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How smart are our companies really? a case study of the current rollout of smart meters in Germany

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The digital transformation and the associated challenges for the energy transition and society remain a challenge due to the increasing number of e-charging stations and heat pumps. Nevertheless, the rollout of smart meters selected in Germany affects only a small proportion of the available consumers. Therefore, the aim of this work is to determine the current status of this technology in companies and to answer the question of which factors influence implementation. For this purpose, data from a case study with 386 companies were used. The focus was on the current status of the technology in companies and their knowledge about the technology. The data were recorded during on-site inspections with the help of an energy consultant. In addition, the frequencies of the answers and the implementation of efficiency measures of selected cross-cutting technologies were compared between companies with a smart meter and companies with an analog meter. Our evaluation revealed that 1) 82 percent of companies have a commitment to implementation. 2) Of these, 10 percent have installed a smart meter. 3) Many of the companies were either unaware of the commitment or did not even know what a smart meter was. 4) Companies with a smart meter have implemented more measures in lighting, energy monitoring, energy purchasing and peak load management than companies with an analog meter. To increase implementation and, thus, usage, companies need to be made much more aware. In addition, there is still a lack of value-added services.

KEYWORDS

smart meter technology, digitalization, energy efficiency measures and potentials, cross-cutting technologies, brief report

1 Introduction

Germany is one of the nations in the European Union (EU) that has established 2032 as the deadline for the implementation of its national power metering policy. By 2030 at the latest, the remaining EU nations want to have implemented 80% of the deployment for power meters (European Commission, 2020). Thus, the majority of EU nations are still in the initial

Abbreviations: EU, European Union; kWh, kilowatt hour; RLM, registered load profile measurement; SM, Smart meter.

rollout process. This aim is too distant in the future, though, given how quickly the energy revolution and the digital transformation are developing.

The rollout of smart meters has stalled and should therefore be urgently investigated in terms of its acceptance and benefits. Although at present one out of every two companies has started with implementation, this means that half of all companies have not yet taken any action (PwC, 2022).

The study by (Berger et al., 2022) addresses the fact that companies are interested in implementation if they can achieve energy savings. The study addresses companies that consume more than 6,000 kWh per year.

The typical annual power usage of private households and many small businesses in the commercial, trade, and service sectors is frequently less than 6,000 kWh. This indicates that the two customer categories mentioned above are not covered by the mandated legal rollout of smart meters. These consumer organizations are free to install smart meters. In addition, there are uncertainties and information deficits regarding the technology and its advantages (Knayer and Kryvinska, 2022).

This is confirmed by, among other things, the numbers for smart electricity meter implementation in Germany. Of the 51 million metering points in Germany, just 0.26% are equipped with a smart meter (Bundesamt, 2022). An important aspect could be that stakeholders do not know what a smart meter or an intelligent meter is. The work of (Schneider, 2020) found that in a representative household survey, 68% of the population did not know the term "smart meter" or "intelligent metering systems". The work of (Chawla et al., 2020) also highlighted this information gap among stakeholders.

It is common knowledge that only few studies have examined the standards for the acceptance of this technology in the workplace. Rather, almost all studies are in the household setting (Gumz and Fettermann, 2023), and most deal with technical (Depuru et al., 2011; Abu Arqub, 2018; Abu Arqub, 2020) and economic (Brophy Haney et al., 2009) aspects as well as the costs (Faruqui et al., 2010) of the technology.

An amendment to the Act on the Digitization of the Energy Transition was passed at the beginning of 2023. In it, the annual costs of smart meters for end customers are reduced, and an obligation for energy suppliers to offer the necessary dynamic tariffs is anchored. Unfortunately, the consumption limit of 6,000 kWh per year for a mandatory retrofit remains (BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ, 2023).

The study by Umweltbundesamt (2021) looks at the possible effects of smart meter rollout in Germany. On average, the meters consume three times as much electricity as conventional meters and are subject to more frequent replacement cycles. A positive effect in terms of costs and environmental compatibility can be achieved only if households actively participate.

Thus, this paper introduces a discussion on whether the current deployment strategy should be reconsidered or whether the increase in acceptance and the associated additional benefits of the technology for all kind of users (Companies and Households) should be made more concrete.

