

CEC/CIEE Natural Gas Storage Research Projects

Presentation for Natural Gas Working Group

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Topics:

- ▶ Summary of PIER Natural Gas Program – Strategic Analysis
- ▶ Summary of Projects
- ▶ Discussion
 - Potential data requests from researchers
 - Interest level in presentations by researchers– both at NGWG meetings and a potential fall 2007 NGWG workshop (1/2 day)?
 - Questions?

Summary of PIER Natural Gas Program – Strategic Analysis

The CEC has managed the PIER program for the State of California since 1999; however, 2005 was the first year for the PIER Natural Gas (PIERNG) program. To date, more than \$10 million worth of natural gas research projects have been approved by the CEC and launched by the PIERNG program. The program covers several areas such as environmental impacts, efficient use of gas, and renewable substitutes for natural gas.

One of these research areas focuses on having an integrated natural gas system that is reliable and secure. For this area, there are six strategic objectives:

1. Develop natural gas storage technologies.
2. Improve safety and security of natural gas production, storage, delivery, and use.
3. Develop innovative tools, methods, and models to improve efficiency of natural gas markets.
4. Reduce peaks for improved asset utilization.
5. Understand and address impacts of LNG on natural gas infrastructure and related interchangeability issues.
6. Develop knowledge base for future decision-making and informed delivery, integration, and infrastructure policy relative to natural gas.

Within the PIER NG Program there is a Strategic Analysis topic area that addresses these objectives. Primary Areas of RD&D covered in the 2007-2011 natural gas strategic analysis research plan are:

- Analyze impact storage would have on the market and the conditions required for investment in storage infrastructure.
- Investigate an efficient interface of electricity and NG infrastructure
- Support improvement of technologies and tariffs for demand response (for example, communication, control and integration, automation strategies)
- Develop a NG system (cyber and physical) that is resilient to natural and man made events, self-diagnosing, and self-healing.

Secondary Areas of RD&D covered in the strategic analysis plan are:

- Support efforts by others to analyze interchangeability impacts on various sectors, such as gas distribution, end-use, system reliability, and transportation.
- Improve the understanding of NG markets.
- Improve means of measuring and predicting economic impacts of NG use.
- Improve the safety of NG production, storage, delivery, and use.
- Improve the NG infrastructure between Mexico and California to accommodate LNG.
- Develop tools and models to assess the risks associated with predominantly NG fueled electric generation.
- Develop tools and models to understand impact policy actions have on infrastructure investment decisions.

The natural gas storage research effort specifically addresses issues defined by the IEPR and the Governor with respect to the need for storage to help provide adequate supply and protect prices. This effort has been undertaken with the understanding that the recent dramatic expansion of gas-fired generation has significantly increased natural gas consumption and contributed to tighter demand conditions year round and increases in natural gas price volatility. It is expected that by expanding and/or better utilizing in-state natural gas storage infrastructure, California's consumers will enjoy reduced gas costs, less price volatility, and greater reliability of supply.

The following pages provide information on the five natural gas storage research projects now being undertaken by the CEC, and managed by the University of California's California Institute for Energy and Environment. Four of the projects will be complete in 2007 and the fifth will be done in 2008.

Project Summary
CEC Natural Gas Storage Research
California Natural Gas Storage Utilization and Economic Analysis
Researcher: Gas Technology Institute (GTI)
March 1, 2007

This project involves defining California natural gas demand trends, collecting supply data, analyzing existing infrastructure, reviewing relevant California energy policy, and analyzing existing and emerging natural gas storage technologies. This research will provide information that answers questions inherent to California's ability to meet future environmental and public needs, in an efficient and effective manner, as well as market demand. These questions include:

- Is the market demand inherently changing and what is the potential impact on natural gas storage?
- What are the potential barriers to enhancing the economic and physical benefits of natural gas storage in California?
- What is LNG's role and how could it integrate into existing storage infrastructure?

This project also includes investigation and analysis of the market power threshold test referenced by state and federal regulators in order to assess its impact on potential gas storage expansion by independent operators.

GTI will be conducting broad and comprehensive natural gas storage and LNG market research in partnership with Southern California Gas Company, Pacific Gas and Electric and other storage operators. The workplan includes three major tasks, as described below.

