Inf Syst Front (2012) 14:125–141
DOI 10.1007/s10796-009-9223-7

The enactment of risk categories: The role of information systems in organizing and re-organizing risk management practices in the energy industry

Susan Scott · Nicholas Perry

Published online: 16 October 2009

Abstract This research explores the role of information systems in risk management during a twenty year period when new governance arrangements led to enterprise-wide change in the UK energy markets. We present a longitudinal case study documenting the role of "A-Trade" transaction and risk management software in the adaptation of energy organizations to competitive demands associated with a simultaneous process of privatization and liberalization. During the design, development and implementation of A-Trade, multiple forms of expertise were brought together in what we describe as organizational encounters with risk. The story of "A-Trade" highlights the shift from a traditional engineer-led culture of risk cognition to market-oriented financial risk management. Our findings are that, firstly, that energy transaction and risk management software development provided an important learning ground during periods of paradigmatic change. Secondly, we provide insights into the enactment of risk categories and the challenges associated with establishing an information infrastructure to support risk management.

Keywords Qualitative IS research · Energy transaction and risk management software · Organizational change · Risk culture

S. Scott (✉)
Information Systems and Innovation Group,
Department of Management,
The London School of Economics and Political Science,
London, UK
e-mail: s.v.scott@lse.ac.uk

N. Perry
Independent Energy Risk Management Consultant,
London, UK
e-mail: pezen2@gmail.com

1 Introduction

Although the use of risk management in a broad range of organizational enterprise has gradually accelerated since the 1980s, the field of information systems has tended to focus on issues that were closer to home such as software risk management (Boehm 1991; Wiegers 1998) or the related area of project management (Drummond 1996a, b). This is both a surprise and a concern: a surprise because the transaction processing systems and report-writing so integral to the risk management "information infrastructure" (Ciborra et al. 2000) are well known to IS researchers; a concern, since the quality of information systems involved in risk management can prove pivotal to the realization of its goals (Harris 2006: 160–161). With a few notable exceptions that either provide high-level reviews (Gorrod 2004) or analysis of technical specifications (Austin and Samadzadeh 2008) relatively little is known about the role of information systems in risk management in specific organizational contexts. The motivation for this paper is to contribute an original longitudinal case study to an under-researched area and develop a better understanding of how risk management categories are entangled in particular risk cultures (Douglas and Wildavsky 1982) and forms of governance (Drori 2006) during periods of enterprise-level change.

The term risk management itself is subject to slight variations in definition; however it centres on activities that contribute to the assessment, mitigation and monitoring of identifiable risks so that the relationship between risk and reward can be optimized (see Bessis 1988: 3–15). Risk management reports should provide information that can be used to improve the way that organizations plan, fund and develop. The exact constitution of risk management changes by sector. For example, in sectors such as

manufacturing its activities may focus on using financial derivatives to manage interest rate, foreign exchange, and commodity cost exposure (Lam 2002). In high-reliability organizations (La Porte and Consolini 1991), such as a nuclear power station where acceptable risks may be zero, standards, check-lists and risk controls co-exist with an intense concern over safety trade-offs. In sum, while the underlying goals of risk management may be shared, the way in which it manifests is contingent upon the history, culture, and specific priorities found in each context.

There has been significant effort among practitioners and academics alike to formalize risk-oriented correlations into sets of principles and administrative procedures to support management. As a result, risk management methods have been developed to bring discipline and commonality to the various "visions of risk manageability" (Power 2007: 6) such as Value at Risk (VaR), Cost-Effectiveness Analysis, Risk–Benefit Analysis, and Cost-Benefit Analysis (see Leiss and Chociolko 1994: 40–42). This codification process has lent itself to the development of software and there have been increasing adoption of risk systems, particularly in financial services and other market-based sectors (Gorrod 2004). Ironically, the more pervasive risk management and risk systems have become, the greater the recognition that risk management is "about balancing processes and people" (Lam 2002: xiv). As we will go on to discuss, risk is often presented in seemingly objective, quantitative terms in formal risk management texts, however it is deeply socially constructed and its management goes to the heart of professional identity. In some sectors, the adoption of a new risk management method has segued with an existing risk culture and been reinforced by a sympathetic institutional logic. However, in others the introduction of new categories of risk represents a major transformation in organizational priorities and management practices. The case study that we present takes place in the energy sector during a transformation of governance and is an example of the latter.

The software package in our case study, referred to by the pseudonym "A-Trade" was developed in response to demand for risk systems to meet regulatory requirements associated with evolving market practices in the energy sector (Vasey 2004). The definition of requirements for this software highlights an encounter between two professional groups, engineers and financial market specialists, and illustrates how understanding of risk changed over time. A-Trade's story shows how these professionals drew together different risk management traditions to co-produce meaning and design work categories around which a new market system would be created (see Bugos (1993) for a description of engineering culture and Fusaro (1998) on energy risk management). As we trace the entanglement of A-Trade in the risk history of the energy sector, our field study provides insights into the following research question: What is the role of information systems in the re-organization of risk management practices?

We approach the study of energy transaction and risk management software from the perspective that risk is socially constructed (Berger and Luckmann 1967:3; Lupton 1999:14)[1] and build our work on the proposition that markets are made and not delivered a priori (see MacKenzie 2006). Considering the close relationship between the development of risk management and computer-based information systems, relatively little recent research focuses on information systems and markets.[2] The majority of IS literature either reviews the state of technology in particular areas of the financial markets (e.g. Fan et al. 2000; Levecq and Weber 2002; Gallaugher and Melville 2004; Weber 2006) or contributes a technical analysis of a domain specific issue (e.g. Leigh et al. (2004) on stock charting). Beyond this IS scholars tend to either use financial market case studies as an illustration of a current debate in the academic literature (e.g. technology acceptance research) or apply a construct from the financial markets to the broader IS domain (e.g. Benaroch (2002) on Real Options for IT risk management). Considering the intensely negotiated, political nature of market design there are surprisingly few qualitative studies of IS in financial markets.[3]

The A-Trade study draws attention to the influence of pre-existing organizational context and prior stocks of knowledge that shape assumptions about how risk is encountered. From this perspective:

> "Risk functions as an organizing category for management in general, a concept in whose name organizing and re-organizing activity is done…risk does not exist independent of management processes in organizations but rather representations of risk, its management, and the organizations that do the managing are co-produced" (Hutter and Power 2005: 9).

[1] In other words, the processes by which a taken-for-granted know-how congeals (see Berger and Luckman 1967:3) about risk management in organizations. From a social constuctivist perspective, risks don't lie outside of society and culture but are instead viewed as "assemblages of meanings, logics and beliefs cohering around material phenomena, giving these phenomena form and substance" (Lupton 1999 p.14).

[2] We wish to make a clear distinction here between research focusing on the broader financial services (e.g. banking, insurance, accounting) and financial *markets* (a way of gathering people for so that they can buy and sell (trade) financial instruments, commodities, or fungible items of value in a relatively troublefree manner).

