OLIVER WYMAN

NEUTRAL

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POWERING DOWN
ON CARBON EMISSIONS

Since there is no stand-alone solution, a synergistic cooperation between different archetypes, industrial companies, and external partners opens the door to an enormous carbon reduction potential. For example,

THE CURRENT STATE OF THE CLIMATE BATTLE

Worldwide, companies across industries are under pressure to actively pursue a reduction of their carbon footprint. The industrial sector accounts for 34 percent of all global carbon emissions and thus plays a major

This is an opportunity for utilities as they are actively accelerating the path to zero-carbon already today. Utilities will likely be the leading and guiding players to satisfy the increasing demand for zero-carbon energy and the emerging need for emission reduction technologies. In order to be successful in this challenging environment, utilities have to reduce the carbon intensity of their existing o f erings on the one hand and expand and reshape their business in the next decades on the other hand. With the right strategy, customer needs can be met and at the same time signi f cant economic potentials can be revealed.

The requirements and needs towards energy supply vary across industries and regions. This study focuses on the sevenieq ves e] ed es ʿ ve

REDUCING CARBON EMISSIONS SECTOR BY SECTOR

The analyzed industries consist of several main sectors. +RZHYHU WKH VHFWRUV GL®HU KLJKO\ UHJDUGLQJ WKHLU processes and products. For example, the iron and steel sector only includes the casting and manufacturing of basic iron and steel, while the machinery sector consists RI D ODUJH YDULHW\ RI GL®HUHQW SURGXFWV VXFK DV IDEULFDWHG metal products, computers, electronics and optical products. Except for the non-ferrous metal and machinery sector, all sectors require more heat than power input. Even though the shares of heat and power input are mostly similar, the properties of the required heat input vary considerably. Most energy intensive sectors also UHTXLUH VLJQL¯FDQW SURFHVV KHDW)RU H[DPSOH PRUH WKDQ 80 percent of the iron and steel sector’s heat demand is used for heating processes that go well beyond 500 degrees Celsius. In contrast, the paper pulp and printing industry mostly requires temperatures between 100 and 200 degrees Celsius for their processes.

The machinery industry mainly uses their heat input for space heating and cooling purposes. The heat requirements, industry processes, and the economic viability of renewable technologies are considered in assessing the potential to switch to zero-carbon electricity and heat. Switching to renewable heat is more complex in general than switching to renewable power. This applies especially to sectors with high heat levels. In paper pulp and printing however the potential to switch to renewable heat is higher which can be deduced from the fact that carbon neutral heat has a share of more than 50 percent already.

INDUSTRY SECTOR

Iron and Steel
Casting and manufacture of basic iron and steel

Chemical and petrochemical
Manufacture of chemicals, pharmaceuticals, chemical, medicinal chemicals and botanical products

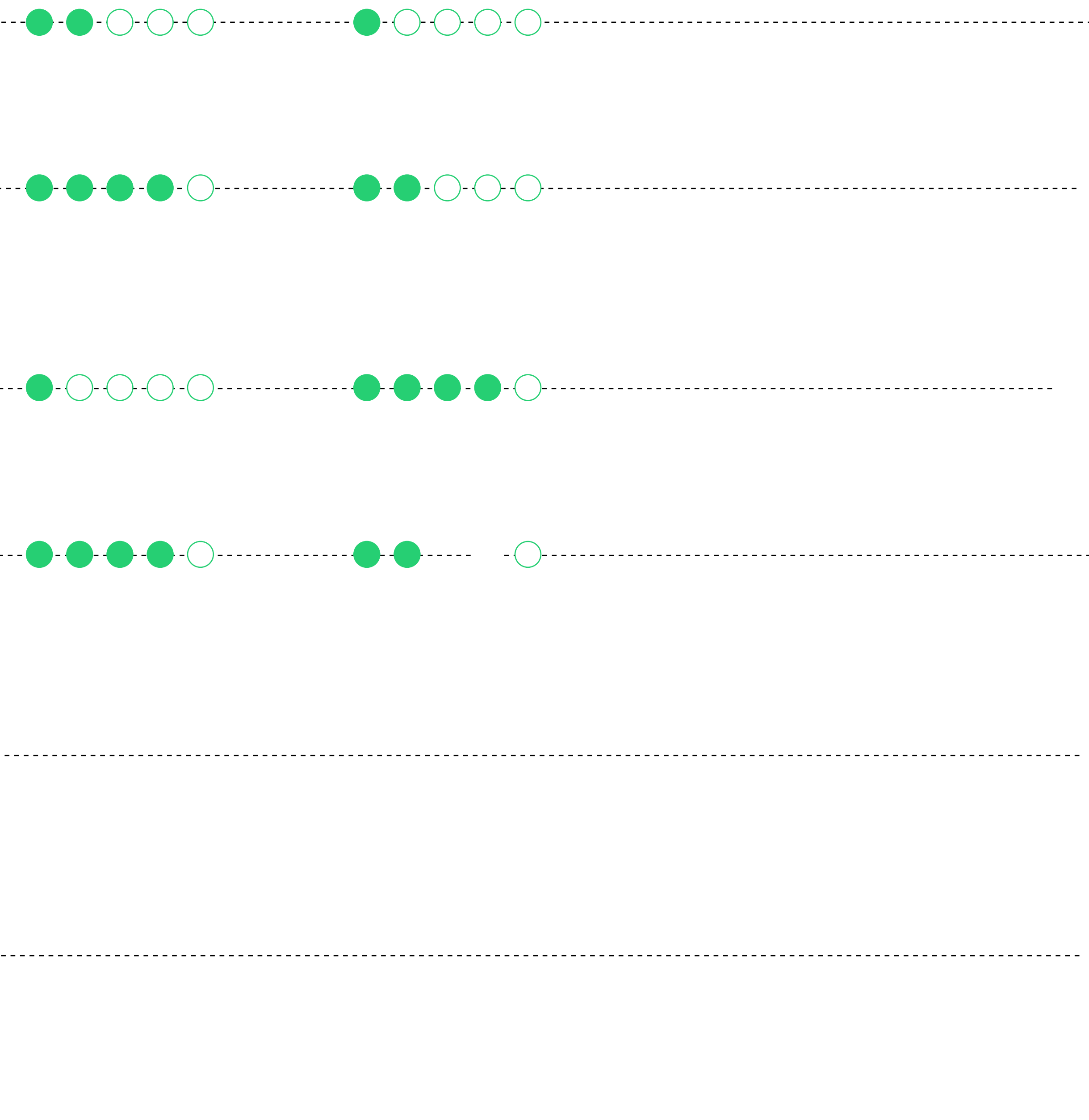
Non-metallic minerals
Manufacture of non-metallic mineral products (mainly cement, glass and ceramic)

