Hamburg ahead

INTERNATIONAL BUILDING EXHIBITION HAMBURG

Energy bunker

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Building the City Anew

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A. INTRODUCTION

A dilapidated WWII air raid bunker that had lain unused for decades in Hamburg's Wilhelmsburg district has been redeveloped, remodelled for future-oriented use, and made accessible to the public, as part of the International Building Exhibition (IBA) Hamburg.

Local Energy Supplier

As the »Energy Bunker«, since 2013 it has combined renewable energy generation, demand-based energy storage and efficient local energy supply. In future it will supply up to 3,000 households from the surrounding area (including 800 apartments within the IBA »Global Neighbourhood« project run by the municipal building society SAGA GWG) with renewably generated heat, and will also generate electricity for around 1,000 homes.

Repurposing an Air Raid Bunker

Following the spectacular conversion and repurposing of the building and the creation of a unique energy concept, the »Energy Bunker« has also become a beacon IBA project and a major visitor attraction. This is not only due to its imposing appearance within the city and the panoramic views of the whole of Hamburg that can be enjoyed from the café; there is more to be found within the building itself and in relation to the energy concept. The bunker forms a bridge between the history and the future of the district, while bringing renewable energy production back into the city and making the energy transition achievable and comprehensible for everyone.

This White Paper seeks to present the "Energy Bunker" from a technical perspective and to collate the most important information on the development of the whole project, as of April 2014. More in-depth information about the bunker is available from the IBA Hamburg GmbH or the respective project partners.

Fig. 1: Bunker before the renovation in 2007

A.1. » Cities and Climate Change«Theme

As part of one of its three themes, »Cities and Climate Change« between 2007 and 2013 the IBA Hamburg directed action towards the environmental regeneration of the city. The »Renewable Wilhelmsburg« Climate Protection Concept, in development since 2008, took a decidedly decentralised approach that aimed to achieve 100 per cent renewable forms of energy within the city.

Aims of the Climate Protection Concepts

- Energy efficient upgrading of buildings
- Highly energy efficient new building
- Local heat grid based on renewable and local forms of energy (including industrial waste heat)
- Generation of renewable forms of energy within the district

With over sixty completed energy-related or construction IBA projects, the first stages of the implementation process could be witnessed from 2013. As a result of the completion of the »Energy Bunker« and the »Energy Hill«

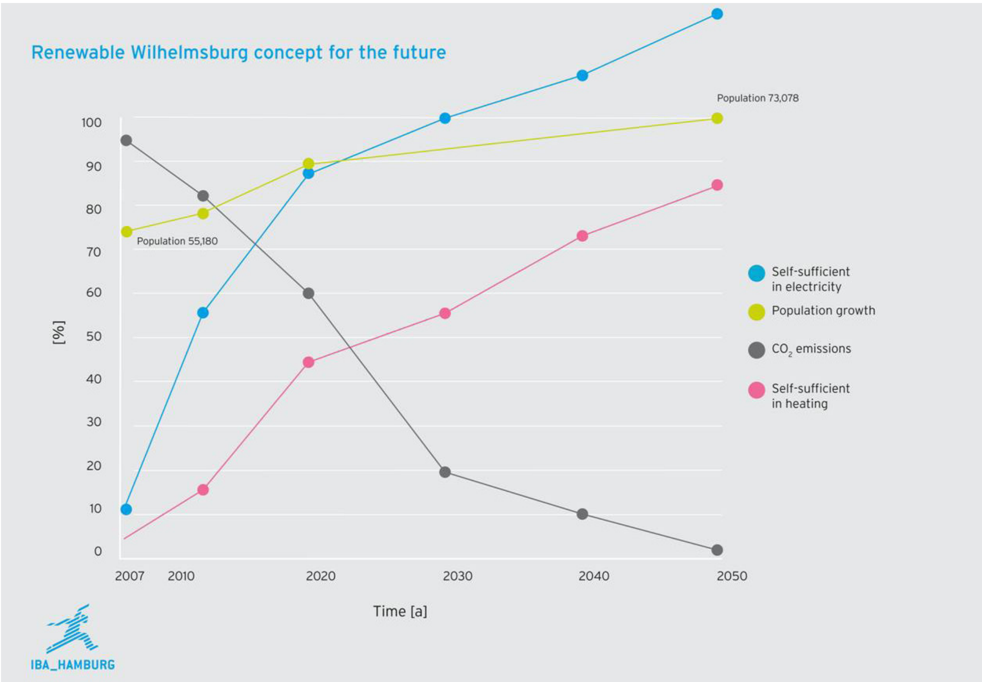

Fig. 2: Aims of the »Renewable Wilhelmsburg concept for the future«

in Hamburg-Georgswerder and the use of geothermal energy planned for 2015, over 50 per cent of the buildings on the Elbe Islands will be supplied with electricity, and every seventh building with heat from renewable energies or combined heat and power. By 2030 the electricity requirements of the residential buildings on the Elbe Islands should be met, their heat requirements by 2050.

Monitoring and Knowledge Transfer

In the research project »EnEff:Stadt – IBA Hamburg«, due to run until 2015, over forty IBA projects are being examined, specifically the energy balances for the surrounding district using monitoring concepts at various levels. This makes the concepts, experiences, and results of the IBA accessible to planners and building owners, as well as presenting them to the public. The multimedia Energy Table, in the IBA exhibition at the »IBA DOCK«, displays and explains the results of this energy monitoring programme in order to provide a more accurate picture of the extensive research that has been carried out. Work is also being done to extend the project and replicate it in other parts of Hamburg and in other European cities.

The »Renewable Wilhelmsburg« Climate Protection Concept is one of the model projects to be included in the research project »TRANSFORM – Transformation Agenda for Low Carbon Cities«, in which the IBA is a Hamburg-based partner, alongside HAMBURG ENERGIE and the »State Ministry for Urban Development and Environment« (BSU).

A.2. History of the Air Raid Bunker

Languishing for decades as an unused, grey block within Wilhelmsburg's Reiherstieg district, the bunker was originally built for specific purposes, under different circumstances.

Both Monument and Memorial

Like most bunkers in Germany, the building is a relic of the Nazi regime. Built by forced labour, it was used as a military battle post, while also serving as a shelter for the local civilian population in wartime. Today, the bunker can not only be seen as a centre for future-oriented inner city energy supply, but will always remain both a monument and a memorial.

Function of the Bunker

Today's »Energy Bunker« is based in the former sixth turret of the Wilhelmsburg air raid defence complex. The bunker building was constructed in 1943 in the middle of the »Rotenhäuser Feld« park, according to plans by the architect Friedrich Tamms. Its outer dimensions are 47 × 47 metres on a broader base (57 × 57 metres), with an original height of 42 metres. As such, the bunker is not only significantly larger than other high-rise bunkers in Hamburg, but, unlike its counterparts, it was not primarily geared towards providing shelter for civilians, but, rather, for serving military purposes. Such anti-aircraft bunkers were intended secure the strategic air defence of cities along with their inhabitants and industries, while at the same time demonstrating the defence capabilities of the German »home front« in the major cities of the Third Reich (Hamburg, Berlin, and Vienna). Another air raid bunker was also built in Hamburg, at Heiligengeistfeld (St Pauli), comprising one gun turret and a smaller control tower.

Construction work on the Wilhelmsburg air raid bunker began in late 1942, driven by the increasingly heavy air raids on Hamburg, and it was completed and ready for use six months later, in mid-1943. Work on the nine-storey bunker was largely carried out by forced labour and prisoners of war, who were housed in the adjacent barracks or brought in every day from various local camps. »Organisation Todt«, which included the major German building contractors, was in charge of the construction of the bunker. Approximately 80,000 cubic metres of reinforced concrete were used.

Bunker Operation during the War

The bunker was in operation for almost two years, from June 1943 to May 1945. During the war it was intended that only the second and third of the nine floors would be used as shelter for the civilian population. Nevertheless, several thousand people are said to have found refuge behind the solid, 2 metre thick outer walls during air raids. Forced labourers or minorities who suffered discrimination against were not admitted. The hospital floor of the bunker was reserved for military units. On the roof were the air defence installations, with four protected turrets containing the main rotating guns, 12.8 centimetre twin weapons. The tracking and target detection of enemy aircraft was carried out from the control tower, 200 metres away, and transmitted to the defence positions via a tunnel. The bunker itself was hit by bombs many times, but was not badly damaged. However, it could not offer significant protection against bombing in the surrounding districts. The most severe war damage in Hamburg was inflicted on Wilhelmsburg and the harbour area. Even today, unexploded bombs from World War II are occasionally found during construction work and have to be defused.

Demolition after the War

After the war the British allies began to demilitarise Hamburg, including the defortifi-

Fig. 3: Blasting operation at the bunker in 1947

cation of the Wilhelmsburg bunker complex. The smaller control tower was completely demolished and later removed. However, when it came to the main bulk of the air raid bunker it was feared that the pressure wave that would result from the necessary detonation would also destroy much of the surrounding residential area, which contained housing that was urgently needed in the post-war period. For this reason, only the interior was blown up, in order to prevent further use. On 17 October 1947 the careful detonation of 1,000 kilograms of explosive material broke all of the supporting pillars and five of the eight inner floors together with their internal walls, fixtures, and stairs. The outer shell of the bunker was torn all the way round and the upper part lifted with the explosion, but sank back onto its base, so that, once the dust had cleared, from the outside the bunker appeared undamaged. Among some of the German population this fuelled the legend that the British had been unable to destroy the bunker. In fact, the British had actually achieved their most important goal, as the bunker would remain unusable and without any proper purpose for over six decades, due to the extensive damage to the building's fabric.

