

# Integrated Energy Resource Management Systems: Meeting the Information Needs of Evolving Markets

BY

JOHN C. TYSSELING, PH.D.  
PRESIDENT  
ENERGY, ECONOMIC & ENVIRONMENTAL CONSULTANTS  
ALBUQUERQUE, NEW MEXICO U.S.A. 87109  
E-MAIL: jct@e3c.com

AND

MICHAEL E. CRAWFORD  
PRINCIPAL  
NESTEGGS  
420 WESTMORELAND  
HOUSTON, TEXAS U.S.A. 77006  
E-MAIL: crawford@nesteggs.com

## ABSTRACT

Advanced information systems requirements are identified to achieve energy market efficiencies sought by regulators and market participants. Natural gas and electric energy distribution systems dependencies on the increasingly complex integration of information relating to scheduling, dispatch and operations monitoring are discussed.

Environmental issues (e.g., Clean Air Act Amendments compliance, Integrated Resource Planning requirements) have become a dominant fuel selection criteria for electric generators. Natural gas has an opportunity to emerge as an economically preferred fuel.

The natural gas and electric distribution markets are being transformed by regulators. Power wheeling, least cost fuel sourcing and stockholder value maximization decisions are made significantly more complex by new competitive forces (e.g., non-utility generators, transferable emission rights).

Enhanced networked information system opportunities are emerging to allow the technical foundation for integrating energy market decisions. "Real time" information requirements are defined. Discussion of the constraints to achieving this integration in both technical and institutional context is provided.

Market inefficiencies constrain the ability of gas to satisfy the energy needs of electric generators. Integrated, inter-firm real-time market decisions are required. Improved decision efficiency is shown to allow more effective compliance with regulatory and market criterion.

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## INTRODUCTION

Restructuring of the regulated market environment in which energy is purchased and sold in North America is providing many opportunities for change. Critical environmental problems associated with use of carbon-based energy resources compound the complexity of future energy market decisions. Information management is becoming the critical element of efficient energy resource decisions, and has become a focus of many market development activities.

The United State Congress' enactment of the Clean Air Act Amendments of 1990<sup>1</sup> ("CAAA") provide a foundation upon which the environmental criteria are

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<sup>1</sup> Public Law 101-549, 104 Stat. 2399 (1990).

expressed in selection of fuel sources to satisfy future energy requirements. Natural gas frequently emerges as a preferred fuel for satisfaction of the increasingly stringent environmental criteria, particularly those associated with increases in marginal (i.e., peak load and incremental demand) electric generation capacity requirements. By all forecasts, natural gas has the *opportunity* to provide a significant contribution to achieve these environmental goals.

Concurrent with the development of the environmental management criteria, both the natural gas and electric distribution markets are being transformed by regulators in the United States. Deregulation of natural gas markets<sup>2</sup> during the past decade has imposed vastly more complex information management problems on all market participants. Satisfaction of electric demands through power wheeling and the development of non-utility generators (NUGs) impose equally complex market

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<sup>2</sup> Regulation of Natural Gas Pipelines After Partial Wellhead Decontrol (Order No. 436), 50 Fed. Reg. 42,408 (Oct. 18, 1985) [FERC Stats. & Regs., Regulations Preambles 1982-1985] ¶ 30,665 (Oct. 9, 1985) vacated and remanded, Associated Gas Distributors v. FERC, 824 F.2d 981 (D.C. Cir. 1987), cert. denied, 485 U.S. 1006 (1988), readopted on an interim basis, Order No. 500, 52 Fed. Reg. 30334 (Aug. 14, 1987), FERC Stats. & Regs. [Regulations Preambles, 1986-1990] ¶ 30,761 (1987), remanded, American Gas Association v. FERC, 88 F.2d. 136 (D.C. Cir. 1989), readopted, Order No. 500-H, 54 Fed. Reg. 52344 (Dec. 21, 1989), FERC Stats. & Regs. [Regulations Preambles 1986-1990] ¶ 30,867 (1989), reh'g granted in part and denied in part, Order No. 500-I, 55 Fed. Reg. 6605 (Feb. 26, 1990), FERC Stats. & Regs. [Regulations Preambles 1986-1990] ¶ 30,880 (1990), aff'd in part and remanded in part, American Gas Association v. FERC, 912 F.2d. 1496 (D.C. Cir. 1990), cert. denied, 111 S. Ct. 957 (1991); Pipeline Service Obligations and Revisions to Regulations Governing Self-Implementing Transportation Under Part 284 of the Commission's Regulations, Docket Nos. RM91-11-000, et al., Order No. 636, 57 Fed. Reg. 13,267 (April 16, 1992), reprinted in III FERC Stats. & Regs. (CCH) ¶ 30,939 (1992), order on reh'g, Order No. 636-A, 57 Fed. Reg. 36,128 (August 12, 1992), 60 FERC (CCH) ¶ 61,102 (1992), reh'g denied and clarifying, Order No. 636-B, Fed. Reg. (Nov. 27, 1992).

