How the energy sector could get it wrong with cloud computing

Robert K. Perrons[1, 2]
[1]*Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia*
[2]*Centre for Strategy and Performance, University of Cambridge, United Kingdom*
E-mail: perrons@alum.mit.edu

(Received 11 November 2014; Accepted 26 February 2015)

Abstract

Cloud computing has significantly impacted a broad range of industries, but these technologies and services have been absorbed throughout the marketplace unevenly. Some industries have moved aggressively towards cloud computing, while others have moved much more slowly. For the most part, the energy sector has approached cloud computing in a measured and cautious way, with progress often in the form of private cloud solutions rather than public ones, or hybridized information technology systems that combine cloud and existing non-cloud architectures. By moving towards cloud computing in a very slow and tentative way, however, the energy industry may prevent itself from reaping the full benefit that a more complete migration to the public cloud has brought about in several other industries. This short communication is accordingly intended to offer a high-level overview of cloud computing, and to put forward the argument that the energy sector should make a more complete migration to the public cloud in order to unlock the major system-wide efficiencies that cloud computing can provide. Also, assets within the energy sector should be designed with as much modularity and flexibility as possible so that they are not locked out of cloud-friendly options in the future.

Keywords: Cloud computing, Energy industry, Public cloud

1. INTRODUCTION

Although the literature offers several competing definitions (e.g., Kushida *et al*., 2011; Motahari-Nezhad *et al*., 2009; Zhang *et al*., 2010), cloud computing is essentially a model for delivering convenient, on-demand network access to configurable computing resources—like, for example, networks, servers, storage, applications, and services—that can be shared by many people, and that can be procured and released relatively easily. Despite the lack of convergence on a single definition, however, few would disagree that it has begun to transform significantly a broad range of industries and academic disciplines (Cherry, 2009; Kuo *et al*., 2011; Marston *et al*., 2011; Sterling and Stark, 2009). Many aspects of the energy sector are already being impacted in several important ways by this technology (Khayyam *et al*., 2013; Perrons and Hems, 2013a; 2013b), and a major consultancy has gone so far as to say that the energy industry's move towards the cloud is "inevitable" (Accenture, 2012)[1]. Zhang *et al*. (2010) identify several popular reasons for migrating functions and capabilities to the cloud:

- No up-front capital investment. Because of the pay-as-you-go pricing model associated with cloud computing, users of these services do not need to invest in information technology (IT) infrastructure to start reaping the benefits of this technology. Instead, customers can rent cloud-related services and facilities according to their needs at the time.

- Reduced operating costs. Customers can acquire and unload cloud-based IT resources relatively easily and quickly to meet their peak load requirements, thereby allowing them to save on operating expenses by letting them pay for the right amount of capacity at a particular moment in time rather than paying for peak-scenario capacity that might rarely get used.

- High scalability. Providers of cloud infrastructure make it possible to scale up resources very rapidly, which in turn makes it possible to handle the kinds of extreme demand variability that sometime arises from "flash crowd effects" and content that goes "viral" unexpectedly.

- Ease of access. Because cloud computing resources are typically web-based, they can be accessed through any device that can connect to the Internet. Thus, in addition to desktop and laptop computers, cloud infrastructure can be accessed through a broad range of devices such as mobile phones and tablets.

- Transferring business risks and maintenance expenses. By using infrastructure rented from external providers, a customer of cloud services effectively shifts their business risk—like, for example, the possibility of hardware breakdowns—to organizations that are potentially more specialized in the provision of these services, and who are therefore in a better position to manage these kinds of risk.

[1]It is worth pointing out that the relationship between IT and energy goes two ways. In tandem to the discussion addressed in this paper about the changes that cloud computing and other IT-related innovations will have on the energy sector, another discussion is emerging in the literature about how the IT sector is using more and more energy as new technologies like cloud computing are adopted in the marketplace (Berl *et al*., 2010). For example, Garimella *et al*. (2013) point out that the overall consumption of electricity in the world's data centers in 2009 was comparable to the total electricity production of Australia. As important as that topic is, however, the energy efficiency with which these emerging IT capabilities are provided is not the focus of this paper.

