The Future From One RTO's Window

The Institute for Regulatory Policy Studies

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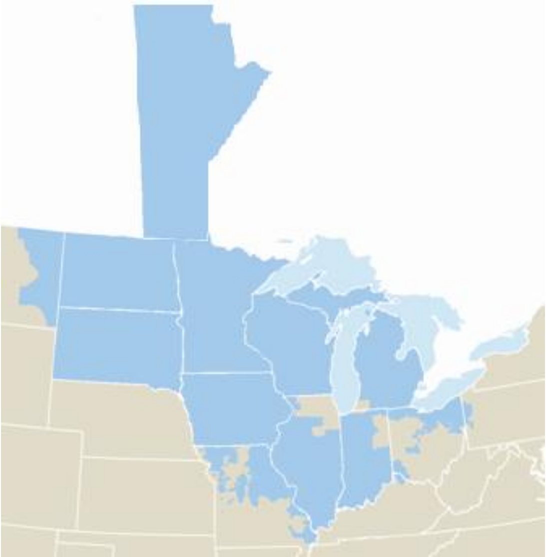
The Midwest ISO's geographic footprint is broad and diverse

Midwest ISO's Reliability Footprint



Midwest ISO's Market Footprint

Interconnected High Voltage Transmission Lines

- 93,600 miles

Installed Generation Capacity

- 138,556 MW (market footprint)
- 159,000 MW (reliability footprint)
- 5,575 generating units

Peak Demand – 7/13/2006

- 116,030 MW (market footprint)
- 136,520 MW (reliability footprint)

Midwest Market Highlights

- $41 billion annual gross market charges (2008)
- 300 Market Participants who serve 40+ million people

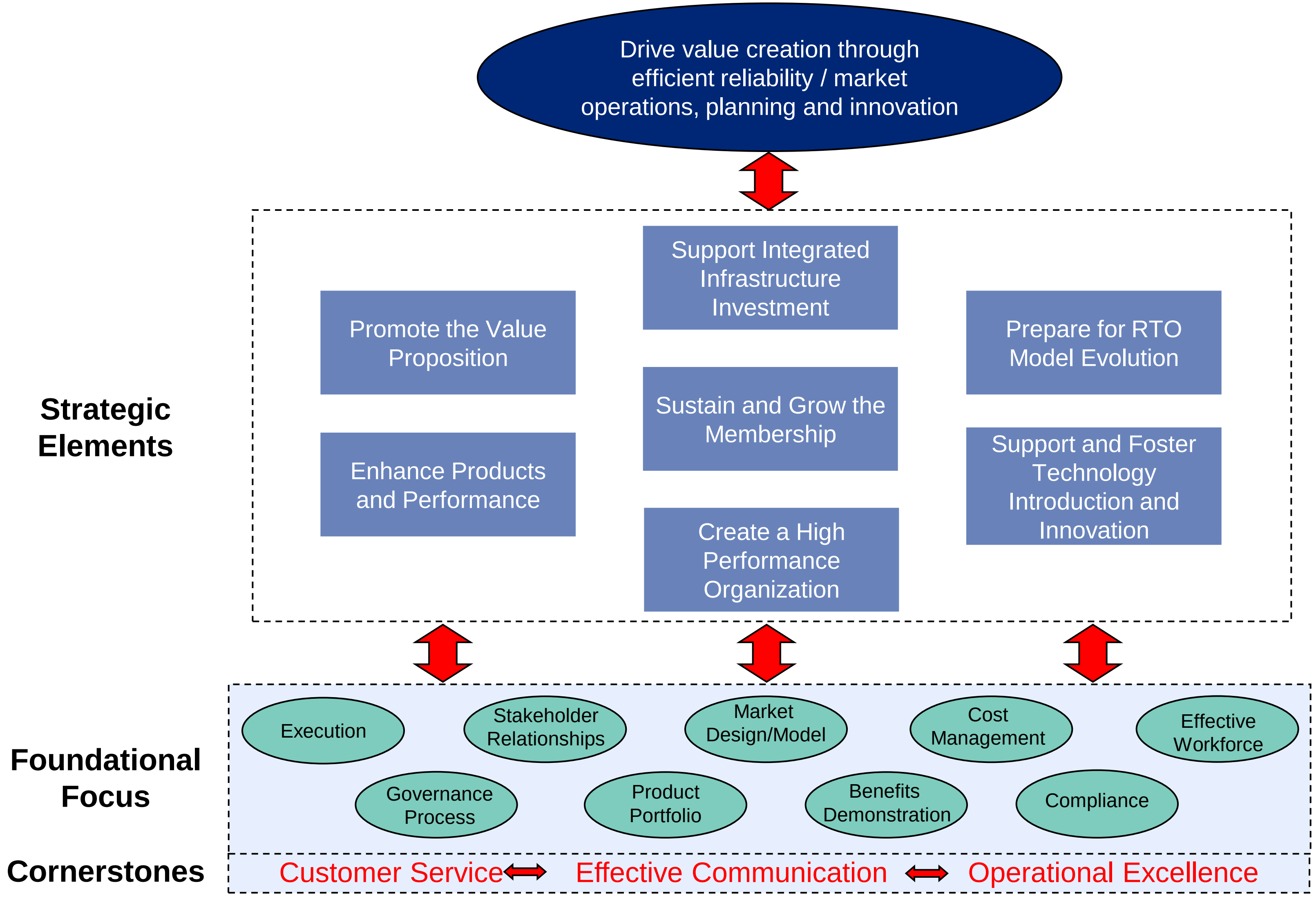
Two Control Centers

- Carmel, IN (Headquarters)
- St. Paul, MN

In 2007, several key issues were identified that drove the Midwest ISO's Strategic Plan. Many of these same issues are continuing to drive our strategic direction, but the context has changed for most.

2007 Issues		2010 Status
• Limited stakeholders ability to understand and confirm value received from RTO	**Value Proposition**	• Members confirming value in open proceedings • State commissions quoting value proposition to state legislatures
• Renewable Portfolio Standards gaining momentum • RTO cost recovery concerns	**State Policy**	• RPS driving construction • Equitable allocation of transmission expansion costs
• FERC policy push for RTOs waning • Energy & environmental policy uncertainty	**Federal Policy**	• FERC policy concentrated on RTO effectiveness • Compliance is significant focus • Energy & environmental policy uncertainty continues
• Overall spend increasing but insufficient • Coordination of projects difficult across multiple boundaries	**Transmission Development**	• Cost allocation / recovery is the key battlefield with state commissions leading discussions
• Capacity overhang decreasing • Policy uncertainty stalling construction • Gas construction default position despite high gas cost	**Capacity Development**	• Capacity overhang returns • Renewable additions driven by state RPS

The Midwest ISO Strategic Plan is very relevant to guide this evolving future



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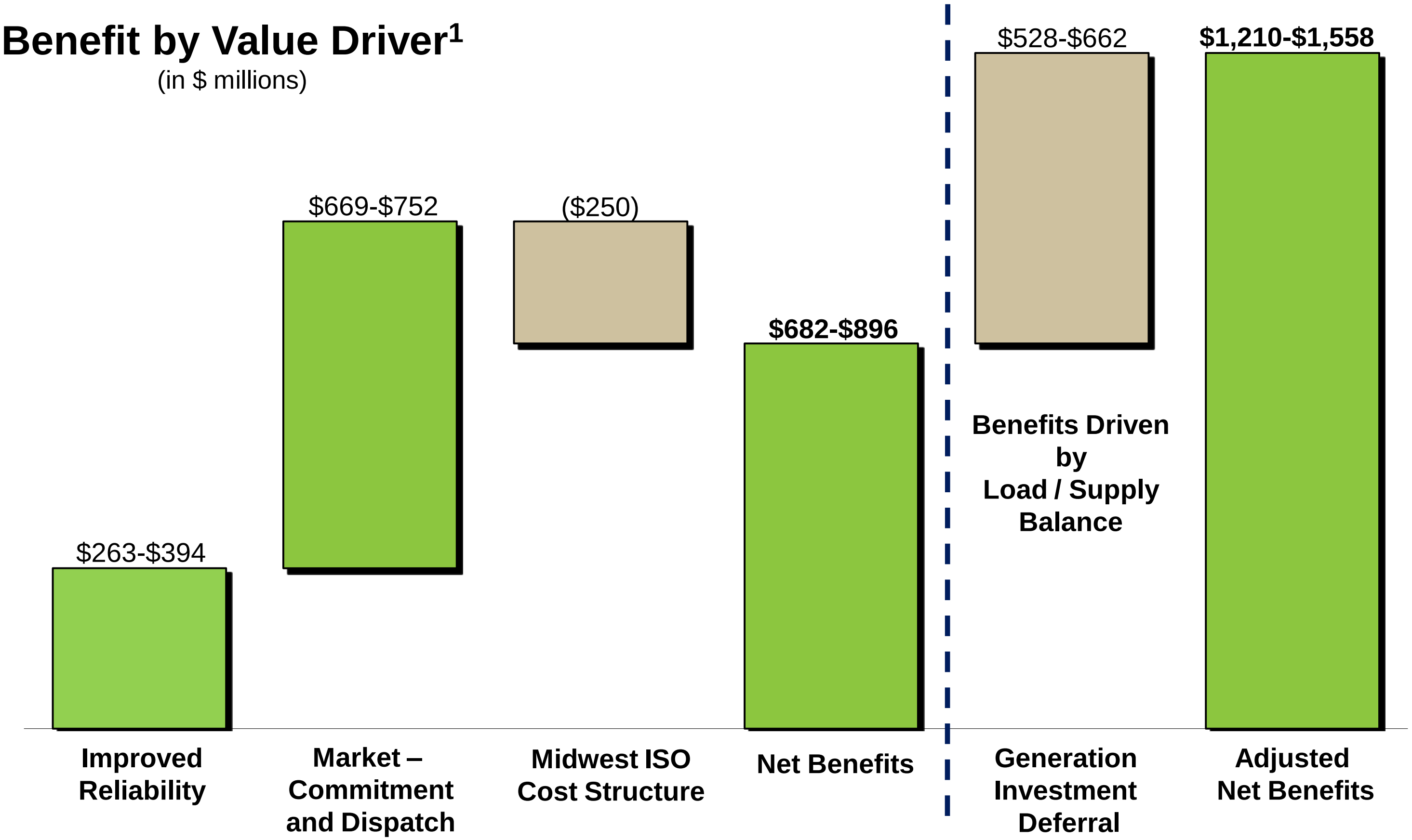
The Midwest ISO 2009 Value Proposition

Benefit by Value Driver[1]

(in $ millions)



Market – Commitment and Dispatch

- Dispatch of Energy ($210 - $264)
- Unloaded Capacity ($199 - $213)
- Regulation ($184 - $194)
- Spinning Reserves ($76 - $81)

Generation Investment Deferral

- Footprint Diversity ($217 - $272)
- Gen. Availability Improvement ($249 - $311)
- Dynamic Pricing ($4 - $7)
- Direct Load Control / Interruptibles ($58 - $72)

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[1]*Figures shown reflect annual benefits and costs for 2009*

Understanding what the generation fleet might look like in the future is critical

- Support Integrated Infrastructure Investment
- Promote the Value Proposition
- Sustain and Grow the Membership
- Support and Foster Technology Introduction and Innovation
- Enhance Products and Performance
- Create a High Performance Organization
- Prepare for RTO Model Evolution

What transmission is needed?

What new products are needed?

How will our members be impacted?