problems. Economic motivations of least cost fuel sourcing and stockholder value maximization are made significantly more complex by regulatory compliance (e.g., integrated resource planning requirements) and specific incentives (e.g., transferable property rights in emission credits).

In short, the ability of the natural gas industry to realize the potential opportunities offered by the new market environment requires significant improvement in strategic information management. Credible forecasts of up to twenty percent increase in natural gas demand<sup>3</sup> will be realized only if market information is efficiently conveyed. Most of this potential demand increase is related to electric generation and industrial fuel requirements. The deregulation of the natural gas markets has focused attention on the participants' ability to perform services required by these customers within the structure of gas transportation through interstate pipelines' natural monopolies.

Control and management of the required information from wellhead nomination and flow metering, through all transportation links with prioritized rights

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<sup>3</sup> See, for example, U.S. Dept. of Energy, EIA, "Monthly Energy Reviews: January 1992," DOE/EIA-0035, December 1991; NERC, "Electric Utility Supply & Demand 1991-2000", July 1991; Gas Research Institute, "Baseline Projection Data Book: 1992 Edition of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2010", Volume 1, 1992; Enron Corp., "Enron Corp's Outlook For Natural Gas," Houston, Texas, 1991; American Gas Association, "1992 A.G.A.-TERA Base Case," 1992; U.S. Dept. of Energy, Energy Information Administration, "1992 Annual Energy Outlook with Projections to 2010," DOE/EIA-0383(92), Washington, 1991; National Economic Research Associates, Inc., "Energy Outlook," Washington, Sept. 23, 1991.

to access available pipeline capacity necessary to satisfy end-user customer demands is in itself a significant challenge. The opportunity to satisfy the simultaneous optimization problems associated with real time air quality management systems, including the efficient scheduling of alternative electric generation facilities and the trading of emission credits, imposes new and complex systems integration problems which the natural gas industry must address to realize its potential.

Implementation of networked market information systems appear a logical solution. However, many institutional and technical obstacles challenge this logical solution. New capabilities are arriving daily which offer means to wield information tools like commercial inter-company networks, electronic mail and other transactions-based systems, all used to uniformly gather and widely disperse transaction data.

Natural gas has been identified as possessing the greatest opportunity in satisfying expanding energy demands during the next several decades. However, traditional hydrocarbon fuels (i.e., coal, oil) will maintain a large share of the energy market. Compliance with environmental constraints which have been placed on the energy market participants will drive many significant economic decisions, with these decisions dependent on the available market information. Recognition of the related simultaneous market information requirements will *define* the efficiency with

which the market challenge is met, and largely determine the fuel chosen to satisfy increased demands.

## EVOLVING ENERGY MARKET DECISIONS

The simplicity of regulated utility energy market environments are a historic relic. Participation in competitive energy markets is requiring difficult philosophic and operational transitions at all levels of the energy industry. At a high level, the evolution of the traditional energy markets is largely predictable, with current focus on access to the information required for efficient decisions.

