CFIN RESEARCH CENTER FOR FINANCIAL SERVICES

Infrastructure Study 2024

The role of energy and digital infrastructure in the entrepreneurial transformation in Germany

with the support of:

LB BW

Munich, September 2024

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Management Summary

Introduction

In an increasingly networked and technology-driven world, the importance of a reliable and secure infrastructure is growing – both in the private- and corporate sphere. The ongoing war in Ukraine casts light on the consequences that one-sided energy dependencies and other geopolitical risks can have on a nation's security of supply. In this context, cyber security is also becoming increasingly relevant. Energy and digital infrastructure are interacting more robustly than in the past as factors relevant to the issues of location and competitiveness. Germany faces the major challenge of mastering the tasks of an effective and networked energy transition through the interplay of state and private sector initiatives.

"We are undergoing a truly unprecedented process of reorganisation with all stakeholders and components of the energy industry. This applies to all sectors and energy sources."
Dr Christoph Helle (MVV Energie)

LBBW and the CFIN - Research Center for Financial Services at Steinbeis University conducted a comprehensive analysis to assess the impact of the energy transition and digitalisation on the entrepreneurial transformation in Germany. For this purpose, a total of 355 German companies were surveyed as part of a primary survey – including 314 companies from various sectors (main sample) and 41 stakeholders from the energy industry (additional sample).[1] Furthermore, in-depth findings were generated through expert interviews with energy sector managers.

The state of Germany's energy infrastructure fails to deliver a convincing performance

"As a company, we are also convinced that the energy transition can succeed. However, there are certain requirements that must be met. In particular, numerous stakeholders have to work together and efficiently, while ensuring that all moving parts are harmoniously interlinked with one another."
Marcel Münch (EnBW)

The state of the energy supply remains one of the biggest business challenges. 84% of the companies surveyed (main sample) state that this factor represents an obstacle for them, and limits the scope for the company's success. Only the shortage of skilled labour and an excess of bureaucracy were rated by companies as major disruptive factors. It is striking that the state of digital infrastructure (e.g. broadband availability) also represents an obstacle for the majority of respondents.

In order to generate an overarching and meaning scope of opinion, the participants were asked to rate the state of the German energy infrastructure using a school grading scale. Here, it is clear that only a minority are convinced: roughly three out of five companies give a score of three ("satisfactory") or worse. Stakeholders from the energy industry

[1] Survey period: 15 March 2024 – 8 April 2024

are somewhat more positive about their own sector, with more than half awarding "very good" or "good" grades (see Figure 1).

According to the survey, the state of the energy infrastructure – which is rated as being in need of improvement – is due to past neglect. Only one in five companies in the main sample is clearly in favour of further development efforts in the areas of electricity, heat and fuels over the last ten years being sufficient to meet today's requirements.

"Germany [...] must [...] reduce its dependence on three energy sources at once: nuclear energy, coal and gas – while of course, at the same time, ensuring its security of supply."
Marcel Münch (EnBW)

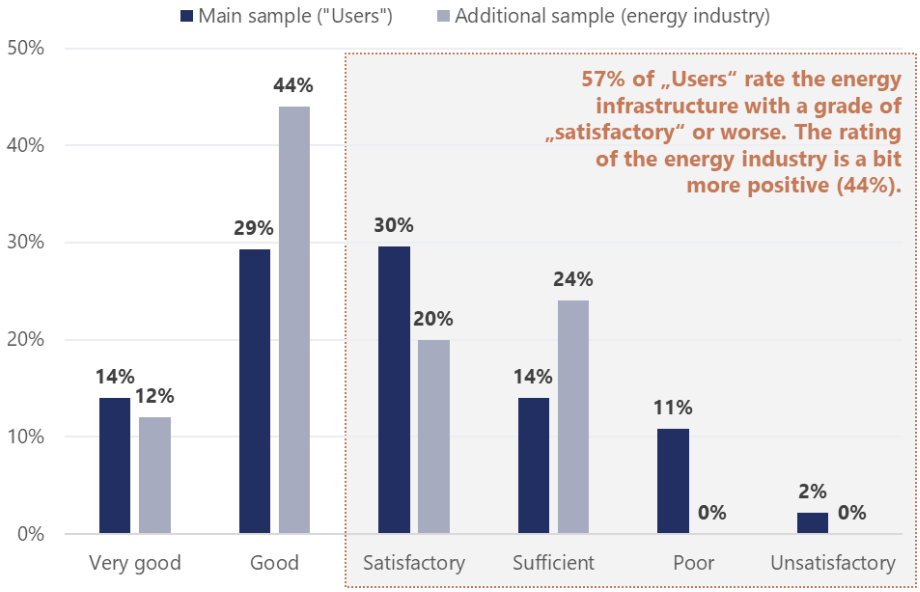


Fig. 1: Assessment of the current state of German energy infrastructure from the perspective of companies (main sample) and the energy industry (source: CFIN)

"The question as to whether the security of the natural gas supply has been permanently resolved can only be answered to a limited extent. Thanks to the rapid construction of LNG terminals, we have succeeded in expanding import opportunities in Germany to a significant extent. Simultaneously, the transport network has been (and is being) upgraded to facilitate an increased west-east flow. This means that the necessary transport and import capacities are available."
Dr Matthias Jenn (bayernets)

90% of companies want to invest in the medium term

As things stand today, almost no company is energy-independent – in other words, a company that generates more electricity itself than it has to purchase from third-party suppliers. Roughly a quarter currently generate their own electricity and/or heat. Companies remain ambitious when it comes to reducing energy consumption – despite having already made frequent savings due to the gas crisis. On average, respondents are planning a reduction of 23% over the next ten years.

Nine out of ten companies (main sample) want to invest in their own energy supply in the medium term. As part of these endeavours, people are not relying on the state: although two-thirds state that the energy transition offers a great opportunity to become less dependent on energy supplies, 78% per cent see this opportunity being jeopardised by

current economic policy measures. Private-sector initiatives are focussed on increasing energy efficiency, expanding the company's own renewable energies and purchasing green energy.

"Technically speaking, we will find a solution for all problems. I suspect that financing will be the biggest challenge. Accordingly, we need a sophisticated system that incentivises private-sector investment."
Dr Matthias Jenn (bayernets)

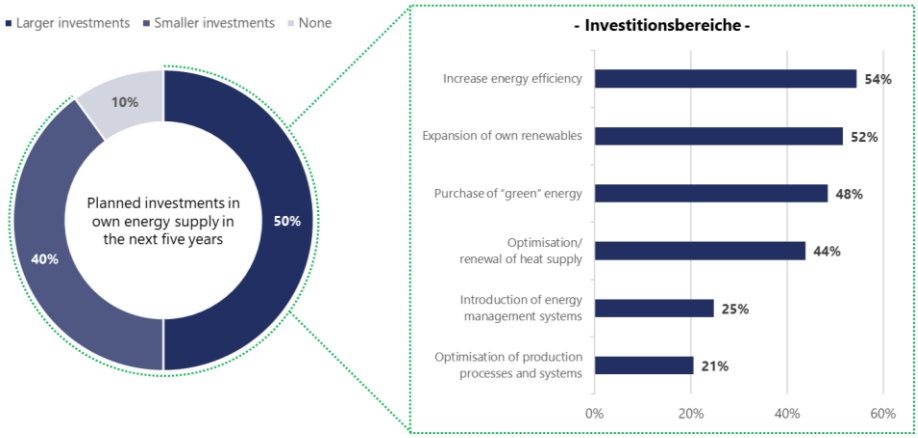


Fig. 2: Envisaged investment areas for companies with regard to their own energy supply (source: CFIN)

The survey also makes the following clear: Companies require a lot of capital to realise their projects. 80% of companies (main sample) need to significantly increase their equity or debt capital, in order to cope with upcoming investments in terms of energy transition and digitalisation. The energy industry itself is also facing an immense financing challenge. At 85%, the proportion with a significant financing requirement is even higher than in the main sample, with a focus on debt components.

The key role played by banks and other private investors

Large sums are to be spent primarily on the expansion of renewables and transmission grids. In this context, 83% rate the role of banks and other private lenders as important (additional sample) – simultaneously, their initiatives are sometimes still rated as having room for improvement.

The energy industry, in particular, is diversifying its financing structure, in order to successfully manage the transformation. Today, 59% already rely on infrastructure or project financing, 17% are planning to do so in the future and an additional 7% have not yet found the right structure for this (despite existing demand). Other off-balance sheet financing is also expected to be used more frequently going forward.

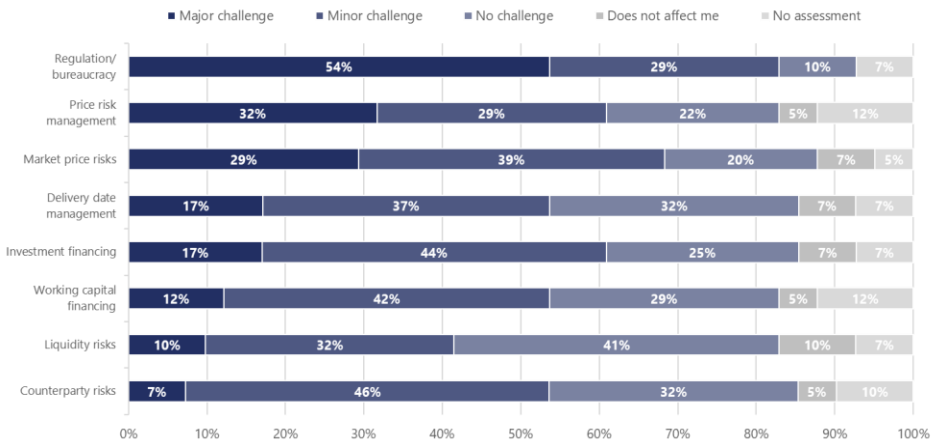


Fig. 3: Challenges facing energy industry finance (source: CFIN)

In addition to regulatory issues, the key challenge with regard to energy industry finance lies in fluctuating market prices and how they are managed. Roughly half of energy companies already use the support of banks in the fields of electricity, gas and emissions trading – and demand is growing. In electricity trading, for example, 22% state that they want to work together in the future. The focus here is on the assumption of market price and liquidity risks by banks and other financial service providers as an alternative to exchange-traded derivatives (hedging).

Strong connection between the energy transition and digitalisation

"We are witnessing a sharp increase in electrical consumption – not only in the areas of heating and e-mobility, but also enormously in data centres. Meeting this demand and ensuring security of supply as usual represent a major challenge for the sector in the years to come. In my opinion, however, the biggest bottleneck will not be in generation [...] the expansion of the transmission and distribution grids will be much more challenging."
Dr Christoph Helle (MVV Energie)

A successful energy transition is closely linked to the effective and continuous development of digital infrastructure – and vice versa. Intelligent energy systems (e.g. smart metering, smart grids) require digital measurement and control mechanisms. Similarly, data centres and digital applications (especially artificial intelligence) are characterised by extraordinarily high and increasing energy requirements. One practical example of sector connectivity is the energy supply and the green waste heat process in data centres. In an optimal scenario, the data centre is powered by renewable energy. The waste heat from the servers is converted into hot water using water coils and utilised in the municipal heat supply with the aid of heat pump technology.

The managers surveyed (main sample) also identified this interdependency: 76% agree with the idea that the energy transition in Germany could fail due to an underdeveloped digital infrastructure. As in the energy sector, companies identify catch-up potential here: Half of all respondents rate the progress made in recent years as inadequate, both in terms of fixed network broadband expansion and mobile communications.

Infrastructure as a location and competitive factor

Only seven per cent of respondents in the main sample stated that the condition of energy and digital infrastructure is only a weak competitive factor. For a large majority, these factors are of high (or very high) importance in national and international competition.

"The interplay between the two areas of infrastructure plays a key role in the competitiveness and appeal of German companies."
Marcel Münch (EnBW)

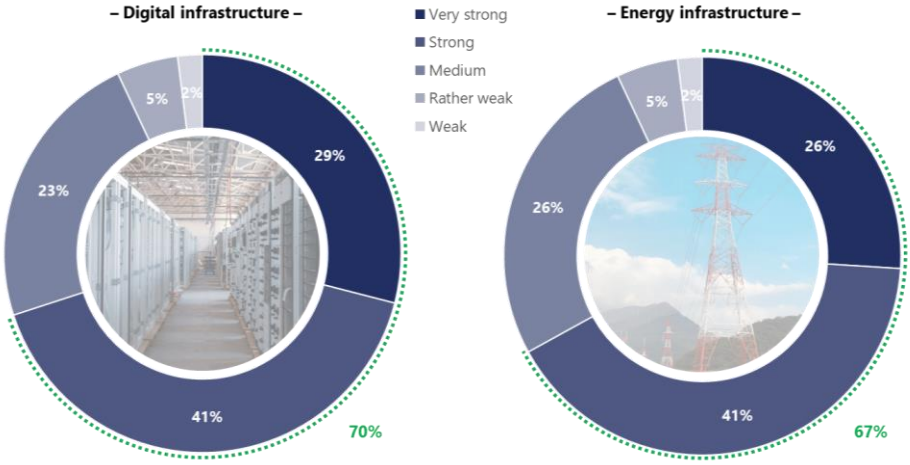


Fig. 4: Perceived connection between national infrastructure and entrepreneurial, international competitiveness (source: CFIN)

"Among corporates, however, [...] broadband expansion is (and will very quickly become) increasingly relevant, both in the competition for customers and employees.
Michael Weiss (LBBW)

Conversely, infrastructural weaknesses are also responsible for the location decisions of companies headquartered in Germany. 23% state that they have already relocated capacities abroad due to weaknesses in the energy sector. An additional 38% are currently considering this – an unwelcome scenario for the German economy. According to interviews with experts, these effects are triggered, in particular, by a lack of cost transparency and economic policy uncertainties. These figures are significantly lower for digital infrastructure.

Bureaucracy and regulation as obstacles to the energy transition?

The energy industry adopts a self-critical stance in the survey: Although it rates the overall situation slightly better than the "users", weaknesses are particularly evident in the expansion of renewable energies, which remains important for the energy transition. Only 41% see (very) good progress here. Looking to the past, it is also recognised that the energy infrastructure has not been developed to a sufficient extent. The experts identify regulatory requirements, dependence on energy suppliers and the sector's persistently high CO2 emissions as the greatest weaknesses.

[...] I would assign particular relevance to the topic of smart metering and smart grids. "Given that we have an increasing number of electricity-based applications, in conjunction with the fact that both decentralisation and simultaneity (e.g. many people charging their e-car at the same time in the evening) are increasing significantly, intelligent control is becoming a key success factor."
Dr Marcel Zürn (LBBW)

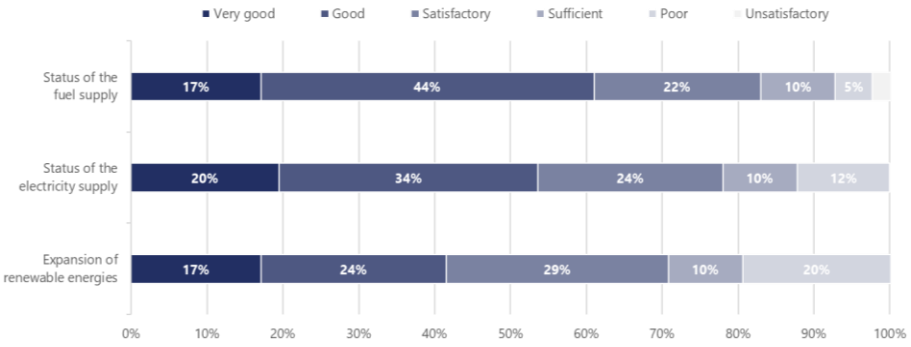


Fig. 5: Assessment of the status of various areas of energy supply by companies within the energy industry (source: CFIN)

When concerning the role of the state, disagreement prevails: While 39% are in favour of stronger state intervention, 34% prefer a freer market. Only a quarter of respondents currently see an optimal level of state intervention. The efforts and initiatives of the German government are viewed in a comparatively critical way: Only 41% awarded a school grade equivalent of one ("very good") or two ("good"). This figure is 47% for industry and 54% for private households. 59% rate the work of their own sector (energy suppliers) as (very) good.

Benefits of an effective digital infrastructure for the energy transition

"Data growth will continue to increase significantly going forward, particularly in view of the role played by applications – such as artificial intelligence and, later on, autonomous driving and the Internet of Things. These innovations will grow, and will require the expansion of digital infrastructure."
Michael Weiss (LBBW)

The advantages of an energy transition with strong digital networking identified by energy industry experts are manifold, the most important of which include:

- Sector connection: Efficient linking of energy generation, transport, storage and utilisation
- Efficiency gain: Optimised control and utilisation of decentralised energy generation and supply
- Transparency: Increased insight into generation and consumption situations thanks to technologies such as smart metering
- Resilience: Real-time monitoring of energy systems enables the early detection of potential issues
- Profitability: Optimised use of resources and switch to renewables enables long-term financial benefits

Although the relevance is rated as very high, the industry identifies weaknesses in the expansion of smart energy infrastructure. In particular, the speed and reliability of the digital infrastructure (62%) and excessive bureaucracy (48%) are cited as disruptive factors.

Conclusion

"On the one hand, an increasing number of applications are being powered by electricity, but liquid and gaseous energy sources will also play a key role in tomorrow's world – hydrogen and derivatives – such as ammonia and synthetic fuels – will play an important role here."
Dr Marcel Zürn (LBBW)

Economic policy developments of recent years have contributed to an increased awareness and relevance of national infrastructure. The disciplines of energy supply and digitalisation, in particular, have – more than ever before – become important factors in international competition, and exert a decisive influence on the choice of location for local companies. Both public and private sector investments and initiatives are crucial, in order to successfully driving forward the transformation of both the economy and society. Germany is facing a historic challenge with its energy transition, which can only succeed with ambitious planning and a willingness to invest, combined with a strong digital component. The results of the study reveal that there is a tremendous need for action; however, expert opinions also provide grounds for optimism.

The detailed survey data and the expert interviews are presented on the following pages.

Direct access to the study results:

The objectives underpinning the "Infrastructure Study 2024" are to be achieved by means of specific surveys of companies, along with expert interviews

Project approach

1 Survey of companies ("users")

Method: Structured survey of companies from various industries

Focus: Energy infrastructure and digital infrastructure, as well as corporate transformation

Target: Comprising a general categorisation of the status quo regarding digital and energy infrastructure in Germany from a broad corporate perspective

2 Survey of the energy industry

Method: Structured survey of companies operating within the energy industry

Focus: Energy infrastructure, along with financing and investment projects

Target: Gaining industry-specific knowledge for an improved understanding

3 Expert interviews

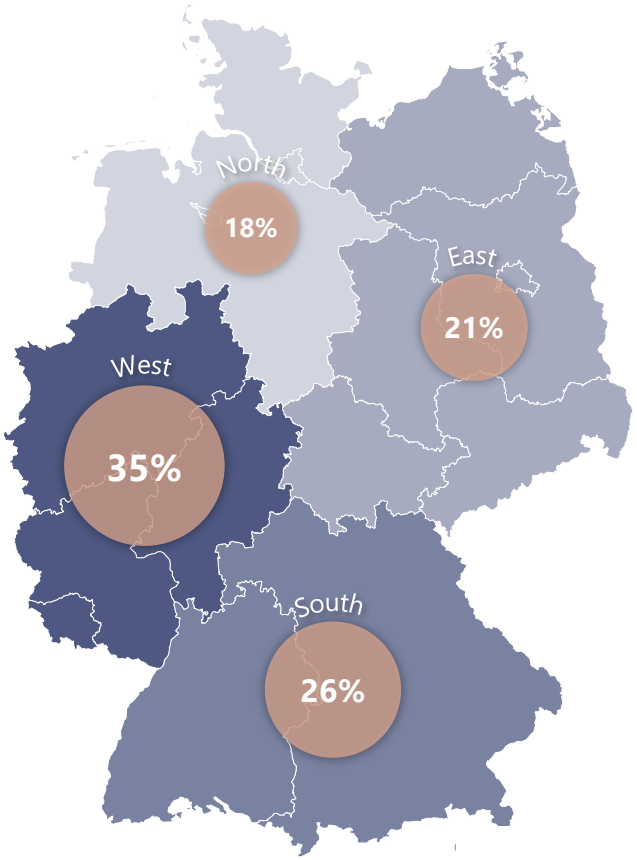
Method: Semi-structured interviews with experts from the disciplines of energy and digitalisation

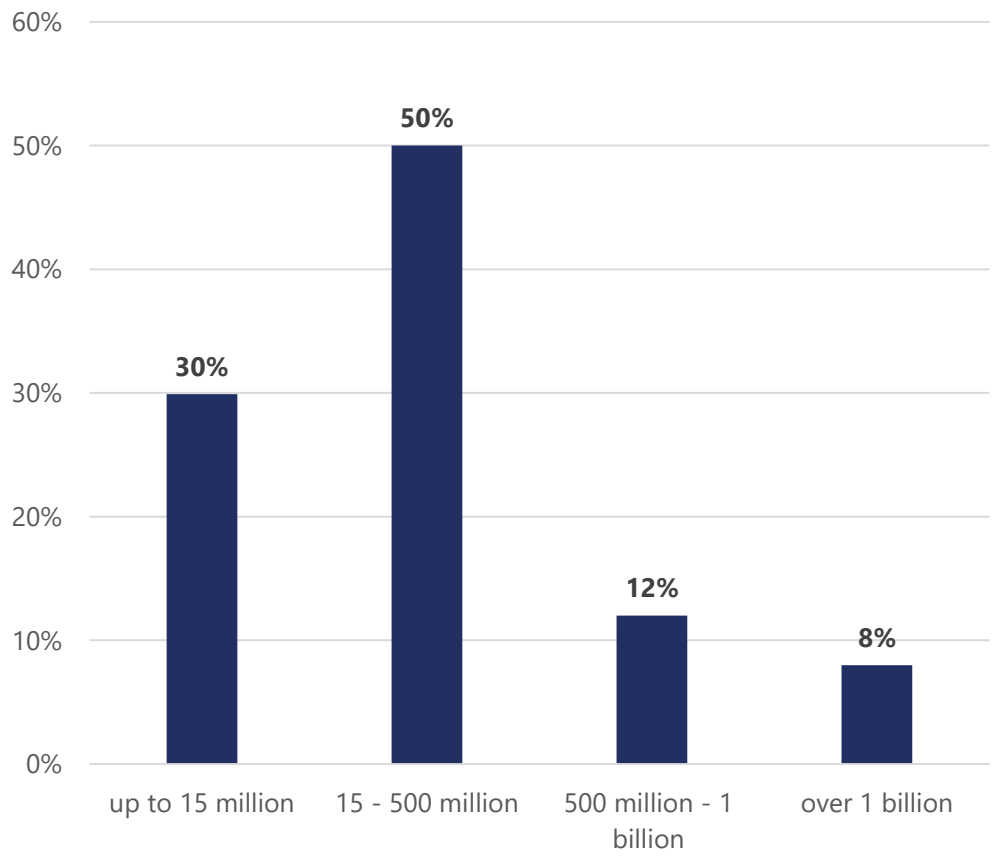
Focus: Company-specific issues relating to digital and, in particular, energy infrastructure

Target: Expansion (and plausibility assessment) of findings from company surveys, combined with gaining company-specific insights

As part of the general survey, 314 companies of different sizes were questioned on the topics of energy infrastructure and digital infrastructure

Regional distribution and company sales in EUR

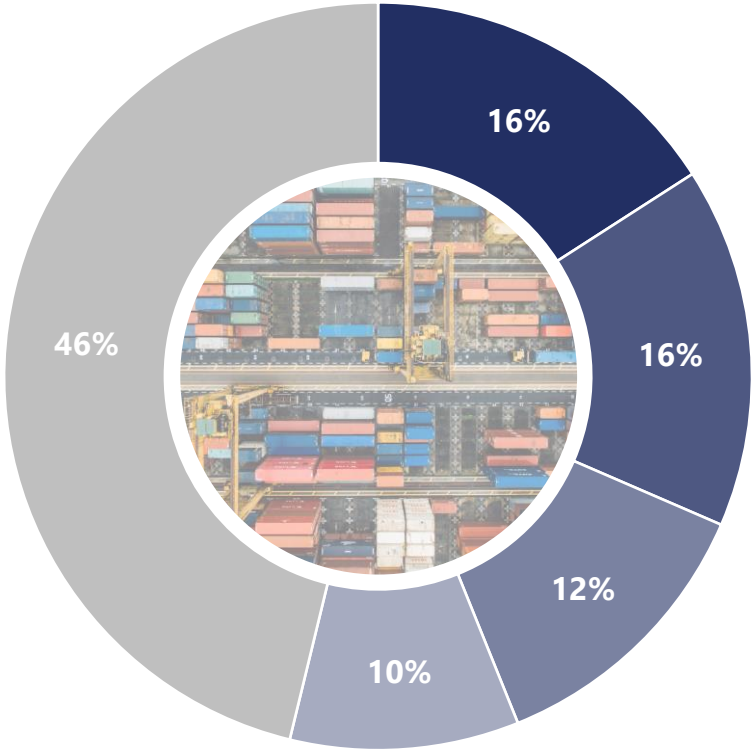




The focus industries defined in advance are each represented in the survey sample with a share of over 10%

Industry distribution of the companies being surveyed

– Industry distribution –



Focus industries (54%)

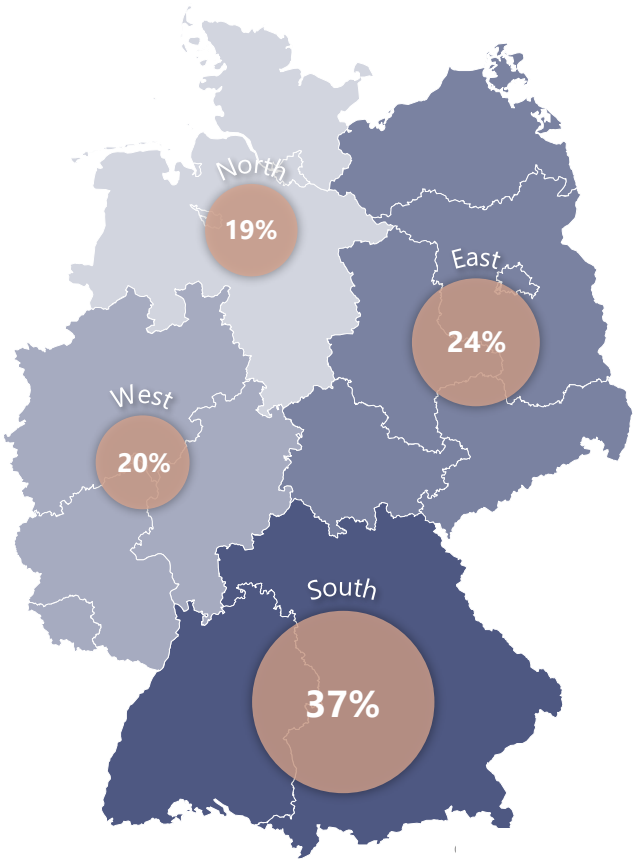
- Telecommunications, media and electronics or IT
- Pharmaceuticals and healthcare
- Mechanical and plant engineering
- Automotive and vehicle construction

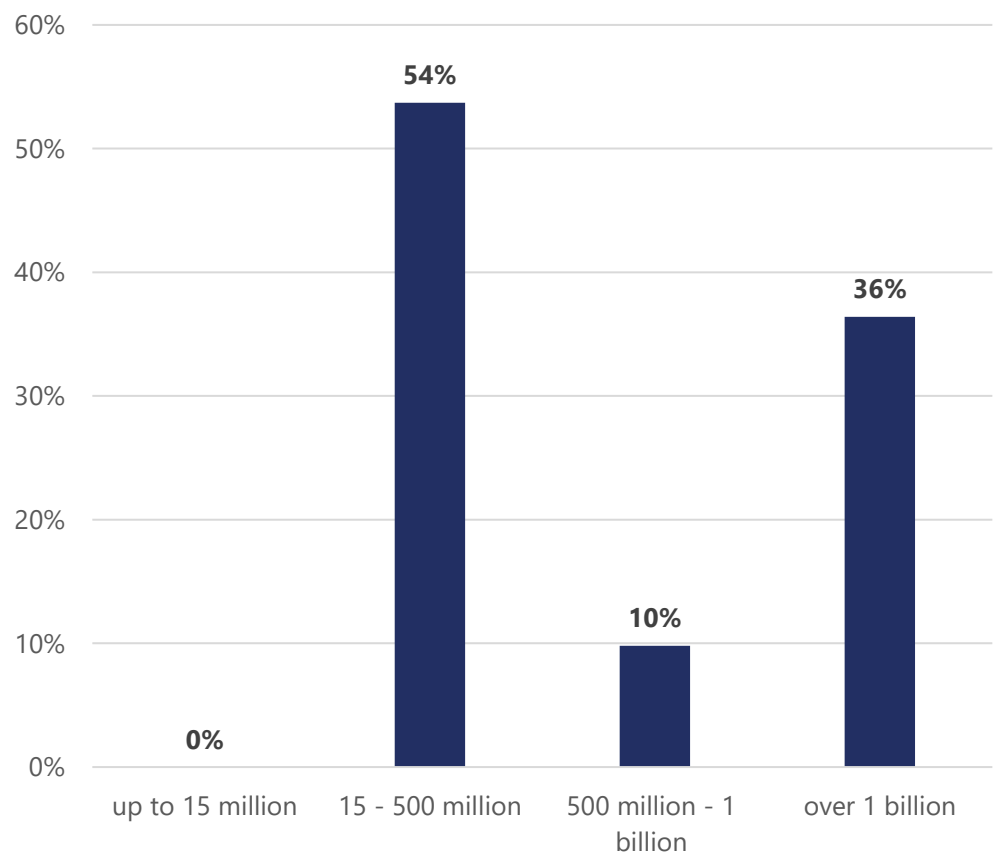
Other sectors (46%)

- Financial services
- Transport and logistics
- Retail and consumer goods
- Agriculture
- Housing industry
- Other services
- Construction industry
- Cross-industry companies
- Chemistry and raw materials
- ...

