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maintenance & asset management

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# CERTIFICATION by EFNMS

**SKILLS AND KNOWLEDGE** are the key factors in European maintenance. The price tag per work hour done in Europe is higher than in the main competitor countries. High quality maintenance supports the fulfilment of the efficiency of European industrial production, climate criteria and the competitive requirements of the circular economy.

High quality maintenance is achieved with excellent skills and superior knowledge. A good education system is the cornerstone of all learning. An evaluation procedure is needed to obtain feedback for further development.

**THE MAINTENANCE** committee CEN/TC 319 Maintenance is making standards for the European Committee for Standardization (CEN). A huge amount of work has been done over decades by writing a lot of standards trying to describe the maintenance landscape. The main maintenance standards specifying the content of maintenance are EN 17007 - Maintenance process and associated indicators, EN 13306 - Maintenance terminology and EN 15628 - Qualification of maintenance personnel. All maintenance related standards can be found by searching keyword "TC 319".

**THE EUROPEAN FEDERATION** of National Maintenance Societies (EFNMS) has renewed the maintenance certification process. Six EFNMS member countries have completed a three-year ERASMUS + project with a new certification concept. The new model will be a fully digitized process, a computerized exam with a new question database, the database now contains around 4000 questions covering certification areas from master to expert (Manager, Engineer, Supervisor) according to standard EN15628. The new questions are multiple choice questions, so automatic correction of the answers is possible, and thus the result of the exam is obtained immediately.

**FOR PERSONS** working in the field of maintenance the certificate proves your expertise, and improves your position (salary, employment, market value). For companies certified personnel guarantees more committed and motivated people on the payroll, better work results and quality. Service providers have an argument for marketing, they have certified personnel ensuring excellent results.

If you are wondering, would I succeed, can I pass the exam? When you have the required education, professional qualification, and have gained work experience in the field. When you have also been following developments in the maintenance field, you know what the others can do, and you know the main features of the standards. Then you are ready to test your skills and knowledge by taking a certification exam organized by EFNMS.

**Ilkka Palsola**
Promaint - Finnish Maintenance Society
EFNMS Certification Committee Chairman

*"High quality maintenance is achieved with excellent skills and superior knowledge.*

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*The online EuroMaintenance 2023 market survey about the Future of Maintenance in Europe is open for participation from July 2022.*


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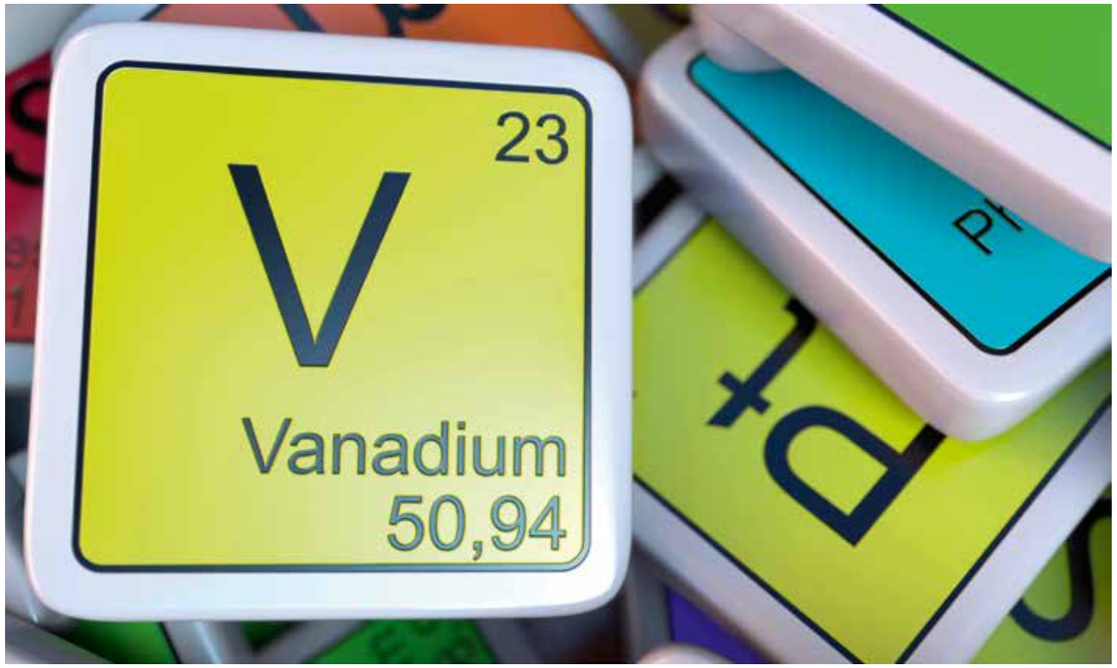
**32** **The importance of materials technology usually only becomes clear when something goes wrong,**

# In Short

According to the association Plastic Europe, **368 million** tonnes of plastic were produced in 2019 worldwide, and around **3 percent,** or 11.4 million tonnes, of this plastic ultimately ends up in the ocean.

**2020**

The Digital Twins market in the U.S. is estimated at **US$2.6 Billion** in the year 2020. The country currently accounts for a **39.6 percent** share in the global market.




# Joint Venture to Start High Purity Vanadium Production

**AN EIT** RawMaterials supported joint venture in Finland between two Australian project development companies, Critical Metals Ltd and Neometals Ltd paves the way for a significant increase in high purity vanadium production in Europe for use in grid scale vanadium redox flow batteries (VRFBs), specialty steel applications and next generation lithium vanadium cells.

The Vanadium Recovery Project (VRP) is targeting a 1.5 million tonne reduction of CO2 reporting to the atmosphere over 10 years compared to conventional mining. The VRP won't have any waste streams and will set a new precedent for circular economy practices in metals processing. The VRP, to be located in Pori, Finland, will receive 'slag' from local steel producers and recover some of the highest purity vanadium products in the world.

Vanadium is a critical raw material according to the European Commission and features superior energy density compared to other battery materials. It is fast becoming recognised as a significant addition to new lithium-ion cathode and anode chemistries used in electric vehicles as well as in VRFBs used for long duration energy storage solutions from renewable sources.

– Innovative projects like the VRP show how circular economy approaches can have a substantial impact on diversifying supply chains. Recovery of metals and minerals from by-products in an environmentally friendly manner will be a very important source of raw materials for Europe, complementing sustainable mining projects, **Olli Salmi**, Innovation Hub Baltic Sea Director at EIT RawMaterials says.

– We believe that in the next 10 years vanadium will be the 'new lithium, **Darren Townsend**, Chief Development Officer at Neometals says.

> *Vanadium features superior energy density compared to other battery materials.*



## Global Energy-as-a-Service [EaaS] market size to reach USD 120.65 Billion by 2029

**ACCORDING** to recent research study published by Polaris Market Research, the global energy-as-a-service market size and share is expected to **reach USD 120.65 billion by 2029**.

Energy-as-a-service refers to a business model in which a company provides electricity-related services. With this approach, customers pay for energy service, minimizing electricity bills.

The EaaS model requires customers to take a subscription for accessing electrical devices owned by a service company.

Leading companies are continuously moving from traditional power models to power as a facility model which is expected to generate lucrative growth opportunities in the upcoming years. The global energy as a service market is expected to witness strong growth during the forecast period owing to increased government investments in supporting renewable power sources.


## New Circular Industrial Park to Luleå Sweden

**LKAB CHOSE** the city of Luleå to be the location for its circular industrial park. LKAB will be extracting phosphorus and rare earth elements as residual products from iron ore production and increase Europe's self-sufficiency in these critical raw materials. Initially, apatite concentrate will be extracted in Kiruna and Gällivare/Malmberget. The concentrate will then be hauled by rail to the industrial park in Luleå, where it will be dissolved and processed to separate the products phosphorus, rare earth elements and fluorine, as well as gypsum as a by-product.

For Luleå, LKAB's planned industrial park means important development for local business. In addition to major investment and up to 500 new jobs, a whole new industrial cluster for chemical engineering will be created.

MAINTENANCE NEXT
NETWORK PLATFORM INDUSTRIAL MAINTENANCE
18 - 20 APRIL 2023

## EuroMaintenance and Maintenance NEXT 2023 to take place in Rotterdam

The largest European maintenance conference will be held in Rotterdam from 17 to 19 April 2023. At the same time, Rotterdam Ahoy will be hosting the largest technology and maintenance exhibition in the Benelux from 18 to 20 April 2023: Maintenance NEXT.

The combination will make Rotterdam the European meeting place for maintenance professionals in the Asset Management industry.

– EuroMaintenance consists of various components, such as the conference and the workshops at the Rotterdam Ahoy Convention Centre. The congress visitors can also visit the Maintenance NEXT exhibition and learn about the innovations and the people behind the innovations, says **Ellen den Broeder**, NVDO General Manager.

# EU Project Helps Transition to a Circular Economy

**A NEW** three-year EIT RawMaterials funded scheme, known as CSyARES (Circular System for Assessing Rare Earth Sustainability), will help companies improve the transparency and sustainability of their supply chains when it comes to critical materials.

Raw materials and advanced materials have a major impact on the environmental footprint of clean technologies and devices. The CSyARES project provides a software solution that integrates sustainability standards, Life Cycle Assessment, and supply chain traceability of rare earths. The tool will enable industry to better monitor and track supply.

-With CSyARES, we see potential in developing solutions for suppliers, brands, and industry as a whole to measure, understand and reduce the climate impact of Rare Earth Metals. As corporations and governments work toward a sustainable future, climate supply chain traceability software that leverages data and blockchain to measure environmental impact can help increase the secondary resource efficiency and accelerate transition to a circular economy, notes **Dr Roland Gauß**, Head of Innovation and Business Intelligence at EIT RawMaterials.

> *Raw materials and advanced materials have a major impact on the environmental footprint of clean technologies and devices.*

-Demand for critical and strategic materials is skyrocketing. The International Energy Agency says that in order to achieve the 2030 and 2050 climate targets will mean a dramatic increase of mineral requirements by 2040, particularly for Nickel, Cobalt, Lithium and Copper. These metals are irreplaceable in technologies like wind turbines, electric vehicles, mobile phones, computers and the defence industry. Rising demand combined with resource shortages and supply chain disruptions means we need to rely on sustainably mined and processed metal, states **Jordi de Vos**, Founder of Circularise, CSyARES project.

The project is led by the Dutch supply chain traceability start-up Circularise, BEC GmbH, Grundfos, London-based Minviro, and the global Rare Earth Industry Association (REIA) partners.

## Climate Change Rarely Addressed from the Viewpoint of Occupational Safety

**CLIMATE CHANGE** is visible in workplaces, but an invisible subject when it comes to occupational safety and health, according to a study performed by the Finnish Institute of Occupational Health and Centre for Occupational Safety.

From the panel respondents, almost two thirds (60%) indicated that questions related to climate change had been discussed in their workplace, at least to some extent. From the viewpoint of occupational safety, the impacts of climate change have only been discussed in a few workplaces (8%).

The most commonly recognised occupational safety risks are increase in slippery surfaces in wintertime, thermal exposure, and the use of protective equipment in hot conditions. Additionally, many workplaces have recognised the dangers of extreme weather conditions, such as storms and floods, and the measures required after them, the variation in the amount of rainfall, and the illnesses caused by ticks and other animals.

## Zero Emissions and Recycling Energy

**WOOD-BASED** SPINNOVA® fibre has been developed in Finland to replace conventionally used textile fibres within the global textile industry. Its carbon footprint is 1,28 kg CO2e per one kilogram of fibre, which is 72 percent lower than for conventionally produced cotton (4,6 kg $CO_2e$/ kg fibre).

As the use of conventionally produced cotton is replaced by the new fibre, one kilogram of fibre helps to decrease $CO_2$ emissions by 6,5 kg, according to research.



# Trends in Mine Maintenance Technology

Today, the emerging digital technologies empowered by Artificial Intelligence (AI) are transforming the Swedish mining industry where failure is not an option owing to severe downtime costs. Such costs can be as high as 30-40 percent of the total equipment operating costs

DIEGO GALAR, UDAY KUMAR AND RAMIN KARIM

James Cameron's Avatar paints a dark vision of the future of mining, where sophisticated remote technologies are used to ruthlessly exploit a vulnerable community's heritage and natural landscape. The movie, set in the 22nd century, shows humans mining minerals on a remote planet. Expansion of the mining colony threatens the existence of a local tribe, a situation evocative of earlier colonization efforts on Earth. The film has an important message: damaging the environment with no regard for local communities is a real risk. Yet from a technological point of view, if James Cameron and his advisers are right, the future of the mining industry is exciting – mining equipment may be triple the size of today's equipment, and real-time 3D models of the mine may be in play.

