energetics

THE FUTURE OF ENERGY MANAGEMENT IN THE DIGITAL ECONOMY

ARTICLES IN THIS EBOOK

FROM THE CEO

The headline, breakthrough technologies in recent years have been dominated by renewables and the progress towards cost effective, higher capacity battery storage. However we are increasingly seeing discussion around the influence of blockchain technologies and the possibilities for peer-to-peer energy trading – a further, future potential shakeup that could influence the shape and form of Australia's energy markets, which are already experiencing an unprecedented transformation. In this ebook we look at the trends and how they may impact the management of energy, the way we work and the new opportunities that may become available to consumers.

An aspect of energy and carbon management that Energetics is watching ever more closely, please feel free to contact the authors if you have any questions or comments on the role of innovative technology driven solutions to Australia's energy and emissions reduction challenges.

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Bitcoin tracking to consume more energy than NZ

Written by Rob Rouwette and Jean-Philippe Nemlich

January 2018

Cryptocurrencies like Bitcoin operate on a peer-to-peer network with no central authority, such as a bank or government to approve transactions. To prevent fraud, the nodes in the Bitcoin network ensure integrity by agreeing on the validity of one another's transactions independently via 'consensus'. Bitcoin settles transactions through a proof-of-work algorithm in order to stimulate nodes to validate third-party transactions. Participants (miners) are rewarded by the creation of new currency. Proof-of-work relies on miners racing to solve increasingly complex mathematical problems to validate blocks of transactions. Bitcoin mining has created an arms race of competing computational power, involving dedicated server farms and huge energy consumption. In this article we discuss the outlook for such models and their application of blockchain technology, and the implications for global emissions.

There has been considerable press recently about the energy intensity of Bitcoin mining and the Bitcoin industry. Estimates of the energy used per Bitcoin transaction in 2017 vary greatly, from 94kWh to 270 kWh, enough to power an average Australian household for 6 to 17 days[2], or drive a Tesla Model S P100D from 450 km to 1350 km. Globally, the cumulative energy consumption to run the Bitcoin system has risen rapidly and at the end of 2017 was estimated at around 37 TWh per year[3] or 0.17% of global electricity consumption. This is approaching the entire electricity consumption of New Zealand[4].

The emissions challenge is a function of the emissions intensity of the electricity consumed: based on the NSW emissions intensity of 0.95 kg CO_2-e per kWh[5], this would result in approximately 35 million tonnes CO_2-e annually. If all Bitcoin miners were based in NSW, they would be Australia's second largest emitter, after AGL Energy Ltd, which reported 43.8 million tonnes CO_2-e in the 2015/16 NGER reporting year[6].

Based on a notional electricity cost of AUD 0.05/kWh, a single Bitcoin transaction in December 2017 would cost between AUD$4,70 and AUD$13,50 in electricity consumption alone. Given that the actual average transaction costs have risen to more than AUD $25 in December 2017[7], a rough estimate of electricity costs might be plausible. Although impossible to provide exact calculations, we can conclude that the emissions and transactional costs associated with Bitcoin are not insignificant.

Sustainable Bitcoin mining?

Could the answer to this problem be renewable energy-powered Bitcoin mining? A number of Bitcoin mining farms in China's Sichuan province are powered by hydro-electric plants, and arguments have been made for solar-powered Bitcoin mining in areas where solar power is cheaper than grid electricity.[8] Although renewable energy sources have low lifecycle emissions, they are rarely available in abundance. In Sichuan's case, the Chinese government is developing plans to improve connections between the local grid and neighbouring grids to make better use of Sichuan's excess hydro capacity. Given global emissions reduction targets, new renewable energy capacity would arguably be better used to displace fossil fuels rather than power new Bitcoin farms. In what could be an important precedent, in early January 2018 Chinese authorities announced plans to limit the cryptocurrency mining industry's electricity use[9].

Do the indirect benefits from Bitcoin mining and validation make up for the high emissions?

As of early 2018, the market value of Bitcoin had fluctuated significantly over a period of a few days, and whilst still very high at around AUD$21,000 (down from a peak of AUD$26,000 a few weeks before)[10], the possibility remains that this is a bubble that could burst, given that the currency has no intrinsic value, relatively few real-world applications and such high energy use and transactional costs.