The aim of this paper is to present the current implementation status of the technology in the context of a case study and to question why this status is the case. Additionally, this article emphasizes the results from (Knayer and Kryvinska, 2022) that the intended rollout is excluding significant customer groups. It also demonstrates the necessity for more investigation into how well and widely businesses are utilizing technology. Finally, these results are to be combined with data from (Knayer and Kryvinska, 2023). The frequencies of efficiency potentials of the cross-cutting technologies lighting, energy monitoring, energy purchasing and peak load management collected there can be compared with the companies with smart meters and with the companies without smart meters. This allows conclusions to be drawn at the technology level as to whether companies with a smart meter are more efficient in these cross-cutting technologies than companies with an analog meter.

Section 2 presents the methodology of the paper, which follows a case study and uses data from a funding project. It also describes the type of data collection, the data basis, and the evaluation methodology used. Section 3 presents the findings of the study and leads to the discussion in Section 4, where the results are critically evaluated. Section 5 summarizes the main findings of the study.

2 Methods

The research data used were collected as part of a funding project between 2016 and 2020 and were anonymized (Umwelttechnik BW GmbH, 2021). A total of 386 companies were surveyed. In total, extensive data on 12 different cross-cutting technologies were recorded and analyzed (Knayer and Kryvinska, 2023).

The data on metering technology were also recorded during on-site inspections with the help of an energy consultant. A distinction was made between analog and digital meters and smart meter technology. In terms of meter technology, simple and closed-ended questions were asked, and the answers were noted. Electricity consumption was checked against energy bills. The standardized questions about the available metering technology were discussed with the employee responsible for the energy topic.

The selection of participating companies was random, as companies interested in the project voluntarily and proactively approached the Chamber of Commerce and Industry (CCI). Due to this self-determined active participation of the companies, the procedure could be repeated at any time, and complete data collection could be carried out.

The data were compared again with the companies in 2022 in the form of a telephone interview (Adams, 2007). Thus, the validity of the information is current. The reconciliation aimed to clarify whether a change in the survey years had taken place. Changes were taken into account in the evaluation.

2.1 Description of the collected data

Table 1 shows the number and size of the participating companies. The metering technology of these companies is evaluated in the study.

Company size is based on the definition of the EU Commission (Kommission and EMPFEHLUNG DER KOMMISSION vom 6, 2003). The participating companies are 180 manufacturing and 206 nonmanufacturing companies.

2.2 Questions about meter technology

Simple and closed-ended questions, which could be answered with "yes" or "no", were asked. The following questions were included in the case study:

- Do you know what a smart meter is?
- Do you know the difference between a digital meter and an intelligent meter?
- Do you know the government's rollout strategy regarding smart meters?
- Do you know the benefits of smart meters for businesses?

The questions were intentionally more general to obtain as clear a statement as possible. The respondents were all familiar with the energy topic and thus could at least be classified as knowledgeable.

TABLE 1 Participating companies.

Organization	Number	%
All Companies	386	100
Large Companies (NON-SME)	100	25.9
Small Companies (SME)	286	74.1

2.3 Evaluation method

Figure 1 shows the procedure of the evaluation method, which is divided into four steps. In step I, the subject of the study, the 386 companies, is first examined in terms of its implementation status of the technology. The aim here is to show which technology (analog, digital, smart meter) has already been installed. Then, in step II, which companies have an obligation to implement the technology and which can retrofit voluntarily are examined. This examination is performed on the basis of energy bills. In step III, the questions are evaluated. Step IV. aims to compare the frequencies of efficiency potentials in the selected cross-cutting technologies of lighting, energy monitoring, energy purchasing, and peak load management of those companies with a smart meter and those companies without a smart meter.

2.3.1 Status of the implementation of metering technology

The data on the metering technology are entered in an Excel matrix. A distinction is made between analog, digital and smart meter technology. The absolute and relative frequencies of the individual technologies are shown. This information indicates the implementation status in the sample companies.

2.3.2 Check for the obligation to implement

The check for a possible implementation obligation is carried out on the basis of electrical energy consumption. Companies with electricity consumption of more than 6,000 kWh per year