Despite the broad appeal for cloud computing, however, the move towards these technologies and services has happened very differently from one industry to the next. Some industries—like, for example, the telecommunications and financial services sectors—have absorbed the technology in an aggressive way, while others have moved much more slowly.

The energy sector has generally been among the slower moving adopters[2]. Many parts of the energy industry have made demonstrable progress towards cloud technologies (Beckwith, 2011; Bochman, 2013), but this headway has often been in the form of private cloud architectures instead of public ones (Accenture, 2012; Feblowitz, 2011), or hybridized approaches that bring together cloud and existing non-cloud IT systems (Mathieson and Triplett, 2011; Mearian, 2012). However, by moving towards cloud computing in a very slow and tentative way, the energy industry may prevent itself from reaping the full benefit that a more complete migration to the "public cloud" has brought about in several other industries.

This short communication is intended to explain how the energy sector's recurring habit of absorbing innovations more slowly and cautiously than other industries may significantly dampen the benefits that cloud technologies and services can potentially provide. First, I will outline three common business models and three types of system architecture through which cloud-based resources and capabilities can be delivered to customers. Then I will put forward evidence showing that, on average, the energy sector tends to behave like a "slow clockspeed" industry that approaches new technologies much more slowly and cautiously than many other sectors. Next, I will point out that the energy industry is exhibiting this same type of risk-averse behavior with regards to cloud computing, and explain that this approach that will quite likely erode much of the benefit that could otherwise be delivered by this technology. I will then conclude with two recommendations for the energy sector: (1) to move more boldly toward the public cloud in the way that several other sectors have in the face of similar technical challenges; and (2) to design new assets in the industry with as much modularity and flexibility as possible so that they are not locked out of cloud-friendly options in the future.

2. MODELS FOR PROVIDING CLOUD-BASED INFRASTRUCTURE AND CAPABILITIES

Cloud computing is an evolving technology that will undoubtedly continue to change in the years ahead but, as shown in Figure 1, three service models currently dominate the market:

- Infrastructure as a Service (IaaS). This offers web-based access to computing power and storage. In this model, the customer does not need to control or manage the cloud infrastructure behind the functionality, but they do have control over the deployed applications and security.

[2]This is not to suggest that every company within the energy sector has been slow to embrace this technology. Emerging anecdotal evidence (e.g., St. John, 2013) suggests that renewable energy providers might be embracing cloud computing technologies more quickly than other parts of the energy industry.

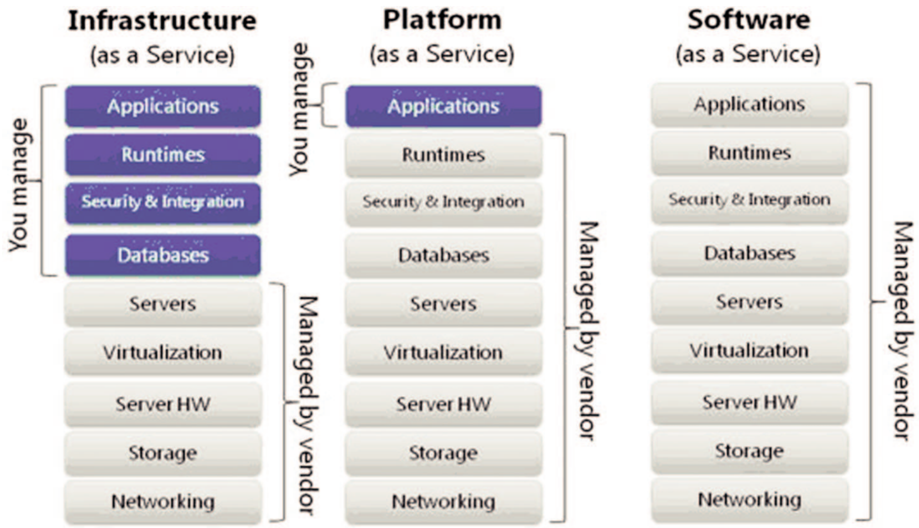

Figure 1. Popular models of cloud computing services (CIO Research Center, 2010).

- Platform as a Service (PaaS). This option gives developers the tools that they need to build and host web applications.

