Digital Business Models Discussion Paper

Digital Business Models as Drivers for Sustainability

Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU)
Expert Group Digital Business Models

Published by

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Registered Offices
Bonn and Eschborn

GIZ Office China
Sunflower Tower 1100
37 Maizidian Street, Chaoyang District
100125 Beijing, PR China
T +86 10 8527 5180

E giz-china@giz.de
I www.giz.de/china

Sino-German Industrie 4.0 Project
Tayuan Diplomatic Office Building 2-5
14 Liangmahe Nanlu, Chaoyang District
100600 Beijing, PR China
T +86 10 8532 4845
F +86 10 8532 4266

E info@i40-china.org
I www.i40-china.org

China Center for Information Industry
Development (CCID)

CCID Mansion, 66 Zi Zhu Yuan Road
100048 Beijing, PR China

T +86 10 6820 0219
F +86 10 8855 8833
E ljt@ccidgroup.com
I www.ccidgroup.com

This publication is a result of close cooperation between multiple entities in Germany and China including the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing Expert Group Digital Business Models in support of the MoU signed in 2015 between BMWi and MIIT following the 2014 joint action plan "Shaping Innovation Together."

Since 2016, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, commissioned by BMWi, and the China Center for Information Industry Development (CCID) are the implementing bodies for the cooperation on the German and the Chinese side, respectively.

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Executive Summary

Environmental sustainability in the manufacturing sector has become increasingly important in the face of climate change. Hence, governments and industries are seeking new green manufacturing solutions based on Industrie 4.0 technologies to stay both profitable and sustainable. The sustainability discussion paper is the result of the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU) Expert Group Digital Business Models (henceforth "the Expert Group"). The paper extends from the study "Value Network as the Foundation for Digital Business Models" by investigating the emergence of digital business models from a sustainability perspective. The insights and lessons drawn from the paper shall pave the foundation for further research on successfully scaling up digital business models.

Chapter 1 covers three aspects. Firstly, it delineates the contextual scope of sustainability. Then it presents an overview of China's and the EU's policy frameworks for enabling environmental sustainability in the industry. Finally, it reveals the relative green innovation market competitiveness in Germany and China.

Chapter 2 provides contemporary use cases from German and Chinese companies. Based on these, the Expert Group has identified three categories of sustainability-oriented digital business models:

1. Increased Resource Efficiency

Increasing resource efficiency via I4.0 technologies continues to be the most prominent approach to remain profitable while improving environmental sustainability.

2. Creation of New Businesses

Companies with experiences in improving their own resource efficiency often utilise their knowhow to branch into new business areas, e.g., via services (consulting on energy efficiency) or the development of new products that enable other companies to realise improved resource efficiency.

3. New Industries

A shifting focus towards sustainability in the private sector as well as in policy making is creating new industries. Use cases of this category were the rarest.

The Experts' recommendations for fostering more sustainability-oriented digital business models have been summarised at the end of Chapter 3:

- Accelerating the establishment and adaptation of data spaces and digital carbon calculation enables enterprises to tap into sustainability gains of digital business models.
- Redesigning policies to holistically integrate sustainability into digital research and development initiatives.
- Making sustainability practices and tools more readily available across the whole industry with a focus on small and medium-sized companies.
- Encouraging more cross-border cooperation on co-achieving a sustainable supply chain.
- Introducing the Environmental, Social and Governance (ESG) criteria into businesses.

1. Introduction

1.1 Background

Sino-German Cooperation on Industrie 4.0 and Intelligent Manufacturing

In July 2015, the German Federal Ministry for Economic Affairs and Energy (BMWi) and the Chinese Ministry of Industry and Information Technology (MIIT) signed a Memorandum of Understanding (MoU) with the objective of supporting German and Chinese enterprises in creating a favourable business environment for Industrie 4.0 and Intelligent Manufacturing. This MoU emphasises the importance of industry cooperation and highlights the shared interest in facilitating further dialogue at all levels between representatives from government, industry, and academia.

BMWi and MIIT commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the China Center for Information Industry Development (CCID) respectively to support the implementation of the MoU. Under the direction of BMWi and MIIT, GIZ and CCID jointly established the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU[1]) as a platform for German and Chinese experts to discuss challenges and opportunities of Industrie 4.0 and Intelligent Manufacturing with the goal of better understanding the relevant business environment and policies, exchanging best practices, and developing joint policy recommendations. These discussions directly inform the bilateral political dialogue.

The AGU expert groups focus on three Industrie 4.0 areas as follows:

- Digital Business Models
- Future of Work
- Industrial Internet

Specifically, the AGU Expert Group Digital Business Models seeks to understand the architecture of digital business models to harness their potential for innovative value creation. The Expert Group Digital Business Models analyses and classifies the building blocks and mechanisms of digital business models with a specific focus on the needs and unique characteristics of Chinese, German, and other European enterprises. Given the global surge for increased economic sustainability, this Expert Group has decided to analyse sustainability-driven applications of digital business models to better understand their role in contributing to current environmental, social and economic developments.

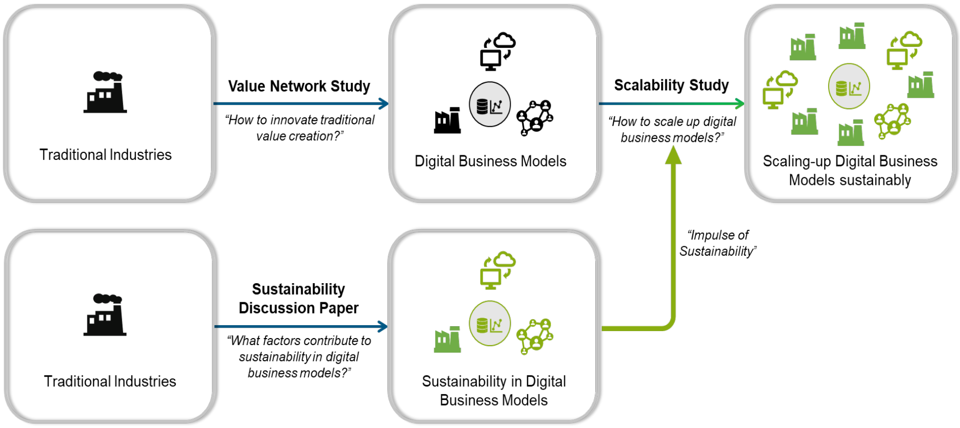
1.2 Objective of this Discussion Paper

Economic growth and sustainability continue to be perceived as mutually exclusive. However, with digital innovation paving the emerging developments of value creation and resource efficiency across industries, we are witnessing a shift away from the old antagonism between sustainability and growth.

This shift is being accelerated by the combinatorial effects of citizen expectations, consumer trends and an increasing awareness of the climate change urgency. Policymakers in many countries are addressing these developments by pushing for the advancement of digitisation and sustainable production (UN 2030 Agenda, European Green Deal, German Sustainability Strategy, Chinese Green Development etc.). Already today, we can observe how the sustainability agenda helps to advance areas such as energy efficiency as well transparency of production processes and supply chains among others. Furthermore, we see new growth opportunities and even completely new industries emerging. The OECD has started to assess green competitiveness across its member states, emphasising its growing importance from an economic perspective".[2]

1 Deutsch-Chinesische Arbeitsgruppe Unternehmen in Industrie 4.0 und Intelligente Fertigung (AGU)

2 Innovation and Business/Market Opportunities associated with Energy Transitions and a Cleaner Global Environment. Issue Paper. (2019). OECD. Accessed on 30th August 2021. https://www.oecd.org/g20/summits/osaka/OECD-G20-Paper-Innovation-and-Green-Transition.pdf



As shown on the graph above, after the Value Network Study[3], the expert group's overall assumption has been that the higher rate of digital business model scalability compared to traditional business models offers untapped potentials to scale positive environmental impacts. Against this backdrop, the Expert Group set a different focus in 2021, looking more deeply into technologies, influential factors, and innovative mechanisms of digital business models, which enable more sustainable practices in the latest value creation trends.