Task 1 - Define California Market Demand Fluctuations and Trending

This task provides the framework for answering the question, "How will California meet future demand fluctuations?" Also investigated are how these fluctuations and changing demand will impact existing gas storage utilization and operation. Thus, this task focuses on defining how natural gas market demand has changed over time and extrapolate for future trending, taking into account current storage and infrastructure limitations, changing policy and regulations, the strength of the California and national economies, as well as the growing importance placed on gas-fired electricity generation. As demand grows, the usage profile of consumers is also expected to change. Traditional seasonal-based natural gas storage facilities may be looked upon to meet variable demand, such as hourly and daily flow. This task will define those fluctuations in seasonal, daily, and hourly sendout; and project future consumer usage trends.

As part of this task, GTI will:

- Collect consumer usage data in collaboration with SoCalGas, PGE, and independent storage operators.
- Research other sources of indirect trending data collected by agencies such as CPUC, AGA, GRI, PRCI, and GSTC.
- Review, interpret and analyze collected data.

- Establish current demand fluctuations, and formulate future consumer demand and usage trends within the state of California.

Task 2 - Define California Natural Gas Storage Deliverability Options

In this task, improved deliverability of existing gas storage fields through expansion, operational optimization, or well remediation will be analyzed for economic feasibility. Alternative (non-traditional) gas storage technologies emerging in the industry will also be reviewed for applicability and feasibility. Some of these technologies include new applications of LNG and dispersed storage (individual or “mobile” assets). Other emerging gas storage technologies involve the use of natural gas hydrates, both in situ and surface applications, as well as cold compressed natural gas storage. Economic analysis will be performed to determine cost benefits of each technology reviewed.

GTI’s analysis will include potential impacts and issues associated with incorporating LNG assets into California’s gas storage infrastructure and provide recommendations as to potential development and coordination with existing underground storage sites. This research will build upon recent GTI efforts in researching LNG interchangeability and utilization. Included in the proposed analysis will be economic feasibility and potential compatibility risks of integrating various LNG/Gas Storage scenarios and related cost benefits, such as above ground versus in situ development.

As part of this task, GTI will:

- Investigate impact that demand fluctuations have on gas storage operations and its ability to adapt to ever changing consumer demand.
- Review and analyze LNG’s impact on existing gas storage assets and operability.
- Economic analysis on incorporating LNG into California gas storage infrastructure.
- Research and determine feasibility of emerging alternative gas storage technologies.
- Review California regulatory policy on integrating LNG into storage infrastructure.

Task 3 - Regulatory/Policy Review

This task encompasses review and analysis of existing regulatory policy as it pertains to gas storage enhancement and expansion. Specifically, as enhancement scenarios are developed in previous tasks to address changing market demand and natural gas usage environment, this task will identify those areas currently inhibited or discouraged by state and federal policy.

Highlighted within this task will be how California policy could potentially be altered to promote expansion and enhancement of independent and regulated gas storage infrastructure. GTI will look to address the question of whether the existing market power threshold test effectively captures exercising of market power in California. Does it take into consideration price elasticity, excess capacity, ease of entry, availability of substitution, etc.? Recommendations of potential alterations of policy will be made if prudent, focusing on the most effective and economically feasible way of promoting further expansion of existing storage facilities as well as establishing new gas storage assets.

Project Summary
CEC Natural Gas Storage Research
Natural Gas Storage Value Assessment
Researcher: Energy and Environmental Analysis, Inc. (EEA)

This research effort focuses on evaluating the infrastructure and value of California's natural gas storage system. There are two major components of the research effort. The first component consists of two conceptual papers that describe the role of natural gas storage in California and broader North American energy markets and juxtapose how gas storage is valued by individual market participants versus how it might be valued from the perspective of public benefits and public policies. The second component will be an analytic report based on a fully specified computer model of natural gas storage operations that provides detailed economic evaluation of current and potential future storage infrastructure in California and surrounding States.

