Smart Energy

A Creator Space™ White Paper

BASF

We create chemistry


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SHOP
ECK
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STADTQUARTIER
LANDKREIS
KOMBINIEREN
SANIERUNG
NEU BAU
TECHNOLOGIE MIX
VER-TEILUNGS-ZENTRUM
VER-SORGER
VARIABLE STROM PREISE
DEZEN-TRAL STEUERN & VERWALTEN
INNEN-STADT
VOR-STADT
LAND
TECHNO LOGIE MIX
ALT BAU
NEU BAU
KOSTEN
RESSOURCEN
TECHNO LOGIEN
FIT ALL
ONE SIZE
VARIABLE TARIFE
STADT WERKE
PRO GNO SE
ENERGIE BERATER
BAU KASTEN PRINZIP
WERT DER IMMO-BILIE
WIR BRAUCHEN EINE INTEGRALE PLANUNG GLEICH ZU BEGINN!
QUARTIER-MANAGER
BANKEN
IMMOBILIEN
DIE TECHNISCHEN LÖSUNGEN SIND VORHANDEN!
FINANZIERUNGS PROBLEM
WIR MÜSSEN NEUE GESCHÄFTSMODELLE ERFINDEN!
ENERGIE GENOSSENSCHAFTEN
ENERGIE-PERFORMANCE-VERTRÄGE
NEARLY ZERO ENERGY DISTRICT
ZIEL DER EU
EIGENTÜMER
STADTPLANER
LOKALE ENERGIE-WIRTSCHAFT
NEUBAU "ENERGIE PLUS HÄUSER"
BESTANDS-MODERNISIERUNG!
ÜBERGREIFENDE BUSINESS-MODELLE
HARMONISIERUNG DER REGULARIEN
KASKADIERTER SPEICHER
FRÜHZEITIGE PARTIZIPATION
BEDARFSPLANUNG UND GEMEINSAME ZIELDEFINITION
NETZ KAPAZITÄT
WIND
PV
HEUTE IST WASCHTAG, DER WIND IST STARK
SEKTOREN KOPPLUNG
200 %
ÜBERANGEBOT
TARIF
NACH-FRAGE
ANREIZ ÜBER DEN PREIS
BETEILIGUNG
BILDUNG
MOBILITÄT
WÄRME
VERBRAUCH
50%
ERZEUGER
AUSBAU DURCH BESITZER
VERSTÄRKEN
ZELLULARER ANSATZ
KOMMUNIKATION
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EMOTION
NIX BEWEGT SICH
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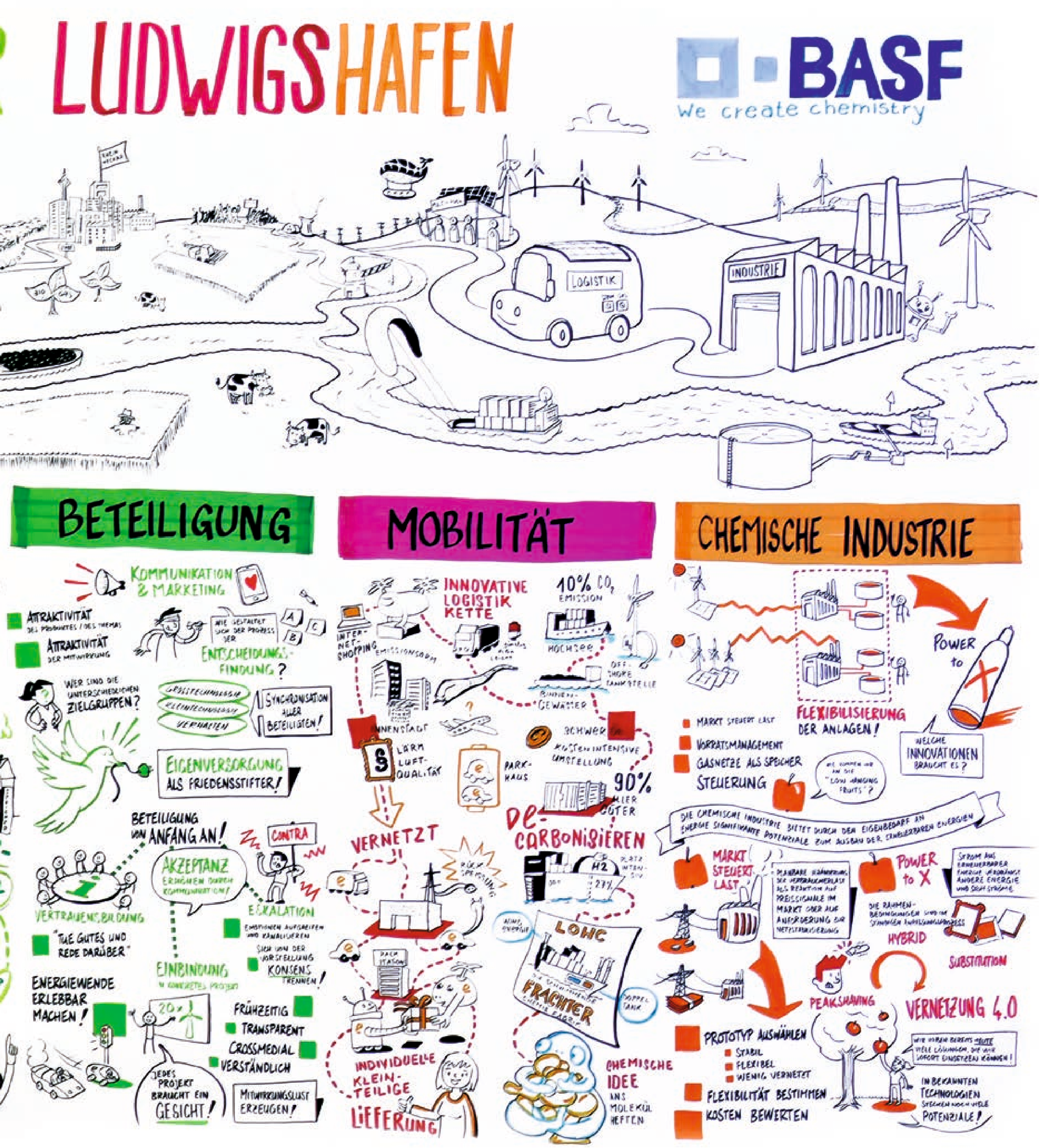

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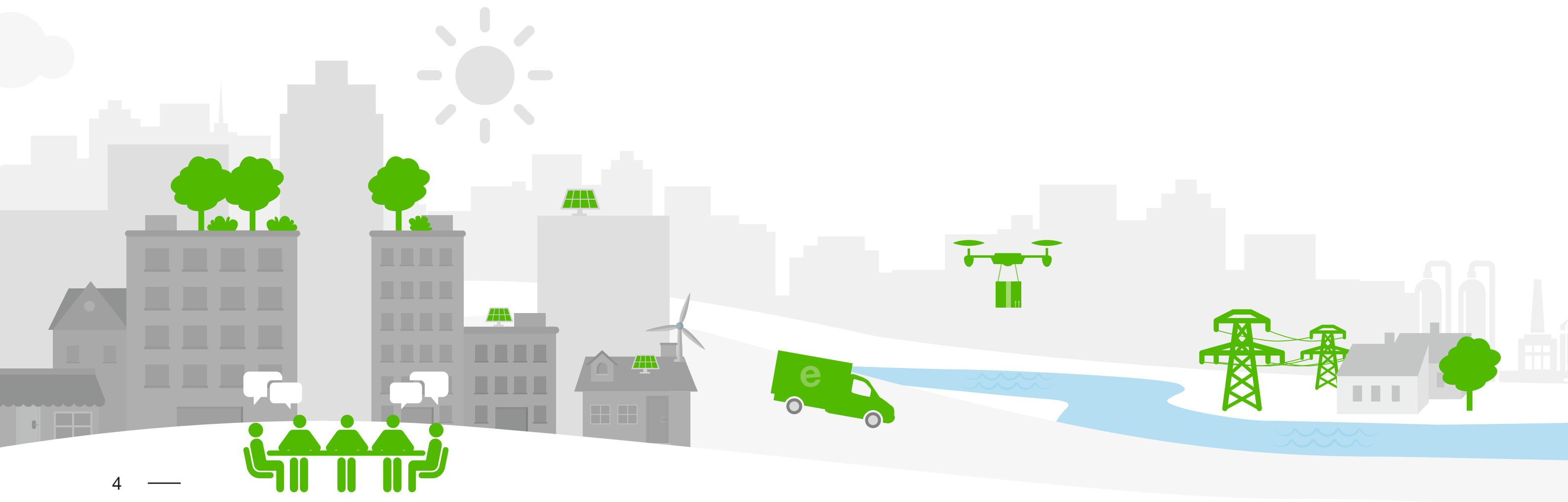


Purpose of the White Paper

Atmospheric greenhouse gas concentrations have risen sharply since the beginning of the Industrial Revolution. The ecological, social and economic impact of the combustion of fossil fuels in industry, transport and buildings is already apparent. Climate change is a global challenge.