- Software as a Service (SaaS). This highly integrated model offers applications that are accessible from various client devices through a thin client interface like, for example, a web browser (Jin *et al*., 2010). All of the elements behind the scenes are managed by the vendor.

3. TYPES OF CLOUDS

As shown in Figure 2, there are basically three kinds of cloud systems available to would-be customers: public, private, and hybrid. Public cloud architectures can be accessed via the Internet, and are typically set up and managed by commercial providers (Sotomayor *et al*., 2009). Among the advantages of this approach is the fact that these systems are extremely reliable, and customers enjoy nearly infinite scalability with regards to the size of their cloud. Also, because of the global nature of the Internet, public clouds can potentially be sourced from any one of the myriad vendors around the world who offer them.[3]

[3]I do acknowledge that there are some barriers that might make it difficult to use cloud computing resources from overseas providers. There are, for example, jurisdictional concerns about some kinds of data, and a growing number of countries have laws pertaining to the transferring of customer information, medical records, and copyrighted items across international borders (Armbrust *et al*., 2009). But these are non-technical barriers rather than an inherent limitation of the technology itself.

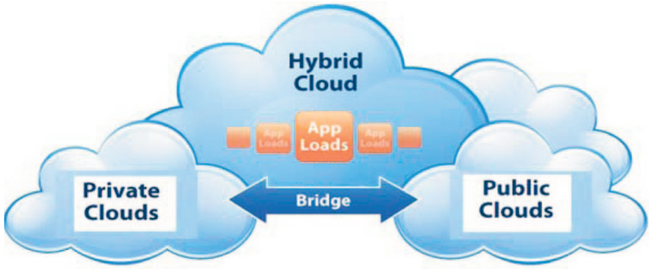

Figure 2. Types of cloud computing architecture (Ramsey, 2013).

But the case for public cloud solutions is sometimes overshadowed by security risks—or, perhaps more importantly, the perception of security risks.[4] Private clouds are one solution for minimizing these kinds of hazard. Whereas public clouds are accessible through the Internet, private cloud architectures try to provide much of these same types of functionality, but within private IT infrastructure that falls entirely within the customer's administrative domain.

Hybrid cloud architectures have emerged as a way for customers to manage these security-related risks while offering the customer some of the enhanced scalability that the public cloud can deliver. And hybrid systems have also been a popular transition strategy that allows customers to move towards the public cloud while contending with legacy systems, or as a stepping stone until software vendors are prepared to offer versions of their products that properly fit into public cloud architectures (Perrons and Hems, 2013a).

But hybrid cloud solutions do have several notable shortcomings. While they do offer some of the scalability, "outsourceability," and cost efficiency of a totally public cloud, these improvements are eroded significantly in a hybrid architecture by the inherent limitations of the private elements of the system. In this way, these mid-ground solutions do help to overcome a few of the concerns that have been raised about cloud computing—but they also detract considerably from the additional value and capabilities that these technologies are capable of delivering.

4. ENERGY SECTOR'S SLOW RATE OF ADOPTION FOR NEW TECHNOLOGIES

This lukewarm adoption of cloud computing technology is not out of character. Although the energy sector's past has been punctuated by brief periods of bullishness with regards to innovation (e.g., Priest, 2007), much of the industry's history can be fairly characterized as "slow clockspeed" where new technologies are concerned. The concept of industry clockspeed has emerged within the literature to reflect the fact that

[4]Companies frequently feel more at ease if their data is safely within their own company's IT infrastructure instead of the public cloud, but Armbrust *et al*. (2009) rightly point out that encrypting data before putting it in the cloud may actually make it more secure than storing unencrypted data within a company that is not quite as focused on IT security.

different sectors tend to evolve and change at significantly different rates. Conceptually similar to the "high- and low-velocity" characterization put forward by Nadkarni and Narayanan (2007a), an industry's clockspeed is essentially the rate of change that occurs within an organization's external business environment (Mendelson and Pillai, 1999). Because of the quick pace with which they release new products, the athletic footwear and semiconductor industries are high-profile examples of fast clockspeed sectors (Fine, 1998). By stark contrast, the commercial aircraft and petrochemical sectors are notoriously slow to change, and are widely considered to be slow clockspeed industries.