[3] Notable exceptions include Drummond (1996a, b) on Taurus in the London Stock Exchange. While Barrett and Walsham (1999) are widely cited in IS research and many of their points are apposite their article focuses on insurance which falls within the broader financial services.

A-Trade was intended to enable a new approach to risk management and as a consequence it was not only deeply entangled in the initial encounters between the two different risk cultures within the energy sector, but also part of the on-going consequences of that encounter. In the next section, we review literature underpinning the conceptual foundations of the paper; this is followed by a brief description of our methodology, and then we present the A-Trade case study.

2 Conceptual foundations

Our conceptual scheme brings together the notion of categorical work with theories of enactment processes and enacted environments to help us illuminate implementation and translation issues involved in adopting a new transaction and risk management technology. The definition of these key terms necessitates a brief review of the source literatures from which they are taken: sensemaking (Weick 1979, 2001) and classification theory (Bowker and Star 1999.) The work of Karl Weick has proved seminal in the field of risk studies providing insight into the effort required for people to achieve mutual interpretation in situations where they have different cosmologies or social worlds. In our sub-section on encounters between different cultures of risk cognition we explore this idea further. Finally, we draw attention to the role of classification theories as intermediaries spanning these different social worlds and providing both conceptual and material organizing technologies with which to manage their membership.

2.1 Processes of enactment and enacted environments

As one of the central tenets of sensemaking, enactment (Weick 1988) has been widely used in organization and management studies literature. Recently, it has been applied to the analysis of efficiency audit practices (Radcliffe 1999); the reorganization of US intelligence (Orton 2000); the relationship between mental model of strategic thinking and performance (Osborne et al. 2001); closeness of customer-firm relationships (Danneels 2003); as well as leadership roles and team effectiveness (Hiller et al. 2006).

Enactment emphasises the link between cognition, action, and the social construction of organizations; it is both the process of making ideas, structures, and visions real by acting upon them and the texture of the reality that emerges from this process. As Weick says in his seminal work:

> "…when people act, they bring events and structures into existence and set them in motion. People who act in organizations often produce structures, constraints, and opportunities that were not there before they took action. Enactment involves both a process, enactment, and a product, an enacted environment." (1988: 307)

Weick (1988) identifies three key influences on the process of enactment: the degree to which actions reflect commitment to a cosmology of beliefs; the capacity associated with the repertoire of responses that is available; and the expectations or assumptions held. This is not limited to personal reflection, it is a multi-level experience in which organization members are constantly translating pieces of the environment into the organization and vice versa (Orton 2000). These sensemaking processes shape the way that organizational actors perceive a situation and therefore act upon it.

His analysis of enacted environments (1988, 1990) has been particularly influential in risk studies for those studying high reliability organizations (contexts in which crises become acute and visible). Enactment's particular contribution lies in highlighting how actors use models based on prior experience to overcome ambiguous situations in a reflexive, experimental process of deduction in order to find a response to fit events as they unfold. Along with Perrow (1984), he helped establish the principle that antecedents of events are present in organizations long before they erupt and that actors respond to crises with already existing knowledge (see Czarniawska 2005: 271).

One of the basic premises of sensemaking is that people have different cosmologies or social worlds that require mutual interpretation. Risk discourse bring this in to sharp focus as significant epistemological differences between disciplines studying risk emerge (see Table 1).

In his review of the risk literature, Renn (1998) notes that thirty years of study has not provided a commonly accepted definition for the term risk in either lay or scientific understanding. However, this has not dampened the effort put into the development of and procedures for risk analysis and risk management. Risk management agencies have called for audit procedures and systems of risk management to become a routine operation in diverse domains, for example health and safety, public policy, and environment studies (see Burger 1990; Adams 1995; Royal Society 1997).

As risk systems become formalised they tend to be imbued with technical language, symbols, and all the technologies of a professional world. In the face of so much assertive expertise it is easy to lose sight of a key insight explored by risk researchers: that risk models don't pre-exist, they have to be formed. Although we can't deny that risk has a realist edge (things explode, people die,

Table 1 Disciplinary cultures of risk cognition and their respective definitions of risk (from Scott and Walsham 2005: 310)

Disciplinary area	Definition of risk
Engineering and physical science	Probability times consequence
Psychology and cognitive science	A function of subjectively perceived utilities and probabilities of their occurrence
Economics and finance	Measurable uncertainty. Exposure times volatility
Health and safety	A chance or possibility of hazard, danger, loss, injury, or other adverse consequences
Sociological perspective of cultural theory	Danger that is socially defined and (in some cases) socially constructed
Integrated interdisciplinary approach	The possibility that human actions or events lead to consequences that affect aspects of what humans value

lights go out) what comes to be defined as risk in organizations is a social construction requiring in-depth understanding of context.

Analysing the processes of definition surrounding the emergence of, or changes in the nature of, a risk object is a central concern of risk studies. How things are defined matters because definitions, classifications, and categories get aligned with economic and political agendas (Bloor 1982: 290) that shape the development of society (see Hacking 2004). In his risk society thesis, Beck highlights controversies over the definition of "acceptable risk" by particular organizations and proposes that such phenomena are co-produced "across institutional and systematic boundaries, political, bureaucratic and industrial" (1992: 58–65). As Bowker and Star say:

> "If social scientists do not understand people's definition of a situation, they do not understand it at all. That definition—whether it is the label of deviant or the performance of a religious ritual—is what people will shape their behaviour toward." (1999: 289)

From this perspective, organizational risk objects are invented or constructed by participants in a particular culture or society and exist solely because people agree to behave as if they exist, or agree to follow certain conventional rules. Understanding context includes the broader socio-political environment in which the organization exists and the diversity of groups/sub-groups, individual differences within the organization itself. Forms of risk management:

> "…represent distinctive social constructions which must be understood as part of the organization of risk cognition in specific professional cultures of knowing. So an engineer sees it this way, an accountant sees it another, same goes for software designers, and risk managers." (Hutter and Power 2005: 8)

When representatives of different cultures of knowing are brought together in situations that bring the differences between their respective definitions of risk to the fore, an intensive process of sensemaking follows. If a way forward is to be found, invention and negotiation often have to precede interpretation. In our sub-section on encounters between different cultures of risk cognition we explore this idea further.

2.2 Encountering risk and its consequences for expert systems of classification

Hutter and Power propose the idea of "encountering risk" as a way of challenging "traditional accounts of the meaning and stability of risk management routines and practices" (2005: 11). The notion of risk encounters has been explored in a variety of studies including the rituals of risk and error at air traffic control and NASA (Vaughan 2005); the rise of the chief risk officer (Power 2005); and an examination of the different civic epistemologies surrounding Bhopal, BSE ('mad cow disease'), and 9/11 (Jasanoff 2005). This body of research takes seriously the pre-existing context of a risk encounter as well as examining the nature of organizational responses (or denials).