As part of the specific survey, 41 companies of different sizes from the energy industry were questioned on the topics of energy infrastructure and digital infrastructure

Regional distribution and company sales

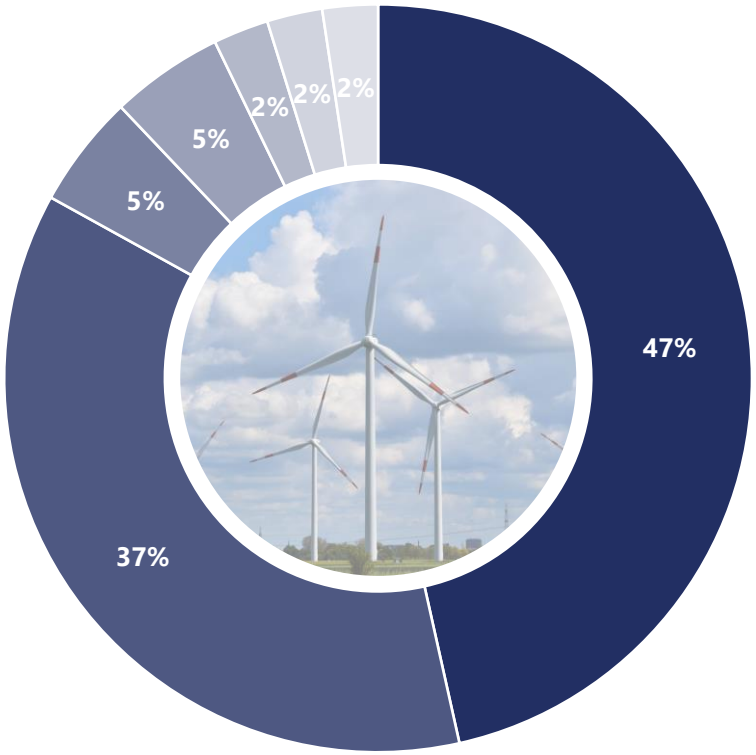




Energy suppliers, municipal utilities and energy producers are particularly well-represented among the energy companies surveyed

Distribution of sub-operational areas of surveyed companies

– Distribution of sub-operational areas –



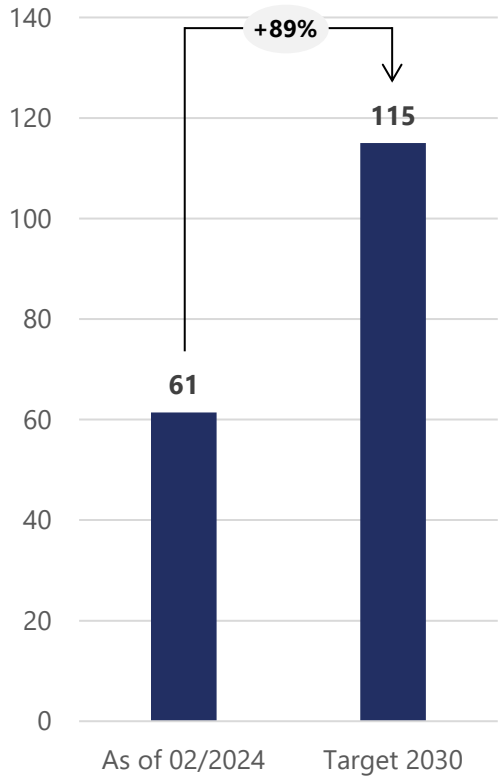
Sub-operational areas: Energy sector

- Energy suppliers / municipal utilities (47%)
- Energy producers (37%)
- Energy trading companies (5%)
- Consultancy and services (5%)
- Transmission system operators (2%)
- Distribution system operators (2%)
- Research and development (2%)

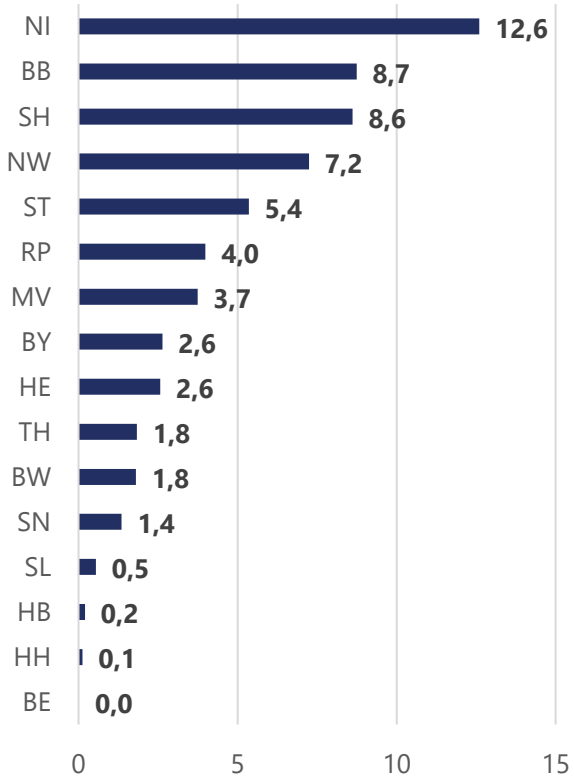
Expansion of onshore wind turbines has risen over the past 5 years following a slump in 2018, but at an insufficient level to achieve the target set under the Renewable Energy Act (EEG)

Expansion of onshore wind turbines in Germany

– Total installed onshore wind power capacity (in GW) –



– Gross regional onshore wind power capacity (in GW) –



– Summary –

- According to the target set under the Renewable Energy Act (EEG), installed wind power capacity is to be increased by approximately 89% by 2030 (02/2024)
- This requires an increase in average monthly net additions of roughly 245%, from 266 MW (Ø 03/2023 - 02/2024) to 653 MW
- Large regional differences (especially the north-south divide) in the expansion of onshore wind power plants

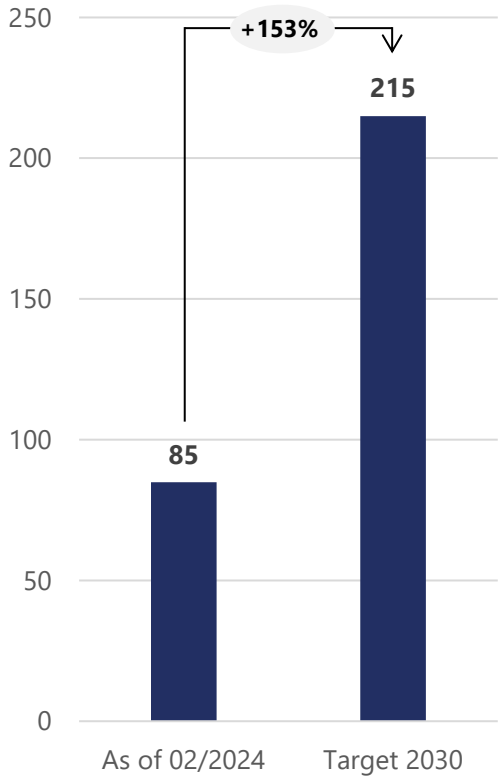
Significant investment sums required to achieve ambitious targets and to equalise regional differences

Source: Federal Network Agency (Bundesnetzagentur) – Statistics on selected renewable energy sources for electricity generation (February 2024)

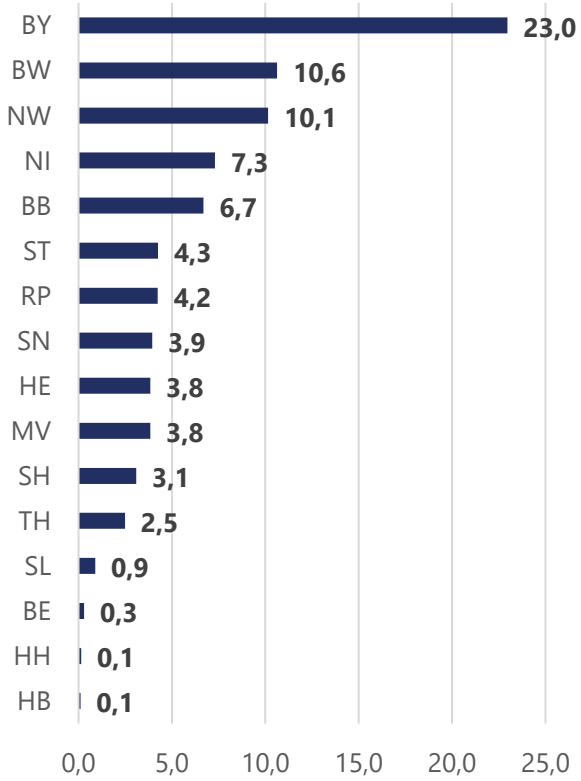
Although, at present, there remains much to be done to achieve the "EEG 2030 Target", the expansion of photovoltaic systems has registered very positive development in recent years

Expansion of solar radiation energy in Germany

– Total installed photovoltaic capacity (in GW) –



– Gross regional output of solar radiation energy (in GW) –



– Summary –

- According to the target set under the Renewable Energy Act (EEG), installed PV capacity is to be increased by approximately 153% by 2030 (as of: 02/2024)
- This requires an increase in average monthly net additions of roughly 24%, from 1,280 MW (Ø 03/2023 - 02/2024) to 1,582 MW
- While BY and BW perform poorly in wind energy in a state-level comparison, they are pioneers in solar energy

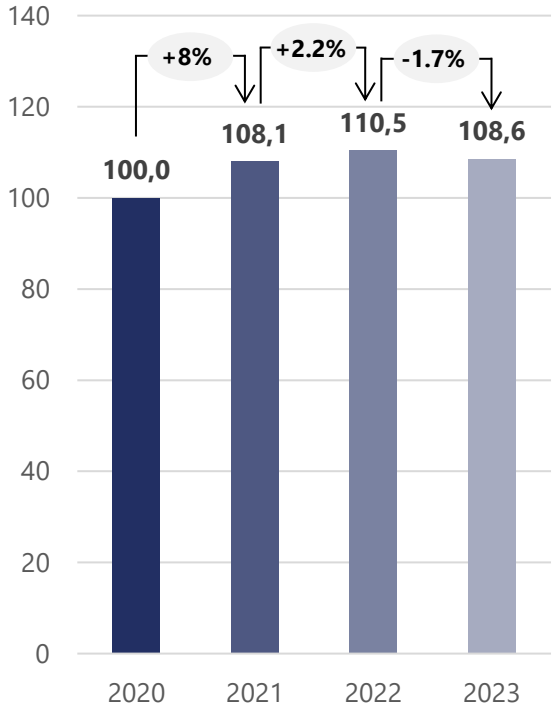
Further efforts are also required within the photovoltaic sector, in order to achieve established EEG targets

Source: Federal Network Agency (Bundesnetzagentur) – Statistics on selected renewable energy sources for electricity generation (February 2024)

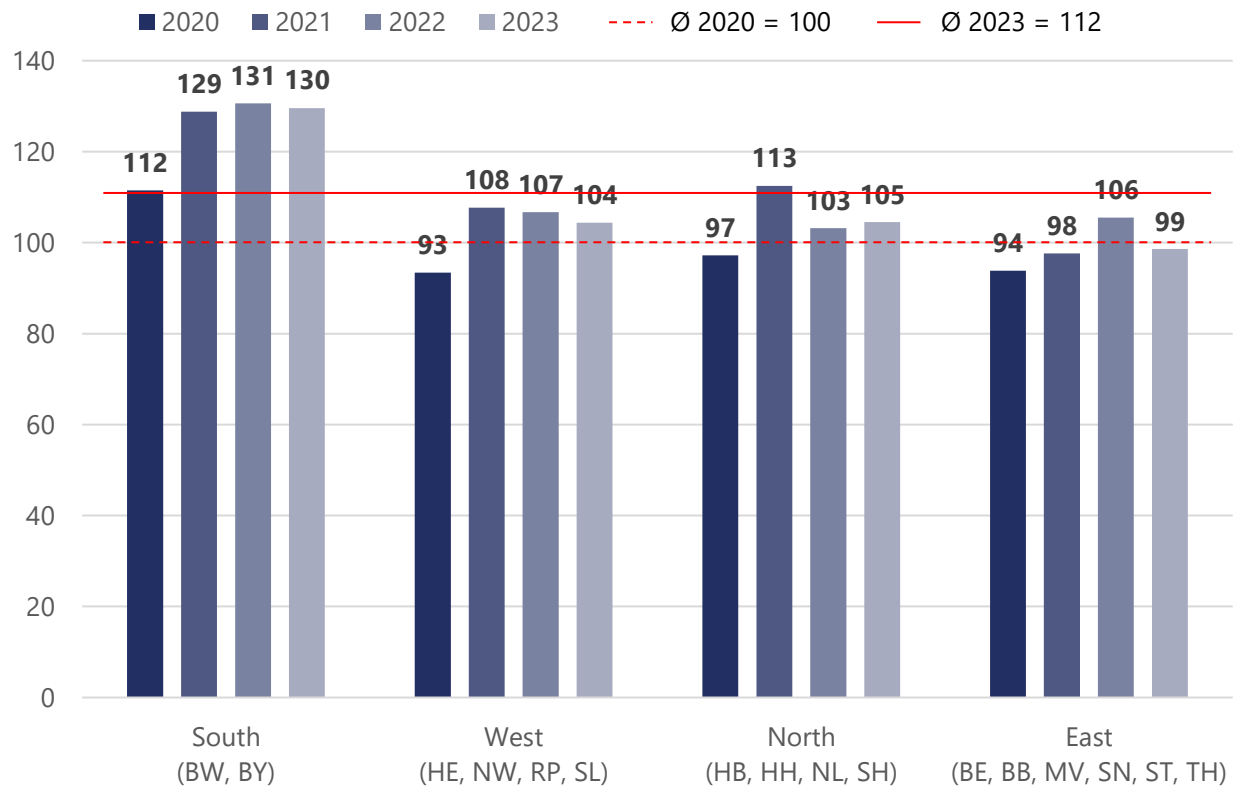
After digitalisation in Germany registered a significant advance in the first year of the Covid-19 pandemic (2020), it fell again in 2023

Digitisation index Germany

– Development of index as a whole –



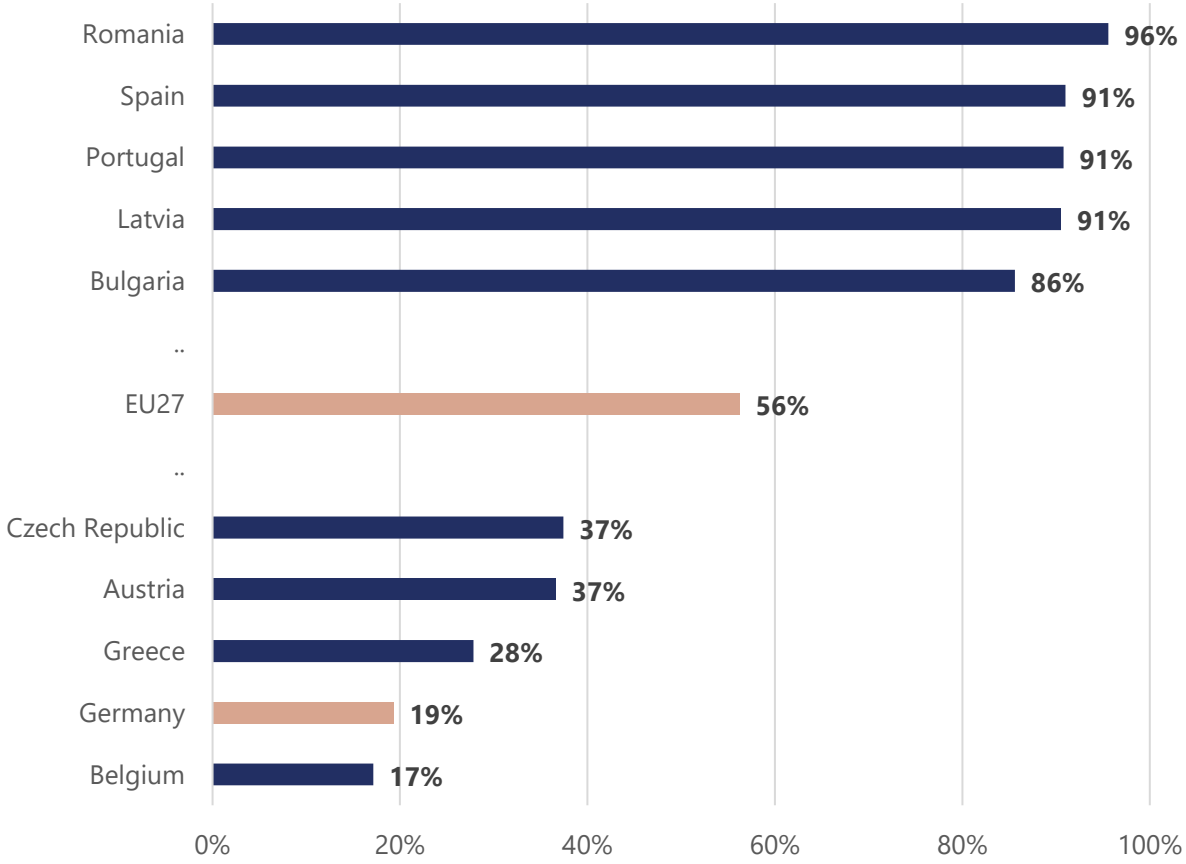
– Index development by federal state group –



Source: German Economic Institute (Institut der deutschen Wirtschaft) – Digitalisation Index 2023

In a European comparison, Germany has a lot of catching up to do in terms of fibre optic network coverage, among other things

Comparison of FTTP fibre optic network coverage 2023



Source: DESI 2023

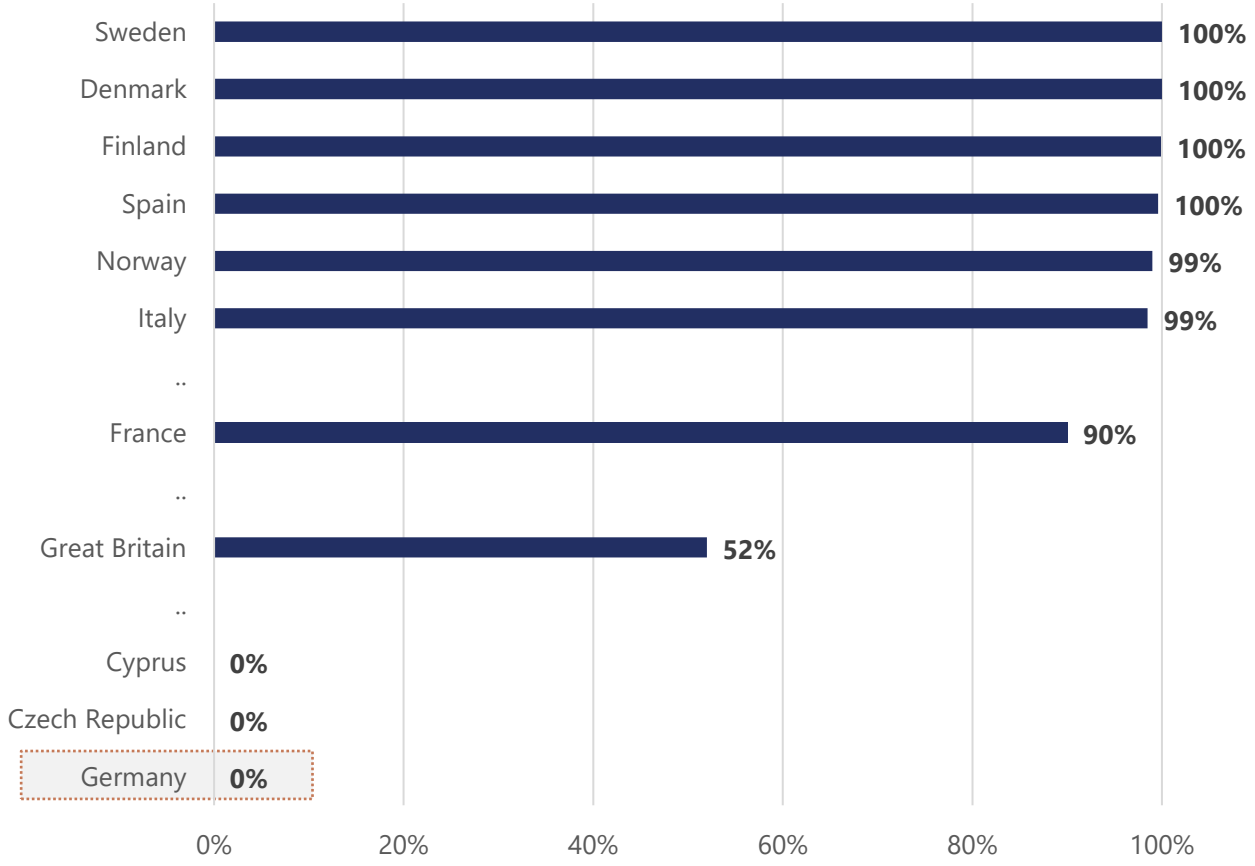
– Summary –

- FTTP stands for "*Fibre to the Premises*", i.e. for households or buildings connected to the Internet with optical fibre
- FTTP coverage results from the ratio between connected households and all households
- Germany ranks second to last – with just 19 per cent coverage
- On average, fibre optic network coverage in the EU27 is 56%

Germany clearly lags behind when seen at EU level in terms of fibre optic coverage

Germany – with a barely measurable distribution of smart meters by the end of 2022, at the bottom of the pack when viewed in a European comparison

Deployment of smart meters in the EU + UK in 2022



Source: CEER 2023

– Summary –

- Germany in last place in an EU ranking by the end of 2022 with the marginal distribution of smart meters
- 13 out of 27 EU countries have a smart meter distribution rate of over 80%
- In the Nordic countries, in particular, the distribution of smart meters is close to 100%

Germany has a lot of catching up to do in terms of the use of smart meters

Robust and reliable energy infrastructure and state-of-the-art digital infrastructure are mutually dependent factors, in order to facilitate a competitive industry

Interrelationships and dependencies (1/2)

– Smart grids –

- **Smart grids** utilise digital technologies to monitor the flow of electricity and optimise control using the principle of **bi-directionality**
- By participating in **load balancing**, companies help to ensure the stability of the electricity grid
- Additional security through the establishment of effective "**micro grids" for the decentralisation of energy systems** requires advanced digital control and monitoring systems

– Smart meters and IoT –

- Analysing and transmitting large volumes of data generated by **smart meters and IoT devices** necessitates a robust **digital infrastructure**
- In connection with so-called "Smart Grids", smart meters help companies **optimise their electricity consumption**
- **Process automation** based on digital structures and, when necessary, **process optimisation using AI** also require reliable energy grids and high computing capacities

– Electromobility –

- **Smart charging** for the intelligent management of charging processes with the aim of preventing grid overloads is only possible with **stable internet connectivity**
- **Vehicle-2-Grid** (V2G) offers companies with large vehicle fleets additional revenue opportunities by **feeding energy back into the grid** at peak load times
- Within **fleet management**, companies benefit from **telematics solutions** for real-time monitoring of the condition and performance of vehicles

As with the use of waste heat from data centres, the combination of state-of-the-art digital and energy infrastructure can lead to an increase in positive effects

Interrelationships and dependencies (2/2)

Legend
- Water/ district heating network (cold/warm/hot)
- Power grid

– Green waste heat process from data centres in the municipal heat supply –

Renewable energies

Generating and feeding green energy into the power grid, which supplies the data centre, the heat pump system and the municipality.

Data centre

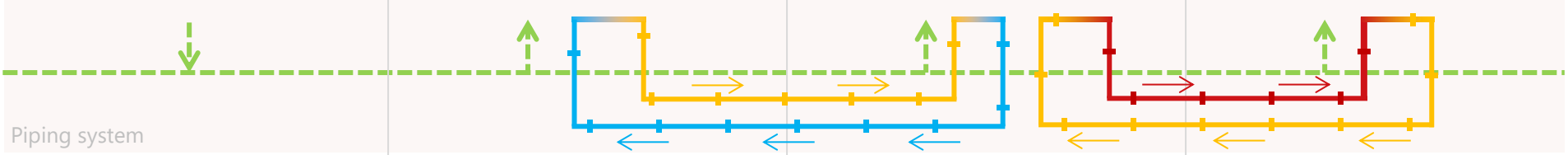
The servers – which are powered by renewable energy – produce waste heat in the form of warm air, which is converted into hot water via water coils.

Heat pump system

The hot water from the data centre is used – together with additional green electricity – to generate hot water for feeding into the district heating network.

Municipality

The regional municipality is supplied with heat in the form of hot water via the district heating network.



The high costs of restructuring the German energy system can only be met through co-operation between the state, companies, financial institutions and households

Media perception[1] – Energy infrastructure (1/2)

– Costs of the energy transition –

Energiewende

So viel kostet die Infrastruktur der Zukunft

Eine exklusive Analyse zeigt: Die Energieinfrastruktur dürfte bis 2045 Investitionen in Rekordhöhe erfordern. Diese Summe wird der Staat nicht allein tragen können.

Catiana Krapp, Klaus Stratmann, Kathrin Witsch
11.01.2024 - 15:43 Uhr

- **Background:** The significant level of investment required for the conversion of the energy system totalling around EUR 1.1 trillion will be needed in the years to come
- **Details:** Costs are incurred, in particular, in the areas of electricity generation, energy storage, CO2 infrastructure, electricity, hydrogen and district heating networks

– Power plant strategy –

Förderung für Gaskraftwerke

Ampel einigt sich auf Kraftwerksstrategie

Stand: 05.02.2024 13:33 Uhr

Es war ein langes Ringen in der Ampelkoalition, nun steht ein Plan: Die Bundesregierung hat sich auf eine Strategie zum Bau neuer wasserstofffähiger Gaskraftwerke in Deutschland geeinigt.

Die Bundesregierung hat sich auf einen Kompromiss im Ringen um den Bau neuer Kraftwerke verständigt. Bundeskanzler Olaf Scholz, Wirtschaftsminister Robert Habeck und Finanzminister Christian Lindner hätten "die wesentlichen Elemente einer Kraftwerksstrategie sowie Festlegungen zu weiteren Vorhaben vereinbart", teilte die Bundesregierung mit.

- **Background:** Fluctuating generation of renewable energy requires flexible emergency capacities
- **Solution:** Federal government's power plant strategy to incentivise investment in hydrogen-capable gas-fired power plants to compensate for power fluctuations

– Missing the target for wind power –

Energiewende

Scholz' Ziele zum Windkraft-Ausbau drohen zu scheitern

Der Ausbau der Windkraft kommt langsamer voran als geplant. Umweltschutzverbände fordern deswegen jetzt weitere Erleichterungen für die Windenergie-Branche.

Klaus Stratmann
15.01.2024 - 18:16 Uhr

- **Background:** The target set by the country's Chancellor, Olaf Scholz, of erecting 4-5 wind turbines a day in Germany will be missed by a wide margin (Ø 2023: 2 installations)
- **Problems & Criticism:** Instead of shortening the realisation time, this has actually increased in recent years, previous de-bureaucratisation efforts insufficient*

Sources: handelsblatt.com, tagesschau.de *Statement based on figures from a study by "Fachagentur Wind" (FA Wind)
1) The content of the slide is based entirely on the respective articles, and is intended to provide an overview of the current media perception of the topic

While politicians endeavour to create investment incentives for private investors by reducing the associated bureaucracy, they are hampering innovation by nationalising infrastructure

Media perception[1] – Energy infrastructure (2/2)

– Expansion of hydrogen –

Infrastruktur in Deutschland

Wie Wasserstoff auf den Weg kommt

von Christine Elsner 24.04.2023 | 12:35

Wasserstoff gilt als Schlüsseltechnologie für die Energiewende. Damit das Gas zum Verbraucher kommt, ist funktionierende Infrastruktur nötig. Wie das in Deutschland gelingen kann.

Wasserstoff - vorzugsweise grüner Wasserstoff - gilt als wichtige Komponente auf dem Weg zur Klimaneutralität. Sowohl die EU als auch Deutschland haben im Sommer 2020 ihre eigenen Wasserstoffstrategien gestartet. Noch aber existiert kein flächendeckendes Verteilnetz für Wasserstoff.

- **Background:** The energy crisis in the wake of the war in Ukraine has brought hydrogen to the fore as a key technology for the energy transition
- **Problem:** Germany is as yet unable to produce the required amount of green hydrogen itself, and investments in grid expansion are also required

– De-bureaucratisation –

Ausbauprojekte

Bundestag billigt raschere Gerichtsverfahren bei Infrastruktur

Verfahren können sich bei Großprojekten über mehrere Jahre ziehen. Besondere Bedeutung sollen die Energieinfrastruktur und Fernstraßen erhalten.

10.02.2023 - 11:49 Uhr

- **Background:** Major projects are often stuck in administrative court proceedings for years on end
- **Solution:** Formation of specialised chambers or senates for planning law to speed up case processing

– Nationalisation –

WIRTSCHAFT TENNET DEUTSCHLAND

Nächste heikle Verstaatlichung – jetzt greift der Bund auch zum Netz-Riesen

Veröffentlicht am 10.02.2023 | Lesedauer: 6 Minuten

Von **Daniel Wetzel**
Wirtschaftsredakteur

Die Bundesregierung will nun auch den größten Stromnetzbetreiber Tennet Deutschland übernehmen. Erste Gespräche wurden bereits aufgenommen. Der Staat mischt sich immer öfter in den Betrieb und die Eigentümer-Strukturen der Energiewirtschaft ein.

- **Background:** Increasing nationalisation of relevant parts of German energy infrastructure
- **Problems & criticism:** Loss of innovative strength and mixed track record in other publicly-owned infrastructure sectors (see the railway operator, "Deutsche Bahn")

Sources: zdf.de, handelsblatt.com, welt.de

1) The content of the slide is based entirely on the respective articles, and is intended to provide an overview of the current media perception of the topic

Despite political initiatives, funding projects and attempts to remove significant bureaucratic hurdles, the expansion of digital infrastructure is described in the media as being too slow

Media perception[1] – Digital infrastructure

– Status quo –

Gastkommentar

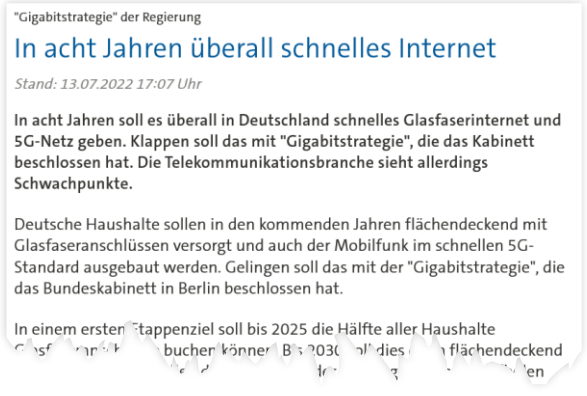
Der beschleunigte Ausbau von schnellem Internet droht zu scheitern

Vor einem Jahr hat die Bundesregierung ihre Gigabitstrategie verabschiedet. Passiert ist seither kaum etwas. Unternehmen fühlen sich eher ausgebremst als unterstützt, mahnt Markus Haas.

28.06.2023 - 11:45 Uhr

- **Background:** Decision on the "Gigabit Strategy" in 2022
- **Current status:** One year after the introduction of a package of measures, little has changed with regard to the planned reduction in bureaucracy, and there is a risk that the targets will not be met

– Political initiatives –



"Gigabitstrategie" der Regierung

In acht Jahren überall schnelles Internet

Stand: 13.07.2022 17:07 Uhr

In acht Jahren soll es überall in Deutschland schnelles Glasfaserinternet und 5G-Netz geben. Klappen soll das mit "Gigabitstrategie", die das Kabinett beschlossen hat. Die Telekommunikationsbranche sieht allerdings Schwachpunkte.

Deutsche Haushalte sollen in den kommenden Jahren flächendeckend mit Glasfaseranschlüssen versorgt und auch der Mobilfunk im schnellen 5G-Standard ausgebaut werden. Gelingen soll das mit der "Gigabitstrategie", die das Bundeskabinett in Berlin beschlossen hat.

In einem ersten Etappenziel soll bis 2025 die Hälfte aller Haushalte

- **Targets by 2030:**
  - Connection of all households and companies to the fibre optic network
  - Comprehensive 5G mobile communications standard
- **Measures:** Faster approval procedures for mobile phone masts, among other things

– Private sector investments –

Digitale Infrastruktur

Milliarden für die Netze: Unternehmen investieren in Rechenzentren und Funktürme

Die Digitalisierung verschlingt viel Kapital, Investoren drängen in den lukrativen Bereich. Auch die Politik will bei Schlüsseltechnologien wie Glasfaser und 5G aufholen.

Daniel Delhaes, Ingo Narat
30.08.2022 - 10:30 Uhr

- **Background:** Successful digital transformation requires significant levels of investment, especially on a private level
- **Investment requirements:** Over the next 10 years, the EU is expected to require equity investments totalling EUR 200 billion

Sources: handelsblatt.com, tagesschau.de

1) The content of the slide is based entirely on the respective articles, and is intended to provide an overview of the current media perception of the topic

Although key technologies with promising potential for an energy transition already exist in Germany, they have so far only been used in isolated cases

Media perception[1] – Interdependencies

– Potential of digital transformation –

ENERGIEWENDE

Das große Potenzial der digitalen Transformation im Energiesektor

VON JOHANNES HETT, NIKLAS KRINGS, JESSE YANG, YANNIK ZWEIDINGER*

AKTUALISIERT AM 07.09.2023 - 16:43

Deutschland setzt auf digitale Transformation für eine erfolgreiche Energiewende, stößt jedoch bei der praktischen Umsetzung auf Herausforderungen. Innovative Technologien und Projekte existieren, doch fehlt eine flächendeckende digitale Infrastruktur, zum Beispiel bei Smart Metern.

MERKEN 3 Min.

Die Energiewende ist in vollem Gange. Deutschland hat ehrgeizige Ziele formuliert und das Potenzial d… digitalen Technologien erkannt. Dennoch stehen wir vor großen …

- **Background:** Optimising the electricity grid and improving energy efficiency through digital transformation as the basis for a successful energy transition
- **Significance:** The German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft) describes the digitalisation of the energy industry as the biggest IT project of all time

– Smart electricity meters –

WIRTSCHAFT BONUS FÜRS STROMSPAREN

Der große Vorteil der Briten in der Energiekrise

Veröffentlicht am 24.01.2023 | Lesedauer: 5 Minuten

Von Claudia Wanner, **Daniel Wetzel**

Großbritannien ermöglicht Verbrauchern jetzt, mit digitalen Stromzählern das Netz zu entlasten und dadurch bares Geld zu sparen. Auch der selbst ernannte Energiewende-Vorreiter Deutschland hat den Vorteil erkannt – kann ihn aber aufgrund veralteter Technik nicht umsetzen.

- **Background:** Germany lags far behind other countries in terms of the technologies needed for a comprehensive energy transition
- **Statistics:** In the UK, 52% of all electricity meters are already smart and digital, compared to just 0.25% in Germany

– Artificial intelligence –

Stromnetz

Mit KI gegen eines der größten Probleme der Energiewende

Intelligente Algorithmen könnten nicht nur dabei helfen, das Stromnetz stabil zu halten, sondern auch die Kosten deutlich senken. Das sind die spannendsten Einsatzmöglichkeiten.

