

Potential Cross-State Power Flow Impacts of the CPP around Minnesota

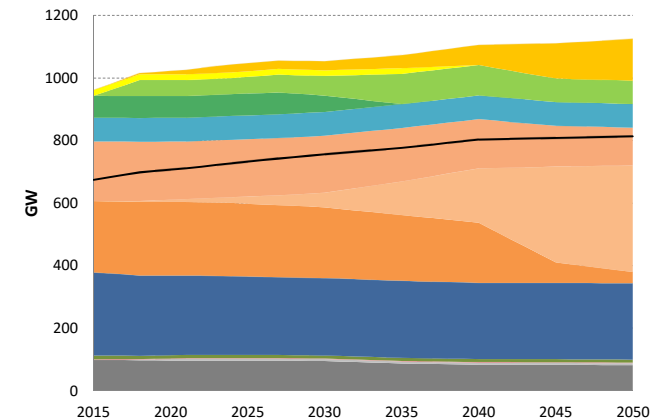
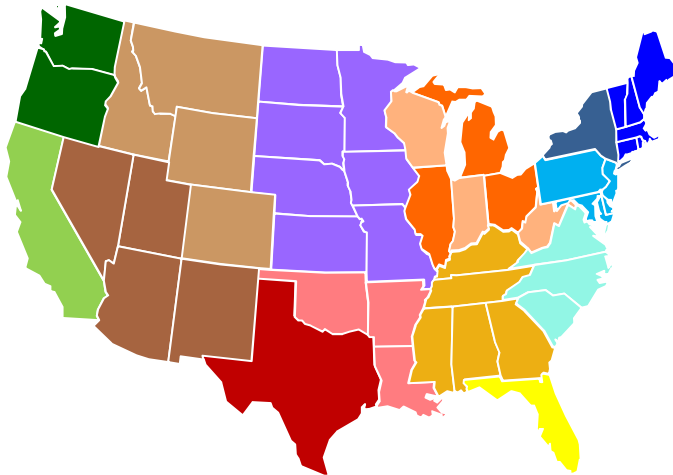
David Young
Principal Technical Leader

31st October 2016



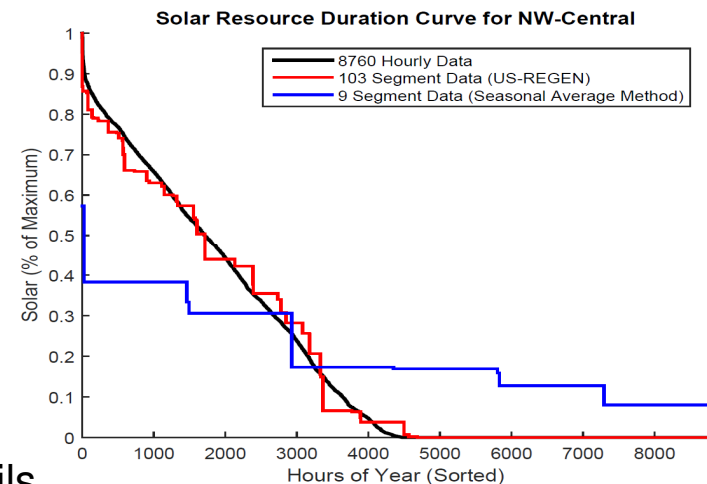
US-REGEN Capable of Analyzing Power Flow Shifts *Between States Under Different Scenarios*

Capacity Expansion Economic
Model, Long Horizon to 2050



State Level Resolution for Policy
and Regulation Analysis

Innovative Algorithm to Capture
Wind, Solar, & Load Correlations
in a Long Horizon Model



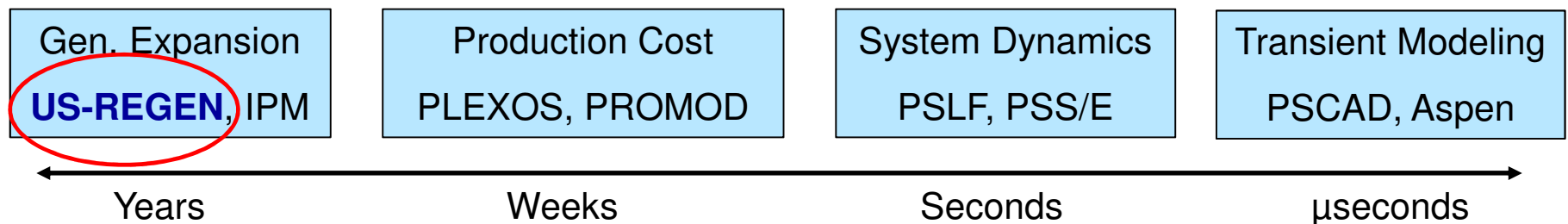
* See <http://eea.epri.com/models.html> for more details