There is some disagreement in the literature about exactly how to define clockspeed, but a few measurement constructs have been proposed, including the average life cycle of products within an industry (Blackburn *et al*., 2004), the number of IT-related tools used to connect collaborating team members and suppliers (Mendelson and Pillai, 1998), and the rate at which organizational structures are changed (Nadkarni and Narayanan, 2007b).

The energy industry tends to behave in a slow clockspeed way with regards to new innovations because the sector is "unusually large, diverse, and complex" (Newell, 2011), and because it often attracts an uncommon amount of political sensitivity when changes are proposed (Deutch, 2011). As Lester and Hart (2011) observe, it "typically takes at least several years to move a new energy technology from 'proof of concept' in the laboratory to full-scale demonstration, and many more years or even decades before that technology can achieve significant market penetration" (p. 26). Figure 3 shows that the upstream oil and gas industry develops and deploys new innovations much more slowly than many other sectors, but this slow rate of technological evolution also tends to be true of almost every other part of the energy ecosystem, from nuclear to coal to electrical power transmission (Lester and Hart, 2011).

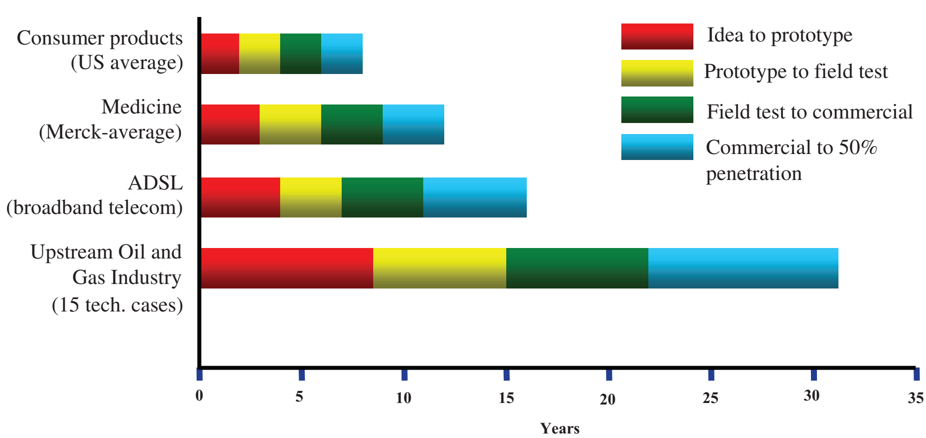

Figure 3. Rates of Technological Change in Different Industries (Ching, 2005).

5. CONCLUSIONS AND RECOMMENDATIONS

In light of the industry's track record for being slow to adopt innovations, it is somewhat unsurprising that many firms in the energy sector have been approaching cloud computing in a rather tentative and measured way. Many companies in the industry have preferred to aim for private clouds instead of public ones (Accenture, 2012; Feblowitz, 2011) or hybridized architectures that combine cloud and non-cloud IT systems (Mathieson and Triplett, 2011; Mearian, 2012). But as noted earlier, by moving towards cloud computing in this way, the energy industry is almost certainly preventing itself from yielding as much benefit as possible from cloud computing technologies and services. Other sectors like healthcare and retail faced many of the same technical and regulatory issues that the energy industry is wrestling with on its journey to the public cloud—like, for example, data security, technical bottlenecks resulting from massive volumes of data, and legal problems arising from moving data across international borders—but still found ways to overcome these challenges and realize the full potential that this technology can deliver (Perrons and Hems, 2013a; 2013b). To unlock the major system-wide efficiencies that cloud computing can provide, the energy sector should do the same.

