The Natural Gas-Electric Interface:
Summary of Natural Gas-Electric Infrastructure and Interdependency Assessments

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Introduction.

The increased reliance on natural gas as the primary fuel for electricity generation and the challenges it raises to both operations and planning have raised concerns in most regions of the country. A number of natural gas and electricity interdependency studies are being planned and conducted in regions throughout the United States – by Interconnections, ISO/RTOs and at least one state (California).[1] DOE is funding and serving a coordination role for three regional studies currently being planned while internally conducting a regional assessment for the Northeast. These studies (both DOE funded and others) range in scope and objectives – from a one-year assessment, to identifying trouble spots, to long range studies (10-20 years) with operational and planning objectives. The State Provincial Steering Committee (SPSC) is currently considering the undertaking of a natural gas regional infrastructure assessment in the West. These previously conducted studies can serve to inform the process by allowing for the review and comparison of objectives, scope, methodologies and outcomes.

This paper first provides brief synopses of the regional gas-electric interdependency studies currently being planned and conducted with DOE funds: (1) the Eastern Interconnection States Planning Council (EISPC)[2] Eastern Interconnection study; (2) the Eastern Interconnection Planning Collaborative (EIPC)[3] multi-ISO study; (3) the Electric Reliability Council of Texas (ERCOT) regional study; and (4) the DOE northeastern study. It then summarizes four completed regional assessments which provide examples of different objectives, scopes and methodologies: (1) Midwest ISO; (2) ISO New England; (3) ERCOT and (4) California. For more information about these and additional studies, Attachment A identifies national and regional interdependency studies conducted since 2009 and provides links to those reports.

DOE funded regional studies currently being planned or underway

- **DOE Reliability/Resiliency Study of the Northeast Natural Gas and Electricity Infrastructure**[4] will update a study conducted by DOE in 2005.[5] The areas included in the study are New England, the New York City metropolitan area, upstate eastern New York, New Jersey, eastern Pennsylvania/Delaware and the Baltimore/Washington D.C. area. The study will assess gas supply and infrastructure delivery capability and gas market needs over the coming year for the selected regions, as well as identify potential trouble spots or bottlenecks in the system.

- **The Eastern Interconnection Gas - Electric Adequacy and Operational Coordination Study** is a multi-regional collaborative effort which includes the following entities: New York ISO, ISO New England, Midwest ISO, PJM Interconnection and Ontario Independent Electricity Service Operator (IESO) and possibly other planning authorities within the Eastern Interconnection. The study area includes the service regions of the participants. It is intended

to be a comprehensive operational and planning assessment and will cover a 10-year study period.

- **EISPC** is leading a collaborative effort to conduct a long-term (approximately 20-year) **indicative analysis of infrastructure requirements of the Eastern Interconnection**. They are currently in the scoping stage and anticipate working with DOE, FERC, NERC, NAESB, representatives of the natural gas and electric industries, and other stakeholders to develop the study parameters. Their vision is to build on work to-date, including other interconnection studies, and to collaborate with the other two interconnections on cross-boundary natural gas and electric infrastructure requirements. [6]

- **ERCOT** is developing a study of their service region that **builds on their prior gas study, *March 2012 Gas Curtailment Risk Study***, which is described below. They are in the early stages of developing the parameters of the study.

Four examples of gas-electric interdependency/infrastructure assessments

1) ISO New England: *Assessment of New England's Natural Gas Pipeline Capacity to Satisfy Short and Near-Term Electric Needs,* June 15, 2012[7]

In 2012, the ISO New England (ISO-NE) commissioned a study aimed at assessing the adequacy of the natural gas pipeline infrastructure in New England to serve the combined needs of the core natural gas market and the regional electric generation fleet. ISO-NE commissioned this report to provide a high level analysis of the potential future gas demands on the regional pipeline network as it is currently designed and as it can be expected to be expanded. This analysis should help to illuminate whether the future natural gas network can meet the firm system requirements of the gas Local Distribution Companies (LDCs) and still have remaining capacity sufficient to meet the needs of the gas-fired generators without firm pipeline capacity contracts.

