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Water Security through "Big Data"

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Big Data is Everywhere!

Lots of data is being collected
and warehoused

- Web data, e-commerce
- Purchases at department/ grocery stores
- Bank/Credit Card transactions
- Social Network
- ***……and metering data***

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How much data?

Google processes 40 PB a day (2015)

Facebook has 4 PB of user data + 15 TB/day (2014)

eBay has 6.5 PB of user data + 50 TB/day (2010)

CERN's Large Hadron Collider (LHC) generates 15 PB/year

"640K ought to be enough for anybody!" (1981)

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Big Data Definition

No single standard definition…

"***Big Data***" is data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it…

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Types of Big Data

- Relational Data (e.g. Tables/Transactions/Legacy Data)
- Text Data (e.g. Web, Global libraries)
- Semi-structured Data (e.g. XML)
- Graphic Data (e.g. traffic cameras, RFID)
- Social Network, Semantic Web (e.g RDF “triplestore”)
- Streaming Data

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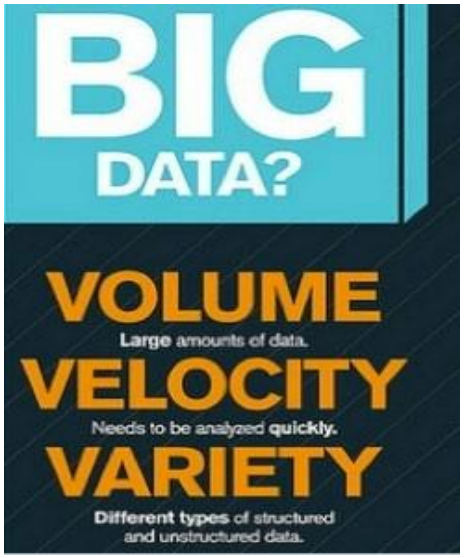
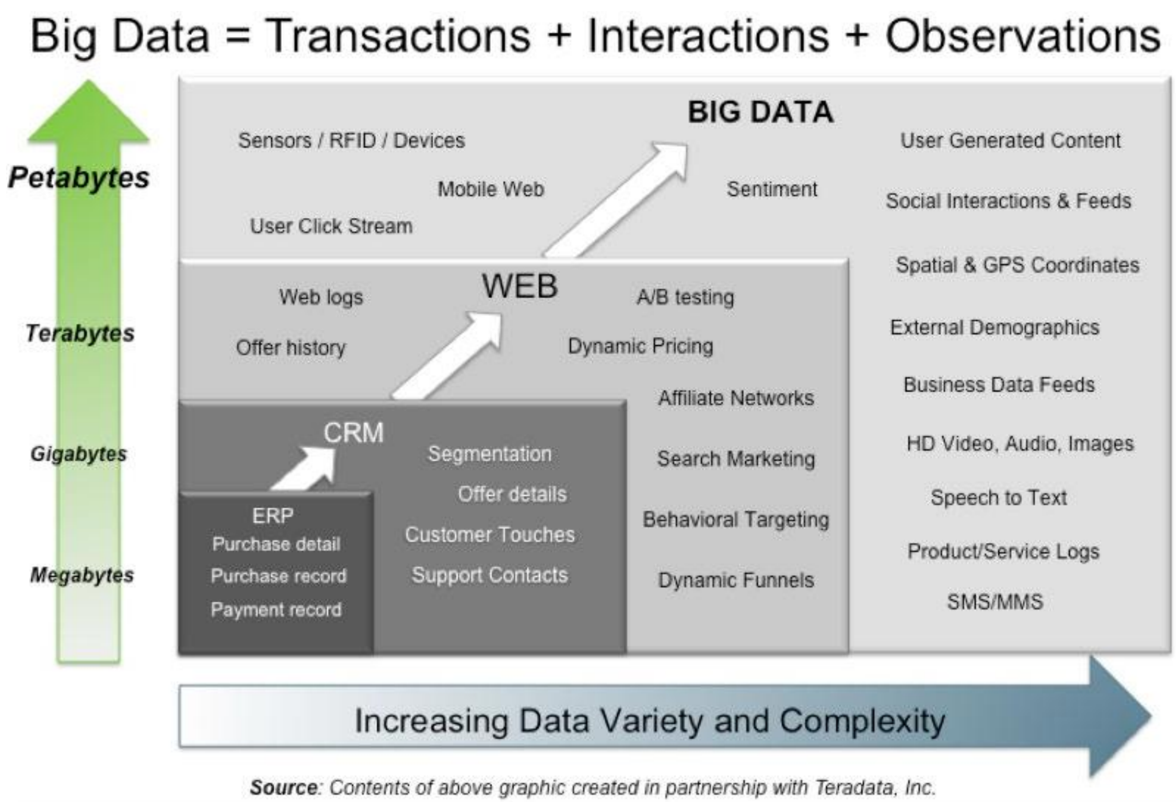
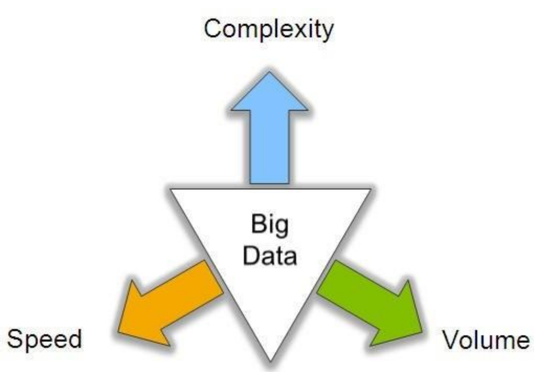
Big Data: 3V's







