IEEE General Meeting 2007
Transmission Issues for Wind Power Integration Panel
07 GM1188 Slides
Inclusion of Wind in the MISO Transmission Expansion Planning Process

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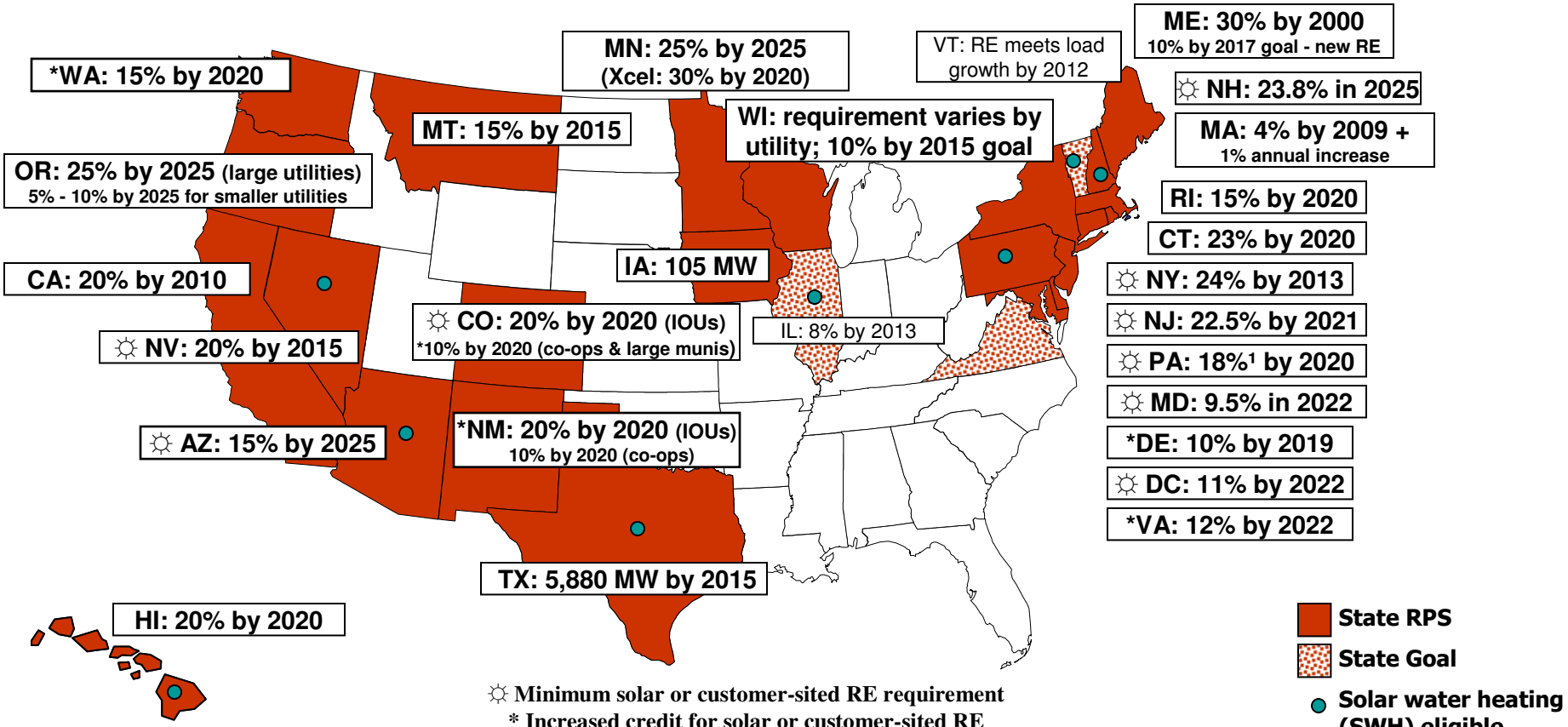
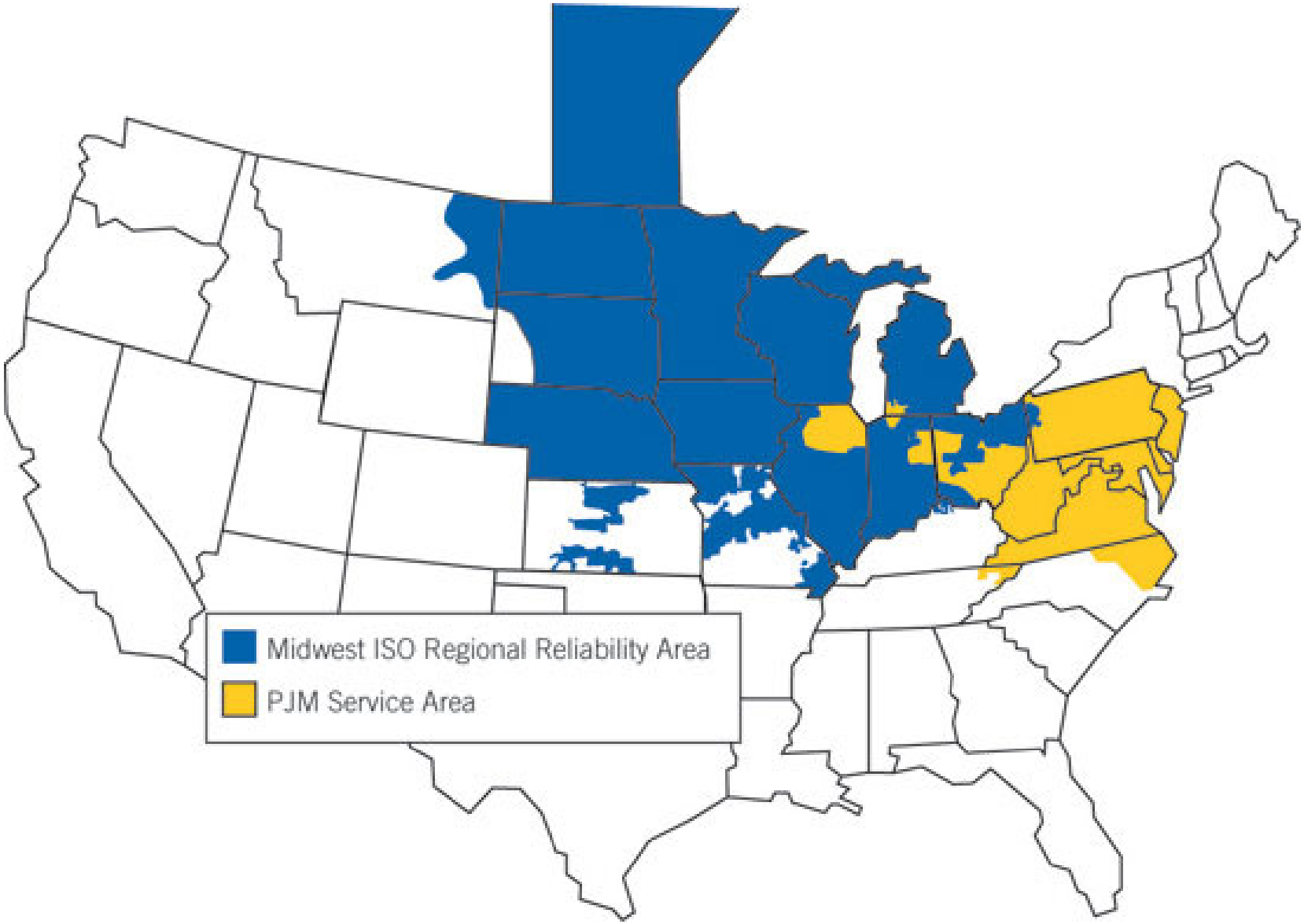
Renewables Portfolio Standards

