A Guide to Electric Sector Modeling Tools

The Clean Power Plan, and Other Applications

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Webinar Logistics

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Synapse Energy Economics

- Founded in 1996
- Leader for public interest and government clients in providing rigorous analysis of the electric power sector
- Staff of 30 includes experts in energy and environmental economics and environmental compliance
- Synapse experts perform operational and planning modeling analyses of electric power systems using industry-standard models as well as models built in house
- We evaluate long-term energy plans, Clean Power Plan compliance options, and the environmental and economic impacts of policy initiatives

Argonne National Laboratory
Center for Energy, Environmental, and Economic Systems Analysis (CEEESA)

- 17 Staff members and 12 Postdocs, located at Argonne National Laboratory and the MIT Energy Initiative.
- Unique *systems analysis* approach, using state-of-the-art scalable modeling tools based on techno-economic optimization (both deterministic and stochastic) and agent-based models.
- CEEESA's research concentrates on the most pressing issues relative to the system-level integration of energy resources through:
  - Power systems analysis
  - Energy systems analysis (including buildings)
  - Environmental systems analysis

Motivation

How will I meet **growth**,
hit **energy efficiency** and **renewable energy** targets,
meet **environmental** constraints,
while assessing a **least cost compliance** path for environmental regulations?

If I'm planning for the Clean Power Plan…
…should I go **rate** or **mass**?
…and should I **auction** or **allocate** allowances?
on what **basis**? and to **whom**?
…and with whom should I **trade**?
…and how will these choices affect my **operations**?

If I'm conducting a **resource plan**…
…how do I take into account my neighbors?
…what about retiring resources?
… fuel price uncertainty?

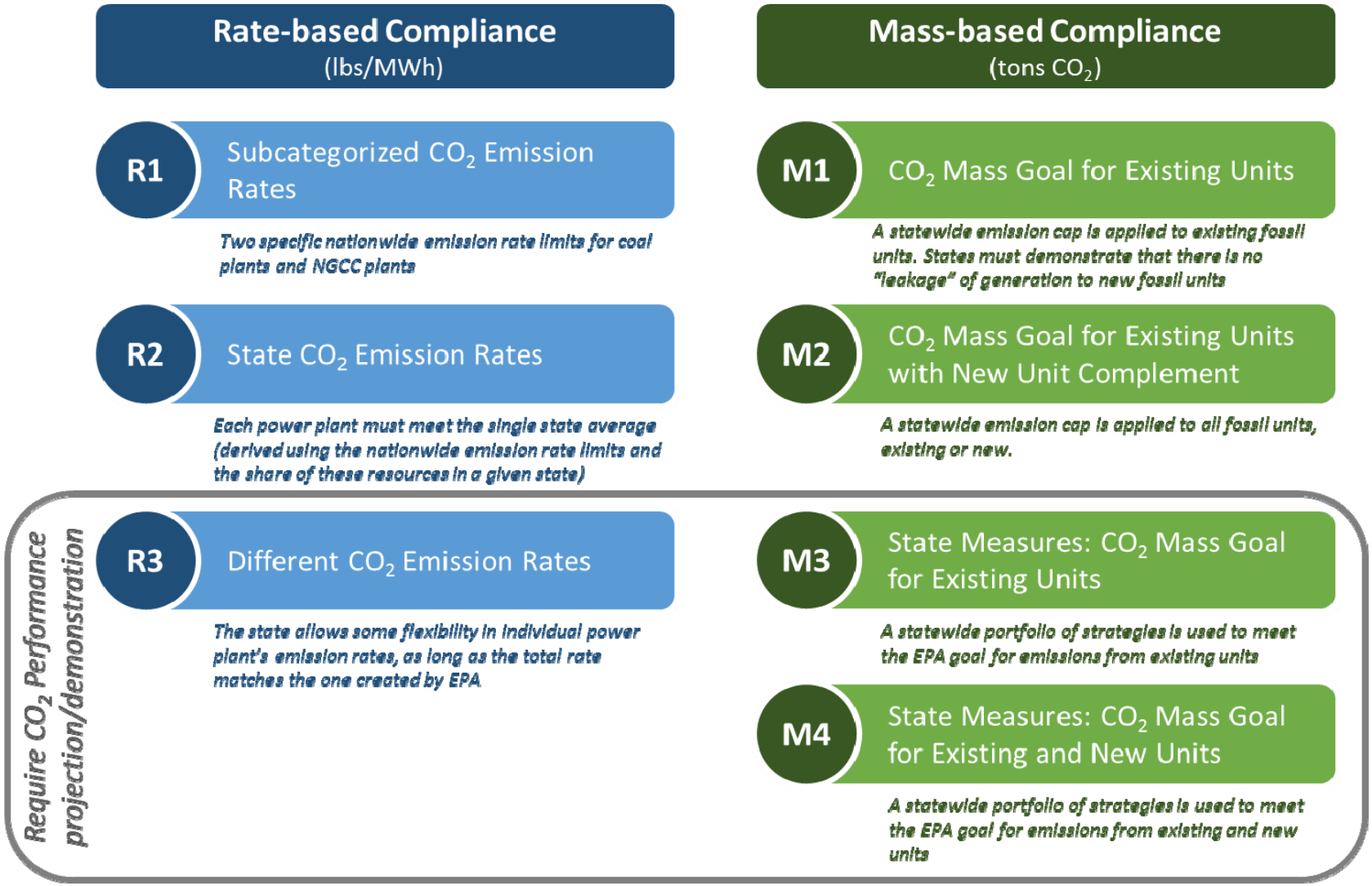
Oh, and **stakeholders**. We need them too.

