Artificial intelligence for the energy sector

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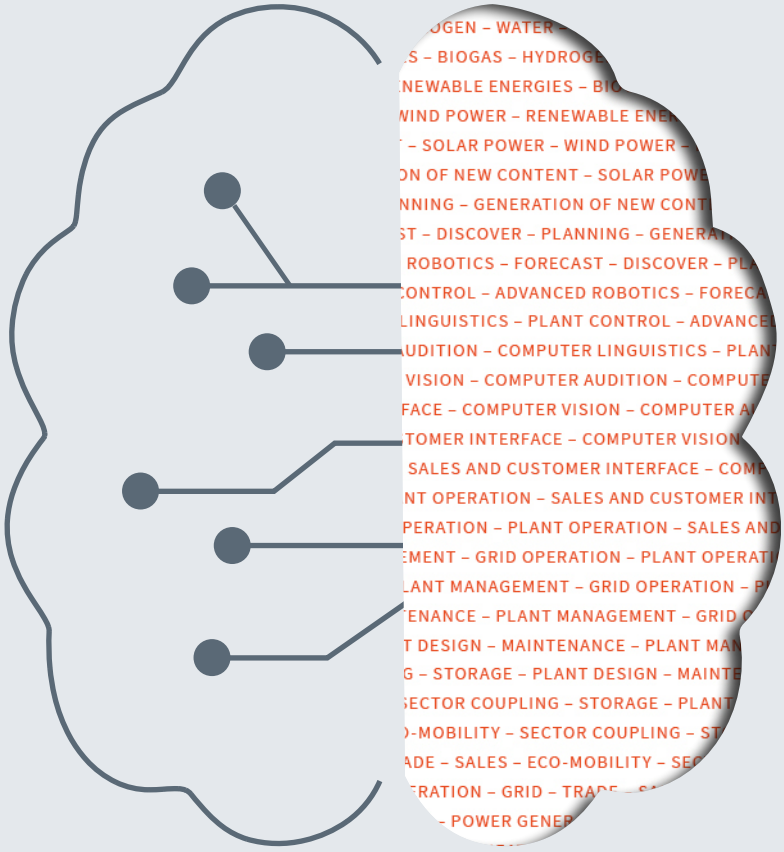
Energie. Wasser. Leben.

Introduction, examples and recommendations
for companies and policy makers



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Editorial

“Together, let us make the energy industry a leading sector for the deployment of artificial intelligence!”

Dear reader,

There are few technologies which garner as much attention as “artificial intelligence” (AI). The use of AI applications is destined to reshape our economy and our society – and this includes the energy sector. Artificial intelligence offers considerable potential for the energy sector and the *Energiewende* [German energy transition].
The energy world is changing rapidly: From the phasing out of nuclear energy and coal to the expansion of renewable energies and electric mobility and the associated volatility, flexibility and decentralisation. In the energy sector it seems as if nothing will be as it was before. Artificial intelligence can play a crucial role in shaping this transformation.
The great number of business examples in this study clearly illustrates: Artificial intelligence is not some distant dream. Even today, AI can be used in the energy sector to improve efficiency, better serve customers, reduce CO2 emissions and adapt work processes. The possible applications of artificial intelligence in the energy sector are multi-faceted. And one thing is certain: Not only does the use of AI contribute to the success of the energy transition (Energiewende) it also makes sense from a business perspective.

In this study, we would like to present a low-threshold introduction to the subject and provide some assistance as to where and how the potential of AI can best be employed in the energy sector – with many practical tips and recommendations for action. The full potential of this technology can only be realised if we succeed in making AI accessible to all stakeholders in the energy sector. We seek to contribute to this goal.

Together, let us make the energy industry a leading sector for the application of artificial intelligence!