> "Encountering risk is above all an event of *problematization* which places into question existing attention to risk and its modes of identification, recognition, and definition". (Hutter and Power 2005: 11 original emphasis).

We use their approach as a form of risk hermeneutic, which follows a fluid process that we can divide into three broad phases for analytical purposes. A risk encounter could have a number of triggers but the central notion is that it marks an occasion when different expert lifeworlds are brought together. A process of problematization takes place in which competing definitions of risk are articulated leading to open controversy. This moves through multiple phases until some form of appropriation, accommodation or suppression of the risk category is achieved. The current understanding of that risk category is then taken-for-granted and folded into

everyday organizing processes until such time as it is disrupted again.

The cognitive conventions (Douglas 1985) associated with professionalized cultures of knowing give the appearance of being enshrined within static systems of classification. These classifications and the categories from which they are composed are evoked as the authority by which distinctive organizational forms and routine practices can be imposed on others. In order to study the way that these kinds of codifications of knowledge are achieved and used, we turn to classification theory and its emphasis on the processes of definition associated with categorical work. In their book, *Sorting Things Out,* Bowker and Star (1999) start from the premise that classification systems manipulate time, place, and definition into a set of categories so that work (bureaucratic or knowledge production) can be done. Citing examples ranging from the classification of diseases, viruses, tuberculosis, race, and nursing work their aim is to understand how people have designed and used classification systems. Following the science and technology studies tradition, they regard categories as historically situated artefacts and, "like all artefacts, are learned as part of membership of communities of practice" (Bowker and Star 1999: 287).

The main axis of their thesis is the contrast between the idealised requirements of a classification system compared with the practical complexities of their implementation and use (see Tables 2, 3).

Bowker and Star call for us to construct an analysis of how classification systems meet up with an emphasis on the fluid dynamics at work: "a plate tectonics rather than a static geology" (1999: 31). They suggest that the focus of such studies should be the work-arounds and interpretive flexibility of technological artefacts ranging from filing cabinets, to desktop folders, to software, and hardware:

> "Classifications are both conceptual (in the sense of persistent patterns of change and action, resources for organizing abstractions) and material (in the sense of being inscribed, transported, and affixed to stuff)." (Bowker and Star 1999: 289)

Bowker and Star (1999) explore this conceptual-material notion of artefacts by analysing longitudinal studies of political and semantic conflict at large levels of scale. We focus on a different level of analysis and examine the categorical work involved in the production of a piece of software that now forms a key part of the information infrastructure in high reliability organizations. We study the encounter between two risk cultures (engineers and financial risk experts) by following processes of "convergence" (Bowker and Star 1999:82) whereby information artefacts and social worlds are fitted to each other through "bricolage" to form the resources and tools of an information infrastructure.

3 Methodology

The A-Trade case study emerged as part of a broader project about IT-enabled credit risk management out of which a specific interest in risk history and market design of the UK energy sector grew. The material used to craft the story of A-Trade and its analysis is based upon a qualitative case study (Creswell 1998) within the broadly interpretive tradition of IS research (Walsham 1993). This methodology was deemed most appropriate for a research question that centred on multiple ways of understanding risk where events were within living memory of the participants.

The fieldwork was undertaken by the lead author in phases between 1997 and 2007. A total of 88 semi-structured interviews were conducted, details of which can be found in Table 4 in the appendix. The research participants were chosen to represent relevant stakeholder groups involved in key changes that took place in the UK energy markets and the development of software during this period (energy professionals pre/during/post market changes; ETRM software developers; ETRM implementation consultants; regulators; risk management professionals). The interviewees were identified by reputation; their standing and experience was cross-referenced through industry press and policy documents to ensure representativeness. A-Trade software was a mainstream ETRM product, a market leader, whose client list comprised a cross-section of EU and USA organizations. The interviews were recorded and transcribed straight away using conven-

Table 2 Differences between an ideal classification system and a classification system in practice (based on Bowker and Star 1999: 10–11)

Properties of a classification system	Classification systems in practice
There are consistent, unique classificatory principles in operation.	People disagree about their nature, ignore, or misunderstand them. Different and contradictory principles are routinely mixed together.
Categories are mutually exclusive	Disagreement or ambivalence may surround the membership of an object in a category.
The system is complete	Reasons are found to ignore data that would make a system more comprehensive. The boundaries of a system may be politically contentious.

Table 3 Encounters between different cosmologies of beliefs in the case study

De facto monopoly	Competitive markets
• Continuation of monopoly privileges	• Competition law against abuse of market power
• Ability to pass through costs	• Market liquidity a primary concern
• Self-sufficiency in physical assets a primary concern	• Enforceability of contract
• Continued utility value of gas, power	• Mandated access to infrastructure
• Efficacy of central planning	• Regulatory stability
• Efficiency of central dispatch and operational control	• Efficacy of profit motive
	• Efficiency of market signals + free agents
• Inward-looking frame of reference	• Market-oriented frame of reference

tional narrative notation (bold for raised voice, italics for emphasis etc).

In addition to field interviews, the corpus of data gathered included: internal X-Infra presentations and email exchanges, in addition to attending company events, and social gatherings where more informal discussions took place. During informal interactions, the authors would tell the contributing party that they were undertaking research on the energy sector and ask if they were comfortable being quoted. Their comments (along with their response regarding consent) were recorded in the lead authors' field journal notes. Research participants also sent historical documents from their private archives, which complemented the publicly available material and helped establish a "convergence of evidence" (Yin 2003:100)

During the data collection phase, we were vigilant for potential bias that may have arisen either because the interviews were conducted by the lead author or because the second author worked for a short period (1998–2001) as a strategy consultant with the company in our case study, X-Infra (a pseudonym). Firstly, repeating relatively standard questions (with appropriate tailoring) for each group of research participants and producing full transcripts so that interpretation could be re-visited was important in this regard. We believe that single attendance at the interviews was counter-balanced by the development of sound propositions tested by lived experience and advice on highly technical energy market risk management topics that this collaboration supported. Secondly, we reported preliminary findings to critical colleagues and actively sought out alternative explanations (Yin 2003: 62). In addition to this, we presented earlier versions of this paper at seminars in order to seek out other perspectives and test the robustness of our data interpretation.

Data handling involved basic sorting, coding, and inductive techniques informed by an adaptation of grounded theory (Strauss and Corbin 1998; Creswell 1998); frequency of data occurrence was weighed alongside distinctiveness and related to our respective stocks of knowledge. After discussion, both authors agree upon identifiable thematic data clusters: the meeting of two risk cultures; transfer of knowledge; innovative information systems design; the organizing processes surrounding its appropriation; and the consequences surrounding its eventual everyday use. Our theoretical foundations were assembled from the prevalent academic literatures on the social construction of risk in organizations (see Section 2.1 and 2.2). Then, inspired by the quotation in Hutter and Power's (2005) recent book *Organizational Encounters with Risk,* in which they refer to risk as an "organizing category" we developed a conceptual scheme that would act as a theoretical lens for our study of encounters with, and enactment of, risk categories.

