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Digitalisation of the energy sector

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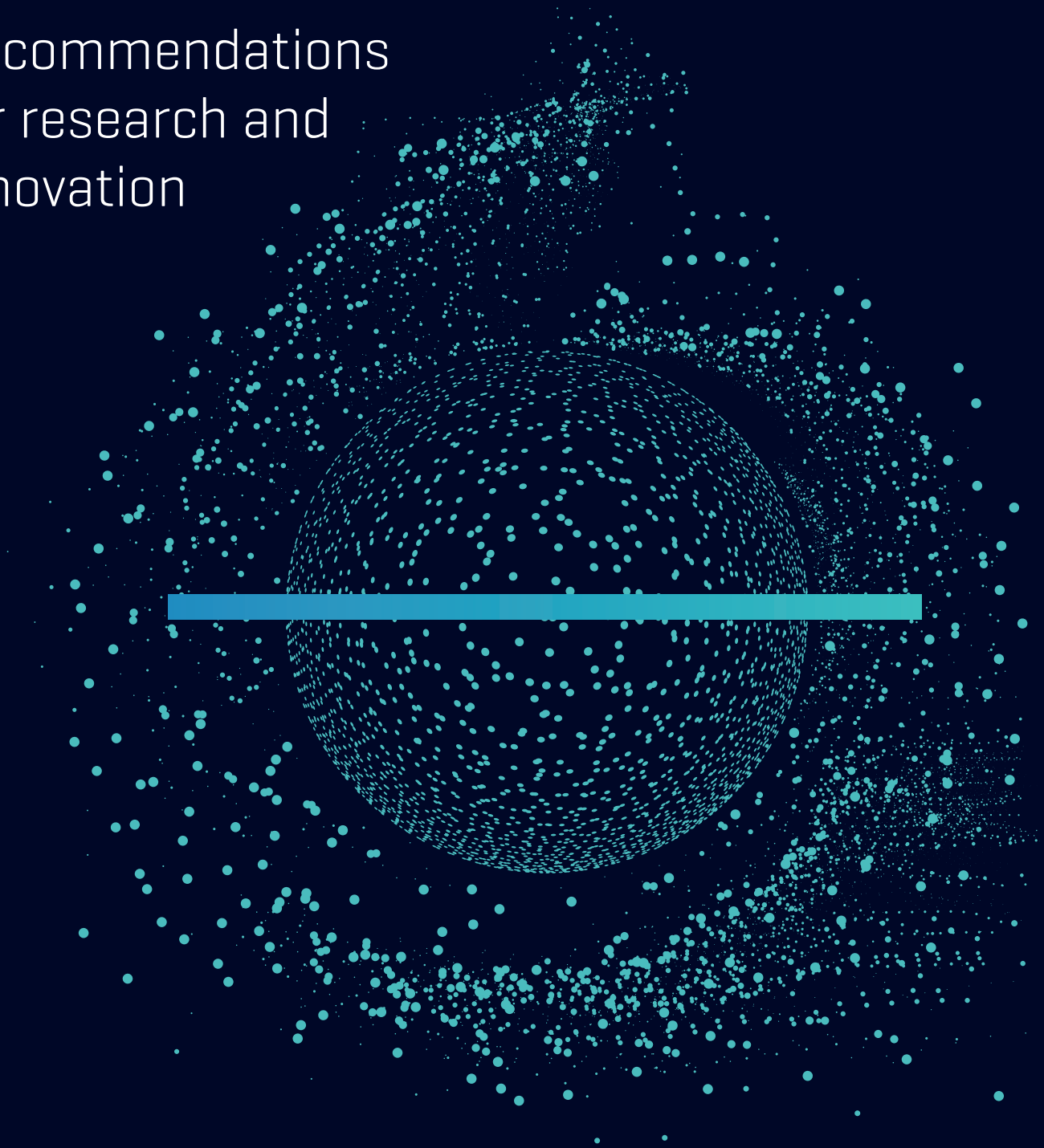
Recommendations for research and innovation



Energi21

The Energi21 strategic body was established by the Ministry of Petroleum and Energy to provide thematic and strategic advice on initiatives promoting research and innovation on renewable energy and climate-friendly energy technology. The Energi21 strategic body draws up the national strategy for this field, based on industrial ambitions and emerging opportunities for future energy and technology markets. Thematically, the Energi21 board's mandate encompasses the entire stationary energy system as well as energy technologies for transport purposes.