We hope you enjoy the study.
Yours sincerely

Kerstin Andreae
Chairwoman of the General Executive Management Board, BDEW, German Association of Energy and Water Industries

Introduction

Background

Artificial intelligence (AI) is regarded as an important "universal technology" of today's world and is the subject of a veritable hype. At the same time, there is a lot of misunderstanding concerning the technology and a great need for information and education: AI is overvalued and feared, burdened with overblown expectations or demonised. What is often lacking is an understanding and sober breakdown of the underlying technologies.
In recent years, significant technological advances have been made, primarily in the field of machine learning, such that AI applications are already being successfully deployed in many areas, including in the energy sector.
It is no longer a question of if but how and with what added value AI will be able to be utilised in the energy sector. The corresponding methods and algorithms are available and are simply waiting to be used for the specific needs of businesses in the energy sector.

It is therefore also important for decision makers in the energy sector to develop a basic understanding of the technology and to understand how and in what areas AI can be used as a new tool.

This is exactly where this study can help.

The implementation of artificial intelligence is an important tool for the facilitation of a sustainable transformation of our energy system. In order to ensure companies' sustainability, it is necessary to actively deal with the technology's chances and opportunities.

Objectives

- **Assistance and knowledge transfer**
  Comprehensible and low-threshold introduction and breakdown for the energy sector
- **Idea creator**
  Creation of ideas through examples and practical tips, to motivate adoption of new projects in practice in different areas within the energy sector (included in the extended German version)
- **Recommendations for action for businesses**
  Illustration, through specific recommendations for action, advice and tips, of how AI projects can be systematically identified and implemented and where common mistakes are best avoided (included in the extended German version)
- **Recommendations for action for policy makers**
  How policy makers can promote a meaningful use of AI in the energy sector, through innovation-friendly framework conditions

The central target group for the study is therefore decisions makers from the energy sector and politics. The intention is to give them a comprehensible but sound introduction to the world of AI while making the topic more accessible. The practical tips and examples included in the extended German version of this study are intended to inspire readers to find value-adding use cases for their own business model and shall help to avoid common implementation mistakes. Through the creation of suitable frameworks, policy makers can also make a crucial contribution to the successful employment of AI.

Executive Summary

“Who” or “what” is artificial intelligence?

When people talk about artificial intelligence today, they mostly mean technologies that can be grouped under the term machine learning. In recent years, considerable progress has been made in enabling machines to be able to apply completely new capabilities to the widest range of problems, driven by better availability of processing power and data. The new capabilities include:

- Computer vision (image processing)
- Computer audition (audio processing)
- Computational linguistics (understanding text)
- Plant control and robotics
- Forecasting
- Discovering
- Planning
- Creating new content

All current AI applications that are based on these capabilities have one thing in common: they have been trained for very specific purposes with very specific data. For example, a translation AI would never be able to recognise pictures and a model trained to predict the lifetime of substations will not be able to identify damage to power lines. Behind these capabilities, that is to say behind machine learning, is a series of algorithms. There is not “one” AI algorithm or one universal approach for every problem. Each approach has its own advantages and disadvantages and is suited for different problems.

However, most approaches have one thing in common: they use probabilistic methods. Statistical methods are used to learn patterns, so that the results are only accurate to a certain probability (depending on the quality of the model).

In addition, especially with complex algorithms (e.g. artificial neural networks) it is not easy to understand which rules have been used to obtain a particular result. These characteristics require a rethinking from users, since most people expect machines always to return correct results. Users must be aware of the characteristics and limits of AI systems.

AI applications are tools (or technical methods) that can be used in many different scenarios. The technology itself is neutral. However, its use can, depending on the type of data concerned and how it is used, raise social or ethical issues.

In addition to often making business sense, the use of AI in the energy sector also contributes primarily to the optimisation of the energy system, to the adoption of climate-friendly technologies and to being able to better meet customers’ needs. From a societal and climate policy perspective, the energy sector is therefore also a particularly suitable sector for using AI in a way which adds value. However, one must not forget that every use-case is different. This means that wherever AI is employed, the social acceptance of the technology must be taken into account, along with the relevant ethical principles.

