Phase I Report
DOE Award Project
FOA DE-0000068

December, 2011

Foreword

Table of Contents

Section **Page Number**

Description of Three Scenarios for Study in Phase II

a) Scenario 1
b) Scenario 2
c) Scenario 3

Conclusions and Observations

a) Technical Topics
b) Process Topics
c) “Lessons Learned”
d) Limitations of Project Results

Appendices

a) Stakeholder Steering Committee Documents
b) Report on Development of 2020 Model (Roll-Up Report)
c) Description of MRN/NEEM Modeling Tool
e) Input Data
f) “Soft Constraint” Methodology
g) Task 5 Results
h) High Level Transmission Cost Estimation Process for Task 5
i) Etc.

Executive Summary

Introduction and Background

Background

DOE Funding Opportunity Announcement – Overview and Purpose

In June of 2009, the United States Department of Energy (DOE) issued a Funding Opportunity Announcement (FOA), DE-FOA0000068, that provided funding[1] to prepare analysis of transmission requirements under a broad range of alternative futures. The DOE FOA covered two specific topics. Topic A was to fund Interconnection-level analysis and planning work while Topic B was to fund cooperation among States on electric resource planning and priorities. The DOE anticipated issuing three awards under each Topic corresponding to the three geographic areas served by the three interconnections (Eastern, Western, and Texas).

In August of 2009, the Planning Authorities in the Eastern Interconnection reached final agreement on the formation of the Eastern Interconnection Planning Collaborative (EIPC). Under the construct of the collaborative, the NERC registered Planning Authorities in the Eastern Interconnection intended to "roll-up" their respective regional expansion plans which were developed under their FERC Order 890 approved regional planning processes to form a model of the Eastern Interconnection. This model would provide a basis for interconnection-wide analysis that would feed information back into regional planning processes and allow EIPC members to identify any inconsistencies among the established regional plans while also allowing members to identify opportunities for potential transmission enhancements to increase the ability to move power or reduce costs. The core objectives served as the foundation for a proposal that EIPC submitted in August 2009 to perform the Topic A work under the DOE FOA. All twenty-six (26) EIPC members[2] support the work prescribed for Topic A. Eight (8) of the twenty-six members are designated as Principal Investigators[3] who bear additional responsibilities under the DOE FOA with respect to project management and reporting. PJM serves as the lead Principal Investigator under the proposal.

The 39 states (plus the District of Columbia and the City of New Orleans) in the Eastern Interconnection formed the Eastern Interconnection States Planning Council (EISPC) and, at the same time that EIPC was crafting its proposal, submitted a proposal for the Topic B work under the DOE FOA. On December 18, 2009; the DOE announced that EIPC and EISPC had been

[1] Funding made available under the American Recovery and Reinvestment Act of 2009 (ARRA 2009).

[2] As of December 1, 2011, the EIPC Members include Alcoa Power Generating, American Transmission Co., Duke Energy Carolinas, Electric Energy Inc., Entergy Services, E.ON, Florida Power & Light, Georgia Transmission Corp, IESO, International Trans. Co., ISO New England, JEA, MAPPCOR, Midwest ISO, MEAG, NBS, New York ISO, PJM Interconnection, PowerSouth Energy Coop, Progress Energy Carolinas, Progress Energy Florida, S. Carolina Elec. & Gas, Santee Cooper, Southern Company, Southwest Power Pool and Tennessee Valley Authority.

[3] Principal Investigators for the project include Entergy Services, ISO New England, MAPPCOR, Midwest ISO, New York ISO, PJM Interconnection, Southern Company, and Tennessee Valley Authority.

selected to perform the Eastern Interconnection work under Topic A and Topic B, respectively, with a total of $16 million in funds made available to EIPC and a total of $14 million in funds made available to EISPC. As part of its proposal, EIPC had retained Whiteley BPS Planning Ventures LLC to support project management, The Keystone Center (Keystone) to support stakeholder process facilitation, and Charles River Associates (CRA) to support macroeconomic analysis and production cost studies.

Statement of Project Objectives – Phase 1 Deliverables

The EIPC proposal incorporated a Statement Of Project Objectives (SOPO) as required under the terms of the DOE FOA. The SOPO was originally submitted as part of the proposal in August 2009 and was then revised during contract negotiations with the DOE in February 2010. The revised version of the SOPO is included in the Appendix to this Report. The objectives stated in the SOPO were twofold.

The first objective was to establish processes for aggregating the modeling and regional transmission expansion plans of the entire Eastern Interconnection and to perform interregional analyses to identify potential conflicts and opportunities between regions. This interconnection-wide analysis was to serve as a reference case for modeling various alternative grid expansions based on the scenarios developed by stakeholders.

The second objective was to perform scenario analysis as guided by a broad stakeholder input and the consensus recommendations of a stakeholder committee formed under the proposal. The analysis would serve to aid federal, state and provincial regulators as well as other policy makers and stakeholders in assessing interregional options and policy decisions.