Drivers. Concerns about the adequacy of New England's regional gas infrastructure to reliably serve electric generation demand include: the increased use of natural gas generally and the increased use of natural gas to provide electricity generation (trends that are expected to continue),[8] the low proportion of firm rights held by electric generators,[9] and weather-related stresses on the system (e.g., 2004 New England Cold Snap which pushed the region's electricity system close to its operating limits and highlighted its vulnerabilities).[10]

Objectives, scope of work and methodology. [11] The study focuses on New England, the pipelines serving this region, and the imported liquefied natural gas (LNG) supplies capable of serving various New England gas markets. It accounts for the requirements of gas LDCs within the six New England states and other firm industrial gas loads. The analysis looks at both winter and summer peak day conditions for both the electric grid and the regional pipeline network in

the future: the "short-term" timeframe (2011 to 2015) and the "near-term" timeframe (2015 to 2020). The study has the following goals:

1. Quantify the amount of natural gas delivery capability available for New England, including pipeline capacity, LNG import capability, and regional peaking capabilities.
2. Assess the level of peak gas demands from all of New England's local gas distribution utilities (i.e., gas LDCs) and other firm customers.
3. Estimate the remaining natural gas supply delivery capability that could be available for the power sector after satisfying the peak gas demands of all firm customers of the regional gas utilities.
4. Calculate the gas demands from the regional power sector for both a reference and repowering scenario.
5. Determine the gas supply surplus or deficit by comparing the projected power sector demands against the remaining gas supply capability for both the reference and repowering scenarios.
6. Estimate the gas supply surplus/deficit values for various gas sector contingency cases.

For this study, ISO-NE developed four cases: (1) nominal gas demand forecast; (2) reference gas demand forecast; (3) higher gas demand forecast; and (4) maximum gas demand forecast. The analysis considers these four cases under two scenarios – a reference case scenario and a repowering case scenario. In the repowering case scenario, a number of coal and oil-fired facilities are repowered as gas-fired generation. The final element is a contingency study which considers the effect of the temporary loss of various elements of natural gas infrastructure on both the reference and repowering cases.[12] Each of the scenarios was examined under peak winter day (i.e., "design day") conditions for the LDC firm gas loads, as well under peak summer day conditions, when firm demands are lower.

Outcomes. In each of the scenarios and cases examining gas supply and demand under winter design day conditions, there is not enough gas supply capability remaining to meet the anticipated power sector gas demand after LDC firm demands are fully met. ISO-NE intends to follow up this study with more detailed studies of the interactions between the natural gas system infrastructure and the power system. Additionally, ISO-NE is one of the collaborators in the EIPC Gas - Electric Adequacy and Operational Coordination Study.

2) MISO: *Gas & Electric Infrastructure Interdependency Analysis,* Feb. 22, 2012[13]

The purpose of the study is to review and analyze current and future natural gas pipelines, storage facilities, and related infrastructure for natural-gas fired electric power generation over a 20-year horizon in the MISO region. The first study, initiated in October of 2011, was based on a 2011 gas price of $4.50/MMBtu. Subsequently, gas prices dropped substantially and a supplemental analysis was prepared using a lower starting gas price ($2.50/ MMBtu).[14] The supplemental report was issued on July 6, 2012.[15]

Drivers. Concerns relating to natural gas and electricity interdependencies in the MISO region include the following: (1) coal plant retirements (which would largely be replaced by natural gas) that may be driven by new federal air regulations, (2) new generation capacity which will largely be natural gas-fueled, (3) significant changes in natural gas flows in the MISO region, and (4) the increased use of short-term transportation and supply contracts and the impact it will have on construction of infrastructure.[16]

Objectives, scope of work and methodology. The first MISO report is aimed at framing the current status of Midwest electric and gas coordination and potential infrastructure supply changes going forward. The specific tasks conducted for the study are as follows:

