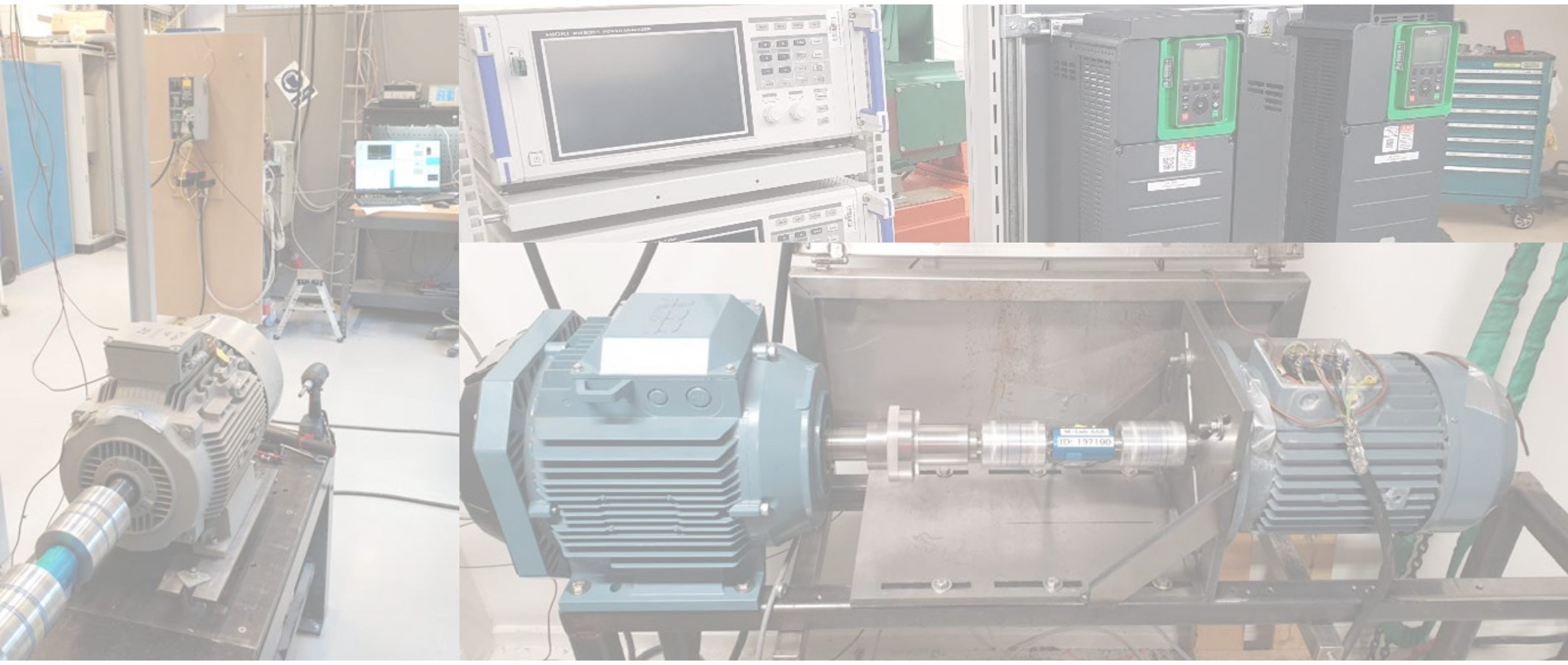
Electric Motor Systems
EMSA



Report on the EMSA Survey on digitalisation in electric motor driven systems

Prepared by: Konstantin Kulterer, Austrian Energy Agency
February 2021

Technology Collaboration Programme
by iea

Electric Motor Systems Annex – 2020

The report was prepared under the IEA Technology Collaboration Programme on Energy Efficient End Use Equipment (4E) – **Electric Motor Systems Annex** (EMSA) programme.

The report was formally approved by the EMSA Members in February 2021.

Authors:

Konstantin Kulterer, Austrian Energy Agency

Acknowledgements to contributors and reviewers:

The authors are very much indebted to the following experts and organisations, who generously supported the preparation of the survey and the report with their significant technical knowledge, texts and review contributions:

Maarten van Werkhoven, TPA advisors, 4E EMSA
Jazaer Dawody, Swedish Energy Agency
Glenn Widerstrom, Swedish Energy Agency

Abstract:

The report summarises the results of the EMSA Survey on digitalisation in electric motor driven systems.

Industrial companies are currently especially using smart sensors, smart control and continuous monitoring as digital technologies, in conjunction with motor driven systems. These three technologies will also have the greatest impact on potential future energy savings. Superior production efficiency, more flexibility and higher system availability are the main advantages, while an increased risk of failure and higher implementation costs are the main disadvantages. The lack of qualified staff and high investment costs are the main barriers. Good technical solutions for cybersecurity and the availability of qualified staff are the most vital enablers. Around three quarter of respondents consider the development of education programmes, the standardisation process to harmonise protocols, and subsidies for research as important policy instruments to overcome these barriers.

About the IEA 4E Electric Motor Systems Annex (EMSA):

Electric motor systems consume about 10 700 TWh annually worldwide and are responsible for 53% of the global electric energy consumption (IEA 2017). This corresponds approximately to the combined electricity consumption of China, the European Union (28 countries) and the USA. The goal of the Electric Motor Systems Annex EMSA is to increase energy efficiency and reduce greenhouse gas emissions worldwide by promoting highly efficient electric motor systems in the EMSA member countries, industrialised countries as well as emerging economies and developing countries.

Further information on EMSA is available at: www.motorsystem.org.

About the IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E):

The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP) has been supporting governments to coordinate effective energy efficiency policies since 2008. Fourteen countries and one region have joined forces under the 4E TCP platform to exchange technical and policy information focused on increasing the production and trade of efficient end-use equipment. However, the 4E TCP is more than a forum for sharing information: it pools resources and expertise on a wide a range of projects designed to meet the policy needs of participating governments. Members of 4E consider this an efficient use of scarce funds, which results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions. The 4E TCP is established under the auspices of the International Energy Agency (IEA) as a functionally and legally autonomous body.

Current members of the 4E TCP are: Australia, Austria, Canada, China, Denmark, European Commission, France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, UK and USA.

The main collaborative research and development activities under 4E include the

- Electric Motor Systems Annex (EMSA)
- Solid State Lighting (SSL) Annex
- Electronic Devices and Networks Annex (EDNA)
- Product Energy Efficiency Trends Annex (PEET)
- Power Electronic Conversion Technology Annex (PECTA)

Further information on the 4E TCP is available at: www.iea-4e.org.

Disclaimer:

The IEA Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP), Electric Motor Systems Annex (EMSA), has made its best endeavours to ensure the accuracy and reliability of the data used herein, but makes no warranties as to the accuracy of data herein, nor accepts any liability for any action taken or decision made based on the contents of this report.

Views, findings and publications of the 4E TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

Contents

1. Executive Summary

The survey was mainly answered by companies from the manufacturing sector (27%) and professional, scientific and technical activities (27%). Roughly half of the companies were small companies; one third of the companies were large organisations.

The greatest share (38%) of the respondents specified to have a lean level of digitalisation in their organisation; 22% stated that they already had an integrated level. 15% of the companies that answered this question considered their level as already smart. 62% of the companies want to invest in digitalisation technologies within the next two years, and another 20% within the next five years.

Of the technologies considered as digital technologies for this survey, more than half of the companies use smart sensors, advanced controls and continuous state monitoring in their organisations or in their products (for manufacturer of motor driven systems). Furthermore, data analytics on production lines, cloud-based services and Internet of Things are adopted by more than 40% of the companies. In connection with motor driven systems, the percentage is lower (around 6–10% lower).

25% of the respondent rate the increase in energy efficiency of electric motor systems by using digital solutions associated with the use of digital solutions to be between 6 and 10%; almost half of the respondents estimate the savings to be even higher: between 11 and 40%. Another 8% think that the savings could reach more than 40%.

Seventy-nine per cent of the respondents consider smart sensors, actuators and smart meters to be an aid for themselves or their customers in saving energy. Furthermore, especially advanced controls and continuous monitoring are viewed as important instruments to save energy.

As to advantages of using digital production technologies, superior production efficiency (82%), more flexible systems and better control (76%), as well as higher system availability through predictive maintenance (73%) were mentioned the most.

In contrast, increased risk of failure (55%), and higher acquisition and implementation costs for infrastructure were cited as the main disadvantages by more than half of the respondents.

Major barriers specified are the lack of qualified staff (67%), high investment (capital) costs (65%) and complexity relating to the integration into existing systems.

Eighty per cent of the respondents consider good technical solutions for cybersecurity and the availability of qualified staff as the most vital enablers for using digital production technologies.

Around three quarters of the respondents consider the development of education programmes and the standardisation process to harmonise protocols, as well as subsidies for research as important policy instruments to overcome these barriers.

