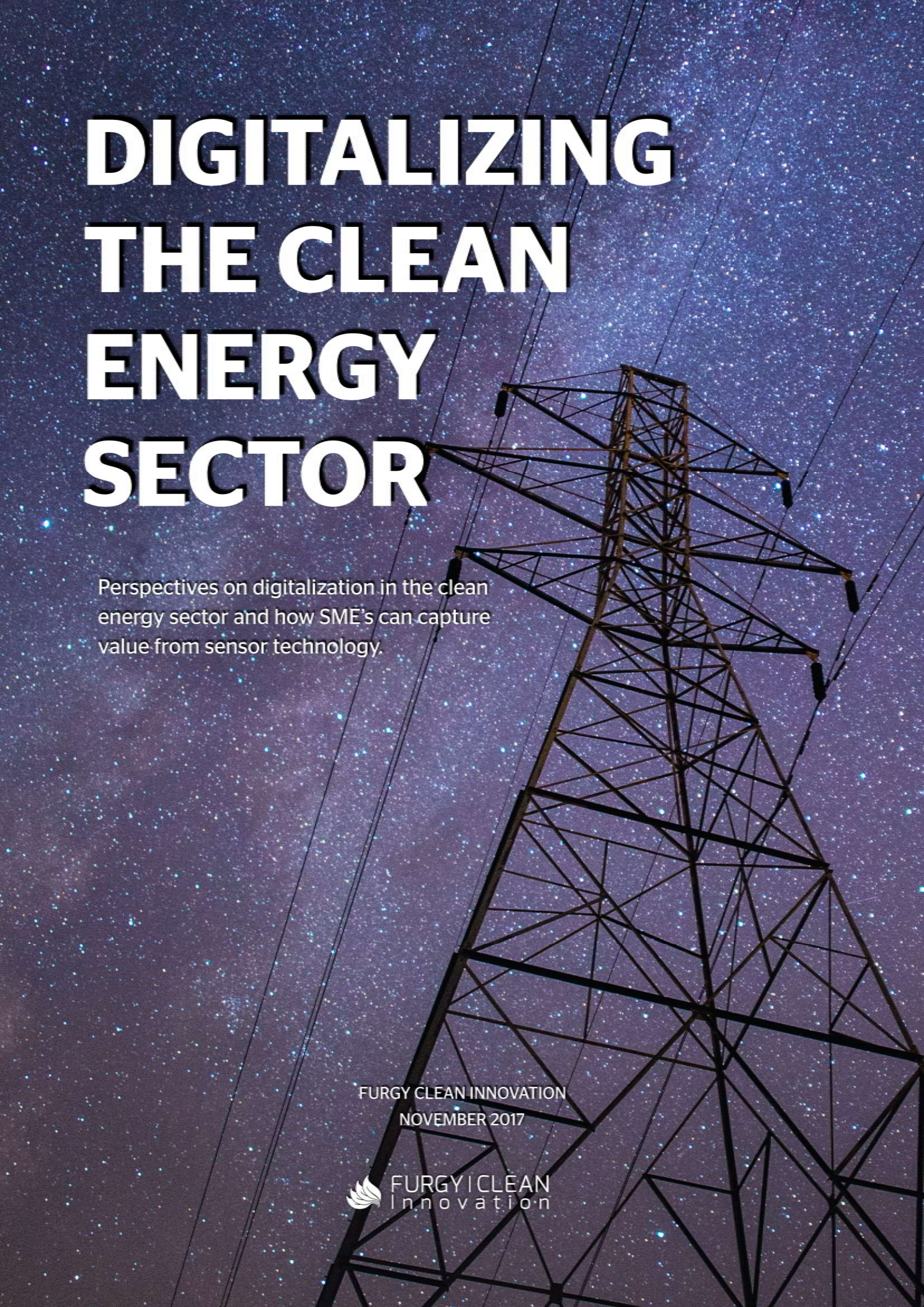

DIGITALIZING THE CLEAN ENERGY SECTOR

Perspectives on digitalization in the clean energy sector and how SME's can capture value from sensor technology.

FURGY CLEAN INNOVATION
NOVEMBER 2017

FURGY | CLEAN Innovation

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Read more on the website: **www.furgyclean.eu**

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PREFACE

In todays rapidly developing technology climate, we are experiencing fundamental changes in many industries and the way business as usual is being conducted. New agendas within the energy sector, are justifying the necessity to transform businesses along the entire value system into being more digital, efficient, service oriented and sustainable.

The technological development is fostering exponential organisations and digital businesses, who are increasing competitiveness amongst incumbents based on new ways of delivering value to customers.

Within the clean energy sector, consumers and industries alike, are demanding more transparency about the source of energy and more control over consumption and distribution. SMART meters are creating more aware- ness and are turning owners of decentralised energy systems into producing consumers (prosumers) of energy.

These changes are going to fundamentally alter the way energy is produced and distributed and disrupt the traditional supply chain of energy.

Producers and sub-suppliers to the clean energy sector are therefore urged to begin transforming their business- es into being more digital, thus beginning to harvest the benefits and new market opportunities that lies ahead in the not so distant future.

As the energy system is being disrupted, creating a competitive edge will be paramount for the continuous existence of many of the SME's. Here, the ability to apply sensory technology to retrieve data, and then use that data to generate new business opportunities will be key factors for sustaining a competitive position in the market.

This report has been written to create a foundation for in- spiring and guiding SME's within the clean energy sector to begin their transformation, by providing an overview of the trends within digitalisation across industries, the technologies available, and how to capture value.

We hope that this will lead to further dialogue amongst decision makers in SME's on how to start the process of digital transformation, and eventually taking the first steps into the future.

To be inspired.