No single model or analysis structure. Different models for different purposes.

Agenda

- CPP CO_2 Demonstration Requirements
- Considerations in Choosing an Analysis
- Analysis Trade-Offs
- Production Cost Models
- Capacity Expansion Models
- Multi-Sector Models
- Non-Optimization Approaches
- Example Analysis Pathways
- Conclusions

Clean Power Plan CO_2 Performance Projections and Demonstration Requirements



Considerations in Choosing an Analysis

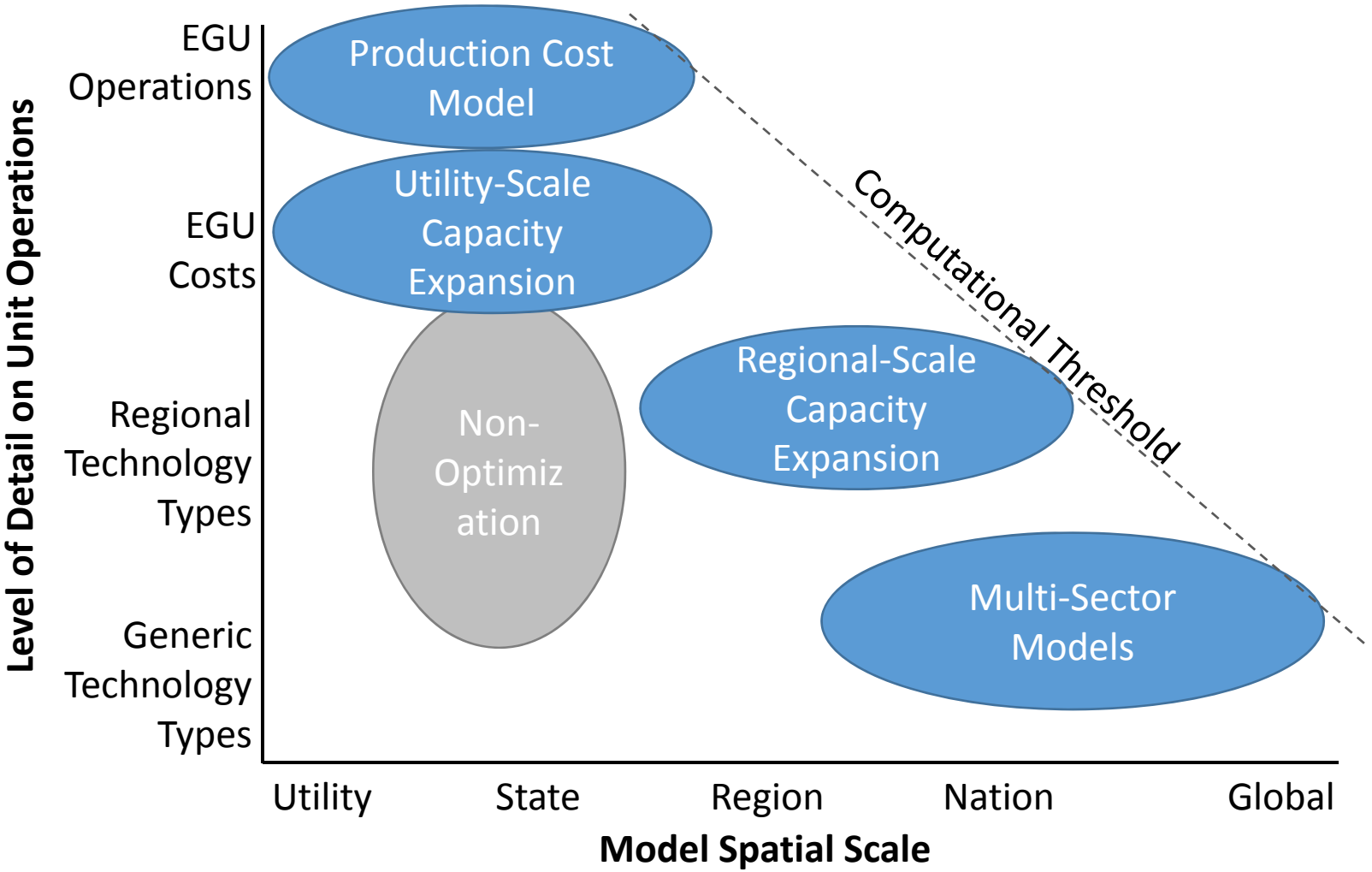
May need to represent:

- Market-based emissions reductions
  - Allowance and/or ERC trading, banking
- Impacts of renewables, integration into grid
- Impacts of efficiency, cost effective procurement
- Transmission constraints
- Interstate impacts (uncoordinated policies)
- Building blocks *[if CPP-based]*
  - EGU efficiency improvements
  - Generation shifting
  - EGU emissions limits
- Transparency
- Computational requirements
- Use of expert modelers

Analysis Trade-offs

	Production Cost Model	Capacity Expansion (Regional Scale)	Capacity Expansion (Utility-Scale)	Multi-Sector Model	Non-Optimization Approaches
Economic dispatch?	✓	✓	✓	✓	✗
Chronological dispatch?	✓	✗	✗	✗	✗
Unit Commitment?	✓	✗	✗	✗	✗
Multi-state / regional scale?	✓	✓	✗	✓	✓
Individual EGUs?	✓	✗	✓	✗	✓
Can choose new resources?	✗	✓	✓	✓	✗
Can retire non-economic resources?	✗	✓	✓	✓	✗
Non-expert use?	✗	✗	✗	✗	✓
Public data?	✗	–	✗	–	✓
Fully auditable by public?	✗	✗	✗	✗	✓

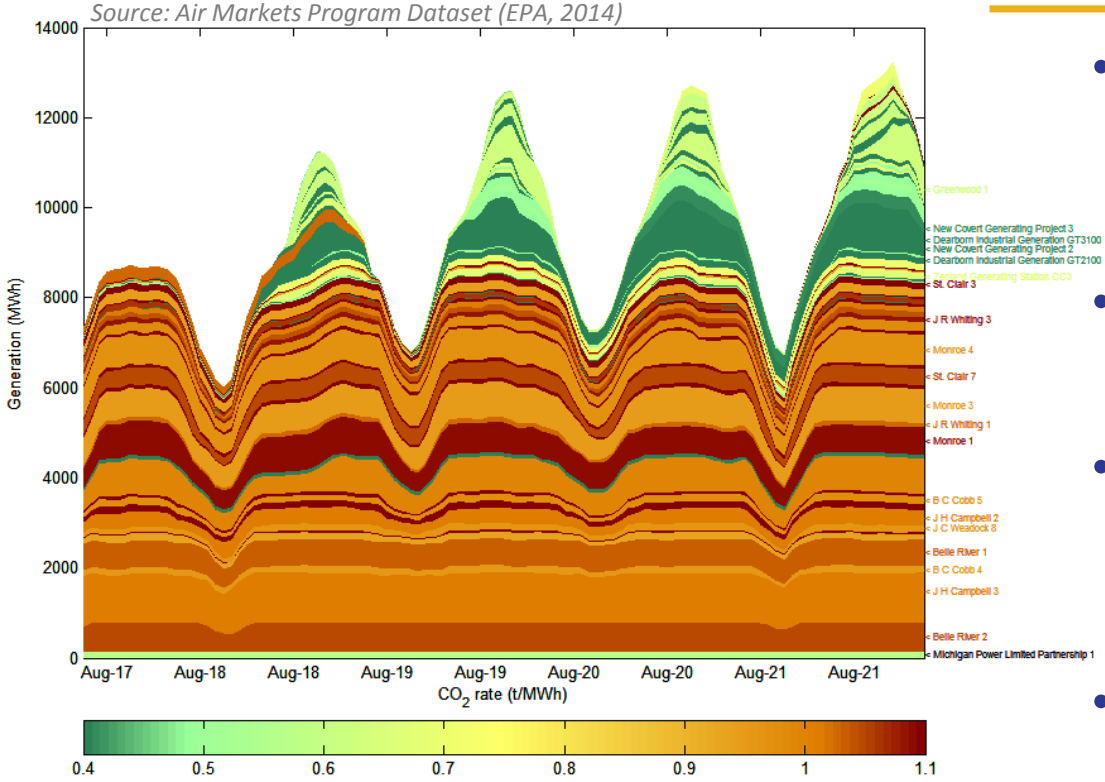
Analysis Trade-Offs



Production Cost Model (PCM)

Historic Generation in Michigan Region

Source: Air Markets Program Dataset (EPA, 2014)



- Designed to determine least cost dispatch of a known set of resources
- High resolution, chronological dispatch
- EGU runtime constraints and transmission can be highly detailed
- Used to forecast hourly market prices, fuel consumption, expected cost of existing resources, operational constraints, & reliability concerns.