In this scenario, the Paris Climate Accord is a major achievement. For the first time ever, the global community pledged to reduce greenhouse gas emissions and to limit global warming. The Paris accord and Germany's existing climate protection commitments underscore the growing importance of renewable energies.

The targets set for greenhouse gases can only be met if every sector contributes: the energy industry, manufacturing, trade, services, construction, transport, agriculture and land use.[1] Germany has taken steps in numerous areas but the measures need to be balanced and fleshed out. Existing measures include promotion of renewable energies, modernization of the building stock, electric car use and reduction of carbon emissions. More are to follow. Even as we need reduction, Germany and the chemical industry, including BASF, must stay competitive in the global market.

In the face of these challenges, the Creator Space™ Tour in Ludwigshafen brought together more than 70 experts from industry, research and society in a so-called summit. Participants came together to create a platform that is now BASF's contribution to promoting collaboration across organizations. It is designed to boost the development of practical and workable solutions that can be pursued and implemented by everybody involved. The summit was essentially about two things: understanding why existing technologies for emission reduction are not being used and exploring which technologies still need to be developed. The ideas generated are ones BASF can act on, given its broad portfolio of products for energy production, energy storage and the reduction of energy use.

This white paper is an interim report which sums up the input to the discussion of the challenges encountered in the energy transition in Germany and potential future action in the areas of housing, mobility and industry. The paper also presents the ideas that emerged from Creator Space Ludwigshafen about how concerned citizens can get involved early to implement energy projects.

In 2015, BASF celebrated the 150th year of its existence by connecting people and ideas around the globe. The aim of this co-creation program, called Creator Space™, is to address challenges of urban living, energy and food in collaboration with existing and new partners. Six cities played host to the Creator Space™ world tour: Mumbai, Shanghai, New York City, São Paulo, Barcelona and Ludwigshafen. At each tour stop, Creator Space connected industry experts, scientists, representatives from government, NGOs and society, as well as artists, to co-create solutions for a locally relevant challenge. The Creator Space™ white paper series consolidates the findings of each tour stop as a basis for continued collaboration. Creator Space™ Ludwigshafen in November 2015 focused on smart energy challenges and solutions.

1

The challenges of the “Energiewende” – Germany‘s energy transition

1 The challenges of the "Energiewende" – Germany's energy transition

One of the main ways to reduce greenhouse emissions is to lower the amount of CO_2 by electricity generation or by a switch to renewable energies in the transport sector.

The targets already set in these areas are revolutionizing electricity supply structures in Germany and Europe (see Figure 1). Securing a reliable electricity supply involves modifying existing supply structures while maintaining the industry's competitiveness and providing electricity to the public at reasonable cost.

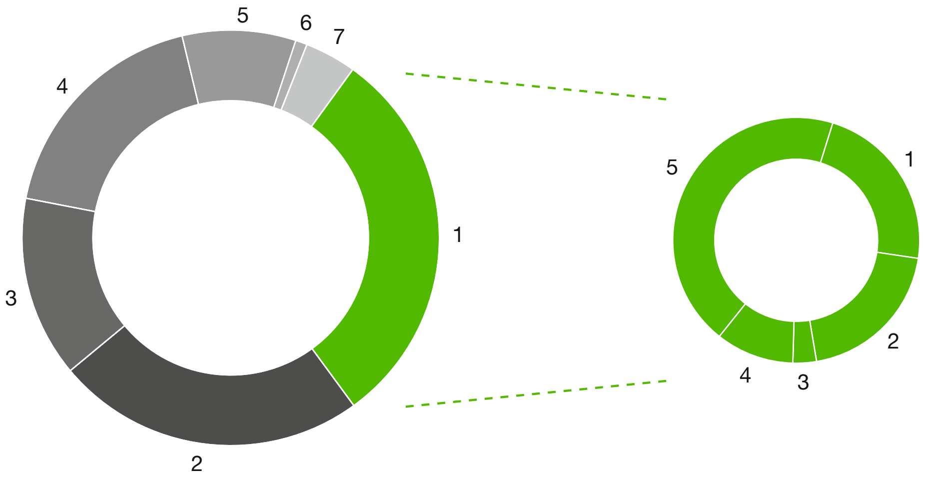
Electricity generation has mainly been centralized in the past. With new technologies like wind power and photovoltaics

- power is provided when the resource is available (wind and sunlight) rather than being geared to meet baseload demand;
- depending on the expansion of renewable energy facilities, a temporary or sustained surplus of electrical power may be available;
- electricity generated at decentralized locations may differ greatly between regions and needs to be delivered, possibly across long distances, in different amounts and at different times to meet varying user demand;
- surplus electricity from decentralized local networks and medium-voltage networks is fed back into the national grid;
- a balance between supply and demand (generation and load) needs to be maintained, for example by storing electricity to be fed into the system later.

> ***„The energy supply of the future is renewable, decentralized, flexible, smart– and the disconnection between supply and consumption will tend to disappear."***
>
> Prof. Dr. Uwe Leprich,
> University of Applied Sciences,
> Saarland

Germany hopes the Energiewende will „make the country one of the most efficient and environmentally compatible national economies while boosting prosperity and competitiveness."

The target is at least **40 %** reduction in greenhouse gas emissions in Germany by **2020**, versus the figure for **1990**, and an **80-95 %** reduction by the year 2050.[3]



1	Renewable	194	30,0%
2	Lignite	155	24,0%
3	Nuclear energy	92	14,1%
4	Hard coal	118	18,2%
5	Natural gas	57	8,8%
6	Petroleum	6	0,9%
7	Other	26	4,0%

1	Biomass	44	6,8%
2	Photovoltaics	39	6,0%
3	Domestic waste[2]	6	0,9%
4	Hydroelectric power[2]	20	3,0%
5	Wind power	86	13,3%

1 Provisional
2 Geothermal share in renewables not shown because of the small quantities involved

Source: Working Group on Energy Balances (AG Energiebilanzen), last revised December 2015

Figure 1: Gross electricity production in Germany 2015 (648 TWh)[3]

The social, political and technological solutions required to raise the share of renewables in total energy consumption include:

- effective expansion of Germany's electricity grids to equip them all to transport the electricity generated by renewable technologies;
- making power plants and cogeneration plants more flexible, and establishing and using powerful storage systems to compensate for fluctuations in electricity output;
- encouraging more flexibility in the use of electricity in households and industrial processes to enable better use of renewable energies and enhance grid stability;
- public acceptance and involvement in energy transition projects.

Next to the integration of renewable energies, the second main element of Germany's energy transition program is energy efficiency. There is huge potential here in the housing sector, for example through the use of efficient heating technologies, ranging from effective thermal insulation to renewable energy storage.

Developing and spreading the use of electric vehicles (electromobility, as the concept of using electrically powered transport is known in Germany) is another important aim. Germany plans to be a leading market for and supplier of electric vehicles by 2020.

The climate protection targets set in the recent past are hard to achieve even now. The latest figures published by the Federal Statistical Office show that Germany reduced emissions by 27 percent between 1990 and 2014.[4] Any further reduction requires substantial technological innovations, both incremental and pioneering. New technologies with higher efficiency grades, lower costs and lower resource consumption need to be available on the market, be more competitive and generate long-term economies of scale. The various different state funding models and rules need to form a coherent system to avoid policy mistakes. Ultimately, the aim is to cost-effectively increase the share of renewable energies in electricity production and create profitable investment models.