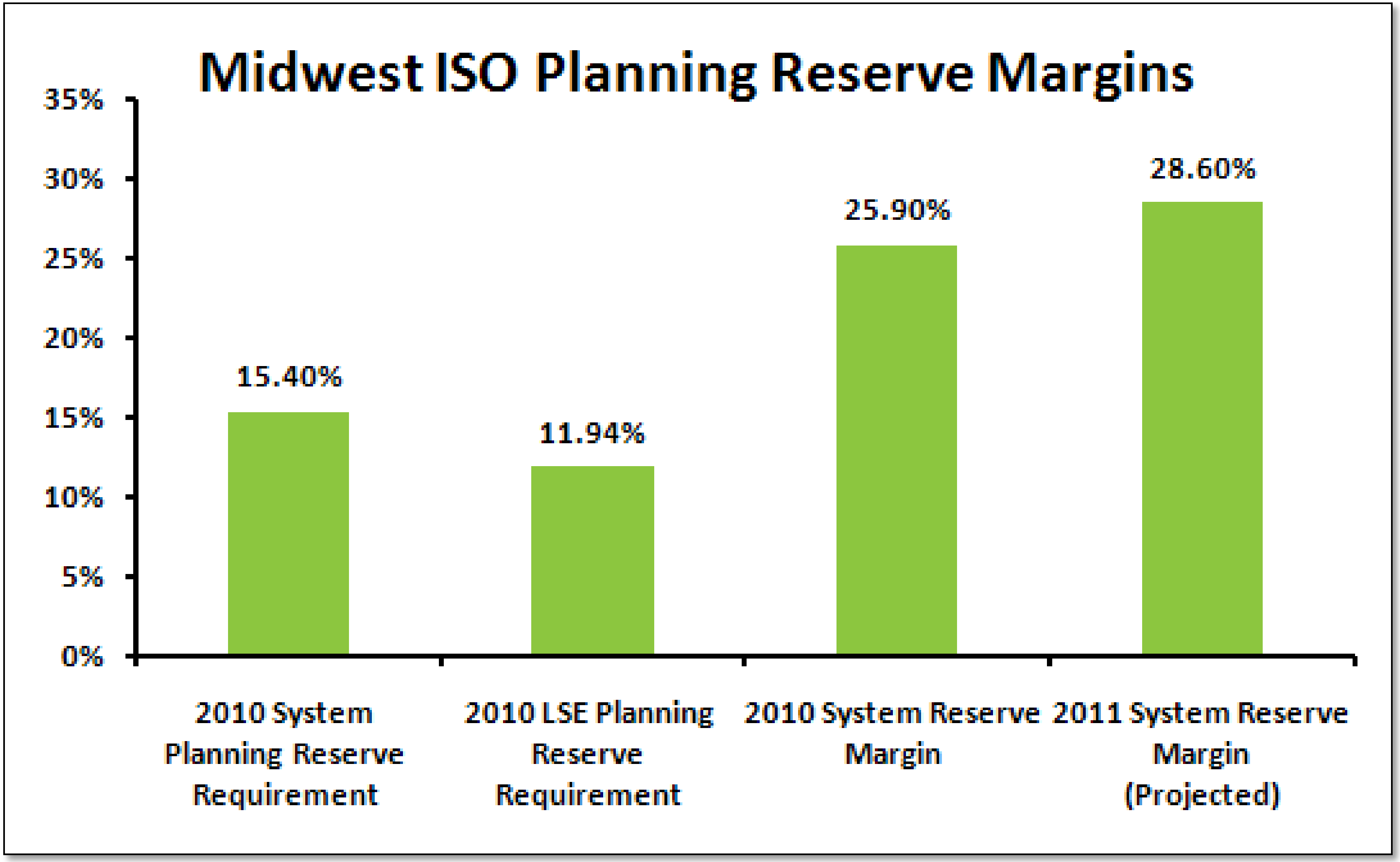
How should we educate policy makers?

What new tools / skills do we need?

What will other RTOs offer?

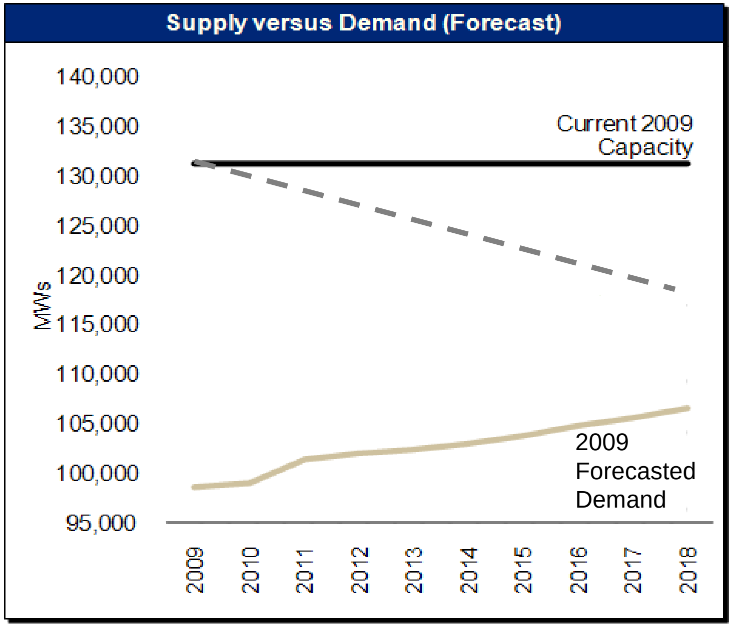
How do we provide value?

How much is enough?

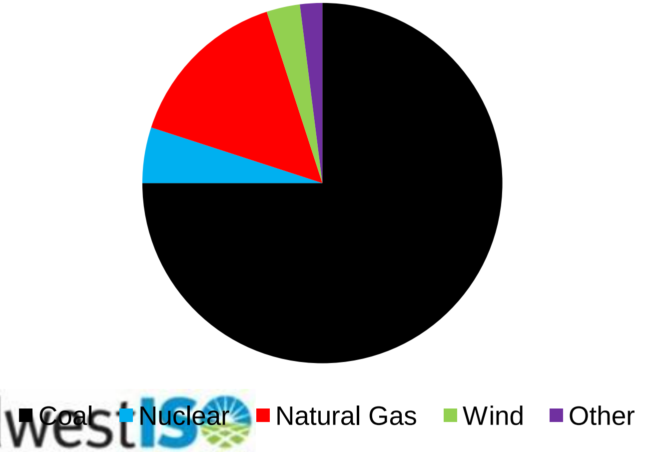


We must look to the future in evaluating Smart Grid options
Envision what the grid will / could look like in 20 years

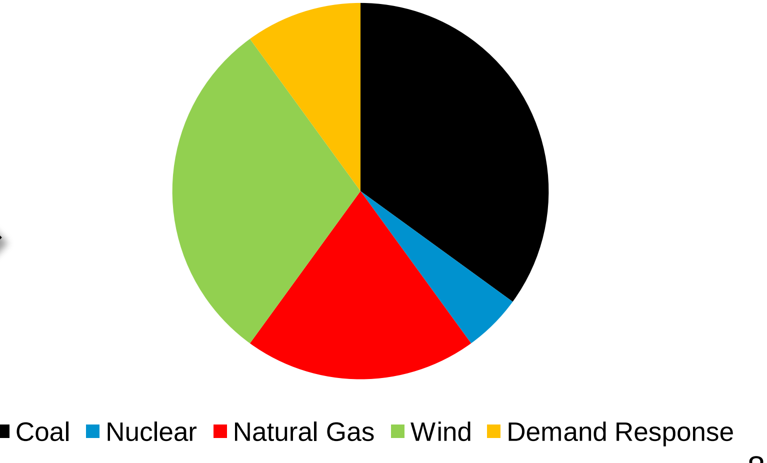
- Do not be "lulled" to sleep by today's overcapacity situation
- Do not miss tomorrow's opportunities by thinking of yesterday's issues and technologies
- Look at future generation portfolio possibilities to understand future issues and the value of emerging business models



Current Electricity Production



Future Electricity Production



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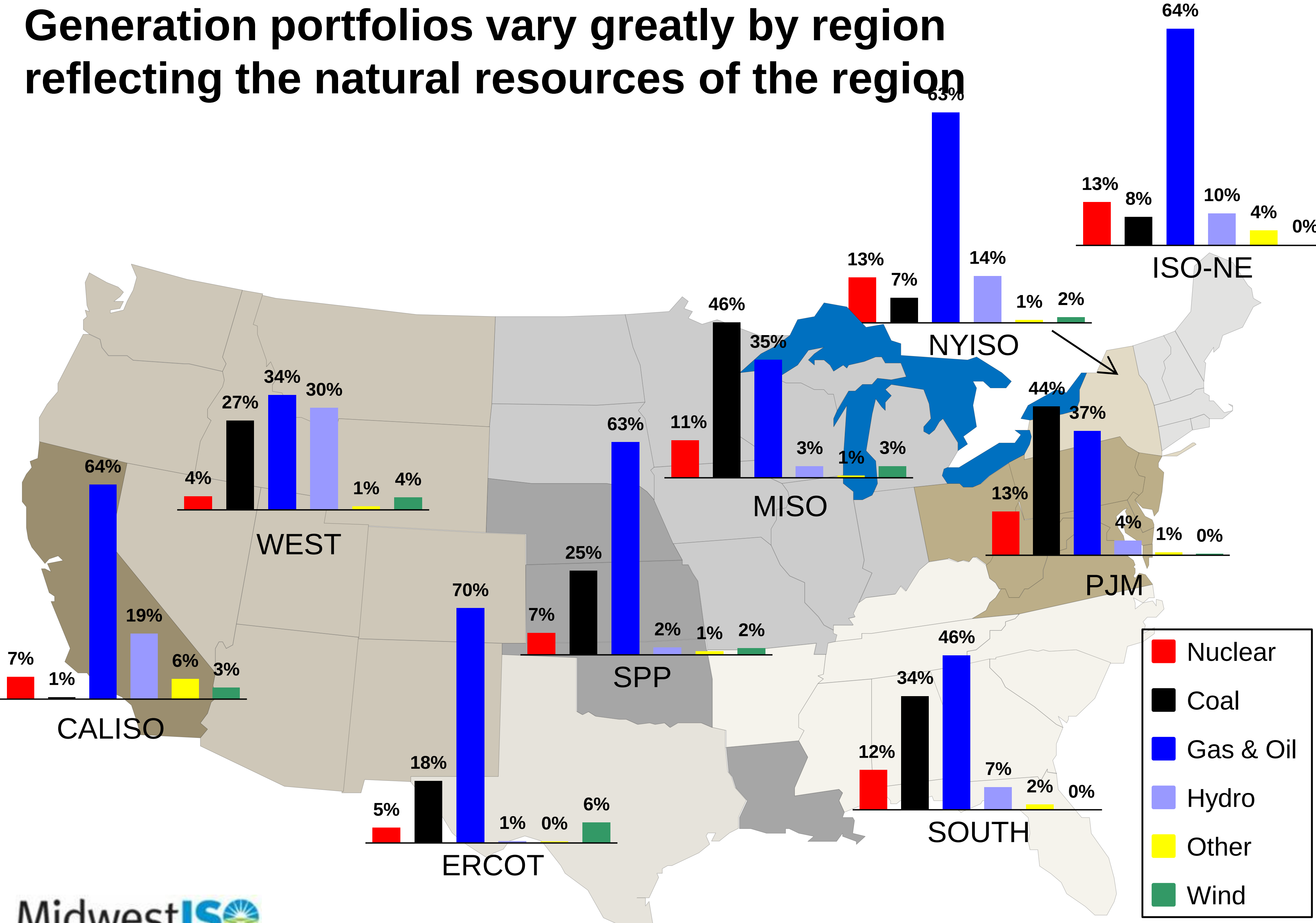
Generation portfolios vary greatly by region reflecting the natural resources of the region