On behalf of the project team,

RAYMOND ORTIZ CHRISTIANSEN

Project Consultant, UdviklingsRåd Sønderjylland

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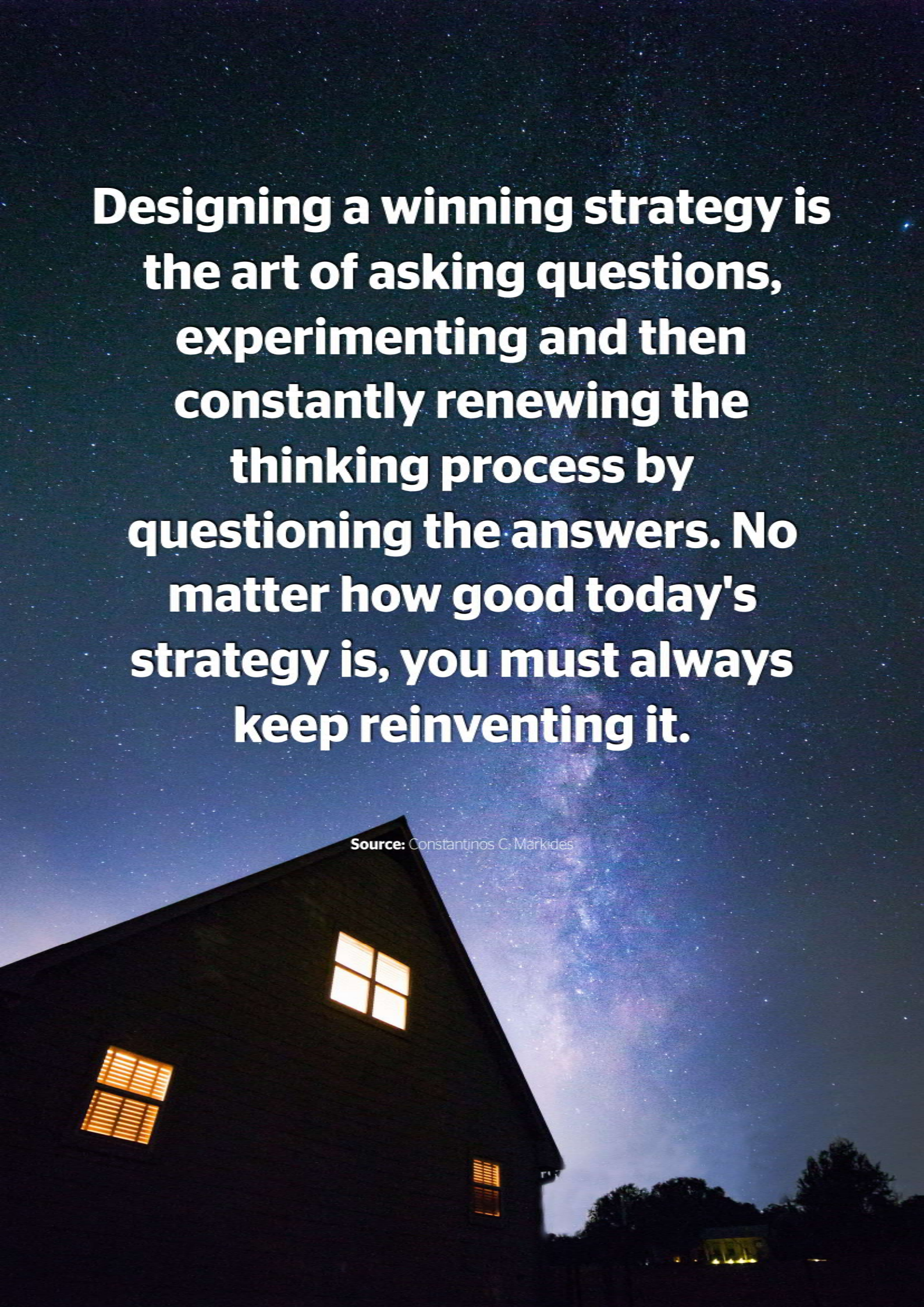

Designing a winning strategy is the art of asking questions, experimenting and then constantly renewing the thinking process by questioning the answers. No matter how good today's strategy is, you must always keep reinventing it.
Source: Constantinos C. Markides

INTRODUCTION AND EXECUTIVE SUMMARY

Digitalisation has become a necessary factor when competing in todays highly competitive business landscape. Across a long line of industries, companies have been adapting to the first wave of digitalisation and have embraced the many benefits of bringing information and communication technologies into play.

The abundance of information and communication technology have bridged the gap on information and communication world wide. Today more than 3,4 billion people are using the internet globally, more than 104 billion emails are sent every day, and the total number of websites exceed more than 1,2 billion.

From 2013-2015 the global internet population grew 18,5%, and the number keeps growing. In Denmark more than 96% of the population are using the internet and in Germany the penetration is 88%, which places them among the most digitalised economies in the world. These figures indicate that digitalisation is becoming more prevalent, and it is di using rapidly. Our willingness to adapt to a digital agenda is strong, and we are demanding more digital products and services to serve our digital needs.

With an increase in demand for fast, digital and personal services, companies are urged to further embrace digital technology that can support these demands. The race for servitization has begun, and whoever can leverage digital technology to create more value for their customers will be the ones with the competitive edge.

Thus, the next digital wave is about to hit us. This time, the digitalisation will go deeper into the core processes and activities of companies making production process- es more digitalised and connected, bringing life to smart products by use of Internet-of-Things (IoT), data analysis and Cloud Computing.

These changes o er a lot of uncertainties and challenges to companies, while also opening the door for new opportunities to be pursued.

Companies working in the clean energy sector should be aware of the new market opportunities by innovating production processes, products, services and business models. Companies are eager to transform their business into a more digital business: However, they lack the knowledge, the organisational structure, the incentive (push) and a roadmap to go from an analog to a digital business.

One key obstacle for many small and medium sized companies in adapting new technologies in their products and go digital is the lack of knowledge on new tech- nologies and the following application. At the same time technologies might arise in other sectors/ industries and serve a different purpose, however that does not deem it inadequate in the clean tech industry.

KEY TAKE-AWAYS FROM THIS REPORT

- Digital transformation is a necessity for securing competitiveness of many companies. Those who manage to adapt and react to the technological development, will have the competitive edge in the future.
- Sensory technology can provide data and insights on operational activities and customer behaviour otherwise comprehensive, costly or inaccessible to acquire.
- Data is becoming a more valuable resource than fx. oil. It can be a highly lucrative commodity, that can be translated into value-adding services.
- Generating, aggregating and analysing data from sensory technology can opens up for new business model opportunities and revenue streams.

EINFÜHRUNG UND ZUSAMMENFASSUNG

In der heutigen, durch starke Konkurrenz geprägten Geschäftswelt ist die Digitalisierung zu einem unumgänglichen Faktor bei der Wettbewerbsfähigkeit geworten.