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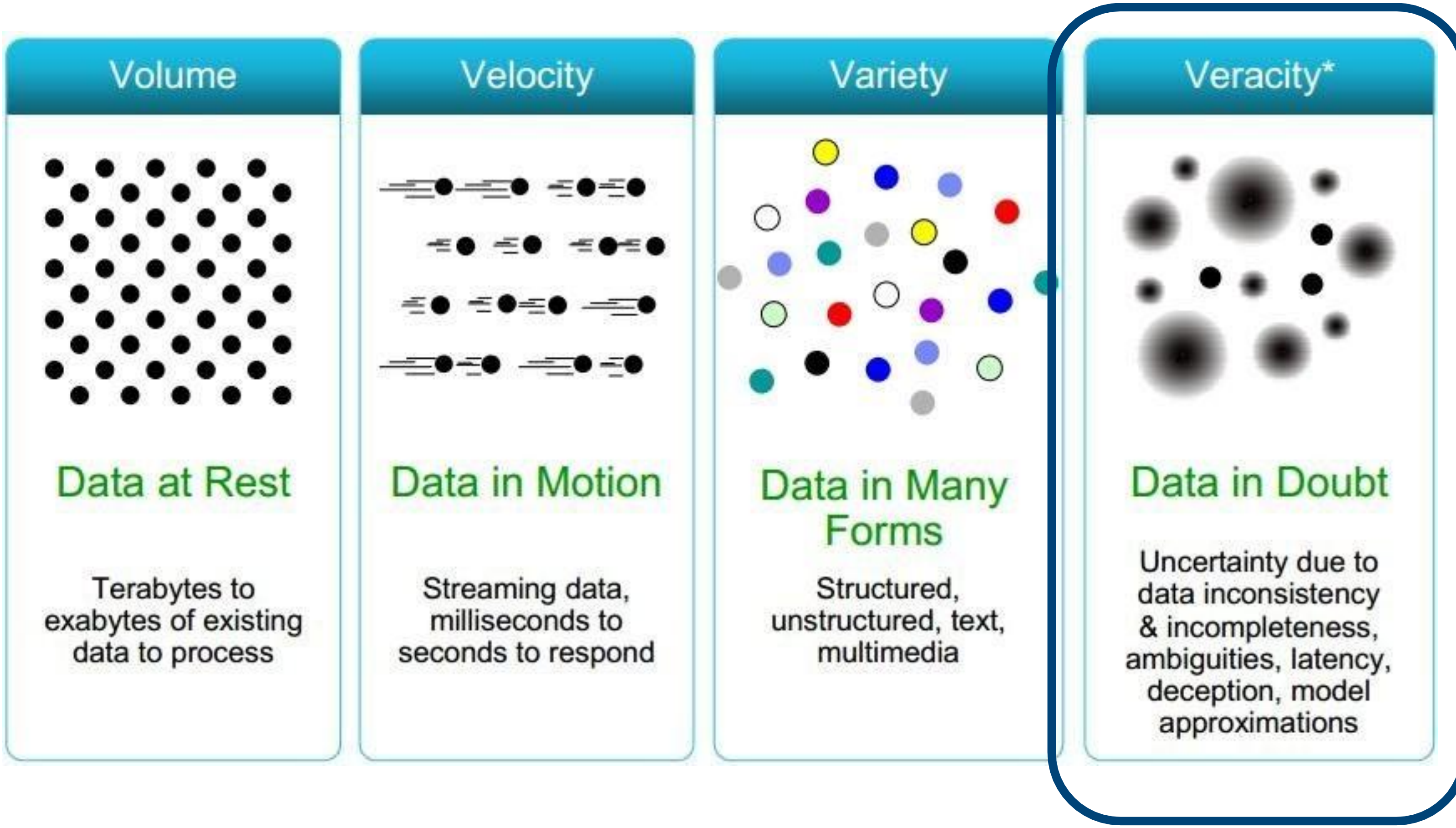
Some Make it 4V's