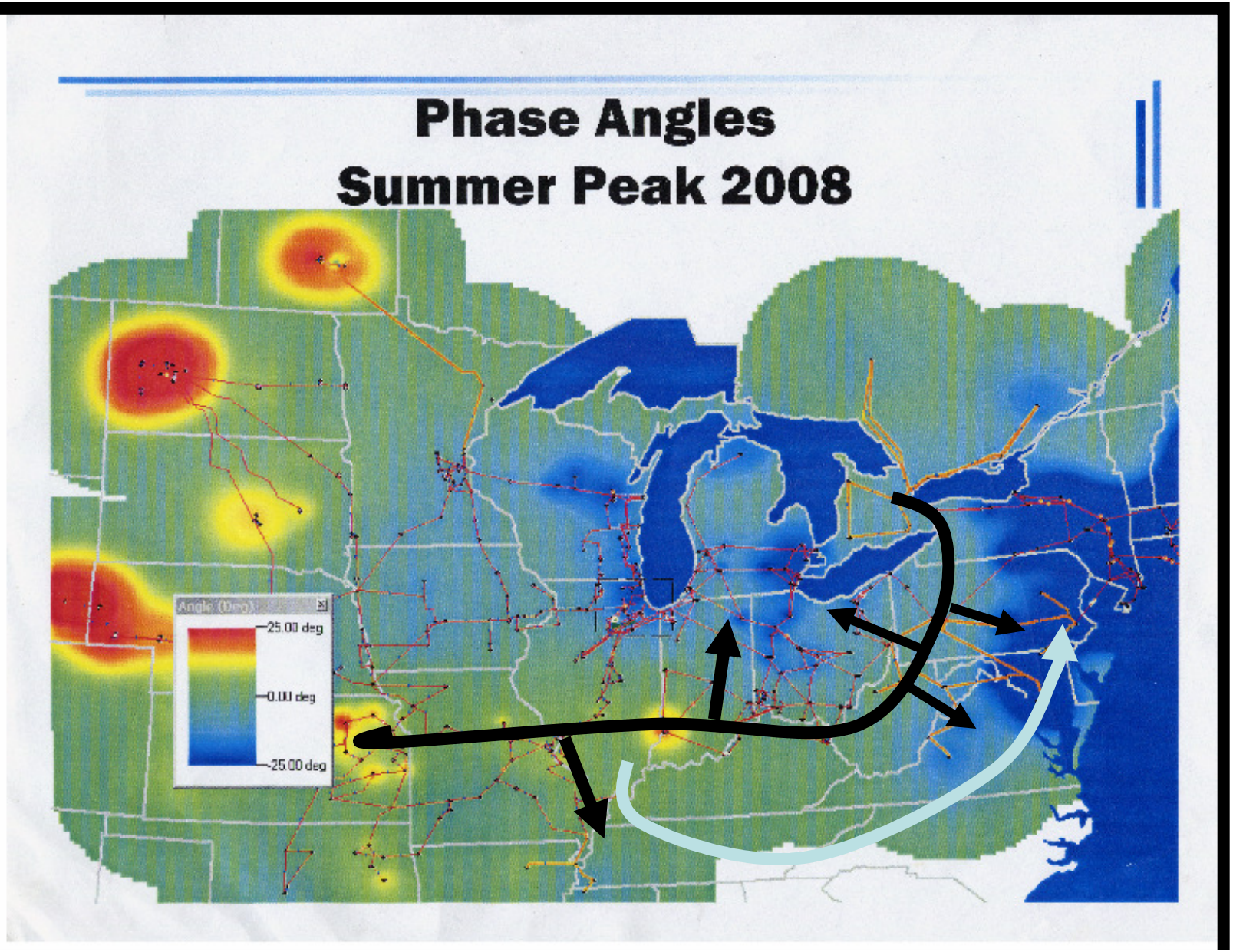


☼ Minimum solar or customer-sited RE requirement
* Increased credit for solar or customer-sited RE
[1]PA: 8% Tier I / 10% Tier II (includes non-renewables); SWH is a Tier II resource

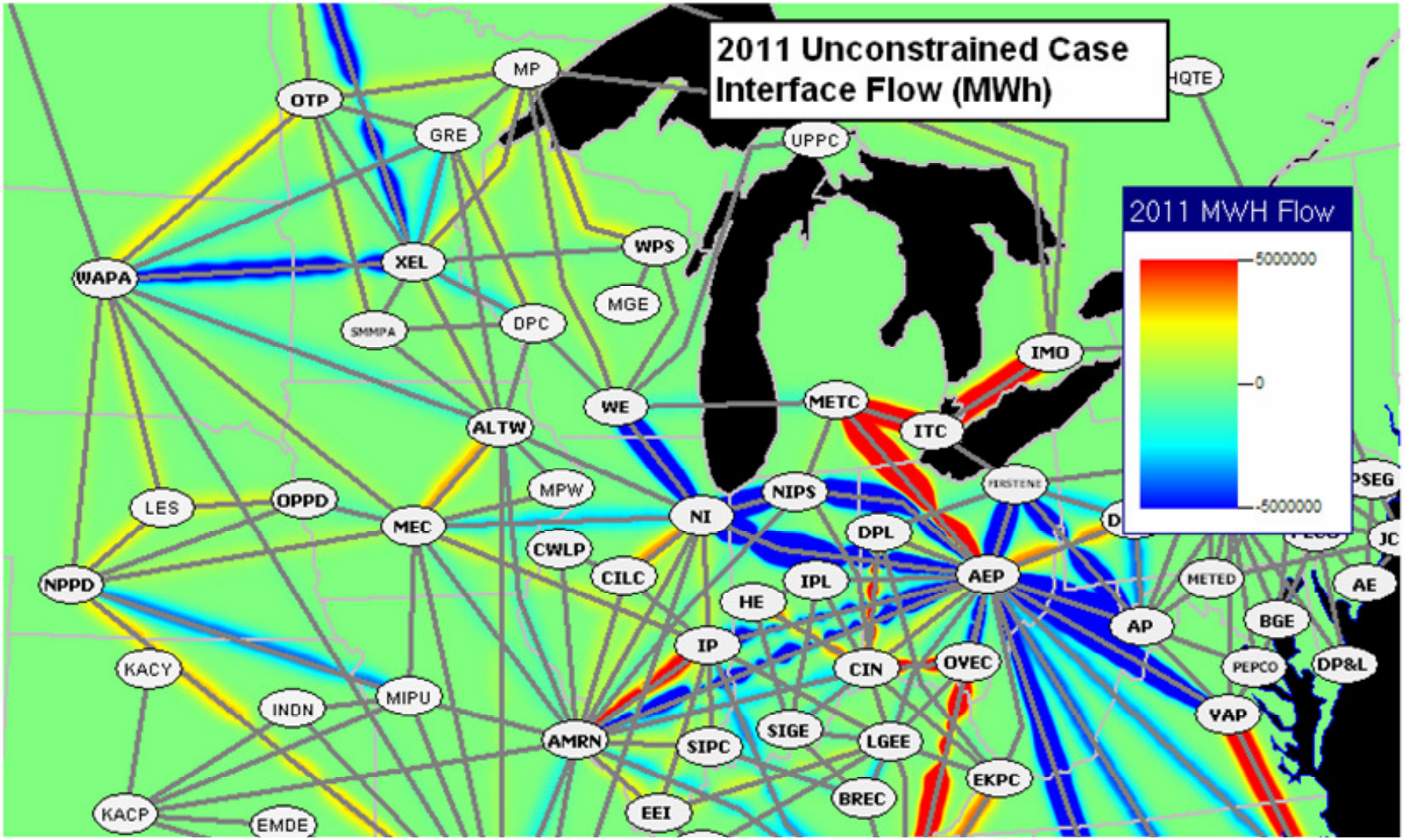
Source: Interstate Renewable Energy Council