PROSYM, PLEXOS, PCI Gentrader, AURORAXMP, GE-MAPS

TRITE EXAMPLE

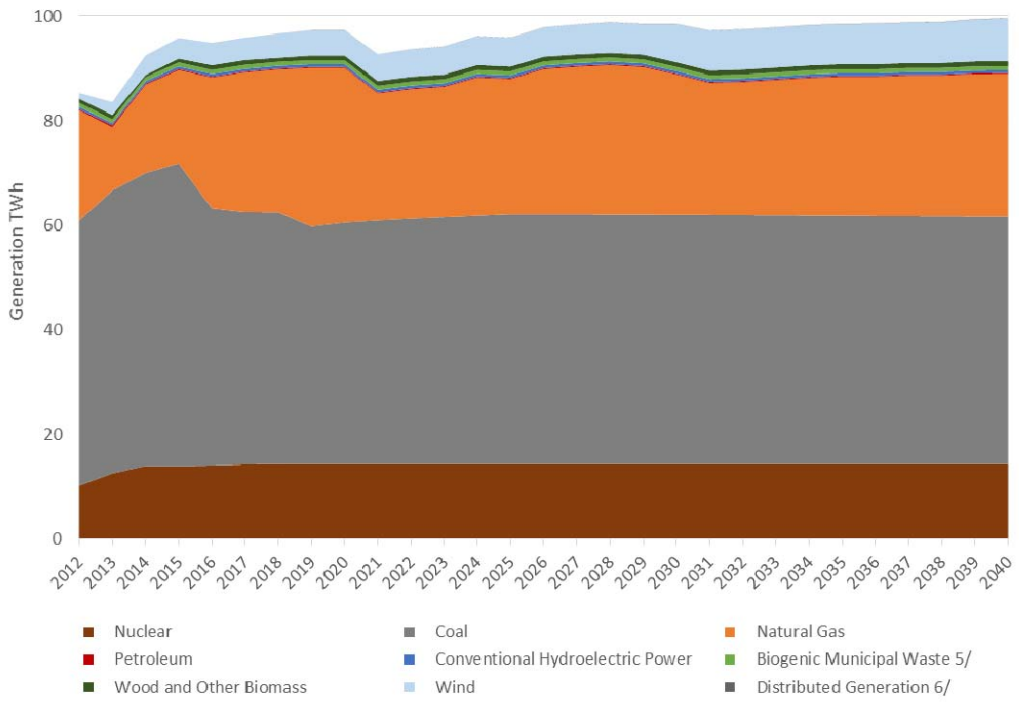
I have to get 100 people from Boston to New York in two days with four cars: an old van, a small sports car, a slower hybrid, and an electric car.

How should I arrange the trips?

Regional-Scale Capacity Expansion Model

Generation in RFC Michigan Region (AEO, 2015)

Source: AEO 2015, Reference Case



- Designed to determine least cost **technology type** buildout under policy and economic constraints
- Low temporal and spatial resolution
- Supply-curve dispatch during **key** hours
- Specific EGUs are not represented (generally)
- Used to forecast fuel trends in fuel consumption, technology uses and development, impact of policies on trends and long-term expectations

IPM, ReEDS, NEMS EMM, HAIKU

TRITE EXAMPLE

Ten years from now, I expect that the transportation demand will double and gas prices will be higher.

Should I be investing in the regional rail system?

Regional vs. Utility Scale Capacity Expansion Model

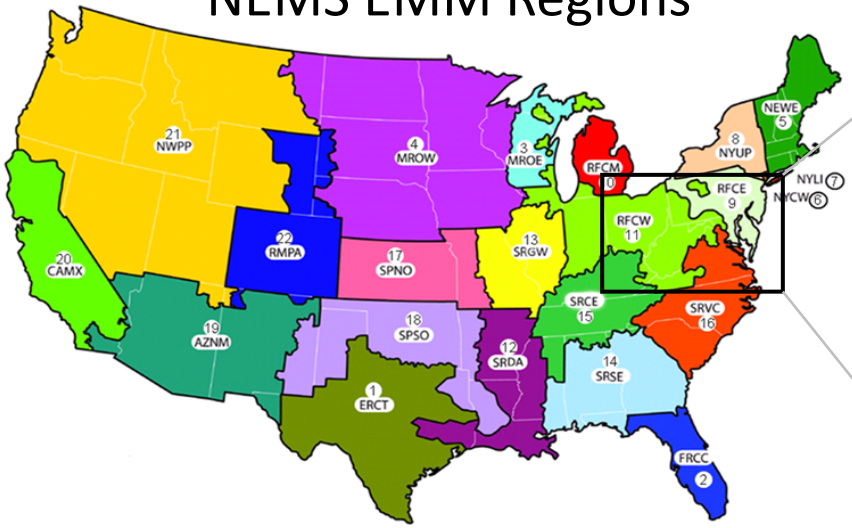
Regional-Scale

- "Model plant" technology types
- Highly simplified transmission
- Broad regional coverage & interstate interactions

