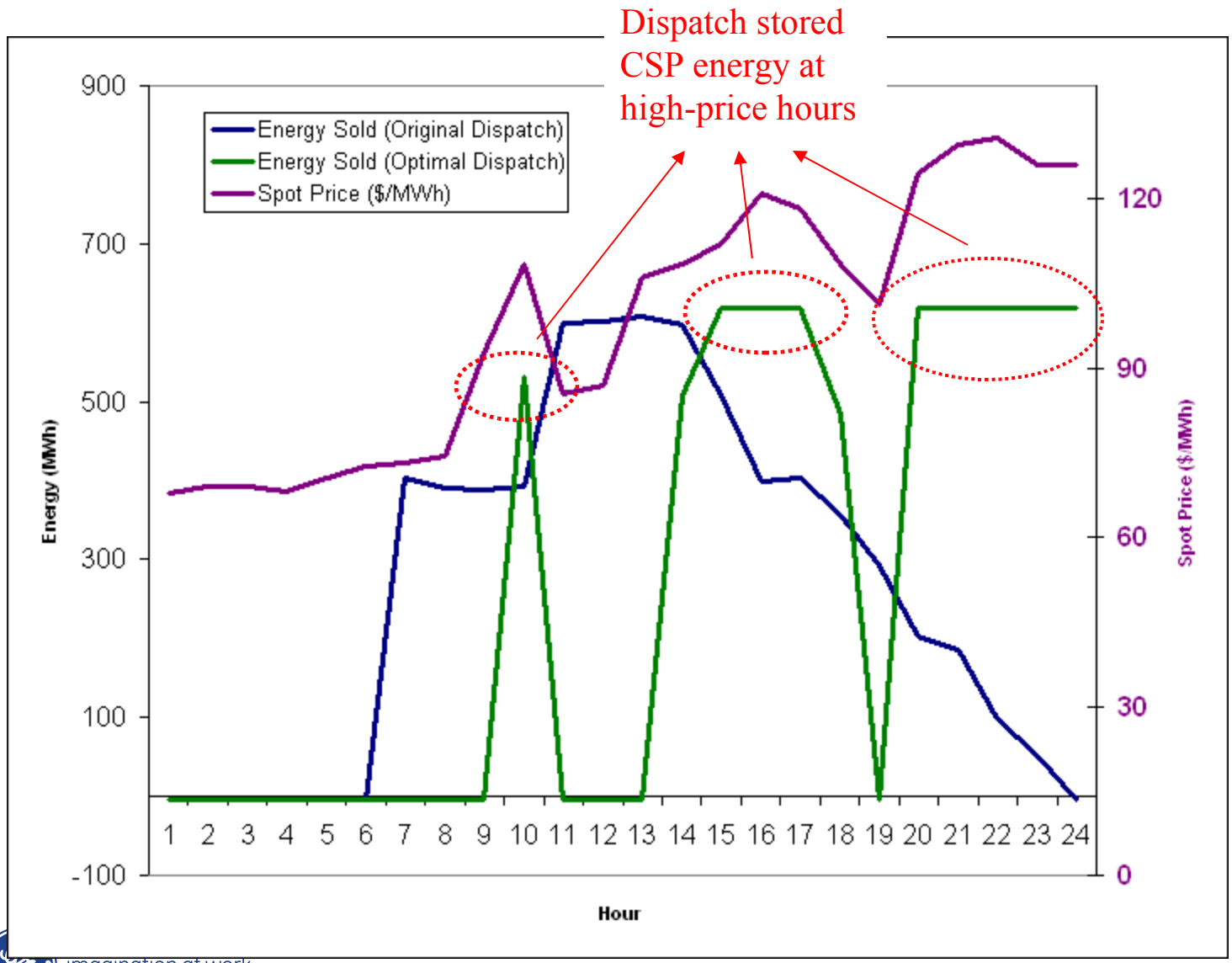
Value is at far less than the cost of a new PSH unit.

imagination at work

CSP Optimal Dispatch Method

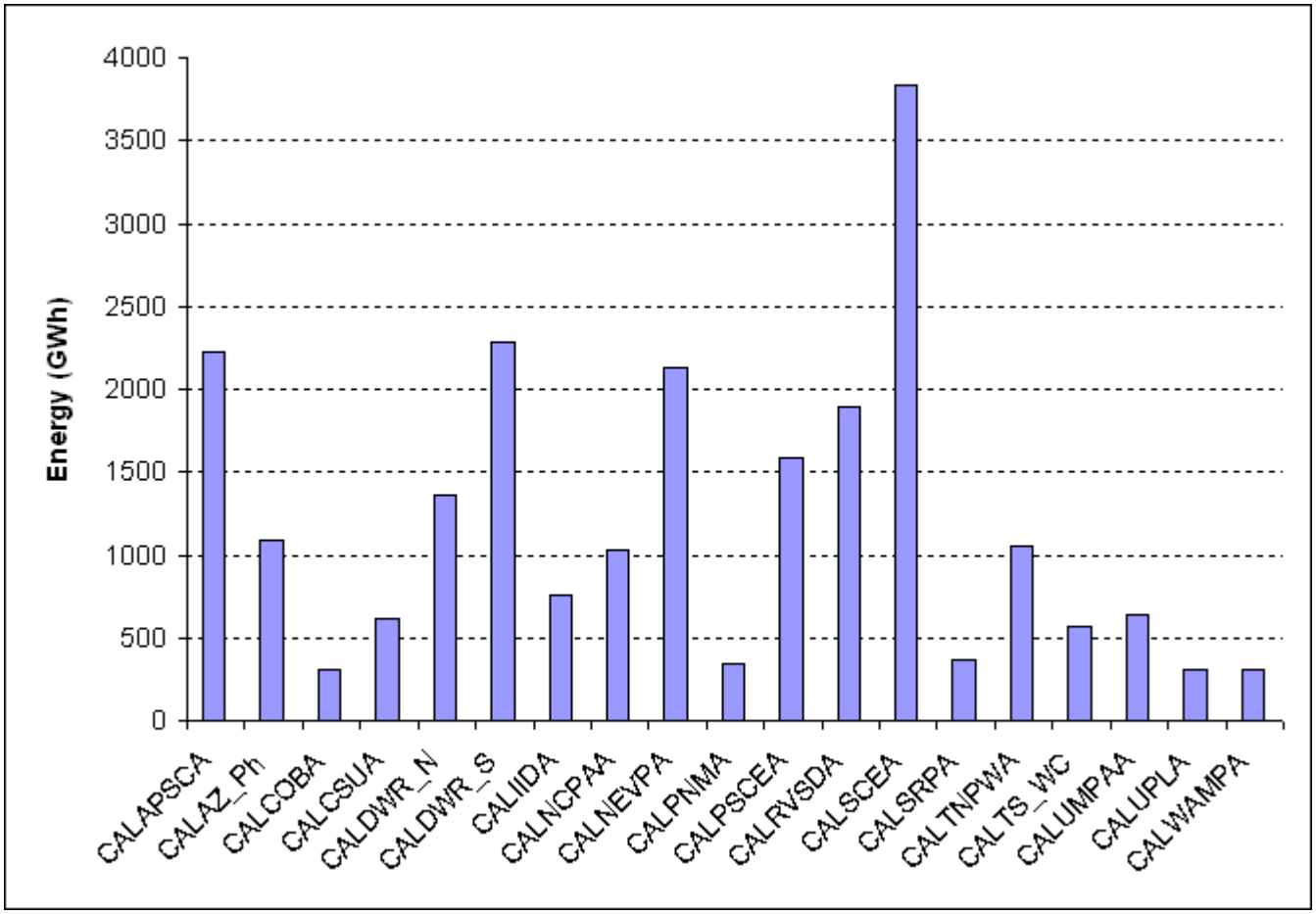
- We build a dispatch model with varying hours of storage to determine the operation of CSP plants.
- The dispatch model is optimized to maximize the yearly revenue subject to constraints on CSP operation.
- Revenue-maximization is done on a daily basis (24 hours).
- Linear program is used to formulate the dispatch model.
- CSP data and spot price data are based on the Local Priority, 30% penetration scenario.

Example of CSP Optimal Dispatch (CALAPSCA Site, 6 hours of Storage, August 9)



In this example, the daily revenue was increased from $656781 to $772376, a 17.6% increase.