2. Background

Digitalisation brings ‘smart’ applications for all kinds of industrial energy systems, of which electric motor driven systems account for the largest part of the industrial electricity use. Electric motor driven systems (EMDS) are currently responsible for some 53% of global electricity consumption (IEA 2017) and approximately 70% of the industrial electricity use.

An optimal motor system includes optimally aligned system components (control, converter, motor, mechanical equipment and application) that are engineered and operated for the right process demands in a specific timeframe. The application of digital technologies to electric motor driven systems can enlarge the scope and accessibility of optimisation, leading to increased efficiency in operations (operational cost, flexibility, procurement, footprint), energy, materials (circularity) and emissions.

The IEA Technology Cooperation Programme 4E EMSA (Electric Motor Systems Annex) works on the assessment of specific developments in the field of industrial digitalisation. The target is to identify the relevant different technology fields (areas), their potential impact on energy use and efficiency, and the potential need for policy measures.

3. Methodology

EMSA conducted a survey on the different kind of digital technologies for motor driven systems in use and their positive or negative effect on energy consumption. This survey included questions on enablers, advantages, barriers and added costs of these technologies for specific projects, and on drivers and barriers for digitalisation in general.

The survey opened on the 14th of June 2020 and closed on the 20th of October 2020.

Since only around one third of the respondents submitted the full survey, all responses were taken into account for all questions. The exception is the question on digital technology use in companies (“Do you use this technology in your organization?”), for which only submitted questionnaires were considered. Sixty-three respondents answered the full survey.

The following chapters present the answers to each question form the survey in detail.

4. General information on companies and personal knowledge

The survey was mainly answered by companies from the manufacturing sector (27%) and professional, scientific and technical activities (27%).

Half of the respondents were from Austria, 13% from Italy, 10% from Germany. The rest of the respondents were distributed to countries from all over the world. The reason for the over-presentation of Austrian respondents is that the Austrian Energy Agency sent a German version of the survey via direct mail, whereas all other countries were reached via general newsletters, especially EMSA Newsflash.

Roughly half of the companies were small companies; one third of the companies were large organisations. The rest (around 20%) were companies with 50–249 persons.

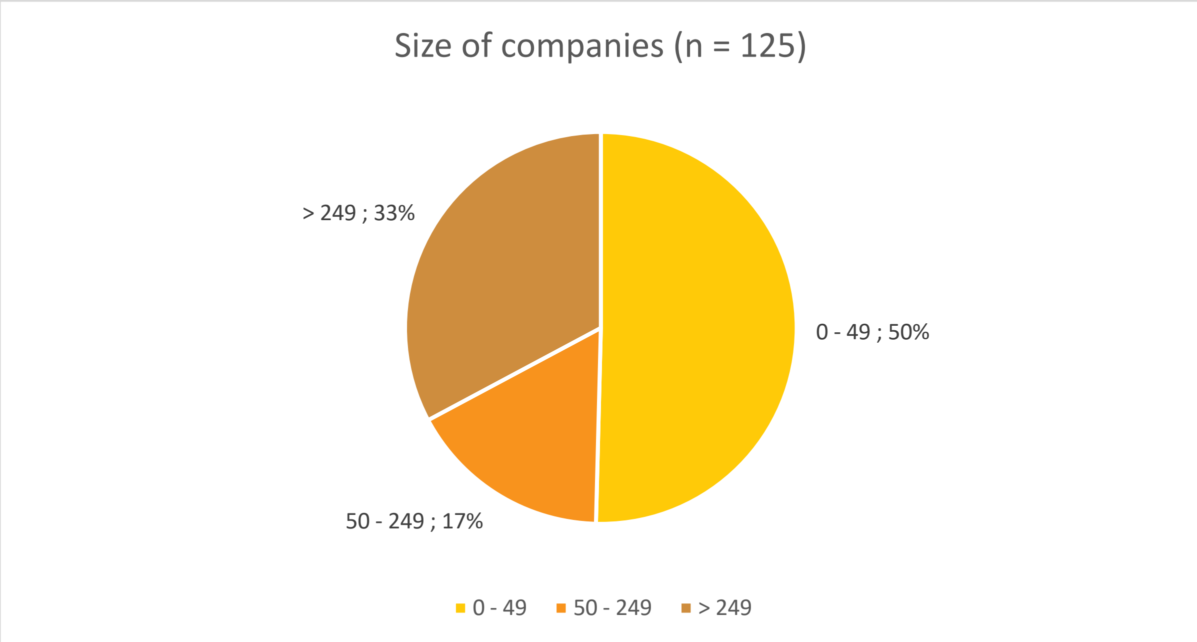


Figure 1: Size of companies that participated in the survey

Around 45% of the respondents rated their knowledge on digitalisation technologies in industry as medium, 35% as high.

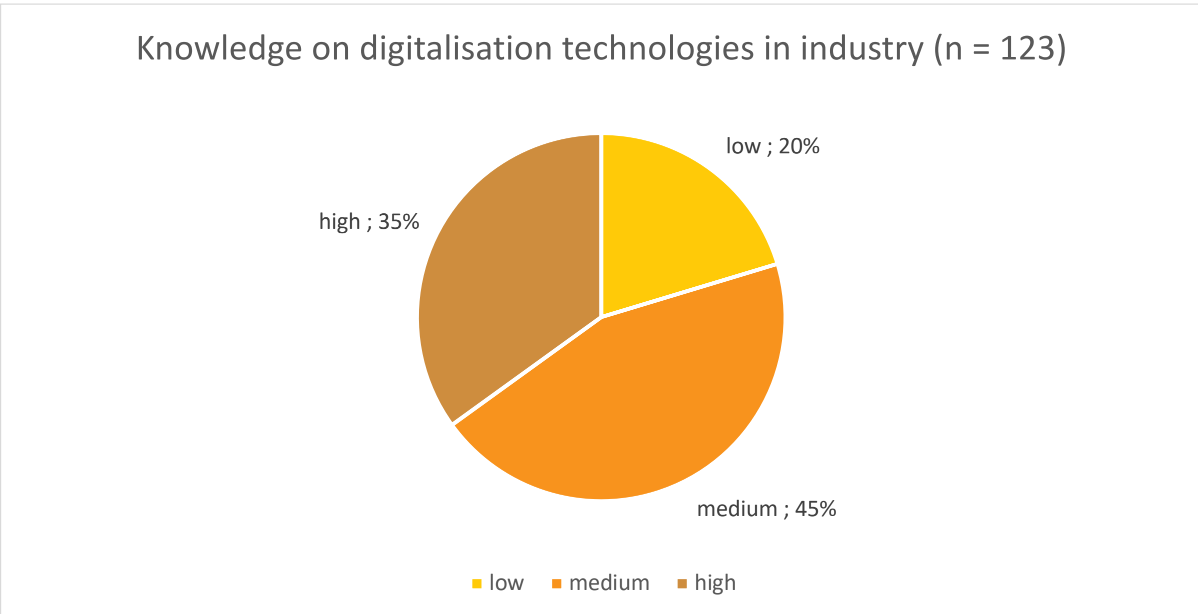


Figure 2: Knowledge on digitalisation technologies in industry

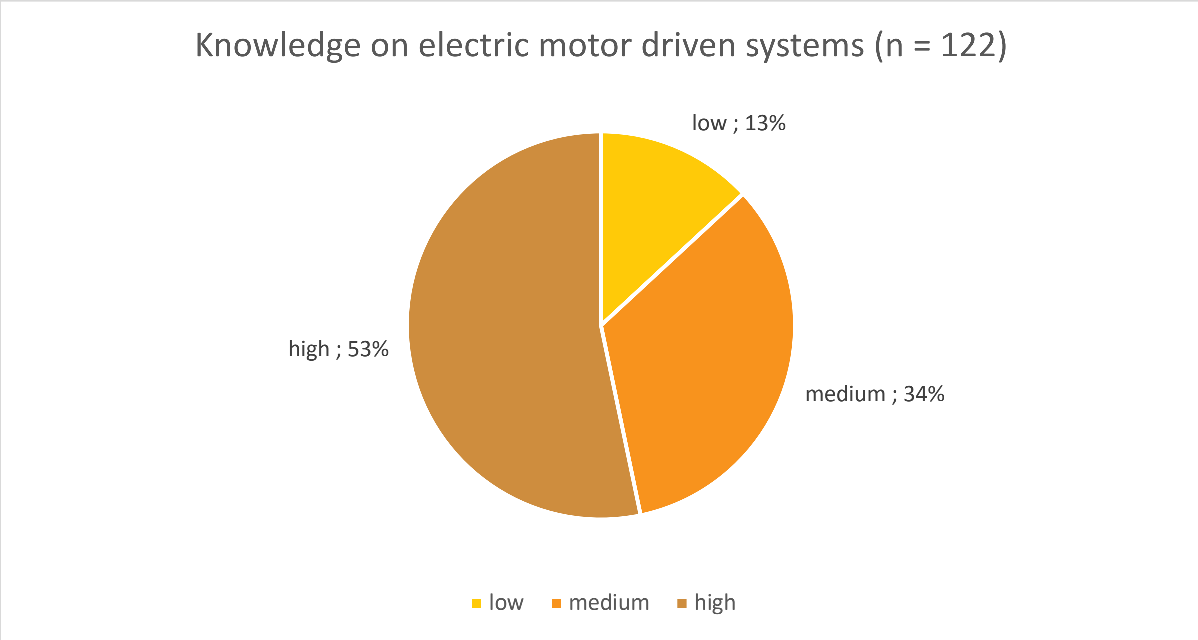


Figure 3: Knowledge on electric motor driven systems

More than half of the respondents (53%) considered their knowledge on motor driven systems as high, 34% rated it as medium. The reason for this high percentage is probably that several respondents were reached through newsletters and newsflashes that focus on energy efficiency in industry and/or motor driven systems.