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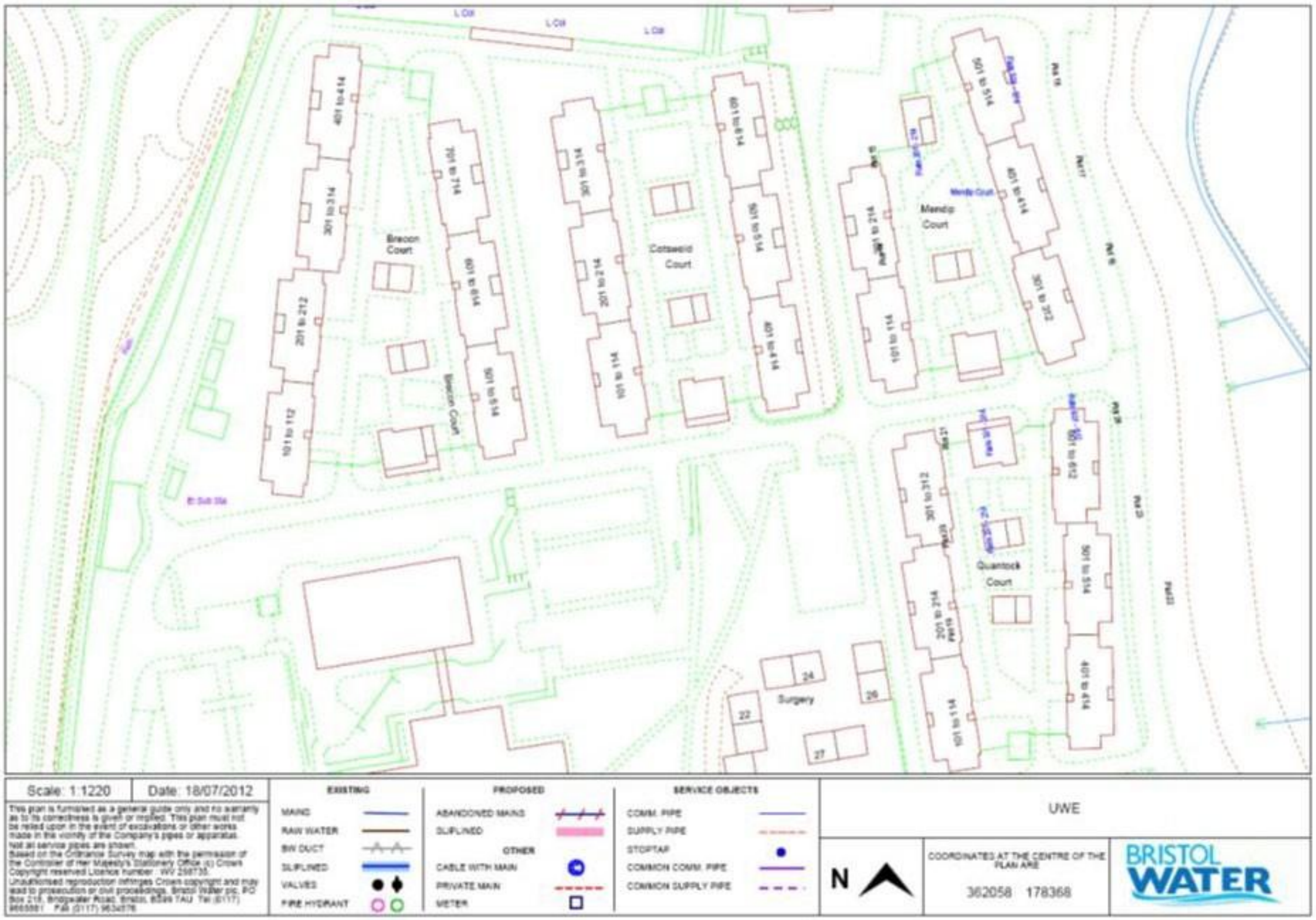
What to do with these data?