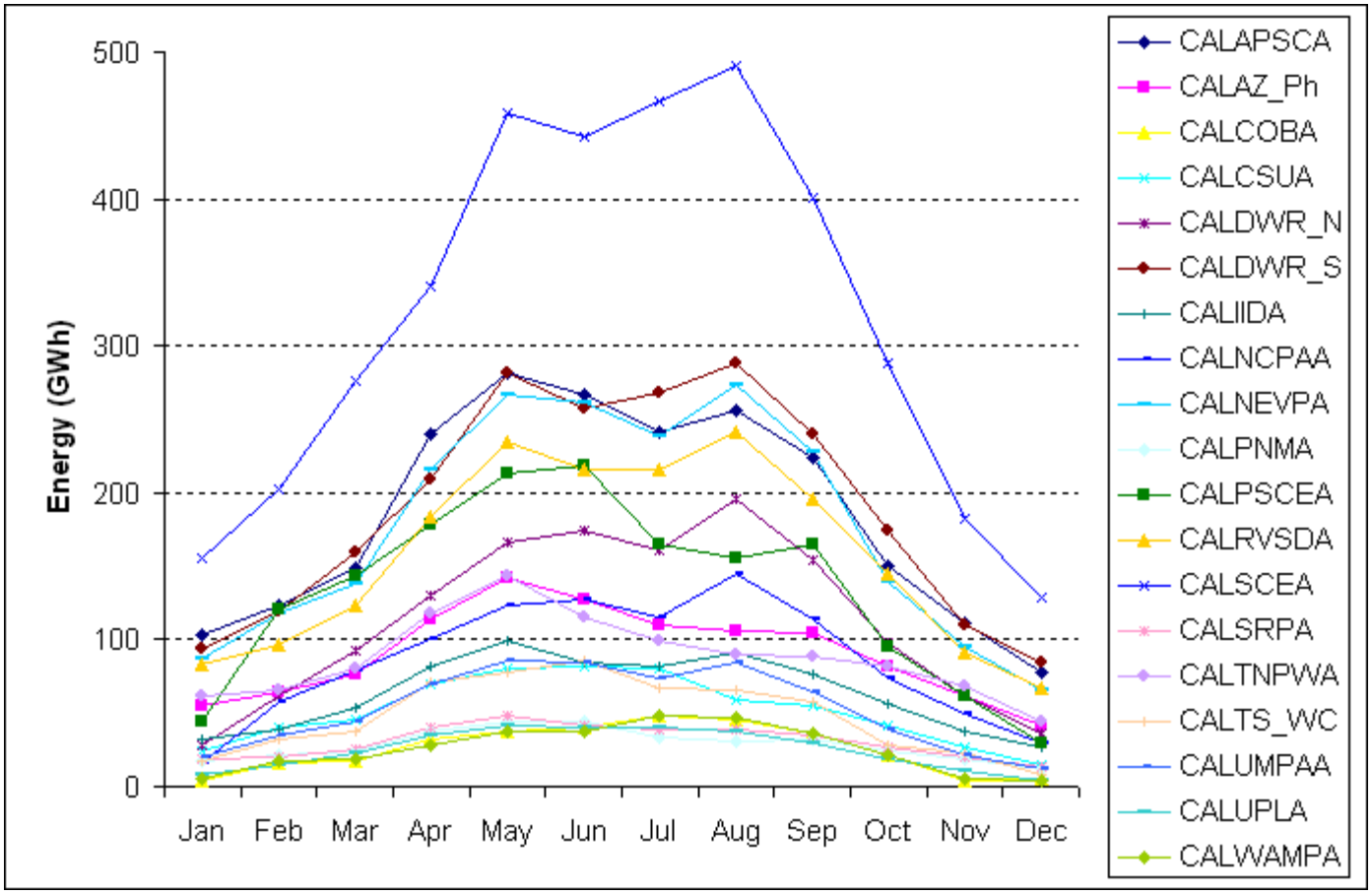
Yearly CSP Energy



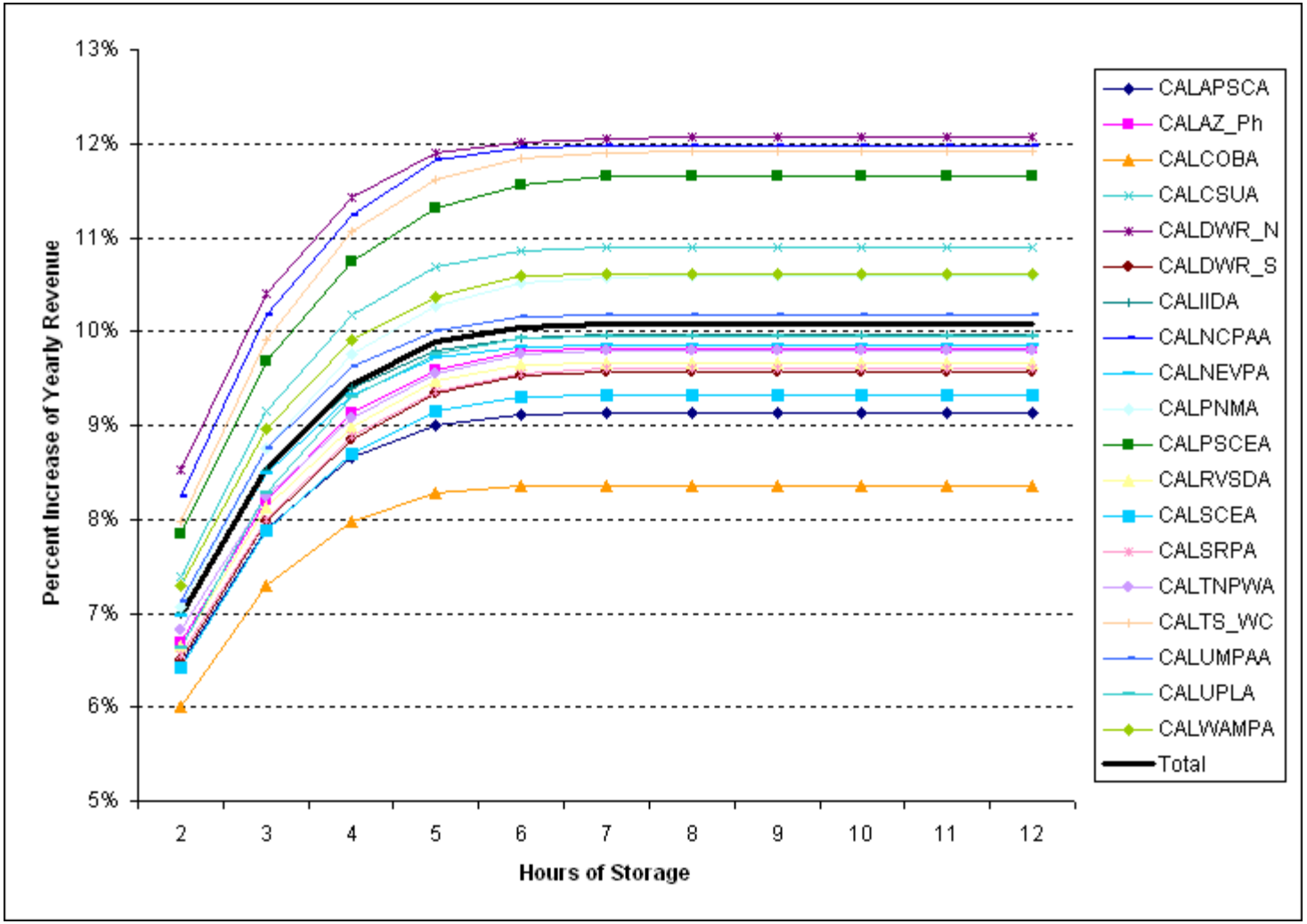
Total Yearly CSP Energy = 22697 GWh

imagination at work

Monthly CSP Energy



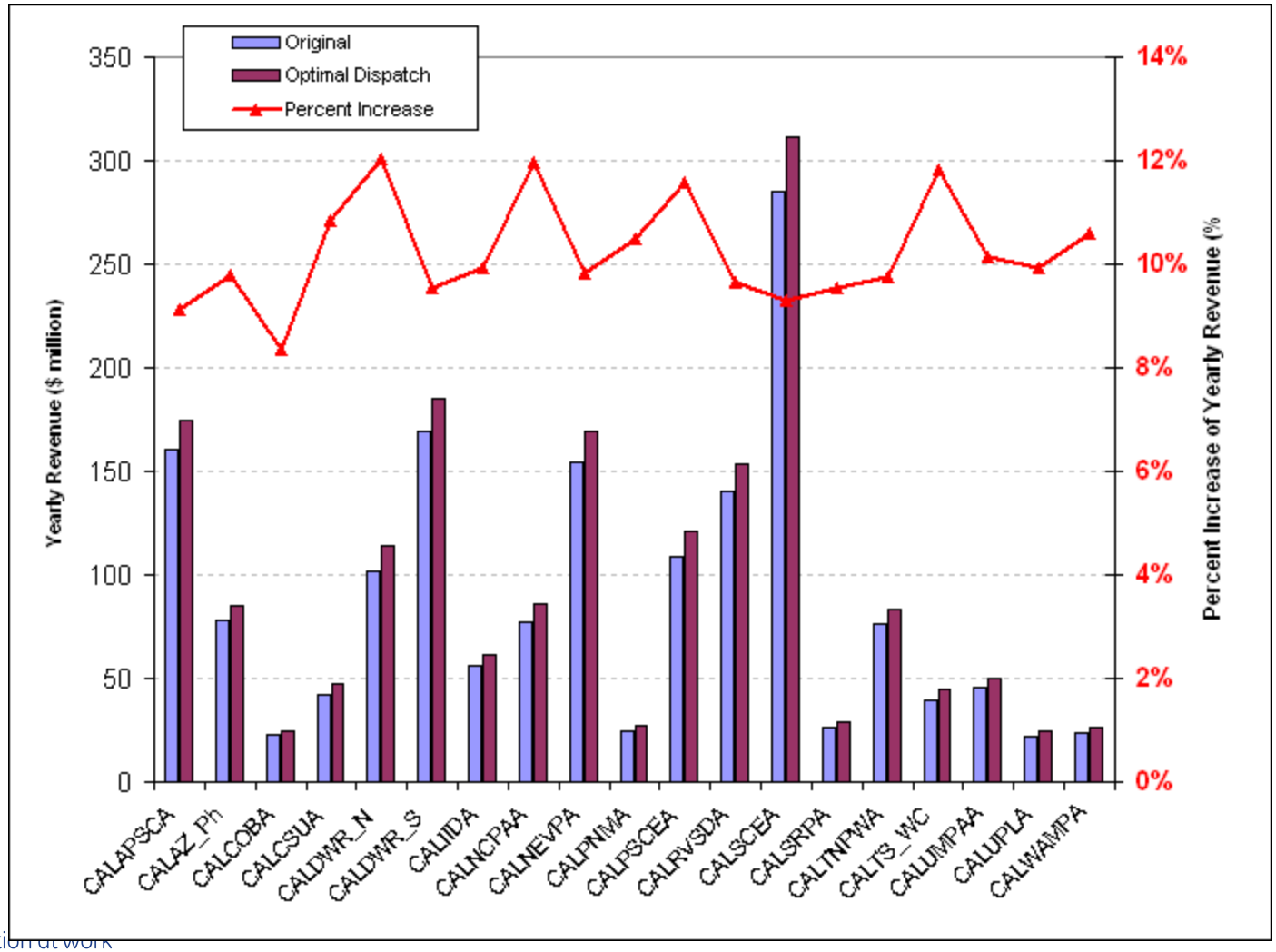
Yearly CSP Revenue Increase vs. Hours of Storage



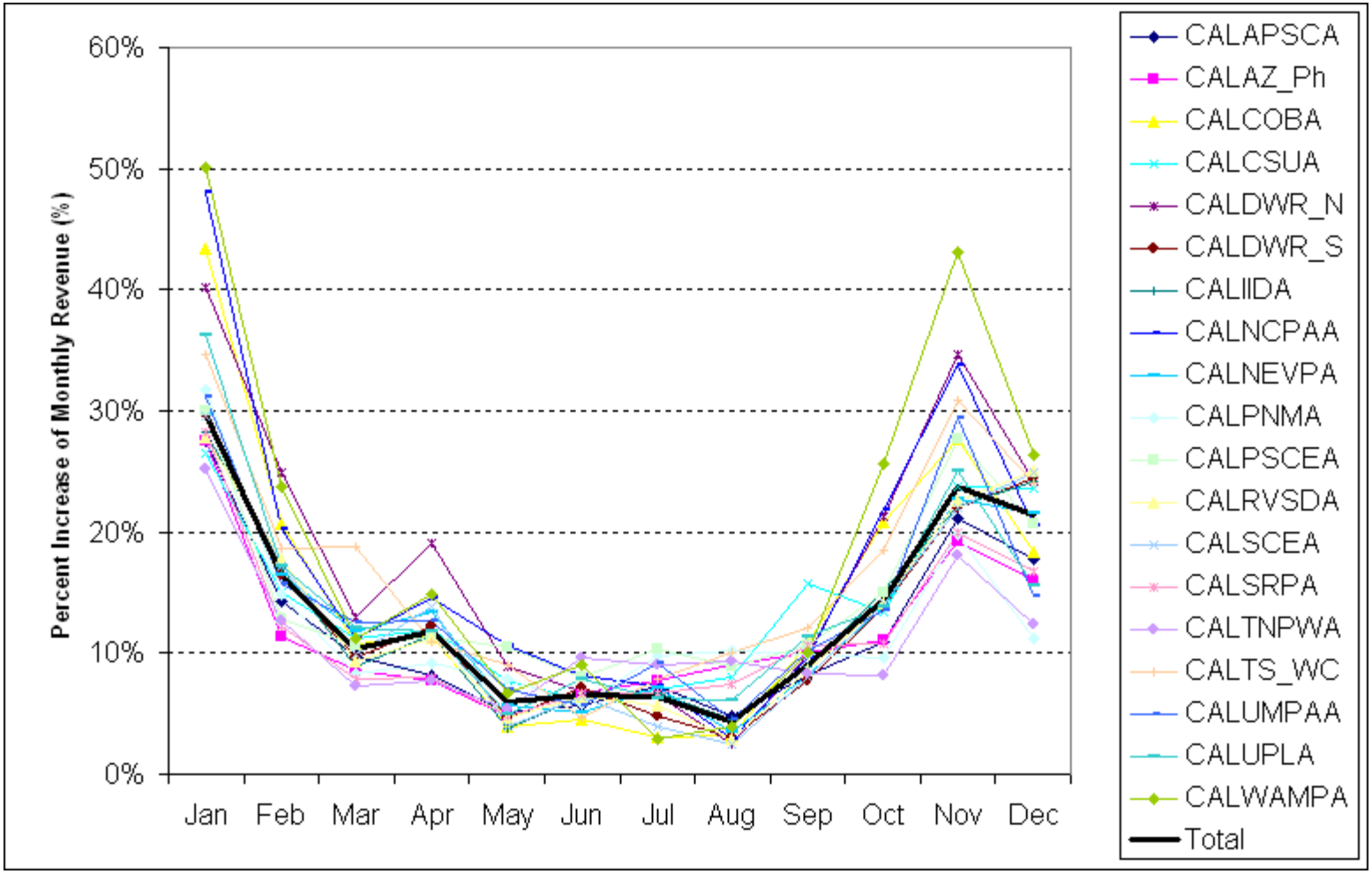
imagination at work

6 Hours of Storage Seems Reasonable

Yearly CSP Revenue Increase (6 Hours of Storage)