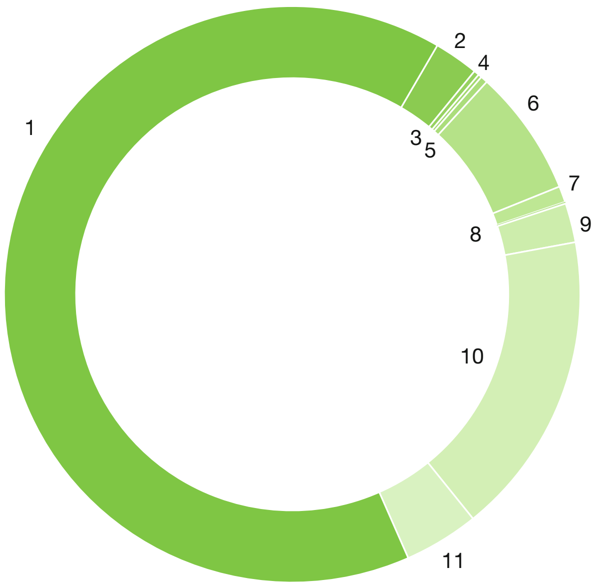
Potential solutions to advance the energy transition process need to be viewed holistically, taking the impacts and interactions of all three parts of the energy equation into account (cost-effectiveness, environmental impact, supply security).

2 Energy supply of the future – city, district and family home

2 Energy supply of the future – city, district and family home

Germany's targets are ambitious: a 20 percent reduction of primary energy consumption by 2020 and a 50 percent reduction by 2050 versus the base year 2008, along with a 10 percent reduction in electricity consumption by 2020 and a 25 percent reduction by 2050.[5]

The federal government aims to have virtually all buildings in Germany climate-neutral by 2050. Buildings account for about 40 percent of energy consumption in Germany and about 20 percent of climate-harming carbon emissions (Figure 2).[6]

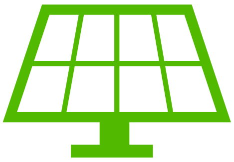


1	**Other uses in all sectors:**	**65,0%**
	Industrial buildings:	**3,4%**
2	Heating	2,5%
3	Hot water	0,3%
4	Air conditioning	0,2%
5	Lighting	0,4%
	Industry/trade, commerce, services buildings:	**10,3%**
6	Heating	7,1%
7	Hot water	0,9%
8	Air conditioning	0,1%
9	Lighting	2,2%
	Private households:	**21,3%**
8	Heating	17,1%
9	Hot water	4,2%

Figure 2: Share of building-related final energy consumption as a percentage of total final energy consumption in 2014[7]

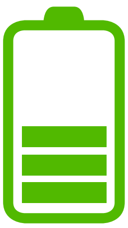
Most buildings need to reduce their energy consumption and raise their energy efficiency. About 85 percent of energy consumption in private households is for heating and hot water alone. Measures to reduce the requirement include a federal government campaign to encourage the use of energy-efficient products and to double the annual energy efficiency retrofit rate from the current figure of just under 1 percent to 2 percent of the total building stock per year.[9]

For a building to be climate-neutral, better thermal insulation and renewable energy utilization and storage are essential.

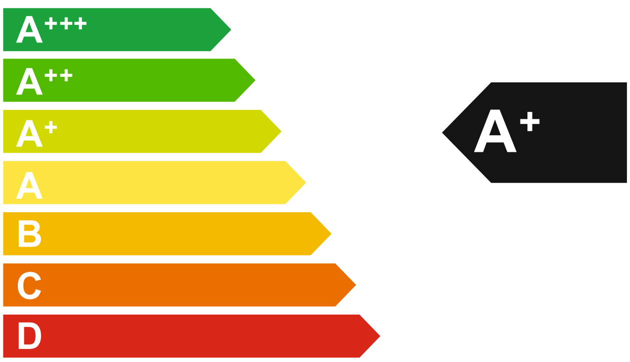


Many single-family and multi-family homes are already using renewable energies. About 1.5 million photovoltaic generation systems and almost as many solar thermal generation systems are used to produce electricity and hot water from solar energy that home owners collect. Almost 90 percent of these facilities are installed on the roofs of private houses. Solar subsidies have recently been cut as the efficiency of the modules grew, and installation rates surpassed expectations.

Other technologies for retrofits in old buildings and installation in new buildings also exist. One example is the use of environmental heat, which is harnessed by installing a geothermal probe or geothermal heat collectors. Geothermal heat is used in conjunction with thermal pumps to heat or cool buildings and provide hot water. There are 850,000 heat pumps in operation in Germany today.[10] The pumps can also use environmental air or groundwater as a source of heat. Although these pumps may be less efficient than near-surface geothermal pumps, they require less investment and can themselves be powered by electricity from renewable energies. In addition to electricity generation and heating technologies, systems to store electricity and heat are playing an increasingly important role. Photovoltaic plants use rechargeable batteries to store solar electricity. Alternatively or additionally, thermal storage systems may be used which use renewable energies to heat non-potable water, hot water, or other substrates such as salt that can store heat for hours or days.



Prohibitive investment costs and long amortization periods for large storage systems are a deterrent to their use. There may be technical problems, and the useful service life of storage technologies depends a great deal on their parameters of use. The storage of chemical, electrical, electrochemical, mechanical and thermal energy is associated with significant costs. Although new technical concepts for efficient, low-cost energy storage become apparent, a legal and regulatory framework to expedite their implementation is currently not in place.



Magnetocaloric materials are poised to revolutionize cooling: They make cooling and air conditioning equipment more energy-efficient and less noisy and do not require refrigerant gases, making them an ideal alternative to conventional compression technology. BASF presented the first prototype of a magnetocaloric wine cooler in collaboration with a US engineering firm, Astronautics, and a Chinese domestic appliance manufacturer, Haier.

The EU Renewable Energy Directive sets ambitious binding targets for the whole of the European Union. Germany is expected to meet **18 %** of its primary energy requirement with renewable energies by **2020** and **60 %** by **2050** and raise the share of renewables in electricity production to **40-45 %** by **2025** and **55-60 %** by **2035**.

Tomorrow‘s energy-efficient cities

Urban neighborhood management concepts offer significant ways to raise energy efficiency and optimize the use of renewable energies. Better technologies with higher degrees of efficiency, more efficient utilization of electricity and heat, larger-scale projects, changes in the way people use energy, and energy-efficient modernization and construction can help.

"An urban neighborhood is an area of spatially connected private and/or public buildings, including public infrastructure."[12]

More and more people are moving into cities. Urban population expansion will reduce the availability of affordable housing in urban areas over the coming decades. At the same time, legislation on new and existing buildings calls for a contribution to the energy transition program. These trends underline the need for affordable contributions from urban residential and public buildings to help meet energy transition goals. To achieve these aims, we need incentives that support integrative solutions. Some already exist. Effort needs to be invested in improving the scale, effectiveness and accessibility of such solutions and in the implementation of a supportive regulatory framework. Planning processes in the construction sector are also undergoing radical change characterized by the active interaction and networking of all stakeholders throughout a building‘s life cycle. These challenges are unleashing disruptive innovation in the construction industry.

Maximizing the benefits of integrated urban planning

One possible approach to raise energy efficiency is the implementation of a policy of integrated urban planning in the construction of new buildings. Building planning and design need to be viewed holistically to address climate protection requirements and create sustainable energy-efficient buildings. Emissions from heating can be reduced by lowering the heating requirement through the use of insulation, energy-efficient heating technologies, heat recovery, storage systems or renewable heat and electricity sources. Some of these technologies can be used more efficiently if implemented in multiple housing units and buildings.

Strengthening the role of the neighborhood manager

Neighborhood managers could be empowered to play a crucial role in future by acting as project controllers/leaders of an urban neighborhood with an integrated design, planning and realization concept. The task of neighborhood managers is to involve all stakeholders and to design the neighborhood in close collaboration with them, while addressing all the technological, sustainable, energy efficient and economic potential involved. Neighborhood managers take charge as project controllers, helped by the application of new planning methods such as building information modeling (BIM).[13] The proposed role would significantly expand the existing remit of the neighborhood manager.