What is more, the consequences of the industry's relatively tepid approach to cloud computing may be amplified by the fact that, once installed, assets in the energy sector tend to last for a long time (e.g., Hewlett, 1992; Reed, 2014). As Lester and Hart (2011) suggest, "much of the existing energy infrastructure (e.g., power plants, refineries, transmission networks, and residential and commercial buildings) has a lifetime of many decades. This mammoth infrastructure, like any long-lived capital, turns over very slowly" (p. 26). It therefore follows that the consequences of today's design decisions within the energy sector will have a considerable amount of momentum behind them, and that the high-level architectures of assets in the decades ahead will be influenced by the choices being made right now. By stark contrast, gains in computing power and efficiency have historically unfolded at an impressive rate (Grove, 1996)—or, at a minimum, at a rate that is considerably faster than the average pace of technological evolution within the energy industry. It is therefore reasonable to assume that many of the technical issues making the public cloud seem risky to the energy sector today will probably be overcome in the short- to medium-term future. System architectures within the energy industry should therefore be constructed with as much modularity and flexibility as possible so that they are not locked out of cloud-friendly options in the years ahead.

ACKNOWLEDGMENTS

Special thanks to John Bradley and Adam Hems from Microsoft, and Parviz Peiravi from Intel for several of the insights and ideas discussed throughout this paper.

REFERENCES

Accenture, 2012. *A new era for energy companies: Cloud computing changes the game*. White paper published online. Accessed on 31 January 2014 from http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-New-Era-Energy-Companies-Cloud-Computing-changes-Game.pdf.

Armbrust M., Fox O., Griffith R., Joseph A.D., Katz R.H. and Konwinski A., 2009. Above the clouds: A view of cloud computing. Technical Report no. UCB/EECS-2009-28. University of California at Berkeley, Department of Electrical Engineering and Computer Sciences.

Beckwith R., 2011. Managing Big Data: Cloud computing and co-location centers. *Journal of Petroleum Technology* **63(10),** 42–45.

Berl A., Gelenbe E., Di Girolamo M., Giuliani G., De Meer H., Dang M.Q., *et al*., 2010. Energy-efficient cloud computing. *The Computer Journal* **53(7),** 1045–1051.

Blackburn J.D., Guide V.D.R., Souza G.C. and Van Wassenhove L.N., 2004. Reverse Supply Chains for Commercial Returns. *California Management Review* **46(2),** 6–22.

Bochman A., 2013. Securing mobile, Big Data and the cloud in the energy sector. Retrieved 7 January 2014 from http://www.greentechmedia.com/articles/read/securing-mobile-big-data-and-the-cloud-in-the-energy-sector.

Cherry S., 2009. Forecast for cloud computing: Up, up, and away. *Institute of Electrical and Electronics Engineers Spectrum* **46(10),** 68.

Ching P.D., 2005. Rates of technological change in different industries. Mr. Ching was the Vice President of Upstream R&D within Shell International Exploration & Production. He showed this slide in a keynote presentation at the SPE-IADC Conference 2005 in Houston, Texas.

CIO Research Center, 2010. SAAS, PAAS and IAAS – Making cloud computing less cloudy. Retrieved 5 January 2014 from http://cioresearchcenter.com/2010/12/107/.

Deutch J.M., 2011. The crisis in energy policy. Harvard University Press, Cambridge, Massachusetts.

Feblowitz J., 2011. Oil and gas: Into the cloud? *Journal of Petroleum Technology* **63(5),** 32–33.

Fine C.H., 1998. Clockspeed: Winning industry control in the age of temporary advantage. Perseus Books, Reading, Massachusetts.

Garimella S.V., Persoons T., Weibel J. and Yeh L.-T., 2013. Technological drivers in data centers and telecom systems: Multiscale thermal, electrical, and energy management. *Applied Energy* **107,** 66–80.

Grove A.S., 1996. Only the paranoid survive: How to exploit the crisis points that challenge every company and career. Currency-Doubleday, New York.

Hewlett J.G., 1992. The operating costs and longevity of nuclear power plants: Evidence from the USA. *Energy Policy* **20(7),** 608–622.

Jin H., Ibrahim S., Bell T., Qi L., Cao H., Wu S., *et al*., 2010. Tools and technologies for building clouds. In Antonopoulos, N. and Gillam, L. (Eds.), Cloud Computing: Principles, Systems and Applications. Springer, London, pp. 3–20.

Khayyam H., Abawajy J., Javadi B., Goscinski A. and Stojcevski A., 2013. Intelligent battery energy management and control for vehicle-to-grid via cloud computing network. *Applied Energy* **111,** 971–981.