This discussion paper presents and analyses relevant up-to-date industry use cases. The findings serve as a basis for further discussions on scalable and sustainability-driven digital business model applications. Recommendations for industry actors and policy makers will be given at the end of this paper.

1.3 Contextual Definition of Sustainability

The Plattform Industrie 4.0's "2030 vision" highlights sustainability as one of the strategic action areas for a successful implementation of Industrie 4.0. The concept of sustainability is divided into environmental, social, and economic aspects.[4]

ESG reporting at company level is becoming an increasingly popular policy tool in developed and emerging countries. According to China's "Environmental Protection Law", the "E" criteria are obligatory for all companies, which include:

- greenhouse gas emissions
- air pollutants
- water (overall usage; the percentage of recycled water)
- energy (overall consumption, the percentage of renewable energy)
- waste management (water and solid dangerous goods)[5]

In the framework of this discussion paper, the expert group focuses foremost on environmental sustainability, which investigates the circular economy[6], carbon neutrality and climate change mitigation.

3 Value Networks as the Foundation for Digital Business Models (2020): Use Cases from Germany and China. Accessed on 30th August 2021. https://www.plattform-i40.de/IP/Redaktion/EN/Downloads/Publikation/China/value-networks.html

4 2030 Vision for Industrie 4.0, Shaping Digital Ecosystems Globally. (2021): Sustainability. Plattform Industrie 4.0. Accessed on 30th August 2021. https://www.plattform-i40.de/IP/Redaktion/EN/Standardartikel/vision.html

5 China's ESG statistics revelation: Key ESG indicators Suggestions. (2019). Accessed on 30th August 2021. https://www.unpri.org/download?ac=6973

6 Circular economy refers to a model of production and consumption involving sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible.

1.4 Policy Background

Both Germany and China have joined the 2016 Paris Climate Agreement and stated their commitments to speeding up the progress towards carbon neutrality. At the same time, the policy frameworks currently in place in both countries have been rated "highly insufficient"[7], contributing towards an estimated 4°C worldwide temperature increase and thereby missing the 1.5°C target as part of their Paris commitments.

In the following discussion, key industrial development policies for the EU, Germany and China will be elaborated.

1.41 The EU and Germany

Following the 2019 European Green Deal initiative, environmental sustainability plays a crucial role in shaping the EU's industrial policy. As the EU aims to become climate-neutral by 2050, European Commission President Von der Leyen has described its time to launch the initiative as "Europe's man on the moon moment". The European Green Deal has received EUR 1 billion from the 2021-2027 EU funding programme 'Horizon Europe', accounting for 35% of the programming's budget.

Resource efficiency is included in the European Green Deal's action plan. In addition, it aims at restoring biodiversity and to cut pollution. The 2021 Portuguese Council presidency has encouraged the use of industrial upgrading technologies (e.g., I4.0 technologies), since they can accelerate resource efficiency gains. Many EU funding opportunities have, therefore, become available for I4.0-related projects. For instance, the European Commission has launched the co-programmed partnership Made in Europe[8] to fund projects that contribute to the European Green Deal's priorities.

Germany announced the goal to achieve a cleaner and low-carbon economy compatible with economic growth: Since the adoption of National Strategy for Sustainable Development in 2002, sustainability has been the guiding principle for German industrial policies.

According to the German Resource Efficiency Programme (i.e., ProRess), Germany has also emphasised the importance of resource efficiency in achieving its climate targets. For example, ProRess II[9] has set out policy approaches that favour more resource-efficient I4.0 products and services for minimising energy and natural resource consumption.

In manufacturing, the German federal government is supporting industry players to utilise digital technologies and data to improve their sustainability performances. For instance, Plattform Industrie 4.0, led by BMWi and the Federal Ministry of Education and Research (BMBF), promotes the use of I4.0 technologies to leverage additional potential for resource efficiency in its "2030 vision in environmental sustainability for Industrie 4.0".[10]

Moreover, BMBF has announced a guideline for the promotion of joint research projects in the field of energy efficient High-Performance Computing (GreenHPC) in May 2021[11]. For the combination of classic HPC, AI and data analysis techniques, the construction of energy-saving high-performance computers and climate-friendly commercial data centres are becoming increasingly important. A reduction in the CO_2 consumption of digital technologies is the goal of the Green ICT point of the Federal Government's Climate Protection Program 2030 for the implementation of the Climate Protection Plan 2050[12].

7 Climate Action Tracker (2021). Accessed on 30th August 2021. https://climateactiontracker.org/

8 Made in Europe co-programmed partnership refers to a co-funded programme between the European Commission and private and/or public partners.

9 German Resource Efficiency Programme (ProgRess) – an overview. (2021). Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Accessed on 30th August 2021. https://www.bmu.de/en/topics/water-resources-waste/resource-efficiency/german-resource-efficiency-programme-progress-an-overview

10 2030 Vision for Industrie 4.0, Shaping Digital Ecosystems Globally: 2030 Vision. (2021) Accessed on 30th August 2021. https://www.plattform-i40.de/PI40/Navigation/EN/Industrie40/Vision/vision.html

11 Guideline for the promotion of joint projects in the field of energy-efficient high-performance computing (GreenHPC) Notice. (2021). Federal Ministry for Education and Research. Accessed on 30th August 2021. https://www.bmbf.de/bmbf/shareddocs/bekanntmachungen/de/2021/05/3621_bekanntmachung

12 Climate Action Programme 2030. (2019). The Federal Government. Accessed on 30th August 2021. https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzprogramm-2030-1673578

Finally, the German Federal Ministry for the Environment, Nature Conservation and Nuclear (BMU) has issued the Digital Policy Agenda for Environment in 2019[13] to make digital technologies support the climate action. For example, the agenda makes the funding available for investments in digital technologies under the environmental innovation programme that helps to decarbonise the industrial sector.

1.42 China

Being an industrial "late comer", China does not only face increasing restrictions on fossil resources but is also restricted by meagre domestic natural resource endowments compared to its population size and energy usage. At the same time, China is aspiring to become an economic and political leader at the global level. The question of achieving more sustainability therefore challenges China perhaps more than most other countries. With 28% in 2019, China has been the biggest emitter of annual CO2 emissions for over a decade now. However, in cumulative terms China, with its 13%, is well behind the historically biggest emitters Europe (32%) and North America (28%).[14]

China has pledged to balance its carbon footprint and high economic growth and development ambitions. In 2015, Xi Jinping re-introduced the principle of "ecological civilisation"[15] as the baseline for China's environmental policy in its constitution. The ecological civilisation principle prioritises ecologically friendly manufacturing and lifestyles over the old output-oriented industrial mass production model.