Caveats

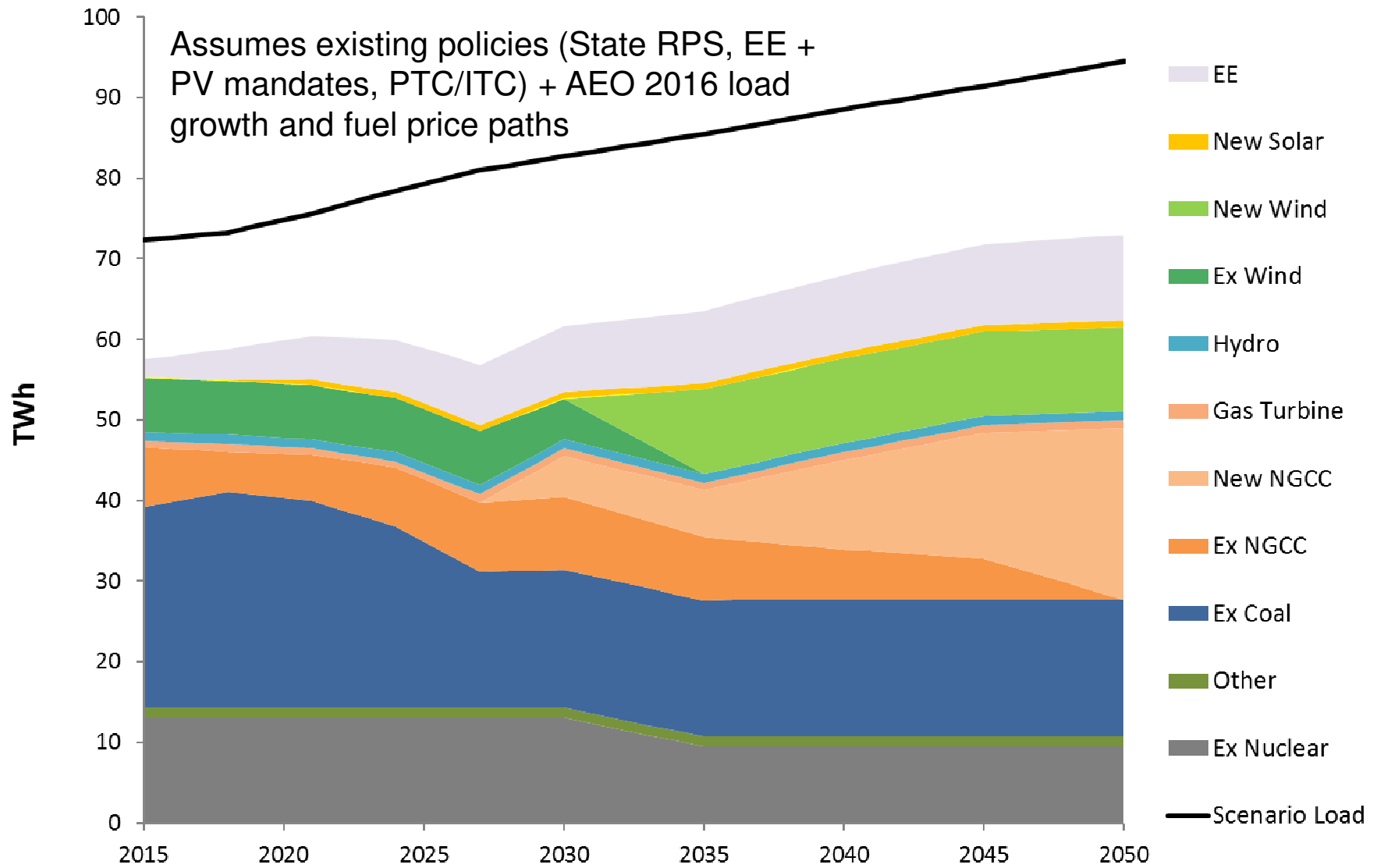
- US-REGEN is an economic capacity expansion model. Scenarios are not forecasts of the future, but can help understand economic drivers in the electric sector
- US-REGEN balances load by state, including interstate TWh flows, but does not recognize any in-state transmission or system operation constraints, including
 - Unit commitment constraints
 - Voltage support and other transmission system reliability constraints
 - Distribution costs and constraints