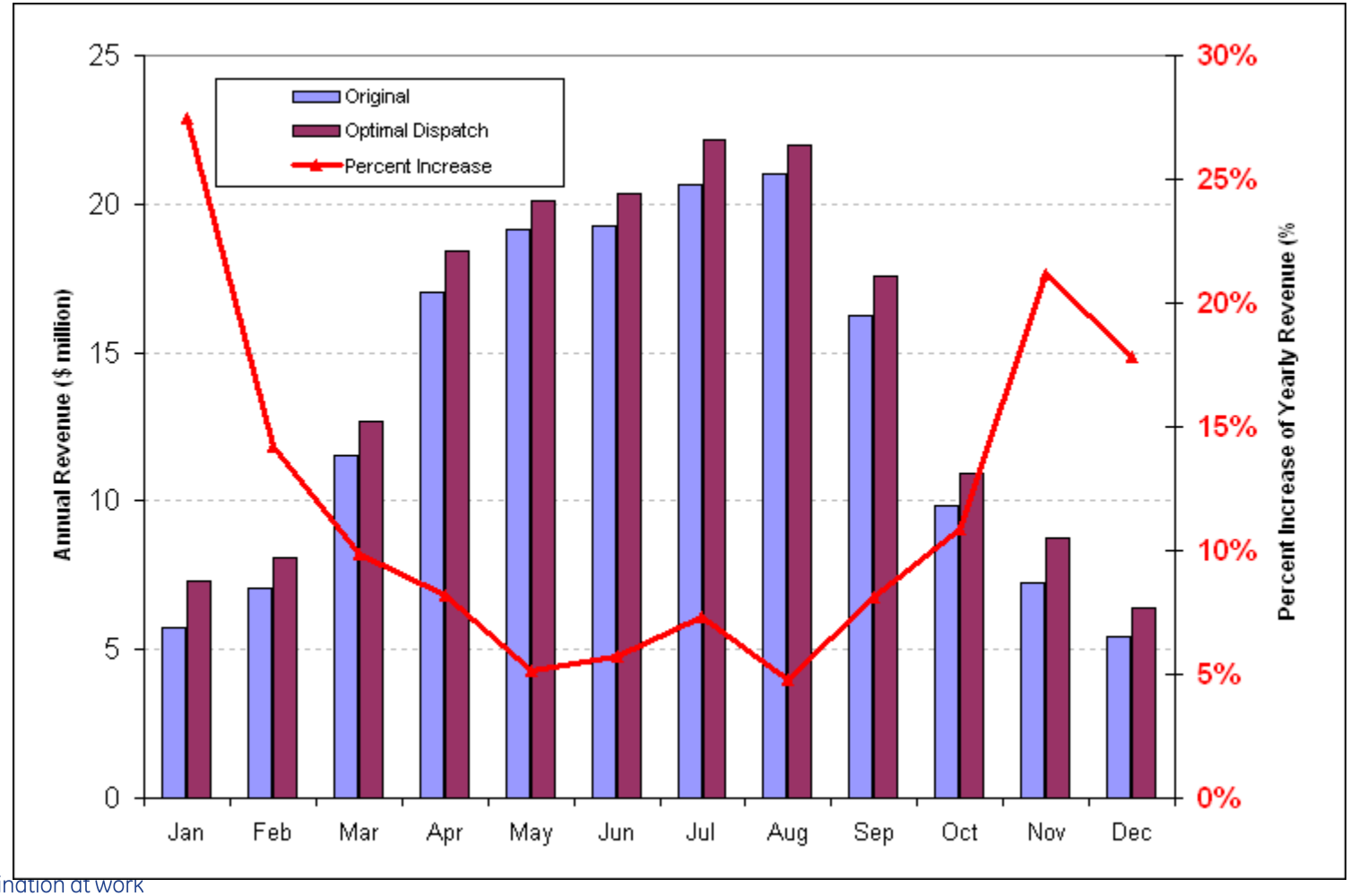


Monthly CSP Revenue Increase (6 Hours of Storage)



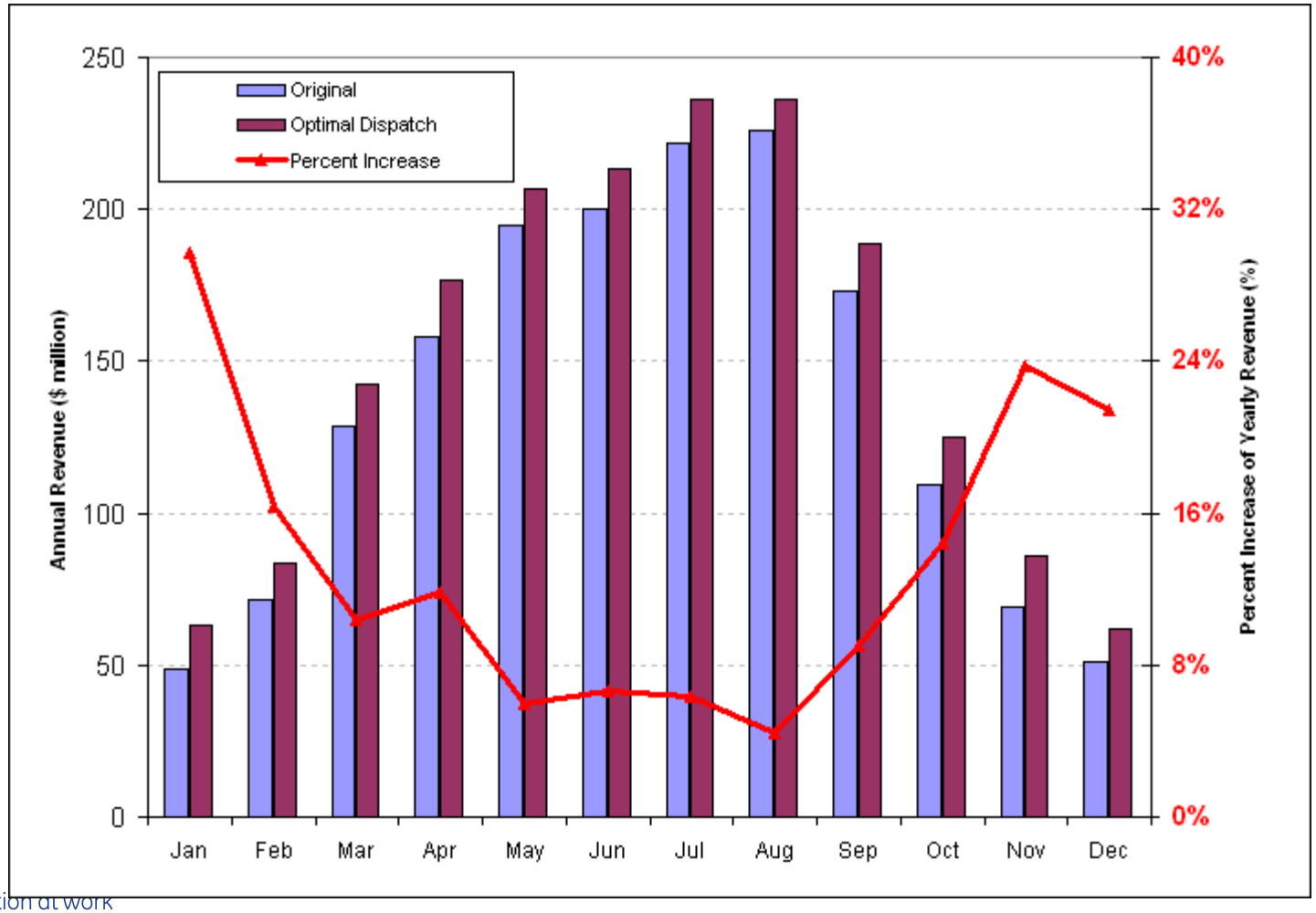
imagination at work

Monthly CSP Revenue Increase at CALAPSCA (6 Hours of Storage)



imagination at work

Total Monthly CSP Revenue Increase (6 Hours of Storage)



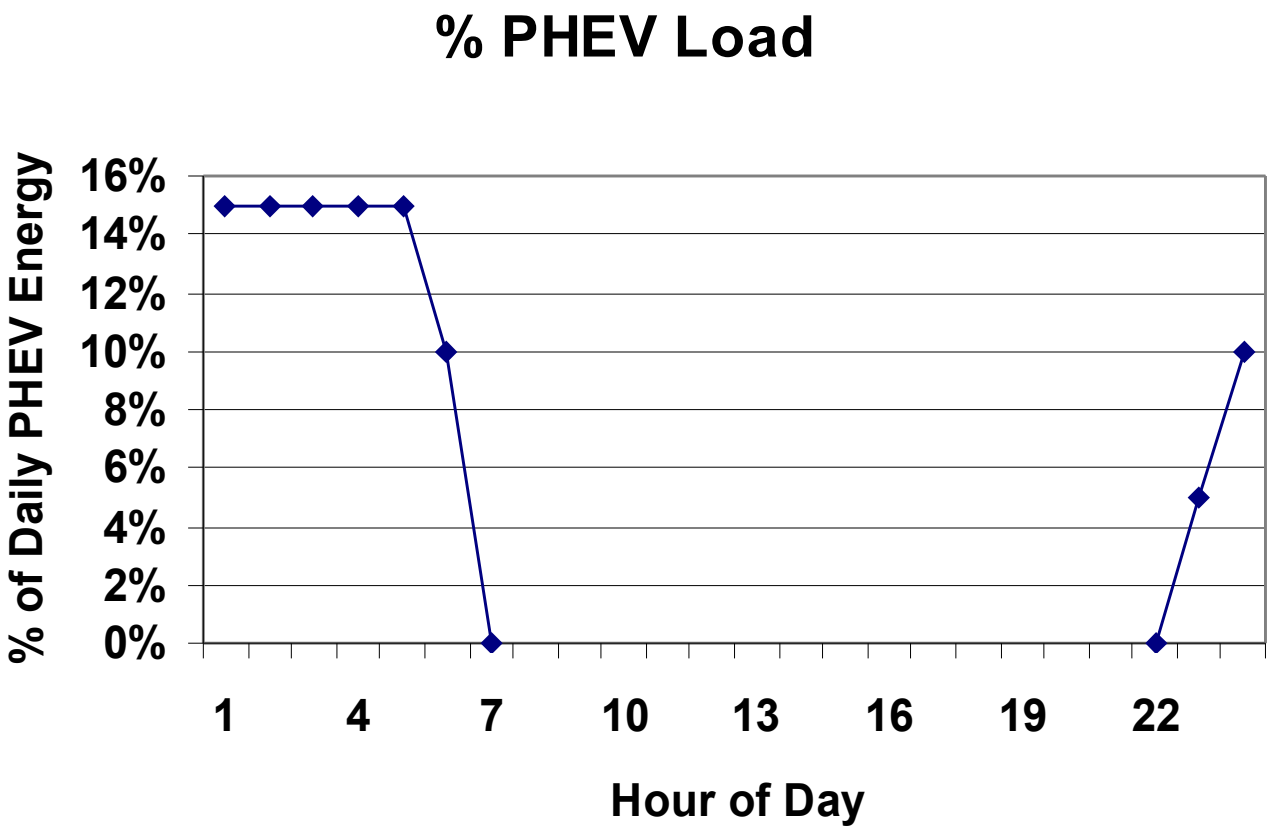
imagination at work

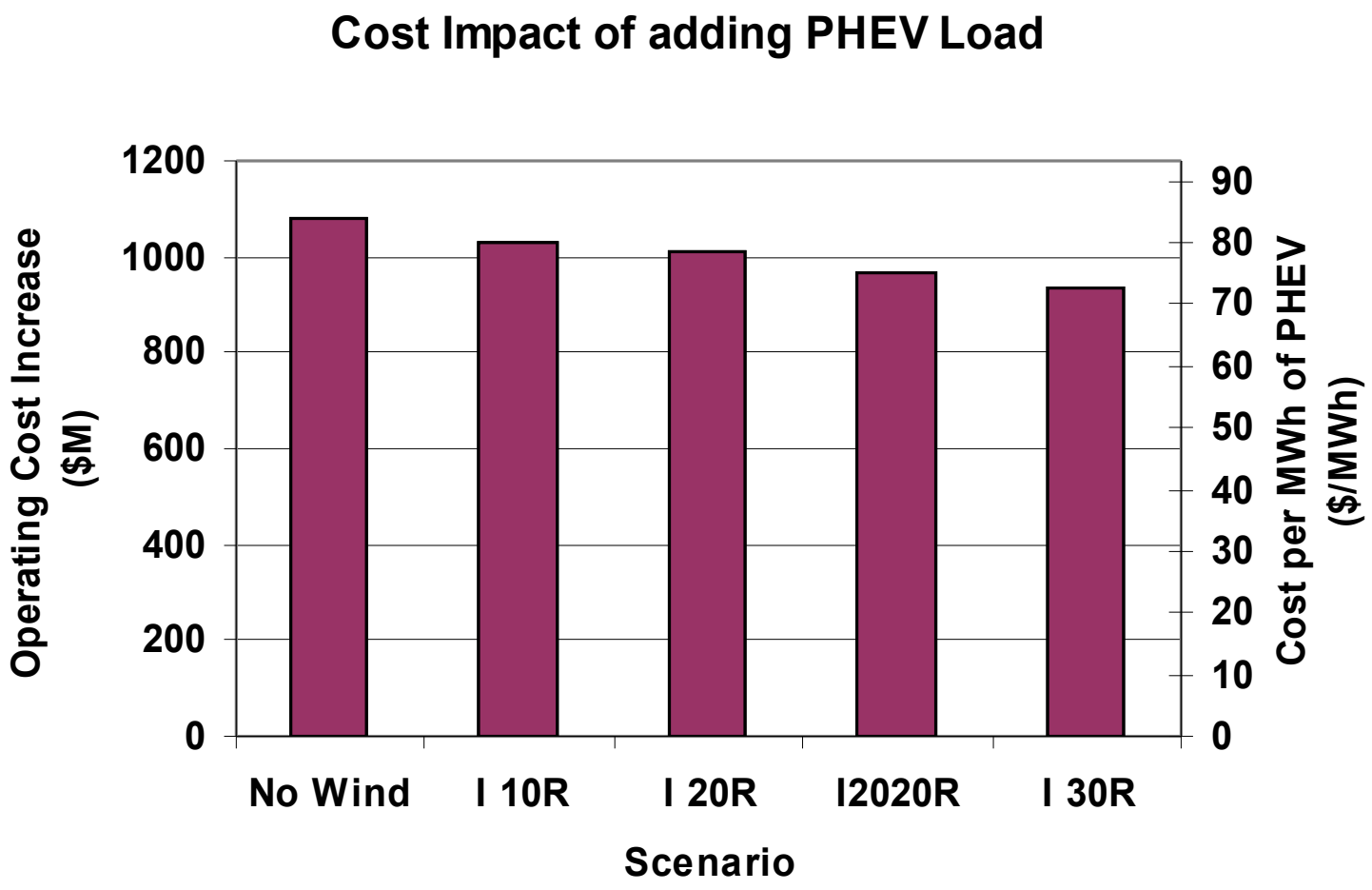
PHEV Operation

- Load profiles were added to simulate a high penetration of PHEV.
- System was simulated with and without renewables.