- Aggregation and Statistical analysis
- Data warehouse and online analytical processing (OLAP)
    - Indexing, Searching, and Querying
- Keyword based searches
- Pattern matching (XML/RDF)
    - Knowledge discovery
- Data Mining
- Semantic analysis
- Modelling

UWE Student Village Study – 3000 student rooms in 3 developments, water consumption data every 30 minutes, qualitative follow-ups, socio-demographic data, citizen science



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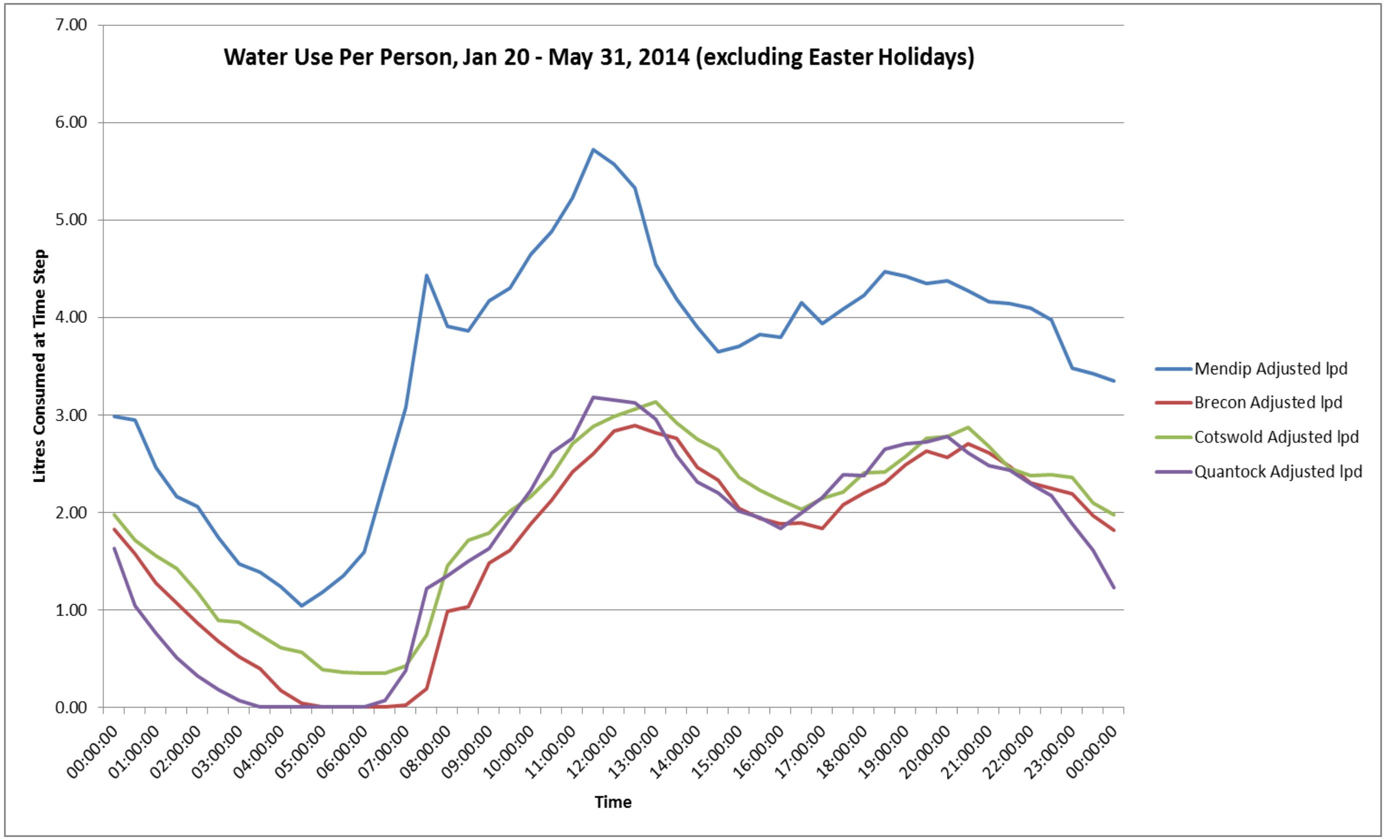
Blue line is with no water-saving fittings, the green, purple and red lines have different water saving fittings. So we know that fittings can work, but not necessarily which ones work best!