Capacity Expansion Models

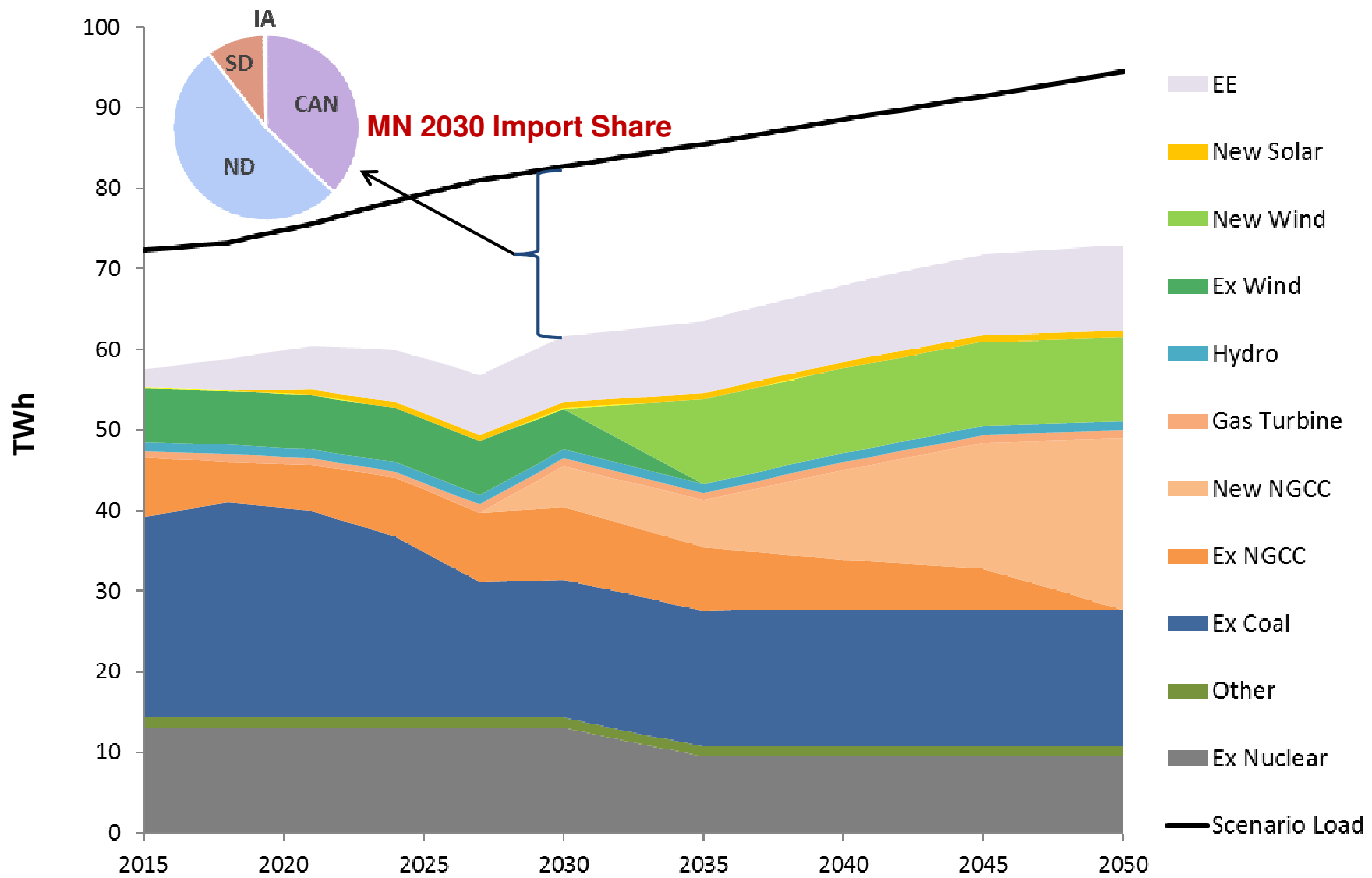
Reliability Models



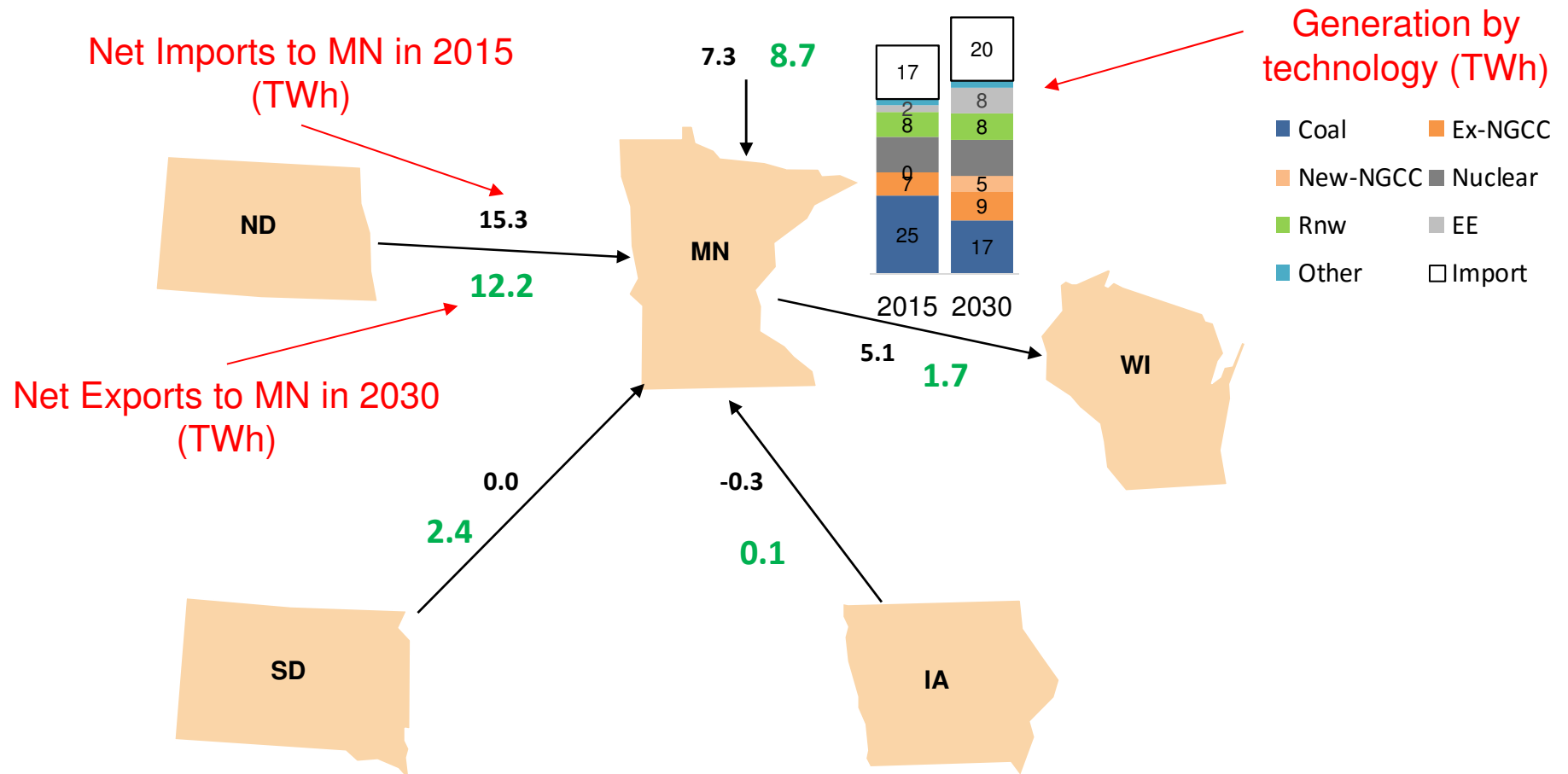
Minnesota Generation under Reference Case Assumptions