- Values assume 15% penetration of PHEVs for light duty vehicles and 3% penetration for heavy duty.
- Maximum offpeak load increase = 15% of daily energy ~ 5300 MW

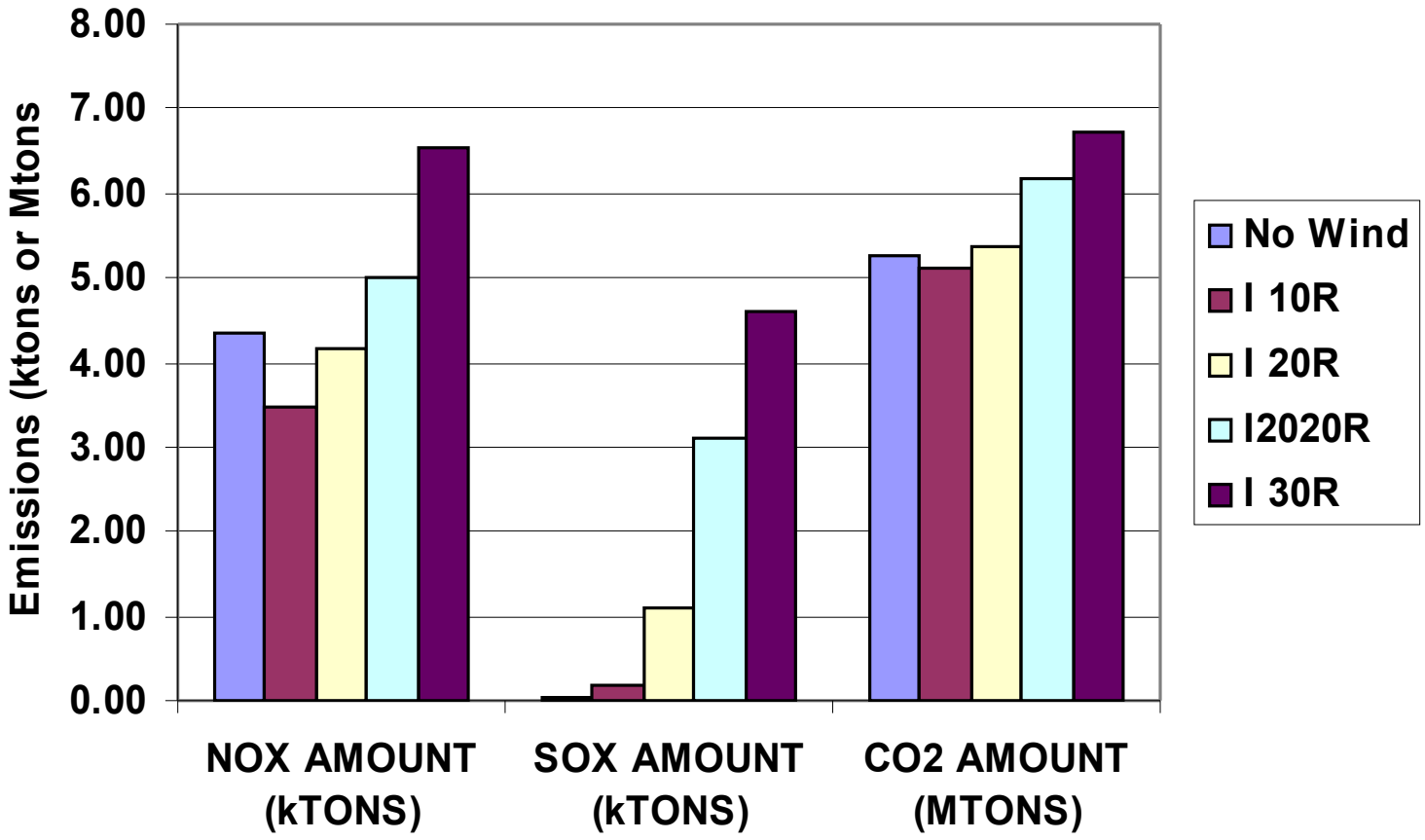
	PHEV Daily Load (MWh)	Annual PHEV Load (GWh)
Arizona	2,558	934
California	21,734	7,933
Colorado	1,051	384
Idaho	704	257
Montana	585	213
Nevada	812	296
New Mexico	885	323
Oregon	1,734	633
Utah	1,312	479
Washington	3,547	1,295
Wyoming	327	119
WECC	35,248	12,865


% PHEV Load
% of Daily PHEV Energy
16%
14%
12%
10%
8%
6%
4%
2%
0%
1
4
7
10
13
16
19
22
Hour of Day