The current developments are gradually heading towards as was imagined in the technological breakthroughs in James Cameron's Avatar, but with one major difference, namely the aspect of sustainability. The mining industry today has environmental sustainability at the top of their agenda when deploying new and emerging technologies. These technologies are expected to facilitate and accelerate innovation and stimulate co-creation leading to effective and efficient decision-making processes, and simultaneously contribute to achievement of the global sustainability goals.

A consortium of mining companies, equipment and system manufacturers and universities has started a new European Union-funded collaboration project NEXTGEN SIMS, a three-year project that will support new technologies, methods and processes enabling a more sustainable and efficient carbon neutral mining operation. A key aspect of the project is to develop autonomous carbon-neutral mining processes. This includes the use of battery-electric mining equipment, full utilization of 5G for optimal connectivity and positioning, autonomous material handling, AI powered traffic and fleet control and collaboration among machines. The project also focuses on the mine worker of the future - 'the modern miner' and safety, for example by developing autonomous mine inspection technology facilitating correct maintenance decision-making.

Furthermore, for social acceptability and increased attractiveness there is a spoken intension from the mining sector on becoming information-driven through adaptation of digital transformation in every part of production and management processes.

> *Current developments are gradually heading towards the technological breakthroughs in James Cameron's Avatar.*

## Autonomous equipment in mining

Cameron´s movie shows a small team of people operating the mine thanks to automation. It seems that protecting the mine's assets requires more staff than operating the mining equipment. In fact, this is a feasible future for mining. Since mining operations imply a degree of repeatability, mining equipment, such as excavators, wheel loaders, mining dump trucks, and so on, has huge potential to be automated, as automation yields cost, safety, efficiency, and environmental benefits to mining enterprises.

Deep mining calls for technological and innovative solutions, and these, in turn, demand new strategic partnerships. LKAB, in collaboration with leading industrial partners, is working on the Sustainable Underground Mining (SUM) project with other globally-leading Swedish companies like Epirock, Sandvik, ABB, and Combitech since 2018. SUM's exciting view of the future of mining stretches from robot dogs and underground drones to self-driving electric behemoths conquering new depths and setting a new world standard for mining. Accordingly, each company involved in SUM contributes its specific expertise, and by working together, the partners will link digital systems and mining operations.

Dog-bots are useful in this context, as they can access almost every place in the mine. LKAB, Vale and many other mining companies are using these robots as an inspection tool in its operational areas. The dog-bot carries a robotic arm capable of acting with dexterity in the operational environment; it can reposition sensors and collect samples in places with difficult access.

Both performance and the working environment are more complex in mines than in conventional scenarios. This makes the control and health-assessment of equipment more difficult. Condition-monitoring algorithms must have better adaptability and robustness. In this regard, Internet of Things (IoT) provides a good solution to connect vehicles in the mine and transmit all kinds of information to the central processing unit to realize intelligent traffic management, vehicle control, and health assessment of mobile units.

Turning a conventional mine into a fully automatized mine or "dark mine" has several implications for maintenance. First, maintainers are not close to the assets and cannot make small adjustments or perform level-one maintenance tasks, so machines need to be more reliable from a design point of view, and traditional maintenance plans will be ineffective. Second, failure is not an option as any machine stoppages may lead to production stoppage - *digital butterfly effect*. Moreover, a failed machine may be working in an atmosphere with gases, and it may be dangerous for humans to repair it on site. The only solution is to have excellent PHM algorithms embedded into the machines in such a way that an asset perceiving a potential failure that will eventually affect its functionality may go to a point safe for humans where it can be repaired and restored.

It is relevant to note that Cameron´s mines need to consider maintenance in the design phase, as the RAMS requirements are more demanding; moreover, the PHM algorithms for the operation phase must be more sophisticated to avoid unexpected shutdowns.

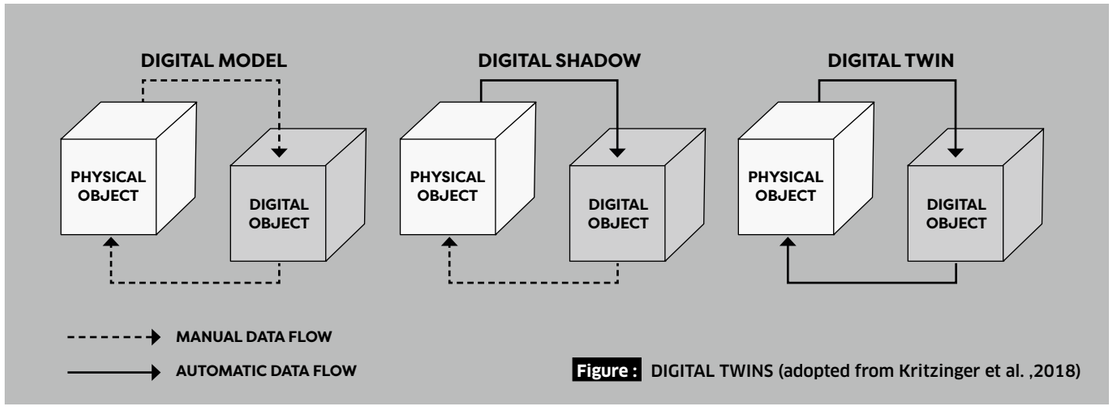



**Figure :** DIGITAL TWINS (adopted from Kritzinger et al. ,2018)

## Digital twins in mining

The idea of digital twin (DT) was initiated by NASA in 1970. Simply stated, based on input data, DTs provide process prediction and risk prevention in the physical world. A digital twin is not a static model but a responsive system connecting physical and digital systems, with numerous potential applications in industry. Other terms for digital twin are digital shadow, digital mirror, digital model, and digital avatar, etc.

A digital twin or digital avatar is a model of a real system that is coupled with the digital realisation of the abstracted model via data generated by and collected from the real system. Coupling the digital representation with its physical counterpart yields the digital twin. The result is not a realistic digital representation of a physical thing; it is an abstracted digital representation of an observed complex physical system.

DTs enable operators to predict the future condition of assets and prevent possible risks. Additionally, DTs show the effect of real things (products) and simulate their behaviour in different environments so that the company owners are at no risk. It is accepted that the first and most popular application of DTs is to be as Crystal balls where failure forecasting can be performed. Moreover, the increasing popularity of prescriptive analytics in maintenance has turned the DTs into potential test sets for different operational and contextual profiles in order to define the best O&M solutions. A digital twin is in part a model of a real system that is coupled with the digital realisation of the abstracted model via data generated by and collected from the real system. Coupling this digital avatar with its physical counterpart yields the digital twin. The result is far from a realistic digital representation of a physical thing; it is, however, an appropriately abstracted digital representation of an observed complex physical system. With the enormous potential to support better maintenance decisions, leading to better outcomes, DTs in mine equipment maintenance is providing noticeable benefits in remote monitoring and maintenance activities. Smart applications can upload health data to a cloud infrastructure, allowing real-time monitoring of multiple mining assets, each of which is modelled by DT software.

One example from the Swedish mining sector is the initiative and project of 'Ai Factory for Mining (AIF/M)', which is supported by LKAB, Boliden, Epiroc, IBM, and Ericsson, etc.

The objective of 'AI Factory for Mining (AIF/M)' is to enable a Digital Twin through the development and provision of an integrated platform and toolkit for fact-based decision-making in mining asset management, empowered by AI and digital technologies. This platform and toolkit aim to contribute to the achievement of sustainable and resilient operational excellence in the mining industry. AIF/M will have a special focus on a) AI and sharing of data and models; b) AI for context-aware analytics; c) cybersecurity; d) innovative business models; and e) distributed computing. The outcome from this project will enable Digital Twin and enhanced analytics based on AI.





## Metaverse in mining

If we think of the mine as the universe, then the metaverse is the digital dimension where the mine's digital entities interact. The metaverse is the expansion of DTs. It is not an augmented reality (AR) or virtual reality (VR) application. While VR-related studies focus on a physical approach and rendering, the metaverse represents a service with more content and social meaning. The metaverse may use AR and VR technologies to augment immersive perception, but platforms without VR and AR can be metaverse applications.

Importantly, the metaverse has a scalable environment that can accommodate many entities, thus reinforcing social meaning among the DTs coexisting in the space, immersed in that space and participating in it. That is why maintainers have to keep an eye on the evolution of DTs and how they transfer those replicas to the metaverse, as degradation mechanisms, maintenance plans, and prognostics will seriously affect the DT once it starts interacting in the digital arena with its counterparts. Maintainers will have to be immersed in the metaverse to observe as avatars how assets behave; this will obviously have an effect on maintainers and maintenance.

Boliden is already streamlining mining so that production can continue around the clock, thanks to 5G networking. In this case, the first 5G underground network allows greater accuracy in terms of determining hazardous areas in the mine itself and targeting employees who are stuck in a particular area by showing a 3D model of the mine with real-time information.

The mine as an immersive virtual reality universe will become the operator's playground. The virtual mine will be a place where the limits of reality are simply the limits of our own imagination. We can do anything with our assets, go anywhere and test everything. This will transform our mining maintenance team, as team members will interact with digital entities every day. Immersive virtual worlds will command an increasing portion of their time. In these virtual mines, maintainers will take the form of avatars in the movie's sense of the word – digital representations of themselves (but not necessarily tall and blue).

Last but by no means least, this way of working will modify our behaviour and way of thinking as maintainers. The Proteus effect is the phenomenon whereby our behaviours within virtual worlds are influenced by the characteristics of our avatar. Avatars with different roles behave differently with virtual entities and modify their decision-making process in a different. This will be relevant in maintenance, as maintainers need to assess risk in a permanent way, but perception in the digital arena may be compromised due to the Proteus effect.

The human factor should be considered in the adoption of new technologies as we move towards the metaverse. Over the next decade, we will spend more time on digital premises – both professionally and personally – with more control over our digital representations. The Proteus effect will take hold. Furthermore, for social acceptability and increased attractiveness there is a spoken intension from the mining sector on becoming information-driven through the adaptation of digital transformation in every part of production and management processes.

The mining industry today is conducting several initiatives to face the challenges of becoming information driven.

The Swedish Mining industry is becoming information-driven and maintenance managers are getting used to data driven decision making and learning to deal with various challenges arising out of data driven decisions strategy in their day-to-day decisions. Their challenges can be broadly classified into three groups-

- Technology-related challenges,
- Business model-related challenges
- Governance-related challenges

As mining in Sweden and other parts of the world becomes increasingly data-driven and dependent on automation, cyber security is of increased concern. These initiatives together make the fantasy become a reality! ■

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# Towards Sustainability with an Autonomous Industry

KAROLIINA SALMINEN, RIIKKA VIRKKUNEN, HELI HELAAKOSKI, ANNA VILJAKAINEN, VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

When moving towards a green and sustainable industry, companies have two kinds of goals. On the one hand, companies save resources and strive for carbon neutrality in their own processes and supply chains. On the other hand, industry must be able to produce climate-neutral products based on the circular economy, which are urgently needed to mitigate climate change.