Non-ferrous metals
Casting and manufacture of basic precious and other non-ferrous metals (mainly aluminum, copper, zinc)

Machinery
Manufacture of fabricated metal products, computer, electronic and optical products, electrical equipment and machinery

Food and tobacco
Manufacture of food products, beverages and tobacco products

Paper pulp and printing
Manufacture of paper and paper products; Printing and reproduction of recorded media



FOUR STRATEGIC PLAYING FIELDS

There are several options for reducing energy-related carbon emissions in the industrial sector. On the one hand, there are offerings for carbon-neutral heat, namely HOHFWUFDWLRQKHDWERPDV and **hydrogen** for heat generation. On the other hand, there are carbon-neutral and autonomous systems for electricity. Besides, the technology fields **waste heat recovery** as well as **system integration** cover measures that increase energy efficiency using waste heat either for other heating purposes or for power generation. The last technology group is **carbon capture and utilization or storage (CCU/S)** which aims to capture emerging carbon emissions in order to further utilize or store them.

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Bridge technologies play a major role in a short-term perspective but have a decreasing priority in the long-term. This applies to the use of sustainable **biomass** for heat generation. The technology is very mature and implemented in various examples across industries. Biomass originates from a variety of sources which includes organic residuals, industrial waste, and municipal solid waste.

