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CHRISTOPH AHLHAUS

The IBA Future Concept Renewable Wilhelmsburg

When, if not now? Where, if not here? Who, if not us? Cities as we experience them today, from their built-up environments, their economies, and their traffic through to their social structure, are the result of industrialisation and are therefore dependent on the combustion of coal, oil, and gas. Agriculture, too, is largely directed at supplying cities with foodstuffs. The overall flow of goods within and for the world's conurbations is based on fossil fuel energy production. Hence the fact that around 80 per cent of all oil, gas, and coal reserves worldwide are used to supply cities, despite cities covering less than 1 per cent of the world's surface. More than two-thirds of all people in the industrialised countries today live in cities. This trend is on the increase: according to the United Nations, forecast growth in the world population will occur primarily in the cities.

In view of the growing threats presented by climate change, cities are both victims and culprits. Culprits, because they are responsible for the largest proportion of worldwide CO_2 emissions. Victims, because the majority of all cities are situated close to the coast, where they are therefore to some extent fully exposed to rising sea levels. Then there is also the considerable economic damage due to climate change. Researchers warn that Germany alone will face costs to its national economy of around 800 billion euros over the next fifty years due to climate change.

Man's ability to halt the rapid rise in global temperature therefore depends primarily on how the cities organise the future. The seismographs for successful cities are their future sustainability and the quality of life of the people living in them. Energy supplies play a key role in this because not only electricity and heating production, but also our mobility, are almost entirely dependent on the climate-damaging combustion of fossil fuel resources.

The question of how cities need to be reacting to these challenges is now being posed all over the world. How can they be converted to a sustainable energy system within a short period of time? How can the energy exploited be used more efficiently? How much mobility will be necessary in the future, or, be possibly improved? Asking ourselves these questions is no easy task, of course, for, ultimately, this is also about how we are to live and work in the future. New technologies, new land use planning concepts, and new energy supply concepts are required, but without forgetting the question of people. Climate protection, economic development, fair educational opportunities, integration, and culture also need to be considered in the quest for sustainable urban development solutions.

I am therefore especially pleased that the Internationale Bauausstellung (International Building Exhibition; IBA) has adopted precisely this focus. And it has stood up to the test. The many innovative ideas and concepts already developed are now the subject of discussion way beyond Hamburg itself. The first concrete projects such as the "IBA DOCK" have been realised and are making a significant impact. The "Klimaschutzkonzept Erneuerbares Wilhelmsburg" ("Climate Protection Concept Renewable Wilhelmsburg") presents an overall model of how a city district can become independent in terms of energy, step-by-step, as well as becoming a great deal more attractive for its residents and from an economic perspective. Based on a comprehensive scientific study, different scenarios establish and compare future energy demand, identifying savings and renewable energy potential, and ultimately devising very concrete measures.

> Climate protection, economic development, fair educational opportunities, integration, and culture also need to be considered in the quest for sustainable urban development solutions.

> The IBA's many future-oriented ideas and projects are already of tremendous benefit for the whole of Hamburg. Furthermore, they provide a strong impetus for international discussion on sustainable urban development.

A series of four steps—beginning with the realisation of the IBA projects up until 2013 and the perspectives for 2020/2030/2050—shows how a city district is able to gradually reduce its energy supply CO_2 emissions to zero. The first step is the climate neutrality of all of the IBA's own construction projects. The new buildings' unavoidable CO_2 emissions are off-set by savings in existing buildings and by the development of renewable energy projects on the Elbe Islands. Not only does the IBA's climate protection concept initiate innovative steps in Wilhelmsburg, the IBA's many future-oriented ideas and projects are already of tremendous benefit for the whole of Hamburg. Furthermore, they provide a strong impetus for international discussion on sustainable urban development.

With the IBA, Hamburg has a special opportunity to be able to develop concepts for a sustainable city and thus to exert a positive influence on the development of cities throughout the world. With the IBA ENERGY ATLAS, Hamburg is taking a leading position on the issue of how societies in cities will live in the future.

ULI HELLWEG

The Necessity of a Climate Protection Concept for a Renewable Wilhelmsburg

Optimised building services engineering and the ambitious renovation of existing buildings reduce energy consumption, while co-generation units and regional and local energy association systems improve energy efficiency. The proportion of renewable energy is gradually being raised to 100 per cent.

This ENERGY ATLAS of the Elbe Islands is a very special step for the IBA Hamburg. On the one hand, it provides us with a reflection of our own work over the last three years with regard to the key theme of "Stadt im Klimawandel" ("Cities and Climate Change") and, on the other, it is the IBA Hamburg's attempt to bring a new direction to the Internationale Bauausstellungen (International Building Exhibitions)—moving away from an *incrementalist perspective* towards *concept-based projects*—meaning that the projects become sustainable only when incorporated into coherent overall concepts.
Since 2007, the IBA Hamburg has been developing and improving projects following its main themes—some of these projects based on approaches from specialists; some of them taken from the *Weissbuch* (White Book) of the Zukunftskonferenz Wilhelmsburg (Future of Wilhelmsburg Conference),[1] drawn up in the course of a broadly participative process on the Elbe Island in 2001/02; and of course the projects initiated by the IBA. The same has also applied to the key theme "Stadt im Klimawandel" ("Cities and Climate Change"): the Wilhelmsburg bunker project stemmed from the idea of setting up a large solar thermal plant inside a World War II bunker, and thereby transformed into the Energy Bunker by the IBA, and developed into the sound and viable project that it is today. Plans to build a photovoltaic unit on the Georgswerder refuse dump, as well as to repower, to revitalise and upgrade the old wind energy units there were arose in existence before loud calls from within the neighbourhood for this "mountain" to be made suitable for public use—and hence the "Energieberg" ("Energy Hill") project came into being.
The energy specifications applying to all the IBA's construction projects are stricter than those prescribed by law—exceeding the *Energieeinsparverordnung* (German Energy Saving Regulations; EnEV) of 2009 by 30 per cent.
In fact, the majority of the projects in fact set themselves targets that are even more ambitious. For example, the "open house" housing construction project is being implemented under the name "Passivhaus Plus" ("Passive House Plus"), meaning that the overall electricity requirements are taken into consideration and largely generated locally from renewable sources. The construction of the new Urban Development and Environment Authority building in the centre of Wilhelmsburg is also intended to be a model project, certified according to the guidelines of the Deutsche Gesellschaft für Nachhaltiges Bauen (German Sustainable Building Council; DGNB), and achieving its Gold Standard.
In addition to the many ambitious energy projects, the IBA Hamburg increasingly worked towards not merely having these projects stand in isolation but utilising the special features of this urban island, and to attempt the preparation of an overall concept, a kind of *road map*, showing the way into the post-fossil fuel and nuclear-free age—the "Klimaschutzkonzept Erneuerbares Wilhelmsburg" ("Climate Protection Concept Renewable Wilhelmsburg").
IBA Hamburg intends to set new standards for resource conservation and climate-neutral construction with this concept: optimised build-