In the next section, we give a brief overview of the energy sector and then present the story of A-Trade. This is a summary version of the case study providing chronological signposts and establishing context. However, it does not represent a summative presentation of the empirical evidence material from our longitudinal study. While we do not depart from the case study in the analysis that follows the case study, we attempt to overcome the restrictions of the journal format by providing further detailed narratives (Bruner 1986, 1990; Czarniawska 1998) to illustrate our points.

4 Case study: Introduction

The energy sector is a high reliability industry (La Porte and Consolini 1991), responsible for the management of potentially volatile commodities in fulfilment of a vital social contract. It has experienced wide ranging reorganization in recent years. Between 1985 and 1996, a process of liberalisation took place in the US and UK gas and electricity industries in which they were transformed from vertically integrated monopolies and re-organized along competitive lines (Fusaro 1998). Industry and academic literature has focused upon documenting the changing landscape and describing the introduction of market disciplines (Sioshansi 2002) shaping the operation and structure of the new energy world (Newbery 1998).

The information processing, analysis, and supervision involved in an engagement with market risk created a new industry in energy trading, transaction-processing and risk-management software (ETRM). Software developers working on financial markets soon shifted their attention to address the needs of energy organizations and by 1992 a handful of products had emerged of which "A-Trade" was one. We examine the role that A-Trade played in the inscription and enactment of what we refer to as risk categories used by actors as they forged a path through their new environment. This provides us with distinctive insights into the way that the structuring of technological artefacts is implicated in the trajectory of organizational and institutional change.

4.1 The story of A-Trade

Soon after it was founded in 1987, X-Infra, won a contract to provide consultancy and computing services for the foreign exchange division of a major company. Their foray into energy markets initially took the form of a one-off commission at a financial services company where X-Infra was already providing FX systems. During this period (1985–1996), the energy industry was forced to make major changes (see Table 5 in appendix) to accommodate regulation (FERC 636/888 in the USA and parallel developments in the UK) designed to introduce competitive dynamics into the monopoly based, vertically integrated gas and electricity industries.

Existing energy companies had to restructure both their physical and financial infrastructure; pipelines and power plants were sold off and those working in the sector had to cope with increasing demands for new skill sets in the pressurized context of rationalisation and redundancies. Exposure to competitive risk left energy organizations vulnerable to price swings and they turned to increasingly sophisticated financial tools such as futures and options (known as derivatives), for insurance against volatility. Derivatives contracts helped them lock-in the future profit margin of their product and protect themselves from an adverse change in prices on the open market. These financial tools came with their own models, language, and risk management paradigm and represented a significant shift in logic for an industry that had been built by engineers.

Electricity generators and the software companies that pre-dated liberalisation attempted to adapt their existing systems. However, it soon became apparent that the new environment demanded different tools. These environmental changes created a new market for software: "almost immediately, [energy organizations] began to demand risk management tools…It was the risk element that attracted financial risk management vendors…into the fray…as energy risk systems" (Vasey 2004: 12). When X-Infra formally launched A-Trade in 1995 they were in direct competition with products developed by major energy companies. Both sides experienced a steep learning curve. The capacity of A-Trade to provide user configured reports in a variety of output formats was highly valued by clients; A-Trade became the lead product in the energy industry capturing a significant proportion of the ETRM market.

By the late 1990s, X-Infra staff found that while they could sell A-Trade as 'best practice' software based on the expertise that they had acquired so far in the energy industry to small companies making their first steps toward new practices, they could not rest on their laurels at meetings with larger clients. To address growing demands for more sophisticated financial risk capability from clients X-Infra acquired a quantitative analysis firm, Prism. This enabled the sales team to re-package the 'at risk' risk measurement functionality into a separate module and consultancy service known by one word: "Analytics".

The success of A-Trade attracted venture capital investment leading to a merger with a strategic consultancy, called Ivy, and then a well received initial public offering (IPO). The resources that this generated were used to acquire rival and complementary software products in a bid to meet both their clients' and Wall St's expectations. However, in 2001 the trajectory of the energy industry then experienced a major blow with the collapse of Enron. In the period of reassessment and rationalization that followed the Enron shock wave, X-Infra made severe cost cuts. This included staff rationalization with a corresponding loss of product and industry knowledge as many of the original 'brains trust' that had championed A-Trade departed. The shortcomings of A-Trade as a hugely extended earlier-generation product were held up to scrutiny and X-Infra announced to staff that A-Trade would no longer be actively marketed and development resources would not be put into new functionality.

X-Infra executives made a strategic decision to focus the company's resources on one of A-Trade's rival products that they now owned as a result of their phase of acquisitions. The new product, Enterprise was based on a more technically advanced platform and would draw on the functionality of various products with the aim of providing a more reliable, modularised, scalable architecture with open interfaces. Although it survived the mega merchant collapse and the dot-com crash, X-Infra was significantly weakened. Their low stock price and steady maintenance revenue stream made them attractive enough to be acquired by a large international software company called Planet Software who subsequently ran X-Infra as a semi-independent division.

In the interregnum that followed, clients surprised both Planet Software executives and members of the original A-

Trade team by choosing A-Trade in preference to Enterprise. These sales were made to new clients as well as existing clients expanding their use in both the USA and Europe. The search for first generation clients willing to make the transition to the first version of Enterprise proved difficult; migration of functionality from Planet Software's product list was complex, and release dates were pushed back. This prompted Planet Software to re-think their product strategy and re-instate limited development on A-Trade to appease both existing and new clients, extending the life of the product.

A-Trade's highly touted advanced quantitative module, "Analytics" is not widely used by energy organizations—even those companies that bought it—and no longer stimulates sales in the same way that it did in the years when clients claimed they wanted a sophisticated financial risk system. Both financial services companies and energy organizations prefer to hold their own market view and utilise their own analytical tools. For some energy concerns, this has meant a retreat to "innate industry conservatism" (Fusaro 1998: xiii) using a partial range of the risk management tools that they have appropriated into their business environment, on the other hand banks have been setting up energy trading desks and are involved in increased speculative trading. The re-organization of the energy industry through the collaboration with financial services expertise and computing know-how has changed all those involved; however, the goals of liberalization have only been partially achieved, which means a further effort to translate market models into energy practice.

5 Analysis

We present our analysis of the A-Trade case study in a substantial section, which is divided into three sub-sections examining risk encounters, categorical work, and the relationship between the enactment of risk categories and information infrastructures. The conceptual scheme described in the methodology provides organizing principles for our discussion. While the case study above serves as an empirical 'base camp' to tell the basic story of A-Trade, we select further narratives gathered during our longitudinal fieldwork to both animate the points made in this section, provide evidence to support our line of argument, and address our research question: What is the role of information systems in the re-organization of risk management practices?

