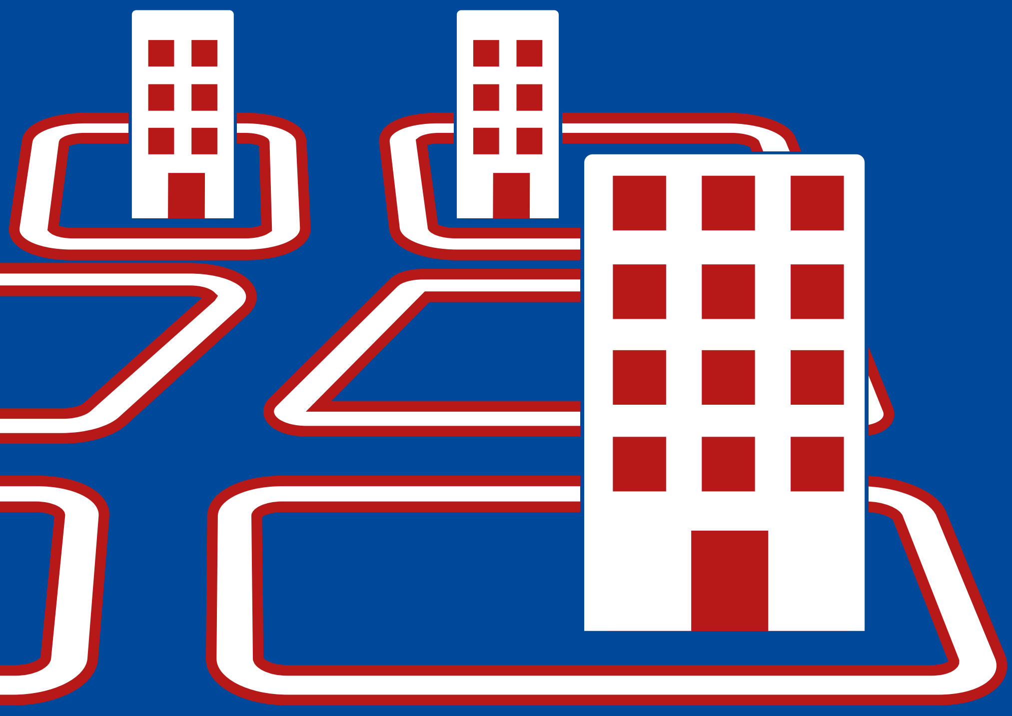
Sino-German Urbanisation Partnership

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

PLUS ENERGY BUILDINGS & DISTRICTS



KEYSTONE PAPER 1

Sino-German Urbanisation Partnership

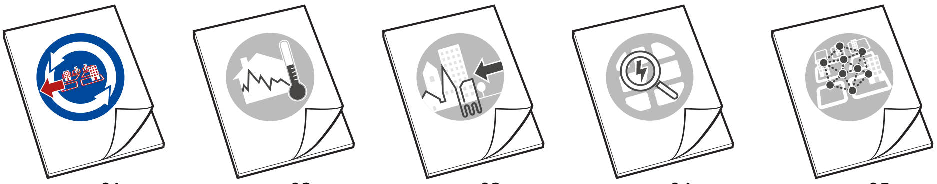
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

This document is part of five keystone papers looking at current emerging topics in the building and city sector, focusing on energy efficiency and resilience. The keystone papers were developed within the framework of the Sino-German Urbanisation Partnership as a basis for the forthcoming working period and cover following topics:



01 Plus Energy Buildings and Districts

02 Energy Efficiency of Buildings and Districts in Urban Renewal

03 Transformative City

04 Climate Risk Management in Cities

05 Urban Renewal in Districts

Prepared by:

BUROHAPPOLD ENGINEERING

Happold Ingenieurbüro GmbH
Pfalzburger Straße 43-44
10717 Berlin, Germany

CONTENTS

LIST OF FIGURES

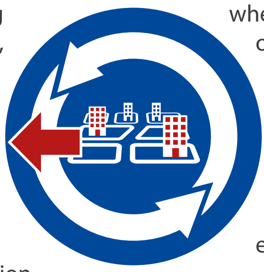
ABBREVIATIONS

BMU	Federal Ministry of the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
CHP plants	combined heat and power plants
DGNB	German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen)
EEG	Renewable Energy Act (Erneuerbare Energien Gesetz)
EEWärmeG	Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz)
EnEG	Energy Savings Act (Energieeinsparungsgesetz)
EnEV	Energy Saving Ordinance (Energieeinsparverordnung)
EPBD 2010	European Energy Performance of Buildings Directive 2010
EU	European Union
GEG	Energy Building Law (Gebäudeenergiegesetz)
GHG	greenhouse gas
KfW	Kreditanstalt für Wiederaufbau (Germany's government-owned development bank)
kWh	kilowatt-hour(s)
nZEB	nearly Zero Energy Building
PV	photovoltaic
WIR-2020	Wildpoldsried Innovative Leadership Plan (Wildpoldsried – Innovativ – Richtungsweisend)
WSVO	Thermal Insulation Ordinance (Wärmeschutzverordnung)

0. EXECUTIVE SUMMARY

Germany's building sector accounts for about a third of the country's total greenhouse-gas (GHG) emissions and 40 % of total energy consumption. The continuous enhancement of building standards is a key element to reduce CO2 emissions of buildings especially during the operational phase. In recent years, several models to maximise thermal performance of buildings have been developed. Well-known examples are the Passive House, the nearly Zero Energy Building (nZEB), and the Plus Energy Building as the next ambitious step in the evolvement of highly energy efficient construction.

In 2011, the Federal Ministry of Transportation, Buildings and Urban Affairs, published first definitions and main attributes of a Plus Energy Building: both the annual primary energy demand as well as the end-of-year energy demand must be less than 0 kWh/m^2 per year. An important characteristic in the assessment of a Plus Energy Building is that it differs from the calculation method as required by the Energy Saving Ordinance (EnEV), the current regulation on energy performance of buildings in Germany, last amended in 2014 / 2016. While under EnEV the guiding audit parameter is primarily the building footprint only, for a Plus Energy Building, the complete building plot is considered. By that, energy generated by e.g. geo thermal systems, are also taken into account. Similar to Passive Houses, Plus Energy Buildings aim to maximise energy efficiency of a building by creating a highly insulated building envelope. Additionally, energy demand is minimised, through integration of highly energy efficient household appliances, the creation of low-temperature heating systems, short operation times for heating and ventilation systems.



The path towards broad dissemination of the Plus Energy Building standard requires the creation of appropriate legislative framework conditions, as the current existing standards do not specifically consider the requirements of a Plus Energy Building. EnEV builds on the foundations of the Thermal Insulation Ordinance (WSVO) from 1977. The WSVO aimed to establish a regulatory framework, to reduce the oil consumption of heating systems. The first EnEV of 2002, replacing WSVO, was drawn up in order to meet the climate protection goals of the German Government towards the climate agreements of the Kyoto summit and since adapted twice. Still, the focal point of the current EnEV is a climate-neutral building stock until the year 2050. As Plus Energy Buildings might have excess energy that feeds back into the grid, another regulation, the Renewable Energy Law (EnEG) and the so-called Renewable Energies Act levy (EEG-Levy), open up further possibilities. The Federal Government implemented the EEG-Levy, to incentivise the installation of renewable energy systems. Through the EEG-Levy, owners of renewable energy systems receive a predefined compensation.