> Neighborhood management has been a feature of urban planning since the 1970s. The responsibility of neighborhood managers is to integrate multiple stakeholders in project delivery, including administrators, politicians, businesses and local communities. The neighborhood manager integrates different aspects, is responsible for planning and realization in urban development and is expected to prevent sequential, uncoordinated neighborhood planning to the fullest possible extent. KfW, a government-owned development bank, established a funding program to support climate protection goals in which the cost of setting up an integrated neighborhood concept and retrofit management to realize the plans is subsidized from the federal government‘s dedicated „Energy and Climate Fund.“[14]

Creating support schemes

Encouragement of strategic cooperation models between property developers, financial backers and energy suppliers is an important approach in the implementation of energy-efficient urban planning. A suitable legal framework can also incentivize investment by providing funding, subsidies, tax breaks and low-interest loans.

> More use needs to be made of **Energy Performance Contracting**. „Energy performance contracting is an established form of public-private partnership in which an energy service company plans, realizes and funds measures to save energy in public buildings and uses the energy savings to repay its expenditure and investments.“[15]
>
> **Energy cooperatives** with direct community involvement are useful forms of collaboration, but the numbers of new energy cooperatives setting up have declined since the introduction of further changes in the funding of renewable energies. Energy cooperatives help to increase levels of acceptance for sustainable energy production among the general public, provide information on technologies, offer advice and services and can help lower the cost of the transition to renewable energies.
>
> **Crowdfunding** is another possible source of investment in renewable energies. Various funding types and project owners exist, for example as cooperatives or based on the loan principle.[16] The support models mentioned are just a few of the many options available to secure cash flow and capital for visionary building investments and to lower the cost burden for owners and tenants.

To create the energy-efficient city of tomorrow and put the approaches outlined here into practice in the best possible way, the regulatory framework needs to provide incentives. Many of the regulations now in force hamper integrated solutions and make it difficult to invest cost-effectively. They also make energy efficiency unaffordable for consumers.

Renewable energy in rural districts

Alongside cities, rural areas play a central role in the implementation of renewable energies. Rural districts account for almost 90 percent of Germany's surface area and offer plenty of room to implement technologies.[17]

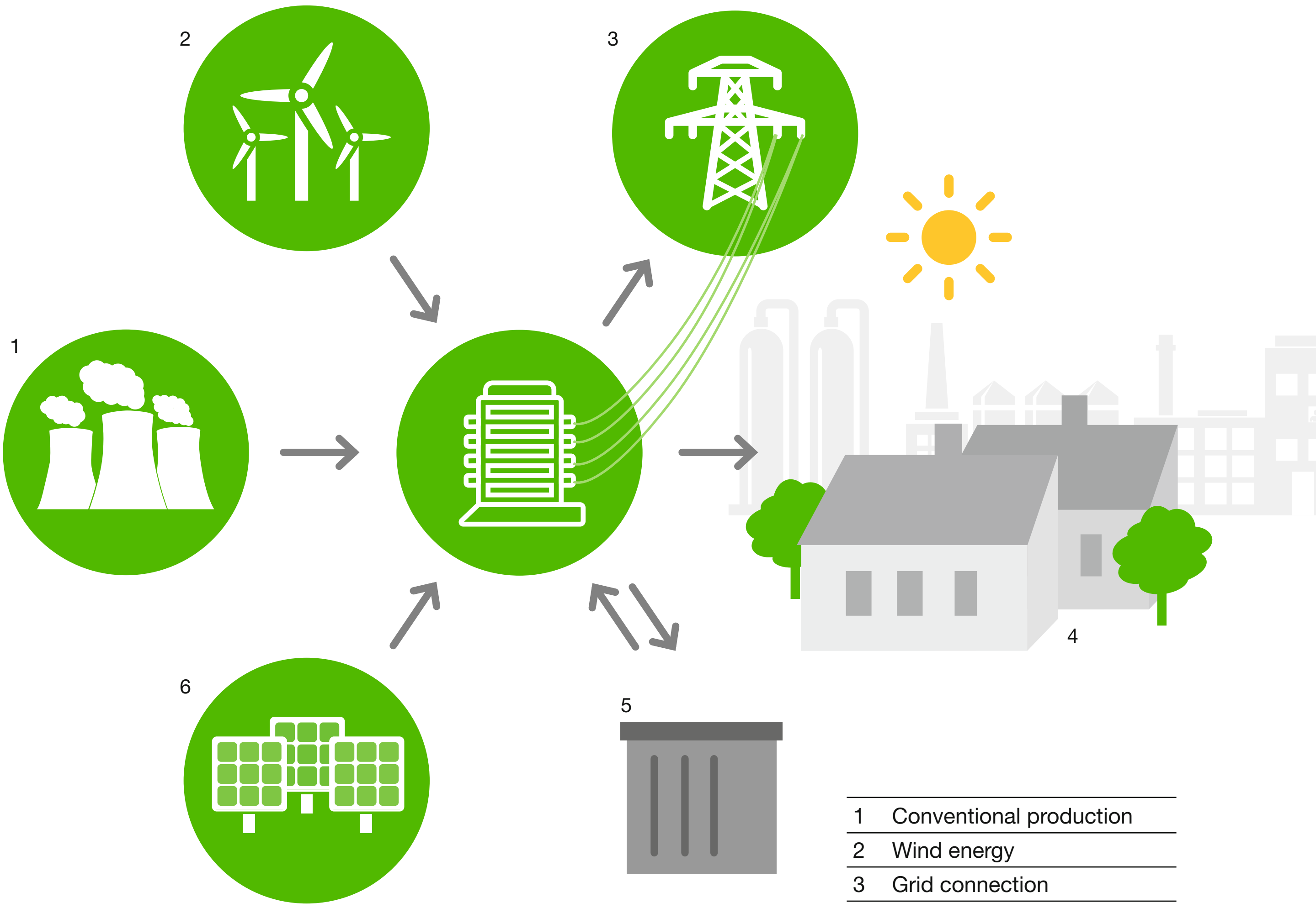
54 % of the population lives in rural areas,
23 % in sparsely populated regions.[17]

Integrated energy supply concepts based on the use of hydroelectric power, solar energy, biomass and wind power in many locations already constitute best practice examples showing what decentralized energy supply in rural areas might achieve. A smart power supply system with suitable flexibility options (flexible production, flexible demand, storage and efficient grids) will maintain a balance between the fluctuating supply of electricity from renewable energies and consumption levels. The use of local and district heating grids provides further opportunities.

The rural district of Wolfhagen combines „energy-efficiency retrofitting of buildings, the use of energy-saving devices, new forms of mobility, proper management in combining solar, biogas and wind power, demand-based energy from a combined heat and power plant which provides quickly dispatchable power if no wind blows or the sun doesn't shine."[18] Managing fluctuations in the amounts fed into the grid in response to over- or undersupply is a challenge. Feed-in tariff incentives may be part of the solution.

Connecting the various sectors – electricity, heat and transport – and electrification of applications may play a bigger role in future. Sector connection – and the associated conversion of electricity to other forms of energy (Power-to-X) – enables the production and consumption of renewable energies to be synchronized, which helps to secure a stable energy supply and provides economic benefits to boot. To accomplish this, a lot still needs to happen. This includes developing and implementing an electricity market modified to meet the new requirements, incentives for the general public, energy assistance systems for better IT process control, cost-effective storage technologies and new business models. A framework conducive to market-driven solutions and equitable distribution of costs is required to enable all this.

One approach would be to provide leasing models for photovoltaic generation systems, storage systems and heat pumps. Power could be understood overall as a service rather than charged solely based on consumption. This would need to be accomplished without damping incentives designed to boost energy efficiency, however.



1	Conventional production
2	Wind energy
3	Grid connection
4	Rural areas/ Municipality
5	Energy storage / Power-to-X
6	Solar power

▲ **Figure 3:** Decentralized energy supply in rural areas

Single-family houses and duplexes – huge untapped potential

Much of the building stock in rural areas is composed of single-family houses that are both potential producers and consumers of energy. Many such buildings are more than 30 years old.[19] The large stock of old buildings in Germany means that buildings in this category must contribute the most to climate protection measures.

35% of Germans own a single-family house or duplex (two-family dwelling).

43% of these dwellings were built between **1949** and **1978**. Three-quarters of them are more than 30 years old and partially or completely lacking in energy-efficiency features [19]

Single-family houses and duplexes differ in terms of heating requirement, occupant mobility preferences and number of occupants. They are also built to different codes and hence differ in energy consumption and energy costs, so a consistent, standardized technology mix would not be a workable solution.