The scope of work proposed by the EIPC in the SOPO was divided into 13 tasks with two distinct parts or phases. Phase 1 included the following tasks:

- Task 1 – Initiate Project
  - EIPC to meet with Topic B Awardee (EISPC) to discuss approach for interaction between entities and to gather feedback on Stakeholder Steering Committee (SSC) structure.
  - The Keystone Center to facilitate the formation of the SSC and any necessary subgroups.
- Task 2 – Integrate Regional Plans
  - EIPC to generate Roll-up Model using regional plans for year 2020.
  - EIPC to perform inter-regional analysis on Roll-up Model.
  - EIPC to indentify conflicts between plans and/or opportunities for regional plan improvement.
- Task 3 – Production Cost Analysis of Regional Plans
  - CRA to perform production cost analysis on Roll-up Model.
- Task 4 – Macroeconomic Futures Definition

    - SSC to reach consensus on eight Futures (each Future having up to nine Sensitivities totaling 80 cases).
- Task 5 – Macroeconomic Analysis
    - CRA to perform macroeconomic analysis and report on each Future and Sensitivity.
    - EIPC to produce high level transmission cost estimates for each of the 8 Futures scenarios.
- Task 6a – Expansion Scenario Concurrence
    - EIPC to assist SSC in selecting three scenarios from the Task 5 work as options for the transmission expansion, analysis, and costing work in Phase 2 of the project.
- Task 6b – Interim Report
    - EIPC to produce interim project report on Phase 1 activities.

Phase 2 of the project proposed building and analyzing transmission expansion options for the three scenarios selected by the SSC in Task 6a at the end of Phase 1. For each of the three scenarios selected, the work in this phase proposed the following tasks:

- Task 7 – Interregional Transmission Options Development
    - EIPC to modify powerflow models built in Task 2 to create interregional transmission expansion models for each scenario[4].
- Task 8 – Reliability Review
    - EIPC to perform reliability analysis consistent with NERC reliability criteria on each scenario.
- Task 9 – Production Cost Analysis of Interregional Expansion Options
    - CRA to perform economic analysis using production cost modeling for each scenario.
- Task 10 – Generation and Transmission Cost Estimates
    - EIPC to perform high level cost estimates for transmission expansion options for each scenario.
    - Costs associated with resource additions and retirements will be developed by CRA for each scenario.
- Task 11 – Review of Results
    - EIPC to produce a draft report on the Phase 2 effort.
    - EIPC to present the results of the analysis, respond to questions, and solicit input from stakeholders.
    - SSC to provide consensus-based comments on the draft report.
- Task 12 – Phase 2 Report
    - EIPC, with CRA providing technical support, to review the input received from the SSC and address it in the final report.

[4] Intended to provide high-level interconnection-wide expansion analysis and not substitute for regional planning processes or state, local or provincial siting processes and will not identify specific routing, siting, environmental or other related issues associated with any potential enhancements to the grid coming out of this task.

There have been two core changes to the SOPO initiated by the SSC and supported by DOE. The first change was on Task 2 regarding the development and use of the Roll-up Model. Upon learning more about the detailed aspects of the various regional plans that EIPC utilized for the Roll-up Model development, the SSC decided to request that EIPC revise the Roll-up Model to construct a Baseline Infrastructure Model. Through a formal process initially led by EISPC, the SSC was able to agree to a revised set of transmission and generation assets that would serve as the basis for the revision to the Roll-up Model for 2020. This new Baseline Infrastructure Model would serve to replace the Roll-up Model as the starting point in all of the DOE project work on a going forward basis.

The second core change to the SOPO relates to the production costing work that was planned under Task 3 in Phase 1 of the project. Under the original EIPC proposal, a production cost analysis was to be performed on the integrated regional plans that served to create the 2020 Roll-up Model. With the move away from the Roll-up Model to a stakeholder derived Baseline Infrastructure Model as the starting point for further analysis, and with the decision to consider a 20 to 25 year time horizon rather than the 10 year horizon assumed in the integrated regional plans used to derive the Roll-up Model, the SSC agreed that this work was no longer providing any relevant value to the project. At the request of EIPC; the DOE, in May 2011, deleted the production costing work originally proposed under Task 3 of the SOPO**.**

Overview of Project Schedule

In the requirements specified by the DOE FOA, the project work was to be completed by June 30, 2013. The restructured EIPC proposal that was submitted in February 2010 called for Phase 1 work to be complete by June of 2011 and for Phase 2 work to be complete by June of 2012, well ahead of the June 2013 deadline. A revised schedule was issued in mid-2011 that moved completion of Phase 1 of the project to December 2011 and completion of Phase 2 to December 2012, still well ahead of the original June 2013 deadline set in the DOE FOA. The slippage in the original schedule was the result of EIPC support of SSC efforts to revise the Roll-up Model to create a Baseline Infrastructure Model, extensive stakeholder education regarding the operation and input assumptions needed for the macroeconomic models and by the increased time taken by the SSC to reach agreement on the futures and associated sensitivities for the Task 5 work. These modifications to the schedule were supported by the DOE and by the SSC as it served to allow the SSC and EISPC to make decisions essential for supporting the stakeholder process. EIPC is not anticipating any further delays in the project schedule, at this point, and is confident that they can meet the original June 2013 deadline spelled out in the DOE FOA.