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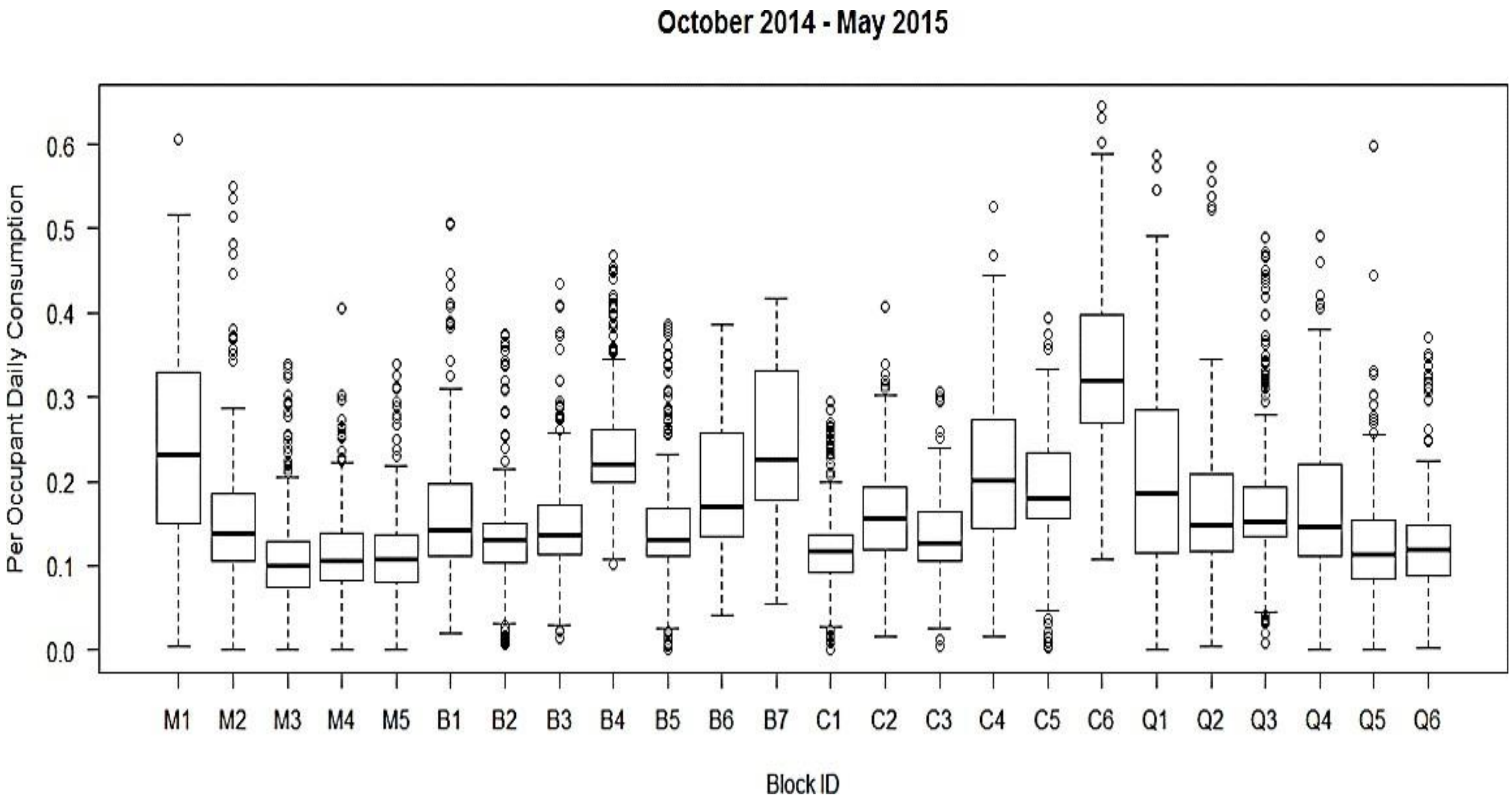
Partly because inter-block variations within the 24 meter zones HUGE…..