5.1 Risk encounters in an emerging risk industry: DOUG meets A-Guy

The transformation of the UK energy sector brought about enterprise-level change demanding translation between the episteme of engineers (Bugos 1993), who structured the functional basis of the energy industry, and the professional management charged with the responsibility for realising competitive potential. The schism between these two groups over the issue of risk management was particularly wide (Fusaro 1998) highlighting different interpretations of what constituted valid knowledge about the nature of risk and disputes over how to define acceptable risk.

Former monopolies had to shift from understanding market risk and competitive risk in an abstract, removed sense to directly experiencing it in a struggle for survival. On the one hand, Enron's use of market disciplines with its seemingly esoteric and complex mathematical definitions of risk became elevated to the status of 'dream standard' (McLean and Elkind 2003). On the other, they also had to come to terms with less glamorous tasks such as establishing audit trails, proving particular kinds of risk management capability, and trade lifecycle capture in order to meet new policy requirements.

A controversy over the definition of 'acceptable risks' (Beck 1992: 58) in an industry signals that it has shifted to a particular phase of modernisation, in which terms of engagement and focus of management attention are redefined. During the prelude to the privatisation of British Gas in 1985–1986, the Chairman Sir Denis Rooke initially resisted the political will to privatise, arguing there was no need to take his corporation out of public ownership, firstly because it was already profitable (one of the benefits of its monopoly status) and secondly because it was already as efficient as it could be.

X-Infra staff members describe tense encounters at the organizations where they first implemented A-Trade between traders and the "guys they called Doug". DOUG was an acronym that the traders used for "Dumb Old Utility Guy", experts at physical generation who were struggling with the introduction of traders into their world. A senior manager complained that he did not understand why the politicians and regulators were putting pressure on energy organizations to embrace a competitive market future: "we are safe; we are reliable; demand is rising; what's the problem?"

In years that followed liberalization, consumption of gas in the UK doubled, but manpower employed in the sector fell by 44% (a de-merged British Gas and its offspring companies shed close to 80% although, of course, at the same time losing market share along some parts of the value-chain). How could senior management have stood with such fixed determination by the integrity of their original claims? Because it made sense to them within their knowledge world, a traditional engineering viewpoint (Bugos 1993).

The sociology of knowledge suggests that there are multiple epistemic cultures (Knorr-Cetina 1999); groups

held together by a shared interpretation of what constitutes the valid basis for truth in the world. Each episteme is anchored to a cultural matrix of legal, political and scientific 'laws' that shape the way we define issues. The BG chairman's definition of efficiency was framed around entirely different issues to those advocating privatisation; and his colleague's world-view was focussed on risks conceived in entirely physical terms. Their standpoint, and that of the financial risk management professionals upon whose skills they had to call during liberalization, reflect divergent cultures of risk cognition. Table 3 summarises the different cosmologies at work:

Some aspects of the gas and power industries are immutable, irrespective of ruling epistemic culture; capital intensiveness; the extreme dependence on complex and relatively static infrastructure; the limited ability to store the commodity (ultra-limited in the case of electricity) and the many physical implications of this; the social importance of reliability in delivery to many classes of customer; the potential for significant safety hazard; all these features must be accommodated without compromise by any paradigm purporting to offer a coherent market model.

Aside from sheer scale, two primary problems confronted the engineers: ensuring the reliability of complex networks to a high standard; and meeting peak demand, which in conditions particularly of extreme weather could exceed average demand many times over for short periods. The engineering solution to the twin problems of reliability and peak demand tended to be the commissioning of overcapacity and redundancy of physical infrastructure on a grand scale.

Proponents of the neo-conservative free markets cosmology saw gas and power as any other physical commodity, to be bought and sold under competitive market conditions using their definition of efficiency and consumer benefit. The challenges of reliability and peak demand were to be met by reliance not only on own capacity, but also by transacting with the wholesale market that would in due course emerge, and become liquid. This represented a huge conceptual leap, in the face of strenuous, apparently authoritative 'technical' assertions that the physical realities made gas and power inherently different from 'conventional' commodities.

Culturally the financial risk managers were convinced that their logic was naturally superior (McLean and Elkind 2003) to the conservative engineering based ethos of the energy managers (Fusaro 1998). The highly paid financial risk management consultants would draw parallels between the politicians granting monopoly status to engineer-run energy concerns and "Stalin", while the modestly compensated energy managers referred to the former as "arrogant yuppie bastards".

As Hutter and Power (2005: 8) say, analysis of risk and response to risk is constructed in the context of its managerial culture and interests. Inevitably then, the two cosmologies were mutually contested, with an open question as to whether the free market programme was in practical terms workable at all. Gradually those with the most entrenched engineering mindset either retired or left the sector. Those that remained began to engage with the challenge of co-producing stocks of knowledge that would be translated into the design process for emerging energy markets.

It was not only knowledge about business processes that was being re-organized, physical spaces were changing too as energy producers assembled risk management trading floors (in many cases set up by former-Enron employees often on the job market as a result of their "rank and yank" human resource policy (see Grey 2003). Regulations in the new competitive environment required energy production to be separated from the generator's retail function; when A-Trade staff asked traders at energy organizations how this was being put into practice they tapped the plasterboard above their desk: "We built a wall". When an A-Trade Presales VP arched her eyebrow, the trader continued: "Its all right, we have separate toilets too". This slightly humorous incident is both indicative of the forced way in which regulation was being translated into practicable measures and how crude the basic reorganization processes were in the beginning.

Management attention in the energy sector had to concern itself with how to capture value in the industry, how to make a market drawing upon a portfolio of specialisms of varying availability, and how to adapt to different market appetites for risk (Lam 2008). New entrants, regulatory changes and consumer choice reconfigured relationships forcing market participants to re-think their business approach.

Beck (1992) maintains that as organizations attempt to manage modernization processes, like the liberalization of the energy and injection competitive risk into the sector, opportunities are created for new risk industries. These industries offer the promise of control and rational order in the midst of uncertainty. Such claims usually play on hopes and desperation rather than assured capability because product development, particularly software, can only take place at the same pace as the production of knowledge about risk:

> "Any client signing up was signing up for potential. No one had a known product at this point. We had to say that we had the risk solution, but practically speaking we had to get it together and assemble it with other products. It took a long time." (VP Product Management, A-Trade)

Although some basic risk management techniques were in use, key parts of the knowledge formation necessary to enable further implementation of more advanced risk categories were entangled in an encounter between two different professional risk cultures. The A-Trade pre-sales team describe awkward conversations and the steep learning curve that accompanied the first software implementation projects:

> "In the early days, the [A-Trade] demo became the place to educate vendor staff about how a swap works, how a futures contract works. It was like a 'risk management 1.01' course."