A Ruin for Decades

Different ideas for using the building, from housing or leisure facilities to various partial demolition scenarios, were considered from time to time, but due to the static condition of the building they were always abandoned on grounds of cost. Once the acute danger of collapse had been ruled out, in the 1950s a single drinks distributor used the adjacent areas as part of its site. Due to outside weather conditions and the large amount of vegetation growing around the building, the concrete façade had declined so rapidly by the Millennium that additional nets were required to secure it. As there was no prospect of a new use for it, the city authorities, as the bunker's owner, reported that the bunker ruins would be demolished, with expected costs ranging from € 5 million to estimated € 12.5 million.

At the same time, there were renewed efforts to retain the bunker as a memorial, as a result of which it was granted protected status in 2001. A viable approach to maintaining the former flak tower was only developed as part of the IBA, and could finally be implemented when the »Energy Bunker« project began.

Fig. 4: Blasted interior in 2009

A.3. Project Outline

Owner	Free and Hanseatic City of Hamburg (FHH)
Architects (redevelopment)	HHS Hegger Hegger Schleiff Planer + Architekten AG, Kassel
Clients	IBA Hamburg GmbH (building), represented by ReGe Hamburg Projekt-Realisierungsgesellschaft mbH and HAMBURG ENERGIE (energy supply)
Project partners	State Ministry for Urban Development and Environment (BSU), State Office for Real Estate Management and Landed Property (LIG, previously Finance Ministry/Real Estate Management), Hamburg-Mitte District Authority, Wilhelmsburg & Hafen History Workshop
Structural engineering	Prof. Dipl.-Ing. Bartram und Partner, Ottersberg-Fischerhude
Energy concept	Averdung Ingenieurgesellschaft mbH, Hamburg, HAMBURG ENERGIE
Technical equipment in building	Pinck Ingenieure Consulting GmbH, Hamburg; Averdung Ingenieurgesellschaft mbH, Hamburg
Building services	Pinck Ingenieure Consulting GmbH, Hamburg
Fire safety	Neumann Krex & Partner, Niestetal
Landscape design	EGL Entwicklung und Gestaltung von Landschaft GmbH, Hamburg
Management of energy centre, solar shell, and local heat grid	HAMBURG ENERGIE
Management of visitors' café	Anne Meyer, Waterkant – Hamburg Event & Locations GmbH
Exhibition planning	hg merz architekten museumsgestalter, Stuttgart
<u>General project facts</u>	
Air raid bunker, date of construction	1943
Interior demolition	1947
Dimensions	47 × 47 m (ground floor base 57 × 57 m), height 42 m (solar shell: approx. 50 m)
Area	Café: 400 m^2 + 100 m^2 terrace; energy centre: 5,625 m^2; solar thermal unit: 2,400 m^2; photovoltaic unit: 1,750 m^2
Energy generation	22,500 MWh heat, 3,000 MWh electricity
Investment	€ 26.7 million
Energy assets	€ 11.8 million (including heat grid, excluding solar shell)
Funding	IBA Excellence funding: € 1.2 million; European Regional Development Fund (ERDF): €3.1 million; Hamburg Climate Protection Concept: € 1.3 million
Building timetable	2010: structural surveys and emergency safety measures March 2011: start of renovation work, debris recovery September 2011: upgrading of façades Spring 2012: start of construction work on energy centre and heat grid October 2012: start of heat delivery March 2013: completion of building and café opening 2015: provisional final work on energy centre and local heat grid

B. OVERALL CONCEPT

The project has two prime objectives: Ensuring local, renewable energy supply and the overhaul and repurposing of a ruined building that is classed as a protected monument. The building will be open to the district once again after the redevelopment work, giving visitors the opportunity to enjoy the views over the harbour from the terrace, sit in the rooftop café, or, in the exhibition, find out more about the wartime history of the air raid bunker and the special energy concept.

Large-scale Buffer Tank as Heat Storage

The »Energy Bunker« has the potential to become a hub of renewable energy supply for Wilhelmsburg's Reiherstieg district. In addition, the outer walls of the bunker building feature solar elements that can be seen from afar. Yet the heart of the energy system lies within the building: the large-scale buffer tank, which is unique in type and size, »caches« heat in the form of warm water, and thus absorbs some of the daily peak demand. At the same time, this storage tank increases security of supply.

Energy Mix

The thermal storage system is fuelled by solar thermal energy, while there are additional large-scale generation units inside the bunker that harness renewable sources of energy and combine heat and energy production in an efficient way. By using this mix, the project seeks to demonstrate that different forms of renewable energy production are not only suitable within cities, but also tackle the problem of fluctuating generation volumes for individual types of energy. This technology allowed the IBA Hamburg to implement an important pilot project in the run-up to the "Renewable Wilhelmsburg" initiative. The enlarged "Energy Bunker" alone will save 95 per cent more CO2 emissions than a conventional energy mix. Over a year, this amounts to 6,600 tonnes of CO2.

Fig. 5: Aerial view of the bunker from the east, showing the surrounding »Global Neighbourhood« in the southwest, taken in 2013

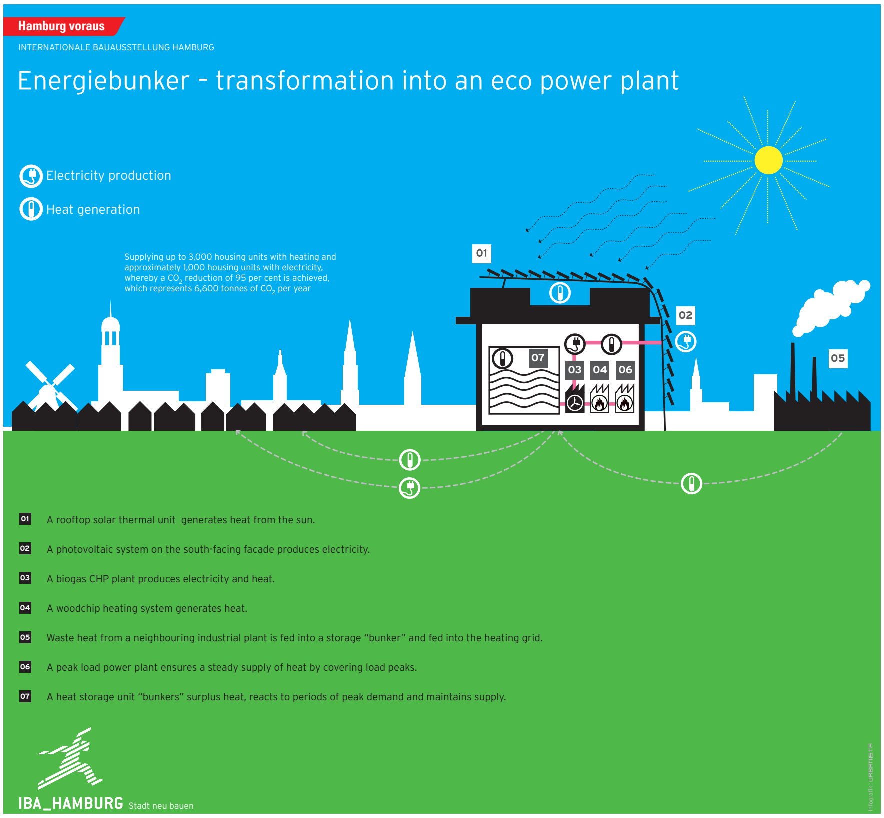

Fig. 6: Energy concept

B.1. Energy Concept

The »Energy Bunker« is the result of a four-year planning and optimisation process, and the related energy concept involved entering uncharted territory in a number of respects. As far as those in charge of the project were concerned, it was clear from the outset that the urban energy supply of the future would have to be designed with a greater emphasis on local and renewable resources. In order to ensure reliable and economic operation, this also required consideration of adequate storage capacities and appropriate forms of technology. The planners therefore opted for a combination of various renewable energy sources and means of production:

1. A solar thermal unit absorbs heat from the sun.
2. The photovoltaic modules on the south façade produce electricity.
3. Inside the bunker, biogas drives a co-generation unit, producing electricity and heat.
4. Industrial waste heat from a nearby factory is collected and fed into the bunker for temporary storage and redistribution.
5. Locally sourced wood chips are burned to produce heat.
6. Natural gas powered condensing boilers can be used in a versatile way in order to cover peak loads and ensure security of supply.

7. The large-scale heat storage system "caches" the generated heat.
8. Finally, the generated heat is distributed to consumers connected to a heat grid.

B.2. Energy Production

The »Energy Bunker« has a power generation capacity of 6.5 megawatts, enabling it to produce 22,500 megawatt-hours of thermal energy, enough to supply a surrounding area of 0.5 square kilometres, containing about 3,000 households. In addition to this, the units also produce almost 3,000 megawatt-hours of electrical energy, which drives the internal systems and is partially fed into the public grid and paid for. The amount of energy generated meets the requirements of 1,000 households.

Germany's Largest Solar Thermal System

The original silhouette of the bunker is now dominated by a »solar shell«. Spread over a 290tonne steel frame covered in concrete, the south façade and roof together provide a c. 4,150 square metre surface for two-tier solar energy capture. While photovoltaic modules on the south façade are used to generate electricity, the solar thermal energy collectors on the roof surface are intended for heat production. With a module surface area of 1,350 square metres (framework surface: 2,400 square metres), this is the largest rooftop solar thermal system in Germany geared towards supplying a heat network.