AI for the energy sector – potential benefits and areas of use

Today, the energy world is fundamentally changing. While in the past, individual power plants produced power, today there are already over 1.7 million decentralised producers, the majority of which use renewable energy sources. In addition to this, there is now a stronger coupling of formerly independent sectors as well as many new controllable consumers, such as electric cars.

The use of artificial intelligence is an important tool for supporting this transformation of our energy system. However, the use of AI is not an end in itself. It helps to manage complexity, make processes more efficient and achieve greater benefits for customers.

The specific added value of the employment of AI may vary greatly, depending on the individual use case but also from company to company.

A main target of this study’s project was to collect, describe and evaluate various AI use-cases regarding their potential for application in the energy sector.

The fields of application of AI for the energy sector include:

- Plant design
- Maintenance, servicing and plant management
- Network and plant operation
- Sales and customer interface

The many practical examples identified within the investigations for this study show that AI is already being used in many various ways in the energy sector.

Recommendations for action for energy supply companies

The successful application of AI often fails not because of a lack of technical know-how but due to a lack of a strategic and structured approach. Especially for large companies, it makes sense to adopt a holistic, strategic approach that considers all levels of the business. It is also important for smaller companies to assess their current situation and then actually decide what could be implemented independently or with external partners.

To support businesses in this, we have summarised some concrete tips, various handouts, further information and many recommendations for action, which you will find in the extended German version of our publication. Factors which determine the success of implementing AI within companies include:

- Approach AI strategically: develop an AI vision for your own company
- Identify cases that add value in a systematic manner
- Create structural conditions
- Build the right organisation for the AI age
- Staff: develop skills and initiate culture change
- Create technical conditions
- Ecosystem: build an AI network and promote exchange of knowledge and ideas
- Responsible use of AI: take concerns seriously and address ethical issues early on
- Avoid common mistakes when implementing AI projects

Recommendations for action for policy makers

Policy makers have an important role to play in enabling the utilisation of AI. This is because it is important, from an international perspective, to avoid being left behind by the AI pioneers in North America and China and to keep our German and European economies competitive in the long-term. At the same time, however, it is important to set a clear heading as to which purposes we do or do not wish to use AI for without putting a brake on innovation. The energy sector should be a leading light in the use of AI and thus contribute to positively shaping “AI made in Germany/Europe”.

This is because AI applications in the energy sector mostly make sense not only from a business perspective but also because they provide an important contribution to the integration of renewable energies, the optimised control of electricity networks, decarbonisation of the economy and thus for the achievement of climate protection objectives.

The promotion of the use of AI in the energy sector therefore also contributes to the sustainable reform of our energy system. Policy makers can provide support in removing barriers and creating suitable frameworks. Areas of action for politicians include:

- Making the energy industry a leading sector for “AI made in Germany/Europe” and promoting use of AI
- Bundling funding options and competencies and simplifying access
- Making energy sector regulations fit for digital innovation and AI
- Not imposing any new regulatory hurdles for the use of AI in the energy sector
- Facilitating data exchange between different market participants and removing legal uncertainty surrounding the handling of data
- Promoting open data without disadvantaging municipal enterprises
- Expanding energy-related AI research – establishing a Europe-wide cluster of excellence
- Encouraging discussion in society as a whole and develop vision for AI

BDEW project
"Artificial intelligence for the energy sector"

As the umbrella association of the German energy and water industry, BDEW actively supports its member companies in taking advantage of the opportunities afforded by the digital transformation. The main area of focus is providing specific support to member companies and providing information and a breakdown of new topics and trends. Key publications on this topic include the “Digital agenda for the energy sector”[1] or the “BDEW blockchain study”[2].

The project, “Artificial intelligence for the energy sector” was launched at the start of 2019 together with experts from BDEW member companies. With support from AppliedAI, use cases were developed and evaluated in a series of workshops, with recommendations for action collected and discussed. The results of that project form the basis of this publication.