Study Results by Task

Task 1 – Stakeholder Steering Committee (SSC) Formation and Creation of Governance Process

In order to become familiar with the issues and tensions within this [policy arena], a substantial assessment phase was required. Keystone conducted an initial round of interviews with known stakeholders active in the energy and transmission fields. These interviews produced both raw material for understanding stakeholder interests within the debate as well as additional names of people who were knowledgeable and had a stake in the debate.

The second round of interviews flowed from these names in the first round, supplemented by EIPC Planning Authorities' internal lists of stakeholders presently participating in each of their FERC Order 890 processes. During the course of interviews of potential stakeholder participants, Keystone collated a straw proposal for what a Steering Committee might look like, given DOE/EIPC objectives and the data they were receiving on representation in the Planning Authority 890 processes.

Part of the process to augment insight into the interests in this [policy arena] involved organizing two webinars to introduce interested parties to what EIPC was planning to do. While the DOE contract with EIPC was being finalized, stakeholders were anxious to see what was already planned and what was still negotiable for the terms of the studies and their stakeholder involvement. To allay that anxiety and show good-faith transparency, EIPC unveiled its intended plan of action in October 2009 in a webinar format where people could join easily and ask questions.

From the results of the stakeholder interviews and in coordination with EIPC, Keystone drafted a straw proposal for composition of the SSC and a process for fairly and transparently selecting the individuals to serve on it. This was the beginning of the Selection Process.

The straw proposal for composition of the SSC and voting process was circulated to a subset of stakeholders interviewed in late 2009 for comments. The proposal went through informal approval processes with DOE, EIPC and sector representatives in various stages. It was discussed at length during the April 2010 Eastern Interconnection-wide Stakeholder meeting, and decided upon after that meeting. That approval allowed for planning of the Selection

Process itself, including how to make the process open and inclusive for all stakeholders, given different regional Order 890 traditions and stakeholder sector makeup.

Concurrent with the active individual stakeholder outreach in the fall of 2009, Keystone staff began to compile potential resources for an SSC Charter, realizing that the SSC would need some governing document to get started on its mission. Because the Selection Process required substantial attention, this deliverable was put on hold for further development after the SSC selection process was underway.

In addition to the consensus documents necessary for the SSC to start work, Keystone undertook the organizational tasks necessary to be able to communicate with the broader stakeholder community (listserv and website) and the more active stakeholder representatives (listservs and website), to interact with the public in real-time for outreach purposes.

Finally, there was the need for coordination with other partners in the EIPC effort, including individual planning authorities, other subcontractors (CRA International), website developers, several DOE and NETL officials involved with the project, and the Topic B Awardee, the Eastern Interconnection States' Planning Council (EISPC). Scheduling and decision flow conflicts had to be worked out over a lengthy period as both EIPC and EISPC learned how best to structure meeting times and agenda items for EISPC to be able to participate, given its own governance structure.

From the beginning of the Selection Process, the priorities were fairness, transparency, and a wide outreach effort. To begin with, Keystone asked for appointed sector coordinators for each region and sector (7 regions and 8 sectors or 56 coordinators, with some being responsible for more than 1 sector and/ or region). This contact information was posted to allow the broad stakeholder community to get involved through emailing or calling the sector/region coordinator.

In addition to contact information, each region and sector was required to post what (1) their process (which had to meet a standard of transparency), (2) the SSC candidates were, (3) when voting/ decisional meetings would take place, and (4) how the choice would be made. Any objections to the process were reported to Keystone for resolution in consultation with EIPC before voting could take place. Regions/ sectors were encouraged to have a preparatory forum for candidates to ask questions, but this call or meeting was not always possible due to scheduling or deadlines.

The process for voting was detailed in the Step-by-Step document and Frequently Asked Questions (FAQ) available online, but basically followed these stages: (1) sectors organize within regions, (2) sectors decide process for Caucus Selection (online, phone, in-person), (3) individuals register to vote (online or with Coordinator, posted and verified by sector), (4) eligible individuals vote for Caucus members, (5) Caucus members put forward SSC candidacy applications (all posted and verified online), (6) Caucus members vote for SSC members (verified by Sector Coordinators and/or Keystone).