If they were to market A-Trade as boundary spanning technology, X-Infra managers realised that the way they represented themselves to clients had to be managed sensitively. Their main competition was software developed by energy organizations whose knowledge claim was their extensive domain expertise; they tended to represent their company with stock photography, the "solution" headlines, and logos consisting of refract geometric shapes, mathematical formulae, or similar abstract symbolism.

In typical small company style, the head developer of A-Trade was also asked to design marketing material for it; in order to differentiate from the competition he designed "A-Guy" and called the advertising campaign 'The evolution of risk management':

> "The cartoon showed four stages, a Neanderthal cave man with a club, Yeoman empire soldier with a pike, WW2 paratrooper with a gun, then the fourth one was an FX guy in a suit looking quite proud of himself standing next to a computer screen with his arms crossed. He is a nice sort of sandy haired guy, rumpled suit, life in IT and finance, people would yell at him, but he'd do his darnedest to get it sorted out. The A-Guy is this nice guy who'll come and fix your sh*t. You can even abuse him a little and he won't get in your face. He'll ask you what he is doing wrong then he'll stay up all night and fix it to make your system work. We put him on the splash screen that appeared when you start up the system and he appeared every week in trade rags".

The willingness to engage in sensemaking with others and skilful handling of membership to multiple communities of practice are important moves toward categorical work: the artful integration of worlds to achieve a new system of work and stabilise it so that it can be routinized.

> "We made the software flexible and there was flexibility in the staff. If there was a hole in a battleship, we'd stay up all night and patch it. We brought FX to the party, that was our thing, so we'd say to the energy folk, 'You tell me how energy is done. This is *your* area of expertise'. Of course after a while we knew a lot about energy and would prove it in different situations but fortunately we never got all those people in the same room at the same time, so we weren't busted!"

Having described the context and professional identities involved in the definition of emerging practices in the energy industry, in the next sub-section we explore the move from articulation to categorical work in more detail to show how encounters with risk can shape the emergence of risk categories.

5.2 Categorical work and the co-production of risk objects: "Getting the dog in the bath tub"

When X-Infra was founded in the late 1980s, financial services were moving from automating transaction processes to systematizing and linking them to core business principles. Whereas reconciliation of accounts and assessment of risk positions had been produced on spreadsheets (automated ledger books) by accountants on a monthly or quarterly basis, there was increasing pressure to have more accurate analyses of exposure as well as identifying opportunities to achieve efficiencies. This coincided with the systematic application of economics-based approaches such as such as Transaction Cost Theory and Value-at-Risk across the corporate financial landscape (Froud et al. 2006). These methodologies required computing power capable of crunching numbers and reports to provide digestible management information.

The original FX system that the X-Infra founders wrote was designed around this agenda and represented its codification of trading-floor back office practice. Screens would prompt staff to insert information that conformed to a standard trade transaction format, for example: book, counterparty, product, date, volume, and price. This classification system formed the foundation of subsequent development work undertaken by X-Infra including the energy transaction and risk management software commissioned by their FX client.

While few banks had a commodities desk, energy formed part of the portfolio of financial brokerages and asset management organizations such as X-Infra's client. Unlike an energy generator, this company was not interested in marking the price of energy to its cost of production. Instead, the requirements specification was designed around the concept of mark-to-market. In other words, they needed software that would record the details of each energy contract entered into including its current price or value at the relevant financial exchange (e.g. the New York Mercantile Exchange or International Petroleum

Exchange) on a daily basis in order to calculate their profits and losses. This was an approach pioneered by Jeff Skilling and others at Enron (McLean and Elkind 2003), but in 1992 it was a highly specialised approach within a niche market.

We quote the head developer for the energy system at length here as he describes how A-Trade developers annealed together financial categories of risk with local energy practices during the design process:

> "The development process involved sitting side by side with guys from the trading desk and finding out what they did. 'What does an oil ticket look like? How do you build a forward curve?' We had to codify the world of commodities, define everything, and bring a whole new pricing methodology to bear. In FX everything you trade is independent; there are bellwether currencies that other currencies tend to follow, but in effect on any day there is no necessary correlation between any two currencies. In commodities that is not the case. There are physical tetherings in energy pricing that have to be taken into account when you are designing a screen. They'd tell me 'natural gas needs to go here, but you've got to show all its different locations' or 'we'll need oil here, but you have to define all the different grades'. So, you have to take FX and jump it up a notch…the physical aspects of the commodities that they were paper trading led to all these new concepts that weren't part of FX." (Head of Development, A-Trade).

Bowker and Star define the categorical work described above as "the juggling of meanings, memberships, and naturalization" (1999: 310–311) emphasising that categories are not just the achievement of skilled action, but also the articulation of relationships. The convergence of the underlying FX risk management principles into energy business processes required both the physical design of prototype screens as well as a further round of collaboration with a new generation of energy personnel who, unlike DOUGs, were willing and capable of understanding how FX worked for their industry. In other words, as the head developer of A-Trade put it: "It takes more than one person to get the dog in the bath tub."

Although this effort was undertaken under the banner of "risk management", in most instances the categories that were being inscribed still represented the fundamental back office accounting needed to enable it (for example, tracking the trade lifecycle). In this regard, A-Trade functioned as a best practice checklist and education package for novice trading organizations all rolled into one. Energy managers knew that the industry was moving toward more extensive use of financial risk management tools, but switching their emphasis from the reliability of physical assets to robust information infrastructure designed to support their use was a longer journey than either they or software companies like X-Infra imagined. The Product Development VP at X-Infra said that:

> "[Infra-X] would sell the product with risk management as the pot of gold at the end of the rainbow. We'd say, 'Lets focus on getting your trades in and then we'll do all this risk stuff.' By the same token, a lot of people went shopping for a back-office system, then were able to check off a box with their execs to say they were also getting full blown risk system… We had to say we had the risk solution, but practically speaking we had to get it together and assemble it with other products. It took a long time".

One of the challenges that slowed things down was the diversity of energy contracts and lack of standards (Vasey 2004:14), which meant that A-Trade developers had to ensure the software design was increasingly configurable. The reporting writing tool that had been the centrepiece of their original FX trading system once again proved very valuable as the demands of their clients (and the external consultants that they employed to help them define their needs) shifted. Using the report writer would neither create nor destroy work, but instead radically reshape it to fit the emerging matrix (Bowker and Star 1999: 231). Effectively the A-Trade report writer acted as a boundary object; once installed at the client site the report writer was used to satisfy the informational requirements of both energy concerns and the financial risk management system of classification. It was:

> "…plastic enough to adapt to local needs and constraints of the several parties employing [it], yet robust enough to maintain a common identity across sites…. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities." (Bowker and Star 1999: 297)

By 2000, the design and development of A-Trade had become thoroughly entangled in the enactment of managerial approaches to risk. There came a point where X-Infra were only able to sell the basic A-Trade system as "plug and play" software to "less knowledgeable" small companies still in the process of re-organization making their first steps toward new practices who were "terrified of competition, terrified of consultants, terrified of change" (VP A-Trade Pre-Sales). As the head of A-Trade development put it:

> "They told us they wanted a risk system, so that they could turn around and say 'We had procedures, recording policies, we were looking out'. But really what they needed was a secure Excel to keep track

because if their spreadsheet jockey dies or loses radio contact it is big trouble. Once they understood, they realised 'Why should we let anyone tell us how to define risk in our business?"