1. Provide baseline level information for the MISO over a 20-year time horizon (2011 – 2030):
    a. Describe sources for natural gas supply, both U.S. and Canada.
    b. Describe current natural gas pipelines in Midwest.
    c. Describe future expansion of natural gas pipelines in Midwest.
    d. Determine maximum total capacity of existing pipeline infrastructure by firm or interruptible firm for pipelines.
    e. Determine usage of natural gas by combined cycle and combustion turbines.
2. Identify available capacity on the existing pipeline infrastructure.
3. Provide an overview of how much additional electric generation capacity can be built using existing infrastructure.
4. Provide an overview of how much additional electric generation capacity can be built, assuming future pipeline additions as planned by the major pipeline companies.
5. Assess the additional pipeline infrastructure and investment costs needed to provide adequate natural gas for an electric power plant expansion plan for the next 20 years.
6. Perform an analysis of gas-fired capacity additions that can be supported based on defined locations provided by MISO. The defined areas are associated with coal capacity reductions or retirements that may be driven by the new EPA regulations.
7. Identify major gas storage locations and capacity and how those locations tie into the interstate gas pipeline infrastructure in the Midwest.
8. Survey MISO-identified pipelines that may have possible natural gas-fired generation issues related to capacity, operating conditions, generation support capabilities, storage, expansion plans, and construction costs to site power generation facilities.

Phase 2 is a high-level "screening" analysis of MISO-region pipelines' main line capacity based on publicly-available data at major interconnections into each pipeline's market area. It is intended to serve as an indicator of capacity availability into the pipelines' market areas. The approach of the study is to determine the number of days that pipeline capacity would be insufficient, based on lower natural gas costs and higher capacity factors, for MISO's embedded gas generation without additional annual firm transportation arrangements.

Outcomes. MISO's initial study found that gas supply availability at the wellhead for use in power generation is not an issue. However, the analysis indicated three major areas of concern: storage, pipeline capacity and timing. Additional findings concluded that the Midwest will need expanded pipeline capacity or additional storage to meet the expected rise in demand due to greater reliance on natural gas as a fuel source. The construction costs to serve the incremental transportation services for power generators will be in excess of $3.0 billion over the next five years. [17]

3) ERCOT: *Gas Curtailment Risk Study,* March 2012[18]

The Electric Reliability Council of Texas (ERCOT) commissioned this study to evaluate the risk of natural gas supply disruptions to electric generating stations within the ERCOT administered portion of Texas. It is intended to accomplish the following: (1) increase ERCOT's understanding of the risks of generation loss from gas supply curtailment in the future, (2) consider potential mitigation measures ERCOT can pursue to reduce risks arising from these curtailments, and (3) to assist ERCOT in objectively assessing the costs and benefits of planning operations for mitigating gas supply curtailment risk to its electric generators.

Drivers. During the first week of February 2011, the Southwest experienced a cold snap. This resulted in extremely cold and windy weather conditions, with temperatures falling by as much as 50 degrees over an eighteen−hour period, including portions of Texas. The scale of generation loss led to controlled load shedding that impacted as many as 4.4 million customers during the event. Extreme low temperature events in 1989 and 2003 similarly created conditions resulting in loss of generation in ERCOT.[19] By fuel type, about 38% of ERCOT's annual average generation is currently accomplished with natural gas, and natural gas' share of electric generation within ERCOT is poised to increase to 50% over the next 10 years. In addition, freezing weather in Texas and outside Texas and the increased reliance on natural gas-fired resources for generation capacity, pipeline disruptions and tropical cyclones, were identified as concerns.

Objectives, scope of work and methodology. This study presents the risks of gas supply curtailment[20] to electric generators within the ERCOT service region over one-year, five-year and 10-year time horizons. It reviews historical incidents of gas supply curtailment experienced by ERCOT's generators, examines the natural gas infrastructure serving these generators, and assesses the risk of gas supply curtailment on a probabilistic and a fundamental supply/demand basis. This study considers the physical capabilities of the natural gas infrastructure in serving electric generators, rather than contractual arrangements to serve electric generators with natural gas. The study has three stages:

1. Review past natural gas interruptions impacting electric generation for insights.
2. For pipeline systems that serve generation, survey pipeline physical limitations to providing natural gas to electric generation in ERCOT.
3. Review scenarios in which ERCOT natural gas supply to electric generating stations could be significantly limited, including conditions of severe cold temperature combined with high wind speeds. Calculate the risk (i.e., assess probability) of such events in the near (one- to five- year) and mid (five- to 10-year) timeframes.

For stage 1, a review of available historical data on natural gas curtailment incidents was undertaken in order to collate and examine the experience to date with natural gas curtailment to electric generators. This information informed the scenario development and was used to identify best practices and lessons to be learned.