In the 75th UN General Assembly, Xi Jinping stated that "China will adhere to an innovative, harmonious, green and multilateral development concept and leverage transformed technologies and industries to facilitate the post-COVID "green recovery" and strengthen sustainable development.[16] He pledged that China will "aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060."[17]

Under the framework of the "Belt and Road Initiative (BRI)", a "BRI International Green Development Coalition"[18] was presented to fulfil the sustainable development goals of the United Nations until 2030 as well as the Paris Climate Agreement.[19]

The 13th Five-Year Plan (2016-2020) of China had made "Green Development" one of the five guiding principles. In December 2020, the Ministry of Ecology and Environment of China stated that during the 14th Five-Year Plan (2021-2025), China aims to increasingly activate market mechanisms to support environmental protection and to accelerate the integration of economic and environmental policies.[20]

To achieve the climate-neutrality goal, China needs to make more sustained efforts from now on. While Chinese authorities have recognised the importance and urgency of changing the traditional extensive growth model and accelerating green transformation in industries, they have also witnessed the increasing significance of digital technologies in sustainable industrialisation.

Meanwhile, a series of policies have been introduced in China to facilitate the development of green technologies in sustainable transformation. Rapid progress in innovation on domestic "green technologies" (e.g., energy conservation, alternative energy, smart grid, and transport) has become more prominent in programmes like "Made in China 2025". Five policy measures introduced in 2019 showcase China's attempts to foster green transformation of the industrial sector:

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13 Get the Environment into those Algorithms! The BMU's key points for a digital policy agenda for the environment. (2019). Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Accessed on 30th August 2021. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Nachhaltige_Entwicklung/eckpunktepapier_digitalisierung_en_bf.pdf

14 Data supplement to the Global Carbon Budget. (2020). Integrated Carbon Observation System. Accessed on 30th August 2021. https://www.icos-cp.eu/science-and-impact/global-carbon-budget/2020

15 State Council Guideline on Accelerating the Construction of Ecological Civilisation. (2015). Accessed on 30th August 2021. http://www.gov.cn/gongbao/content/2015/content_2864050.htm

16 Statement by H.E. Xi Jinping President of the People's Republic of China at the General Debate of the 75th Session of The United Nations General Assembly. (2020). Ministry of Foreign Affairs of the People's Republic of China. Accessed on 30th August 2021. https://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1817098.shtml

17 Ma, Tianjie. (2020) Researchers unveil roadmap for a carbon neutral China by 2060. China Dialogue. Accessed on 30th August 2021. https://chinadialogue.net/en/climate/researchers-unveil-roadmap-for-a-carbon-neutral-china-by-2060

18 BRI International Green Development Coalition. (2021). Accessed on 30th August 2021.http://en.brigc.net/

19 Mette Halskow Hansen, Hongtao Li, Rune Svarverud, 2018. Ecological civilization: Interpreting the Chinese past, projecting the global future. Global Environmental Change, Vol. 53, November 2018, Pages 195-20.

20 The Ministry of Ecological Environment issued the "14th Five-Year Plan" direction for ecological and environmental protection. (2020). Chndaqi.com. Accessed on 30th August 2021. https://www.chndaqi.com/news/319078_4.html

- Promoting pilot cities and zones to create experimental clusters
- Enhancing public private partnerships for pollution prevention
- Issuing green bonds. These green bonds are worth 282 billion CNY in total, ranking only second in the world after the United States
- Prioritising green products in public procurement
- Setting comprehensive standards for green manufacturing.[21]

The Guideline[22] on green economy issued by the State Council of China in 2021, emphasises green and low-carbon technologies, cultivating and building green technology innovation centres, and strengthening the status of enterprises as the mainstay for green and sustainable innovations. More specifically, MIIT has issued an Action Plan[23] n 2020 to stress the importance of digital technologies in empowering SMEs in strengthening resilience, increasing production capacity, and achieving sustainable development.[24]

2. Introduction of Use Cases

2.1 Three Categories of Use Cases

The following use cases from China, Germany and France (i.e., the EU Member State participants) showcase how adopting Industrie 4.0 technologies can lead to environmental sustainability as well as to profitability. These use cases are grouped into three categories:

- **Increased Resource Efficiency**

This cluster includes use cases that have mainly leveraged Industrie 4.0 technologies to improve the resource efficiency of traditional business operations. The objective is reduction of the carbon footprint to achieve carbon neutrality as well as cost reductions.

- **Creation of New Business**

This cluster focuses on use cases that have added a new business that ameliorates the sustainability of its operation or customers. To achieve carbon neutrality, demand for new products and services is emerging, adding new portfolios to businesses.

- **New Industries**

This cluster covers new industries emerging through the focus on sustainability, e.g., from traditional industries such as oil and gas, energy or manufacturing. Companies in this cluster create new products and services outside their industry boundary. It also includes start-ups developing assets to address the need for sustainability.

2.2 Increased Resource Efficiency

2.21 Baowu Carbon Technology – Digital Virtual Factory

Introduction

Baowu Carbon Technology Co., Ltd. (hereinafter called Baowu Carbon) Shanghai headquarters has realised the integrated control of all production bases by establishing a digital virtual factory.

21 Holzmann, Anna and Grünberg, Nis. (2021). "Greening" China: An analysis of Beijing's sustainable development strategies: Main findings and conclusions. Accessed on 30th August 2021. https://merics.org/en/report/greening-china-analysis-beijings-sustainable-development-strategies

22 State Council. (2021). The Guideline on Accelerating the Establishment of a Circular and Low-carbon Manufacturing Ecosystem in China. (2021) Accessed on 30th August 2021. http://www.gov.cn/zhengce/content/2021-02/22/content_5588274.htm

23 The Action Plan refers to "Action Plan for the Digital Empowerment of Small and Medium-sized Enterprises" issued by MIIT in 2020.

24 Being able and not afraid to digitally transform, how digitisation helps small and medium-sized companies overcome their difficulties. (2020). People.cn. Accessed on 30th August 2021. http://finance.people.com.cn/n1/2020/0529/c1004-31728243.html