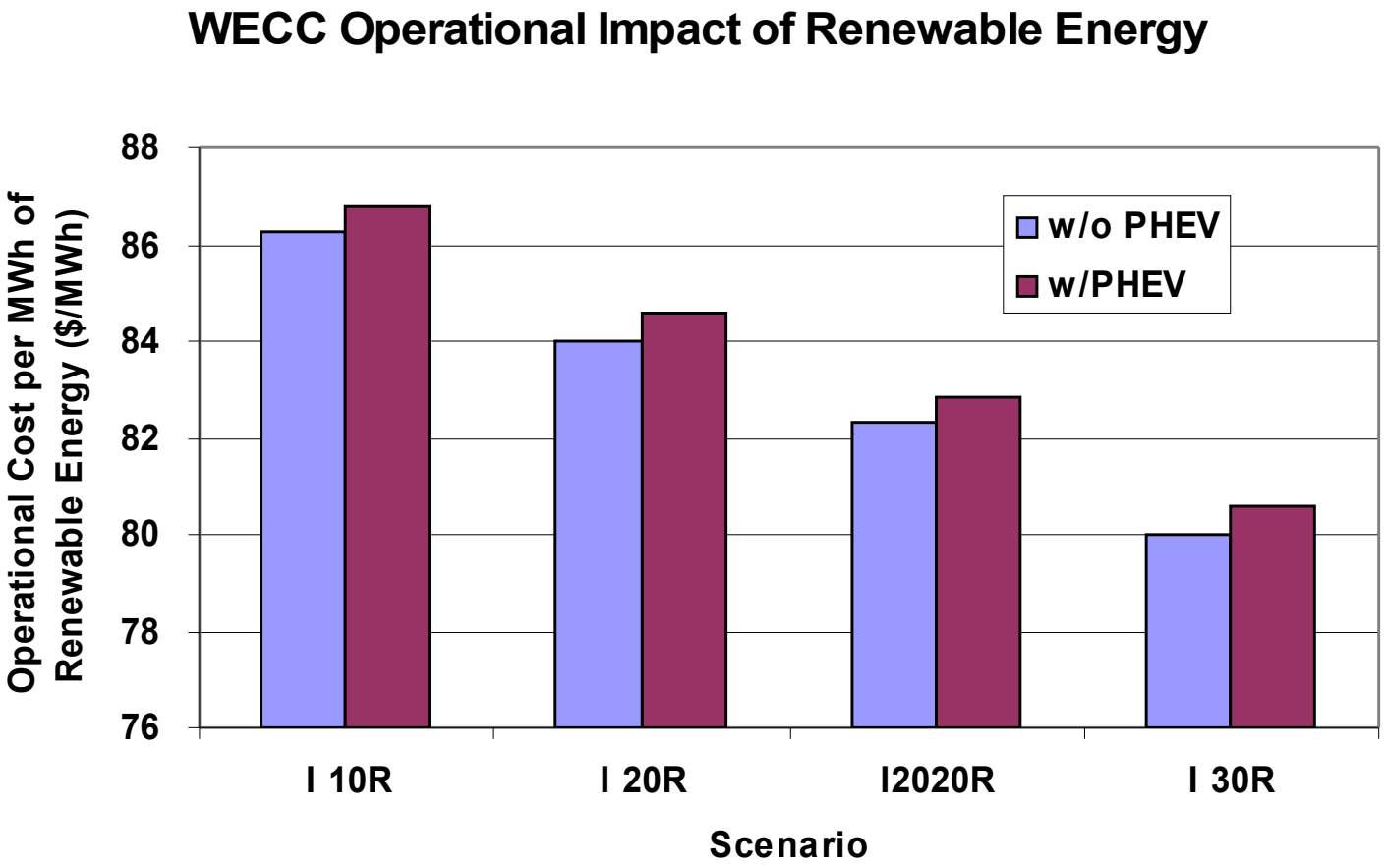


imagination at work

Emission Impact of Adding PHEV Loads

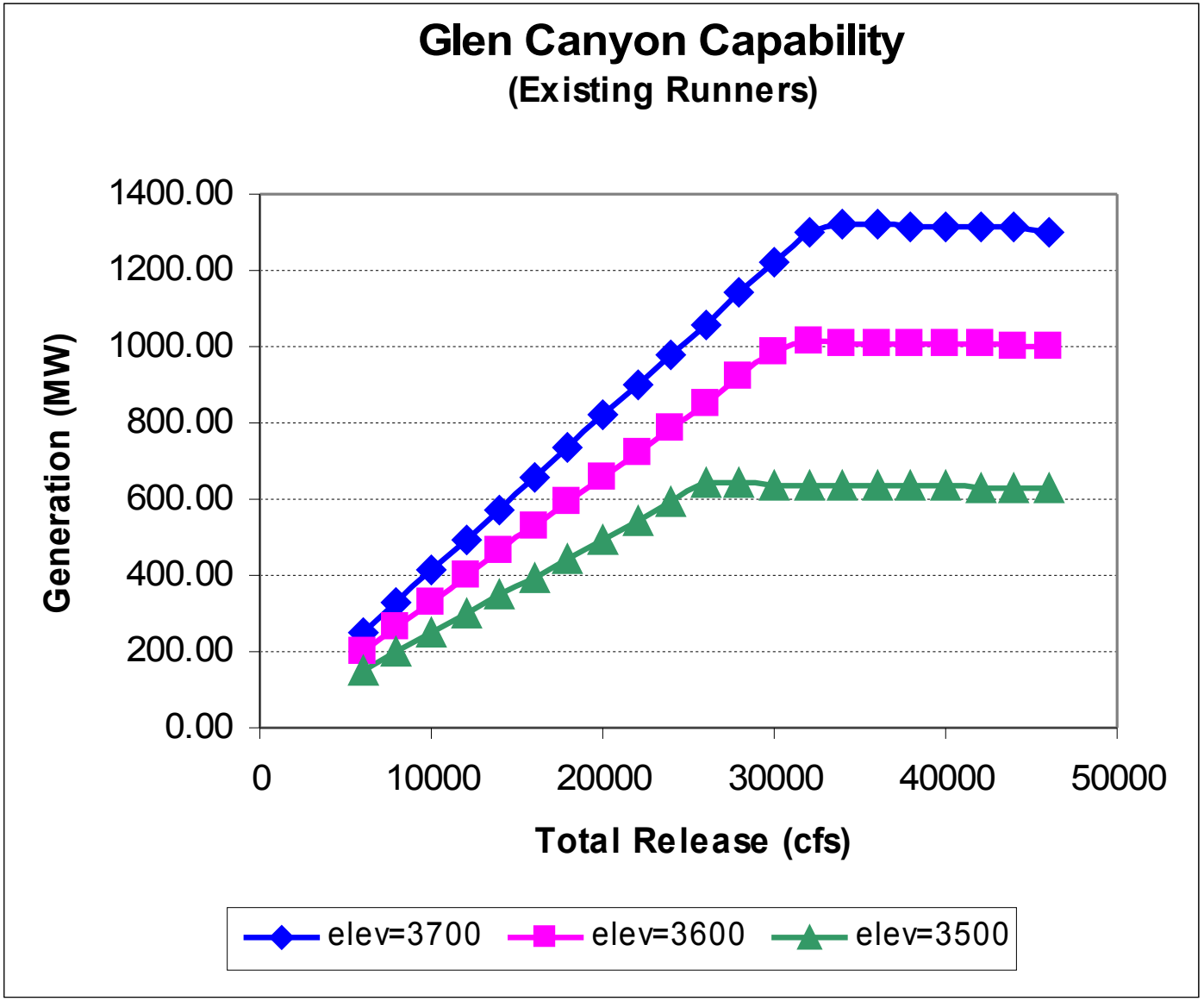


imagination at work

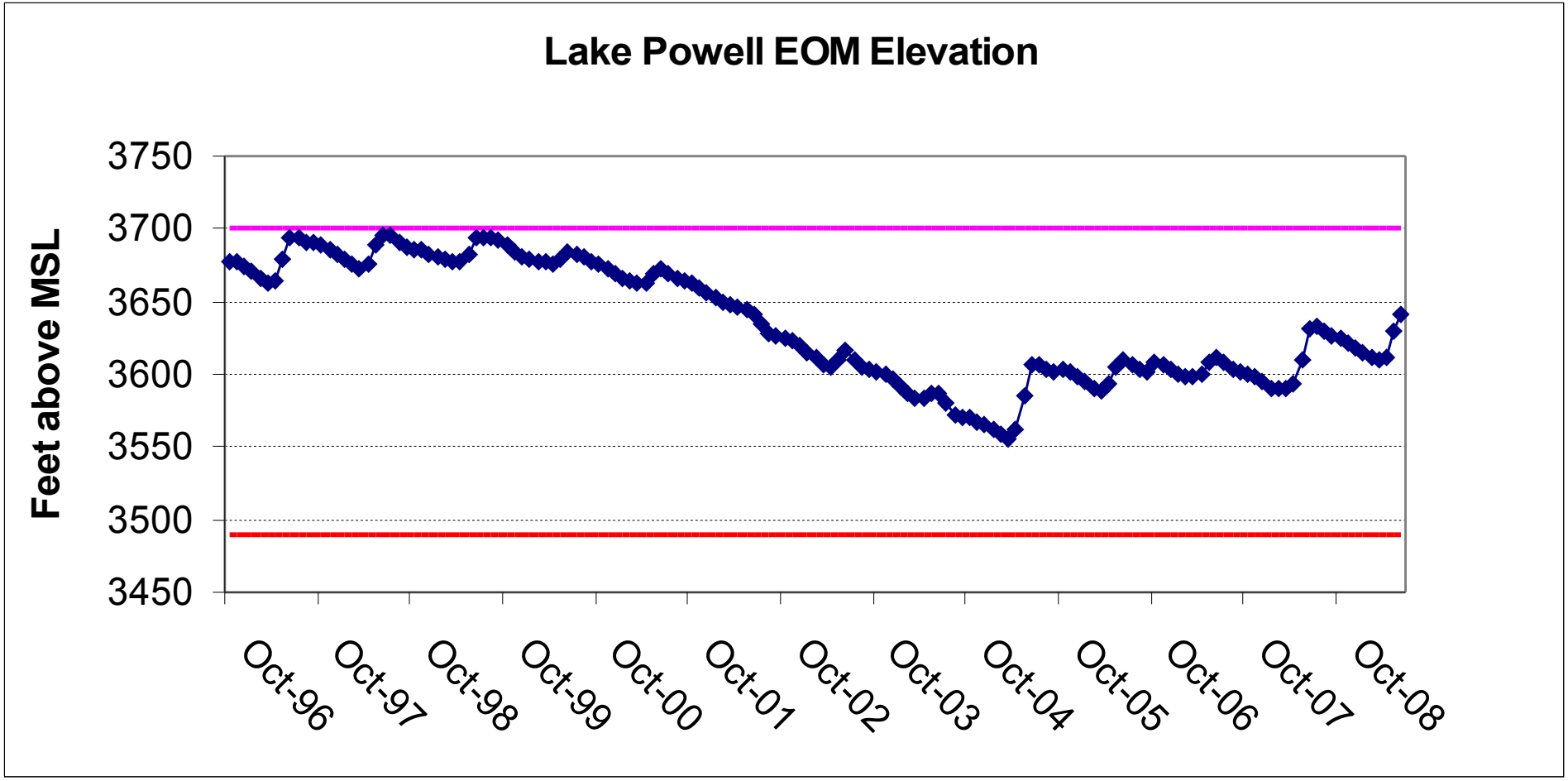

WECC Operational Impact of Renewable Energy
Operational Cost per MWh of Renewable Energy ($/MWh)
88
86
84
82
80
78
76
w/o PHEV
w/PHEV
I 10R
I 20R
I2020R
I 30R
Scenario

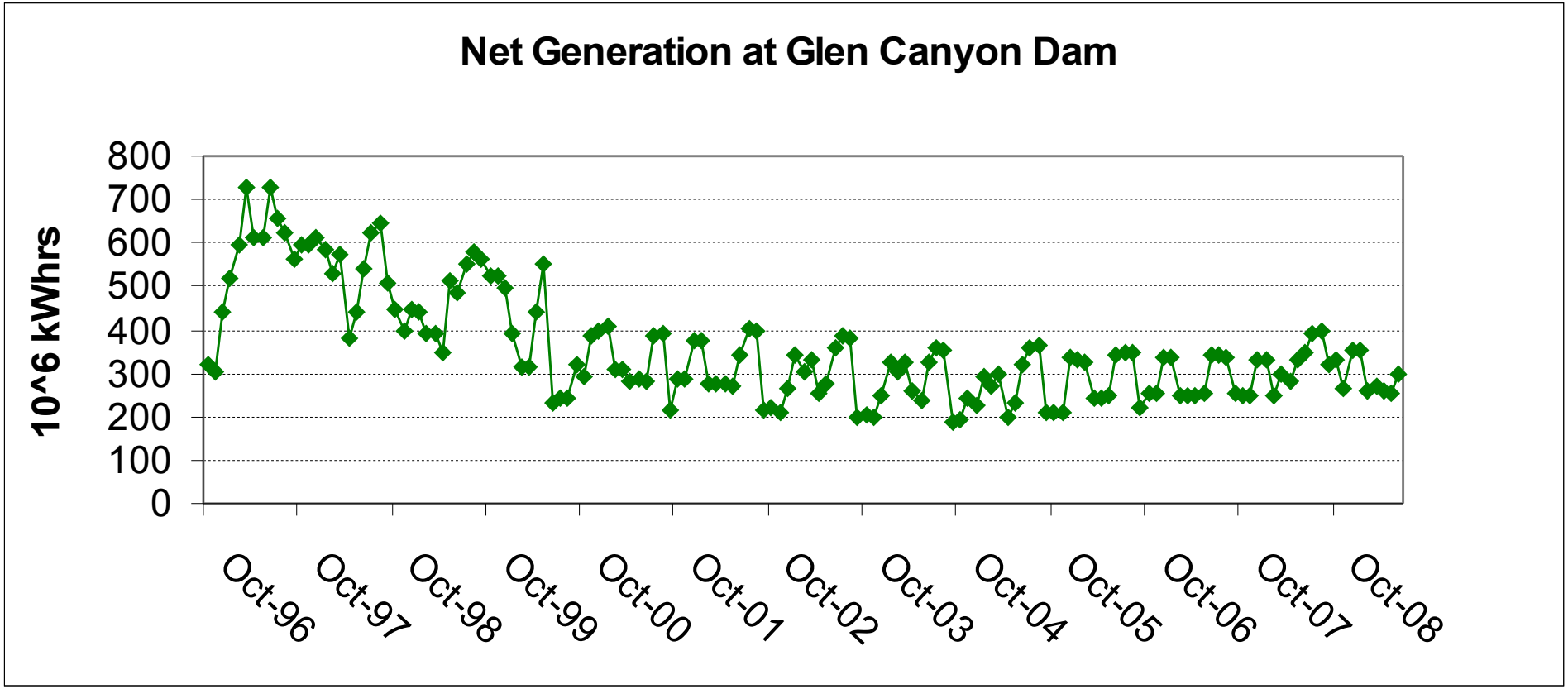
Hydro Flexibility

- Base operation allowed more flexibility on hydro plants than is apparently available.
- New cases were run with reduced hydro capacities to flatten the hydro operation.



imagination at work


Lake Powell EOM Elevation
Feet above MSL
3750
3700
3650
3600
3550
3500
3450
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07
Oct-08



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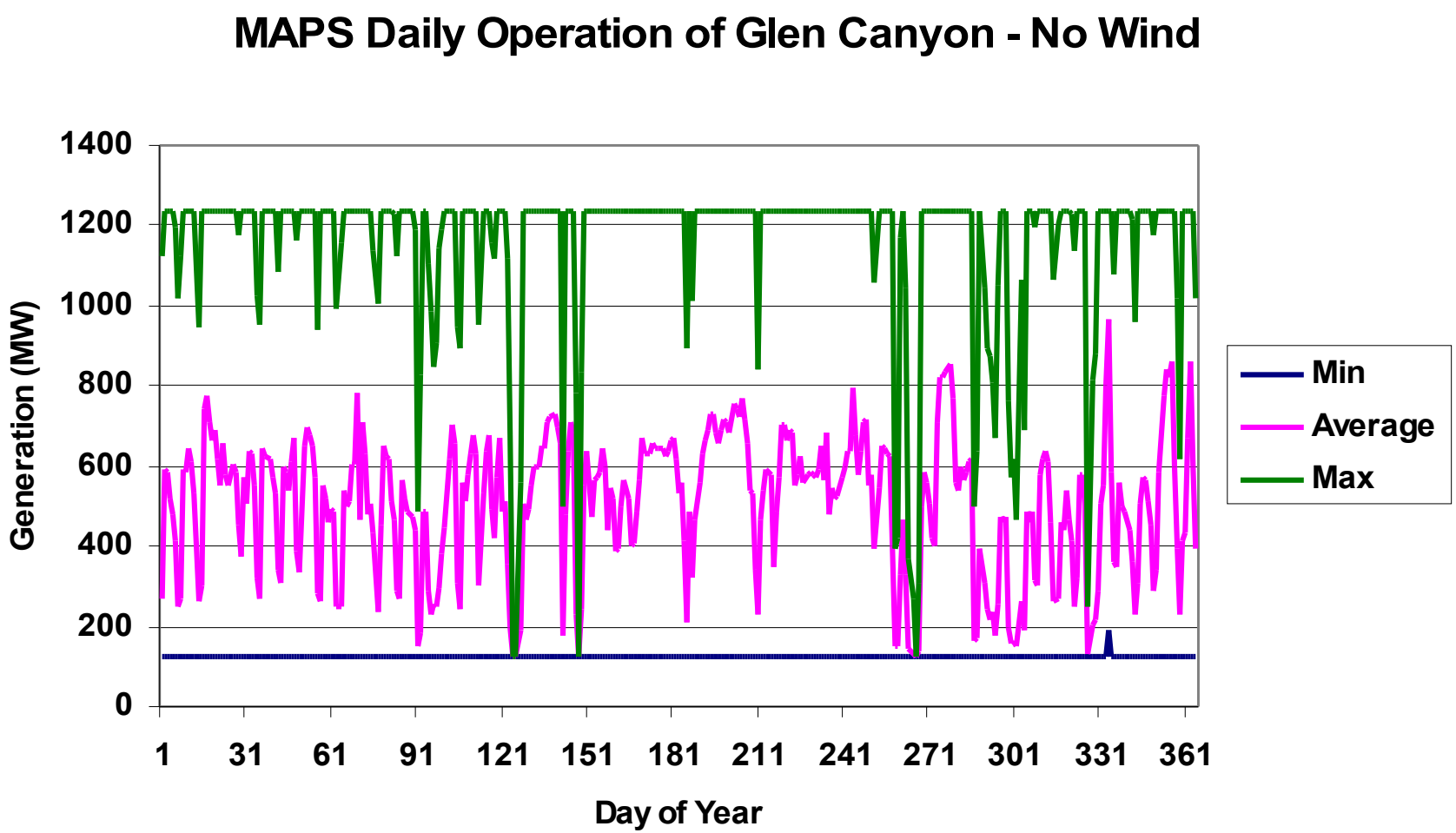