Minnesota Continues to Rely on Imported Power Through 2030 and Beyond



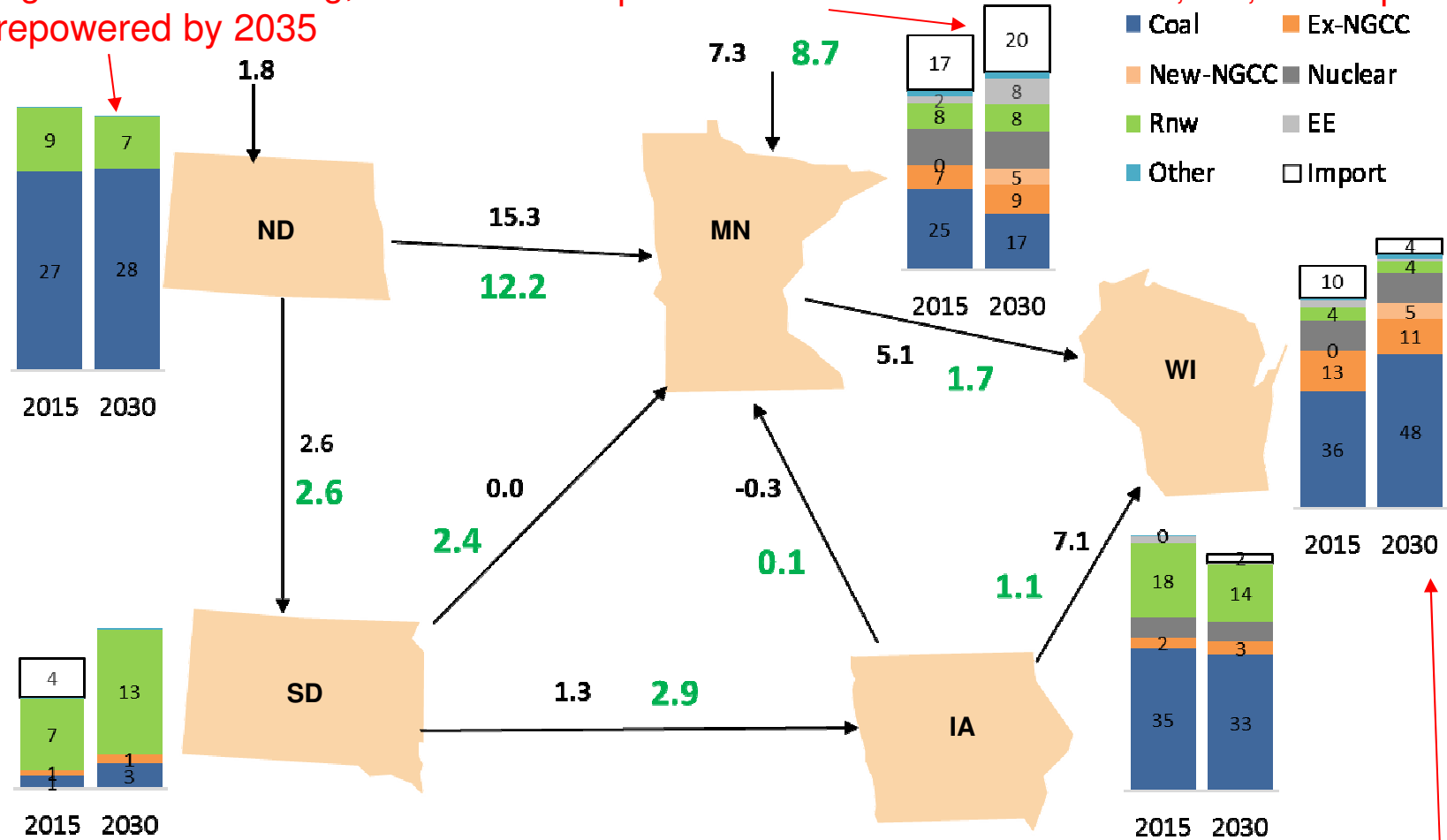
Tracking the Role of Imported Power Under the CPP Requires Modeling Surrounding States



Reference Case Sees Considerable Change in the Generation Mix Across the 5 States

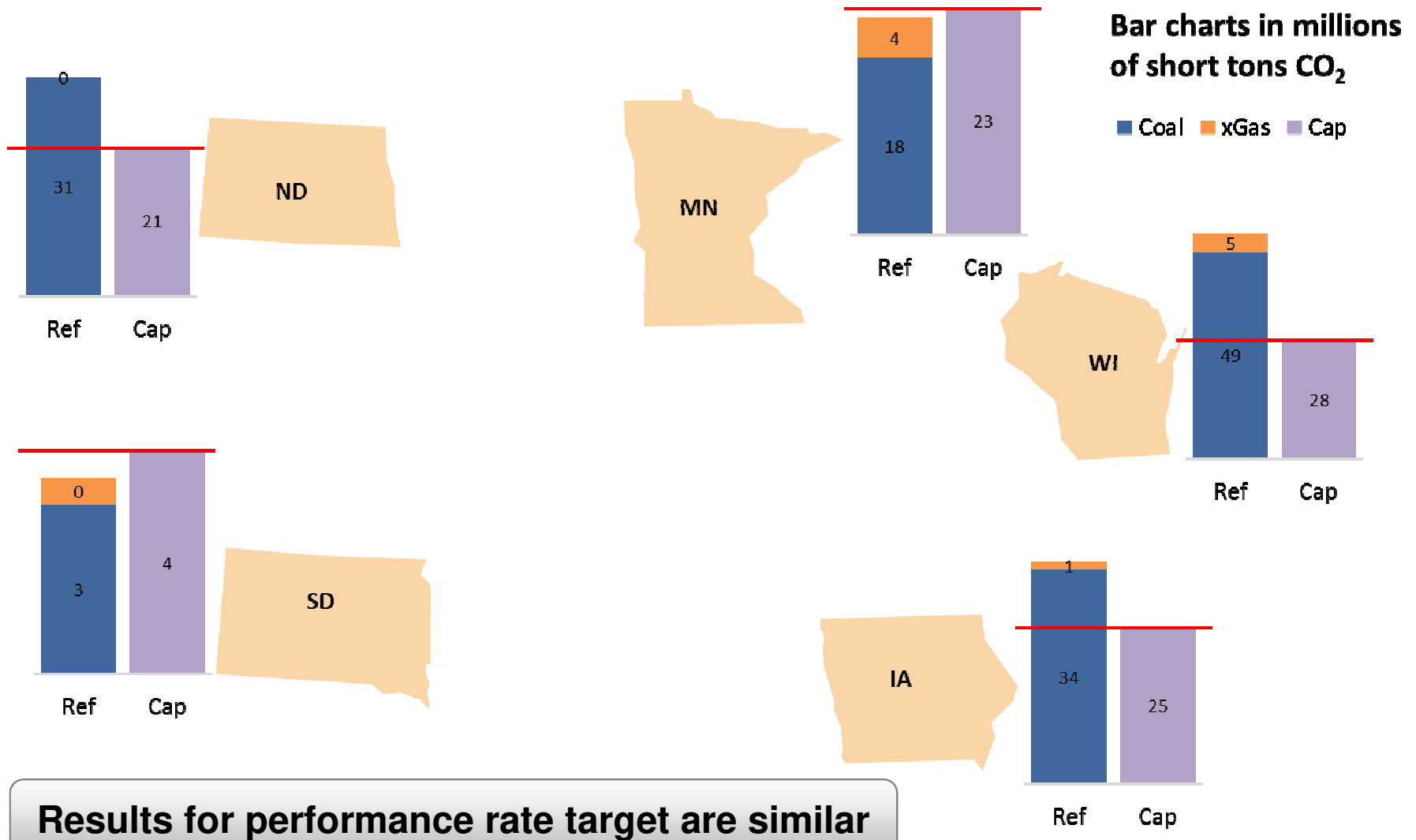
Existing wind units retiring,
all repowered by 2035