Still, Plus Energy Buildings remain an exception and are mostly realised as model projects. While the schemes offered by Kreditanstalt für Wiederaufbau (KfW), the government-owned development bank, can be combined for establishment of a Plus Energy Building, currently, there is no programme specifically supporting their construction. Furthermore, the majority of the realised projects are implemented as individual buildings. The largest potential of Plus Energy Buildings can be achieved when established in settlements or through a number of housing units constructed at once in an apartment complex. By that, initial construction cost are lowered and units can support each other with surplus energy fed back into a decentralised grid. As example projects, such as Wildpoldsried or Active-House in Frankfurt show, implementation of the approach is possible both in rural and in dense urban environments.

Regarding the reduction of GHG emissions, also with Plus Energy Buildings, primary energy consumption remains the guiding principle and embodied energy is not considered in the current assessment methods. While some voluntary sustainability certification schemes include a life cycle approach, a paradigm change also for mandatory standards regarding GHG emissions would be required. By that, emissions including production of building materials, their potential for recycling, as well as transportation and logistics involved in a construction process would be considered and strengthen the commitment towards a carbon-free building sector until 2050.

1. SETTING THE SCENE

Germany's building sector accounts for about a third of the country's total greenhouse-gas (GHG) emissions and 40 % of total energy consumption.1 Minimising emissions in the building sector therefore forms an important pillar of the German Federal Government's climate strategy, aiming to achieve carbon-neutrality by 2050. The continuous improvement of building standards is considered as a key element in reduction of GHG emissions. Here, Plus Energy Buildings lead the path towards future buildings as prosumers (producers and consumers of energy)2, and push the boundary of current construction standards. While Plus Energy Buildings might not become the norm in construction practice, nonetheless, they might trigger marketability of several technological solutions.

1.1 PATH TOWARDS PLUS ENERGY BUILDINGS AND DISTRICTS IN GERMANY

Over the past decade, a number of new standards for low-energy buildings have been developed, implemented and progressively improved. A well-known example is the so-called *Passive House*. A Passive House is a building with a maximum primary energy demand of 120 kWh/m² per year, including all household appliances. Thermal performance of the building envelope is maximised and thermal balance optimised, while ventilation heat losses are reduced through high airtightness and integrated heat recovery systems.

Another variant of a low-energy building is the *nearly Zero Energy Building (nZEB).* Primary energy demand of a nZEB is, as the label already indicates, nearly zero or zero, with renewable energy sources covering the remaining demand. By 2019 for public and by 2021 for private buildings, the European Union's (EU) member states are required to implement the nZEB standard. With the improvement of energy performance of buildings, the EU aims to minimise carbon-emissions of its member countries towards the achievement of the EU's climate goals. In Germany, the provisions of EPBD 2010 will result in the combination of existing regulations on building energy performance to one single ordinance, called the Building Energy Law (GEG).

The *Plus Energy Building* is the next ambitious step in the evolvement of highly energy efficient construction practice. Buildings constructed to the standard, can be considered as intelligent, decentralised energy power plants. They produce more energy than they require per year, feeding excess energy back to the grid, or utilising it for other sectors, e.g. e-mobility. In 2011, first definitions and main attributes of the standard were published by the then *Federal Ministry of Transport, Building and Urban Development*. Since then, they have been gradually refined. **In general, the following applies to all Plus Energy Buildings: both the annual primary energy demand as well as the end-of-year energy demand must be less than 0 kWh/m² per year.**3

Fullest potential of Plus Energy Buildings is reached through the formation of smart, decentralised grid networks within neighbourhoods and districts. Here, individual buildings and building blocks generate energy and support each other during peak demands or supply bottlenecks. While the current focus of research on Plus Energy Buildings is on new builds, also existing structures have already been successfully refurbished (e.g. multi-family houses of 1930s in Neu-Ulm).4

An important characteristic in the assessment of a Plus Energy Building is that it differs from the calculation method as required by the *Energy Saving Ordinance (EnEV),* the current regulation on energy performance of buildings in Germany, last amended in 2014 / 2016. **While under EnEV the guiding audit parameter is primarily the building footprint, for a Plus Energy Building, the complete building plot is considered.** By that, energy generated from energy sources located not directly on the building but its site, e.g. geo thermal energy systems or wind turbines, are taken into account. For a building constructed under the Plus Energy standard, a variant of different technology from energy-efficient building envelopes and on-site generation of renewable energy can be combined. Furthermore, energy generated that is not used by the building itself, can be utilised for different purposes.

1.2 TECHNOLOGY FOR IMPLEMENTATION OF THE PLUS ENERGY STANDARD

In the planning process of a Plus Energy Building, climatic conditions as well as the local specifications of the building site are taken into consideration**. In the early phases of the design process, large amounts of heating and cooling can be saved through design and construction measures.** Compact building design, roofs supporting the installation of PV- or solar thermal systems, and the optimisation of passive solar gains through façades and windows facing south, are considered. In addition, dedicated floor plan layouts can contribute to passive energy savings. For example, by minimising the surface area of walls between rooms with less and higher heat demand, transmission heat losses can be reduced significantly. Another important aspect in the design of a Plus Energy Building is that sufficient spaces for building services need to be taken into account. The building services are required to be located strategically, aiming for short pipe routings, minimising heat losses.5

1 BMU (2016): Climate Action Plan 2050. Source: https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf

2 BMWi (2016): Was ist ein „Prosumer"? In: Energiewende direkt. 22.03.2016. Source: https://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2016/06/Meldung/direkt-erklaert.html

3 BMU (2016): Wege zum Effizienzhaus Plus. Source: https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/bauen/energieeffizienzhaus-plus.pdf;jsessionid=3C76675F0394565393EEE2D70A389EE9.2_cid287?__blob=publicationFile&v=1

4 Siegele, Claudia (2018): Monitoring zweier Plus-Energie-Sanierungen in Neu-Ulm. Das große Versprechen. In: db-Metamorphose, db 06/2018. Source: https://www.db-bauzeitung.de/db-metamorphose/energetisch-sanieren-effizienzhaus/

5 BMU (2016): Wege zum Effizienzhaus Plus.

Plus Energy Buildings

Energy Efficient Building

- Design of a Compact Building
- Optimised Orientation
- Thermal Zoning
- Heat Insulation
- High Performance Windows
- Avoid Thermal Bridging
- Airtightness
- Screens to Depict Behaviour Visually
- Low System Temperature
- Short Pipe Runs
- Hydronic Balancing
- Efficient Operating Systems
- Demand-controlled Systems
- Efficient Appliances
- Efficient Lighting
- Heat Recovery
- User Awareness

Renewable Energy Sources

- Solar Gains through Windows
- Lightshelfs / Mirrors
- Solar Collectors
- Biogenic Fuels
- Geothermal or Ambient Heat
- Heat Recovery
- Photovoltaics
- Wind Turbines
- Low Voltage System

Figure 01: Pillars of a Plus Energy House (based on Fraunhofer Institute for Building Physics; BMWi, 2016, adapted by BuroHappold)

Similar to Passive Houses, Plus Energy Buildings maximise thermal performance of the building by a highly insulated building envelope. Reduction of transmission heat losses through the building envelope builds the foundation of the overall energy performance. Progressive improvement of German energy regulations and technology in the last decades already resulted in outstanding standards regarding insulation of outer walls. By avoiding thermal bridges and ensuring a compact, airtight building envelope, additional energy savings are achieved. While thermal performance of windows has been gradually improved, they remain a weak point amongst the structural components of the building envelope. Nonetheless, through well-planned orientation of the building, windows can also yield large amounts of solar gains and by that compensate their initial transmission heat losses.6

Another aspect for minimising energy demand in a Plus Energy Building is the integration of high-end technology. Energy efficient household appliances, establishment of low-temperature heating systems, short operation times for heating and ventilation further minimises a building's energy demand. Additional measures include heat recovery from ventilation and wastewater, and efficient room lighting.