Maintenance-Free Technology

The system has a thermal output of 750 kilowatts. The collectors are mounted at a shallow 15 ° tilt towards the south, thus ensuring that the elements receive as little shade as possible, as well as constituting a good use of space and little surface vulnerable to wind attack. In addition to cost-effectiveness and efficiency, emphasis was placed on a robust and virtually maintenance-free system due to its exposed position, which is hard to reach.

Fig. 7: Expanse of CPC vacuum tube collectors on the roof

Vacuum tube collectors manufactured by Ritter XL Solar are used at the »Energy Bunker«; they are piped according to the company's own system and connected together to form a massive field of collectors. The vacuum tubes are constructed as double-walled, insulated glass vessels, similar to a Thermos flask.

Support from CPC Mirrors

The optimal utilisation of direct or diffuse sunlight is supported by CPC (compound parabolic concentrator) mirrors, in which the tubes are embedded, and which reflect the sunlight back onto the tubes. The inner tube contains a highly selective absorber layer within a vacuum. It becomes very hot, and its heat is transferred through water-filled metal pipes. At a standstill, maximum temperatures can reach 350 °C, while the steady processing temperature is between 60 and 180 C. The system avoids the conventional water and glycol mixture in favour of pure water, due to the lower heat transfer and water's higher level of efficiency. In order to prevent freezing in winter, the flow through the collectors must be at least 5–8 °C at all times. This is ensured by short heat impulses from the solar pump. If there is a power cut, a battery system intervenes.

Photovoltaic System

Additional electricity is produced on the south façade using a photovoltaic unit. The photovoltaic modules here are also fastened to their own steel frame, anchored to the concrete a few metres in front of the façade. This allows the modules to be optimally aligned with the position of the sun, with a 36 ° tilt. Being fixed at a height also eliminates the problem of shade, while the good wind conditions lead to natural ventilation and hence a higher than average level of efficiency. However, the high wind loads required a stable structure and robust modules. The planners therefore chose components made by the German company Solon, which featured a layer of very thick solar glass. The frame surface of 1,750 square metres allowed for an area of 670 square metres made up exclusively of modules. The photovoltaic system therefore has a rated output of 0.1 megawatts-peak, resulting in 780 full load hours per year and electricity generation of 78 megawatt-hours per year. Normally, the electricity generated is used to run the facilities in the energy centre inside the bunker, such as pumps and controls. Any surplus is fed into the public electricity grid.

Fig. 8: Photovoltaic unit on the southern side

Fig. 9: Natural gas powered co-generation unit

Co-generation Unit

The co-generation unit also produces both heat and electricity through the effective use of combined heat and power in a unit, and through a single-stage process. It has an electrical output of about 510 kilowatts and a thermal output of 600 kilowatts, and began operation within the bunker in early 2014. It is expected to reach electricity production of 2,700 megawatt-hours per year and heat production of 3,750 megawatt-hours per year for about 7,500 annual peak hours. It is driven by natural gas produced in the Dradenau wastewater treatment plant in Hamburg. During the decomposition of organic waste from the sewers, biomethane is realised, captured, and processed so that it can be easily fed into the natural gas network and sold. HAMBURG ENERGIE has agreed a delivery contract for this natural gas and has funded the provision of the necessary amount for the city-wide natural gas network. The co-generation unit can be controlled in a flexible way and should therefore be able to supply balancing energy for the needs-based operation of the electricity grid, at the very least, in conjunction with many other such units. If the amounts of electricity being supplied were too high at any point, the operation of the co-generation unit would be curtailed, or ramped up if the amounts were too low. In times of increasing but fluctuating renewable forms of energy, operators have a much greater need of different forms of balancing energy (depending on how short term the availability might be). This provides energy producers with a new business model, and possibilities for the temporary storage of simultaneously generated heat are demonstrated.

Wood Chip Boiler

In late 2015 the most powerful unit within the "Energy Bunker" will be incorporated into the energy centre and become operational. The large boiler is fuelled by wood chips and has an output of 2 megawatts, plus a heat output of 10,500 megawatt-hours per year. In the future, this will amount to nearly half of the heat produced. The "Energy Bunker" does not use wood pellets as fuel, as these are industrially processed and expensive, but, rather, rough, undried wood chips that can be used inexpensively in large quantities and suit the conditions within the bunker. According to the supply agreement, the wood chips should come from Hamburg and the surrounding area, and are made mainly from felled trees and gardening waste. Old and waste wood or treated materials are not burned in the bunker. The wood chips are delivered on average once a week by lorry. There is a driveway on the street side for this purpose, as well as a hatch installed on the building. The wood chips are kept in a large storage room and are then transported to the boiler in the northeast corner of the "Energy Bunker" via screw conveyors. The exhaust gas and particulate emissions from this central and highly efficient boiler are many times lower than with heat production using many pellet or wood chip boilers. The waste gases from the burning processes run together with the exhaust gases from the co-generation unit and pass through an electric filter system that ensures the resulting emissions are far below the permitted levels. The exhaust air is discharged through a 50 metre high chimney so that the emissions, which are already low, can dissipate more easily within urban areas and not remain concentrated.

Fig. 10: View from the bunker to the west, with the towers of Nordische Oelwerke in the background

Industrial Waste Heat

In districts that, like Wilhelmsburg, lie close to industrial and harbour areas, waste heat from industrial production processes is increasingly being evaluated and harnessed as a new local source of energy. From summer 2014, waste heat will be channelled from the industrial complex of Nordische Oelwerke (see Fig. 10, page 15), alongside the Veringkanal about 300 metres away, and transferred to the "Energy Bunker" for storage and redistribution. This adds 500 kilowatts in output and 4,000 megawatt-hours in heat production per year, which amounts to 18 per cent of the energy mix in the bunker. In principle, waste heat is an energy source that does not require additional resources. Until now, the heat generated during the production process escaped unused through the chimney, so non-renewable energy had to be used to cool the equipment.

Heat Exchangers in the Chimney

In future, the heat will be removed from the waste air by heat exchangers in the chimney and quickly supplied to the »Energy Bunker« via a newly laid hot water pipe. The heat can then be stored and redistributed. As an additional effect, cool water runs back to the factory and can be used there for ventilation. The available quantities of heat, which fluctuate greatly within the production process, can be balanced by the energy mix and incorporated into the overall concept of the »Energy Bunker« due to the possibility of heat buffering. This sensible, economically advantageous, and low CO2 method could act as a model for similar supply sites within the city, while also revealing urban planning mistakes that have been made in the past. The malodorous emissions from Nordische Oelwerke put a heavy burden on the residents of the Reiherstieg district, which lies immediately beside the plant. These emissions were significantly reduced through the installation of modern filter systems as part of a co-operation agreement stipulated by the authorities.

Peak Load Boilers

In order to ensure security of supply for connected consumers even during periods of extreme cold or peak demand, or if there is a temporary failure of other systems, the bunker has two natural gas-powered two-vessel boilers, and when it is complete it will have four. A boiler is planned as a fail-safe – as a back-up if the other systems fail. The peak load boilers are connected in series to the renewable heat producers and the heat buffer storage tank, and can be activated intermittently, in order to bring a sinking flow temperature back to the desired level. The natural gas-powered boilers each have an output of 2.15 megawatts and produce 3,570 megawatt-hours per year. It is expected that they will contribute an annual average of about 15 per cent of the heat production for the heat buffer storage tank.

Fig. 11: Large-scale buffer storage tank, installed in the bunker shortly after work began

B.3. Heat Buffer Storage Tank

At the heart of the »Energy Bunker« project is a large-scale heat storage tank with a capacity of 2,000 cubic metres, which is about the volume of a 50 metre long swimming pool. This enables the reliable use of renewable energy sources and ensures cost-effective supply to connected consumers even at peak load times.

Great Differences in Temperature

Warm, completely desalinated water is stored in a wide, well-insulated steel tank that is on average 20 metres high and about 12 metres across, and can absorb or release heat energy depending on the situation. Within the pressure-free, open tank there are layers of different temperatures which vary by 40 °C, with the top the hottest at over. CO2 heat can also be fed into the tank at different heights using heat exchanger plates, while heat is always taken from the top level, which is the warmest. During the night the tank is usually loaded up with any surplus heat that has been generated, so that this can be used for the morning peak load and released over the rest of the day to supply the connected consumers. Due to the buffering effect of this tank, it was possible to scale down the maximum thermal power needed for the area of supply, and thus reduce the necessary technical output. An output of 6.5 megawatts was required, as opposed to 11 megawatts, as the rest can be buffered by the stored heat energy. The total heat output of the »Energy Bunker« can even be increased to 12 megawatts over the short term if the heat is fully used. The reduction of the nominal capacity makes it possible to use renewable forms of energy within the heat supply concept in a cost-effective way, while increasing the amount of annual renewable heat work due to the high run-times of the generators, at about 85 per cent. In theory, the tank could also cover the heat supply alone for 18 hours; in summer it could meet the requirements for several days.

Priority Circuit

A priority circuit determines what is fed into the buffer storage tank and when. The priority is given to solar thermal heat, which is the most environmentally valuable, as it does not require raw materials to be purchased and consumed. In descending order of priority come industrial waste heat, which is also derived without the additional use of resources, then heat from the co-generation unit, and finally heat from the wood chip boiler. This interaction between different sources of heat, the necessary control technology, and a storage tank of such dimensions make this project a model example of this type of system. As such, the technology is being researched and optimised so that projects that seek to imitate it can benefit from this experience and help to put climate protection measures into practice.