KLAUS TÖPFER

Climate Change and Climate Policy

The United Nations Framework Convention on Climate Change's 15th Conference of the Parties (COP 15) was held in Copenhagen one year before the publication of this book from 7–18 December 2009. At a critical juncture in the unravelling global climate conditions it was a particularly disappointing example of the inherent difficulties of this global negotiation process, and yet, before this meeting, the ideal preconditions for a new, successful, internationally co-ordinated climate policy seemed to be in place. For the first time, the global threat of climate change had been placed on the agenda by the heads of state themselves—more than 100 government leaders took part: from Obama to Wen Jiabao, Angela Merkel, Brazil's Lula, and the Indian premier Singh, through to Zenawi, Ethiopia's head of government, and the presidents of the small island states in the Pacific.
The preparations for Copenhagen were based on the *Bali Road Map*, the guideline for further negotiations agreed upon two years ago by the nations party to the UN Framework Convention on Climate Change. Exceptionally difficult negotiations were even able to achieve approval of this *Road Map* by the then Bush government. The run-up to Copenhagen also featured, for the first time, an increasing number of actively involved and prominent voices from within the private sector. *Green Tech*, namely environmentally and climate-friendly technologies, was already being defined as the driver behind a new, long "Kondratiev Wave"[1] holding the promise of green growth. A *Green New Deal* was presented as a paradigm shift in the common battle against economic and environmental crises. Leading company directors in Germany also, are seeing Blue-collar jobs[2] going and Green-collar jobs[3] coming. The race for the best technological solutions, the *Green Race*, seems to have begun. An unparalleled effort by non-governmental organisations saw the issue and importance of Copenhagen being anchored in civil society more strongly than ever. The climate experts were clearer and more urgent in their demands for political action. Expectations were high—without any clear and matter-of-fact consideration really having been given to what would make "Copenhagen" a success or what any alternative might look like. This significant weakness on the part of all the negotiating parties was evident even in the preliminaries to the conference. Neither was the indiscriminate elevation of Copenhagen to a kind of end game in planetary climate salvation particularly helpful. Against this background, the outcome of this conference so laden with expectation, the "Copenhagen Accord," has been largely labelled inadequate or, drastically, determined an absolute failure.
All of this dust is slowly beginning to settle. It is time to take an objective look at what the achievements of Copenhagen mean without the tactical rhetoric, and how the substance of these achievements can be rendered useable. We need to analyse the considerations forming the basis of the positions of the key negotiating parties, such as the United States of America and China, but more especially also of India, the developing countries in Africa, as well as the small island states. Retrospective finger pointing does little to create a good negotiating atmosphere to achieve tangible and urgently required successful outcomes.

Hamburg House at Expo 2010 in Shanghai
The first certified passive house in China

With the pilot project in Wilhelmsburg, the IBA Hamburg creates an example of what many Wilhelmsburg residents will be able to achieve in the future.

Co-operation on climate policy on a worldwide scale cannot be postponed further. Climate change is a reality. The thirteen-year gap between the conclusion of the UN Framework Convention on Climate Change and the implementation of the Kyoto measures is alarming. Meanwhile, rising greenhouse gas emissions leave no room for a repetition of this failure. This gap of global silence is sheer lost time. It could carry a high price if the forecasts of the climate experts prove to be true. It is therefore crucial that immediate action be taken—action with concrete results in terms of a reduction of CO_2 and all other emissions, caused directly or indirectly by human beings, which influence our climate.
At least 80 per cent of the world's resources are used in cities. This percentage and the associated emissions will increase with ongoing urbanisation. Cities thus bear tremendous responsibility for avoidance of and adjustment to climate change. This obligation can be met only with clear strategies and innovative solutions. The "Zukunftskonzept Erneuerbares Wilhelmsburg" ("Future Concept Renewable Wilhelmsburg") is very easily integrated into such an approach. It is not about waiting for internationally binding targets to be set from above but about initiating change from below. It demonstrates how climate neutrality can be brought about through civil involvement and creative solutions. With the pilot project in Wilhelmsburg, the IBA Hamburg creates an example of what many Wilhelmsburg residents will be able to achieve in the future.

Three starting points for concrete action deserve special mention:

City Involvement

It has been reported often enough that, with the new millennium, the world has entered an "urban millennium." More than 50 per cent of the world's population now lives in cities, in agglomerations, in megacities, and large urbanised regions. This percentage will continue to increase. Climate policy will therefore be particularly successful if cities are increasingly able to use energy efficiently in an improved, indeed revolutionary, way. This will be possible if city energy supplies are able to become increasingly decentralised, and thus also more likely to become less carbon-intensive.
This makes cities the focus of the climate policy agenda and it is therefore especially welcome that Hamburg is taking on a pioneering role in this regard. In setting itself the goal of gradually moving this large, cosmopolitan, vibrant city in the direction of climate neutrality, the IBA in Hamburg sends a signal to the world. This signal comes at just the right time. The recent EXPO 2010 took place in Shanghai: its theme was "Better City—Better Life". Partnership between cities is a tremendous opportunity for mutual support in efforts aimed at energy-efficient and carbon-neutral energy supplies—and it is possible for the IBA Hamburg to adopt a global agenda based on this event as it moves into its final implementing years.
In the city context, these are perspectives linked to a decentralised approach. Hence the city's overall target has to be broken down according to the individual city districts and neighbourhoods. In this regard, too, Hamburg is exemplary. It is therefore to be welcomed that this "Future Concept Renewable Wilhelmsburg" takes the form of its own *ENERGY ATLAS*. It is to be hoped that the measures already achieved and those still to be implemented here will have a multiplying effect in Germany and beyond. Beyond the EXPO 2010, as the IBA moves towards completion in 2013, there is the opportunity for working together on city district concepts in Shanghai. The dynamics of this huge Chinese megacity certainly provides conditions requiring the ongoing development of new solutions with scientifically verifiable effectiveness.

Concentration on Existing Buildings

More than 40 per cent of greenhouse gas emissions derive from buildings already in existence. It is therefore rational, and imperative, that attention is paid to this source of climate-damaging

MARGRET MARKERT

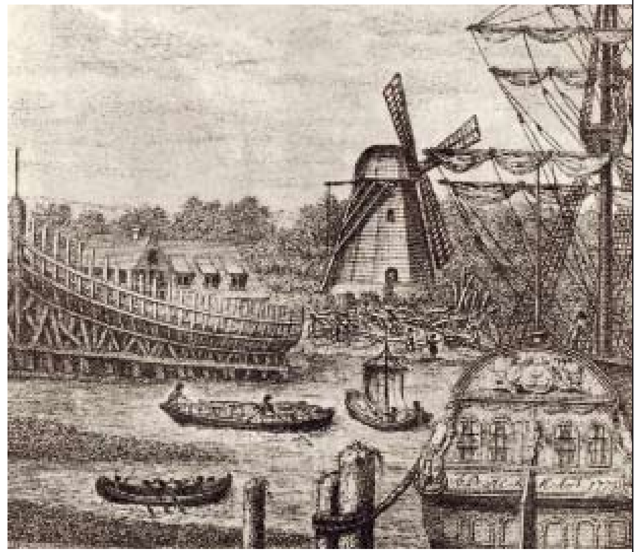
A Brief Energy History of the Elbe Island

Seen from today's perspective, power generation on the Elbe island of Wilhelmsburg was ahead of its time even in the seventeenth century. In an era when growth constraints and a shortage of energy resources were yet to become evident, the River Elbe and the wind were used to generate power for the production and transport of goods. There is written mention in 1582 of a windmill, rebuilt after a fire in 1874.
In addition to the dairy farming that formed the livelihood of the Elbe island's residents, wood rafting and the timber trade have been a feature of Reiherstieg since the seventeenth century. This building material was transported along the River Elbe to the timber docks where there was a saw mill and, as of 1706, to the first shipyards on the northern Reiherstieg.[1]
A good two hundred years later, the industrial community of Harburg-Wilhelmsburg was one of the most important centres of the German oil industry. The origins of this development form part of colonial history: Harburg merchants made palm oil from Africa the lubricant of the emergent industrialisation, processing it for both engineering and for cosmetic and pharmaceutical production. In 1880, the company Noblée und Thörl was a leading European processor of tropical oil seed.[2]
The refineries and tank facilities belonging to Shell (then still Rhenania Ossag), Schindler, and DEA (Deutsche Erdöl Aktiengesellschaft/ German Oil Company) on the Reiherstieg and Köhlbrand then transformed what was once the natural Wilhelmsburg Elbe island landscape into an expansive harbour and industrial area, a process that extended into the nineteen-twenties.