The following definitions have been used to determine low, medium, and high knowledge:

- low: no education, less than 1 year experience;
- high: part of education plus at least 2 years of working experience in this field,
- medium: in between.

5. Digital production technology in the companies/organisations

The largest share (38%) of the respondents specified to have a lean level of digitalisation in their organisation; 22% stated that they already had an integrated level. 15% of the companies that answered this question considered their level as already smart.

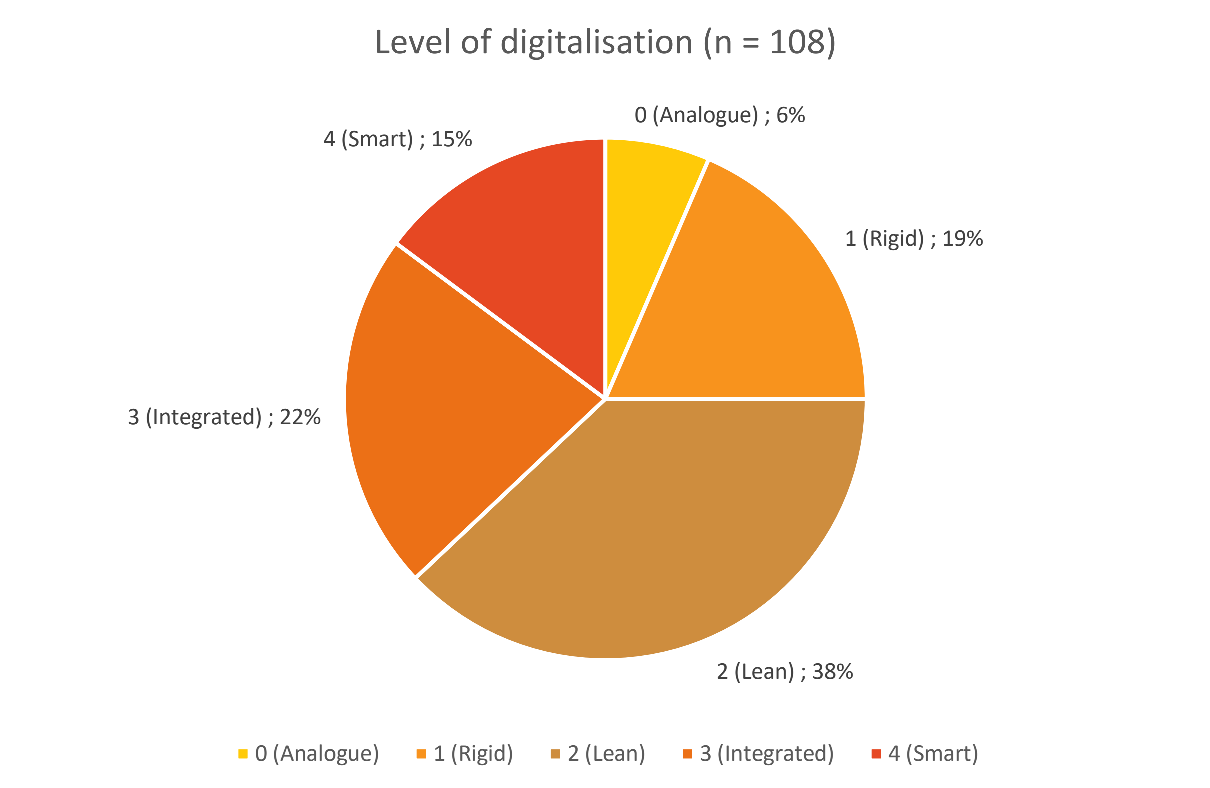


Figure 4: Characterisation of the level of digitalisation of the organisation

The following definition from UNIDO was used to characterise the degree of digitalisation [2]:

Digital production technology (DPT) combines hardware (e.g. advanced robots and 3-D printers), software (e.g. big data analytics, cloud computing) and connectivity.

- 0 = analogue production: no digital production technology used throughout the whole production process (e.g. phone contact with suppliers, use of machinery that is not microelectronic-based)
- 1 = rigid production: DPTs limited to a specific purpose in a specific function (such as use of computer-aided design (CAD) only in product development; use in selected machines operating in isolation)
- 2 = lean production: DTPs involve and connect different functions and activities within the organisation/company (such as the use of CAD/CAM (computer-aided manufacturing) linking up product development and production processes, basic automation).
- 3 = integrated production: DPTs integrated across different activities and functions, allowing for the interconnection of the whole production process (such as use of enterprise resource planning systems, fully “paperless“ electronic production control and system, industrial robots)
- 4 = smart production: DPTs allow for fully integrated, connected, and smart production processes, where information flows across operations and generates real-time feedback to support decision-making (such as use of smart sensors and

machine-to-machine communication, cobots[1], big data analytics, cloud computing, artificial intelligence and 3-D printing).

Sixty-two per cent of the companies have a strategy to become more digitalised; twenty-four per cent do not.

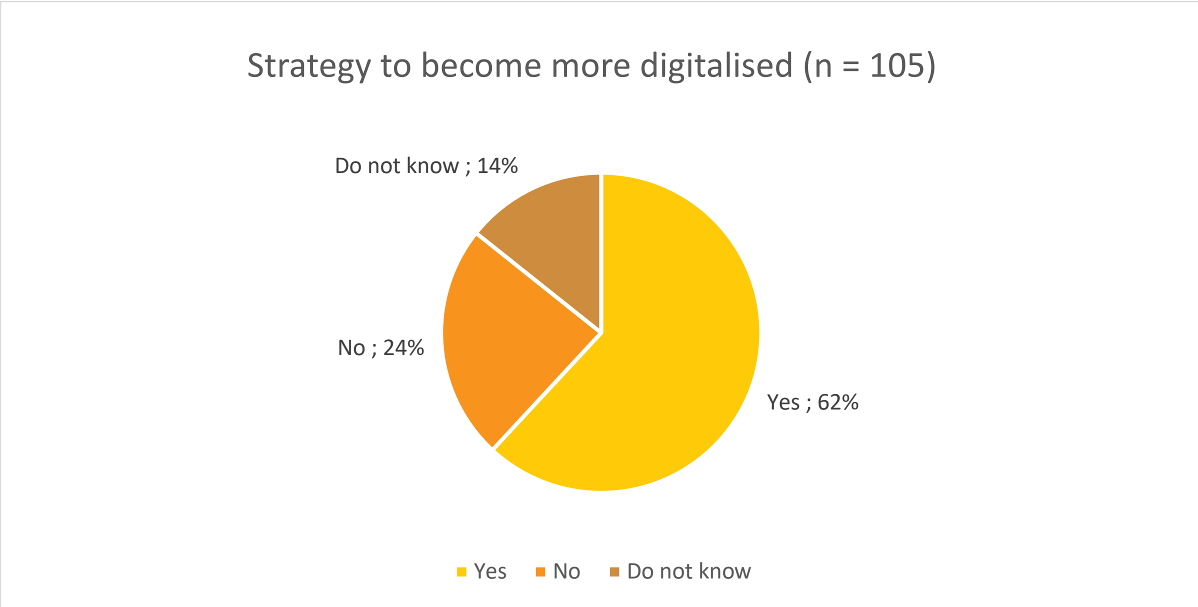


Figure 5: Share of companies that have a strategy to become more digitalised

Similar to the strategy, 62% of the companies want to invest in digitalisation technologies within the next two years, and another 20% within the next five years. Eighteen per cent of the companies do not plan to invest.

[1] Collaborative robot (cobot): A robot that physically interacts with humans. Designed to learn new tasks, cobots are built with passive compliance features and integrated sensors to adapt to external forces. Cobots are typically safe, cost-effective, easy to use and suitable for small-scale production and reduced production cycles. They are also portable and easy to configure and reconfigure for different tasks.