Task 2 – Integration of Regional Plans for the Year 2020

[Pending Input]

Stakeholder Specified Infrastructure

Transmission Limits to be used in Task 5 Work

Task 3 – Production Cost Analysis of Regional Plans

The project SOPO initially called for the EIPC to perform economic analysis of the integrated regional plans using production cost modeling. The production cost analysis would assess all hours of the future year and would forecast energy production costs, constraints limiting dispatch and interregional transactions, anticipated emissions, renewable energy production, and other pertinent factors. In addition, the production cost analysis would use a model that simulates the hour-by-hour operation of the transmission and generation system in the Eastern Interconnection, incorporating transmission reliability and environmental considerations. One of the key inputs for Task 3 was to include the results from Task 2 development of the Eastern Interconnection-wide model based on an integration (roll-up) of the existing regional plans. The subtasks defined in the SOPO for Task 3 are:

Subtask 3.A. Perform production cost modeling for the Roll-up Integration Case.
Subtask 3.B. Document and communicate results of production cost modeling and post the analysis on the EIPC website.

As the initial work on Task 3 began, the EIPC concluded that the results from the analysis contemplated would be less valuable due to the changed direction of the SSC regarding the macroeconomic analysis. On that basis, the EIPC approached DOE with a recommendation to eliminate Task 3 and apply the resources that would have been used in Task 3 to directly provide additional support in other tasks, most notably Task 4 and Task 5. DOE agreed with this modification and issued new project documents to record the change.

Specifically, the EISPC and the SSC recommended that the roll-up case for the year 2020 should not be used as the starting point for the resource Futures to be analyzed in Task 5. In addition, the macroeconomic analyses in Task 5 and transmission build-outs in Phase 2 of the project are now being targeted for the year 2030, or possibly even 2035, instead of the year 2020 originally described for Task 3 in the SOPO. As such, the analysis proposed in Task 3 would not be directly comparable to the analyses to be completed in Task 9, the production cost analysis of the three scenario transmission build-outs. Thus, the production cost analysis proposed in Task 3 would be of little value to the project participants and the DOE.

Stakeholders also questioned the value of performing a production cost analysis of the roll-up case in early discussions on Task 3. However, they expressed a desire to complete a production cost analysis of the results from the first macroeconomic future labeled as “Business as Usual” (BAU).

Task 4 – Selection of Macroeconomic Futures

Futures Definitions

Work Group Charge and Objectives

The original charge of the Scenario Planning Work Group (SPWG), which was approved by the SSC in July 2010, was to:

- Recommend to the EIPC Stakeholder Steering Committee (SSC) a set of diverse macroeconomic futures for selection, and if so directed by the SSC, make recommendations as to the eight futures to be employed and up to nine sensitivities to be used within each.
- Fully develop the eight macroeconomic futures and the sensitivities selected by the SSC, so that they meet CRA's needs.
- Recommend to the SSC which three scenarios should be assessed in reliability studies.

Subsequently, the SSC decided that the third bullet would be done with a work group led by the chairs of the SSC. The role of the SPWG was to make recommendations to the EIPC Stakeholder Steering Committee for their consideration.

The work group objectives were established as follows:

- The portfolio of eight macroeconomic futures will represent a wide range of forecasts.
- The portfolio will consider factors such as state and federal public policy objectives, reliability mandates, and economic considerations.
- The WG will effectively coordinate with the Modeling Work Group (MWG) as the purposes of these groups are interrelated and outputs will be informative to one another.
- The portfolio of macroeconomic resource futures will be recommended to the SSC as the consensus position of the working group. If the working group is unable to reach consensus on eight recommended macroeconomic futures, a range of opinions or additional futures may be presented.
- The WG will inform and receive input from the SSC throughout the process such that the SSC endorses the portfolio proposed by the WG, or alternatively, will find that the WG has helped the SSC to substantially narrow the range of issues to be debated by the SSC in sufficient time to meet the overall EIPC schedule.
- The WG will fully coordinate and collaborate with EISPC, since EISPC ultimately can decide four of the macroeconomic futures and one of the transmission expansion scenarios.
- The SPWG will coordinate with the Roll-up WG (RUWG) as needed.

Structure

The structure included up to three representatives from each sector, ex-officio members from the DOE and EPA, and an EIPC liaison. The objective was to agree upon and develop narratives

of eight macroeconomic futures and the nine sensitivities that would go with each future. These eight futures were to be passed on to the SSC Modeling Working Group which would develop the representative data inputs for the CRA model for each future and sensitivity.

Coordination with EISPC

Throughout the process, the SPWG coordinated completely with the EISPC. Originally, the agreement between the EIPC, SSC and the EISPC was that the EISPC would have the final say on four of the eight macro scenarios. Due to the willingness of both the EISPC and the SPWG to work together and to compromise, the SPWG and EISPC were able to make joint recommendations to the SSC regarding the eight macro scenario Futures and the 72 Sensitivities. The EISPC and SSC were able to use the recommendations and, through their willingness to compromise, were able to reach consensus ultimately on the eight Futures and 72 Sensitivities that were ultimately analyzed.