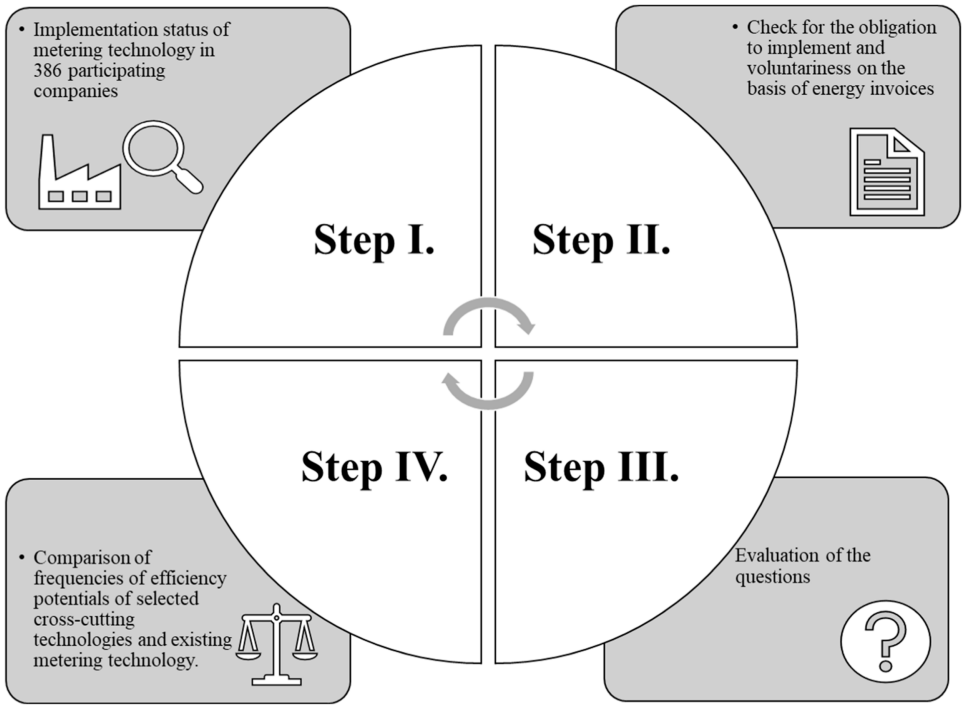

FIGURE 1
Procedure of the evaluation method.

have an obligation to implement smart meters in Germany. This consumption limit determines whether conversion to a smart meter is mandatory. Companies with an electricity consumption of less than 6,000 kWh per year can carry out a voluntary conversion.

Companies with electricity consumption of more than 100,000 kWh per year have already installed RLM (registered load profile measurement) meters in Germany but should also carry out a conversion. The reason is that it is precisely this customer group that could access the load profiles much more easily and transparently through the conversion and thus generate savings. Therefore, consumers with an electricity consumption greater than 100,000 kWh per year are also considered in the evaluation.

The distinction is made with the help of the current electricity bills.

2.3.3 Evaluation of the questions

Just as important as the actual state of implementation is the question of why. The answers to the questions in Section 2.2 were noted for each company and then entered into the Excel matrix. Only yes or no answers were permitted. An evaluation can be shown with the statistical frequencies for each answer option. The sum of the yes and no answers is obtained to determine the reasons for or against the technology of the participating companies.

2.3.4 Comparison of frequencies of efficiency potentials in selected cross-cutting technologies with existing metering technology

After it is known which companies have installed a smart meter, a comparison between companies with smart meters and conventional analog meters is to be carried out. The comparison is to be carried out with the selected cross-cutting technologies of lighting, energy monitoring, energy purchasing and peak load management. These technologies were included in the comparison because they are very simple energy efficiency measures that are usually already implemented in companies. If the measures have already been implemented, this results in a low energy efficiency potential. The data on the frequency of efficiency potentials of the selected cross-cutting technology will be determined and compared with each other. In addition, the potentials will be analyzed with the results from the study (Knayer and Kryvinska, 2023).

3 Results

3.1 Implementation status and Obligation to implement the measurement technology

Table 2 shows the implementation status and the implementation obligation of the companies. Of the 386 participating companies, 318 (82.4%) are required to install a smart meter, while the remaining 68 (17.6%) companies can retrofit voluntarily.

Only 34 (10.7%) of the companies required to implement have installed a smart meter. Furthermore, 256 (88.5%) of these companies have already installed modern (digital) metering equipment that could be retrofitted using a smart meter gateway. 28 of the 318 companies nevertheless still have analog meters in use.

No company that can voluntarily perform a retrofit has installed either a smart meter or a modern (digital) metering device. These companies still have analog meters in use.

3.2 Evaluation of the questions

The evaluation of the questions is shown in Table 3.

The evaluation shows that 222 (57.51%) of the companies surveyed know what a smart meter is. However, only 34 companies (10.7%) have installed a smart meter.

The question about the difference between a digital meter and a smart meter is answered with yes by 249 companies (64.51%). This result coincides with the high number of digital meters installed, i.e., 256 (80.5%).