PROPERTIES OF CARBON-REDUCING TECHNOLOGIES

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CORE TECHNOLOGY

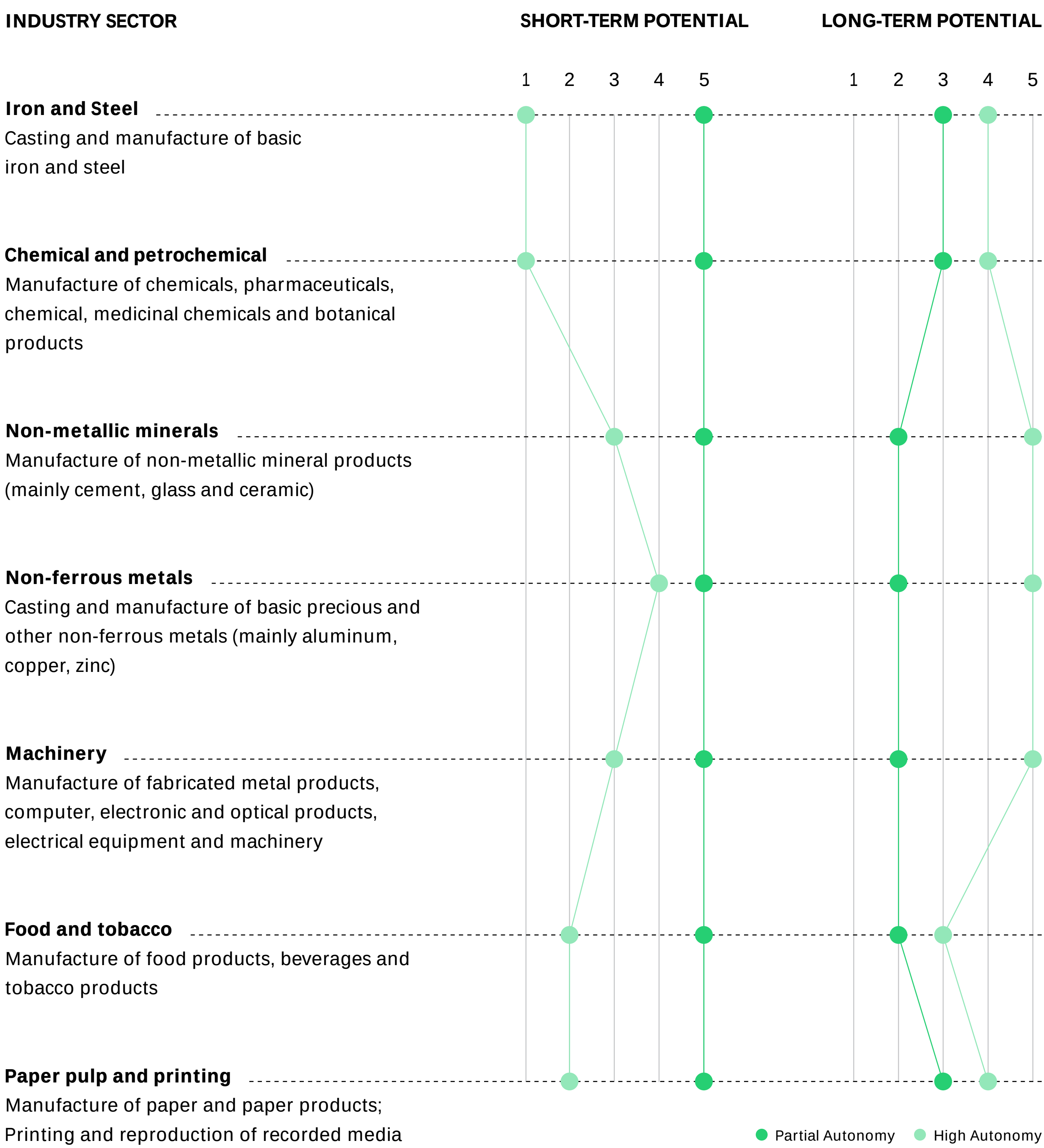
The playing field Core Technology covers technology solutions that play a major role in the short-term as well as in the long-term in reducing the industries' carbon emissions. This applies to power autonomy through local solutions for carbon-neutral power generation. Power autonomy evolves over time and is therefore divided into **partial autonomy** and **high autonomy**. Partial autonomy describes a setup in which conventional electricity from the grid is supplemented by locally generated zero-carbon electricity while the grid still serves as the major electricity source. In the case of high autonomy, most of the electricity is sourced from local zero-carbon electricity generation. Consequently, highly autonomous solutions do require storage and load management systems.

PROPERTIES OF CARBON-REDUCING TECHNOLOGIES IN DIFFERENT SECTORS

In the short-term, partially autonomous solutions are highly relevant in all industry sectors as this technology is ready for implementation, the required investment is rather low, and the process continuity is not endangered. As storage technologies evolve in a long-term view, high autonomy will slowly replace partially autonomous solutions. This trend will likely begin in the non-ferrous metals and the machinery industry as electricity is the main energy source in these sectors. In the iron and steel as well as in the chemical and petrochemical industry, high autonomy will probably not be equally important as in other sectors since the relative share of power in the energy mix is lower and technologies like hydrogen or CCU/S will emerge in the future. Nevertheless, those sectors should not be neglected as their electricity demand is high in absolute terms and is likely to increase by at least 50 percent in a long-term perspective.

LEVELIZED COSTS OF ELECTRICITY

In this group, the maturity of the technology and the price of electricity generation are major influencing factors. To unlock the full potential of decentralized power autonomy, the cost of renewable electricity must be lower than the one of conventionally generated electricity. Levelized costs of electricity (LCOE) is a common measure to compare the average net present cost of electricity generation for a generating plant over its lifetime. On a global level, the LCOE of utility-scale renewable electricity generation technologies is decreasing considerably. For example, the LCOE of solar photovoltaic (PV) technologies declined by over 70 percent from 2010 to 2018 while the LCOE of wind power generation dropped by roughly 25 percent. Following this trend, renewable electricity prices for solar, wind and hydrogen plants will probably be lower or equal to conventional electricity prices by 2030. Thus, power autonomy will likely have a major impact in cutting down the industry's carbon footprint.