MN replaces coal with new NGCC units, EE, and imports



Assumed rising gas prices returns WI coal from cycling to baseload role

Under Reference Case Generation Mix Changes, ND, WI, IA Fall Short of the CPP Mass Target by 2030

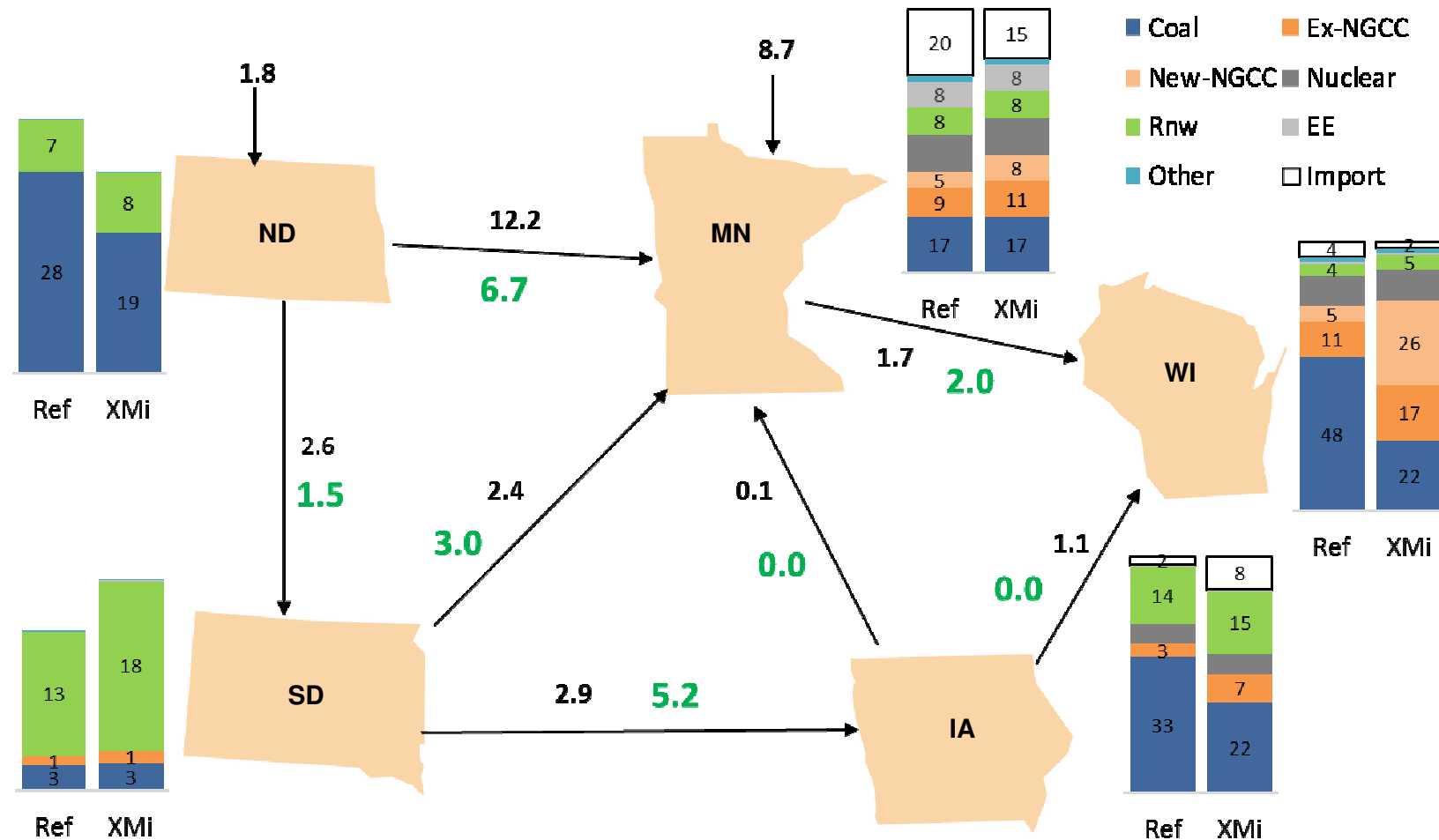


Clean Power Plan Scenarios

	IA, MN, ND, SD, WI	Trading?
Ref	No CPP	N/A
XMi	Existing Mass	No
XMn	Existing Mass	Yes
NSCn	Mass + NSC	Yes
RTi	Performance Rate	No
RTn	Performance Rate	Yes