The question about the rollout strategy of the government and the question about the benefits of smart meter technology are answered in the affirmative by less than one-third of the companies in both cases. This result means that two-thirds of the companies show a strong need for information here.

TABLE 2 Implementation status and obligation to implement the measurement technology.

Implementation status vs. implementation obligation	Number	%
	386	100%
Companies with an obligation to implement (electricity consumption >6,000 kWh/a)	318	82.38%
- Installed smart meters	34	10.69%
- Installed digital meters	256	80.50%
- Analog meters in use	28	8.81%
Companies for which implementation is a voluntary option (electricity consumption <6,000 kWh/a)	68	17.61%
- Installed smart meters	0	-
- Installed digital meters	0	-

TABLE 3 Evaluation of the questions.

Questions	Yes		No	
Do you know what a smart meter is?	222	57.51%	164	42.49%
Do you know the difference between a digital meter and an intelligent meter?	249	64.51%	137	35.49%
Do you know the government's rollout strategy regarding smart meters?	109	28.24%	277	71.76%
Do you know the benefits of smart meters for businesses?	99	25.65%	287	74.35%

TABLE 4 Energy efficiency potentials of selected cross-cutting technologies sorted by manufacturing non-SMEs with and without smart meters.

Energy efficiency potentials of selected cross-cutting technologies sorted by manufacturing non-SMEs with and without smart meters	All companies		Installed smart meters		Analog meters in use	
	Abs 53	Rel. (%) 100	Abs 25	Rel. (%) 47	Abs 28	Rel. (%) 53
Lighting technology	22	42	9	36	13	46
Energy monitoring, peak load management and energy purchasing	23	43	5	20	18	64

3.3 Comparison of frequencies of efficiency potentials in selected cross-cutting technologies with existing metering technology

The 34 companies with installed smart meters were compared with the 28 companies with analog meters. The 34 companies are 25 manufacturing and 9 nonmanufacturing non-SMEs. The 28 companies with an analog meter are all manufacturing non-SMEs. In order to be able to present a comparison between manufacturing non-SMEs, the 9 nonmanufacturing companies were removed from consideration. Thus, all 53 companies are manufacturing non-SMEs. The results of the comparison can be seen in Table 4.

The potential is relatively similar for lighting technology in both the companies with smart meters and the companies without smart meters, but lower. The results are insignificantly different from the overall potential of the companies listed here. When it comes to energy monitoring, peak load management and energy purchasing, the results are clearer. Here, companies with a smart meter have an efficiency potential of around 20%, which corresponds to an implementation level of 80%. By comparison, companies with an analog meter have an implementation status of only 36%, with an efficiency potential of 64%. Nevertheless, in both areas, the companies with a smart meter are more efficient than those still equipped with an analog meter.

4 Discussion

4.1 Starting point of this work and objective

Companies lack knowledge about the technology's advantages and are hesitant about it. This is true even for businesses that are required by law to install the equipment and have annual power usage above 6,000 kWh. They will refit the technology but not put it to use.

Furthermore, there are not many studies that have looked at the technology's acceptability standards in the workplace. Instead, there are several studies that focus on the household sector (Knayer and Kryvinska, 2022).

However, it is still unknown what factors affect smart meters' adoption and utilization in businesses.

The advantages of deploying smart meters for businesses have not received enough investigation.

4.2 Main conclusion of the study

Of the 386 participating companies, 318 (82.4%) are required to install a smart meter, but only 34 (10.7%) of the companies have installed one.

Approximately 40% of the stakeholders surveyed do not know what a smart meter is. This follows the results of (Chawla et al., 2020) where about 50% of the respondents did not know what an SM was. It is therefore unlikely that rejection of the technology, as often described in the literature, is based on purely technical aspects. Here, the information and awareness deficit of companies becomes clear, which is also reflected in the question about the rollout strategy. Compared to the results of (Schneider, 2020), the results in the household sector are even more serious. Here, 68% of the respondents did not know what a smart meter or an intelligent meter is.

Only approximately one-third of the companies are aware of the government's strategy. Therefore, the awareness of those affected with regard to the technology should be increased. The greater the benefits are, the greater the acceptance and, thus, the implementation of the technology.

This is all the more important in Germany because many consumer groups (households and small businesses) are not obliged

to install the technology and, instead, have the option to retrofit voluntarily.

However, companies that are obliged to install the technology should also be trained so that they actively use the technology. This point is also shown by the results of this study because although the difference between digital and smart meters is known (64.51%), mainly digital meters are installed (80.5%). This result is because the advantages of the technology are not known (25.65%) or because value-added services are not yet available in a way, that is, compatible with the market. The work of (Gumz and Fettermann, 2023) also indicates that a major obstacle is unfamiliarity with the technology.