Harbour Development and Industrialisation

With Hamburg joining the German customs union in 1888 and the development of the free port, Wilhelmsburg from early on became a link in the southern expansion of the harbour, even though it did not even belong to Hamburg at that stage. As the "most ideal industrial area in the German empire" and the "Eldorado of the future!" within a decade the island was being exploited for future industrial estates by property speculators and real estate companies. New harbour basins, canals, factories, and today's Reiherstieg district had been built by the outbreak of the First World War in 1914. In 1875, Wilhelmsburg had almost 4,000 residents—by 1914 the population had already reached 32,000. The island community became an industrial town with substantial energy requirements. Investors such as Hermann Vering initiated extensive development measures in the west of Wilhelmsburg. As of 1890, smoke began belching from the factory chimneys. The local authorities were completely overwhelmed by the rapid industrialisation process. In 1890, the local council still largely comprised farmers, shipbuilders, and other artisans; a few years later it was dominated by heads of industrial companies, chairmen of property companies, and the Wilhelmsburg industrial railway.
In the period before the First World War, Neuhof, in the extreme north-west of Wilhelmsburg, became a location for the oil industry. The petroleum harbour had already been established in 1879 in Finkenwerder, and this

Reiherstieg shipyard with saw mill
From a steel engraving by F.C. Löhr, around 1775



Power for the first steamships
Coal supplies are bunkered in Hamburg harbour

A breath of fresh air in Wilhelmsburg's urban development
The Dutch windmill on Siedenfelder Weg, restored in 1997

industrial sector was further developed in the nineteen-twenties. The Neuhof power station, connected to the grid in 1928, with what was then the largest diesel engine in the world, became the most important power supplier. Unlike Hamburg, which "had already boasted electric lights and trams for decades, as well as electromotive power in its shipyards and factories," Wilhelmsburg was connected to the electric grid only in 1912. The Siemens Elektrischen Betriebe power station in Harburg had a total output of 670 kilowatts distributed across seven transformer stations via a 10,000-volt line.[3]
From this point until well into the era of the Weimar Republic, Wilhelmsburg was a working-class residential area of Hamburg. Up until about 1925, approximately one-third of Wilhelmsburg's residents were factory workers who earned their living with Hamburg companies.

Economic Fluctuations and Industrial Crises

The First World War brought a halt to the rapid industrial development, production declined, and employment figures dropped accordingly. A significant dependence on imports meant problems for the oil and chemical industries in particular. The major shipyards, producing warships for the navy, were the only ones to benefit. In 1918, 10,863 people earned their living in the shipyards. It was only after the great inflationary crisis of 1923 that overall industrial development stabilised. Pre-war population numbers were again reached in Wilhelmsburg in 1929. Following their merger in 1927, Harburg-Wilhelmsburg was one of the largest industrial regions in the Weimar Republic, its around 110,000 residents and an industrial workforce of approximately 26,000 in more than a hundred large enterprises making it more important than Breslau, Königsberg, Halle, or Kassel.[4]
In the mid-nineteen-twenties Hamburg's harbour further encroached on Wilhelmsburg, with Rethe and Reiherstieg being dredged. The Prussian premier Otto Braun wanted a unified industrial policy for Prussia. "The plans for Harburg and Wilhelmsburg were part of this overall strategy, ensuring the German empire's supply of cheap potash for agriculture and oil products for industrial use and for mass consumption, while simultaneously consolidating the lower Elbe region in the face of competition from Rotterdam and London, with defensive aspects also playing a role: the imperial army provided support for the development of Harburg into an oil port."[5]
The Great Depression of 1929 brought with it tremendous problems for the Wilhelmsburg economy as the majority of the commercial operations were reliant on the import of raw materials. In order to stabilise the Elbe economic region despite the developing crisis, Hamburg and Prussia agreed on the foundation of the Hamburgisch-Preussische Hafengemeinschaft GmbH (Hamburg-Prussian Harbour Association) in July 1929. The objective was the financing of the building and operation of future harbours in the lower Elbe economic region, as well as new transport and infrastructure measures.

Wartime Economics

As of 1934, the National Socialist regime began systematically planning for the war. By 1938, the major Howaldtswerke shipyard and the Maschinenfabrik Augsburg-Nürnberg AG (M.A.N.) engineering works had housing built

DIETER D. GENSKE, JANA HENNING-JACOB, THOMAS JOEDECKE, ARIANE RUFF

The Basics and the Initial Situation

The goal is the transformation of the fossil fuel/nuclear city into a solar, sustainable city that is ultimately able to source 100 per cent of its supply from renewable energy.

The IBA Hamburg's key theme of "Stadt im Klimawandel" ("Cities and Climate Change") is a reaction to the current challenges facing cities as a result of climate changes and the growing scarcity of fossil fuel resources. The goal is the transformation of the fossil fuel/nuclear city into a solar, sustainable city that is ultimately able to source 100 per cent of its supply from renewable energy. This transformation is taking place at a sociocultural, urban planning, economic, and ecological level and requires entirely new strategies.

Meeting the energy requirements within the IBA area solely by means of renewable energy will save resources. Decentralised renewable energy production also reduces ecological energy footprints *extra muros*. This means that no resources will be consumed from outside the IBA area, no space will be taken up, and no greenhouse gases will be emitted. The regenerative energy supply, the increased energy efficiency, and the reduced energy consumption will reduce greenhouse gas emissions, particularly CO_2, within the IBA area.

The different energy consumers—households, commerce, trade, service providers, industry, and mobility—have to share energy resources. Each of these energy protagonists has their own spatial resources that they can utilise for energy production. The areas to be used for energy purposes comprise not only wasteland, open areas, and traffic areas in the urban environment, but more specifically roof and façade surfaces. Only households, commerce, trade, and service providers are taken into consideration as energy protagonists here. The further consideration of additional energy protagonists will form the subject of later reviews.

Energy potential needs to be compared with the energy requirements necessary for electricity generation and heating. To this end, a scenario analysis

1. determines the current and long-term development of energy requirements
2. establishes the potential for energy savings
3. examines the options for increasing efficiency, and
4. analyses the impact of implementing renewable energy.

This then allows measures to be deduced for optimising energy supply and reducing greenhouse gases.

Four periods are determined up until the forecast horizon of 2050, each of them being considered with two different scenarios:

1. The IBA Hamburg's starting year, 2007
2. The IBA Hamburg's final year, 2013
3. The European Commission's target year of 2020, also the city of Hamburg's target year for the reduction of greenhouse gas emissions by 40 per cent
4. The EU's target year of 2050, by which time CO_2 emissions in all of the industrialised nations are to have been reduced by up to 95 per cent in comparison to 1990.

The first projects aimed at the goal of post-fossil fuel energy supplies on the Elbe Islands are being implemented within the scope of the IBA up until 2013.

The commercial districts are also characterised by especially high electricity demand. The current electricity requirements here are based on the number of employees in the commercial, trade, and service provider sectors represented in the IBA area.

11 Energy demand in individual urban areas in 2007

Energy demand 2007

USE Urban environment types		Absolute demand per UET (final energy demand)		Demand per hectare UET (final energy demand)		Demand per energy consumption area (final energy demand)		Demand per resident (final energy demand)	
		thermal GWh/a	electric GWh/a	thermal GWh/ha	electric GWh/ha	thermal kWh/m²	electric kWh/m²	thermal kWh/EW	electric kWh/EW
MIXED USE									
I	Pre-industrial/historic city centre < 1840	0,29	0,05	1,84	0,32	239	42	4107	721
IIa	Nineteenth-century construction units < 1938	25,84	5,20	2,67	0,54	209	42	3851	775
IIb	Nineteenth-century and pre-war imitative buildings > 1990	3,89	1,26	1,66	0,54	130	42	2400	775
IIc	Nineteenth-century and pre-war villas < 1938	1,07	0,16	0,45	0,07	234	34	n/a	n/a
III	Reconstructed areas 1950s	20,10	3,51	2,64	0,46	206	36	3564	623
IV	Village-like, small-scale	8,95	1,87	0,29	0,06	154	32	n/a	n/a
RESIDENTIAL									
V	19th-century and pre-war company and co-operative housings	38,61	6,32	1,41	0,23	220	36	5500	900
VI	1950s social welfare housing	7,08	1,27	0,75	0,13	234	42	6079	1093
VII	1970s high-rise housings	50,58	8,86	1,76	0,31	211	37	4842	848
VIIIa	Multistorey housings 1960s–1980s	36,65	6,28	1,08	0,18	210	36	5403	926
VIIIb	Multistorey housings 1990s	0,94	0,26	0,67	0,18	131	36	3374	927
VIIIc	Multistorey housings Low Energy Standard	0,00	0,00	0,00	0,00	60	36	n/a	n/a
VIIIc+	Multistorey housings Passive House Standard	0,00	0,00	0,00	0,00	45	36	n/a	n/a
IXa	Single-family home dwellings	74,13	13,43	0,42	0,08	188	34	8580	1554
IXb	Single-family home dwellings Low Energy Standard	0,32	0,18	0,13	0,08	60	34	n/a	n/a
IXb+	Single-family home dwellings Passive House Standard	0,00	0,00	0,00	0,00	45	34	n/a	n/a
SPECIAL TYPES									
S1	Schumacher buildings 1920s–1930s	20,16	3,68	2,94	0,54	230	42	4239	775

CO_2 Emissions

Building renovations and increasing the proportion of renewable energy bring about a reduction in greenhouse gases. The potential for the reduction of CO_2-equivalent emissions can thus be derived from two components:

- Savings through the energy renovation of buildings and more efficient energy supply technology in existing buildings
- Savings through the production and use of renewable energy.