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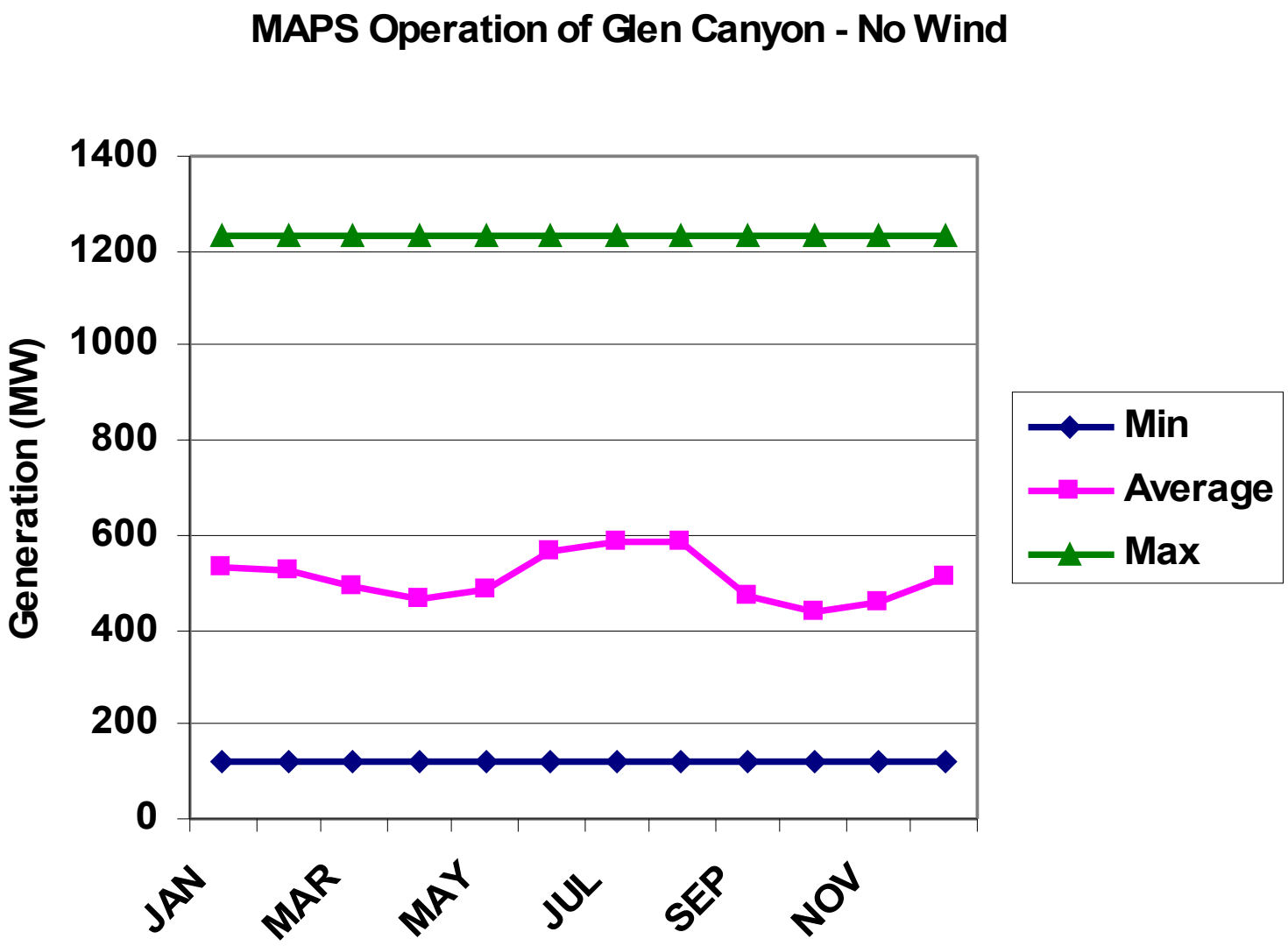
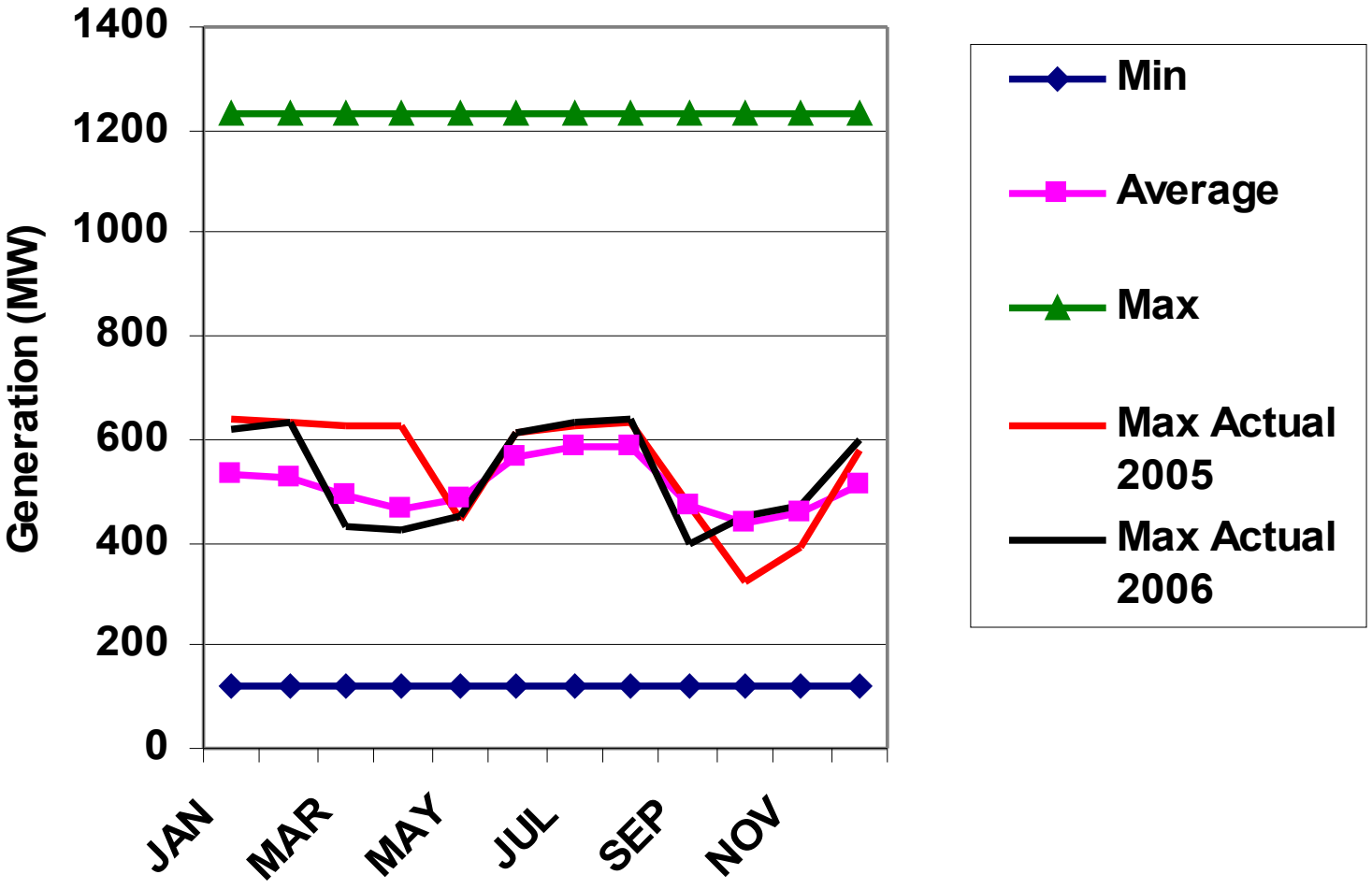
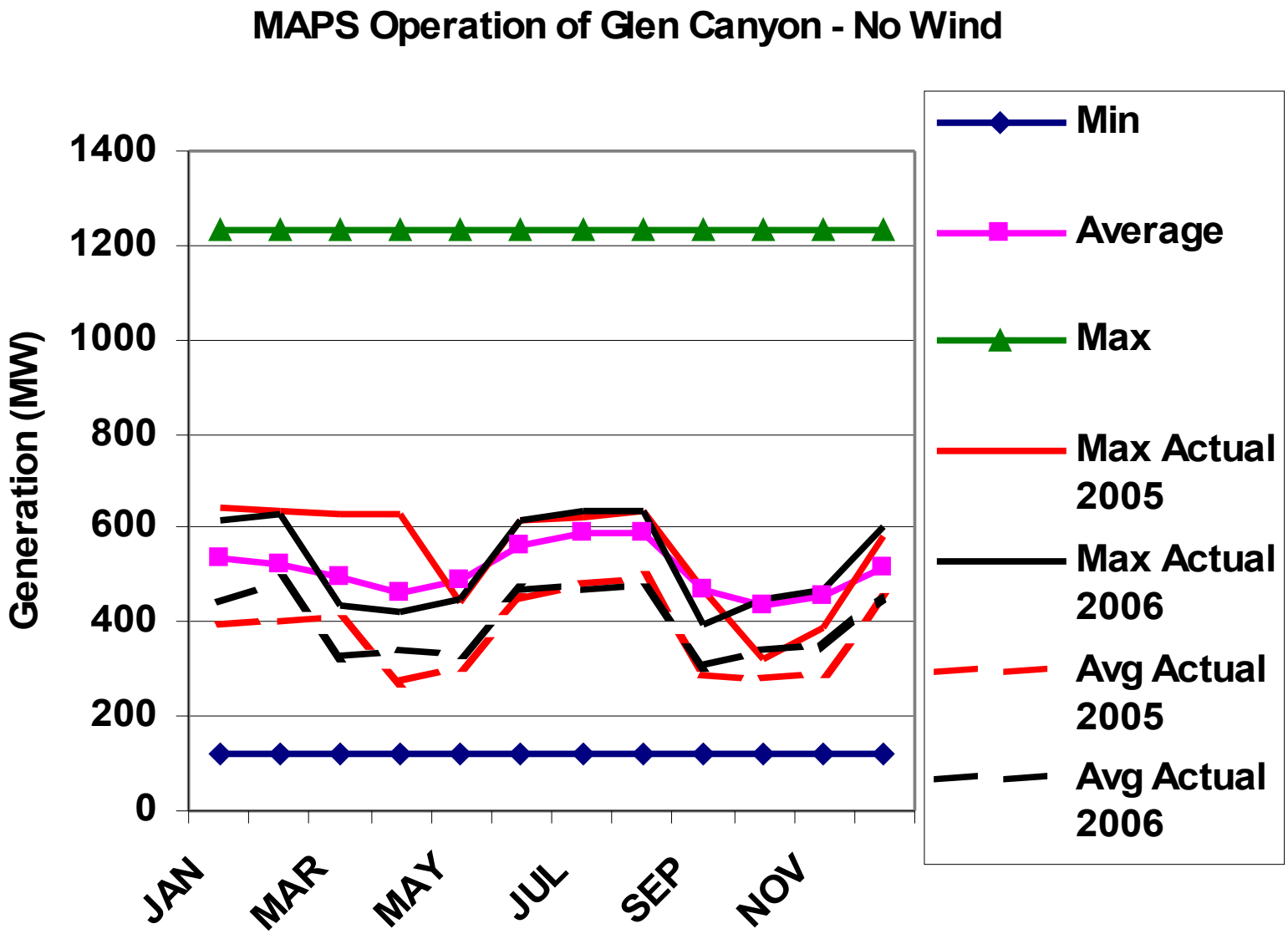

MAPS Operation of Glen Canyon - No Wind
Generation (MW)
1400
1200
1000
800
600
400
200
0
JAN
MAR
MAY
JUL
SEP
NOV
Min
Average
Max