Anna Gauto
31.10.2023 - 04:00 Uhr

- **Background:** One of the biggest issues facing the energy transition are fluctuations in electricity generation using renewable energies
- **Example:** Virtual power plants, i.e. a large number of systems that communicate intelligently with each other (and commonly referred to as "battery swarm storage"), offer initial solutions

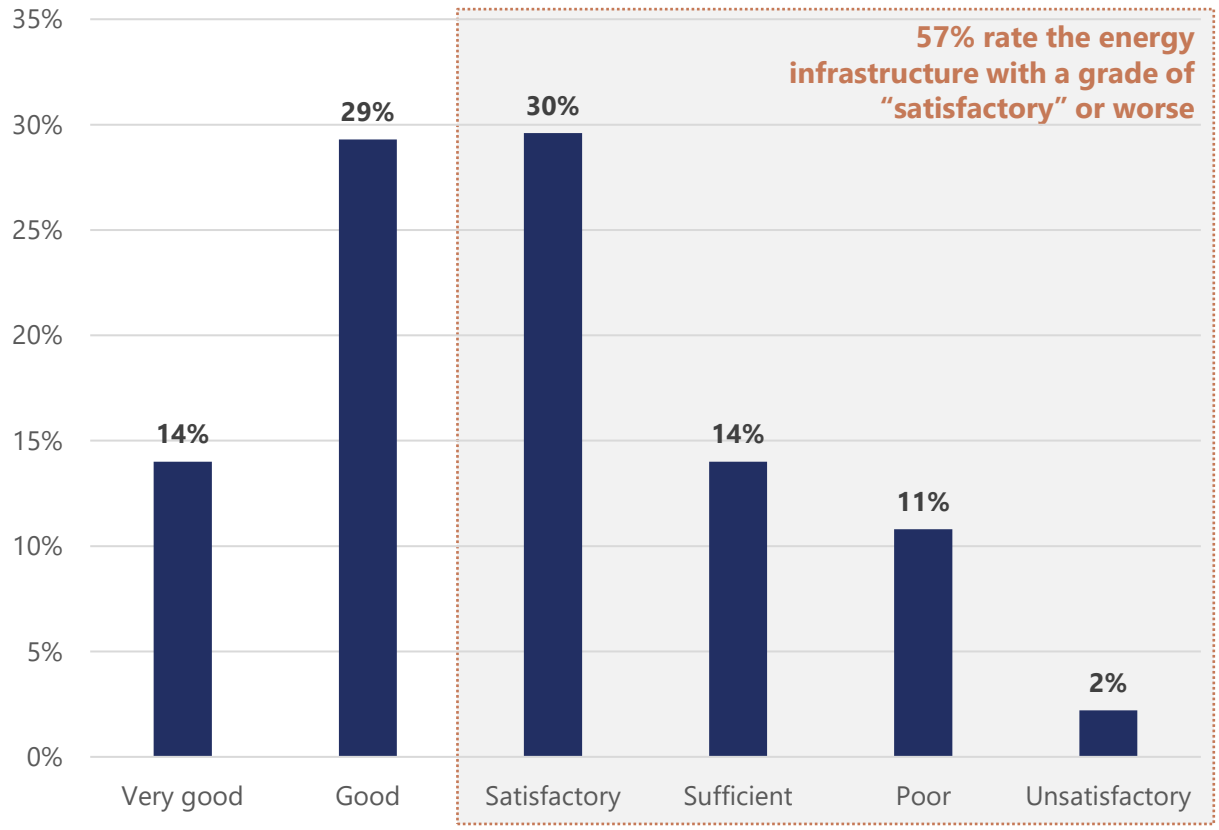
Sources: FAZ.net, welt.de, handelsblatt.de

1) The content of the slide is based entirely on the respective articles, and is intended to provide an overview of the current media perception of the topic

At 57%, more than half of companies rate the current state of the energy infrastructure in Germany with a grade of "satisfactory" or worse

Rating: State of the energy infrastructure in Germany

Main sample: "Users"



Question: How do you rate the current state of the energy infrastructure in general (electricity, heat, fuels) in Germany?

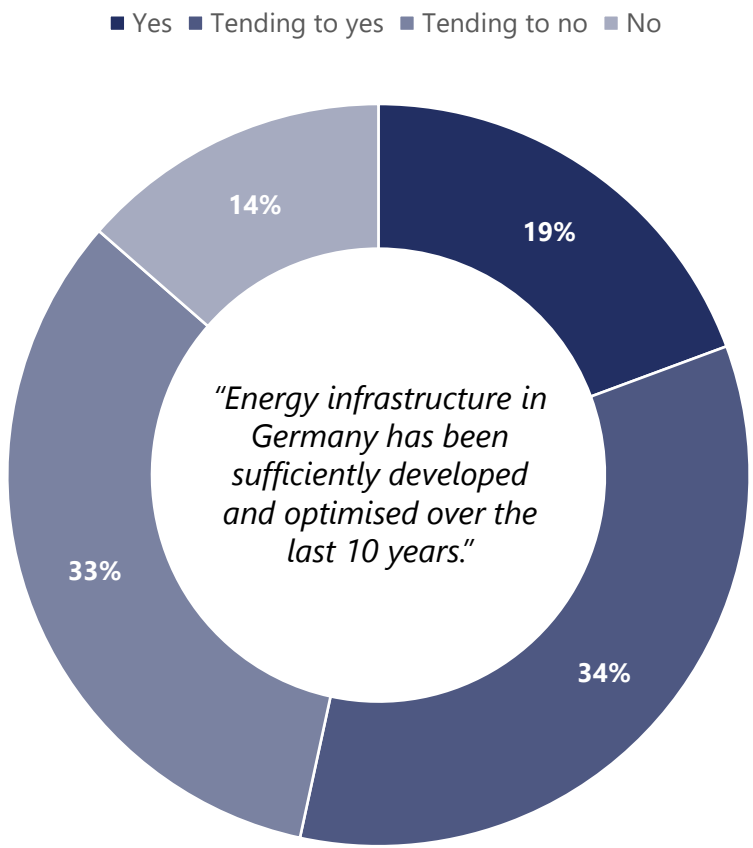
– Key takeaways –

- 14% of companies rate the condition of the energy infrastructure as "very good", a further 29% as "good"
- Just under one in three companies awarded a grade of "satisfactory" and a further 14% a "poor"
- 13% classify the energy infrastructure as inadequate or unsatisfactory
- On average, this results in only a "satisfactory" rating

Condition of infrastructure in Germany requires improvement according to the majority of respondents

Only 19% of the companies surveyed rated the development of the energy infrastructure in Germany over the last 10 years as "sufficient"

Development of the energy infrastructure in Germany



– Key takeaways –

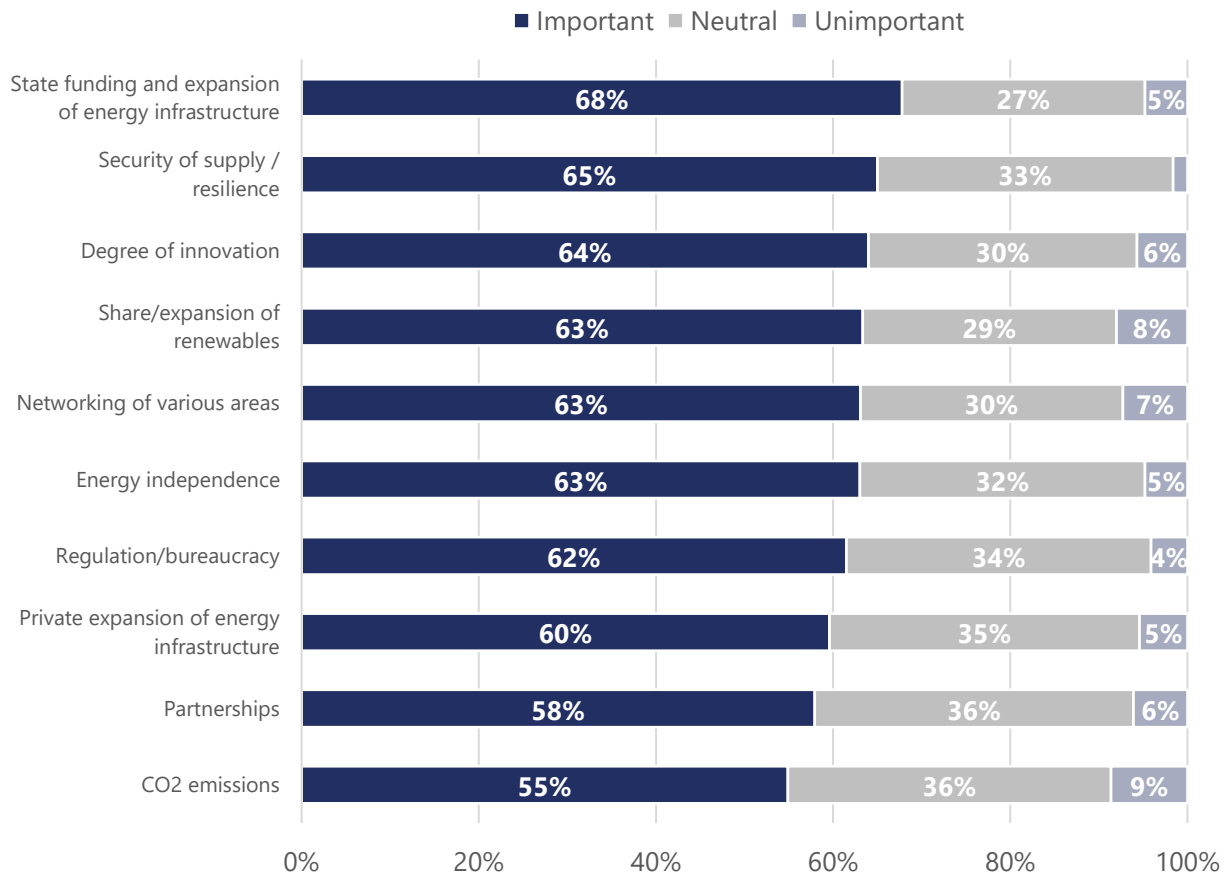
- Only 19% of companies rate the continuing development and optimisation of the energy infrastructure in Germany over the last 10 years as "sufficient".
- Almost one in two companies does not agree, and sees a considerable need to catch up in this area in some cases
- Approval ratings are significantly higher in the north and east than in the south and west of Germany

At 19%, only a minority rate the progress of expansion regarding energy infrastructure as sufficient

Question: In your opinion, has energy infrastructure in general (electricity, heat, fuels) in Germany been sufficiently developed and optimised in the last ten years?

Companies see the state as a key stakeholder with regard to German infrastructure; state funding or state expansion is the most important factor in this context

Relevance of energy infrastructure factors



– Key takeaways –

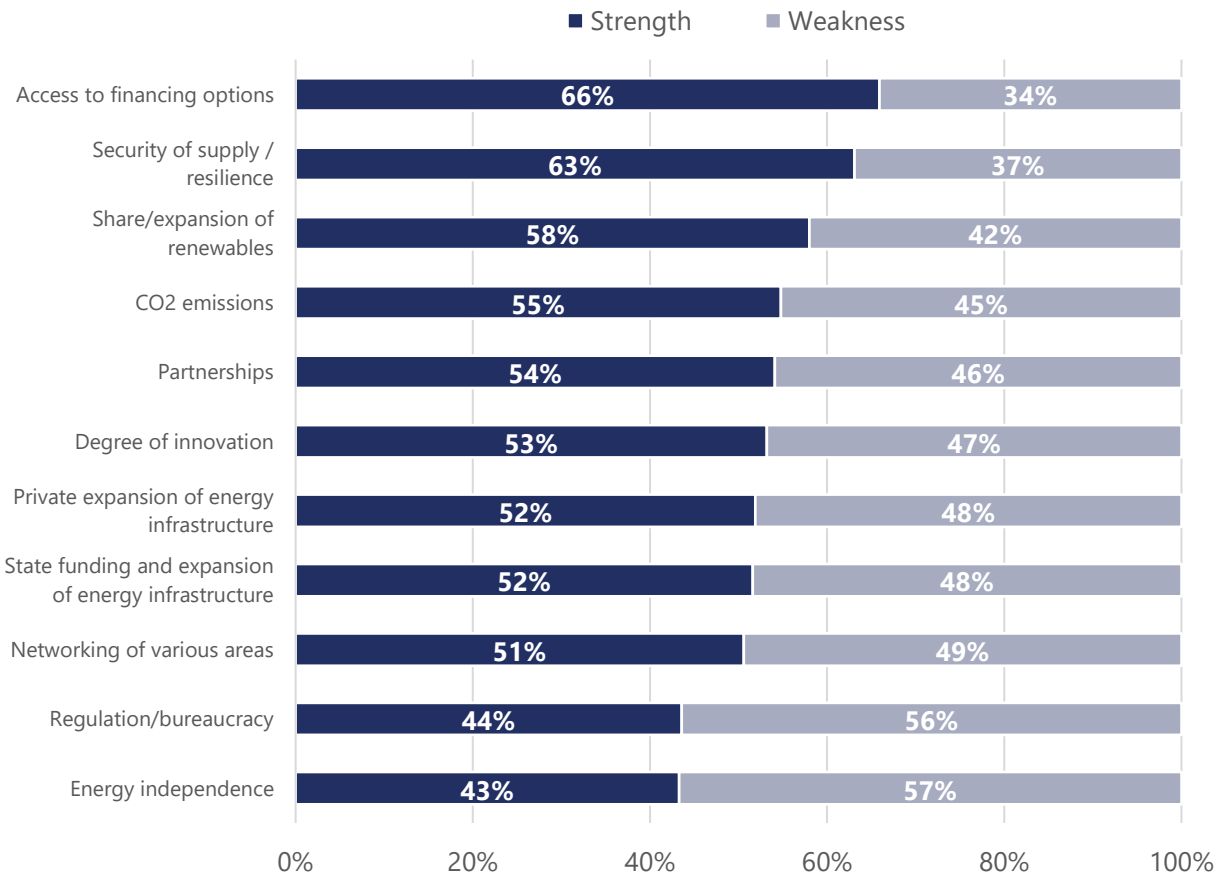
- State subsidies and the state-led expansion of energy infrastructure as the most important factor from a company perspective
- CO2 emissions in the context of energy infrastructure are important to a majority, but are the least important to companies when compared with other factors

The state plays an important and decisive role for companies in the context of energy infrastructure

Question: How important are the following factors to you from a business perspective when you think about the German energy infrastructure?

Two-thirds of companies rate access to financing as a strength of the energy infrastructure in Germany

Strengths and weaknesses of the energy infrastructure in GER



Question: Where do you see strengths and weaknesses in the German energy infrastructure?

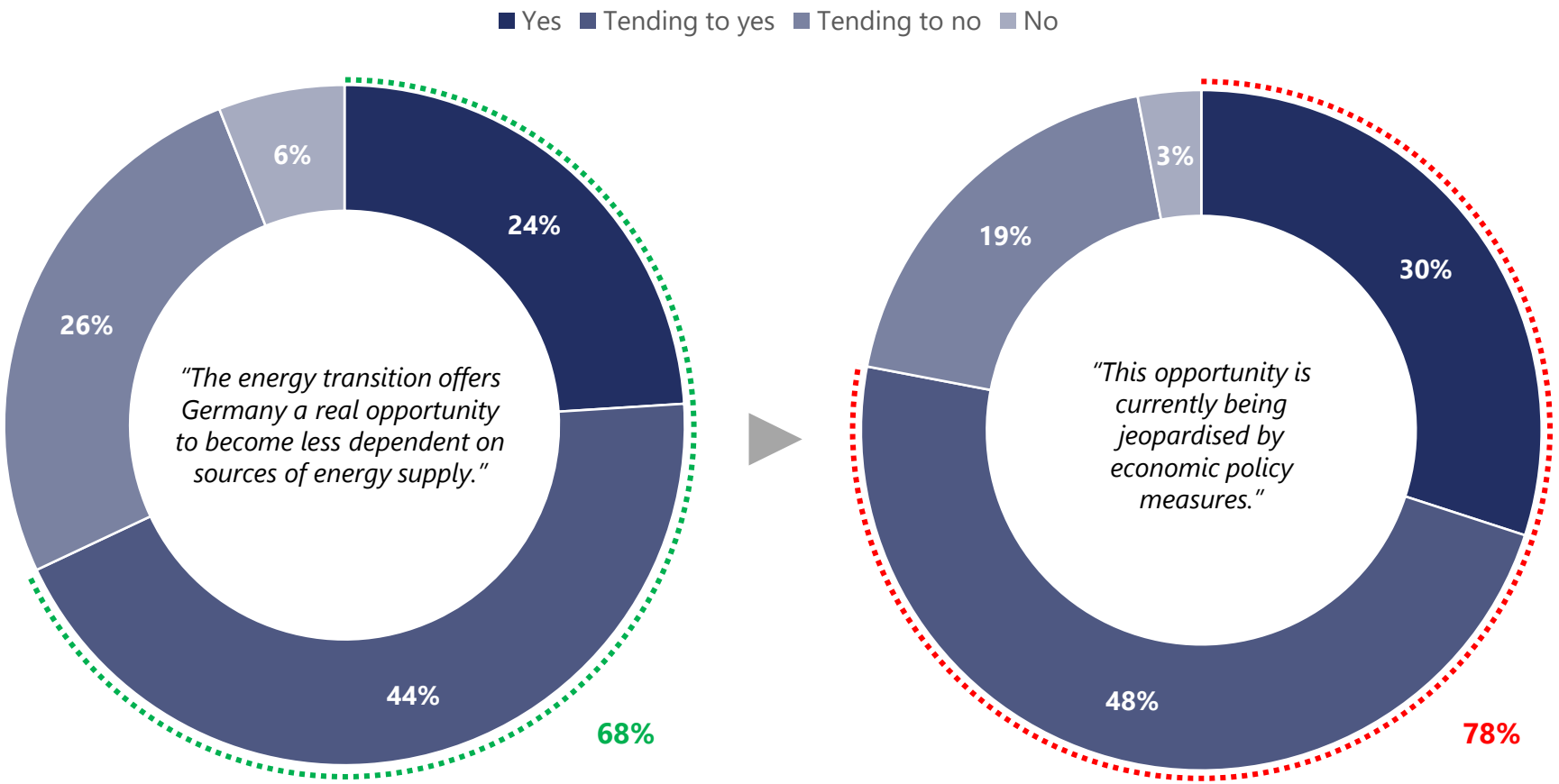
– Key takeaways –

- Access to financing and the security of supply are emphasised, in particular, as strengths of the German energy infrastructure
- The greatest weaknesses, on the other hand, are seen in regulation and German bureaucracy, as well as Germany's energy-related independence

Weaknesses within German energy infrastructure are attributed to politics

While 68% see the energy transition as an opportunity for greater independence from energy supplies, 78% believe this opportunity is jeopardised due to current political activity

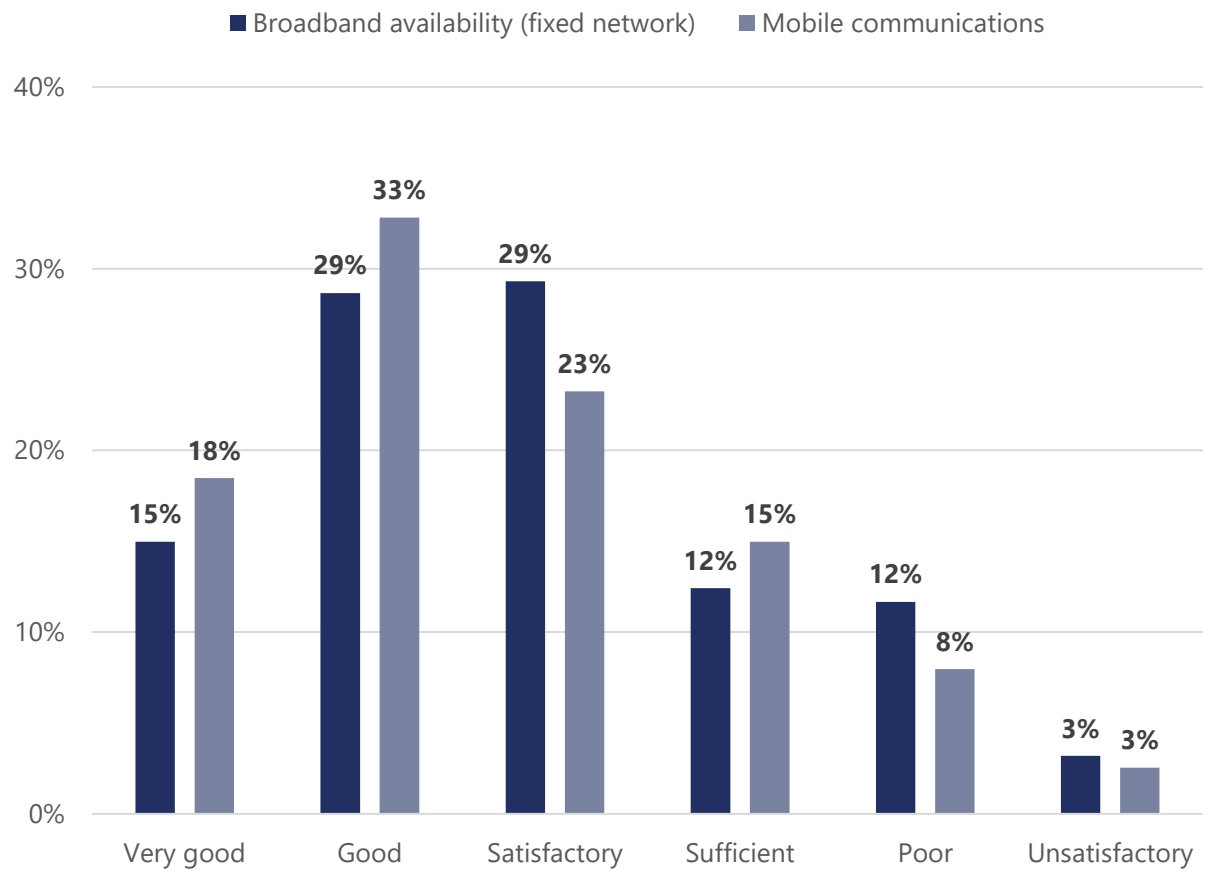
Germany's independence from sources of energy supply



Questions: In the context of the energy transition, do you see a real opportunity for Germany or the EU to free itself from dependencies on sources of energy supply (e.g: oil/gas/LNG, in future H2); do you see this opportunity jeopardised by the current state of economic policy action?

Regarding the state of digital infrastructure in Germany, mobile communications perform slightly better than broadband availability in the fixed network at a medium level

State of digital infrastructure in Germany



– Key takeaways –

- The current state of digital infrastructure is rated in similar fashion in the two areas of broadband availability and mobile communications
- The state of digital infrastructure scores slightly better than the state of energy infrastructure
- The greatest regional discrepancy exists between the assessment of eastern and southern German companies (with regard to broadband availability: 55% vs. 37% respond with [very] good)

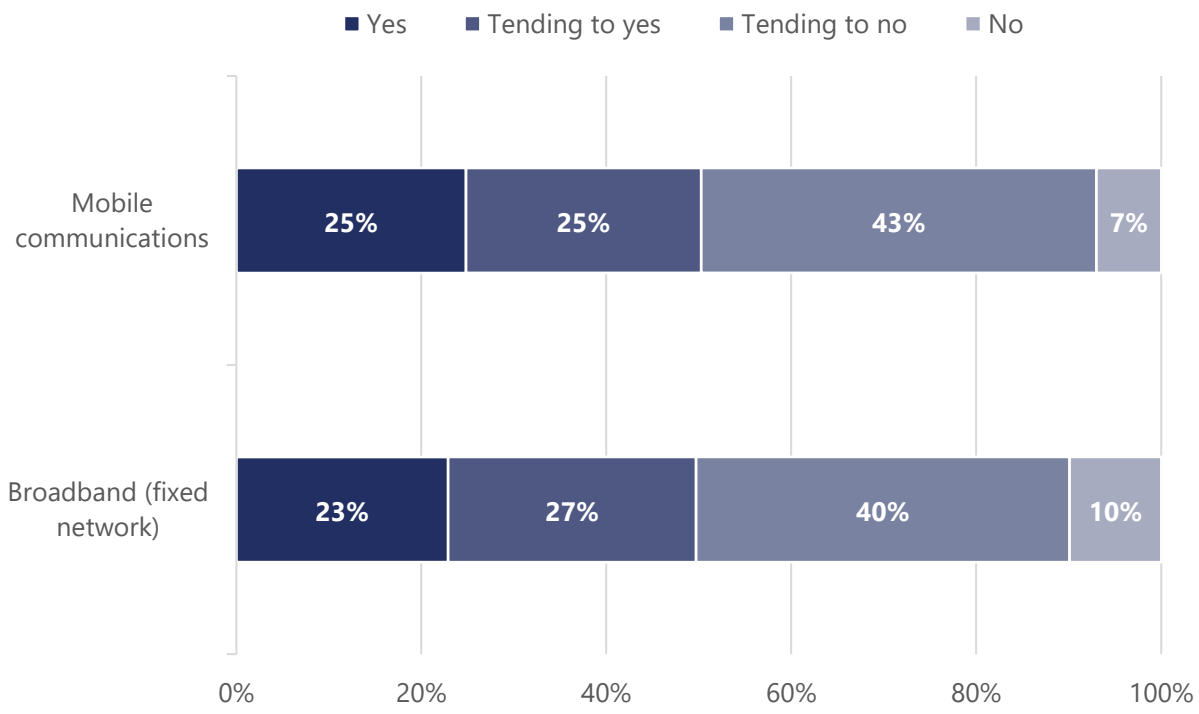
On balance, the condition of digital infrastructure is rated as "satisfactory"

Question: How do you rate the current state of digital infrastructure in Germany in terms of broadband availability (fixed network) and mobile communications?

The continued development and optimisation of digital infrastructure in Germany over the last 10 years is rated as "sufficient" by just a quarter of companies

Development of digital infrastructure in GER

"Digital infrastructure in Germany has been sufficiently developed and optimised over the last 10 years."



– Key takeaways –

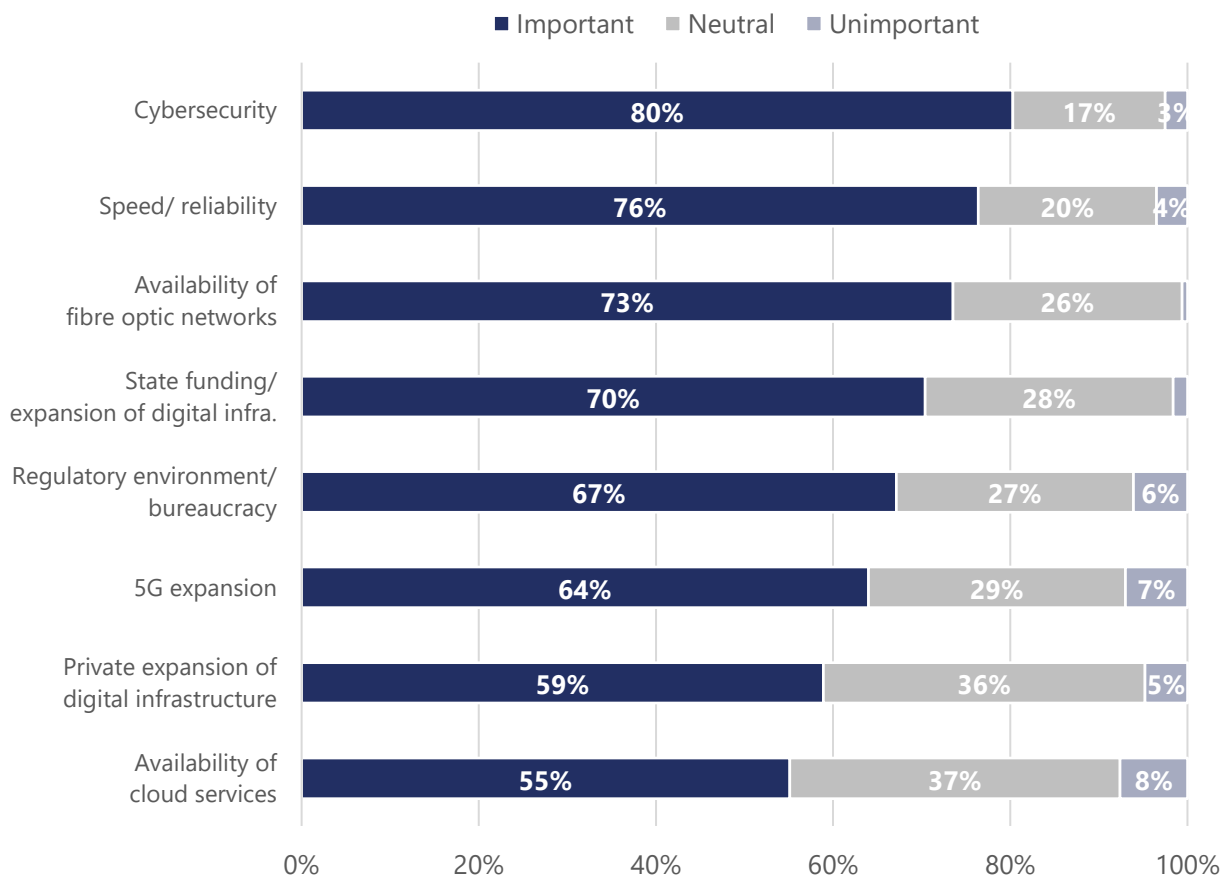
- In terms of mobile communications and broadband availability (fixed network), only a quarter of companies attest to sufficient development in the last 10 years
- 50% rate the development in mobile communications as (rather) "sufficient"
- With regard to broadband availability, the corresponding value is also 50%

Half of companies state that too little has been done to develop digital infrastructure

Question: In your opinion, has digital infrastructure in Germany been developed and optimised sufficiently over the last ten years?

Cybersecurity is considered by most companies to be the most important factor with regard to digital infrastructure

Relevance of digital infrastructure factors in GER



– Key takeaways –

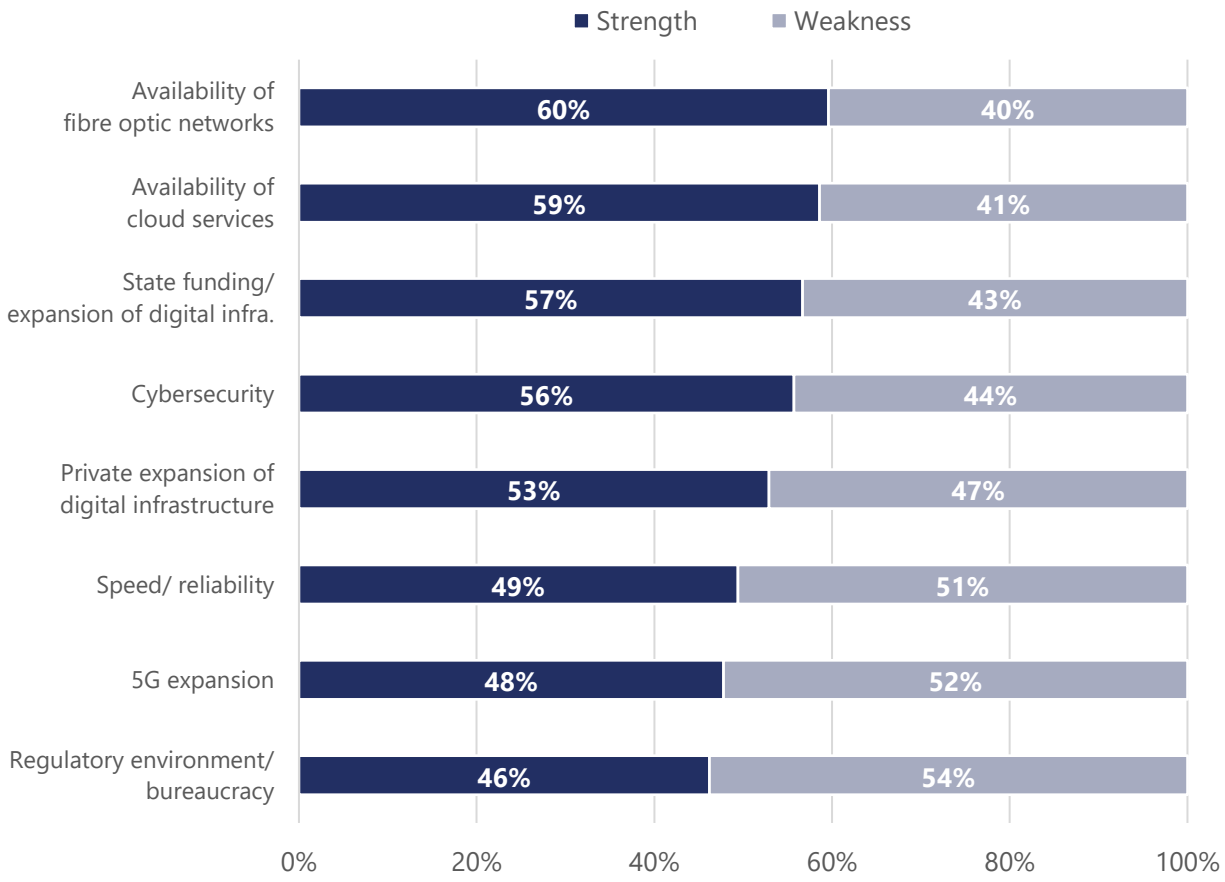
- With regard to the expansion of digital infrastructure, companies consider state funding (or state expansion) to be more relevant than private expansion
- The telecommunications focus industry stands out from the other focus industries (average 49% "important" responses), in particular, in the assessment of private expansion (70% "important" responses)

Security is considered the most important factor for companies in terms of digital infrastructure

Question: How important are the following factors to you from a business perspective when you consider German digital infrastructure?

40% of those companies surveyed identify a weakness in the availability of fibre optic networks in Germany

Strengths and weaknesses of the digital infrastructure in GER



Question: Where do you see strengths and weaknesses within German digital infrastructure?