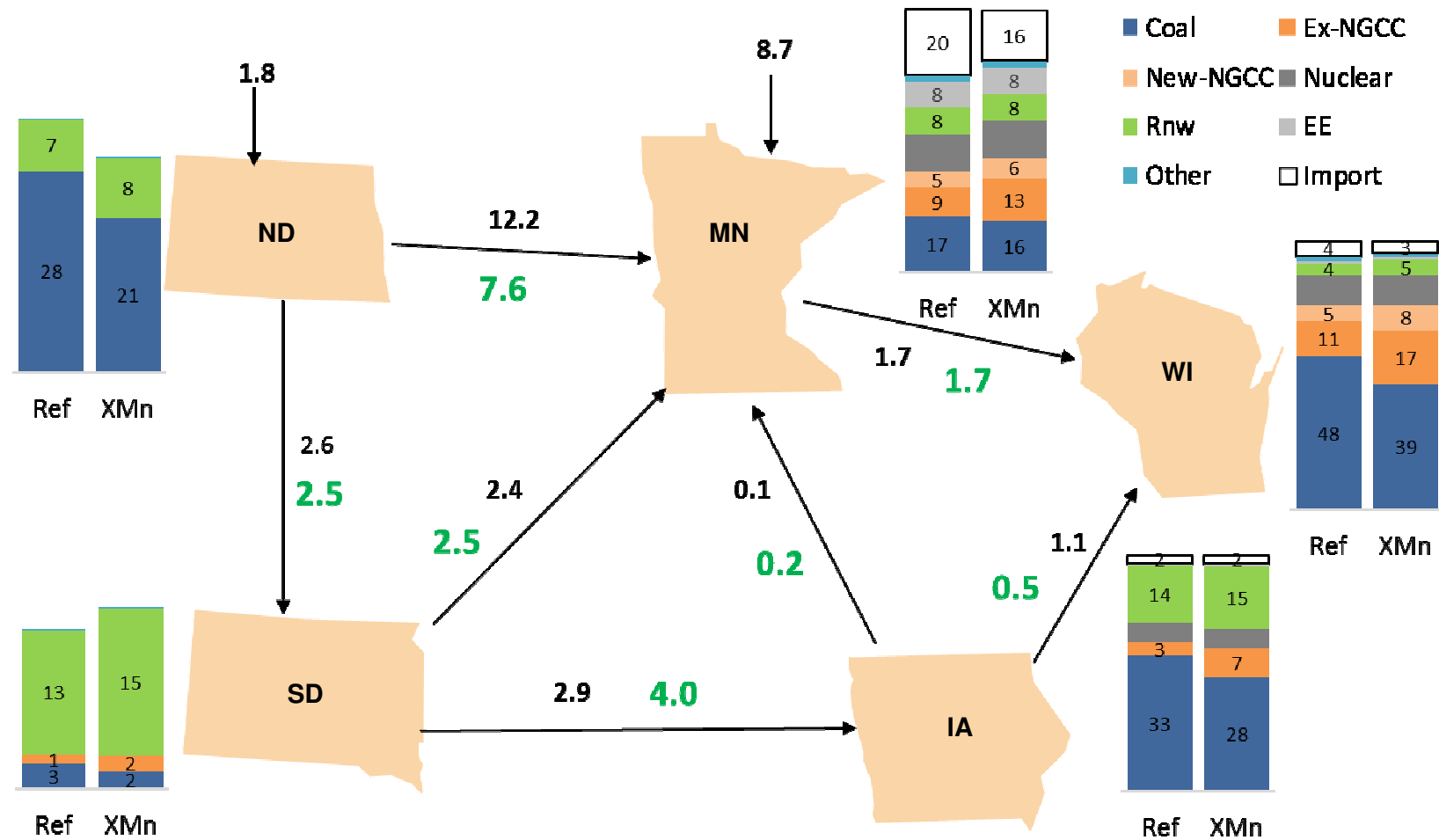
Goal is to understand how different targets and trading rules impact regional generation and inter-state power flows.

Without Trading, Only Way for ND to Meet Mass Target is to Reduce Carbon Emissions from Generation



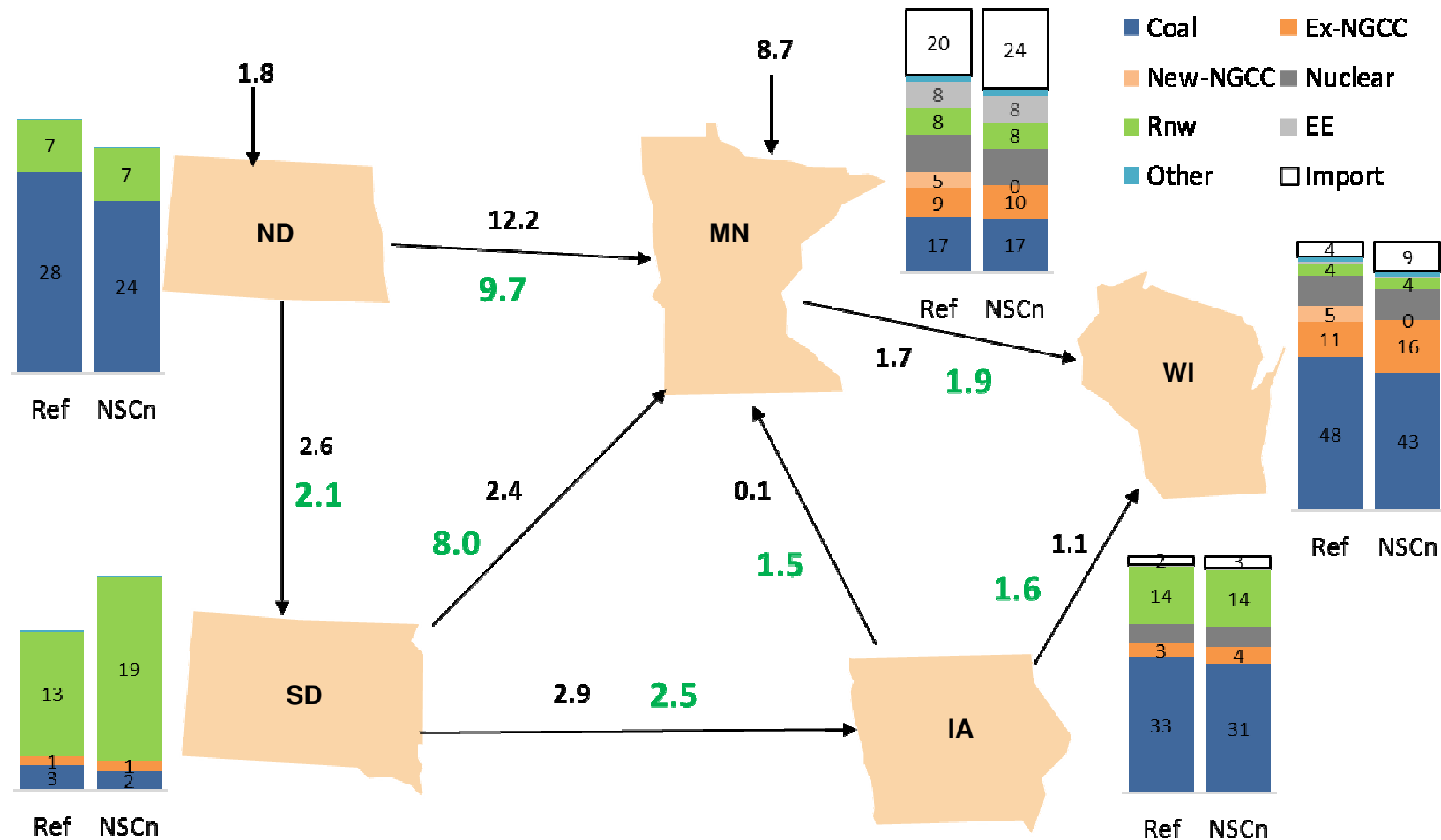
Minnesota replaces 5.5TWh from North Dakota with NGCC generation – North Dakota essentially 'exports' part of its compliance obligation to Minnesota.