INDUSTRY SECTOR
SHORT-TERM POTENTIAL
LONG-TERM POTENTIAL
1 2 3 4 5
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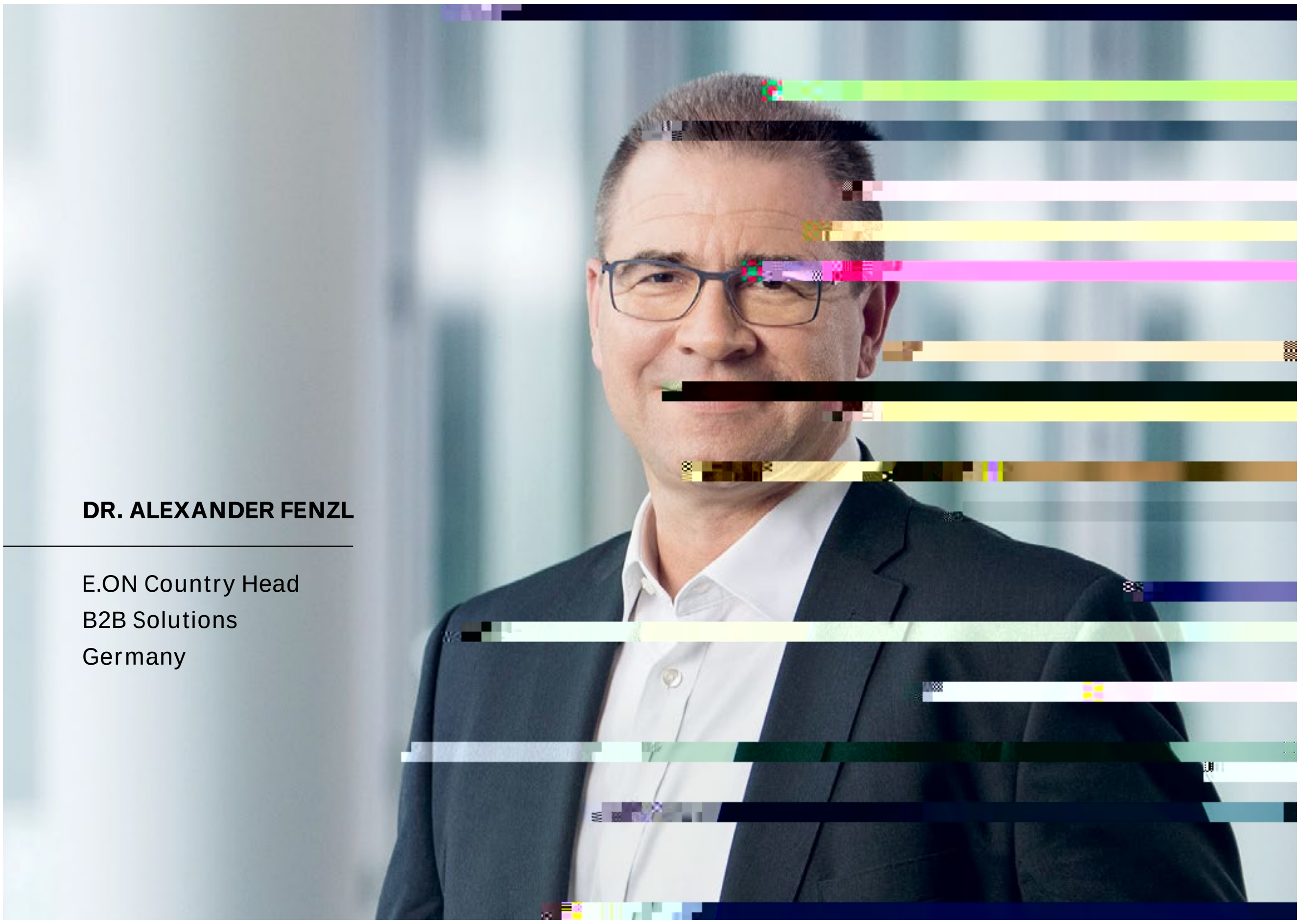
Partial Autonomy
High Autonomy



DR. ALEXANDER FENZL

E.ON Country Head
B2B Solutions
Germany

How can utilities help industrial clients to reduce their carbon footprint today and in the future?
In order to persist and be successful in the future, it is important that companies work sustainably in every respect. This applies particularly to the use of energy. Through their collaboration with E.ON we are already preparing companies today for the requirements of tomorrow's new energy world. In this way, we help them to signi f cantly reduce their energy costs and CO_2 emissions and at the same time ensure that their company's operational business runs smoothly.

What are key success factors for utilities in this role?
E.ON has high ambitions for climate protection and energy-e f cient energy solutions to improve people's lives. With increasing regulatory pressure, companies are therefore looking for new technical and regulatory ways to reduce their energy costs in the best possible way and to reduce their CO_2 emissions sustainably. In consideration of this, we use innovative and established technologies to design the most economically sensible and e f cient solution for our B2B customers.

In this way, together with our customers, we create a sustainable future for our planet and a prof table future for companies.

What is a key project where E.ON helped an LQXVWULDOFOLHQWWRUHGXFHWKHLU footprint?
E.ON has developed a system for the "retail" segment that can reduce the energy consumption, especially of supermarkets by up to 35 percent. The partners E.ON and Real are implementing the concept for the f rst time in Germany at the Real site in Krefeld. An intelligent building management system takes over the control of heating, ventilation, air conditioning, lighting and cooling. From this point on, a self-learning measuring and control system learns how the electricity consumption of the individual components behaves during the day, in order to subsequently optimize the total electricity consumption through intelligent control technology. Retail markets generally have a high energy intensity. With the E.ON system, the real-market Krefeld will signi f cantly improve its carbon footprint. The system is therefore particularly suitable for large branch networks.

