Multi-regional Electricity Market Planning in the US

Europe and Eurasia Initiative on Enhancing Market Performance

Technical Workshop

Douglas Gotham

February 26, 2020

Information Sources

- Sources of information include the notes and recollections of the presenter, the EISPC Archive on the NARUC website, and the EIPC DOE Project Overview website.
  - https://www.naruc.org/cpi/eispc-archive/
  - https://eipconline.com/doe-project-overview

USAID
FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Reasons for Eastern Interconnection Multi-regional Study

- Recognition of interdependence
  - what happens in one region affects other regions
- Changes occurring in the generation portfolio
  - renewable energy development with some states instituting renewable portfolio standards (RPS)
  - carbon emission limits at the regional level with the potential for federal action
  - other policy initiatives, such as energy efficiency requirements
- Economies of scale

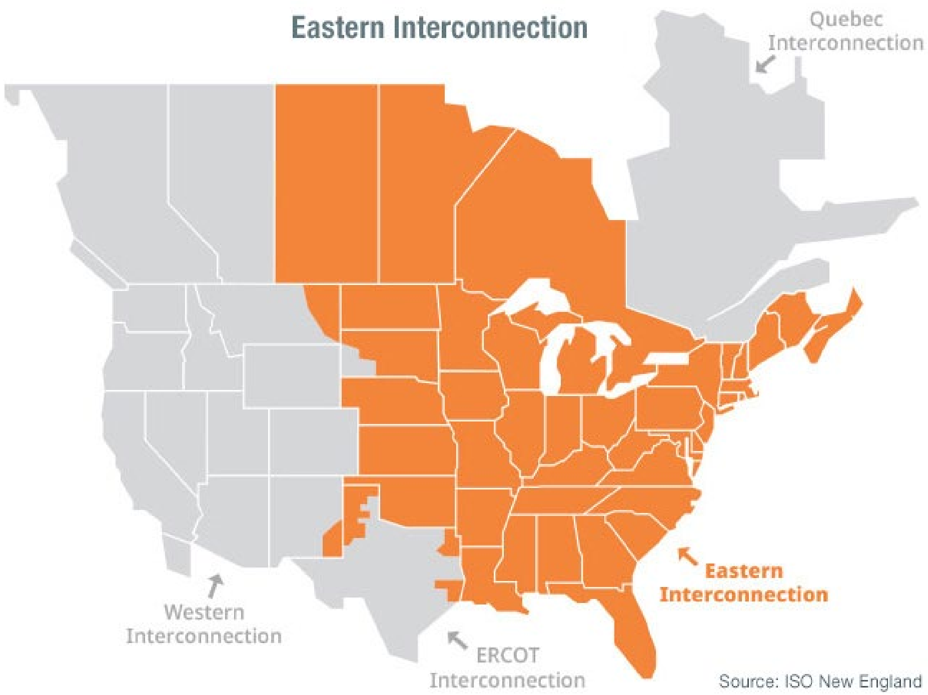
Interdependence - August 2003 Blackout

US Department of Energy (DOE) Funding Opportunity

- DOE elected to provide funding for two groups to examine multi-regional planning in the Eastern Interconnection.
  - the Eastern Interconnection States Planning Council (EISPC)
  - the Eastern Interconnection Planning Collaborative (EIPC)
- A similar effort was undertaken in the Western Interconnection.
- The work was intended to be informative rather than actionable.

Eastern Interconnection States Planning Council (EISPC)

- EISPC was formed in 2009 along with its companion organization, EIPC, to examine transmission requirements for a large geographic area under a broad range of possible future outcomes.



EISPC

- Policymakers
  - Made up of representatives of 39 states and the District of Columbia (non-voting members from Canada)
  - Two delegates per state (and DC) from the regulators and energy offices
  - Provide inputs to EIPC
  - Prepare studies and whitepapers

EIPC

- Engineering
  - Made up of 20 planning authorities; regional transmission organizations (RTOs) and transmission owning utilities
  - Run models and prepare transmission plans
  - Receive strategic advice from EISPC and other stakeholders

EISPC Initial Challenges

- Split regulatory jurisdiction between federal regulators and state regulators
- Protectionism
- Lack of trust
- Some thought it was unnecessary
- Limited resources for regulators
- Parochialism

EISPC Structure

- Administered by NARUC with dedicated staff.
- Each state and DC had 2 delegates.
  - Voting required both a majority of delegates and electricity sales weighted delegates
- Executive committee with representation from each region of the Eastern Interconnection.
- Work groups assigned to different tasks.
- Membership in the EIPC Strategic Steering Committee, with equal representation across different regions.

