KES Future Notes

The Engineered Future – A Likely Preview

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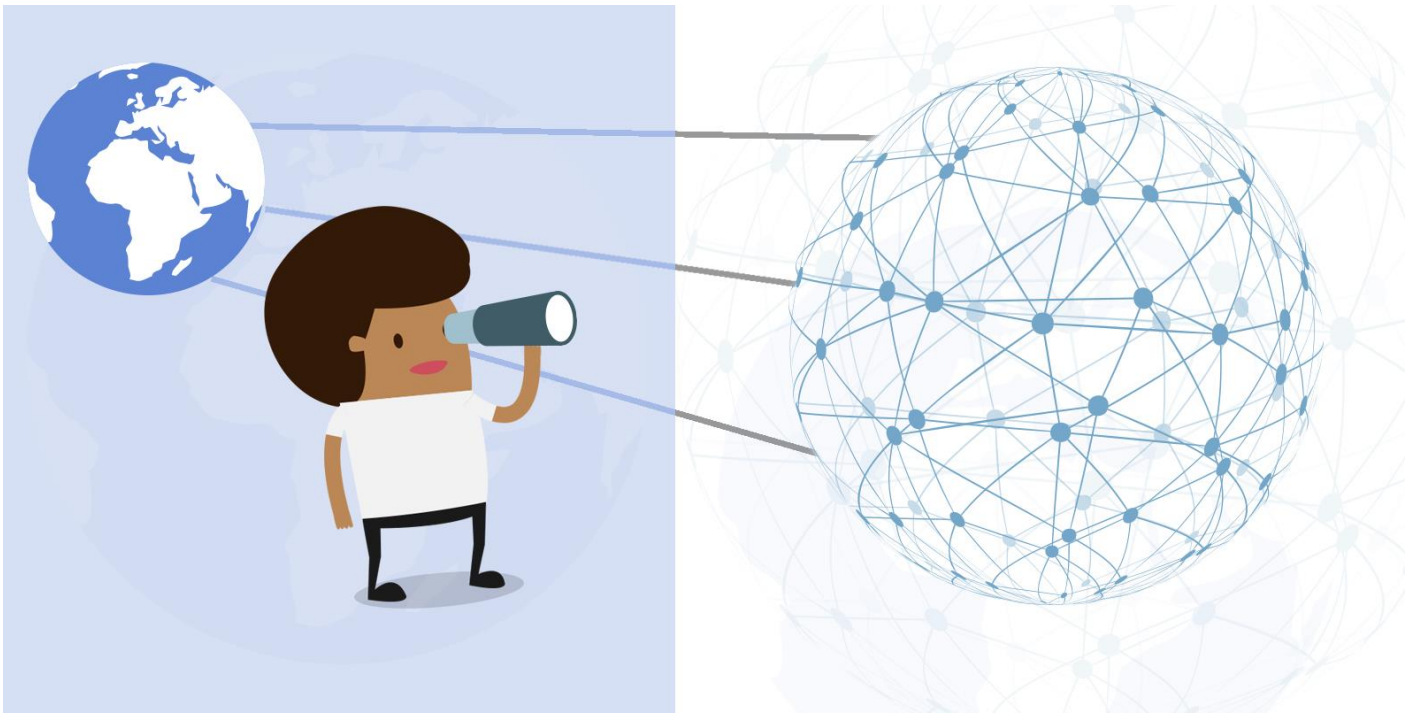

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Summary

There are several technological advances that have occurred over the last two decades. These have fundamentally changed the operations of many organizations and industries. The engineering and energy industries are renowned for, and thrive on innovation. Innovation has also become a source of direct income for economies across the world.

In this paper we look at the topics around which innovation will clusters in the future of the engineering and energy industry globally.

We present KadMap® – a digital solutions platform which will be at the centre of these future developments.

Keywords: Data-Driven, Digital Earth, Uncertainty, Artificial Intelligence, Data Science, Big Platform, Prediction, KadMap, Industry 4.0

Contents

Introduction

Innovation is the essence of technology/engineering whether space or energy or computer programming, engineering has thrived on innovation to make life better and more convenient in the world. Innovation in the industrial and resource dominant economies was a secondary or auxiliary partner in yesteryears. Today, innovation – a direct product of man's mind, is now a primary driver of economies especially in information technology (IT). As a result of this trend, science, technology, engineering and mathematics (STEM) have been given priority in leading countries of the world as they been proven to directly affect an economy significantly. The advances in IT have reached a phase where its potential to affect the physical and not just the cyber world is palpable. These advances are now at the cusp of merging in with traditional engineering a unique way to cause another great leap in human history. Thus, the buzz about artificial intelligence (AI) and industrial internet of things (IIoT) has become common place in a new technology race targeted at engineering itself. In this paper, we take a look at the future of this trend and talk about salient features which are most likely to occur in the energy and engineering (EE) industry in particular.

1. The Future of Engineering is IT-Driven

Engineering developments and of course the rapid advancements in IT over the decades have made the world much smaller. IT has not only added a different dimension to communication, but has also added channels for insights into our everyday activities.

There are two major aspects of IT which will have the most impact on engineering in the future – data science and software/application development. In data science, we take a finite data set and perform a series of analyses on it (statistical analyses in particular) and come up with various results to make sense of the data. The data science aspect of IT has taken an industry like advertising and marketing to new heights previously unattainable. It is not just about the presence of data alone, but also how the data is used (interpretation, visualization, inference, etc.) that impacts whole industries. In application development, we create the interface for data manipulation, visualization and interaction, and also set up the data storage method such that the data scientists can have access to meaningful data. The speed of application development has greatly increased compared to the 1960's – 1990's

due to the proliferation of assistive coding and APIs[4] in new generation applications. This has also led to an exponential increase in programmers worldwide.

2. The Digital Earth and the Digital Energy and Engineering (EE) World

Currently, just about every aspect of human endeavour of the most advanced economies of the world have a dedicated website to it and mobile apps for them are rapidly increasing. This implies a rapidly increasing footprint of activities of the physical earth on data servers mostly on the large interconnected network we know as the internet. Consequently, with access to the world wide web on this network, we can get a very good idea of just about anything on earth. This suffices to say that there is a separate earth being created at this point, away from the physical planet earth. What is this separate earth? It is a digital copy of earth and it is still at its early phases.

Digital Copy of Earth

Within this digital earth, man strives to be the dominant creative force – replicating anything on the physical earth onto it. This is digitization[5]. Human activities now have an imprint on this digital earth before even having any physical presence, with some individual having completely migrated into this

[4] Application programming interface
[5] Digitization: is the creation of a digital copy/representation of a physical entity.

digital world. This is the reality we face at this point. It is not different for the EE industry future - we are looking at the digital counterparts in (see: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[6]) a digital EE world. This is going to feature more as we go deeper into digitizing the EE enterprise itself. Currently digitization of some sort has occurred for some activities within the organization. They have been abstracted onto an isolated (non-connected network) digital space in form of enterprise software for accounting, HR, etc. The coming digitization of the EE industry will not only be applied in the immediate work-space (the enterprise) but in the industry as a whole. People, physical enterprise entities (assets/products/services) and operations will each have a digital equivalent in the digital EE world. A current manifestation of this digitization process is the industrial internet of things (IIoT[7]).

3. A Standardized Platform for the EE Industry

In the digital revolution/era, we are witnessing surges in massive web-based platform software or "massware" with billions of users. We could adduce this from a metaphorical perspective, where a clan (company) settling a geo space (domain) on this contrived digital planet (world wide web) and creating a culture (delivering service) while exerting and propagating considerable influence (affecting several other website and services). The culture is an accumulation of interactions with the tools provided by the clan leaders. Over time and massive data accumulation, repetitive and thus predictive patterns begin to emerge and this leads to very interesting possibilities especially one which we are familiar with – artificial intelligence.

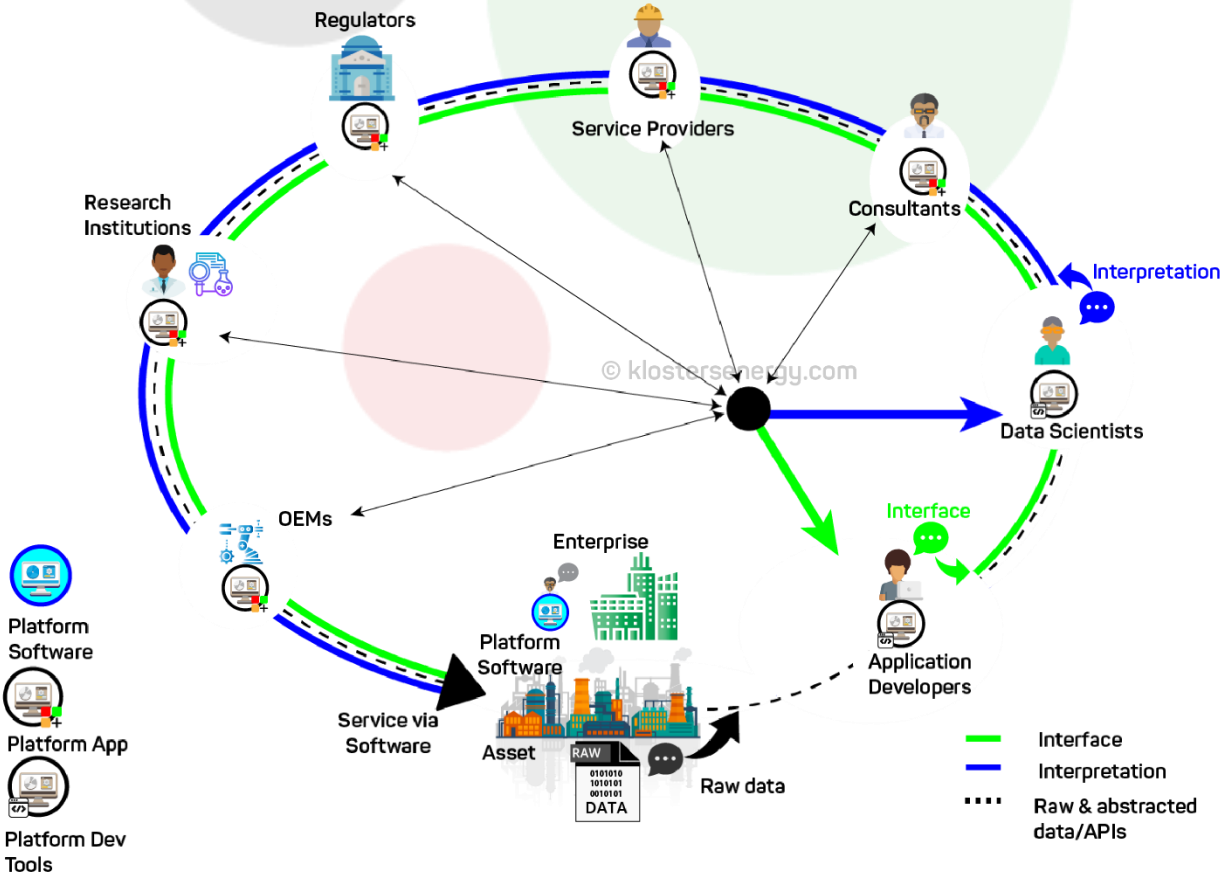
In a data driven future, data will be a very important resource. This data will be required on a massive scale similar to the massware metaphor we have just referenced. This will require a big platform (digital EE world) exclusive to the EE industry (see: *A Big Platform for the Engineering and Energy Enterprise – What Is It and Why Do We Need It?*[8]). Among other benefits, such a platform is necessary to implement massive data dependent technologies such as artificial intelligence (AI). AI

[6] http://bit.ly/SvSDigitEngMod-KES
[7] The industrial internet of things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. (*Wiki*)
[8] http://bit.ly/BigPlatEEInd-KES

works for intelligible and consistent data and such a platform would ensure such with the implied data volume due to its client base.