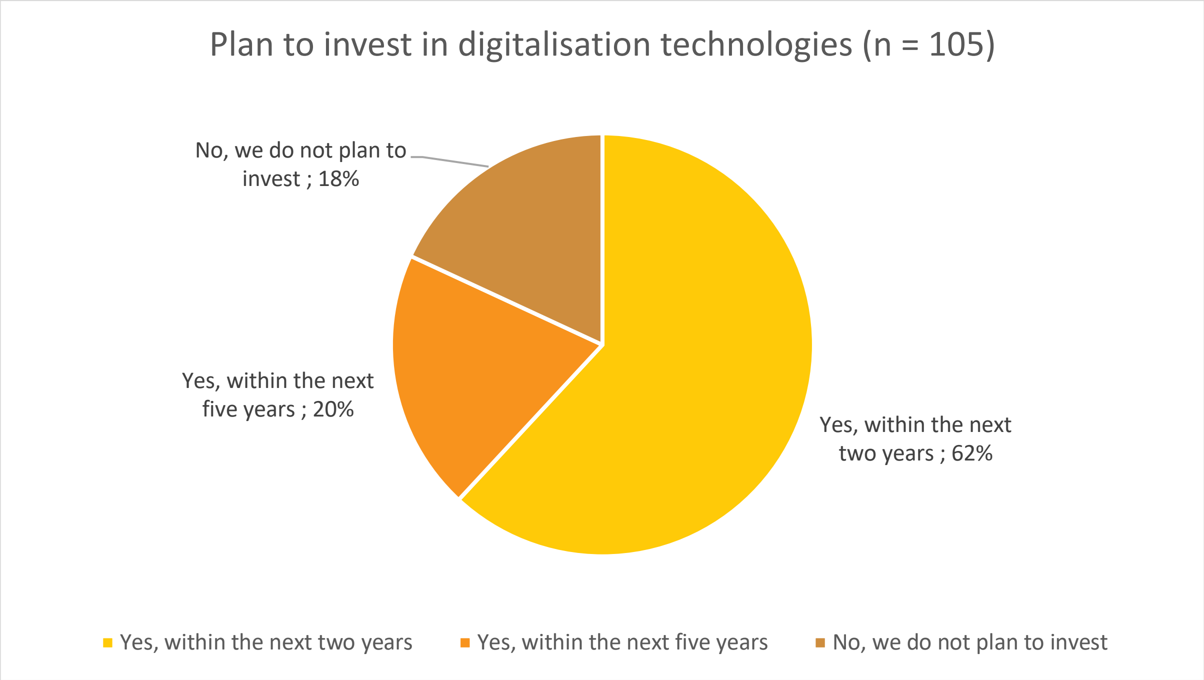


Figure 6: Plan to invest in digitalisation technologies

6. Use of digitalisation technologies

In this section, only the 63 respondents that completed and submitted the full survey were considered.

Of the technologies considered as digital technologies for this survey, more than half of the companies use smart sensors, advanced controls and continuous state monitoring in their organisations or in their products as manufacturer of (components of) electric motor driven systems.

Furthermore, data analytics on production lines, cloud-based services and Internet of Things are adopted by more than 40% of the companies. In connection with motor driven systems, the percentage is lower (around 6–10% lower).

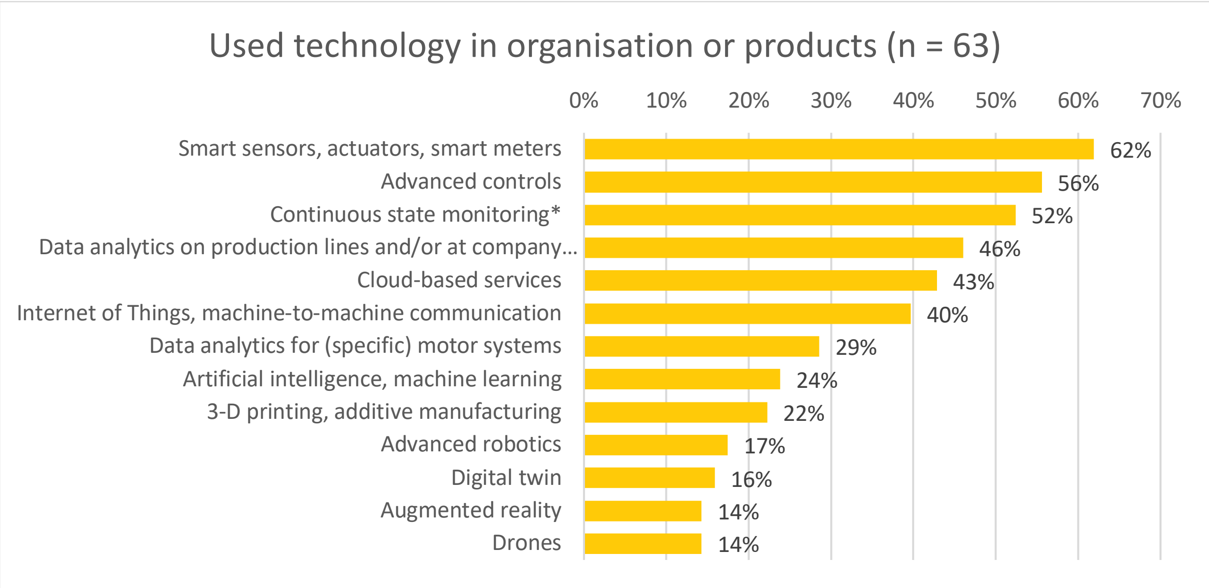


Figure 7: Share of organisations that use different digital technologies

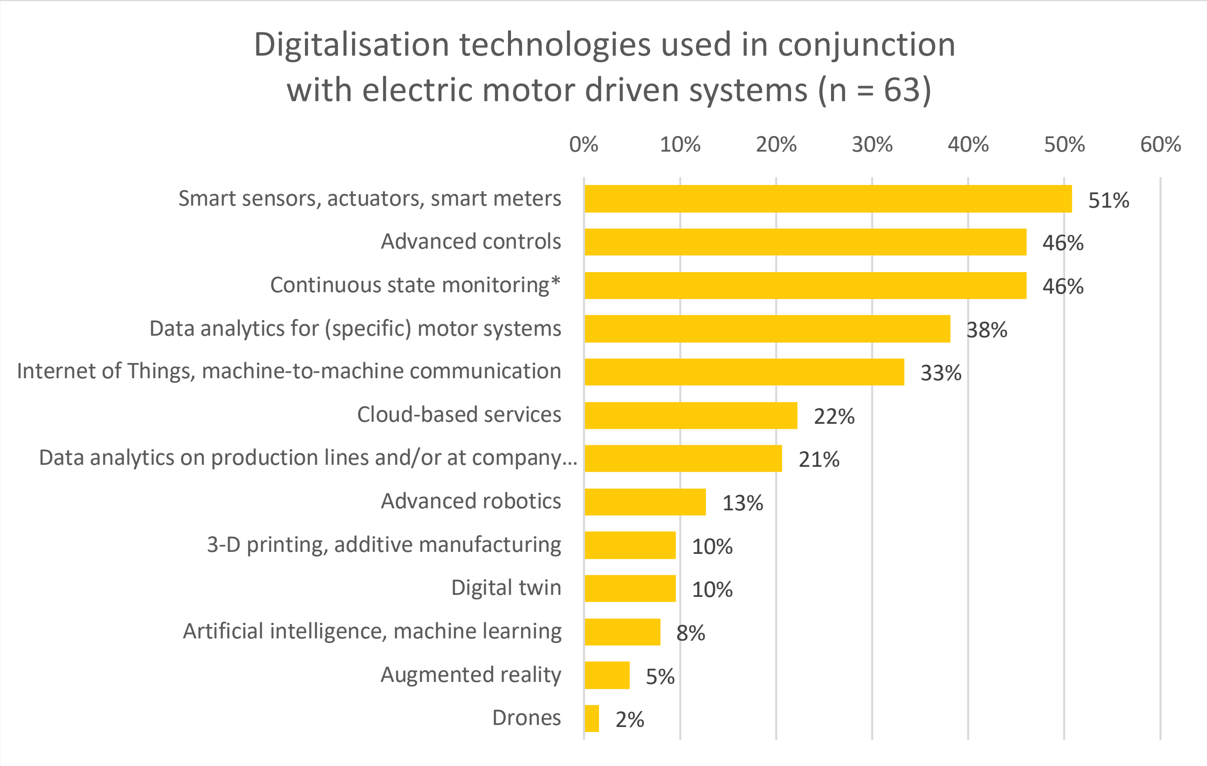


Figure 8: Use of digitalisation technologies in conjunction with electric motor driven systems

Seventy-nine per cent of the respondents consider smart sensors, actuators and smart meters to be an aid for themselves or their customers in saving energy. Furthermore, especially advanced controls and continuous monitoring are viewed as important instruments to save energy.