Midwest ISO Regional Reliability Area
PJM Service Area

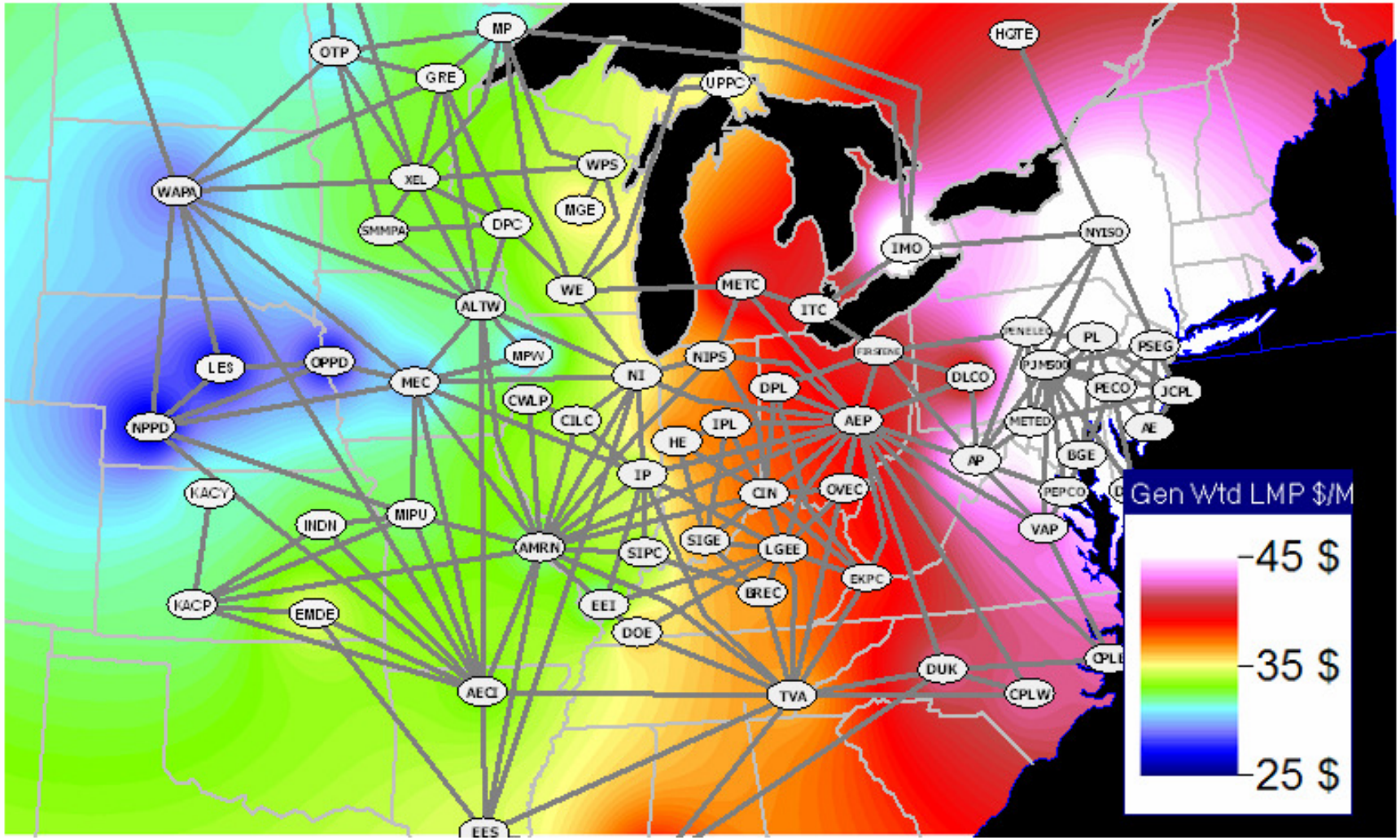
Phase Angles
Summer Peak 2008



2011 Unconstrained Interface Flow



Generation Weighted LMP Contour Map



Wind Integration Studies

- Two Examples
  - 10% Wind energy across MISO-in paper
    - 2016 Study year
  - 20% Wind energy across MISO
    - Optimal generation expansion plan associated with the mandated wind energy
    - 2021 study year
    - 40,000 Mw of wind capacity by 2027
      - 12,600 Mw mandated by states in reference case
      - 26,000 Mw added to meet 20% mandate by 2021

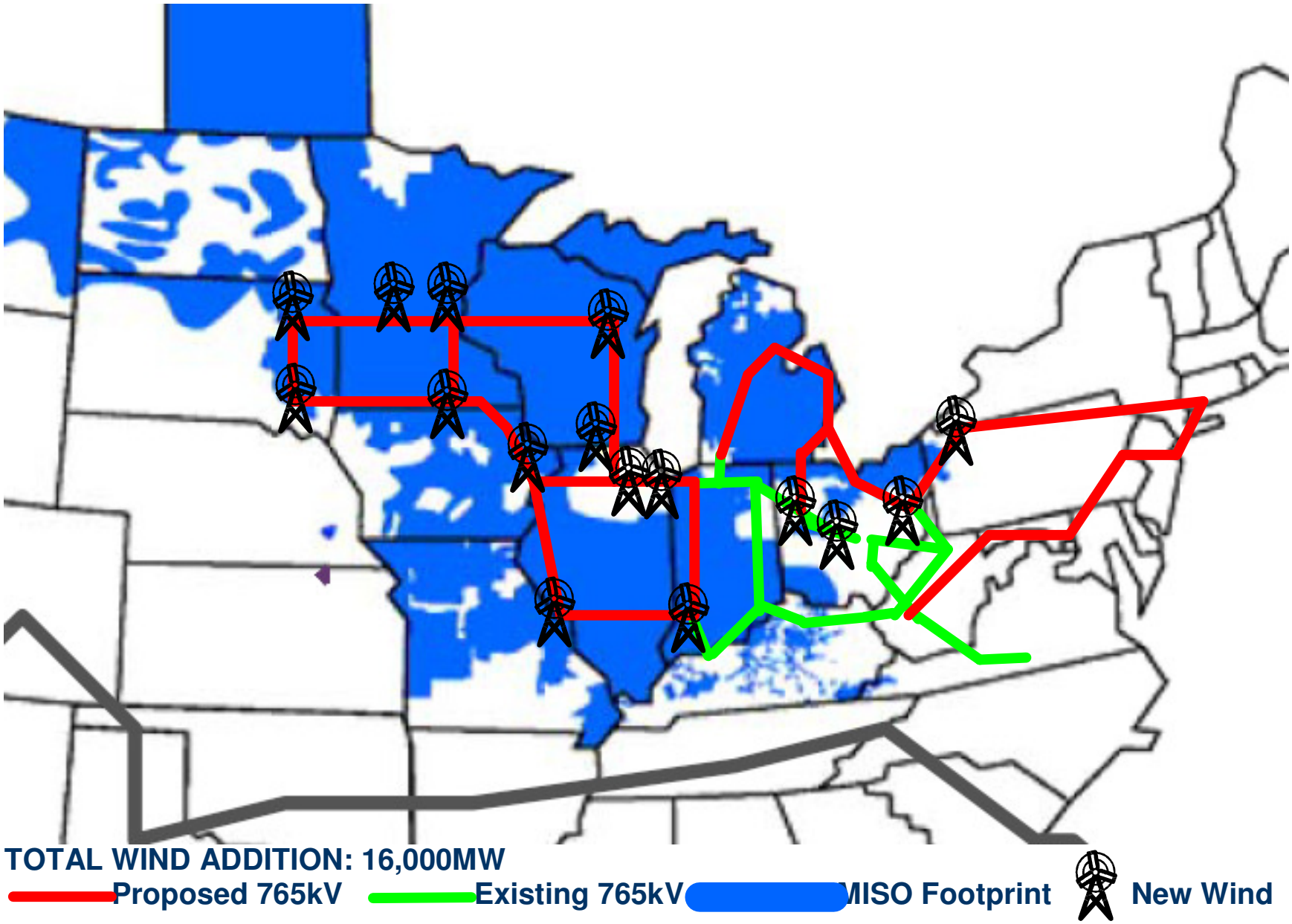
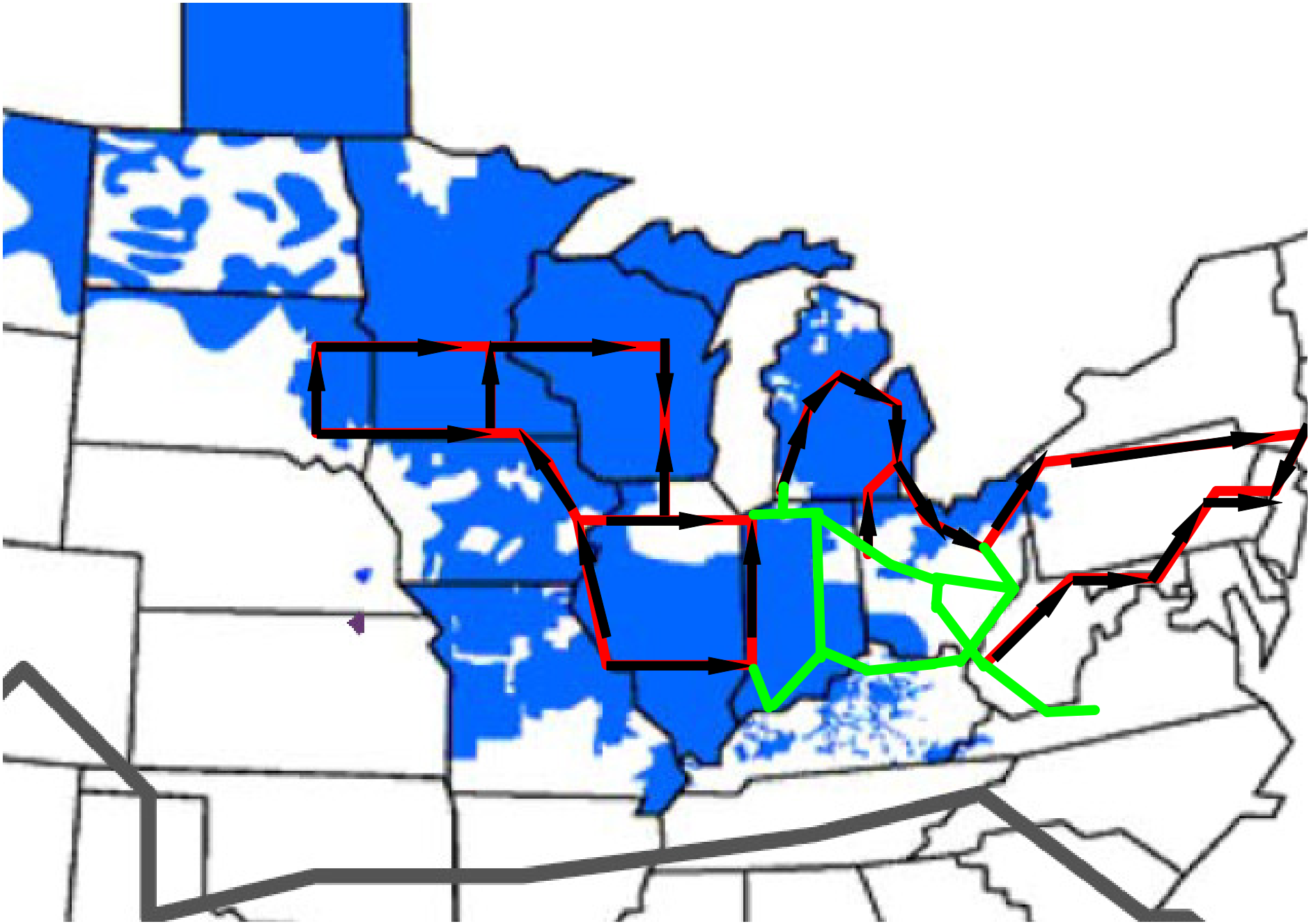
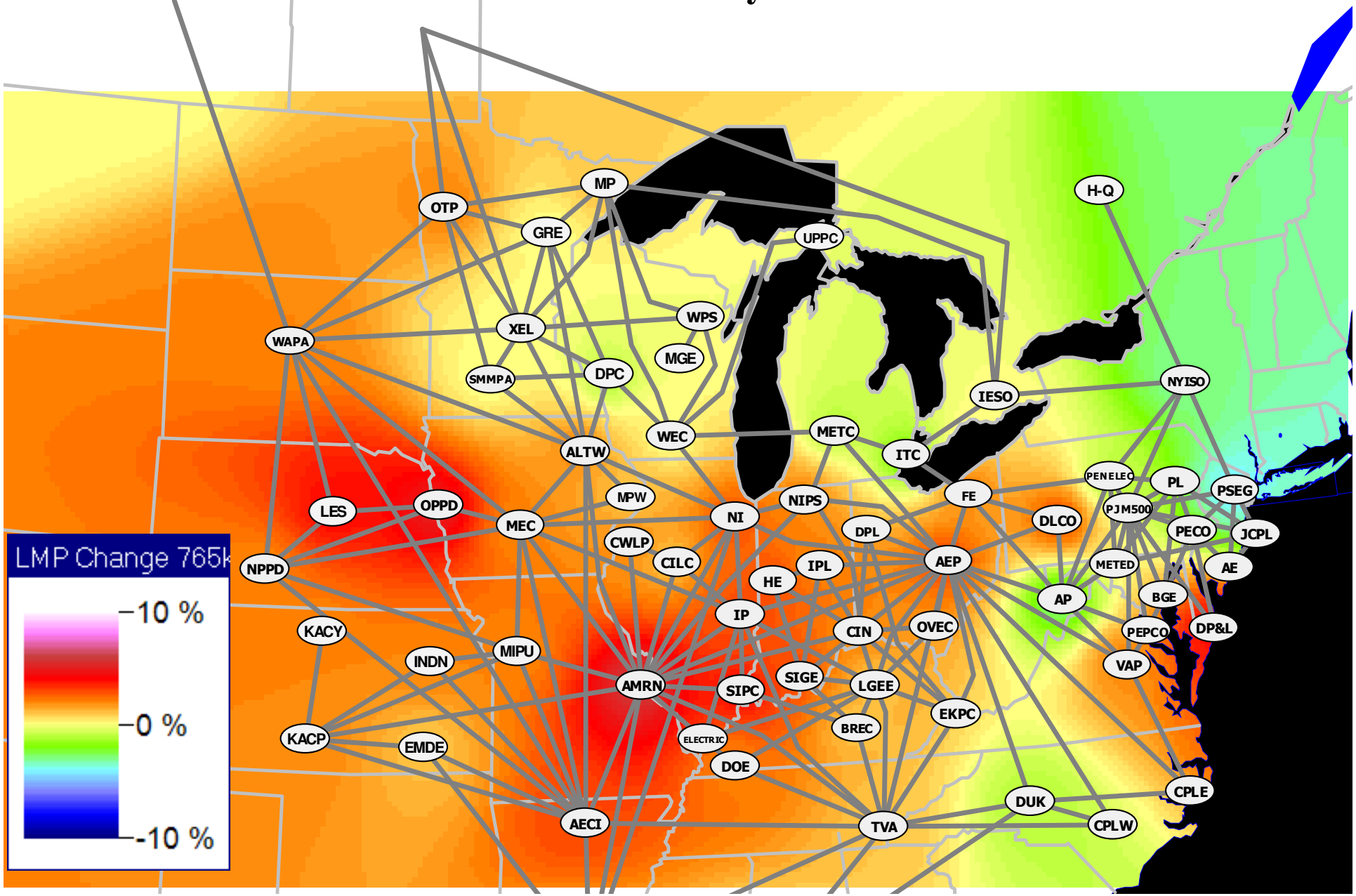