EEA plans to provide the following items in this value assessment:

- A discussion of how natural gas storage is valued by natural gas market participants *versus* how it might be valued from the perspective of public benefits and public policies
- A description of current and likely future natural gas storage infrastructure in California and surrounding states and how that infrastructure is expected to be operated
- A quantification of the future economic value of natural gas storage in California and surrounding states under a variety of scenarios

The study will present detailed data and analyses related to natural gas storage including:

- Examination of future monthly and daily natural gas loads by sector
- Response of monthly and daily natural gas loads to weather
- Methods of measuring the economic and reliability benefits of natural gas storage
- Barriers to optimum construction or utilization of natural gas storage
- Policies to enhance the economic value of natural gas storage
- Utilization of storage capacity at LNG terminals
- Interaction of LNG deliveries and use of underground storage
- Optimum siting of new storage facilities (that is, value of storage of certain volumes at different locations)
- Relationship of storage facilities outside of California to storage and other market activity in California
- Historical and potential future hub-to-hub trading opportunities and values
- Role of natural gas storage in electric reliability
- How different amounts of storage capacity and rules for its use might affect electric reliability.
- Regional utilization and valuation of natural storage (Northern *versus* Southern California, and storage outside of California)
- Interrelationship of storage in different locations and appropriateness of alternative Market Power Tests

The workplan is divided into three parts:

Part 1 – EEA will write two conceptual papers on how natural gas storage is valued by individual market participants compared to how it might be valued from the perspective of public benefits and public policies. The two papers will cover similar topics, but one will be a technical economic report while the second will be a “plain English” document for the general public. The papers will include background on how gas storage is now used in California and surrounding markets and the likely evolution of storage markets in the future. These two papers on the conceptual value of natural gas storage will be completed by November of 2007.

Part 2 – EEA will develop a framework for measuring the value of natural gas storage under a variety of scenarios, EEA will expand the current Rockies implementation of its *Regional Infrastructure Assessment Modeling System (RIAMS)* to include California and surrounding States. This includes specifying the infrastructure and natural gas demand characteristics for the new geographic areas to be included in the model. This large simulation area is needed to capture the extensive interaction of storage and other market activities across the Western U.S. EEA will link results from its Gas Market Model that simulates gas prices and transportation in the broader North American gas markets with the modified version of RIAMS to be developed herein. EEA will use the model to calculate the economic and security value of storage under various conditions. All the model development work will be done by end of 2007.

Part 3 – EEA will perform analytic case studies with the expanded RIAMS model to investigate the value of storage under a variety of different scenarios. As a first step for the case studies, EEA will complete a Base Case that provides a projection for storage utilization in the Western States for a specified study year. After the Base Case has been completed, EEA will complete approximately 30 cases studies with the RIAMS model that investigate, among other items, the utilization and adequacy of storage infrastructure. The first set of case studies could investigate the sensitivity of the market to different weather conditions. The second set of case studies could investigate the impact of liquefied natural gas (LNG) on the California market and how LNG imports interact with underground gas storage. The third set of case studies could investigate the interaction of storage over the entire simulation area and the opportunities for hub-to-hub trading of stored gas by exchange or other mechanism. The fourth set of case studies could investigate the impact of gas storage on the reliability of gas-fired power generation. The final set of case studies could investigate the value of storage at different locations inside and outside of California. The overall purpose of all case studies is to simulate the value and public benefits of storage under a variety of conditions to yield insight into how additional storage infrastructure or better use of the current storage infrastructure is needed to improve the reliability of natural gas and electricity within California. The Base Case and ten of the case studies will be completed during 2007, and the remaining twenty case studies will be completed during 2008.

Project Summary
CEC Natural Gas Storage Research
Barriers to Expansion of Natural Gas Storage Facilities in California
Researcher: MRW & Associates
March 1, 2007

Expanding in-state natural gas storage infrastructure has the potential to improve California's natural gas market by providing market participants greater ability to mitigate price volatility through arbitrage. More stable natural gas prices would benefit both gas and electric ratepayers and provide greater cost predictability for businesses. The current approach to assessing market power for natural gas storage facilities may be inhibiting optimal development of these facilities in California. If so, a revised methodology for assessing market power might lead to the development of additional independent storage facilities.

The goal of this project is to provide an assessment of whether market power threshold tests or other barriers to entry are inhibiting expansion of gas storage infrastructure in California and examine a range of market power tests that might allow for increased infrastructure development.

This project will address the following questions:

- A critical issue for each of the existing independent natural gas storage facilities in California has been obtaining market-based rate authority, which has been conditioned on a finding of no market power. What are the major approaches to assessing market power in the energy industry and what impact has the existing approach to assessing market power for storage projects had on the development of storage projects in California?