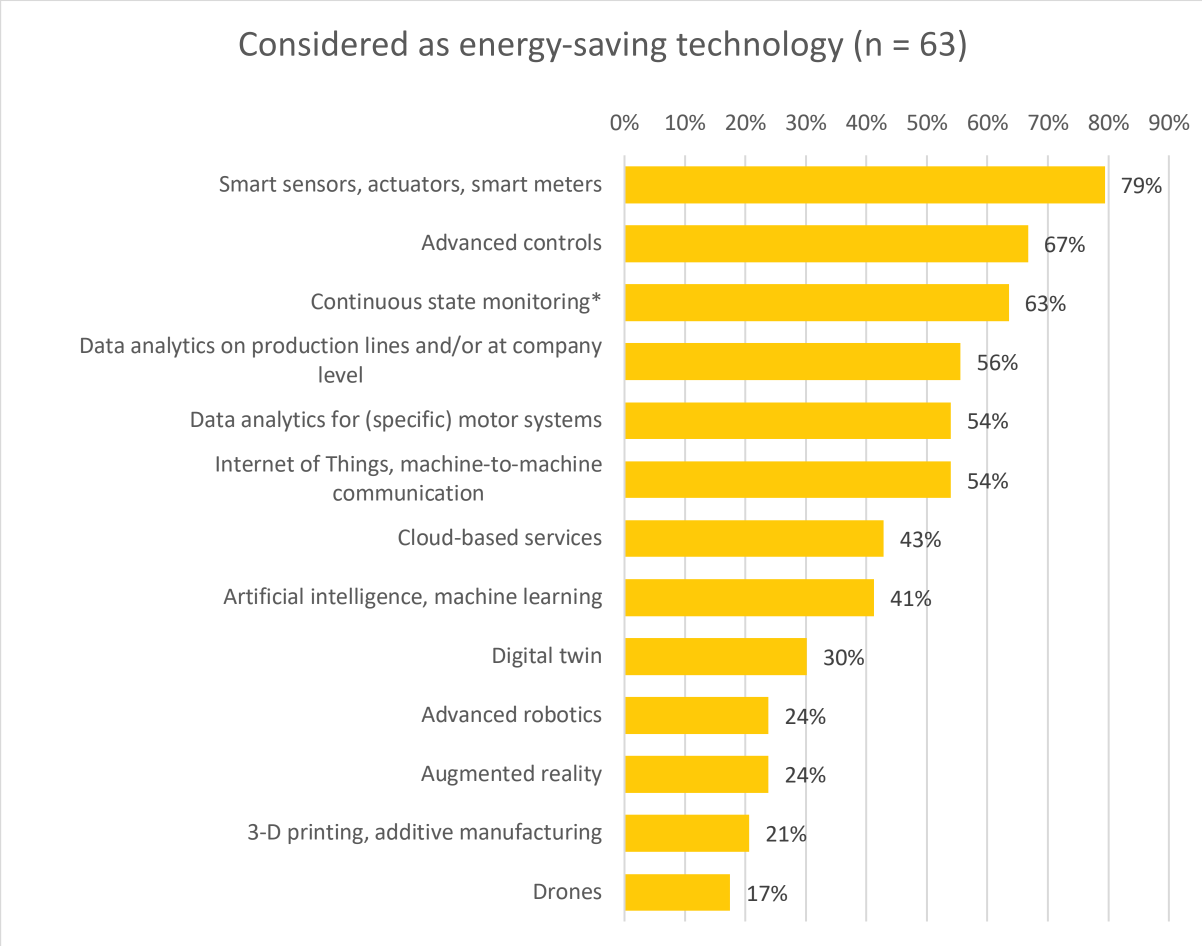


Figure 9: Digitalisation technologies that are considered as help to save energy

The graph in Figure 10 shows that a quarter of companies rate the increase in energy efficiency of electric motor systems by using digital solutions associated with the use of digital solutions to be between 6 and 10%, while almost half of the respondents estimate the savings to be even higher: between 11 and 40%. Another 8% think that the savings could reach more than 40%.

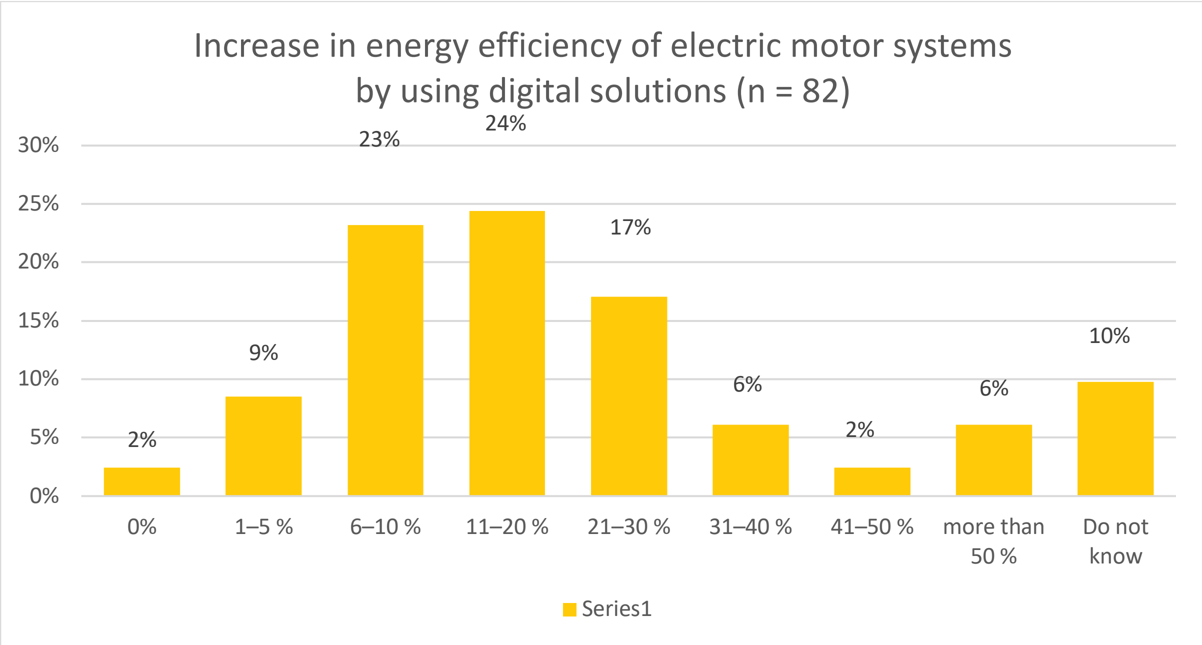


Figure 10: Estimation of increase in energy efficiency of electric motor systems by using digital solutions

7. Advantages, disadvantages, barriers, enablers

As to advantages of using digital production technologies, superior production efficiency (82%), more flexible systems and better control (76%), as well as higher system availability through predictive maintenance (73%) were mentioned the most. Of further importance, with more than half of respondents considering this as a large advantage, are higher quality of products and improved production processes, cost reductions through lower energy use, and better understanding of parameters of systems.