DR. HANS-JOSEF ZIMMER

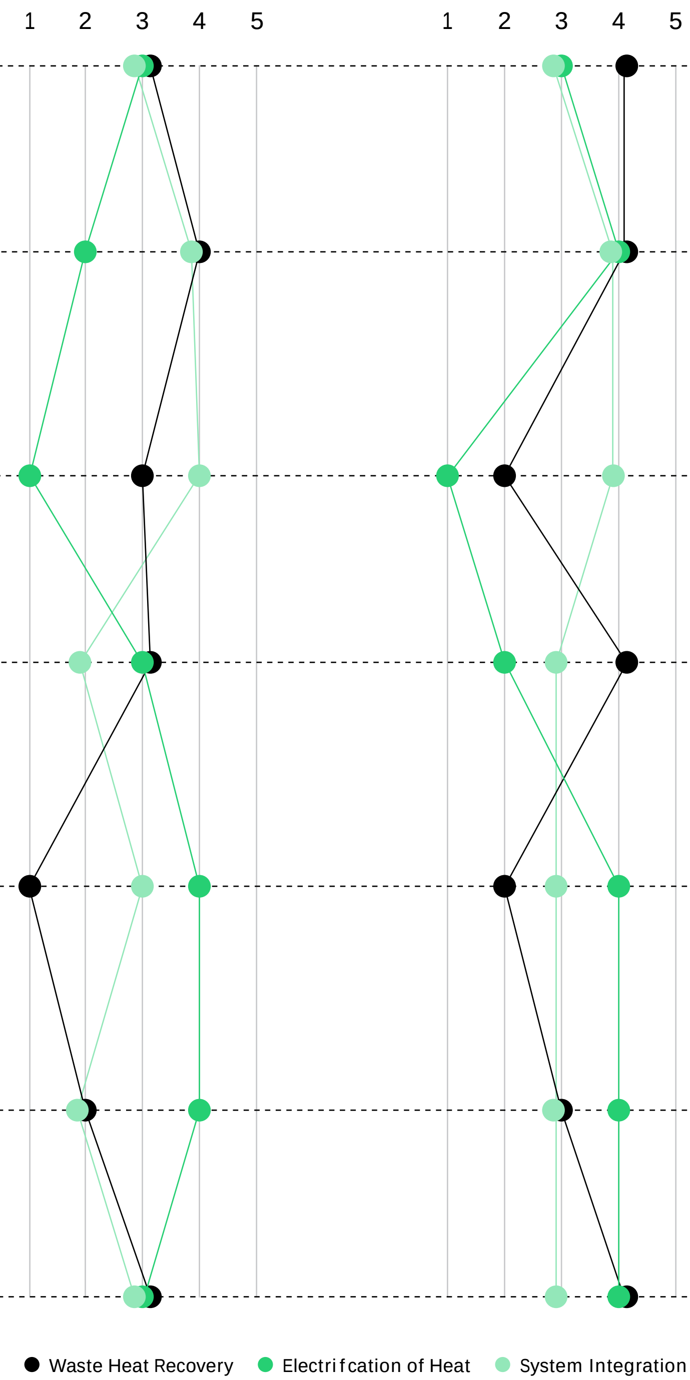
Member of the Board of
Management of EnBW AG

What technologies will play a role in reducing the carbon footprint of industrial clients?
In order to achieve the reduction targets in industry, all

NICHE TECHNOLOGY

Niche Technology covers technologies whose implementation is highly dependent on local circumstances and the industry sectors' requirements. Therefore, the short-term priority is on average at a medium level and slightly increases in a long-term

INDUSTRY SECTOR | **SHORT-TERM POTENTIAL** | **LONG-TERM POTENTIAL**



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NEXT GENERATION TECHNOLOGY

Next Generation Technology includes approaches that are not fully developed today but are likely to unleash a major impact on carbon reduction after future technological breakthroughs. This applies to all types of CCU/S as well as to the use of hydrogen produced by zero-carbon electricity for heat production.

PROPERTIES OF CARBON-REDUCING TECHNOLOGIES IN DIFFERENT SECTORS

Carbon capture and hydrogen technologies have a very similar pro f le regarding their priority development over time and sectors. The short-term priority of hydrogen as a replacement for fossil fuels to generate heat is low due to inferior technology readiness. However, there are several promising use-cases for hydrogen in the future. Focusing on hydrogen as a heat source, there is an emerging potential in industries with high heat levels.

CCU/S has a low potential in a short-term perspective. The foremost reason is the lack of available technology for industry-scale applications and the high associated investment costs for these technologies. Nonetheless, from a long-term perspective, there is a high potential for CCU/S in emission-intensive industries with a high CO_2 concentration level in their emissions. This applies to the iron and steel, chemical and petrochemical, and non-metallic minerals industries. The priority of CCU/S soars on the one hand because there are no alternative, comprehensive zero-carbon technologies available for sectors with high heat levels. On the other hand, the facilities in the above-mentioned sectors often have a lifetime of beyond 50 years. In contrast to process innovations, implementing CCU/S does not require rebuilding facilities. This results in a high future priority despite the additional costs of CCU/S for companies.