The California Public Utilities Commission (CPUC) has asserted its jurisdiction over independent gas storage facilities located in California that offer service to multiple users. Before these facilities can be constructed (or expanded), they must receive from the CPUC a Certificate of Public Convenience & Necessity (CPCN) and also a CEQA review. In the course of these filings, a storage operator may request authorization for market-based rates. In light of the new FERC rule, will the CPUC continue to rely on FERC-based market power assessments? Alternatively, what market power tests might the CPUC employ when considering CPCN applications?

- Section 312 of the Energy Policy Act (EPA) of 2005 permits FERC to grant storage projects market-based rates when such rates are in the public interest, even if those projects cannot demonstrate that they lack market power. FERC's new rules implement this legislation. What impact will this new FERC authority and approach have on CPUC decision-making and on the location of potential storage projects in the West?
- The importance of market-based rate authority for independent storage projects is clear and the approach used to assess market power can have a major impact on the viability of a proposed storage project. What other barriers to entry might contribute to an underdeveloped

storage market in California and how important are those other issues relative to market-based rate authority?

In order to address these questions, MRW will conduct a comprehensive analysis of barriers to expanded independent gas storage infrastructure in California, focusing on potential regulatory barriers associated with market power tests. This analysis will draw upon existing academic literature on market power and market power tests in the energy industry. The research plan includes:

- Review of academic research on market power tests used in the energy industry
- Review and assessment of FERC's revised approach to assessing market power
- Evaluation of the impact of new FERC rules on expansion of gas storage in California
- Analysis of the interplay between California and federal regulatory frameworks
- Research on the historical regulation that has shaped California gas storage development
- Calculation of historical and current market concentration measures in California
- Examination of products and services provided by storage facilities and consideration of alternative providers of these products and services
- Critical discussion of regulatory and other barriers to gas storage expansion in California

The research should be completed by the summer of 2007.

Project Summary
CEC Natural Gas Storage Research
A Daily Simulation Model Of The California Natural Gas Transportation And Storage Network
Researcher: UC Davis

The proposed research will use nonlinear programming techniques in a simulation model of transportation and storage logistics for the California natural gas market. The role of storage facilities in California is analyzed in the context of a network where daily supply and demand are balanced combining transportation, injections or withdrawals from underground storage and short-term storage in pipelines. Optimal decisions by utilities, customers, pipelines and storage operators in the northern and southern systems should bring the California network towards an equilibrium where spatial and intertemporal arbitrage opportunities have been exhausted (to the extent that regulatory and capacity constraints permit).

The analysis will be performed on daily data versus a prior version which used monthly data. The daily data reveals seasonal and weekly cycles on the demand side of the market as well as on flow and storage decisions. The model depicts flows from supply nodes (the producing areas serving California) to demand nodes (PG&E and SoCalGas service areas) that move along fixed capacity arcs and can be temporarily stored at intermediate nodes (underground storage facilities) along the way. The relative costs of gas from different producing regions at different times of the year and week as well as the cost of storing gas are the driving forces shaping the optimal daily profile of flows and inventories, which the nonlinear algorithms solve for.

The spatial focus is California but the model accounts for the links with other parts of the North American network. Included are direct links with producing regions from which California obtains its gas (Canada, Rocky Mountains, San Juan basin, Permian basin) as well as indirect links with other demand regions that compete for the same sources of gas. Demand is disaggregated by customer type to capture the different seasonal patterns in natural gas consumption by core, industrial and electricity generation customers. Cost tradeoffs between transportation and storage activities are represented in the model through transportation and storage cost functions which relate the amount of natural gas used up as fuel by compressors with the load factor in pipelines and storage facilities.

First, the model will be calibrated to a base-case year using historical data and then used to analyze certain scenarios such as ones to analyze the effects of non-marginal changes such as infrastructure expansions (pipeline and storage), regulatory rule changes, and changes in supply and demand profiles. For instance, the change in optimal flow and storage patterns as a result of introducing an LNG regasification facility in Baja California will be investigated. The degree to which regulatory requirements about storage for core customers determines the observed timing and allocation of gas injections will also be analyzed. Another interesting question to explore is that of the relative effectiveness of pipeline versus storage capacity for responding to the increased variability in demand.

The modeling work should be completed by the summer of 2007 with the scenario analyses completed during the fall of 2007.