By that, energy consumption of a Plus Energy Building is already reduced to a minimum. Remaining energy demand is eventually covered by a combination of active and passive systems. **Active measures** for renewable energy include primarily generation of renewable energy, such as:

- Solar thermal energy systems (water heating)
- Photovoltaic (PV)-systems, with modules consisting of photovoltaic cells generating electricity through release of electrons by impact of sunlight
- Wind power plants, converting kinetic energy of rotating wind turbines to electricity
- Geothermal energy and heat pumps systems

6 BMU (2016): Wege zum Effizienzhaus Plus.

- Cogeneration or combined heat and power plants (CHP), as decentralised systems for housing units or districts, producing electricity and heat at the same time while minimising energy losses through short transportation ways
- Building automation systems, managing, optimising and monitoring all processes of the technical appliances integrated in the Plus Energy Building

In contrast to active technologies, passive solutions do not require implementation of further technical or intelligent equipment, or additional use of energy. **Passive measures** for energy gains include:

- Heat recovery systems, using the potential of excess or waste heat of ventilation systems or wastewater disposal
- Night cooling, utilising cold night air to naturally cool down interior spaces and thermal storage masses
- Wind towers, originating from traditional cooling methods in hot regions, bringing cold outside air into the building through the stack effect
- Passive solar energy gains, through design measures of the façade

Excess energy generated on-site and thus not immediately needed by the building itself, either due to low-energy demand or peaks in supply (e.g. due to wind or sun conditions), can be fed back into the grid or stored through energy-storage technology. This increases energy independence of the building, restraining electricity, heating/cooling during supply bottlenecks or instabilities. **Energy-storage technologies** include:

- Thermal energy storage systems, e.g. through ice storage tanks providing heat via a heat pump system in winter and cooling energy during summer, or hot water storage tanks, storing and dispensing hot water heated by external sources
- Battery storage systems, storing electricity produced e.g. by PV-systems or wind-energy for periods with lack of sunlight or wind, either for short-term (hours up to days), or long-term (weeks up to months)7

7 WSGreen Technologies (2018): Plusenergiegebäude in China. Status Quo & Entwicklungsmöglichkeiten. Stuttgart.

2. REGULATORY FRAMEWORKS

The path towards broad dissemination of Plus Energy Building requires the creation of appropriate legislative framework conditions. Existing building codes, such as the EnEV or the *Renewable Energies Heat Act (EEWärmeG)* in Germany do not specifically consider the Plus Energy Standard, but provide a common ground for energy conscious design. Nonetheless, while Plus Energy Buildings exceed the current requirements due to their outstanding energy performance, they also need to provide evidence that they comply with the latest German building codes.

2.1 FROM WSVO TO EnEV: EMERGENCE OF GERMANY'S ENERGY STANDARDS FOR BUILDINGS

Germany's thermal regulations for buildings root in the Thermal Insulation Ordinance (WSVO) from 1977. The oil crisis of the 1970s resulted in efforts to increase independence from energy imports. Hence, the WSVO established a first regulatory framework to reduce the oil consumption of heating systems. In 1976, also the Energy Conservation Act (EnEG) was introduced and amended several times since then. Today, EnEG outlines the general requirements of energy efficiency in buildings, as a legal framework for the Federal Government to implement regulations on thermal performance of buildings.

The WSVO was updated twice, in 1984 and 1995, and eventually replaced by EnEV in 2002. The first EnEV was drawn up in order to meet the climate protection goals of the German Government towards the climate agreements of the Kyoto summit. EnEV was amended several times since then, resulting in today's EnEV 2014/16, also with the current regulation including the Federal Government's goal of a climate-neutral building stock by 2050.

The WSVO focused only on constructive measures of a building. In contrast, EnEV includes technical appliances and primary energy demand in the assessment of the energy performance of a building. The current regulation requires that primary energy demand of a new (residential) building is only 75 % compared to a reference building of similar typology, orientation and geometry, and is constructed according to specific regulations concerning the envelope and building services.1

The overall framework on building energy performance in Germany is based on the provisions of EPBD 2010. EnEV implements its guidelines and regulations, adapting limiting values of a building's annual primary energy demand and transmission heat losses. Assessment of primary energy demand is then further outlined in specific technical guidelines, such as DIN V 18599 (or DIN V4108-6, combined with DIN V4701-10 for residential buildings).

Implementation of the European Directive on the Energy Performance of Buildings (EPBD) in Germany

EU Directive
Overall energy performance of buildings

EnEG Energy Conservation Act
Specification of economic viability

Amendment to the EnEV
Material regulations regarding requirements, methods, energy performance certificates, inspections

- **Technical guidelines, standards** (for example simplified data aquisition, energy consumption values),
- **DIN V18599** "Energy efficiency of buildings",
- **DIN V 4108-6,**
- **DIN 4701-10 Supplement 2,**
- **DIN V 4108 ...**

Requirements of the German Act on the Promotion of Renewable Energies in the Heat Sector (EEWarmeG)

100 percent compliance with the Renewable Energies Heat Act based on:		Minimum requirement
Renewable energies	Solar radiation	15%
	Solid biomass	50%
	Liquid biomass	50%
	Gaseous biomass in GHP	30%
	Geothermal energy and ambient heat	50%
Acceptable alternatives	Waste heat recovery systems	50%
	CHP plants	50%
	Energy saving measures	≈15%
	Local or district heating with renewable energy in the above-mentioned percentages or acceptable alternatives	

Figure 02: EU and German legislation on EE in buildings (Fraunhofer Institute for Building Physics, BMU, 2016, adapted by BuroHappold)

1 Federal Government of Germany (2015): Energieeinsparverordnung. Source: http://www.gesetze-im-internet.de/enev_2007/index.html

In addition to EnEV, new construction in Germany is required to comply with EEWärmeG. Through this regulation, building owners need to source a certain amount of their heat from renewable energy, depending on the underlying technology (see Figure 02). As Plus Energy Buildings might have excess energy that feeds back into the grid, another regulation, the so-called *Renewable Energies Act Levy (EEG-Levy),* is highly relevant. The Federal Government implemented the EEG-Levy to incentivise installation of renewable energy systems. By that, owners of renewable energy systems receive a predefined monetary compensation, for excess electricity.2

With introduction of the nZEB standard as required by EPBD 2010, existing building energy codes are planned to be combined in GEG. However, currently it remains unclear, if until end of 2018, the Federal Government concludes on a consensus. However, at present, the law is still in draft stage. The first draft (GEG 1.0) of January 2017, which defined nZEB-Standard for public buildings as buildings meeting a minimum requirement of a KfW Efficiency House 55, was criticized in terms of cost-effectiveness and could not be adopted for implementation. The second draft (GEG 2.0 – status November 1, 2018) is predominantly based on the regulations and building standards defined in the existing EnEV 2016. Nevertheless, the definition of nZEB for Germany is still open for discussion and should be officially passed and adopted until January 2019. 3