4. New Entrants into the EE Supply Chain

Building services on this digital EE world requires a mass of people with a specialized skillset. Two main professions we will focus on here are the application developer and the data scientist – two major areas in IT. They work hand-in-hand. These professionals do not always possess a mono-disciplinary background (i.e. pure data scientist or application developers). Some are multidisciplinary, having their dominant discipline mixed in with a branch of engineering - something we call the i-engineer (more on this shortly). Just as data scientists and application developers are key to the translation and synchronization of the physical earth to the digital earth, so will they be key to this data-driven engineering future on an industrial scale.



Role of IT professionals in the EE Industry

The digitization of the physical engineering assets/activities into the digital world is not something done just for the sake of it or because it feels good to do so. There are enormous benefits to be reaped from digitization (see: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[9]). The benefits of the data-driven future (and thus digitization) will impact the supply chain of the EE industry. Certain services/products will be degraded/diminished in either scale or demand and some others will be upgraded. Some might be completely eliminated altogether as the supply chain becomes more efficient and effective.

5. Service-via-Software - SvS

The data-driven future will herald the creation of digital equivalents of the EE industry (digitization). However, this process will not happen overnight, it will take some time perhaps up to a decade to record significant progress. Eventually just about every service that is currently done physically in the EE industry will have some sort of counterpart in the digital EE world. It is likely to start with the most data-intensive (and thus digital friendly) services which are quite straightforward to digitally replicate. The benefits which will emanate from these initial digital services is going to encourage and fast-track the digitization of even those seemingly unneeded services as well as other digitally-challenging services. "SvS" is a coinage[10] describing the digitization of EE services. There is going to be a reorganization of the way we carry out services in the EE industry.

6. Redistributed/Upgraded Responsibilities and Obsolete Roles within the EE Enterprise

Some of the roles taken up by a single individual in the conventional EE enterprise are going to be sliced and diced up and added to other employees, while other roles will go away altogether. New

[9] http://bit.ly/SvSDigitEngMod-KES
[10] http://bit.ly/SvSDigitEngMod-KES

roles will emerge as well. This is standard business evolution. It is not something that is particularly native to digitization, but a regular occurrence when there is a technology leap.

7. Increase in Precision Instrumentation

For accurate digital representation, we have to be able to measure things accurately to represent them just as they are and translate that to the digital EE world without a loss in precision. This will demand more instruments and more precise instruments. Also, some of the instruments may need additional sensors/channels in order to obtain additional information which was previously not needed or was deemed unnecessary.

8. From Support Groups/Function to Mainline – A Role Change for the IT Pro

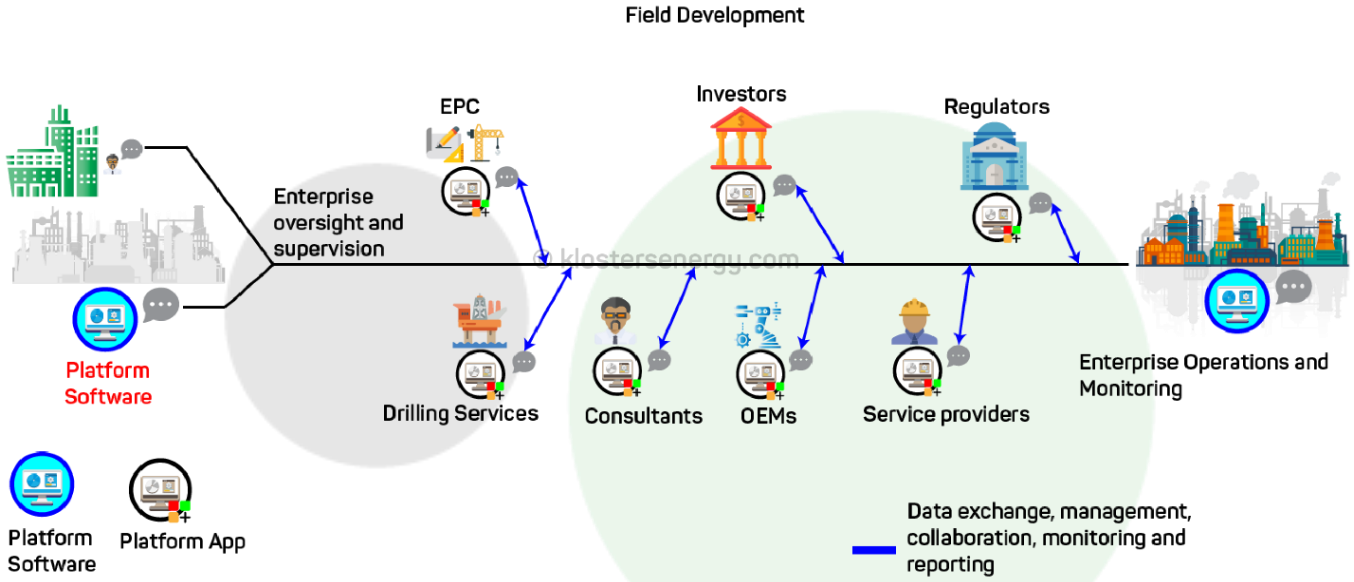
In the late 1970's we witnessed the independence of the IT pro, moving away from US government laboratories and NASA and coalescing around Silicon Valley to develop IT products. Traditional offline software was the bane of the IT industry.

The 2000's witnessed the new generation of these IT pros with the exponential propagation of the world wide web. The web-based applications came into prominence, adding tremendous value and even eclipsing the IT industry previous net-worth. Along with this internet age, came the need for IT pros in the translation of physical entities on the physical earth into digital equivalents such as websites. They were also required for maintenance of these digital equivalents.

With the data-driven of the EE industry future drawing closer, the IT pros within this industry will also increase. We estimate a tripling in number (at the very least), of the current of IT pros in the EE enterprise. Not only will this tripling happen to their numbers, their influence will also be triple of what it is currently. They will no longer just be in the support group/function of the EE enterprise but also in the mainline actively administering, monitoring and maintaining a digital homeostasis required for the normal functioning of the digital EE world. Once again, the IT pro also includes conventional engineers with a significantly upgraded knowledge of IT.

9. Effects on Development of Products and Facilities

We will witness an increase in the speed of development of facilities and any engineering project as well. The digital paradigm will enable us see what we previously could not in the physical world. The digital paradigm gives us an advantage, a sort of third eye to look at things from a different perspective and as such perform optimizations that were not even thought of in the physical world.



Data-Driven Operations in the Digital EE World

Part of this advantage would also manifest in rapid development of facilities and everyday physical items. We will experience better coordination and management of projects and services and quicker completion of milestones with quality and safety standards maintained. These will inevitably reduce cost, especially of big engineering projects.

10. Real-Time, Everything

Everything we begin to look at in this digital EE world is in real-time. Real-time will becomes the new report/status update. Waiting for reports will be for record and archiving purposes as just about every information you require could be obtained on the fly. These information would be directed/targeted at

the precise groups/individuals on-the-fly. They would able to respond to them, take actions, delegate and give feedback in real-time.

11. More Robust AI

This comes along naturally. AI in the energy industry today is for prediction and ultimately for better decision making. With the rise of the data-driven engineering, advances in the means of processing and storing data is also going to give rise to AI with increased learning capacity. Eventually we are going to have a digital EE world that is more intelligent.

12. i-Engineer, the New Engineer

What we at KES[11] call the i-engineer like we hinted before is a multidisciplinary and hybrid engineer - a cross between the data scientist the application developer and a regular engineer. This kind of engineer will become mainstream because the efficiency they would bring to the digital EE enterprise. There is going to be a lot of training or "re-engineering" of this new engineer in order for him/her to deliver more effectively. We anticipate that as much as 60% of their abilities are going to be IT-based.

13. Data-Driven Engineering

AI deals with prediction. Prediction is a means of reducing/eliminating uncertainty which is the greatest concern in EE asset operations (see: *Interfacing Artificial Intelligence, Risk Management and Asset Integrity*[12]). Uncertainty had been tackled before however.

Before the Newtonian era of physics and mathematics, craftsmen went through a lot of trial and error in making or building things. The level of over-engineering to overcome failure (a consequence of

[11] Klosters Energy Services, Company
[12] http://bit.ly/IntegAI-RM-AIM-KES

uncertainty) was indeed enormous. The Newtonian era also known as the empirical era brought about more material precision (certainty) in the construction of engineering monuments and the designs of equipment improved as well.

Empiricism, also known as evidenced-based thinking, relies on experimental setups (mainly on a laboratory scale) to make observations. It is organized. There is data collection in these experimentations – from which correlations, dependent variables, constants and other relationships can be established. With empiricism, we can then move from hypothesis to theory to law – a progression that is foundational to modern science. Let us call the scientific empiricism level 1 – the foundational level.

Engineering is built on application of these scientific relationships on a larger magnitude/scale. While level 1 is more precise than the previous era, it still has several uncertainties inherent. This is the reason that we use factors of safety, since we have to account for unknown variables/forces. This application features standards/standardization a lot, which is again a collective observation with general rules to safely executing an engineering operation. It also features engineering judgment, which is again based on successive periods of observation which we call "years of experience". Let us call the engineering (science application) level 2 – the application level. Humans have been leading levels 1 and 2 over the last few hundred years.

Further refinement to engineering over the years led to more precise designs. Recently, computers have helped to further increase this precision.

All these advancements notwithstanding, failure/uncertainty has not been completely eradicated. Yet where we are today is a chasm from the pre-Newtonian era of hypothesis/natural philosophy.