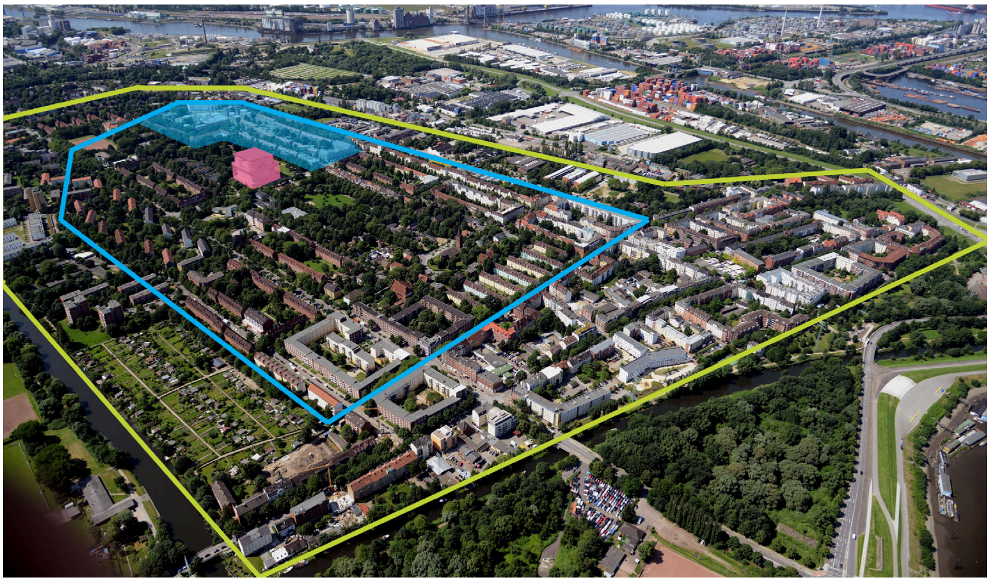

Fig. 12: Current area supplied by the bunker, with the planned area for expansion

B.4. Local Heat Grid

The heat generated and »cached« in the bunker is distributed to households and other consumers via a local heat grid especially designed for this purpose. Water circulates through the mains and is heated by exchangers in the bunker to 60 or 80 °C (in summer and winter respectively). This heat is transferred to the buildings and released into their internal heating systems via heat exchangers. It is used to heat homes and heat water, so the housing units do not require their own boilers. The mains pipes are configured according to the Tichelmann system:

The flow and return of hot and cooled water run in parallel. The flow pipes become more tapered as they go further away from the bunker, while the return pipes widen.

Overall Completion by 2015

By the end of 2015 the completed energy centre and heat grid should reach around 3,000 households within the Reiherstieg district, spread over an area of 0.5 square kilometres. This neighbourhood includes residential buildings, public institutions, and commercial and retail premises and services. Since there was no existing (long-distance) heat grid within the district, HAMBURG ENERGIE developed its own grid, covering more than 7 kilometres, and laid conduits to apartment blocks and buildings whose owners wished to be connected. The proposed supply area was defined on the basis of its proximity to the bunker and the structure of the buildinge, thus keeping down the construction and operational costs. Residents were neither compelled nor required to connect to the grid, so supply agreements had to be handled on an individual basis. The supply terms offered were inevitably influenced by the market level of long-distance heating and had to compete with the operational costs of existing heating systems. Initially, the principal aim was to ensure a simpler method of supplying large contiguous blocks, such as existing housing estates and schools.

Current Supply Situation

Since late 2012, 600 homes from the nearby »Global Neighbourhood« have been connected to the grid, and have been receiving all of the heat required for their heating and hot water from the bunker network. The "Global Neighbourhood" is a SAGA GWG-owned housing estate that dates from the 1930s, and has been redesigned and made more energy-efficient in one of the IBA's model projects. Despite the switch to a renewable energy supply, the residents have saved an estimated € 0.40 per square metre in heating costs; exact figures will become available at the end of 2014, but sampling has already given us some indication of the situation. In addition, CO2 emissions from the estate have been reduced to zero, and the primary energy requirement of the buildings has plummeted from 300 to 9 kilowatt-hours per square metre per year. The »World Commercial Park« and the »Centre of Language and Exercise«, also IBA projects, are also among the first consumers to be connected to the grid.

Lower Primary Energy Factor

As far as the buildings' owners are concerned, one major advantage of connecting to the bunker's heat supply network is that HAMBURG ENERGIE guarantees a primary energy factor of under 0.3 due to the use of renewable energy sources for the heat delivered. Such a good primary energy factor (as a comparison, natural gas is 1.1) makes buildings eligible for better funding from public development banks such as KfW and IFB Hamburg when a new energy-efficient construction is planned or the upgrading of an old building to make it energy-efficient.

B.5. Further Development of the Energy Network

When it is completed in late 2015, with the woodchip boiler installed, around 3,000 households from a 0.5 square kilometre supply area will be connected to the network. As the energy concept's treatment of control technology and hydraulic engineering represented a step into uncharted territory, the fact that the »Energy Bunker« concept has been implemented according to plan should be considered a major success.

Supplying the Whole District

Nevertheless, the ambitions of the engineers and planners go even further. If the production and storage capacities of the bunker are gradually increased, in future it could supply the whole Reiherstieg district (covering 1.2 square kilometres) with heat energy from the bunker. Another goal is to link it up with the energy grid in Wilhelmsburg Central or the IBA-supported efforts to supply Wilhelmsburg with geothermal energy.

Collaborations with Scientific Experts

These options are currently being examined as part of the SMART POWER Hamburg research project, involving the partners HAMBURG ENERGIE, RWTH Aachen, HAW Hamburg and the State Ministry for Urban Development and Environment. The basic idea behind the expansion and increased use of the facilities within the bunker is to implement »smart grids« – intelligently networked and virtually controlled energy grids. The possibility of ramping up or scaling back co-generation units according to demand from the electricity grid, and thus providing balancing energy, is being investigated. So far there is not enough capacity for this balancing energy, which is urgently needed in times of energy transition, especially since most co-generation units are installed and (heat-)operated with a view to their heat production capacity.

Fig. 13: Completed Energy Bunker in mid-2013

Using them as electricity-operated co-generation units can work only if it is possible to store the generated heat within the bunker, so that the connected consumers are guaranteed a reliable heat supply. Further research and findings can be viewed in the »EnEff: Stadt – IBA Hamburg« programme and »TRANSFORM – Transformation Agenda for Low Carbon Cities« (cf. Chapter A.1).

Power to Heat

Another idea is the potential "caching" of surplus electricity by converting it into storable heat through the »power to heat« system. Using an electric heating system that basically works as an immersion heater, electricity can be converted into heat and fed into the bunker's tank, for instance on days that provide a high level of wind and solar power. However, the tank cannot absorb heat at random, as it can only be heated to a maximum temperature of 90–100 °C. In addition, according to current legal guidelines, the use of electricity for heat significantly downgrades the primary energy factor of the supplied heat so that it is much higher than the level that HAMBURG ENERGIE, the operator, has guaranteed to its customers.

B.6. Opening of the Bunker

A modern eatery has been created in the northwestern tower of the bunker as part of the renovation work. Called Café <vju>, it is open to visitors and, with its spectacular views, has been a popular venue since shortly after it was opened.

Café, Terrace, Events Venue...

The café consists of a glass-walled dining room that seats 50, plus a 100 square metre terrace for eating outside in summer. In addition to the fully equipped kitchen, toilets, storage rooms, a foyer and another function room were created on the eighth floor, offering space for events, private parties, and conferences for up to 200 people. The café is reached via a new lift, supplemented by a fire escape staircase. The café is run by Waterkant Hamburg Event & Locations GmbH, who have established a concept based on the special atmosphere of the space with its old concrete, modern décor and exceptional location, coupled with quality food and drink. Selected by tender, Waterkant have also taken over the catering and the everyday responsibility for all the parts of the bunker that are accessible to the public, including the entrance area, viewing terrace, and exhibition space.

Viewing Platform

Since its construction, the eighth floor of the bunker has had a 30 metre high platform that overhangs by about 6 metres, which was used for the smaller guns. As part of the renovation, this surface was made into a unique viewing platform running around the building. It is now open to the public and offers 360° views over large swathes of Hamburg, the harbour, and Wilhelmsburg. The bunker's links with its immediate environment in the form of its future supply area - Nordische Oelwerke (which supplies it with industrial waste heat) and other IBA projects such as the »Global Neighbourhood«, Wilhelmsburg Central, and the bunker's »sister project«, the »Georgswerder Energy Hill«, are clearly visible from here. The café makes use of the northwestern corner of the viewing platform, with its own exit onto the outdoor terrace, while other visitors can reach it via a direct exit from the lift lobby. Visitors can go up to the viewing platform during the café's opening hours, free of charge.

Fig. 14/15: Café, and view over the city from there

Exhibition Concept

An important part of the »Energy Bunker« concept is the dissemination of knowledge about the history of the bunker and the aims and operations of the new systems, which rely on renewable energy production. The project partners and the Wilhelmsburg & Hafen History Workshop hoped to create a documentation centre in one of the old turrets, but despite a concerted effort they were unable to secure medium-term funding for the initiative post-2013. After issuing a tender, the decision was therefore made to proceed with a robust, adaptable type of exhibition that would be appealing and represent in an accessible way all aspects of the bunker. Information is conveyed using small info cubes placed under 20 key words (e.g. »shelter«, »ruins«, »solar thermal energy«) in 20 different places, and containing informative text, images, and QR code links to other media, such as films, podcasts, and photo galleries. Visitors progress from cube to cube on an exciting journey of discovery that begins at »Rotenhäuser Feld« park and ends on the tenth floor of the »Energy Bunker«.