2.2 RAISING THE AMBITION – DEFINITIONS AND STANDARDS FOR PLUS ENERGY BUILDINGS

For the assessment of a Plus Energy Building, the Federal Government outlined guiding principles to be applied in addition to the standard calculations required by EnEV. **According to this definition, Plus Energy Standard is achieved, when annual primary energy demand and annual final energy demand are both negative ($\Sigma Q_p < 0$ kWh/m² and $\Sigma Q_e < 0$ kWh/m² per year). Moreover, the respective building is required to correspond to all other specifications of EnEV.**4

The most significant modification to standard calculations of EnEV is a change in the boundaries used for the assessment. **In the standard calculation procedure of EnEV, the built up area of the building itself is used as a boundary. For Plus Energy Buildings, the boundary of the complete building is utilised in performance calculations. By assessing the complete plot, energy from renewable energy sources generated on-site (e.g. heat pumps, wind turbines, etc.) is included in the assessment.** In case of multiple buildings being located on a single plot, the total share of energy generated through renewables is assigned to the respective buildings in proportion to their total useable area.

In addition, all appliances used need to fulfil the highest energy rating (A++ or higher, according to the Energy Consumption Labelling Ordinance of 1997). Furthermore, they are required to integrate smart metering systems. Eventually, besides annual primary energy demand and annual final energy demand, the share of energy generated by renewables on-site compared to the energy consumed by the building, must be shown in the total balance, based on monthly calculations as outlined in EnEV.5

2 Bundesnetzagentur (2018): EEG-Umlage. Was ist die EEG-Umlage und wie funktioniert sie? Source: https://www.bundesnetzagentur.de/SharedDocs/FAQs/DE/Sachgebiete/Energie/Verbraucher/Energielexikon/EEGUmlage.html
3 Karwatzi, Jan (2018): Zusammenfassung zum Entwurf des Gebäudeenergiegesetzes (GEG). Source: http://www.oekozentrum-nrw.de/fileadmin/Medienablage/PDF-Dokumente/181125_Zusammenfassung_GEG-Entwurf.pdf
4 BMUB (2016): Wege zum Effizienzhaus Plus.
5 BMUB (2016): Wege zum Effizienzhaus Plus.

3. FINANCIAL INCENTIVES AND SUBSIDIES

Construction of a Plus Energy Building might be more expensive due to higher technical specifications compared to a standard building that complies with the minimum requirements of EnEV. This accounts especially for individual private developments. Currently, there is no programme specifically supporting the construction of Plus Energy Buildings. At present, the Federal Government's programme on Plus Energy Buildings focuses on the construction and research of several model homes. Projects aiming to achieving the standard, however, can combine existing financial subsidy programmes for energy efficient construction, but will not receive further excellence funding. Currently, programmes are offered by the Federal Government and Kreditanstalt für Wiederaufbau (KfW), the government-owned development bank, dedicated finance initiatives by subnational governments, as well as private banks.

3.1 SUBSIDY PROGRAMME FOR RESEARCH AND DEVELOPMENT ON PLUS ENERGY MODEL HOMES

In 2011, the Federal Government introduced the Efficiency House Plus Programme to support research and development on Plus Energy Buildings and their underlying technology. With the programme, 37 individual residential projects aiming for the Plus Energy standard throughout Germany were financially assisted. The supported and monitored building types are ranging from detached single-family homes to multi-story apartment buildings. The programme aimed to develop and optimise several technologies separately from each other and implement them in a variant of designs and local characteristics.

The projects were accompanied by a research programme of Fraunhofer-Insitute for Building Physics. The research programme analysed the planning and construction process, as well as the monitoring of the subsequent operational phase. While the initial focus was on construction of new residential buildings of different sizes, the next phase of the programme targets educational facilities.1

3.2 KFW EFFICIENCY STANDARDS AND POTENTIALS FOR PLUS ENERGY BUILDINGS

KfW offers financial subsidies in form of loans or grants for new constructions as well as for existing buildings that fulfil a certain predefined standard. Buildings are divided into a number of different categories, so-called Efficiency House Standards that distinguish between refurbishment of existing buildings and new constructions.

KfW's Efficiency House categories are based on the yearly primary energy demand and transmission heat losses of a building. For example, the *KfW Efficiency House 40* describes a building that only consumes 40 % of the minimum energy limits predefined by EnEV. KfW's Efficiency House categories include *KfW 40, KfW 40 Plus, KfW 55* for new constructions, and *KfW 55, KfW 70, KfW 85, KfW 100* and *KfW 115* for refurbishments. When a project is eligible for a subsidy, according to the respective efficiency class, KfW then offers a low-interest loan, with a repayment allowance.

The *KfW 40* Plus category is currently KfW's most ambitious efficiency standard also offering the highest subsidy amount for private residential buildings. The Plus category has increased requirements, also including energy storage and building technology. Still, the definitions and standards outlined by BMU on the Plus Energy Building exceed KfW's requirements by far. Nonetheless, owners aiming for financial assistance can combine KfW subsidies.

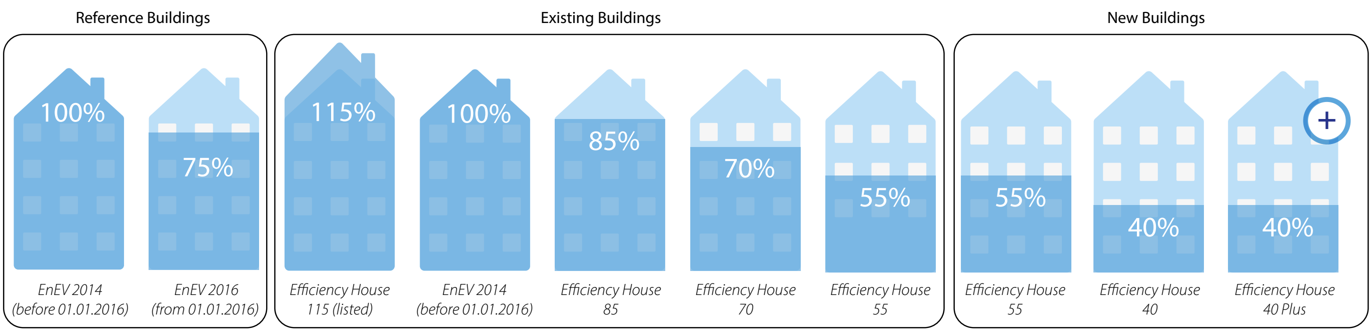


Figure 03: KfW Efficiency House Standards for existing and new Buildings

1 BMUB (2016): Wege zum Effizienzhaus Plus.

Besides the Efficiency House Programme, KfW also offers schemes specifically targeting the integration of renewable energy systems and storage technology. For example, KfW's *Renewable Energies Programme* issues loans for integration of renewable energy technology, e.g. heat pumps, CHP plants, and wind- or PV-systems.1 Another KfW programme supports integration of battery storage technology in combination with PV-systems.2 KfW's *BMU-Environmental Innovation Programme*, aims for environmental sustainability. Small and medium enterprises as well as municipalities can apply for a subsidy targeting measures on waste prevention, air pollution control, and utilisation of sustainable construction materials during the construction process. In addition, the programme financially supports reduction of wastewater production, sustainable mobility, and other measures for environmental protection. While the scheme does not specifically target Plus Energy Buildings, also here, specific measures in new construction or refurbishment of constructions aiming for the standard, can be subsidised.3