ECONOMIC VIABILITY OF NEXT GENERATION TECHNOLOGY

Key success factors for hydrogen are the availability of su f cient zero-carbon electricity and a solid network of adequate infrastructure. The economic viability depends on competitive zero-carbon electricity prices. Like for hydrogen, the availability of suitable infrastructure plays a key role for CCU/S. From an economic perspective the distance between the capturing site and the storing facility is crucial. Thus, it is uncertain which part of the carbon emissions can be stored via CCS and which part can be stored and used via CCU. In general, impact factors for both technologies are the CO_2 price and regulations like a border tax for carbon-emission intensive products that are uncertain from today's point of view. In particular, the di f erences in the willingness to pay between a carbon neutral produced product and an alternative heavy-emission product are critical.

THE PATH OF HYDROGEN

Hydrogen is part of the Next Generation playing f eld and is currently more recognized in public and politics than CCU/S which is often perceived rather skeptically. For hydrogen, a foundation of national strategies and public support exists. Currently, Chi ! C ʊ ꭿ l ȩ M ᴰ al я

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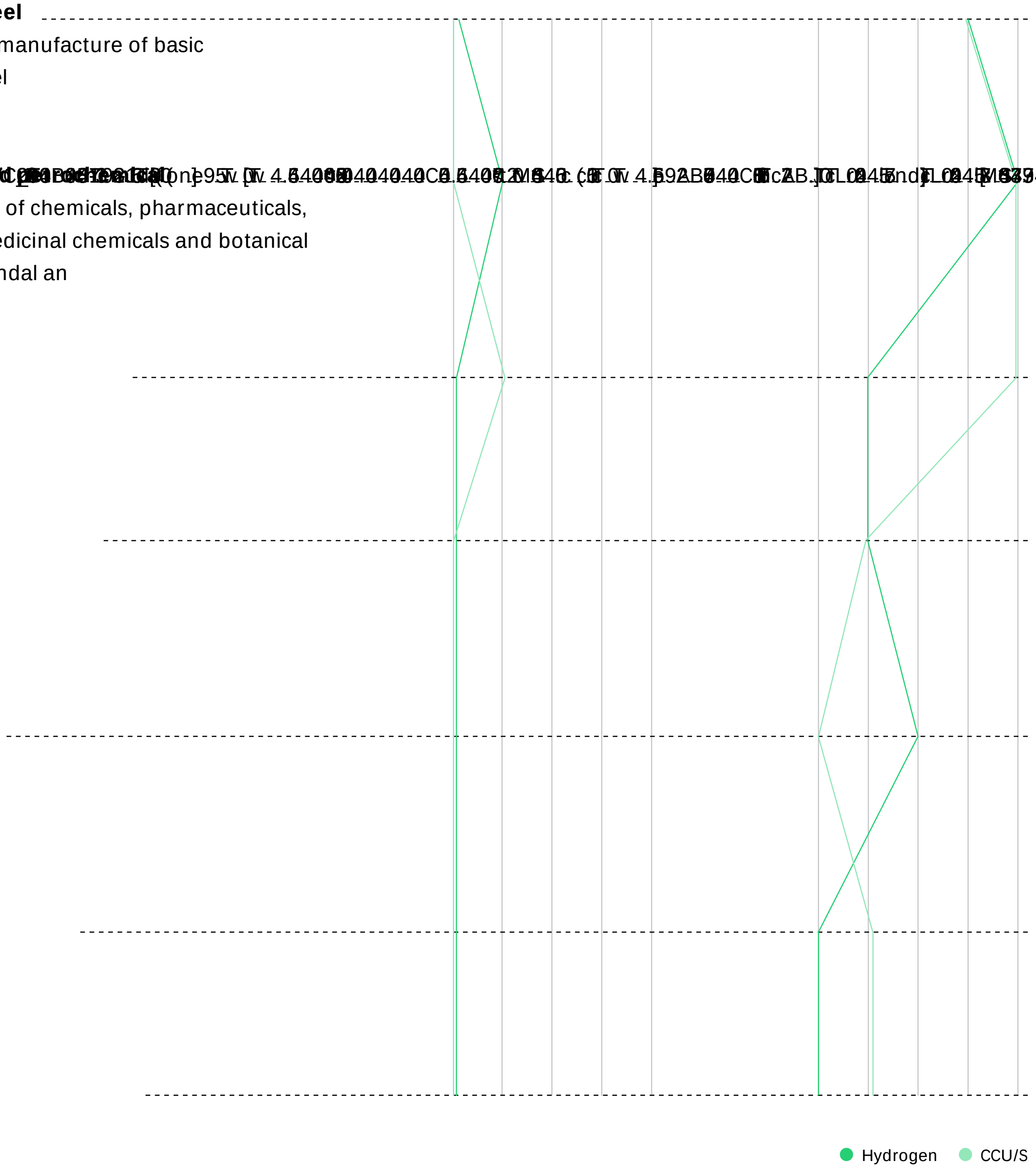