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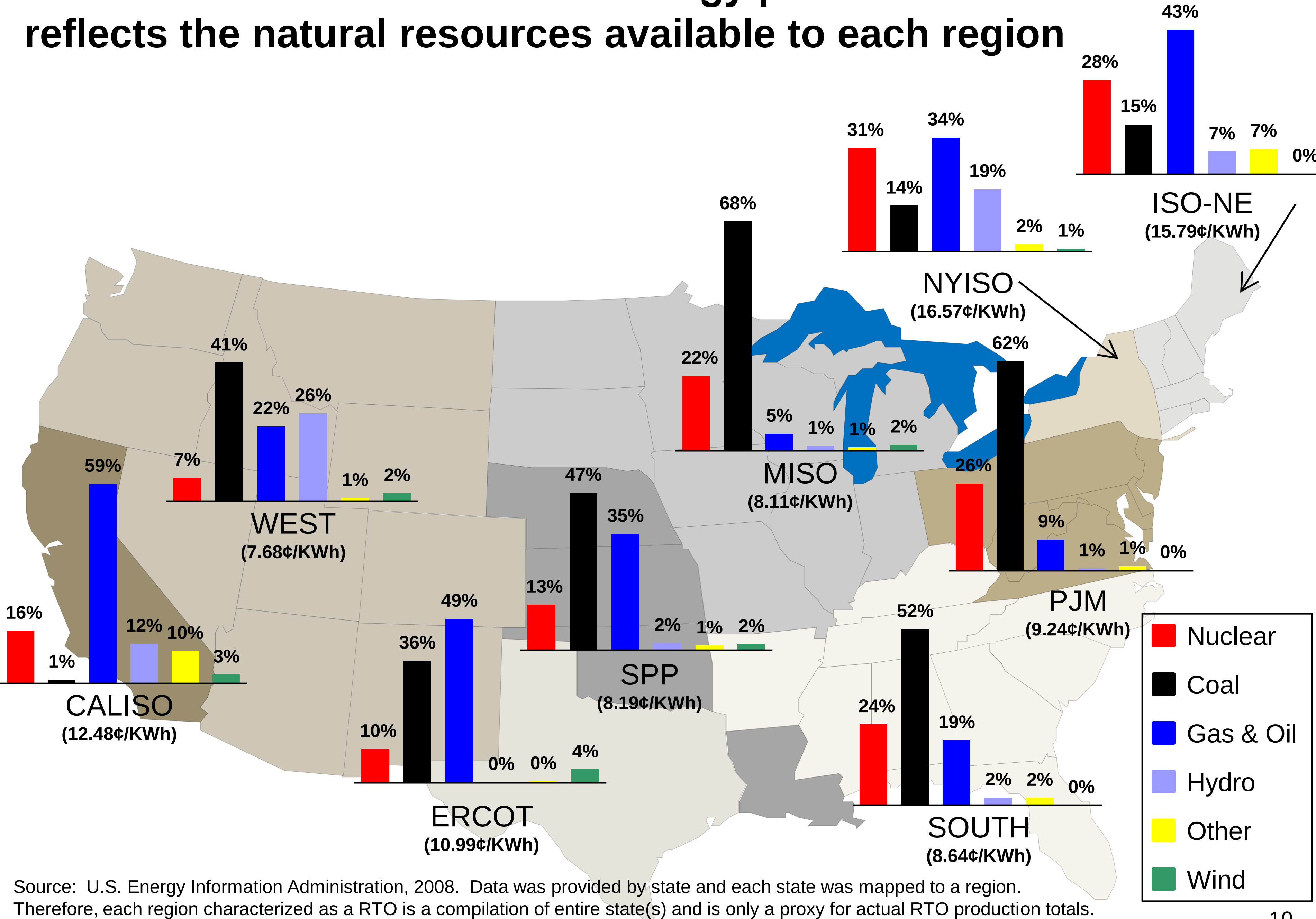
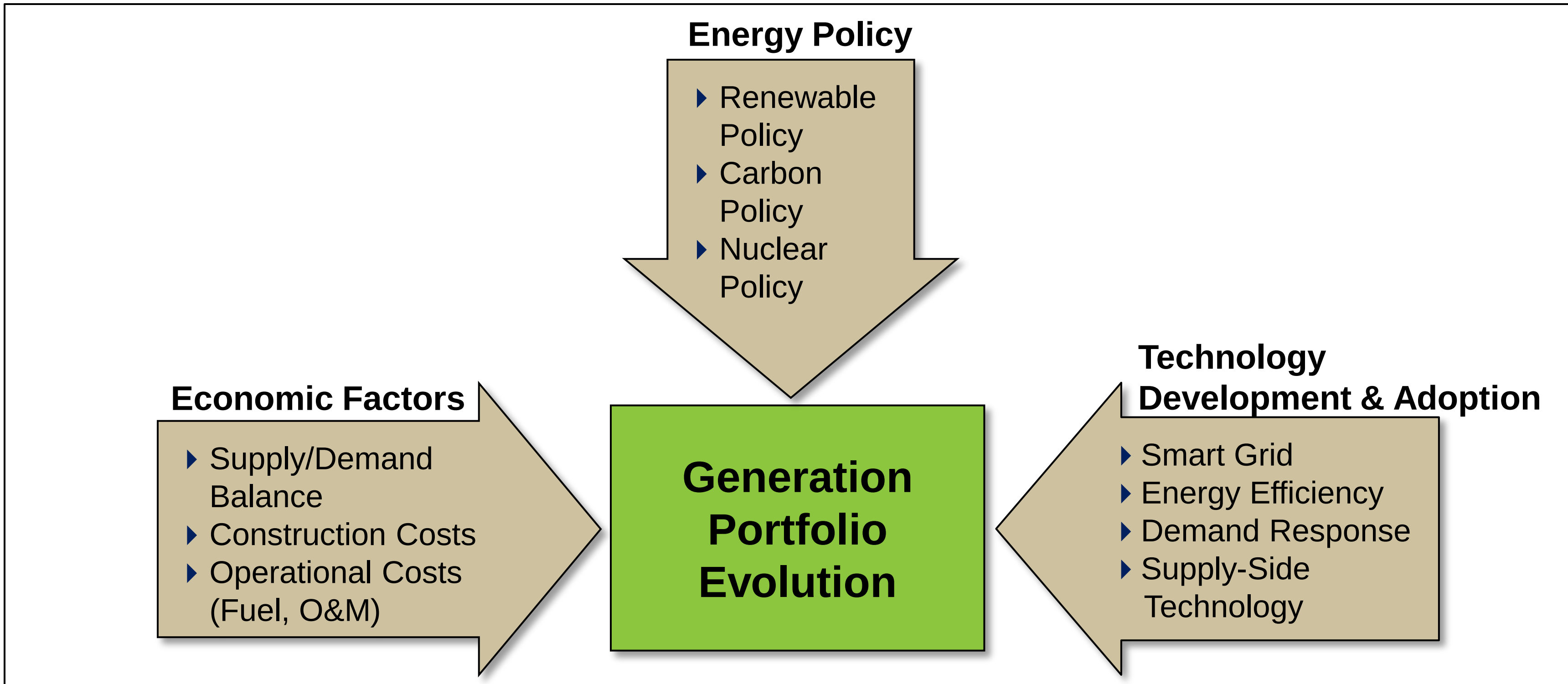
Source: U.S. Energy Information Administration, 2008. Data was provided by state and each state was mapped to a region. Therefore, each region characterized as a RTO is a compilation of entire state(s) and is only a proxy for actual RTO totals.

The nation's current electrical energy production reflects the natural resources available to each region



Source: U.S. Energy Information Administration, 2008. Data was provided by state and each state was mapped to a region. Therefore, each region characterized as a RTO is a compilation of entire state(s) and is only a proxy for actual RTO production totals. The weighted average retail price is shown under each region.

The future generation portfolio will be shaped by a host of influences



A versatile transmission system expansion is required to accommodate multiple potential generation futures

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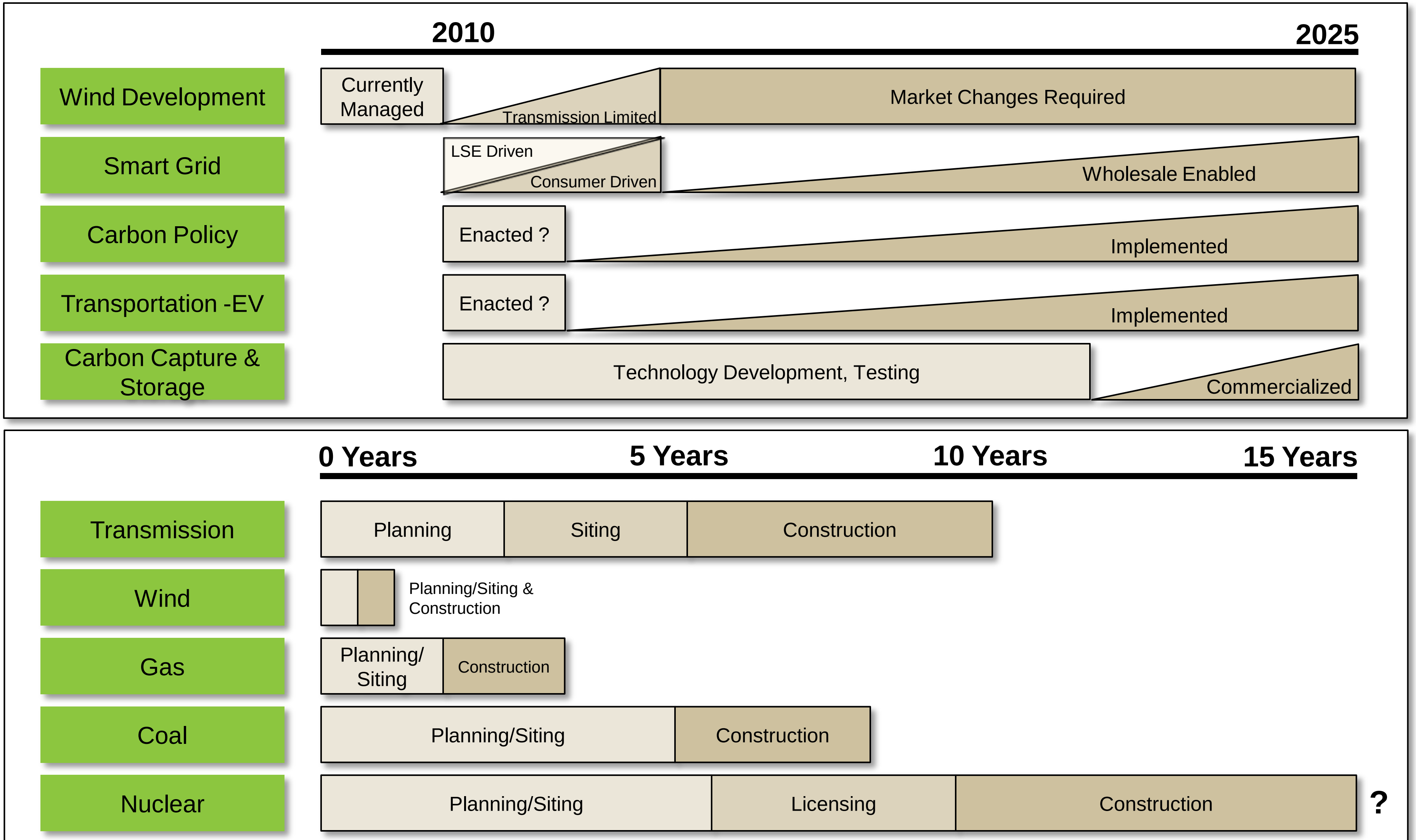
Policy issues and technology development/adoption will impact the generation portfolio over time and could be constrained by the lead times required to build transmission and generation



The Midwest ISO has developed a series of potential future scenarios that demonstrate the potential effects of these influences

Scenario	Reference	Federal RPS	Carbon Cap	Smart Grid + EV	Gas Future
Description	Business as usual	20% energy to be served by renewable resources	39.5% carbon reduction by 2029	Adds effect of Smart Grid and Electric Vehicles to the “Federal RPS” and “Carbon Cap” scenarios	Only gas-fired resources are built
Key Assumptions	▸ State RPS requirements ▸ Installed generation to be constrained based on economic drivers	▸ State RPS requirements ▸ Federal RPS of 20% ▸ Installed generation to be constrained based on economic drivers	▸ State RPS requirements ▸ Allows existing fleet retirements with retro-fit sequestration available	▸ Federal RPS of 20% ▸ 39.5% carbon reduction by 2029 ▸ EV penetration included in energy growth rate ▸ Allows existing fleet retirements with retro-fit sequestration available	▸ State RPS requirements
Key Findings	▸ Wind installed generation increases 21,600 MW compared to 2009 ▸ Retail impact – 4% increase over current MISO retail rates	▸ Managing large increase in intermittent resources will have significant impact on operations ▸ Retail impact – 14% increase over reference scenario	▸ Carbon output decreases 30% ▸ Retail impact – 23% increase over reference scenario	▸ 277% increase in capital costs over reference scenario ▸ Retail impact – 33% increase over reference scenario	▸ Most flexible fleet operationally of all scenarios ▸ Retail impact – 11% decrease over reference scenario

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The Federal RPS case highlights the impact of meeting our region's requirements under a 20% mandate. This case is used to illustrate the Midwest's work to reliably integrate large amounts of wind into the portfolio.