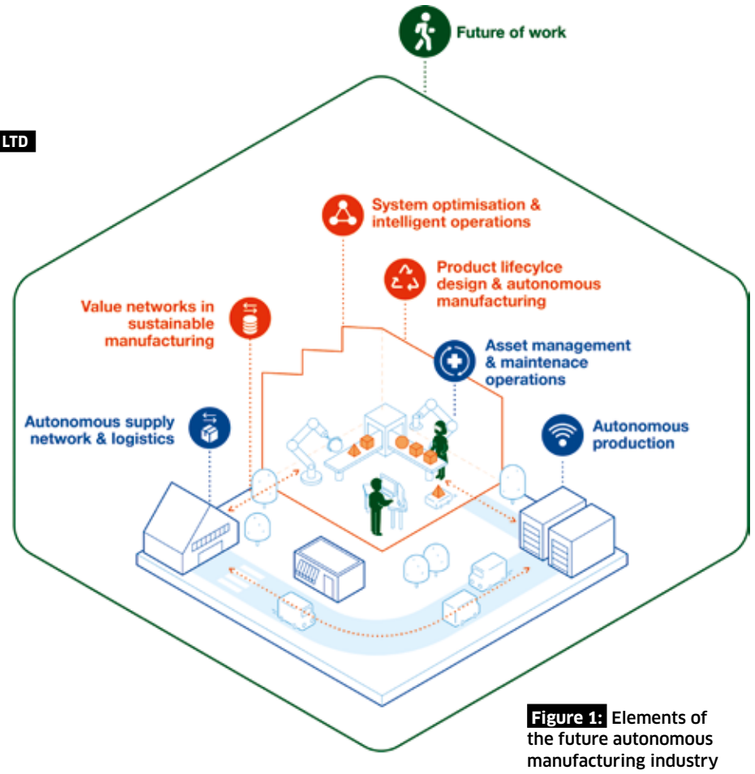



**Figure 1:** Elements of the future autonomous manufacturing industry

In a changing global context, including the national protectionism highlighted by the pandemic and the vulnerability of global supply chains, industrial autonomy is also increasingly valued. Twin transition is a systemic change that cannot be solved by technology alone, but where digital technology innovations, including automation, also play a significant role. Together with about 30 VTT experts from different fields, we have created a vision for future manufacturing. The purpose of our work was to challenge current thinking, to support companies in preparing for future disruptions, and to secure global growth opportunities and Finland's competitiveness.

## Autonomous manufacturing in 2035

In the autonomous factories of 2035, people and machines will work together, utilizing their own strengths and skills. Skilled people perform more advanced, holistic and strategic tasks that can also be performed remotely. Intelligent machines are aware of their own state, are able to predict and correct their own actions, and improve their performance through continuous learning. Customized products that utilize recycled materials and parts are manufactured on adaptive production lines.

Digital systems and adaptive automation are prerequisites for meeting sustainability requirements in a cost-effective way and for creating new products and businesses. Information is shared between different actors in real time, enabling a higher level of supply chain automation and the transition to circular economy business models. Production capacity is provided on demand to a wide range of customers and material losses and waste have been reduced. The use of sustainable solutions and recyclable materials has increased, and the logistics footprint is smaller.

Asset management and maintenance operations will evolve from predictive and prescriptive maintenance towards self-conscious and self-healing machines. Fleets of multi-purpose robots and drones are working with continuous maintenance and inspection tasks. Fieldworkers are using efficient AR/VR/MR systems with all the needed information at hand at the right time. Spare parts are prescribed and created on-demand locally or nearby with additive manufacturing enabling easy maintenance logistics.

In autonomous manufacturing, data and information flow in several systems that connect companies, employees, production assets and customers throughout the life cycle of products and services - from concept to manufacturing, use and recycling. When building the future manufacturing, several different levels and perspectives must be taken into account in order to take full advantage of the opportunities of green and sustainable industry throughout the supply chain. In VTT's vision, we have identified the key elements for future autonomous manufacturing. These are presented in Figure 1.

## What autonomy means for companies

The transition to autonomy has economic, environmental and social benefits for businesses. Increasing the transparency of the production process improves resource and cost efficiency. Better foresight enables factories to customize and adjust production volumes, allowing customers to respond flexibly to changing expectations and market changes and reduce storage levels. Manufacturing customized products requires adaptive production lines and short delivery times, which requires automation.

Sharing lifecycle data enables real-time decision-making. This, with the help of artificial intelligence, brings automated, optimized and more efficient processes to the entire supply chain. The small environmental impact of the supply chain will be a significant competitive factor for many Finnish companies in the future. This requires common rules for sharing data and ensuring security. Companies therefore need to understand the business potential of data sharing and should prepare for the implementation of the processes, rules and tools needed to share data.

Minimizing the physical and cognitive load on employees leads to better well-being and productivity as autonomous machines and robots perform repetitive, dangerous, and simple tasks and support the employee in increasingly complex tasks. Intelligent systems, in turn, help with decision-making by providing data-based solutions or predictions. Raising the level of autonomy will increase the opportunities for remote working in industry, where Finland can be a pioneer. An intelligent and interactive work environment makes the industry an attractive workplace, giving workers the opportunity to be involved in making a climate-neutral future.

**THE FINNISH MANUFACTURING** industry is export-orientated and international. Its offerings are dominated by high tech solutions and related digital services. Increased autonomy is one of the solutions for the required transition towards more sustainable industry.

Finland has world-class expertise in artificial intelligence, which is one of the main technical enablers for autonomous manufacturing. Academia and industry are also successfully developing new innovations for circular and bio-based materials to address the challenge of resource sufficiency. Finland is also well positioned in human technology collaboration research, especially from human-cantered perspective and empowering workers with new technologies and work roles.

# Digitalisation Redefines Plant Management and Monitoring

DR CÉSAR BUQUE, TÜV SÜD AG
PHOTOS: TÜV SÜD, SHUTTERSTOCK

Assessment of plants by combining periodic inspections with continuous and permanent monitoring and the use of suitable algorithms can help to make the most of existing tolerance ranges in operation.

Alongside artificial intelligence (AI) and machine learning (ML), the Industrial Internet of Things (IIoT) is paving the way not only for near-autonomous chemical, power or manufacturing plants of the future, but also for increased operational safety, higher plant availability and significantly reduced total cost of ownership (TCO).

Plant operators face enormous challenges related to ageing infrastructures and increasingly ambitious requirements for optimum production performance. These challenges are compounded by the ageing of industrial assets and the lack of qualified and trained personnel for operational control management. Today's industrial asset integrity management (AIM) and process safety management (PSM) are characterised by periodic inspections and assessments with intervals often determined by international standards, regulatory frameworks and applicable manufacturing guidelines. Yet these inspections only provide information about the condition of the asset at a specific point in time, failing to consider the impacts of continuous production processes on asset integrity.





The results are highly conservative estimates of the remaining lifetime, as asset condition and performance are frequently calculated and predicted on the basis of data that are years old and fail to sufficiently consider the dynamics of ongoing operations. The problem is that in industrial production, AIM and PSM are constantly influenced by various intrinsic and extrinsic events, which remain unaddressed in current strategies.

## Making the invisible visible: IIoT sensors as game changers

Common technical standards (ASME, BetrSichV, etc.) fail to sufficiently reflect the numerous intrinsic and extrinsic influences and interactions to which assets are continuously exposed during production processes. While difficult to predict, complex degradation mechanisms and safety parameters impact on overall integrity and process safety, potentially resulting in unexpected failures or machine faults which may cause plants to shut down immediately. Potential sources of failures may remain undetected leading to incidents that may cause injuries to engineers and technicians or environmental pollution.

> *Continuous data acquisition and analysis and permanent monitoring of plant behaviour will characterise the AIM and PSM assessments of tomorrow.*

The IIoT also opens new horizons for process safety management in the form of digitalisation of risk management using sensor data and a database for strategies such as PHA, HAZOP and LOPA and algorithms for SIL/SIF computation. Properly designed and permanently installed IIoT systems provide more information about previously invisible connections and dependencies between plant performance and various integrity and process safety events. This allows machine learning to use data collected from different sources to identify predictable adverse incidents in advance. Proper analysis of connected data turns them into useful information for reliable, real-time decisions and represents a step towards optimised, more resilient and more efficient management of asset integrity and process safety.

This development will soon be complemented by artificial intelligence, which uses self-learning algorithms and expert information, e.g. from TÜV SÜD databases, to recommend appropriate solutions for specific issues. At this stage, decision-making will no longer be based exclusively on rigid historical data, but also take into account the actual condition of the plant.

## Ultrasonic corrosion monitoring

Pressure bearing components, especially those that transport hazardous chemical substances, are subject to various types of degradation over time, such as corrosion. These degradation mechanisms pose both economic and technical challenges. Worldwide, the costs of corrosion alone amount to more than 2.8 trillion US dollars per year. From a technological perspective, degradation refers to the gradual weakening of the material at varying degrees of severity. Permanently installed IIoT ultrasonic sensors can seamlessly monitor component condition, thereby enabling continuous asset health monitoring (AHM).

One recommended approach is risk-based inspection (RBI). RBI identifies likely degradation mechanisms and failures as well as their consequences for production, the environment, and the investment. The RBI experts draw up precise positioning recommendations for the ultrasonic IIoT sensors. In the next step various types of sensors with different configurations are affixed to highly critical locations (locations that involve a high failure probability or severe failure consequences). The sensors gather data on wall thickness and crack/material behaviour over time. TÜV SÜD and the Technical University of Dresden are currently working on the development of special thin-film ultrasonic sensors which will soon offer the opportunity to cover entire object surfaces with permanent IIoT sensing. These sensors thus offer unprecedented ultrasonic capabilities, measuring not only wall thickness, but also extrinsic parameters that affect the progression of anomalies, such as temperature, pressure, and humidity.

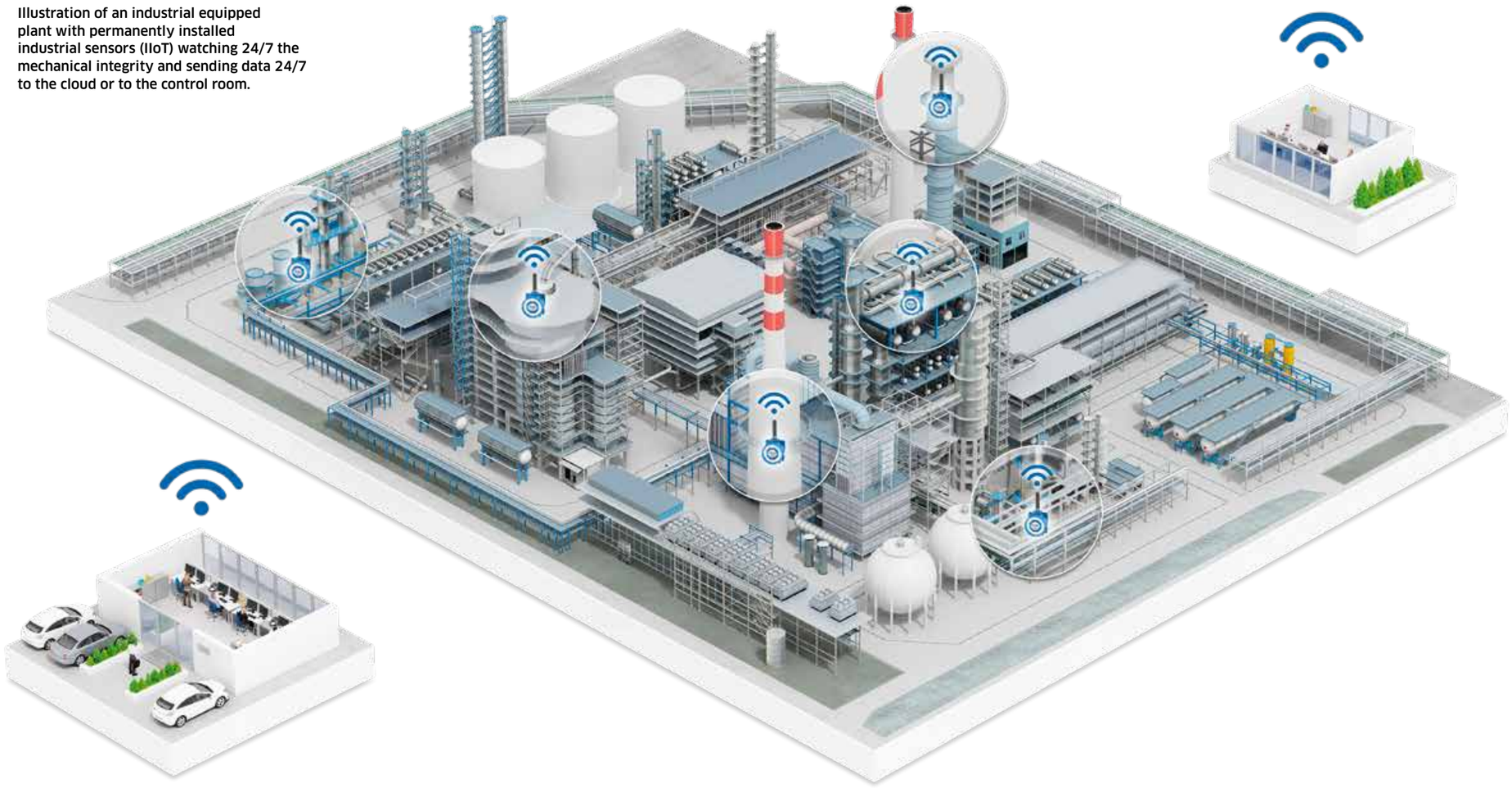
The collected data are automatically uploaded to the cloud and analysed in real time. They include corrosion and crack growth rates, dynamic fitness-for-service assessment, and the remaining lifetime. If defined thresholds are reached or exceeded, operators are alerted by email. TÜV SÜD's AHM solutions provide continuous monitoring and informative data on the behaviour of critical assets over a period of more than 5 years. Authorised personnel can access the relevant information on a digital dashboard.