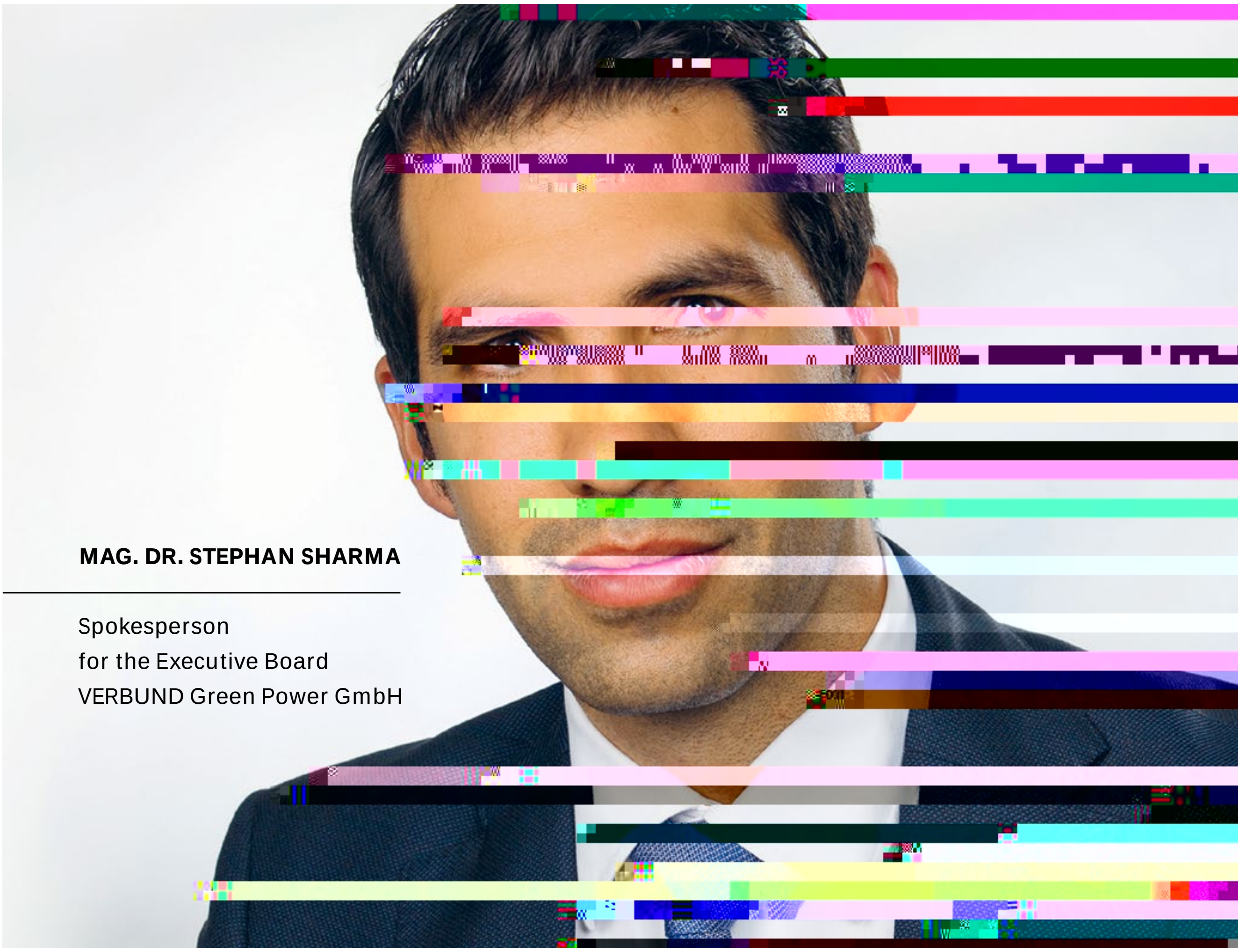

MAG. DR. STEPHAN SHARMA

Spokesperson
for the Executive Board
VERBUND Green Power GmbH

What are the prerequisites for a successful carbon reduction in the industrial sector?
This is our chance of the century: the historic economic crisis, caused by the Covid-19 pandemic and the climate crisis, can be resolved. The prerequisite is a clear path of transformation towards a decarbonized and sustainable economic system. To incentivize that transformation, climate emissions need to become globally traded commodities based on a worldwide emission database. The emission prices must be traded transparently with a compensation mechanism which includes di f erences depending on region.

Which technologies will play a major role in the reduction of the industry's carbon footprint in Europe?
It will be a mix of technologies. First of all, we should use the potential of the existing economic viable technologies like photovoltaic and storages to optimize the energy balance sheet for industrial customers. Secondly, as we will not be able to reach zero carbon footprints in all industries, technologies like "Carbon Capture and Recycling" will play a major role. Thirdly, technologies like hydrogen for industrial process or recycle-batteries for electric mobility will play an important part.

What experiences did you make in the implementation of carbon reduction technologies for industrial clients?
Our industrial customers are highly motivated to lead the change in their sector. The key is to provide them economically viable business models. This is currently the case for photovoltaic projects, which we are implementing across all industries very successfully. Additionally, we are running hydrogen projects with industrial clients (in the steel and petrochemical sector) and o f er carbon compensation strategies. One thing is clear, in the end the costumer will decide and those industries which are frontrunners will have a relevant competitive advantage.