Increasing the role of the energy consultant

There is potential here to expand the role of energy consultants and extend their remit. At present, the job of an energy consultant is to rate the energy efficiency of a building and its technical facilities, identify deficiencies, propose ways to remedy them and see to it that the proposals are implemented correctly. Aspects such as the housing situation and choice of technologies might be added. The energy consultant could design and develop appropriate integrated concepts.

Modular principle

To meet disparate requirements, different scenarios and categories can be designed for different technology solutions of generating and storing renewable energy. Then the technologies can be grouped and standardized. Funding opportunities should be addressed, too. Based on a modular system, the energy consultant assembles a suitable individual solution for a particular family home. Criteria used for grouping would be technical in the first instance as well as responding to the occupants‘ individual needs. Appropriate criteria might include type of building, location, site, weather, infrastructure, and similar. Examples of individual criteria would include number of occupants, habits, needs, and so on. The great challenge facing the energy consultant will be to find the best mix of technologies and energies in the given circumstances. In an universally applied modular system, smart connections between all households would be essential in order to meet the heating and electricity requirement of each household, stabilize the grid and ensure a consistent supply of electricity. Forecast-based connected solutions for the technologies deployed will form the basis for feeding in and compensating for fluctuating energies. At present, more research and development is needed for reliable storage technologies, in particular for seasonal storage systems that can store heat in summer and deliver it in winter. Energy information and advice services for home owners need to be improved along these lines to facilitate energy efficiency retrofit planning.

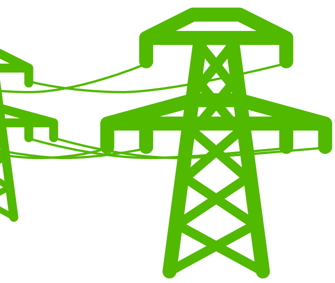
3

Storage, production and transport technologies: yes, in principle, but not in my back yard

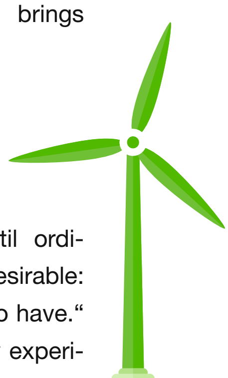
3 Storage, production and transport technologies: yes, in principle, but not in my back yard

Support for systematic implementation of the energy transition program is high in many sectors of the German population, but many people are unwilling to accept changes that impact their immediate environment.

Political representatives, urban planners and many others involved in implementing decisions know from experience that public discourse on behavioral modification and a „participation culture“ are necessary to bridge acceptance problems. Protests tend to flare up on all sorts of issues for many different reasons. The result is that resolutions and plans are toppled before they even get to the permission stage. Plans to build wind turbines or expand national transmission and distribution grids typically attract protest because of allegations of noise pollution or flickering lights. Protest also arises from diffuse anxiety about health impacts or because people fear effects on property values. Negative experience with other large projects, having to submit to government guardianship in the past, perceived arrogance or inadequate involvement in decision-making can also fuel resistance.



Shaping a future based on sustainable energy concepts involves eliciting the consent of local communities for the installation of certain technologies. An official political mandate to implement change – no matter how democratic the process was – is not enough. Much of the problem is due to poor communication, a lack of involvement of local communities at an early stage, and – more importantly – an absence of livable, hands-on examples demonstrating that smart energy really is workable and brings many benefits.



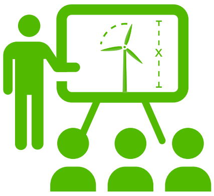
Creating trust

Attitudes to smart energy will not change until ordinary people embrace it as trendy and socially desirable: „Electric cars are cool, solar heating is the thing to have.“ This can only come about as a result of everyday experience in all sorts of contexts, the opportunities for which are lacking at present. There is also a lack of well-thought-out incentive systems that do not compete with or detract from each other and are understood by all sectors of society.

The media can do a lot to improve matters. Smart energy tends to be portrayed in the context of some crisis or other, or as part of an intellectual debate between specialists or lobbyists for various NGOs.

It is important to counter these images with examples of everyday use that people can identify with. Communication analysis shows that timely information and opportunities for dialog directed to the general population help to prevent conflicts from escalating and may even improve the quality of planning. As with any project, an energy transition project will be more convincing if fronted by an actual hands-on representative of local government, an institution or industry rather than a faceless public authority or company.

Encouraging information-sharing and communication



„Convincing“ is probably overstating the case – but local communities are willing to tolerate technology if they believe and understand how it benefits society. Smart energy projects tend to present experts who discuss the issues on a technical level. They need to appreciate that emotions are involved, too and that people may have their very own personal anxieties and associations with a project. These may be sadness at the prospect of losing a familiar rural landscape, rage at high-handed developers, half-baked theories based on social media scare-mongering, and much more. Politicians, planners and players need to invest serious work in stakeholder and issue analysis.

> Turning concerned citizens into experts, engaging with and answering questions, choosing the right language – all this needs to be tested and put into practice. And it is no trivial matter.

That‘s because, quite apart from providing information, dialog requires a willingness to consider and rethink all the positions, including one‘s own, and to admit and engage with the points of view of others.

Clarifying interests

If projects seem to be about to escalate, it helps to get all the parties to the table for a mediation session. Presenting a consensus is no longer an option, the agreed targets need to be redefined and mutual respect restored. Clarity of perspective is required when decisions are ready for implementation, however. It takes political integrity when majority decisions are put to vote. „Know who you‘re dealing with, take it seriously, use language that will be understood, show that you‘re willing to compromise“ are only a few simple recommendations that are too often ignored. Yet the media could be a source of support, for example by reporting when politicians support fundamentally different decisions in a local setting than for the nation at large. A lack of consistency and backbone undermines a democratic opinion-forming process in which all are held accountable and shoulder responsibility. The unconscionably long decision-making processes in some areas, delaying tactics – frequently involving the courts – and undue attention to a few isolated „troublemakers“ put democratic processes at risk and make a nonsense of the drive to convert society to sustainable forms of energy. All multipliers are therefore called upon to be open in their treatment of the issues and show a willingness to change.