## Acoustic emission testing

Scanning the entire surface and volume of a critical industrial asset, such as a pressure vessel or storage tank, is not always cost-effective. Acoustic emission testing (AET) can identify exactly where an asset is affected by ongoing and active degradation, without having to scan the entire asset. AET is typically done by placing a set of sensors on the asset wall for a few hours to measure the acoustic waves caused by ongoing and active mechanical stresses, for instance formation and growth of cracks, deformation slip bands, or recrystallisation effects related to twinning and phase transformations. Using triangulation, experts can precisely locate the origin. Cumulation further increases accuracy. Pinpointing developing anomalies such as cracks with reliability is crucial for the overall integrity of the plant. Specialists can target and analyse events at these locations and make appropriate recommendations. This fosters mechanical integrity and the efficient use of economic resources.

DIGITALISATION

Illustration of an industrial equipped plant with permanently installed industrial sensors (IIoT) watching 24/7 the mechanical integrity and sending data 24/7 to the cloud or to the control room.



## Intelligent algorithms for power plants

If conventional power plants were able to handle rapid changes between peak and minimum loads, it would be possible to integrate more wind and solar energy into the power grid. However, existing plants are not designed for frequent changes in thermal loads; the accompanying severe temperature fluctuations expose materials to thermal stresses, which can lead to creep damage and thermal fatigue in steam generators and pipelines. Given this, plant operators frequently engage in precise and permanent tracking of parameters such as temperature and pressure to monitor component fatigue.

TÜV SÜD physicists and engineers developed an analytical software called TSE "Temperature-Stress-Exhaustion". Using the collected data e.g. continuous temperature and pressure data the TSE software provides a realistic calculation of component condition under consideration of the applicable standards and regulations, thereby extending the tolerance range and ensuring more flexibility for operationally required thermal loads. The assessment also provides valuable input for the optimisation of condition-based maintenance and the potential extension of inspection intervals.

## Mastering Digitalisation

**THROUGHOUT** the digitalisation process, various risks and challenges need to be anticipated, mitigated and mastered. In addition, the requirements of regulatory frameworks must be met. Drawing on over 150 years of experience in industrial services, plant managers and operators around the globe trust TÜV SÜD when it comes to digitalising their AIM and PSM processes. The experts provide support with goal identification and scope definition and help operators to equip their facilities with IIoT sensors, dashboards and AI modules including machine learning. Remote and digital robotic inspections and digital twins of assets round off the Industry 4.0 services offered by TÜV SÜD.

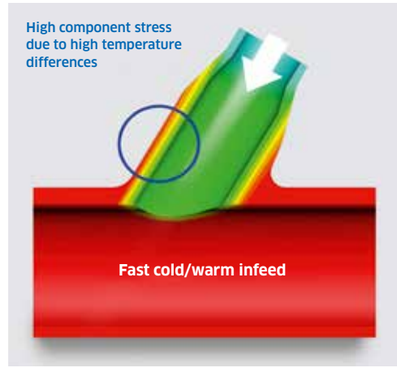



**Fig. 1:** Mechanical stresses caused by temperature changes.

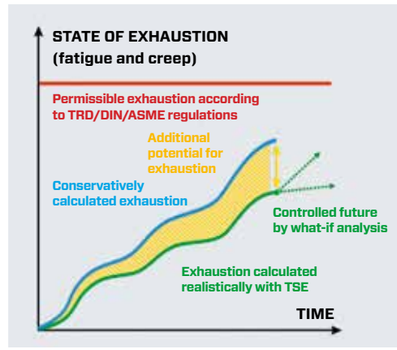



**Fig. 2:** Advantages of realistic evaluation of exhaustion status.

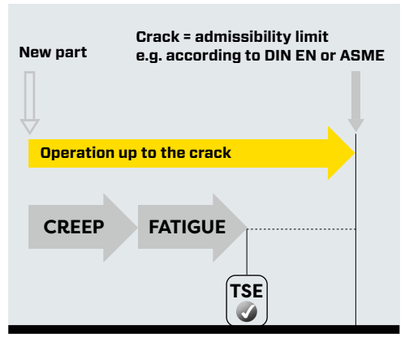



**Fig. 3:** Determination of the exhaustion status and pre-crack fatigue life potential by TSE.

Taking the example of a nozzle, Fig. 1 shows how rapid temperature changes in the fluid and the associated temperature distribution in the component result in the formation of mechanical stresses. These, in turn, cause material fatigue, as can be seen in Fig.2. TSE determines the current state of exhaustion and evaluates the loads that have occurred in operation so far. Fig.3 illustrates the advantage of determining exhaustion as precisely as possible. Using the remaining service life of the component calculated in this manner and what-if analyses, the experts can control the future development of exhaustion.

## On the way to autonomous plants

The IIoT and AI are paving the way for automated assets and are ushering in a fundamental transformation of industrial asset management. TÜV SÜD works with major industrial operators to complement periodic inspections with continuous monitoring using IIoT sensors and enable long-term economic asset management with artificial intelligence. Emerging AI applications are beginning to be able to interpret and recognise complex dependencies. TÜV SÜD's AI application is currently still in the final stages of development. Plant operators will soon benefit from AI that uses not only patterning, trending and reasoning, but also the knowledge that TÜV SÜD engineers have accumulated over the years. Machine-learning algorithms are already supporting plant operators with AIM and PSM information in real time. As AI and ML progress, the information obtained will also be constantly refined.

Continuous data acquisition and analysis and permanent monitoring of plant behaviour will characterise the AIM and PSM assessments of tomorrow. Supplemented by digital twins and meaningful analysis of big data, plant availability and plant safety will increase while total cost of ownership will decrease. ■

ADVERTORIAL

# Manual or Automatic Lubrication?
## How to Decide

**Lubrication is an essential part of machinery maintenance for nearly every production facility. On average, lubricant purchases only amount to 3 percent of a maintenance budget, but lubrication-related activities can influence an estimated 40 percent of total maintenance costs.**

In order to achieve optimum reliability and maximum benefits from a lubrication program, several factors need to be taken into account. These factors are summarized by the five R's of lubrication:

- Right lubricant
- Right quantity
- Right time
- Right point
- Right method

The starting point of an effective lubrication program is the detailed mapping of all lubrication points, including their working conditions, lubrication requirements, and criticality. This information is needed to select the most suitable lubricant and the quantity of lubricant needed, as well as to calculate the adequate relubrication intervals. These are the first three R's.

The fourth "R" refers to best practices, such as tagging and color-coding (or other methodology) of both lubrication points and tools in order to avoid cross-contamination.



### MAINTENANCE COSTS INFLUENCED BY LUBRICATION-RELATED ACTIVITIES

Besides lubricant costs, half of the acquired components will require relubrication. Overtime, labour is mostly a result of machine failures typically caused by inadequate lubrication. In addition, approximately 5 percent of labour costs can be attributed to lubrication activities.

The fifth "R" can be defined once the application conditions, asset criticality, and maintenance strategy are analysed. This will help you decide whether to automate each lubrication point. To make that decision, the pros and cons of automatic lubrication should also be understood and considered.

Once the five R's are defined, you can determine the best way to lubricate a component with the resources available.

### CRITICALITY ANALYSIS

A thorough criticality analysis of each asset will illustrate the impact of a failure in terms of:

- Overall production cost
- Overall maintenance cost
- Environmental impact
- Health and safety of personnel

The most critical assets are commonly the first targets of automatic lubrication.

### MAINTENANCE STRATEGY

The maturity level of a maintenance program (corrective, preventive, predictive, etc.) will dictate the skill and knowledge level required of personnel involved in lubrication-related activities.

As the maturity of maintenance and associated lubrication programs increases, so does the complexity of tasks that lubrication technicians must be capable of completing. These include activities such as:

- Lubricant analysis
- Continuous adjustment of lubrication routes
- Contamination control and fluid reconditioning
- Inspection routes

Therefore, as more mature maintenance programs are adopted, the areas where skilled maintenance technicians can add value to your operations need to be carefully considered. For example, are they best utilized performing manual relubrication, which can easily be automated, or by using their skills and knowledge to perform more analytical tasks, lubricant analyses, and making improvements to the lubrication program?

### BENEFITS OF AUTOMATED LUBRICATION

There are many advantages to using automatic lubrication systems. These include reduced waste and risk of bearing failure, cleanliness, less labour, and improved environmental health and safety. The benefits of this system can be seen across multiple industries. For example, an automatic lubricating system would be ideal for pharmaceutical industries where they have to deal with multiple types of equipment, harsh environments, and hundreds of lubrication points. By having this system, they ensure their machines are working at peak performance to produce a quality product every time.

### REDUCED WASTE AND RISK OF BEARING FAILURE

Relubrication quantities are dictated by the physical space available in the bearing, while relubrication intervals are dictated by the working conditions that determine the degradation rate of the lubricant. This includes factors such as speed, load, temperature, and the type of bearing.

A single-point automatic lubrication system can deliver the right amount of grease at the right time to each lubrication point. This reduces both grease waste and the risk of bearing failure. Especially when such system is coupled with ultrasonic sensors and a remote monitoring system, lubricating based on bearings' condition, assuring perfect lubrication at the right time, always. One good example is the OnTrak & Smartlube from UE Systems.

Consider, for example, a bearing that needs to be relubricated with 2 grams of grease every week. With a standard grease gun, this would mean that the bearing should receive about 1.3 "strokes." However, manually delivering 0.3 strokes is difficult, and it would likely result in a full two strokes being delivered. In other words, the bearing would receive 3 grams instead of 2 grams each time.

If we assume the technician is satisfied with two strokes because he doesn't see any grease coming from the seals, after a year, the bearing will receive 156 grams (52 weeks times 3 grams per week) instead of 104 grams (52 weeks times 2 grams per week). This means that up to 52 grams (50 percent) of the grease will be wasted.

### CLEANLINESS

An automatic lubricator can supply a continuous and accurate flow of fresh and clean lubricant.

Lubricant contamination will also affect bearing life and increase the risk of failure. In manual lubrication programs, avoiding grease contamination can be a challenge.

Processes must be clean to ensure no external contamination ingress into the grease, and each lubrication point should have a cap on its grease fitting. In addition, the utmost clean relubrication process for each point must be followed every time.

In the previous example, the technician will relubricate the given point 52 times a year. As a result, the bearing will be exposed 52 times to external contamination as well as to over-and under-lubrication.

By comparison, a properly installed single-point automatic lubricator can supply a continuous and accurate flow of fresh and clean lubricant, keeping the application in proper condition while at the same time preventing contaminant ingress.

### WHEN TO USE AUTOMATIC LUBRICATION

Automatic lubrication alone certainly is not the solution to all your lubrication issues. It must be properly understood to boost its potential benefits. However, there are solutions available in the market for virtually every application, so it is difficult to imagine that a critical application is not worth equipping with an automatic lubrication device.

# Where do You Stand on the Key Topics of Asset Management?

**If you were to answer the question 'what is your biggest challenge within maintenance'?, your answer probably can be linked to one of the following themes: Smart Industry, Asset Performance Management, Sustainability, Safety or The Human Factor. Therefore, these are the pillars for EuroMaintenance 2023.**

What is in Europe the status about Predictive Maintenance? Is this 'the holy grail' every factory will benefit from? And how many companies are really making use of Artificial Intelligence and Robotics? On some grounds we struggle, don't know where to start. On some grounds we are taking first steps to professionalize, and we are discovering the benefits. And on some grounds, some of us can act as an example to others. What's the status per country, per branch and can we learn from companies who are best in class?