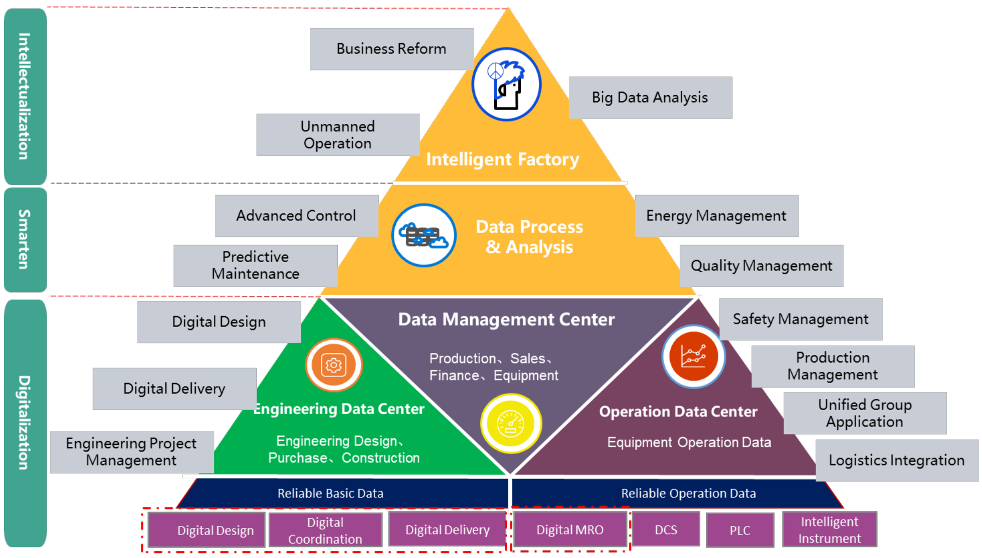


Figure 1: The structure of Baowu's digital virtual factory

Description of the technology

Baowu Carbon digital virtual factory primarily relies on the applications of Cloud Computing, Industrial Big Data, Industrial Internet of Things (IIoT), and AI technologies. These applications aim to improve management and resource efficiencies and concentrate on controlling all production processes, optimising products, and managing the whole lifecycle of the assets. A two-way information connection and real-time performance feedback on market demands, operational plans, production schedules, on-site operation and automated controls can be achieved through information-sharing and real-time feedback. This feedback is accessible from different levels: from customer service, business management, operation execution to the process control. The vertical integration control of production bases has been used to satisfy the development conditions of safety, environment protection, energy saving, processing and product quality assurance. The digital virtual factory has transformed traditional chemical factories from the sectional management model into the integrated management model. The field data, personnel data and resource data can be shared in time to meet market demands, optimise raw materials distributions and collaborate on end-to-end supply chains.

IIoT is applied to connect the Shanghai headquarters' digital virtual factory with its production bases across China. Through sensors installed in all production bases, real-time production and equipment operation data can be received. Machine status remote management has been achieved by IIoT-driven data collection, analysis and management. Consequently, there have been reduced unscheduled shutdowns during production.

In addition, the remote centralised control enables the digital virtual factory to predict machine failures. Analysing the data collected from the production bases, the digital virtual factory can monitor the operation status of the production equipment and flag potential disruptions early. The centralised control centre determines the maintenance needed. Depending on the nature of the prescribed maintenance, the control centre either remotely provides the respective production base with repair instructions or dispatches local engineers to the location.

Results

The digital virtual factory is commercially helpful for Baowu Carbon to reduce operation costs by 25%, increase the productivity by 30%, and lower the rate of product quality rejection by 28%. More importantly, the digital virtual factory reduces the energy consumption per unit output by 12%.

2.22 BHS Corrugated – Digitalised Production of Cardboard[25]

Introduction

BHS Corrugated (BHS) is a world-leading company in the development, production, and installation of production facilities for manufacturing cardboard, including the provision of the machines that produce cardboard from paper rolls (i.e., corrugators). Cardboard is widely used in many industries with many different types depending on their strength, size, and colour. To maintain BHS independence from Big Data platform providers and maintain lower costs for itself and its customers, BHS first developed an internal data platform called "ICorr" with high industry security standards to monitor all applications around the corrugators.

Description of the technology

Using ICorr, BHS can optimise the cardboard manufacturing process by collecting data from the corrugators. The analysis of the data provided in real time from the corrugator allows BHS to apply Big Data techniques to generate new knowledge about process interdependencies. The Big Data application is embedded in the machinery, for example in combination with intelligent corrugating rolls that can store data for long periods. This data can be transmitted to other machines or be used for predictive maintenance, for example, predicting which parts may need to be replaced before they wear out. This predictive maintenance feature will help make the entire cardboard production more sustainable by having fewer defunct machines. Furthermore, BHS uses the data collected throughout the factory to optimise in-house logistics for paper rolls and produce cardboard, which has increased the production efficiency and reduced resource costs.

Results

ICorr has enabled a more resource-efficient way of producing corrugated cardboard through machine data monitoring. Moreover, ICorr has reduced waste generation. For example, its Splice Synchronisation System brings individual splice points together to minimise waste. Finally, ICorr provides an energy-efficient way of corrugated cardboard production. For example, its Warp Control System optimises the temperatures at the wet end of the corrugator, thus, enabling colder and more energy-saving production.

2.3 Creation of New Businesses

2.31 ENGIE – From Oil and Coal to Natural Gas and Renewables

Introduction

ENGIE is a major player in renewable energies in France and positions itself as a leader in the zero-carbon transition. Beginning in 2014, ENGIE has resolved to implement a strategic shift to reduce exploration for fossil fuels. As a result, ENGIE increased investments in renewable energy (e.g., solar, wind, geothermal, biomass, hydro and nuclear) and energy efficiency services. In 2015, ENGIE decided to completely stop new investments in coal-fired power plants and dispose of €15 billion of assets to reinvest in projects to promote low-carbon and distributed energy. Currently, ENGIE plans to invest EUR 22 billion in renewable energy, energy services such as heating, and cooling networks and distributed energy technologies.

In the past, ENGIE's business model was based on selling and providing energy at competitive prices. Today, the focus of ENGIE's business model has shifted to consulting their clients on how to consume less energy while increasing the share of renewables in their energy mix and reducing overall costs. ENGIE has adjusted its strategy to become a service provider of clean and renewable energy as well as an energy efficiency consultant.

Three data-fuelled performance levers are the foundation for ENGIE's strategic transition:

25 Patricia Kraft, Roland Helm, Michael Dowling "Customer Value Creation with Industrie 4.0: Business Models in the German Mittelstand" International Journal of Technology, Policy and Management, forthcoming in 2021.

- Digital technology reinforces the technological component of ENGIE's solutions;
- ENGIE offers consulting support to the world's 500 biggest companies as they build their net-zero transition;
- Funding that multiplies ENGIE's impact on clients through the creation of financial partnerships.

Detailed description of the technology

In 2006, Villers-St-Paul Utilities (VSPU) ENGIE was created to offer a single point of contact to the Villers-St-Paul Chemical Park's three chemical companies (i.e., ARKEMA, Dow and Chemours). The VSPU team has adopted many digital tools such as Big Data to manage the platform's energy performance. These digital tools provide a much more operational approach to energy efficiency and to cost reduction.

Results

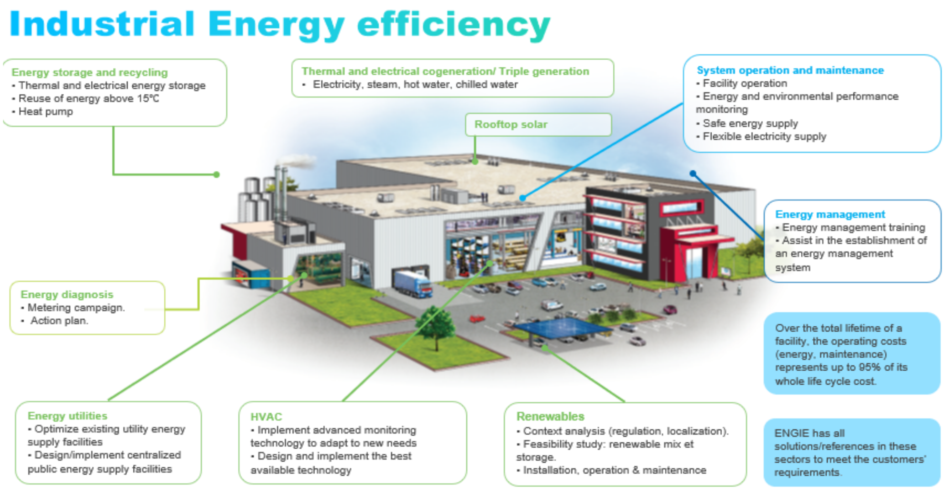


Figure 2: Overview: Services for Industrial Energy Efficiency

ENGIE is improving the energy efficiency of energy-intensive private and public buildings. The first step in an Engineering, Procurement and Construction (EPC) project is to estimate the actual energy consumption, the carbon emissions and the potential missing data to establish a strong diagnosis. Deploying a network of IoT sensors as well as the IoT platform is required to identify the specific operational "behaviour" of the assets and generate initial data from which we will measure the improvement.