By example, satisfaction of electric generation demands and corresponding environmental compliance requirements -- particularly those to be addressed through the Acid Rain title of the CAAA<sup>4</sup> -- requires the identification and selection from the array of alternative fuel supply and emission control strategies. Compliance with the acid rain requirements imposes a permanent fifty percent reduction (from 1980 levels) in sulfur dioxide emissions, and a ten percent reduction in nitrogen oxide emissions by 2000. Electric generators can accomplish this by

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<sup>4</sup> Title IV, CAAA, *supra* note 1, at 2584.

changing fuel sources, relying on advanced (e.g., clean coal) technologies or scrubber installation. The strategic business assessments of management and facility operators must include the specific fuel costs, the costs for rights to continue emissions, the value of transferable credits associated with emission reductions, alternative energy supply opportunities, and demand management capabilities.

The fuel requirements of electric generators can be provided by a variety of energy supplies, including mixes of combustion fuels (e.g., natural gas, fuel oil, low sulfur and high sulfur coal), and non-combustion resources (e.g., nuclear, solar and hydro-power). Each of these energy supply portfolios imply differences in fixed costs (e.g., additional capital costs of scrubbers) and variable fuel costs.

The economic evaluation for the combustion fuels across all portfolio arrays must address the same simple fuel supply requirements; that is, the heat content of the fuel demand in the boiler is essentially constant for steam turbine generation. This last point is particularly important in the context of the increasingly transparent relationship *between* fuels, wherein it is anticipated that significantly more continuous evaluation of fuel alternatives will characterize future market decisions.

The evolution from typed contracts and carbon paper, through a predominant use of fax machines and multi-line phones, to a proposed electronic marketplace has



not essentially changed the decisions required to arrive these agreements. These changes can not be intend to break the *iron hearts* of the energy industry. These tools must be molded to match or echo the present transaction mechanism, and yet should allow for the enhanced requirements and capabilities provide by access to the information.

In a real sense use of the technology in the ways this thesis suggests offers the choice between greater speed or greater elegance. Greater speed means doing the same thing faster, with more information and with concomitant personal stress. Greater elegance means using the distinguishing aspects of the evolving tools to subtly shift the methods used to transact, so that the means of information dissemination provide a lever long enough to move the world of energy trading into multi-level, multi-term and multi-party transactions, and by so doing, far outstrip the accomplishments possible using only greater speed. In that world, all the parties involved make decisions based on their acumen, undistracted by the mechanics of the transaction, and competing at the top of their bent.

In the evolution of the North American energy market during the next decade there is no question that coal will continue to dominate the fuel supply chosen by electric generators. However, "non-traditional" coal resources are penetrating historically impenetrable markets as a result of the coals' specific environmental

attributes. Likewise, natural gas is providing significant competition to coal in the dynamic electric generation fuel markets and as an industrial fuel supply.

## THE ENERGY MARKET INFORMATION PROBLEM

Energy marketers must now address unfamiliar complexities. The innocence of competition based exclusively on delivered price has been lost. *Flexibility* - - interpreted in a wide range of contexts -- and *portfolio risk management* must now be dealt with in competitive fuel supply markets. Critical market factors include the ability to assure delivery of energy resources of specific quality, at a particular location, within a critical timing parameter, and with pricing paradigms which are derivatives of a wide array financial and commodity market models. These are unfamiliar parameters which are currently being defined,<sup>5</sup> and which are all dependent on efficient communication and information management.

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<sup>5</sup> The Federal Energy Regulatory Commission is participating in defining some these parameters, but actions to date have been limited to very discrete data set definitions and discussion of access to limited natural gas pipeline transactions sets. See Standards for Electronic Bulletin Boards Required Under Part 284 of the Commission's Regulations, FERC Docket No. RM93-4, Order No. 536, 59 Fed. Reg. 516 (January 5, 1994), reprinted in III FERC Stats. & Regs. (CCH) ¶ 30,988 (1994) (issued December 23, 1993). See, also, the reports of the working groups submitted at various times subsequent to the issuance of Order No. 563. With respect to the electric industry, see, for example, Policy Statement Regarding Regional Transmission Groups, FERC Docket No. RM93-3-000, issued July 30, 1993.