On Our Road to EuroMaintenance, a market survey on the previous mentioned themes will be held. What are the new business requirements for maintenance organizations in Europe regarding technical availability, safety, sustainability, lifetime extension and costs? Which new working methods are applied to meet these new requirements? This market survey about the Future of Maintenance in Europe will be open for all European companies.

The survey will be executed this year and the results will be presented at EuroMaintenance, the largest maintenance congress in Europe, to be held from 17 to 19 April 2023 in the brand new, state-of-the-art, Rotterdam Ahoy Convention Centre in the Netherlands.

## ONLINE MARKET SURVEY

The market survey is executed by Mainnovation in cooperation with the NVDO, the Dutch Maintenance Society, and the EFNMS, the European Federation of National Maintenance Societies.

– The survey is one of the activities we organize on Our Road to EuroMaintenance. Mainnovation is expert in market research in the field of Maintenance and Asset Management. As a partner of EuroMaintenance, they are in the lead and of course the NVDO will make every effort to enthuse asset owners to participate, says Ellen den Broeder, NVDO General Manager and Project leader EuroMaintenance 2023.

Maintenance- and Asset Managers and Reliability Engineers will be invited to fill in the online survey. With the added information about the branch in which they operate in, the size of the maintenance organization and in which country they work, results can then be compared with other companies or other branches. And it will also be interesting to find out, which country is ahead when it comes to IoT, Smart Industry or Sustainability.

– The goal is to be able to compare results amongst the different countries and within different branches. Which industries and countries are leading the step forward? This is valuable information for every maintenance society and of course for the participating companies, Den Broeder says.

## LEARN FROM BEST PRACTICES

The analyzed results of the market survey will be presented at EuroMaintenance. Besides numbers, figures, and comparisons the best practices will be shared.

– The best-in-class companies who are really ahead, and can be considered as an example to others, will be identified. Which best practices are they applying? Mark Haarman, Managing Partner from Mainnovation explains.

## HOW TO PARTICIPATE

The online EuroMaintenance 2023 market survey about the Future of Maintenance in Europe is open for participation from July 2022. The survey can be approached via the websites euromaintenance.net and nvdo.nl and you will most likely get an invitation for participation via your national maintenance organization.

When all results are gathered and analysed, a Vision Document EuroMaintenance will be presented at the conference. All participants will receive this raport as well as an individual benchmark analysis about their branch. This way you can compare your results with others, and you can map out where your improvement potential lies. ■

DIGITALISATION

# Driving Evolution for Preventative Maintenance

Maintenance digitalisation is a solid investment in productivity and profitability for manufacturers. And, as affordability and accessibility rise, the industry has begun to look at digitalisation in a new light.

JANNE-PEKKA KARTTUNEN, CEO, DISTENCE OY

Finland-based company Distence Oy has been providing machine condition monitoring solutions for large manufacturers for over a decade, giving them a unique perspective on the changes ahead.

Companies need proactive strategies to minimise expensive downtime and keep their equipment running smoothly without critical incidents. Maintenance digitalisation has been discussed for over a decade, but global shifts over the past 12 to 24 months are driving significant progress in the industry.

Let's look at why the timing is right for companies to explore how the digitalisation of preventative maintenance can lower risk and increase productivity and profitability.

## A revolution in remote work fuels new discussions around digitalisation

Reliability and uptime have always been the primary drivers for preventative maintenance, but key factors are aligning for digitalisation to break through in new ways. However, **Janne-Pekka Karttunen**, CEO of Distence oy, says there is a challenge facing the industry as this change unfolds.

– Digitalisation of maintenance is a huge topic and for a maintenance engineer or manager it can be hard to answer the question What does this mean for me and my daily work?"

According to Karttunen, companies wanting to capitalise on the benefits of digitalisation can help smooth the transition by considering how to dovetail new ideas into existing processes. Creating a better understanding between maintenance engineers or other personnel and those with data expertise can move the industry forward in beneficial ways.

## What's changed in the landscape?

The events of the past two years mean working in distributed teams is suddenly common across many industries that hadn't embraced remote work in the past. Manufacturing companies that viewed remote work with reservation have learned to use digital tools like never before.

With the need to keep businesses running amid modern-day challenges, a new way of delivering professional services emerged. This shift swept through every industry and every type of work, creating both demand and urgency for remote solutions to industry condition monitoring.

For example, many vendors providing services like oil analyses or vibration-based inspections are moving to remote services and inspections. Digitalisation is a rapidly developing perspective across manufacturing companies, opening up the potential for significant change.

## Digitalisation is a smart investment

The need for a sustainable and cost-effective solution for condition monitoring has existed for a long time. Still, manufacturers saw modern solutions as expenses that didn't fit into existing budgets.

## Increases in affordability and value

The affordability of remote condition monitoring technology has increased in recent years, and the value companies are getting from it, is far beyond what they may have realized in the past. Manufacturers are no longer looking at the cost of a new system as a new expense, but assessing the value of the analytics it provides, and the resulting recommendations they can use to maximise the lifetime value of their assets.

## Positive returns from digitalisation

As well, studies over time have shown a positive return on investment from Internet of Things (IoT) and digitalisation projects. This potential for positive returns encourages more managers and directors to promote digitalisation initiatives.

Having a business case and a clear user-driven use case is often one of the success factors of digitalisation projects. In parallel, more organisations begin to understand investments in maintenance development are not expenses but investments in productivity and quality.

## Investment in reliability is an easier sell

It has been a challenge to adopt new technology in an industry where there is pressure for cost reductions and savings. Looking at what manufacturers can gain from remote condition monitoring requires

Reliability and uptime have always been the primary drivers for preventative maintenance,

DIGITALISATION

an open dialogue and mindset from maintenance, operations, and management teams.

The conversation around these topics has shifted with proven results showing the benefits of digitalisation and remote condition monitoring.

## Condition monitoring offers valuable insights

Machine condition monitoring leverages the digitalisation of preventative maintenance techniques to create a powerful new approach to maximise machine health across your facility. Distence Oy's objective, as a leading provider in this space, is to ensure your rotating industrial assets last longer, produce more, and perform better.

With remote condition monitoring, you get an end-to-end solution. It allows you to combine wireless sensors and highly accurate sensing technologies into one platform that integrates into your existing IT infrastructure.

The solutions offered by Distence via their Condence platform use open interfaces, making it possible to combine several methods of machine health analysis. The technology can easily adapt to different environments and machines, making it a widely recognised solution for facilities ready for a new approach.

## Breaking down barriers

Even when organisations recognise the gap between their needs and what their current system can manage, progress can be slow. However, the events of the past two years are spurring more progress than ever before.

As an industry, we must work as a collective to move past limiting beliefs and envision a better future with greater rewards for all involved. You may have even heard some of these concerns mentioned in your organisation:


### 1. We already have enough data

This abundance might be true in some organisations where data is collected for production purposes. However, if the quality of that data is not sufficient for other use cases, it can trigger costly or impractical approaches. Having access to the right information is often the primary need, and this challenge can be solved with AI and machine learning.

### 2. We need to consider the "10-year perspective"

Industrial investments are often viewed from a 10-year perspective, but technology is evolving much faster now than it used to. It is now more essential than ever to ensure technology can be updated continuously, that it develops over time, and is future-proof.

### 3. We need one system to do it all

Maintenance employees already have multiple systems they use daily, so adding one more can feel overwhelming. It can be compelling for maintenance engineers to wish for one system that solves every problem. In maintenance, a more practical approach is to ensure integration between systems and create workflows that support operational processes.

## Evolution lies ahead: how can manufacturers prepare?

The need for reliability and maintenance professionals is not going anywhere, yet it can rise to another level. The question is how we can re-imagine the operational processes that may be limiting us, not the access to technology.

- **User-centric software engineering**
  One of the core principles in software development is to encourage vendors and to design technology that is user-friendly and supports more efficient business processes.
- **A new approach to delivering peak reliability**
  Using results and process-oriented methods to deliver reliability is an effective approach that can help achieve buy-in from operations teams.
- **Smooth implementation of new projects**
  Digitalisation could support the implementation phase of Industrial Internet of Things (IIoT) projects, as the majority of manufacturers report challenges during the implementation phase.
- **Training is key**
  Condition monitoring allows manufacturers to scale up the capacity of how many machines they can monitor. In doing so, you might take a maintenance engineer from monitoring a small number of machines manually, to being able to monitor thousands of machines, then performing maintenance where and as needed for optimal machine health.

According to Karttunen, The digitalisation of condition monitoring is a triangle of:

a) understanding the data, its structures and models, and how it is processed,
b) understanding the maintenance procedures, and creating a workflow that supports the function and business process,
c) and understanding the physics of these industrial machines."

Having access to the right information is often the primary need, and this challenge can be solved with AI and machine learning.

## Why is the transformation of preventative maintenance so critical to the manufacturing industry?

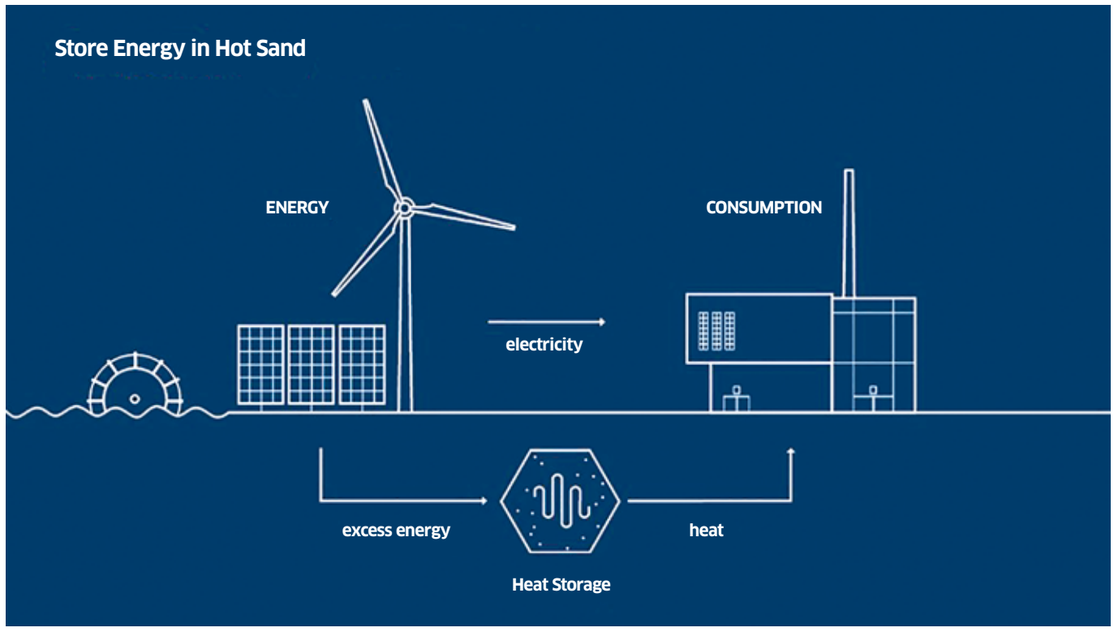
One might compare the shift to preventative maintenance to how communication has evolved over the past few decades. Technology didn't change our need to communicate, but it transformed our capacity to share ideas and connect with one another.

No longer do we simply communicate with one person at a time through single written or spoken messages. Now we can send a message to thousands with the tap of a computer keyboard.

Technology will not change the need for preventative maintenance. It won't alter the principal design of a pump or an electric motor, nor will it quickly disrupt many principles of industrial processes.

However, it could transform our operational processes and how we organise our businesses around them, and this is where enormous opportunity lies.

Condence offers machine conditioning monitoring solutions that combine affordability with deep insights and benefits that drive business performance. As more manufacturers adopt digitalisation and condition monitoring as the new standard, the industry is poised for dramatic increases in both productivity and profitability. ■




# Sand-Based Heat Storages are a Hot Topic

We need new ways to store large amounts of energy. One solution is sand-based heat storage.