1 Available at → www.bdew.de/energie/digitalisierung/die-digitale-energiewirtschaft-agenda-fuer-unternehmen-und-politik
2 Available at → www.bdew.de/service/publikationen/blockchain-energiewirtschaft

Recommendations for action for policy makers

Artificial intelligence is a key technology for the economy and society in general. It is already apparent today that AI will bring far-reaching social and economic challenges, opportunities and changes with the energy sector duly affected.

The many various AI applications that already exist today in the energy sector give a taste of the potential yet to unfold as a result of that technology.

Policy makers also have an important role to play in enabling the utilisation of AI. This is because it is important, from an international perspective, to avoid being left behind by the AI pioneers in North America and China and to keep our German and European economies competitive in the long-term. At the same time, however, it is important to set a clear heading as to which purposes we do or do not wish to use AI for without putting a brake on innovation.

In the public perception, AI is often associated with negative connotations (e.g. surveillance or job losses). Concerns about the technology are also stronger in Germany than other countries[3]. Wherever a concrete use of AI has so far been experienced, the potential is judged more positively and realistically[4]. Low-threshold services providing experience with AI in practice are thus important starting points for promoting the popularity and application of AI.

Making the energy industry a leading sector for "AI made in Germany/Europe" and advancing the energy transition (Energiewende)

The energy sector is a vital part of our economy and our society. We believe that it is a particularly good example for the use of AI and can help create a positive image for the concept of "AI made in Germany/Europe". This study shows that companies in the German energy sector are already successfully using AI applications today, across various stages of the value chain.

For example, companies are already using AI technologies to successfully decarbonise the sector and thus achieve climate protection objectives. Through AI, energy systems can be better controlled, for example, through improved feed-in forecasts or pattern recognition. With regard to the required reduction in greenhouse gas emissions in all sectors, there will also be a need, in the future, to further facilitate sector coupling concepts. The energy sector is a central driver behind sustainable mobility based on renewable energy sources, for example in the field of electric mobility. Here too, the use of AI technologies can contribute.

Optimum controllability and intelligent networking of the gas and electricity networks, as well as the different voltage levels will be of increasing relevance in the future. For example, intelligent networking of the different voltage levels is the basis for the creation of sustainable mobility structures, necessary for achieving climate protection goals.

Against the background of a continuously increasing share of volatile renewable energies, the use of AI technologies will play an even more important role in the future with regard to ensuring security of supply and system security. This is because plant-specific feed-in forecasts enable an improved localisation of potential bottlenecks and an improved ability of network and plant operators to act quickly and efficiently, thus avoiding inefficient output reductions. In addition, this data can serve as the basis for the targeted expansion of new energy installations and thus contribute to an efficient allocation of resources.

The promotion of AI in the energy sector therefore also contributes to the sustainable reform of our energy system. Policy makers can provide support in removing barriers and creating suitable frameworks. In the following, we have summarised key recommendations for action on the following topics:

- → **Facilitation of business development**
- → **Legal framework**
- → **Education and research**
- → **Society**

3 See, for example, BCG Gamma (2018) – Artificial Intelligence: Have no Fear. Available at → www.slideshare.net/TheBostonConsultingGroup/artificial-intelligence-have-no-fear
4 Ibid.

Facilitation of business development

Recommendation for action:

→ **Make the energy and water industries a leading sector for “AI made in Germany/Europe”**

AI has great potential in the energy sector to secure the efficient use of energy and environmental resources in the long term and to actively drive the Energiewende forwards. As an export, AI technologies could also promote the worldwide transformation to a sustainable energy system and act as a beacon for the “AI made in Germany/Europe” label.
Targeted AI research and industry support can aid the economy, especially in areas that are not the focus of support on other continents. The EU is today still investing less than its competitors in North America or China. Therefore, the funds for research but also for industry support, should be further increased.