EISPC Scope

- Identify “energy zones” of interest for low-carbon or carbon-free generation.
- Conduct studies on key issues (renewable energy integration, baseload low-carbon resources, facilitate state participation in interconnection-wide planning).
- Develop inputs for and provide insights into the work being done by EIPC.
- Develop a process for reaching decisions/consensus of all states/provinces.

EIPC Structure

- While the EIPC members were the planning authorities, they took direction from the Strategic Steering Committee (SSC), which had representation from a number of different groups.
  - EISPC, transmission owners/developers, generation owners/developers, other suppliers, transmission dependent utilities/public power, non-governmental organizations, consumer advocates, Canadian provinces
  - non-voting representation from the US Department of Energy

EIPC Work

- The original work plan consisted of 2 phases.
- Phase 1
  - primarily an examination of the combination of the regional transmission plans
- Phase 2
  - development of multi-regional plans
- A third phase was added later, which consisted of a study of the interactions between the natural gas and electricity systems.

EIPC – Phase 1

- Combine the various regional transmission plans that had been developed independently into a single plan (known as the Roll-Up).
- Perform interregional analysis of the Roll-Up to identify deficiencies.
- Conduct economic analysis of 8 different potential future outcomes.
  - three of these would then be used in Phase 2

SSC Work Groups

- Roll-Up Work Group
  - provide feedback to EIPC during the integration of the existing regional transmission plans and address potential enhancements to gaps discovered through the analysis
- Scenario Planning Work Group
  - develop and recommend a diverse set of macroeconomic futures and sensitivities
  - recommend which 3 scenarios should be used for Phase 2
- Modeling Work Group
  - develop the specific inputs to be used in the macroeconomic futures and sensitivities

Transmission Plan Roll-Up (Phase 1, Task 2)

- Develop a guide for documenting the process.
- Conduct gap analysis.
  - stitch together individual regional plans into an interconnection-wide plan
  - identify potential conflicts and opportunities
- Develop options to address reliability concerns.
- Document and communicate results.

2020 Roll-Up

- The multi-regional analysis was to be performed for a year in the future (2020) by combining the individual plans and conducting load flow analyses of the combined system.
- The regional transmission plans relied on numerous assumptions, such as location and size of future generation resources, that were not always consistent with other plans.
  - a process was developed to allow the SSC to specify future resources in a more consistent manner

Stakeholder Specified Infrastructure (SSI)

- Criteria were developed to determine transmission and generation that would be included in the model (under construction or scheduled to be operating by a certain date).
- Exceptions were allowed to either add or remove facilities.
- EISPC developed a process for determining exceptions
  - members could propose to add or remove facilities and after discussion, a determination was made by unanimous consent or by vote

Load Flow Studies

- The resulting transmission model was used in load flow studies to identify possible problems (overloading of lines/transformers, undervoltage, etc.).
- It was also used to determine the transfer limits between regions in the next step of the analysis (macroeconomic modeling of future scenarios).

Load Flow Study

- Also known as a power flow study, a load flow study is an analysis of the flow of electric power through an interconnected system.
- Power flows across multiple lines from sources (generators) to sinks (loads) according to physical laws.
- Flows are affected by the physical characteristics of the transmission components (impedance), injections at sources, and withdrawals at sinks.

Load Flow Study (continued)

- A load flow represents conditions at a single instant in time, rather than across a time period.
- It is the simultaneous solution of multiple non-linear equations (numerical solution rather than optimization).
- The solution can be used to identify conditions outside of normal operation levels.
- It is often repeated under different system conditions (high load vs. low load, outage of system components).
- Examples: Power World, PSS/e, PSLF

USAID FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Macroeconomic Futures (Phase 1 Task 4)

- EISPC and the SSC collaboratively developed 8 "futures" through the Scenario Planning Working Group.
  - based on a consistent set of assumptions on technologies, policies, and costs
  - each future was designed to be different from the others and was intended to model how the industry may evolve over time
- Each future had additional sensitivities.
  - designed to change a single input from the base future

Alternative Futures

Future	Label	Definitions
1	BAU	Business as usual scenario
2	CO_2/N	High CO_2 cost scenario, national implementation
3	CO_2/R	High CO_2 cost scenario, regional implementation
4	EE/DR	Aggressive energy efficiency (EE), demand response (DR), and distributed generation (DG)
5	RPS/N	National renewable portfolio standard (RPS), national implementation
6	RPS/R	National RPS, regional implementation
7	NUC	Nuclear resurgence
8	CO_2+	High CO_2 costs scenario with aggressive EE, DR, DG, and nationally implemented RPS