In vielen Branchen haben Unternehmen bereits Anpassungen im Rahmen der ersten Welle der Digitalisierung vorgenommen und viele Vorteile durch Informations- und Kommunikationstechnologien für sich genutzt. Die Fülle von Informations- und Kommunikationstechnologien hat die Verfügbarkeit von Informationen weltweit enorm verbessert. Heute nutzen 3,4 Milliarden Menschen weltweit das Internet, mehr als 104 Milliarden E-Mails werden täglich gesendet und die Anzahl von Websites beträgt mehr als 1,2 Milliarden.

Von 2013-2015 wuchs die globale Internetbevölkerung um 18,5 Prozent und steigt weiterhin an. In Dänemark nutzen mehr als 96 Prozent, in Deutschland 88 Prozent der Bevölkerung das Internet, womit diese zu den meist digitalisierten Wirtschaften der Welt zählen. Diese Zahlen zeigen, dass die Digitalisierung immer präsenter wird und sich schnell in immer mehr Bereiche erstreckt. Die Bereitschaft sich dem digitalen Zeitalter anzupassen ist groß und es gibt eine enorme Nachfrage nach Produkten und Dienstleistungen um die digitalen Bedürfnisse zufriedenzustellen.

Mit einer steigenden Nachfrage nach schnellen, digitalen und personalisierten Dienstleistungen stehen Unternehmen vor der Herausforderung, verstärkt digitale Technologien zu nutzen, um dieser Nachfrage gerecht zu werden. Der Wettstreit um die besten Produkt- und Dienstleistungskonzepte hat begonnen und derjenige, der die digitale Technologie nutzen kann um einen Mehrwert für seine Kunden zu generieren, wird einen Wettbewerbsvorteil haben.

Die nächste Welle der Digitalisierung rollt daher schon auf uns zu - und sie wird tiefer in die Kernprozesse und Aktivitäten von Unternehmen eindringen als zuvor. Noch stärker digitalisierte und vernetzte Produktionsprozesse, smarte Produkte durch das Internet-of-Things (IoT), Cloud Computing und künstliche Intelligenz werden zum Alltag erfolgreicher Unternehmen gehören.

Diese Veränderungen bringen eine Reihe von Unsicherheiten und Herausforderungen für Unternehmen mit sich, bieten gleichzeitig aber auch neue Möglichkeiten.

Unternehmen aus dem Clean Tech Sektor sollten sich ihrer Marktchancen durch Innovationen in Produktionsprozessen, Produkten, Dienstleistungen und Geschäftsmodellen bewusst sein. In vielen Fällen sind Unternehmen bereits heute bestrebt, ihre Geschäftsmodelle entsprechend den Anforderungen der Digitalisierung umzustrukturieren. Jedoch fehlt Ihnen oft das Wissen, die Organisationsstruktur, der Anreiz oder der Businessplan, um von einem analogen zu einem digitalen Business überzugehen.

Ein entscheidendes Kriterium für viele kleine und mittelständische Unternehmen der Branche bei der Anpassung ihrer Produkte ist das fehlende Wissen über die neu verfügbaren Technologien und deren Anwendungsmöglichkeiten. Gleichzeitig entstehen technische Neuerungen in anderen Branchen, deren Anwendungen zunächst einem anderen Zweck dienen, die aber auch in der Clean Tech Branche zu Innovationen führen können.

KERNAUSSAGEN DES BERICHTES

- Digitalisierung ist eine Notwendigkeit zur Wettbewerbssicherung vieler Unternehmen. Wer sich an die technologische Entwicklung anpassen und darauf reagieren kann, wird in Zukunft einen Wettbewerbsvorteil haben.

- Die Sensorik kann Daten und Erkenntnisse über operative Aktivitäten und das Kundenverhalten liefern, die andernfalls teuer zu erwerben oder nicht verfügbar wären.

- Daten sind zu einer wertvolleren Ressource als Öl geworden. Es ist ein höchst lukratives Gut, das in wertschöpfende Dienstleistungen umgewandelt werden kann.

- Das Generieren, Aggregieren und Analysieren durch Sensortechnologien gewonnene Daten eröffnet neue Geschäftsmodelle.

INDLEDNING OG RESUMÈ

Digitalisering er blevet en nødvendig faktor når det gælder konkurrenceevnen i det højt konkurrencepræget forretningslandskab idag. På tværs af en række industrier har virksomhederne tilpasset sig den første bølge af digitaliseringen og har omfavnet mange af fordelene ved at bringe informations- og kommunikationsteknologierne i spil.

Tilgængeligheden af informations- og kommunikations teknologier har bygget bro mellem information og kommunikation verden over. I dag bruger mere end 3,4 milliarder mennekser verden over internettet dagligt. Mere en 104 milliarder emails bliver sendt hver eneste dag, og det totale antal hjemmesider overstiger 1,2 milliarder. Fra 2013-2015 steg den globale internet population med 18,5% og bliver ved med at stige. I Danmark anvender mere end 96% af befolkningen internettet og i Tyskland er tallet 88%, hvilket placerer de to lande, særligt Danmark blandt de mest digitaliserede økonomier i verden. Disse tal indikerer at digitaliseringen er fremherskende og hurtigt voksende. Vores villighed til at tilpasse os en digital dagsorden er stærk og vi kræver flere digitale produkter og services, til at udfylde vores stigende digitale behov.

Med en stigende efterspørgsel for hurtige, digitale og personlige services, opfordres virksomhederne til at yderligere omfavne digitale teknologier, som kan understøtte denne efterspørgsel. Kapløbet om servitization og dem som er villige og i stand til at udnytte de digitale muligheder til at skabe mere værdi for deres kunder, vil være dem med den konkurrencemæssige fordel.

Og med det, er den næste bølge af digitalisering ved at ramme os. Denne gang vil digitaliseringen gå dybere ned i kerneprocesserne og -aktiviteterne, og gøre produkttionsprocesserne mere digitale og forbundne, og dermed give liv til smarte produkter ved implementering af f.eks. Tingenes Internet (IoT), data analyse og Cloud Computing.

Disse forandringer byder på en masse usikkerheder og udfordringer, men også et vindue for nye muligheder at blive udforsket.