For stage 2, a survey was conducted of the natural gas-fired electric generators within ERCOT's service region to assess the natural gas infrastructure serving their facilities. The survey requested information on the pipelines, local distribution companies, and storage facilities

serving each electric generator. The information provided through survey responses was supplemented by a number of data sources to create a compilation of the natural gas infrastructure serving electric generators within ERCOT's service region.

For stage 3, the risk assessment was approached as a combined economic and quantitative analysis, with the final objective being development of risk-based likelihoods of natural gas curtailments that could impact natural gas-fired generation for scenarios that are specific to ERCOT. There were three main analytical efforts involved in this stage: (1) identification of scenarios, (2) the probabilistic analysis of each of the scenarios to determine the risk associated with their occurrence, and (3) a fundamental analysis for each scenario identified – i.e., modeling to examine the sufficiency of the natural gas infrastructure and supply and its impact on natural gas service to electric generators in the ERCOT region.

Outcomes. The natural gas pipeline infrastructure serving ERCOT generators was found to be adequate to meet anticipated peak demand during the analysis period in the scenarios analyzed.[21] ERCOT is currently developing an additional study that will build from this work.

4) California CEC: *The Value of Natural Gas Storage and the Impact of Renewable Generation on California's Natural Gas Infrastructure,* December 2009[22]

In 2009, California conducted an analysis of the natural gas system in the state, with an emphasis on storage. The report was commissioned to better understand the nature of the natural gas storage infrastructure within California as it relates to reliability and price volatility, and the adequacy of the gas infrastructure as renewable energy becomes an increasingly larger portion of the state's generating mix. The study had three objectives: (1) to define and describe the value derived from natural gas storage; (2) to develop a detailed model that could be used to evaluate the response of the state's natural gas system to various future scenarios, including a variety of weather scenarios, and to draw conclusions about the system's adequacy; and (3) to specifically understand the capability of California's natural gas infrastructure to respond to variations in renewable generation, in the future, under a 33% renewable portfolio standard (RPS). This summary focuses on the second and third objectives. The model developed for this study depicted the natural gas infrastructure for California and the Western U.S.

Drivers. The California energy crisis of 2001 showed the past inadequacy of the natural gas infrastructure in California to cope with significant weather-related increases in gas demand.[23] Between 2001 and 2009, California invested significantly in expanding this infrastructure, by increasing capacity along current pipelines, adding new natural gas pipelines into and within the state, and adding additional natural gas storage capacity within the state. However, the dramatic expansion of gas-fired generation continues and both price volatility and reliability remained concerns.

Objectives, scope of work and methodology. In the second phase, evaluating system adequacy under future scenarios, ten cases were modeled focusing on the effects of differing weather patterns on the natural gas system within California in the 2009-2010 period, with an additional emphasis on how gas storage infrastructure within the state responds to the changes in demand.[24] Detailed objectives for the second phase included the following:

1. Develop a model of California's natural gas infrastructure that is integrated with a national model.
2. Quantify the seasonal impact of variations in weather on the natural gas in storage in California based upon storage utilization and natural gas prices using 10 different weather scenarios.
3. Quantify the peak day impact of variations in weather on natural gas demand levels and prices in California using the same weather scenarios.

In the third phase of this project (the 33 percent RPS modeling effort), five cases were modeled in the 2019-2020 period representing mixtures of differing inputs –varying weather patterns, varying renewable generation, and differing mixtures of renewable technologies. Detailed objectives for the third phase include the following:

1. On a monthly basis, identify the average natural gas demand levels, storage working gas levels, and natural gas pipeline flows into and within California.
2. For the peak demand day, identify the demand for natural gas within the three main demand sectors – power generation, industrial, and residential/commercial.
3. Identify the sources of supply for natural gas for California and quantify the level of supply provided by these sources on an average and peak-day basis.
4. Using separate sensitivity analyses, quantify the natural gas demand impact of variations in weather and renewable generation on the base case scenario.
5. Quantify the impact of differing renewable generation mixes (e.g., higher solar photovoltaic capacity, higher wind capacity, etc.) on natural gas demand compared to the base case scenario.