As a result, ENGIE has helped the three chemical companies to achieve a 5% reduction in energy consumption in steam networks and 16000 tonnes of CO_2.

2.32 Tencent Cloud – Energy Studio

Introduction

Comprehensive energy - namely the user-side energy management - covers energies such as electricity, heat, water, gas, coal, and oil. It runs through all phases from production, transmission to storage and consumption. Following the gradual popularisation of distributed energy resources, energy storage, and electric vehicles, a single enterprise now faces an energy system composed of multiple energy sources, multiple equipment, and multiple technologies. It is thus difficult for enterprises to do comprehensive management, as they need to deal with many co-suppliers, system chimneys, and highly integrated operation and maintenance costs. Moreover, due to the broadness and depth of the business divisions, it is difficult for suppliers in each division to provide overall solutions and achieve high commercial marketing efficiency.

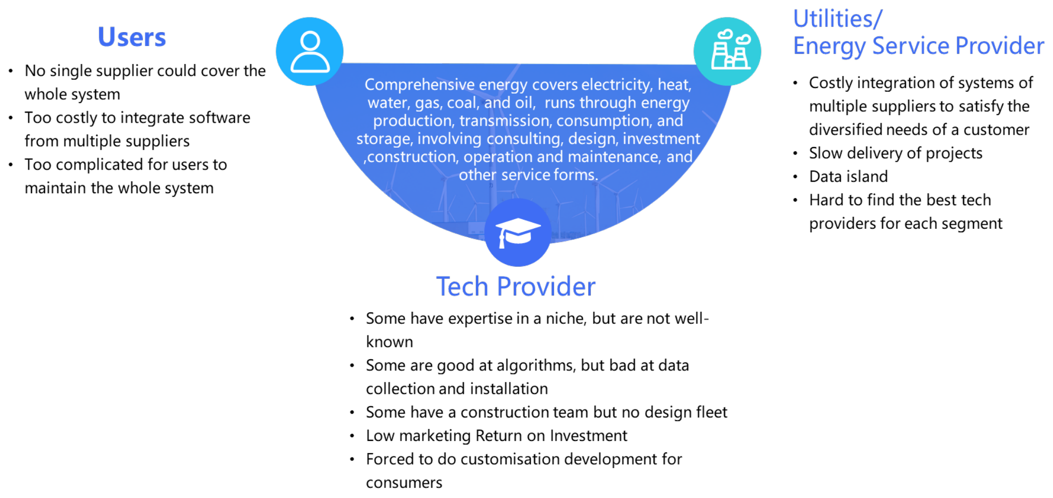


Figure 3: Difficulties found in a fragmented application system

Tencent Cloud Energy Studio addresses the difficulties mentioned in Figure 3: it improves delivery efficiency, and eventually reduces user costs. Through an open comprehensive energy product library, Tencent Cloud enables suppliers of various industries and various sizes to upload their comprehensive energy-related products. Users can then select combinations in the product library; meanwhile, cross-application communication becomes quicker and more flexible through the unique "data connection" component for the combination applications. Tencent Cloud's Energy Studio also provides drag-and-drop components to form a large screen, which greatly reduces the difficulties and costs resulting from the integration of different suppliers.

Description of the technology

The Energy Studio covers the following functions and technologies:

1) Open Energy Product Library: A transparent energy product library that allows all real-name entities to upload their energy products; the users can then search for items and suppliers.

2) Data Tandem: The software products in the product library can use the standard and visual modeling tools provided by data tandem to define the input and output data models and the object and frequency of interactive data. The data tandem performs automatic data transmission to integrate software products without intruding on the original technology stack and architecture of software products.

3) Cockpit: Data assets deposited in the data connection can be visualised through hundreds of chart components in the cockpit. Users can have zero-code and large-screen customisation of data monitoring and it can be adjusted anytime, anywhere, without incurring additional costs.

Results

Since the launch of a comprehensive energy workshop in September 2020, it has gathered 300 registered enterprise users (including energy users, energy service providers, and energy product suppliers), and has released more than 80 products onto the shelves. Many suppliers have been in the energy saving fields for more than ten years; They have been suffering from high marketing costs and low publicity. Through Tencent Cloud Energy Studio, users can search for their products more easily. Meanwhile, suppliers can also combine other suppliers' products with theirs in the energy product library to provide more integrated services to end users. The products are easily integrated to provide users with more services.

2.4 New Industry

2.41 KraussMaffei – Digital Trading Platform for Sustainable Plastics

Introduction

In 2018, KraussMaffei started evaluating the impact of digital changes on the behaviour of people in their daily business lives. The digital platform business trend was found to be strong. KraussMaffei combined this behavioural change with another fundamental change in the plastics industry: the change towards circular economy.

Description of the technology

Polymore is the digital trading platform for the plastics materials market, especially in the fragmented and illiquid area of recyclates and compounds. Polymore matches the buyers' specific requests according to their application needs with suitable developers who can offer accordingly via the platform. Both parties stay anonymous, until they are sure that price and quality fit to each other. This was an important request of both parties while doing the concept validation. Especially the technical expertise of KraussMaffei, combined with the strong market access of more than 50,000 machines installed worldwide turned out as key enablers for success.

Beyond the customised basic matching approach, Polymore developed a marketplace for post-industrial wastes. This marketplace helps plastics converters get more market reach and make selling their materials and bringing plastics wastes back into the production cycle of plastics materials more convenient.

Results

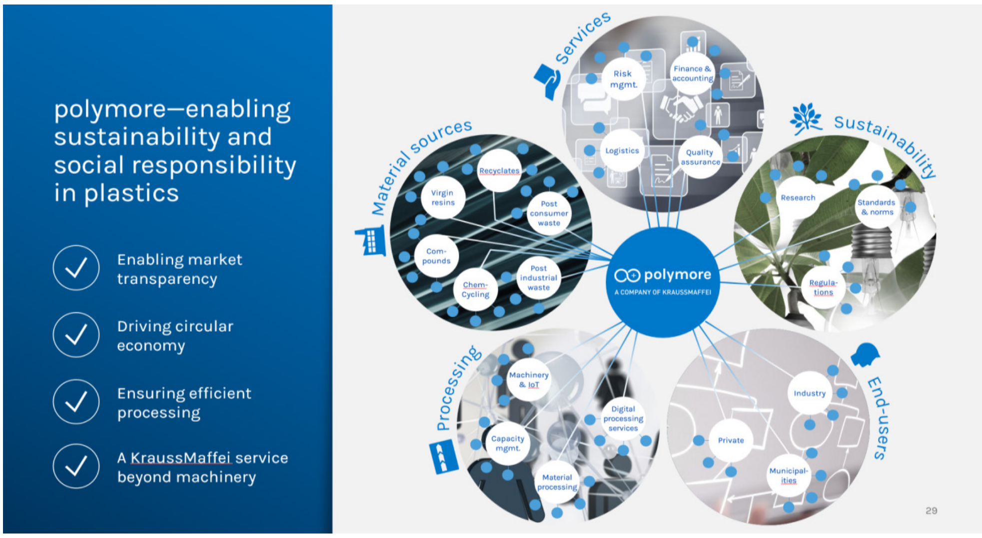


Figure 4: Overview of Polymore's sustainability aspects

After one year online, Polymore attracted requests for material of more than 100.000 tonnes. 75% of the requests addressed recyclates. Due to the high traffic, despite just being a B2B portal for a special niche, the portfolio has been enriched by master-batches, standard and recyclates-compounds and other circular economy materials like regrinds and partially post-consumer-waste. The platform has been opened meanwhile also to other customer groups, like traders, distributors and master-batches. In the meantime, Polymore has created a very detailed and unique database for producers, traders with their capabilities and specialties. Besides, the invention of the so called "test-batch-process" was a success. As converter processes are very sensitive against material changes, most buyers order test materials before taking a series delivery into account.