Bitcoin's value mainly stems from its popularity as the number one cryptocurrency, its decentralised and secure nature, and its potential as an equity investment. Blockchain technology is seen as a potential backbone for a transaction layer for the Internet-of-Things. But for any blockchain technology to support a Peer-to-Peer (P2P) economy (e.g. in energy trading), it needs to be able to handle a large quantity of micro-transactions and do this securely, fast and in a cost-effective manner. And in order for blockchain-powered P2P trading of energy to contribute to emissions reductions it arguably needs to use a transaction algorithm that is more sustainable and cost-effective and with much lower transaction settlement latency than Bitcoin's.

If not Bitcoin (or even blockchain), then what?

An underlying problem for many proof-of-work systems (including Bitcoin's) is that they require clients to do useless work, such as inverting a hash function. This means that a lot of resources, mainly electricity, are wasted. To mitigate the loss, some alternative coins use a proof-of-work system where the work performed is actually useful.

Ethereum, until recently the second biggest virtual currency, uses a similar Proof-of-Work algorithm to Bitcoin, but has plans to change to a more energy-efficient Proof-of-Stake algorithm. Instead of consuming computing power to validate transactions, Proof-of-Stake requires existing currency to be put in escrow as a guarantee against fraud. The energy consumption of Proof-of-Stake is negligible, but the algorithm means that only those wealthy enough to stake resources are able to validate transactions, effectively creating a plutocracy[11].

Towards the end of 2017, another digital currency started to challenge the pre-eminence of Bitcoin. XRP is the native currency of Ripple, a real-time settlement system backed by a number of major financial institutions, including Santander, UBS and Westpac. Like Bitcoin, XRP uses blockchain technology to power its ledger, but unlike other crypto-currencies it isn't a 'trust-less' system relying on the mathematics of proof-of-work to validate transactions. Instead it uses a consensus protocol that requires users to extend trust to validating servers, and ultimately to the Ripple company, which acts as the central issuing authority. Ripple argue that their currency is less energy-intensive, faster and more scalable than Bitcoin, but critics point out that, unlike other crypto-currencies, the Ripple model is highly centralised[12].

DAG (Directed Acyclic Graph) is emerging as one of the main competitors to blockchain technology. DAG is a new technology without blocks or miners, which aims to be efficient, lightweight and scalable. In DAG every new transaction must verify one or more previous transactions, resulting in a structure that is a finite directed graph with no directed cycles. DAG claims to solve many problems that blockchain technology has to date. There are no miners, hence none of the costs or emissions associated with mining. Moreover, unlike most blockchain-based systems that are relatively slow, DAG allows making hundreds of thousands of transactions per second.[13] Today, projects like IOTA[14], aim to create a secure and decentralised financial ecosystem for the Internet-of-Things using DAG technology.

The energy consumption and associated emissions of Bitcoin mining are significant and unsustainable at the current rate of growth. This makes Bitcoin and other Proof-of-Work-based blockchains ill-suited to powering P2P energy trading, where emissions reductions can be a key goal. Other technologies such as Proof-of-Stake or DAG offer the promise of lower energy use, reduced transaction costs and latency and improved scalability, but remain relatively unproven in real-world applications. Given the opportunities that exist for innovative products and services, we expect this to change rapidly over the next few years.

Blockchain (n)

A distributed ledger, a list of transactions that is replicated across a network of computers, rather than being stored in a single database on a central server. Each computer (or node) on the network stores its own copy of the blockchain, and when a new transaction is recorded every node creates their own updated version of the transaction to achieve consensus. Blockchains use cryptography and digital signatures to authenticate transactions and enforce access rights[1]

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What can Blockchain technology bring to the electricity grid of the future?

Written by Jean-Philippe Nemlich, Rob Rouwette, Alister Alford

Blockchain is disrupting our financial systems with the rise of cryptocurrencies like Bitcoin. It is being heralded as "the foundation of the Internet of Value"[1]. The decentralised, secure nature of blockchain makes it highly useful for recording transactions, and eliminates the need for a trusted party to facilitate digital relationships. It is seen as a potential backbone for a transaction layer for the Internet, yet how does this impact conventional business models? Furthermore, what impact will it have on our energy systems? Will a distributed ledger alter how we create, purchase and use energy? What impact, it any, could it have on emissions?

In this article, Energetics reviews the current thinking around the potential impacts of blockchain in the context of Australia's changing energy mix.

What is the role of blockchain in peer-to-peer trading?