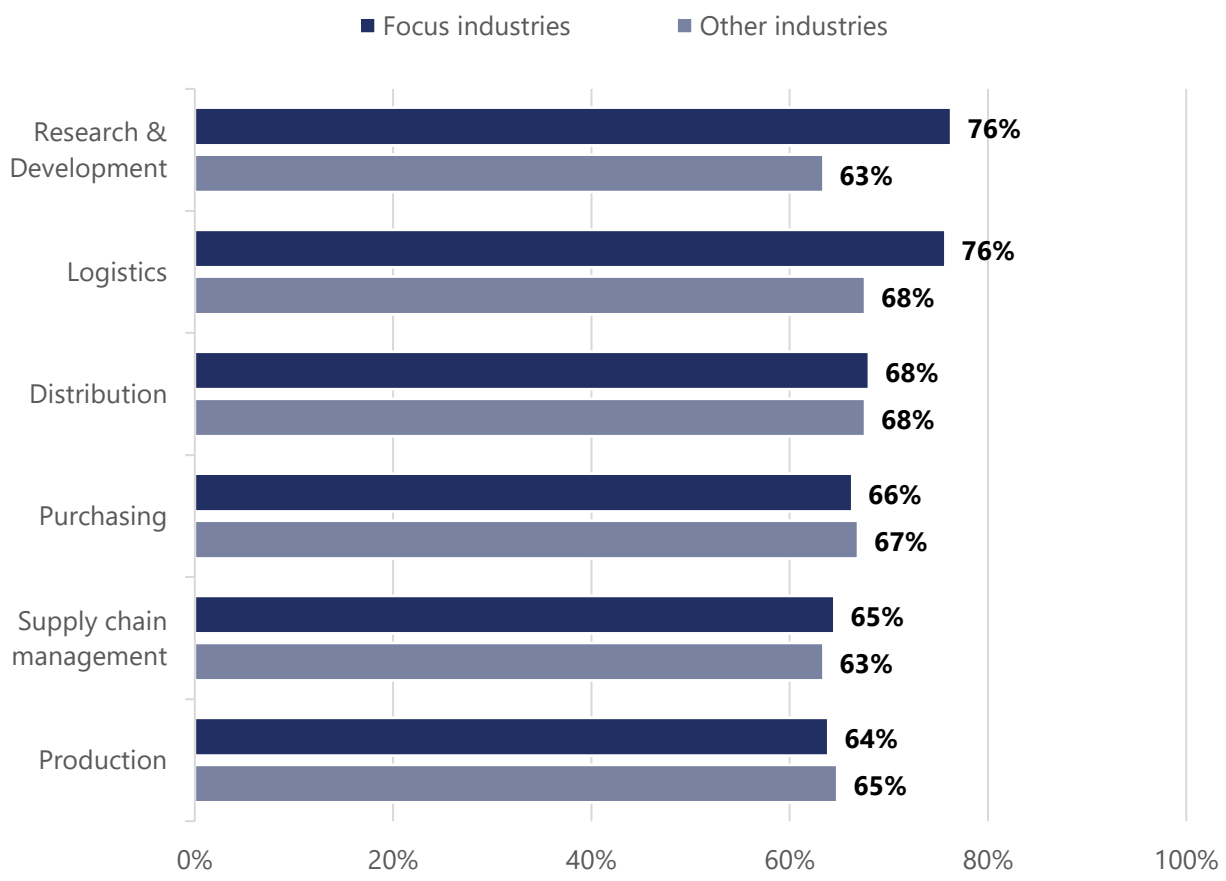
– Key takeaways –

- At 54%, the regulatory environment and levels of bureaucracy are most frequently cited by companies as a weakness in Germany's digital infrastructure
- Some major discrepancies exist when comparing the ratings between the various focus industries
- I.e., almost 60% of the automotive industry rate the availability of cloud services as a weak-ness (value for other industries: 35 - 40%)

Regulatory environment and major bureaucratic hurdles are Germany's greatest weaknesses

The digital infrastructure is (very) important for the companies surveyed in the focus industries, in particular, within both research and development and logistics

Relevance of digital infrastructure in various areas



– Key takeaways –

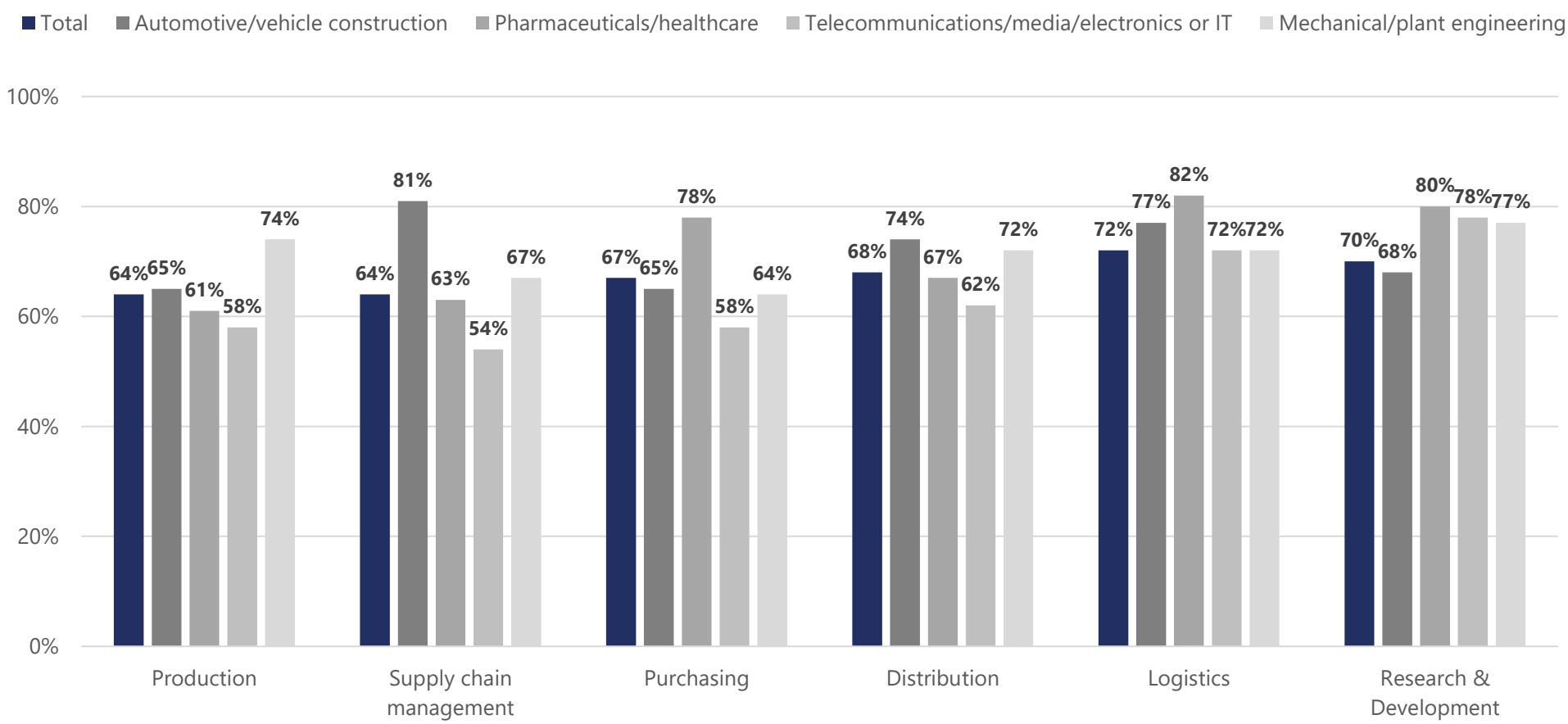
- Companies in the focus industries differ significantly from one another in only two areas
- Digital infrastructure is categorised as (very) important for at least two thirds of companies in all areas
- Companies are, therefore, heavily dependent on a well-developed infrastructure in Germany for their operational processes

All of the industries analysed benefit from an advanced digital infrastructure in Germany

Question: In which areas is digital infrastructure particularly important for your company? (Responses included: "Very important" & "Important")

Digital infrastructure is (very) important in all areas for a majority of the companies surveyed in the focus industries

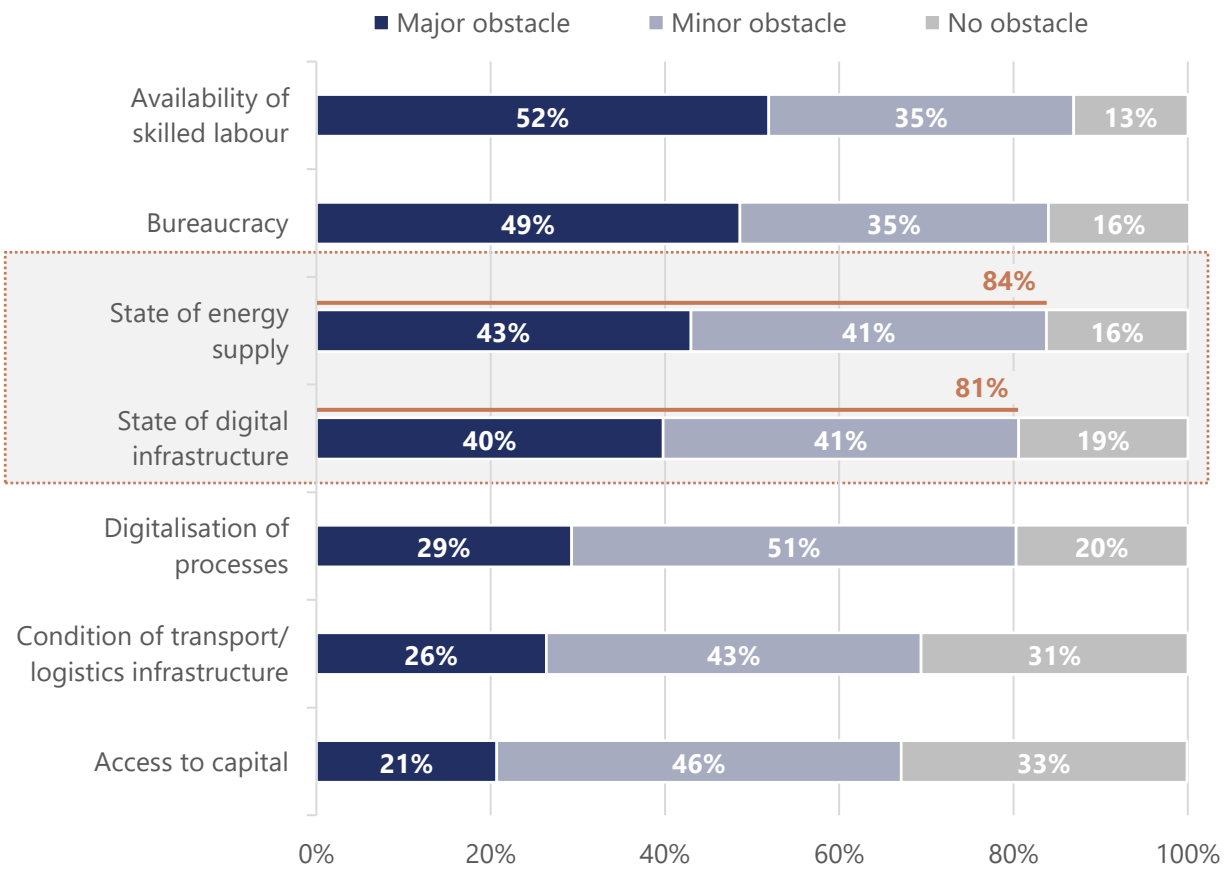
Relevance of digital infrastructure within focus industries



Question: In which areas is digital infrastructure particularly important for your company? (Responses included: "Very important" & "Important")

The current state of digital and energy infrastructure in Germany is described as an obstacle by over 80% of the companies surveyed in each case

Obstacles and challenges faced by companies



Question: In your opinion, what are the biggest obstacles for your company to operate successfully?

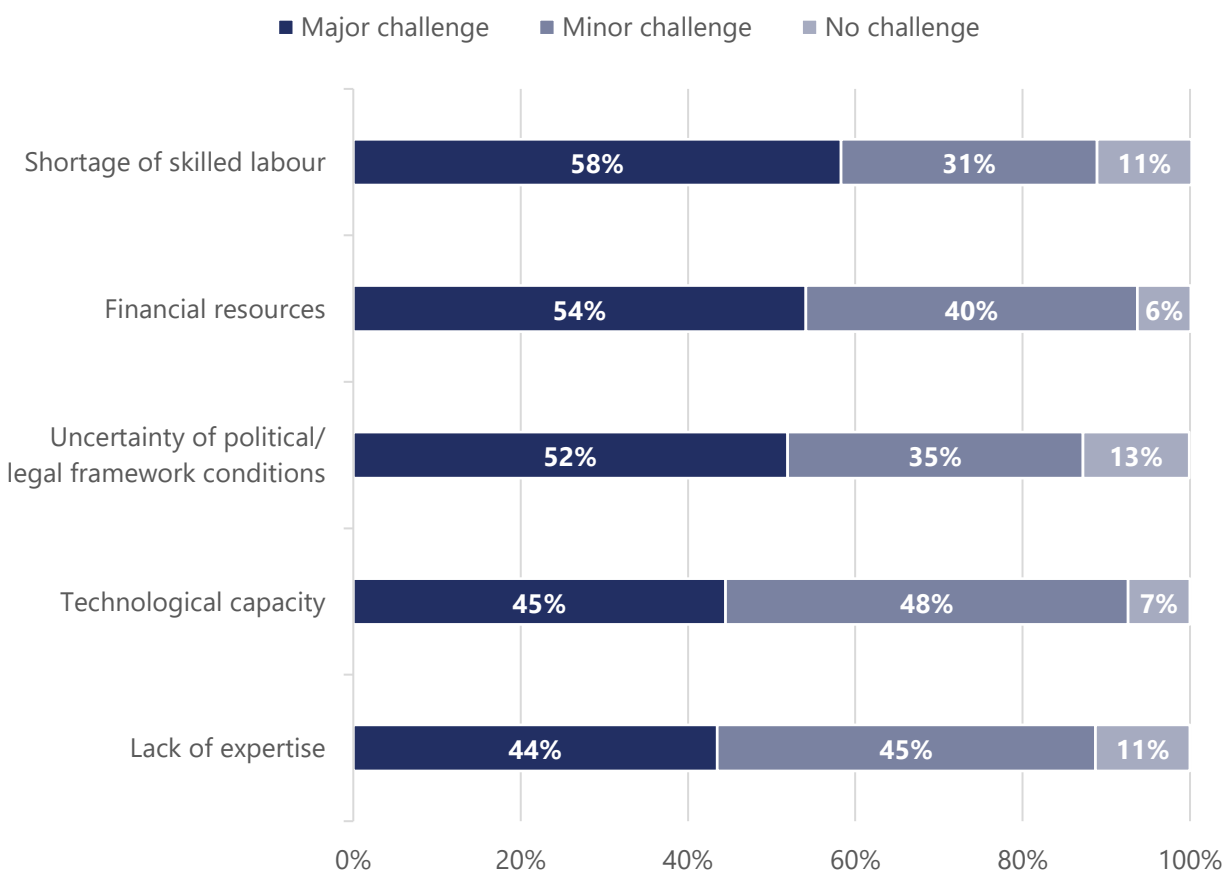
– Key takeaways –

- The greatest obstacles to the competitiveness of German companies comprise the shortage of skilled labour (87%) and bureaucracy (84%)
- Within infrastructure, the condition of the energy supply is perceived as the greatest obstacle (84%)
- This is followed by the digital infrastructure (81%)
- Access to capital, on the other hand, is seen as the smallest obstacle (67%)

Current state of digital and energy infrastructure represents a major obstacle for companies

The greatest challenge in implementing measures to optimise the energy supply in the company is seen in the lack of skilled workers

Challenges in optimising the energy supply



– Key takeaways –

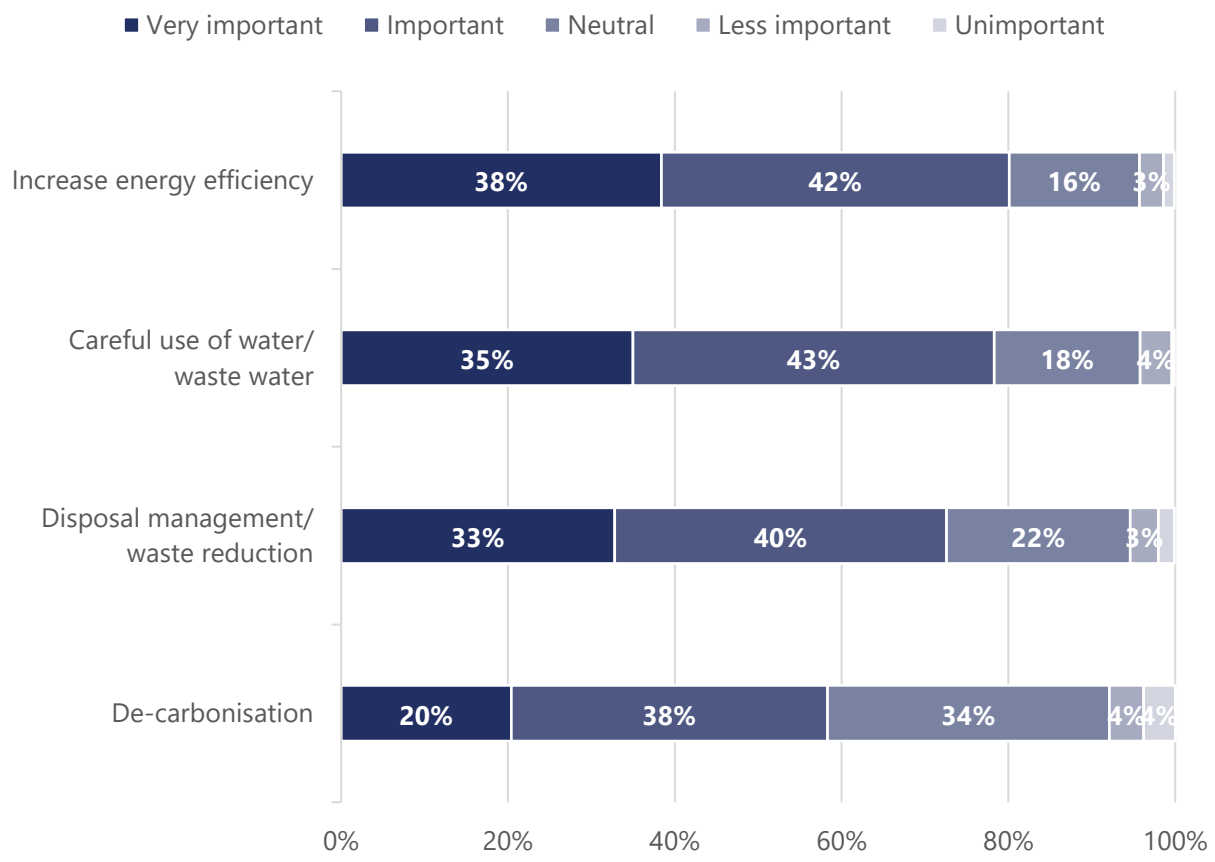
- At 58%, most companies see the lack of skilled workers as a major challenge when implementing measures to optimise the energy supply
- A lack of financial resources (54%) and uncertain political or legal framework conditions are also frequently mentioned

The shortage of skilled labour is also highly relevant in the context of energy infrastructure and supply

Question: [If energy investments are planned]: How would you rate the challenges associated with implementing measures to optimise your company's energy supply?

With regard to achieving a sustainable positioning, increasing energy efficiency is most important to the companies surveyed

Relevance of factors for sustainable positioning



– Key takeaways –

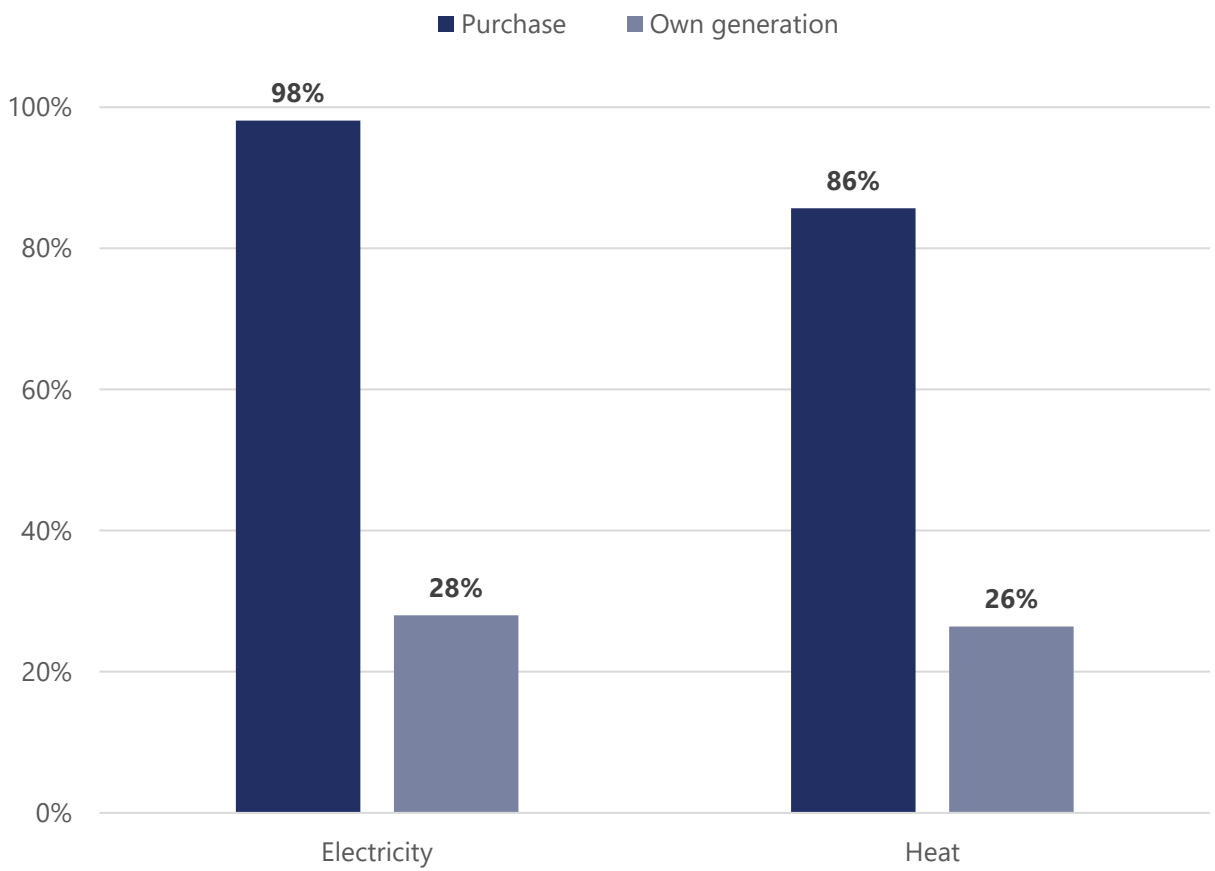
- 38% of companies state that increasing energy efficiency within the company is very important in terms of sustainable positioning
- De-carbonisation is situated at the lower end at 20%, as the area could be less tangible for respondents and is, therefore, more difficult to associate with specific measures

When concerning sustainability, companies focus on areas that go hand-in-hand with real-terms cost savings

Question: For the sustainable positioning of your company in terms of environment: How important are the following factors to you?

Energy in German companies – both thermal and, in particular, electrical energy – continues to come primarily from the purchase of energy suppliers

Energy origin in the company



Question: Where does the energy that your company uses originate?

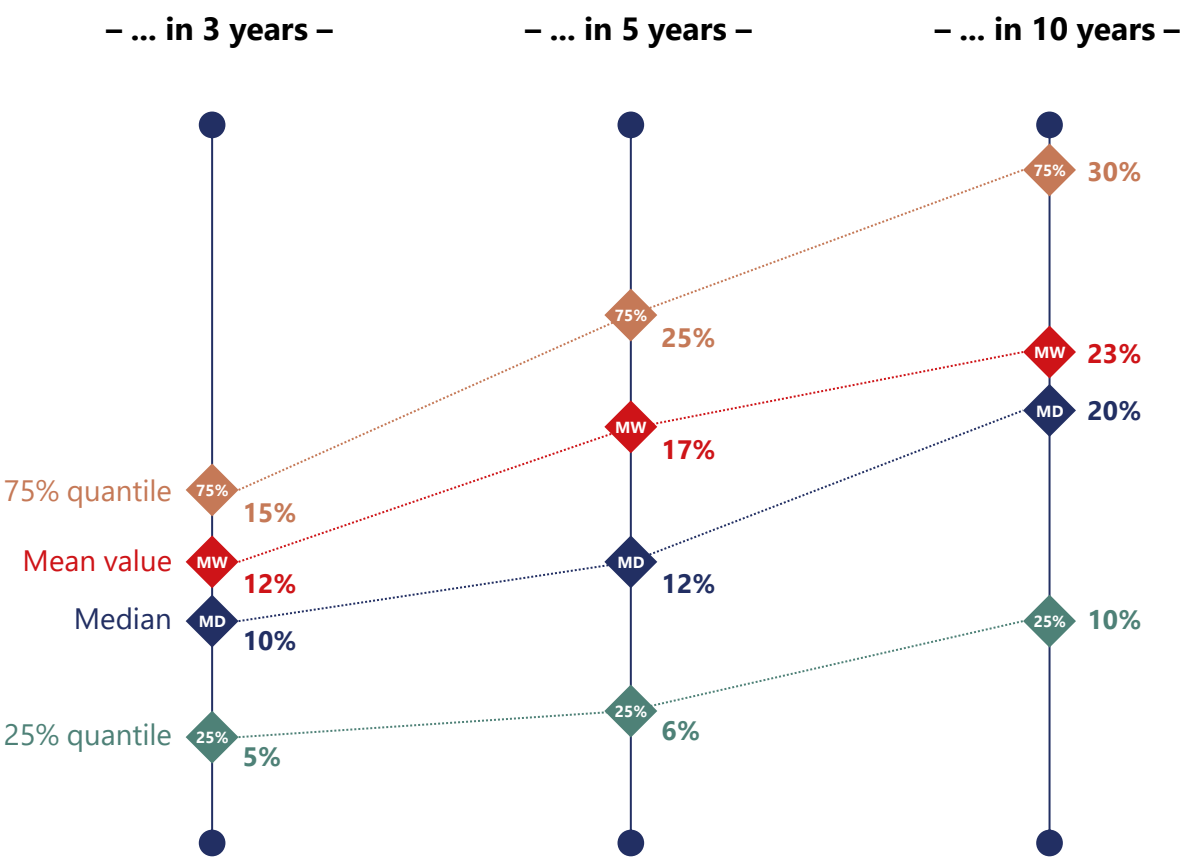
– Key takeaways –

- Slightly more than one in four companies surveyed obtains electricity and thermal energy at least partly from their own generation
- Furthermore, almost all companies purchase electrical energy to fully cover their needs
- In terms of thermal energy, the purchase is slightly lower at 86%

Significant proportion of companies obtain at least some of their energy from their own generation

A quarter of companies plan to reduce their energy consumption by at least 25% within the next five years

Planned energy consumption reduction within the company



Question: By what percentage does your company plan to reduce its energy consumption?

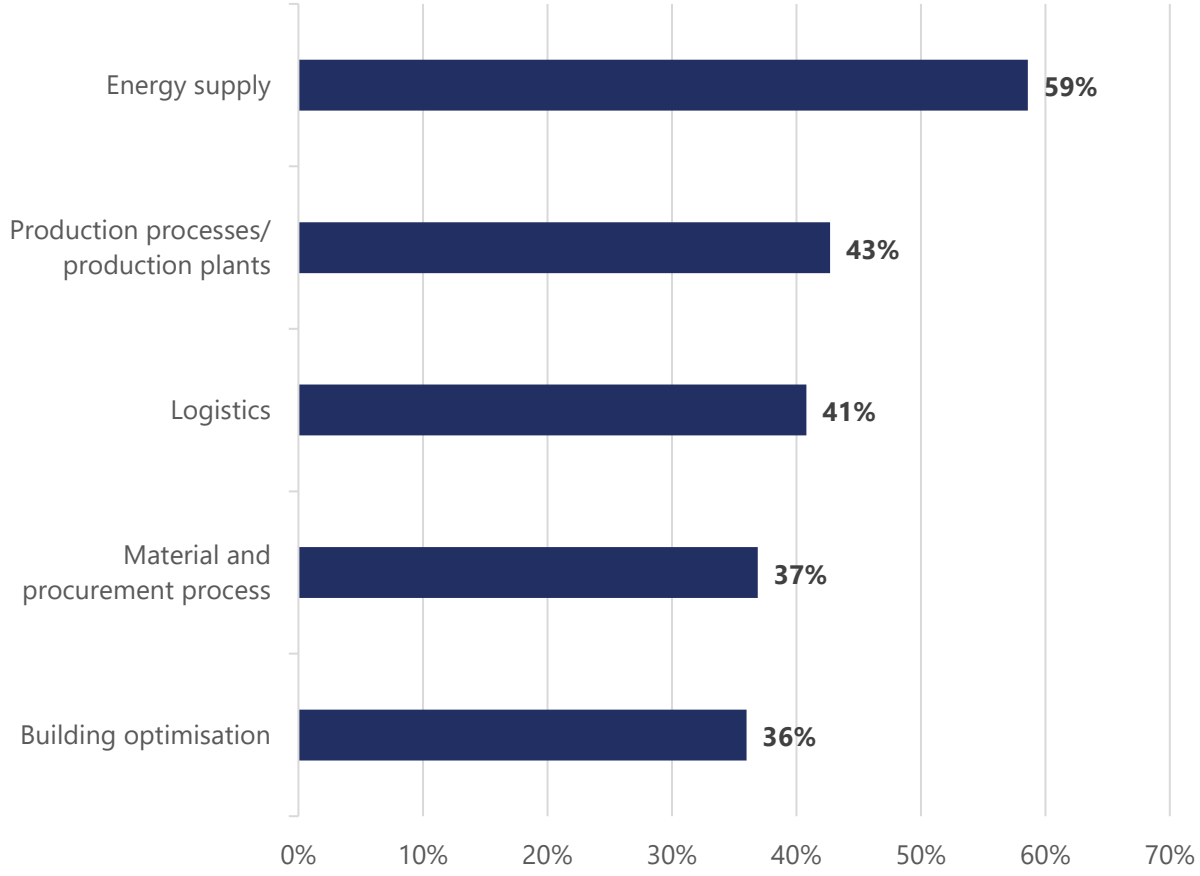
– Key takeaways –

- Companies intend to reduce their energy consumption by 10% (median) within the next three years
- With a time horizon of five years, this figure rises to 12% and in 10 years to 20%
- Mean values are slightly higher due to some extreme values
- Range of data increases with increasing time horizon

Reducing energy consumption is both a short- and long-term goal for many companies

In terms of reducing CO2 emissions, companies are primarily focussing their efforts on sustainable energy supply

Areas of the planned reduction in CO2 emissions



Question: In which areas are you planning to reduce your company's CO2 emissions?

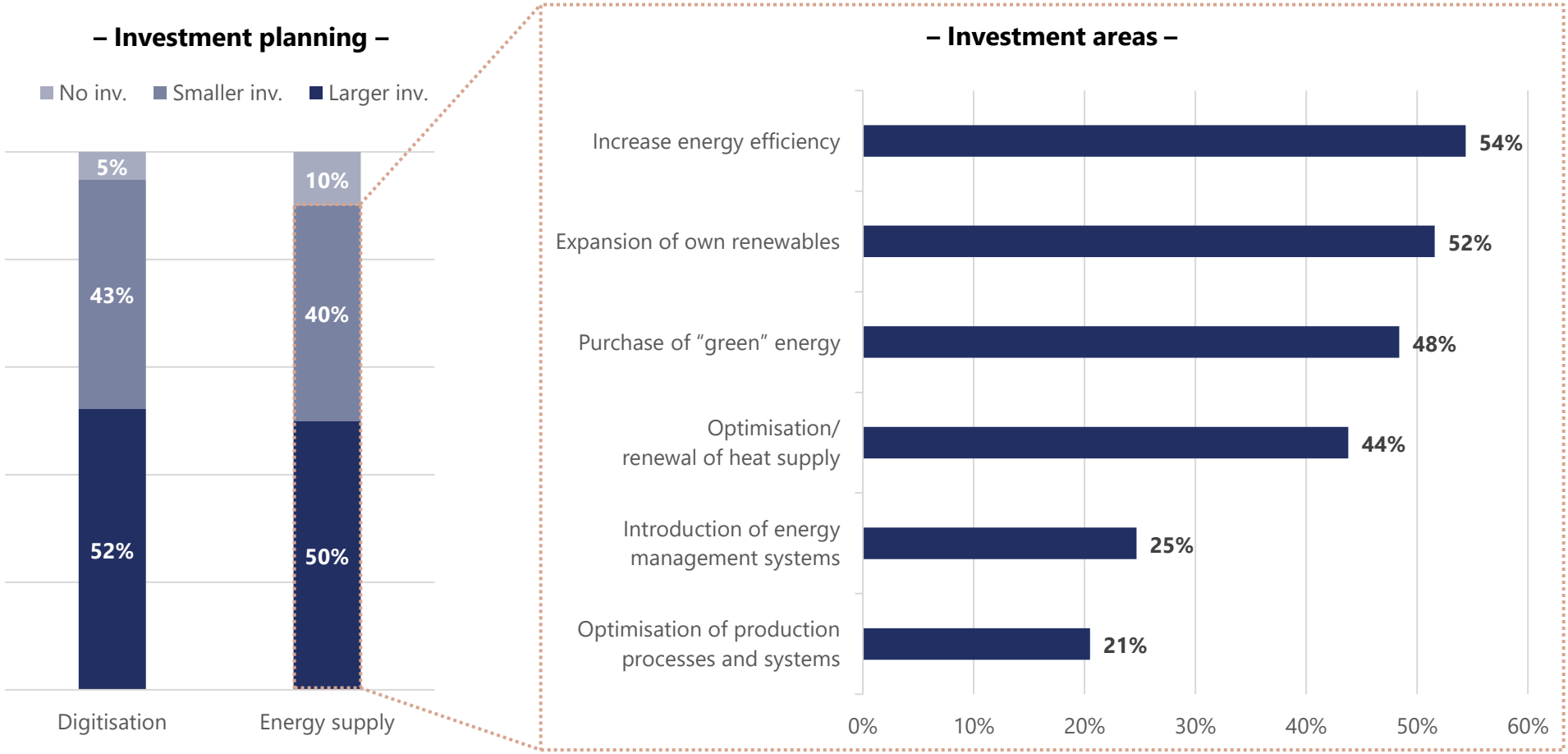
– Key takeaways –

- With regard to the reduction of CO2 emissions in the company, energy supply was mentioned by far the most frequently (59%)
- This is followed by the two areas of production processes and systems (43%) and logistics (41%)
- Only 36% plan to reduce CO2 emissions with regard to building optimisation

Most companies are planning to reduce CO2 emissions in terms of energy supply

90% of the companies surveyed plan to make at least minor investments in their energy supply, with increasing energy efficiency being the top priority

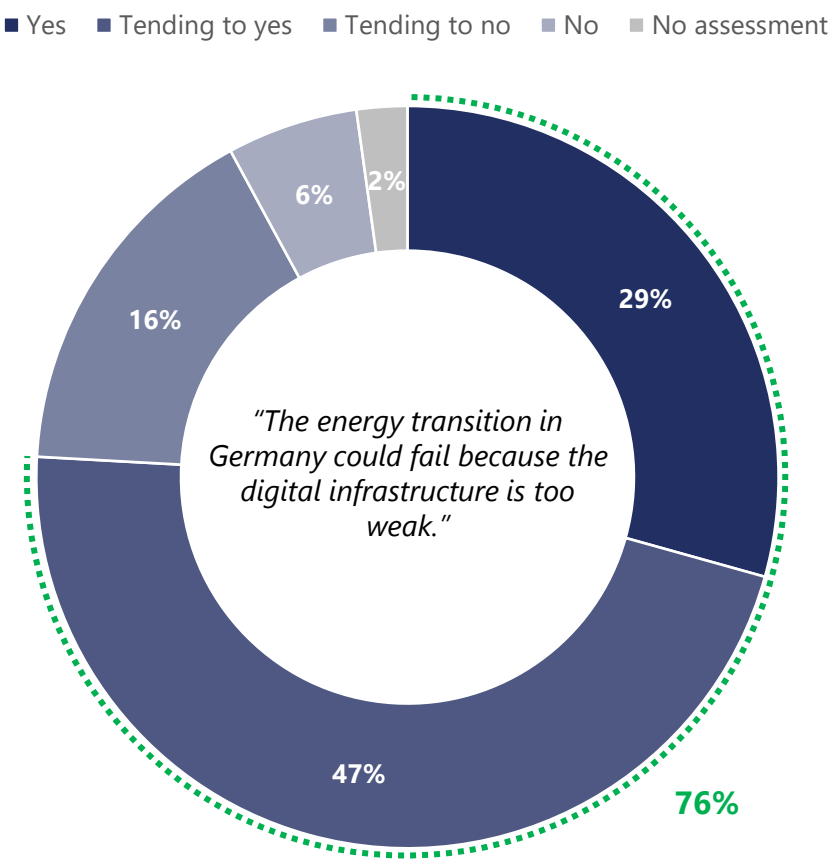
Envisaged areas of investment in energy supply



Questions: In which areas are you planning investments in your company in the next five years?; [If energy investments planned]: In which areas do you want to invest in energy supply?