MAPS Operation of Glen Canyon - No Wind

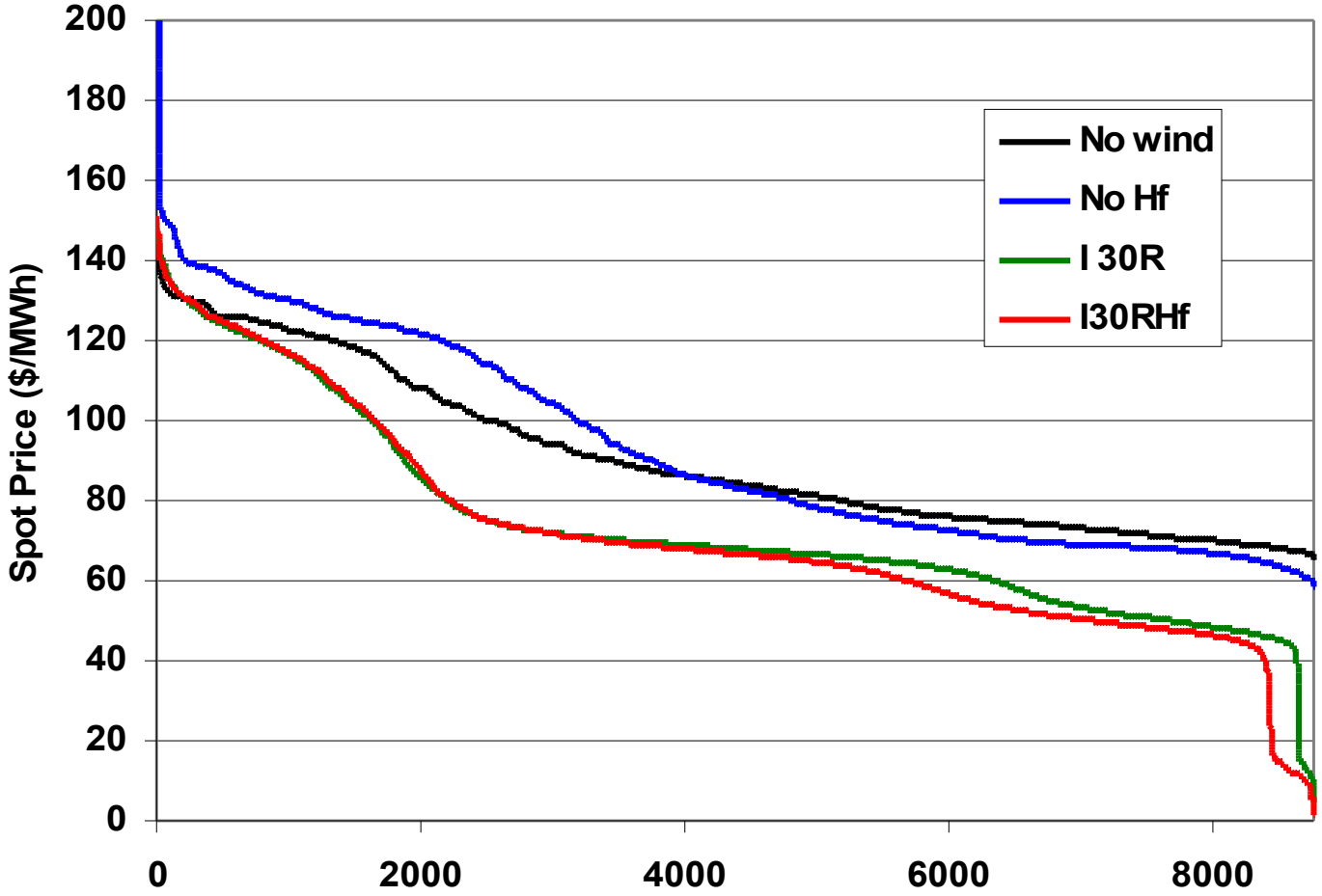


imagination at work



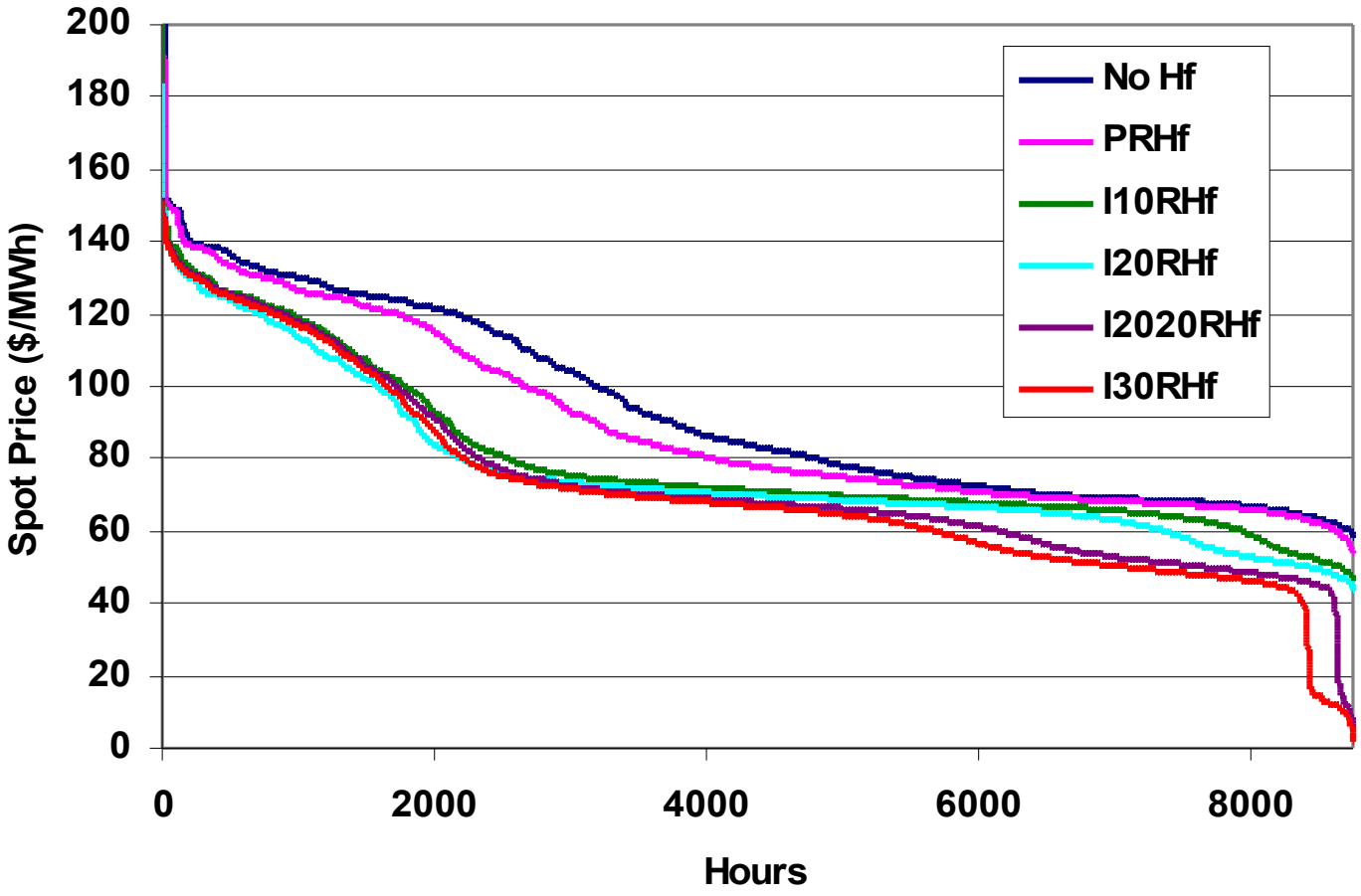
imagination at work

Spot Price Impact of Flat Hydro



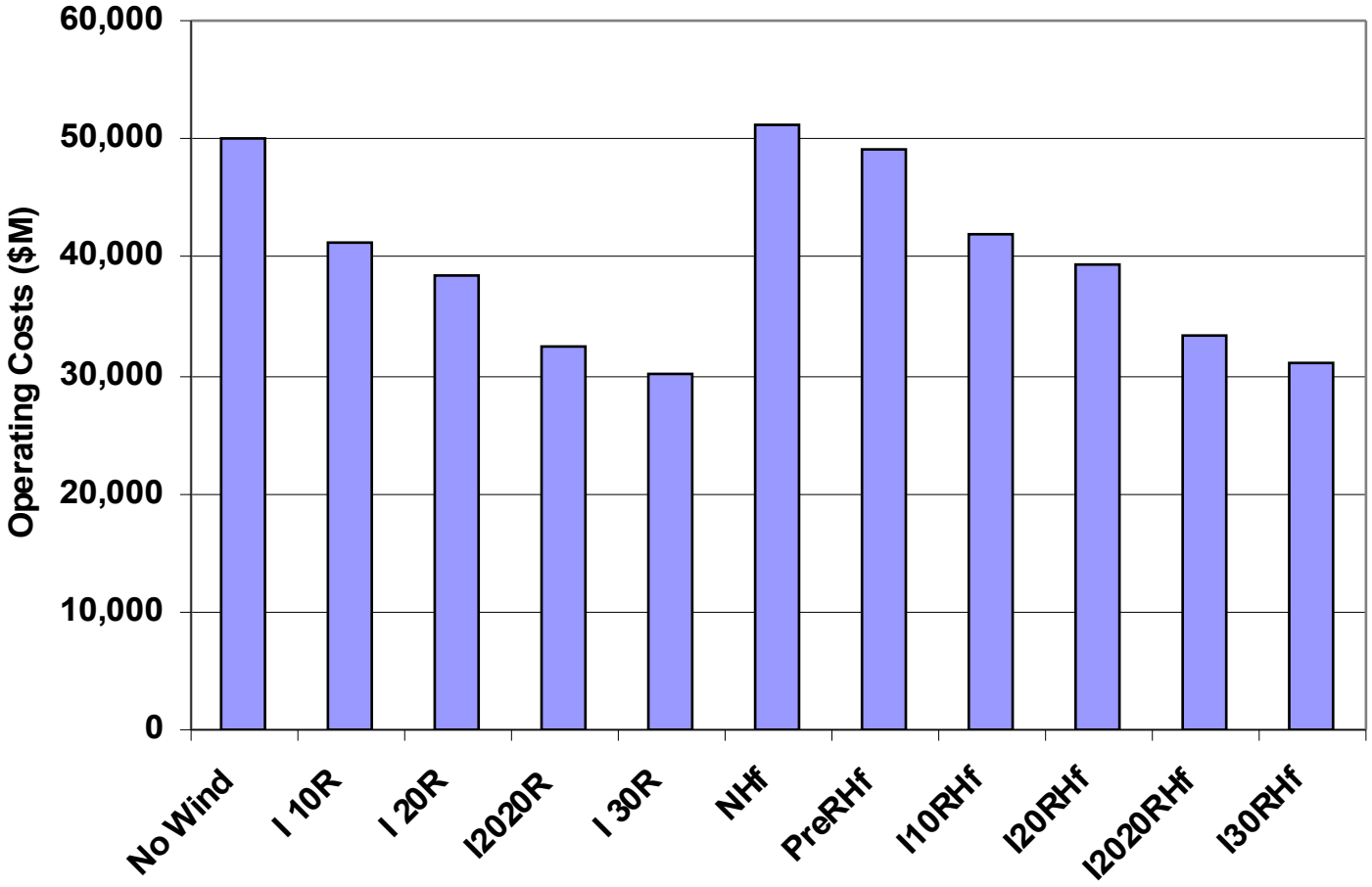
imagination at work

Spot Price Impact of Flat Hydro

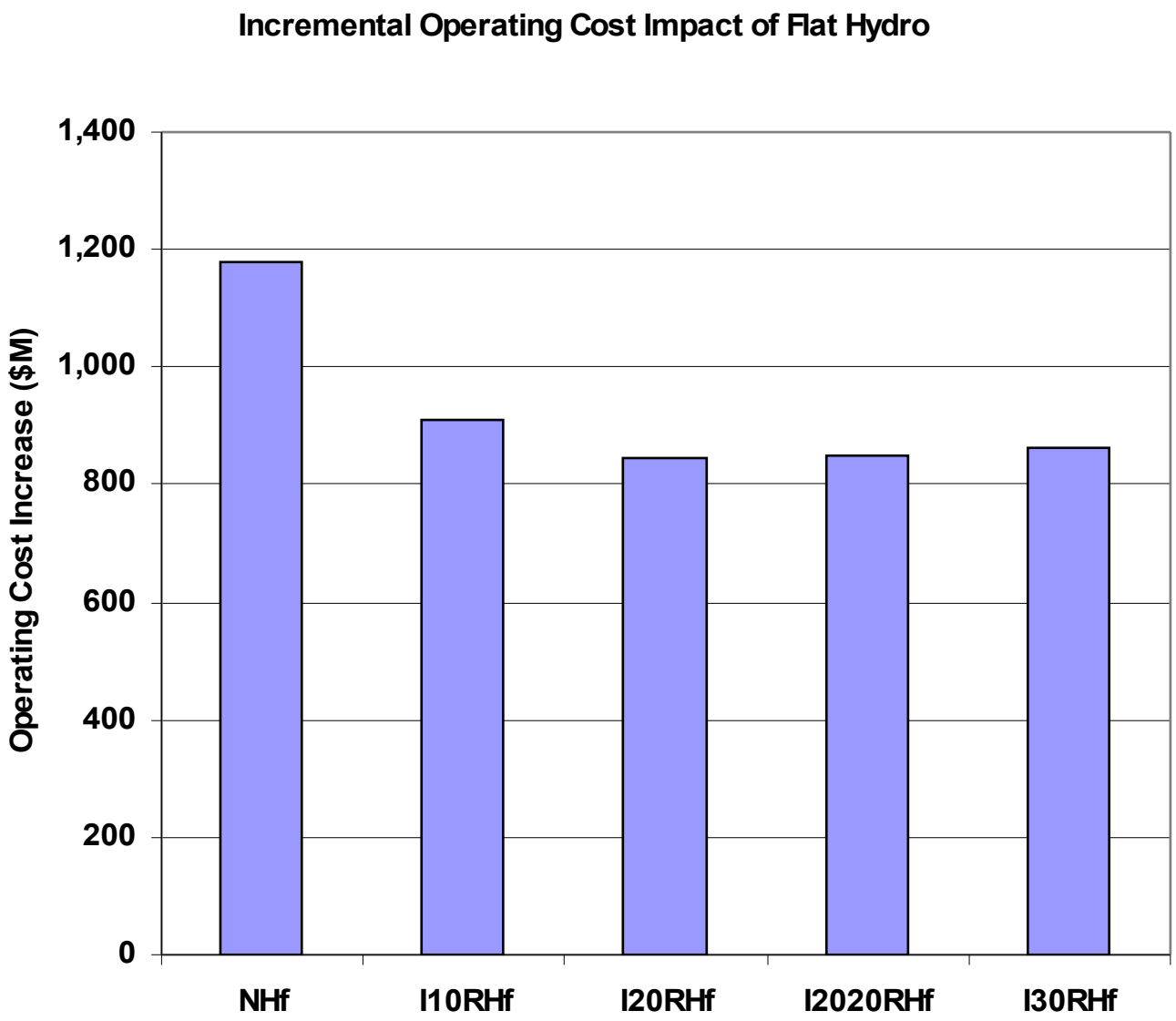


imagination at work

Impact of Flat Hydro on WECC Operating Costs

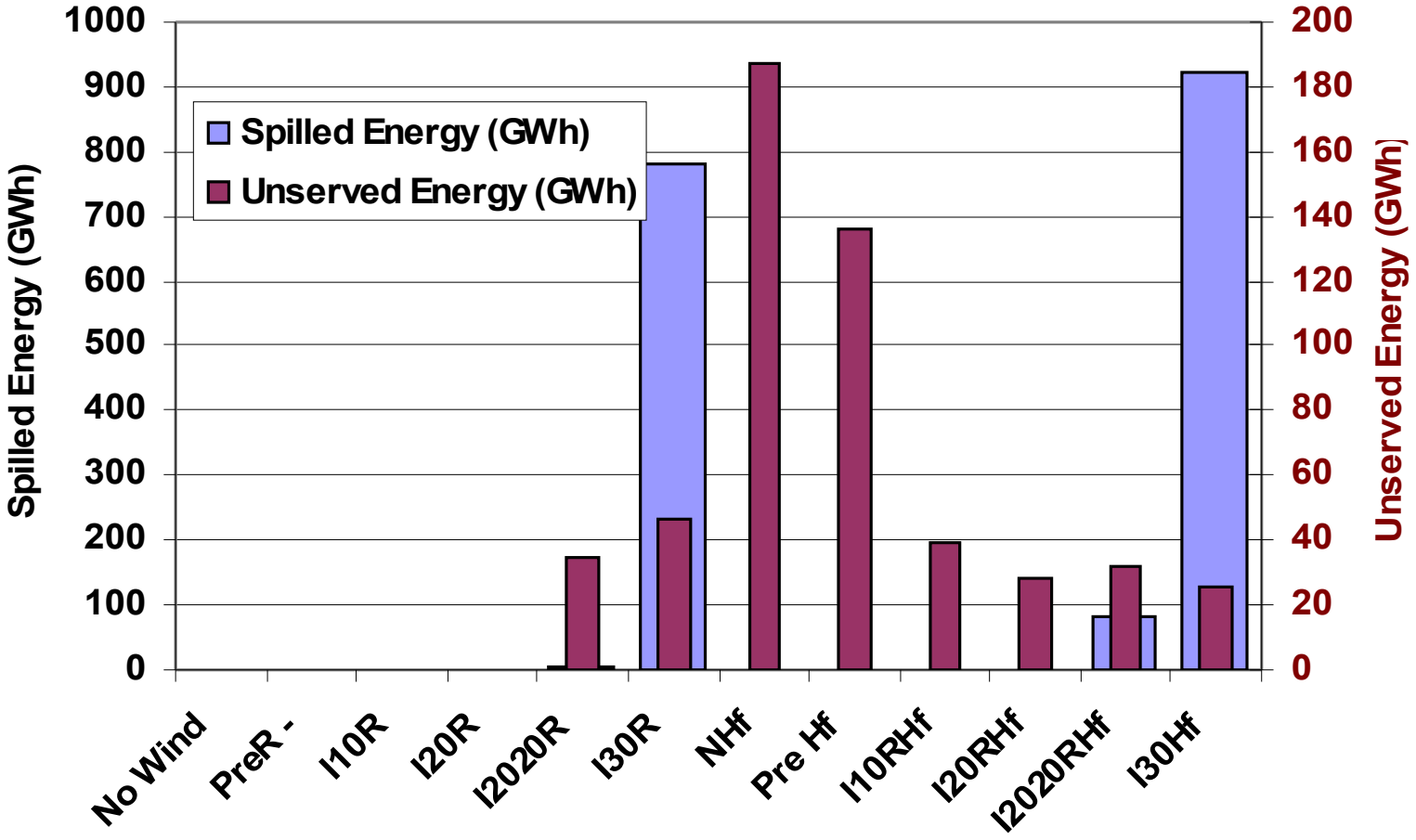


imagination at work