With the matching concept, Polymore managed many new B2B relations, and several hundred tonnes of plastics waste and recyclable materials have been fed back into the loop of plastics materials production. Moreover, Polymore has been contributing with its knowledge to several activities on the standardisation and technology innovation processes for enhancing a circular economy in the plastics industry.

Currently, the platform is already in the validation phase of the next-level service for customers, to create even more transparency, flexibility, and convenience in feeding plastic wastes and recyclates into the market. Hence, Polymore contributes to reducing CO_2 emissions and increasing sustainable plastics products.

2.42 Shanghai HGB Digital Technologies – Chemical-Industry Data Governance

Introduction

Shanghai HGB Digital Technologies Co., Ltd. was established in 2020 to carry out the carbon calculation of coal chemical companies to realise their carbon peak and carbon neutrality plans. It also focuses on the digital transformation of chemical shop floor, chemical industrial park, and supply chains. The company provides close service of data operation and data assets for the entire supply chain. A software-as-a-service (SaaS) carbon footprint asset management platform was launched in early 2021 to carry out the visualisation and real-time monitoring, reporting and verification (MRV) of carbon emissions. Environment-friendliness, energy-saving and operational safety are the three focuses of the platform.

Description of the technology

Compared to traditional SaaS providers, the company's data-driven business model through capital connection is formed from customer demands for scenario creation. The company also provides data management and data value-added operation services covering the entire supply chain. The chemical industry's data collection is borne with many problems, such as high repeatability, large statistical workload, serious resource redundancy, integrational development difficulty, data inaccuracy and ineffective data utility. The high utilisation rate of data brings significant benefits to enterprises. Carbon pollution is a huge concern for the chemical industry. Moreover, finding the optimal methods and tools to improve the management and technical process transformation is difficult.

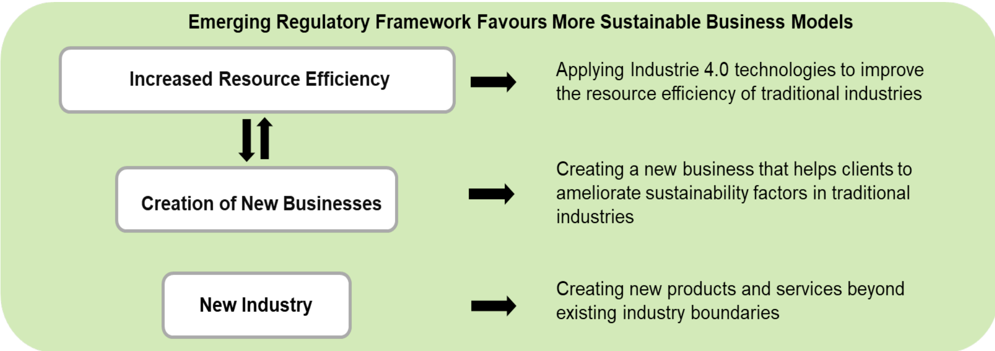
The company's data-driven platform model thus provides the possibility to achieve sustainable knowledge management and helps the entire industry to effectively benchmark under the data standards. The SaaS platform makes carbon calculation more accurate and reliable. Furthermore, the platform helps chemical manufacturers to introduce effective management tools for carbon emissions and carbon trading.

Results

The platform could reduce 2453 tonnes of carbon emissions for each coal tar processing machine in a chemical factory each year. The platform could also help chemical industries monitor and detect carbon-intensive machines for optimising the resource utilisation of its manufacturing process. Moreover, the platform assists chemical companies' carbon sink management by statistically revealing how many more trees are required to offset the carbon emissions they have produced.

3. Observations and Recommendations

3.1 Observations



The graph above illustrates that most use cases analysed for the purpose of this paper have leveraged Industrie 4.0 technologies to increase resource efficiency. Potentially, the generated knowhow of improving resource efficiency within one's enterprise might translate into the creation of new businesses by utilising these internal learnings to help other companies or creating new products. Finally, there was a much lower number of use cases available which represented the category of new industries creation.

- Improving resource efficiency to increase profitability is the easiest way for companies to initiate more sustainable practices with the support of digital technologies and simple data management.
- This accumulated knowledge for improving resource efficiency allows some enterprises to create new services such as consulting for peer businesses or for their existing customers to further optimise their production processes.
- Nonetheless, fewer enterprises could be identified which created new industries. The likely reason could stem from, apart from the unavailability of breakthrough technologies, a lack of keen market insights and creative business ideas. An overall unfavourable regulatory framework, business environment, and unsatisfactory short-term gains may also be important factors.

3.2 Recommendations

1) Policy Reforms: Advancing digitisation and sustainability in an integrated and holistic way

- Developing digitisation-oriented policy regulations and initiatives with sustainability built in from the beginning. Making the industries more efficient and making them more capable of managing costs are mutually important. It is the prime time to start making the industry greener and more cost-efficient and then able to further innovate.
- Offering more tailored government benefits that support the integration of sustainability and digital transformation of the industry.
  - These government benefits could include grants or tax reductions for the development and application of more sustainable technologies and practices.
- Issuing data protection policies to protect the industry from cyberattacks before deploying any digital tools for its production.
- Developing a regulatory framework that welcomes more eco-friendly and low-carbon digital companies.
- Creating additional incentives and opportunities tailored for start-ups to utilise digitisation for more sustainable business practices. "New-Industry" use cases are still rare. A supportive regulatory framework and financial incentives are necessary to harness the potential for sustainability by creating niche industries based on new digital business models.
- Measuring: policy instruments to support the measurement of sustainable actions and impacts (e.g., sustainability indicators, company reports).

- Pricing: raising the costs of unsustainable actions.
- Regulation: avoiding unsustainable actions and developments.

2) Sustainability Spillover: Adopting sustainability practices and tools across the economy with a focus on SMEs

- Accumulated know-how for improving resource efficiency can be utilised in creating new businesses.
  - Training schemes should be developed to further facilitate this process to enable SMEs to develop new businesses.
- Initiating campaigns to sensitise, share common practices, and build capacities.
- Supporting existing intermediaries and networks which promote sustainability practices and tools.

3) Supply-Chain Transparency: Accelerating the establishment and adaptation of data spaces

- Data about the locations, conditions, and the environmental qualities of a good can and should become transparent to all the stakeholders involved in the whole supply chain.
- Leveraging SaaS and Big Data analysis to complete carbon calculation for implementing "carbon-peak and carbon-neutral" actions.