Imagine a time when every resource can become a service that is dynamically traded on an open market. Your solar panels, home battery storage and electric vehicle all communicate with each other and with smart appliances such as thermostats, air conditioners, fridges, dishwashers and washing machines. The 'chatter' is not only in your home but also in your neighbourhood, precinct and city, with the purpose of finding the optimum (lowest cost) energy behaviours. The Internet-of-Things (IoT) enables the scaling of a peer-to-peer (P2P) economy.

With this technological capability we see a platform for innovative business models to emerge. The IoT has made the P2P model more viable and lately, cryptocurrencies are some of the most talked about exponents of the virtualisation of the economy. Virtual currencies are not created by a central banking authority; instead, the creation of new currency and the recording of transactions between parties is managed in a decentralised manner, for example through a blockchain.

What impact will peer-to-peer trading have on electricity markets?

In the current electricity market, consumers are connected to producers through retailers. If you have solar panels on your roof and are generating excess electricity, you cannot sell this electricity directly to your neighbour. Instead, both parties need to go through a retailer in order to trade. With the number of prosumers (a person who both consumes and produces items such as electricity) increasing as more people install solar panels, this trading principle is coming under pressure due to the inherent inefficiency and associated cost of transactions. P2P trading is a logical development, and it appears to be within reach with the emergence of a new communication and transaction framework.

Peer-to-peer economy

A Peer-to-Peer (P2P) economy is a decentralised model whereby parties interact to buy or sell goods and services directly with each other, without intermediation by a trusted central authority[2]. As mediation carries a transaction cost, P2P trading is ideally suited to trading that involves small transactions. However, removing the third party from the transaction carries a greater risk that the provider may fail to deliver, that the product will not be of the quality expected, or that the buyer may not pay. So P2P trading requires scalable, decentralised and secure systems to authorise, execute and record transactions and to provide the trust that the central authority would offer in more traditional economic models. Ideally these systems would have low transaction costs, as trades can be small in value and high in volume.

Furthermore, what will really drive the need for the 'grid-of-the-future' is the increased share of intermittent (renewable) energy sources combined with a large number of smart appliances and small-scale electricity storage units that will undoubtedly become part of the building landscape in the next decade. The IoT has the potential to be the backbone of a smart grid, creating a much more efficient system where demand and supply of electricity are matched through artificial intelligence (AI) and micro-transactions. Traditional energy retailers will have to adapt their business models in order to be profitable in this new environment.

As the 'grid-of-the-future' becomes more intelligent and increasingly efficient at utilising resources distributed across the network, the current regulatory models for funding the operational and capital expenditure on distribution and transmission networks will need to adapt to fully enable these benefits. Under a highly distributed model the 'grid-of-the-future' is poised to experience growing pains similar to the current rebalancing of large scale generation sources and maintenance of system security. The concentration and nature of the ownership of these network resources presents a significant challenge to establishing an appropriate regulatory framework.

What is the impact of blockchain and peer-to-peer trading on greenhouse gas emissions?

In order for blockchain technology to be useful in the context of a smart grid, it needs to be able to handle a high volume of micro-transactions in real-time. For example, the algorithm that underpins the Bitcoin system requires vast quantities of computational power, making it incredibly power-hungry and unsuitable for running the transactions in a smart grid. However, there are already various other cryptocurrencies or virtual tokens either in existence or under development that are much more energy efficient. It can be expected that the energy required for running the system will only be a fraction of the total energy that is traded, and thus the additional emissions will be quite small.

More importantly, creating a smart system allows us to make better use of available (intermittent) resources, predict behaviour (supply and demand) and transact energy accordingly. As a result, distributed ledgers enable the grid of the future with high penetration of renewables and millions of prosumers active in P2P trading.

So it appears that the contribution to emission reductions is more likely to be indirect. What should be more significant is the pricing mechanism that peer-to-peer trading enables which could accelerate the transition to renewables and batteries.

In conclusion, there is not a simple answer to the question of whether blockchain-enabled P2P trading of electricity will result in emissions reductions, rather that the impact will be indirect by enhancing the business case for small-scale solar PV and batteries.

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Can the changing nature of work contribute to mid-century emissions reductions?

Written by Dr Mary Stewart

Energetics' first flexible working contract was awarded in 2007. Since that time we have transitioned to being a company that has approximately 50% of our work force on some form of formal flexible working conditions, ranging from reduced hours to set working from home days. We are very good at enabling our people to work flexibly while still protecting the boundaries between work and home.