Power generators identified a number of these critical problems in comments filed in interstate natural gas pipelines' regulatory restructuring cases before the U.S. Department of Energy's Federal Energy Regulatory Commission.<sup>6</sup> However, even resolution of the issues identified to date will not satisfy the full panoply of changed requirements facing the joint interests of power generators, industrial customers and fuel supply market participants.

Transformation from traditional regulated monopoly functions to "open access" regulation of both natural gas and electric generation markets imposes vastly more complex information management problems on all market participants. The natural gas industry is beginning to deal with these information issues.<sup>7</sup> However, the coal industry, fuel oil marketers and emissions trading market participants will be made subject to unfamiliar market information problems associated with energy

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<sup>6</sup> Comments of the Ad Hoc Group of Power Generators Concerning the Impact on Power Generation Natural Gas Use of Inflexible Pipeline Operational Limitations, Narrow Tolerances and Onerous Penalty Provisions and Request for Industry-Wide Technical Conference, Texas Eastern Transmission Corporation, Docket No. RS92-11-000, et al., October 19, 1992.

<sup>7</sup> There has been developed and introduced a wide variety of functionality in the interstate pipelines' compliance with electronic bulletin board requirements under the provisions of FERC Order No. 636. At a minimum, these systems are to provide for capacity access and reallocation information. In conjunction with the development of these systems a number of additional information services are being developed, including proposed systems encompassing sophisticated electronic trading activities. These systems remain proprietary and available only if subscription fees are paid. In the case of the Canadian pipelines, a much more comprehensive system of information technology utilization appears to be in process of implementation, although the integration of these systems *between* proprietary interests remains limited.

supply and environmental management issues. At a national level the U.S. Congress has provided a foundation for natural gas to emerge as a preferred fuel, but coal will continue to dominate fuel supply markets for power generation and industrial requirements, albeit a dramatically altered market environment.

Importantly, the Federal Energy Regulatory Commission has sought to respond to these priorities through implementation of regulatory reform based on "competitive market" paradigms. However, the specific experience of the energy industry market participants has provided only limited exposure to the continuous trading, financial derivative products, and sophisticated trading environments which will be required to address the complexities of the paradigm. Achieving the potential of this competitive market opportunity in the sophisticated energy market transactions environment will be determined largely by the efficiency of the market information mechanisms which emerge.

### **Statement of the Information Management Issue**

Both natural gas and electric energy distribution are highly dependent on an increasingly complex integration of information relating to scheduling, dispatch and monitoring. The dynamics of the information problem is compounded by

environmental and other regulatory priorities (e.g., least cost purchasing). Response to all criteria is a technical information problem faced by all energy suppliers and distribution utilities. The ability to optimize the required decisions is not being systematically addressed on an integrated, inter-firm basis. Implementing improvements to the efficiency of these decisions will allow more effective compliance with both regulatory and market criterion.

Efficient use of available information, including the development and use of unique data attributes, is the source of market power for all participants in the energy industry. Information management is the proprietary key to competitive advantage in today's energy distribution markets. Regulation is confronting the necessary availability of this information such that market power is not unduly exerted by the utilities' possessing natural monopoly power over the required information. Energy firms who wish to participate must address these developing market regulations. The policy-makers enacting these regulations, in turn, seek an equilibrium of efficient resource use (including environmental degradation) and sufficient economic incentive to motivate market participants.

Indeed, it is in the context of the energy market decisions which the parameters of "real time" activities must be defined. In order that alternative energy supplies may be substituted, the facilities which demand these energy resources

must be in a position to both communicate and select the energy resource mix which attains the objectives of its market activities. Biasing of energy market decisions can be accomplished simply by defining *asymmetrical* market timing requirements between fuels. For example, defining electric generation demand as determined within one-tenth hour cycles, and assuring gas delivery volumes within 24 hour cycles, assures that a "continuously" variable coal fuel derived from a on-site stockpile will be preferred for its market reliability characteristics.