Coordination with CRA

Early in the process, the group expressed significant concern about understanding the models that would be used and the model inputs that would be required. The concern was that it was difficult to construct futures and sensitivities without understanding how the model would use the inputs and what the outputs might be. Charles River Associates (CRA) furnished information in the form of webinars, answering questions verbally and in written form and providing presentations at Working Group meetings. This information was very helpful to the group in grounding them in the kinds of information that would ultimately need to be developed.

Futures Development

The group began working in August of 2010. Initial discussions included the process by which the group would develop the futures. Different processes were discussed including:

1. Building futures from the bottom up ("Deloitte" approach)
    a. Identifying 4-5 key drivers of transmission development
    b. Developing ranges of plausible outcomes for those drivers
    c. Combining those drivers into plausible and internally consistent futures
    d. Testing the futures to ensure they cover a full range of plausible futures
2. Shell Approach
    a. Identify focal question
    b. Identify two key drivers of the question
    c. Build 2x2 matrix resulting in four futures
3. Building off existing futures
    a. Locating and reviewing existing futures that have been developed by others, e.g., Western Electricity Coordinating Council futures
    b. Customizing those futures for this application
4. Hybrid approach
    a. Identifying key drivers
    b. Identifying futures ideas

c. Iterating between driver discussions and futures discussions until futures began to emerge

There was discussion of the criteria for choosing futures. Some suggestions were:

- Diversity in forecasts/outcomes (e.g. not just a "green" future)
- Diversity in key Drivers
- Diversity in Transmission outcomes
- Diversity in Policy drivers/outcomes
- Plausibility (affordability, consumer acceptance)
- Ease of communicating the results
- Time commitment required
- Likelihood of achieving consensus with method
- Whether "single bullet" futures should be included or combined with other policies to form a future.

Ultimately the SPWG decided to take the hybrid approach described above. The group began to brainstorm drivers and futures in September and the group met in a face to face meeting in early October 2010 and in subsequent conference calls of the group. The group reviewed drivers and futures that had already been developed and added futures ideas. These futures ideas were grouped and prioritized and the group split into smaller groups to develop the futures ideas more fully. Futures ideas ultimately included:

- Business As Usual (BAU)
- Carbon capture
- National RPS
- Nuclear resurgence
- Transportation electrification
- Aggressive EE
- Distributed Generation
- Canadian imports
- Commercial storage
- High coal retirements
- Regional implementation of RPS & carbon capture
- National RPS + imported hydro
- Rapid technology development and offshore wind
- Shale gas works – low-cost natural gas, high availability
- Balanced/diversified/economic fuel mix + regional RPS + EE/DR proliferation+ DG + Storage
- Commercial storage + aggressive EE/DR/smart grid + National RPS
- Aggressive EE/DR/smart grid + accelerated penetration of small DG near customer load
- Nuclear resurgence + regional implementation of RPS and carbon reductions + increased imports of Canadian low carbon power
- National RPS + accelerated retirements and no new builds of coal + transportations electrification

- Carbon constrained + national RPS + nuclear resurgence + increased Canadian low carbon power
- High transportation electrification case
- BAU Enhanced Roll-up
- Enhanced Storage Future
- Increased Consumer Awareness
- High Coal Retirements
- Significant increase in interregional transfer capacity
- Multiple policy future
- New Storage Capacity Development
- Transmission Lite
- Path to 80% reduction in carbon emissions by 2030.

Key drivers were identified that were considered important for all futures. These key drivers included:

- Policy goals of the future
- Policy implementation approach
- Economic performance
- Load growth
- Technology performance
- Fuel prices and availability.

A template was developed that identified the central idea, provided a more detailed narrative of the idea, identified the performance of the key drivers in the scenario and provided a list of sensitivity ideas.

The SPWG presented six futures ideas in more detail to the SSC at their October 2010 meeting. The purpose of this presentation was to update and receive initial feedback from the SSC. Decisions were not expected at this meeting. The six futures presented were:

- Business as Usual
- Carbon Constrained – National Implementation
- Carbon Constrained – Regional Implementation
- Aggressive Energy Efficiency/Demand Response/Distributed Generation/Smart Grid
- National RPS – National Implementation
- National RPS – Regional Implementation.

Subsequent to the October SSC meeting the group developed more detailed descriptions of additional futures and continued to work with EISPC to develop recommendations for the SSC. Some Futures ideas were combined and the concepts of "single focus" Futures, which relied on a single idea or technology, were included with other Futures. For example, the Consumer Awareness and Activism Future and the Transmission Light Futures were combined as were the Mixed Policy Future and the 80% CO_2 Reduction by 2050 Future.