Digital21

The Digital21 strategic body was established by the Ministry of Trade, Industry and Fisheries. The body focuses on the business sector's ability and opportunities to develop and deploy new technology and knowledge in line with increasing digitalisation. In August 2018 the board presented the Digital21 strategy, containing 64 strategic recommendations of importance for digitalisation across the entire range of the Norwegian business sector.

Background

In spring 2019, the Energi21 board took the initiative to establish a collaborative project with the Digital21 board to assess the role of the enabling digital technology areas *artificial intelligence, autonomy, Big Data management* and the *Internet of Things* in the context of digitalisation of energy systems. The selected digital technology areas all represent key areas in the Digital21 strategy and are essential to realising the Energi21 strategy's priority technology area, "Digitalised and integrated energy systems".

The project's objective was to describe the status, key research and innovation thematic areas and measures needed to promote the utilisation of enabling digital technologies in the energy sector. Additionally, the project assessed the digital scope of opportunity for the energy sector. The project's recommendations are targeted towards the industry itself, research and educational institutions, the public agencies funding research and innovation and the authorities.

The project was co-headed by the Energi21 and Digital21 boards. A multidisciplinary group comprising representatives of the ICT and energy industries was established and contributed valuable insight and effort. In addition, the representatives capitalised on knowledge from within their professional networks.

Important drivers of digitalisation in the energy sector

Modern society is dependent on a reliable supply of energy. The energy sector's importance for society is growing, and an interruption of the energy supply can paralyse vital functions and processes. The energy system as a whole is a key infrastructure for value creation in society.

A transition is taking place in the energy landscape and energy systems. Profound changes are anticipated along the entire energy value chain, from production to distribution to consumption. New sources of production are being integrated into the grid, and solar and wind power are gaining increasing sway among energy technologies, particularly internationally. Centralised production solutions are being replaced by more decentralised solutions.

There is also a change in the demand for energy, away from fossil fuels and towards renewable energy. A strong trend towards electrification of the transport sector on land, at sea and in the air is already underway. The *Klimakur 2030*[1] long-term climate policy, presented 31 January, states that in Norway, new passenger vehicles could be completely electric by as early as 2025. There are plans to introduce more than 50 electric ferries along the Norwegian coastline. Efforts are underway to develop electric high-speed vessels to be in operation within a few years. These are strong drivers for the electricity supply sector and represent a shift in which the demand for power (measured in watts) increases relative to the demand for energy (measured in watt-hours). Also emerging is a marked development of hybrid propulsion solutions driven by multiple energy carriers such as electricity, hydrogen and biofuels.

Energy-efficient, environment-friendly smart buildings and cities are emerging – and microgrids are being developed with intelligent low-emission solutions. Most of the changes relate to the consumption side of energy. Consumers will exert a greater influence on market design, business models and the earning potential of industry actors. In the future, some aspects of energy consumption will need to be adaptable to the variation in available production. This constitutes a major change in the way the electricity system is currently run and will require extensive application of ICT. Cybernetics will play a key role in restructuring the power grid to the smart grid of the future.

Digitalisation will be a vital tool and a prerequisite for safeguarding security of supply and ensuring flexibility and cost-effective solutions for the future energy system.

(In addition, digitalisation is a key factor in achieving efficient utilisation of the future's various energy resources and integration of climate-friendly energy technologies. A well-functioning digital energy system depends on an interplay between technology, society, the environment, markets and consumers.)

1 *The **Klimakur 2030** long-term climate policy discusses various measures and instruments for achieving at least a 50 per cent reduction in non-ETS emissions in 2030 compared to 2005. Source: Norwegian Environment Agency.*

Digitalisation means that many more physical components will be equipped with sensors to measure physical parameters related to energy use, the condition of components and more. The sensors will be interconnected within the grid using two-way communication. The data will be compiled and analysed, and control signals will be returned to optimise energy use, among other things. The digitalised system will open up new opportunities for reliable analyses and sound decision-making.