Trading CO₂ May Change The Result Depending on ND's Incentive to Buy or Sell Allowances



Region imports 44m tons CO₂ allowances from rest of U.S. in this scenario

Adding the NSC Increases Reliance on Wind for Regional Compliance; Increases MN Imports

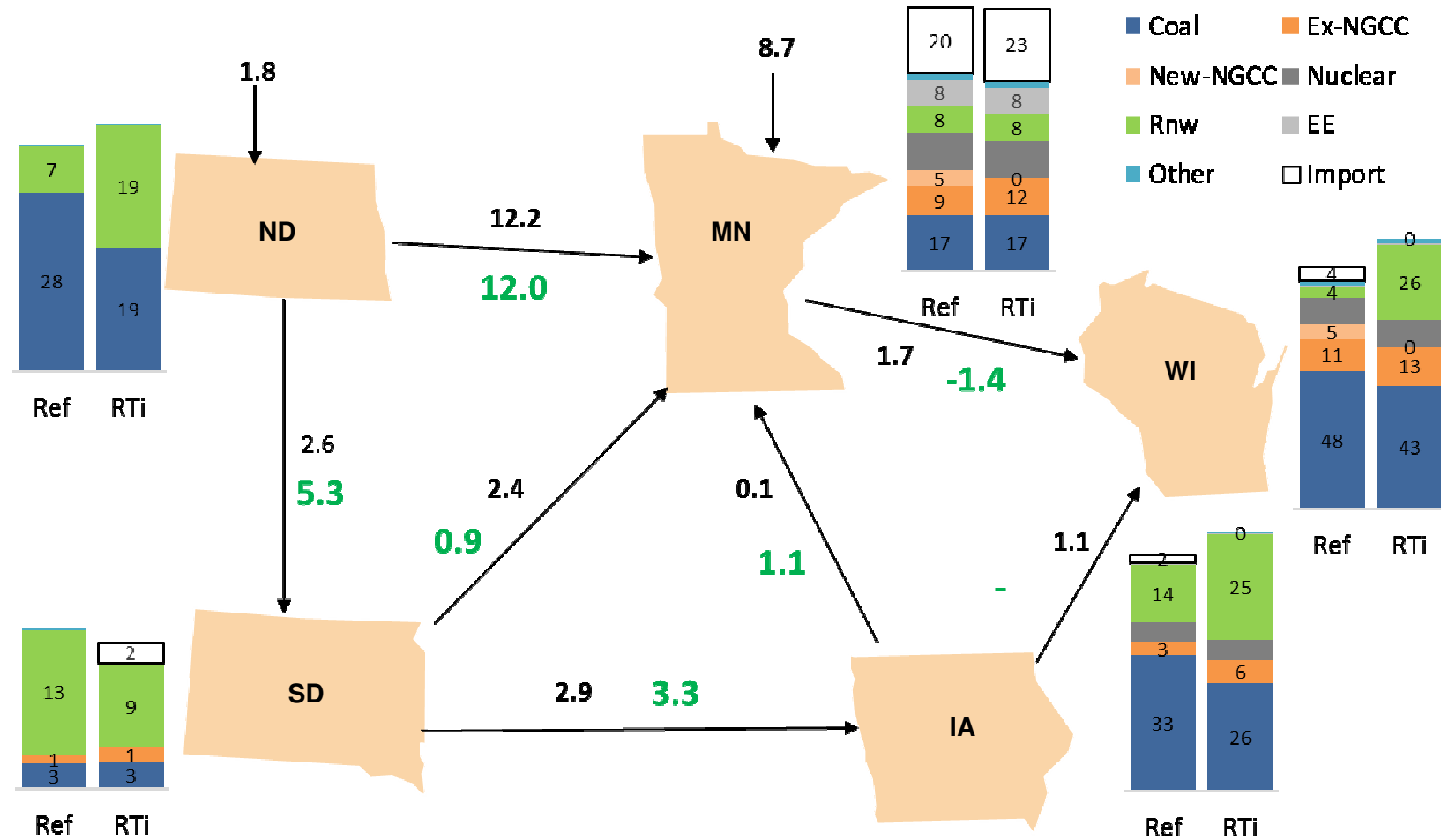


Higher costs in the 5 states encourages more purchases of CO₂ allowances from rest of the U.S., to run more existing coal