3.3 SUBSIDIES OF SUBNATIONAL GOVERNMENTS AND COMMERCIAL BANKS

Besides KfW and funding by the Federal Government, also dedicated subsidies from subnational governments or subnational development banks exist. For example, a programme in Berlin supports energy refurbishments of residential buildings, while a programme in the state of Hessen, subsidises energy efficiency in rental housing construction and renovations. In such subnational programmes, usually, besides the environmental aspect, regional focal points are also of high importance. In addition, the EU also provides dedicated programmes targeting energy performance of buildings. 4

Apart from public entities, several commercial banks (e.g. UmweltBank, GLS-Bank, EthikBank) offer low-interest loans targeted at sustainable construction. The so-called "green banks" base their business case on ethically and ecologically sustainable investments. Loans can be utilised for construction of new buildings, as well as for the refurbishment of existing ones, targeting high-energy efficiency standards. To be subsidised, the projects need to fulfil certain defined minimum requirements. For example, projects are required to comply with predefined minimum energy efficiency standards, to integrate renewable energy systems for heating and warm water, and/or to utilise sustainable construction materials with high ecological standards in the building's construction. Eventually, the interest rate is defined in correspondence with the ambitiousness of the construction project. Several subsidies issued by private banks can be combined also with other funding options of KfW, depending on the individual application requirements.

1 KfW (2018): Merkblatt Erneuerbare Energien – KfW-Programm Erneuerbare Energien „Standard" (270). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000000178-Merkblatt-270-274.pdf
2 KfW (2018): Merkblatt Erneuerbare Energien – KfW-Programm Erneuerbare Energien "Speicher" (275). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000002700_M_275_Speicher.pdf
3 KfW (2018): Merkblatt Innovativer Umweltschutz in Unternehmen – BMU-Umweltinnovationsprogramm (230). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000000279-Merkblatt-BMU-UIP-230.pdf
4 WSGreen Technologies (2018): Plusenergiegebäude in China. Status Quo & Entwicklungsmöglichkeiten.

4. BEST PRACTICE CASE STUDY

4.1 EFFICIENCY HOUSE PLUS, BERLIN

Figure 04: Efficiency House Plus, a single-family model home in Berlin Charlottenburg © Sebastian Rittau

The so-called Aktiv-Stadthaus (Active-Urban House), a plus-energy multi-storey building, located in Frankfurt am Main, designed by HHS Planer+Architekten, Kassel. The building's intention is to apply technology and current innovation of single-family plus-energy houses on large-scale apartment buildings, and to determine its feasibility. The eight-storey, 150 m long and 9 m wide building was constructed on an area, previously considered as unsuitable for residential developments, utilised as a parking space. The Aktiv-Stadthaus includes a total of 74 apartments, as well as two shops and a car sharing station for electric vehicles. The Aktiv-Stadthaus was planned as part of the ZukunftBau research initiative of BMU, and the Federal Office for Building and Regional Planning (BBR). Funding was provided by the ZukunftBau scheme, also utilised for accompanying research regarding energy consumption of the building.1

Backbone of the Aktiv-Stadthaus is an optimised building envelope, a highly efficient PV system on the roof as well as façades, and an energy storage device in the building's basement. In addition, a heat pump produces heat from waste water, utilised for heating of water and interior spaces. Heating and hot water, and all other energy related functions, are based on electricity. In case of failure of the electricity systems, a 140 kW gas condensing boiler was installed. A decentralised ventilation system, ventilating each dwelling separately, also forms part of the building's concept.

Essential for achieving the Plus-Energy Standard, is the use of solar energy. The roof area, as well as parts of the southeast façade, are covered with monocrystalline PV-modules. The 770 high-efficiency modules on the roof, generating 250 MWh, produce by far the largest part of the electricity output. The 350 façade modules, with an output of 55 MWh, provide a supplementary contribution to the electricity production. A lithium-iron-phosphate battery with a capacity of 250 kWh was installed in the basement for energy storage. The energy storage device is charged in case of surplus energy. If electricity continues to be generated when the battery is already full, the produced energy will be redirected to the Aktiv-Haus own charging station for electric vehicles. If excess electricity remains, it is fed back to the public electricity grid.2

Analysing, monitoring, and evaluating results concerning user behaviour is also an important part of the Aktiv-Stadthaus project. To this purpose, development partners, such as the Steinbeis-Transfer Centre for Energy, Buildings and Solar Technology as well as the Technical University of Darmstadt, are on board proving and evaluating the effectiveness of the concept. In addition, a touch panel integrated in each dwelling serves as an interface between residents and the incorporated technology. Occupants can utilise this panels to track their energy consumption and electricity output of the PV-system. Furthermore, to encourage occupants for energy saving behaviour, they are able to compete with the other residents in a ranking of individual energy consumption. 3

1 Schoof, Jakob (2015): Die Zukunft des Wohnens? Aktiv-Stadthaus in Frankfurt. In: Detail, München. Source: https://www.detail.de/artikel/die-zukunft-des-wohnens-aktiv-stadthaus-in-frankfurt-13636/

2 Baunetz Wissen (2018) Aktiv-Stadthaus in Frankfurt am Main. Deutschlands erster Geschosswohnungsbau mit Effizienzhaus Plus-Standard. Source: https://www.baunetzwissen.de/elektro/objekte/wohnen/aktiv-stadthaus-in-frankfurt-am-main-4702961