Kuo M.H., Kushniruk A. and Borycki E., 2011. Can cloud computing benefit health services? A SWOT analysis. *Studies in Health Technology and Informatics* **169,** 379–383.

Kushida K.E., Murray J. and Zysman J., 2011. Diffusing the cloud: Cloud computing and implications for public policy. *Journal of Industry, Competition and Trade* **11(3),** 209–237.

Lester R.K. and Hart D.M., 2011. Unlocking energy innovation: How America can build a low-cost, low-carbon energy system. MIT Press, Cambridge, Massachusetts.

Marston S., Li Z., Bandyopadhyay S., Zhang J. and Ghalsasi A., 2011. Cloud computing–The business perspective. *Decision Support Systems* **51(1),** 176–189.

Mathieson D. and Triplett C., 2011. Are there clouds in our blue sky research programs? *Journal of Petroleum Technology* **63(9),** 16–18.

Mearian L., 2012. Shell Oil targets hybrid cloud as fix for energy-saving, agile IT. Retrieved 7 January 2014 from http://www.computerworld.com/s/article/9225827/Shell_Oil_targets_hybrid_cloud_as_fix_for_energy_saving_agile_IT.

Mendelson H. and Pillai R.R., 1998. Clockspeed and Informational Response: Evidence from the information technology industry. *Information Systems Research* **9(4),** 415–433.

Mendelson H. and Pillai R.R., 1999. Industry clockspeed: Measurement and operational implications. *Manufacturing & Service Operations Management* **1(1),** 1–20.

Motahari-Nezhad H.R., Stephenson B. and Singhal S., 2009. Outsourcing business to cloud computing services: Opportunities and challenges. *Institute of Electrical and Electronics Engineers Internet Computing* **10,** 1–17.

Nadkarni S. and Narayanan V.K., 2007a. The evolution of collective strategy frames in high- and low-velocity industries. *Organization Science* **18(4),** 688–710.

Nadkarni S. and Narayanan V.K., 2007b. Strategic schemas, strategic flexibility, and firm performance: The moderating role of industry clockspeed. *Strategic Management Journal* **28(3),** 243–270.

Newell R.G., 2011. The energy innovation system: A historical perspective. In: Henderson R.M. and Newell R.G. (Eds.), Accelerating energy innovation: Insights from multiple sectors. University of Chicago Press, Chicago, pp. 25–47.

Perrons R.K. and Hems A., 2013a. Cloud computing in the upstream oil & gas industry: A proposed way forward. *Energy Policy* **56,** 732–737.

Perrons R.K. and Hems A., 2013b. Cloud computing: What Upstream oil and gas can learn from other industries. *Journal of Petroleum Technology* **65(2),** 74–81.

Priest T., 2007. The offshore imperative: Shell Oil's search for petroleum in post-war America. Texas A&M University Press, College Station, Texas.

Ramsey M., 2013. Hybrid cloud strategies and trends. Retrieved 5 January 2014 from http://www.golime.co/blog/ bid/183532/Hybrid-Cloud-Strategies-and-Trends.

Reed S., 2014. Shell says earnings will decline 48%. *New York Times*, January 18 issue, p. B2. Also published on the New York Times' web site on 17 January 2014 with the slightly different title "Shell Says Quarterly Earnings Will Fall 48%". Accessed on 23 January 2014 from http://www.nytimes.com/2014/01/18/business/energy-environment/shell-issues-profit-warning.html.

Sotomayor B., Montero R.S., Llorente I.M. and Foster I., 2009. Virtual infrastructure management in private and hybrid clouds. *Institute of Electrical and Electronics Engineers Internet Computing* **13(5),** 14–22.

St. John J., 2013. IBM's cloud platform for Indian renewable energy. Retrieved 8 January 2014 from http://www.greentechmedia.com/articles/read/ibms-cloud-platform-for-indian-renewable-energy.

Sterling T. and Stark D., 2009. A high-performance computing forecast: Partly cloudy. *Computing in Science & Engineering* **11(4),** 42–49.

Zhang Q., Cheng L. and Boutaba R., 2010. Cloud computing: State-of-the-art and research challenges. *Journal of Internet Services and Applications* **1(1),** 7–18.