Large majority of companies surveyed identify a crucial link between a well-developed digital infrastructure and the energy transition

Link between the energy transition and digitalisation



– Key takeaways –

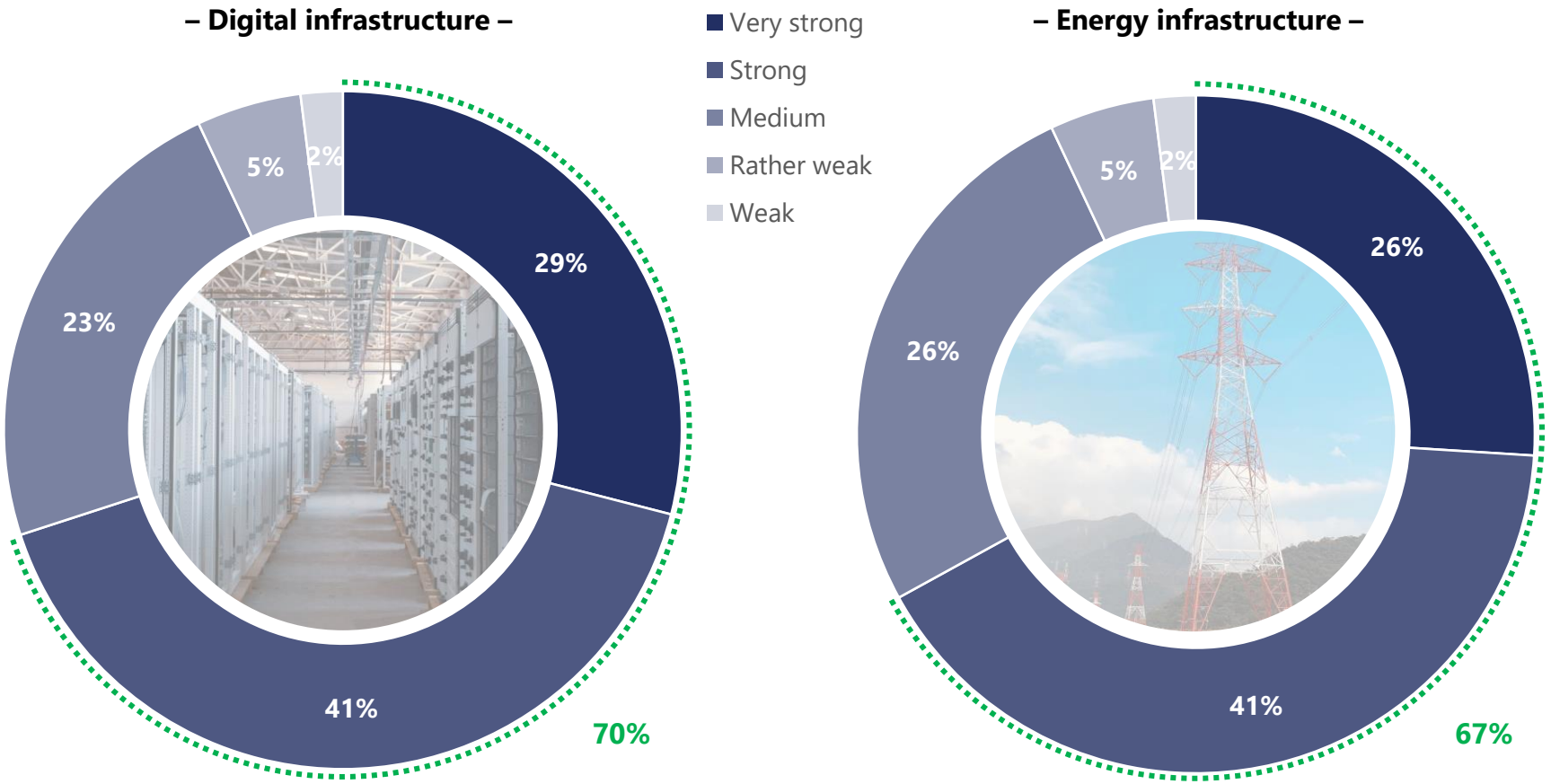
- More than three-quarters of companies agree with the statement that the energy transition could fail due to an underdeveloped digital infrastructure
- Significant approval ratings could be due to the fact that respondents refer less to factors such as bandwidth etc. and more to smart networking in terms of application (e.g. use of smart meters)

Successful energy transition in Germany requires a well-developed digital infrastructure

Question: What do you think of the following? "The energy transition in Germany could fail because the digital infrastructure is too weak."

Over two-thirds of companies rate the influence attributed to the state of the digital and energy infrastructure on international competitiveness as very strong or strong

International competitiveness

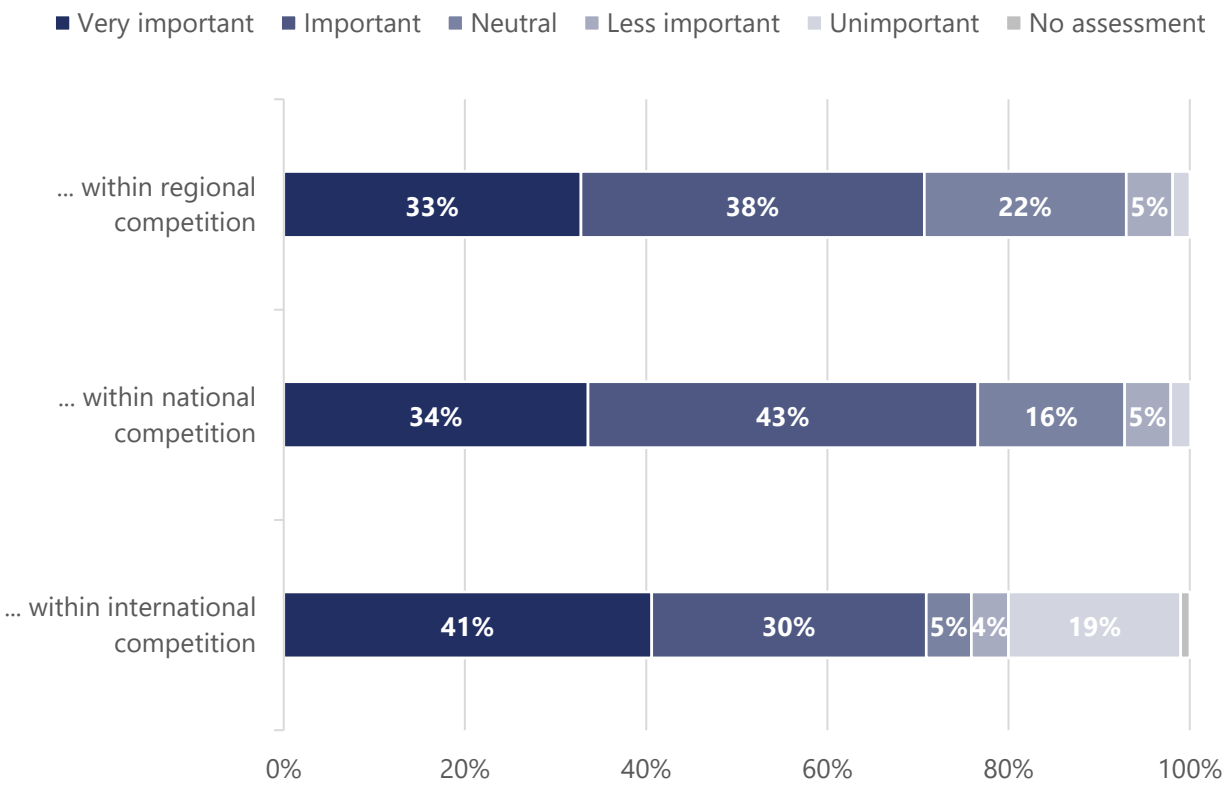


Questions: In your opinion: To what extent is the condition of the national energy infrastructure (e.g. power plants, electricity grids) [digital infrastructure (e.g. fibre optics, mobile communications)] linked to business competitiveness when viewed in an international comparison?

The influence of efficient energy supply and utilisation is rated as (very) important, in particular, with regard to national competitiveness

Efficient energy supply as a competitive factor

– Influence of efficient energy supply on competitiveness



Question: How important is efficient energy supply and its utilisation for your company in order to be competitive?

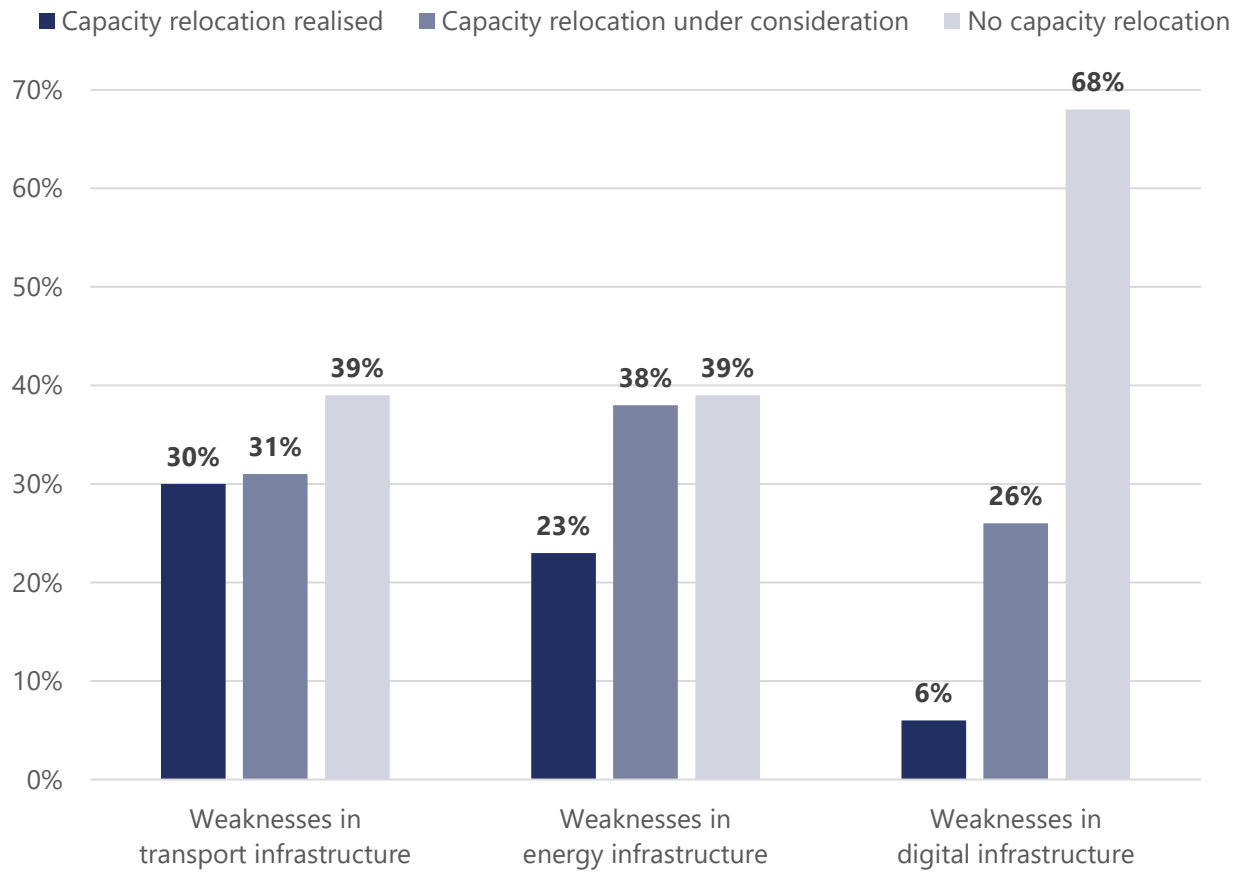
– Key takeaways –

- Every third company identifies a high degree of relevance in efficient energy supply/utilisation with regard to regional and national competitiveness
- With regard to national competitiveness, an above-average number of companies from the East (37%) and South (35%) consider an efficient energy supply to be very important

Efficient energy supply/utilisation is generally considered to be highly relevant in terms of competitiveness

Almost one in four companies surveyed has already relocated capacities abroad due to weaknesses in the energy infrastructure in Germany

Reasons for relocating capacity abroad



– Key takeaways –

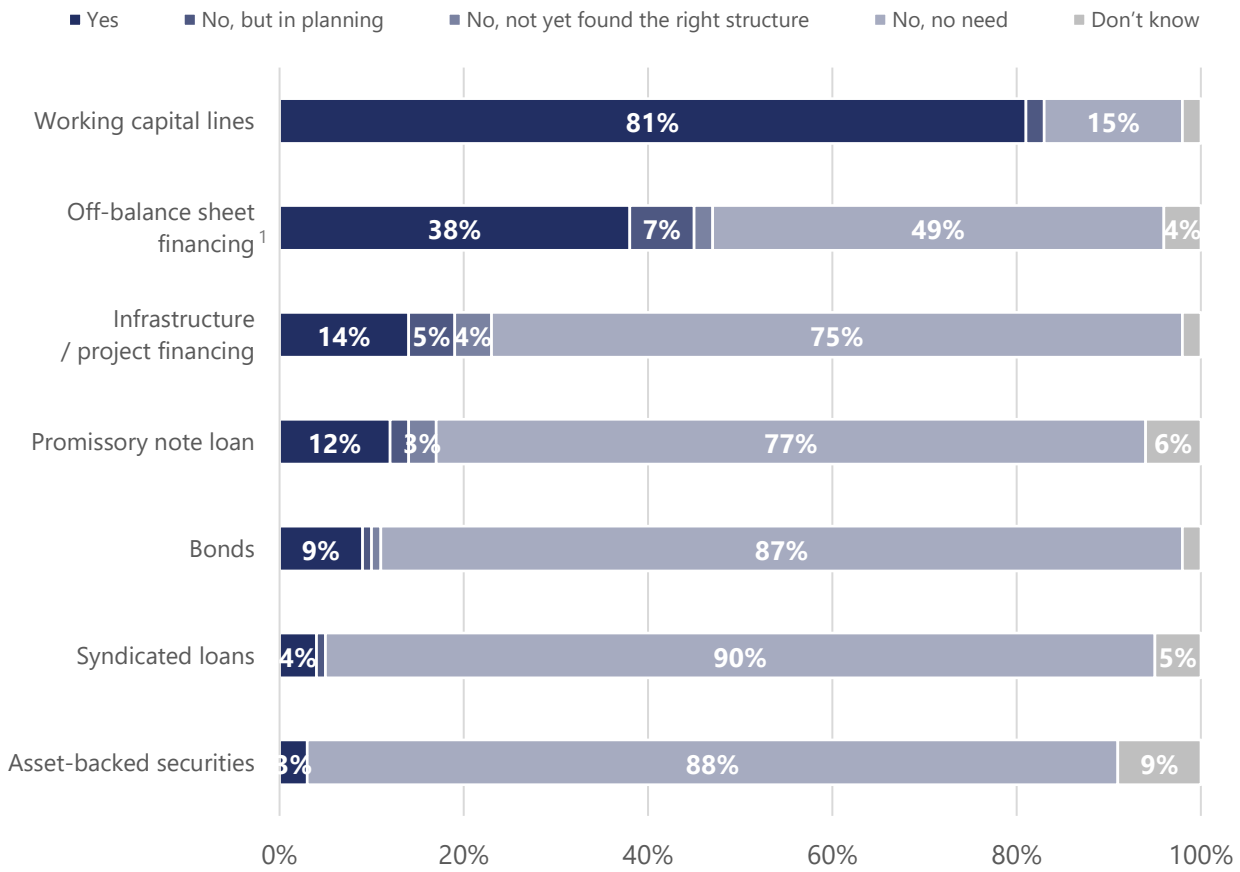
- 30% of German companies have relocated capacities abroad due to weaknesses in the transport infrastructure
- As a result of energy infrastructure, 23% have already taken this step
- Weak digital infrastructure, on the other hand, is less of a reason for companies to relocate capacity

Infrastructure is understood as a relevant factor for the appeal of Germany as a business location

Question: Are you considering relocating production and other capacities of your company abroad due to the following location disadvantages?

By far the most common type of financing used by companies is working capital, followed by off-balance sheet financing[1]

Types of financing used



Question: Does your company use the following types of financing?
1) excluding infrastructure/project financing

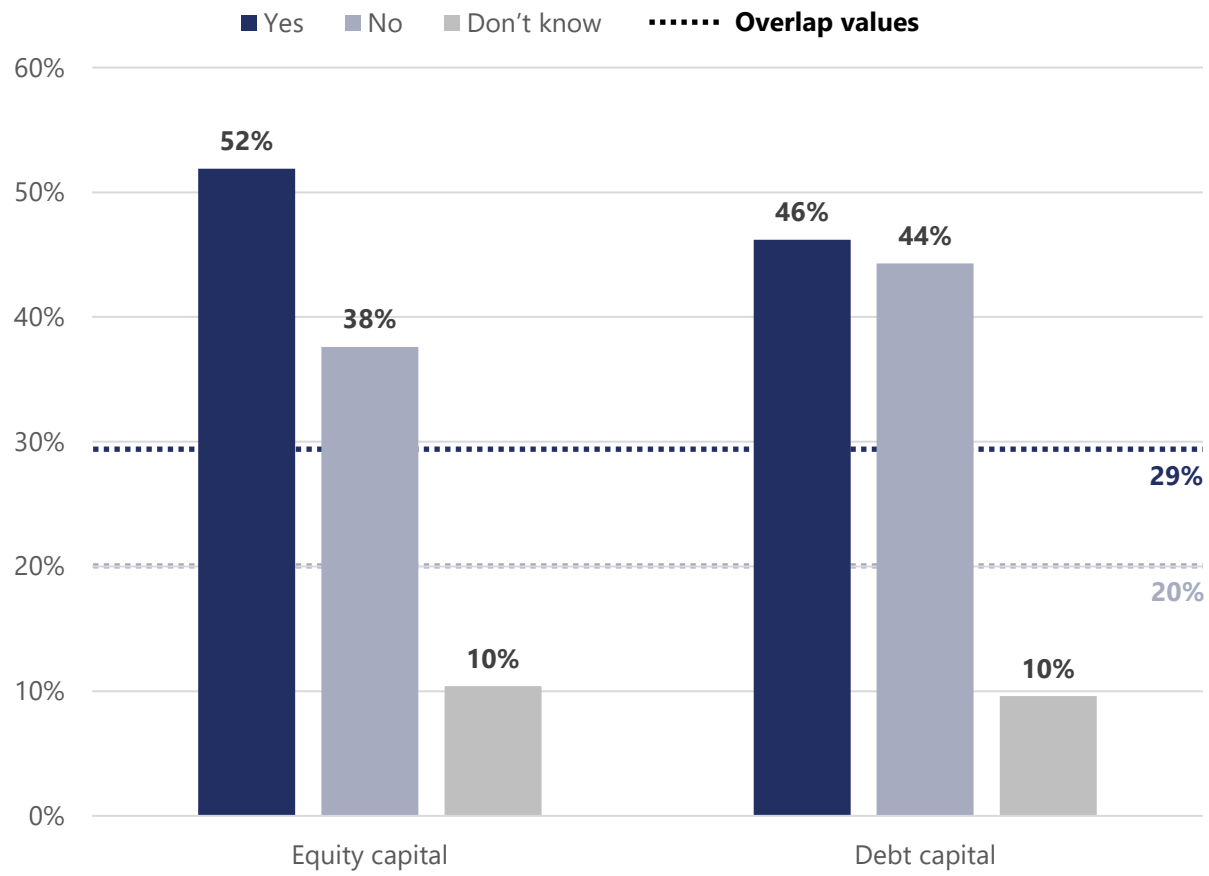
– Key takeaways –

- 81% of companies use working capital lines for financing
- Off-balance sheet financing[1] is utilised by 38%, with a further 7% planning to do so
- Certain forms of financing – such as bonds, syndicated loans and asset-backed securities – are only worthwhile for large companies due to the high fixed costs involved

Project financing offers the greatest potential for structural adjustments

Almost one in three companies must increase their equity and debt capital to cope with future investments with regard to the energy transition and digitalisation

Required increase in financing components



– Key takeaways –

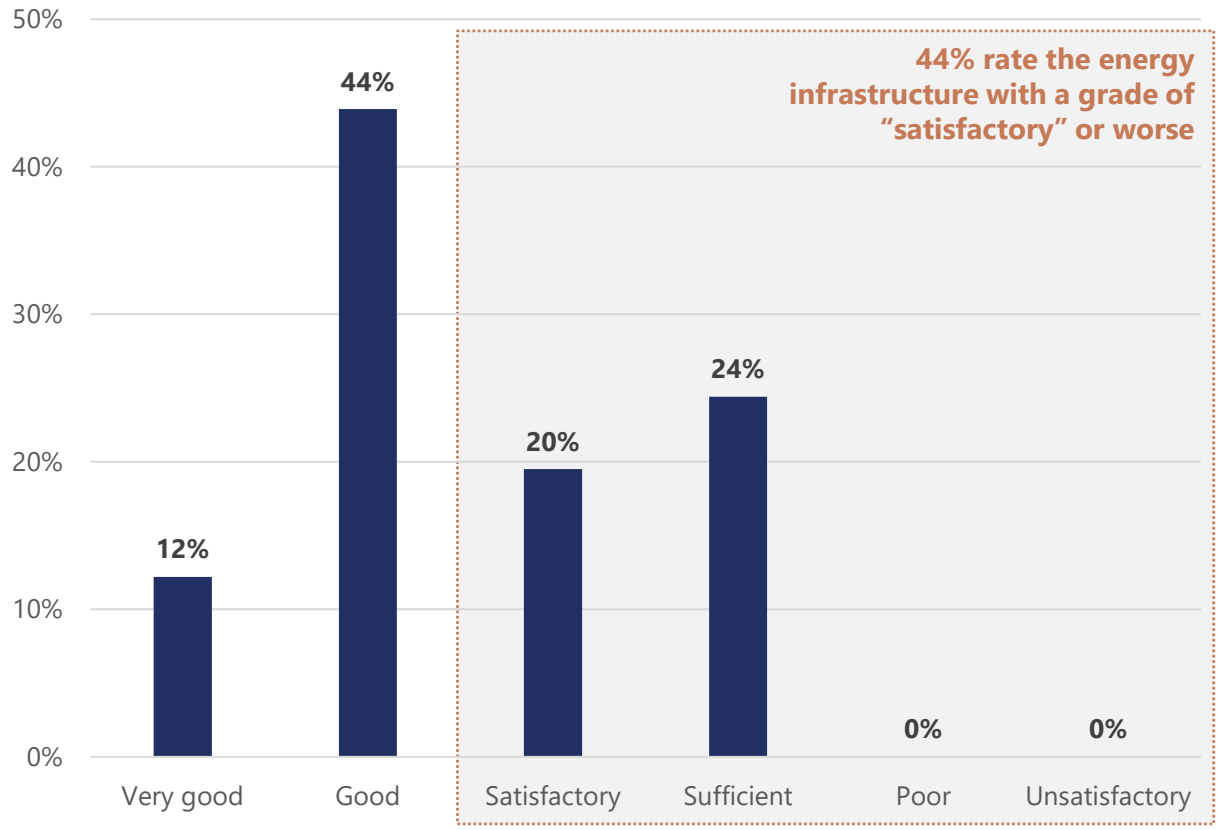
- 52% of companies would have to increase their equity, in order to cope with future investments in digitalisation/energy transition
- Slightly fewer companies (46%) need to increase debt capital
- Special analysis shows that 29% require an increase in both equity and debt capital, while 20% do not require an increase

High capital requirements to cope with future investments in the energy transition and digitalisation

Question: To manage upcoming investments within energy transition and digitalisation in your company: Do you need to significantly increase the following financing components in future?

The current state of the energy infrastructure is rated better by companies in the energy industry than by companies in other sectors

Rating: State of the energy infrastructure in Germany



Question: How do you rate the current state of the energy infrastructure in general (electricity, heat, fuels) in Germany?

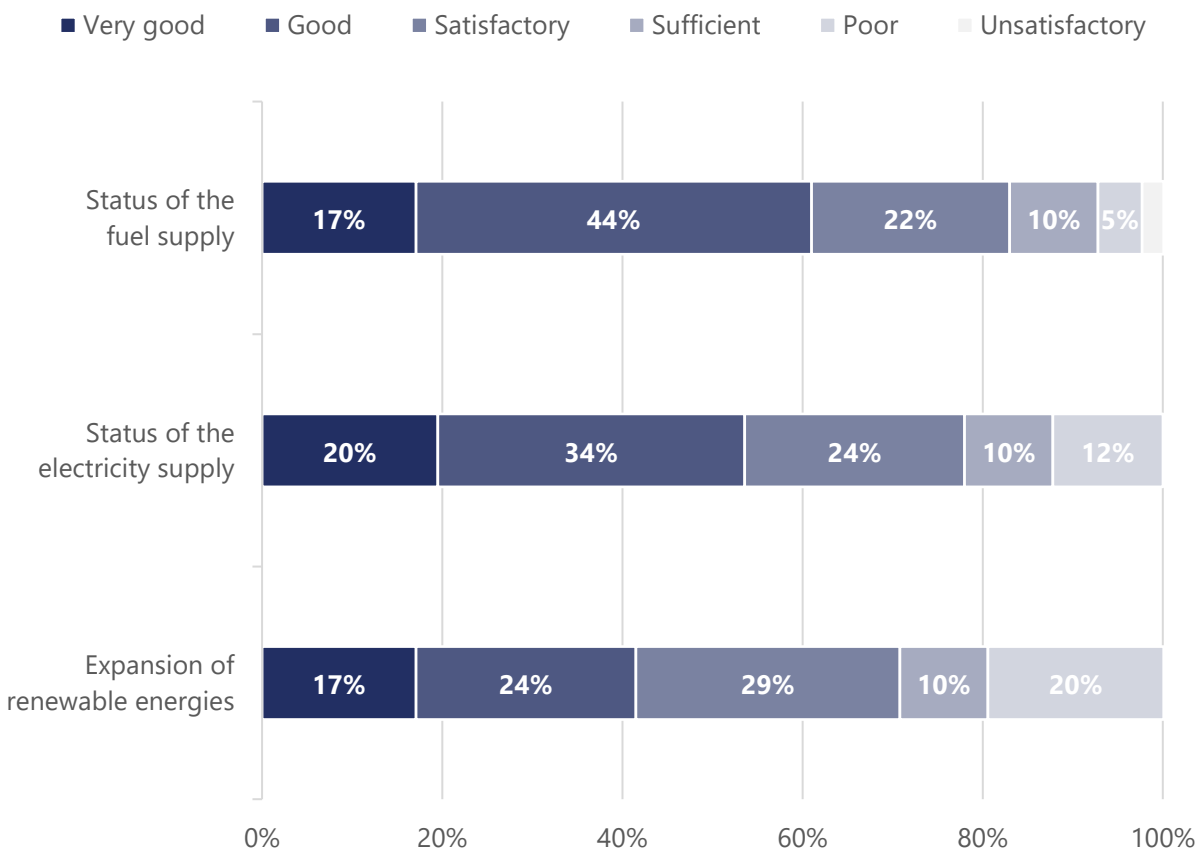
– Key takeaways –

- A small majority of energy companies (56%) rate the energy infrastructure in Germany as "very good" or "good"
- The remaining 44% are divided into the ratings "satisfactory" and "sufficient"
- On average, the current state of the energy infrastructure, therefore, is awarded a rating of 2.51

Many energy companies rate the current state of the energy infrastructure as "good"

In terms of energy supply, the state of the fuel supply is categorised as the best compared to that of the electricity supply and the expansion of renewable energies

Rating: Energy supply areas in Germany



– Key takeaways –

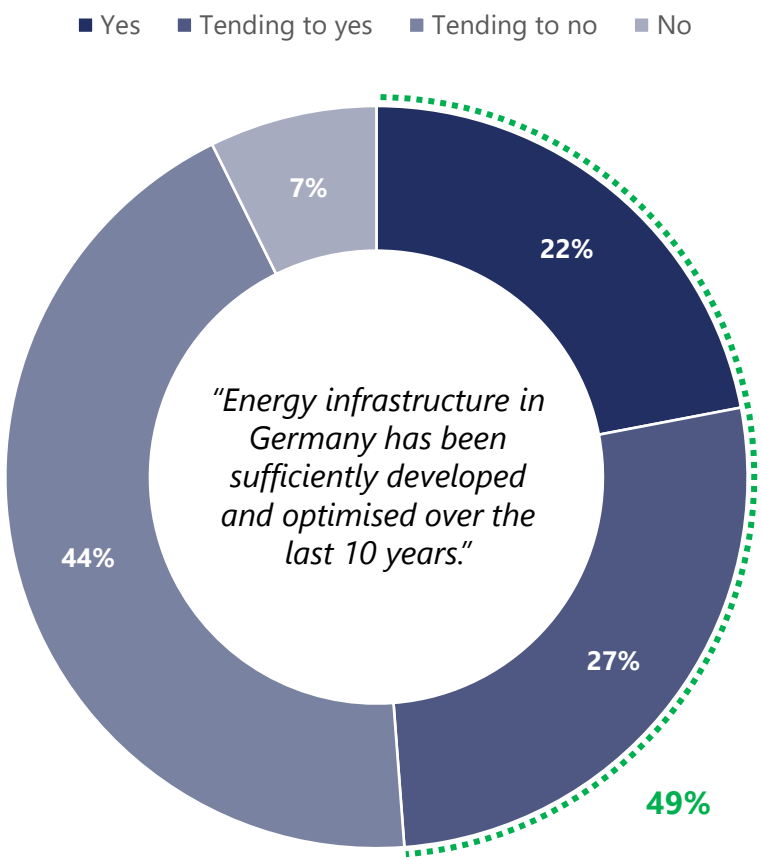
- 61% of energy companies rate the state of the fuel supply in Germany as (very) good
- The corresponding figure for the power supply is 54%
- Status of the expansion of renewable energies falls slightly behind with 41% (very) good ratings

State of long-term established energy supply routes performs best

Question: How do you assess the current state of the electricity supply in Germany?; How do you assess the current state of the fuel supply (e.g. gas, oil) in Germany?; How do you assess the expansion of renewable energies in Germany?