Virksomheder i Clean Energy sektoren bør være opmærksomme på de nye markedsmuligheder, ved at innovere deres produktionsprocesser, produkter, services og forretningsmodeller. Mange virksomheder er også ivrige efter at omstille deres forretning til en mere digital én af slagsen. Dog, er der en mangle på viden, organisatoriske strukturer, incitament og en køreplan om at gå fra en analog til en digital forretning.

Én af de største barriere for mange små og mellemstore virksomheder når det handler om at implementere ny teknologi i deres produkter er manglen på viden af de teknologiske muligheder og deres anvendelsesområder. Samtidig ser vi teknologier vinde frem i andre sektorer/industrier hvor de f.eks. tjener et andet formål, end de ville i Clean Energy sektoren, hvilket ikke nødvendigvis gør den irrelevant.

HOVEDPOINTER FRA RAPPORTEN

- Digital omstilling er en nødvendighed for at sikre virksomhedernes konkurrenceevne. De som formår at omfavne og reagere på den teknologiske udvikling, vil have den konkurrencemæssige fordel i fremtiden.
- Sensor teknologi can indbringe data og indsigter på drift og kundeadfærd, som på anden måde er omfattende, omkostningstunge eller utilgængelige at få fat i.
- Data er ved at blive en mere dyrebar resurse en f.eks. olie. Data kan være en yderst lukrativ vare, som kan omsættes til værdiskabende services.
- At generere, omsamle og analysere data fra sensor teknologi, kan skabe nye forretnings- og indtjeningsmuligheder.

THE CLEAN ENERGY SECTOR

When referring to the clean energy sector, we are referring to suppliers and sub-suppliers, within one of the four defined areas of the clean energy sector (see figure 1). The SME's targeted with this report may not necessarily be categorised as clean energy companies, but may constitute an important part of the supply chain - for example by delivering components or services to the sector, which may not be specialised or exclusive for clean energy purposes.

The clean energy sector can thus be comprised of companies that operates and/or supply products and services related to energy storage, energy efficiency, energy infrastructure or energy production.

ENERGY STORAGE - Batteries - Fuel cells - Heat, Gas - Water storage	**ENERGY EFFICIENCY** - Pumps and Compressors - Ventilation, Cooling, Heat, and Accumulators - Lighting - Electrical motors, Generators, and Transformers - Insulation and Window glass - Sensors and Control systems
ENERGY PRODUCTION - Wind Power - Solar panels and power - Biomass - Biogas - Geothermal energy - Wave and Hydro energy	**ENERGY INFRASTRUCTURE** - Transmission and Distribution of electrical power - District and Central heating - Natural Gas - Conversion technologies - Pipes and Cables

Figure 1: Characteristics of the Clean Energy Sector. **Source**: CLEAN

DECENTRALISATION

Solar roof-tiles, home batteries, geo-thermal systems, and other clean energy solutions are being commercialised, fostering a new kind of energy consumer that produces their own energy (a prosumer). This growing tendency means that energy production incrementally is being produced locally and excess energy is being sold and redistributed to those who have a nearby demand, as e.g. our neighbours.

In an ideal situation this kind of solution is utilising energy more efficiently, due to its shorter travel distance, hence a lower loss of energy. However, there is a long way to go still, and one of the biggest challenges is upgrading the existing infrastructure to handle peer-to-peer transactions, and the resilience of the grid, to be able to handle the future increase in electrical devices on the grid, such as electric vehicles.

“At least 40% of all businesses will die in the next 10 years... if they don’t figure out how to change their entire company to accommodate new technologies.”

Source: John Chambers, Executive Chairman, Cisco System

DIGITALIZATION TRENDS

Moore's law depicts that the computer processing power doubles every 18th month. This is an exponential increase in computer power, which mean that we keep getting faster and faster computers that can perform calculations in nano-seconds. But why is this important for the small and medium sized business owner?

It is important because; while the technological develop- ment is exponential, human development is rather linear (figure 2). This means that the pace at which we can learn, analyse, and respond, is challenged by technology. These processes which has been uniquely performed by people are now being performed by computers because it is faster and eventually cheaper.

This growth pattern also means that once technological capability surpasses human expectation, disruption is likely to occur, as described as a phase in the 6D's of exponential technology. (Singularity University, 2016). Once something has been digitized, the progression is followed by a deceptive period where growth is initially slow. In this phase some may believe in the future of the technology, while others may choose not to.

Once the technology surpasses human expectation the disruptive phase begins. In this phase the technology disrupts exist- ing markets by outperforming on efficiency and cost. In the case of the camera, the digital camera outperformed the analogue camera on both these variables. Moving from the disruptive phase to the demonetising phase means that the money is increasingly removed from the equation to the point of being free or close to free. With the digital camera, shooting an image has become practically free, compared to the rather expensive 35mm film roll. Next phase in the progression is a dematerialization process. This phase means that the analogue image to a very large extent sieges to exist.

The last phase is called the democratisation phase. In this phase the technology has become so broadly accessible, that practically any- one can have access to it. Today it is almost impossible to find a smartphone without a camera function with virtually no extra cost of using.

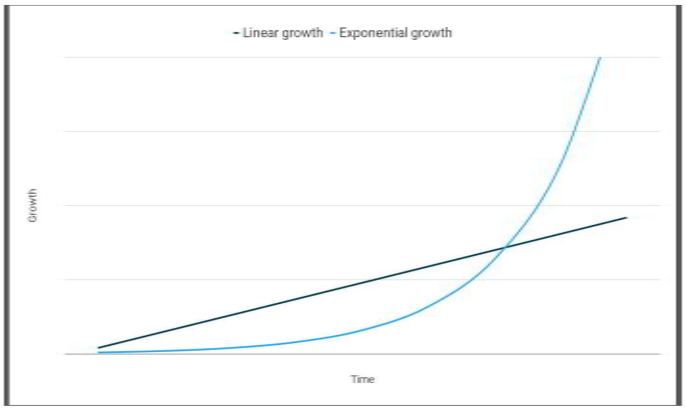


Figure 2: Exponential vs. Linear growth. **Source:** Exponential Organisations, Salim Ismail 2015

The point to be made here, is that technology may not always seem to grow exponentially at first, which is why businesses should be aware of the threats and opportunities within their own sector before they are outcompeted by those who manage to embrace technology into their core businesses.