Scenario	Reference	Federal RPS	Carbon Cap	Smart Grid + EV	Gas Future
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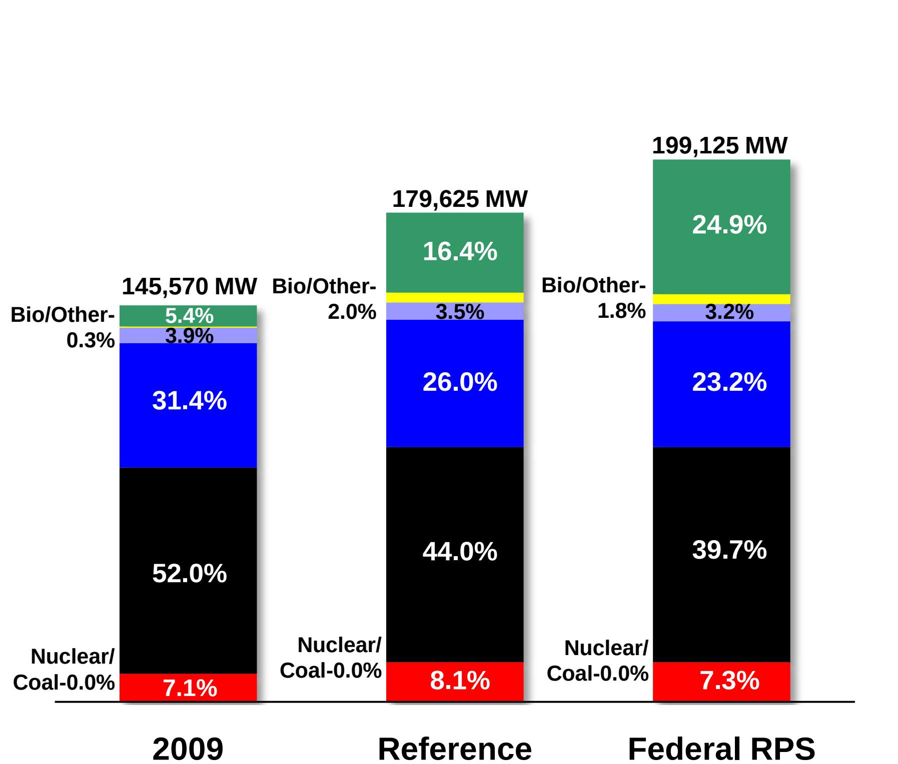
Federal RPS

Installed Generation – 2025 (MWs)

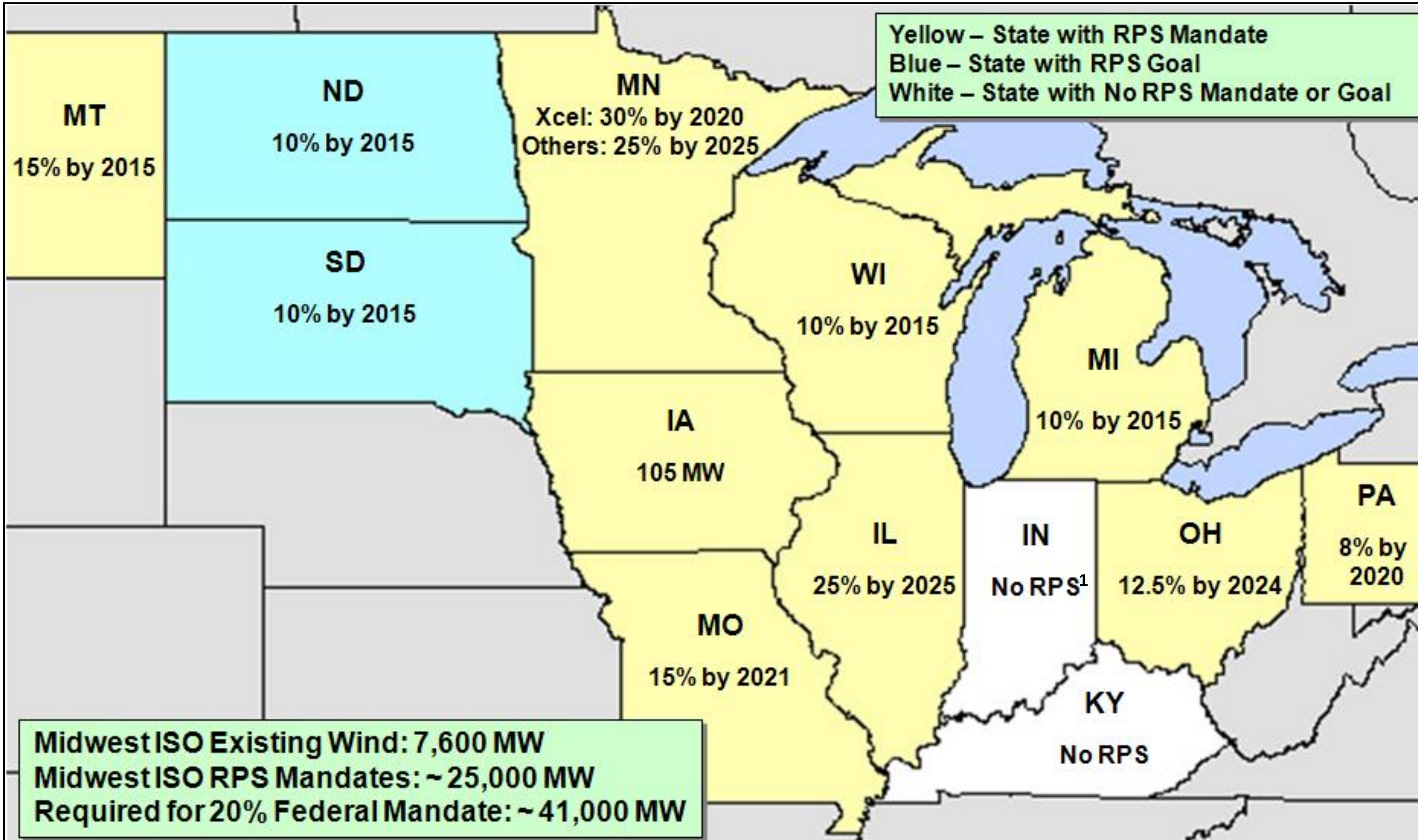


		% △		% △	
Wind/ Solar	7,805	↑277%	29,405	↑68%	49,505
Biomass/ Other	397	↑806%	3,597	0%	3,597
Hydro	5,609	↑13%	6,359	0%	6,359
Gas & Oil	45,725	↑2%	46,745	↓1%	46,145
Coal	75,673	↑4%	78,995	0%	78,995
Nuclear/ Coal	0	0%	0	0%	0
Nuclear	10,361	↑40%	14,524	0%	14,524

Scenario	Reference	Federal RPS	% △
Top 3 Fuels (Production)	1. Coal 2. Nuclear 3. Wind/Solar	1. Coal 2. Wind/Solar 3. Nuclear	
Carbon Output in 2025 (tons in Mils.)[1]	498.0M 0.75 tons/MWh	442.0M 0.66 tons/MWh	↓11%
Production Cost (Bils.)	$261	$259	0%
Capital Cost (Bils.)[2]	$99	$153	↑55%
LMP ($/MWh)	$21.71	$20.33	↓6%
Retail Cost (¢/KWh)[3]	9.02¢	10.27¢	↑14%

[1]2005 Midwest ISO Base CO_2 Output: 535M tons
[2]Capital Cost includes generation costs only
[3]Retail Cost (¢/KWh) is in 2010 dollars
Note: 15% reserve margins used in scenario
Note: 8% wind capacity credit used in scenario

The majority of the Midwest ISO states have adopted Renewable Portfolio Standards



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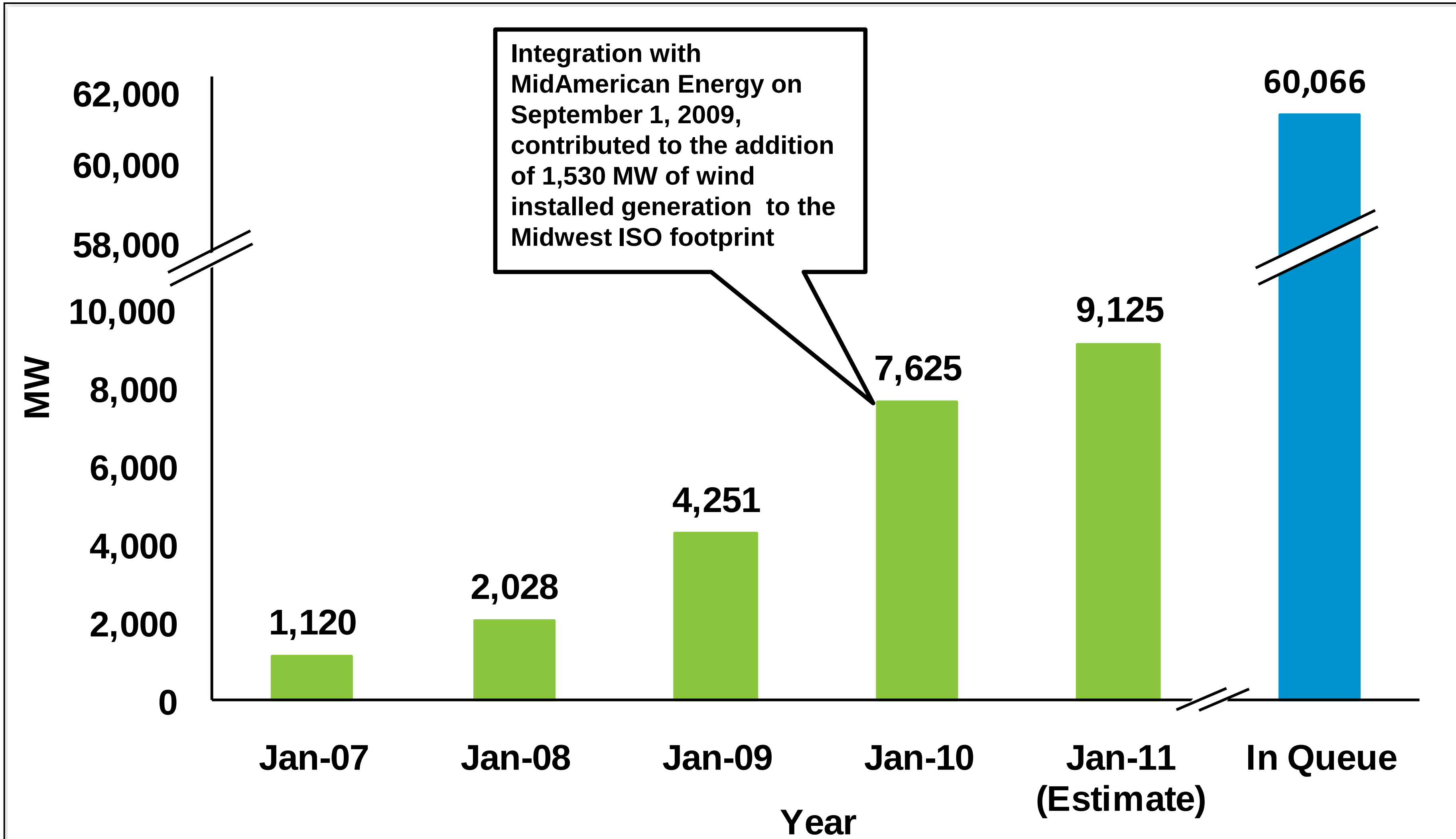
Note: Existing Wind In-Service as of 2/01/10

Installed wind generation has been steadily increasing in the Midwest ISO market



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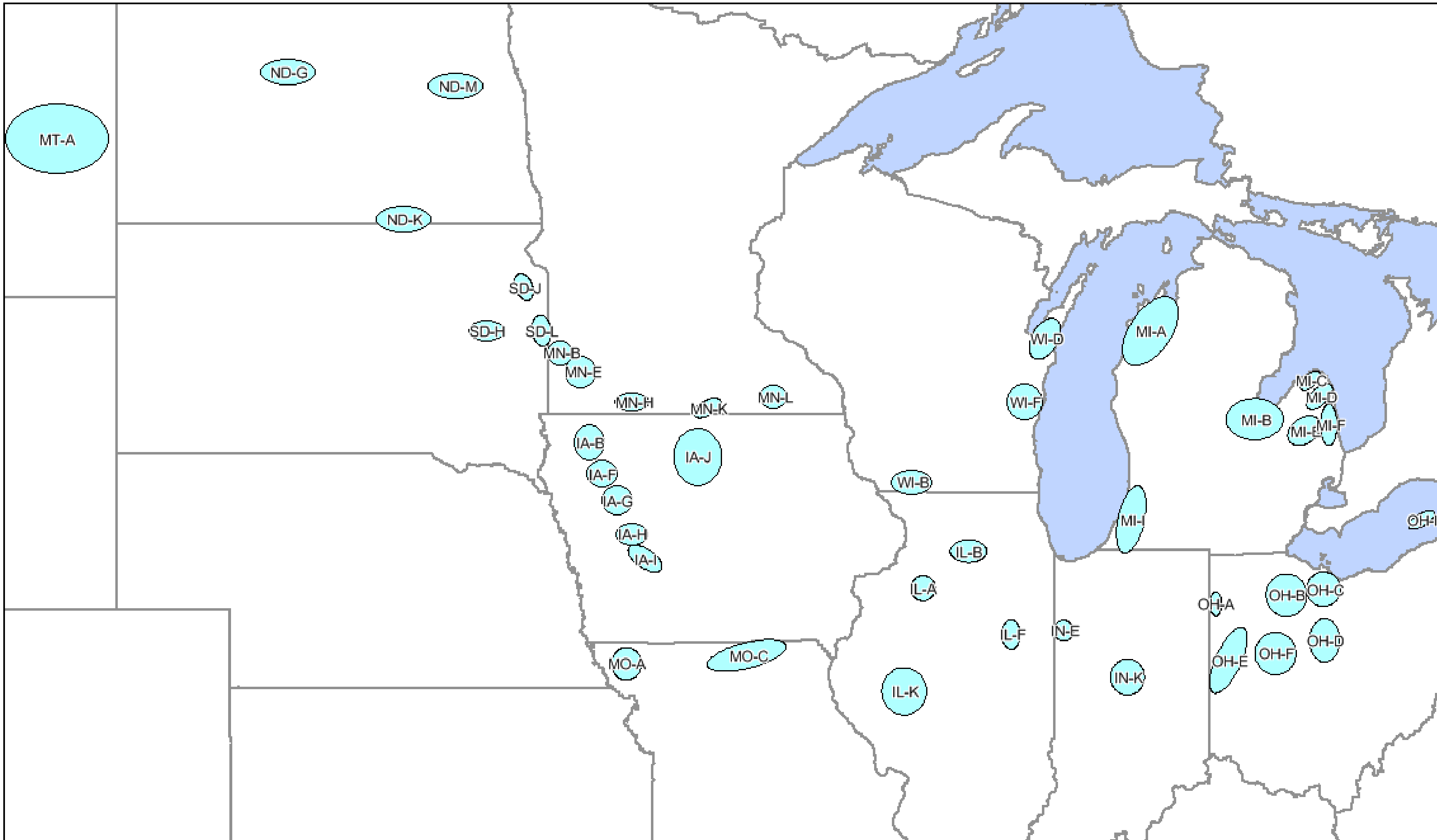
Regional Generation Outlet Study Zones



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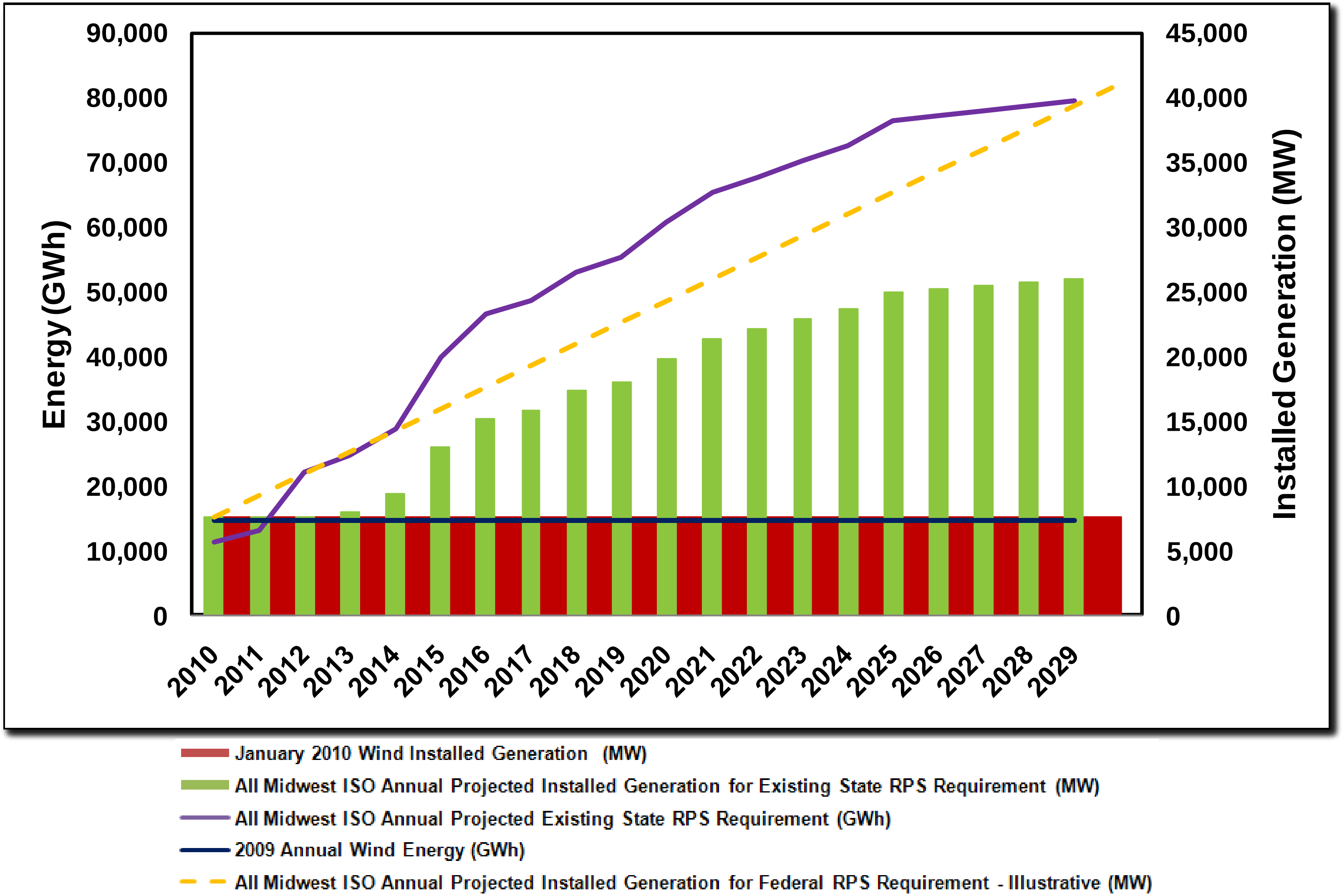
To meet the projected energy requirements in the Midwest ISO states, wind in the footprint will increase dramatically



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Notes: Nameplate MW estimate is based on 35% wind capacity factor
Region Generation Outlet Study is developing transmission plans for 25,000 MW of wind to meet current RPS mandates in the Midwest ISO states. Federal 20% RPS mandate equates to 41,000 MW.

Inherent characteristics of wind have significant operational impacts on the Midwest ISO operationally

Driver	Market Issue	Current Tools
Variability of wind	Surplus generation events	Wind forecast
Negative correlation of wind and load	Over and under commitment	Manual curtailment
Transmission congestion caused by wind location	Ramp management	Fast start unit commitment
	Congestion management	

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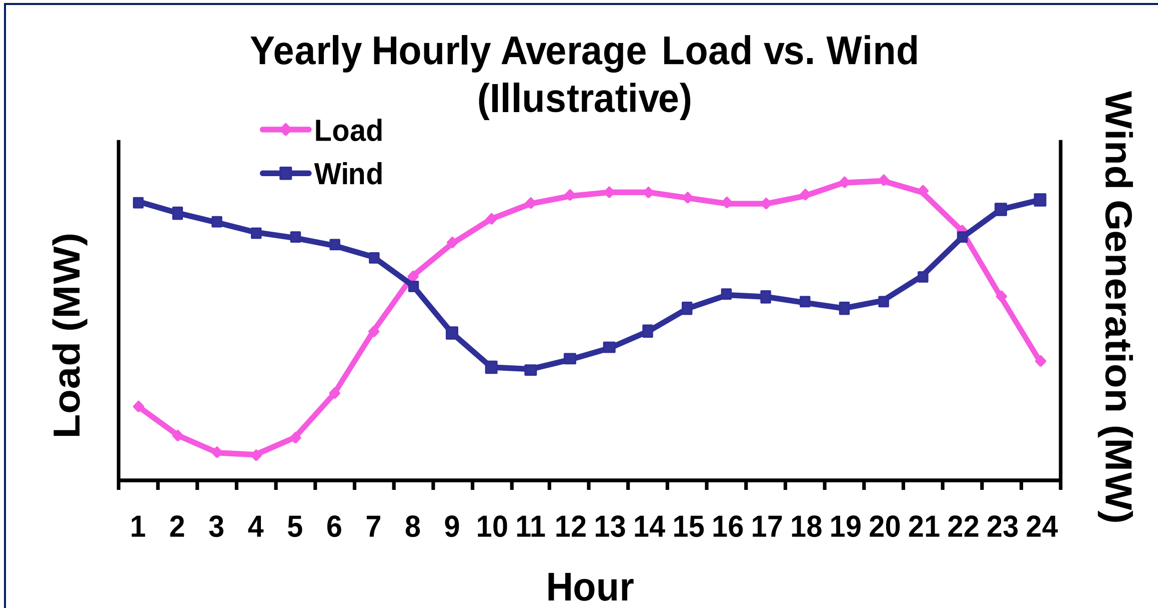
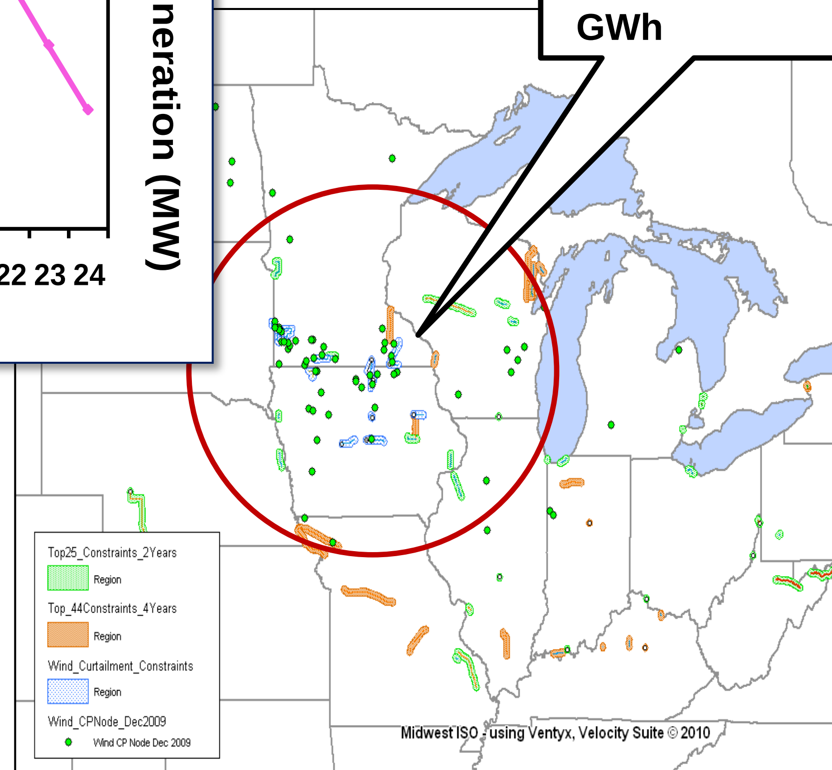
The mismatch between "normal" load and wind generation profiles may contribute to congestion and surplus generation events which are currently managed through manual curtailments of wind



18 surplus generation events occurred in 2008 and 7 in 2009



In 2009, Midwest ISO manually curtailed wind units 1,227 times for a total of 220 GWh

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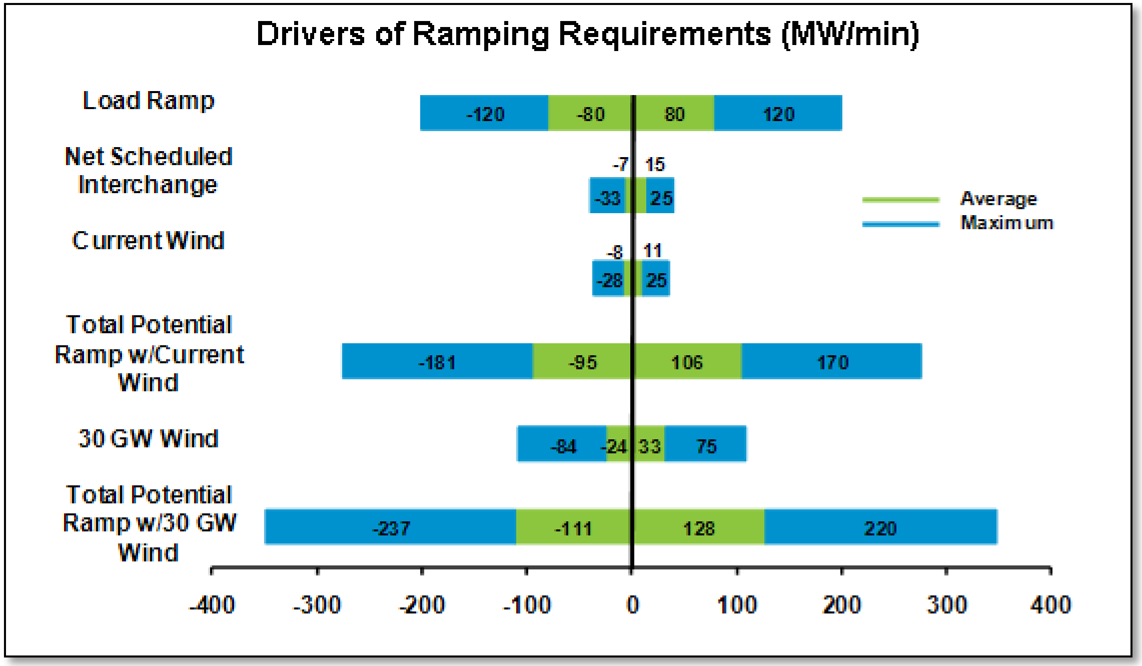
Wind variability creates a significant ramping challenge which will require improved tools and may require new market products to manage

- The current wind variability and profile impact ramp requirements as significantly as Net Scheduled Interchange
  - RPS wind capacity levels will dramatically increase the operational difficulties
- Current operational methods to manage this ramp include:
  - Load and wind forecasting
  - Pre-commitment of units
  - Use of fast-start units and spinning reserves to manage unexpected variability
- Improved operational and market methods - under development
  - Improved load and wind forecasting
  - 30-minute reserve products
  - Ramping service product



New tools are being considered to help manage operational impacts of wind on the Midwest ISO

Driver

- Variability of wind
- Negative correlation of wind and load
- Transmission congestion caused by wind location

Market Issue

- Surplus generation events
- Over and under commitment
- Ramp management
- Congestion management

New Tools/Processes

- Enhanced wind forecasting
- Market dispatch of intermittent units
- New 30-minute reserve product
- Potential new ramping service product

While potential climate change policy could have significant impacts on the Midwest's generation fleet, the actual impacts will depend on the willingness of policy makers to increase costs

Scenario	Reference	Federal RPS	Carbon Cap	Smart Grid + EV	Gas Future
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Carbon Cap

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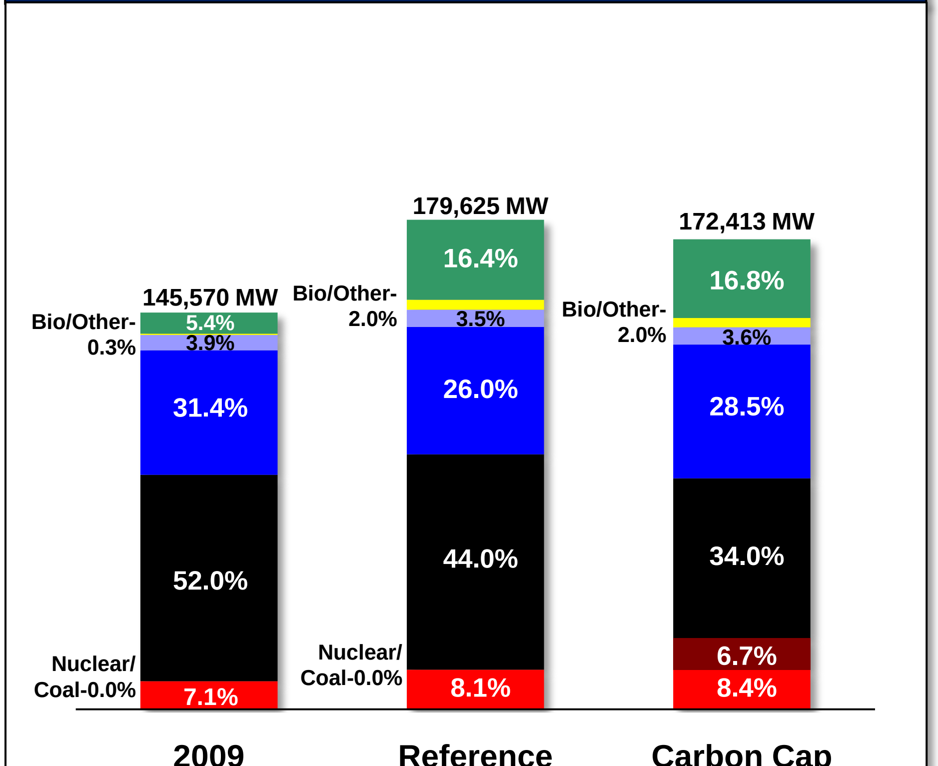

	2009	% △	Reference	% △	Carbon Cap
Wind/ Solar	7,805	↑277%	29,405	↓2%	28,905
Biomass/ Other	397	↑806%	3,597	↓6%	3,397
Hydro	5,609	↑13%	6,359	↓2%	6,259
Gas & Oil	45,725	↑2%	46,745	↑5%	49,145
Coal	75,673	↑4%	78,995	↓26%	58,564
Nuclear/ Coal	0	0%	0	N/A%	11,620
Nuclear	10,361	↑40%	14,524	0%	14,524

Scenario	Reference	Carbon Cap	% △
Top 3 Fuels (Production)	1. Coal 2. Nuclear 3. Wind/Solar	1. Coal 2. Nuclear 3. Wind/Solar	
Carbon Output in 2025 (tons in Mils.)[1]	498.0M 0.75 tons/MWh	338.0M 0.56 tons/MWh	↓32%
Production Cost (Bils.)	$261	$262	0%
Capital Cost (Bils.)[2]	$99	$131	↑32%
LMP ($/MWh)	$21.71	$27.36	↑26%
Retail Cost (¢/KWh)[3]	9.02¢	11.12¢	↑23%

[1]2005 Midwest ISO Base CO_2 Output: 535M tons
[2]Capital Cost includes generation costs only
[3]Retail Cost (¢/KWh) is in 2010 dollars
Note: 15% reserve margins used in scenario
Note: 8% wind capacity credit used in scenario

This case examines the potential influence of Smart Grid and electric vehicle adoption layered on top of Federal RPS and carbon reductions. This case is a platform to discuss Smart Grid in the Midwest ISO.

Scenario	Reference	Federal RPS	Carbon Cap	Smart Grid + EV	Gas Future
Description	Business as usual	20% energy to be served by renewable resources	39.5% carbon reduction by 2029	Adds effect of Smart Grid and Electric Vehicles to the "Federal RPS" and "Carbon Cap" scenarios	Only gas-fired resources are built
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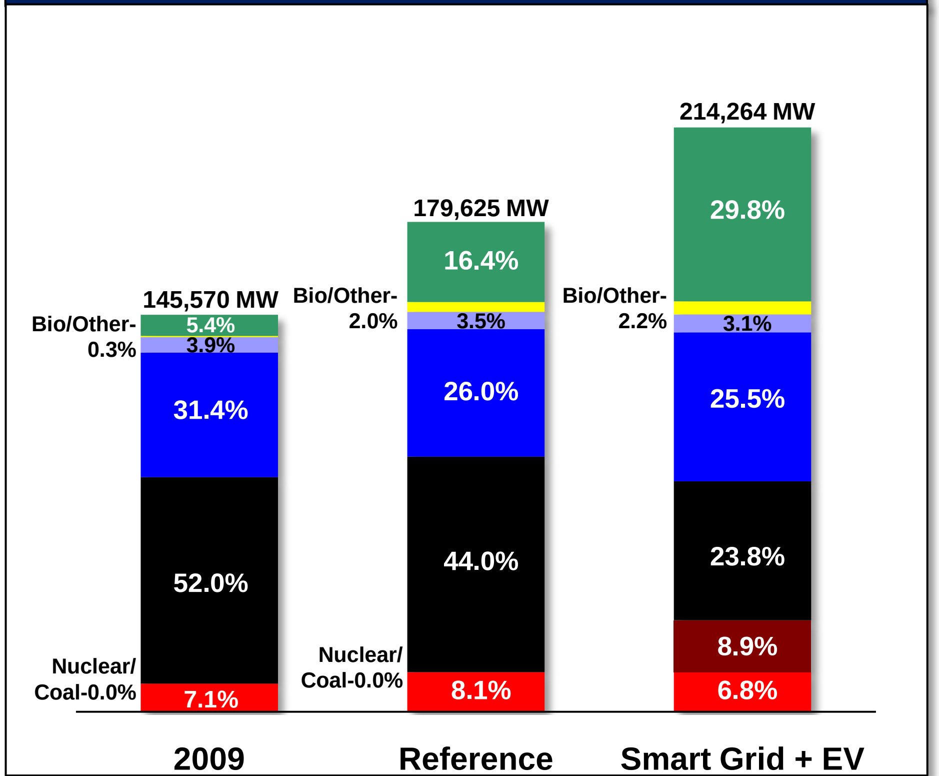
Smart Grid + EV

Installed Generation – 2025 (MWs)



	2009	% △	Reference	% △	Smart Grid + EV
Wind/ Solar	7,805	↑277%	29,405	↑117%	63,805
Biomass/ Other	397	↑806%	3,597	↑33%	4,797
Hydro	5,609	↑13%	6,359	↑3%	6,559
Gas & Oil	45,725	↑2%	46,745	↑17%	54,545
Coal	75,673	↑4%	78,995	↓35%	50,996
Nuclear/ Coal	0	0%	0	N/A%	19,038
Nuclear	10,361	↑40%	14,524	0%	14,524

Scenario	Reference	Smart Grid + EV	% △
Top 3 Fuels (Production)	1. Coal 2. Nuclear 3. Wind/Solar	1. Coal 2. Wind/Solar 3. Nuclear	
Carbon Output in 2025 (tons in Mils.)[1]	498.0M 0.75 tons/MWh	334.3M 0.42 tons/MWh	↓33%
Production Cost (Bils.)	$261	$297	↑14%
Capital Cost (Bils.)[2]	$99	$274	↑177%
LMP ($/MWh)	$21.71	$28.78	↑33%
Retail Cost (¢/KWh)[3]	9.02¢	11.98¢	↑33%

[1]2005 Midwest ISO Base CO_2 Output: 535M tons
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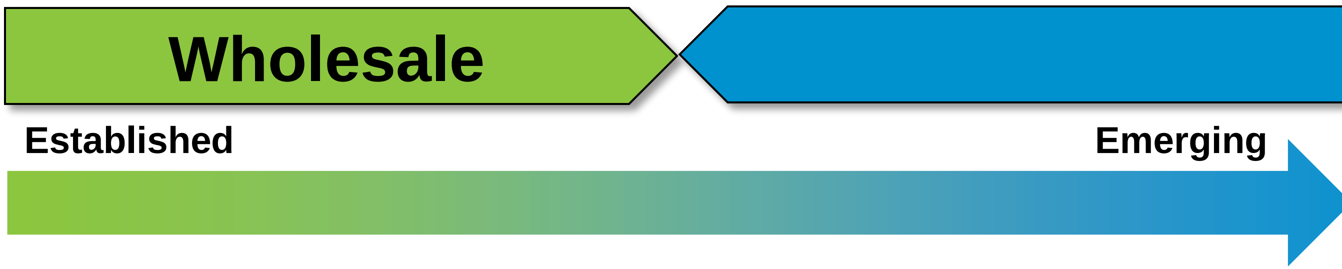
[3]Retail Cost (¢/KWh) is in 2010 dollars
Note: 15% reserve margins used in scenario
Note: 8% wind capacity credit used in scenario
Note: Scenario includes impact of Federal RPS and Carbon Cap scenarios

Significant progress has been made on the wholesale Smart Grid capabilities because they improve reliability and reduce costs. New applications must enhance those benefits while also enabling energy policy changes.



Improve Reliability

- Wide-Area Visualization
  - State Estimation
  - Contingency Analysis
  - Synchrophasor Monitoring
- Congestion Management
- Transmission Automation

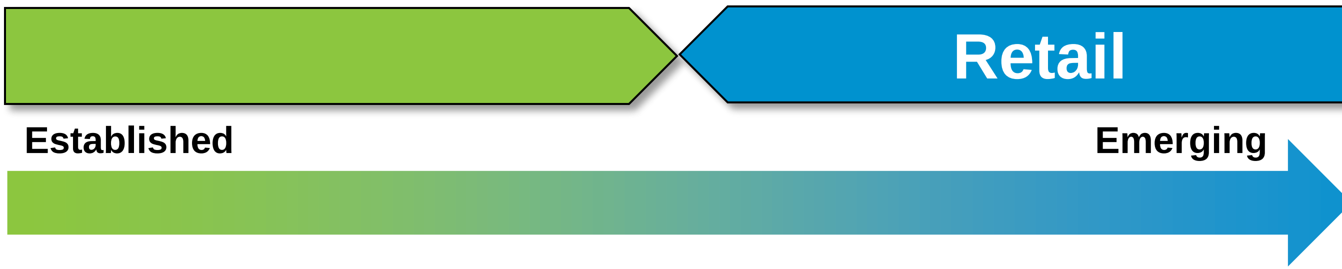
Generation Optimization

- Energy
- Regulation
- Reserves

Generation Portfolio Evolution

- Renewables (Wind / Solar)
- Storage
- Demand Response
- Distributed Generation

Most retail Smart Grid capabilities have struggled to prove their economic value to consumers or to utilities



Smart Distribution

- Automated Switching
- Outage Analysis
- Distributed Generation

Usage Monitoring – AMI / Smart Meters

Usage Modifications

- Price Responsive Demand (Consumer Choice)
  - Example: Programming pool pumps to turn off when price of electricity is high
- Direct Load Control (Utility Choice)
  - Example: Utility deferring use customers' water heaters & HVAC
- Direct Load Control (Wholesale Dispatched)

Transportation Electrification

- PHEVs
- EVs

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The key to Retail Smart Grid value is leveraging it to improve wholesale generation dispatch optimization and reduce generation portfolio evolution costs

Wholesale

Generation Optimization

- Energy
- Regulation
- Reserves

Generation Portfolio Evolution

- Wind
- Solar
- Storage
- Demand Response

Interoperability

- ***Reliability***
- ***Incentives***
- ***Alignment***
- ***Data***

Retail

Usage Modifications

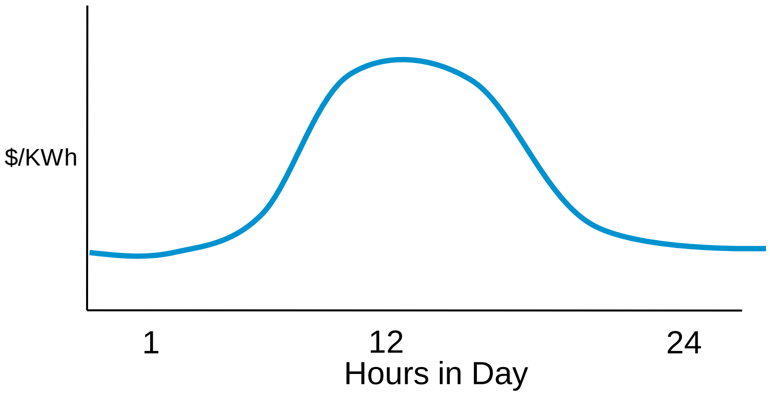
- Price Responsive Demand
  - *Consumer* choice
- Direct Load Control
  - *Utility* choice
  - Wholesale dispatched

Transportation Electrification

- PHEVs
- EVs

Interoperability requirements start with appropriate price signals to retail customers

Daily Avg. Price Curve For Wholesale Electricity



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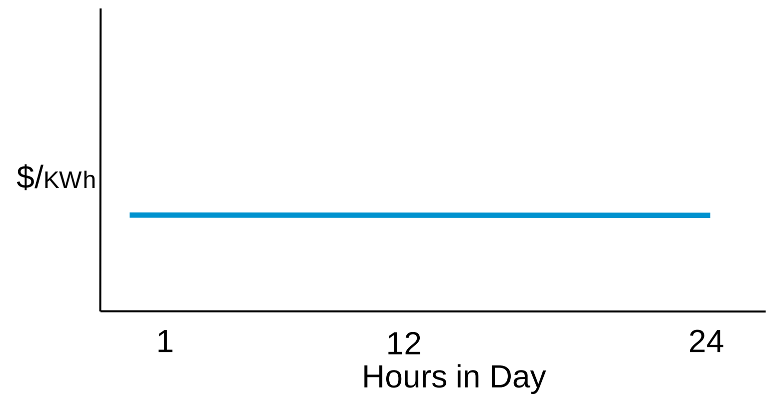
Daily Avg. Price Curve For Retail Electricity



Price signals enable consumers to make their own choices on when to modify usage – resulting in varying degrees of energy efficiency, peak shaving and valley filling

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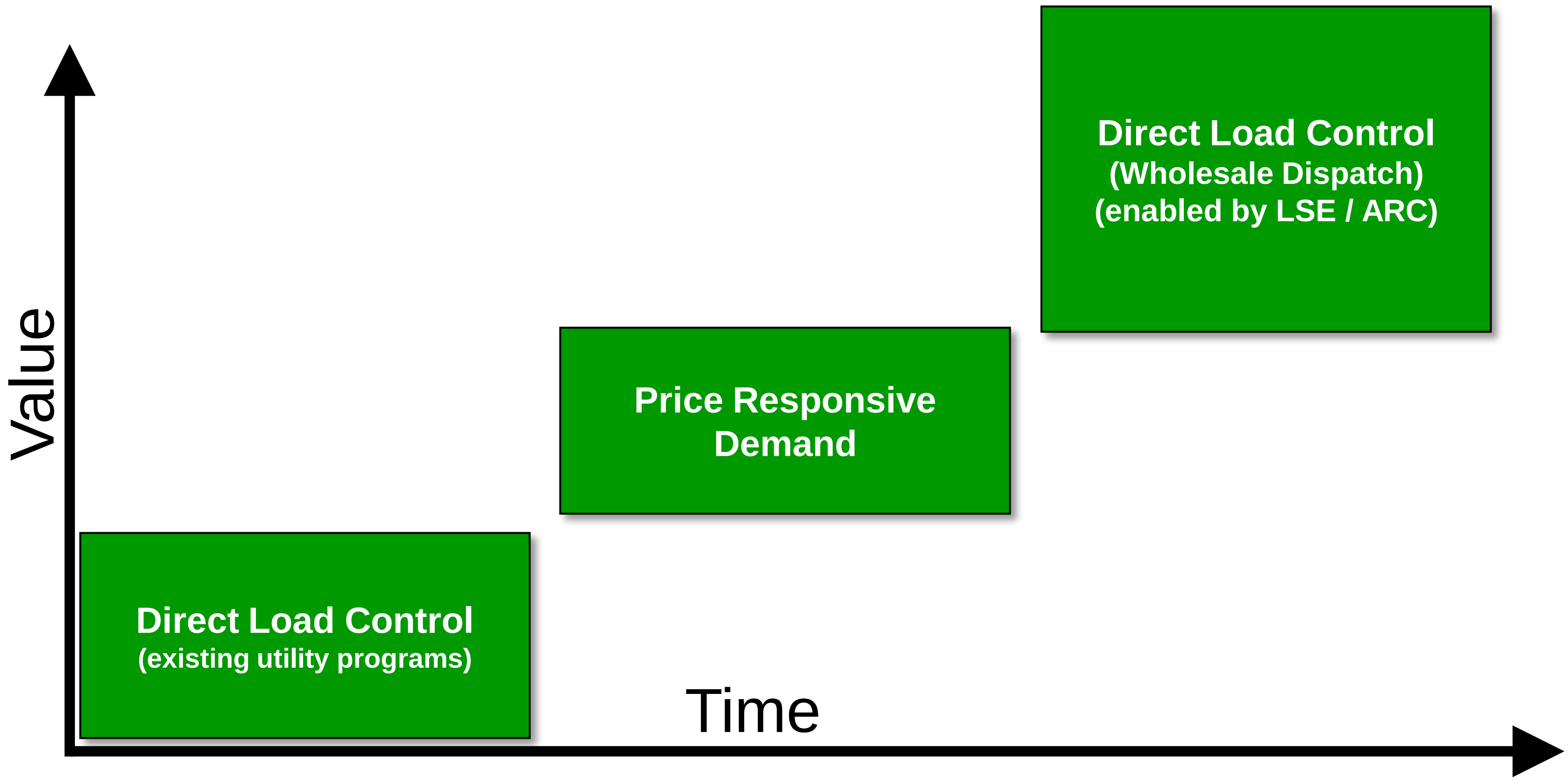
The real value occurs when loads are enabled as supply-side resources and deployed optimally alongside generation resources



Advantages/ Benefits:

Direct Load Control (existing utility programs):
- Peak shaving
- Emergency Response

Price Responsive Demand:
- Energy efficiency
- Peak shaving
- Valley filling

Direct Load Control (Wholesale Dispatch):
- Peak shaving
- Valley filling
- Ramp management
- Regulation provider
- Operating reserves provider
- Uncertainty management

MidwestISO Energizing the Heartland

Midwest ISO is enabling Demand Response in all areas of the market, but much work is still required to attract retail participation

- Existing opportunities for DR to participate in the Midwest ISO
  - Resource Adequacy
    - Load Modifying Resource
    - Demand Response Resource
  - Energy Market
    - Price Responsive Demand (Day-Ahead Market only)
    - Demand Response Resources
  - Ancillary Markets (Regulation / Spinning Reserves / Supplemental Reserves)
    - Demand Response Resources
  - Emergency Demand Response
    - Emergency Demand Response

- Emerging opportunities for DR to participate in the Midwest ISO (programs currently pending FERC approval)
  - Aggregator of Retail Customers – will allow participation in Resource Adequacy, DA Energy Market, and Ancillary Services Markets
  - DRR Type I – will expand participation to Spinning Reserve Market

MidwestISO Energizing the Heartland

Green font indicates participation as a demand side resource
Blue font indicates participation as a supply side resource

What role does energy storage play?