The issues to be addressed include technical data criterion, resource substitution parameters, regulatory compliance and market efficiency. At the core of all these issues are complex, integrated information management algorithms. Presently, energy resource management systems are not equipped to address these issues on an integrated basis.

### **Description of the Networked Information Systems Opportunities**

A leased-line network using traditional phone technology is a possibility, as are satellites, but Frame Relay emerges as a prime candidate for the network, both for its speed and low cost, as well as its capacity to be a natural lead-in to SMDS (Switched Multimegabit Digital Service) and ATM (Asynchronous Transfer Mode), the network circuit standards for the turn of the century.

The InterNet uses the TCP/IP protocols, and UNIX provides ample tools for wide-area networks. Most companies are aware of, or now implement the computing resources necessary to communicate at this level. Lesser or less-tested network protocols may seriously handicap those who employ them.

A tremendous amount of information is now available from the industry, albeit in scattered locations. The thought and investment put in these technologies will translate into a greater ability to communicate in a network context, and the information now provided by these proprietary offerings will reach a wider audience.

### **Synopsis of Current Natural Gas Industry Market Practices**

The natural gas industry is reaching near-conclusion to a decade-long regulatory transition to "market based" operational principles. The federal regulation of interstate gas markets now seeks to allow all potential buyers and sellers of natural gas the freedom to engage in open trading of the gas commodity. However, required transportation services of natural gas pipelines remain subject to regulations as natural monopolies. Certainly, any observer of the marketing relationships from wellhead to burnertip will be unconvinced that market power has been routed from

the competitive landscape of the natural gas industry through the regulatory reform process.

Market power, defined simply as the ability to achieve preferential access to market opportunities, is exerted largely through the control of access to interstate pipeline capacity and specific gas resource supplies. This control can be both a matter of property rights and information systems, and is not necessarily a violation of law or "fair" market principles. It is simply a fact which all natural gas market participants must understand and be prepared to address in their efforts to sell or purchase gas supplies.

More importantly, in order for the natural gas industry to satisfy the potential demands of the electric and industrial customers it must confront the obstacles of the regulated market environment, and achieve efficient national and international marketing practices through a system of traditionally inefficient, regionally-based transportation systems.

The existing transportation systems' competitive market inefficiency is neither deliberate nor inexplicable. Prior to deregulation efforts gas markets tied specific supply sources to specific demand regions. Natural gas systems were based entirely on principles of natural monopoly utility service. Although regulatory



reform has created an environment where market efficiency *can* be realized, the investments in systems necessary to achieve these competitive goals are yet to be completed.

Control of access to specific gas supplies is assumed to be outside the purview of regulators, and long subject to competitive allocation systems. However, gas supply contracting alternatives may be dramatically affected by the available market information systems.

*Efficient utilization* of available pipeline capacity is a significant reliability issue for the natural gas industry. The ability of the market to deliver available gas resources to expanding demands is only as reliable as demonstrated -- or as it is "perceived to be demonstrated" -- by the delivery systems.

As previously indicated, a principle obstacle to natural gas marketing is access to interstate pipeline capacity. Historically all firm pipeline capacity rights have been controlled by other interstate pipelines or the local distribution companies (LDC) as downstream customers of the interstate pipeline. Under provisions of the regulatory reform firm transportation (FT) capacity can be reassigned to third parties, allowing reliable service to those acquiring the capacity. Alternatively, interruptible transportation (IT) is available subject to service queue interruption in favor of

higher priority shippers. Allocation of costs to these services in the new market environment remains a non-trivial issue.

Significant regulatory work remains to insure that traditional LDC (and other) capacity right holders allow this capacity to be reassigned efficiently without undue discriminatory impacts on other market participants. Key to the efficiency and enforcement of these capacity assignment programs will be the integration of information management systems with both pipeline operation systems and required marketing information. Management of the access to pipeline capacity can dramatically impact both the operational feasibility and economics of utilizing natural gas to satisfy electric generation and industrial fuel requirements.