When discussing technological trends it is important to stress that technological innovation have been seen to alter and even converge industries, and for this reason many of the technological trends that we are experiencing prevalent in some industries, may very well be relevant in other industries as the maturation of technology continues. The presentation of trends in the following section are therefore merely a few examples of some of the most prevalent and discussed technologies within the energy sector, thus not excluding the influence and impact of others.

INDUSTRY 4.0

The term industry 4.0 is best explained in relation to previous industrial waves - beginning with the first industrial revolution in the late 18th to early 19th century. In this period technological breakthroughs such as the steam engine, powered the cotton mills. Later, technological advancements within steal and electricity, paved the way for assembly lines and mass production. Technologies that remain a crucial part of our industrial economy. The third industrial revolution was powered by computers, automation, and IT - making analogue technology digital.

Now, we are hearing about Industry 4.0. aka. The fourth industrial revolution. In this era to come, technological advancements within robotics, genome technology,

Machine Learning, Artificial Intelligence (AI), IoT, 3D Print- ing and many more are bridging the gap between the physical and the digital realm. Industry 4.0 goes beyond mechanics and automatisation, by applying intelligence, inter-connectivity, and flexibility to machines and devices, making them capable of performing more complex task with a higher degree of autonomy, and predictive and analytical capabilities.

SMART GRID TECHNOLOGIES

"The smart grid is a vision of a future energy delivery infrastructure, a steppingstone to the utility sectors digital transformation that will improve network resilience and empower consumers." (Gartner, 2017). With the increasing consumption of energy, the demand for new ways of controlling the flow and exchange of energy is increasing as well, which will put pressure on the exiting infra- structure and the utility companies. Some of the related concepts within new energy distribution are: Transactive energy, which is the economic and controlling methods for managing the exchange of energy and Distributed Energy Resource Management Systems (DERMS) which is a platform for local energy resource management.

BLOCKCHAIN

The blockchain technology is one of those technologies that has the potential to alter and even disrupt multiple industries. The technology is said to be foundational, because it has the potential of fundamentally changing the way our economic and social systems operate today (IDA Universe, 2017). The most known example today on the usage of the blockchain technology is BitCoin. The financial sector are prevalent in their experimentation of blockchain technology, but its application has been predicted to be far more reaching.

Blockchain is a technology that enables direct transactions between peers in a safe, reliable and transparrent way without the involvement of an intermediary. Block- chain decentralises transactions making the system more resilient to centralised security issues and exploitation. Within the energy sector the potential of blockchain is huge (Scanergy Project, 2017). Take our energy distribution system as an example. The blockchain technology can be used to enable the transaction of excess energy to be bought and sold, safely and effectively, without the mediation of a centralised energy supply company.

On other areas, blockchain can ensure the security of the many interconnected devices that we are experiencing with the increasing amount of IoT devices present in our every day surroundings.

INTERNET OF THINGS (IOT)

In the broader context the Internet of Things (IoT) is the concept of everyday devices connected to the internet. This enables devices to communicate with each other, and being controlled remotely by users. It has been on the Gartner Hype Cycle for Emerging Technologies the last several of years (Gartner, 2017), but is estimated to reach its peak within the next few years. It is estimated that we by 2020 can expect between 26 - 50 billion de- vices connected to the internet. (Gartner 2017).

As the Internet of Things is di using into the consumer market, making smart technology abundant and easily accessible, we can expect similar tendency within the B2B markets. Expectations from consumers products and services in terms of design, user experience and personalized services are increasingly becoming a de- mand among B2B customers, e.g. operators of industrial machinery.

BIG DATA

The broad definition of big data is when traditional methods of generating, accumulating, managing and analysing the data fail, because the amount of data simp- ly is too large. This could be because the rate at which the data is generated and accumulated is simply too frequent or if the data sources consist of incompatible values.

Simply put, big data is when the data that your are in possession of, cannot be handled by traditional methods.

ARTIFICIAL INTELLIGENCE (AI) AND MACHINE LEARNING (M2M)

The general idea about AI and machine learning, is that machines are able to perform cognitive tasks, learn from experience and improve its cognitive abilities. To quote Herbert Simon a nobel prize winner in economics: "learn- ing is any process by which a system improves performance from experience." (Qin and Tang). One of the key benefits of machine learning, is that it can be used to solve highly complex issues, by the process of observing, analysing, predicting and suggesting, faster and more precise than humanly possible.

In the energy sector machine learning can be used to turn data into insights and analytics into predictions.

For example in a decentralised heating system, these tech- nologies can be used to forecast the most optimal flow temperature, by combining weather forecast, consumption patterns, etc. Using technology such as sensors in combination with AI, this information can be analysed in real time, providing a foundation for optimal performance.

“Less than 1% of data in businesses is analysed and turned into benefits.”

Source: SAP blog.

DIGITAL TRANSFORMATION

Beginning the process of a digital transformation may seem cumbersome for many small and medium sized businesses. And while there are many aspects of becoming a digital business, the following sections will provide some perspectives on how to think about digitalisation. Succeeding in becoming a digital business requires a unique blend of technology, business operations leader- ship and talent development. (Gartner, 2017). Further- more aligning digital initiatives with business objectives is crucial for successfully delivering on the value proposition to the customer.

CUSTOMER EXPERIENCE

The future of competition is customer centric. Digitalization has shifted the power to the customers, democratising the global market for products and services. Customers today have the possibility of making purchases all over the world. This also fosters more quality- and cost aware customers with high demands in products and services. It is therefore crucial that companies apply customer-centric principles when thinking about how to improve their products and services.

One approach is to find out if there are any pains for the customer, that potentially could be improved upon and turned into gains. Uncovering the pains could be done by performing a quick survey, or keeping track of recurrent themes from incoming customer service calls. Uncovering the pains can serve as a foundation for designing a technological solution for meeting customers needs.