Recommendation for action:

→ **Bundle funding options and competencies and simplify access**

In terms of numbers, there is no shortage of state initiatives and funding plans. The different initiatives at European level, at National level and at Federal state level are, however, overall confusing. The different funding conditions, formalities, access requirements and bureaucratic processes in each case act as additional obstacles to the utilisation of the funding measures, not only for smaller companies.
In addition, the special aspects of SMEs in the energy sector are often not considered. SMEs in the energy sector are mostly local utilities with a municipal ownership structure – to date available funding has not taken this into consideration.
The same applies to political initiatives – here too, the competencies for research, digital policy, economic policy and AI strategy are spread across different ministries, each of which have their own plans, sometimes with quite different goals. Increased central coordination and control would be helpful in this area.

Legal framework – promote legally compliant handling of data and provide regulatory support for AI

Recommendation for action:

→ **Make energy sector regulations fit for digital innovation and AI**

In order to drive digital innovation and AI forward in the network sectors, the regulatory frameworks must provide suitable incentives. However, the regulation of incentives does not sufficiently take into account the specifics of network innovations (higher risks, higher OPEX share, short lifespans). Innovative entities using the new technologies should not be disadvantaged. In practice, R&D activities by network operators can lead to a loss of efficiency. The corresponding instruments in the German regulation of incentives (see Sec. 25a ARegV [German Incentive Regulation Ordinance]) have not lived up to expectations; they should be evaluated and improved.

Recommendation for action:

→ **Facilitate data exchange between different market participants and removing legal uncertainty surrounding the handling of data**

For the development of innovative AI solutions, a stronger exchange of data between different market participants makes sense. In this regard, support for new technological concepts, such as data trustees or other similar database solutions, with which relevant data can be made available transparently, would be valuable.
In the form of the GDPR, clear guidelines were issued on handling personal data with potentially severe penalties for companies that do not comply. Above all, there are significant uncertainties due to the increased use of cloud infrastructure and the storage of data by non-EU cloud providers (for example in the scope of the privacy shield) some of which cannot be influenced. Smaller actors find it difficult to weigh up the legal implications of cloud use. To eliminate legal uncertainties and to make the potential of cloud solutions available to all as an important basis for the use and scaling of AI, issues of liability should be more clearly defined and concepts for stronger data sovereignty should be supported.
Against this background, the GAIA-X initiative launched by the German Federal Government is welcomed.
Likewise, legislation should be developed to move away from the approach of prohibitions with the possibility of permission, to specific data usage rights. This would free providers and users of data from due diligence obligations and remove obstacles.

Recommendation for action:

→ **Promote open data without disadvantaging municipal enterprises**

In principle, open data should be further promoted also from a legal perspective, via uniform interfaces. In this way, additional potential for the energy and water industries can also be utilised. At the same time, however, the special role of municipal enterprises must be taken into account when implementing open data initiatives for the public sector. They are in competition with other companies and provide public services of general interest. They should therefore not be disadvantaged by having disclosure requirements unilaterally imposed on them. This must be considered, for example when designing and implementing the European Open Data / Public Sector Initiative (PSI Directive).

Recommendation for action:

→ **Facilitate data access – make data from manufacturers available**

It is also worth drawing up legal guidelines for facilitating access to data for other areas too, since to date there are only guidelines for personal data. Every data exchange which goes beyond this is subject to private law agreements. Especially when using large suppliers’ systems, smaller users are generally not in a position to negotiate special data access rights for the systems they use. The legislature could increase data availability through clearly regulated data access rights at user level.
Particularly in the field of electric mobility, there is a lack of data to better integrate electric vehicles into the energy infrastructure, for example for load management which benefits the network.
This requires better access to vehicle data (e.g. charging progress, amount of energy required, power draw etc.) which to date has not always been made available from manufacturers to a sufficient extent using standardised interfaces. The vehicle user should be able to have access to this data and decide to whom they want to make it available.