Outcomes. The general conclusions were the following: (1) even under the extreme conditions analyzed, the California gas market is still able to function due to the infrastructure expansions that have occurred since 2000, and (2) California's natural gas infrastructure is generally adequate to meet the potential swings in demand caused by intermittent reductions in wind and solar renewable generation. Notwithstanding the generally positive results, in both of the modeling efforts, some potential localized constraints were discovered.[25] The report also concluded that the North American natural gas market is highly integrated and that conditions outside of California can have a significant impact on storage activity within the state.

End Notes

[1] See Attachment A. In addition, a number of national studies have been conducted. *Id.*

[2] EISPC is the parallel to SPSC in the Eastern Interconnection.

[3] EIPC is the parallel to the Western Electricity Coordinating Council (WECC) in the Eastern Interconnection.

[4] This study is being conducted internally by the Office of Electricity Delivery and Energy Reliability (OE). The project lead is Alice Lippert, Senior Technical Advisor, OE.

[5] DOE conducted a number of regional natural gas reliability/interdependency studies approximately five to seven years ago. These were considered internal studies and, although the results were shared with some stakeholders,

reports were never published. The results are classified "official use only." Alice Lippert, DOE(OE) (Sept. 25, 2012).

[6] The project lead is Bob Pauley, economist, EISPC.

[7] This summary is derived from *Phase I: Draft Assessment of New England's Natural Gas Pipeline Capacity to Satisfy Short and Near-Term Electric Needs* (June 15, 2012), commissioned by ISO New England and conducted by ICF International ("*ISO-NE Report*").

[8] In recent years, the wholesale power market in New England has seen an increase in the construction of new gas-fired generation, aimed primarily at serving both intermediate and peaking requirements, and base load as well. At the same time, the gas-fired generating fleet has been running at higher load factors with the decline in natural gas prices. This trend is expected to continue. *ISO-NE Report* at 1. See also, Energywire, *Who pays for new Natural Gas pipeline infrastructure? FERC, electricity market at impasse*, Peter Behr, E&E reporter (July 16, 2012), available at: http://eenews.net/public/energywire/2012/07/16/1. (Power generators' average daily gas usage on Algonquin's system jumped from around 200,000 decatherms per day in mid-2009 to 400,000 decatherms per day at the end of last year. The summer peak demand has grown close to pipeline capacity.)

[9] The 2004 Cold Snap highlighted this issue. While the gas system during this cold weather event was able to meet the demand of its firm customers, many generators have interruptible service and thus have limited rights to delivery under tight conditions. While there was ample gas supply beyond the Northeast, the availability of gas transportation for non-firm customers within New England was a limiting factor and a root cause of both high gas prices and gas unit unavailability. *Final Report on Electricity Supply Conditions in New England During the January 14 - 16, 2004 "Cold Snap,"* ISO New England Inc. Market Monitoring Department (October 12, 2004) at 1-3, available at: http://www.iso-ne.com/pubs/spcl_rpts/2004/final_report_jan2004_cold_snap.pdf.

[10] New England's dependence on natural gas for electric power generation can cause acute problems during periods of extremely cold temperatures. In 2004, New England experienced the coldest temperatures, of the last 20 years, at the time of the winter electricity demand peak. While the January 2004 Cold Snap did not ultimately result in interruption of electrical demand, it pushed the electricity system in New England close to its operating limits, particularly in regard to the capacity limitations of the natural gas pipeline network. *Final Report on Electricity Supply Conditions in New England During the January 14 - 16, 2004 "Cold Snap,"* ISO New England Inc. Market Monitoring Department (October 12, 2004) at 1-3, available at http://www.isone.com/pubs/spcl_rpts/2004/final_report_jan2004_cold_snap.pdf.

[11] For more details see, *Scope-of-Work (public version) Assessment of New England's Natural Gas Pipeline Capacity to Satisfy Short and Near-Term Power Generation Needs*, ISO New England Inc. System Planning Rev. 2 (May 17, 2011) available at: http://www.isone.com/committees/comm_wkgrps/strategic_planning_discussion/materials/pv_final_sow_isone_2011_natural_gas_study_5_17_11.pdf.

[12] Due to the nature of this Critical Energy Infrastructure Information (CEII), the details of the contingency analysis are provided in Section 6 of the Confidential Report. *ISO-NE Report* at 7.