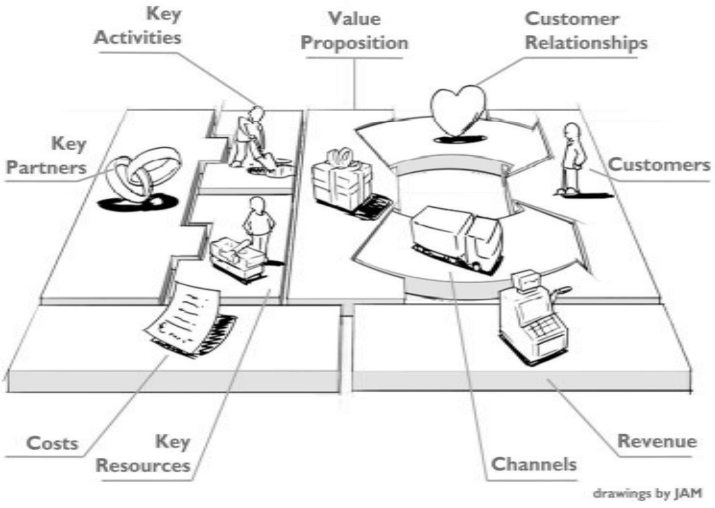
This value mapping exercise can provide new perspectives into the thoughts, feelings and behaviours of the customers, which regardless of the technology can help improve the approach to customer service in general.

BUSINESS MODEL INNOVATION

Justifying the investment needed to perform a successful transformation, needs an solid articulation of how the investment can add value to the existing operation. Knowing what value proposition will deliver great customer experience, can serve as the justification needed for undergoing the transformation. The framework Business Model Canvas by Alexander Osterwalder og Yves Pigneur (2010) is a tool for designing how value can be delivered to your customers, through the 9 building blocks that constitute an entire business. The 9 blocks are:

1. **VALUE PROPOSITION** - What value will you be delivering to your customers?
2. **CUSTOMERS** - Who are they, what are their needs and habits, etc?
3. **CUSTOMER RELATIONSHIP** - What kind of relationship do you want with your customers?
4. **CHANNELS** - How will you deliver your service or product to your customer?
5. **KEY ACTIVITIES** - Which key activities will you have to perform to be able to produce the value wanted?
6. **KEY RESOURCES** - Which resources do you need to perform those activities?
7. **KEY PARTNERS** - Who will your have to work together with to deliver your value proposition?
8. **COST** - What are the related cost? Can you save something long-term?
9. **REVENUE** - How can this contribute to new revenue streams?

Each element represents a part of the business that in interplay with the rest of the elements should constitute a healthy business. The advantage of taking a broader business model perspective into play is that the application of sensory technology in one context



may, as a result, suggest new opportunities else where in the business model, which may not have been possible before. Fx. Applying sensor technology into a product for condition monitoring purposes, may open up for a discussion on expanding the value propositions to include new service agreements, new types of customer relationships, and new revenue streams like selling data-as-a-service.

CULTURE AND MINDSET

Businesses that are able to transform their culture and build digital capabilities are 2,5 times more likely to succeed in their digital transformation (McKinsey, 2017). Therefore, building a culture that is open to embracing risk and experimentation, breaking down siloed thinking, and fostering a customer-centric approach to all aspects, are important cultural changes to consider when venturing into a digital transformation.

When it comes to developing digital capabilities, it is necessary that activities, people, culture and structure are aligned with the overall digital strategy of the company. The digital strategy should therefore be closely aligned with the overall business strategy and goals.

Many companies lack the knowledge, resources and talent to drive a digital transformation and therefore it is often left to executives to manage digital initiatives, restricting the e ort to a level and division area. Talent development and role modelling initiatives are necessary for the strategic efforts to reach across the entire organisation, and drive the change e ort, from multiple levels in the organisation.

SENSOR TECHNOLOGY AND DATA

Having the right knowledge about business operations and customer behaviour can unlock hidden potential for adding value to businesses and customers. Data as a driver for decision making, is becoming more relevant as the accessibility and abundance of data becomes available. Generating, accumulating and analysing data is therefore an important part of the process of becoming a digital business.

Data can provide decision makers and operations managers with the new and valuable insights as well as an overview on how to improve and optimise business. For example, imagine an empty dashboard that can be designed to provide the exact insights that you need to successfully deliver value for your customers. In the energy sector, smart meters can provide insightful data about consumption patterns on certain times of the day. This overview can provide realistic key insights into where improvement should be applied or how things are operating in real time.

Constructing the dashboard is a creative process, which should not be limited by feasibility in the first round. Most things can be measured and the technical setup is often a question of design. Instead, imagine the output. What would be valuable insights your business? What would be displayed on the dashboard, where would the dash- board be installed, who would use it and in what context?

GENERATING DATA

Data can be generated in many ways and for many di e- rent purposes. Much of the data generated in the energy sector are measured for surveillance and control pur- poses, to ensure that the system operated as it should. Other data such as those generated from fx. smart meters, are used to measure consumption, primarily for billing purposes. Common for these data generating methods, are that they are based on sensor technology.

In this section we will focus on the general purpose of a sensor and how sensor technology can provide valuable insights. In essence, sensors should be seen as an extension of the company's operating knowledge base. Sensors can perform measurements in remote and inaccessible places, that otherwise would be impossible to gain insights on. It can decrease the need for costly manpower significantly, and it can provide accurate and frequent influx of data with low operating cost. Sensor technology opens up a vast amount of opportunities to e.g. lower cost, improve efficiency, and generate valuable insights about operations - so called master data.

ACCUMULATING DATA

The data generated by the sensors can be used locally or transmitted to another location for aggregation and analysis purposes. The latter requires the necessary infrastructure to enable the data to be transferred, quickly, securely, and lossless.

During the last couple of decades we have seen a rapid development within wireless network technologies, from 1st generation network technology (1G) to 4G as we currently know it today. But as with many other types of infrastructures, the cellular networks are also becoming increasingly congested due to the vast increase in connected devices on the network. This has lead to the talk about a 5G network, but so far we are still trying to find out how this should look and what technology we should built it on.

Industry specific protocols may be available, such a the wm-bus protocol, which is used in smart meter solutions used by some Danish centralised heating companies,to remotely measure consumption on each individual household.

ANALYSING DATA

Data that is analysed and put in to play in decision making situations, and used for optimisation and predictability provides the greatest value. Data must in most cases be managed and/or analysed before it can become useful in operational activities or to the business development. In many cases data which is

logged and transferred into a spreadsheet can reap many new insights after a bit of analysis. In other cases data can be used to monitor and automate processes, in which case interpreting the meaning of the data is less significant as opposed to creating algorithms that can perform calculations and data processing to solve a class of problems.