Klotz im Park

In 2009 the Wilhelmsburg & Hafen History Workshop launched a programme of events entitled »Klotz im Park« (which roughly translates as »Monstrosity in the Park«), to run alongside the renovation of the bunker. The aim was to collate, exchange, and discuss valuable memories and important insights, and to preserve them for present and future generations. Encounters between the last eye-witnesses of the bunker's wartime use and long-time Wilhelmsburg residents with visitors and youth groups gave rise to intense annual debates focused on key themes. An annual events day held during the construction phase also allowed rare access to and glimpses of the inside of the bunker, along with artworks inspired by the project. Together with archive material and special research, the impressions gained as a result of this initiative have played a major part in the current exhibition (concept by merz architekten museumsgestalter, Stuttgart) housed in the »Energy Bunker«.

Fig. 17: Exhibition cube

Accessible Battle Positions

From the same floor, visitors can access another old part of the bunker on guided tours, via a stairway to the tenth floor, where one of the four former turrets has been made accessible once again.

Fig. 16: Renovated battle position

C. IMPLEMENTATION PROCESS

The »Energy Bunker« was certainly one of the most ambitious and complex projects carried out as part of the IBA Hamburg, and the planning and implementation process also entailed major challenges. There were almost no precedents for the renovation or the energy concept, as a comparable project had never been undertaken anywhere in the world.

However, it offered the opportunity to implement concepts that had previously been discussed only in purely theoretical terms, and to put innovative forms of technology into practice. The smooth operation of the energy centre, solar shell, and heat grid, and the bunker's unexpected popularity (it received over 100,000 visitors) are testament to its successful implementation.

C.1. Concept Development

The initial ideas for the use of the bunker suggested by the State Ministry for Urban Development and the IBA in 2004 and 2006 focused on a »solar bunker«, recognising the suitability of the extensive roof and façade surfaces for capturing solar energy. The Hamburg-based firm of architects Czerner Göttsch presented a concept for the renovation of the bunker and supply of energy to the neighbouring SAGA housing estate. However, a cost-benefit comparison between the marketable energy and the repair and renovation costs for the bunker was considered unfavourable, especially once its poor structural and general condition became apparent in 2008.

From Solar Bunker to Eco-Power Station

The need to clear and renovate the interior of the bunker enabled the concept to be greatly expanded to encompass an eco-power station with additional generators and an integrated heat storage facility. The initial ideas for this came from the IBA Hamburg's advisory board on climate and energy. The concept became better defined through a series of discussions on the optimum tank size, a feasible mix of energy sources, and the scope and form of the heat grid.

IBA Expert Events

More suggestions, feedback, and contributions to the concept were made and discussed at the IBA Laboratories, which focused on the themes of »Energy and climate«, »Architecture and climate change« (both in 2008) and »Energy atlas« (2010). As a result, the long-favoured solution that involved a seasonal tank with a volume of approximately 10,000 cubic metres and the focus on generating balancing energy had to be discarded, to take one example. The number of properties and consumers from the surrounding area that might potentially connect to the bunker increased significantly, but the structural requirements of a tank of these dimensions within the bunker were considered too great. The concept development phase, which had begun in 2006, came to an end in 2009 following the IBA's »Energy Bunker« technical discussion, and the elements of the overall concept that is now being implemented were largely decided, subject to the necessary structural repairs and the securing of funding for the project

Preserving the »Concrete Monstrosity«

The aim of the architects was to implement the new uses in and around the building with minimal impact on the original structure, for reasons of both conservation and cost-effectiveness. As far as possible, the basic structure was therefore left untouched (remaining floors, old parts of the façades), repaired (outer walls), or restored (e.g. the inner supporting pillars). Existing elements such as curves in the staircase, openings, and passages were used as part of the renovation. Overall, the bunker has retained its solid appearance as a »concrete monstrosity«, although it has now been enhanced by the solar shell attached to its outer surfaces, and interrupted in places by the openings made for the café and the energy centre. As such, the bunker showcases the district, and vice versa.

C.2. Condition of the Building

Although the bunker had survived to the mid-2000s relatively unscathed on the outside, there was extensive damage to the structure and its overall condition, to the extent that it was in danger of collapse. As few useful construction plans for similar bunkers (e.g. the Arenberg Park Flak Tower in Vienna) had survived, the planners had to gradually put together a picture of the condition of the building and carry out a detailed investigation of the building components.

3D Scans and Historical Surveys

3D scans, structural surveys and concrete surveys were produced following the first tentative visits and explorations of the ruins with safety and caving equipment. The static assessments were based on current surveys, the few surviving documents or earlier surveys (last carried out in the 1990s). The results of these were checked and painstakingly recalculated and supplemented with careful suppositions. In particular, it was unclear how the roof structure of the upper floors, which had been partially preserved, had originally been calculated, measured, and reinforced, or how the strained beams, which had lost their main load-bearing structure of supports, were still holding up.

Demolition, Infill, or Redevelopment?

In addition to emergency safety measures, in 2007 three different scenarios were tested out for the further development of the former air raid bunker:

1. Demolition of the whole building, down to the foundation slab (costs: € 12.5 million)
2. Infill of the building to prevent collapse (cost estimated at € 6.5 million)
3. Safeguarding of the structure, rubble clearance, and renovation of the outer shell (cost estimated at € 5 million)

The third solution was ultimately implemented in conjunction with the chosen »Energy Bunker« usage concept, but the scope of the construction work had to be expanded significantly. The detonation had formed cracks in the outside of the building, and the long-term consequences of the blast (water infiltration, rusting, frost damage, and chipping) had taken their toll on many of the concrete building components, although the concrete, after 70 years, had otherwise fully hardened.

Extent of Damage

A schedule of the extent of the damage to the façade was made as part of the initial emergency safety measures in 2010. This included a large crack running around the building and reaching up to the third floor, along with many other cracks, instances of damage, and particularly weathered areas, especially in the corners. It was essential to renovate the outer shell and seal the roof surfaces, as if water continued to seep it would damage the upgraded inner structure once again. Many other special reports and surveys had to be carried out in the course of the planning work and during the construction phase with regard to aspects such as suspected ordnance.

Fig. 18: Interior view: inside the bunker before renovation

C.3. Planning Process

At the beginning of the project development in 2007, the planning process was dogged with uncertainty. For a long time the possibility of neither structural rescue, technical and economic feasibility of the energy concept, nor the securing of funding to cover the whole project could be assured. Nevertheless, the continual optimisation of plans and the clearly defined objectives allowed many obstacles to be eliminated with the help of the project partners.

Use Transfer

For the planning stage and transfer of use, the building was handed over to the IBA Hamburg GmbH, which in turn entrusted architects, engineers, and construction firms with further planning tasks. Plans by HHS Hegger Hegger Schleiff Architekten + Planer (Kassel) and structural engineers Prof. Bartram und Partner (Ottersberg-Fischerhude) formed the basis for the conversion, along with the energy concepts devised by Averdung Ingenieurgesellschaft (Hamburg) and Pinck Ingenieure Consulting GmbH (Hamburg), which were further developed as the project progressed.

Comprehensive Construction Site Logistics

Finally, the plans stipulated that the building should be made safe, the interior cleared of rubble, and the structure repaired, in order to prepare it for conversion. At the same time, HAMBURG ENERGIE addressed the implementation of plans for the energy systems, which concerned not only the assembly and installation of the systems within the building and on the roof, but also the construction of the heat grid. The construction site logistics in and around the building presented a major challenge for the lead planner due to the range of parallel construction and technical measures, the tight schedule in the run-up to the opening of the IBA at the beginning of 2013, and the launch of the energy supply to the SAGA »Global Neighbourhood« housing estate in late 2012.