TOTAL WIND ADDITION: 16,000MW
Proposed 765kV
Existing 765kV
MISO Footprint
New Wind

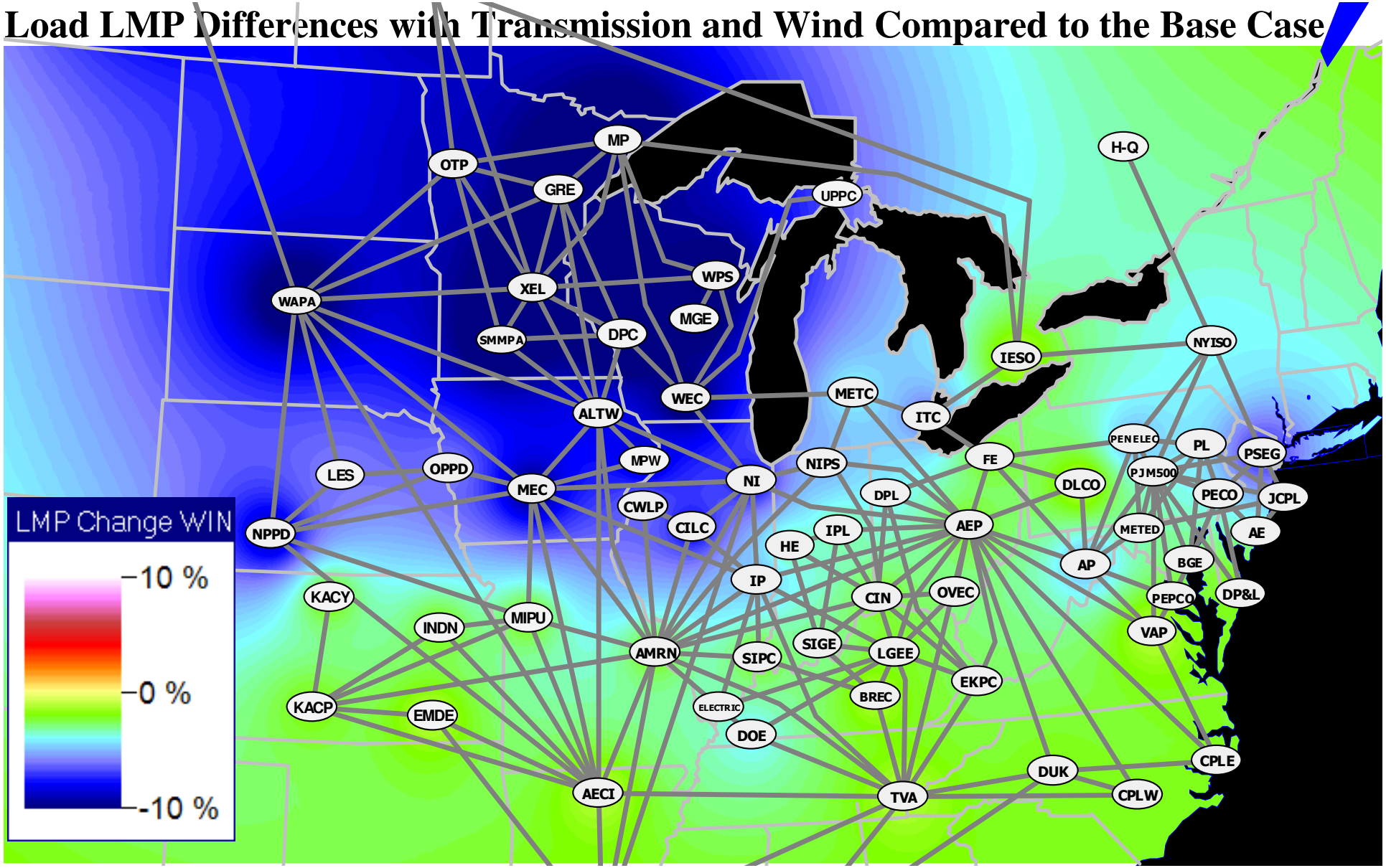
Figure 4


Proposed 765kV
Existing 765kV
MISO Footprint

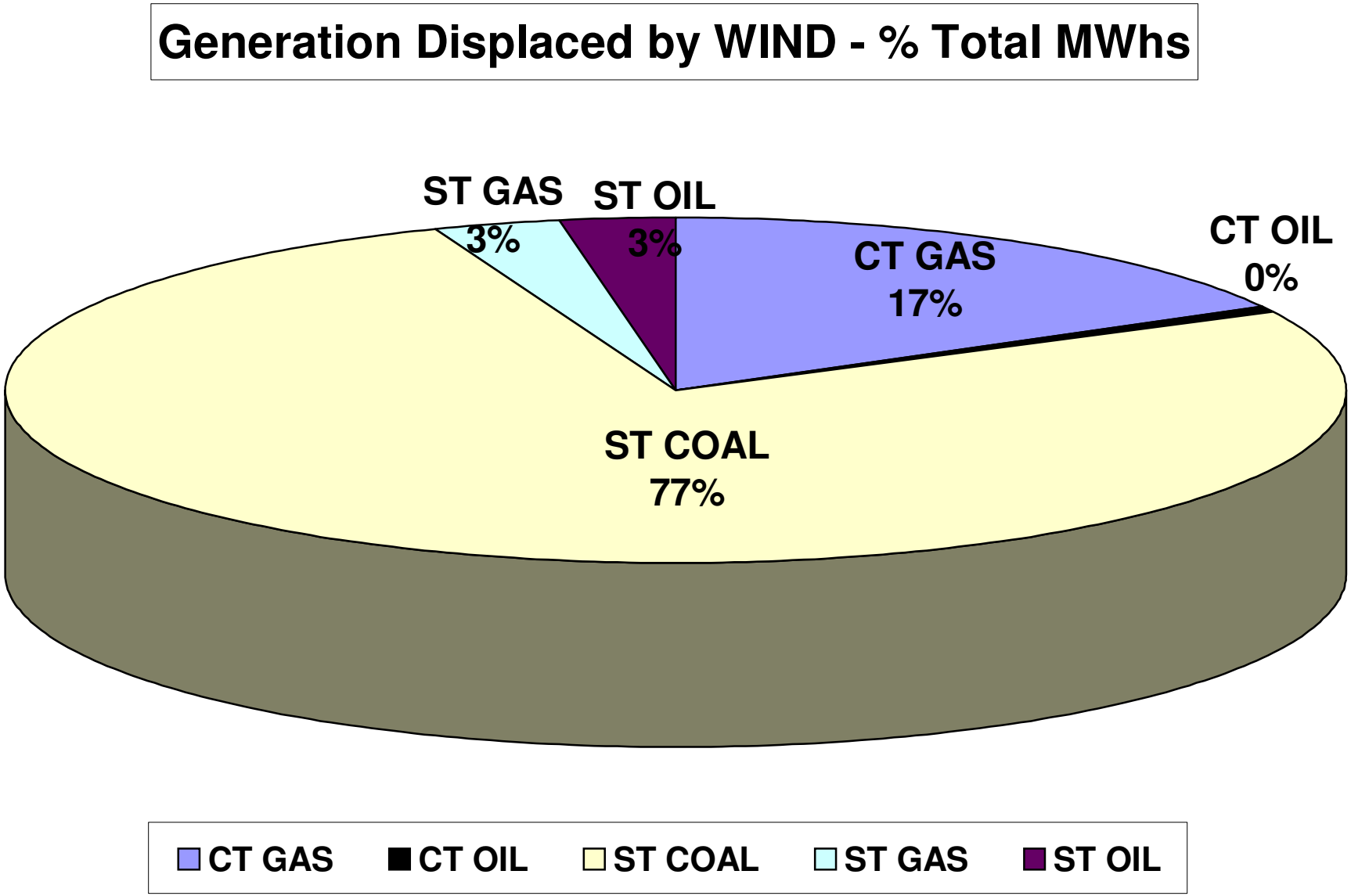
Load LMP Differences with Transmission Only



Load LMP Differences with Transmission and Wind Compared to the Base Case



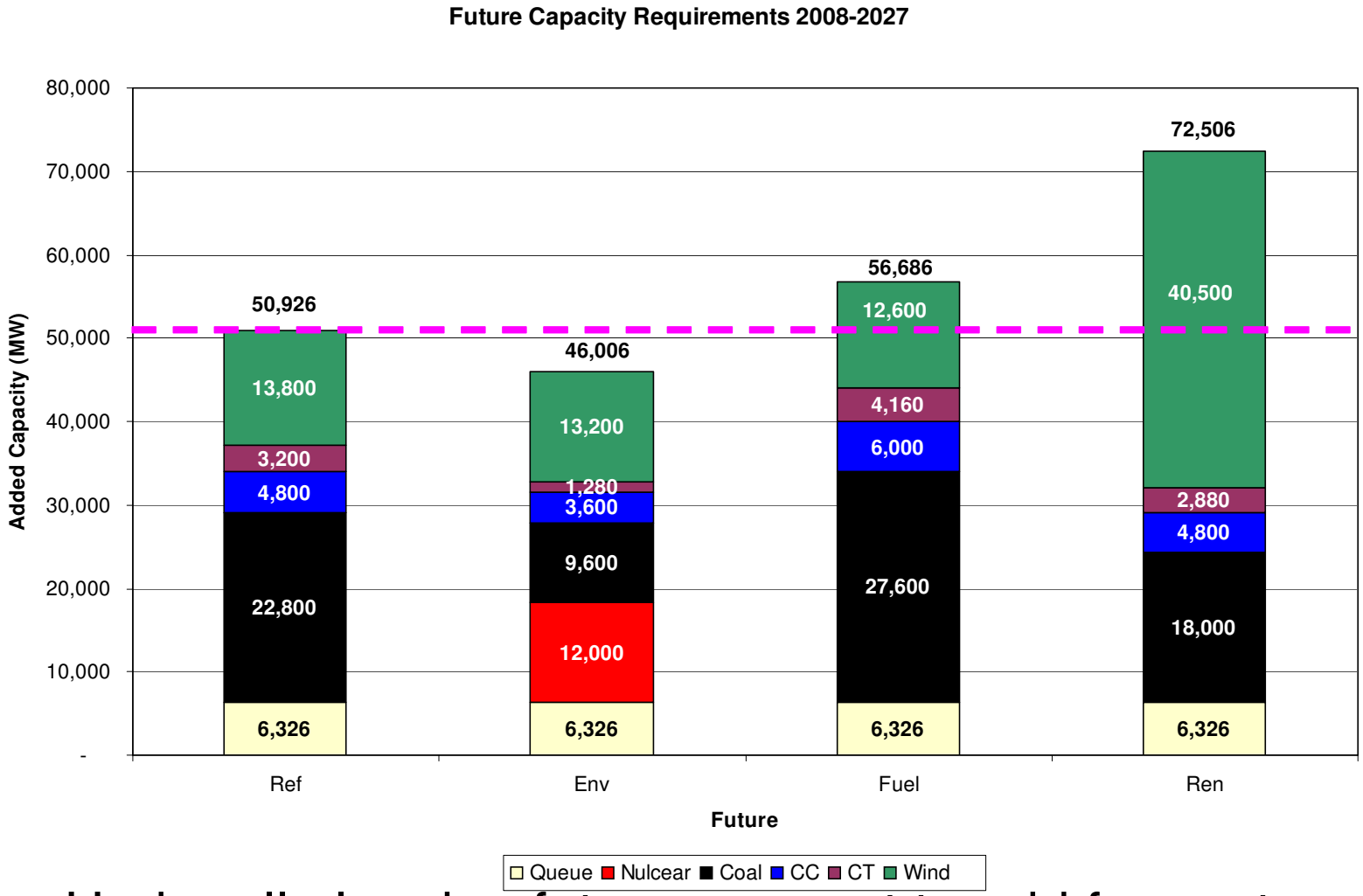
67 Twh/yr wind generation
43M tons/yr CO2 displaced, 286 M tons/yr load ratio scaled to the US total load
MISO is about 15% of the US electric load using capacity