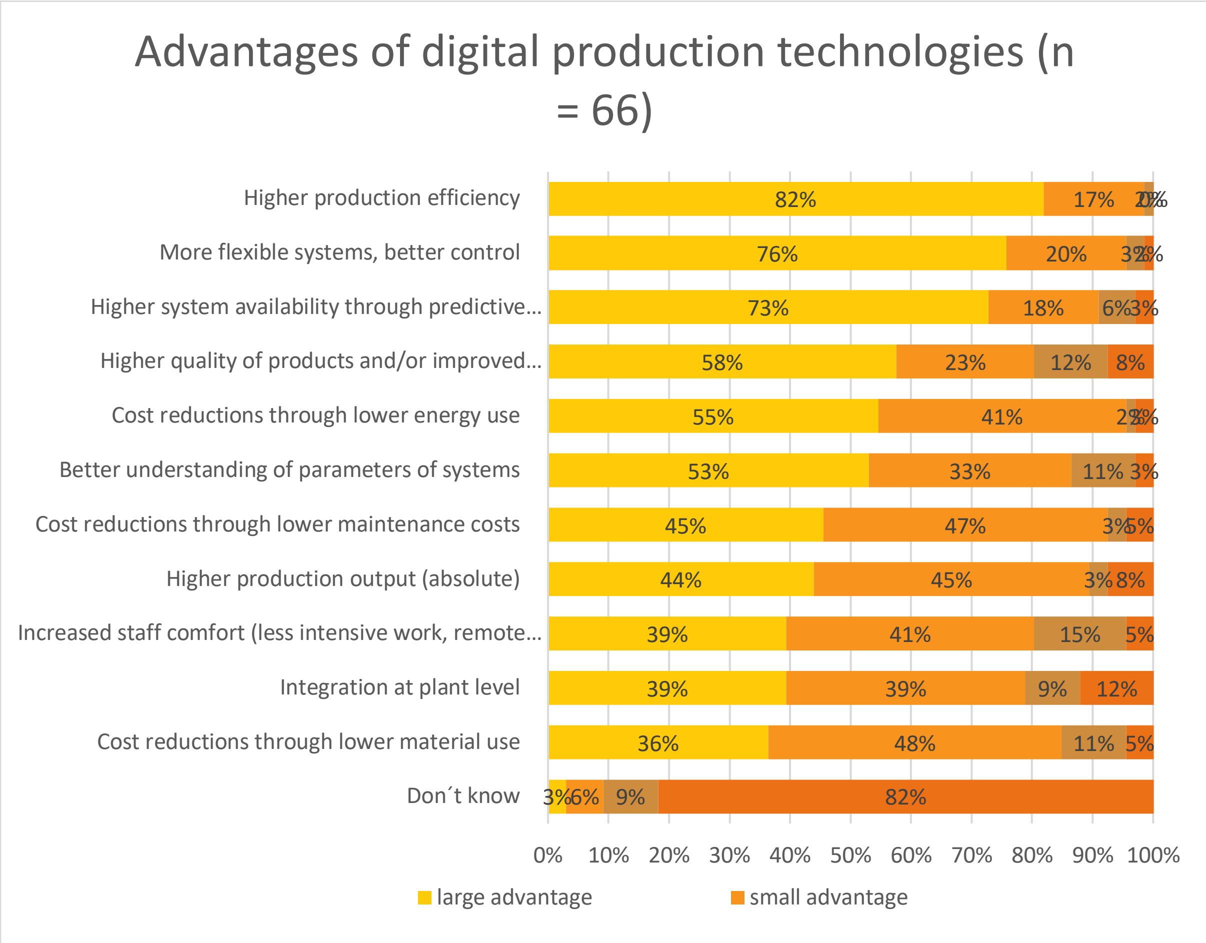


Figure 11: Main advantages of using digital production technologies

In contrast, increased risk of failure (55%), and higher acquisition and implementation costs for infrastructure were cited as the main disadvantages by more than half of the respondents. Higher operation costs are not considered as a large disadvantage.

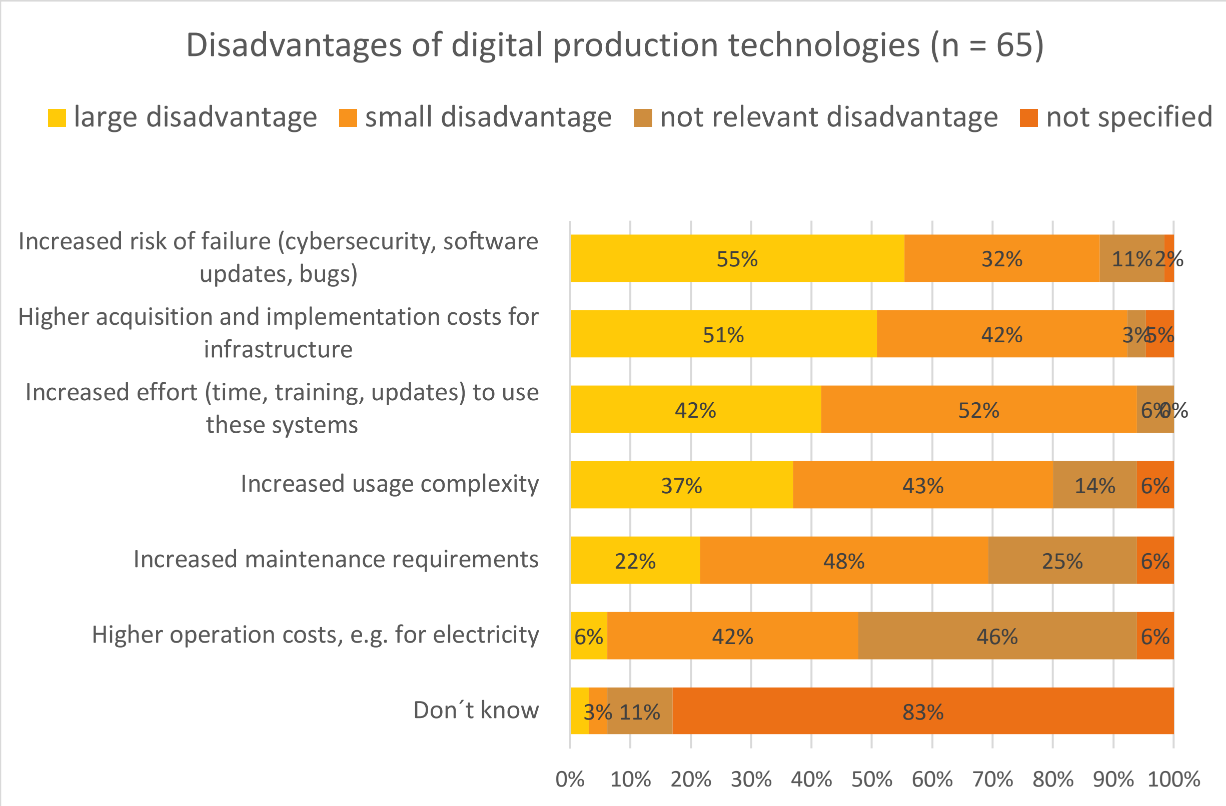


Figure 12: Main disadvantages for users of digital production technologies

Major barriers specified are the lack of qualified staff (67%), high investment (capital) costs (65%) and complexity relating to the integration into existing systems. Too much regulation or a lack of harmonised regulation are considered by around half of the respondents as less important barriers.

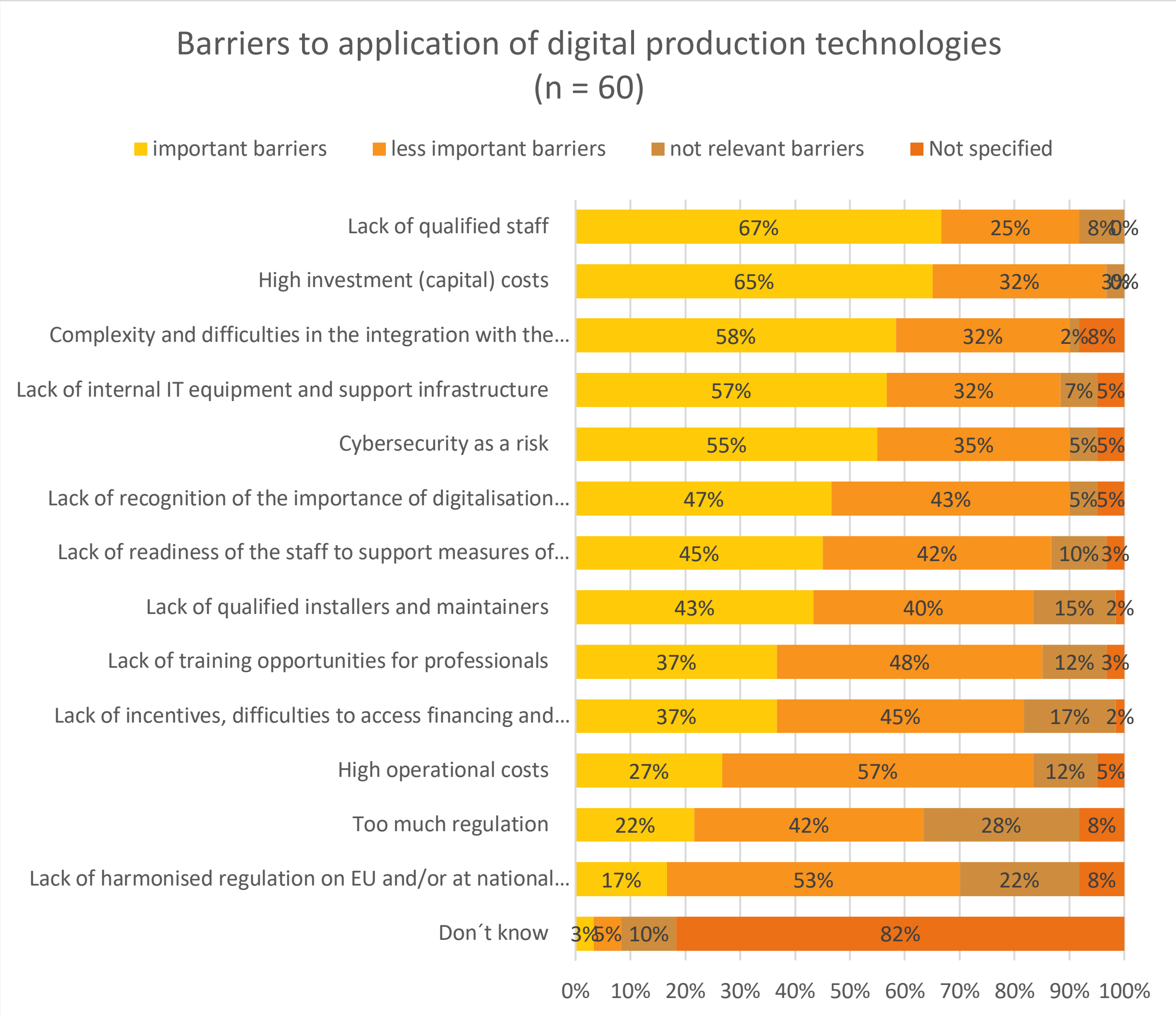


Figure 13: Important barriers that could prevent organisations from applying digital production technologies

As can be seen in Figure 14, 80% of the respondents consider good technical solutions for cybersecurity and the availability of qualified staff as the most vital enablers for using digital production technologies. Relevance (with more than two thirds of agreement) is also accorded to the further education of employees and standardised transfer protocols as well as open interfaces to integrate components of various manufacturers. Subsidies for business development and strict legislation to increase data and IT security is seen as important enablers by only one third of the respondents.