Fig. 19: Exterior view: detail of the old bunker façade

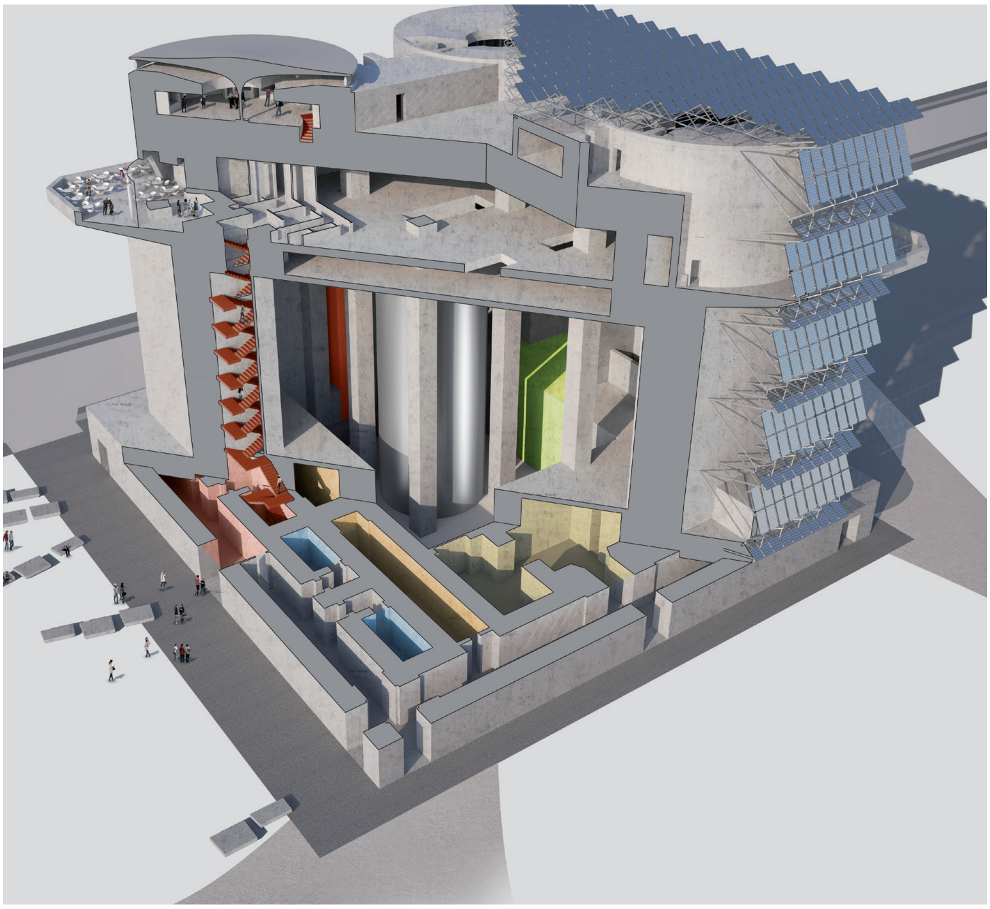

Fig. 20: Diversity: visualisation of the planning within the Energy Bunker

C.4. Partners, Funding, and Support

The Free and Hanseatic City of Hamburg was and is the owner of the bunker building, but it is represented by the State Office for Real Estate Management and Landed Property (LIG, previously the Finance Ministry/Real Estate Management) State Office for Real Estate Management and Landed Property (LIG, previously Finance Ministry/Real Estate Management, the IBA Hamburg GmbH became the official clients for the building renovation, and directed, commissioned, and co-ordinated all the planning stages. In the later stages of project development the IBA Hamburg was also represented by specialists from the local Association for Implementation of Major Construction Projects (Realisierungsgesellschaft für bauliche Grossprojekte - ReGe). The »Energy Bunker« is also a certified IBA Excellence Project.

External Project Group

The local administrative institutions (the State Ministry for Urban Development and Environment, and the Hamburg-Mitte District Authority) got together to form a project group, following which HAMBURG ENERGIE, the newly established municipal power supplier, came on board to run the energy centre and the heat grid. However, the planning, construction, and operation of the solar shell were outsourced separately to a contractor. Another branch of HAMBURG ENERGIE competed alongside other companies and was deemed to have the best tender for the implementation of this part of the project and its operation for at least 20 years.

Sub-Projects

Overall, the »Energy Bunker« project consists of four sub-projects that can be seen as strictly separate from one another according to their responsibilities, in particular in the context of the financing and funding situation:

1. Building renovation and conversion (client and support: IBA Hamburg GmbH; funding: Free and Hanseatic City of Hamburg);
2. Energy centre and heat grid (client, operator, and funding: HAMBURG ENERGIE; support: ERDF);
3. Solar shell (client, operator, and funding: HAMBURG ENERGIE; support: FHH climate protection funds);
4. Exhibition (IBA Hamburg GmbH)

The total amount of these investments was € 26.7 million gross. On top of this, the company running the café offered a private investment to set up the café.

Ongoing revenues are generated by the leasing of the building to HAMBURG ENERGIE and the operators of the café. HAMBURG ENERGIE is planning to refinance its net investment of € 9.8 million over a period of 20 years through the production and sale of energy.

Subsidy Concept

The project was highly eligible for external programme funding, and the relevant applications were made. The European Regional Development Fund (ERDF) funded the construction of the energy centre and the heat grid with a total of € 3.1 million. The money came from the 2007–2013 funding period, under field of action 1.3 ("Environmental technology, resource efficiency, renewable forms of energy"), and was made available in 2011. The City of Hamburg also funded the construction of the solar shell with € 1.3 million of funding from the Hamburg Climate Protection Concept.

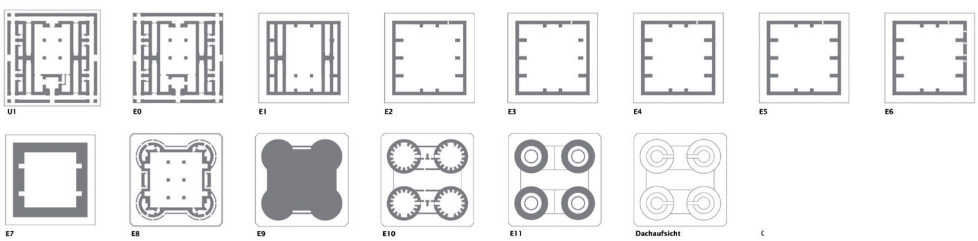

Fig. 21: Multiple layers: ground plans and roof views of the former air raid bunker before the conversion

C.5. Restoration of the Building

Before the current uses could be implemented, the ruined building needed to be repaired. The first step was to clear the interior of the bunker of the 25,000 tonnes of concrete rubble from the collapsed floors. As the original design of the bunker provided for very few openings and it was no longer accessible on the inside due to the demolition, an external staircase was built into the framework on the eastern side of the building. This allowed emergency structural repairs to be carried out on the upper floors in order to prevent collapse. During the construction phase the experts involved were faced with major problems that do not normally rear their head in »normal« construction, as described below.

Unexploded Ordnance in the Building Rubble

A 15 × 7 metre access hole was carved out of the western outer wall. Within two weeks the breakthrough was complete, and construction vehicles could enter the bunker via a ramp raised on the outside. Heavy demolition vehicles used gripper tongs to loosen and remove the concrete rubble, working carefully from top to bottom. Plans to use individual chunks of concrete for the exterior design could not be implemented due to the high cost, as the rubble would have eroded further without additional protection and might have contained the remains of munitions. The building had to be probed for unexploded ordnance by a specialised firm, and all the rubble had to be transported over the ramp by truck and disposed of externally.

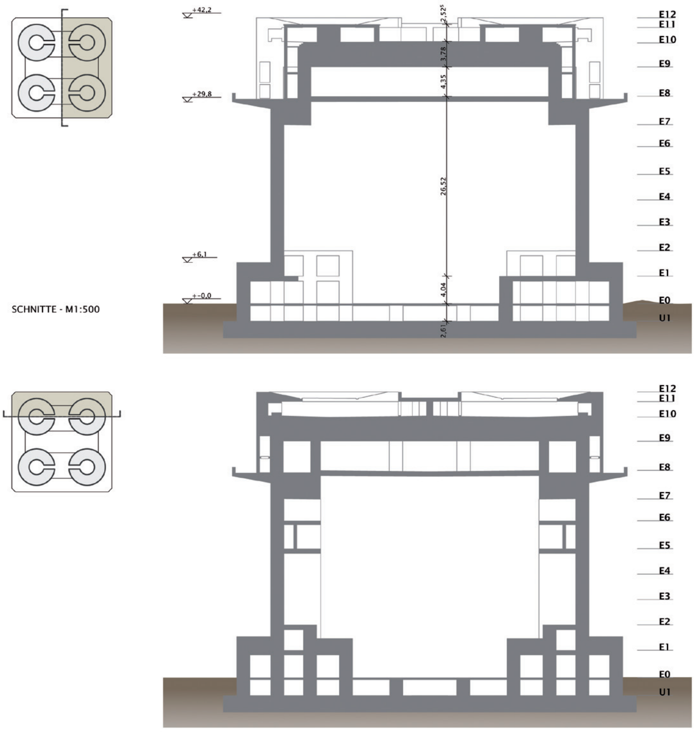

Fig. 22: Monolith: cross-sections of the former air raid bunker before the conversion

Fig. 23: Start of conversion: for construction vehicles to gain access...

Fig. 24: ... a large hole had to be made in the side

Inadequate Structural Engineering

After the remains of the ceilings, walls, and supports had been removed, from the foundation slab up to and including the sixth floor, the structure had to be restored. The solid 2 × 2 metre thick, c. 28 metre high concrete pillars and the walls of the historic supporting structure had to be rebuilt from the bottom, and connected with the suspended stumps at the top – a technically complex process. The areas created inside (upper floors, base area) were also restored. The access system, consisting of a staircase (plus an escape route), lift, and cable ducts, was also installed.

Fig. 25: Above: remains of the historical support structure

Fig. 26: After successfully joining the old and new parts of the support structure

Badly Damaged Façade

Another focal point of the construction was the restoration of the concrete façade, over 70 years old. Large-scale preservation of the original concrete façade with its surviving black camouflage could not be carried out, as the damage (e.g. cracks and chips) was worse than originally thought. In addition to the targeted elimination of individual gaps, the whole outer shell was covered with a 9 centimetre thick layer of gunned concrete. The upper cantilever slab and other roof surfaces were sealed, the drainage system restored, and functioning lightning protection installed.

Fig. 27: Affixing the gunned concrete to the outer façade

C.6. Installation of Energy-related Components

The energy concept is being implemented in stages. It was begun in spring 2012 with the first work on the energy centre inside the building. A steel tank for the storage reservoir was delivered in parts and assembled on site, before being insulated and technologically equipped. The peak load boiler was fixed to the foundation slab of the bunker at an early stage. The first part of the local heat grid was installed in the nearby »Global Neighbourhood« in 2012, laid from house to house, so that the first heat to come from the bunker was delivered on schedule to the municipal housing association SAGA GWG. The solar shell – a separate project – was installed in late 2012/early 2013.