Data processing and storage will become cheaper and more accessible through e.g. cloud-based solutions. Software and methodology for analysing large amounts of data (including artificial intelligence, machine learning, pattern recognition and more) are advancing rapidly.

Digitalisation can simplify, improve and renew the energy sector

Digitalisation opens up opportunities for the energy sector

New digital solutions will help to raise efficiency in the operation and maintenance of the energy system, provide a more reliable supply of energy and improve preparedness. Digitalisation and higher data quality also provide a more accurate basis for decision-making regarding investments and make it possible to automate a number of decision-making processes.

Digitalisation makes it easier to take advantage of demand response, integrate larger amounts of variable renewable electricity generation, and ensure effective coordination between distributed energy resources (e.g. solar panels and batteries) and the rest of the energy system.

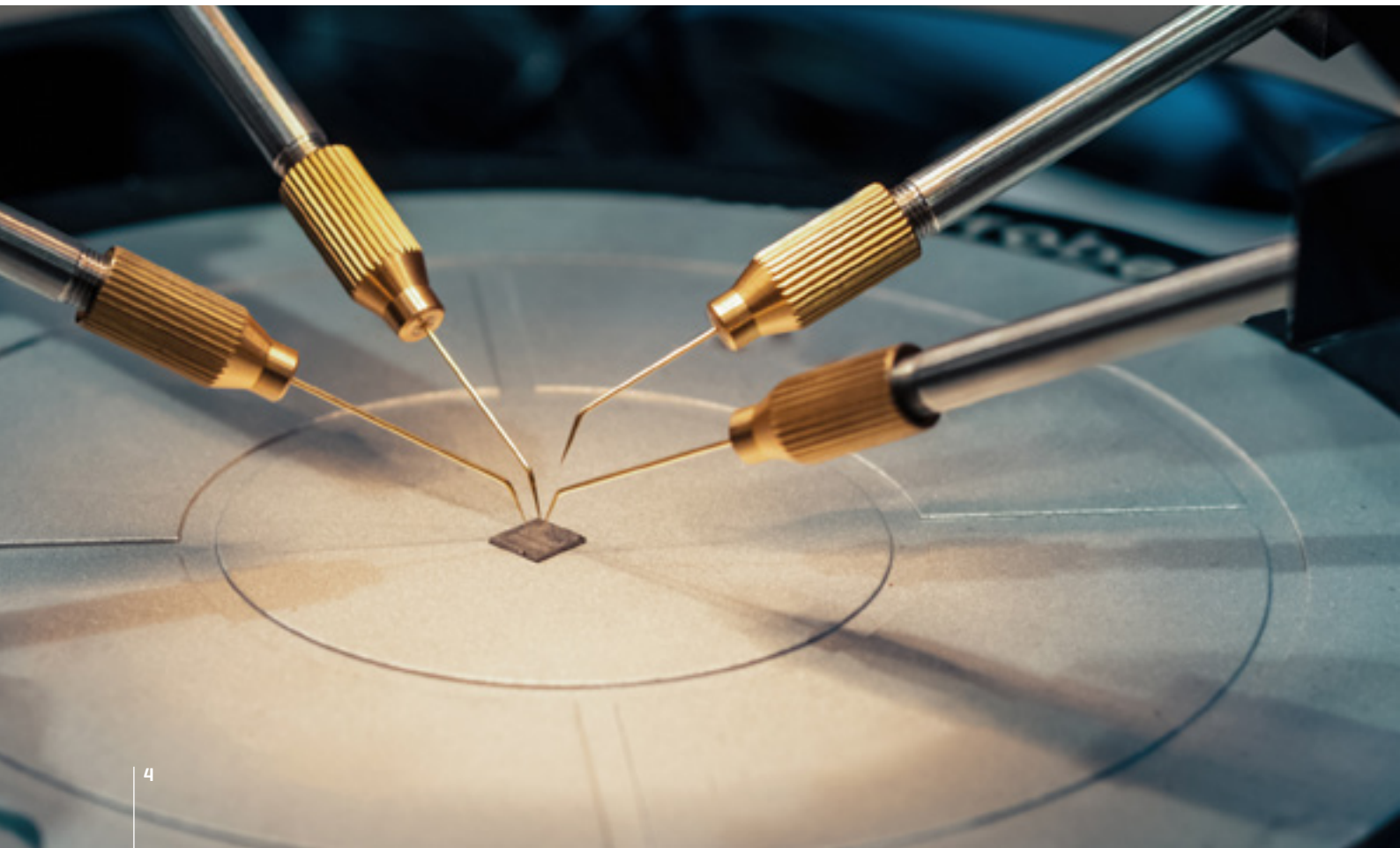
There will be a need to *develop new business models and understand consumer behaviour,* and to develop new market designs, new types of regulatory frameworks and new incentives. The contours of this are already emerging today. As digitalisation extends its reach and becomes a more integral part of the energy system, there will be a need to give increasing priority to *cyber-security and personal privacy.*