LIISA NASKALI, PROJECT MANAGER AND MIIKA PELTOLA, COMMUNICATIONS SPECIALIST, POLAR NIGHT ENERGY

We have a liftoff. A crane lifts a massive steel cylinder off a truck in Vatajankoski's power plant area in Kankaanpää, Western Finland. The seven-meter times four-meter cylinder swings slightly on a wire and looks a bit like a space rocket.

Although Vatajankoski, an energy utility company, is not preparing for a space flight, this is a historic event. The "rocket" is the first commercial sand-based high-temperature heat storage in the world. It utilizes an automatic heat transfer system developed and patented by Polar Night Energy, a Finnish startup from the city of Tampere.

Once the heat storage has safely landed on the earth's surface, about 50 cubic meters of sand is poured into it from an opening on the roof of the cylinder.

Vatajankoski uses the heat stored in the sand to raise the temperature of waste heat generated by their data servers. The temperature of the 60-degree waste heat from the servers needs to be raised to between 75 and 100 degrees Celsius depending on the season, before it can be fed into the Kankaanpää district heating network. The heat storage built in the beginning of 2022 can provide 100 kW of heating power and can store 8 MWhs of thermal energy.

> *One good way to store energy for long periods of time is heat.*

– The starting point of this project was not long-term storage, but could we make seasonal energy storages with the same technology, with more than thousand times higher capacity? ponders **Lauri Hölttä**, Production Manager at Vatajankoski.

– Such a storage would allow us to utilize the cheap energy of the summer season as much as possible to charge the storage, and then use this stored energy to fulfill the heat demand of the winter season. It would reduce heat production based on combustion.

## Energy Storage Is a Challenge

Storing energy is one of the key challenges as we move from combustion technologies to more sustainable forms of energy production. By 2030, the world's current energy storage capacity is projected to multiply, and annual growth rates are in double digits.

R&D around the topic is active. Polar Night Energy is part of an EU ERA-Net SES project called NewSETS together with LUT University, Flexens and Pumped Hydro Storage. The project studies the utilization of electricity and heat storages as part of a flexible and independent energy network. NewSETS will do a case study about the Åland archipelago.

– Storage is needed when energy production and consumption do not meet. One good way to store energy for long periods of time is heat, says **Tommi Eronen**, CEO of Polar Night Energy.

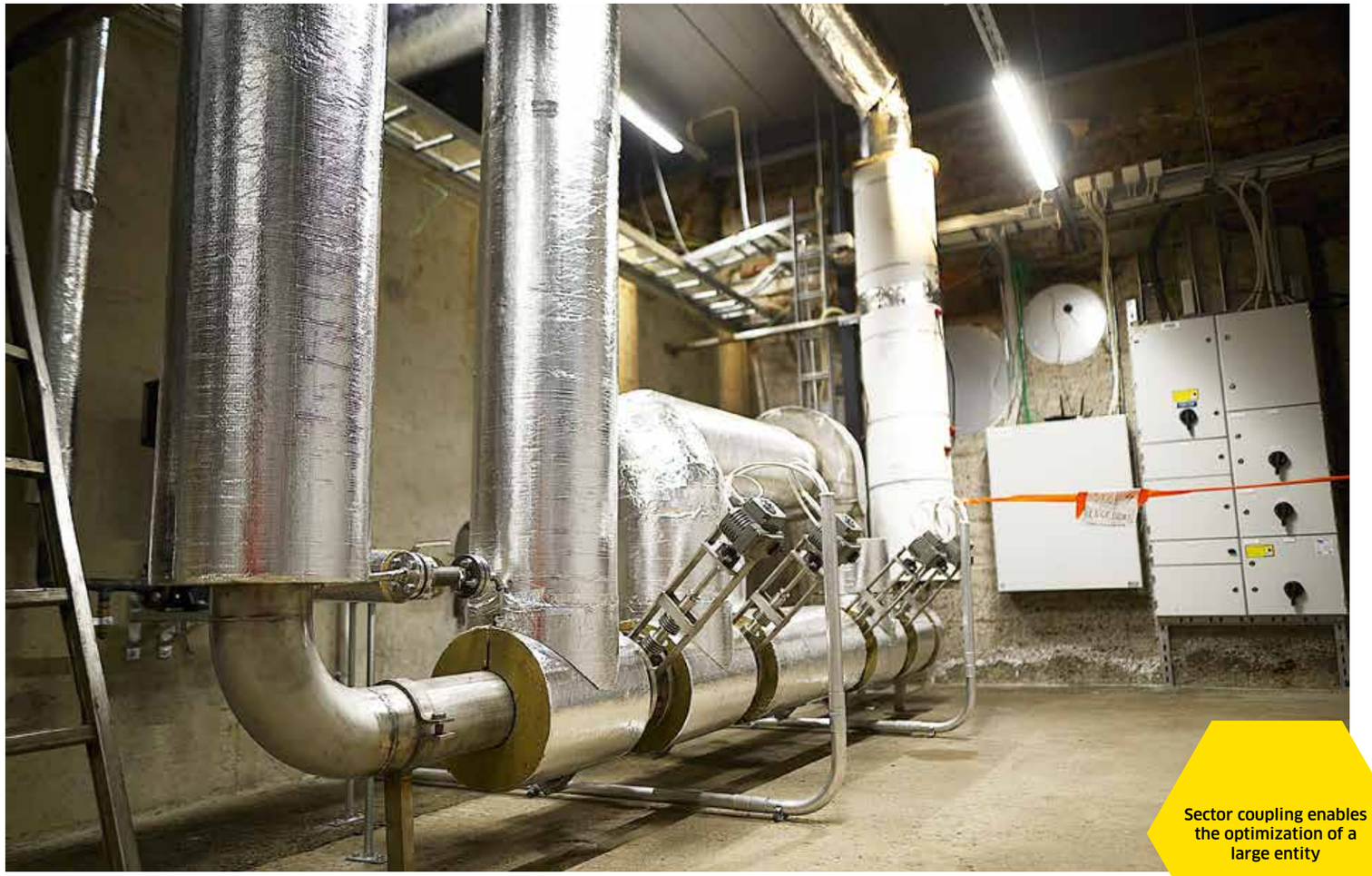
Globally, heat production is largely based on combustion and fossil fuels, which are being feverishly sought to be replaced. It means there's a need to electrify heat production, to recover waste heat, and to find new ways of storing heat.

## Sand-based Thermal Energy Storage

A common way to store heat is to heat up water. This includes both domestic water boilers and water-based district heating storages. Water-based heat storages function as short-term and high-power storages. However, storing large amounts of energy in water is expensive and takes up a lot of space.

Storing energy is one of the key challenges as we move from combustion technologies to more sustainable forms of energy production.

Markku Ylönen (left), CTO, and Tommi Eronen, CEO of Polar Night Energy.



Sector coupling enables the optimization of a large entity

> *There is an economic pressure to give up fossil fuels.*

Many solid materials, such as ordinary sand used by Polar Night Energy, can be heated to temperatures well above the boiling point of water. Sand-based heat storages can store several times the amount of energy that can be stored in a water tank of a similar size; this is thanks to the large temperature range allowed by the sand.

– In addition, a sand-based heat storage can be used in industrial applications that require temperatures above the boiling point of water. In practice, the maximum temperature of a sand-based heat storage is not limited by the properties of the storage medium, but by the heat resistance of the materials used in the construction and automation of the storage. The maximum temperature of our storages built so far is about 600 degrees Celsius, but we are planning to raise it even higher, says Eronen.

## From Season to Season

Polar Night Energy's solution can be used for both short-term and seasonal storages, allowing energy to be stored even for months. The sunshine of the summer can be stored for the darkness and cold of the polar night. At the same time, part of the capacity of the storage can be utilized in leveling the shorter-term consumption profile or in the frequency management of the electricity grid.

– The structure of our heat storage is simple. It is an insulated tank made of concrete or steel, filled with sand and pipes. Additionally, equipment outside the storage is required, such as automation components, valves, a fan and a heat exchanger or a steam generator, Eronen explains.

The basic operating principle of the storage is also simple. Electricity is converted to heat by heating air in a closed-loop piping using electrical resistors. When hot air is circulated in a closed loop through the storage, heat moves from the air to the sand.

The storage is unloaded by blowing cool air through the pipes. It heats up as it passes through the storage, and it can be used for example, to convert water into process steam or to heat district heating water in an air-to-water heat exchanger.

In addition to electric heaters, heat can be recovered from hot gas or sufficiently warm waste heat streams. However, the stored waste heat must be above 500 degrees Celsius, as the storage is driven by temperature difference and the storage temperature is also high.

## Towards Climate-neutral District Heating

The Eagle has landed. Vatajankoski is on its way to climate-neutral district heating.

– We want to mitigate climate change and offer our customers sustainable energy solutions. Most of our production is already renewable or completely emission-free. A small number of fossil fuels are still used in heat production, but they are planned to be phased out soon, says Lauri Hölttä.

The use of renewable and zero-emission energy has long been slowed down by high prices. According to Hölttä, this has now changed through taxation and emission rights, although some challenges remain.

There is an economic pressure to give up fossil fuels. In the case of renewables, which culminate on biofuels in Finland, the problem will be availability. Using waste heat, the challenge is that production and consumption do not meet, so thermal energy must be stored somewhere. The energy demand for district heating is many times higher in winter than in summer.

According to Hölttä, seasonal storages play a big part in giving up fossil fuels and later biomass.

– Different technologies exist, but for example sand and blast-furnace slag are suitable for longer-term storage. Sand is a simple solution – something you may not even think of.

Sand is indeed an effective solution for reducing climate emissions. According to a report by Mission Innovation, sand-based high-temperature energy storage could save more than 100 Mt CO2e annually after 2030. Saved emissions would be around 3 percent of the current emissions of the whole European Union. ■

## Sector Coupling – No Wasted Energy

**SECTOR COUPLING OR SECTOR** integration is the interconnection of different energy sectors, such as renewable electricity generation, heating, cooling, and transport. Tuomas Vanhanen, who is writing a doctoral dissertation on sector coupling, answered MaintWorld's questions.

**Why and where do we need sector coupling?**
– Sector coupling enables the optimization of a large entity. The result is economic value and savings in energy and reductions in emissions. In line with the EU's new sector integration strategy, energy systems must be developed as whole.

**Do we need more than traditional electric batteries for energy storage?**
– Long-term storage of electricity in conventional batteries does not make sense. Instead, the excess electricity should be stored, for example in the form of hydrogen or heat, and it should be utilized in industry and in district heating networks.

**What kind of heat storages will play a significant role?**
– Ordinary water-based heat storages are now being built. Storages based on solid materials are probably the next step. Storages based on melting and cooling of salts will be of interest, as will new types of storages based on chemical reactions. As far as electricity is concerned, converting it to hydrogen and to methane is also a natural evolution of our energy system, because we have big players in Europe with money invested in the gas infrastructure and an interest to promote electricity-to-gas solutions.

**What are the biggest barriers to the introduction of new storage technologies now?**
– Policies both enable and discourage, and general attitudes have a major impact on the types of policies promoted. Policies impose market boundary conditions that materially affect the profitability of technologies. Existing infrastructure also affects the interests of operators.

MATERIALS TECHNOLOGY

SENIOR RESEARCH FELLOW SUVI SANTA-AHO, TAMPERE UNIVERSITY, ENGINEERING MATERIALS SCIENCE, MATERIALS CHARACTERISATION RESEARCH GROUP

# To Repair or to Redesign?

The importance of materials technology usually only becomes clear when something goes wrong, such as if a component fails during a production process or breaks under wear. The number one question should be “how do we prevent this from happening again”.

The significance of materials technology and non-destructive testing is bound to grow in the future, as digitalisation and sustainable development start to place new requirements on products and components. Materials technology parameters are chosen based on standards, which means that the real potential of using materials technology to optimise the properties of materials according to their intended use is lost.

The current craze is innovation ecosystems, which offer one way to bring experts in different technological disciplines together with businesses to brainstorm new approaches. The role of materials technology and non-destructive testing in production chains is the subject of a project called “Smart Manufacturing in an Ecosystem”, which is a research collaboration between Tampere University and local mechanical engineering businesses and funded by Business Finland.