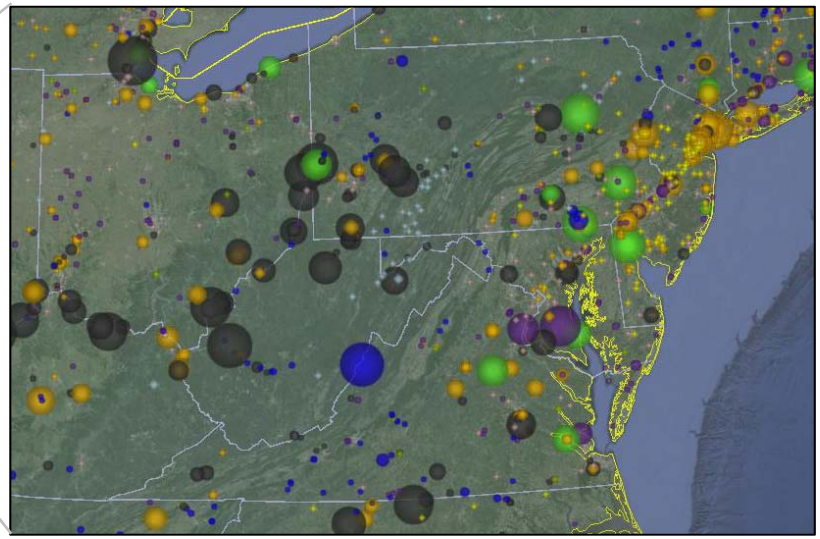
Utility-Scale

- Specific EGUs represented
- Opportunities for specific transmission
- Narrow geographic coverage

NEMS EMM Regions

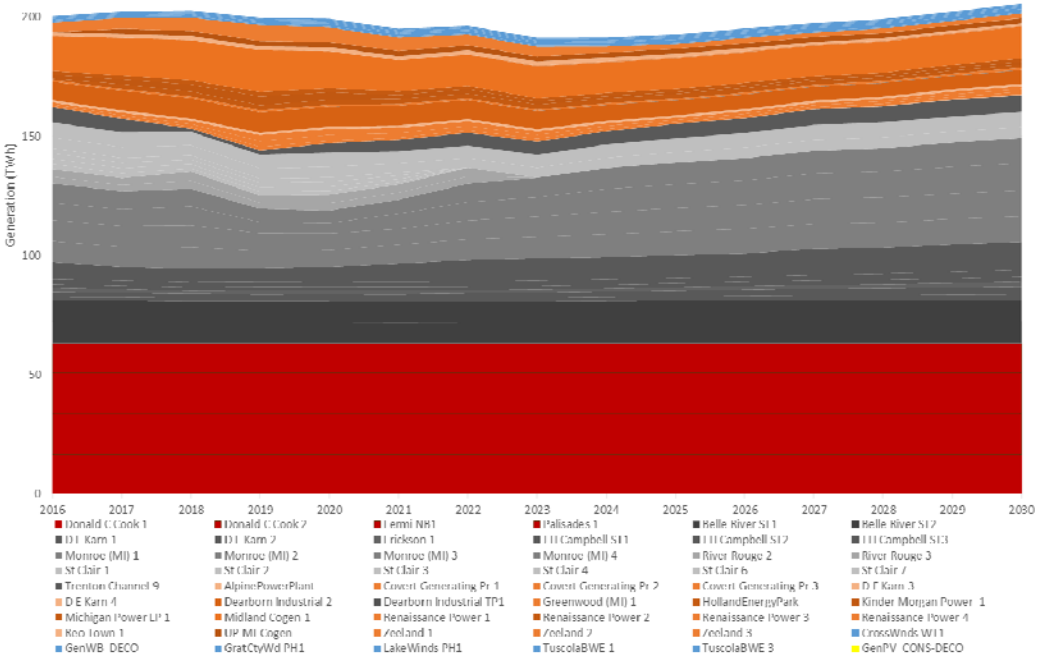


Mid-Atlantic Power Plants



Generation in Michigan State

Source: MPSC/MDEQ CPP Ref Case, High Gas (2016)



Utility-Scale Capacity Expansion Model

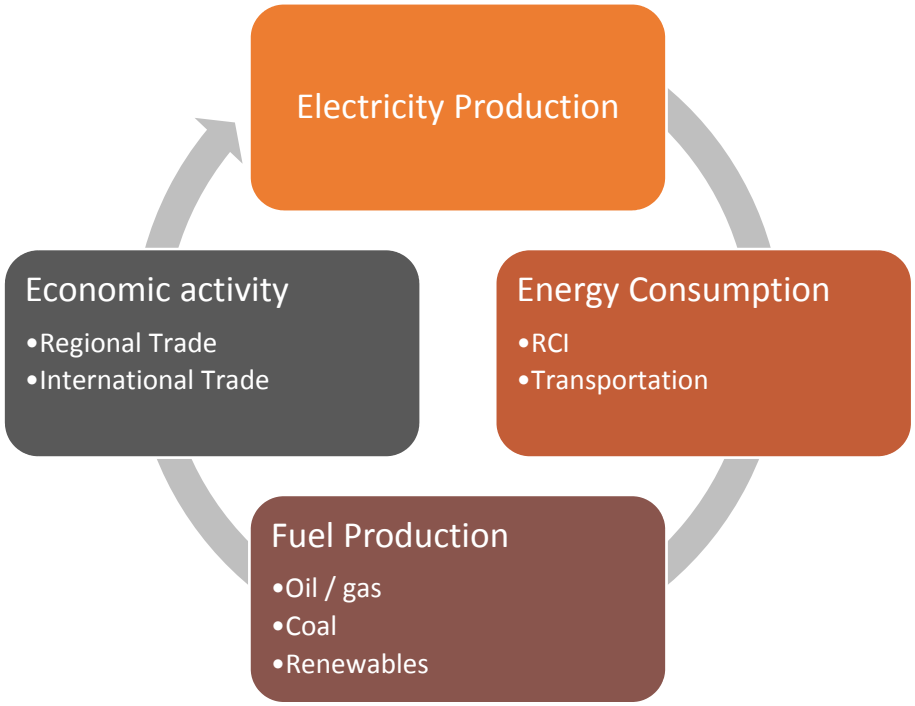
- Designed to determine least cost **unit** buildout under policy and economic constraints
- Medium temporal resolution; high spatial resolution
- Supply-curve dispatch during typical week
- Specific EGUs represented
- Used to examine least-cost portfolio development for utilities and/or states; test new resource requirements; integrated resource planning