USAID FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Sensitivities

Sensitivities	Future 1: BAU	Future 2: CO_2/N	Future 3: CO_2/R	Future 4: EE/DR	Future 5: RPS/N	Future 6: RPS/R	Future 7: NUC	Future 8: CO_2+
Expand transmission	√	√	√		√	√	√	√
+/- Load growth	√	√	√		√	√	√	
+/- Gas price	√	√	√		√	√		√
+/- Renewable cost or deploy	√	√	√		√	√		√
Delay regulations	√							
CO2 Cost Adjust		√	√				√	√
PHEV variations				√	√	√		
Extra EE savings				√				
Clean Energy Standard					√	√		
Small Modular Reactors							√	
Higher RPS limits								√

Modeling Work Group

- EISPC worked with the Modeling Work Group to determine the values to be used for the variables in all futures and sensitivities.
- Primary inputs: energy and peak load demand; reserve margin requirements; existing generation characteristics; new generation costs and characteristics; environmental retrofit costs; cost of capital; emissions limits/costs; local renewable standards; fuel prices

USAID FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Macroeconomic Analysis (Phase 1 Task 5)

- The macroeconomic analysis of the various futures and scenarios was performed by a third party consultant, Charles River Associates, with a pair of models.
  - MRN, a model of the economy
  - NEEM, a model of the electricity sector

Multi-Region National (MRN) Model

- General equilibrium model, based on the concept of an equilibrium point between consumption and investments; driven by decisions of consumers and producers.
- Goods, services, and payments flow between households, government and firms.
- Firms profit-maximize.
- Households receive wages (for labor) and goods and services from firms.
- Households provide labor, payments (for goods and services) and capital (for investments) to firms.

North American Electricity and Environment Model (NEEM)

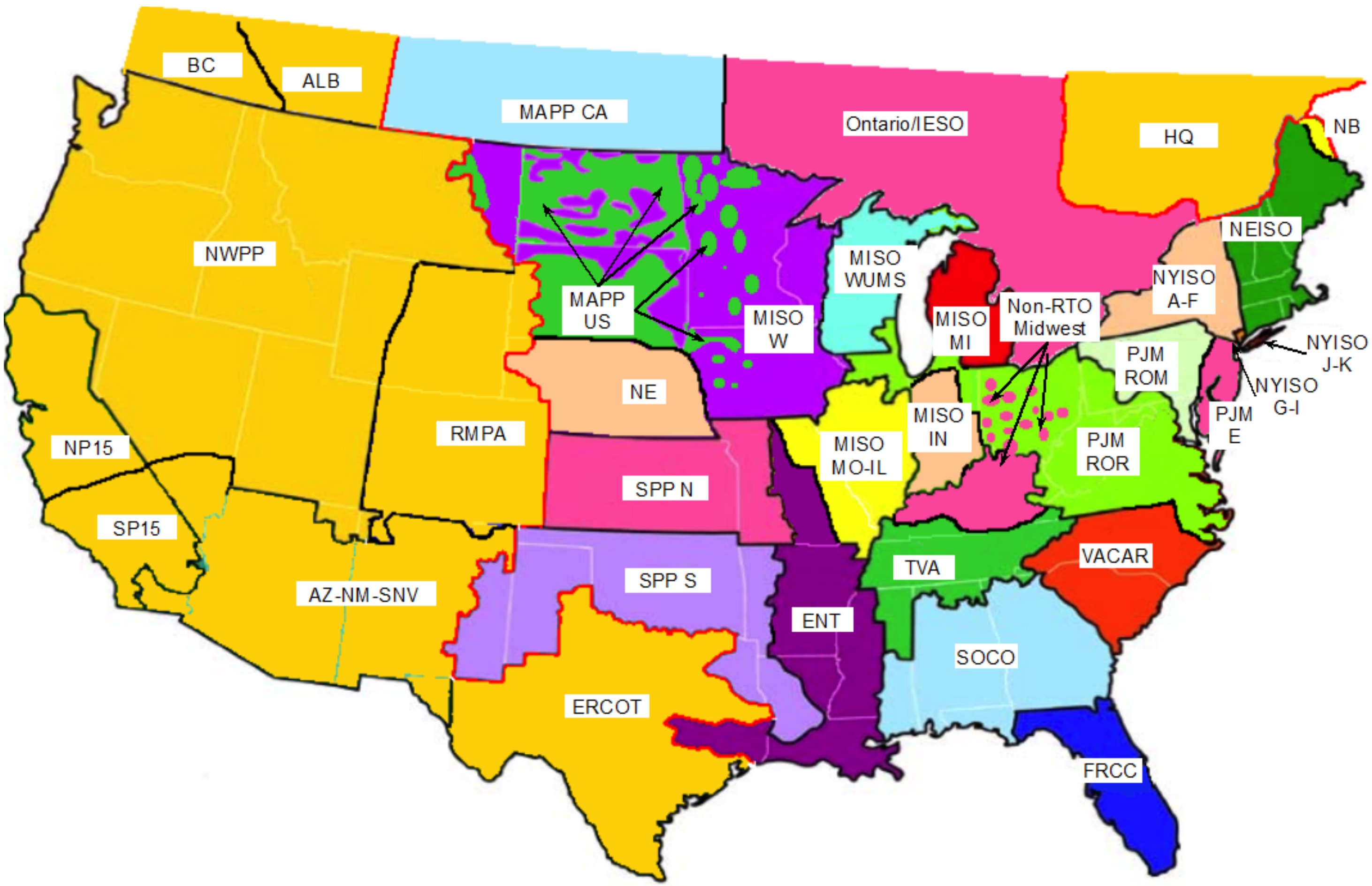
- An optimal capacity expansion model.
- Simulate capacity expansion and environmental compliance.
- Find the least cost solution to serve load, maintain reliability, and comply with environmental policies.
- Propose retirements, construction, and retrofitting of generating units.
- NEEM uses a “pipe and bubble” architecture.
  - pipes represent the import & export transfer limits between NEEM regions
  - bubbles represent the NEEM regions (based on historical congestion)