Project Summary
CEC Natural Gas Storage Research
Analysis of California Natural Gas Market, Supply Infrastructure, Regulatory
Implications and Future Market Conditions
Researcher: Black and Veatch Lukens Energy Group (B&V)
March 6, 2007

B&V will analyze the California and Western North America market to understand whether natural gas underground storage will play a significant role in meeting natural gas demand needs for the forecasted growth in the California natural gas market. The analysis will consider competing assets to underground natural gas storage, review out-of-state alternatives and review potential impediment to the increase of natural gas underground storage in California. The specific areas of analysis that will be pursued includes:

Developing an Understanding for Growth in Natural Gas Demand and Demand Elasticity: B&V will analyze historical consumption of natural gas in California. To better understand future trends in consumption, B&V will interview selected large utilities / consumers or used pre-existing consumption data to understand the potential for change in the demand elasticity for natural gas consumption. This information will be incorporated in a fundamental analysis of the California market to understand how the seasonal price basis and demand patterns may change in future years.

Examining the Economic Benefits of Instate v. Out-of-State Storage: With demand for natural gas projected to grow in California, additional storage facilities can help manage demand fluctuations for natural gas. Key causes of these fluctuations include power generation facilities that burn natural gas and space heating requirements for the residential and commercial sectors. It is critical to identify the most economic solution possible provide storage capacity to the California market while balancing operational, environmental, and reliability requirements. Alternatives to in-state development include the expansion of traditional storage facilities east of California, on pipelines serving the California market. To understand the trade-off of promoting in-state development, this study will analyze the impacts to storage value from increased costs of utilization from long haul transportation. Reservoir development costs and pipeline transportation costs play a significant role in determining whether a new storage facility can be developed. Additional consideration involves assessing the need and viability of storage between northern and southern California, inter- and intrastate constraints, and designing appropriate incentives to stimulate regional storage developments.

Estimating an Economically Optimal Portfolio to Meet California Peak Natural Gas Demand: Peak demand for natural gas is driven by many factors which include weather, population growth, economic growth, conservation efforts and price of other fuels, such as oil. The potential for peak demand to grow on a disproportional basis to annual demand creates a challenge for industry and the State of California to balancing supply and demand. Determining the operational and economic feasibility of the various options to meet peak natural gas demand in California requires an understanding of technology, regulatory structure and business practices utilized in the energy industry. This study will consider underground storage, conservation, LNG supply, pipeline supply, LNG peak shaving facilities, and fuel switching to determine the

most economic alternative for the State of California. The results of this study can be used as a means to better understand the economic alternatives for meeting demand for natural gas within California.

Developing an Expectation for Long Term Natural Gas Price Volatility for the California Natural Gas Market: In general, volatility of prices and ultimately volatility of returns on investment discourage potential investments. However, volatility plays a major role in determining the value and development of natural gas storage. Value can be created by market price arbitragers in two ways: First, they exploit the time spread between summer and winter natural gas prices. Second, they exploit the gyrations of the natural gas market that frequently offer natural gas price combinations beyond summer-winter spread. For many storage facilities that have the ability to charge market based rates, the income stream from arbitraging market prices can be comparable or superior to the income from traditional storage use to meet peak day demand needs. Volatility of the natural gas market enhances the profitability of storage facilities. Expectations for volatility will play a major role in determining whether the market will support additional storage facilities independent of a demand driven need. Volatility in natural gas prices depend on the relationship between supply, demand, infrastructure, other commodity prices and the imbalances that can occur between these variables. The study will utilize a fundamental model to understand the markets sensitivity to various factors. With the main factors identified, an expectation in future volatility can be developed which will allow us to draw conclusions as to whether the market will support storage development independent of meeting growing natural gas demand.

Evaluation of the Regulatory Impediments to the Development of New Underground Gas Storage in California: Changing demand patterns coupled with diminishing natural gas supplies in the lower 48 States and increasing LNG imports require a growing network of storage facilities to meet seasonal load variations and pipeline balancing requirements. California currently has nine storage facilities in operation. Additional capacity is the State is needed, but will it be developed? In addition to the geological limitations, regulatory requirements can determine whether new facilities are constructed to serve California. While traditional cost-based storage rates may not accurately reflect the value of service in peak periods and may not provide a return to create incentives necessary for the construction of new storage facilities, even if a storage facility could obtain market based rates there may exist other obstacles preventing and stymieing storage development. These obstacles arise from regulations that affect the economic siting of storage, standards issues with gas pipelines, and the permitting process in general.

The research should be completed by the end of the summer 2007.