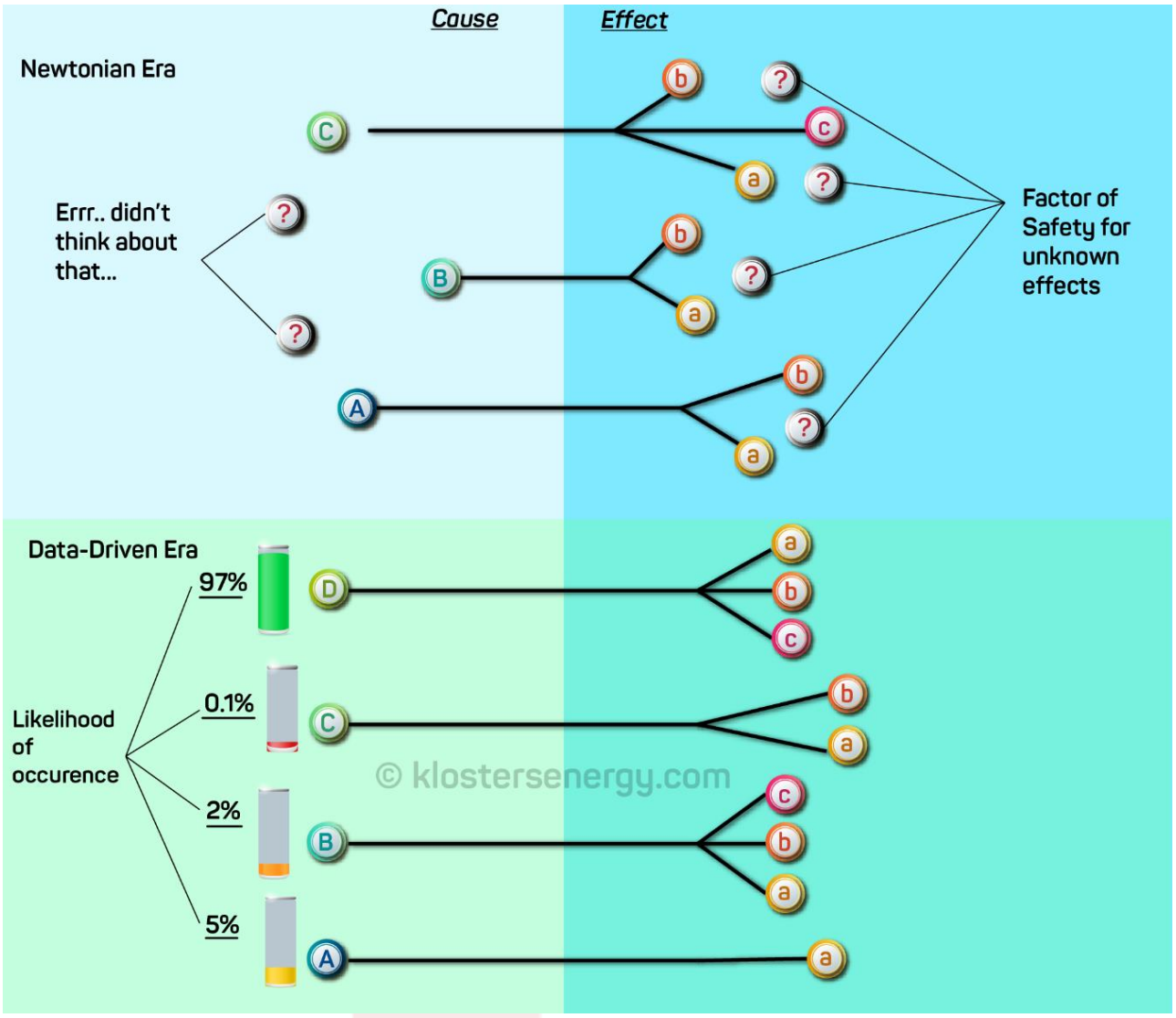
Now when we bring in computers, which have a far superior levels of data collection and processing/computation, there is a potential we could harness. While level 1 involves conceptual thinking and intuition, level 2 involves execution and experience. We cannot delegate conceptual thinking and intuition to computers, they are simply not capable (at the moment). We can however delegate observation (data collection) to them (see #3 above). This will however require a large-scale collaboration between man and computers. This is the data-driven era and it is rife with enormous potential especially in the area of AI.

Now, the data-driven era implies that we now have the job of aggregating an abundance of data sources or footprints that has been created in the EE industry till date to analyse them and obtain more insight into what has worked and what has failed and the reasons behind them.

We can illustrate further with a design scenario. We can have a very well-designed pump of a given specification deployed in 5 locations with what we assume is slightly varying environmental characteristics, and to be utilized by the same company (so slightly uniform staff operation philosophy). Despite the slight variance in these important factors we keep getting huge failures from 2 locations. A simple addition of safety factors in engineering (which would increase production costs) or reengineering the pump (increased cost again), would not suffice. Prolific and detailed data logging and analysis with resolution options, autonomously carried out by an AI program will reveal underlying information which the pump manufacturer can resolve the issue (see: *Artificial Intelligence (AI) in Assets - The Knight Rider Facility*[13]). The AI program should make prediction of effect (prognostics) and prediction of cause (diagnostics) very reliable.

In the Newtonian era (which we are still in!) we go from assumed cause to experienced effect and design against it augmented with factors of safety to fill in the gaps for the unknown (uncertainty). In the data driven era, we will have a more total picture of what we are designing against (which includes likelihood of occurrence and their more precise effect(s)) and thus design more efficiently.

[13] http://bit.ly/AIAssetsKnightRider-KES



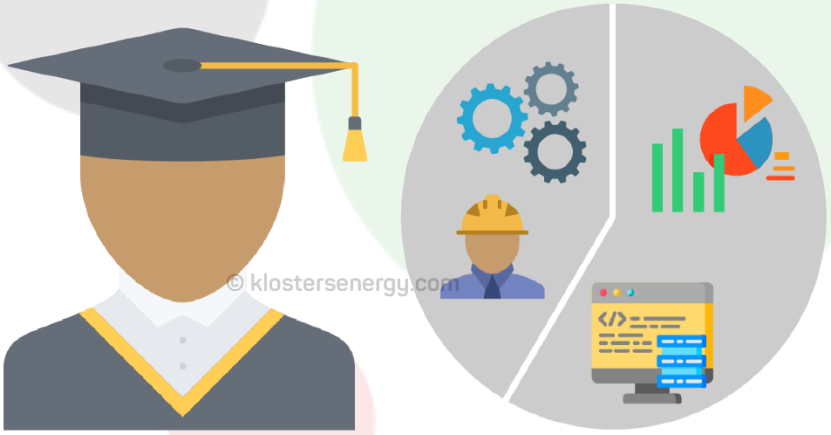
Engineering Operations Approach in Newtonian-Era vs Data-driven Era

Note that this can also be applied to several operations including managerial, financial, safety (it is already being done here), etc. of the EE industry.

Further into the future advances in data science will enable computers take charge of level 1 (scientific empiricism) such that we can finally leave the Newtonian era into a data-based era. This will initiate a new engineering evolution dealing with more data/statistics and fewer engineering formulae. Problems that could not be solved empirically or reliably by empiricism alone will be solved statistically or data-driven.

14. Academia Adjustment for the Engineering Programs

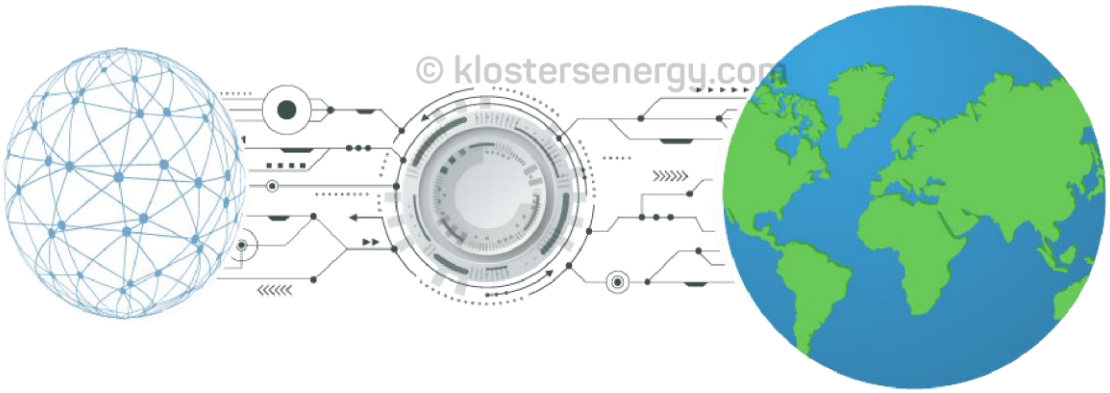
The data-driven era would affect the training of the kind of engineer that would add value in this digital EE world. There will be adjustments made for engineering and other EE industry related disciplines in institutions of higher learning. This engineer will amass knowledge of multiple engineering fields which would account for about 40% of course materials and the other 60% related to data. Some will veer off completely into the data discipline while also being very an effective engineer or in this case, i-engineer. What this would mean is that the entire engineering model-based structure becomes a reference point while we focus on the data. It becomes a point to check that our data operations somewhat conform to the traditional engineering models. This has happened in the case of computer aided drawing (CAD) solutions, where the theoretical (mathematical) knowledge now serves as reference point, while students focus on learning how to utilize the software.



Course Composition for the i-Engineer, 40% Traditional Engineering, 60% IT and Data Science

15. A Domain for the Machines

Human input will be essential at the initial stages of the digitization and linking of the EE industry and the digital EE world. As we go deeper into this digitization, data will be accessed and manipulated more by the machines than of humans. This will require a platform where these machines can more easily and faster with a distinct data format – distinct from the human readable format if need be.



Machine Nexus Point from Where they Access the Digital EE World

This is intriguing, because since the close of the last decade, 2009 to be precise, we saw the rise of the internet of things (IoT[14]). This is important because to take advantage of IoT there needs to be specialized interfaces between the physical machine and digitized machine on the digital EE world. This platform is their nexus – or what we may call their own internet. They will have a standardized means of communication between themselves and get into this digital earth without any human interference. While we humans will be able to monitor and control, the machine access is still necessary as it is simply more efficient and convenient especially with large and very frequent data transactions and other very routine functions. Eventually this nexus is going to grow so significant it going to become its own network space. It is a bit scary since this reads like something of a sci-fi movie like Matrix or Terminator which talk about these features while going ahead to showcase that they are bad news.

16. Advanced Interfaces/Visualization

The digital representations are bytes of data; they still need assistance in "translation" to make sense to users. This translation is in the form of data interaction and visualizations. Visual representations of data give insight to what we previously could not know due to technology limitations. With data, we are able to compare abstract and derived data and discover new relationships. We can visualize this

[14] The internet of things, or **IoT**, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Source

data more elaborately and in multiple dimensions. This is not only applicable to charts and infographics, but also to model representations of physical entities like pipelines and facilities and reservoirs.

Visualization technology such as virtual reality (VR), augmented reality (AR), mixed reality, holograms, etc. will become more prominent in day to day operations for inspection, surveillance, design, etc. of facilities.

These advanced means of data manipulation, interactions and visualization thus would stimulate the creation of more advanced user interfaces, control and experiences.

17. Increased Reliability

Reliability is the ability of an equipment to function as intended throughout a given period of time effectively and efficiently. With the *a priori* data which would be widely available in this data-driven future, the reliability of services and not just physical products or machines (assets/equipment) will also increase. This increase will be as a result of the availability of data, the computer processing power and the applications and ensuing benefits. For the uninitiated, reliability is a data-driven science or engineering discipline. Without data we cannot talk about reliability. In the data-driven future, reliability engineering will come to the fore.