INSIGHTS

Data can provide insights that has previously been out of reach. It can be a costly a air to use human resources to collect data. The data may be used to generate insights about your customers use of your product (behaviour), it may also provide data about your products performance, and so forth. These insight may be valuable in terms of how you design, produce, sell or market your product or service.

For example with the use of Smart Meters utility companies can gather data and carry out analysis on di er- ent behavioural patterns on the consumers. Gaining a profound knowledge about consumption habits, may create opportunities for leveraging the energy resources differently based on peak and slump periods.

MONITORING

Data can be used to monitor systems or products to ensure that they are fully functional and operating most efficiently. The system or products operational status can be remotely detected, so that any changes to this, may trigger a notification, giving you the chance to react fast, and without inconvenience for your customer. This could be one way to deliver customised and personal service, and in turn increasing consumer surplus.

Example: Within thee utility sector many companies use solutions that enable them to monitor, regulate and con- trol their systems. This technical solution gives them a better overview of the operations of their entire systems health condition. They are able to see if certain pumps are not functioning correctly or if the water flow is not as expected in areas of the piping system. The technology helps them optimise their maintenance by specifying exactly where maintenance is necessary and should be prioritised.

PREDICTING

Looking beyond monitoring and observing anomalies within systems of operation, intelligent use of data can be used to optimise and predict when maintenance is due. Predictive maintenance is one of the areas where potential for adding value is very high. With the use of intelligent software, such as machine learning, the system can optimise the frequency of maintenance service and predict when components due to wear and tear, are at a critical stage and needs to be replaced. This type of predictive analytics can help leverage and prevent many system breakdowns before it is too late. This in turn means lowering idle time during maintenance service.

The value to be gained from this type of predicability is the personalized service that a company can provide to its customers while at the same time saving the customer from expensive repair and idle time loss.

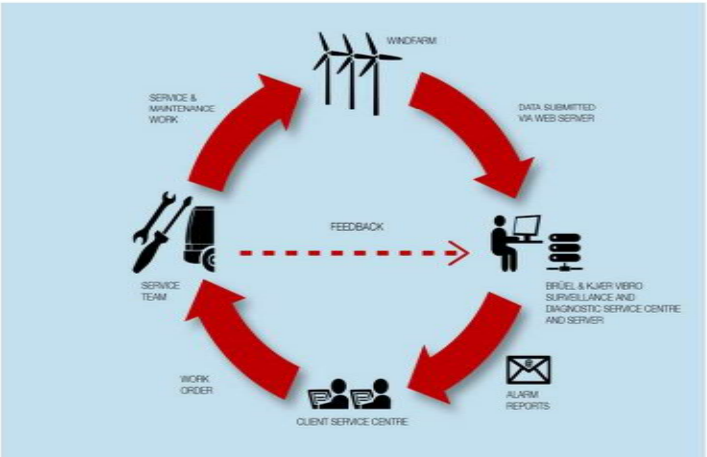
CASE

Condition Monitoring System of Wind Turbine

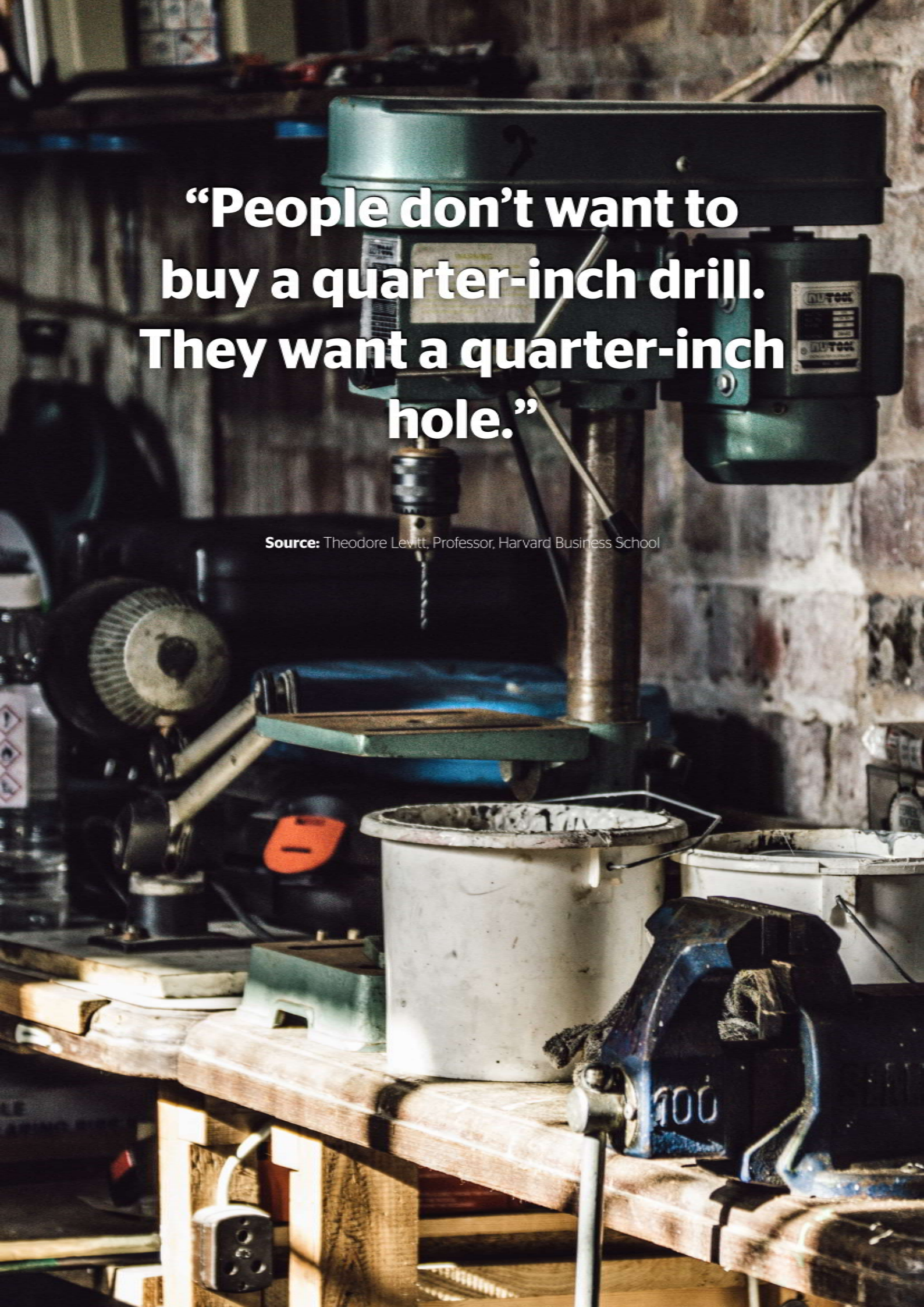
Company: Brüel og Kjaer Vibro

The Danish company Brüel og Kjaer Vibro created a monitoring system for wind turbines that with the use of sensor technology monitors and performs diagnostics on the health conditions of the turbines. By implementing a number of different sensor technologies on bearings, shafts and gearboxes, they can monitor their current state, such as lubrication defects, bearing misalignments, bearing looseness, shaft unbalance, electrical faults, etc.