The project promotes the development and reinforcement of a multidisciplinary mechanical engineering business ecosystem while also producing data that can potentially be used more widely going forward. The businesses involved in the project include Sandvik and several other businesses. The ecosystem engages in multidisciplinary cooperation with various units of Tampere University (Engineering Materials Science, Automation Technology and Mechanical Engineering) and internationally with RWTH Aachen University. The ecosystem believes in the power of working together: none of the organisations can control everything alone, but by pooling their resources they can make significant contributions.

## Better quality control required to improve machining techniques

Non-destructive testing (NDT) refers to a range of analysis techniques used to evaluate the properties of components without damaging them so that they can be used normally for their intended purpose after the testing. Industry uses NDT, for example, to check the standard of work in finished components.

NDT generates real value when it is used to ensure that finished components comply with the relevant requirements. Raw materials can be analysed to ensure their quality, but final inspections are usually not performed until the end of the production process when the component is finished and can only be “accepted” or “rejected”.

In the context of different machining techniques, NDT can be used to check that grinding,

## What is materials technology?

**DIFFERENT** materials such as metals, plastics and ceramics typically have completely different properties. This means that the technologies involved in their production are also fundamentally different.

**Materials technology** involves selecting materials with the properties that best meet the service requirements of a component as well as maintaining the performance of the materials over the operating life of the component by resisting corrosion, fatigue, temperature and other harmful events.

**Materials Science** is closely related to materials technology. Materials Science is a multidisciplinary field that connects material properties to the material’s chemical composition, micro-structure and crystal structure.

**Non-destructive testing (NDT)** is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects and discontinuities without causing damage to the original part.

*The significance of materials technology and non-destructive testing is bound to grow in the future.*

for example, has not resulted in grinding burns, which can shorten the fatigue life of components. Damage caused by machining during the production process can rarely be spotted by visual inspection alone. With respect to grinding, the key parameter is the temperature between the grinding wheel and the component, which must not get so high as to cause microstructural changes or residual stresses.

Only NDT can detect this kind of damage. The useful properties achieved by grinding, such as accurate dimensions and higher fatigue strength, can be undone in an instant by a simple mistake.

Developing more sophisticated grinding techniques and increasing competence also requires better quality control. This can be due to, for example, the introduction of new materials that will be machined using existing techniques or the deployment of innovative machining techniques, such as 3D printing or heat treatment for microstructural customisation, that will be applied to materials that have been used before.

Research into NDT in the context of quality control increases understanding and awareness of the various techniques and their potential and creates opportunities for using the data in new ways. This is why research is so important for the development of quality and production control.

New approaches can be discovered by combining innovative and conventional techniques, such as smart computing and modelling, and by increasing cooperation between different scientific disciplines, as was done in the "Smart Manufacturing in an Ecosystem" project.

## Quality control measures process performance

Going forward, a potential trend could be the use of NDT as a means of adjusting and controlling machining parameters in real time instead of focusing on simply testing the standard of the finished article at the end of the production process. This approach aligns well with the principles of sustainable development and resource efficiency.

The reliability and accuracy of the data based on which the production process is analysed is crucial. This is why only high-quality, measured data should be used to evaluate the standard of finished products. In the case of the "Smart Manufacturing in an Ecosystem" project, the results of NDT were verified by means of laboratory analyses. As long as a sufficiently large sample of data is collected, the absolute quality-control measurements taken during the production process can be verified and a calibration curve drawn.

## Minor variations allowed

The ultimate definition of quality is the ability of a product to meet the customer's expectations. Contemporary quality assurance techniques focus on controlling variation by means of what are known as process capability indices. The modern view is that minor variations in quality are allowed, and the key is for a process to be able to produce output within certain specification limits. This approach attributes variations in the finished product to variation at the individual stages of the production process. An anomaly in the properties of the material or the machining technique, for example, can therefore escalate during the process and result in the finished product's being rejected or, in the worst-case scenario, a defective product's being delivered to a customer, which in turn can cause serious financial and reputational damage and even jeopardise the entire business. Not intervening in these kinds of deviations during the process and only applying quality control procedures to the finished products creates high wastage rates and, above all, a lot of unnecessary work. Integrating NDT into the production process provides an effective solution to this problem. ■

**The ultimate definition of quality is the ability of a product to meet the customer's expectations.**

**The importance of materials technology usually only becomes clear when something goes wrong.**

## Case: Non-destructive testing helps to replace an old machine tool

**ONE WAY** to find new applications for NDT is to use it in connection with tool upgrades as a means of maintaining a consistent performance of the manufacturing process through the transition. The research team involved in the 'Smart Manufacturing in an Ecosystem' project applied NDT to a number of real-life cases, one of which sought to maintain consistent quality through the deployment of new manufacturing technology. In this case, NDT served as a means to verify the results of analyses comparing components produced using two different machine tools. The goal was to use the comparative data to establish optimal machining parameters and quality criteria for the new tool.

Could an innovative smart manufacturing concept be developed by combining NDT measurements and experimental research?

NDT also shows considerable potential in the analysis of material properties beyond the identification of quality deviations, which is what these techniques have conventionally been used for. Modern methods of signal processing and the use of artificial intelligence provide new ways to interpret the results of traditional measurements. The data can then be used in, for example, modelling. Combining other measured material properties with NDT data may lead to the discovery of new, more practical applications of these conventional techniques. This creates new opportunities and potentially a link to the performance and useful life of finished components.


# Process Safety as an Integral Part of Overall Safety Management

Investments in process safety increase the ability to manage the entire industrial production process, which helps to improve reliability and control emissions. They also have a positive impact on productivity.

**SANNA PIETIKÄINEN, SENIOR OFFICER, PROCESS SAFETY, FINNISH SAFETY AND CHEMICALS AGENCY**

Process safety is an integral part of the overall safety management of chemical plants. It draws on both engineering and leadership competence and focuses, in particular, on preventing chemical spills and minimising their consequences.

Weaknesses in process safety can at their worst lead to serious personal injury or substantial environmental or property damage. There are various ways to improve safety, including technological solutions, the correct positioning of machinery, effective change management as well as procedural development and staff training.

The definition of process safety is not clear-cut, but in this article the concept is understood to mean the management of risks relating to the handling and storing of chemicals in industrial contexts.

Process safety can be improved by investing in the entire plant, individual processes and people. The way in which buildings and stores are located on the property, how machinery is positioned inside the buildings, what chemical spill containment systems are in place and what fire-fighting equipment is available, all affect the level of process safety. Critical elements within the production process itself include hazardous chemicals and the way they can react with each other, various process parameters (such as pressure, temperature, pH and flow rate) and the degree of process automation.

These systems are designed and operated by people, which is why people also play a key role in determining the level of process safety. The organisation running the plant and its decision-making and executive bodies are also made up of people. All of the aforementioned components of process safety are in a constant state of flux while the plant is in operation, and the risks presented by changing circumstances need to be carefully managed.

All efforts to improve process safety should start with risk assessment. The consequences of process failures (explosions, large fires, clouds of toxic gases) can be too catastrophic to contain afterwards. This is why the focus must be on prevention, and accidents can only be prevented if the risks are known.

## Risk assessment in a fundamental role

A systematic approach is crucial in the assessment of process safety risks. It is essential that the chosen method is comprehensive enough to factor in the root causes of human error as well as not just the risks that are inherent in the process but also those related to storage (including loading and unloading) and other handling. If the information provided by one method is not enough for a comprehensive assessment, a second method can be pursued to complement the data. While it is essential that the person performing the risk assessment has experience of the chosen method or methods, it is the operator (workers) who ultimately

> *A systematic approach is crucial in the assessment of process safety risks.*

Process safety can be improved by investing in the entire plant, individual processes and people.

provide the data about the process itself.

The objective of risk assessment is to identify risks – such as spills, unwanted chemical reactions and events such as overheating – and the specific root causes of the risks (e.g. in the case of pipe failure, the reasons for the failure) as well as the consequences of the risks materialising (such as the damage caused by a fire resulting from a gas leak). The probability of the event is then determined taking into account all the known mechanisms of exposure to the identified risks (e.g. a gas leak can be attributable to pipe failure resulting from corrosion, clamp failure or physical impact, or to valve failure resulting from worn or cracked seals).

The final step is to assess the severity of the event by factoring in all the known consequences of the event. A gas leak, for example, can lead to death by asphyxiation or a devastating fire.

The results of the risk assessment give the operator information based on which they can evaluate the adequacy of the precautions they have in place. This includes both safeguards designed to prevent accidents and measures that will help to limit the consequences if an accident does happen.

In the context of process safety, it is important that the risk assessment covers the entire plant, including outdoor areas and any separate buildings or spaces in which chemicals or explosives are stored, handled or used. This promotes the principles of continuous improvement by allowing the operator to establish the baseline for process safety at the plant, set targets and monitor progress against relevant indicators.

Continuous servicing and process maintenance are essential for ensuring the safe operation of any plant.

## Human factors

Many accidents are either directly or indirectly attributable to human factors. People design and build the plants and processes, carry out risk assessments, choose the techniques and procedures to be applied, operate the processes, and service and maintain the equipment.

The actions of people therefore influence many safety-critical aspects of the operation at several different stages of a plant's life. Human factors can be examined in various contexts, such as the operating environment and the organisation, relationships with other people, the choice of tools and equipment, and the competence required for the work.

While the focus is usually on the risk of human error, human factors can also have a positive impact through, for example, the ability to deal with unexpected situations more flexibly than an automated system. There are two types of human failure: errors and violations.

A human error is an action that later turns out to be a mistake. Some errors are slips or lapses, and others are errors of judgement or decision-making. Violations, on the other hand, are intentional deviations from the rules or agreed procedures.

## Regular maintenance

Continuous servicing and process maintenance are essential for ensuring the safe operation of any plant. This is why all chemical plants need a maintenance system that sets out both preventive and corrective procedures. In most cases the system is computerised and consists of a preventive maintenance plan and lists of pending and completed actions.

Safety-critical equipment includes all those components that can, if they malfunction, cause a dangerous situation or that the plant relies on to prevent accidents – alarms, for example. Safety-critical components must be identified and incorporated into the preventive maintenance plan. What this means in practice is servicing, testing and replacing safety-critical components often enough to stop them from ever failing.

The data held in the maintenance system can be used, for example, to check whether scheduled servicing or repairs have been carried out, to provide feedback to workers who report issues, to monitor the relationship between preventive and corrective actions, and to measure process safety. Indicators of process safety include, among others, the timeliness of scheduled servicing and repairs as well as fault statistics.

With so much emphasis put on occupational safety, process safety can end up being seen as a secondary priority. Understanding of the importance of process safety is nevertheless growing all the time, and the Finnish Safety and Chemicals Agency is working hard to give it enough attention in its enforcement and communications policy. Despite the several interfaces where process safety and occupational safety overlap, the two are not the same. Process safety deserves – and needs – its own spotlight. ■





TEXT: TARJA RANNISTO

# The Icelandic Maintenance Association Looks to Strengthen Education in the Field

THE PRESIDENT OF ICELANDIC MAINTENANCE ASSOCIATION STEINER ÓMARSSON

The Icelandic Maintenance Association (EVS) members appreciate EVS for emphasizing collaboration and knowledge sharing.

With the growth of Icelandic industrial production, the need to increase knowledge in the maintenance field has grown significantly. While local companies are aware of their responsibilities in the professional and technological development of the maintenance industry, investment should also be made in training and education.