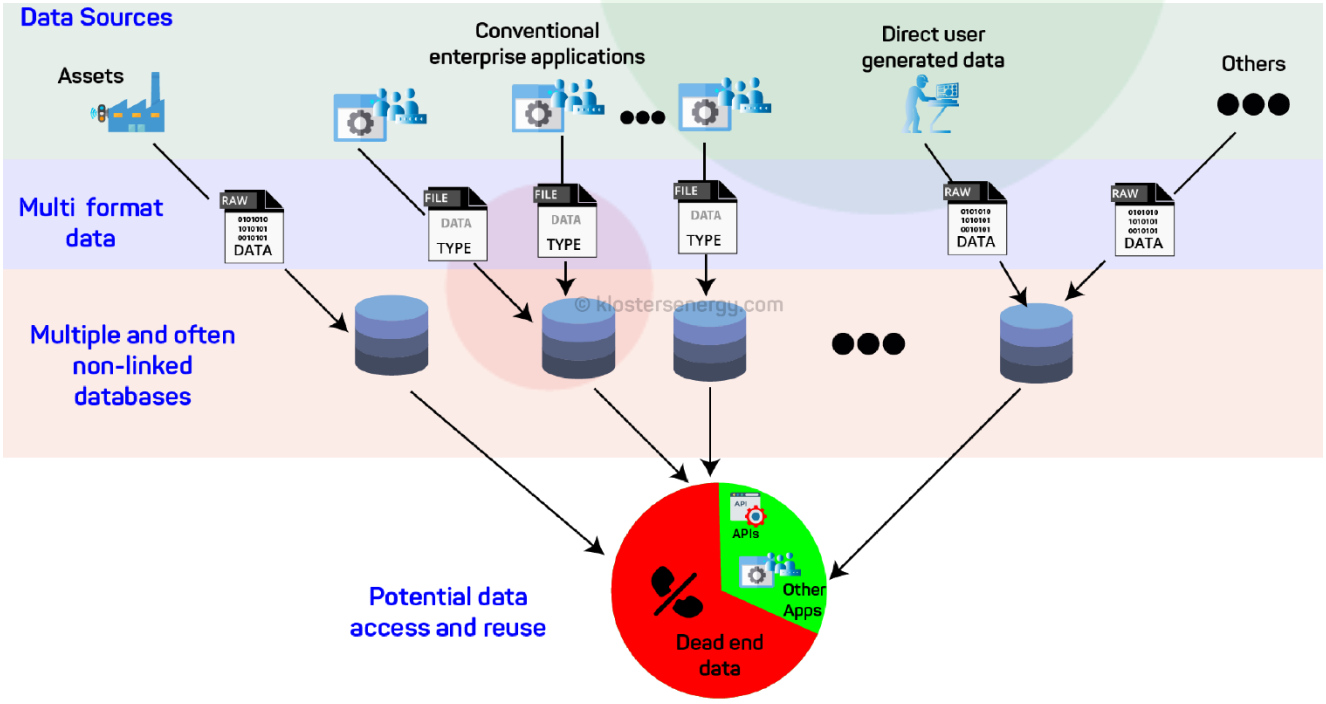
18. Perfect Contracts

When we look to previous point on data-driven engineering (#13) we see the effects on design, where huge data on several design projects have been recorded and the increased certainty to be had while selecting design parameters. This advantage of prediction or certainty applies to the administrative and contractual side of engineering as well. When the execution of services/operations is known including the likelihood of various events with contractual implications, we have a dream come true for contract owners. Contract will be drafted and executed with no amendments, no change orders, no addendums, etc. just like a perfect contract.

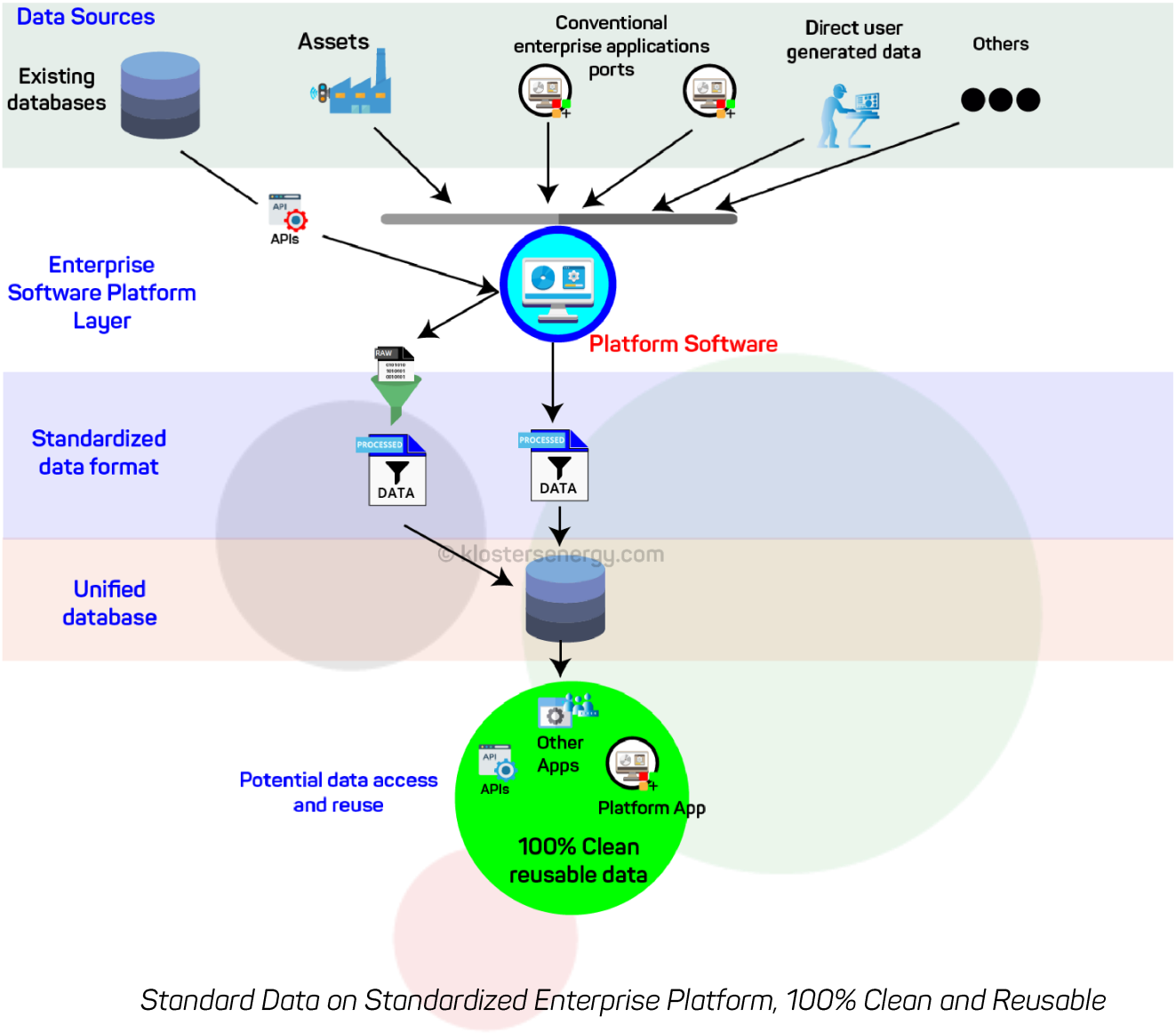
19. Data Sovereignty over Software

Every industry operates procedures, protocols, certifications, etc. which remain standard without regards to organizations. The EE industry is prolific in this which is a testament to its consistent and continuous refinement philosophy. This streamlines errors, increases efficiency, adherence, transferability/globalization, ensures QAQC, etc. The case for global digital data will follow the same trajectory where, regardless of software, data will become standardized especially in format. The advantages of standardization (such as efficiency, QAQC, etc.) will also accrue to standardized data. Software development will also experience a boost as development will be simpler and faster enabling development of several brilliant apps in quantity and record time. Standard reference data will allow genericization of data which will enable developers to develop apps without using private data.

Currently we have a lot of traditional enterprise software with varying data format and data access. In the future just as we have standard industry procedures which are uniform across enterprises within that industry, so will data have set formats which will be uniform across applications.



Dead-end Data in Traditional Enterprise Software



Standard Data on Standardized Enterprise Platform, 100% Clean and Reusable

KadMap®

The name "KadMap" is a coinage for the holistic digital framework and infrastructure to deliver digital asset solutions. It is developed and maintained by Klosters Energy Services (KES). Embedded in the name KadMap®, are acronyms for keywords such as asset, data, management and platform.

KadMap®

KadMap® hosts a range of digital solutions to myriad challenges affecting engineering and energy (EE) assets and operations.

The scope of KadMap® encompasses several assets and operations of the EE industry. For more on KadMap® click here.

Conclusion

Data driven future is on the horizon. This data-driven future will significantly change the operations of the EE industry. It will add more value to the EE enterprise financially and otherwise in addition to great efficiency.

KES is undertaking the task of coordinating the digital platform – KadMap®. KadMap® will feature AI capabilities, user intuitive data interfaces, IIoT capabilities, standardized data, application development capabilities and much more.

KadMap® is currently in development to deliver the benefits discussed and to ultimately assist owners in achieving optimal production. Finally, KadMap®'s development strategy along with release dates have been outlined in the annex of this publication.

Reviewers

1. Chukwunyelu Chukwuka
2. Chidiebere Nwaoha

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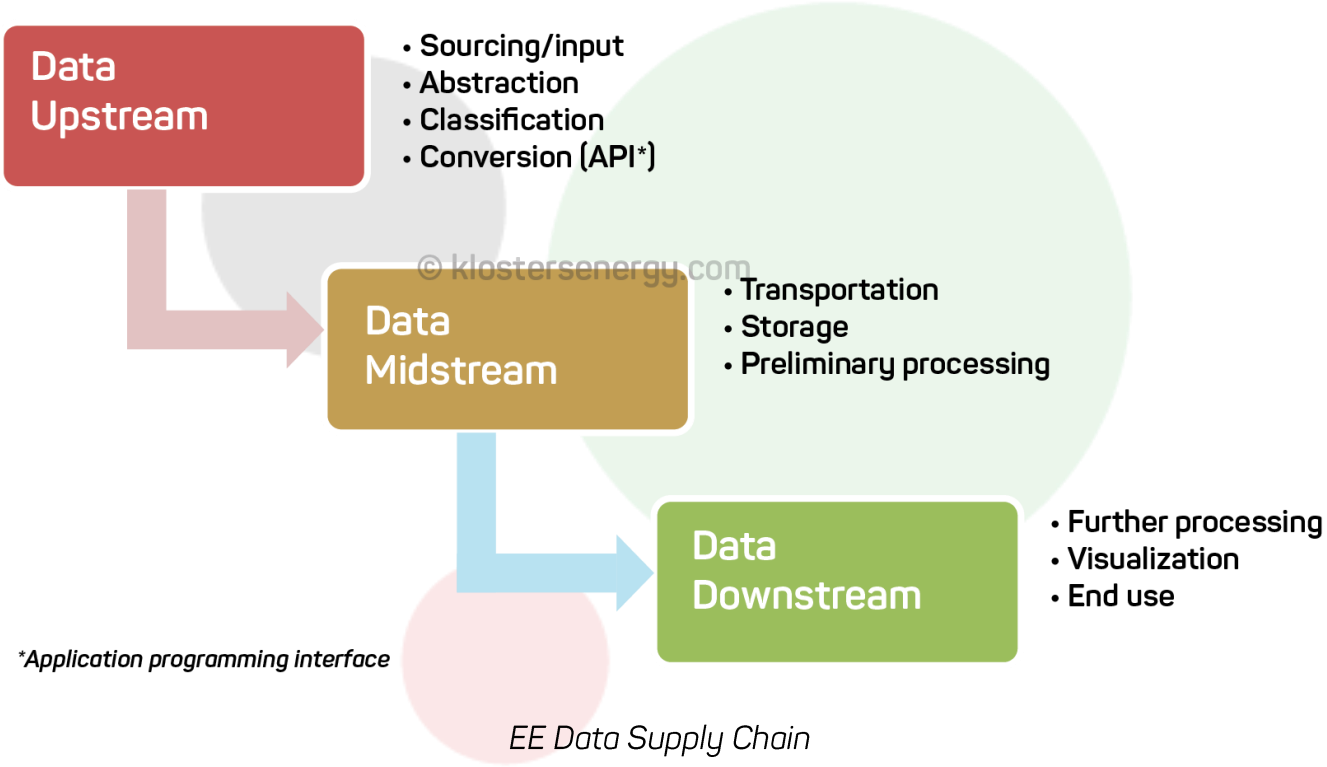
Annex

KadMap®

KadMap® is a very data-oriented solutions platform with particular focus on digitization and data abstraction, specializing in the upstream (data sourcing/input, abstraction, classification and conversion) to the midstream (transportation and storage of data, including preliminary processing), to the downstream (further processing, visualization and end use) phases of data.