Figs. 28–33: Fitting of the peak load boiler, assembly of solar collectors, and installation of the co-generation unit

Current State of Implementation

Large cranes lifted the steel frame in pieces onto the structure, where it was anchored to 30 centimetre thick base points on the building, exact to the millimetre. The solar modules were installed by February 2013 and connected to the energy centre via pipes. Since early 2014 the recently installed natural gas powered co-generation unit has been in operation, positioned south of the buffer storage tank and underneath the visitor balcony inside the bunker. According to current plans, it should be possible to use industrial waste heat from summer 2014 if the corresponding systems are installed in Nordische Oelwerke and the pipe to the bunker is laid.

Future Steps

The last phase of expansion for the energy centre comprises the installation and operation of the wood chip boiler in the northeast corner of the bunker and the beginning of the heating period in late 2015. The driveway for the delivery of the wood chips, the wood chip storage space, and the chimney system are already in place. The expansion of the heat grid is set to take place in stages. According to a rough plan, after the »Global Neighbourhood« (to the southwest) has been connected, three more sub-networks to the north and east will be established in succession, and consumers from those areas connected to the grid.

C.7. Creation of the Visitor Areas

The operation of the visitor café together with the public visitor areas in the bunker was put out for public tender in early 2012. Of the applications received, the bid by Waterkant – Hamburg Event & Solutions was ultimately chosen. The company comprises a team of experienced restaurateurs, club owners, and cultural workers who want to incorporate the unique location of the bunker café into their business plan in order to implement a special concept.

Café Opening at the IBA Launch

The Waterkant company was also involved in the actual design of the spaces, and was responsible for setting up the café and the kitchen. The café was completed under great pressure, allowing it to be opened at the same time as the IBA at the weekend of 23/24 March, although much work still remained to be done. The renovated viewing platform and the accompanying exhibition were opened at the same time, having been installed in previous weeks. There is a lift and escape staircase for access to and from the inside of the building. At the end point of the eighth floor is the café foyer, the coffee roasting station, and toilets; via a door visitors can go directly onto the viewing terrace that runs around the outside. Colourful, sturdy seating made out of recycled plastic, produced by the artist Gerhardt Bär and young people from the district as part of the IBA-sponsored »Social Plastic« training project, was set out for the visitors. As the bunker is not designed as a meeting place, a maximum of only 200 people may be in the building at the same time. In addition, the balcony on the second floor inside the bunker, which offers views over the energy centre and access to the turret on the tenth floor, can carry only a maximum of 30 people due to the escape routeing. Access to both areas is restricted to guided tours. Other than that, the bunker is publicly accessible.





Figs. 34-39: Creation and opening of the café, the finished front façade, and various events

C.8. Monument Protection

In 2001 the Wilhelmsburg air raid bunker was recognised by the Hamburg Monument Protection Office as worthy of protection and placed under the appropriate preservation regulations. The building's status as an architectural monument is due not only to its World War II origins, albeit a testament to Nazi ideology; rather, it also features construction elements such as the concrete façade, blackened by bitumen paint, and the blasted condition inside (including rubble). The latter also recalls the demilitarisation of Germany by the Allies.

Original Material vs Cost-Effectiveness

Due to the bunker's classification as a monument, the IBA Hamburg and the planners involved had to work closely with the Hamburg Monument Protection Office on plans for reconstruction and redevelopment. Several intense discussions explored how the building's monumental status and the original material could be preserved as effectively as possible, while also ensuring that the bunker, after the redevelopment work, could be used cost-effectively in conjunction with the new technology. Ultimately, the redevelopment and repurposing guaranteed that the building would be preserved over the long term. The architects made efforts to keep changes to the concrete components (e.g. gaps) to a minimum and to use the existing structure, in order to avoid expenditure on elaborate drilling and sawing.

Preservation of the Original Façade

The conditions accompanying the building's protected status affected minor details as well as key aspects. For instance, the solar installation was mounted on a steel structure attached to the building so that it did not distort the outline of the core structure and stood in front of the bunker. As far as possible, the interior has been kept in its original state, with necessary original components such as supporting pillars and walls added. In terms of monument protection, it was hoped that the original concrete façade could be preserved, but this was not possible due to its poor structural state and the risk of the concrete being chipped. Instead, it was agreed to provide the façade with a solid, rough, gunned concrete cladding and to preserve the »observation windows«. The old concrete façade remains visible in areas (protected from potential crumbling by grids) of these offset surfaces, which cover a total of 600 square metres.

Fig. 40: »Observation windows« on the eastern side...

Fig. 41: ...and the »old« façade on the viewing terrace

C.9. Participation and Involvement

The local people were heavily involved in the development of the project, and not only because of the strongly reciprocal nature of the relationship between the bunker and its immediate surroundings. They were informed about the status of the planning stages and construction both directly, through the appropriate bodies (e.g. the Rehabilitation Advisory Board and the IBA/igs Participation Council), and the media (e.g. district newspapers and websites). In 2010 and 2011 alone there were three open project dialogues with interested residents and other citizens, in which the project and the upcoming building work were presented. In its turn, the IBA fielded questions, suggestions, praise, and criticism.

High Noise Levels

As one result of this dialogue format, the construction processes involved in the upgrading of the façades were altered, as they were associated with unacceptably high noise levels for the residents. The issue of co-operation with the controversial, odour-emitting Nordische Oelwerke plant, which was to deliver industrial waste heat, was the subject of open and fierce discussions. As part of the range of participation initiatives, people were able to access the interior of the bunker for the first time in decades, an experience that provoked powerful emotions for many inhabitants of Wilhelmsburg.

Notice to the Sole Tenant

The reconstruction plans for the bunker had an impact on various other issues that then had to be considered, or became evident during the course of the project. The sole existing tenant and user of the bunker building, the drinks manufacturer Meerkötter, which had been based there for almost 60 years, had to be given notice due to the construction work. By mutual agreement, the

Fig. 42: A group of visitors walking to the interior of the bunker during the conversion phase

business was relocated to the nearby Veringhof complex. Paradoxically, a few months later its presence there was threatened due to firm plans by the city authorities to relocate there the opera workshops from Barmbek, in order to create space for 750 apartments in Barmbek. The users of the bunker area, often called the »Wilhelmsburger Zinnwerke« (»Wilhelmsburg Tinworks«) as an old tin processing plant once stood there, soon fought back in a creative way, and following months of "battle" on several levels they had done enough to convince the authorities that Meerkötter should relocate to another site within the city; medium-term security for the tenant was obtained.

Relocation of the Adventure Playground

Wilhelmsburg's adventure playground had hitherto directly bordered the southern side of the bunker. Its ground surface was needed for the site equipment, so the playground had to be moved to make way for the reconstruction of the bunker. A nearby playhouse for children from the Reiherstieg district was created in 2011 in conjunction with the Hamburg-Mitte District Authority, 100 metres away in the "Rotenhäuser Feld" park. The adventure playground now lies on a spacious new area formerly occupied by the old power house for the bunker, but which had to be demolished due to its poor structural condition. The playground is now provided with new storage space and enough room for creative expansion.

Rotenhäuser Feld Master Plan

The creation of the adventure playground within the park was also integrated into a planning and participation process aimed at upgrading the adjacent "Rotenhäuser Feld" area. In conjunction with the Hamburg-Mitte District Authority and in co-operation with interested local residents, a number of suggestions for improving the much-used and central yet somewhat neglected park spaces within the Reiherstieg district were developed in 2010 and 2011. Some of the ideas, such as a climbing course and a better system of paths, have already been put into action. Hands-on planning activities encourage the residents to play an active role. Other concrete suggestions were incorporated into a master plan that can be implemented gradually.

Fig. 43: Planting activity in Rotenhäuser Feld...

Immediately around the Bunker

The upgrading and improvements implemented in »Rotenhäuser Feld« relate especially to the area in front of the bunker, which is in the middle of the park. In addition to improved access to the bunker, the partial demolition and reconfiguration of Neuhöfer Strasse is also taking place directly in front of the building. The severe separating effect of this street, used by harbour traffic, has been considerably mitigated by narrowing the road lanes, creating a walk-through green island in the middle, and providing new crossings.

Environmental Protection and Nature Conservation

A sizeable bat colony that is specially protected hibernates in the bunker in winter. The construction times and tasks were adapted to conditions in order to protect the animals, and they now have special entry and exit shafts. Following the redevelopment work, the colony can still be found in the bunker and has grown slightly in numbers. Another environmentally friendly aspect of the building is its resource-efficient drainage: rainwater from the flat roof surfaces of the bunker seeps directly into infiltration ditches at the foot of the bunker.

Fig. 44: ... and explaining the plans

D. CONCLUSION AND FUTURE PERSPECTIVES

As part of the IBA Hamburg, this former air raid bunker in Wilhelmsburg has completed the transformation from dilapidated war memorial to forward-looking eco-power plant. After only a short time, the »Energy Bunker« has become a symbol of inner city urban climate protection, bringing the concept to life. It represents a milestone for »Renewable Wilhelmsburg« in a number of different respects.

Creating a Visitor Experience

The bunker, which has long towered over the rest of the district, has become more closely connected to the city. It was opened up during the reconstruction work, making its history and current usage visible. The viewing terrace, café, exhibition, and guided tours have made it a popular visitor attraction, and it continues to be successful even after 2013.

Innovative Approach

The "Energy Bunker" project attracted investment for conceptual and technical innovations that have proven worthwhile for system operators and consumers alike, and have had an impact on environmental considerations and cost-effectiveness. As a local power plant, the »Energy Bunker« is also an example of the implementation of decentralised energy policy that creates local jobs and earnings.