Simultaneously, it is also being recognized that pipeline capacity information is just a starting point for satisfying the information requirements of market participants. The parameters of the requirements for information, versus the costs of providing the information, provide the nexus of the today's debate among industry participants. This debate reflects attitudes of industry participants who may "fall on their own sword" of regulatory controls, rather than recognize the opportunity they face and *address long term solutions with a shared vision of required market evolution.*

The pipelines' and LDCs' desire to retain traditional customers and assure continued domination of service offerings within their service territories "motivates" their participation in efficient capacity assignment and market information systems. Much of the regulatory oversight of these systems, whether within federal or state jurisdictions, relates to determining the financial risks which will be borne by the regulated firms balanced by the market efficiency requirements of third parties seeking to obtain control of the natural gas pipeline capacity required for the services sought.

#### **Service Reliability: Defining Real Time Information Requirements**

Issues relating to the domination of competitive market opportunities by the existing LDC's, and access to desired natural gas pipeline service by electric generators and industrial customers will turn on the provision of necessary market information (e.g., pipeline operational information). Further development and access to the pipeline information systems will benefit all natural gas market participants. However, these individual pipeline systems serve only as a requisite foundation for achieving the energy market efficiency sought by the U.S. Congress and regulators; and, more significantly, will provide the basis for realizing the market potential for the natural gas fuel.

Of course, the coal industry which has dominated the electric generation market will seek to maintain their market position. The failure of the natural gas market to provide efficient service to electric generators will be cited as a principal reasons for preferred reliance on clean coal technologies and scrubbers to achieve CAAA requirements. For the natural gas industry to achieve its potential as a "clean fuel" alternative to electric generators it must overcome the reliability arguments which tilt fuel choice decisions to coal. An electric generator who can look out his window and see the coal pile must be placed in a position whereby he is "indifferent" to satisfying his energy demands with the same level of service reliability through use of natural gas. This service reliability standard requires significant improvement in the natural gas marketing information systems available to market participants.

It is asserted that the electric industry is facing investment requirements ranging to hundreds of billions of dollars during this decade to satisfy their CAAA compliance obligations. In order that those capital investments be favorable to the natural gas fuel source resolution of the service reliability issue must be demonstrated. In light of the real time, continuous monitoring and compliance requirements (under the CAAA)<sup>8</sup>, and given the breadth of substitutable energy resources available to satisfy these requirements, delivery of natural gas service must

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<sup>8</sup> The requirements for continuous emissions monitoring for electric generators are defined at Section 412 of Title IV, CAAA, *supra* note 1, at 2624.

be made equally flexible, continuous and reliable in order to satisfy these dynamic market demands. The relationships of fuel supply substitutability and requirements for evaluation of energy market parameters (e.g., including emissions profiles) *defines* the "real time" characteristics of the dynamic energy marketplace. Failure to demonstrate the ability to serve market requirements assures failure of marketing efforts regardless of the otherwise desirable qualities of the product(s) offered.

### **Challenges to Electric Market Paradigms**

The market in which electricity is sold and purchased is subject to much of the same economic motivation as found in the gas industry. However, dissimilarities are significant, particularly in the sense of implementing "open access" competitive market paradigms on both the interstate and intrastate distribution systems. A very noteworthy dissimilarity is the extent to which the electric industry participants have achieved some degree of success in establishing effective transaction "networks" allowing wholesale market transactions of surplus generation capacity.

However, in spite of the history of significant market transactions, the electric market participants now face significant regulatory reform. Requirements for continuous emissions monitoring and management of distribution facilities has

significantly compressed the timing of market decision requirements, with the electric markets now functioning within quarter-hour (or less) scheduling and dispatch parameters. Issues such as regional transmission groups<sup>9</sup>, in which market participants formally establish trading relationships, are likely to dramatically alter both market motivations and pricing paradigms. Wheeling of generation capacity and specific facility utilization is requiring significant improvement in distribution and marketing information systems. The implementation of integrated resource planning strategies and increasingly broad definition of "least cost purchasing" requirements are forcing industry participants to develop sophisticated, integrated management tools.<sup>10</sup>

It is anticipated by many observers that federal regulatory reform required by the electric industry will substantially mirror the regulatory evolution which has occurred during the last decade in the natural gas industry. The restructuring of service offerings to achieve "open access" goals, and attendant cost reallocations, are certainly a part of the reform which is anticipated.