The CO_2-equivalent savings according to urban environment type are based on the difference in emissions before and after the energy-saving measures undertaken in each scenario. This enables localisation that then illustrates the effect that the funding of energy renovations in the individual urban environments will have on CO_2 reduction.

The CO_2-equivalent emissions are further reduced by the production and use of renewable energy. CO_2 credits result when the electricity produced using renewable energy exceeds demand. It needs to be noted that a renewable electricity deficit has to be compensated by the established electricity mix. The Federal German electricity mix emission factor is assumed, a mix that will become ever "greener" in the decades to come.[25] The emission factor of the typical Wilhelmsburg heating mix is assumed for a renewable heating deficit (Table 19).[26, 27]

Energy production using fossil fuel energy is predominant in the IBA's starting year. Heating energy and hot water demand is met by a variety of energy sources (heating oil, gas, coal) and by electricity. The area under consideration is not connected to the Hamburg district heating network; there is only a relatively small island network in the eastern section of Central Wilhelmsburg. Hot water supply by means of solar collectors is negligible, while electricity demand is also largely met by conventional means. The model assumes the Federal German electricity mix, which comprised about 15 per cent renewable energy in 2007. Renewable electricity production began in the IBA's starting year with wind power units at the Georgswerder disposal site and in the direct proximity thereof (approximately thirteen gigawatt-hours of electricity per year). Smaller photovoltaic roof-mounted units are used for electricity generation in individual cases but these are of little consequence.

Emissions in the IBA's starting year 2007 thus amounted to 207,823 tonnes of CO_2. This means CO_2 emissions per resident of 3.76 tonnes per year (for the residential and the commercial, trade, service provider sectors only). The high CO_2 emissions are due to the fact that, in 2007, only 1 per cent of the heating demand and about 10 per cent of electricity requirements were met by renewable means.

Emissions of households, commerce, trade, service providers in the IBA's starting year 2007 thus amounted to 207,823 tonnes of CO_2.

Direct CO_2 emission values for the different forms of energy production (without upstream and disposal)

Energy production	thermal $tCO_2/GWhEnd$[1]	electric $tCO_2/GWhEnd$[1]	Source
Federal Germany Energy Mix			
2007	245 [2]	579 [2]	[5] [6] 2008
2013	230 [2]	512 [2]	(BMU[5] 2009b), (UBA [6] 2008)
2020	211 [2]	429 [2]	(BMU[5] 2009b), (UBA [6] 2008)
2050	118 [2]	25 [2]	(BMU[5] 2009b), (UBA [6] 2008)
Wilhelmsburg Heating Mix			
Households	217[3]		(BEI 2009)
Commerce, trade, service industry	225[3]		(BEI 2009)
Fossil fuels			(GEMIS [7] 2009)
Heating oil	266–270	646	(UBA [6] 2009a)
Natural gas	202	456	(UBA [6] 2009a)
Anthracite	344–353	862	(UBA [6] 2009a)
Brown coal	359–367	1050	(UBA [6] 2009a)
District heating from Coal [4]			
70% Co-generation	219		(GEMIS [7] 2009)
35% Co-generation	313		(GEMIS [7] 2009)
0% Co-generation	407		(GEMIS [7] 2009)
Moorburg grid	238		(IBA-Hamburg 2009)
Renewable energy	0	0	(UBA [6] 2009a)

[1] Based on final energy demand. [2] Based on the projected energy mix for the 2009 guideline scenario (BMU 2009. Table 10. p. 95). [3] Weighted mean based on the energy mix calculated by the Bremen Energy Institute (BEI 2009. Table 5–11. p. 42) and the fossil fuel emission factors listed in this table. [4] Electricity credit for electricity produced by coal taken into account. [5] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. [6] Federal Environment Agency. [7] Global Emissions Model of Integrated Systems.

12 Direct CO_2 emission values for the different forms of energy production

HARRY LEHMANN

Wilhelmsburg on the Way to the Solar Industrial Age

Napoleonic bridge built in 1814
First north-south crossing of the Elbe island of Wilhelmsburg

The energy system used in a region for a period of time establishes parameters within which social, technical, and economic structures are formed. The type of energy supply, therefore, is not simply one of a number of constituents; it is a determining factor in human development. History to date can roughly be divided into three periods characterised by their energy use: the hunter and gatherer society, the "pre-industrial solar age," and the "fossil fuel/ nuclear industrial age."

Human beings roamed this planet as hunters and gatherers for some two million years. During this time, man's net energy yield was about 0.2 to 2 kilowatt-hours per hectare and year; this allowed for the development of settlements in only a few favourable locations. The situation altered dramatically with the invention of agriculture about 12,000 years ago. There were some ten million people living on the earth in this period. The pre-industrial solar sector was integrated within natural energy and material flows, use of which was more or less sustainable. At the end of this period, in the seventeenth century, the population had grown to about 500 million worldwide. Next to wind and water, biomass was the dominant energy resource during this period. It fed both people and "machines" (such as horses, oxen, and slaves). Agricultural land produced ever higher yields, with the consequences significant population growth and increased affluence. The net energy yield rose in highly developed agricultural civilisations such as Mexico to 8,300 kilowatt-hours per hectare and year, or, in China, up to 78,000 kilowatt-hours per hectare and year. This represented a 50,000-fold increase in land use efficiency over the millennia.

Advances in transport technology ultimately enabled the exploration, exploitation, and colonisation of the world. Biomass "fuel" and its inefficient converters (human and animal) meant, however, that land transport remained limited in terms of range and speed. A human being managed to travel around twenty-five kilometres per day, while beasts of burden could cover twice that. It is therefore no wonder that waterways were of tremendous importance for human development, enabling the transport of large volumes within feasible time periods. It took news, and people, years to circumnavigate the globe.

Space dependency led to a decentralised social structure. There were no "system" advantages to be derived from a central infrastructure. Settlement size was defined by the availability of resources—the production of increased yields allowed for the formation of towns and cities in strategic locations.

Rapid population growth in the pre-industrial solar age (eighteenth century) in Europe triggered major crises (such as famine, for instance). The introduction of new plant species (potatoes), colonisation, and emigration reduced the pressure. Emergent commercial production increased the consumption of resources at the same time, however. The people in Europe suffered as a result of insufficient agricultural yields and a crisis in the supply of wood, the most important pre-industrial raw material.

reasons for this are the renovation of existing buildings, improved building standards, and greater efficiency in thermal energy supplies in this sector.

Electricity

Electricity demand in the IBA area is strongly influenced by the fact that, by 2050, the number of consumers there is set to increase, commercial areas will expand, and auxiliary electricity will be required for renewable energy production. Electricity demand in individual households is set to decline by about 20 per cent within the forecast horizon. This is due, on the one hand, to more efficient household appliances with energy consumption labelling, for instance, or intelligent electricity meters (smart metering), but this greater energy efficiency will be compensated by the use of additional appliances, particularly computers, as well as audio and video technology. There will be very little effort made in the commerce, trade, and service provider sector with regard to energy optimisation in increasing production automation.[3] The overall electricity demand for households and the commerce, trade, and service provider sector will therefore increase by about 50 per cent in absolute terms, this being as much as about 60 per cent in R1 as, without the Moorburg power station, more heat pumps will be used for the supply of thermal energy.