EE Data Supply Chain

KadMap® is an umbrella for all the technology involved from one end to the other in the EE data supply chain featuring both hardware and software making KadMap® the world's first of its kind end-to-end digital solutions platform.

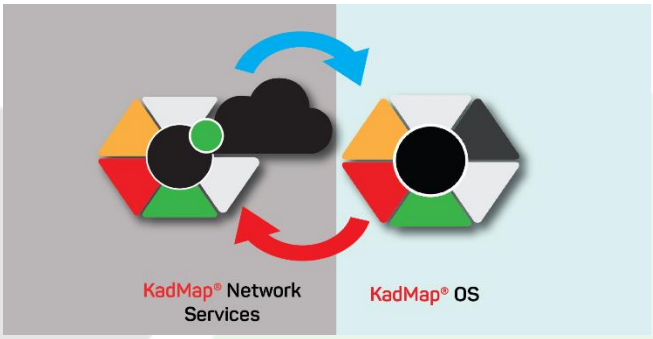
The end-to-end integrated scope of KadMap® is a huge challenge which KES has been progressively addressing since 2007. KES' strategy has been to utilize a project-based approach by creating and executing an integrated project dubbed "KadMap® Development Project", with this challenge as the goal, and each project deliverable a milestone towards addressing the challenge.

Two deliverables are of particular importance in the project:

1. KadMap® OS

2. KadMap® Network Services (KNS)

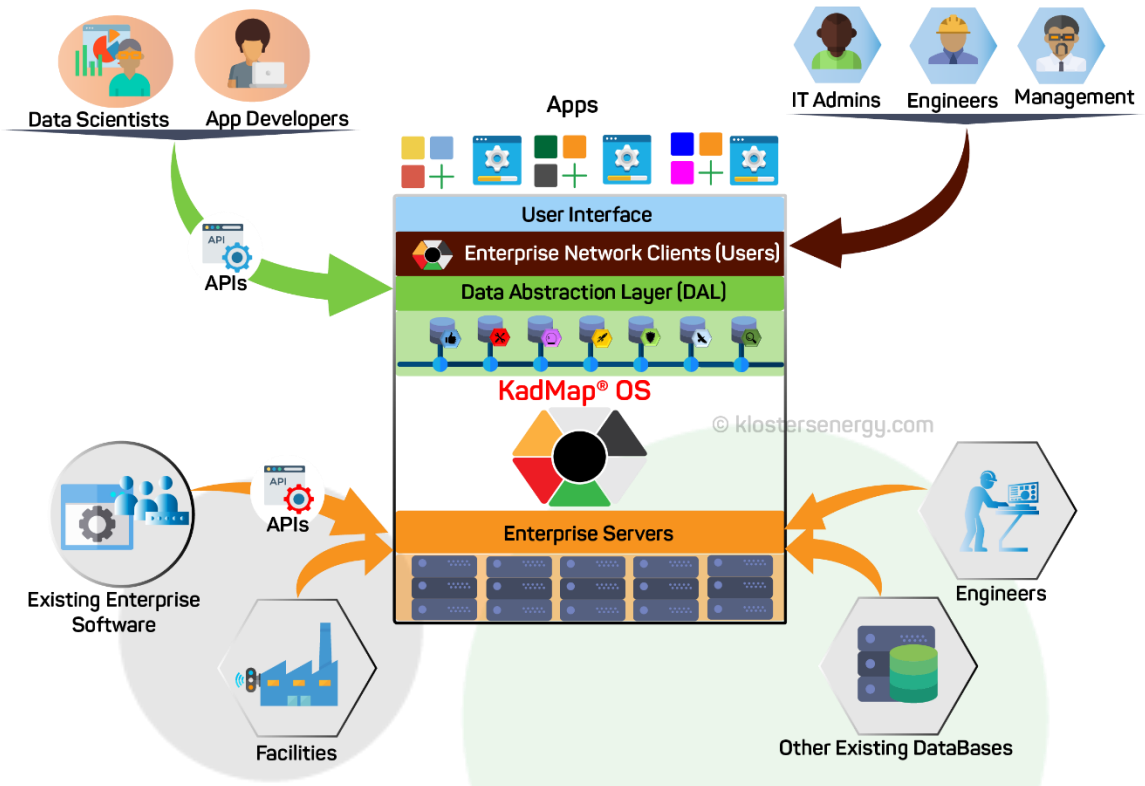
KadMap® OS and KNS both form the base infrastructure required to deliver the entire scope of KadMap®.



KadMap® OS and KNS – the base infrastructure

KadMap® Operating System

KadMap® OS (operating system) is a multi-client (server-based), multi-network, data-oriented operating system developed with the energy and engineering (EE) enterprise and operations in focus. Its architecture was developed with the inherent needs, infrastructure configuration and security concerns unique to the EE enterprise.

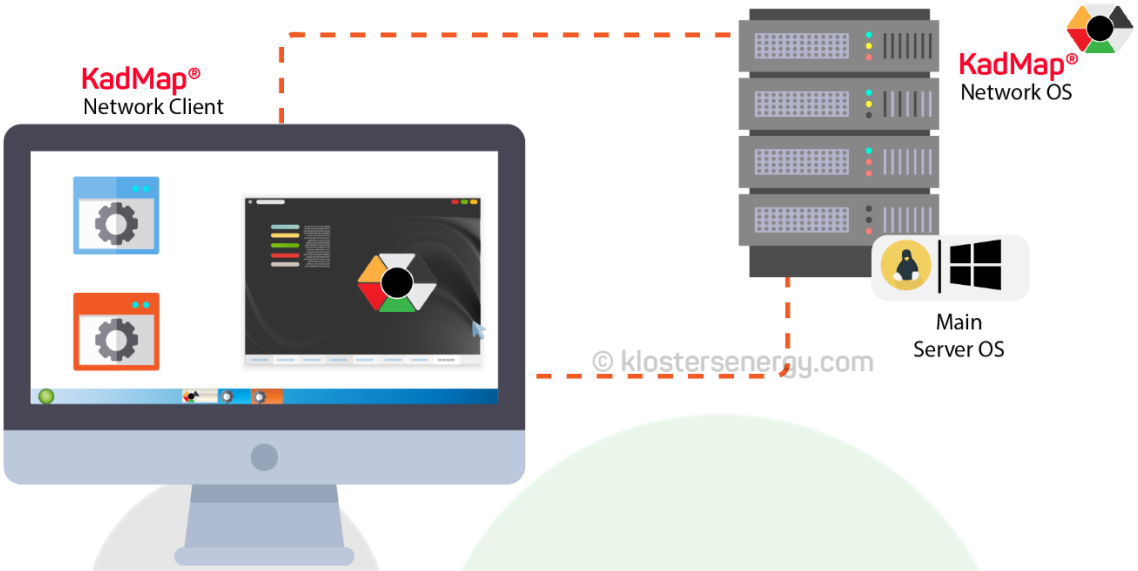


KadMap OS Architecture

KadMap® OS' philosophy and operations centres around data - its transmission, storage, security, visualization, access, etc. and thus features a heavy emphasis on data technology.

There are two main sides/components of KadMap® OS:

1. Client side (Network Client) – Which is for data input, organization, manipulation and rendering of data and application instances. It is installed on the local machines utilized by staff in the EE enterprise.
2. Server side (Network OS) – Which is for local hosting of applications, network administration and storage of data within the EE enterprise. It is also the gateway to KNS which delivers a range of critical functions. It is installed on the main server in the EE enterprise.



KadMap® OS Components (Enterprise Edition)

The network OS on the server side of KadMap® OS holds the data abstraction layer (DAL) which is a collection of KadMap® data libraries and APIs.

The DAL provides a common programmable interface for the development of apps for EE assets and operations.

The DAL is a comprehensive and robust deliverable required to fulfil the fast solution development potential of KadMap®. The DAL would facilitate fast development of applications capable of complex data manipulations/computations and foster the development of light utility apps with very specialized functions for the EE industry.

Part of the upstream aspect of KadMap® is executed in KadMap® OS as it provides means of data input from EE assets, employees and data sourcing from other existing software/databases.

There are several essential enterprise-wide software utilized in EE enterprises. In order to enable the enterprise continue utilizing these software, it is essential that KadMap® OS is collocated (installed) alongside these software. KadMap® OS is designed to be deployed alongside an existing OS while optimizing hardware usage on the machine (server and network client machines) with no conflict.

The industrial internet of things (IIoT[15]) interfacing is also enhanced and facilitated as KadMap® OS provides interface with sensor data from EE assets for several critical applications, analyses or other purposes (e.g. asset integrity. See: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[16])

The client side (network client) KadMap® provides for data manipulation and visualization. These of themselves are done by apps which are hosted on the server side (from KNS, precisely KadMap® App Store) and made available networkwide via the network client. The network client also enables remote collaboration on an industrial scale over given operations.

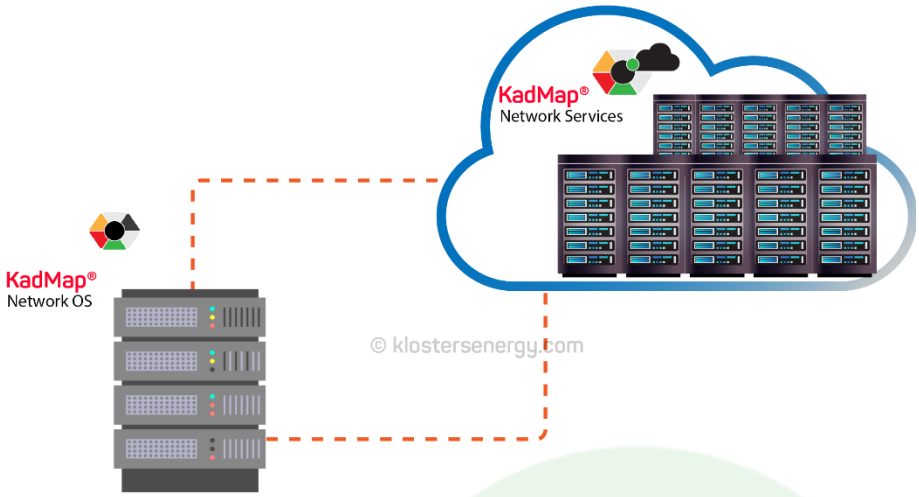
KadMap® OS architecture very importantly, allows for a high level of security and privacy whilst delivering significant benefits to the EE enterprise.

KadMap® Network Services (KNS)

KNS is a distinct network of servers and supercomputers storing and processing data from authenticated and KadMap® OS installed EE networks. Clients privacy and security is paramount and therefore their permission (via contracts) is required and their data is collected anonymously (preserving privacy).