3 Schoof, Jakob (2015): Die Zukunft des Wohnens? Aktiv-Stadthaus in Frankfurt.

CASE STUDY

4.2 AKTIV-STADTHAUS, FRANKFURT

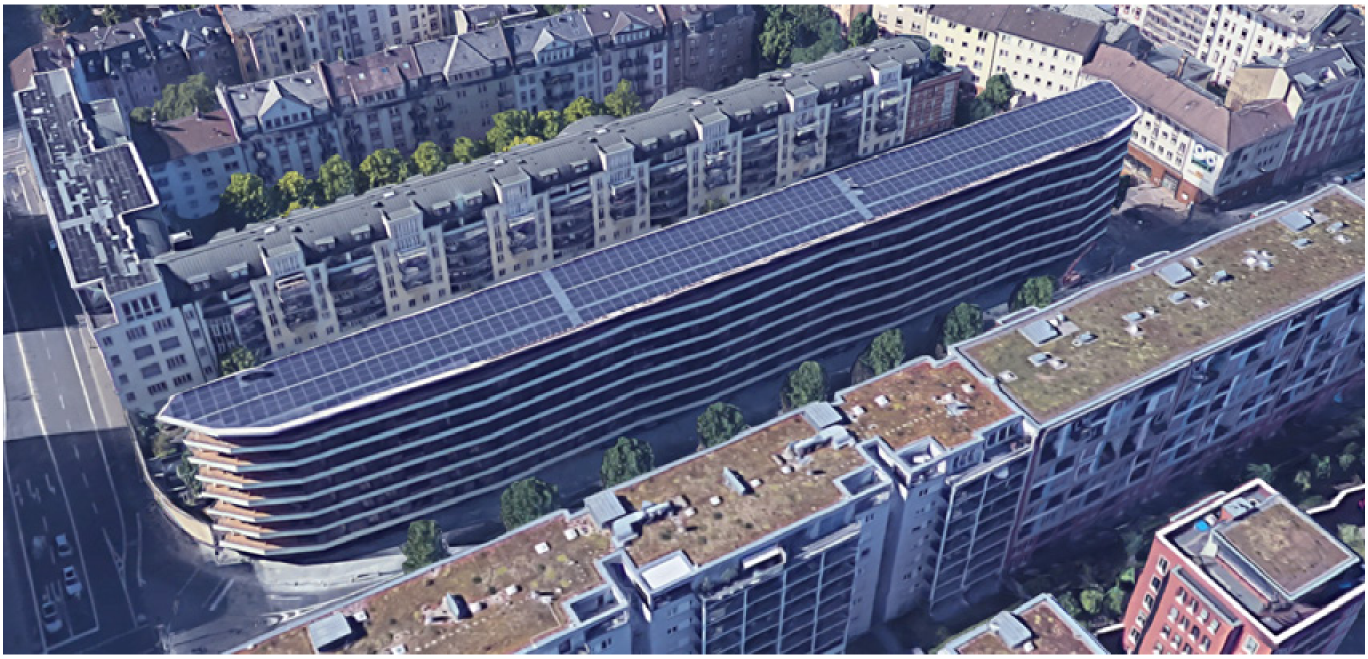


Figure 05: Active-House, Residential development in Frankfurt ©2019 Google, Map data ©2019 GeoBasis-DE/BKG (©2009), Google

The so-called *Aktiv-Stadthaus (Active-Urban House)*, a plus-energy multi-storey building, located in Frankfurt am Main, designed by HHS Planer+Architekten, Kassel. The building's intention is to apply technology and current innovation of single-family plus-energy houses on large-scale apartment buildings, and to determine its feasibility. The eight-storey, 150 m long and 9 m wide building was constructed on an area, previously considered as unsuitable for residential developments, utilised as a parking space. The Aktiv-Stadthaus includes a total of 74 apartments, as well as two shops and a car sharing station for electric vehicles. The Aktiv-Stadthaus was planned as part of the *ZukunftBau* research initiative of BMU, and the Federal Office for Building and Regional Planning (BBR). Funding was provided by the ZukunftBau scheme, also utilised for accompanying research regarding energy consumption of the building.[1]

Backbone of the Aktiv-Stadthaus is an optimised building envelope, a highly efficient PV system on the roof as well as façades, and an energy storage device in the building's basement. In addition, a heat pump produces heat from waste water, utilised for heating of water and interior spaces. Heating and hot water, and all other energy related functions, are based on electricity. In case of failure of the electricity systems, a 140 kW gas condensing boiler was installed. A decentralised ventilation system, ventilating each dwelling separately, also forms part of the building's concept.

Essential for achieving the Plus-Energy Standard, is the use of solar energy. The roof area, as well as parts of the southeast façade, are covered with monocrystalline PV-modules. The 770 high-efficiency modules on the roof, generating 250 MWh, produce by far the largest part of the electricity output. The 350 façade modules, with an output of 55 MWh, provide a supplementary contribution to the electricity production. A lithium-iron-phosphate battery with a capacity of 250 kWh was installed in the basement for energy storage. The energy storage device is charged in case of surplus energy. If electricity continues to be generated when the battery is already full, the produced energy will be redirected to the Aktiv-Haus own charging station for electric vehicles. If excess electricity remains, it is fed back to the public electricity grid.[2]

Analysing, monitoring, and evaluating results concerning user behaviour is also an important part of the Aktiv-Stadthaus project. To this purpose, development partners, such as the Steinbeis-Transfer Centre for Energy, Buildings and Solar Technology as well as the Technical University of Darmstadt, are on board proving and evaluating the effectiveness of the concept. In addition, a touch panel integrated in each dwelling serves as an interface between residents and the incorporated technology. Occupants can utilise this panels to track their energy consumption and electricity output of the PV-system. Furthermore, to encourage occupants for energy saving behaviour, they are able to compete with the other residents in a ranking of individual energy consumption. [3]

1 Schoof, Jakob (2015): Die Zukunft des Wohnens? Aktiv-Stadthaus in Frankfurt. In: Detail, München. Source: https://www.detail.de/artikel/die-zukunft-des-wohnens-aktiv-stadthaus-in-frankfurt-13636/

2 Baunetz Wissen (2018) Aktiv-Stadthaus in Frankfurt am Main. Deutschlands erster Geschosswohnungsbau mit Effizienzhaus Plus-Standard. Source: https://www.baunetzwissen.de/elektro/objekte/wohnen/aktiv-stadthaus-in-frankfurt-am-main-4702961

3 Schoof, Jakob (2015): Die Zukunft des Wohnens? Aktiv-Stadthaus in Frankfurt.

CASE STUDY

4.3 TOWN OF WILDPOLDSRIED, BAVARIA

Figure 06: Wildpoldsried in Bavaria, a plus energy town, producing 500 % more energy than it requires © Richard Mayer

The town of Wildpoldsried in the state of Bavaria is the first settlement in Germany that went completely off-grid and produces 500 % more energy than it requires for operation. Moreover, GHG emissions per capita are half of the German overall average. This is made possible through a stable and diverse micro grid, consisting of a broad range of renewable energy sources.

The renewable energy sources of Wildpoldsried include 11 wind turbines, a biomass plant sourced by local farmer's bio-waste, 3 small hydropower systems, and more than 2,100 $m^2$of solar thermal systems.1 This allows the town and its 2,600 residents to be completely independent from the power grid. The community profits from sale of surplus energy, as fed back into the grid, and spearheads the path towards renewable energy transformation of settlements in Germany.

The commitment towards sustainable energy in Wildpoldsried started with the introduction of renewable energy to its residents back in 1999 when the town council developed a sustainability concept titled Wildpoldsried Innovative Leadership Plan 2020 (WIR-2020). The WIR-2020 concept analysed how the town can enhance sustainable growth by investing in new public facilities without incurring debt. The sustainability concept of Wildpoldsried rests on three main pillars:

- Generation of renewable energy and commitment towards energy efficiency
- Green buildings, and utilisation of ecologically sustainable construction materials with a focus on wooden structures in new buildings
- Water resource protection and ecological wastewater treatment. 2

The first step of Wildpoldsried's path towards energy independence was the realisation of a wind energy project, supported by several committed residents. 25 % of the total investment volume of around 2.2 million Euro was shared amongst the town's citizens, 100,000 Euro were financed through the Government of Bavaria, while the largest amount was acquired through loans in conjunction with guaranteed remuneration tariffs. Shortly after the first project, the programme gained momentum and led to the establishment of a second wind park in 2002, and large acceptance amongst residents.