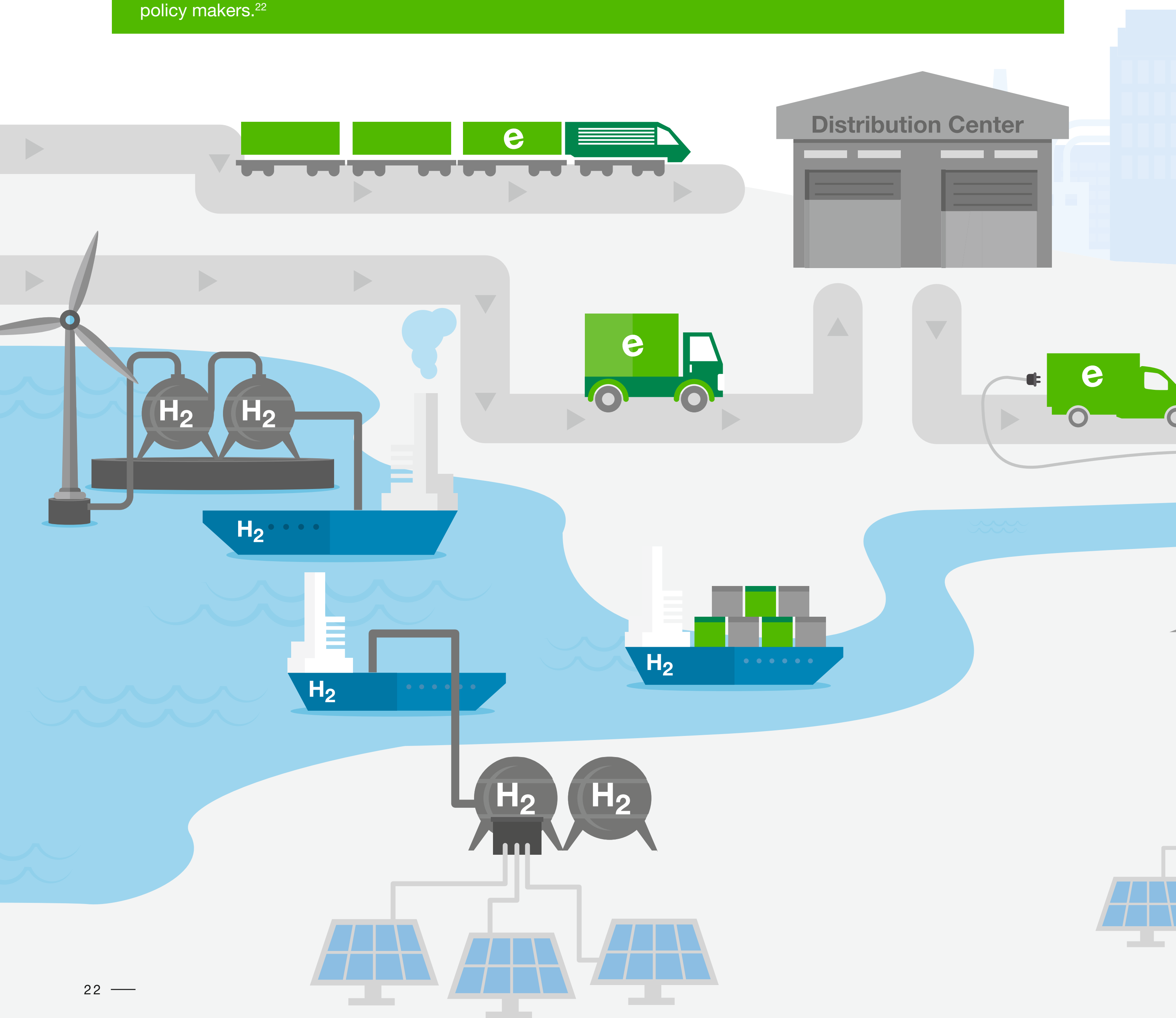
Experiencing energy

Many examples of energy conversion at work receive too little attention. Role models that are more than symbols and gimmicks can help. An office building in Stockholm uses the collected body heat of commuters in the station across the way for cooling and heating.[20] Many of the vehicles in the BASF car pool in Ludwigshafen are „electromobile“. Company employees can find out for themselves that electric cars are nimble, easy to use and definitely fit for purpose. Initial skepticism is replaced by a positive user experience.

> „Know who you‘re dealing with, take it seriously, use language that will be understood, show that you‘re willing to compromise.“

4 Innovative renewable mobility concepts

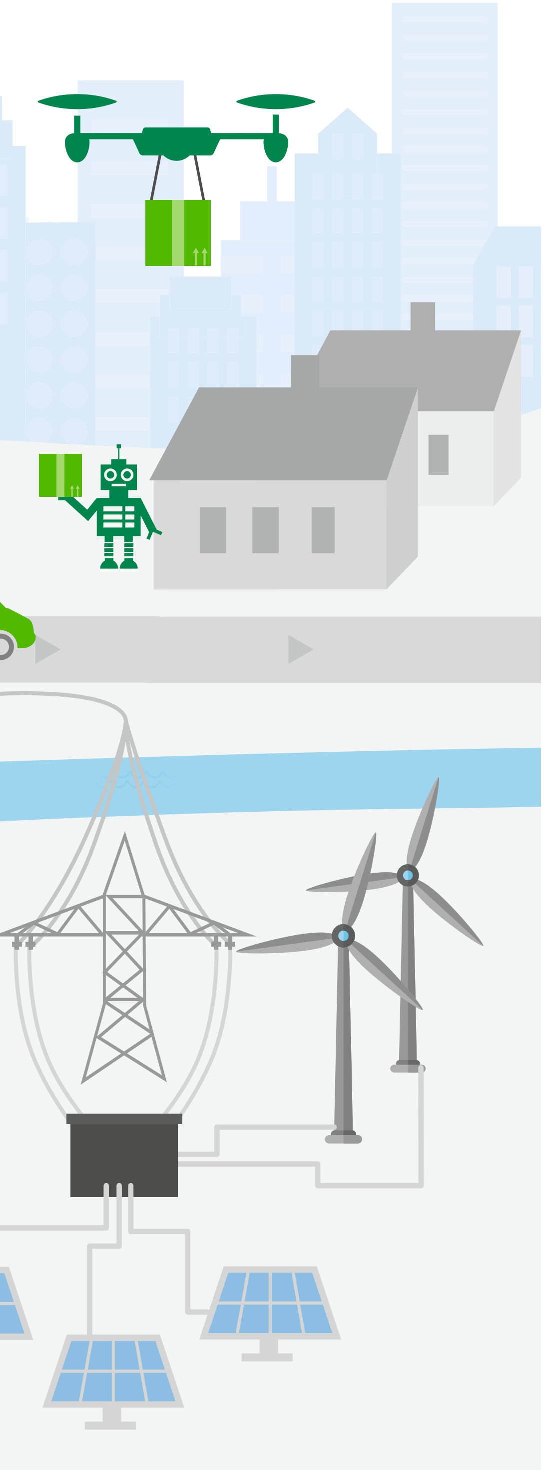
The European Union has set political targets requiring car manufacturers to reduce average CO_2 emissions to 95 g/km for 95 percent of new cars by 2020.[21] The European Environment Agency's 2015 report indicates that average emissions are on track, at 123.4 g/km, but the reduction still poses a huge challenge for car manufacturers and policy makers.[22]

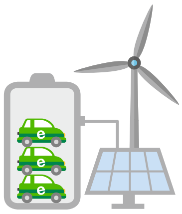


In Germany, CO_2 emissions in the transport sector have not declined since 1990, despite fluctuations, and they have in fact been nudging upwards since 2007.[23] In addition, in many cities, limits for airborne pollutants like dust particles and nitric oxide are exceeded on a regular basis, with major health impacts.[24] Electricity and hydrogen produced from renewable sources would reduce local and global CO_2 emissions from transport, and nitric oxide and particle matter could be reduced or eliminated altogether. Alongside passenger traffic, the transport of goods accounts for more than one third of CO_2 emissions.[25] An optimized logistics concept coupled with accelerated and improved integration of new technologies and renewable energies could reduce these emissions, both for the good of the climate overall and cleaner city air.

Rethinking delivery vehicles

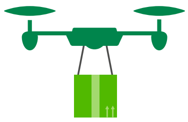
With their high inner city mileage rates and the growth in delivery traffic due to the increasing popularity of online shopping, delivery vehicles have a lot to contribute. Deutsche Post and UPS are already using new electric vehicles, ranging from electrically powered delivery bikes to vans. What‘s more, these and all other electric storage systems could contribute to grid stability in a future smart grid by storing renewable energy when not in use. Business models that address battery wear and batteries that can deliver plenty of charge-recharge cycles will be essential.





Using storage potential

There is vast potential for synergies between renewable energies and mobility. Cars sit unused for most of the day and, if electrified, would have a storage potential sufficient to back up the country‘s power supply for days at a time.



Flying drones

Ground-based or flying drones could help out in the supply chain, initially for emergency deliveries or deployment in rough terrain. Regulatory obstacles aside, mass delivery drone deployment would require innovations in the design of battery and fuel cells, software and light-weight materials.

Rethinking shipping

Fuel cells might have a future in shipping. Lower emissions are of interest in the first instance for passenger ships, yachts and harbor operations. Vibration-free, noiseless engines increase the comfort of those on board and would be relevant for research vessels, too. Numerous projects already exist: small fuel cells to supply electricity, diesel and natural gas fuel cells as partial propulsion systems on several experimental ships, even hydrogen-powered submarines. Full-scale production, container ships and integrated propulsion solutions would be advantageous in the long term. Utilization of renewable energies and fueling through offshore wind farms seem like obvious choices.

Alongside tougher emission regulations for vehicle manufacturers and inner cities, technical innovations will be the main driving forces involved in extending the range and lowering the cost of renewable mobility and accelerating its breakthrough on markets. Bold investment in private and public research and pilot projects holds the key to innovation in these areas.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5 The chemical industry: energy-intensive, flexible, innovative

5 The chemical industry: energy-intensive, flexible, innovative

With the climate protection targets set by the European Union and massive expansion of renewable energies, it is clear that an industry as energy-intensive as the chemical industry can and must contribute.