Capacity Expansion Model vs. Load Flow Model

- Capacity Expansion
  - determine future resource needs
  - optimization
  - simplified or no transmission network
  - detailed generation information
  - solved for multiple years using typical hours
- Load Flow
  - identify transmission system violations
  - numerical
  - detailed transmission network
  - generation output only
  - single instant in time

Examples of capacity expansion models: EGEAS, NEEM, NEMS, NESSIE, ReEDS, Strategist, WASP

NEEM Regions



MRN-NEEM Modeling Runs

- The MRN and NEEM models were run for each future and sensitivity to find the economic additions and retirements of resources over time.
- EISPC and the SSC analyzed the results to choose 3 scenarios that would be subject to further analysis in Phase 2.

Business As Usual Example (GW)

	2010 In-Service	---- Additions ----			---- Retirements ----			2030 In-Service
		2015	2020	2030	2015	2020	2030	
Coal	271.9	8.5	0.0	0.0	66.8	14.8	0.0	198.8
Nuclear	99.8	2.7	4.5	0.0	0.0	0.6	1.5	105.0
CC	132.7	30.7	17.7	26.2	5.5	0.0	0.0	201.8
CT	120.3	4.7	4.4	4.4	2.2	0.0	0.0	131.7
Steam Oil/Gas	74.5	0.0	0.0	0.0	37.6	0.4	0.4	36.1
Hydro	44.6	0.0	0.0	0.0	0.0	0.0	0.0	44.6
On-Shore Wind	18.7	22.2	12.1	14.8	0.0	0.0	0.0	67.8
Off-Shore Wind	0.0	0.5	0.0	1.1	0.0	0.0	0.0	1.6
Other Renewable	3.6	2.3	3.3	4.5	0.0	0.0	0.0	13.7
New HQ/Maritimes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	17.1	0.0	0.0	0.0	0.0	0.0	0.0	17.1
Total	783.3	71.6	42.1	50.9	112.1	15.8	1.9	818.2
DR	33.1	-1.3	16.8	22.1				70.7

Expansion Scenario Selection (Phase 1 Task 6)

- A small work group, called the Scenario Task Force, was created to select the 3 scenarios for Phase 2 analysis.
  - consisted of members of EISPC and other stakeholders

"The main, guiding objective for the selection of scenarios to be studied in Phase 2, is to end up with a set of scenarios that are defined by different policy drivers, and to determine what different transmission buildouts may be needed to support these policy drivers." – Scenario Task Force memorandum to SSC, 2011

Selected Scenarios

- After narrowing the options from 76 future/sensitivity runs to roughly one per future, the Scenario Task Force recommended three scenarios to the SSC, which adopted them.
  - 1. Nationally Implemented Federal Carbon Constraint with Increased Energy Efficiency and Demand Response
  - 2. Regionally Implemented National Renewable Portfolio Scenario
  - 3. Business As Usual

EISPC Studies and Whitepapers

- While the collaborative effort with EIPC was underway, EISPC commissioned a number of studies and whitepapers on topics of interest to electricity planning.
- The reports are archived and available on the NARUC website.
  - https://www.naruc.org/nrri/nrri-library/