Economic Results

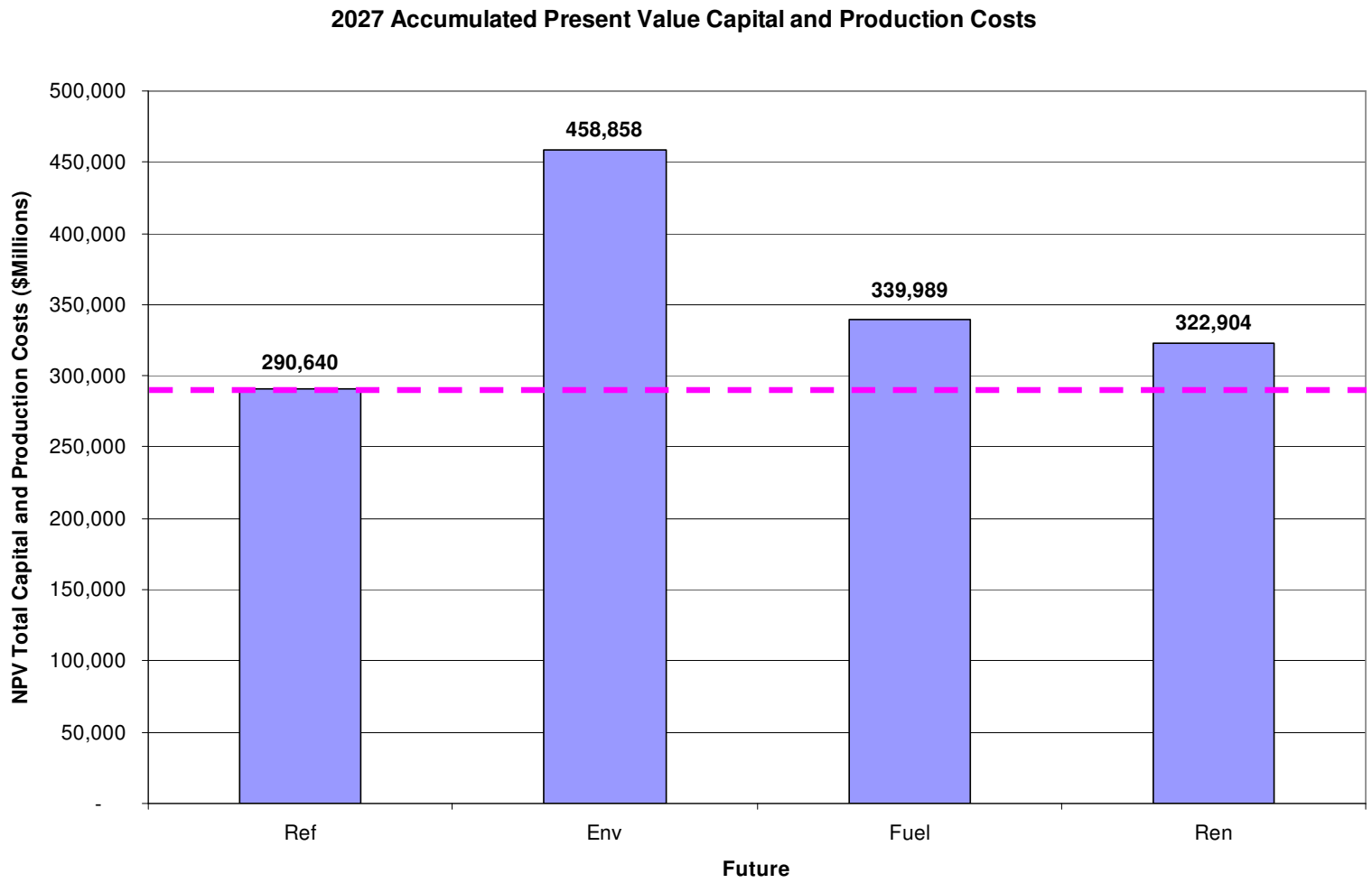
- $6.9B/yr Net Generator Revenue reduction – 2016$
- $4.6B/yr transmission annual carrying charge-cost not recovered in the study
  - $31B 2016$, $13B 2006 $ PV at 8% Discount Rate
- 2.2B/yr Wind generation Revenue
  - 74% of annual carrying costs for a 2006 generator
  - 54% of annual carrying costs for a 2016 generator
- Net benefit from generation and transmission $100M/yr.
- Other benefits may occur from a reduction in the deferment of capital expense due to a reduction in generator reserve margins and reduction in generation interconnection costs

Future Scenarios for MTEP 2008



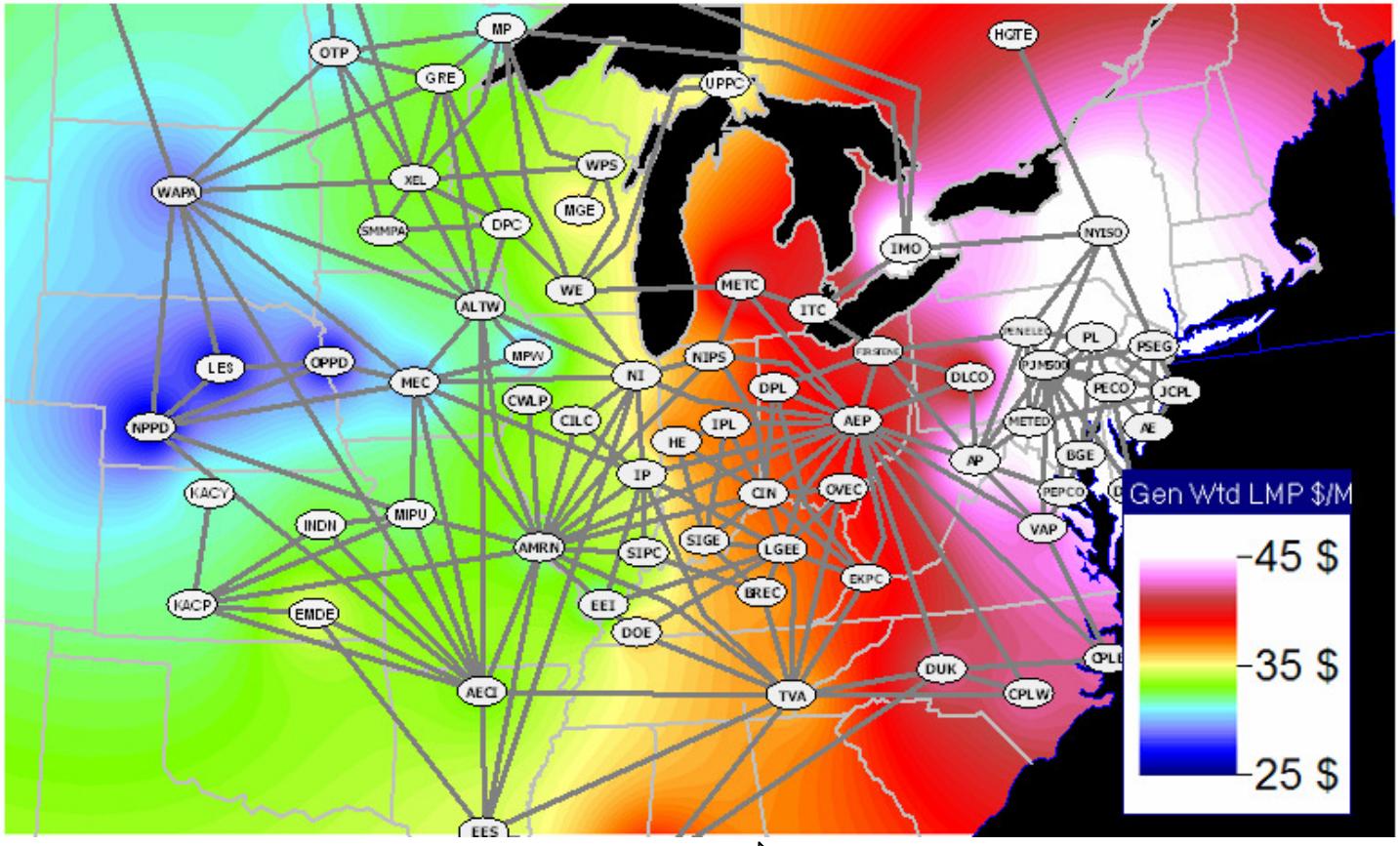
- Under all planning futures, expect to add from x to y MW of low cost generation to the Midwest ISO footprint in the form of Coal, Nuclear or Wind