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How can we use Blockchain to improve Water Security?

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Blockchain

What is Blockchain? - A secure and transparent network of files that can be shared across a digital ledger system. Data is combined into 'blocks' and recorded via consensus from several nodes in a distributed database with complex cryptographic layers. The data is immutable without altering the entire Blockchain, ensuring a high degree of cybersecurity.

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Potential Blockchain applications

- **Record keeping** - In situations where data is collected by multiple parties, Blockchain can be used to provide an immutable record of data by inputting it into the same decentralised system.
- **Auditing** - companies that are required to disclose their financial information can keep this data on an immutable public ledger, decreasing the need for manual auditing. The use of timestamps can also increase the legitimacy and transparency of audits.
- **Faster transactions** - Santander found that implementing Blockchain into bank transactions provides a system for more rapid payments, while dramatically reducing transaction costs. This helped to reduce delays and fees incurred by traditional banking systems.
- **Customer engagement** - Through a public ledger, water companies would be made more accountable to their customers by storing their expenditures, water quality data, and pricing structures in a publicly accessible Blockchain system.
- **Digital water technologies** - The use of high-resolution sensors increases the volume of asset related data being obtained by utilities. Digitising asset management can be made more reliable with this distributed ledger technology. Open data systems can help set up a basis for trustworthy utilities and Blockchain can increase the speed at which information is available to stakeholders.

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Blockchain in Energy

Electron - By using Blockchain, Electron predict that they will be able to extract more value for every kW through increased efficiency and flexibility of transactions, and the company believes they can lower the overall cost of their energy balancing systems, and subsequently reduce energy prices for UK consumers.

Innogy SE has launched hundreds of Blockchain-powered charging stations for electric cars across Germany. Their new e-mobility solution, Share&Charge allows owners of electric cars to charge their vehicles at any of Innogy's new charging stations by making digital payments using the Share&Charge app which uses Ethereum Blockchain as a transaction layer. In the future, this app may also create a platform for vehicle hire, helping those looking for private transport to discover available vehicles and agree electronically on the terms and conditions of hire. The agreement is then coded into a 'smart contract' that automatically charges the driver and pays the vehicle owner.