Strategist, System Optimizer, PLEXOS-LT, AURORA$_{XMP}$

TRITE EXAMPLE

Two years from now, I expect to transport 120 people in two days, and my van is broken.

Do I repair the van, or buy a bus?



Multi-Sector Model

- Designed to find least cost technology buildout and consumption given constraints and inter-sector interactions.
- Low temporal and spatial resolution
- Little or no transmission representation
- Highly simplified supply-curve dispatch
- Technology types represented
- Used to examine impact of policies across sectors (e.g. fuel standards, emission standards, energy policies, economic policies)

MARKAL, NEMS (whole) EPPA, NewERA

TRITE EXAMPLE

How will a change in transportation modes impact sales of seat warmers?

If I make nicer seat warmers, will more people stay in their cars instead of taking the train?

Non-Optimization Approaches

- Purpose-built **screening** tools used for simple simulations or bookkeeping purposes
- Transparent & user-friendly

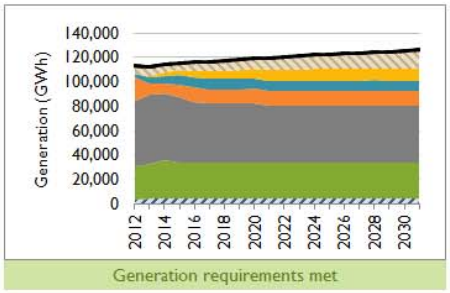
Synapse CP3T

Clean Power Plan Planning Tool

Dashboard - Michigan

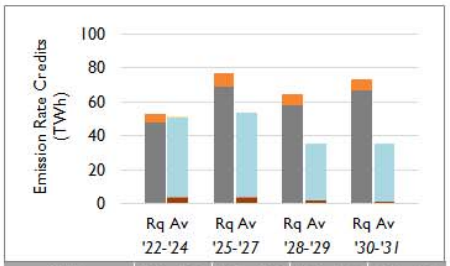
Click to return to start page | Restore default Excel functionality

This panel allows you to view key diagnostics of your scenario.



Generation requirements met

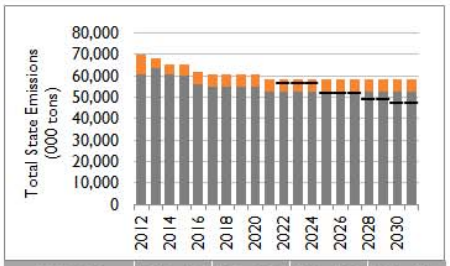
CP3T does not have a default cost requirement



GWh	'22 - '24	'25 - '27	'28 - '29	'30 - '31
Required ERCs	53,056	76,834	64,644	73,704
Available ERCs	51,690	53,888	35,751	35,584

Select rate requirement: R1. Technology-Specific

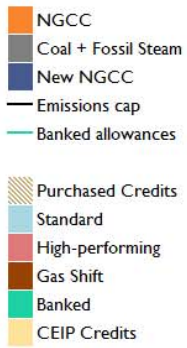
Have questions about rate-based compliance?



000 tons	'22 - '24	'25 - '27	'28 - '29	'30 - '31
Emissions cap	170,563	155,681	98,214	95,088
Emissions allowed	175,214	175,054	116,863	116,703

Select mass requirement: M1. Existing Only

Have questions about mass-based compliance?



More detailed charts
Summary tables
Model calculations
Main library

Control Panel

This panel allows you to adjust inputs to your scenario.

Scenario Name Enter your scenario name

Click here to see a list of sources and default assumptions being used in this scenario

Renewables

Select a setting for renewables: State RPS

Edit renewable capacities and gen. | *Edit renewable costs*

Edit renewable locations

Energy Efficiency

Select a setting for energy efficiency: State EERS

Edit energy efficiency savings and sales | *Edit energy efficiency costs*

Fossil and nuclear units

Apply the CPP default heat rate adjustment to coal units? No

Apply the CPP default capacity factor to NGCC units? No

Edit capacities, capacity factors, emission rates, and fuel switching for existing unit

Edit non-fuel costs | *Edit fuel prices*

Add new fossil and nuclear capacity | *Edit env. retrofit costs for existing units*