Projected final energy consumption (total)

	Heating demand [1] GWh [final]/a	Electricity demand [2] GWh [final]/a
2007	550	143
2013	520	148
2020	529	181-185
2030	447	184-195
2040	374	187-202
2050	357	220-236

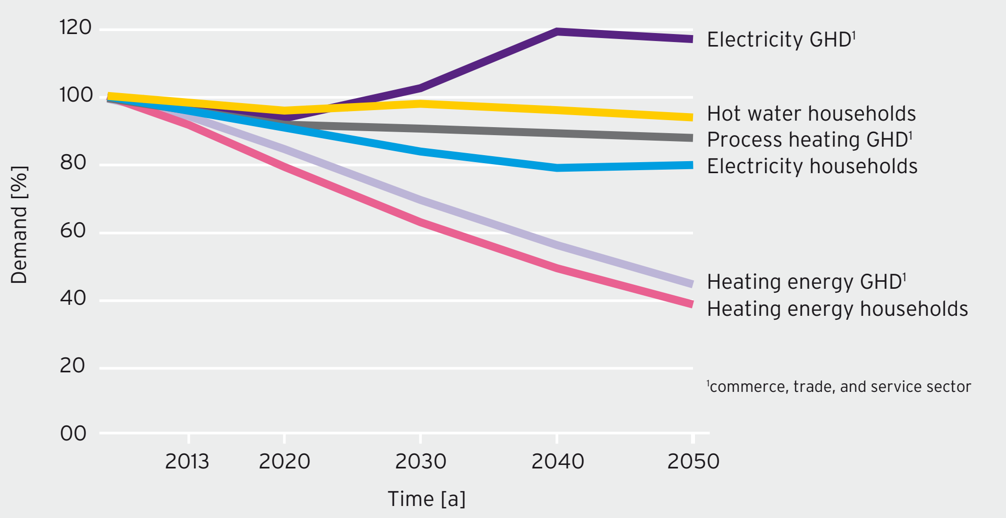
[1] Water demand includes the energy required for heating, hot water supplies, and process heating.

[2] Electricity demand is somewhat higher in reference scenario 1 because there are more heat pumps in use.

01 Forecast of the overall energy consumption for households and the commerce, trade, and service provider (GHD) sector in both reference scenarios (R1 and R2), depicting overall absolute energy consumption. This decreases with respect to thermal energy demand and increases in terms of electricity, even though a contrasting trend is evident in some areas. For instance, there is a relative saving in terms of household electricity demand, but the absolute overall demand increases because the number of consumers in the IBA area increases until 2050 and all of the energy participants, including the GHD sector, are taken into account.

02 The change in relative energy demand divided according to households and/or the commerce, trade, and service provider sector (GHD) and individual energy performance in the reference scenarios

Final energy demand in the reference scenarios



Excellence scenario 1

Heating	Demand GWh[final]/a	Yield (renew.) GWh[final]/a	Self-sufficiency coverage %
2007	550	6	1
2013	521	72	14
2020	526	263	50
2030	427	279	65
2040	342	286	84
2050	335	285	85

Electricity	Demand GWh[final]/a	Yield (renew.) GWh[final]/a	Self-sufficiency coverage %
2007	143	13	9
2013	145	78	54
2020	171	164	96
2030	158	183	116
2040	143	218	152
2050	153	341	224

19 Energy demands and energy yields development, as well as the resulting coverage for thermal energy and electricity in excellence scenario 1

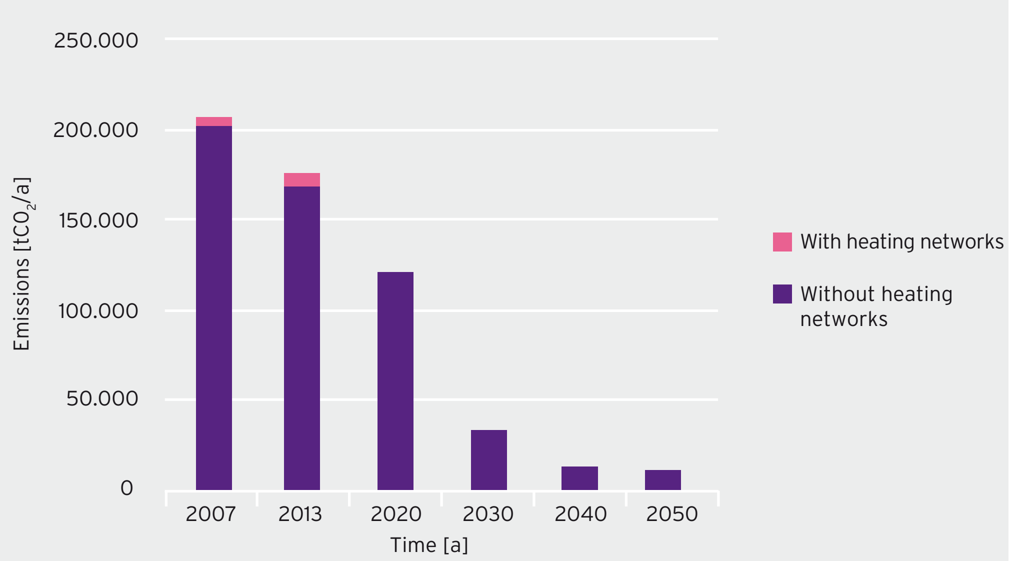
Excellence scenario 2

Heating	Demand GWh[final]/a	Yield (renew.) GWh[final]/a	Self-sufficiency coverage %
2007	550	6	1
2013	521	72	14
2020	526	222	42
2030	427	231	54
2040	342	245	72
2050	335	286	85

Electricity	Demand GWh[final]/a	Yield (renew.) GWh[final]/a	Self-sufficiency coverage %
2007	143	13	9
2013	145	78	54
2020	171	150	88
2030	158	161	102
2040	143	157	110
2050	153	191	125

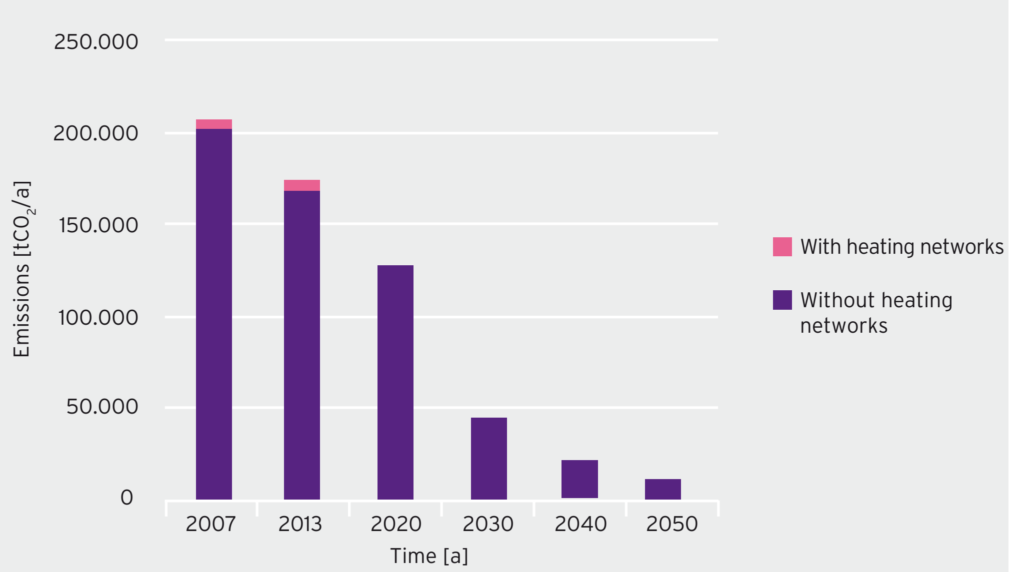
20 Energy demands and energy yields development, as well as the resulting coverage for thermal energy and electricity in excellence scenario 2, in which the electricity demand for producing organic methane has already been deducted.