Regarding the attestation of a sufficient development of the German energy infrastructure in the last 10 years, a two-part understanding emerges with a slightly positive tendency

Development of the energy infrastructure in Germany



– Key takeaways –

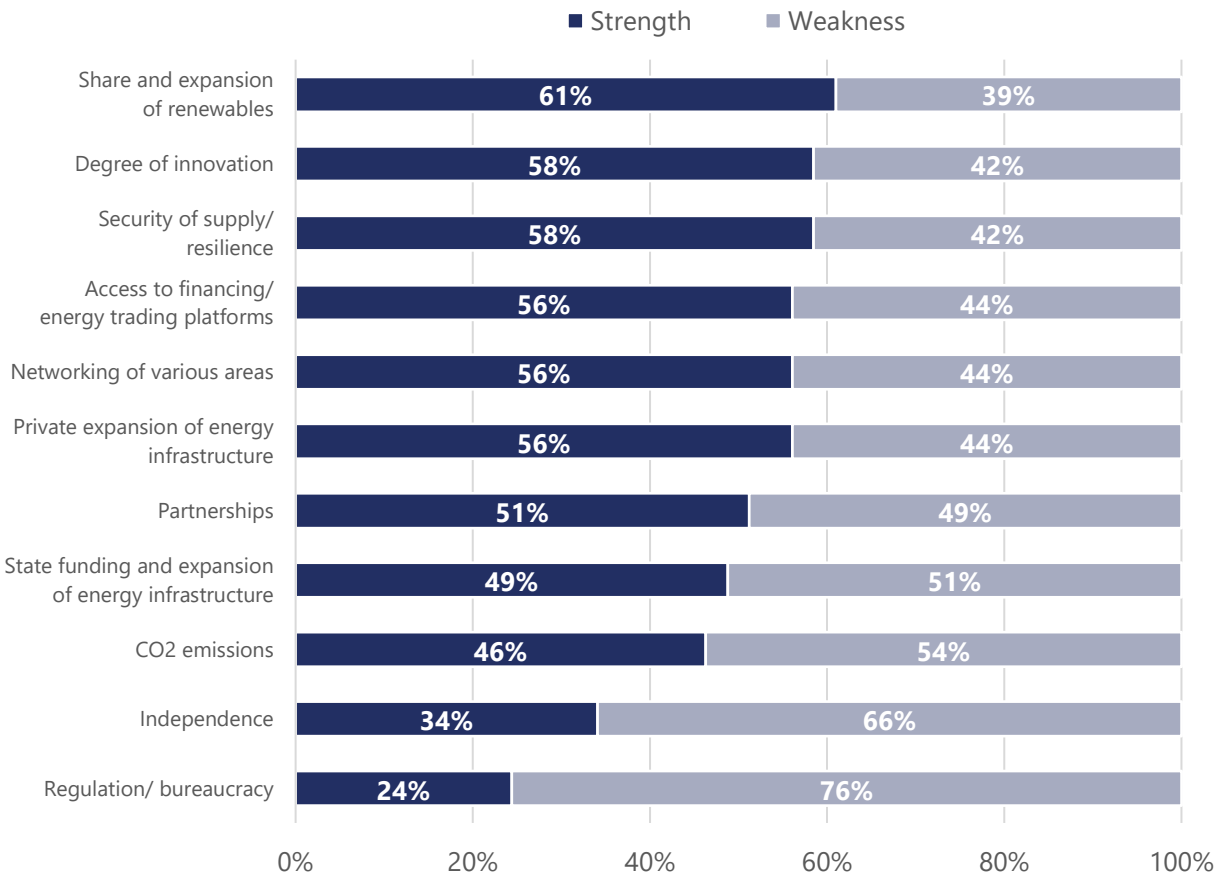
- 22% of energy companies agree with the idea that the energy infrastructure has been sufficiently developed over the last 10 years
- A further 27% tend to at least agree
- A 44% share remains rather sceptical about the idea
- 7% reject the idea outright

Energy companies present a mixed picture with regard to the idea of sufficient development of the energy infrastructure

Question: In your opinion, has energy infrastructure in general (electricity, heat, fuels) in Germany been sufficiently developed and optimised in the last ten years?

Companies from the energy industry also most frequently categorise Germany's regulatory requirements and excessive bureaucracy as weaknesses

Strengths and weaknesses of the energy infrastructure in GER



Question: Where do you see strengths and weaknesses in the German energy infrastructure?

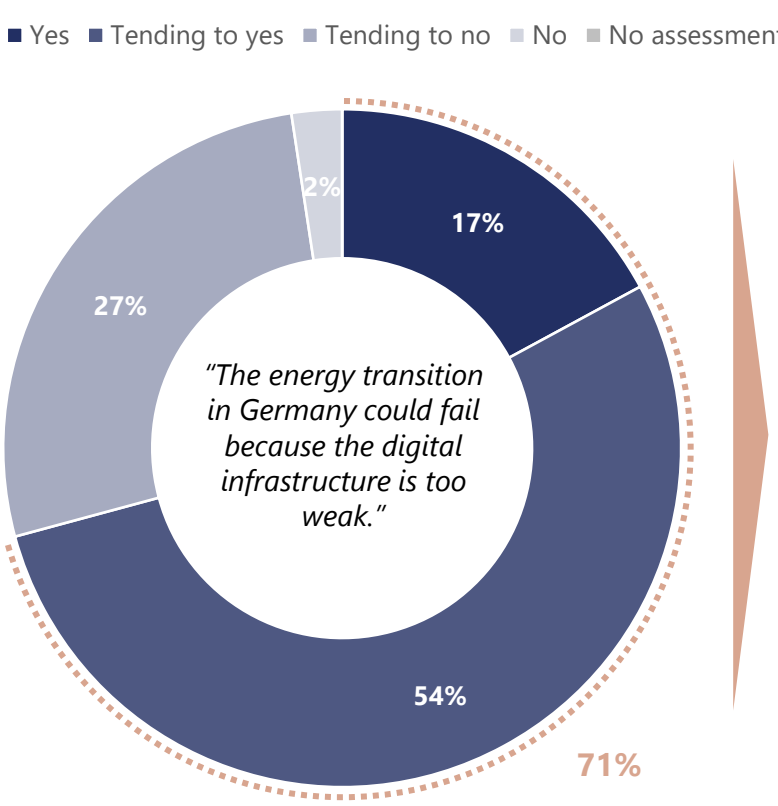
– Key takeaways –

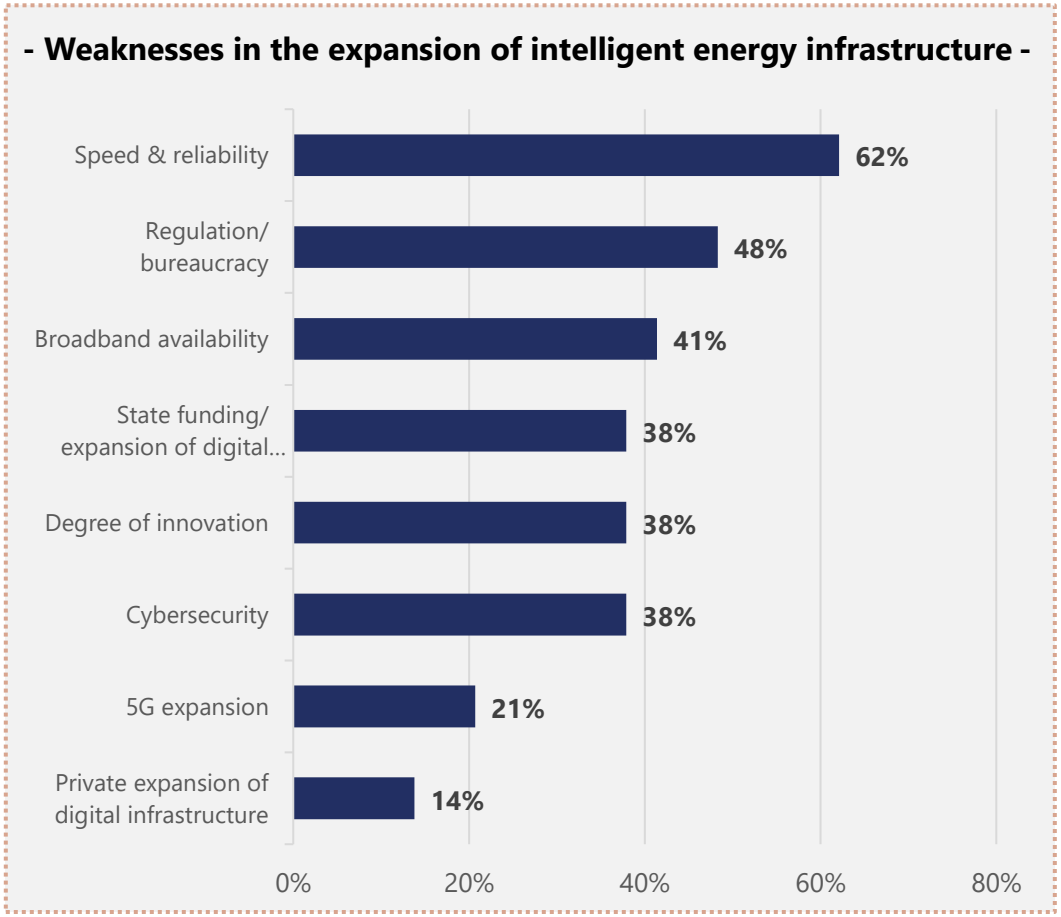
- At 76%, the most frequently cited weakness is regulation and bureaucracy in Germany
- Another major weakness (66%) is Germany's major dependence on energy imports
- More than half of respondents also see the state subsidy for expansion as a weakness

Excessive bureaucracy stands out as a major weakness of the German energy infrastructure

A significant majority identify a connection between the state of digital infrastructure and a successful energy transition in Germany

Influence of digitalisation on the energy transition





Questions: What do you think of the following? "The energy transition in Germany may fail due to an underdeveloped digital infrastructure"; [If in favour]: What are the three biggest weaknesses in Germany's digital infrastructure that continue to hamper the expansion of a smart energy infrastructure?

One frequently-cited advantage of a powerful digital infrastructure for the energy transition is the increase in energy efficiency and resource utilisation

Advantages of digital infrastructure for energy transition

1. **Sector connection**
   Enabling the efficient connection of different disciplines – such as energy generation, storage and distribution
2. **Increased efficiency**
   Improved control of decentralised energy generation and decentralised energy consumption, e.g. through "Smart Grids"
3. **Improving transparency**
   The deployment of technologies – such as smart metering – is only possible with an efficient digital infrastructure
4. **Resilience of the energy infrastructure**
   Improved real-time energy infrastructure monitoring capabilities for the early-stage detection of potential issues
5. **Increased profitability**
   Creating new business models and business opportunities in the field of renewable energies by optimising the use of resources

– Key takeaways –

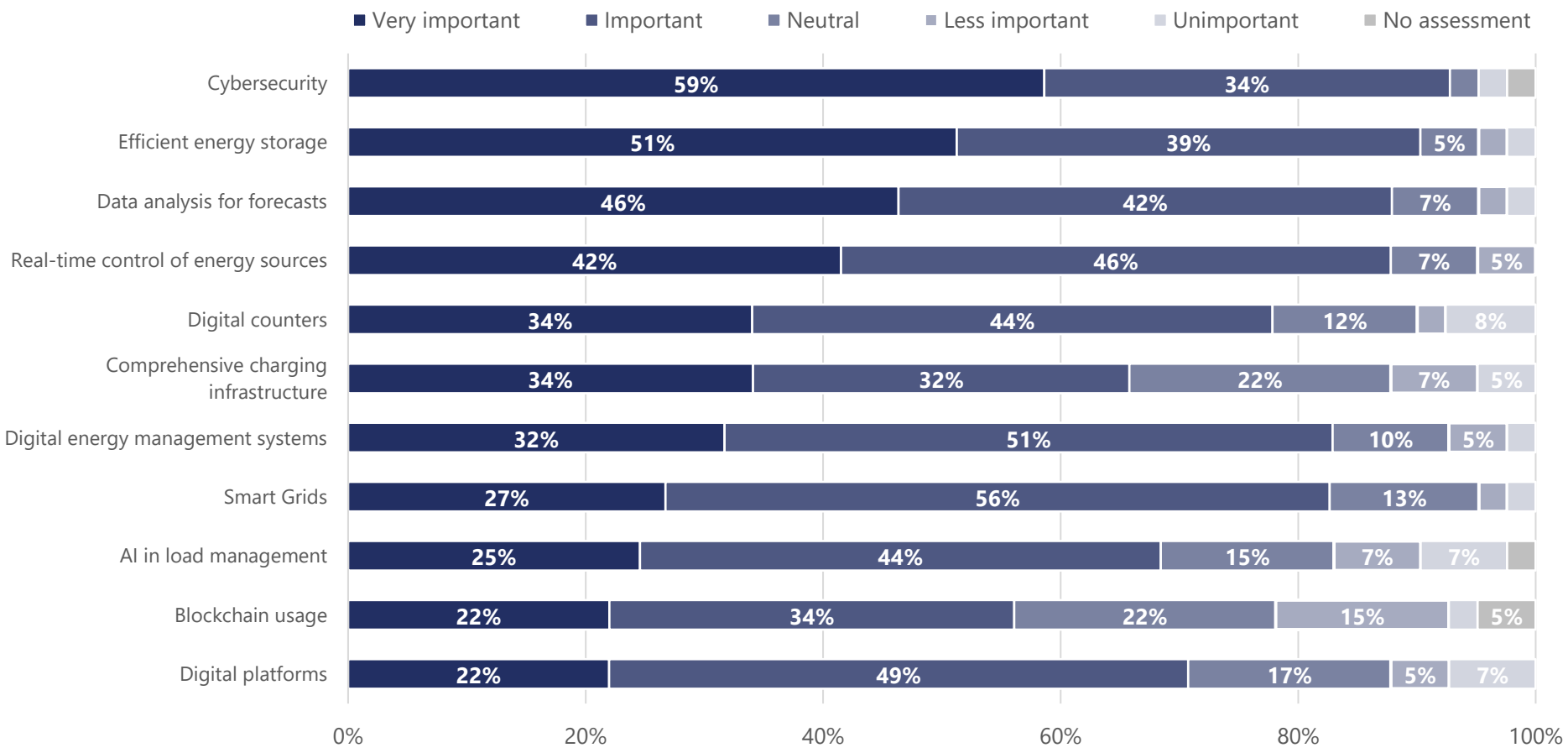
- The most frequently-cited advantage of an efficient digital infrastructure for a successful energy transition is an increase in efficiency
- This is also associated with other aforementioned benefits – such as increased profitability and the sector connection
- In addition, improvements in transparency and increasing the resilience of the energy infrastructure are mentioned several times

Efficient digital infrastructure should contribute to the energy transition – primarily by increasing efficiency

Questions: What are the most important advantages of an efficient digital infrastructure to ensure a successful energy transition?

Energy companies identify cyber security as the most important factor in the energy transition in Germany

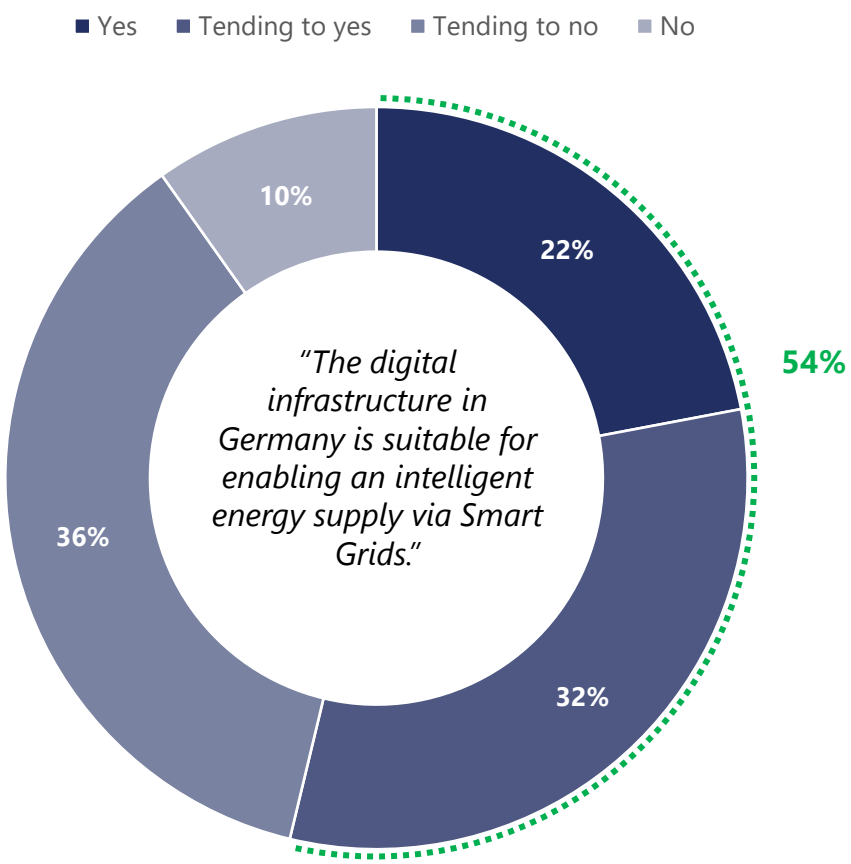
Relevance of various factors in the energy transition



Question: How important are the following areas in terms of accelerating the energy transition in Germany?

Only a small majority of energy companies consider the current digital infrastructure in Germany to be suitable for enabling energy supply via Smart Grids

Digital infrastructure and Smart Grids



Question: Is digital infrastructure in Germany currently suitable for enabling an intelligent energy supply via Smart Grids?

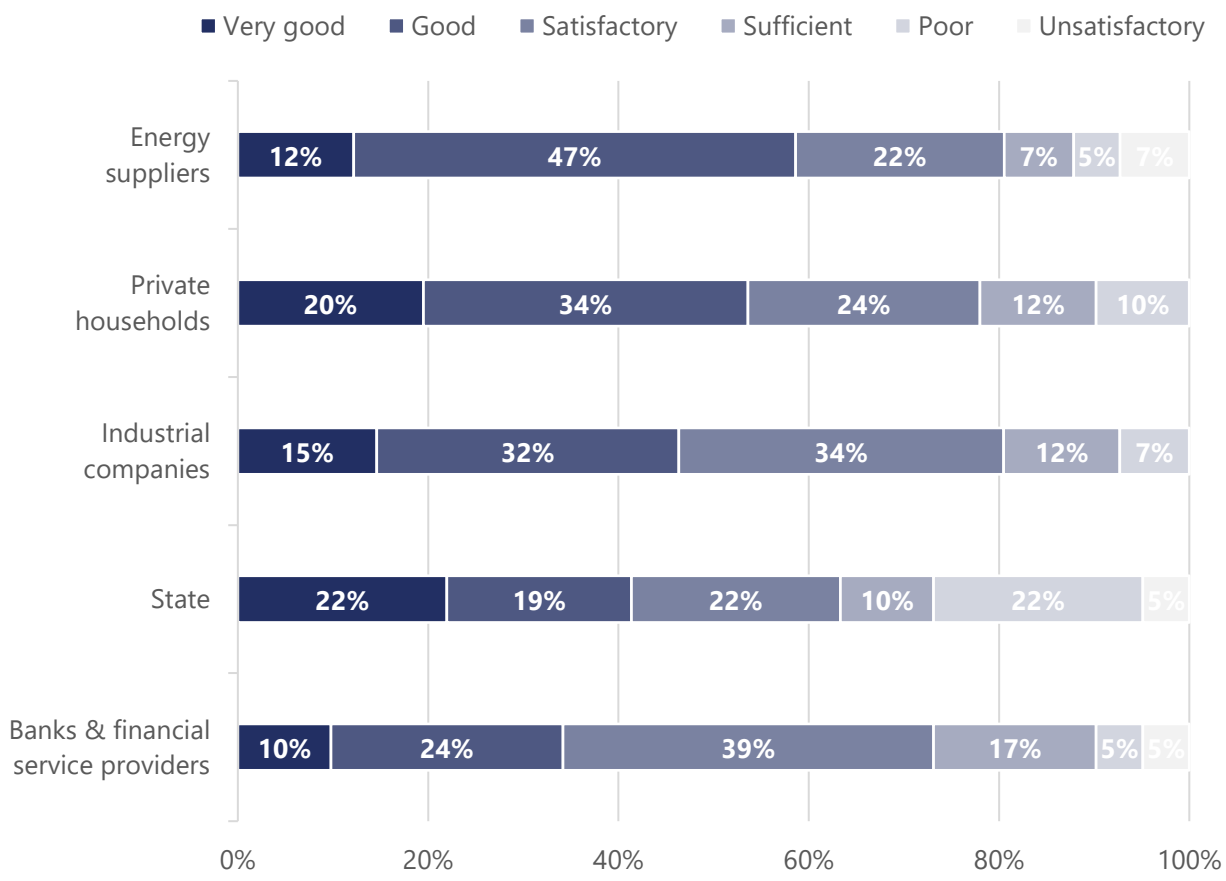
– Key takeaways –

- Only 22% of energy companies agree with the idea that the current digital infrastructure is suitable for an energy supply via Smart Grids
- Low approval ratings could result from respondents' reference to specific application technologies – such as the roll-out of smart meters, rather than factors such as broadband expansion or 5G coverage

Just under half of companies feel that the digital infrastructure is not suitable for the use of Smart Grids

Energy companies believe banks and financial service providers have potential to catch up in terms of their efforts to drive forward the energy transition

Evaluation of various players in the energy transition



– Key takeaways –

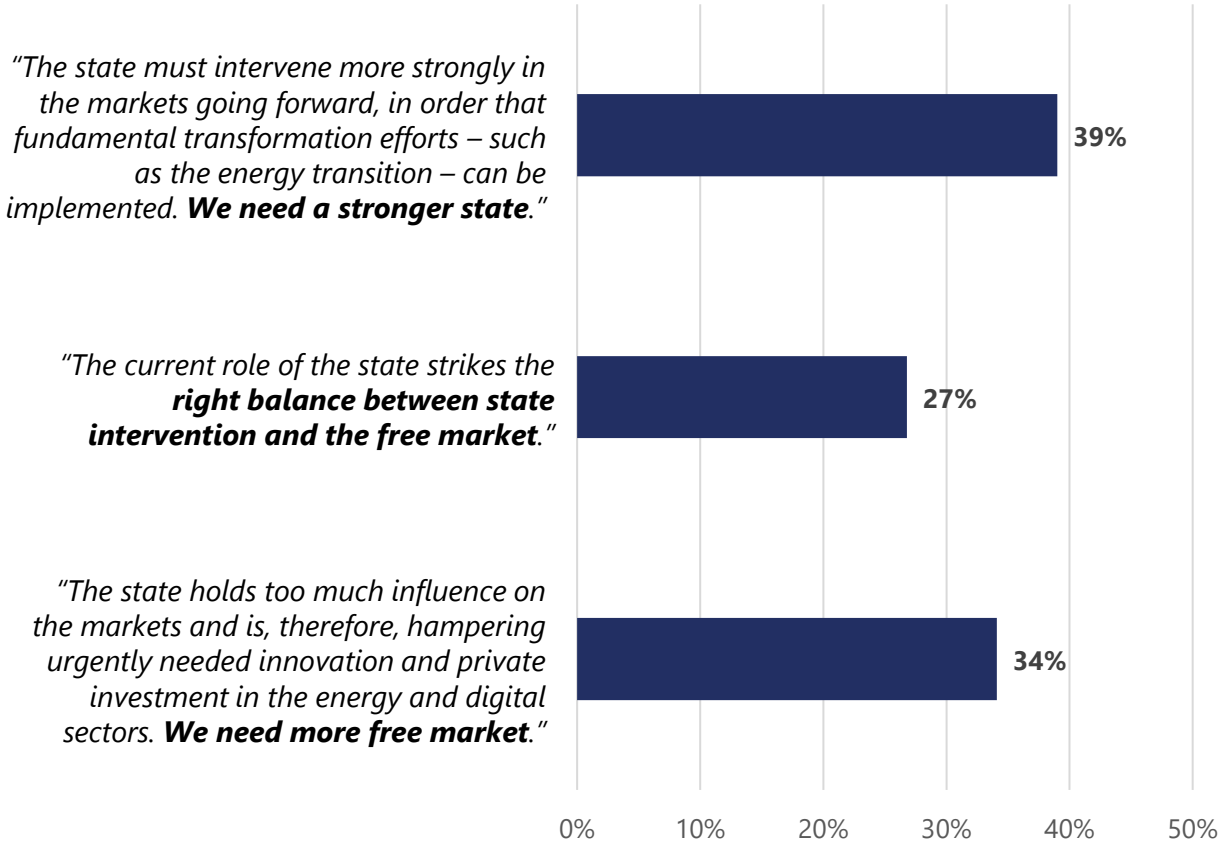
- Energy companies rate the efforts of both energy suppliers and households as predominantly good in driving the energy transition forward
- Banks and financial service providers perform worst here
- Opinions differ most strongly with regard to the assessment of the state's efforts

Divided opinions on the assessment of the state's efforts regarding the energy transition

Question: How do you rate the efforts and initiatives of various stakeholders in driving forward the energy transition in Germany?

Just under 40% of energy companies believe that the state will have to intervene more strongly in the markets going forward, in order to realise far-reaching transformation efforts

Role of the state in the transformation



– Key takeaways –

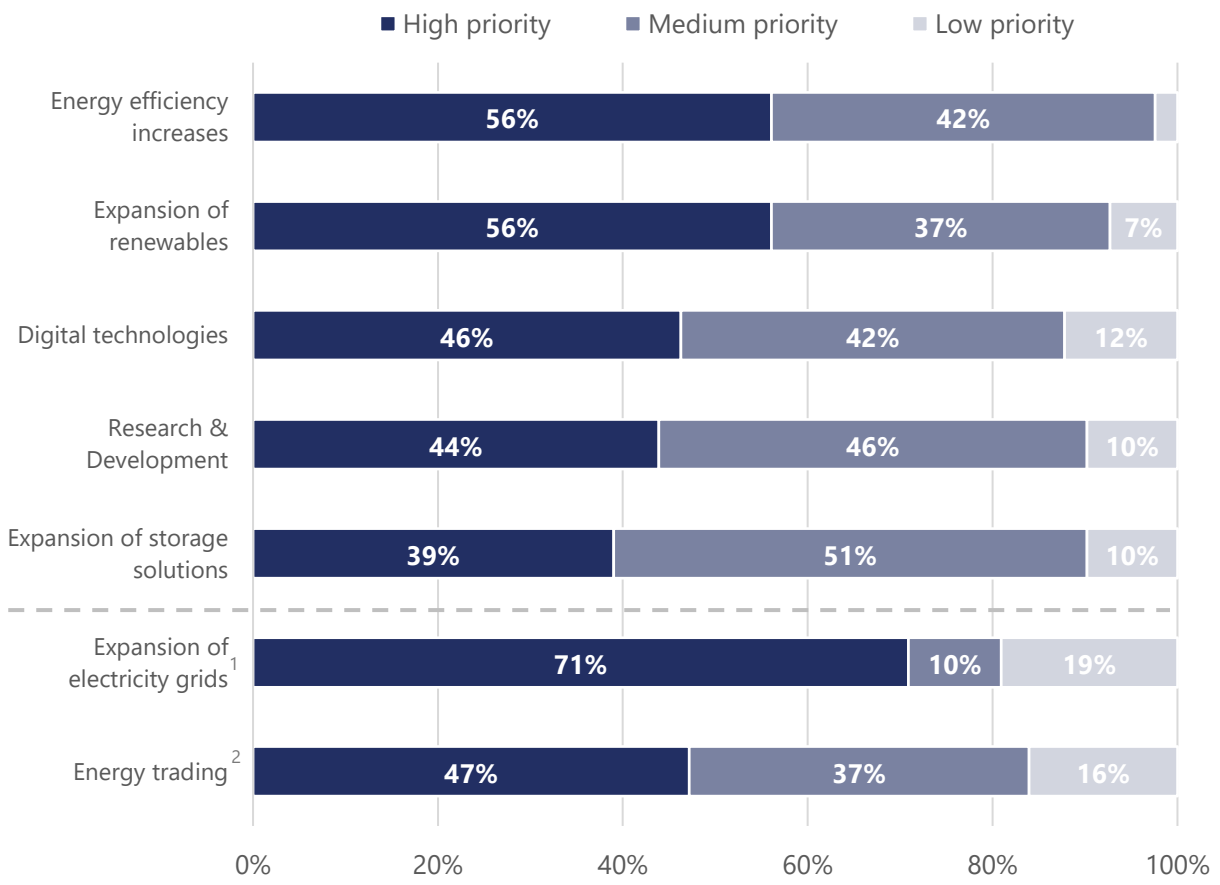
- 39% of energy companies surveyed agree with the idea that a stronger state will be needed in the future to implement transformations
- A further 27% see the current role of the state as representing the right level of intervention
- The remaining 34%, on the other hand, are in favour of a freer market

Small majority in favour of a stronger state in the implementation of transformation efforts

Question: Which idea do you agree with most regarding the role of the state in the transformation of energy infrastructure?