The SPWG reached consensus on the six futures listed above that had been presented to the SSC in October but could not reach consensus on the last two futures. The SPWG and EISPC developed and presented four additional futures for consideration by the SSC. The SPWG also took a "straw poll" of the futures and they are presented here in order of the rank they received in the straw poll:

1. Nuclear Resurgence
2. Combined Federal Climate and Energy Policy
3. Consumer Market Awareness and Activism/Free Market/Transmission Light
4. Environmental Moderation

The SSC chose Nuclear Resurgence and the Combined Federal Climate and Energy Policy Futures. The SSC also decided that the Consumer Market Awareness and Activism/Free Market/Transmission Light (CMAA/FM/TL) Future would be captured by defining at least two sensitivities to the BAU case that would approximate some of the conditions in the CMAA/FM/TL Future and that the Environmental Moderation future would be captured by using four sensitivities to the BAU case.

Sensitivities

Sensitivity Development

As futures were developed suggestions for possible sensitivities were developed at the same time. Each future was originally allocated nine sensitivities; later, it was learned that the sensitivities were very fungible and there was more flexibility in how to allocate the sensitivities as long as the total number of runs performed by CRA did not exceed eighty runs.

A key sensitivity that was developed for all of the futures is the revised transfer capability sensitivity. This sensitivity was needed because of the nature of the CRA NEEM model which is a "pipe and bubble" model that uses transmission constraints as an input to determine what kinds of generation should be built and where those generating resources should be located. One of the questions this analysis is meant to answer is the question of how much additional transmission would be needed to support certain public policy outcomes. To answer this question, a way to "open the pipes" in the NEEM model was needed to see if this would make a difference in the type, size and location of generation chosen by the model in the different futures. CRA, working with the EIPC, developed a technique to reduce the overload charges on pipes in the model. Overload charges represent the marginal price of the next MWh that would flow over the pipes. By reducing the overload charges, more power would be allowed to flow

over the pipes thus allowing generation to be built in different locations. CRA developed a methodology that used shadow prices on the pipes to set the overload charges. There was significant discussion about whether to set the overload charges at 25% of the shadow price or at 75% of the shadow price. Depending on the future, the SSC chose either 25% or 75% of the shadow price. In some cases, notably the large transmission buildout futures, both sensitivities were run and in Future 4 – Aggressive EE/DR/DG/SmartGrid, neither was run because the demand in this future was lower than existing demand and, presumably, additional transmission would not be needed.

There was conversation within the SPWG about whether to have a core set of sensitivities that would be the same in all futures. The reason for this was to provide for more comparability among the results of the futures. Sensitivities that appear in several futures include high and low load growth and high and low natural gas prices. Ultimately, the SSC chose to have high and low load growth in several futures and also to include changes in natural gas prices in several. Sometimes this meant to include high gas prices and sometimes it meant to include lower natural gas prices.

The SPWG and EISPC presented a list of sensitivities to the SSC at the December 2010 meeting. There were many areas where the SPWG and EISPC agreed and some areas where the two groups differed. Decisions on some sensitivities were made at the February meeting and the results of those decisions were posted on the EIPC web site. The SSC decided to leave a few sensitivity decisions open so that decisions could be made as results became available from the initial CRA MRN/NEEM runs. The concept was to keep some sensitivities available to develop information that might be helpful to determining what the three scenarios should be for the detailed transmission build-outs.

Coordination with Modeling Working Group

The SPWG began coordination with the Modeling Working Group (MWG) early in the process to ensure that the MWG would have a good understanding of the futures that were being chosen. The MWG was responsible for developing the detailed quantitative inputs to the CRA MRN/NEEM models that would reflect the futures and sensitivities. The SPWG and the MWG held joint meetings in the Fall of 2010 to discuss the futures, sensitivities and the input data that would be used. These efforts are described in more detail in the Modeling Working Group section below.

Data Inputs

Formation of the Modeling Working Group

The SSC created the Modeling Working Group (MWG), along with the Roll-Up Working Group (RUWG) and the Scenario Planning Working Group (SPWG) at their July 2010 meeting. The charge to the MWG was described as follows in the notes of the SSC meeting:
Modeling Work Group, focused on developing a better understanding of the capabilities, assumptions and outputs of the CRA NEEM (macroeconomic) model, that will be used to

evaluate the 8 Resource Futures … that will be used to analyze the final 3 Scenarios. (July 15-16, 2010 SSC Meeting Summary)

The SSC also directed the Modeling and Scenario Planning Work Groups to work closely together "because their purposes are interrelated and their outputs will be informative to one another, particularly as they determine how to proceed with developing the assumptions and inputs for the macroeconomic model."

More specifically, in October 2010, the SSC approved the "Charters" of its three Working Groups and defined the purpose of the MWG as the following four functions:

- Develop a better understanding of the capabilities, inputs and assumptions, and outputs of the CRA MRN/NEEM (macroeconomic) model that will be used to evaluate the 8 Macroeconomic Futures and sensitivities and the GE MAPS (production cost) model that will be used to analyze the Roll-Up Plan and the final 3 Transmission Build out Scenarios.
    - Identify concerns or issues, seek answers, make recommendations and report to EIPC Stakeholder Steering Committee (SSC) regarding the MRN/NEEM and GE MAPS modeling to be performed.