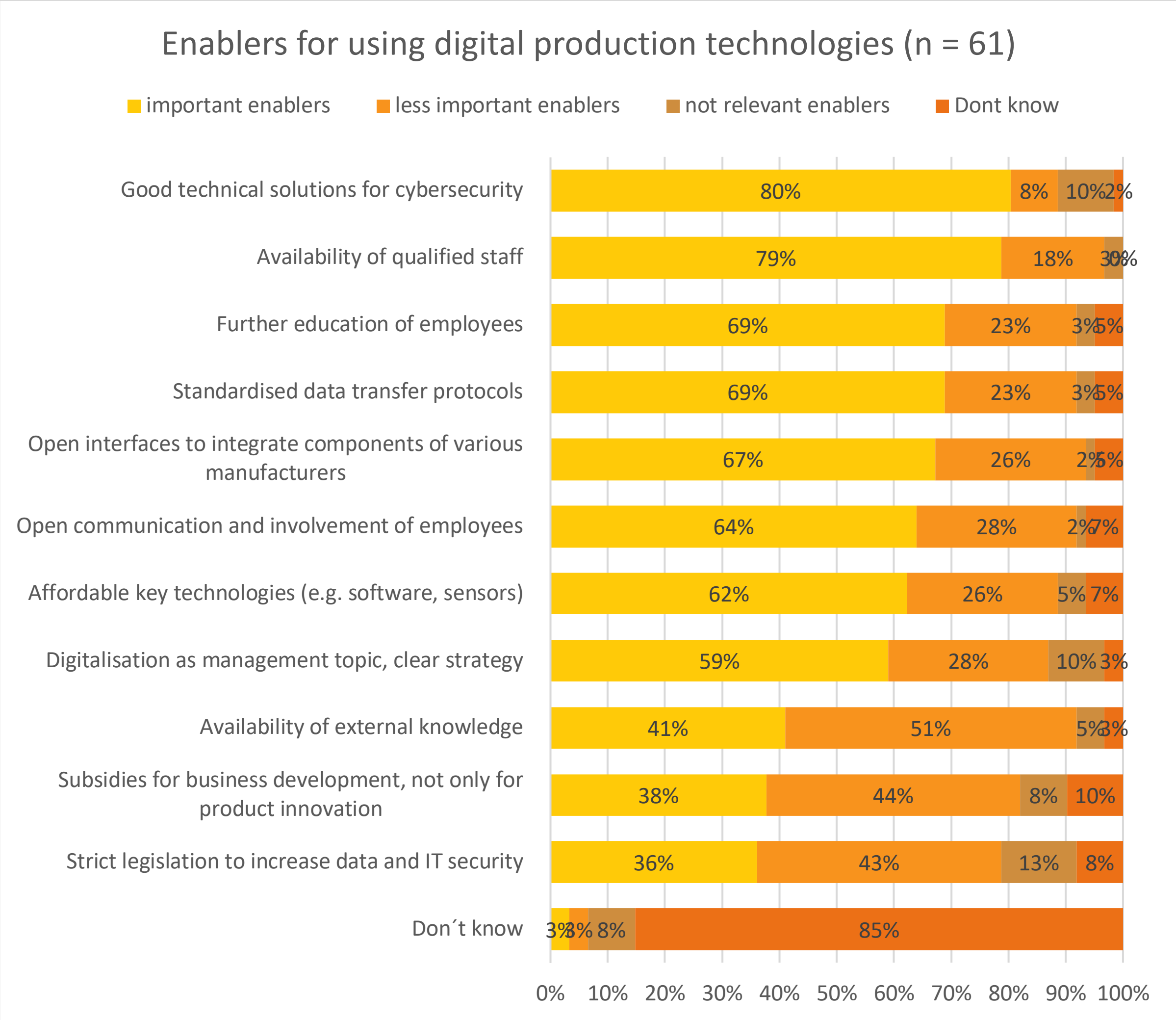


Figure 14: Important enablers for using digital production technologies

Around three quarters of the respondents consider the development of education programmes and the standardisation process to harmonise protocols, as well as subsidies for research as important policy instruments to overcome these barriers.

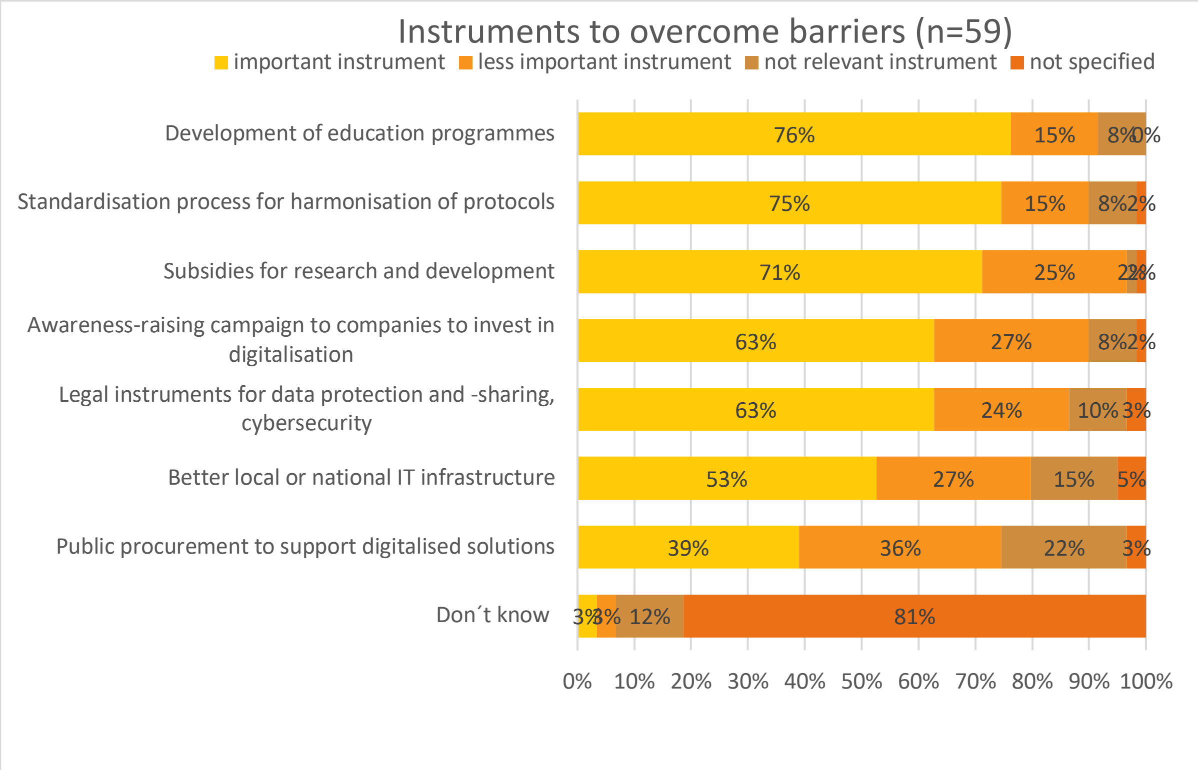


Figure 15: Important instruments to overcome barriers to using digital production technologies

8. Detailed description of digital use cases for electric motor driven systems

Twenty respondents answered the additional questions for specific use cases. With respect to these specific examples of motor driven systems, where digital technologies are already used, controls (frequency converters), motors, fans and pumps were particularly mentioned.