This knowledge enables them to advance on defaults be- fore the systems breaks down, which means a reduction in idle time from several weeks to 3 days.



Source: Brüel og Kjear Vibro, High Tech Summet DTU, 2017. http://www.bkvibro.com/en/condition-monitoring/wind-turbines.html



“People don’t want to buy a quarter-inch drill. They want a quarter-inch hole.”

Source: Theodore Levitt, Professor, Harvard Business School

CAPTURING VALUE FROM DIGITALIZATION

Understanding how digital technology can create value, does not always start with the technology. The technology in itself does not create the value, it is the way it is applied and how it is utilised that will generate the value for the consumer and eventually the business.
The potential for capturing value from the application of sensor technology, will depend on how the generated data is used intelligently to support the interplay between business goals, customer needs and the interoperability of other technologies.

NEW BUSINESS MODEL AND MARKET OPPORTUNITIES

The data generated, aggregated and analysed could reap opportunities for new products, business models and revenue streams. Besides consumer IoT applications - which has a huge market potential - the B2B application of IoT solutions has the potential of capturing up to 70 percent of it. (McKinsey, 2017). The B2B market are like the B2C market demanding a higher level of service together with the products that they procure.

New ways of delivering value to customers, could mean a potentially new way of developing the companys business model, to a more digital and service oriented one.

SERVITIZATION: AS-A-SERVICE (AAS)

It is estimated that one of the major areas for generating value can be found within service operations. (See figure 5). A vast amount of as-a-service companies have emerged during the last decade, as for example Soft- ware-as-a-Service (SaaS) companies such as dropbox and MS Office 365, where users pay a subscription fee in return for a user license to their software solution.

Thinking about products or data as-a-service creates many new possibilities in providing value adding activities for customers who may not have the need for managing, servicing machinery or analysing data themselves.

INTEROPERABILITY

Interoperability is the concept of systems, applications, devices and interfaces working together. Within the future of energy, interoperability is a precondition for capturing the value of IoT solutions and integrated devices. Designing products and services for the future, meet these demands and conditions, which could impact the sustainability and life-cycle of the product and service.

For example, when a consumer buys an electric programmable termostat, it may be relevant to look at how the termostat could operate interdependently with an outdoor weather station, for optimal setting. Because of the demand for interoperability and compatibility by consumers that want to combine systems and devices, companies must closely consider which platform could support the interplay with relevant products on other markets.

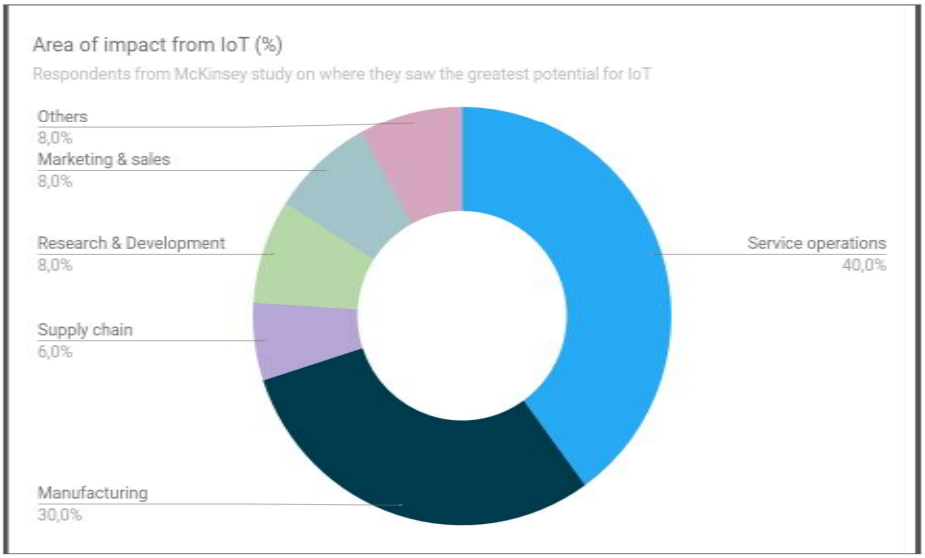


Figure 5: Areas of impact from IoT.
Source: McKinsey 2017.

SUMMARY AND OUTLOOK

The rise of new technology systems are dependent on a number of factors all moving in the same direction. The barrieres to getting started from a technological point of view are low, but the potential value to be captured is preconditioned by factors such as e.g. organisational resources and digital infrastructure.

Developing and acquiring the right competencies - for example within data management and analysis, are paramount for the success of the digital transformation and sustainability. Theses resources are necessary in order to extrapolate valuable insights and knowledge, that can further develop the business. Already today we are seeing a battle for the brightest talent within IT and engineering across a lot of industries, and the pace at which we can supply and develop these competencies, is slower than our need for them to develop digital solutions.

Stakeholders within the clean energy sector have to work towards streamlining the ambitions on creating the necessary conditions for growth and development to happen. With the increasing number of connected de- vices and the prevalence of emerging platforms such as; IoT and smart grid solutions., policy makers must ensure that the legislation and the infrastructural conditions are abundant in order to secure a streamlined process in implementing and deploying these solutions.

The existing, most often centralised, energy infrastructure needs to be updated to suit the needs of tomorrow. With the increasing amount of connected devices, and the notion of decentralised energy production, the cur- rent system needs to be agile in order to sustain a robust energy infrastructure. Renewable energy production and smart grids combined with energy efficient technologies, will make up the future of the clean energy sector.

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