Excellence scenario 1



21 Annual CO_2 emissions for households and the commerce, trade, and service (GHD) sector in excellence scenario 1

Excellence scenario 2



22 Annual CO_2 emissions for households and the commerce, trade, and service (GHD) sector in excellence scenario 2

CO_2 Emissions in the Excellence Scenarios

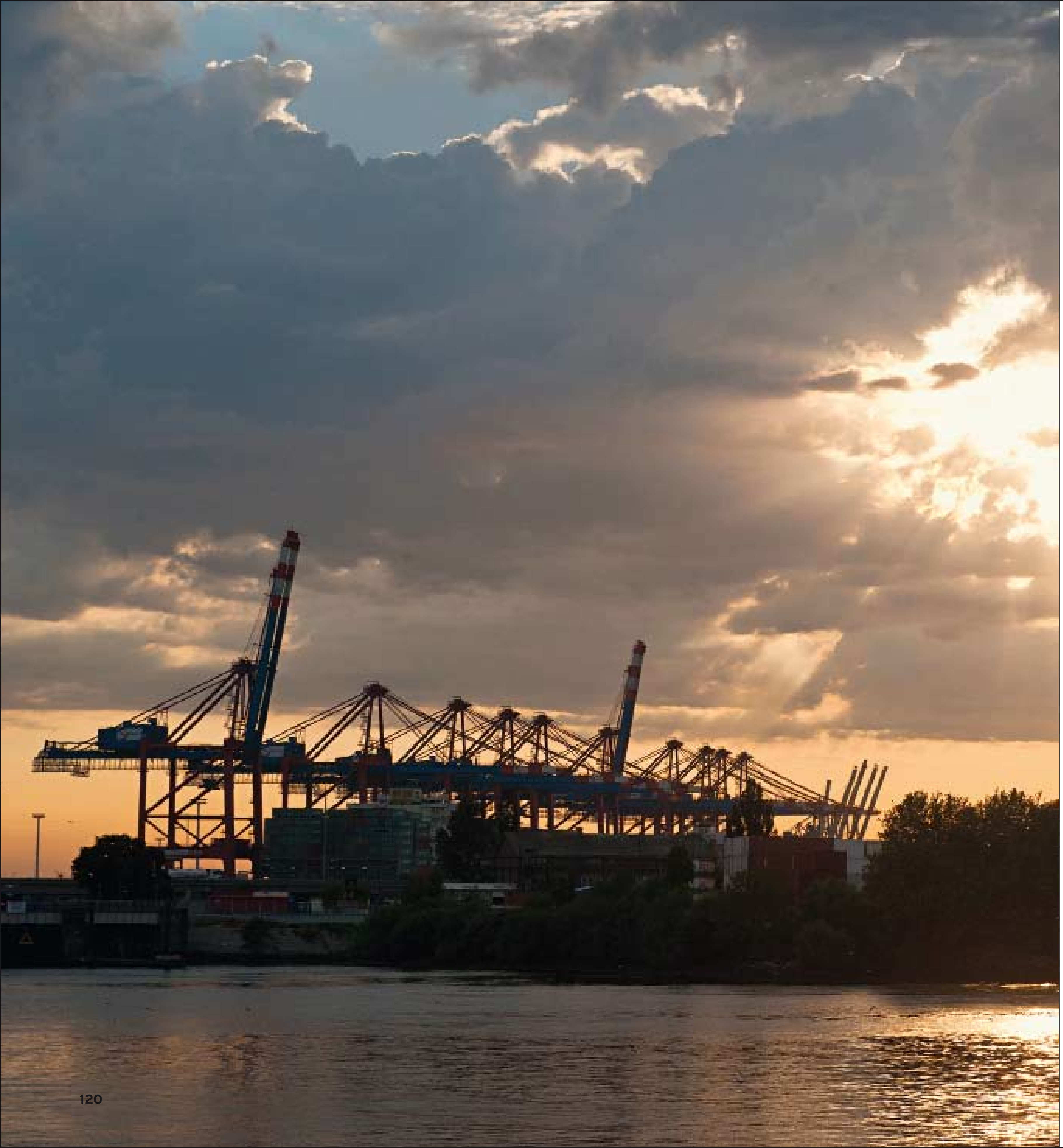
In the excellence scenarios, efficiency measures and the targeted substitution of fossil fuel / nuclear energy for renewable energy leads to a considerable reduction in CO_2 emissions. Even by the conclusion of the IBA, about 50 per cent more greenhouse gases will have been saved than in the reference scenarios. In 2020, about four times the quantity of greenhouse gas is saved than in the Moorburg scenario (R2).
At the end of the forecast horizon in 2050, the emissions in the excellence scenarios amount to only 5 per cent of the 2007 emissions, while in the Moorburg scenario (R2) greenhouse gases are still polluting the atmosphere at just under 40 per cent of the 2007 levels. Households and the commerce, trade, and service provider sector emit practically no CO_2 by 2050, making the IBA area almost climate-neutral in respect of these energy protagonists.

Bibliography

Bundesministerium für Umwelt, Naturschutz und Realtorsicherheit (Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety) (ed.): *Leitszenario 2009. Langfristszenarien und Strategien für den Ausbau erneuerbare Energien in Deutschland.* Carried out by Joachim Nitsch and Bernd Wenzel. Berlin 2009

Notes

1 Prognos AG/Öko-Institut (ed.): *Modell Deutschland, Klimaschutz bis 2050: Vom Ziel her denken.* Study on behalf of WWF Germany, carried out by Almut Kirchner, Felix Chr. Matthes et al. Basel/Freiburg 2009.
2 Ibid.
3 Ibid.
4 Ibid.
5 Ibid.
6 M. Sterner, M. Specht: "Erneuerbares Methan." *Solarzeitalter* (1), 2010, 51–8.



STEFAN SCHURIG

People, Cities, Climate Change

The Development of Cities from Petropolis to Ecopolis

The transformation from the fossil fuel industrial age to the solar age has to take place in cities.

The prospects for a rapid international agreement on addressing climate change have been significantly diminished by the Copenhagen debacle of December 2009. The future of climate protection mechanisms such as the trade in emissions certificates is thus very uncertain. This makes national and regional climate protection measures all the more important for cities, which generate almost 80 per cent of emissions worldwide. The transformation from the fossil fuel industrial age to the solar age has to take place in cities. This is not only about the ways and means of producing energy in the future. Equally important is the introduction of energy saving and efficiency measures because these can be very quick and cost-effective to implement. Also, in the future a city's overall spatial planning will be directed towards mobility reduction including the creation of new urban experiential realms, and towards understanding the likely space requirements for renewable energy sources, in addition to early efforts to reclaim nutrients from wastewater.

With the goal of gradually supplying Wilhelmsburg solely with renewable energy, the IBA sets an excellent example for other cities.

The ENERGY ATLAS with the future-oriented concept "Erneuerbares Wilhelmsburg" ("Renewable Wilhelmsburg") shows precisely how this goal is to be reached, and demonstrates that this is a beneficial path for Hamburg, and particularly the people in the IBA's demonstration region.

At the start of the great climate showdown in Copenhagen in December 2009, there was no superlative too exalted for describing the significance of this "historic" gathering. With a mantra of biblical metaphors, we were told that the climate conference was "the last chance to save the Earth" (Source: *Märkische Allgemeine*). If we take a look at the depressing facts from the experts, then these superlatives are no exaggeration at all. There is no doubt that there are only a few years left to prevent the average global temperature from rising above the dangerous 2º Celsius limit. Everything above that, according to the experts, is considered to be beyond man's control.

With the Kyoto Protocol, thirty-seven industrial nations, including Germany, entered into an agreement, binding under international law, to reduce greenhouse gases by 5 per cent based on 1990 levels. This first period of commitment expires in 2012. A minimum requirement for avoiding the greenhouse effect running completely out of control would have been agreement in Copenhagen on a commitment by the industrialised nations, binding under international law, to reduce their own CO_2 emissions by 40 per cent by the year 2020. What was also required was agreement on finding functioning mechanisms for co-ordinating and monitoring CO_2 reductions. None of this was achieved. Instead, agreement was reached at the end of the conference on what is known as the "Copenhagen Accord": climate change is happening, greenhouse gases need to be reduced, the development of renewable energy sources needs to make headway, and the destruction of the rainforests has to stop. This leaves us no further ahead than we were before.