4) International Frameworks and international cooperation matter

- Regarding the ongoing major international policy shifts and initiatives for sustainability (Chapter 1.4), enterprises should pay closer attention to dynamic regulatory frameworks, policy trends of different countries, and markets for strategically planning ahead. Failing to adequately prepare for new regulations might become costly. At the same time, incentives for sustainable practices are becoming increasingly attractive.
- European and Chinese companies need to cooperate with their suppliers more closely to achieve ESG goals together. ESG should be applied across the whole supply chain.

5) ESG as a whole: Increasing enterprises' ESG motivation and actions

- Developing frameworks for quantitative measurement: setting up systematic ESG measurement methods and standards according to globally accepted standards such as GRI (Global Reporting Initiative) and the Value Reporting Foundation.
- In Implementing the leading role of market mechanisms, the capital market should offer more ESG-induced investment schemes.
- Accelerating the progress of mandatory ESG reporting for all companies
  - Adding ESG performance as an important item into companies' (financial) performance disclosure reports.
  - Incentivising company executives to take ESG as a significant factor of business success.

3.3 Outlook and Next Steps

This paper aims to serve as a starting point for further discussions on sustainability as a driver for innovating digital business models. In this regard, it has to be mentioned that with growing adoption of digital business model enablers such as Cloud services and Industrial Internet platforms, the estimates of the data centre energy consumption increase vary widely[26]. Global data centre electricity demand in 2018 was estimated to be almost 1% of global final demand for electricity.[27] For 2030, estimates range from 3-13%[28]. This percentage is

26 Anders Hove and Nicole Kim Fuerst, "Evaluate the potential of data centers for grid flexibility and sector coupling in Germany and China", 28 April 2020.

27 Eric Masanet, et al., "Global Data Center Energy Use: Distribution, Composition, and Near-Term Outlook," Evanston, 2018.

28 Andrae S. G. Anders and Thomas Edler. (2015). "On Global Electricity Usage of Communication Technology: Trends to 2030," Challenges 2015, 6(1), 117-157, https://doi.org/10.3390/challe6010117, p. 133.

2.54% in Germany 2017[29] and 2.61% in China 2018[30], and the trend is rising rapidly. This development must be accounted for in further analyses of digital business model sustainability.

Furthermore, especially in terms of ESG, social aspects require more in-depth research when measuring the sustainability impacts of digital business models. For example, (social) externalities of improved resource efficiencies at the cost of unemployment should be further investigated and discussed.

Finally, assessing all relevant aspects of the impact of digital business models on the environment would require a much broader and deeper view of enabling technologies and underlying infrastructures needed – which however – cannot be analysed within the limited framework of this digital-business-model-centric discussion paper.

Nonetheless, within its limited scope, this paper already identified many of the opportunities of the application of I4.0 technologies for improving sustainable business practices. Due to the growing importance of digital business models in the ongoing sustainable transformation of industries in the EU and China, it is highly recommended to further investigate this specific field.

4. Annexes: Further Use Cases

4.1 Increased Resource Efficiency

4.11 China Resources – Wind Power Management System

Introduction

China Resources Pingdu Longxin Wind Farm is part of the electricity supply industry. Its main businesses involve the construction, operation, sales, and consulting of wind energy power stations.

The company adopts advanced technologies, such as Big Data analysis, Internet of Things, and Industrial Internet platforms to remotely monitor and predict the status of wind turbines in real time to achieve centralised control, operation, and maintenance of regional wind farms.

Description of the technology

Using the Internet of Things to detect the operating status of equipment in real time, including equipment current and voltage, the management system predicts the wind farms' shutdown time. The maintenance period is rationally arranged to improve the power generation and the need for on-site technical personnel has decreased.

The company collects wind power equipment data and analyses it to arrange the time for equipment power generation, overhaul, and maintenance accordingly. Therefore, this process improves the efficiency of single-machine power generation and enhances corporate benefits.

29 Ralph Hintemann, "Digitalisierung treibt Strombedarf von Rechenzentren Boom führt zu deutlich steigendem Energiebedarf der Rechenzentren in Deutschland im Jahr 2017," Borderstep Institute for Innovation and Sustainability, 2018, at https://www.borderstep.de/wp-content/uploads/2018/12/Borderstep-Rechenzentren-2017-final-Stand_Dez_2018.pdf

30 Report by Greenpeace and the North China Electric Power University, 2019.

Results

Wind-power generation efficiency was increased by 15%. At the same time, the number of maintenance staff fell by 30%.

4.12 Suzhou Luoxiang Software Technology – Digital Modelling

Introduction

Suzhou Luoxiang Software Technology Co., Ltd. provides enterprises with standardised and customised intelligent software services for lifts.

Description of the technology

The company uses digital modelling technologies to standardise the development of lift components, and it must design lifts through parameter setting and parametric sketching of component combinations. The method of digital modelling is used for the development of elevator design. The digital-modelling method generates the inspection diagram, 2D diagram, and 3D diagram of the same-family products. Compared with the traditional method of manually designing the components contained in the product one by one, the design efficiency and accuracy are improved. For example, after the customer has determined the building dimensions, the person only needs to select the lift type and operating parameters; The design of the corresponding components can be completed within 1 minute, and the corresponding 2D, 3D and inspection drawings can be automatically generated.

Secondly, the company also uses digital technologies to develop software applications, carry out product catalogue management, component management and corresponding illustration management. Hence, the workload and man-made errors have been reduced.

The same management method can be applied in other divisions within the company or in others in the same industries to improve the development efficiency for similar products.

Results

The development efficiency is increased by 400%, the design span reduction increases thirty-fold, and the product documentation workload falls by more than tenfold. At the same time, the required number of development staff fell by more than 40%.

4.2 Creation of New Businesses

4.21 Qingdao Haier Energy Power – Smart-Energy Stewardship Service

Introduction

Qingdao Haier Energy Power Co., Ltd. has innovated and built an open energy management system based on an Industrial Internet platform. Relying on technologies including the internet, Big Data, and Cloud Computing, Haier has realised the transformation from traditional remote operation and maintenance to smart energy mode based on COSMOPlat.

Description of the technology

By providing customised new energy and new technology solutions for users, Haier helps improve the disordered status of energy management of SMEs, and contributes to energy conservation and emission reduction, green development and high-quality development.

The open energy management system based on an Industrial Internet platform solves issues such as high energy cost, low energy security, no energy-consumption detection, no energy storage, manual maintenance, and no value-added services. Therefore, its Industrial Internet platform helps reduce cost and save energy as well as consumption for enterprises.

The open energy management system also realises enterprise energy data integration across regions and multiple energy media, and systematically creates energy solutions to empower enterprises' green development.

Results

The electric power's expected difference in Haier Development Zone was less than 3% in 2019. This difference reaches the required standard of no more than 3% between the applied and the actual consumption of electricity sales business for direct whole power distributors in Shandong.

4.22 Shanghai Ideal Information Industry Group– Adopting Digital Platforms

Introduction

The core businesses of Shanghai Ideal Information Industry (Group) Co., Ltd. includes an information integration system, application software development, software and hardware product development, value-added service operation and IT outsourcing service.

Description of the technology

The company strives to hone its abilities in large-scale consulting project planning on informatisation and top-level designs, and creating comprehensive solutions for different industry applications such as "smart community", "smart park" and "smart governance", "industrial Internet" and "smart logistics".

The company has built an Industrial-Internet-platform-powered system that integrates emerging technologies such as Cloud Computing, Big Data, micro-services, 5G and so on.