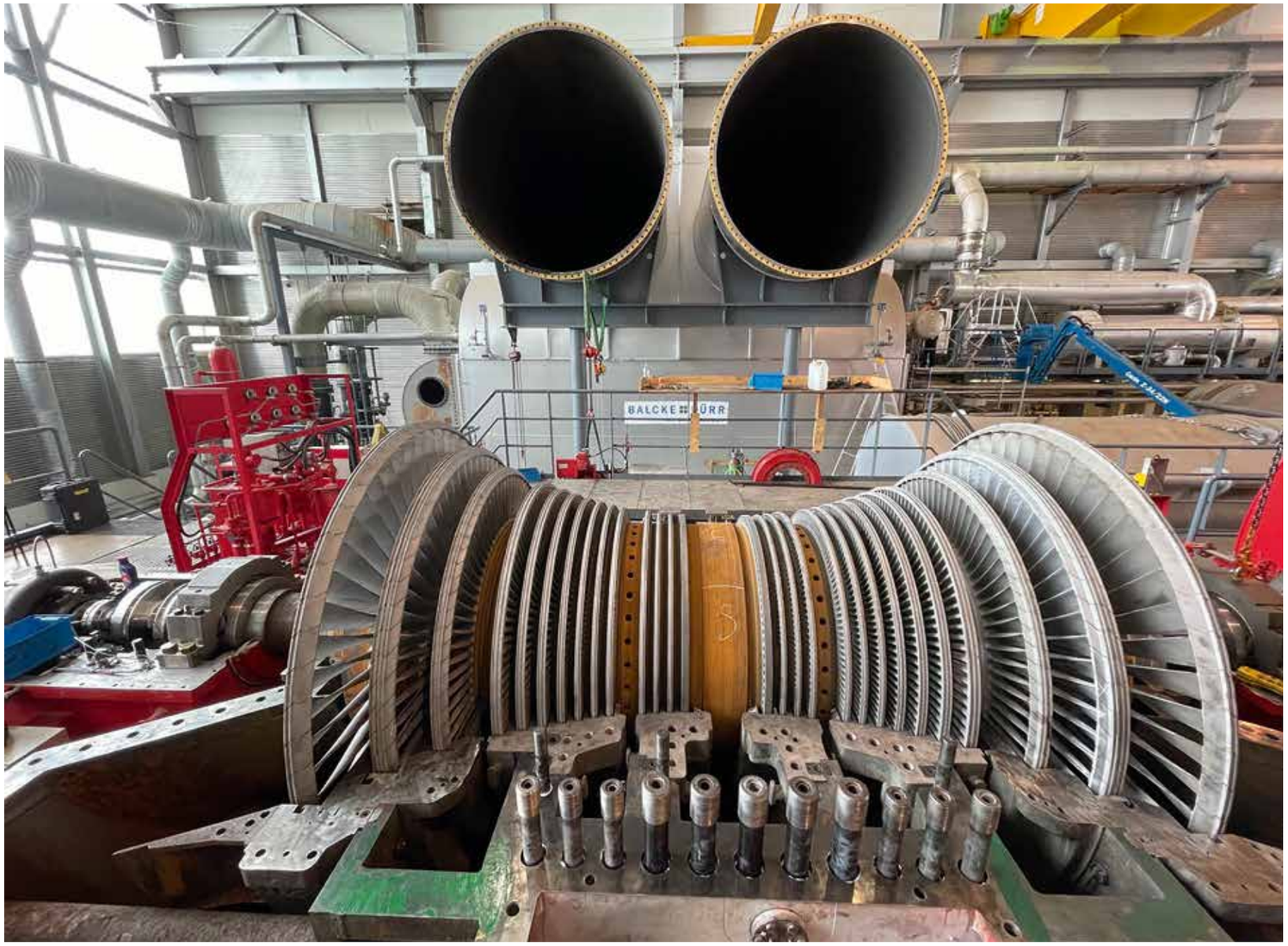
The President of Icelandic Maintenance Association **Steiner Ómarsson** believes that focus should also be given to training in the field. According to him, it will take a lot of work to raise the level of education and training, but without proceeding, there will be no opportunity to learn enough about the field and keep up with international standards.

– Looking back at my own study times, I see that although it was possible to focus on technical studies as a major, the teaching was somewhat lacking, says Ómarsson.

In 2005, Ómarsson completed his Mechanical Engineer degree at the University of Reykjavik and has since worked on a wide range of processes in the field.

– I was really excited to start working on new maintenance functions in my hometown, he recalls from the early stages of his career.

**Until now, Maintenance in Iceland has mainly meant repair work that the industry has been used to.**








Ómarsson has gained a strong knowledge and experience in maintenance. He says that he even grew up in the proximity of the maintenance industry from an early age in a small town where maintenance and repair provided a livelihood for many.

Today Ómarsson holds the position of Maintenance Manager at HS Orka, a private company. The company operates in the renewable energy sector and builds electricity and waterpower plants.

> *With the growth of Icelandic industrial production, the need to increase knowledge in the maintenance field has grown significantly*

Ómarsson considers his personal strengths to be good knowledge of maintenance processes and practices. That's what he wants to focus on in future as well. He thinks the quality level of the maintenance sector in Iceland should be higher than what it is. Until now, maintenance in Iceland has mainly meant repair work that the industry has been used to.

– I see that, we are in a very good position to strengthen monitoring and preventive maintenance in companies, and also in training, he says.

Ómarsson aims to strengthen maintenance processes across the country through the Icelandic Maintenance Society.

– This year we will be able to expand the power plants so that we can get more power from them. Of course, the project requires a lot of work and new equipment that we have acquired for it. A lot of interesting work to come, he says.

## To strengthen maintenance training

Through increasing teaching, the Icelandic Maintenance Society would have the opportunity to take responsibility. Cooperation is already taking place with different schools and is exploring opportunities to offer courses or training. According to Ómarsson, there is no need to take big steps to add training immediately, but any course that increases the expertise of the maintenance industry is useful.

It is popular for Icelandic students to apply for a course or a whole degree abroad and then return to Iceland for work.

Information is disseminated and shared not only in education but also through companies. For example, aluminium operators have a huge amount of expertise and knowledge in the maintenance sector, where information can be transferred to those at the beginning of their careers or to partners as well.

– I would say that, after all, we are well placed to offer stable career paths in the field of maintenance, within for example the fishing and aluminium industries and electricity companies. Employment is good and the work is of high standard, Ómarsson says.

As an island, Iceland's physical cooperation with its neighbouring countries can be challenging. Although cooperation is active, particularly with other Scandinavian countries as well as with the UK, the geographical distance and suppliers sometimes causes grey hair.

– If we need a special service from other countries, it can be challenging to arrange it quickly.

Despite the distances, The Icelandic Maintenance Management Association is an active member of the European Federation of National Maintenance Societies (EFNMS) and participates in international conferences, Annual Assemblies and other events. EVS also holds annual general meetings. ■

- **EVS, the Icelandic National Maintenance Society was established in 2009**
- **In 2016 EVS became a part of EFNMS, the European Federation of National Maintenance Societies, first as an observing member but then as a full member from 2019.**
- **EVS has facilitated training events, meetups for members, translated the ISO 55000 standards into Icelandic in association with the Icelandic Standards (IST) and is currently working on translating EN 13306 Maintenance terminology with IST.**

# Disciplined and Smart Asset and Maintenance Management in Iceland

Asset and maintenance management has always been important for Iceland – a small, isolated nation, involved with fishing in open seas, power production, and heavy industry, to name few areas of concern.

Being a small nation, where people work in small agile groups, there have been a lot of unwritten tacit rules, with fewer formal written procedures. As companies, and the Icelandic society in general, has steadily become bigger and more mature in recent decades, there is now more need for written rules and transparent well-defined procedures. Also, as Iceland is now less isolated as the world is getting "smaller" and more interconnected, we have needed to become more disciplined, "smarter" and more administrative as required for global cooperation and business management in general.

This was addressed at the EVS winter meeting, which took place on December 1st, 2021, at Hotel Natura in Reykjavík and on Microsoft Teams. Following are excerpts from some of the presentations that were given at the meeting.





## "Re-start" of EFNMS Certification

**GUÐMUNDUR JÓN BJARNASON**, Managing Director at *DMM Lausnir*, is EVS' EFNMS delegate. He addressed the "Re-start" of EFNMS Certification. From 2018 until late this year, EVS has taken part in an Erasmus+ project, *Qualification, Validation and Certification of Maintenance Personnel*, together with national maintenance societies from Sweden, Czech, Finland, Hungary and Slovenia, see www.cemaint.eu.

As stated in the project: *European industry needs to work smarter to increase profitability and competitiveness. Working smarter with a combination of automation, digitalization and maintenance, with a higher availability in the production processes, will also prevent the flow of production to low-cost countries.* However, maintenance is not adequately emphasized in the academic world, there is a need for validation of non-formal and informal maintenance learning and experience together with formal learning. In other words, certified objective maintenance competences are needed for the individuals and companies concerned, within and across European nations.

To achieve this, EFNMS has for many years certified Maintenance Managers and Maintenance Technician Specialists. This has been done in cooperation with some of the National Maintenance Societies based on standardized exams. However, the question database has been somewhat limited, largely based on written questions and restrictions as to who can take part. This has been identified as one of the main reasons why the European EFNMS certificates have not become widespread certificates recognised by individuals and companies around Europe as the symbol for objective maintenance competences.

Still, the EFNMS certificates are known and respected in the societies where they are used, they are based on a good foundation and issued by a respected party, the EFNMS and the National Maintenance Societies involved. The aim of this project was to get past the limitations mentioned above, that is to create a database of multiple-choice questions that will be disseminated through EFNMS, its European Certification Committee (ECC) and its National Maintenance Societies around Europe. The dissemination will be in the form of European Maintenance "Knowledge Passports" and Certificates issued by EFNMS to maintenance professionals around Europe seeking employment and working for European companies. The project has created a database of questions that will be used in pilot validation projects in Sweden, Finland, and Hungary in 2022.

Following the pilot projects and finalization of this new certification platform EVS intends to bring the certification to Icelandic companies and individuals as an important step to further improve asset and maintenance management in general in Iceland. By taking part in this development, EVS has tried to contribute experience and practical approaches that have been important in our small culture, in particular agility and ownership.

## Landsnet's road to digital

**LANDSNET** commenced operations in 2005 as the single Transmission System Operator (TSO) for electricity in Iceland. It is responsible for the operation and maintenance of the electricity transmission system and is required to develop the grid in an economical and secure way. **Guðlaugur Sigurgeirsson**, Head of Asset Management and Digitalization at Landsnet presented Landsnet's "road to digital" during the event.

For some years Landsnet has been implementing Asset Management (AM) in accordance with ISO 55001. The structure of AM specified in the standard has been used as a guideline during the build-up of Landsnet's asset management. All required documentation has been generated to include AM Policy and a Strategic Asset Management Plan (SAMP) to get maximum benefit of AM's best practices. At this point no decision has been made to go for ISO certification.

Early in 2019 Landsnet made a strategic decision to implement all new substations as "digital substations". Most of AM's effort has been on designing and building new substations in accordance with IEC 61850, the main communication standard for control and protection equipment. The benefit of digital substations is expected to be significant to include less wiring, lower CAPEX and OPEX, increased personnel safety, less environmental impact to name a few. Landsnet plans to complete and have 24 new digital substations in operation within two to three years.

The digital substation technology opens new ways to control and operate the transmission system. Landsnet is implementing "Smart Grid" solutions to meet increasing demand for renewable energy in Iceland. Capacity of the grid has been reached and faster control and optimized energy flow is applied to fulfil the needs of the electricity market.

These are the new challenges in asset management and maintenance planning. Opportunities to take transmission assets out for service are reducing yet reliability requirements of the grid remain high.

## Spareparts, 3D printing

**GEIR GUÐMUNDSSON** gave a speech about 3D printing, which originates from the ´80s with SLA technology - Stereolithography Apparatus. In the beginning it was used to create small 3D plastic objects layer by layer based on 3D computer models, primarily for show and for rapid prototyping. Other methods were developed, such as FDM - Fused Deposition Modelling, where a plastic tip was melted layer by layer and SLS - Selective Laser Sintering, where plastic powder was melted together using laser.

In the last two decades there has been a lot of development regarding materials used, precision, size, speed and capacity, lower prices, and more powerful and affordable 3D printers for companies and for the public. So called Additive Manufacturing is used today for the production of items and parts for expensive and complex items produced in low volumes in particular, but there are still hindrances, e.g. regarding surface quality, density, strength, production time and prices.

For many years it has been forecast that in the future spare parts will not be shipped between countries, but 3D printed on-site based on production recipes. Still, we are not there, and current strategies have more to do with sending 3D models to big service companies which create the parts and send them to the customers. It is important to have several issues in mind regarding the 3D printing of spares, such as quality; will guarantees still be valid if 3D printed spares are used; Production rights; Relations with 3D printing service providers and to have 3D models securely stored. Whilst 3D printing has evolved in recent years, so have other techniques such as CNC manufacturing which has become cheaper and less time consuming.

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