THE NEW ROLE OF UTILITIES

Utilities can build on strong capabilities and comprehensive experience in supporting industrial companies to reduce their carbon footprint. In order to support industrial clients with profitable business models, utilities must clearly define their strategy. The strategic direction should build on the utilities' current product and services portfolio and aim at ensuring sustainable long-term profits in the energy market of tomorrow. There are four strategic archetypes that utilities can occupy. Each archetype covers an excerpt of utility roles clustered along with their characteristics and required capabilities. Within these archetypes, a utility can occupy one or more roles, furthermore utilities can focus on one archetype or diversify themselves across several of them. To provide the industrial customers with integrated offerings along the value chain, utilities however also need to collaborate with external partners covering activities beyond the scope of utilities' operations. Hence, establishing strong partnerships is beneficial to all parties. In combination with those partnerships, the unique skill sets and
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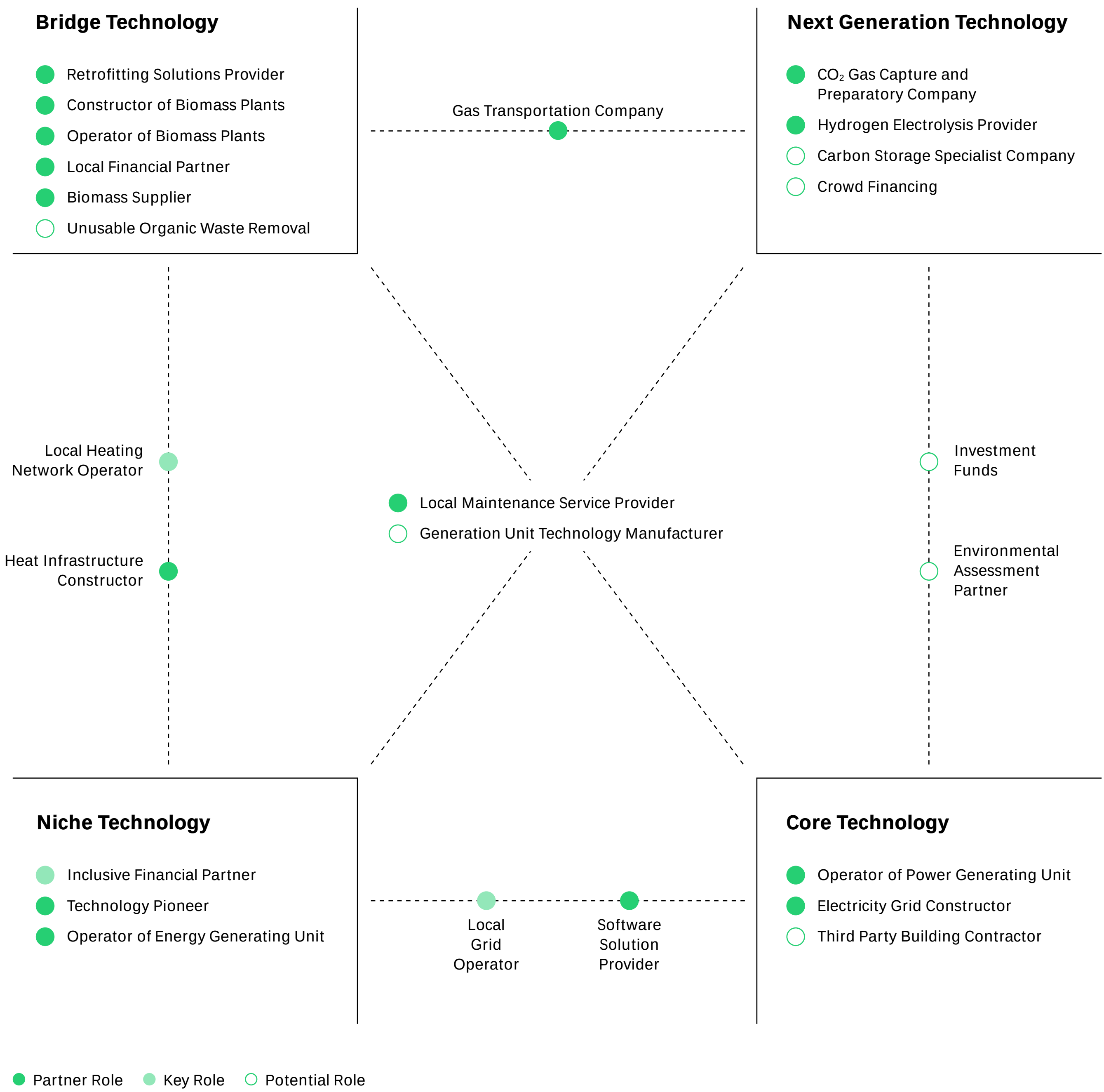
DIFFERENT ROLES OF UTILITIES AND PARTNERS



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