[Figure 5: Production and operation centre based on the Industrial Internet platform applied to one steel construction plant]

This system connects the key production line's facilities and other operating systems to enable timely production of industrial applications. The purpose of this system is to have an Industrial Internet platform as its core product and explore the new business potential created by the Industrial Internet platform.

The company helps its customers to adopt new Industrial Internet platform systems to realise operational efficiency and productivity by utilising the digital potential through converging their operational data and production data, and using real-time data to manage and operate plant.

By collecting data on equipment depreciation, product energy consumption and spare parts, the company can provide refined price quotations, optimised production schedules and product management. As a result, manufacturers who adopt the company's Industrial Internet platform can have just-in-time deliveries, predictive maintenance, and reduction in energy consumption. Furthermore, it manifests that when the data value moves to the tertiary industry, more opportunities could be created from these digital business models.

Results

By adopting the Industrial Internet platform to connect the key production line's facilities and other operating systems, product defect rate is reduced by 15%. Energy consumption per unit of production is reduced by 10%. Total operational cost is reduced by 20%.

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Authors

Prof Dr Svenja Falk, Accenture Research

Yuanzhi Li, China Center for Information Industry Development

Prof Dr-Ing Reiner Anderl, Technische Universität Darmstadt

Dr Christian Bartsch, KraussMaffei Technologies GmbH

Klaus Bauer, TRUMPF Werkzeugmaschinen GmbH + Co. KG

Jiangning Chen, Shanghai HGB Digital Technologies

Prof Michael Dowling, University of Regensburg

Clemence Laguette, ENGIE SA (at the time of compiling the report)

Dr Junhai Li, Baowu Carbon Technology Co., Ltd.

Dr Steffen Preissler, Fraunhofer Center for International Management and Knowledge Economy

Wen Yang, Haier COSMO IoT Ecosystem Technology Co., Ltd.

Dong Zhang, China Telecommunications Corporation

Zhongxin Zhang, Dep-Newit Shanghai Enterprise Management Consulting Co., Ltd.

Yingya Zhou, Tencent Cloud

Contributors

Kai von Carnap, Mercator Institute for China Studies

Christian Dorfmüller, Startup Factory Kunshan Co.,Ltd.

Dr Fuqiang Ding, China Telecom Shanghai Ideal Information Industry Group Co., Ltd. Shanghai Internet Big Data Engineering Technology Research Center

Dr-Ing, Christoph Legat, Hekuma GmbH

Prof Christiane Prange, Tongji University School of Economics and Management Shanghai (at the time of compiling the report)

Gao Zihe, Foxconn Industrial Internet Co., Ltd.

Prof Dr Kristin Shi-Kupfer, University of Trier

Prof Yu Jiang, Chinese Academy of Sciences

Yübo Wang, Technische Universität Darmstadt

Editors

Dr Huifang Gao, China Center for Information Industry Development

Yuting Gu, Deutsche Gesellschaft für Internationale Zusammenarbeit

Ronald Metschies, Deutsche Gesellschaft für Internationale Zusammenarbeit

Yedong Wang, Deutsche Gesellschaft für Internationale Zusammenarbeit

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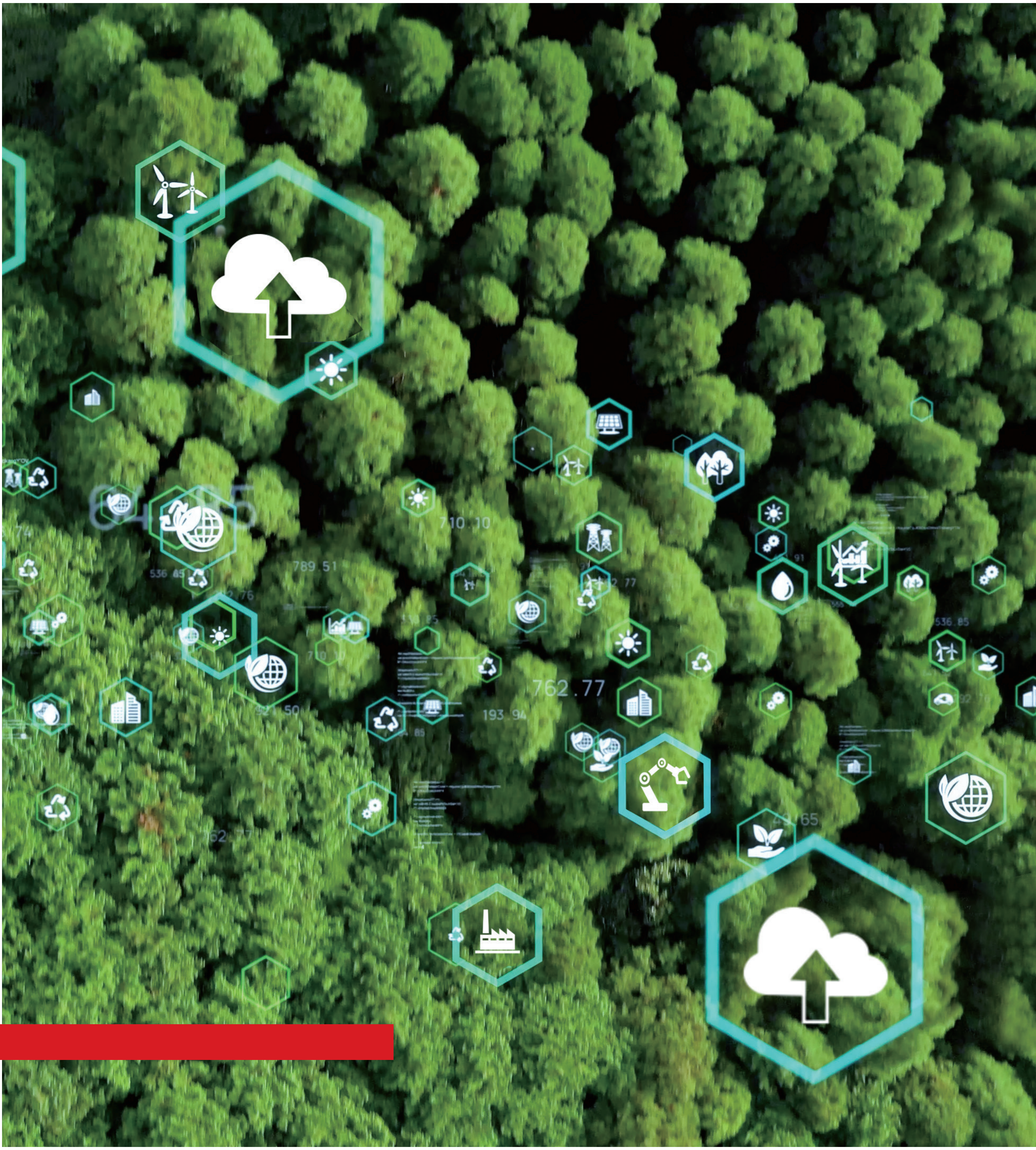

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

GIZ Office China
Sunflower Tower 1100
37 Maizidian Street, Chaoyang District
100125 Beijing, PR China
T +86 10 8527 5180

E giz-china@giz.de
I www.giz.de/china

Sino-German Industrie 4.0 Project
E info@i40-china.org
I www.i40-china.org

China Center for Information Industry
Development (CCID)

CCID Mansion, 66 Zi Zhu Yuan Road
100048 Beijing, PR China
T +86 10 6820 0219
F +86 10 8855 8833
E ljt@ccidgroup.com
I www.ccidgroup.com