Electricity grids represent an elementary component for the efficient distribution of renewable energies, which is also reflected in the investment priorities of energy companies

Investment priorities with regard to energy infrastructure



– Key takeaways –

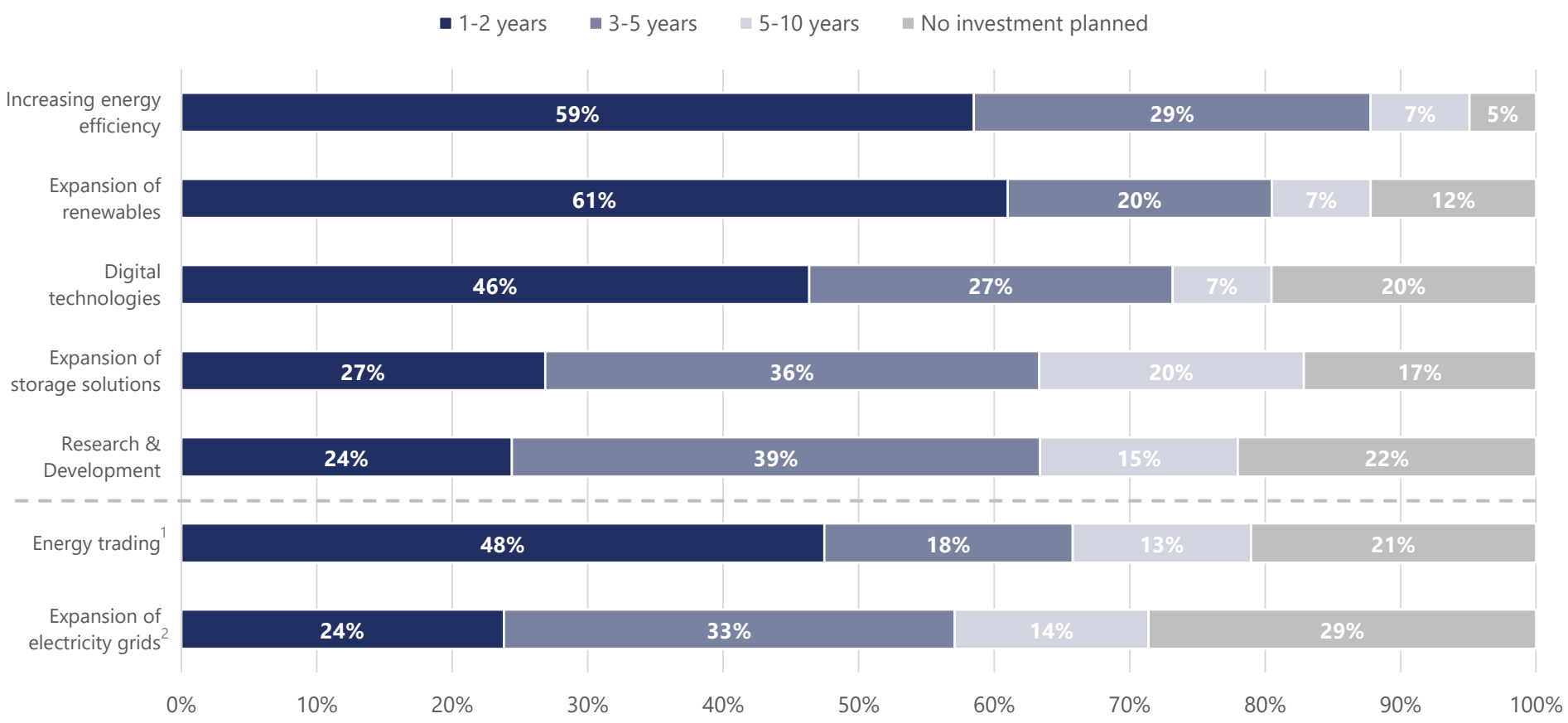
- Expansion of the electricity grids enjoys a high priority for 71% of the relevant energy companies
- This is followed by the increase in energy efficiency and the expansion of renewable energies with 56% each
- With a share of 39%, the fewest companies rate the expansion of storage solutions as a high priority

Even before the expansion of renewables, increasing efficiency is a high priority for companies

Question: Please rate the priority within your company for investments and initiatives with regard to energy infrastructure.
1) Includes responses from energy suppliers and grid operators; 2) Includes responses from energy suppliers, producers, trading companies and service providers

Over the next five years, the energy companies surveyed intend to invest, in particular, in increasing energy efficiency and expanding renewable energies

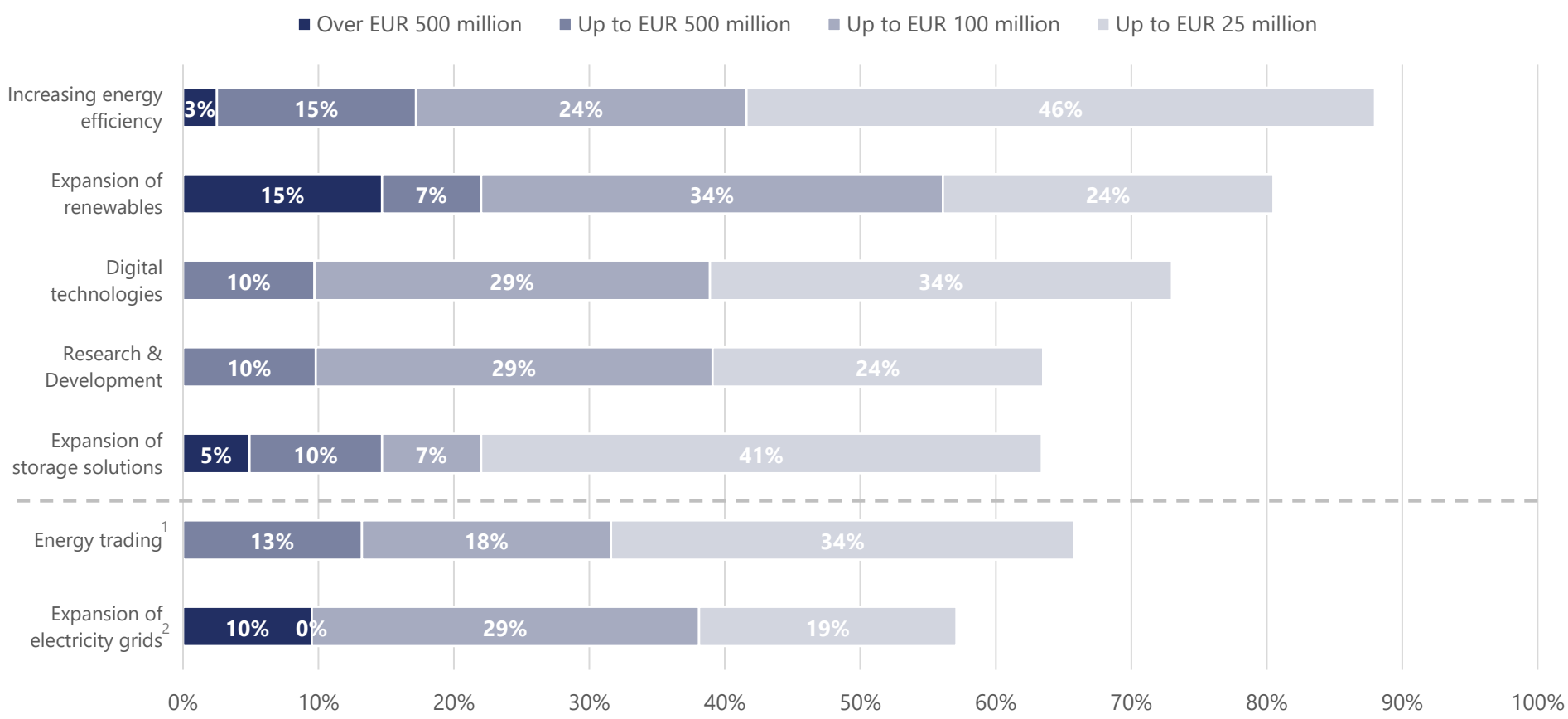
Time horizon of investment planning



Question: What specific areas are you planning to invest in over the next few years?
1) Includes responses from energy suppliers, producers, trading companies and service providers; 2) Includes responses from energy suppliers and grid operators

In terms of the envisaged investment amounts, the volumes for the expansion of renewables and electricity grids are the largest

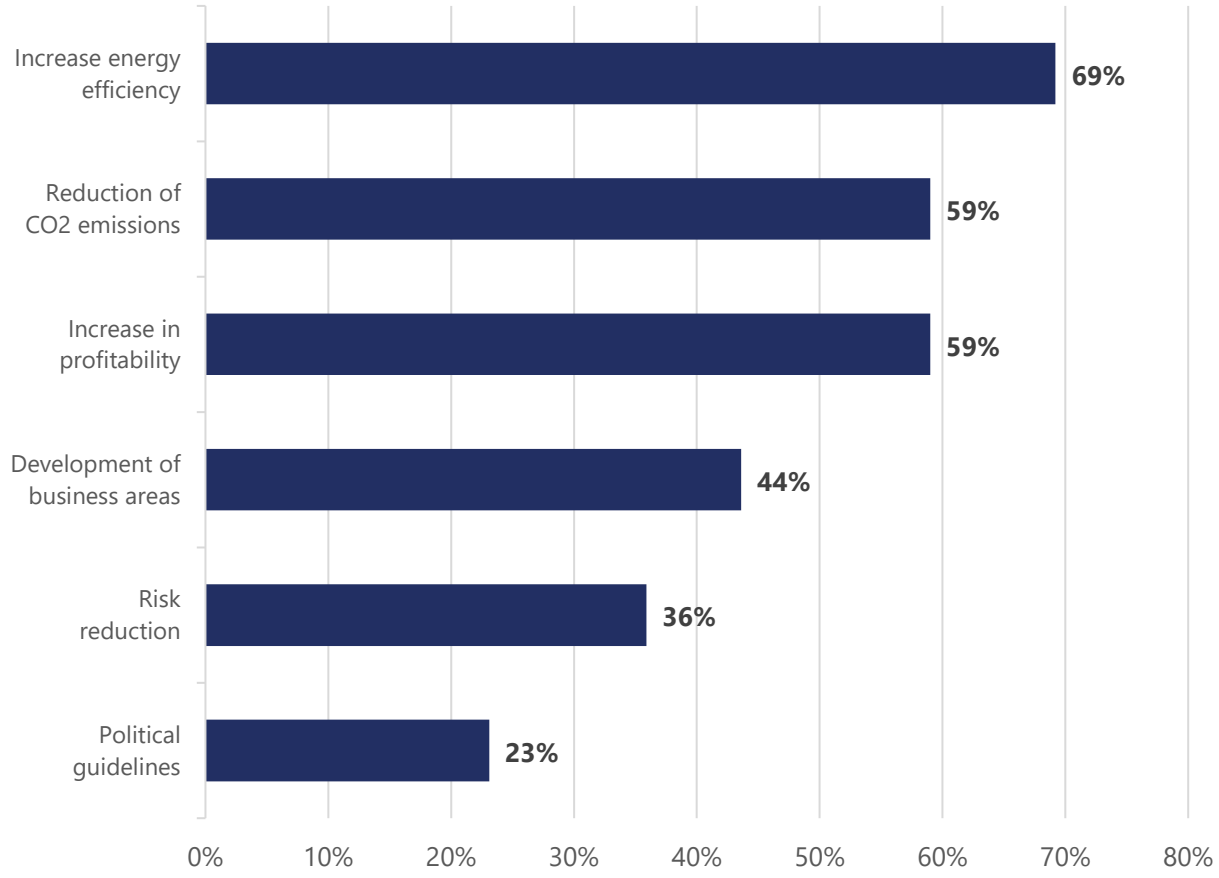
Envisaged investment amounts



Question: [Investment areas next 1-5 years]: What amounts are you planning to invest in the following investment areas?
1) Includes responses from energy suppliers, producers, trading companies and service providers; 2) Includes responses from energy suppliers and grid operators

The most frequently-cited reason for investment projects over the next five years is to increase energy efficiency

Primary reasons for investment projects



Question: [Investment areas next 1-5 years]: What are the primary reasons driving your company's investment plans?

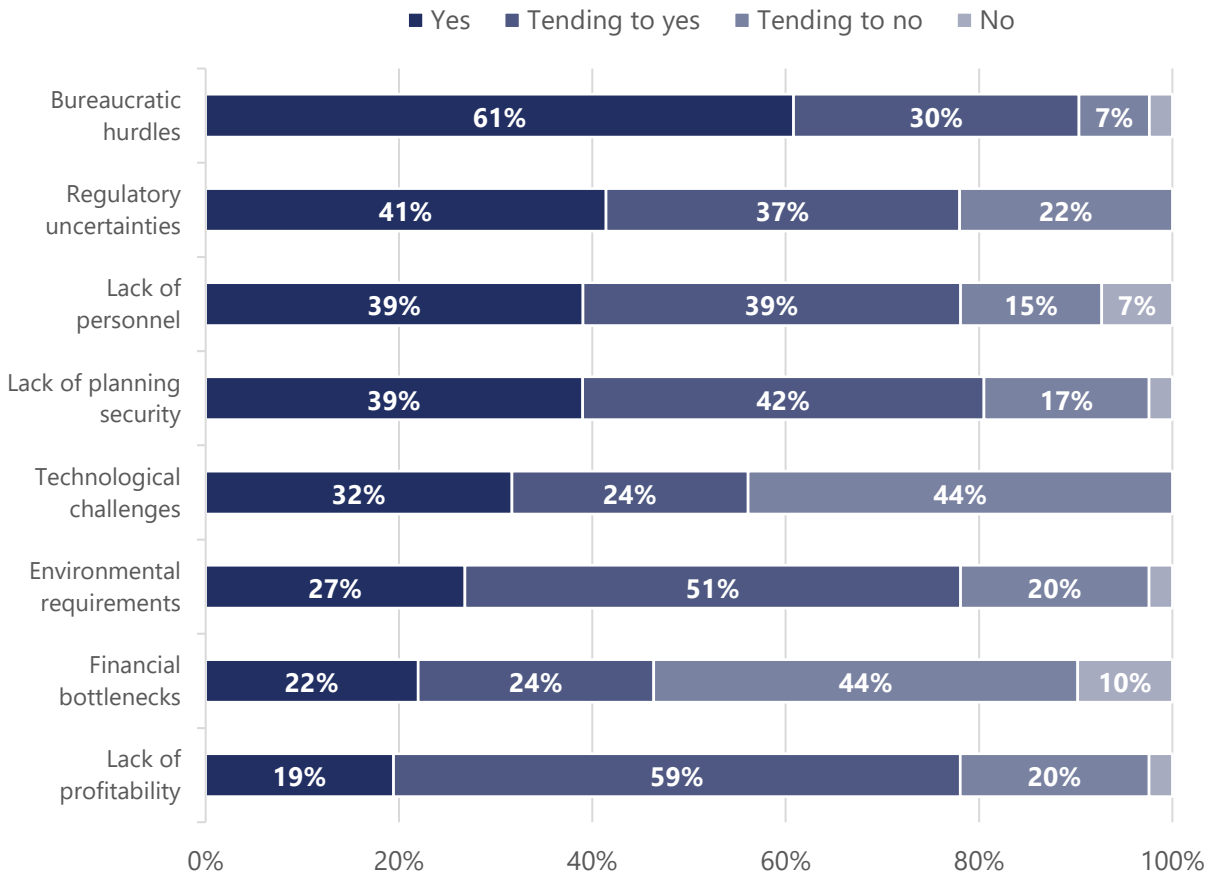
– Key takeaways –

- At 69%, most companies cite increases in energy efficiency as the key reason for investment projects in the coming years
- Reduction of CO2 emissions and increase in profitability are behind with 59% each
- By contrast, political requirements are the main reason for investment for only 23% of energy companies

High level of energy efficiency as a decisive reason for future investment projects

Energy companies identify bureaucratic hurdles as by far the biggest obstacle to investment in energy infrastructure

Barriers to investment in energy infrastructure



Question: What obstacles do you perceive when investing in energy infrastructure?

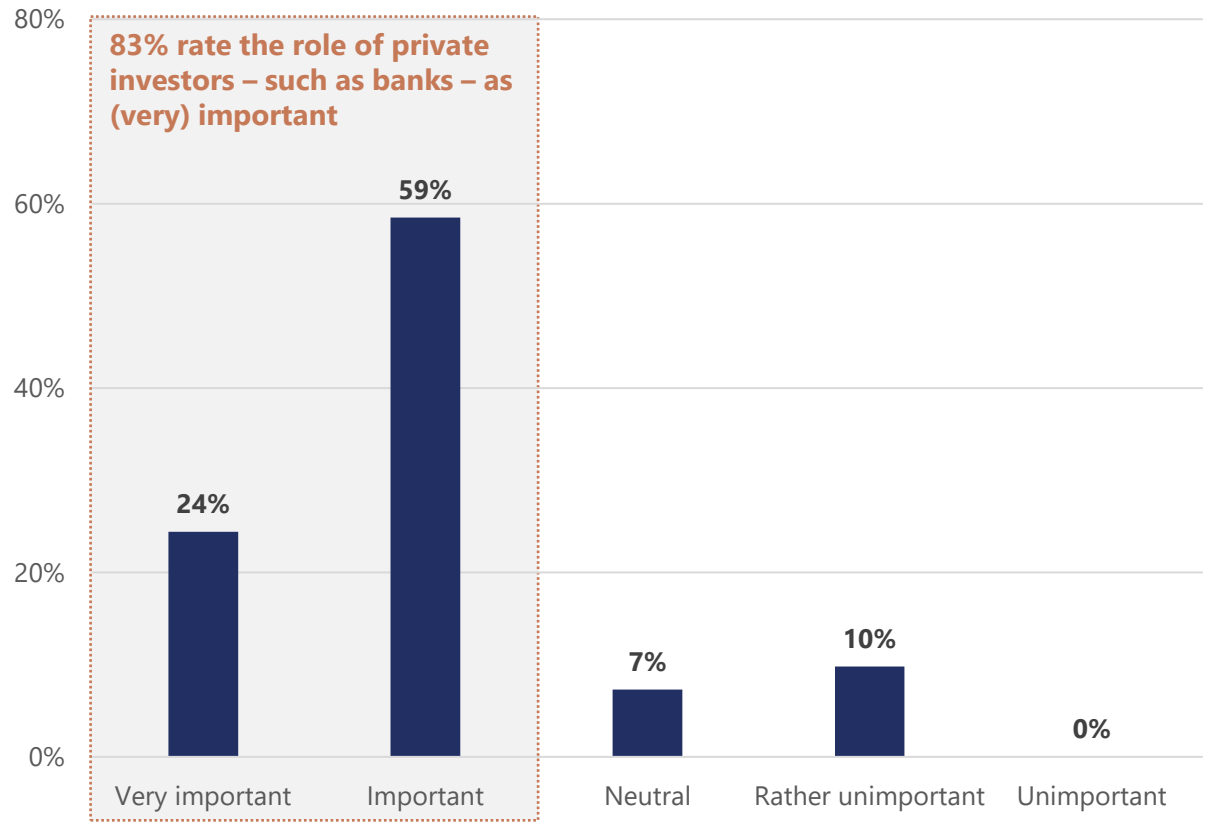
– Key takeaways –

- 61% see high bureaucratic hurdles as a clear obstacle to investment in energy infrastructure
- Regulatory uncertainties (42%) and a lack of personnel (39%) follow by a noticeable margin
- By contrast, technological challenges (32%) and, in particular, financial bottlenecks (22%) are perceived as less of a decisive obstacle

The state, in particular, is in a position to promote investment in energy infrastructure by reducing bureaucracy

Banks and other private investors are recognised by companies in the energy industry as playing an essential role in the expansion of energy infrastructure

Relevance of banks for the expansion of energy infrastructure



– Key takeaways –

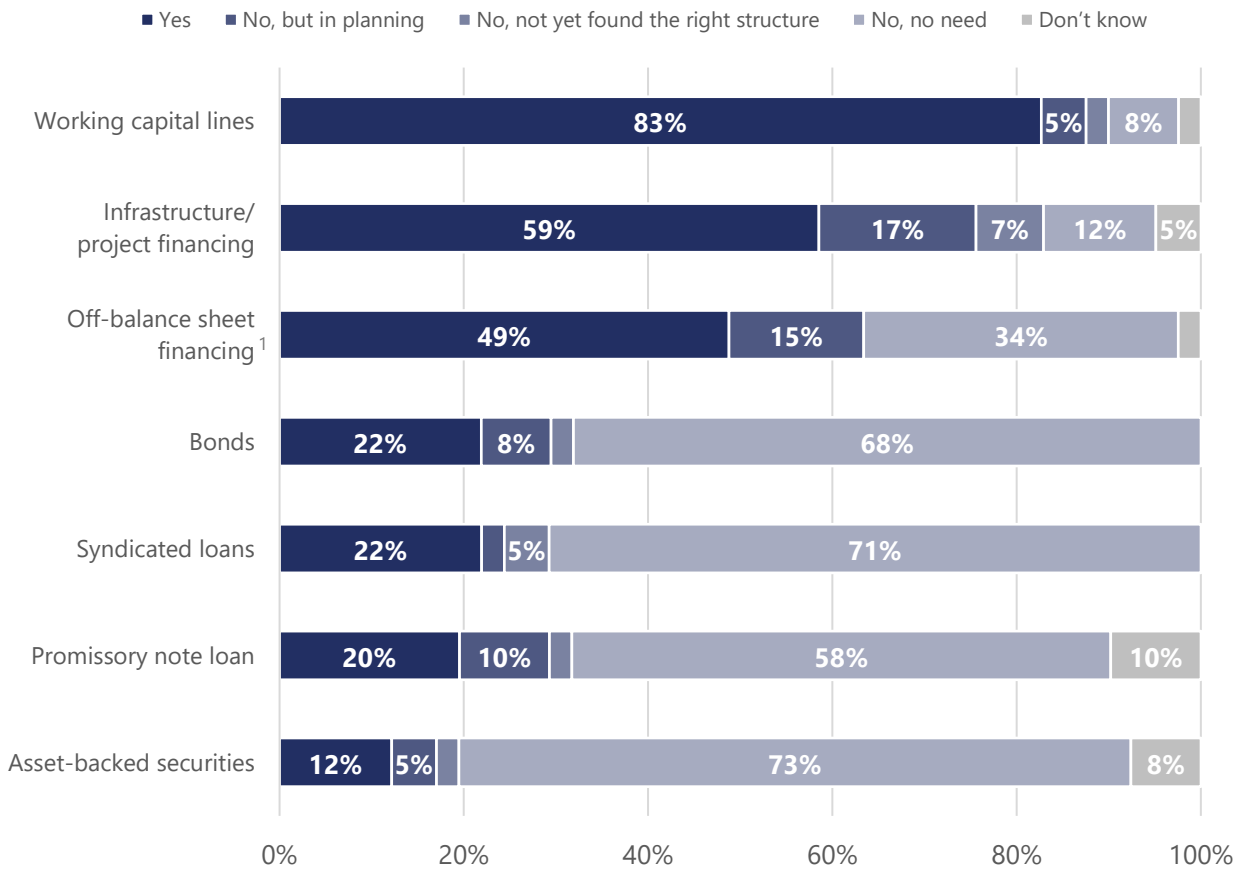
- The role of banks and other private investors is categorised as important or very important by 83% of energy companies
- An additional 7% rate their relevance for the expansion of the energy infrastructure as neutral
- Only 10% rate the role of banks as rather unimportant, 0% as completely unimportant

Banks and other private investors play a fundamental role in the expansion of energy infrastructure

Question: How important do you consider the role of banks and other private investors to be in the expansion of energy infrastructure?

The energy companies surveyed use project financing significantly more frequently due to their size and respective business models

Types of financing used



– Key takeaways –

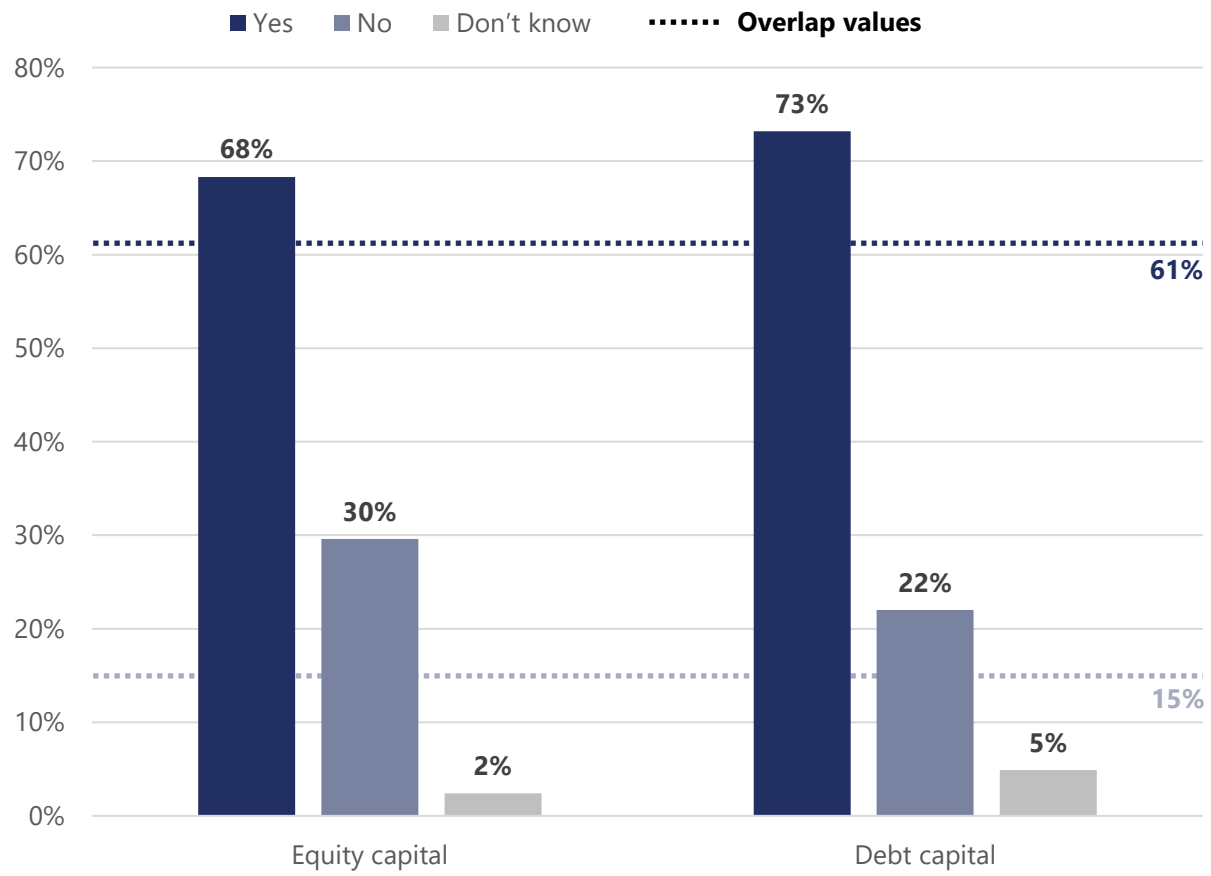
- The most frequently used type of financing among companies in the energy industry is also conventional working capital (83%)
- At 59%, energy companies utilise project financing significantly more frequently than the general average
- Here, and with regard to off-balance sheet[1], a significant proportion are planning their use

Energy companies are seen as important customers for individually structured financing

Question: Does your company use the following types of financing?
1) excluding infrastructure/project financing

The energy transition requires significant investments from companies in the energy sector, which is also evident in the required increase in equity/debt capital

Required increase in financing components



– Key takeaways –

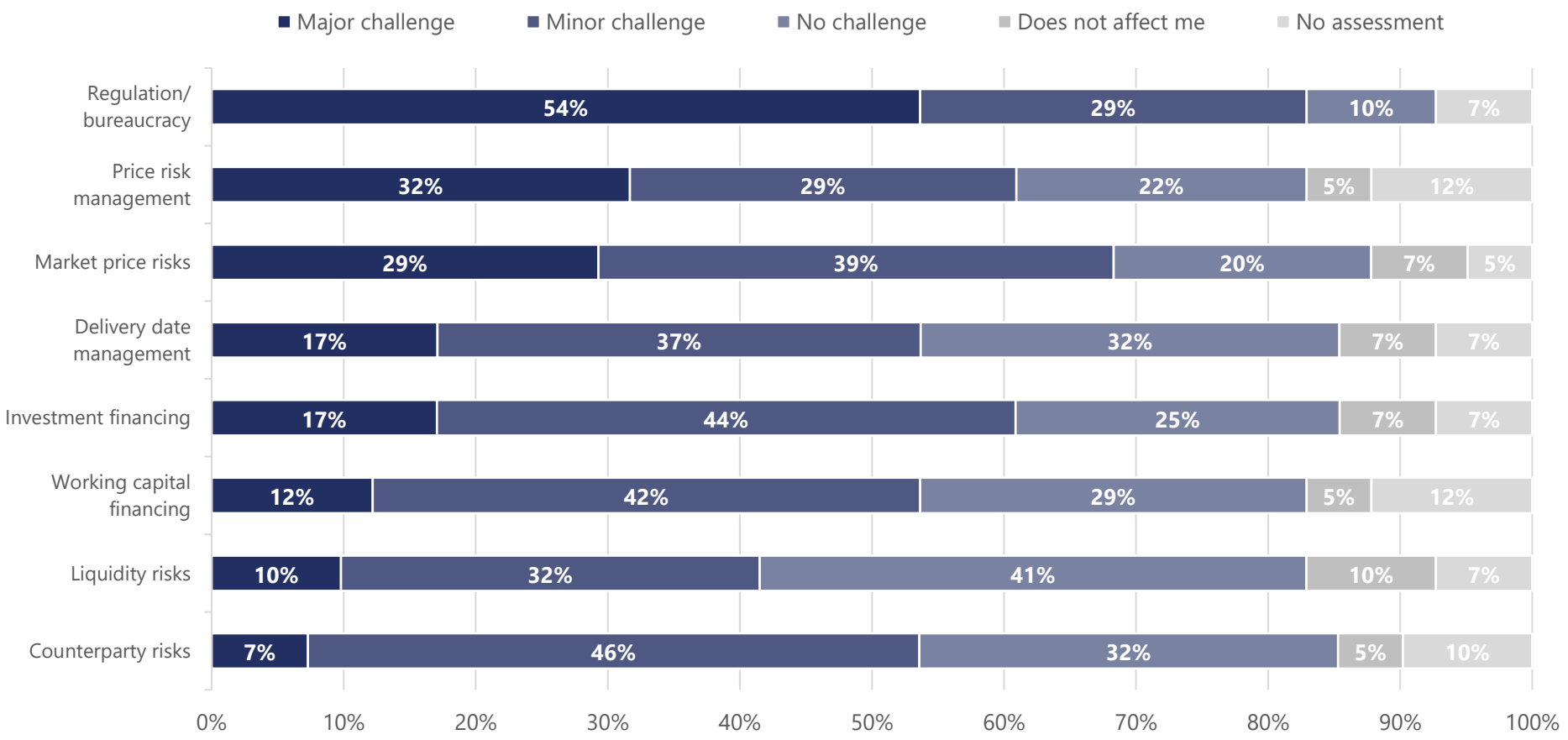
- 68% of energy companies need to increase their equity, in order to cope with future investments in the energy transition
- Slightly more companies (73%) need to increase debt capital
- Special analysis shows that 61% require an increase in both equity and debt capital, while just 15% do not require an increase

The majority of energy companies require an increase in both equity and debt capital

Question: In order to manage upcoming investments with regard to the energy transition in your company: Do you need to significantly increase the following financing components in future?

As with regard to energy infrastructure, energy companies also see the greatest challenges in the financial sector in the regulatory framework and bureaucracy

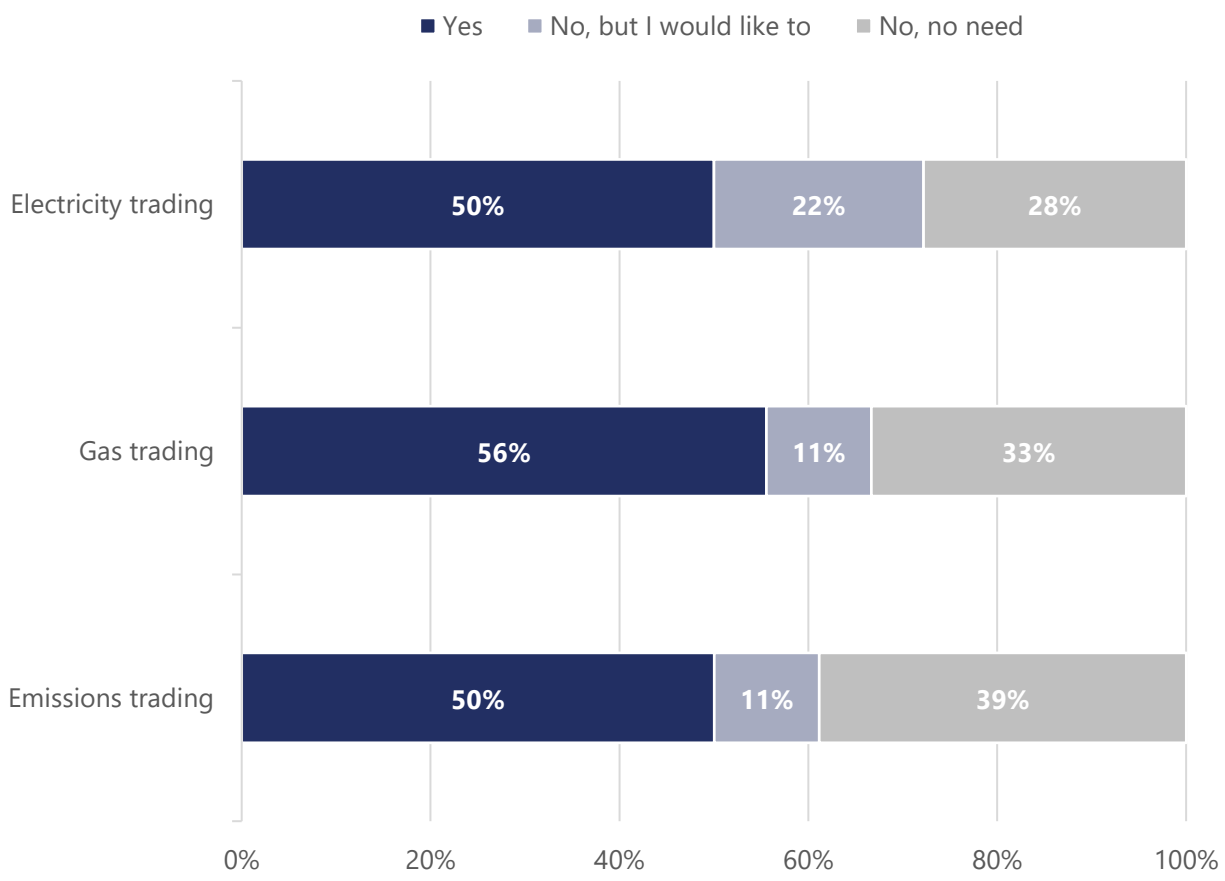
Challenges in the financial sector



Question: What challenges is your company currently facing in terms of finance?

Demand for support from banks and financial service providers is at a similarly high level for electricity, gas and emissions trading

Support services used by banks[1] (1/2)



Question: Do you use the support of banks and financial service providers in the following areas?
1) Includes responses from energy suppliers, producers and trading companies

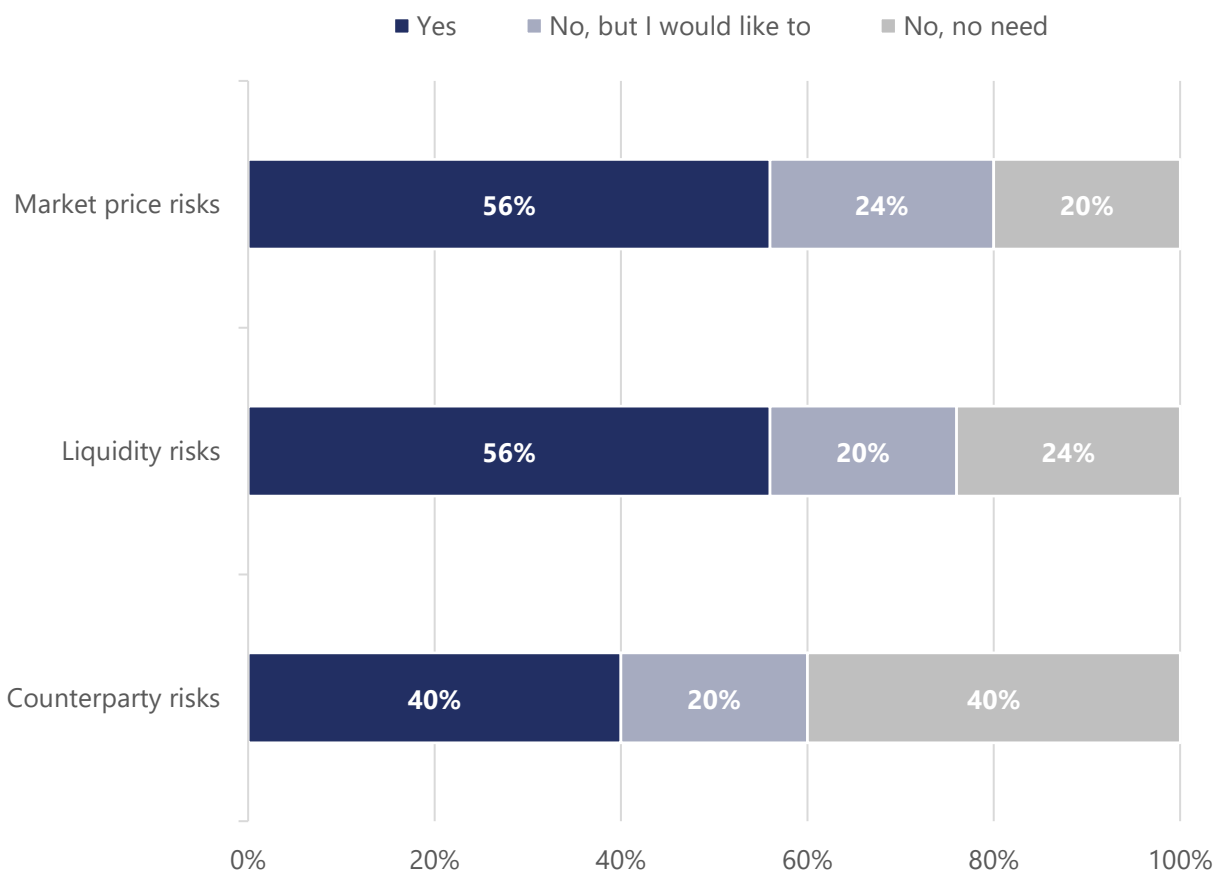
– Key takeaways –

- Energy companies express the greatest need for support in electricity trading, 50% are supported by banks or financial service providers and a further 22% would like to do so
- This is followed by the need for support in gas trading (56% and 11%) and emissions trading (50% and 11%)

Around two-thirds of energy companies in need of support

More than half of energy companies use the support of banks to manage market price and liquidity risks

Support services used by banks[1] (2/2)



– Key takeaways –

- 56% of the relevant energy companies hedge against market price risks with the support of banks, a further 24% would like to do so
- With regard to liquidity risks, the corresponding figures are at a similar level, at 56% and 20%
- With regard to counterparty risks, banks support 40% of companies, while a further 40% have no need to do so

Banks and financial service providers important partners in risk management

Question: [If available bank support in trade]: In terms of emissions, electricity and/or gas trading, do you make use of support from banks and financial service providers through derivative structures to manage the following risks? 1) Includes responses from energy suppliers, producers and trading companies

Marcel Münch
SVP Finanzen, M&A und Investor Relations
EnBW AG

How do you assess the developments unfolding within the German energy transition? Are we on track for success?