Potential for value creation in the interface between domain knowledge and data science

There is a potential for Norwegian value creation in combining energy-related domain knowledge with digital technology and expertise. Norway's energy system can serve as a good testing ground for digital energy solutions and systems. Valuable knowledge, services and technology can be developed by stressing the application of enabling digital technologies.

Digitalisation of the energy sector as an endeavour will bring change in several dimensions

The transition to widespread use of digital tools changes companies/organisations as well as the tasks of individual employees. A method that promotes an integrated approach to people, technology and organisation is needed. It is important that energy and grid companies succeed in finding an organisational structure and innovation culture with the flexibility needed to adapt to digital systems and solutions. It will also be crucial to safeguard cyber-security.



Priority areas for research, development and innovation

Big Data management and cyber-security will be of vital importance

For the energy sector, it is important to emphasise the application of Big Data technology and processes more than on developing fundamental technologies per se. Essential prerequisites for data-driven innovation are access to data, ownership and security risk. It is important to achieve a balance between the interests of suppliers and operators when it comes to ownership of, access to and responsibility for data.

Data must be stewarded securely to ensure that access is restricted to authorised personnel, data integrity is safeguarded, and data cannot be misused. Cyber-security is an ongoing process involving people, technologies and companies' business and development strategies. Cyber-security is an essential part of the framework for the future energy system.

Artificial intelligence (AI) will be imperative for monitoring, controlling and operating the energy system of the future

There is significant potential for effective use of artificial intelligence in the energy sector. AI can be applied to control all or parts of the energy system – for forecasting production from intermittent energy sources, monitoring the status of components, calculating service life, and so on. Norway may enhance competitiveness by combining AI with domain knowledge through physical models (hybrid modelling). Efforts should be made to develop effective systems for interpretable artificial intelligence (IAI). This will be of particular relevance to critical parts of the energy supply sector. The application of IAI can enable each energy system operator, installer and maintenance worker to receive adequate real-time information about all critical components within the entire power system, and thus at any time to take responsibility and apply his/her domain knowledge. Power generations and grid operators as well as major consumers in the energy sector will have a better basis for planning, streamlining and coordinated system optimisation. The development of coordinated funding schemes for IAI based on Nordic social values and Norwegian energy system experience is recommended. The national IAI community is fragmented, and steps should be taken to establish a strong, integrated environment and activity level in this field in relation to competence-building and AI application.

Sensor technology and the Internet of Things offer new opportunities for Big Data access

The use of sensor technology is critical for digitalising the energy system and reaping the benefits of digitalisation. Sensors rely on solutions for communications, power supply, durability and required maintenance to deliver reliable data. The digitalisation of energy systems will require an integrated approach which views of modern sensor technology, IAI, Big Data management, communications solutions and cyber-security. The raw data from IoT should be converted locally into compact, relevant and reliable information so as not to overburden the communications system, but without oversimplifying or losing important information. Research and innovation activities and the prioritisation of thematic areas and measures should reflect this.