Wien Energie is researching the use of Blockchain technology for the decentralized handling of transactions in the energy industry. Through the use of a pilot project, an end-to-end solution for Blockchain systems in the e-economy can be tested for the first time. Blockchain hardware (nodes) can be integrated into existing energy infrastructure, making it possible to harmonize the services of all applications such as photovoltaic systems, electromobility and storage.

US Department of Energy's National Renewable Energy Laboratory (NREL) announced a partnership with Blockchain start-up BlockCypher, to demonstrate secure peer-to-peer energy transactions - taking place in real time and without a centralized arbitrator - forming the basis for a distributed energy marketplace. (Nicholson, S. 2018). The conclusions of the study were that current energy markets lack an effective interface for distributed energy resources and that Blockchain could offer a compelling framework for new market systems built around this emerging asset class.

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Demand forecasting Case studies

DemandWatch analyses patterns from historical demand data to identify daily and hourly cyclical patterns, and time-series autoregression modelling which adds “short-term memory” for improving prediction precision. This combination of functions allows the software to more accurately predict short-term water demands (24-48 hours). The software generates water demand forecasts at hourly intervals, but can predict demand at finer user-defined temporal resolutions. The outputs of **DemandWatch** can be used to perform accurate simulations that reliably predict network operational performance over subsequent hours or days.

TROVE wanted to improve their bottom-level forecasting by paring live smart-meter data with the SCADA data, and data from other sensors being captured at the sub-station level, to produce an accurate hourly forecast (Trove 2018). With increased forecasting accuracy, stability and confidence, the company is looking to more accurately match the supply and demand of energy. These are similar to the goals that Bristol Water highlights within it’s 5-year business plan and so it is possible that a model of similar structure to the one produced by TROVE could be employed.

Demand forecasting Case studies

Deep Thunder - Deep Thunder can provide sufficient precision to enable utilities to plan for power usage, outages and emergency maintenance. For example, the severe storm that affected the New York City metropolitan area on January 18, 2006 led to innumerable downed trees and power lines. As a result, electricity service was disrupted to more than 250,000 residences and businesses and took nearly a week to be restored in some areas. Deep Thunder's operational forecast was available on an internal-to-IBM website before noon on January 17, 2006; more than 15 hours before the impact of the event. If local utilities and government agencies had access to this detailed and correct prediction as opposed to other forecasts which did not provide such information, they may have been able to lessen some of the effects of the storm.

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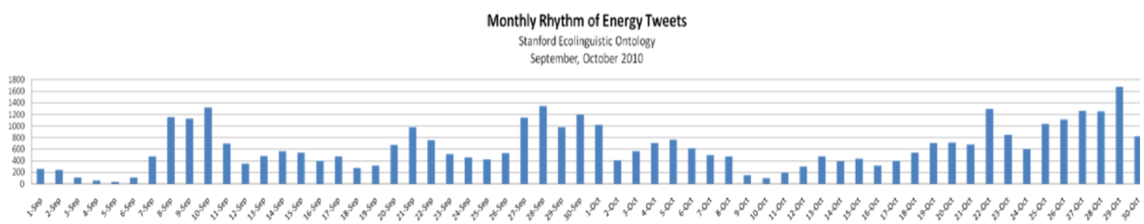
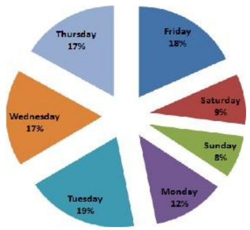
Semantic analytics Case Studies

Energy related conversations on social media – For this investigation, all energy related phases are derived from the United States Department of Energy (DOE), the EPA, the National Academy of Science, and the Environmental Defense Fund. Tweets containing terms from the taxonomy were acquired on a daily basis using the NodeXL Twitter Importer module (Rainie et al. 2012).

In addition to the message itself, other data such as the username of the message sender, along with the time and date of the message was also collected.





There are potential applications for tracking public opinion and behaviour change related to sustainability and energy consumption, as well as for analysing domain-specific, user generated content on social media platforms.

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