- Identify with CRA the matrix of specific required inputs for MRN/NEEM to be provided by SSC and advise the SSC and Scenario Planning Work Group (SPWG) on model inputs, outputs, processes and limitations to assist them in the development of the 8 Macroeconomic Futures.
    - Coordinate with the Roll-Up Work Group (RUWG) to identify any issues that could impact model inputs, assumptions, modeling, or results.

- In coordination with and within the parameters set by the SPWG, make recommendations to the SSC on the values for the inputs and assumptions to be used for modeling the 8 Macroeconomic Futures.
    - Identify as appropriate data or analyses needs
    - Work with resources (e.g. DOE / National Laboratories)
    - Collaborate with CRA to ensure model consistency

- Review outputs and results of MRN/NEEM and GE MAPS modeling and provide a report on the interpretations to SSC

Sub Teams

For the purpose of Task 4, the MWG formed several "sub-teams" to consult with CRA and the other Working Groups to provide advice and recommendations on the numerous data inputs required for the MRN/NEEM model in or to most effectively represent the designated futures and their respective sensitivities. These sub-teams are:

- Existing Generation

- New Generation
- Environmental
- Load Forecasts/Demand Response/Energy Efficiency
- NEEM/Transmission
- Fuel Prices/Emissions
- Economic Parameters
- Canadian Parameters

In the Fall of 2010, CRA prepared an extensive document describing the MRN/NEEM models, their operation and also published a matrix containing the default data inputs and assumptions that CRA was currently utilizing. CRA and EIPC held a series of webinars and meetings at the request of the SSC Working groups to provide further explanations and to answer stakeholder questions. The MWG, working with the SPWG, submitted a series of modeling-related questions that CRA and EIPC posted responses to on the EIPC website. As a result of these activities, the MWG became more familiar with the CRA models and input requirements and, through their sub-teams, began further exploration into certain key areas that were needed to model the energy futures under development by the SPWG and the SSC. ***[Additional information on the MRN/NEEM Models is provided in Appendix D to this Report]***

Key Input Data Assumptions

The input data assumptions for the CRA models were reviewed and investigated by each of the MWG sub-teams, which then provided their recommendations to the MWG and ultimately for decision by the SSC. This section provides the highlights of those activities.

Existing Generation

In response to CRA's explanation that the source for existing generation in the NEEM model is from the Ventyx "Energy Velocity" database and that these units are then aggregated by type, size, heat rate, etc in their models, the MWG expressed a desire to verify that input data. Accordingly, CRA organized a webinar with several sub-team members who were also licensed for access to the Ventyx database for this purpose. Ultimately, the SSC agreed to use the Ventyx database for existing units.

New Generation

CRA noted that its default source for new generation information was from the AEO 2010 report—but that the AEO 2011 data was expected to be issued shortly and could be utilized to update the NEEM inputs. The sub-team spent a great deal of time exploring various data sources for capital cost and operating characteristics of new units—with a special focus on wind generation and to a lesser extent, new nuclear and coal technologies. The sub-team also

reviewed the AEO assumptions for transmission interconnection costs. The SSC agreed to use the AEO 2011 as the source for new generation data. Finally, this sub-team also devoted significant efforts to explore the appropriate factors to be utilized for wind generation (e.g. – capacity factor, capacity contribution and maximum penetration levels) and in the end, the SSC approved the characteristics to be utilized for the various NEEM regions relying primarily upon the recommendations from the PAs for their respective regions.

Environmental Issues

The sub-team devoted much of their efforts to understanding the modeling for the EPA "non-carbon" regulations and, through discussions with CRA, arrived at a recommended methodology that was approved by the SSC. However, shortly after the initial BAU case was run, the EPA issued proposed air and water usage regulations that were significantly different than previous expectations. The SSC directed the MWG to work with CRA and the EPA to modify the initial assumptions to more accurately reflect the new proposed regulations. That was done and the new methodology was approved by the SSC for use in all of the energy futures as appropriate.

The sub-team also explored in detail the modeling to be used to represent a national carbon policy and, after much debate, the SSC approved the use of a carbon tax to achieve a target reduction in carbon emissions of 42% in 2030 and 80% in 2050. CRA was given the flexibility to iterate their models in order to determine the carbon tax needed to reach these target levels as closely as possible.

The sub-team also reviewed CRA's modeling assumptions for the REGGI regions.

Load Forecast/Demand Response/Energy Efficiency

The sub-team reviewed the load forecast assumptions provided by the EIPC Planning Authorities in the Roll-Up Case—including the demand response and energy efficiency assumptions that were included. The CRA default assumptions were also reviewed and the EISPC provided detailed information on the states' DR/EE goals for consideration as well. The sub-team analyzed all of the information, and, with assistance from the DOE, provided the input load shapes for CRA to use in its models. This sub-team also reviewed wind load shape data from various sources and recommended for use in the NEEM models.