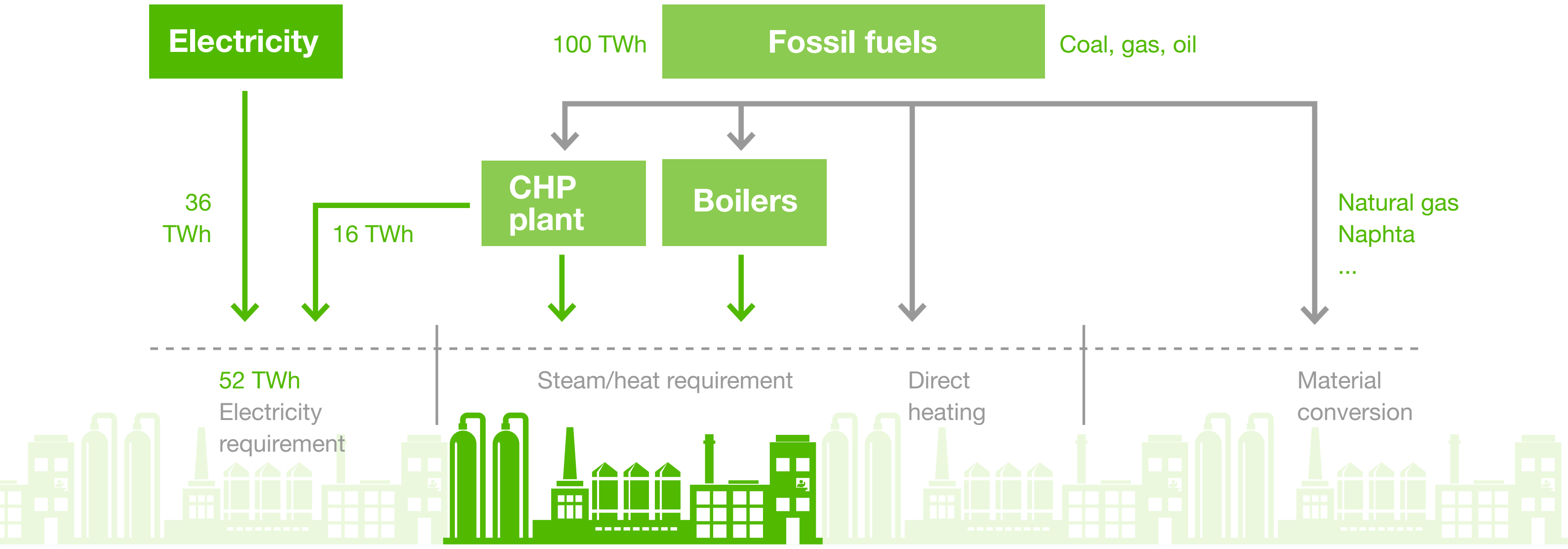


Figure 4: Energy requirements of the chemical industry in Germany

The industry contributes by developing innovative products and technologies, for example in power transmission and conversion, batteries and storage systems.
As a consumer of energy and raw materials, the chemical industry can also contribute significantly to the integration of renewable energies without losing competitiveness. There are numerous opportunities to do so in chemical plant production processes and value chains.
These opportunities can be divided into two categories: „Power-to-X“ and „market controls load“.

Improving usage concepts

„Power-to-X“ may involve the conversion of entire value chains. The starting point might be electrolytic generation of hydrogen. In this simple scenario, this hydrogen only replaces hydrogen production from fossil fuels. In the event of a significant surplus of hydrogen, new value chains can open up (hydrogen energy system). This would usually involve the construction of chemical plants from scratch, requiring significant investment. The investment risk is high as well because of possible changes in the energy policy framework. These approaches have been investigated by scientists for years and are set to play a major role in decarbonizing the global energy system.

If surplus renewable energy is converted to heat (**Power-to-Heat**), that heat could be used straight away to heat devices such as steam reformers. Heat can also be used to produce steam (in capillary evaporators, for example). The aim is to replace fossil fuels for heat production.

With **Power-to-Chemicals**, electrolytically produced hydrogen takes the place of natural gas in the chemical value chain or replaces desulfurization in the oil and refinery business. Ammonia and methanol synthesis are typical examples here.

If excess electricity is used to produce hydrogen by hydrogen electrolysis, this hydrogen can be stored and later converted back to electricity, for example using fuel cells. To make better use of existing infrastructures, hydrogen needs to be converted to synthetic methane. The existing natural gas infrastructure can be used to store this methane (**Power-to-Methane**).

Making plants more flexible

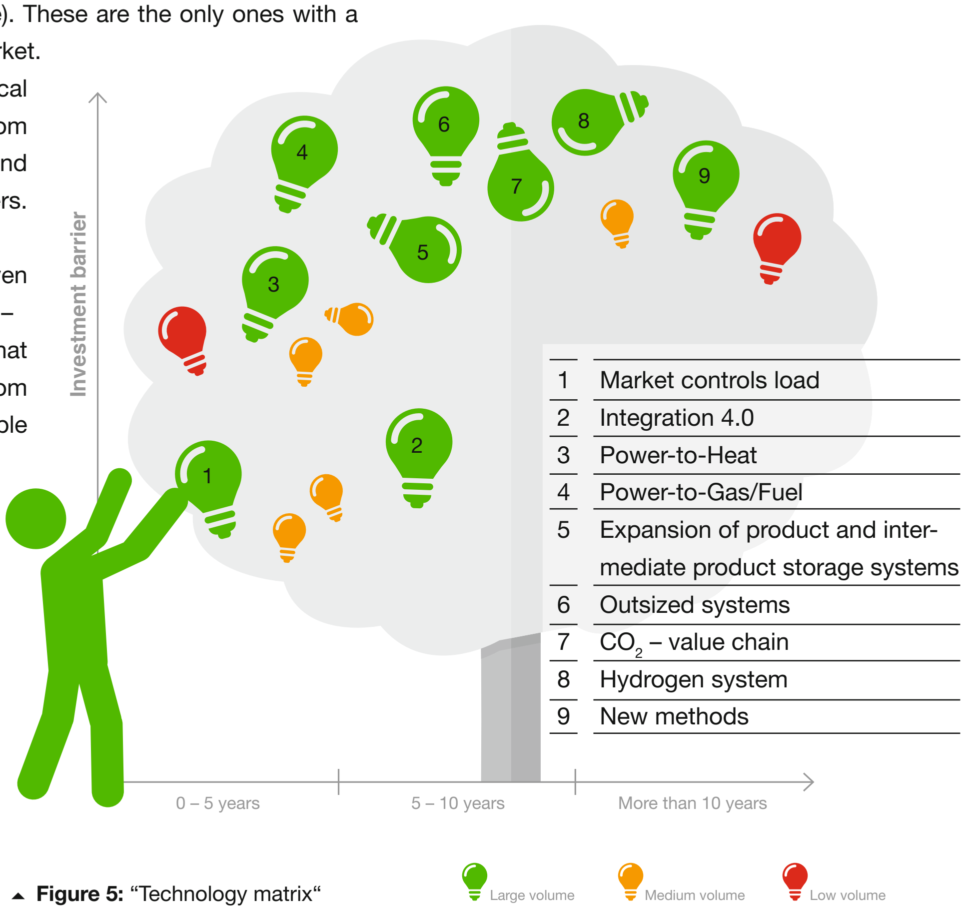
„Market controls load“ is the term for technologies that increase the flexibility of existing chemical plants. These technologies make it possible to efficiently control individual chemical plants or entire chemical value chains.
They enable chemical companies to disconnect production steps and place production inputs into interim storage (materials, electricity, heat/cold), as well as to perform hybrid processes, some involving heating with electricity in chemical plants. This allows chemical companies to exploit temporary power surpluses in the short or medium term or scale back production in the event of a shortage of power. A few chemical plants (chlorine electrolysis) are already involved in this market segment. Heat and electricity storage systems are also widespread and set for further development. Investment volumes and risks in this category are limited.

To better assess the potential of existing chemical plants to provide energy „services,“ a „prototype“ of a flexible chemical plant with a stable production process would be useful. Systematic analysis and optimization of the prototype in terms of power range, ramp rates, additional cost and power market revenues could help to estimate the overall potential of the chemical industry in supporting existing facilities.

For feasibility assessment purposes, potential contributions of the chemical industry to the integration of renewable energy that are essentially based on interventions in chemical plant processes can be classified in a technology matrix (Figure 5).