ENERGY EFFICIENCY THROUGH COST EFFICIENCY

Energy Savings Potential and Refurbishment Costs

The differences in building size, age, and construction mean that energy savings potential requires varying effort to achieve. The goal is the achievement of the greatest possible reduction in heating energy requirements per square metre of energy consumption area, thus keeping the costs of energy saving measures as low as possible.
On a percentage basis, the greatest energy savings potential is that of small and large multiple-family units in fragmented, village-like surroundings and/or in nineteenth-century housing areas and welfare housing. The savings to be achieved here are between 60 and 75 per cent of the original heating energy requirements. These buildings are also largely on a par in terms of the costs, at between 250 and 300 euros per square metre of living area. The single-family home areas have a savings potential of approximately 60 per cent of the original heating energy requirements, but with significantly higher renovation costs of approximately 400 euros per square metre. High-rise buildings exhibit the lowest savings potential of all the building types, considered to be approximately 45 per cent of original consumption, but the costs are also the lowest here at approximately 120 euros per square metres of living area. These figures provide owners with a basis for determining savings potential and estimated costs.
The costs incurred per kilowatt-hour saved per urban environment type were also analysed in order to obtain a complete energy overview. The optimum here is to achieve the lowest possible investment costs per kilowatt-hour saved. The costs per kilowatt-hour saved for the small and large multiple-family units are the same for practically all of the urban environment types, at approximately two euros. With modern multiple-family units and single-family homes the saving of one kilowatt-hour, at 5 to 13 euros per kilowatt-hour is at least 2.5 times as expensive. The implementation of the "Klimaschutzkonzept Erneuerbares Wilhelmsburg"

> The implementation of the "Climate Protection Concept Renewable Wilhelmsburg" requires that multiple-family units be renovated as quickly as possible in order to be able to rapidly exploit greater savings potential.

Example: Refurbishment of a 1920s multiple family unit (urban environment type nineteenth-century blocks IIa)
Number of floors: 5, number of housing units: 15
Heated living area: 1,349.11 m^2, heated building volume: 5,942.00 m^3
Renovation measures carried out: insulation of exterior walls (composite thermal insulation), insulation of the top floor ceiling and the cellar ceiling. Windows and technical installations replaced.
Costs of building shell renovations: approx. 273,800 Euro, costs of building technology renovations: approx. 94,700 Euro
Amortisation period with constant energy costs: 14 years, amortisation period with rising energy prices (increase 6 %/a): 10 years

	Prior to renovation	after renovation
Building shell	Not renovated	EnEV2009 New Buildings
Heating system	Gas-fired boiler	Heat pump with ground sensors
Energy source	Natural gas	Ground/electricity
Heating energy requirements	228.86 kWh/m^2a	82.44 kWh/m^2a
Final energy requirements	359.89 kWh/m^2a	31.10 kWh/m^2a
Energy costs (natural gas 0.07 ct/kWh; electricity 0.18 ct/kWh)	33,987.18 euro/year	7,552.31 euro/year

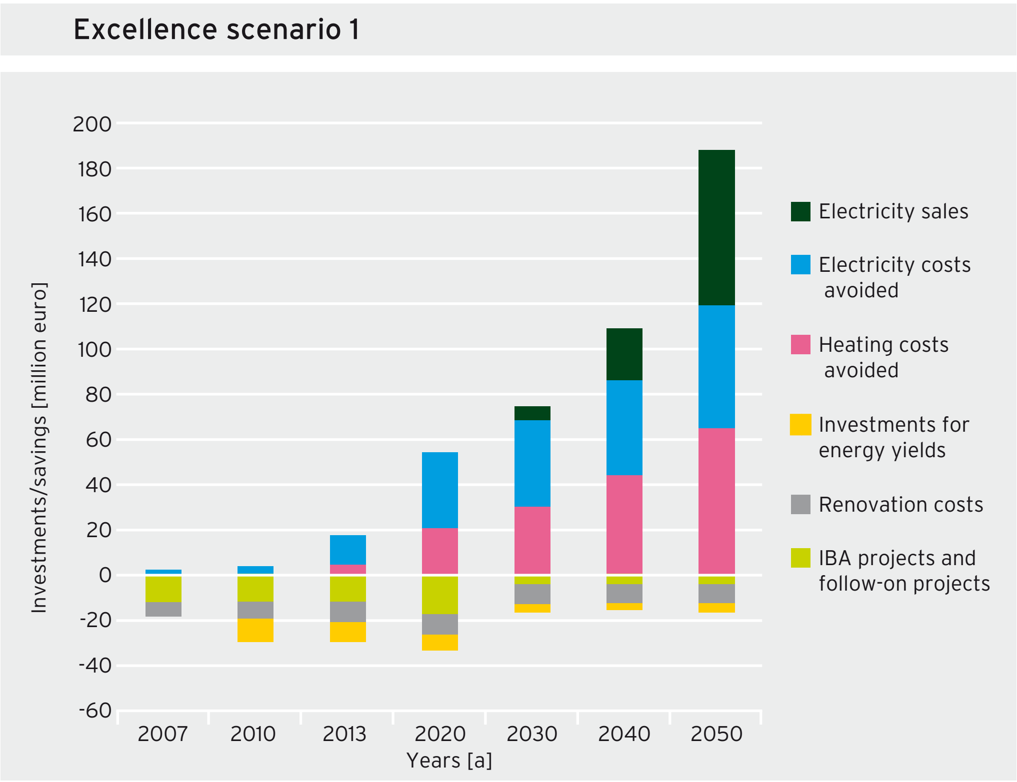
Example: Refurbishment of a 1950s single-family home from the (urban environment type single family home area IXa)
Number of floors: 1, number of housing units: 1
Heated living area: 101 m^2, heated building volume: 380 m^3
Renovation measures carried out: insulation of exterior walls (composite thermal insulation), insulation of the roof (interim and rafter insulation), insulation of the cellar ceiling. Windows and technical installations replaced (installation of a heat pump, drilling of geothermic probes, installation of photovoltaic and solar thermal units).
Costs of building technology renovations: approx. 31,450 Euro
Amortisation period with constant energy costs: 31 years, amortisation period with rising energy prices (increase 6%/a): 17 years

	Prior to renovation	after renovation
Building shell	Not renovated	EnEV2009 New Buildings
Heating system	Gas-fired boiler	Heat pump with ground sensors
Energy source	Natural gas	Ground/electricity
Heating energy requirements	182.81 kWh/m^2a	51.69 kWh/m^2a
Final energy requirements	331.81 kWh/m^2a	21.19 kWh/m^2a
Energy costs (natural gas 0.07 ct/kWh; electricity 0.18 ct/kWh)	2,345.90 euro/year	385.23 euro/year