Summary of 2027 Costs



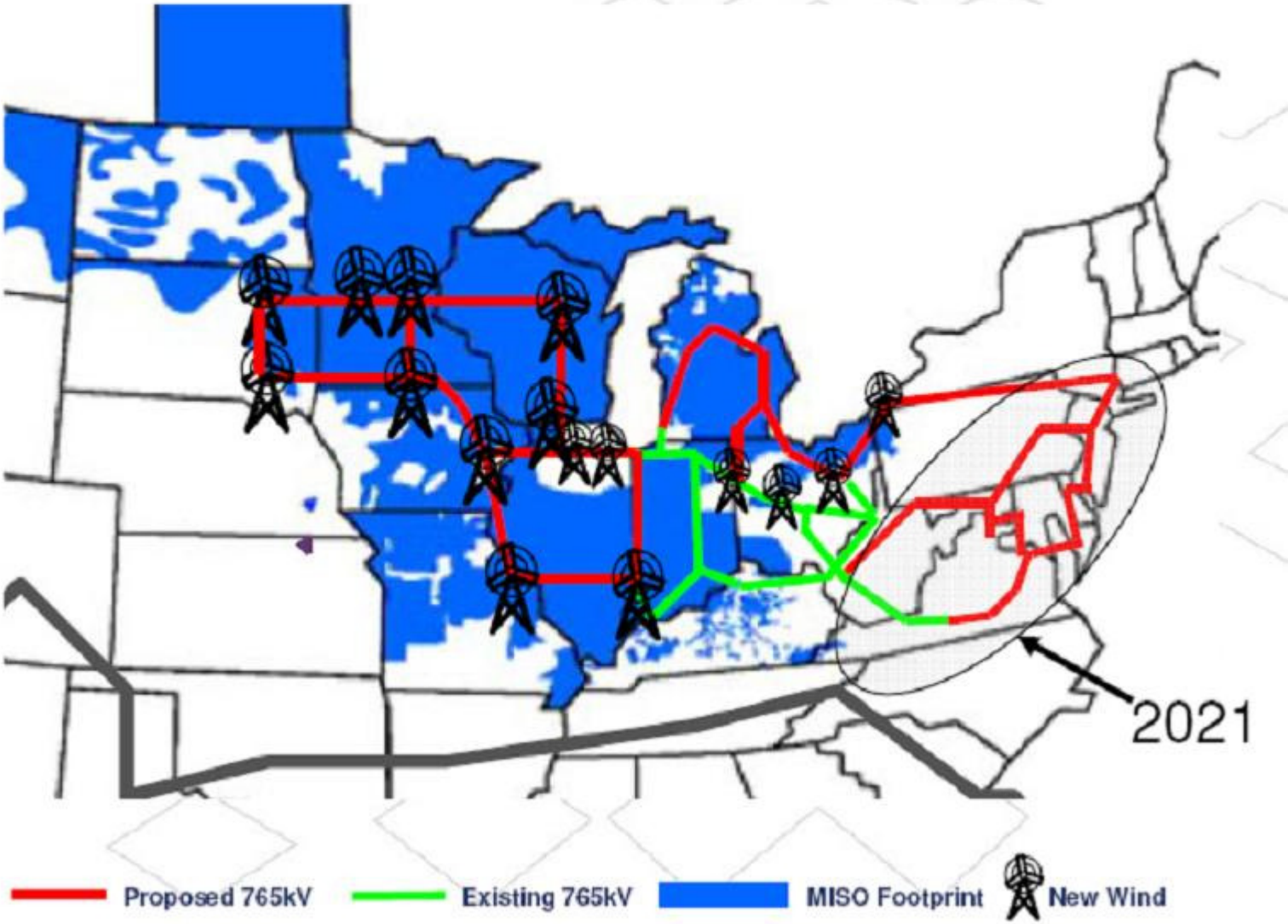
Generation Weighted LMP Contour Map

Power flows from low price to high price areas
to provide the direction and terminals for the transmission expansion