Imports / Exports

Select a setting for imports / exports: Fill Generation Gaps

Edit import / export levels in 2015 through 2031

Purchase credits for Clean Power Plan compliance from other states

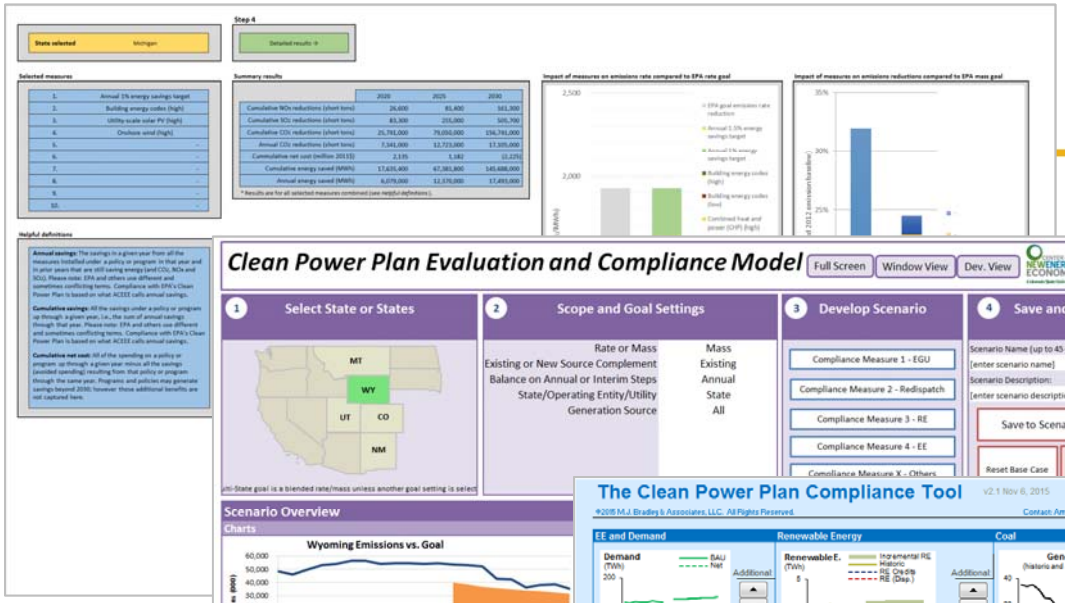
Displacement

CP3T allows users to choose which fossil resources are displaced with new renewables and energy efficiency.