Local Energy Supply

Increased local energy supply and the greater efficiency of renewable systems are important to the success of the energy transition. In practice, however, highly efficient large-scale renewable energy systems are rarely able to be integrated into city districts. By using the existing bunker building, a 6.5 megawatt eco-power plant could be created with very little disruption to the surrounding residential area, and its energy has to travel only a short distance to reach consumers.

Smart Energy Mix

The fluctuating output of many renewable sources of energy can be countered by a smart combination of different raw materials and systems. Energy from the sun, industrial waste heat, natural gas, and wood chips can be incorporated in a way that is as environmentally friendly and cost-effective as possible. This also allows the reliable portion of the base load generated to increase, while reducing CO2 emissions.

Efficient Technology

For the first time ever, solar thermal energy has been used to support the supply from a heat grid. In particular, the use of high temperature collectors allows the efficient recovery and storage of heat, thus enabling solar energy to be used cost-effectively all year round. The large buffer storage tank increases not only the security of supply and the reliable use of renewable forms of energy, but also cost-effectiveness. The planned plant capacity could be reduced by almost 50 per cent via the storage capacity, as peaks in demand can be addressed by energy preproduced and temporarily stored overnight, and thus "cached" within the system.

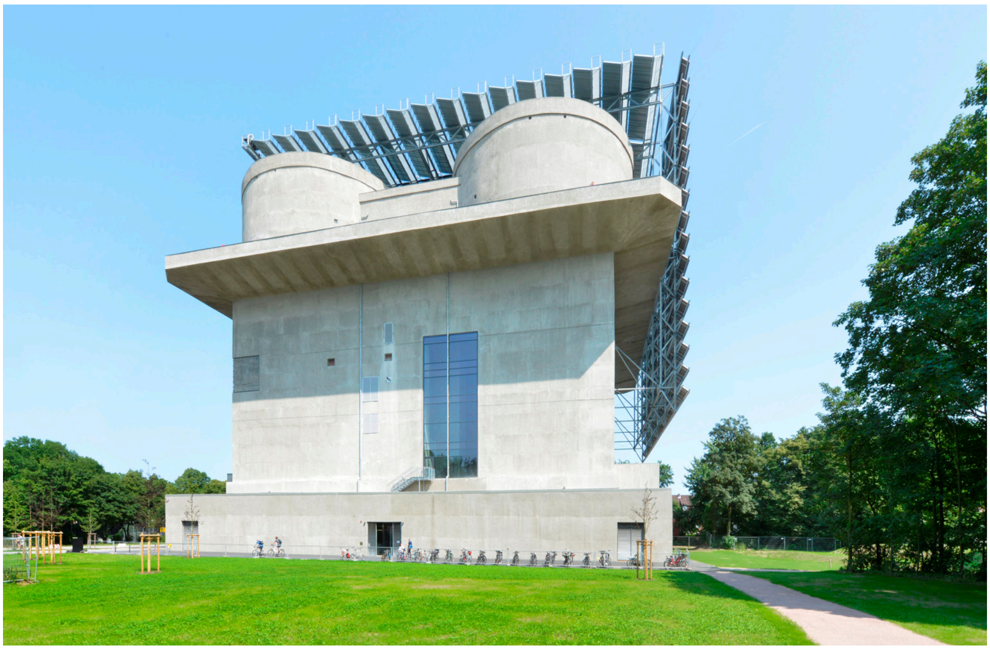

Fig. 45: Energy Bunker in the summer of the IBA Presentation Year, 2013

Key Innovations in the Overall Process

1. Use of the ruins of a former bunker for decentralised energy production within an inner city residential district

2. Mix of renewable energy sources to ensure reliable supply to the surrounding area

3. Integration of a large-scale solar unit into a heat supply network

4. Introduction of a large-scale buffer storage tank to cover peak loads at certain times of the day

5. Control and hydraulic technology for versatile input and output

6. Creation of a spectacular day trip destination for tourists and local residents, plus the opening of a monument that had been closed for decades.

Key Aspect: Structural Repair

Apart from the energy-related issues, the structural repair of the damage caused by the partial demolition decades ago presented major technical challenges. The load-bearing structure and building shell were restored following detailed surveys, accompanying safety measures and the clearance of rubble. The building thus remains a monument and a memorial to the horrors of the Nazi regime and World War II. At the same time, as an »Energy Bunker« it now has a peaceful and forward-looking purpose, namely the production and distribution of renewable energy to up to 3,000 households in the surrounding area. The specially designed exhibition on site informs visitors about both the history and the future of the bunker.

Fig. 46: First illumination of the interior, 2012

Wide Range of Uses

Unlike with other power plants, the production of renewable energy in the »Energy Bunker« can be experienced up close by members of the public. Even the architecture, with the solar shell and recessed windows, makes the special use of this building particularly conspicuous. The unparalleled views from the freely accessible viewing platform, the visitors' café and the exhibition, which is spread throughout the building, make the bunker a good day trip destination. Regular guided tours offer visiting experts, and people who are simply interested in learning more, the opportunity to discover the energy centre.

Transferability

The spatial situation of the partly demolished air raid bunker in Wilhelmsburg is an exceptional case, but the project provides encouragement for other urban structures that are seen as unusable or inconvenient to be used to produce energy. Smaller multi-storey bunkers in other districts or cities may be suitable for urban energy production or storage. By repurposing the Georgswerder landfill site to create the »Energy Hill«, the IBA was able to make part of an old urban brownfield site useable once more, and integrate it into the city more effectively. In certain cases, the somewhat fraught co-existence between residential and industrial areas within our cities may also spark new potential and lead to greater compatibility, as the use of industrial waste heat within the »Energy Bunker« demonstrates.

Perspectives

The energy concept for the »Energy Bunker«, developed as part of the IBA Hamburg and now implemented, serves as a model in a number of different ways. For instance, the storage tank provides valuable knowledge about the practicality of implementing complex control and hydraulic technology. The innovative devices and technological systems used in the bunker may also be tested and demonstrated for their State Office for Real Estate Management and Landed Property (LIG, previously Finance Ministry/Real Estate Management), Hamburg-Mitte District Authority, State Office for Real Estate Management and Landed Property (LIG, previously Finance Ministry/Real Estate Management), Hamburg-Mitte District Authority, potential applicability to other projects. The monitoring programme »EnEff:Stadt« has collated detailed performance and operational figures that permit the effectiveness of the components to be tracked. As part of the »Smart Power« project, there is also ongoing research into the possible extension of the bunker's energy production and storage capacity, as well as the further linking of smart energy networks. As such, the »Energy Bunker« is not a completed project under the auspices of a completed IBA, but rather the starting signal for the further expansion of renewable and environmentally friendly energy supply on Hamburg's Elbe Islands.

Fig. 47: »Crossing the Elbe«, a light installation by Anthony McCall, 2013/2014

APPENDIX

Prizes and Awards

Exhibited in the German Pavilion at the Architecture Biennale in Venice, 2008
http://updating-germany.de/projekte/001-energiebunker

European Solar Prize 2013
http://www.eurosolar.de/de/index.php/europ-solarpreise-2013/1813-wuerdigung-hhs-planer-architekten

Exceptional mention for the "Land of Ideas" 2013/2014 (part of the "Renewable Wilhelmsburg" Climate Protection Concept)
http://www.land-der-ideen.de/ausgezeichnete-orte/preistraeger/klimaschutzkonzept-erneuerbares-wilhelmsburg

Deutscher TGA Award, in the modernisation category, 2014
http://www.tga-praxis.de/deutscher-tga-award

Nominated for German Design Award 2015
http://www.german-design-council.de/nc/designpreise/german-design-award/2015.html

Further Links and Information

Neues Leben für ein Mahnmal, NDR.de, 2011
http://www.ndr.de/ratgeber/reise/hamburg/Energiebunker-Neues-Leben-fuer-ein-Mahnmal,energiebunker111.html

Energiebunker Wilhelmsburg, Behörde für Wirtschaft, Verkehr und Innovation, 2013
http://www.hamburg.de/efre/3120246/energiebunker/

Projekt Energiebunker, HHS Planer und Architekten GmbH
http://www.hhs.ag/projekte-infrastruktur-energiebunker.de.html

Vorzeigeprojekt: Der Energiebunker in Wilhelmsburg, Hamburger Abendblatt, 2013
http://www.abendblatt.de/wirtschaft/article114595938/Vorzeigeprojekt-Der-Energiebunker-fuer-Wilhelmsburg.html

Erneuerbare-Energien-Kraftwerk im ehemaligen Flakturm, Baunetzwissen.de
http://www.baunetzwissen.de/objektartikel/Heizung-Energiebunker-Wilhelmsburg_3146129.html

Flakbunker - Zeugen der Geschichte des Zweiten Weltkriegs, Geschichtswerkstatt Wilhelmsburg & Hafen
http://www.geschichtswerkstatt-wilhelmsburg.de/bunker/flakbunker-geschichte/

Bunker als Öko-Kraftwerk, Frankfurter Allgemeine Zeitung, 2011
http://www.faz.net/aktuell/wirtschaft/immobilien/planen/umnutzung-bunker-als-oeko-kraftwerk-1651918.html

Reisetipp Hamburg, Süddeutsche Zeitung, 2013
http://www.sueddeutsche.de/reise/insidertipps-fuer-die-staedtereise-hippes-hamburg-1.1674524-8

Elbinselreportage Energiebunker Wilhelmsburg, Hamburg 1 (Video)
http://www.hamburg1video.de/video/iLyROoafz0-3.html

List of Illustrations