Recommendation for action:

→ Create innovation-friendly conditions for the use of AI systems

Many areas of the energy sector are subject to strict rules and regulations. In the case of AI systems, however, not all decisions can be traced in detail (black box feature) – nevertheless, if its use promises significant potential, such as in reducing complexity and optimising decision-making in network control or in increasing automation of electricity trading, its use should not be excluded on principle. Instead, clear rules and guidelines for the testing and design of AI systems, which include and take into account possible risks at an early stage of development, would be better. In order not to put a brake on innovation in this area, rather than laying down strict rules, it would be preferable to have guidelines, compliance with which for example could be verified in the scope of internal compliance processes.

Recommendation for action:

→ No new regulatory hurdles for the use of AI in the energy sector

When developing (AI-specific) regulations, it must be taken into account that the potential benefits of the technology for the energy sector should not be unilaterally held back. For example, the EU Commission's AI white paper[5] proposes that AI applications in the energy sector be considered "high-risk applications", such that in case of doubt it must be assessed or proven for each use that it does not involve "significant risk".

The energy industry acknowledges its responsibility and will continue in the future to use only new technologies in particularly critical areas, such as network control, after an extensive examination of the possible risks. A sweeping categorisation of all AI applications in the energy sector as critical means increased bureaucratic costs. For smaller energy companies, this could mean insurmountable costs which hold back and obstruct the start of AI projects. There is the risk that many useful applications would not be implemented and that the huge potential would not be exploited in the energy sector.

Education and research

Recommendation for action:

→ Firmly establish digital competence in education and research, promote further education

Digitisation is spreading into all areas of life. This means that AI technology and its application is no longer restricted to the technical professions or engineering, but that digital and data literacy is also required in many other areas. It is therefore necessary to promote life-long learning and to anchor digital education in schools.

Recommendation for action:

→ Establish the learning of digital skills firmly in the curriculum

Digital education should start right from primary school. In this way, primary school pupils can be introduced to technologies that they will later come into contact with on a daily basis in their working life. The more familiar children are with AI technologies, the more flexible and successful they will be with them in later life. For this reason, it is also necessary to firmly establish digital competencies such as basic programming skills and data analysis in the secondary school curriculum. Applied knowledge on AI must also have a firm place at universities and further education colleges outside of computer science and engineering courses. In addition, the specific practical applicability of courses should be more strongly taken into account in the accreditation process. In real world work environments, professionals must be able to interpret results created by artificial intelligence and integrate them into their working environment. These skills must be taught during vocational training and university degrees in the form of practice-based course content in order to prevent the divide between research and energy industry practice from becoming too large.

5 → www.ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_de.pdf

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Recommendation for action:

→ Promote exchange between the energy sector and educational institutions

In order to ensure that research and practice do not lose the connection to one another, different types of exchange must be promoted. On the one hand, exchange with trainees should be strengthened, for example through internships in energy supply companies or project days in educational institutions, for example in the form of so-called “energy days”, to better prepare pupils and students for the requirements and opportunities offered in the energy sector. Industry sponsors can help in giving students a realistic picture of the requirements within the energy sector as early as possible. On the other hand, investment must be made in institutional exchange, for example through strengthened collaboration between universities and energy companies. Increased use of shared professorships could help regarding this matter, in which, for example, the professor works 50% for the university and 50% for the company. This could significantly increase the flow of information in both directions.

Recommendation for action:

→ Promote life-long learning

Everyone must be included in the digital change. In companies, it is not possible or desirable to compensate for a lack of digital competence simply through new employees. There is currently only a limited number of experts available and knowledge is needed in particular at user level. Therefore, large-scale further education formats for employees should be promoted, specifically online courses and nanodegrees in the areas of AI and data science. Access to existing education opportunities at universities and colleges must be facilitated. In this respect, elite US universities such as the Massachusetts Institute of Technology (MIT) are good examples, in that they provide free access to course materials and online courses. The further training of multipliers in education and career guidance should have particularly high priority.
Many companies, including in the energy sector, have already developed upskilling programmes for their own employees. These could theoretically be made available, for example via PPPs[6] , in order to make a positive contribution to the utilisation of AI beyond the company concerned.