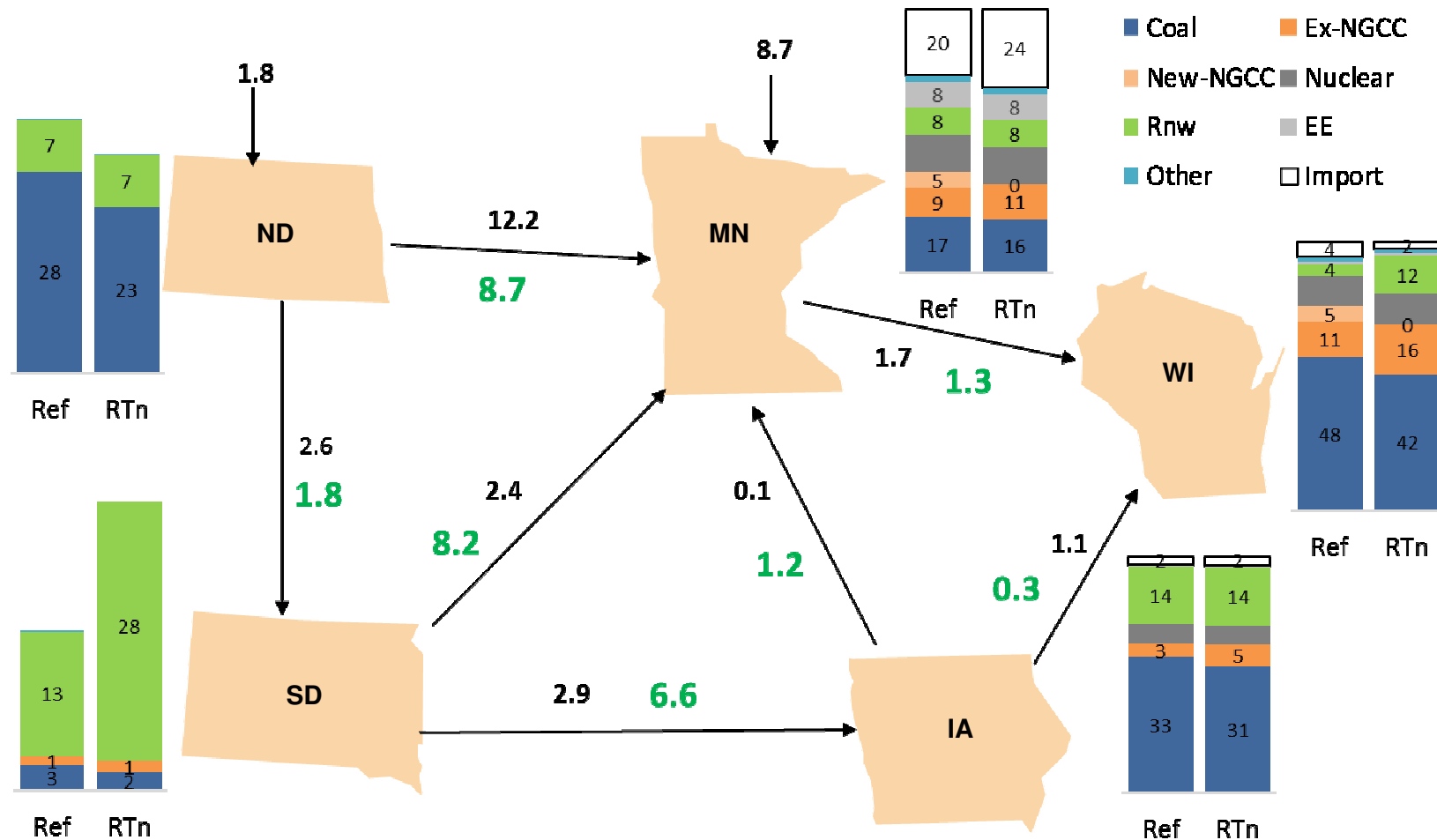
Observations

- Countervailing impacts on MN imports created by two Clean Power Plan drivers
 - ND lowers coal generation by at least 17% vs 2015 under any CPP scenario here
 - Significant new wind in ND/SD in mass + NSC scenario (and in rate scenarios)
- North Dakota will have an incentive to reduce exports under a mass target, *unless* existing coal fleet revenues more than cover the cost to purchasing additional allowances needed for CPP compliance
- Trading opens another channel for CPP compliance that may reduce reliance on power flow changes to meet CPP targets

Without Trading, Rate Encourages Wind in North Dakota



With Trading, ERCs Procured Where Wind is Cheapest, Provided Excess Wind Can Be Exported



With trading, region sources many ERCs from ND/SD wind, but also imports 21 million ERCs from the rest of the U.S.

CPP Compliance and Inter-State Power Flows are Interdependent

- CPP compliance requires Minnesota to meet load and CPP targets simultaneously
- Choice of CPP targets in neighboring states will likely impact Minnesota power imports
 - Less coal in IA/ND/WI under any scenario; reduces potential imports
 - More wind in ND/SD under rate or mass + NSC; increases potential imports
- Minnesota may have to build new generation capacity in-state to offset lower imports
- Minnesota's reliance on imported power implies that its generation mix will be influenced by CPP target decisions in neighboring states, despite Minnesota expecting to meet the CPP targets by itself.

Key Takeaways

- Minnesota can meet CPP targets under reference assumptions – but meeting load depends on the CPP target choices of its neighbors
- Minnesota's neighbors' CPP choices could impact Minnesota through several channels
 - Reduced imports into Minnesota (mostly coal, thereby requiring Minnesota to replace that power from in-state sources); or
 - Increased imports into Minnesota (mostly more wind); and
 - Opening up to trading may incentivize selling ERCs or CO₂ out-of-state, which may reduce Minnesota fossil
- Minnesota power supply mix will have less coal, more wind, and likely more variability, with implications for reliability in balancing power and transmission system operation within Minnesota



Together...Shaping the Future of Electricity

David Young
Principal Technical Leader
650-855-8927
dyoung@epri.com

Key Modeling Assumptions

- Load growth and fuel price paths based on the AEO 2016 Reference Case (version without the CPP)
- Technology costs based on EPRI technical reports
- Inter-state transmission capacities from NREL, with additional input from utilities in some states
- Includes existing policies
 - State renewable portfolio standards (current as of June 2016)
 - Regional Greenhouse Gas Initiative
 - Production Tax Credit for wind, Investment Tax Credit for solar
 - Minnesota solar mandate; Minnesota EE mandate
 - New Source Performance Standard for fossil units (no new coal units without CCS)