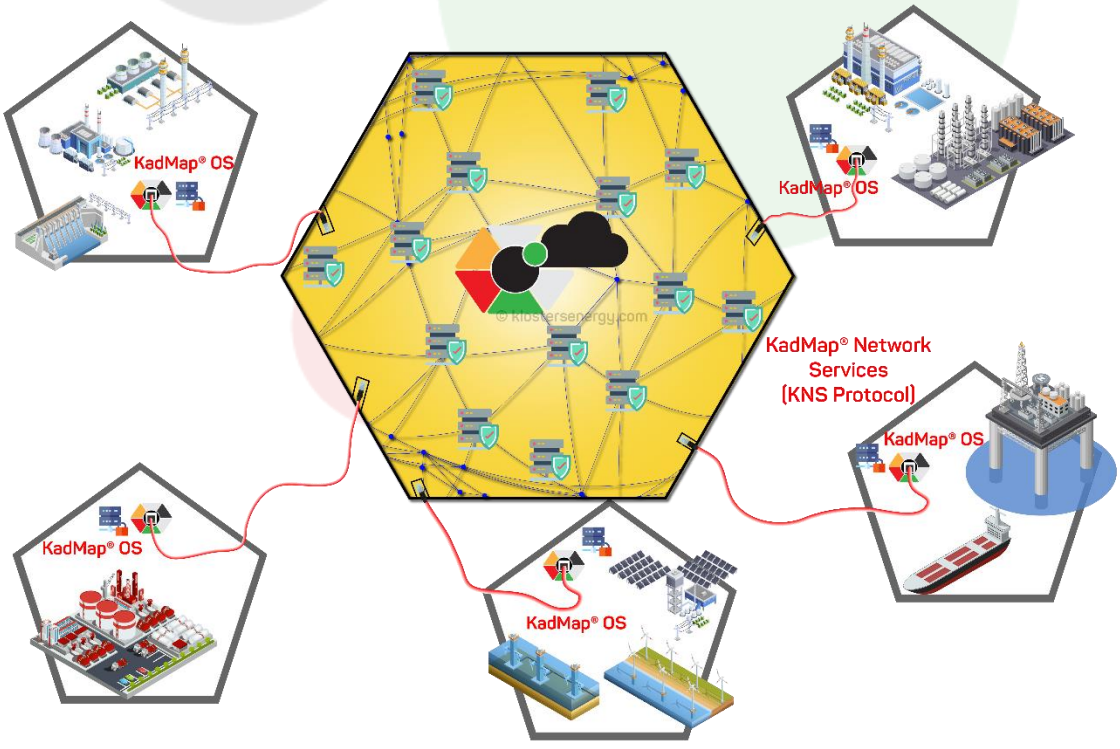
KNS also serves as machine nexus by storing data in a way that is machine readable and programmable without human interference.

[15] The industrial internet of things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. (*Wiki*)
[16] Visit http://bit.ly/SvSDigitEngMod-KES



KadMap® OS – KNS interface

The KadMap® OS powered machine of the EE enterprise and EE asset interact with KNS remotely and without human intervention.



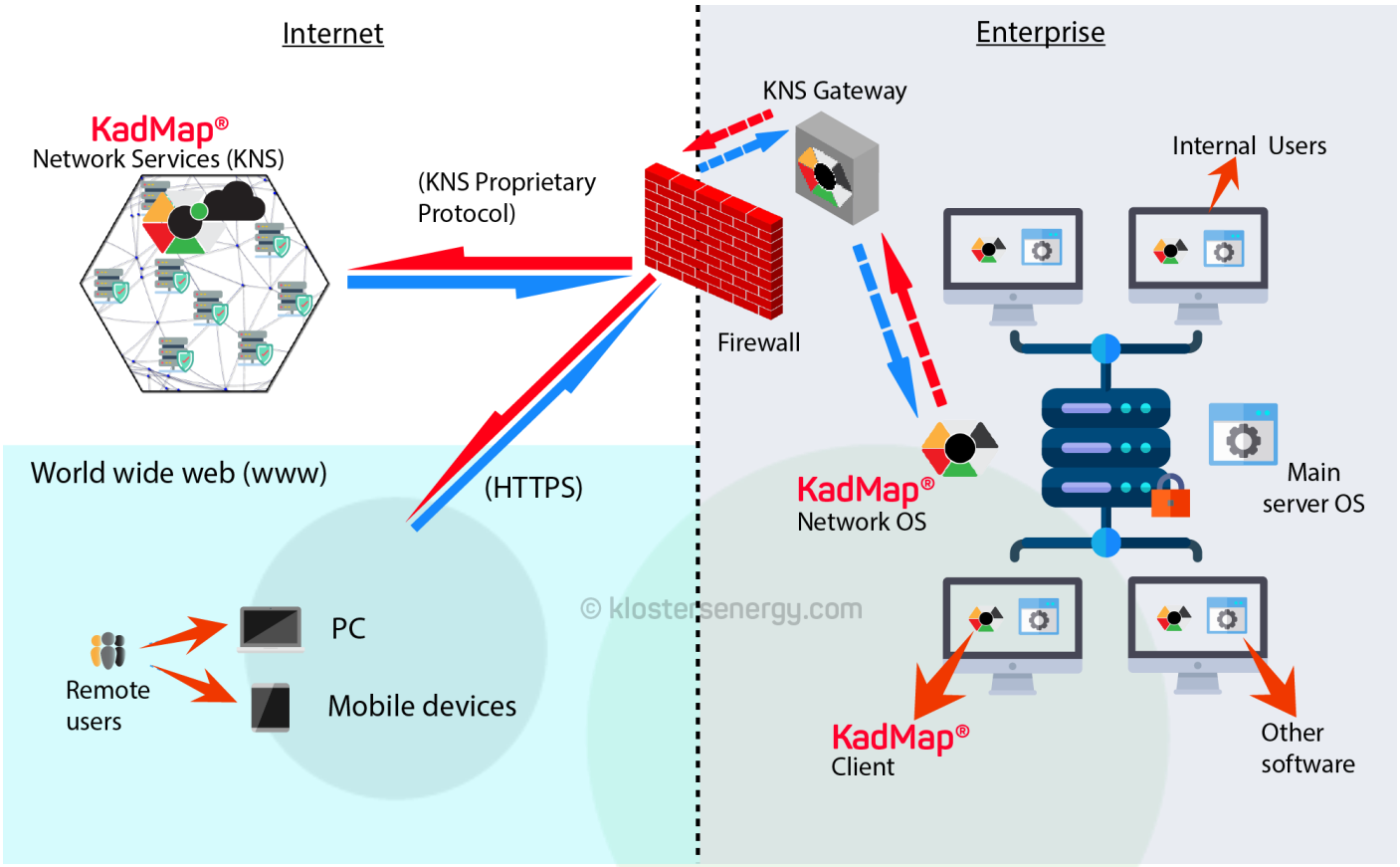
KNS – IIoT resources

The KNS provides an IIoT resource rich environment with high security, privacy and interface enabling developers create highly beneficial applications and enabling data scientists carry out in-depth analyses from feedbacks (live and archived) from EE asset sensors and devices.

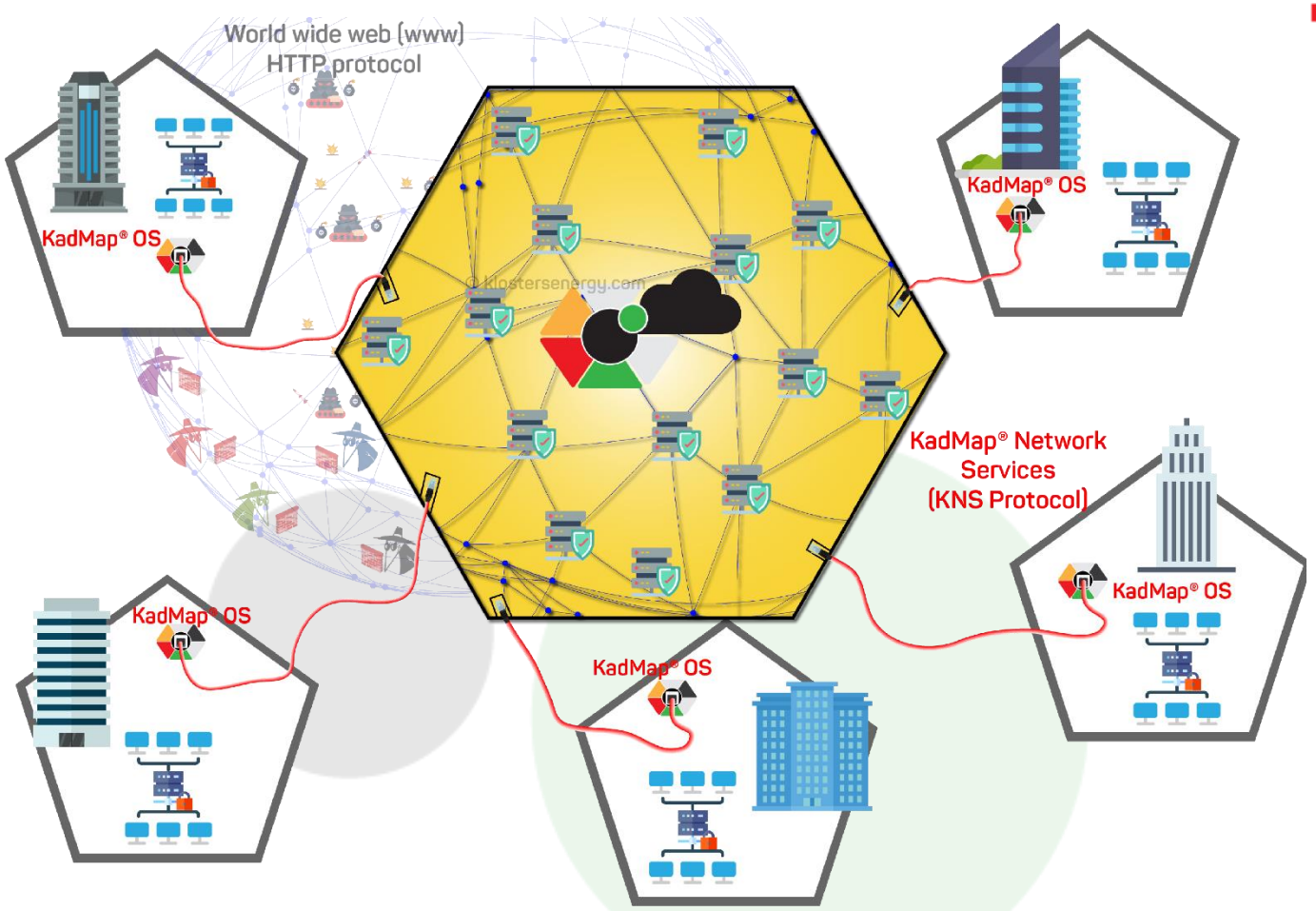
With KNS the EE industry will have a massive niche in cyberspace which is completely exclusive and accessible only by KadMap® authenticated EE enterprises. The hardware (supercomputers and high data storage servers) are high performance machines designed to deliver the heavy machine resources that are required to undertake high precision data analysis and calculations undertaken in the EE industry. The KNS utilizes a highly secure proprietary protocol (different from that used to access the World Wide Web (www) (http)) optimized for data operations which also contributes to KNS' robust security profile.

The KNS can be accessed only via a KadMap® network. Access is monitored and logged. KadMap® applications are also catalogued on the KNS after detailed security and QAQC checks in order to keep clients maximally protected at all times.