USAID
FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Studies and Whitepapers

- "Market Structures and Transmission Planning Process in the Eastern Interconnection," Christenson Associates, June 2012.
  - https://pubs.naruc.org/pub.cfm?id=536DCD10-2354-D714-5174-465A1016B9E0
- "Economics of Resource Adequacy," Astrape Consulting, January 2013.
  - https://pubs.naruc.org/pub.cfm?id=536DBE4A-2354-D714-5153-70FEAB9E1A87
- "Assessment of Demand-Side Resources within the Eastern Interconnection," Navigant Consulting, March 2013.
  - https://pubs.naruc.org/pub.cfm?id=536D6C3B-2354-D714-5123-0C220D38FEA2
- "Assessment of the Nuclear Power Industry," Navigant Consulting, June 2013.
  - https://pubs.naruc.org/pub.cfm?id=536D6E09-2354-D714-5175-4F938E94ADB5

USAID FROM THE AMERICAN PEOPLE

National Association of Regulatory Utility Commissioners

Studies and Whitepapers (continued)

- “Current State and Future Direction of Coal-fired Power in the Eastern Interconnection,” ICF International, June 2013.
  - study https://pubs.naruc.org/pub.cfm?id=536DEE07-2354-D714-5143-BBCD27E6D510
  - whitepaper https://pubs.naruc.org/pub.cfm?id=536E08C0-2354-D714-51C4-E0BF6E879D5F

- “Co-Optimization of Transmission and Other Supply Resources;” Illinois Institute of Technology, Iowa State University, Johns Hopkins University, Purdue University, and West Virginia University; September 2013.
  - https://pubs.naruc.org/pub.cfm?id=536D834A-2354-D714-51D6-AE55F431E2AA

- “EISPC Energy Zones Final Report,” The EISPC Energy Zones Workgroup, October 2013.
  - https://pubs.naruc.org/pub.cfm?id=536DD003-2354-D714-51E0-4C54C88745B5

Studies and Whitepapers (continued)

- "Transmission Planning Whitepaper," Navigant Consulting, January 2014.
  - https://pubs.naruc.org/pub.cfm?id=53A151F2-2354-D714-519F-53E0785A966A
- "Study on Long-term Electric and Natural Gas Infrastructure Requirements in the Eastern Interconnection," ICF International, September 2014.
  - https://pubs.naruc.org/pub.cfm?id=536DFAF7-2354-D714-512C-1BA1BBD00009
- "White Paper: Applications of the Energy Zones Mapping Tool, " Illinois Institute of Technology, October 2014.
  - https://pubs.naruc.org/pub.cfm?id=536F3F42-2354-D714-512C-2F7A9F6A549F
- "White Paper: Long-term Electric and Natural Gas Infrastructure Requirements," Illinois Institute of Technology, November 2014.
  - https://pubs.naruc.org/pub/536DCA2E-2354-D714-5112-CBD58ED9B81A

Studies and Whitepapers (continued)

- "Data Mining White Paper," Navigant Consulting, December 2014.
  - https://pubs.naruc.org/pub.cfm?id=536DB9F5-2354-D714-518B-5B353C767439
- "Load Forecasting Case Study ," University of North Carolina at Charlotte and Illinois Institute of Technology, January 2015.
  - https://pubs.naruc.org/pub.cfm?id=536E10A7-2354-D714-5191-A8AAFE45D626
- "A Study on Probabilistic Risk Assessment for Transmission and Other Resource Planning," Electric Power Research Institute, January 2015.
  - https://pubs.naruc.org/pub.cfm?id=536DCE1C-2354-D714-5175-E568355752DD
- "PRA White Paper – A White Paper on the Incorporation of Risk Analysis into Planning Processes," Electric Power Research Institute, January 2015.
  - https://pubs.naruc.org/pub.cfm?id=536DCF19-2354-D714-5117-47F9BA06F062

Studies and Whitepapers (continued)

- "Utility Involvement in Distributed Generation: Regulatory Considerations White Paper," National Regulatory Research Institute, February 2015.
  - https://pubs.naruc.org/pub.cfm?id=536EF3DF-2354-D714-510E-B20295D42469

- "Multistate Coordination Resources for Clean Power Plan Compliance," NARUC, June 2015.
  - https://pubs.naruc.org/pub.cfm?id=536E1A75-2354-D714-517B-25E4EB9B793E

Recorded Webinar

- "EISPC Co-Optimization of Transmission with Other Resources Demonstration," Energy Exemplar, January 2015.
  - http://pubs.naruc.org/pub/53EF5B53-2354-D714-518F-A1EA6AE7CFF1