The results from the efficiency comparison show that the efficiency potential in the selected cross-cutting technologies tends to be lower for companies that have already installed a smart meter. Studies such as Kollmann and Moser (2014); Anda et al. (2013) have already identified and partially proven savings of 4%–12% or even up to 57% (D'Oca et al., 2014) with smart meters. However, these results were mostly not possible on a technology level, but were based on the total consumption of different actors. Moreover, these only considered households as end customers. The results in this comparison for the cross-cutting technology lighting technology differ only insignificantly from the results from (Knayer and Kryvinska, 2023) which indicate the potential with 52% for manufacturing non-SMEs. The results are clearer for energy monitoring, peak load management and energy purchasing. Companies with a smart meter have a potential of 20%, which corresponds to an implementation level of 80%. In comparison, companies with an analog meter have only 36% implementation status, with a potential of 64%. From the work of (Knayer and Kryvinska, 2023), 38% efficiency potential can be read off for the companies observed here in this cross-cutting technology.

Although the government has reduced costs through the amendment, households and small businesses remain unaffected due to the consumption limit of 6,000 kWh per year. In addition, value-added services such as dynamic tariffs will not become mandatory for all energy suppliers until 2025.

In particular, industry and commerce should be investigated more specifically and more frequently in connection with technology adoption.

4.3 Limitations of the work

Companies were surveyed as part of an efficiency program; it may be that the employees responsible for the energy topic are not responsible for the digitization strategy in the company. In addition, the person responsible for energy may not necessarily be responsible for compliance with and the review of all legal requirements related to digitization and energy. This includes the rollout strategy, which is usually maintained in a legal register as part of an ISO 50001 energy management system.

The questions were deliberately posed in a simple and closed-ended manner (only yes or no answers allowed). However, this method also means that, if necessary, the tendency was to give a no answer if the stakeholders did not immediately know what was at stake.

4.4 Further research and contributions

It was shown that many companies are not yet sufficiently informed about smart meter technology and are therefore not involved in the rollout.

This work is intended to raise awareness of the fact that not only technical and financial barriers but also information plays a decisive role in the decision for or against a technology. In addition, the results show that the previous communication strategy should be expanded to include all participants. This also needs to be done several times.

In the course of a successful rollout, aspects of sustainability with regard to replacement cycles of digital electricity meters compared to conventional meters as well as the consideration of the electricity self-consumption of smart meters should be reviewed and reduced in perspective. The replacement cycles will be significantly shortened, and thus, existing resources will be used more frequently. These cycles should be extended in the future, e.g., in the form of more robust construction. At the same time, it is necessary to consider environmentally compatible reprocessing and recycling of the meters. Since digital meters have a higher rate of self-consumption, whether energy efficiency can be improved must also be examined. In Germany alone, this aspect affects more than 50 million metering points.

Finally, the efficiency comparison carried out is to be extended to other cross-cutting technologies. The aim must be to investigate whether smart meter technology can help companies to change their energy consumption behavior and generate savings.

5 Conclusion

The aim of this work was to investigate the question of the implementation status of smart electricity meters in companies and the level of knowledge of the technology in the companies.

To that end, a survey was conducted in 386 companies as part of a funding project. In addition to the implementation status, which companies would have to carry out a mandatory retrofit of the technology was examined. These results were blended with four questions and evaluated. The results show an information deficit and, thus, a need for research on the technology in the corporate environment, as the majority of the companies do not know what a smart meter is (42.49%). In addition, it is not known what advantages the technology brings (known by only approximately a quarter of the companies). Finally, the legal framework, the so-called rollout strategy, is known by only approximately one-third of the companies. Among other things, this contributes to the fact that companies have a very low implementation rate of 10.7%.

The results can be used to expand the current communication strategy, as more and better targeted information can contribute to a better understanding and alignment of technology in organizations.

The technology is still considered a driver of the energy transition. Therefore, in addition to the acceptance of this technology by users, raising prior awareness, if necessary several times, is of enormous importance.

The results of the efficiency comparison can also be further expanded. With the comparison of frequencies, it is possible to derive a trend between the use of a smart meter and

the implementation of efficiency measures in the companies. Furthermore, the transmitted data from the smart meter can be used, for example, to provide companies with energy saving recommendations. This goes hand in hand with the value-added services and the planned benefits such as dynamic tariffs.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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