The data exchanges, remote collaborations and network access are also highly monitored and logged. Corporate espionage, security threats and malicious programs/wares are greatly minimized if not completely eliminated.



KadMap® OS – KNS Enterprise Architecture



KNS – A Trusted Collaboration Network

For more in-depth insight on KadMap® OS and KNS, see: *A Big Platform for the Engineering and Energy Enterprise – What Is It and Why Do We Need It?*[17].

The KadMap® Development Project

The end-to-end integrated scope of KadMap® is a huge challenge. KES' strategy to surmount this challenge has been the adoption of a project-based approach. This involved the creation of an integrated project dubbed "KadMap® Development Project" which is currently in execution. The goal of this project is to surmount the challenges inherent in the end-to-end scope of KadMap®. Each

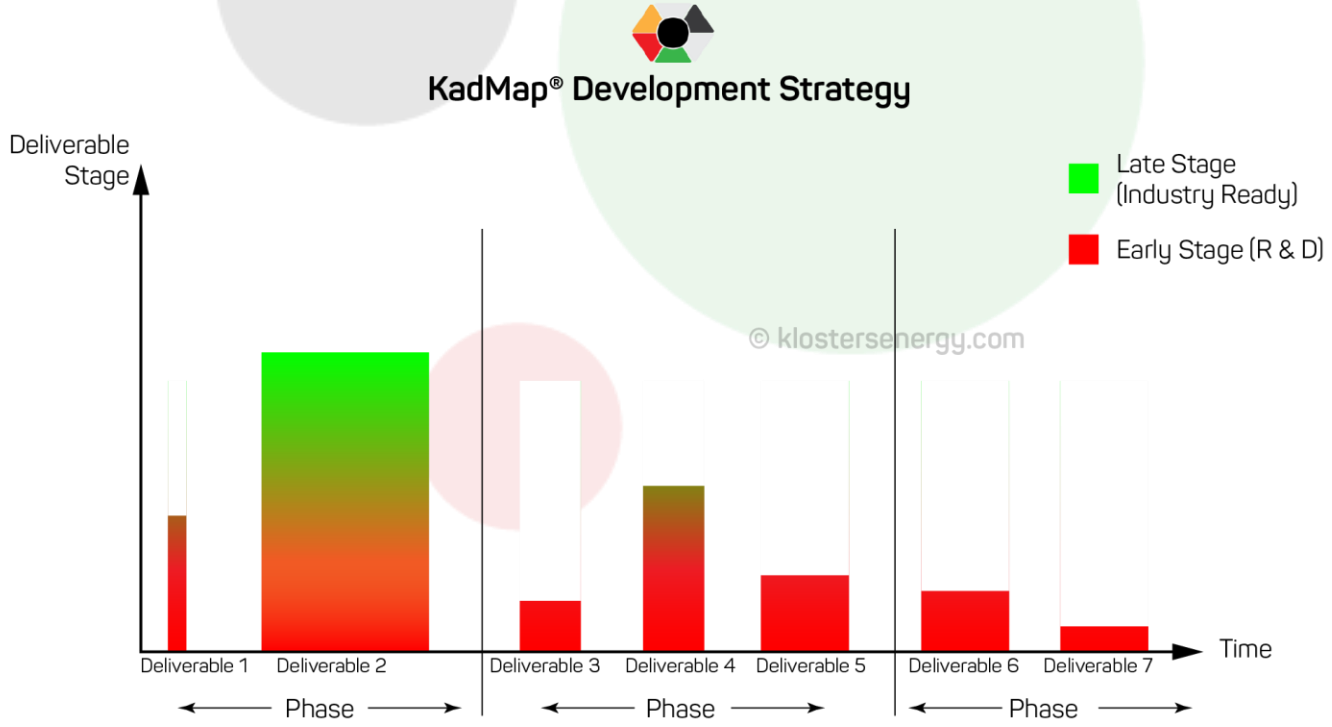
[17] http://bit.ly/BigPlatEEInd-KES

subsequent project deliverable is identified and configured as a milestone towards addressing the challenges.

Thus, the KadMap® Development Project is an ongoing project, outputting multiple deliverables in form of digital solutions and updates to KadMap®.

Each deliverable in this project is realized by following stipulated stages of activities from research to testing, verification, QAQC, industry engagements, etc. among others in a systematic and efficient manner tailored for the EE industry.

Furthermore, the project is split into phases which may overlap in time. The phases have generally specified goals while each deliverable is a push towards the specified phase goal.



KadMap® Development Strategy

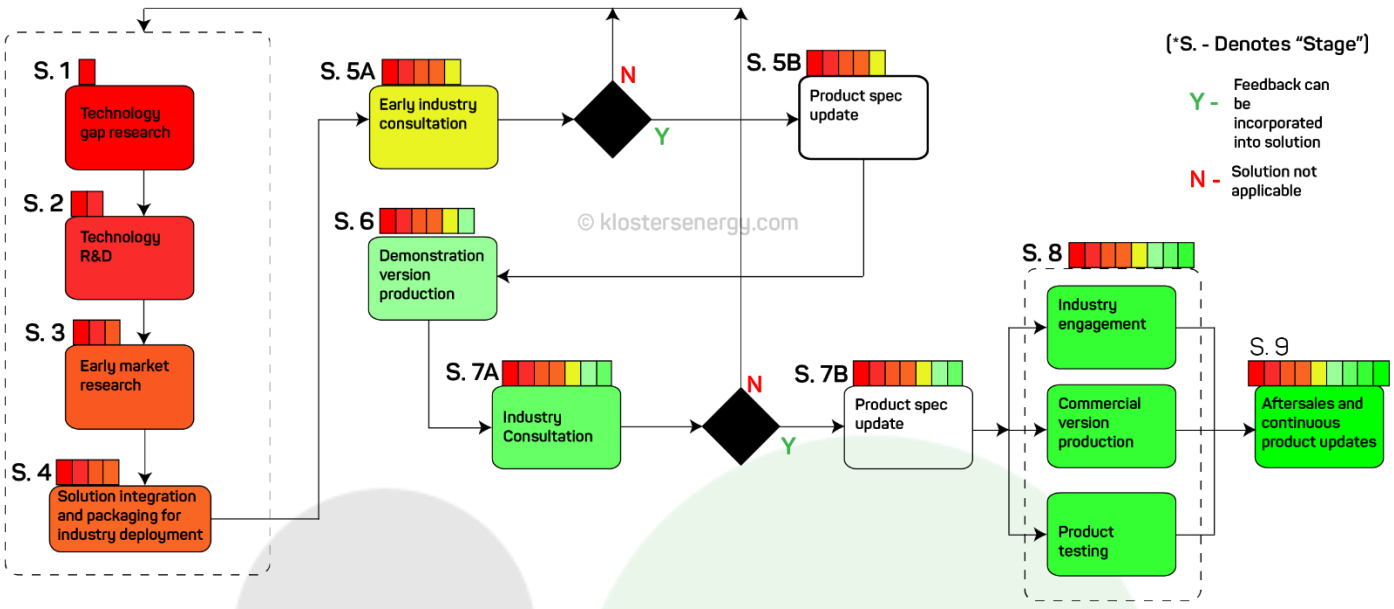
The deliverables are well incubated (and usually developed concurrently) sometimes for several years at a time in order to attain seamless integration, interface and compatibility between all developed solutions.

There are 9 stages in total required for the incubation and development of a KadMap® deliverable from inception to industry:

1. *Technology gap research*	2. *Technology R&D*[18] *including validation/verification of findings*	3. *Early market research*
4. *Solution integration/packaging into distinct product for industry deployment*	5A. *Early industry consultation*	5B. *Product specification update*
6. *Demonstration version production*	7A. *Industry Consultation*	7B. *Product specification update*
8A. *Industry engagement*	8B. *Commercial version production*	8C. *Product testing*
	9. *Aftersales and continuous product updates*	

Stages 1-4 are incubation stages, stages 5-7 are intermediate development stages, and stages 8-9 are full scale production and deployment stages.

[18] Research and Development



KadMap® deliverable development process

At various stages of development of a deliverable, key partnerships are instigated for various purposes such as knowledge, consultation, finance, etc. The Liverpool Logistics Offshore and Marine (LOOM) research institute, Liverpool, United Kingdom, our key partner at the stage 2 of R&D, is one of such instances.

From its early beginnings in 2007, KadMap® has evolved into a very potent asset to facilitate and lead the world's fourth industrial revolution – the digital revolution. KadMap® has been through two development phases and is currently on the third.

Phase	Objective	Timeline	Deliverable
1	Develop robust data framework capable of abstracting the assets and operations of EE enterprises	2007-2015	• KadMap® Framework • *Others*
2	Development and packaging of viable digital	2014-2018	• KadMap® web interface application (WIA)

	solutions for EE industry		• *Others*
3	Deployment of solution to EE Industry	2018-2022	• KadMap® OS • KNS • *Others (including KadMap® Apps)*

Phases of KadMap® Development along with objectives, timelines and deliverables

As an engineering company in the energy industry, our journey started with the development of conventional physical services in the form of asset integrity management (AIM) services. With information technology (IT) as one of our major strengths, we also began software designs of novel enterprise AIM systems. Simultaneously, we also began conceptualizing the digital equivalents of these services with application of our engineering knowledge and experience as our targeted users are engineers as well. This prompted the development of a digital framework (which later came to be known as KadMap®) as the backbone necessary to deliver these digital services.

This framework, KadMap®, quickly became the centrepiece of our attention and developments at KES. Our initial services were limited to a section of the lifecycle of EE assets (see illustration below). As we began to see some success in the design of these digital equivalents and the framework development, we realized that the team could replicate such throughout the entire life cycle of an EE asset.