Only recently however has the linkage between our ability to enable our people to work flexibly and our core business of assisting Australia's largest energy users to transition to a low carbon future become apparent. Given the amount of work that the built environment and infrastructure will have to do to meet our mid-century targets under the Paris Agreement, the changing nature of work should not be overlooked.

What is the magnitude of the emissions reduction challenge?

In 2016 Energetics undertook a significant piece of work on modelling emissions reductions to 2030 for the (then) Federal Department of Environment[1]. You can read more in the National Energy and Climate Policy Centre on our website. Our work indicates that a cumulative total reduction of 963 Mt CO_2-e by 2030 is possible. For the purposes of this article, the opportunities from the report have been aggregated into different sectors to build Figure 1. The sectors considered in this figure have been chosen to specifically draw out the emissions reduction potential of changing where and how we work. For this reason the following sectors are defined:

- Commercial built environment and infrastructure/the built form, including commuting
- Transport, freight transport and air transport
- Residential
- Industrial which has a broad definition including agriculture, manufacturing and resources
- Energy generation
- Land use and land use change
- Waste and water management

Figure 1 demonstrates that, after land use and land use change, the sector which has the greatest potential to contribute to Australia's emissions reduction challenge by 2030 is the built environment.

Underlying constructs

This information is based on analysis of emissions reductions requirements and potentials to 2030. Of interest here are the opportunities listed below which relate to the changing nature of work, and the changing infrastructure requirements which will underpin this change.

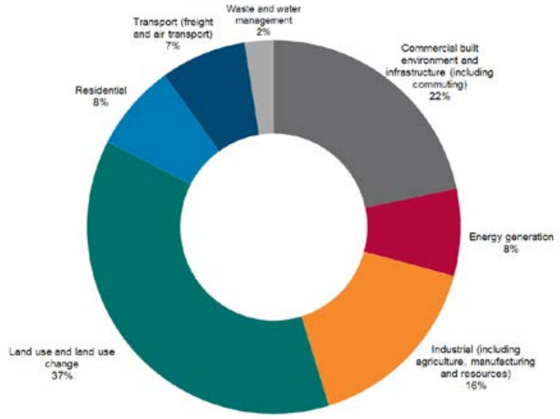

Figure 1: Cumulative contribution of sectors to emissions reduction by 2030

In the work conducted to date the impact of the changing nature of work to 2030 is projected to be limited. At the same time using commercial buildings differently by changing how we choose to work could contribute some of the total impact of new builds on emissions reductions which is 14 Mt CO_2-e (or 1.5% of total emissions reductions). This would suggest that the impact of changing working conditions could contribute between 3% and 5% of total emissions reductions required to 2030 to ensure we are on a trajectory to meet our 2oC target in 2050.

Table 1: Abatement potential

Group	Opportunity	Cumulative abatement potential by 2030 - (Mt CO_2-e)	Contribution to total (%)
Low carbon precincts	Integrated urban transport	10.2	1.1
	Precinct scale design	16.3	1.7
Digital Infrastructure	Smart hubs/teleworking	2.3	0.2

How flexibility can help

In order to assess whether this is a fair reflection of how changing how and where we work has the potential to contribute to emissions reductions we need to look at what flexibility has the potential to change.

What does working differently look like?

It is easy to refer to 'the changing nature of work', it is in trying to define what this means that the challenge lies. The aspects which are most likely to impact emissions are:

- **Going to work to meet, not to work:** how many times do you hear people say "I'll work from home today; it's the only way I get stuff done."? Increasingly we will see people going into the office for fewer days and fewer hours in the day.
- **Reduced transport requirements for commuting**
- **Increased intensity of use for residential buildings**: where people do work from home, to a great extent this needs to be underpinned by adequate access to data.
- **Potential for regional hubs of co-working spaces** will grow where people find it difficult to work from home, or preferable to leave the house.