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<sup>9</sup> *Supra* note 5.

<sup>10</sup> See, for example, Mark Nelson and Andrea Horwath, "Integrating Energy and DSM Forecasting for Utilities," presented to Institute of Gas Technology's Energy Modeling: Methodology, Models, and Applications Conference, April 25-27, 1994, Atlanta, Georgia.

Consistent with the experience of gas industry market participants, it is likely that participants in reformed electric markets will discover substantially expanded requirements for access to operational and transactions related market information. There is every reason to believe that enhancement of information technologies will have *at least* as dramatic an impact on the opportunities faced by market participants as has been experienced in the natural gas industry. Indeed, it is likely that supply and demand management functions will be integrated from the consumers meter, through the distribution facilities, and integrated into the dispatch function during the course of this market evolution.

Clearly, within the context of the simultaneous compliance with regulatory reform, energy policy initiatives and environmental criteria implementation, the electricity industry faces dramatic challenges. Satisfying the requirements for availability of, and access to, the necessary market information will define the efficiency with which these market challenges are met by participants in the electric industry. In this context, fuel selection must be assessed both as a short and long term issue.

Fuel selection will primarily be determined as a function of capital investment decisions. These decisions are dependant on perceptions of energy market circumstances. In particular, the perceptions relating to investment risk and

uncertainty, and reliability of fuel supplies, will determine the outcome of the long term facility determinations required. Short term decisions relating to fuel selection criteria for electric generators are generally insignificant to realization of the potential growth in natural gas demands associated with the investment required by the electric generators.

## INTEGRATED ENERGY RESOURCE MANAGEMENT

Controlling and managing the required alternative fuel supply information is in itself a significant challenge. The opportunity to satisfy the simultaneous optimization problems associated with real time air quality management systems - including the efficient scheduling of alternative electric generation facilities, the trading of emission credits and explicit risk management activities -- imposes new and complex systems integration problems which the alternative energy suppliers, transporters and distribution industries must address.

The ability to accomplish increased efficiency in energy market transactions requires extensive interaction between numerous market participants. At the heart



of the efficient market transaction is a core information network which must integrate the management and operations of multiple oil and natural gas transportation hubs, coal transportation and trading systems, alternative energy resources, emissions credit trading activities and electricity distribution and trading.

The ability to react, maintain flexibility and manage market (and distribution system) risks requires implementation of sophisticated, high speed, distributed information systems. Multiple systems with these capabilities continue to be developed with independence from each other, but it is in the *integration* of these systems that their real value can be realized.

Looking to the future it is clear that energy market transactions will become increasingly transparent, allowing much greater geographic diversity and breadth of price discovery to be the market foundation upon which transactions are based. Transactions across the energy market will become increasingly frequent, with very short duration (hourly, or less) and longer duration transactions becoming an increasingly important component in the risk management portfolios for all market participants. Indeed, the day of "virtual energy markets" is not outside the realm of

possibility.<sup>11</sup> Looking to this vision, however, requires recognition of the appropriate steps to achieve the potential. Leadership through these transitions and market dynamic implies advantage and opportunity.

In order that opportunities for natural gas service be maximized, "upstream" and "downstream" pipelines must facilitate effective and efficient communications between producers and consumers. These communications requirements must also be extended to allow comparisons of market competitors where multiple service alternatives are available (e.g., at "market centers" or "market hubs"). Furthermore, the market information must not only be available, but market participants must be allowed by the information systems to efficiently complete a transaction and schedule delivery of the natural gas commodity. The ability to simultaneously complete transactions across multiple transportation systems poses very significant systems integration problem, which are dramatically compounded by the "real time" efficiency requirements which the emerging market demands.