Select a setting for displacement: Split displacement

Edit detailed displacement assumptions

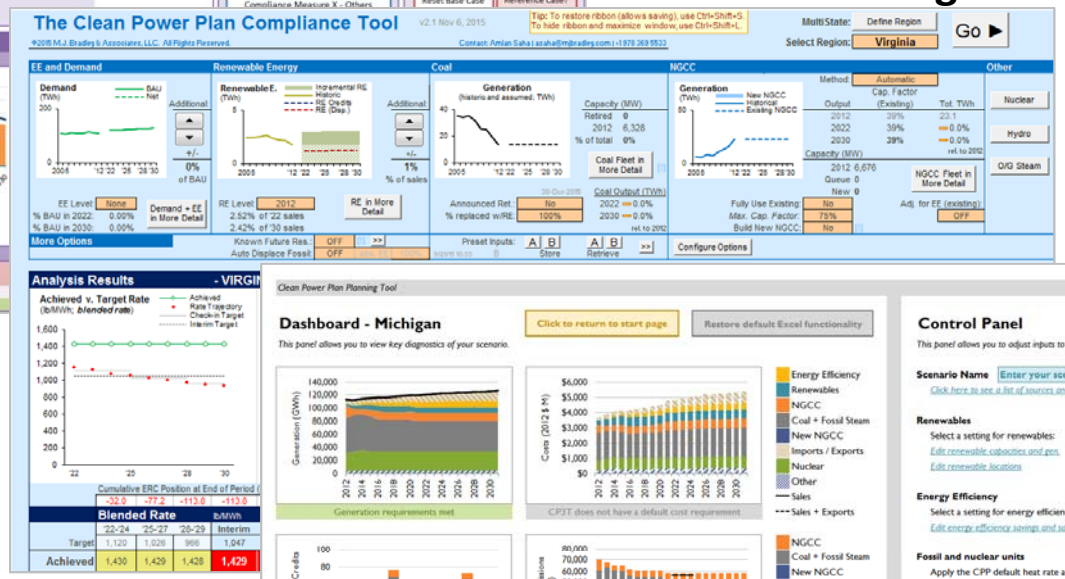
Non-Optimization Approaches



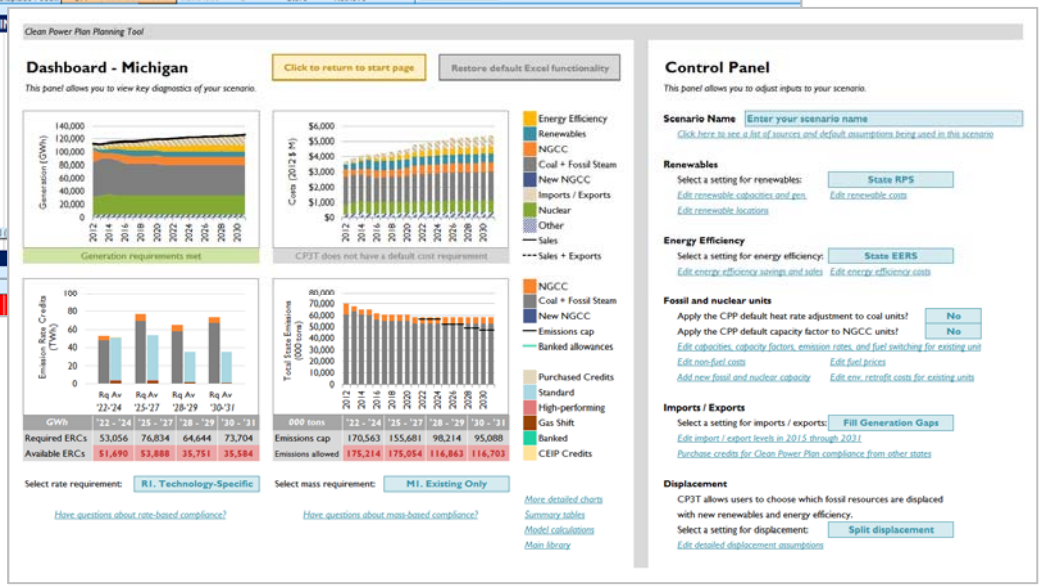
ACEEE SUPR2

Energy Strategies Five-State Tool

MJ Bradley CPP Planning Tool



Synapse CP3T

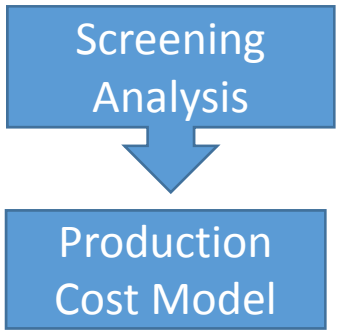


- All four built to examine Clean Power Plan compliance options
- Significant stakeholder planning value even outside of CPP

Example Analysis Pathways (I)

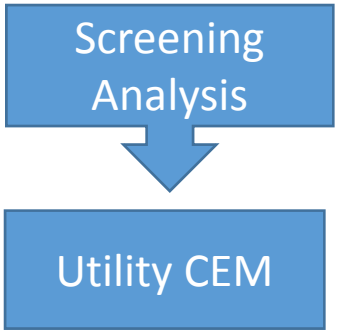
Screening Analysis

- Seeking **broad stakeholder engagement** - no budget
  - Harness screening analysis, vet with stakeholders and utilities
  - Pros: Wide engagement, focused discussions
  - Cons: May not represent real policy outcomes or behavior, does not capture economic forcing, may over or underrepresent ease of compliance

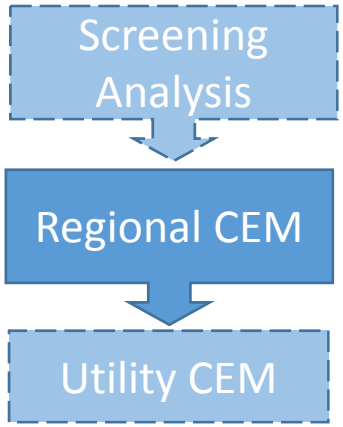


- Ability to **use utilities' model(s)** with stakeholder control over assumptions, portfolio choices, and compliance routes
  - Begin with screening analysis for portfolio construction, test through utilities' production cost models
  - Pros: operationally sound outcomes, costs consistent with utility estimates, captures economic shifts (i.e. fuel prices, allowance prices)
  - Cons: May not capture economic portfolio development

Example Analysis Pathways (II)



- Proprietary model available, require EGU specificity
  - Begin with screening analysis to narrow options, develop portfolios in utility-scale capacity expansion model
  - Pros: Detailed analysis, seeks least cost solution, fewer user decisions. Identifies impacts at specific EGUs, allows for unit retirement as compliance solution.
  - Cons: May not pick up interstate impacts or wide allowance trading region. Limited runs available.



- Multi-state strategic compliance review
  - Test basic compliance options through use of regional capacity expansion models. (Use screening analysis to narrow options, refine outcomes with utility-scale CEMS)
  - Pros: Comprehensive analysis, seeks least cost solution. Captures interstate electricity and allowance trading.
  - Cons: May need to be fine-tuned to capture subtleties of regulations. Not unit-specific.

Conclusions

- Screening models are freely available, powerful stakeholder engagement tools
  - May substantially over or under-estimate costs of compliance
  - May contain significant undocumented implicit assumptions
- States may want to carve out space for utility-scale tools
  - Consistent with utility planning
  - Highly specific, detailed
  - Create plans that are cost effective, equitable, and achievable
- Cost of proprietary models (and/or services) pales in comparison to electric system revenues, costs of operation, and potential impacts of even marginal policy choices
- States may be able to leverage utility models, or seek cost-sharing opportunities to create effective regulations.

Questions?

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