The goals set out in the WIR-2020 vision were already achieved in 2013. Today, the town of Wildpoldsried can be considered a blueprint or a flagship project for energy independent settlements. Solutions carried out in Wildpoldsried can be scaled up towards other towns or districts with higher population numbers. While the WIR-2020 concept for Wildpoldsried was widely successful, nonetheless, the town's vision remains under constant redevelopment. For example, e-mobility is gaining momentum in Wildpoldsried, with the fleet of local administrative

1 Gemeinde Wildpoldsried (2018): Erneuerbare Energie - Wildpoldsried Innovativ Richtungsweisend. Source: https://www.wildpoldsried.de/index.shtml?Energie

2 Gemeinde Wildpoldsried (2018): 2. Klimaschutzleitbild der Gemeinde Wildpoldsried. Source: https://www.wildpoldsried.de/se_data/_filebank/alte_pdfbank/leitbild2018.pdf

services being 100 % electric. Wildpoldsried's vision also foresees that "each building is a power plant", boosting the share of PV-systems on individual buildings. New wind power plants are integrated in an inter-municipal cooperation project, sharing initial investments. 3

Apart from technical solutions focusing on energy efficiency and renewable energy, the overall development concept of Wildpoldsried includes also sustainable town planning measures. For example, the town aims for short, walkable distances, and integration of shared spaces to reduce traffic speed throughout all new developments. Furthermore, Wildpoldsried aims to introduce a vacancy management plan, to incentivise for locals the renting-out of their vacant flats, before reclassification of land for residential purposes.4

Besides an implementation of concrete projects, the town of Wildpoldsried also supports local research and development on renewable energy and storage technology. For example, from 2011 to 2013, the town collaborated with universities and Siemens in a programme focusing on the implementation of smart grid technology, including monitoring systems and energy storage facilities. In a subsequent programme from 2014 to 2018, grid stability of decentralised grids and their operational management was examined.5

Findings of the research projects are implemented and closely monitored. To disseminate findings of local success stories, the town publishes case studies, and offers visits to national and international guests. For local residents, the town offers courses on energy efficient behaviour, energy consulting, rental and repair services for e-mobility, and aims for full transparency when new (energy) projects are planned and implemented.

3 Gemeinde Wildpoldsried (2018): 2. Klimaschutzleitbild der Gemeinde Wildpoldsried. Source: https://www.wildpoldsried.de/se_data/_filebank/alte_pdfbank/leitbild2018.pdf
4 Gemeinde Wildpoldsried (2018): 2. Klimaschutzleitbild der Gemeinde Wildpoldsried.
5 IREN2 Konsortium (2018): IREN2 – Für das Stromnetz der Zukunft. Source: http://www.iren2.de/

5. EMERGING TRENDS

5.1 INTEGRATION OF SMART MICRO GRIDS IN PLUS ENERGY DISTRICTS

The Plus Energy Building concept includes new perspectives in terms of energy supply for urban neighbourhood development. Particularly when implemented on a large scale in new settlements or existing districts, possibilities for to combine different sectors are enhanced. In addition, through implementation on a larger scale, initial construction cost can be lowered, through economies of scale. Above all, especially surplus energy generated by Plus Energy Buildings holds a lot of potential for neighbourhoods and districts. When implemented on a large scale, an entire area can be supplied with decentralised forms of energy, with individual buildings supporting each other with excess energy.

Energy supply in Plus Energy Districts can be organised in decentralised, intelligent micro grids. Micro grids in small towns or neighbourhoods, such as in the above-mentioned town of Wildpoldsried, face fluctuating supply and demand of electricity. This is caused by electricity produced often by a large number of different renewable energy sources and can affect network stability. This requires an intelligent network management balancing supply and demand under consideration of weather conditions affecting energy production and demand, additional decentralised battery storage facilities, and intelligent metering systems. 1

Feeding back energy into the energy grid also entails financial benefits for building owners or occupants, through feed-in remunerations, regulated in Germany through the EEG-Levy. Towns, neighbourhoods and individual building owners by that can profit economically, especially in combination with enhanced energy efficiency measures reducing their own energy use. Eventually, the lesser energy a building or district requires, the more excess energy can be resold, and the sooner initial construction cost of the building, district or an infrastructure project amortises.

5.2 TOWARDS A CARBON-NEUTRAL BUILDING SECTOR – EMBODIED ENERGY AND CO^{2}-ASSESSMENTS

Active and passive technical measures increase energy efficiency and reduce carbon emissions of a Plus Energy Building during its operational phase. Nonetheless, no current official framework of highly energy efficient constructions considers embodied energy and the full life cycle in their calculation methods. Especially for technologically advanced constructions, production, transportation and recycling of materials can reduce large proportions of the total energy performance, compared to the energy used for operation.

The amount of embodied energy of a new building can be reduced by extensive integration of sustainable construction materials recycled at the end of the life cycle. In Germany, the full life cycle of most new buildings is set for around 50 years. Such materials require low amounts of primary energy demand in their production. Short distances in transportation can further lower the amount of embodied energy.

The certification system of the German Sustainable Building Council (DGNB) considers embodied energy, through consideration of primary energy demand of construction materials.[2] For future energy performance calculations required by legal standards, DGNB proposed to use CO_2 emissions as target value in the assessment process instead of primary energy demand. For the GEG, which is currently in development, DGNB proposed that rather than comparing the respective building with a reference model, assessment should be carried out with absolute limits on CO_2-emissions of a building. The proposal also includes the integration of a CO_2 tax, if target values are not met by a project developer.[3] The current GEG draft law incorporates the mandatory declaration of CO_2 emissions in the Energy Performance Certificate (Energieausweis). Furthermore, while the main requirement and reference for energy efficiency of new buildings in the GEG draft law remains the annual primary energy demand, the utilisation of CO_2 emissions as target value, as well as the implementation of absolute limits on CO_2 emissions are in discussion and should be officially adopted for new buildings by 2023. Moreover, the current draft law includes an innovation clause, which acknowledges energy performance assessments using absolute limits on CO_2 emissions instead of the primary energy demand as key performance indicator. [4]

1 Metzger, M.; SIEMENS AG (2013): Herausforderungen und Lösungskonzepte für Verteilernetze am Beispiel des Projektes IRENE. Source: http://www.projekt-irene.de/downloads/konferenz-energie-innovativ_18apr2013_metzger.pdf

2 DGNB (2018): Framework for "carbon-neutral buildings and sites". Source: https://static.dgnb.de/fileadmin/en/dgnb_ev/reports/Framework-carbon-neutral-buildings.pdf

3 DGNB (2018): Proposal: The contents of a future German Building Energy Law in just three pages. Source: https://static.dgnb.de/fileadmin/en/dgnb_ev/Position_Papers_and_Statements/DGNB-discussion-proposal-GEG-2050.pdf?m=1529591090&

4 Karwatzi, Jan (2018): Zusammenfassung zum Entwurf des Gebäudeenergiegesetzes (GEG).

6. DISCUSSION

Since the second half of the 20th century, regulatory frameworks for energy performance of buildings in Germany have come a long way. Since the first WSVO was adopted in the late 1970s, legislation has been progressively updated. Recent developments have been strongly influenced by the EU's climate goals and resulting directives on energy performance, which will result in comprehensive implementation of the nZEB standard by 2019 / 2021.

Apart from building energy codes setting mandatory minimum standards, German research has developed several models further raising the ambition, accompanied by technological innovation and research. The Plus Energy Building is currently one of most progressive forms. It reduces energy demand to a minimum through a highly insulated envelope, and integrates energy-efficient appliances and building services. In addition, it covers remaining demand through renewable energy, generated on-site.

While a number of model projects have been established, Plus Energy Buildings remain on an experimental stage, with the standard not being implemented extensively yet. Full integration of the standard remains rather cost-intensive, in particular for independent, private constructions. Despite the possibility of combining existing subsidy schemes, there is no dedicated public programme supporting the standard as defined by the Federal Government. Broad dissemination and marketability of technologies would require further financial incentives or dedicated support programmes. Tax concessions for private developers could increase attractiveness. Reducing complexity and providing a one-stop-solution for Plus Energy subsidy programmes, would further lower barriers.