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<sup>11</sup> With integrated energy systems it is possible to envision continuous real-time market-based allocation of alternative energy resources which reveal price to customers on the basis of incremental costs of all alternative resources which are available, including all avoidance and opportunity costs as an integrated part of the pricing paradigm. As initially envisioned the integrated energy resource management systems proposal would certainly not achieve such a standard, but its implementation of systems integration standards which provide movement in the direction of this goal is expected to provide significant net economic gains to participants in the effort.

In summary, the emerging energy industry market demands require both energy supply and distribution networks to rely on highly interdependent and increasingly complex integration of information relating to scheduling, dispatch and monitoring. The dynamics of the information problem is compounded by environmental and other regulatory priorities (e.g., least cost purchasing). The ability to respond to all criteria is a technical information problem faced by all energy suppliers and distributors. Optimization of the required decisions is not being systematically addressed on an integrated, inter-firm basis. The ability to improve the efficiency of these complex decisions will allow more effective compliance with both regulatory and market criterion.

Efficient use of available information, including the development and use of unique data attributes, is the source of market power for all participants in the energy industry. Information management is the proprietary key to competitive advantage in today's energy distribution markets. It is demonstrated that the integration of energy resource management systems can provide economically efficient solutions to these emerging market issues.

## **Statement of Specific Issues & Technologies Requiring Development**

Attempting to distill the preceding discussion to a "scope of work" or "project plan" is presumptuous. Indeed, for each individual entity participating in today's energy market the specific system development requirements and systems integration needs are different. These differing requirements, in fact, define the problem.

The marketing and operational systems information requirements must be first defined to establish standard parameters.<sup>12</sup> Establishment of these parameters must be based initially on market requirements, and then brought into conformance with the operational systems requirements of the energy suppliers, pipelines, electric distribution systems and customers. These information standards must be established to address multiple platform requirements of the existing information systems.

In conjunction with the definition of these standards, there must also be a specification of system management enhancements. The continuous, dynamic service requirements of the electric generator and other customers must be

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<sup>12</sup> The natural gas Electronic Bulletin Board working groups and the Electronic Data Interchange (EDI) efforts taken to date are beginning to address some of these parameters. However, significant work remains to be done, and this work must be extended to include a broad array of operational data and transactions data which is not now part of the standardization efforts.

incorporated. The integrated management of systems operations including well production (nomination and scheduling), flow monitoring, storage facility utilization and market forecasting must be incorporated to satisfy the matching of natural gas supply and demands. Similar parameters will need to be integrated for other fuels.

Specifically with respect to the satisfaction of the needs of the evolving energy markets these systems must integrate real time emissions monitoring. The solutions provided must address the optimization of the simultaneous emissions minimization and cost minimization problems, including the accounting for possible emissions credit trading, transportation cost options, energy supply costs and alternative energy sources dispatch (e.g., "wheeling" power). These systems must also consider near term dynamics in demand through specific load-demand and atmospheric conditions forecasts.

The networking capabilities now available suggest that it is a matter of a resolution by the energy industry and its regulators to adopt the protocols required to achieve the effective exchange and efficient utilization of integrated energy market information. Allowing a data pipe to the outside world is somewhat daunting, arousing concerns of intrusion and malicious interlopers. These problems have been solved to a great degree of satisfaction by the banking and securities industries. There is a significant capacity for both the free movement of information

and a protected source of that information. The nature of the network topology itself helps to control access, but some other tools might include encryption, packet authentication and the judicious use of firewalls.

In total, the specific systems integration effort may be best conceived of as a constrained optimization problem which is required to operate effectively in a "real world" transactional environment. Systems will have to be defined which incorporate best technologies available while satisfying the operational requirements, cost constraints and the practicalities of imperfect market operations. These requirements impose a formidable technical, business and (potentially) regulatory challenges. These challenges must be addressed by a highly skilled, well informed, technically qualified interdisciplinary teams.