However, management at X-Infra and their more advanced clients simultaneously realised that basic trade lifecycle capture and the use of VaR to double-check against their own spreadsheet figures wasn't enough. X-Infra hoped that more advanced risk categories could be included within the A-Trade product by incorporating the advanced quantitative capability provided by their acquisition of Prism and promoting X-Infra's capacity to support the development of proprietary management approach to risk. They realised:

"People have different needs, different problems. It was getting hard to have one risk solution. In fact we began to call risk 'Analytics' because risk as too broad a term. What passed for as risk management when we first sold [A-Trade] was pretty much a basic report to show how their financial instruments hedged their physical exposure. But energy managers were now saying: How do I model a generator? How do I model a coal-fired generator versus a nuclear-fired generator? How do I look at my entire load on the energy industry? How to I model the impact of weather on electricity. This was an industry growing up." (VP Product Management)

In the next section, we analyse the maturation of managerial approaches to risk management and the role that A-Trade has assumed in the energy industry as part of the "information infrastructure" (Ciborra et al. 2000) that supports it.

5.3 The enactment of risk categories, shifting management attention, and information infrastructure

A-Trade is not used in a uniform way by its client base, indeed even within a single organization it may be used to perform various roles. This is explained to some extent by the diversity of organizational profiles in the energy industry and owes much to the interpretive flexibility of technological artefacts (Orlikowski 1992); it is well known that innovations make departures from the intentions of their original design as they are folded into context and become appropriated as part of situated practice (see Suchman 1987). However, in the case of A-Trade we suggest that its story evolved alongside the co-production of risk objects described in the previous sub-section, shifting management attention, and processes of enactment (organizational legacies, events, changing institutional environment) that have shaped its use.

We suggest that the low adoption rate of Analytics risk categories reflects their users' sensemaking-in-crisis. The majority have abandoned the advanced financial risk management "Analytics" module either because the unsettled period after the mega merchant collapse has made them retreat from using sophisticated financial risk management approaches or because they prefer to use in-house resources to develop proprietary risk models.

The categorical work involved in this phase of A-Trade's development overwhelmed some (particularly smaller) clients who fell back on their conservative repertoire of responses. The mathematical explanations of the risk categories in the Analytics module exceeded their needs, which could be met by using the A-Trade report writer to produce localized versions of their existing limited use of Value-at-Risk models. Staff redundancies and departures significantly weakened the human resources at X-Infra (and later Planet Software) capable of educating this group of users and helping them to model long term legacy contracts and translate them into structured equivalents.

The mega merchant collapse engendered significant uncertainty in the energy industry and in the "expectation" (Weick 1988) of further instability many companies backed away from speculative trading (so closely associated with Enron's business model). The loss of the industry's primary market maker meant, Enron, brought adverse conditions for trading activities (for example, poor liquidity, lack of opportunities to hedge long term contracts). Trading personnel were downsized and in some cases energy companies closed whole trade desks. Instead of exploring ways of making trading a key driver for their business, management attention was fixed on surviving events and the competitive risks that followed in their wake.

The larger or better resourced companies continued their use of financial risk management approaches, but didn't pursue A-Trade's Analytics capability because it demanded a commitment of expert resources from both their own team and X-Infra that were in scarce supply. As discussed, they had also reached the stage where they preferred to define the risk categories that they used in their contracts from first principles for themselves. As Bowker and Star (1999: 72) say, all classification systems are developed within a context of organizational practice and it is important for the definition of working categories to be owned by the users and the cosmology in which they must be enacted. A former Ivy financial risk management consultant made an analogy between buying A-Trade as a 'risk management solution' and believing that by simply buying a workout video you can lose weight:

"In the early days, clients sort-of-knew they needed 'risk management' (whatever ***it*** was) and hoped it might be achieved by buying the software (like

> buying a workout video 'to lose weight'). But there comes a point where the person realises that it is not enough, they have to change their way of life (maybe including a video, but mostly through acquiring and acting upon a genuine understanding of how to look after themselves properly)." (original emphasis)

However, users prepared to use advanced risk management methods were the minority and for the most part energy managers no longer felt they could afford to give expansive programmes of financial risk management innovation their attention. What the Enron debacle did do was reinforce their previous interest in operational risk; pre-liberalization this centred on reliability of physical assets, now their definition of operational risk encompassed the "information infrastructure" (Ciborra et al. 2000). While users were unable to appropriate the Analytics risk categories, A-Trade's back office trade capture system had assumed a significant role in the re-organization of many energy organizations and achieved sufficient stability to become naturalized in energy firms. The customised FX categories became 'part of the furniture', so much so that when X-Infra tried to remove A-Trade from development both clients and the original A-Trade team (now ex-employees) felt that they did not understand how important the product had come to its users.

Clients had suffered a long and arduous journey in order to make A-Trade part of their professional practice. They had localised the software in ways that were not communicated in the formal specifications or generalized market assessments carried out by Planet Software managers unfamiliar with fine-grained usage of the product. When they implemented A-Trade, clients were forced to go through an uncomfortable phase of definition work, but once installed A-Trade became part of what defines their work practices. Clients are not yet ready for a new product because A-Trade is still part of the organization of the "information infrastructure" (Ciborra et al. 2000) within energy firms.

The back office A-Trade functionality had become "local" (Bowker and Star 1999: 193). Ironically, the more familiar and standard the requirements surrounding the management of an information infrastructure become, the more deeply A-Trade patterns the installed base of each organization. The myriad of work-arounds and organization specific adaptations coded by the report writer have created inter-dependencies that connect A-Trade to relationships of time and place. In the end, the way that problems are framed introduces:

> "relationships between representations [and] work… the look and feel of being in a place and using a genre of representations…how wires, people, and bits are put together in a large organization" (Bowker and Star 1999:192–193).

We take a metaphorical turn here and re-introduce A-Guy. Whereas the logos of rival companies (abstract geometric shapes, mathematical formulae etc.) remained unchanged during their bid to be the "risk solution" of choice for energy organizations A-Guy went through numerous transformations. His prototypical "FX guy" blue suit, tie, and brown shoes appearance went through an officially sanctioned adaptation for the physical energy product screens where he was accessorised in a hard hat and muddy boots. However, behind official backs, A-Guy went through various incarnations either at the hands of bored programmers, cheeky consultants, or power users: unofficially he wore cowboy boots and a Stetson in the southern USA; a turban in the London office; he sported Christmas outfits in the appropriate season; and in France (where staff have protested in the streets against moves to liberalize energy organizations) he appeared on screens with arms crossed posing in front of the Arc de Triomphe.