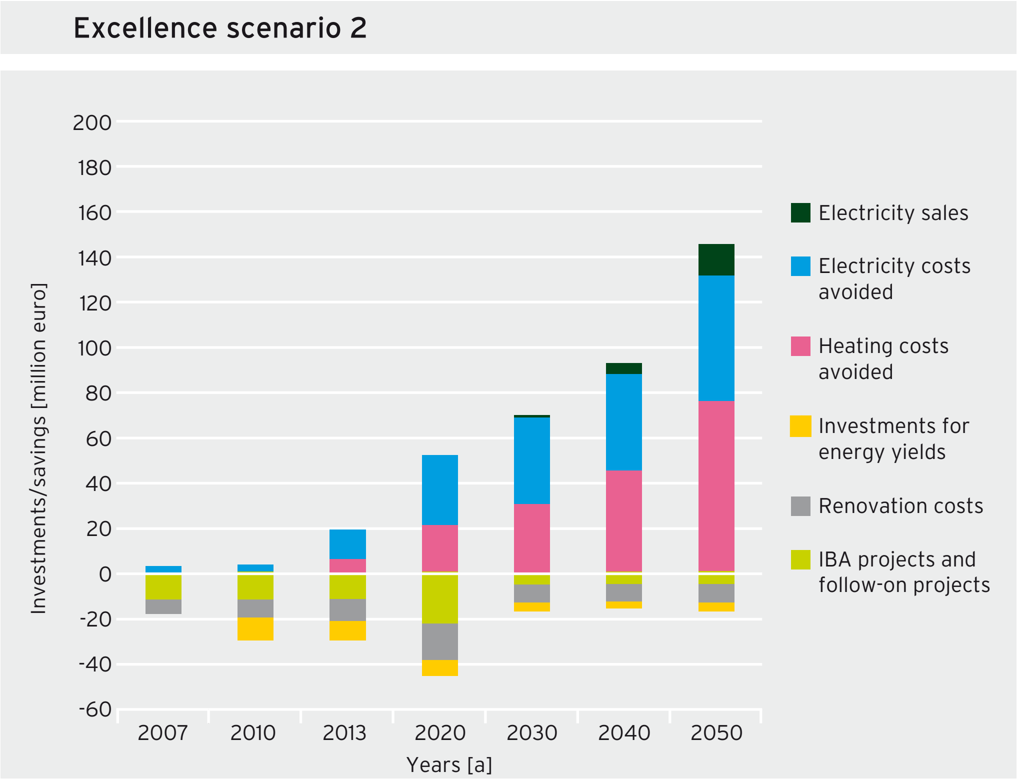
Example: Refurbishment of a 1970s high-rise building (urban environment type high-rise housing VII)
Number of floors: 14, number of housing units: 254
Heated living area: 18,012 m^2, heated building volume: 68,360.00 m^3
Renovation measures carried out: insulation of exterior walls (composite thermal insulation), insulation of the roof (slope insulation of flat roof) and the cellar ceiling. Windows and technical installations replaced (installation of a heat pump, drilling of geothermic probes, installation of photovoltaic and solar thermal units).
Costs of building shell renovations: approx. 2,280,000.00 Euro, costs of building technology renovations: approx. 257,000.00 Euro
Amortisation period with constant energy costs: 22 years, amortisation period with rising energy prices (increase 6 %/a): 14 years

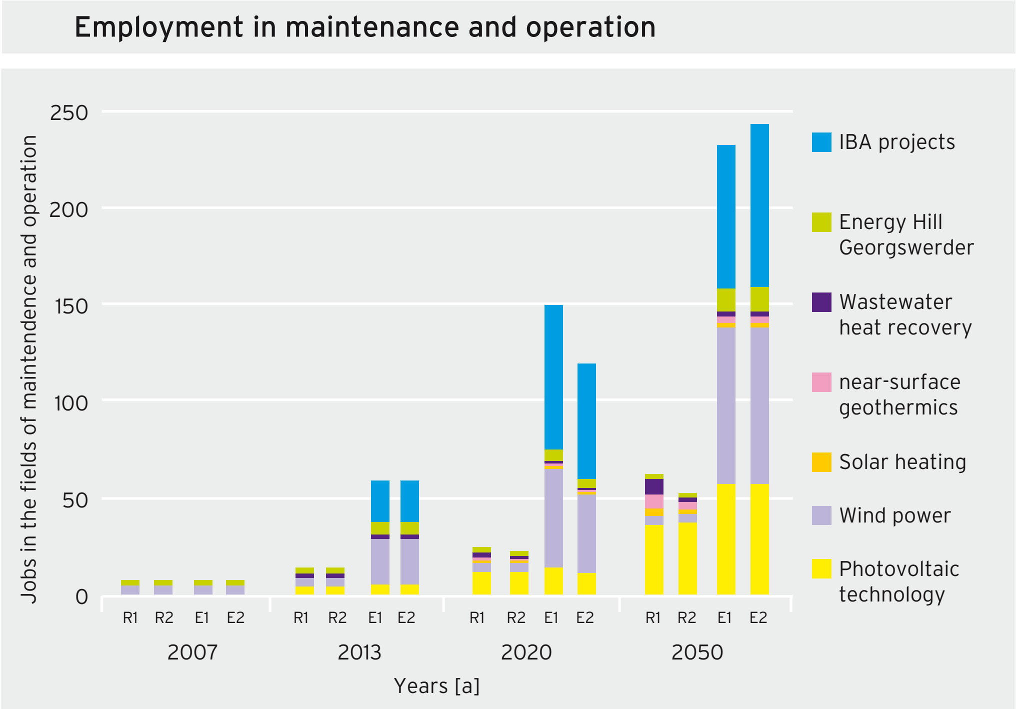
	Prior to renovation	after renovation
Building shell	Not renovated	EnEV2009 New Buildings
Heating system	Gas-fired boiler	Heat pump with ground sensors
Energy source	Natural gas	Ground/electricity
Heating energy requirements	69.10 kWh/m^2a	34.58 kWh/m^2a
Final energy requirements	132.11 kWh/m^2a	16.67 kWh/m^2a
Energy costs (natural gas 0.07 ct/kWh; electricity 0.18 ct/kWh)	169,569.57 euro/year	54,046.81 euro/year

09 Annual investments and savings for excellence scenario 1



10 Annual investments and savings for excellence scenario 2





11 Employment as a result of the maintenance and operation of energy technology for the reference (R1, R2) and excellence (E1, E2) scenarios

impact of the excellence scenarios, on the other hand, with an investment volume of 330 million euros, is not much greater, at approximately 3,000 man years. The employment impact is heavily dependent on the renovation rate. It is assumed that the building shell energy renovations take place within the scope of the planned building maintenance. The employment impact will therefore be triggered in part by the building maintenance anyway.

The conversion to renewable energy supplies will create new jobs. These derive from the production of technology units on the one hand, and in the field of maintenance and operation of existing units on the other. The maintenance and operation of the units in particular can create long-term employment in the IBA area. The number of jobs created can be calculated from the services installed in Germany[9] and the total number of jobs in maintenance and operation[10] in the IBA area. In the reference scenarios, between fifty and sixty jobs will be created in the maintenance and operation of renewable energy technology by 2050, with as many as about 230 jobs in the excellence scenarios.

The conversion to renewable energy sources does mean, however, that fewer employees will be required in other occupations in the long term, such as chimney sweeps and heating oil retailers, for instance. The expansion of the areas of activity, such as the transfer of monitoring tasks to chimney sweeps within the parameters of the German Energy Savings Regulations (EnEV), can prevent the loss of jobs in some cases. Overall, the investments made and the measures taken within the scope of the IBA Hamburg provide an opportunity for the Wilhelmsburg economy to become well positioned in areas that will be important in the future, thus creating and safeguarding jobs on a sustainable, long-term basis. The skills advantage thus acquired gives the companies involved a competitive edge that will be increasingly in demand in the future, from outside the IBA area in particular.

In the reference scenarios, between fifty and sixty jobs will be created in the maintenance and operation of renewable energy technology by 2050, with as many as about 230 jobs in the excellence scenarios.

MANFRED HEGGER

Spatial Energy Concept

Introduction

Energy—in the form of power—is invisible as energy forms and sources are not generally captured by our sense of sight, i.e., our eyes. To say that electricity simply comes from the socket shows not only that our energy supply is omnipresent and taken for granted, but also indicates that we are often unaware of its value and its origins—because it is invisible.
The visible elements of power supply are everywhere, however. Our landscape images are characterised by pipelines, substations, and wind turbines. Massive power plants, waste incinerators, oil storage facilities, or transformer stations manifest the very dependence of our urban life style on conventional energy supplies. Supply boxes and electricity meters, sensors, switches, and sockets have become essential components of our buildings and their interiors. We endeavour to reduce energy consumption by means of heavily insulated façade systems, sunshade devices, and ventilation ducts—and to generate distributed power using solar panels that often look like they have made an emergency landing on our roofs. Only rarely do we manage to turn this energy infrastructure into an aesthetic enrichment of our everyday landscape.
The renewal of our cities' energy supplies means a significant change to the form and performance of city, landscape, and architecture. This article attempts not only to describe these necessary changes but also to draw up guidelines for dealing with this transformation, resulting in a new image of the city that its residents will hopefully experience as an exemplary enhancement of their daily life.