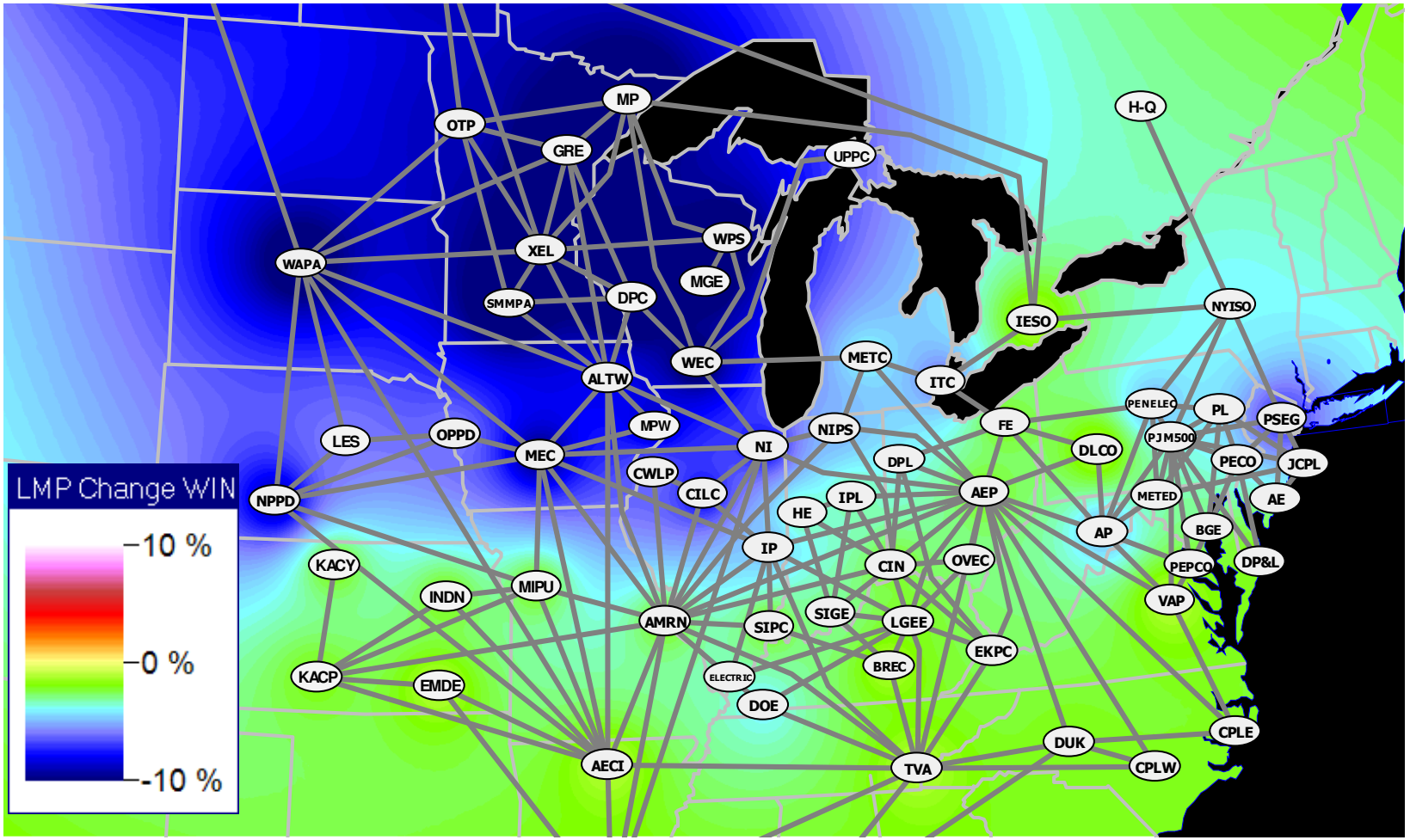


Market flow West to East

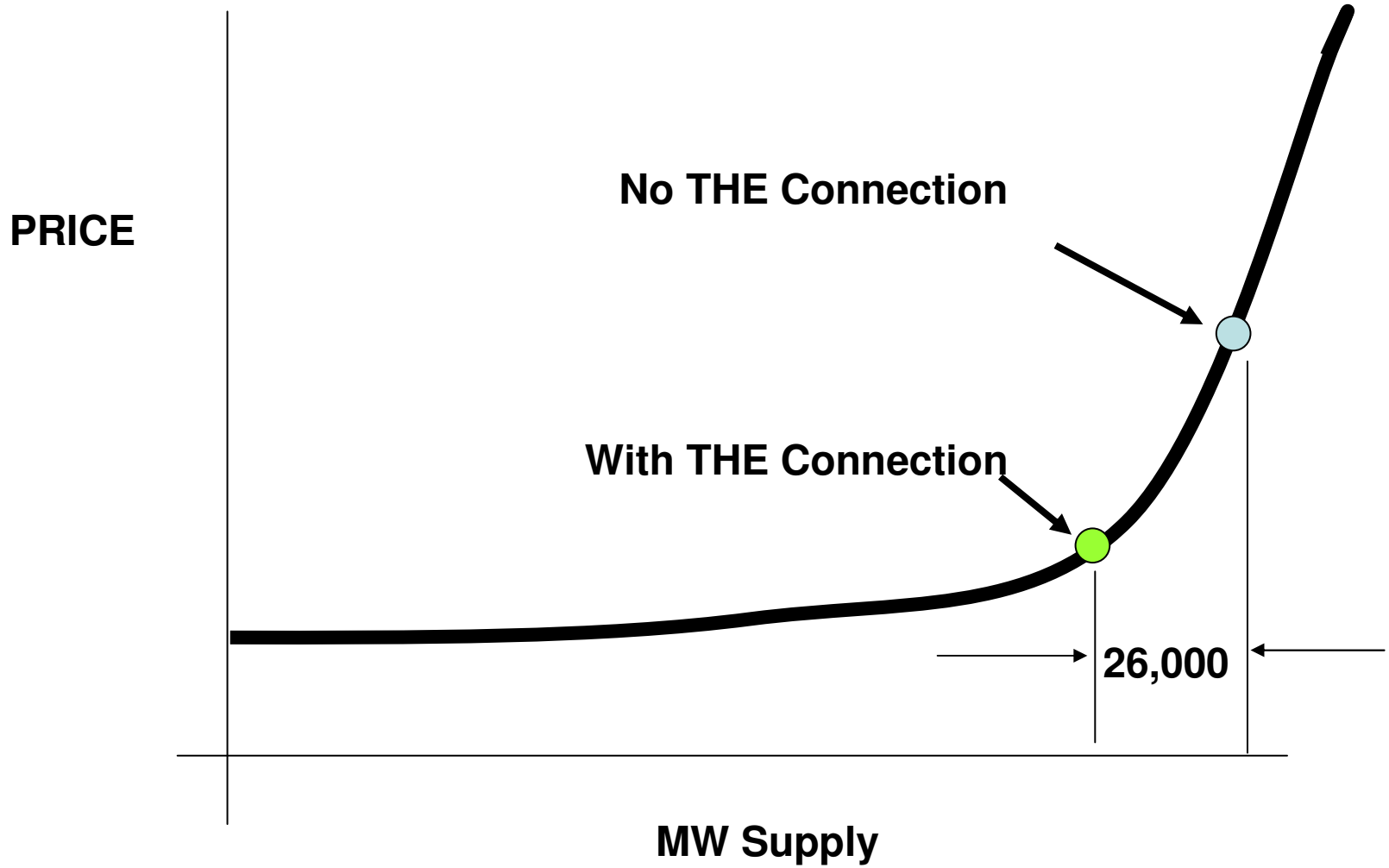
Proposed Year 2021 Overlay

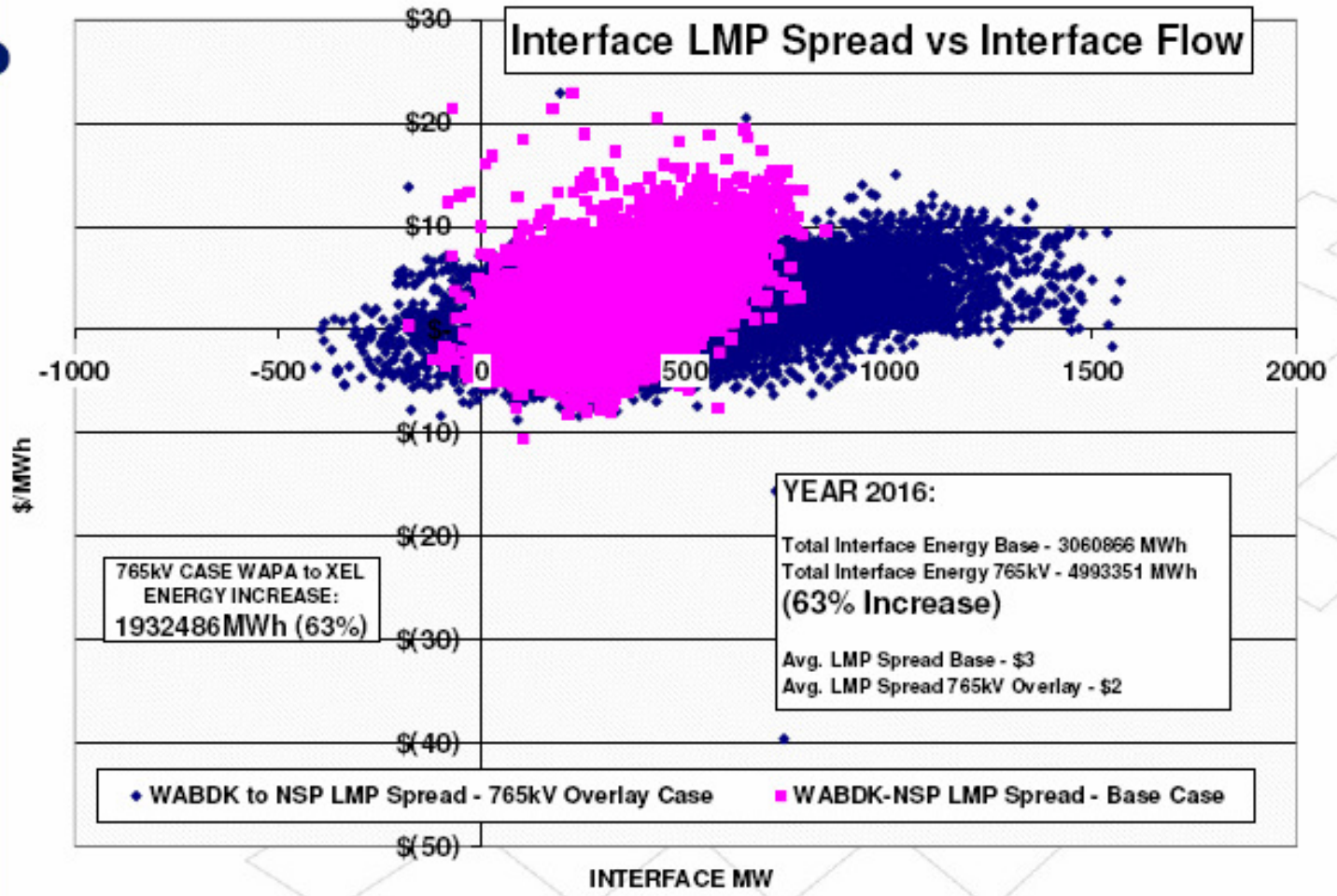


% CHANGE LMP – WIND CASE + Overlay vs. Base



Wind lowers the average Load LMP for all areas


PRICE
No THE Connection
With THE Connection
26,000
MW Supply


Interface LMP Spread vs Interface Flow
$30
$20
$10
$
$(10)
$(20)
$(30)
$(40)
$(50)
-1000
-500
0
500
1000
1500
2000
$/MWh
INTERFACE MW
765kV CASE WAPA to XEL
ENERGY INCREASE:
1932486MWh (63%)
YEAR 2016:
Total Interface Energy Base - 3060866 MWh