Münch: Let's shed a bit of light on the subject: We have been working on the energy transition since 2000 – since the first Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz). With this in mind, this is a project that has been running for around two and a half decades. We have made some great progress in the meantime, but there is still a lot to do. The original intention was to reduce CO2 emissions from energy generation, in particular, by expanding renewable energies. Since then, the pressure on the energy transition to succeed has increased dramatically: Firstly, through the accident involving the nuclear reactor in Fukushima (accelerated phase-out of nuclear energy), the goal of an accelerated phase-out affecting coal and then through the consequences of the war in Ukraine (loss of Russian gas supplies). As a result, Germany has found itself in a situation where it must reduce its dependence on three energy sources at once: nuclear energy, coal and gas – while of course, at the same time, ensuring its security of supply. And so, the challenges have grown in magnitude over time.

Do you think the energy transition is feasible under these difficult conditions? And if so, under what conditions?

Münch: I consider this to be a very ambitious goal, but I also believe that it is possible. As a company, we are also convinced that the energy transition can succeed. However, there are certain requirements that must be met. In particular, numerous stakeholders have to work together and efficiently, while ensuring that all moving parts are harmoniously interlinked with one another. It is essential not to lose sight of the primary objective, namely creating a decarbonised energy supply in Germany that does not require nuclear energy and, at the same time, guarantees a high level of dependability we have become accustomed to.

Where do you think there is the most work to be done? Is there an investment backlog?

Münch: I would not speak of an investment backlog. As EnBW, we maintain a holistic view of the energy transition or "Energiewende", because we are the only fully integrated energy supplier that covers the entire process chain – including generation, grid operation, end customer sales and, for example, the charging infrastructure for electric vehicles. In my opinion, (i) the expansion of renewable energies, (ii) the expansion of grid infrastructure and also (iii) the expansion of readily-available power plant capacity (gas-fired power plants) are highly relevant to the success of the energy transition. These aspects are interlinked and must, therefore, be pursued in their entirety. In order to achieve this, investments in all three areas will have to be increased on a massive scale in the years to come. Incidentally, this is not because too little has been invested and done in the past, but simply because there is still so much to do.

In addition to increased investment activity, what other success factors do you identify?

Münch: In my opinion, there are three factors that will determine the energy transition's ultimate success: Firstly, we need to increase the speed of all process steps. This starts with speeding up authorisation procedures – we often lose a lot of time here. And there are also levers to ensure greater efficiency in terms of project realisation itself. This also includes, for example, channelling objection options for projects more effectively and ideally mapping them via a single authority – project developers are currently facing implementation hurdles at various levels. On balance, we should also move away from continuously discussing the appropriateness of certain levels of ambition, for example, whether things can actually be realised by a certain year. This is because: Things that we do not initiate today will not have been realised in 2030. We, therefore, need determination and speed, especially when initiating projects. Secondly, we must eliminate shortages within supply chains, in order to ensure security of supply and material security on our transformation path. And, last but not least, we also require a large number of highly qualified staff to support this enormous reorganisation effort.

Do you have specific examples of how such processes and projects can be realised more quickly and efficiently?

Münch: Our transmission grid subsidiary – TransnetBW – is currently developing "Suedlink", one of the largest single projects of the energy transition in Germany. A total of approximately 700 kilometres of cable will be laid from the North Sea to the south of Germany. Due to prevailing legal requirements, we have to install these lines as underground cables, through six federal states and over – or under – more than 10,000 properties. This represents a gigantic investment project in terms of scale and complexity, which must be put into operation by 2028. In my opinion, a large dose of pragmatism is needed to make projects of this scale a success in the given time frame. For the large-scale, second-generation routes, i.e. the follow-up projects after Suedlink et al., consideration should be given to whether overhead lines can be used instead of underground cables – all in the interests of speed and, above all, cost efficiency. We are talking about potential savings of EUR 20 to 30 billion in

> „We need determination and speed, especially when initiating projects."

investments alone with such a switch, which would be reflected in a reduction in the grid fees to be borne by all electricity customers of over EUR 1 billion p.a. over the next few decades. In my view, the LNG terminals in northern Germany serve as a good example of quick and pragmatic action. We have actually achieved something that many would not have expected: Within a few months, ships were procured, jetties and pipelines were authorised, built and put into operation. I find this example very encouraging, because it shows that we have the strength and speed to implement things when we need to.

> „The LNG terminals in northern Germany serve as a good example of quick and pragmatic action."

If the pace of investment and implementation does not increase to the extent you have outlined: What danger do you see for Germany?

Münch: It depends on the compromises we are prepared to make – specifically with regard to the phasing-out of coal and decarbonisation. EnBW, for example, has set itself the goal of phasing out coal-based energy supplies by 2028. The slower the pace of expansion concerning renewables, grid infrastructure and the available capacity (in the form of gas-fired power plants), the longer these coal-fired power plants would have to be kept in reserve by the companies. Both national and international investors naturally hold certain expectations, and their understanding of the fact that energy companies are less ambitious when it comes to phasing out coal is very limited. We, therefore, not only have to shoulder socio-political pressure, but also the requirements of investors, in order to be able to realise the high-level investment sums going forward. This means that competitiveness within the energy industry also depends on the success of the energy transition – a circular interdependency, if you like.

When it comes to statistics on the expansion of digital infrastructure, Germany is often found at the bottom of European rankings. Connectivity is, without doubt, also highly relevant for the energy supply sector – for example, in smart distribution or the charging infrastructure. What importance do you attach to ensuring an efficient digital infrastructure, and is there a mutual dependence here in terms of a successful transformation?

Münch: We also have a need to implement things more quickly within digitalisation. Weaknesses in this area entail a significant impact on the local economy and, of course, on the energy sector. It is difficult to estimate the extent to which this will enable a specific, measurable acceleration of the energy transition, but it is definitely a requirement. A parallel expansion is, therefore, necessary. A prioritisation – expansion of energy infrastructure or digital infrastructure – does not seem very prudent to me, as the deficits in one sector would have a negative impact on the other. The interplay between the two areas of infrastructure plays a key role in the competetiveness and appeal of German companies.

Speaking of competitiveness: Have you experienced any concrete effects on the economy or industry against the backdrop of the energy infrastructure, for example, in terms of decisions regarding location?

Münch: Energy-intensive companies, in particular, are naturally facing major challenges due to rising energy prices. It is not at all easy for politicians to differentiate between a general sense of lamentation due to increased costs and a real-terms issue. After all, high prices also promote the acceleration of both innovation and transformation. At a certain point, however, excessively high energy costs also have a destructive effect, and then location decisions are made that have a negative impact on Germany as a business location. It is, therefore, important to ensure that the costs of the energy transition do not get out of hand. Although solar and wind are not a liability in themselves, the total system costs are and will be associated with high capital requirements. Taking countermeasures with a spirit of pragmatism, a willingness to compromise and efficiency then helps to mitigate the rise in energy costs – which automatically results in increased competitiveness.

You would like to phase out (commercial) energy generation with coal by 2028. These power plants are of major systemic relevance and may, therefore, have to be kept in reserve beyond this point in time. What does the future look like here, including against the background of dependency in the gas sector?

Münch: We are firmly convinced that decarbonised energy supply in Germany will look like this in the future, that we have a very large proportion of renewable energies at our disposal, that we have back-up capacities mainly in the form of gas-fired power plants – all linked by high-performance grid infrastructure for both transmission and distribution. A lot will change, especially in terms of distribution: In the past, electricity usually flowed quite simply in one direction; however, today and in the future, there will be a large number of energy generation units, making intelligent networking and control highly relevant. We also anticipate a significant overall increase in electricity demand due to the ongoing electrification of the heating sector and car fleets, for example.

What role does hydrogen play?

Münch: The first fuel switch from hard coal to natural gas – which we are already in the process of delivering at three of our sites in Baden-Württemberg – will enable us to cut emissions by 50 to 60% alone. However, energy generation will only become completely emission-free when decarbonised gases or hydrogen are utilised. Ideally, this hydrogen is produced from renewable ener-

gies or through CO2 capture. That would be the system of the future: Gas-fired power plants, which replace natural gas with hydrogen or decarbonised gases in a second fuel switch and serve to cushion supply bottlenecks for "classic" renewables (e.g. wind and solar).

> „In the future, there will be a large number of generation units, making intelligent networking and control highly relevant."

Can the required amount of hydrogen be produced or extracted?

Münch: If the focus were exclusively on using green hydrogen only, you would first have to have enough renewable energy to not only cover the general electricity demand, but to generate even more to produce the hydrogen – because the process is very energy-intensive. In our opinion, we simply have too little land area in Germany for this – solar projects in sunnier countries, for example, seem better suited for this. And so, I assume that we will also be importing hydrogen on a larger scale. CO2 capture projects, which are already being planned in the USA, for example, can also play a role. It remains to be seen as to where hydrogen can be produced most cost-effectively and to what extent. It can definitely be the system of the future. For this reason, we are also planning our gas-fired power plants currently under construction as "hydrogen-ready", meaning that we can achieve complete CO2 freedom when green hydrogen is available in sufficient quantities.

When will Germany reach the point where it can cover its energy needs with a combination of renewable energies and hydrogen?

Münch: I believe we will be pleasantly surprised that many things are progressing comparatively quickly – if we now make a concerted effort. My expectation is that the phasing-out of coal (i.e. an end to commercial coal-fired power generation) will be possible in Germany by 2030. The switch from natural gas-based, readily available power to hydrogen should be achievable by the middle or end of the 2030s.

Dr Christoph Helle
Chief Representative
MVV Energie AG

How do you rate the state of energy infrastructure in Germany? Where do you see the greatest need for action, in order to successfully realise the energy transition?

Dr Helle: We are undergoing a truly unprecedented process of reorganisation with all stakeholders and components of the energy industry. This applies to all sectors and energy sources – not just electricity, but also gas, heat and, in the long term, CO2 capture and transport. Within the electricity sector, Germany started the transformation process relatively early on, and we have been quite successful, at least on the generation side, with over 50 per cent renewables. I see the area of transmission and distribution grids as a key challenge. There is also a tremendous need for action in terms of heat transformation.

What do you think: Where will we be in 2035? Are you optimistic that the ambitious targets can be achieved?

Dr Helle: What I find more exciting than the perspective of a "central planner" – who considers which goals should be achieved in which year – is a view of prevailing framework and financing conditions. Ultimately, these are the factors that lead to goal achievement – or failure, respectively. In my opinion, there is also no "standard solution", and that makes it difficult to declare a universally valid target state – aside from the overarching goal of decarbonisation. The focus should, therefore, be more on creating efficient conditions so that optimal structures are possible during implementation. Clear sources of guidance are required for different paths. One good example is the duality required in the gas market: The transition to green gases, on the one hand, and the fossil gas phase-out, on the other – the framework conditions for both paths still need to be specified. The same applies to district heating and topics such as CO2 capture and transport. Contrary to the opinion of some industry representatives, I do not believe that we are over-regulated in Germany; within the energy sector, in particular, there is a need for government bodies to define framework operating conditions and "rules of the game" in terms of market design.

> „Contrary to the opinion of some industry representatives, I do not believe that we are over-regulated in Germany."

MVV has set itself the goal of being "climate-positive" by 2035. What exactly is behind it?

Dr Helle: There are various "1.5-degree scenarios" issued by the Intergovernmental Panel on Climate Change (IPCC) – and none of them can do without negative emissions. This means that we not only have to reduce CO2 emissions to zero, but also remove carbon dioxide from the atmosphere, in order to mitigate the consequences of climate change. We already have a pilot project in Dresden – a biowaste fermentation plant that captures and stores more CO2 than it releases into the atmosphere.

How ambitious do you think the climate positivity programme is?

Dr Helle: We find ourselves in a pioneering role with this target, and the project is correspondingly ambitious – for several reasons. (i) We have projected the 1.5-degree target onto our company and thus selected a very strict benchmark. (ii) There are no restrictions, e.g. in terms of footnotes: We include the entire MVV in the target. (iii) We achieve the target exclusively through our own measures, i.e. not through offsetting, certificates and the like. (iv) We do not accept any "residual values" in the planning that are not clearly defined, but instead back up the primary target with specific intermediate steps and measures. In order to achieve this ambitious goal – and for others to follow in our path – we require a clear framework, especially with regard to negative emissions and CO2 capture. In addition, physical infrastructure is also required, for example, in the form of CO2 transport networks.

> „We not only have to reduce CO2 emissions to zero, but also remove carbon dioxide from the atmosphere, in order to mitigate the consequences of climate change."

Where do your measures to achieve climate positivity specifically focus on?

Dr Helle: As part of our "Mannheim Model", we are working on the energy transition with three pillars. The first pillar comprises the decarbonisation of the electricity sector, in particular, through the robust expansion of renewable energies. The second pillar concerns the heating sector – formerly known colloquially as the "sleeping giant". We are active in this area on a broad scale – including through the transformation of district heating – for example, by installing large heat pumps. Last year, we inaugurated the first of these heat pumps in Mannheim. These technologies can be used to produce 100 per cent green heat. By 2030, district heating production will be completely climate-neutral, for which we are also tapping into sources of waste heat potential. The third pillar comprises the area of customer solutions. We are actively offering the region the opportunity to participate in the energy transition across all size categories – i.e.

private households, commercial properties and ground-mounted PV.

Figure: River heat pump from MVV Energie AG in Mannheim | © MVV Energie AG

Electrification in Germany is continuing to increase, and the demand for electricity is rising. Initial media reports concerning regional power shortages due to heat pumps and wallboxes are having an unsettling effect on the population. Will we experience more problems of this kind in the future?

Dr Helle: We are witnessing a sharp increase in electrical consumption – not only in the areas of heating and e-mobility, but also enormously in data centres. Meeting this demand and ensuring security of supply as usual represent a major challenge for the sector in the years to come. In my opinion, however, the biggest bottleneck will not be in generation, where we are making relatively good progress in terms of expansion. The expansion of the transmission and distribution grids is much more challenging. As electricity is no longer just distributed "from the top down", but rather decentralised generation is playing an increasingly important role, we now face a major challenge in Germany. We need appropriate locations and capacities for grid expansion and transformers. A large proportion of our investment capital is currently being channelled into this area. Overall, however, I remain optimistic and believe that such press releases will remain the exception in the future.

Dr Matthias Jenn
Managing Director
bayernets GmbH

How do you rate the energy transition's success to date, and where do you see the greatest need for action in the years to come?

Dr Jenn: We have achieved so much in recent years as part of the energy transition, but there is still a long way to go before we reach 100% climate neutrality. Within the electricity sector, we continue to face significant challenges in terms of both generation capacity for renewables and grid expansion. There is also a lack of storage options, particularly when addressing the need to compensate for seasonal fluctuations. With gases, we have a tried-and-tested system in the form of the natural gas network, which we need to convert to the transport of climate-neutral gases, in particular: hydrogen. We hope that the go-ahead for this hydrogen core network will be given soon, in order that we – as an industry – can begin the transformation as soon as possible – because here, too, we still find ourselves at the starting line. On balance, I believe that the declared goal of becoming climate-neutral in Germany by 2045 is extremely ambitious. Bavaria – which aims to be climate-neutral by 2040 – has been struggling for a long time, especially when it comes to expanding wind energy. Although new concessions have now been made by politicians, real-terms action has yet to follow – but at least politicians have recognised that we have a major deficit. Much more has also been initiated in terms of the energy transition at federal level following the change of government, albeit not always without conflict.

> „On balance, I believe that the declared goal of becoming climate-neutral in Germany by 2045 is extremely ambitious."

In your opinion, what would be the formula for success for the transformation?

Dr Jenn: As a first step, it would, of course, be prudent to save as much energy as possible. In view of the fact that ultimate energy consumption has been relatively stable for many years, however, I have my doubts as to whether we will achieve any significant success in this respect in Germany. In any case, we will have to continue expanding generation capacities and infrastructure to a significant extent – including storage options for green electricity. Electrification is on the increase, and I don't think we will be able to import large quantities – our neighbouring countries usually need their own green electricity locally with the requisite flexibility. Where green electricity cannot be utilised, we have to fall back on molecules. These can be transported over greater distances, and the transport capacity of the infrastructure is also significantly higher. An HVDC line, for example, has a capacity of around 2 gigawatts, while the most powerful pipeline in our grid can transport more than ten times that amount of energy. When supplemented by ship transport, this results in a significantly larger radius for importing molecules when compared to electrons. In summary: We need to maximise both the national production and import operations of green electricity and climate-neutral molecules. Only with such a combination will we be able to permanently eliminate fossil fuels from the energy mix.

Figure: Construction of the MONACO gas transport pipeline: Caterpillars lowering the pipe into the trench | © bayernets GmbH

Will energy storage systems play an important role?

Dr Jenn: According to the latest technological developments, decentralised electricity storage systems, for example in private homes, do not offer sufficient storage capacity – they cannot bridge longer periods of darkness. And the situation is even more difficult for industry due to its high-level energy requirements. We, therefore, need molecules again as a storage medium, for example, in the form of hydrogen.

Your company operates a gas transport network; with this in mind, recent years have certainly been something of a tumultuous phase for you. How do you assess the time and the political action in the aftermath? Has the gas crisis been permanently overcome?

Dr Jenn: On balance, I think the federal government handled the crisis well – especially as it was new in office at the time. In hindsight, however, one or two things may be solved differently going forward. The question as to whether the security of the natural gas supply has been permanently resolved can only be answered to a limited extent. Thanks to the rapid construction of LNG terminals, we have succeeded in expanding import opportunities in Germany to a significant extent. Simultaneously, the transport network has been (and is being) upgraded to facilitate an increased west-east flow. This means that the necessary transport and import capacities are on hand. One decisive factor going forward will be whether we can channel LNG to Europe and Germany and, if so, at what price. Furthermore, the existing import pipelines – especially from Norway – must be available to us.

Is your business model as a gas network operator finite?

Dr Jenn: The substance transported today (natural gas) will no longer be used as a fossil fuel by 2045 at the latest. As long as there is a need for natural gas to be transported, we are legally obligated to transport it. However, even after 2045, our systems can continue to be operated in a prudent manner. Alternatives to natural gas include biomethane, and potentially also synthetic methane in the future, and of course hydrogen. It remains difficult to say whether we will need more or less transport capacity in the long term than we do today.

Would pipelines have to be modified from a technical standpoint to be able to transport hydrogen?

Dr Jenn: In principle, the existing pipelines can be used to transport hydrogen. However, due to its properties, contact with hydrogen can lead to the embrittlement of material, which can be particularly problematic with older pipes. Renovations may then become necessary. In addition, there are shut-off valves, as well as gas pressure regulating and measuring systems at regular intervals in our current network. A replacement operation

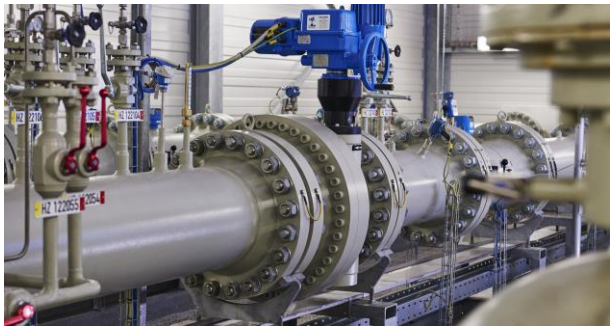


Figure: Measuring and control system| © bayernets GmbH

would be necessary here, as the previous components are not fully suitable due to the size of hydrogen molecules. Up to this point, everything is already feasible, technically speaking, today. One area where there is still a need for development, however, concerns hydrogen compression. There is currently no extensively tested technology for transporting larger quantities – but compression manufacturers are working hard on this challenge.

Where do you see sensible fields of application for hydrogen?

Dr Jenn: In various industries, there are sectors that will urgently need hydrogen in tomorrow's world, as electricity cannot generate the necessary degree of heat, for example, in the steel industry. The chemical industry also requires hydrogen as a raw material in production. The area of heat supply is also an exciting field of application. In my opinion, there won't be a one-size-fits-all solution here – heat pumps are often not suitable for old buildings, for example, and the electricity grid in larger cities would not even allow for a fully-electric heat supply. A hydrogen network is considered a sensible option here, especially in areas through which larger supply lines for power plants or industrial sites run. The continued use of existing gas networks with hydrogen also appears fundamentally attractive from the perspective of local authorities, in particular, because the associated costs are significantly lower than for local or district heating projects. In many cases, these cannot be financed at all.

What do you think: When could gas networks in Germany be converted to hydrogen on a large scale?

Dr Jenn: I assume that we will start with conversion efforts as part of the hydrogen core network in the near future. Moreover, in my opinion, the primary question concerns the issue of imports: where can we obtain sufficient quantities of climate-neutral hydrogen? I suspect that the first large-volume imports will come from Norway, in the form of blue hydrogen. In addition, North Africa and the SoutH2 Corridor project – in which we are involved – offer exciting prospects. Honestly, at present, I assume that we will not reach the point within this decade where large quantities of greenhouse gas-neutral hydrogen are available. In the course of the thirties, however, it is essential that we manage to do so. We will see a gradual ramp-up and selective blending with the natural gas stream to incentivise significant production capacities.

> „Honestly, at present, I assume that we will not reach the point within this decade where large quantities of greenhouse gas-neutral hydrogen are available."

Your company is also researching the topic of CO2 transport. What exactly is behind it?

Dr Jenn: There are unavoidable CO2 emissions. One example is the cement industry, where CO2 is released during manufacturing processes. Waste incineration also results in higher, unavoidable CO2 emissions. One solution that works well today is the filtering of CO2 from exhaust gas streams. The isolated carbon dioxide can then be stored, for example, by injecting it into former natural gas reservoirs. Alternatively, it can also be used as a raw material for the chemical industry, for example, in the production of methanol.

How does a circular CO2 economy work?

Dr Jenn: The idea of a CO2 circular economy could look something like this: Carbon dioxide is captured in Germany and then transported by ship to Saudi Arabia. Large quantities of green hydrogen are produced there using solar power and processed together with the imported CO2 into liquefied synthetic gas (LSG), which can then be transported back to Germany. Here, it is burnt to generate electricity, whereby the CO2 is captured again. This means that, ideally, the CO2 never leaves the cycle. However, it is clear that the process is

comparatively complex and involves energy losses associated with both conversion and transport.

In conclusion: Do you believe that the energy transition in Germany can be a success?

Dr Jenn: Without doubt, there is no guarantee. After all, we are trying to turn an energy system that has grown over many decades (and one which is based on fossil fuels) completely on its head – and in a very short space of time. We are, therefore, dealing with a highly complex and time-consuming task. However, I am absolutely optimistic that we will manage this. The situation also harbours numerous opportunities: if Germany takes on a pioneering role, technology and expertise could become an export hit in the long term. Technically speaking, we will find a solution for all problems. I suspect that financing will be the biggest challenge. Accordingly, we need a sophisticated system that incentivises private-sector investment. In my opinion, the state should only get involved where there is no other way.

„Technically speaking, we will find a solution for all problems (associated with the energy transition). I suspect that financing will be the biggest challenge."

Dr Marcel Zürn
Sector head energy and utilities
Landesbank Baden-Württemberg

Michael Weiss
Sector head TMT
Landesbank Baden-Württemberg

The study results reveal that companies in Germany identify a connection between the state of digital infrastructure and the success attributed to the energy transition. Do you share this perception?

Dr Zürn: In any case, I would advocate that this statement holds true. Without an efficient digital infrastructure in place, the energy transformation will not succeed. We require an intelligent approach to energy infrastructure, in order to link generation and consumption in the smartest way possible.

Weiss: I can only agree with that. In my opinion, there are three key areas in which significant interdependdencies exist between the energy and digitalisation sectors. Firstly: smart grids, an area that is becoming increasingly relevant due to the growing decentralised generation of energy. Intelligent measurement and control systems are required here to ensure optimum efficiency. Secondly: remote monitoring and control, for example, in the wind power sector. The exchange of real-time information is essential here, in order to optimise system-side yield. Thirdly: e-mobility and the associated charging infrastructure necessitate a significant degree of digital networking, in order to be able to plan and bill charging processes in an intelligent manner.

Can the digital sector's current network expansion keep pace with these requirements? Will this require new technologies – such as blockchain – in tomorrow's world?

Weiss: The application areas mentioned are not excessively data-intensive by nature – when compared to metaverse applications, for example, which require a very high level of computing and transmission power. Digital grid expansion is considered fundamentally suitable for supporting the energy transition. I, therefore, do not believe that blockchain will play a major role. We don't require continuous traceability here, as we do when exchanging financial information, for example. Decentralised transmission technologies, on the other hand, can be useful for applications where high transmission volumes are a key factor.

> „Without an efficient digital infrastructure, the energy transformation will not succeed ."
> Dr Marcel Zürn

From the energy industry's perspective: Which of the three areas mentioned above (smart grids, remote monitoring, e-mobility) do you consider to be particularly relevant?

Dr Zürn: Although all areas will play a major role, I would assign particular relevance to the topic of smart metering and smart grids. Given that we have an increasing number of electricity-based applications, in conjunction with the fact that both decentralisation and simultaneity (e.g. many people charging their e-car at the same time in the evening) are increasing significantly, intelligent control is becoming a key success factor. Ultimately, this means harmonising the increasingly volatile electricity generation of renewable energies with the fluctuating demand for electricity in the most effective way possible. This is also essential in terms of safeguarding grid stability. At the moment, the grid operator is often essentially "blind" and only receives a data point on the consumers' energy consumption once a year. Smart metering creates greater transparency within the system, which can ultimately lead to the intelligent control of both supply and demand. Dynamic electricity tariffs with time-variable tariffs are a keyword in this context. Energy management can be optimised thanks to a significantly enhanced information base.

Let's take an objective look at the issue of digital infrastructure: How do you rate their expansion and quality as a location and competitive factor?

Weiss: A distinction should be made here between broadband expansion and mobile communications. The expansion of mobile networks is having an increasingly noticeable effect private individuals; in the B2B sector, this is not the primary technology for communication, and the Industrial Internet of Things (IoT) is still a long way off. The opposite is true in terms of fibre optic expansion: The demand from private customers is not so pronounced here – as can be seen from the noticeably moderate development of contracts concluded in the high bit rate range and the take-up rates for fibre optic connections. Among corporates, however, broadband expansion is (and will very quickly become) increasingly relevant, both in the competition for customers and employees.

How would you describe the situation characterising the energy sector by way of comparison?

Dr Zürn: Companies generally have no concerns about grid and supply security – this is guaranteed in Germany within grid infrastructure. What causes greater uncertainty, however, is the issue of cost. For example, a total of EUR 450 billion is to be invested in the expansion of transmission and distribution grids by 2037. Companies are naturally left wondering as to how these amounts will be financed, and what impact this will have on future energy prices. For this reason, many investment decisions pertaining to energy-intensive processes are no longer made in Germany's favour.

How would traffic change as a result of increased AI use? And what impact would this have on energy requirements?

Weiss: We will witness a real increase in the medium term, possibly even a doubling – although it is difficult to estimate how long this will take. This is due, in particular, to the increasing introduction of AI by large software providers – such as SAP and Microsoft. The expansion of data centres is also registering enormous progress in this context, particularly in cloud and edge data centres. Incidentally, these are also becoming increasingly important from the perspective of energy consumption. Most operators take extreme care to ensure that they build energy-efficient data centres.

Can this energy consumption be offset by using the waste heat from these data centres?

Weiss: There are certainly concepts in place from data centre developers and operators to actively use waste heat in the heat supply of municipalities. In most cases, deals are concluded so that the data centres are located in return for favourable framework operating conditions, for example.

Dr Zürn: We are seeing robust interest here, particularly against the backdrop of municipal heating planning. This concerns the expansion of the grids, on the one hand, and the decarbonisation of the heat supply on the other – in a shift away from coal and natural gas. District heating is becoming increasingly heterogeneous, and a data centre as an existing heat source serves as a very attractive prospect for municipalities.

What challenges do you see in the transformation of the energy and digital sectors?

Weiss: I see the biggest challenge in securing critical infrastructure against threats from physical and cyber attacks. This applies in equal measure to the energy and digital sectors. The current geopolitical situation is triggering an increase (rather than a decrease) in these risks. Another major bottleneck factor concerns the shortage of skilled workers, which also entails a challenging effect on construction capacities – this circumstance also affects both fibre optic and energy network expansion. We are seeing low capacities at construction companies, while services are simultaneously becoming increasingly expensive. At government level, leaner and faster authorisation processes would also be very beneficial.

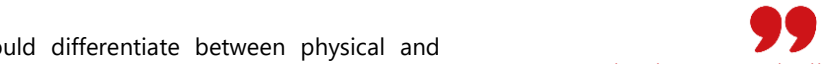
What can companies do to protect their critical infrastructure from digital and physical attacks?

Weiss: The BSI regularly collects status reports on the operators of critical infrastructure. On balance, many companies continue to move too slowly in this area, and are nowhere near a level that would do justice to the level of attack. However, there is a potential for synergies moving forward: As both infrastructures work with lines and cables and are both digitally networked, security can potentially be increased across the board through effective collaboration.

Dr Zürn: I would differentiate between physical and cyber security at this juncture. On a physical level, individual companies enjoy very limited options for ensuring security – for example, in the case of submarine or longer underground cables. A company can only efficiently monitor this itself to a very limited extent. This is where I see government agencies as shouldering an obligation here. In practice, the scope of cyber security measures depends to a significant extent on the size of the provider. Large energy suppliers have more options here than smaller municipal utilities, which often do not have the necessary resources at their disposal. Therefore, not only is effective collaboration between the sectors important, but close cooperation within the industry is also necessary.

What do you think the state of digital infrastructure in Germany will look like in ten years' time?

Weiss: Data growth will continue to increase significantly going forward, particularly in view of the role played by applications – such as artificial intelligence and, later on, autonomous driving and the Internet of Things. These innovations will grow, and will require the expansion of digital infrastructure. Accordingly, the expansion of transport capacities must be continuously driven forward. I suspect that expansion efforts within the digital sector will always lag a little behind demand. The expansion of mobile communications is currently progressing very well, and 100% coverage of households will be achieved quickly; however, in 10 years, 6G may well be the prevailing standard, along with significantly higher bandwidths. The fibre optic coverage will certainly reach 90%. However, these estimates are based on "current expectations". Geopolitical factors, in particular – such as increases in defence budgets or trade partner restrictions – can entail major losses in prosperity, and a delay the transformation process at the very least. Overall, however, I remain optimistic, especially because digitalisation as a competitive factor is of great interest to all players.



„I see the biggest challenge in securing critical infrastructure against threats from physical and cyber attacks." Michael Weiss

... what is the situation characterising the energy sector?

Dr Zürn: The expansion of renewable energies is progressing steadily, and will become increasingly favourable in future – the interest here is immense, especially as the demand for electricity continues to rise. The share of renewable energies in total electricity generation will continue to rise in the years to come. We can, therefore, assume that an increasing proportion of the electricity consumed in Germany can be covered with the help of renewable sources. This is also necessary, in

order to be able to realise the phase-out of coal in a timely manner, for example. The energy system's transformation is currently focussed on electricity generation. The next step is the actual energy transition itself, i.e. both the switch to "green electrons" and the energy system-side switch to "green molecules". On the one hand, an increasing number of applications are being powered by electricity, but liquid and gaseous energy sources will also play a key role in tomorrow's world – hydrogen and derivatives – such as ammonia and synthetic fuels – will play an important role here. In order to render hydrogen usable for end users, and to bring producers and consumers together, the long-distance gas network operators are currently working on a hydrogen core network. This initial network – with a length of approximately 10,000 kilometres – will largely consist of rededicated natural gas pipelines and newly built pipelines, and will be put into operation from the beginning of the 2030s.

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