EE Asset Lifecycle

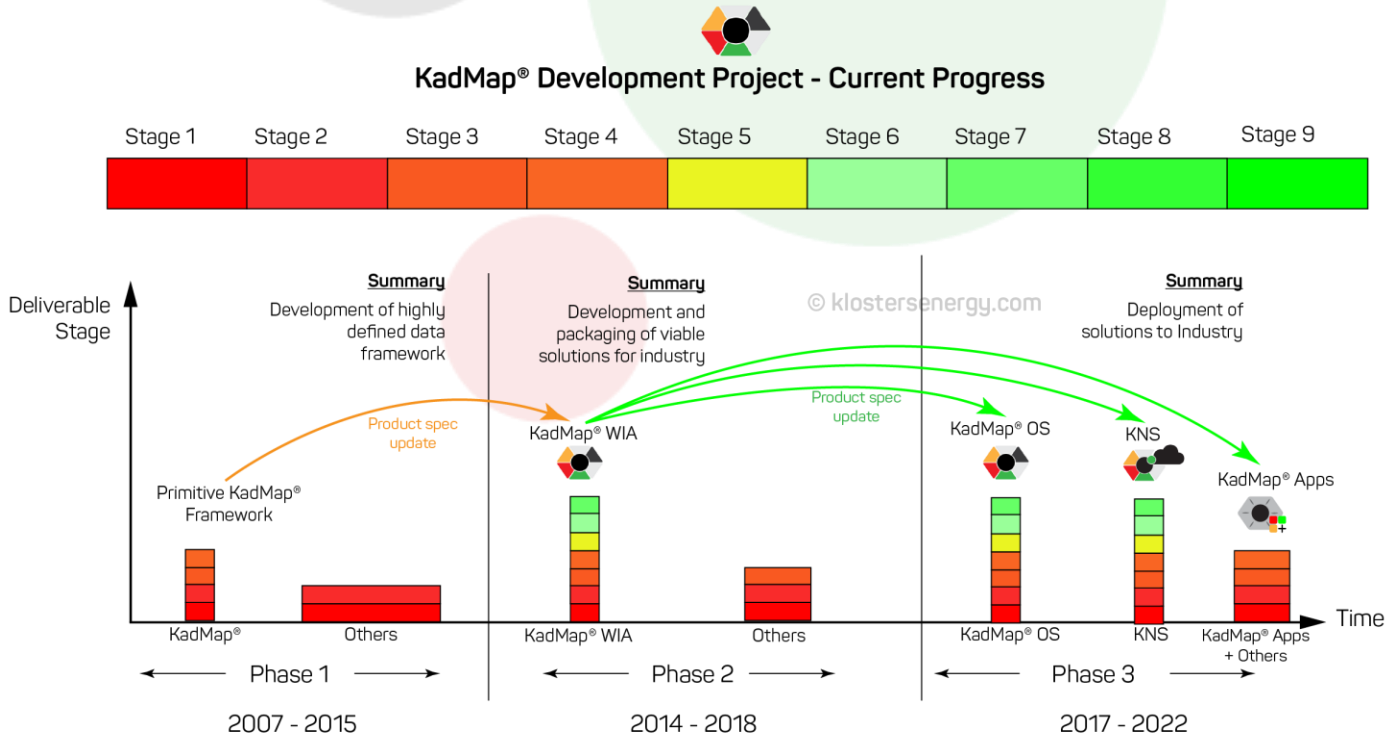
In order to achieve this, we had to increase the complexity and robustness of KadMap®. We also had to device a new strategy of development – the KadMap® development project strategy to maintain sanity and organization even as the complexities and solutions increased.

Sufficient definitions/specifications of the infrastructure, abstraction, data operations and technology marked the beginning of phase 2.

Phase 2 saw us take these definitions/specifications to begin development of KadMap® Web Interface Application (WIA) – to be available/delivered over the www. It also saw the development and deployment of an early version of our first digital service – R-AIM (remote asset integrity monitoring) (see: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[19]).

We had positive feedbacks as well as critical comments/recommendations as we went on several industry consultations. The implementations of these recommendations heavily refined KadMap® WIA as it also increased commendations.

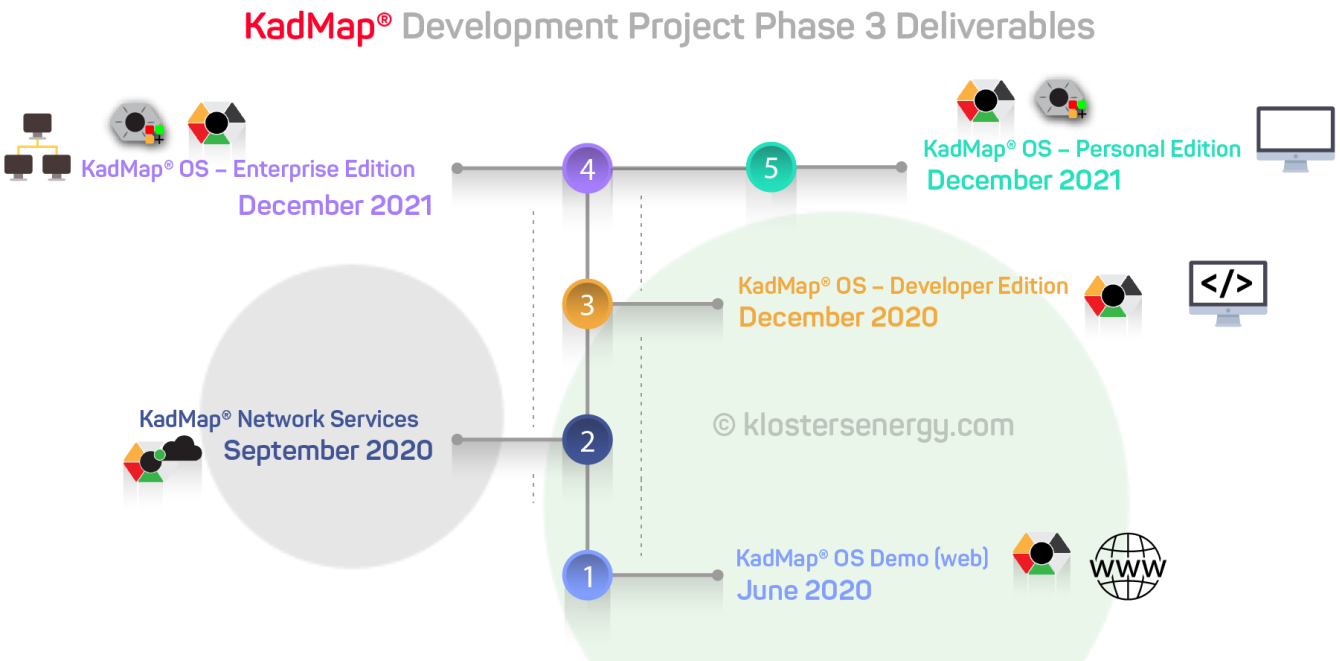
The final product specifications update (stage 7A of KadMap® deliverable development process) manifested as evolution of the user interface, critical details of our R-AIM service and eventually the KadMap® WIA architecture. The KadMap® WIA architecture evolved and split to give rise to 3 subsequent deliverables – KadMap® OS, KNS and KadMap® Apps, all inheriting the progress made thus far.



KadMap® Evolution

[19] http://bit.ly/SvSDigitEngMod-KES

The evolution of the KadMap® WIA architecture marked the start of phase 3 - the final commercial development and testing of these deliverables as well as industry engagement. Phase 3 is currently underway with key dates as follows:



Key Dates for KadMap® Phase 3 Deliverables

Within phase 3, we are also at the stage of industry engagement (stage 8A) which involves mass industry sensitizations of all product stakeholders in form of targeted media outreach, conferences/exhibitions, road shows, etc. and product launching. As such, we will be hosting and attending a series of industry events which will be announced on our websites (www.klostersenergy.com) and (www.kadmap.com) in the coming months. We do invite you to visit and sign up to our news letters to stay updated on these events and our latest developments.

Afternotes

Klosters Energy Services (KES) is a technology engineering (TechEng) Company - we combine the traditional feel of an engineering company with the futuristic feel of a "Tech" (IT) company.

We provide digital asset solutions with the latest cutting-edge technology with a view to reducing OpEx, increasing asset availability, increasing efficiency, optimizing performance and maintaining a high level of safety for the global energy and engineering industry.

For more information on our solutions, to follow our development, and get updates:

Visit us at www.klostersenergy.com and www.kadmap.com.

Follow us on Twitter : @klostersenergy @kes_kadmap

And on LinkedIn : www.linkedin.com/company/klosters-energy-services-limited

About Industry Papers

KES' "industry papers" is a series of publications focused on propagating awareness and solutions among professionals in the energy and engineering industry. It features captivating illustrations and is written in lecture or first-person explanatory format giving a conversational feeling to our audience.

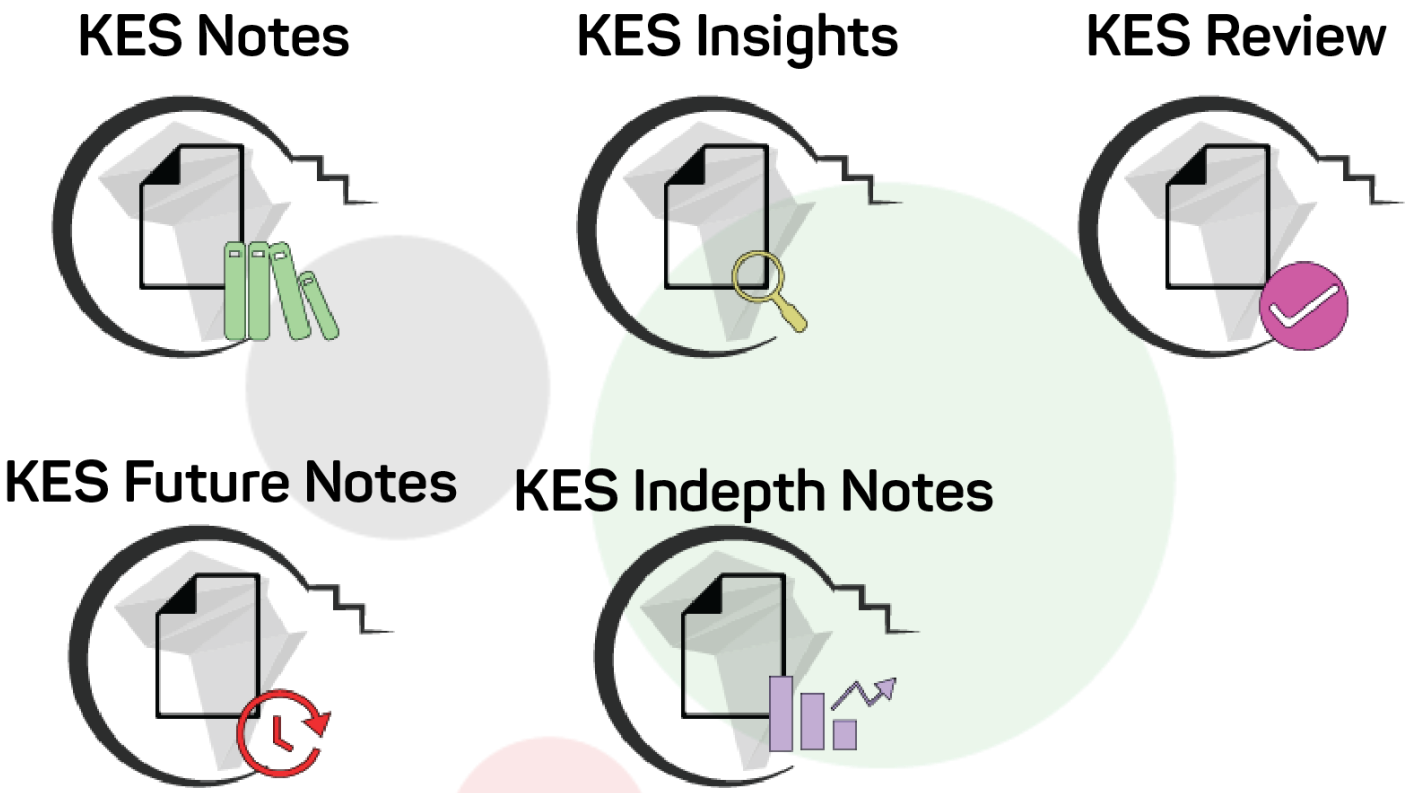
Industry papers uses a unique referencing system and a peer review system populated by our network of academicians and experienced industry professionals. Reviewers of publications can be viewed by the URL provided at the "Reviewers" section of each publication.

About KES Notes

KES' industry papers features various genres distinguished by the focus' depth range and angle on a selected topic. "KES notes" presents a general exposition on a selected topic. Others include:

- KES Insights: It presents KES' perspectives on a given topic of concern

- In-Depth Notes: It presents a more technical exposition on a given topic
- KES Review: It presents our opinions and views on a trending industry topic
- Future Notes: It presents futuristic ideas on certain solutions or scenarios which may not have a complete scientific explanation but will no doubt propel the industry forward



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