Impacts on the built form

Currently large commercial buildings are constructed to service a 40 hour work week. They typically are at peak energy (and emissions) loads for 60 hours a week; with significant effort invested in reducing energy and emissions from the building for the remaining 108 hours of the week. We chose to construct large buildings which are designed to be essentially vacant for more than 50% of their life. There are standards that require that the emissions intensity of the built form is understood and reduced (such as GreenStar), but the fact remains that the majority of building stock is still constructed using steel and concrete, both of which are emissions intensive. As we look to 2050 we need to consider intensifying how buildings are used, potentially reducing desk space and focussing on meeting areas – but also considering how we might make a building 'work' 168 hours a week, and not only 60. That way we will get better return for the emissions we invest on constructing the buildings in the first place.

Impacts on transport infrastructure

Changing how and where we work could reduce the total emissions impacts of transport by simply reducing the number of trips taken. Although it is unlikely to be so straightforward, as public transport would continue to operate irrespective of the number of commuters (within reason). Two effects could result:

- **A reduction in commuters and a reduced load on public transport**. The potential does exist for people to switch more readily from cars to public transport.
- The **impact of electric vehicles may be reduced** as people make fewer trips.

The overall impact is likely to be reduced use of roads and lower vehicle emissions.

Impacts on residential emissions

As people choose to work more frequently from home, the efficiency of our current residential building stock will come into question. The potential exists for emissions to increase as people use less efficient heating and cooling technology at home than they do at the office. The ability to address these impacts is much reduced compared to a corporation's ability to address their impacts on climate change, and may need to form a part of work from home conditions. An example here is that companies may require you to undertake a home energy audit or emissions assessment as part of a work from home agreement.

Impacts closer to home

The potential also exists for changing work arrangements to enhance the growth of regional hubs and co-working spaces, and reduce the number of people who head into the office. We have seen some evidence of this where restaurants have opened their doors as co-working spaces during the daytime when they are usually closed. These buildings are now utilised for more than 80% of the working week, as opposed to many commercial buildings which are utilised for well less than 40% of a week.

Understanding the potential opportunity

How people choose to work in the future has potential to help Australia in meeting our mid-century targets. Moving the focus of commercial buildings to being on places to meet as opposed to places to work, and seeking innovative opportunities to increase their utilisation beyond the current rate of approximately 35% will contribute significantly to emissions reductions both from emissions associated with materials of construction, and from the use of the building itself. Changing transport patterns will also contribute to lower total emissions.

Care needs to be taken that inefficient residential building stock does not undermine these emissions reductions. Planning needs to adequately consider that people may want to work flexibly from somewhere near home, if they do not want to work from home itself.

Table 2: Abatement potential of different groups of opportunities to 2030[2]

Group	Cumulative abatement potential by 2030 - (Mt CO2-e)
Built environment	65.9
Low carbon precincts	26.5
Digital infrastructure	7.9
Intelligent management systems	52.9
High performance energy generation and distribution	59.4
Energy efficient equipment (industrial)	83.7
Energy efficient equipment (commercial)	67.3
Low carbon transport	132.9
Land management	359.1
Fugitive emissions	42.7
Waste management	24.2
Management of gases	40.1
Total	962.6

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Big data analytics and energy management systems – so many platforms, so little time

Written by Junyan Tan

February 2018

There is a multitude of platforms offering different aspects of energy management for large energy users from Building Management Systems (BMS), Energy Management Systems (EMS), Energy Accounting Systems (EAS) and Energy and Facility Management Systems (EFMS). With the advent of Power of Choice[1] on 1 December 2017 across most Australian states and the rise of the Internet of Things (IoT), the number of smart meters and energy-using pieces of equipment connected across the country will increase significantly. At the same time, platforms are proliferating to match the increasingly varied needs of the owners of these devices.

While more and more organisations are becoming aware of the power of smart devices coupled with Big Data analytics, we see companies struggling to understand just how different platforms work, interact and how to select the platforms most aligned to their organisational goals. In this article we provide an overview of these systems and the key considerations that need to be factored into the selection of a platform.

What are the critical points of difference across the systems on offer?

A simplified hierarchy[2] of how key energy management systems connect to each other is shown below.

These systems can be provided by a Cloud based platform or a standalone software package installed on a local server or desktop computer. BMS systems are likely to be local installations or at least have local backups as continuous control of local equipment is required. Other systems are more likely to be Cloud platforms for easy consolidation of different assets as they are highly extensible and easy to access. We now consider the features of the different layers outlined in the diagram below.