NEEM/Transmission

The sub-team initially reviewed the revised NEEM regions and transfer limits provided by the PAs for the CRA models. As a result of discussions with the PAs, several modifications were made to the initial inputs. The PA's also provided the wheeling charges and hurdle rates to be

used in the models for review and discussion with the sub-team. The PA's inputs were ultimately adopted by the SSC.

A major effort of this sub-team was devoted to exploring the "soft constraint" methodology proposed by CRA to address the transmission expansion issue for Task 5. (See below for further details.) The follow-on work for the sub-team was to develop a methodology for analyzing the soft constraint output data in order to determine the "hard transfer limits" to apply to select futures. This methodology will be discussed further under Task 5.

Finally, the sub-team reviewed the high-level transmission cost methodology developed by the Planning Authorities for application in Task 5.

Fuel Prices/Emissions

The sub-team focus was on coal and natural gas prices. CRA's MRN model derives the coal prices based upon economic parameters for use in the NEEM model. The sub-team recommended, and the SSC agreed, to utilize this feature for the studies. Natural gas prices were a major focus of the sub-team's efforts since it was anticipated that this would be a major driver of the resource expansions for many of the futures. After considerable debate and analysis by the sub-team, the SSC agreed to use the AEO 2011 gas prices as the base assumption and a hybrid of AEO 2010 and 2011, developed by the sub-team, for the high gas price cases.

Economic Parameters

The sub-team focused on a review of the economic assumptions utilized in the CRA MRN model and how they interact with other parts of the models. The factors reviewed by the sub-team included: discount rate, GDP deflators, co-efficients of elasticity and substitution factors as well as tax rates. The sub-team also reviewed how the assumptions for balanced budgets, labor and GNP were developed by the models. The SSC agreed to utilize the CRA's default assumptions for these factors.

Canadian Parameters

The sub-team provided input data for several Canadian regions regarding such factors as load forecasts and shape, wind output, and other economic parameters. This sub-team was also instrumental in providing data on new generation expansion plans for the Canadian regions and advice on how to model cross-border hydro transactions into the Northeastern US regions.

iv) EIPC Inputs

As noted above, the EIPC Planning Authorities had a significant role in the development of several key input parameters for the CRA models and participated in numerous webinars and other discussions with Stakeholder Working Groups and sub-teams regarding the following topics:

- Wind capacity factor –by region
- Wind capacity contribution to reserve – by region
- Wind maximum penetration – by region
- Load forecasts, energy efficiency and demand response projections
- NEEM Regions
- Transfer limits between NEEM Regions
- Wheeling Charges between regions
- Hurdle Rates between regions
- High-level Transmission Costing Methodology (for Task 5)

v) Transmission – The "Soft Constraint Methodology"

The CRA MRN/NEEM models utilized for the Task 5 analysis are primarily resource expansion models which represent transmission through the use of transfer limits between the various regions or "bubbles" included in the model. These models do not explicitly model the transmission system or include transmission capital costs. In order to address stakeholder questions and the desire to have more information regarding the potential transmission implications of the various resource futures as input into their determination of the final three Scenarios for detailed analysis in Phase II of the Project, CRA, in consultation with EIPC, developed the "soft constraint methodology." In brief, this methodology was designed to provide information to stakeholders regarding the most likely locations for potential increases in transfer limits based upon the economic signals ("shadow prices") provided as outputs from the NEEM model. Following several presentations and stakeholder discussions, it was agreed that CRA would modify its models to implement this methodology for the Task 5 analysis. For each of the eight energy futures, the SSC would determine whether CRA would utilize one or more sensitivities under the "soft constraint" approach and the SSC would then make a subsequent determination whether to utilize increased transfer limits for subsequent sensitivities based upon that information. [Additional information on the "soft constraint" methodology is provided in Appendix f to this Report]

Finally, as described in more detail under Task 5, the Transmission sub-team developed a methodology for SSC approval to analyze the soft constraint data in order to determine the increased "hard transfer limits" to apply to subsequent sensitivities. The PA's then developed a

procedure to provide high level estimates of transmission facilities and costs to approximate those increased transfer limits.

Task 5 – Macroeconomic Modeling

Task 6 – Selection of Scenarios for Detailed Transmission Analysis

Description of Three Scenarios for Study in Phase II

a) Scenario 1

b) Scenario 2

c) Scenario 3

Conclusions and Observations

a) Technical Topics

b) Process Topics

c) "Lessons Learned"

d) Limitations of Project Results

Appendices

a) Stakeholder Steering Committee Documents

b) Report on Development of 2020 Model (Roll- Up Report)

c) Description of MRN/NEEM Modeling Tool

e) Input Data

f) "Soft Constraint" Methodology

g) Task 5 Results

h) High Level Transmission Cost Estimation Process for Task 5

i)