[13] This summary is derived from *Gas & Electric Infrastructure Interdependency Analysis* (February 22, 2012), commissioned by MISO and conducted by EnVision Energy Solutions ("*MISO February 2012 Report*"), available at: https://www.midwestiso.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Natural%20GasElectric%20Infrastructure%20Interdependency%20Analysis_022212_Final%20Public.pdf; and *Embedded Natural Gas-Fired Electric Power Generation Infrastructure Analysis: An Analysis of Daily Pipeline Capacity Availability* (July 6, 2012), commissioned by MISO and conducted by EnVision Energy Solutions ("*MISO July 2012 Report*").

[14] Based on $4.50/MMBtu, the operation of the existing or 'embedded' gas fleet was not materially affected from the way they ran in previous years. However, gas prices dropped significantly in the ensuing months. The price dropped to the point that gas-fired energy became potentially economic when compared to energy produced from the existing coal fleet. Further, gas-fired units could run at higher capacity factors solely based on these economics. MISO staff performed a supplemental analysis using the Electric Generation Expansion Analysis System (EGEAS)

model based on a 2011 starting gas price of $2.50/MMBtu to determine the resulting capacity factors on the embedded gas Combustion Turbines (CTs) and Combined Cycles (CCs) over a 20-year time horizon (2011 – 2030). *MISO February 2012 Report* at 6.

[15] *Embedded Natural Gas-Fired Electric Power Generation Infrastructure Analysis: An Analysis of Daily Pipeline Capacity Availability* (July 6, 2012) MISO, available at: https://www.midwestiso.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Embedded%20Gas%20Units%20Infrastucture%20Analysis.pdf.

[16] See note 13.

[17] *MISO February 20120 Report* at 95.

[18] This summary is derived from *Gas Curtailment Risk Study* (March 2012), commissioned by ERCOT and conducted by Black & Veatch ("*ERCOT Report"*), available at: http://www.ercot.com/content/news/presentations/2012/BV%20ERCOT%20Gas%20Study%20Report%20March%202012.pdf.

[19] A FERC-NERC investigation found that, although the generation loss associated with these extreme weather events was not primarily driven by gas supply curtailment, natural gas supply was impacted as a result of weather and contributed to the loss of generation. It was stated that "For the Southwest as a whole, 67 percent of the generator failures (by MWh) were due directly to weather-related causes, including frozen sensing lines, frozen equipment, frozen water lines, frozen valves, blade icing, low temperature cutoff limits, and the like." *Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011*, Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) (August 2011) p.8.

[20] Curtailment was defined for the purposes of this study as "the loss of normally expected gas delivery as a consequence of supply or transportation interruptions caused by weather driven, contractual or operational issues." *ERCOT Report* at 1.

[21] Based on the responses by generators to the survey, it appears that ERCOT's electric generators create reliability and redundancy of gas supply capability through their interconnections with multiple pipelines and access to a level of capacity that is well in excess of their peak natural gas needs. *ERCOT Report* at 25.

[22] This summary is derived from *The Value of Natural Gas Storage and the Impact of Renewable Generation on California's Natural Gas Infrastructure* (December 2009), commissioned by the California Energy Commission (CEC) and conducted by ICF International ("*California Report*"), available at: http://ucciee.org/downloads/CNGStorage.Brock.pdf; and *Developing a Multi-State Natural Gas Infrastructure Simulation Model to Analyze the Value of Natural Gas Storage in California*, CEC ("*California: Developing a Model*"), available at: http://www.energy.ca.gov/pier/portfolio/Content/ar07/Developing%20a%20Multi%20State%20Natural.htm.

[23] Californians have relied on natural gas for home heating and industrial uses for decades. In the early 2000's there was a dramatic expansion of gas-fired generation in California that significantly increased natural gas consumption and contributed to tighter demand conditions year round. Elevated demand plus a variety of other factors resulted in significant natural gas price volatility in both summer and winter months. *California: Developing a Model.*

[24] The worst case scenario analyzed in this section of the report reflects a replication of the 2000-2001 energy crisis in California, depleting the amount of natural gas in storage at the end of the withdrawal season to levels similar to those in 2000-2001. *California Report* at 2.

[25] Based upon the gas storage modeling effort, gas supply to the Los Angeles area appears to be constrained on peak demand days in some of the more extreme weather scenarios, which could become a potential issue in the future. Additionally, the results of the 33 percent RPS modeling effort show that in some of the cases, pipelines into the San Diego market area become constrained on peak demand days. *California Report* at 4.