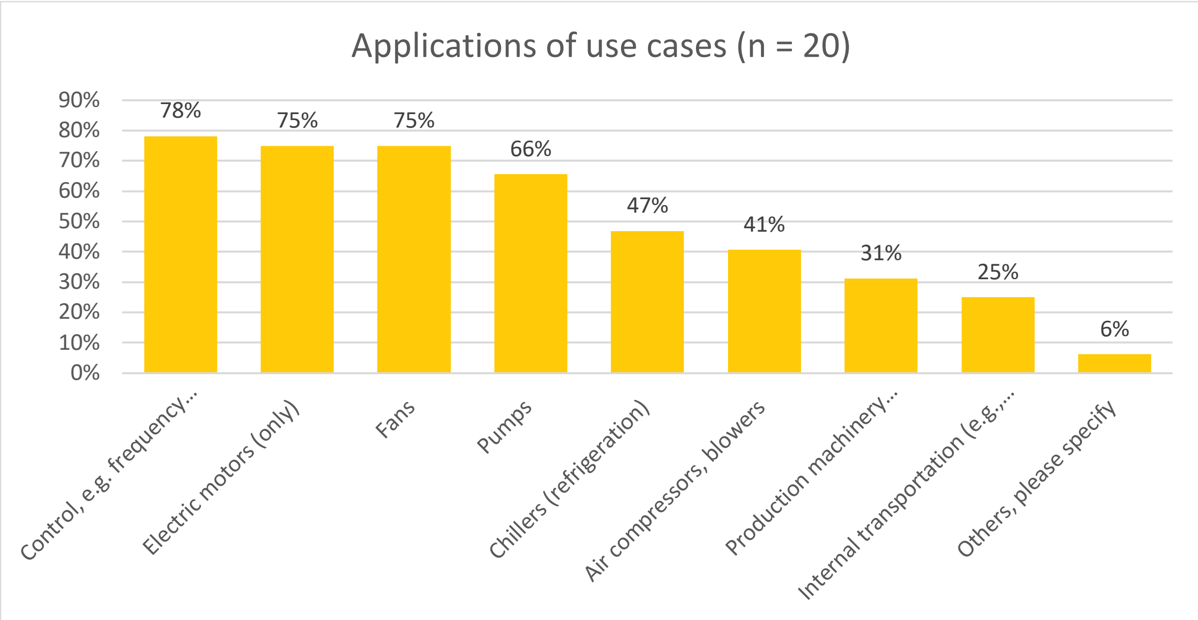


Figure 16: Share of different motor driven systems in the total digitalisation use cases mentioned

According to the interviewees, smart sensors (84%) and advanced controls (78%) are particularly relevant for these applications. Furthermore, Internet of Things (IoT), continuous state monitoring and data analytics for motor driven systems are relevant.

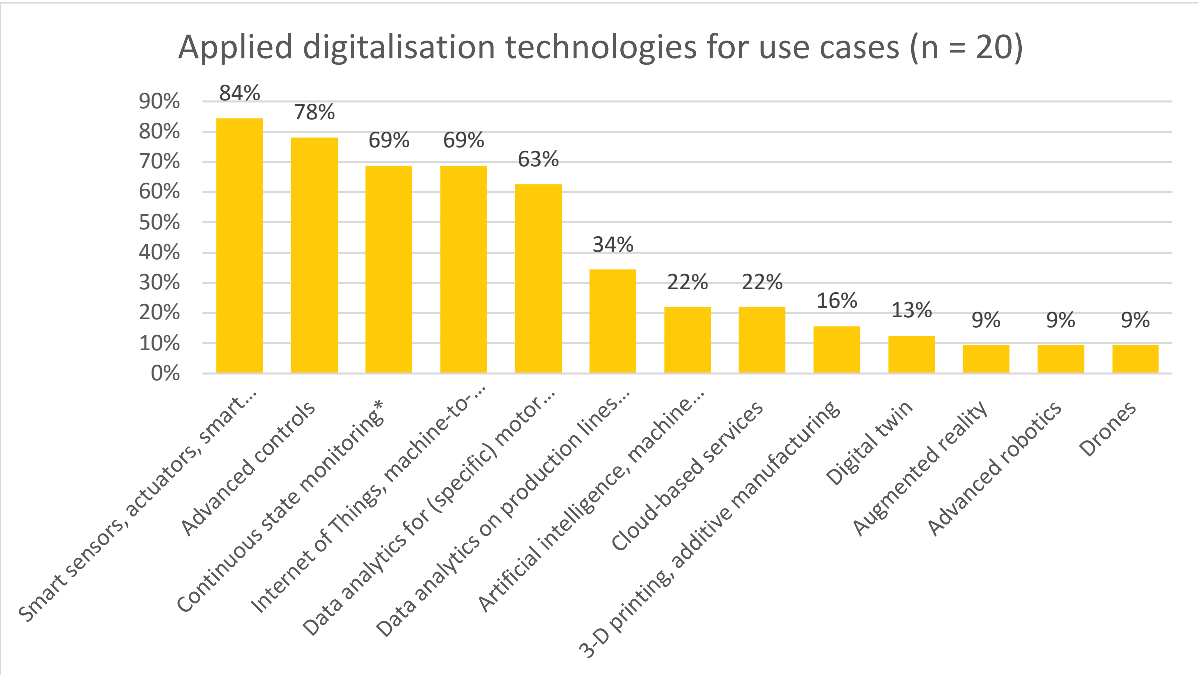


Figure 17: Share of different digital technologies used in digital use cases mentioned

These applications are mainly used in new installations (60% of mentioned use cases), but are also applied in existing systems (40%).

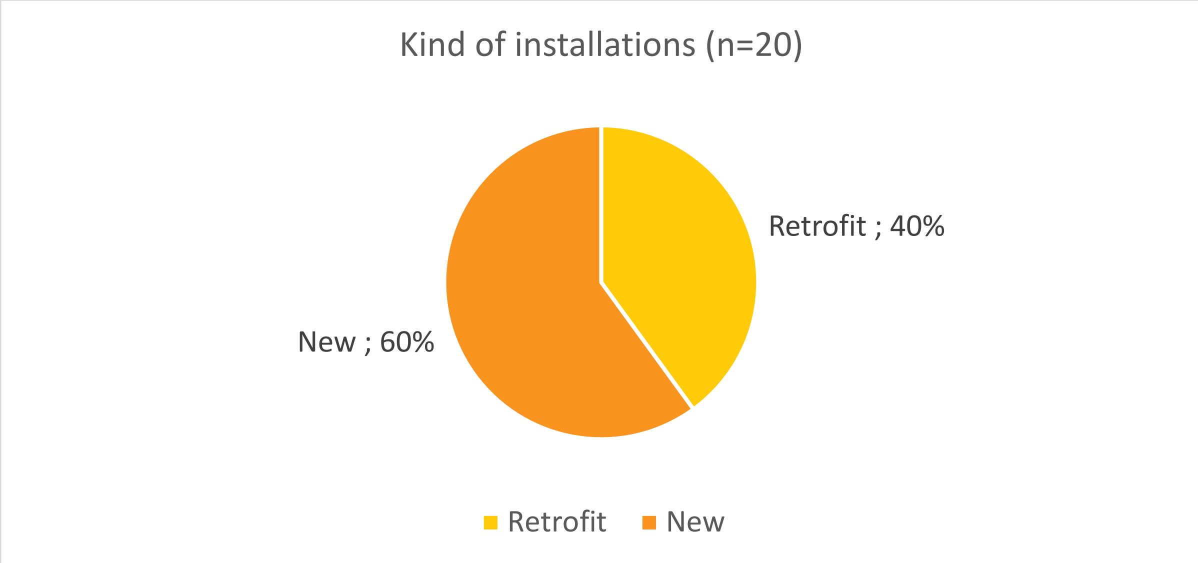


Figure 18: Kind of installation (new or retrofit)

The use cases were briefly described and commented on in an open text field. The following list gives a summary and some interesting quotes:

- Remote monitoring system, data analytics, automated actions by pump provider.
- The application of digital technologies, specifically for electric motors, other than variable frequency drives (VFDs) and programmable logic controllers (PLCs) are limited.
- VSDs for pumps and motor control, robotics for specific production are the main applications.
- Data monitoring system provider: “Furthermore, we can optimise the performance of the entire motor-driven system through monitoring and thus increase efficiency. Using our expertise combined with artificial intelligence, we are able to predict certain situations and prevent them from arising in the future."
- Frequency converters as smart components to achieve higher availability and increased efficiency.
- Fan manufacturer: “Some of the machines that we use to manufacture our products are connected to one another via bus systems. We also use sensors connected to inverters to reduce/increase motor rotation depending on each case. Running this type of sensor in conjunction with the control of the motor saves energy and money of course. "
- Self-management building software based on sensors, wireless controllers operating everything from lighting to ventilation, heating and cooling, automatic controllers and artificial intelligence (AI).
- Data monitoring and analytics of fan system providers.
- Software provider: “Quick and secure information transfer from e.g. smart meters that react to deviations enables the networking of distributed systems in relation to energy monitoring."
- Increase in energy efficiency through frequency converters.
- Fan manufacturer: cloud for data monitoring, energy savings, increased availability, pre-maintenance, accurate/precise control.
- Digital twins of buildings displayed with augmented reality.

9. References

[1]. International Energy Agency: World Energy Outlook, 2017

[2]. United Nations Industrial Development Organisation (UNIDO): Industrial Development Report 2020. Industrializing in the digital age. Overview. Vienna, 2019