Autonomous systems will be increasingly important in the energy system

Autonomous systems are systems that can operate either fully or partially independently, with varying degrees of human intervention. Autonomous ships' systems are already operational, and Norway is a leader in this field. Norway's advantages in autonomous systems for the maritime sector are a result of collaboration between industry, research groups and technology companies. Autonomous systems are also of relevance to the energy system. The growing complexity and integration of multiple energy technologies and systems will require automated systems for control, monitoring and operation to safeguard security of supply and balance the grid. There is still work to be done to achieve fully self-regulating energy systems without human operators, but it is possible to integrate individual solutions into the system using existing technologies. Autonomous energy systems require a digitalised energy system and must incorporate effective self-modelling for early warning of unexpected and adverse developments. Digitalisation and autonomous systems are closely linked and should be viewed as part of the same overall context.

Digital buildings open up opportunities for increased energy efficiency and better power management

In light of projected developments for buildings of the future, the IT systems of buildings will need to be scalable and their sensors fully capable of collecting more information than is currently the case. Sensors in buildings should be capable of sensing, among other things, energy and power demand, temperature, air quality, the presence and impacts of moisture, occupancy, and energy production. Standards and guidelines regarding future-oriented, integrated investment plans for building-related digitalisation technologies (building, information modelling, design, planning, and construction and operation of buildings) will be of growing importance in new constructions and upgrading of data capture in existing buildings. Digital technologies and solutions will be needed to achieve energy-efficient, automated buildings. One important measure will be testing and demonstration projects for new and changing forms of digital control of energy-efficient buildings adapted to future areas of application.

Recommendations – widespread need for new competence and dynamic instruments

Need for digital competence development in the energy sector
The report recommends an evaluation of Norway's educational programmes in digitalisation of the energy sector. Important elements are a professional profile and activities. It is essential to integrate domain knowledge and ICT skills to develop technology and services with the proper functionality. In order to use results from digital solutions in important decision-making in practice, interpretation and use of Big Data must be based on domain knowledge. Energy-sector companies should cooperate with the university and university college sector and research institutes regarding the educational pathways within digitalisation to ensure recruitment of knowledge resources for the digitalised and integrated energy systems of the future.

Strategic competence-building in digitalisation
Norway cannot be the best at everything and must instead identify strategic areas within which to develop and strengthen competence of importance and build effective mechanisms to make competence more readily accessible for industry. Targeted research efforts will be important for building strong Norwegian national teams in these key enabling digital technology areas and lowering the barriers to participation for SMBs. The establishment of a scheme for research centres focused on industry-oriented digitalisation, along with a set of criteria, has been proposed as a useful instrument to address this.

Instruments for research and innovation activities should reflect the market's needs
Technology development within digitalisation is advancing rapidly. Instruments to promote research and innovation activities should reflect the market's needs for fast access to knowledge and technology. Financing and support schemes should reflect these developments and provide opportunities for fast-paced "sprints" when developing new solutions. The key to realising the inherent potential of digitalisation lies in data sharing. There is a great need for data standardisation systems and for systems providing access to and sharing of data. Steps should be taken to enable new and existing actors alike to provide input on regulatory frameworks and framework conditions for the energy system of the future.

Cooperation and an innovation ecosystem are critical factors for digital business development
Capitalising on business opportunities within digitalisation will require changes in the culture, competence and willingness to take risks of energy companies. The digital landscape is complex, and it may be difficult to identify the type of digital competence a company needs. Investing in a targeted business concept is more likely to prove profitable than investing more broadly. Sound framework conditions should be established, with a scope of action that promotes innovation and a mode of thinking aimed at digital business. This encompasses both external regulation and internal routines within companies/organisations. Cooperation and an innovation ecosystem are critical factors for digital business development. It may be profitable for large energy companies to cooperate with smaller start-ups that have innovation competence.

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Design
TANK Design

Trykk
07 Gruppen
Oslo, april 2020

ISBN: 978-82-12-03850-9 (TRYKK)
ISBN: 978-82-12-03851-6 (PDF)

FOTOKREDITERING
Side 3, 4 og 7: Getty Images
Side 6: Boris Bobrov