Criteria include investment risk, volume or significance of the specific contribution to integration, and assessment of the likely length of time to market. From a macroeconomic and microeconomic point of view, technological developments should be chosen that will contribute most to the integration of renewable energies at a low cost of investment (cost of capital, operating expense). These are the only ones with a chance of survival on the market.
Contributions from the chemical industry face competition from other branches of industry and infrastructural service providers.

To get companies to act – even if investment barriers are low – there needs to be certainty that more low-cost electricity from renewable energies is available on the market.



▲ **Figure 5:** “Technology matrix“

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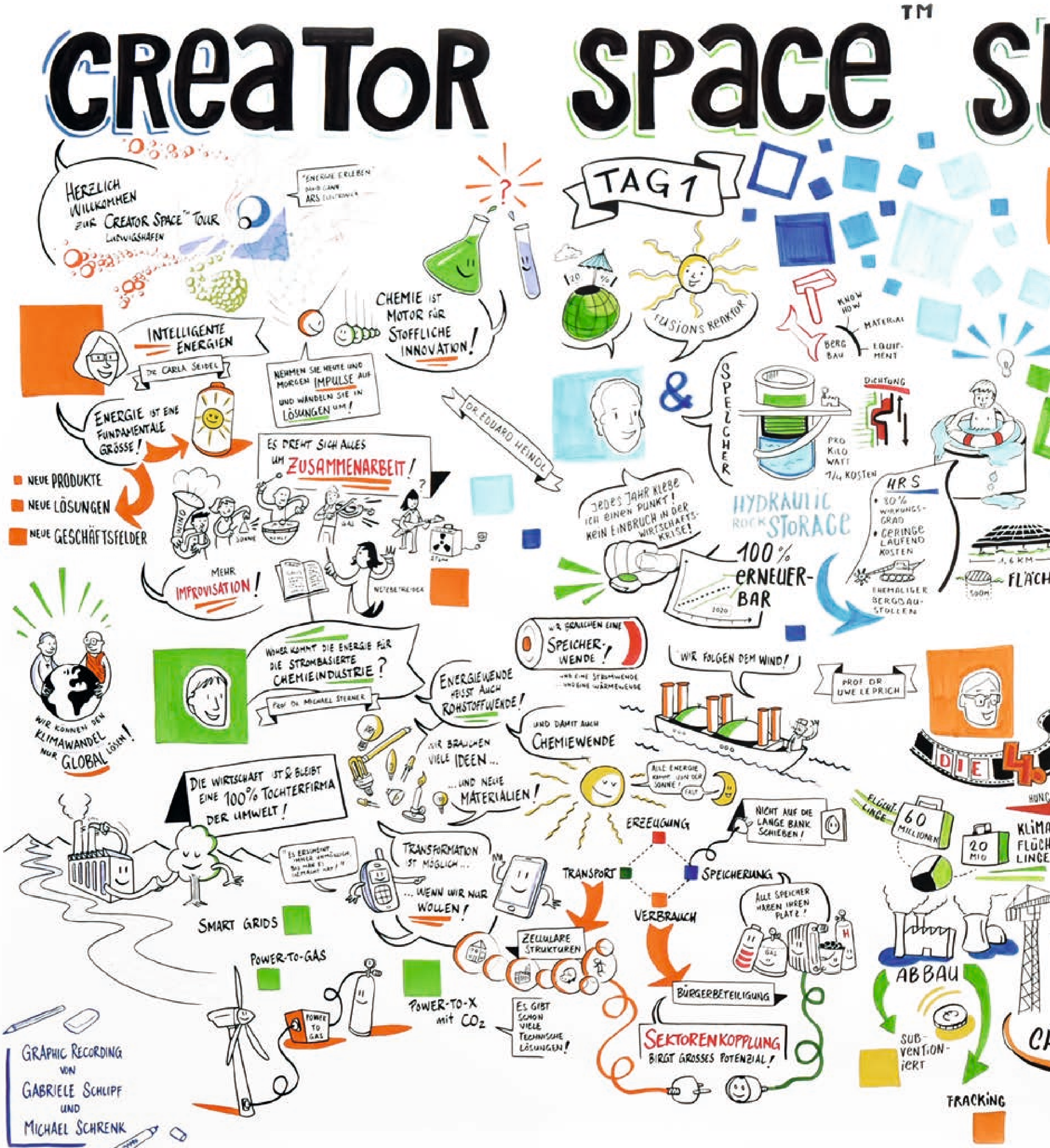
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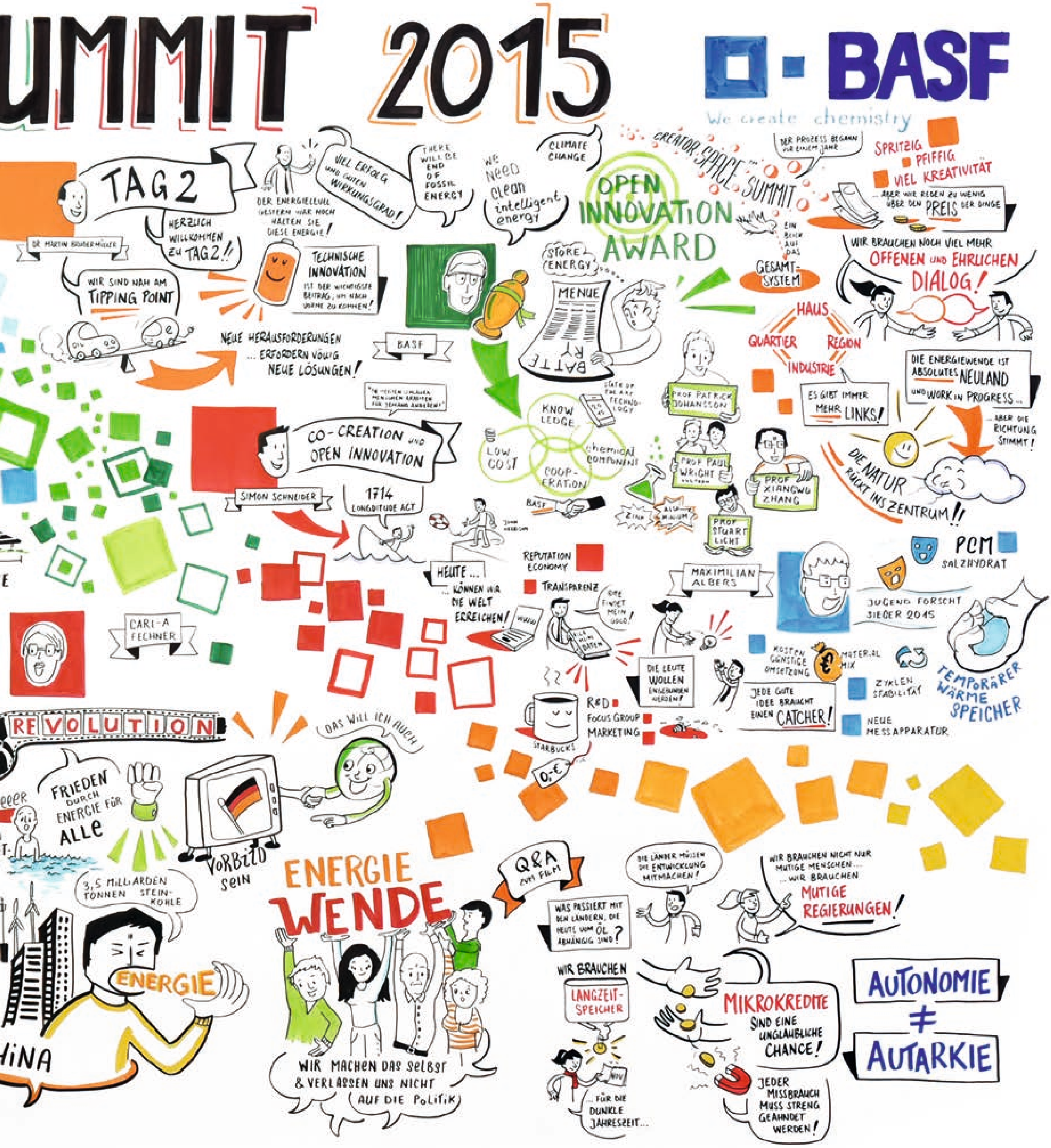
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