Recommendation for action:

→ Expand energy-related AI research – establish a Europe-wide cluster of excellence

In order to further develop the energy industry into a leading sector for “AI made in Europe”, AI research should be expanded with a focus on applications in the energy sector, with the research landscape in Europe more strongly coordinated, for example in the scope of a Europe-wide cluster of excellence. Furthermore, a corresponding central research institute should be established, which has the appropriate resources and equipment to attract cutting-edge international research. At the same time, the practical relevance of the research must be ensured, for example by holding regular discussions about the academic agenda with practice representatives.

6 PPP stands for Public Private Partnership

Society

Recommendation for action:

→ Strengthen trust in “AI made in Germany/Europe” through clear guiding principles

In the future, AI will not only be a way of working but will increasingly also influence our private lives. The employment of AI is therefore not only an economic and technological challenge but it also has an overall societal and ethical dimension. With its strong social and legal system, Germany and the European Union provide good conditions for taking a pioneering role with regard to the ethical use of AI. In order to make Germany and Europe an attractive AI location, however, a certain degree of social acceptance for the technology is required, that will only result from an informed society.

Recommendation for action:

→ Encourage discussion in society as a whole – develop positive guiding principles for AI

The social discourse on AI currently swings between two extremes: AI is either presented as a threat, endangering jobs and hastening people’s loss of control to machines, or it is portrayed as the panacea for all of today’s problems. Through public education, for example national information campaigns, the discourse on AI must become objective, on the one hand to remove fear in society surrounding AI and on the other to obviate huge expectations in the technology. Neutral reporting in public media, disseminating knowledge from research and practice and involving the public in digitisation projects in companies or public administration are key steps in achieving a greater acceptance of the technology in society.

Recommendation for action:

→ Ensure a responsible use of AI

A central requirement for this societal acceptance is the responsible use of artificial intelligence. AI is a tool that can be used for many purposes. It is the task of policy makers to ensure, through ethical guidelines and a binding legal framework, that ethical aspects are always taken into account whenever the technology is used. In addition to the benefits to society as a whole, Germany and the European Union can set themselves apart from international competitors who attach less importance to ethical concerns when using AI. The energy sector should be a central area of application in this regard.

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GLOSSARY

Artificial intelligence

Artificial intelligence is a major branch of computer science. In addition to the creation of “intelligent” machines or “artificial intelligence”, the focus of research today lies in automating “intelligent” behaviour, creating “intelligent” computer systems, problem solving and machine learning.

Algorithm

An algorithm is a precise and systematic method, consisting of sequences of well-defined instructions aimed at solving a problem.

Machine learning

Machine learning is a subset of artificial intelligence. This information processing approach independently generates knowledge – or learns – from experience. Through the processing of existing data sets (experience) according to a statistical model, patterns and regularities can be “recognised” in the training data.

Artificial neural networks

Just like biological neural networks, artificial neural networks are collections of individual information processing units (neurons) which are arranged in layers in a network architecture.

Black box

A black box describes a system whose input and output data, and external behaviour, are visible, but whose internal structure is, or is designed to, remain inaccessible or difficult to access.

About

BDEW, German Association of Energy and Water Industries

The German Association of Energy and Water Industries (BDEW) and its regional organizations represent over 1,900 companies. The membership comprises both privately and publicly owned companies at the local, regional and national level. They account for around 90 percent of the electricity production, over 60 percent of local and district heating supply, 90 percent of natural gas, over 90 percent of energy networks and 80 percent of drinking water extraction as well as around a third of wastewater disposal in Germany.
→ www.bdew.de

appliedAI Initiative

The appliedAI Initiative is Germany's largest initiative dedicated to promoting the use of artificial intelligence. Together with a large network of national and international businesses that use and produce this technology, appliedAI holistically supports the initiation and establishment of AI activities in companies, as well as their technical implementation, by means of further education services, strategic support and cross-company exchange formats.
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