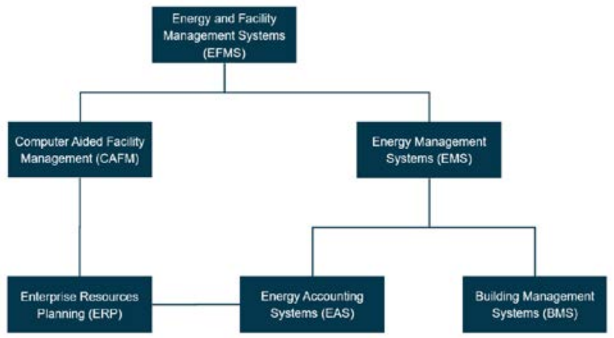

Figure 1: Key energy management systems

Energy Accounting Systems (EAS) and Enterprise Resource Planning (ERP): how they work together

EAS platforms measure, analyse and report energy costs and associated consumption at the organisational level. These platforms incorporate utility billing data and other variables such as area, temperature, production, budgets and forecasts for purposes such as monitoring environmental impacts and reducing energy costs.

An EAS is often integrated with an organisation's ERP to allow management of energy costs in relation to other enterprise resources. An ERP collects, stores and manages data from various business activities (such as manufacturing, operations, purchasing, sales and accounting) and allows for useful information to flow to stakeholders.

The Building Management System (BMS): offering control

The BMS provides direct control of building equipment such as heating, ventilation and air-conditioning (HVAC), lighting and access control. There is an array of systems available to Australian companies which communicate through a variety of protocols (mostly open but a few remain closed). They may be incompatible for older legacy systems but most systems installed since 2010 should communicate through more than one protocol to interface with equipment from a range of manufacturers. The BMS can be utilised hand in hand with the EAS to help organisations monitor and quantify energy efficiency savings; not only from the perspective of consumption but also to have visibility of the cost savings.

The role of an Energy Management System (EMS)

EMS is a broad umbrella term for platforms which provide energy management applications such as utility bill tracking, sustainability reporting, managing BMSs, demand response and fault detection to name a few. Because EMS, BMS and EAS functionalities are so closely entwined, you often find combined platforms offering functions as different modules instead of separate systems. A relatively recent innovation in EMS platforms comes from using a data analytics engine to continuously and predictively fine tune buildings.

The EMS market is complex due to the broad number of applications available. Most platforms provide slightly different subgroups of applications to distinguish themselves from competitors.

An overarching system: the Energy and Facility Management System (EFMS)

EFMS is an even broader umbrella which interfaces and controls all the platforms below it as well as providing additional applications such as work orders, facility bookings, building and workplace optimisation and overall reporting. Most EFMS are modular in nature as they need to tailor each to a different organisational need. For example, a property management company might not need a facility booking functionality while it is paramount for a large university. The EFMS also interfaces with platforms such as Computer Aided Facility Management (CAFM).

So there is a lot of choice in the market! How do you go about making the best decision for your organisation?

Three initial steps to take when choosing a platform

Energetics' recommends that you take the following steps:

1. Identify your organisation's purpose
2. Do some research into systems
3. Identify the core users and platform managers

These steps assume the reader would be the manager or executive championing uptake of the platform and has basic understanding of data platforms. The first step allows you to get a clearer understanding of your organisation's primary current needs for the platform which could be sustainability reporting (NABERS, GRESB etc.) or production key performance indicators. It then flows into the next step which enables your research to be much more targeted and not bogged down in options that offer little real value. This is a quick evaluation to kick-start the process and not meant to produce an exhaustive list of all requirements.

The research step requires a read-up on existing systems and trends to update and verify your requirements. For large organisations, professional research firms such as Verdantix provide useful background reading for executive decision making.

Identifying those roles within your organisation which will be the main users of the platform is critical as you want those users to review a demo system to ensure a potential platform can provide the value you seek. For large organisations, the platform managers and core users are likely to be separate so it is useful to identify the users responsible for the ongoing management/ maintenance of the platform. The platform only serves its desired purpose if it's properly set up and well maintained. More often than not, we see organisations investing a huge amount into a platform only to find later that they are not extracting the value intended because of the quality of the data feed.

The sequence of these three steps can be interchanged depending on your organisation's needs and current situation as well as the knowledge levels of decision-makers.

It is worth noting too that the three steps outlined form part of your own procurement procedures and are not intended to replace them.

Energetics can help you to assess your organisation's needs and the options best suited to meet your goals. Please feel free to contact the author or any one of our consultants.

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