Most projects supported by the Federal Governments' own model programme on Plus Energy Buildings targeted single-family homes, such as the Efficiency House Plus in Berlin Charlottenburg. For research on individual forms of technology, a single-family unit allows for fine-tuning during research and monitoring processes. Although this particular typology remains widely popular throughout Germany, it does not appear to be the future of sustainable urban housing. Residential developments including multiple dwellings are superior to detached houses of the same standard, regarding their energy performance and overall ecological footprint. Hence, a scheme aiming for the Plus Energy Standard with several units would provide even higher benefits, allowing upscaling, through lower initial construction cost per dwelling, as well as during their operational phase.

Establishment of Plus Energy Districts through combination of several units within a neighbourhood takes full advantage of the principle of buildings as small, individual power plants. As already shown on a small scale in the town of Wildpoldsried, through commitment in planning and participation of a variety of local stakeholders, evolvement of a rural town towards a lighthouse project for energy production is possible. Besides lowering the town's GHG emissions and energy demand, it also benefits economically, through selling excess energy. The same model applied in a dense, urban environment would multiply its impact. Besides scaling up energy performance of whole neighbourhoods and districts, the ecological footprint is lowered drastically through compact city planning, integrating new forms of energy supply, e-mobility, commercial and industrial uses, with each other.

With highly ambitious concepts, such as the Plus Energy Building, gaining momentum, energy performance during operation remains the guiding principle of current and of planned legislation. So far, only voluntary certification schemes include a life cycle approach. For mandatory standards, a paradigm change would be required. Such an approach would not only include emissions from production and logistics of construction materials, but also include potential for recycling, after the operational phase of the respective building ends. This would increase commitment towards a carbon-neutral building sector, as targeted for Germany's building sector until 2050.

7. REFERENCES

Baunetz Wissen (2018) Aktiv-Stadthaus in Frankfurt am Main. Deutschlands erster Geschosswohnungsbau mit Effizienzhaus Plus-Standard. Source: https://www.baunetzwissen.de/elektro/objekte/wohnen/aktiv-stadthaus-in-frankfurt-am-main-4702961

BMU (2016): Climate Action Plan 2050. Source: https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf

BMWi (2016): Was ist ein „Prosumer"? In: Energiewende direkt. 22.03.2016. Source: https://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2016/06/Meldung/direkt-erklaert.html

BMU (2016): Wege zum Effizienzhaus Plus. Source: https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/bauen/energieeffizienzhaus-plus.pdf;jsessionid=3C76675F0394565393EEE2D70A389EE9.2_cid287?__blob=publicationFile&v=1

DGNB (2018): Framework for "carbon-neutral buildings and sites". Source: https://static.dgnb.de/fileadmin/en/dgnb_ev/reports/Framework-carbon-neutral-buildings.pdf

DGNB (2018): Proposal: The contents of a future German Building Energy Law in just three pages. Source: https://static.dgnb.de/fileadmin/en/dgnb_ev/Position_Papers_and_Statements/DGNB-discussion-proposal-GEG-2050.pdf?m=1529591090&

Gemeinde Wildpoldsried (2018): Erneuerbare Energie - Wildpoldsried Innovativ Richtungsweisend. Source: https://www.wildpoldsried.de/index.shtml?Energie

Gemeinde Wildpoldsried (2018): 2. Klimaschutzleitbild der Gemeinde Wildpoldsried. Source: https://www.wildpoldsried.de/se_data/_filebank/alte_pdfbank/leitbild2018.pdf

Bundesnetzagentur (2018): EEG-Umlage. Was ist die EEG-Umlage und wie funktioniert sie? Source: https://www.bundesnetzagentur.de/SharedDocs/FAQs/DE/Sachgebiete/Energie/Verbraucher/Energielexikon/EEGUmlage.html

Karwatzi, Jan (2018): Zusammenfassung zum Entwurf des Gebäudeenergiegesetzes (GEG). Source: http://www.oekozentrum-nrw.de/fileadmin/Medienablage/PDF-Dokumente/181125_Zusammenfassung_GEG-Entwurf.pdf KfW (2018): Merkblatt Erneuerbare Energien – KfW-Programm Erneuerbare Energien „Standard" (270). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000000178-Merkblatt-270-274.pdf

KfW (2018): Merkblatt Erneuerbare Energien – KfW-Programm Erneuerbare Energien „Standard" (270). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000000178-Merkblatt-270-274.pdf

KfW (2018): Merkblatt Erneuerbare Energien – KfW-Programm Erneuerbare Energien "Speicher" (275). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000002700_M_275_Speicher.pdf

KfW (2018): Merkblatt Innovativer Umweltschutz in Unternehmen – BMU-Umweltinnovationsprogramm (230). Source: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000000279-Merkblatt-BMU-UIP-230.pdf IREN2 Konsortium (2018): IREN2 – Für das Stromnetz der Zukunft. Source: http://www.iren2.de/

Schoof, Jakob (2015): Die Zukunft des Wohnens? Aktiv-Stadthaus in Frankfurt. In: Detail, München. Source: https://www.detail.de/artikel/die-zukunft-des-wohnens-aktiv-stadthaus-in-frankfurt-13636/

Siegele, Claudia (2018): Monitoring zweier Plus-Energie-Sanierungen in Neu-Ulm. Das große Versprechen. In: db-Metamorphose, db 06/2018. Source: https://www.db-bauzeitung.de/db-metamorphose/energetisch-sanieren-effizienzhaus/

Metzger, Michael und SIEMENS AG (2013): Herausforderungen und Lösungskonzepte für Verteilernetze am Beispiel des Projektes IRENE. Source: http://www.projekt-irene.de/downloads/konferenz-energie-innovativ_18apr2013_metzger.pdf

WSGreen Technologies (2018): Plusenergiegebäude in China. Status Quo & Entwicklungsmöglichkeiten. Stuttgart.

DISCLAIMER

Title:

Keystone Papers for the key topics of the Sino-German Urbanisation Partnership

Imprint

The keystone papers are published as part of the "German-Chinese Urbanisation Partnership". As part of the International Climate Initiative (IKI), the project is commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in cooperation with the Ministry of Housing and Urban-Rural Development of the People's Republic of China.
As a federal company, GIZ supports the German Federal Government in achieving its goals in international cooperation for sustainable development.

Editor:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Sitz der Gesellschaft
Bonn und Eschborn
Sunflower Tower
Maizidian Str. 37, Chaoyang District
100125 China, Beijing
T +86 10 85275180, F +86 10 85275185
E giz-china@giz.de
I www.giz.de/china , www.sustainable-urbanisation.org/en

Editorship:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Peter Sailer, Xueling Liu, Jia Fu, Yunqing Bi

Main authors:

Happold Ingenieurbüro GmbH
Pfalzburger Straße 43-44
10717 Berlin, Germany
Thomas Kraubitz, Peter Scheibstock, Gabriela Guillen,
Joachim von Bergmann

Coordination and Responsibility:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Peter Sailer

Layout, graphics:

Happold Ingenieurbüro GmbH
Pfalzburger Straße 43-44
10717 Berlin, Germany

PLUS ENERGY BUILDINGS & DISTRICTS

Sino-German Urbanisation Partnership

Keystone Paper for the key topics of the Sino-German Urbanisation Partnership

Editor:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Main Authors & Layout:

BUROHAPPOLD ENGINEERING

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany