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Regulatory Context and Motivation for a New Approach
A Proposed Regional Approach to Comply with EPA Existing Source Rule for GHG Emissions

- EPA is required to issue an “existing source rule” under Section 111(d) of the Clean Air Act.
- This will likely require States to develop state implementation plans, which may result in state-specific or power plant-specific caps on emission.
- State-specific or plant-specific caps would allocate allowed emissions very inefficiently across power plants because they may not account for the relative costs of the plants and the operational needs of the power systems.
- This presentation outlines an alternative market-based regional approach that takes advantage of the existing wholesale power market structure, administered by regional Integrated System Operators (ISOs), would serve the environment, power sector, and electric consumers better than state-specific or plant-specific emission caps.
The Concept:
Market-based Regional Approach to Valuing and Reducing GHG Emissions from Power Sector
The Concept: ISO-Administered GHG Constraint

Concept includes the following features:

- Translate EPA requirements into ISO-level targets on CO₂ emissions
  - Ideally with a single long-term target (*e.g.* X% reduction over 2000 level, by 2030)
  - Short/intermediate term targets may be necessary to guide the “emissions path,” but could limit flexibility of meeting the targets and possibly be less cost effective

- ISO sets an initial path of “carbon values,” that are used in dispatching (based on emissions profiles and bid offers) to reach the expected regional target

- Plant dispatch minimizes total cost while meeting reliability and CO₂ constraints

- The resulting power market prices, paid by load, reflect the emission constraints

- Generators are charged the per-unit carbon value for their CO₂ emissions

- Revenues collected are returned to load on a non-variable basis (maintaining proper price signals for demand-side resources)

- ISO adjusts carbon value path carefully when updated projections of emissions deviate significantly from original assumptions
Key Principle: Recycle Carbon Revenues Back to Load

To send the efficient economic signals to generators and minimize impact on consumer bills, a keystone of this approach is to recycle carbon value back to load. Below describes the flow of value of emissions:

- Load pays for emissions in power prices
- Receiving the carbon revenues and result in paying for cost of re-dispatch and carbon-rent to low emissions suppliers
- Reduces the “cost” to ratepayers
- Methods for recycling the carbon revenues should not reduce end users’ volumetric charges to maintain load’s incentives for conservation

ISO-Administered Market
Clears market, collects CO₂ payment and returns payments to load-serving entities

End-Users
Pay for power and receive refunds through retail rates

Generators
Bid into market prices that includes the value of emissions (pay ISO CO₂ value x emissions volume)

Load-serving Entities
Pay for power and receives CO₂ payments
Several Considerations Revenue Recycling

- Keep it simple
  - Share of load in MWh is easiest, and likely does not distort incentives
- Avoid perceived or actual appropriation of funds by generators or Load Serving Entities
  - Maintain clear separation between generation and load
  - Customers pay through higher power prices, so customers receive the revenues back
- Provide compatible incentives
  - Locational marginal prices provide good incentives to load-serving entities to adjust consumption, so perhaps no need to embed additional incentive in the refund
  - Likely ignores the marginal carbon intensity of load at various locations, which could be important in severely constrained portions of systems
  - The concept of Marginal Carbon Intensity may be an approach to develop further
- Fair
  - Distribution of carbon revenues to load should not punish past location decision
Potential Effects on Retail Rates

- The ultimate incentives will depend on how retail rates are structured – no different from today.
- Carbon revenue recycling to load-serving entities by itself says little about end-user incentives, since those are determined by retail rates outside of ISO decision making.
- California’s AB32 discussions centered around discussions about not refunding allowance value to end-users through reductions in **variable portions of rates** – these insights may be useful here.
- Could make a condition of participation that load-serving entities refund carbon revenues to end-use customers in ways that maintain conservation incentives.
Presumptions Associated with an ISO-based Approach (Relative to Section 111(d) Requirements)

Our presumptions about the regulatory requirements include:

- The ISO-administered approach to reducing CO₂ emissions must be proposed to EPA by the states who choose to implement and enforce such an approach.
- EPA will not impose any such approach because a federal implementation plan (imposed when a state fails to submit an adequate state plan) is usually uniform across all states, not specific for states that operate within an ISO.
- States would need to demonstrate that the approach can be implemented and enforced to achieve the emissions reduction required by the federal guidelines. States can do so by:
  - Requiring covered power plants to adhere to the relevant ISO rules (as an enforceable condition in the generators’ air permits).
  - Using a transparent approach to adding a “carbon value” to generators’ bids to ensure compliance.
  - Demonstrating their ability to achieve the desired emission outcome by ex-ante modeling and setting procedures to adjust the carbon value based on the projected emissions reductions relative to targets.
Key Advantages Over Alternative Approaches
ISO-Based Approach Provides Significant Advantages

- Uses existing ISO market structure
- Optimization ensures continued focus on reliability and cost
- Avoids direct control of plant emissions, minimizing inefficiencies and costs of regulation
- Applies an efficient carbon price, without flowing a tax to government – refund to load
- Best plants win
- Can benefit from events in other states
- Regional influence on EPA
Comparison of approaches – effect on existing plants

<table>
<thead>
<tr>
<th>Conventional CO2 regulations</th>
<th>Market-based optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency standard or CO2 intensity standard (CO2 / MWH)</td>
<td>Plant owner’s decision</td>
</tr>
<tr>
<td>CO₂ limit – tons / year</td>
<td>Plant owner’s decision, subject to market success</td>
</tr>
<tr>
<td>Best available retrofit technology (BART determinations)</td>
<td>Plant owner’s decision</td>
</tr>
<tr>
<td>Renewable energy standards, plant shutdown agreements, energy-efficiency requirements, or other measures</td>
<td>Plant owner’s decision</td>
</tr>
</tbody>
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Key Design Parameters that Need to be Considered and Developed
Design Requires Answering Many Important Questions

While many questions need to be answered, some solutions are already available:

- How to translate EPA existing source rule into ISO-region targets?
- How to determine the shape and level of initial carbon value path?
  - Many paths can lead to the same emissions reduction target, but with different cumulative emissions
  - Need to allow the system to adjust without creating short term reliability problems
  - Need to ensure that prices do not become politically unacceptably high
- When and how to adjust the path if emissions deviate from expectations?
  - Could be adjusted based on historic or forecast emissions relative to target
  - Probably want to avoid very large shifts in price increases or decreases
  - May need safeguards to ensure commitment to emission reduction target?
- How to demonstrate compliance?
  - Set commitments with simulations and demonstrate compliance with measurements
Other Important Implementation Considerations

Some initial thoughts about implementation challenges include:

- How to deal with market seams and power imports(exports) as they relate to emissions?
  - Rules are needed for dispatching (if dispatchable) resources from outside the ISO
  - California’s AB32 has developed rules, which could serve as a starting point

- How to recycle carbon charges to load without affecting incentives?
  - Need to avoid providing volumetric refunds that distorts demand-side incentives

- How to deal with state and ISO boundaries?
  - States only partially in an ISO?
  - Generating facilities outside of an ISO but located in state that participates in ISO? (State implementation plans that must cover all existing sources, regardless of ISO membership)

- How to deal with market participants that join or leave ISO over time?
  - Since ISO approach is more efficient, likely more costly for generators to be regulated outside ISO approach
  - But such decision may dependent on carbon value paths and emissions profiles of individual utilities or generator
A Key Challenge: Setting Carbon Value Path

Many factors need to be considered in developing carbon value path:

- System reliability need to be considered explicitly when setting a value path
  - Setting a carbon value path will likely require detailed understanding of its potential impact on reliability through resulting pattern of retirements and new entry
  - It will also require detailed operational modeling to understand potential interactions between changes in capacity mix and operational constraints

- Pace of emission reduction and retirement decisions will need to be explicitly considered
  - There will likely be trade-offs between pace of emissions reductions and level of resulting stranded costs for regulated assets
  - May need to consider regulatory processes for paying for stranded costs
Simple Simulated Examples
Illustrative Value Paths Examples

We developed 3 illustrative carbon price paths to reach ~30% emissions reduction by 2035

1. Start low and rise steadily (blue line)
   - Least impact on existing fossil generation early
2. Start high and rise slowly (red line)
   - Most impact on existing fossil generation
3. Wait and then accelerate price increase (green line)
   - Least displacement of coal
   - Creates steep increases later
   - Potentially problematic for investments
**Resulting carbon emissions differ by path…**

While all price paths achieve the same annual reduction in 2035, the cumulative effects are different.
...as do energy market prices

- Waiting longer requires larger jump in energy prices later
- After accounting for refunding carbon revenues to load, energy price increases less than 1 ¢/kWh through 2030, to 2-3 ¢/kWh thereafter
Capacity Factors for fossil units depend on carbon value path...

Coal

Natural Gas Combined Cycle
...as does the generation mix...
...and the likely pattern of retirements and additions to the generation mix

No carbon value

![Cumulative New Builds and Retirements](image)

$10@6$

$5@10$

$30 in 2030@10$

$10@6$
Some Major Take-Aways From Initial Simulations

- Margins of infra-marginal generators significantly affected by carbon price path.
  - Low-carbon generation may see significantly increased margins, if revenues depend on wholesale prices (rather than contracts)
- With 100% refunding of carbon costs to load, total impact on retail rates likely dependent on
  - ISO energy mix (how coal/CO2 heavy)
  - Required CO2 reductions to comply with existing source rule
  - Ability of low-carbon generation to fully benefit from higher wholesale prices due to carbon adder
Potential Next Steps
Lots of Work to Do: Potential Next Steps

- Reach out to states and begin to build coalition among states
- Communicate the idea to broader audience, possibly including audience in other ISO regions
- Continue to document areas needing further exploration (already done some in this presentation)
- Discuss further implementation steps and articulate the time needed to update regional market design
- Use simple examples to test various implementation methods
- Simulate market impact for different types of utilities
- Understand treatment of cross-sector emitters (such as CHP, perhaps others)
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• Cost of Capital & Regulatory Finance
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• Demand Response & Energy Efficiency
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• Energy Asset Valuation & Risk Management
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Appendix
Legal and Regulatory Context

- EPA is under a presidential directive to propose draft guidelines to the states under section 111(d) of the Clean Air Act no later than June 1, 2014, and after taking comments on the draft, to finalize the guidelines by June 1, 2015.

- The federal guidelines are expected to require states to develop and submit plans for reducing carbon dioxide emissions from existing power plants no later than June 30, 2016.

- The federal guidelines will specify the stringency and timeline for reductions required by each state.

- The Act gives states considerable flexibility to determine how to achieve emission reduction from existing power plants; states must demonstrate their section 111(d) plans meet the requirements of the federal guidelines.

- A state’s 111(d) plan must apply “standards of performance” to the covered power plants. Legal experts have interpreted this to mean that meeting the standards will be a condition for a covered plant’s air operating permit.

- A state’s plan must provide for implementation and enforcement of the standards of performance.
Simple Simulation

We used a simple model to show the potential implications of the proposal

- **Xpand** is a long term capacity expansion model for a electricity generation system

- It optimizes long term capacity expansion, retirement, and dispatch decisions by minimizing the present value of total system costs, including:
  - Cost of new capacity
  - Fixed O&M
  - Variable O&M
  - Fuel costs
  - Emission costs

- Subject to meeting:
  - Demand
  - Environmental requirements
**Modeling Parameters**

Major inputs and outputs that capture the most important features of an electric system:

- **Major Model Inputs:**
  - Electricity load forecast by load blocks
  - Existing generating units’ costs and operation characteristics
  - Fuel price forecast
  - Units emission profiles
  - New unit costs by generation type

- **Major Model Outputs**
  - Economic new build and retirement
  - Generation mix
  - Energy prices
  - Carbon emissions
Modeling Parameters

We modeled a proxy for MISO:

- Sub-regions simulated
  - 4 NERC regions: MRO-E, MRO-W, RFC-W, SERC-Gateway

- Load assumptions
  - Peak load in 2012: 76 GW (out of total 98 GW in MISO-North)
  - Total Load in 2012: 435 TWh (out of 526 TWh in MISO-North, based on load that takes MISO transmission service)

- Generation capacity
  - 107 GW existing capacity in 2012 (out of 131.6 GW in MISO-North)
  - 4-5 generating technologies for each fossil fuel; all other generating technologies are explicitly modeled
  - Assumed a 14.2% planning reserve margin required
  - No specific RPS requirement to allow for economic additions of renewables (instead of mandated),
  - Assume no cost declines of renewables and wind additions are capped at 3GW/year

- Fuel prices
  - Coal prices stay nearly constant over periods
  - Gas prices increase based on EIA AEO 2013

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Energy Margins: Coal

- Coal unit margins increase initially across all scenarios because it is still economic to be dispatched before gas when the carbon prices are still relatively low (below $20/ton in all three scenarios).
- Then as carbon prices increase, the margins decline, reflecting less dispatch and lower capacity factor.
Energy Margins: Nuclear

- Energy margins for nuclear units increase quite dramatically as carbon prices increase, due to its zero carbon footprint.
- Would this be considered a “windfall profit” for certain existing technologies? Would this be an acceptable result?
Energy Margins: Wind

Energy Margins:

- Assumes wind as merchant generators, fully exposed to market prices
- Energy margins increase quite significantly as both gas prices and carbon prices increase
Mixed story:

- For scenarios without carbon price in the initial period, the energy margins for CCGTs decline, due to the increased gas prices and therefore less dispatch against coal.
- For scenarios where carbon prices are imposed from the beginning, it becomes more economic than coal to be dispatched, and therefore the energy margins increase.
- However, over time, as gas prices increase, coal becomes more economic again until the carbon prices rise to a high level.
Capacity Factor: Coal

- NoPolicy
- Price 1
- Price 2
- Price 3
Capacity Factor: CCGT

NoPolicy
Price 1
Price 2
Price 3
Generation Mix: No Carbon Price

![Generation Mix Chart](image-url)

- Solar
- New_Wind
- Wind
- ST_Oil
- ST_Gas
- CT_Oil
- New_CT
- CT_Gas
- New_CC
- CC
- Biomass
- Hydro
- New_Coal
- New_Nuclear
- Coal
- Nuclear
Generation Mix:
Carbon Price: $5/ton in 2013 @ 10% Growth Rate

![Generation Mix Diagram]
Generation Mix:
Carbon Price: start $30 in 2030 @10% Growth Rate
Capacity: No carbon policy

Cumulative New Builds and Retirements

- New_SolarPV
- New_Wind
- New_Coal_CCS
- New_Coal
- New_Nuclear
- New_CT
- New_CC
- ST_Oil
- ST_Gas
- Coal

New Builds
Retirements
Capacity
Carbon Price: $5/ton in 2013 @ 10% Growth Rate

Cumulative New Builds and Retirements

- New_SolarPV
- New_Wind
- New_Coal_CCS
- New_Coal
- New_Nuclear
- New_CT
- New_CC
- ST_Oil
- ST_Gas
- Coal
Capacity
Carbon Price: $10/ton in 2013 @ 6% Growth Rate

Cumulative New Builds and Retirements

- New_SolarPV
- New_Wind
- New_Coal_CCS
- New_Coal
- New_Nuclear
- New_CT
- New_CC
- ST_Oil
- ST_Gas
- Coal
Capacity
Carbon Price: start $30 in 2030 @ 10% Growth Rate

Cumulative New Builds and Retirements

- New_SolarPV
- New_Wind
- New_Coal_CCS
- New_Coal
- New_Nuclear
- New_CT
- New_CC
- ST_Oil
- ST_Gas
- Coal