Attachment A

The following are recent (2009-2012)[1] natural gas regional/national infrastructure assessments WIEB has identified (links to the studies are provided after the table):

Geographic Area of the Study	Group Responsible (Contractor Used)	Title & Date of Release	Notes / general conclusions	Study Range
New England ISO service region	New England ISO (ICF Internat'l)	Phase I: Draft *Assessment of New England's NG Pipeline Capacity to Satisfy Short and Near-Term Electric Needs* June 15, 2012	NG pipeline capacity will be insufficient to satisfy gas needs at New England's power plants, during the next 10 years.[2]	2011-2020
ERCOT service region	ERCOT (Black & Veatch)	*Gas Curtailment Risk Study*[3] March 2012	Natural gas pipeline infrastructure is sufficient to meet projected needs during the analysis period in the scenarios analyzed.	1-yr, 5-yr & 10-yr time horizons
MISO service region	MISO (EnVision Energy Solutions)	*Gas & Electric Infrastructure Interdependency Analysis* February 22, 2012	The Midwest will need expanded pipeline capacity or additional storage to meet the expected rise in NG demand from electricity generation.	2011-2030
NYISO, ISO-NE , PJM and Ontario IESO service regions	NYISO (TBD)	In April 2012, NYISO issued an RFP for a comprehensive study of the gas-electric interface within the state and adjoining regions. End of 2013 (target for completion)	NYISO, ISO-NE, PJM and Ontario IESO are participating in this multi-regional gas study. As of Sept. 11, 2012, revisiting scope of work	10 yrs.
NYISO & NY State Energy Research and Development Authority (NYSERDA)	Charles River Associates	*The Ability to Meet Future Gas Demands from Electricity Generation in New York State (Final Report)* July 2002	Although results are dated, report is included as an example of scoping.	Examines cases in 2002, 2005 and 2010
California and the Western U.S.	California Energy Commission (CEC) (ICF Internat'l)	*The Value of Natural Gas Storage and the Impact of Renewable Generation on California's Natural Gas Infrastructure* December 2009[4]	It surveys the infrastructure of the Western U.S., but analyzes the implications for California. Concludes CA's natural gas infrastructure is generally adequate.	2008-2020
Pacific NW (NW US and Western Canada)	PNUCC-NWGA Power & Natural Gas Planning Task Force[5] (Work being performed by task force members)	*Natural Gas Limitations resulting from an Extended Winter Peak Load Event* Developing reliability analysis of I-5 corridor.	The Task Force is developing a series of additional studies/reports.[6]	10 yrs.

Attachment A

Wyoming	Wyoming Infrastructure Authority, et. al. (ICF Internat'l)	*Wyoming Wind Collector System and Integration Study: Phase 2* Dec. 2010	It assesses the infrastructure necessary to support a 12 GW wind collector system incl. gas pipeline and storage for firming capacity	2010
National	NERC	*2011 Special Reliability Assessment: A Primer of the Natural Gas and Electric Power Interdependency in the US* (Phase I) December, 2011	General conclusions regarding storage, communications and reliability	Includes some projections through 2030
National	NERC (Coordinating with INGAA and NGSA)	Phase II Reliability Assessment (expected December 2012)	"Phase II of this study will leverage this report as a platform for discussion with both industries."	TBD
National	INGAA (ICF Internat'l)	*National Pipeline and Storage Infrastructure Projections through 2030* October 2009	Projects infrastructure needs and costs through 2030	2010-2030
National	INGAA	*North American Natural Gas Midstream Infrastructure Through 2035: A Secure Energy Future* *June 2011*	Update to the October 2009 Report –provides updated projections on infrastructure needs and costs	2011-2035
National	American Public Power Institute (APPA) et al. (Aspen Environmental Group, AEG)	*Implications of Greater Reliance on NG for Electricity Generation* July 2010	Presents a broad assessment of issues that would arise as utilities replaced their base load coal-fired electricity generating units with new units fired by natural gas.	Through 2030
National	American Public Power Institute (APPA) et al. (AEG)	*Gas Storage Needed to Support Electricity Generation* June 2012	Update to the June 2010 Report --provides more detail on gas storage and explores changes to gas storage in the past two years	2010-2012