The search for a "risk solution" and the attention focused on the concept of risk management acted as a "forensic resource" (Douglas 1990: 1) for those involved. By framing organizational change activities as risk projects managers are announcing a call to action. Businesses tend to be sluggish and resist regulatory influence, but risk holds a different place in organizational sensemaking, its evocative, threatening nature urges a more proactive re-ordering of meaning. Other interests are attracted by the resources that risk agendas generate and 'hitch a ride'. The key words of "risk management" may have helped managers secure a budget for A-Trade, but our research shows that one of the ways it has been used has been to develop a basic operational, transaction-processing infrastructure.

On both theoretical and practical grounds, risk studies teach us that we should not find this so unusual. Bowker and Star (1999:320–322) emphasise that categorical work is both organizational and informational; it is always embedded in practice and the act of classification is an infrastructural practice. The role of fundamental organizational information systems in mitigating risk is often overlooked. Although they are far removed from the hubris of regulatory changes and risk events, Perrow (1984) and Weick (1988) would argue that these routine, daily information-processing systems play a key role in the mindful management of organizations.

6 Conclusions

We present a longitudinal case study documenting the progress of a leading energy transaction and risk manage-

ment software package, called A-Trade, from inception to its integration within the "information infrastructure" (Ciborra et al. 2000) of key energy organizations. The research question driving the study focuses on understanding the role of information systems in the re-organization of risk management practices. One of our key findings is that designing energy transaction and risk management software provided an important learning ground for managers during periods of regulatory change.

During the design and development of A-Trade, managers from different professional epistemic cultures (Knorr-Cetina 1999) joined together to produce and transform prior classifications of risk so that new risk categories could be embedded in a software package. We suggest that this kind of categorical work (Bowker and Star 1999: 310) is fundamental to making risk management information systems work in context by serving as a site of negotiation and invention as regulatory requirements are worked out in practice. The sales and implementation projects played a particular, unexpected, role in professional education, (re) training, and organizational change. We maintain that this is because ETRM are codifications of a full risk management paradigm, much of which must be adopted more-or-less in canonical form in order to run the software at all.

It is sometimes assumed by those that are not familiar with markets (commodity or otherwise) that their design and regulation develop in a clinical context using highly rational, best-fit criteria. The value of our longitudinal case study lies in the way that it highlights changes in a sector over time and the influence of political ideology on the design of markets. It is important for practitioners to be aware that their organizations (and indeed their careers) may be subject to 'new-paradigm vogue'; that when risk paradigms shift in a sector its prescriptions become mandatory whether understood or not—indeed, whether truly applicable or not.

Each new change in market governance and regulation stimulated management 'projects' in energy organizations many of which centred on new categories of risk. The term risk (like safety in other contexts), energises management, releases budgets and triggers a need to validate actions by seeking best practice consensus. When a risk or regulation project is announced, it creates a bubble of demand for software packages and a flurry of effort. Other interconnected interests often 'hitch a ride' on the budget that is found for it; in our case study, risk project budgets did not result in a vibrant, efficient spot market for energy, but extensive work was undertaken to ensure compliance, audit, and reporting . Since both effective trading activities in markets and risk management depend upon robust "information infrastructure" (Ciborra et al. 2000), it is possible that this has created capability that might hold potential for the future. In other words, if the energy markets experience another paradigm shift, it may be these pathways for compliance and reporting (rather than the highly promoted risk analytics) that are A-Trade's lasting contribution to the emergence of competitive, efficient energy markets.

Appendix

Table 4 Profile of fieldwork interviews

Profile of interviewee (organized by group)	Number of interviews
Energy Professionals (pre/during/post-market changes)	
Central Electricity General Board	5
Regional electricity generators	4
UK National Power (Grid)	5
A-Trade Sales and Marketing	6
Electronic Energy Trading Platform (Senior Vice President, Business Development and Sales)	4
ETRM Software Implementation Consultants	
Energy Organization (Implementation and use of ETRM software)	6
Energy Market Strategy and Design Consultants	7
A-Trade Implementation and Project Management	5
X-Infra Strategy Consultant	6
X-Infra VP Business Development	4

Table 4 (continued)

Profile of interviewee (organized by group)	Number of interviews
Regulators	
Energy regulators (USA, UK, Norway)	4
NETA Designers/Consultants	6
ETRM Software Developers	
Founder Members of A-Trade	6
A-Trade Design and Development	4
Risk Management Professionals	
Energy exchange (Chief Operating Officer; Chief Risk Officer; Chief Information Officer; Chief Executive; Director of Business Development)	4
UK Clearing House (CEO, Director of Energy Clearing Services)	4
Wholesale Power Generator, Director Credit Risk Management	2

Table 5 Major events in the energy industry mapped onto case study chronology

Major events	Case study chronology
1985 FERC 436 and consequent 'flight to spot' in US spot	
1986 oil price collapse	X-Infra founded 1987
1989 introduction of electricity Pool in England and Wales	
1992 FERC 636	1992 first version of A-Trade developed for financial services company
1994 start of power trading in the USA	1995 X-Infra markets A-Trade product
1998 advent of competition and collapse of wholesale price in German power market	
2000 new gas interconnector between UK and continental Europe starts to have impact on UK gas price and brings liquidity to Zeebrugge	1998-9 X-Infra acquires Ivy, Prism, etc 2000 X-Infra IPO
2001 NETA (in UK power)	
2001 Enron bankruptcy	
2002 energy merchant sector collapse	2002 X-Infra stops development work on A-Trade
2003 start of recent sustained oil price surge	2003 Planet Software acquires X-Infra
2004 aberrational forward-market events in UK gas and power	
2004–2005 financial players and hedge funds commence really large-scale energy trading	
2005–2006 Russia interrupts gas supplies to Ukraine, Italy, and other European countries	2005 Planet Software resumes development of A-Trade
2005–2006 oil forward curve moves into contango at front end	2006 New clients purchase A-Trade

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Susan Scott is a senior lecturer in the Information Systems and Innovation Group, Department of Management, at The London School of Economics and Political Science. Her research focuses on the role of information systems in the transformation of work practices with particular emphasis on the financial services sector. Susan has published on: IS and risk management; electronic trading; the strategic organization of post-trade services; organizational reputation risk; enterprise resource planning and best practice. Her background includes a B.A. in History and Politics of Africa (SOAS), MSc. in Analysis, Design and Management of Information Systems (LSE), and a Ph.D. in Management (University of Cambridge).

Nicholas Perry is an independent commercial and risk consultant working in the energy industry. Prior to consultancy he worked in commercial functions in major energy companies, and was a Board Director of Enron Europe Ltd and of Teesside Power Ltd. He has advised energy companies, energy users, governments and market regulators in Europe and the USA, and written extensively on energy and risk