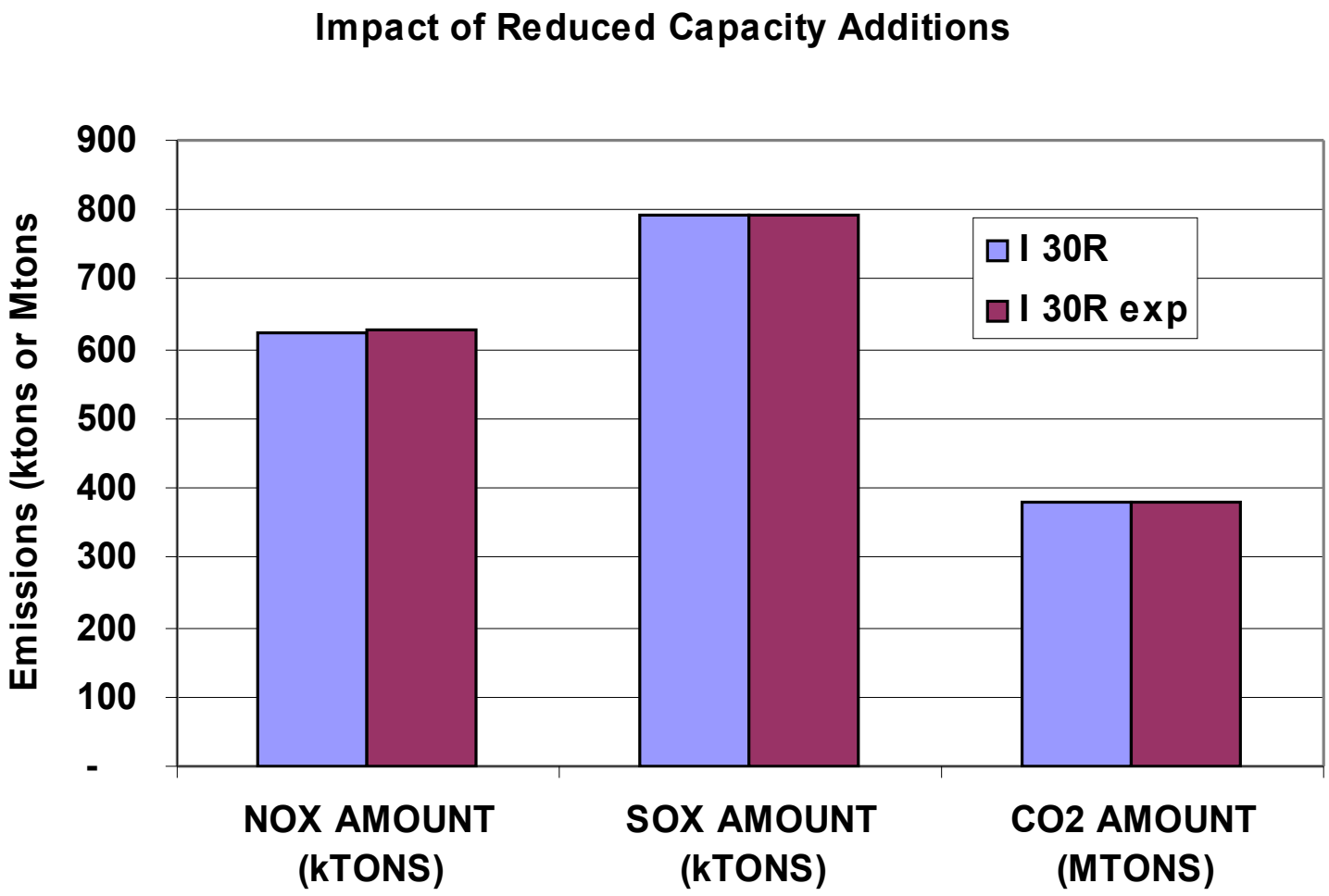
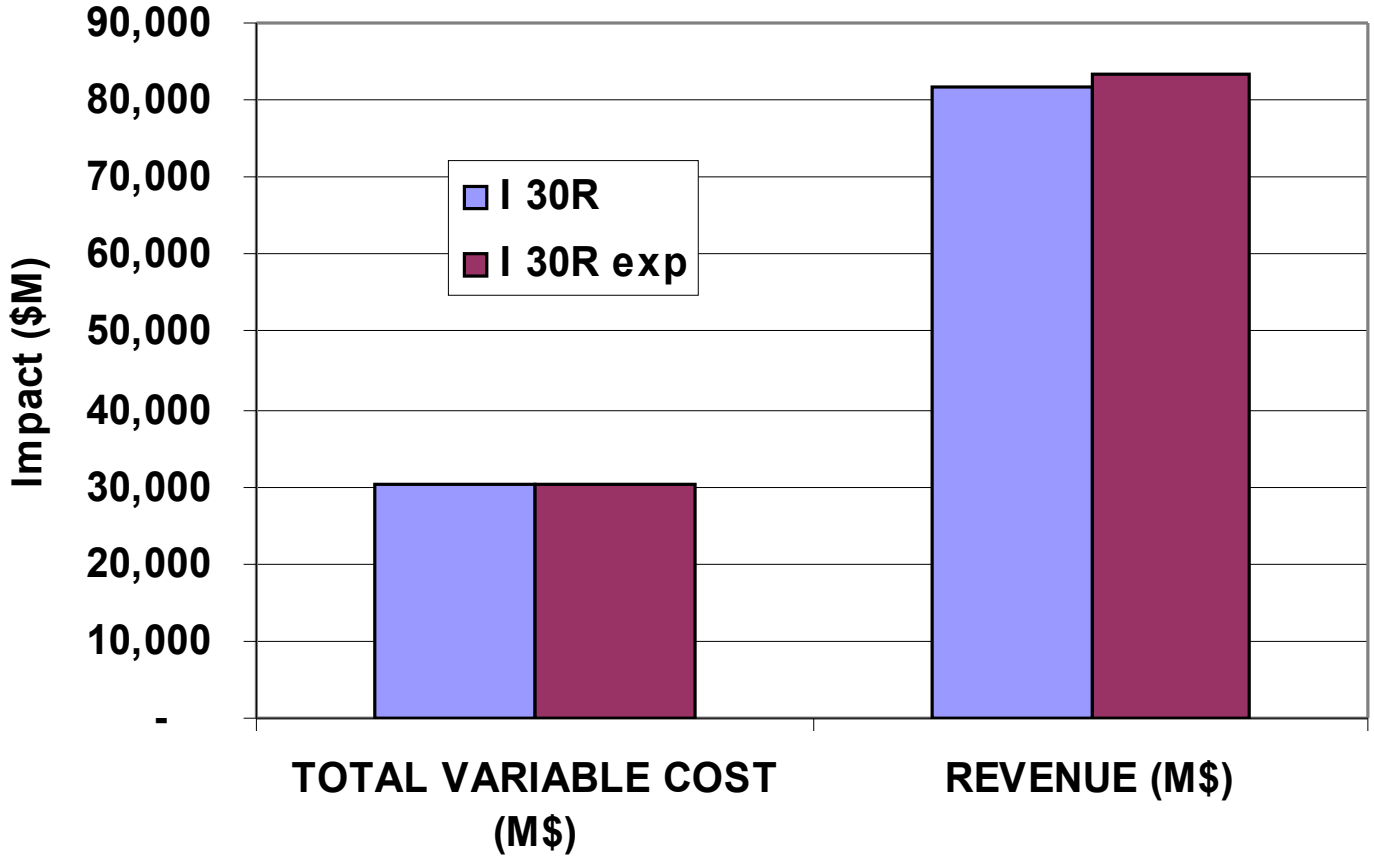
imagination at work

Impact of Flat Hydro



Unit Expansion Plan

- All additions inside footprint scheduled after 2012 were cancelled due to the capacity value of renewable generation, 6450 MW ~ 18%


Impact of Reduced Capacity Additions
Emissions (ktons or Mtons)
900
800
700
600
500
400
300
200
100
-
I 30R
I 30R exp
NOX AMOUNT (kTONS)
SOX AMOUNT (kTONS)
CO2 AMOUNT (MTONS)

Impact of Reduced Capacity Additions