- Widespread renewable resources and a smart grid is better enabled with the availability of cost-effective energy storage
- House and Senate bills have been introduced promoting tax incentives for faster innovation and deployment of energy storage technology
- Major benefits anticipated from energy storage:
  - Grid optimization for bulk power production
  - System balancing with variable or diurnal renewable resources
  - Integration of plug-in electric hybrid vehicles
  - Deferral of T&D investment
  - Ancillary services
- Energy storage needs vary by application, depending upon the scale and duration of the power required
- Compressed air storage and pumped storage are grid-scale applications; other technologies being pursued are largely distributed utility applications

Midwest ISO enabling storage in its footprint

- Stored Energy Resources are resources capable of supplying Regulating Reserves through the short-term storage and discharge of electrical energy in response to Midwest ISO setpoint instructions
- Supply of Regulating Reserves cleared on Stored Energy Resources must be less than or equal to the market-wide Regulating Reserve requirement
- Current methodology approved by FERC by order dated December 31, 2009
  - Found proposed compensation and operational conditions to be comparable to other products
  - Stored Energy Resources can set MCP
  - The Midwest ISO's proposal was generally designed for fly-wheel technology
  - The Midwest ISO was directed to and is studying other forms of stored energy technologies

Selected Energy Storage Technologies by Level of Technology Maturity

Laboratory	Prototype	Commercial
Lithium ion	**Flywheels**	
	Nickel metal-hydride	**Pumped storage**
Ultracapacitors	Lead acid/carbon	
	Sodium sulfur	
Flow batteries	Advanced CAES	**Compressed air energy storage (CAES)**

IRC Plug-in Electric Vehicles Study

Study Parameters

This study had five primary objectives:

1. Identify operational, load, and price impacts to the North American electricity grid from light-duty PEVs as their adoption increases;
2. Identify potential PEV products and services;
3. Ascertain the market design adaptations that might be necessary to incorporate PEV services into existing markets and provide a standardized approach to mobile loads;
4. Determine key technologies, communications, cybersecurity, and protocols required to enable PEV products and services; and
5. Determine the types of investments in Information Technology (IT) infrastructure needed to integrate PEVs, and estimate their costs.

Outcomes & Recommendations

- The study estimates that one million PEVs could be deployed in North America within a five- to ten-year timeframe.
- Researchers believe that PEV sales are likely to be heavily concentrated in large urban areas. Available capacity for demand reduction depends on the number of PEVs available locally, charging energy, and likelihood that the vehicle is charging. Therefore, based on PEV load projections, major cities appear to offer the greatest opportunity for ISO/RTO products derived from PEV load management.
- With regard to wholesale-energy price impacts, the effect varies greatly by ISO/RTO, based on the penetration and concentration of PEVs. Initial research indicates that the short-term wholesale energy price impact of one million PEVs ranges from near zero to up to 10%, depending on the region, available resources, and load (both time of day and day of the year).

Smart Grid Investments by Region and Type

Total PEVs in Midwest ISO footprint equals:

1. Consumer PEVs: =65,022
2. Fleet PEVs =29,956

Total = 94,644

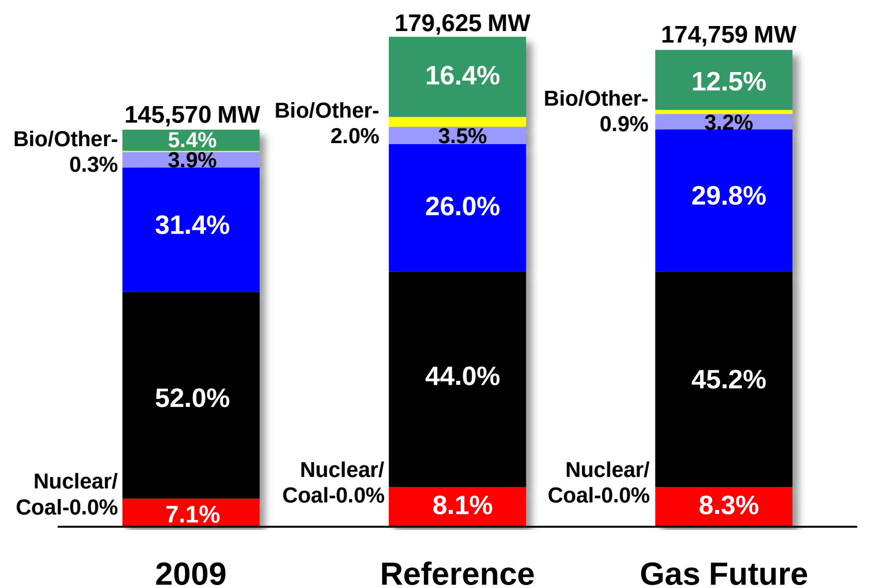
ISO/RTO	Total PEVs	Load if everyone charged at the same time (MW)	Load if charging is staged over 8 hours (MW)	Load if charging is staged over 12 hours (MW)
ISO-NE	61,074	338	75	50
NYISO	43,738	242	27	18
PJM	144,172	797	178	119
Midwest ISO	94,644	523	117	78
SPP	30,459	168	38	25
ERCOT	42,769	237	53	35
CAISO	267,654	1,480	331	221
TOTAL	**684,510**	**3,785**	**819**	**546**

This case looks at a future where all policy discussions stall and all construction defaults to gas

Scenario	Reference	Federal RPS	Carbon Cap	Smart Grid + EV	Gas Future
Description	Business as usual	20% energy to be served by renewable resources	39.5% carbon reduction by 2029	Adds effect of Smart Grid and Electric Vehicles to the "Federal RPS" and "Carbon Cap" scenarios	Only gas-fired resources are built
Key Assumptions	▸ State RPS requirements ▸ Installed generation to be constrained based on economic drivers	▸ State RPS requirements ▸ Federal RPS of 20% ▸ Installed generation to be constrained based on economic drivers	▸ State RPS requirements ▸ Allows existing fleet retirements with retro-fit sequestration available	▸ Federal RPS of 20% ▸ 39.5% carbon reduction by 2029 ▸ EV penetration included in energy growth rate ▸ Allows existing fleet retirements with retro-fit sequestration available	▸ State RPS requirements
Key Findings	▸ Wind installed generation increases 21,600 MW compared to 2009 ▸ Retail impact – 4% increase over current MISO retail rates	▸ Managing large increase in intermittent resources will have significant impact on operations ▸ Retail impact – 14% increase over reference scenario	▸ Carbon output decreases 30% ▸ Retail impact – 23% increase over reference scenario	▸ 277% increase in capital costs over reference scenario ▸ Retail impact – 33% increase over reference scenario	▸ Most flexible fleet operationally of all scenarios ▸ Retail impact – 11% decrease over reference scenario

Gas Future

Installed Generation – 2025 (MWs)

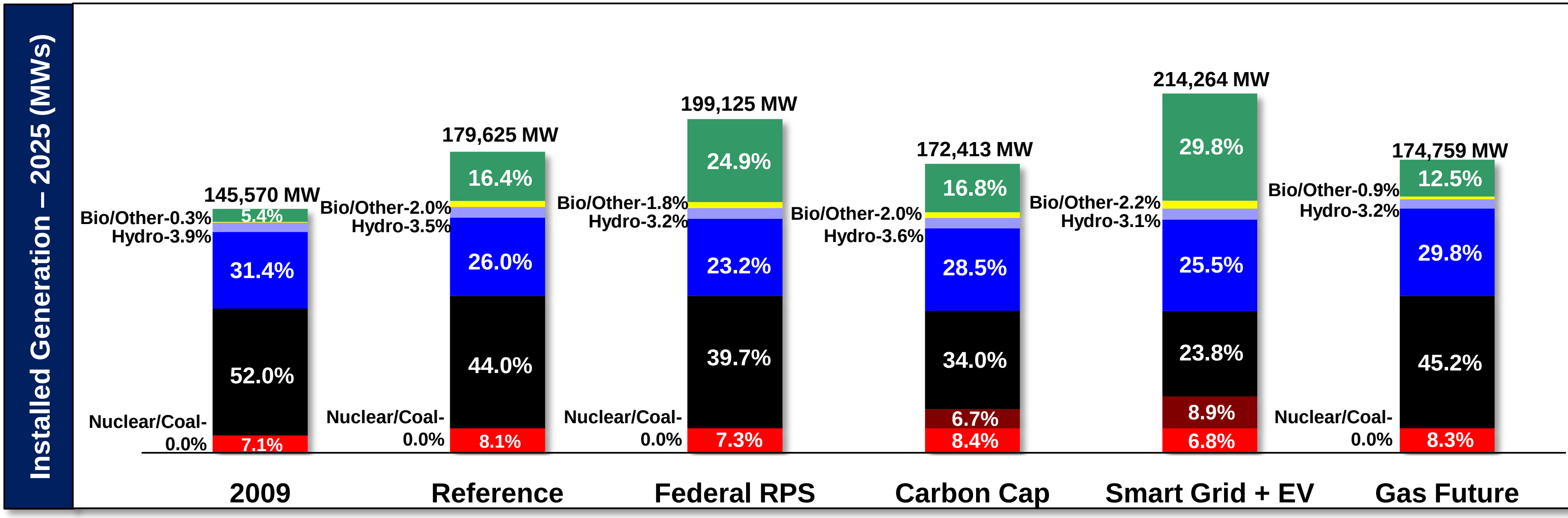


	2009	% △	Reference	% △	Gas Future
Wind/ Solar	7,805	↑277%	29,405	↓26%	21,905
Biomass/ Other	397	↑806%	3,597	↓56%	1,581
Hydro	5,609	↑13%	6,359	↓12%	5,609
Gas & Oil	45,725	↑2%	46,745	↑12%	52,145
Coal	75,673	↑4%	78,995	0%	78,995
Nuclear/ Coal	0	0%	0	0%	0
Nuclear	10,361	↑40%	14,524	0%	14,524

Scenario	Reference	Gas Future	% △
Top 3 Fuels (Production)	1. Coal 2. Nuclear 3. Wind/Solar	1. Coal 2. Nuclear 3. Wind/Solar	
Carbon Output in 2025 (tons in Mils.)[1]	498.0M 0.75 tons/MWh	513.4M 0.72 tons/MWh	↑3%
Production Cost (Bils.)	$261	$298	↑14%
Capital Cost (Bils.)[2]	$99	$84	↓15%
LMP ($/MWh)	$21.71	$55.22	↑154%
Retail Cost (¢/KWh)[3]	9.02¢	8.00¢	↓11%

[1]2005 Midwest ISO Base CO_2 Output: 535M tons
[2]Capital Cost includes generation costs only
[3]Retail Cost (¢/KWh) is in 2010 dollars
Note: 15% reserve margins used in scenario
Note: 15% wind capacity credit used in scenario

Total Installed Generation Summary



Wind/ Solar	7,805	29,405	49,505	28,905	63,805	21,905
Biomass/ Other	397	3,597	3,597	3,397	4,797	1,581
Hydro	5,609	6,359	6,359	6,259	6,559	5,609
Gas & Oil	45,725	46,745	46,145	49,145	54,545	52,145
Coal	75,673	78,995	78,995	58,564	50,996	78,995
Nuclear/ Coal	0	0	0	11,620	19,038	0
Nuclear	10,361	14,524	14,524	14,524	14,524	14,524
Total	**145,570**	**179,625**	**199,125**	**172,413**	**214,264**	**174,759**

*All values in MWs

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