Total Interface Energy 765kV - 4993351 MWh
(63% Increase)
Avg. LMP Spread Base - $3
Avg. LMP Spread 765kV Overlay - $2
WABDK to NSP LMP Spread - 765kV Overlay Case
WABDK-NSP LMP Spread - Base Case

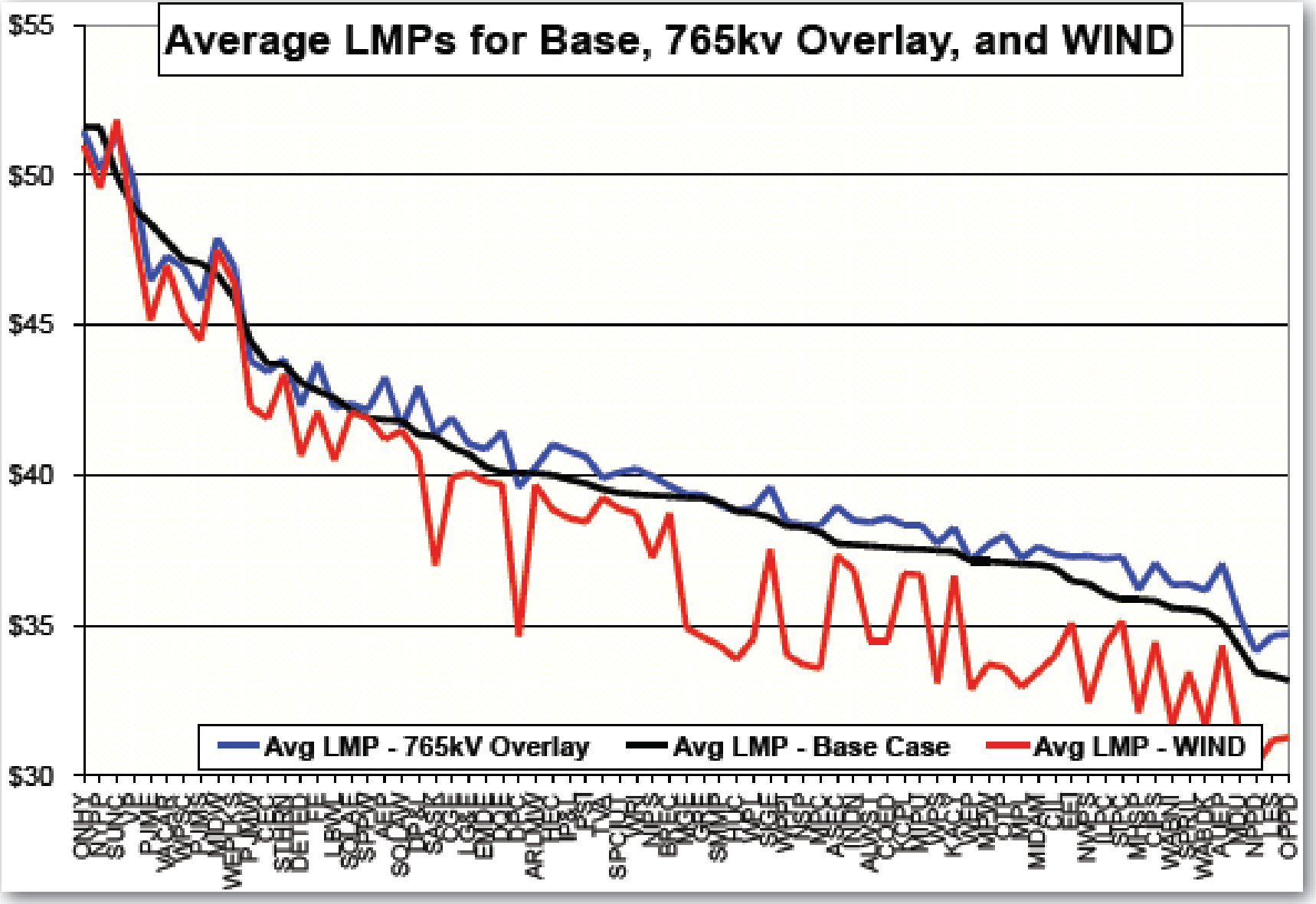


Figure 7.4-22 Average Hourly LMP

Economics

- 7,000 miles of lines
- $40B including substations and reactive compensation
- $4.7B per year adjusted production cost benefit.
- If 50% of the line revenue is from generation interconnection and 50% from energy, benefit/cost ratio is aboau1.6/1 for MISO alone.
- Plans for further studies involving PJM and possibly others are progressing.