Links to studies:

- ISO-NE (overview): http://www.iso-ne.com/committees/comm_wkgrps/othr/clg/mtrls/2012/mar82012/march_2012_clg_babula.pdf (A copy of the draft report can be obtained through WIEB staff.)
- ERCOT: http://www.ercot.com/content/news/presentations/2012/BV%20ERCOT%20Gas%20Study%20Report%20March%202012.pdf
- MISO (February & July Reports): https://www.midwestiso.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Natural%20Gas-Electric%20Infrastructure%20Interdependency%20Analysis_022212_Final%20Public.pdf https://www.midwestiso.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Embedded%20Gas%20Units%20Infrastucture%20Analysis.pdf

- NY (2002): http://www.nyserda.ny.gov/en/Page-Sections/Energy-Prices-Supplies-and-Weather-Data/Current-Outlook-Summary/~/media/Files/EDPPP/Energy%20Prices/Current%20Outlook/Presentations/the_gas_report.ashx
- NY-ISO (2012 RFP announcement):http://www.iso-ne.com/committees/comm_wkgrps/othr/egoc/mins/2012/egoc_mtg_38_draft_for_approval_minutes_052412.pdf
- California: http://uc-ciee.org/downloads/CNGStorage.Brock.pdf
- Pacific Northwest I-5 Assessment (page 49): http://www.columbiagrid.org/client/pdfs/2012SA-webversion.pdf
- Wyoming: http://www.icfi.com/~/media/Files/ICFi/Reports/wyoming_collector_integration_final.ashx
- National/NERC 2011: http://www.nerc.com/files/Gas_Electric_Interdependencies_Phase_I.pdf
- National/INGAA 2009: http://www.ingaa.org/File.aspx?id=10509
- National/INGAA 2011 (executive summary): http://www.ingaa.org/File.aspx?id=14911
- National/APPA 2010: http://www.publicpower.org/files/PDFs/ImplicationsOfGreaterRelianceOnNGforElectricityGeneration.pdf
- National/APPA 2012: not yet available online; a copy can be obtained through WIEB staff.

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[1] The 2002 New York study is also included in the table as an additional example of the scope an assessment could have.

[2] New England: Supply at wellhead sufficient. Firm contracts can be met (primarily LDCs contract this way). Power generators primarily contract for interruptible pipeline transportation services. Under all scenarios modeled (winter design day conditions), there is not enough gas supply capability remaining to meet the anticipated power sector gas demand after LDC firm demands are fully me.

[3] ERCOT: Curtailment is defined as the loss of normally expected gas delivery as a consequence of supply or transportation interruptions caused by weather-driven, contractual or operational issues. Study considers the physical capabilities of the natural gas infrastructure in serving electric generators rather than the contractual arrangements to serve electric generators with natural gas.

[4] California: The CEC has prepared (or commissioned) a number of related reports e.g., *Impact of Variations in Renewable Generation on California's Natural Gas Infrastructure*, Oct. 2009 (ICF), http://www.energy.ca.gov/2009publications/CEC-500-2009-083/CEC-500-2009-083.PDF. Links to related reports can be found at the following sites: http://www.energy.ca.gov/publications/ and http://uc-ciee.org/all-documents/a/lbrsearch.

[5]The Pacific Northwest Utilities Conference Committee (PNUCC) & Northwest Gas Association (NWGA) have been coordinating efforts over the past 12-18 months to investigate the interdependencies of natural gas and electricity generation. Their mission is to explore and address the long-term planning and reliability challenges stemming from the high interdependence of the Pacific NW's two main energy delivery industries --power and natural gas. On the operational side, the Task Force has developed the Northwest Mutual Assistance Agreement which currently has 18 member/signatory companies. Each signatory entity utilizes, operates or controls natural gas transportation and/or storage facilities in the Pacific Northwest. Copies of the Northwest Mutual Assistance Agreement are available from Kevin Sullivan, Western Energy Institute: (971)255-4734.

[6]*Natural Gas-Electricity Primer*, Power and Natural Gas Planning Task Force (August 2012), available at http://www.ferc.gov/eventcalendar/Files/20120830220205-primer.pdf; *The Role of Natural Gas in the Northwest's Electric Power Supply*, White paper (June 13, 2012).