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THROUGH POSITIVE
ENERGY DISTRICTS

TRANS-PED CASE STUDY **BRUNNSHÖG**

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Brunnshög is a sustainable neighbourhood that is currently being developed on the outskirts of Lund, a city of approximately 100.000 inhabitants in the south of Sweden. The neighbourhood will include Sweden's two largest research facilities (MAX IV and ESS) and will house up to 40.000 people living and working there by 2050. While Brunnshög will be a green district with large parks, courtyards, and pedestrian and cycling infrastructure, the project also aims to create a range of sites that support new connections and collaboration between researchers, entrepreneurs, and businesses. Brunnshög has a strong sustainability agenda, aiming to produce more energy than it needs, while promoting cycling, walking, and public transportation over other mobility options.

DIMENSION 1

TIME

PROJECT HISTORY

The Brunnshög project started in 2009 after the decision to locate two research facilities, ESS and MAX IV, in the outskirts of Lund. At the site, the city of Lund is developing a sustainable district that integrates the research facilities into an urban context. As such the city aims to develop the full potential of these major investments.

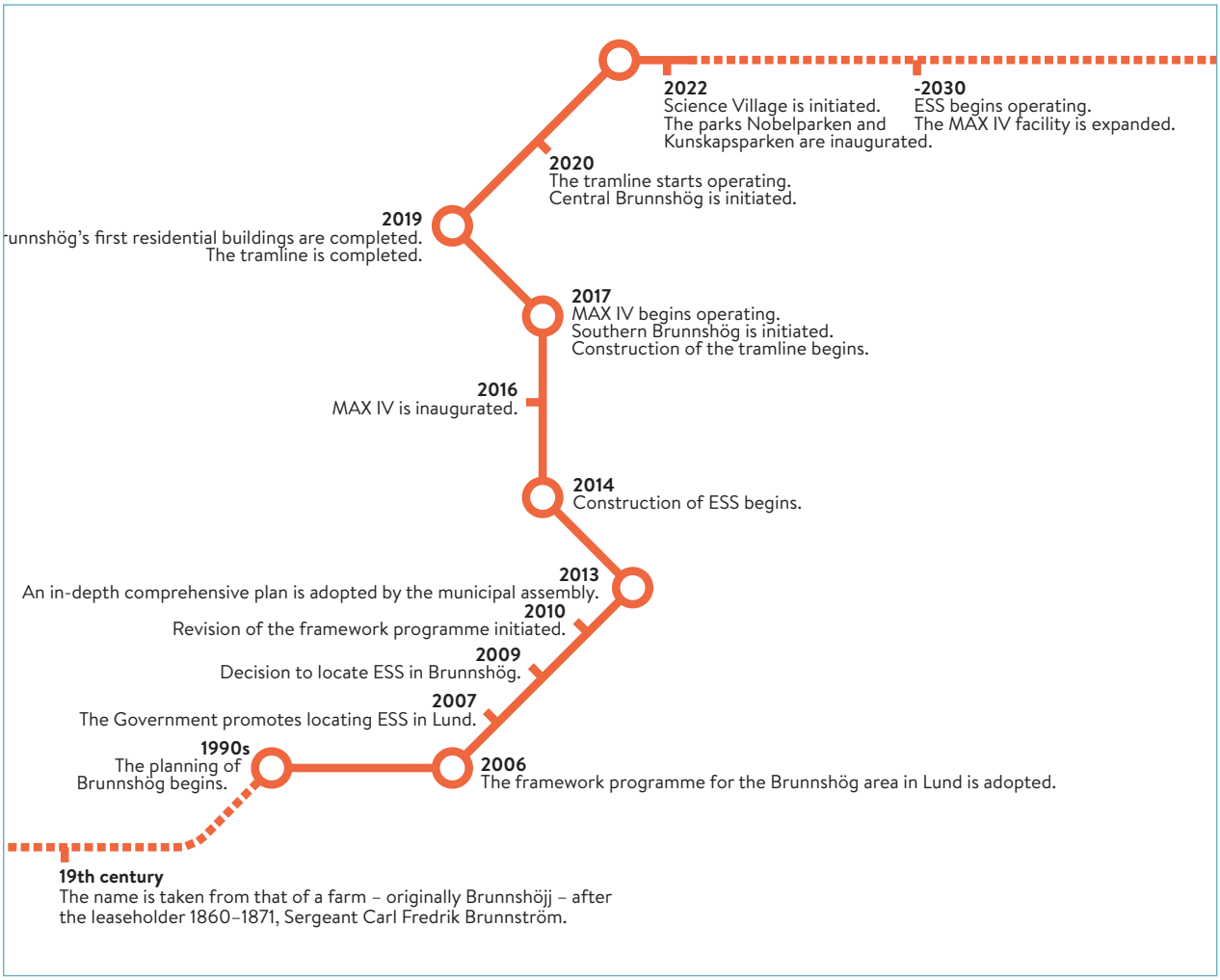

figure 1: timeline of the Brunnshög project (City of Lund)

The district, which is expected to accommodate about 40 000 residents and workers in the long term, is currently being built. The first stage area, southern Brunnshög, is almost completed, providing a glimpse of the environment that is planned for the entire district - a dense and urban environment, built on a human scale with pedestrian-friendly amenities.

More than ten years have passed since the project started, and much has happened along the way. In 2019, the first residents moved into what then was still considered to be a large construction site. The same year, the municipal power company Kraftringen inaugurated the world's largest low-temperature district heating network, powered by the excess heat generated by MAX IV and - when it is in operation - ESS. In 2020, the tramway connecting Lund's new district to the city center was opened, offering a smooth and environmentally friendly transport option with high capacity for residents, workers, and visitors. In 2022, the district's large parks - the 21-hectare Kunspasparken and the 4-hectare Nobelparken - were inaugurated to attract both Brunnshög residents and people from Lund to the new district.

Today, some 1 600 people live in Brunnshög and the district is a dynamic and rapidly evolving neighbourhood committed to innovation, sustainability, and quality of life. However, the journey towards becoming a PED and achieving Brunnshög's vision – summarized in the project's tagline 'a future to believe in' – has just begun.

MAIN REFERENCE(S)

- The History of Brunnshög from Prehistoric Times to the Future [book], 2020 (in Swedish and English)

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PROJECT AMBITIONS

When the visions for Brunnshög become a reality, an inspiring and global living environment where up to 40 000 people live and work will have been created. Brunnshög is home to top-class facilities and laboratories, in parallel with a dense and varied urban environment that contains various types of houses and lush parks, shops and schools, workplaces and services.

The strategy for Brunnshög can be divided into three main components:

1. **knowledge intensity:** The world's premier research and innovation environment is being developed, with MAX IV and ESS as the initial driving force.
2. **sustainable urban planning:** Brunnshög becomes a knowledge-intensive and global living environment where new solutions for sustainable urban development are constantly being explored.
3. **regional attractiveness:** An international destination for knowledge, culture and recreation is being created and will inspire new discoveries and new knowledge.

MINIMISE, BALANCE AND MAXIMISE

Brunnshög will point the way to a smarter and more sustainable society. At the same time, sustainability is a broad term that needs to be more clearly defined to be useful. That is why three profile areas have been created – minimise, balance and maximise.

MINIMISE

Minimising the climate impact caused by urban expansion involves producing sustainable energy, reducing energy use and adapting the urban environment to climate change so that it can cope with the effects of a changed climate. In other words, the plan is to make it easy in Brunnshög to live in a climate-smart way.

How the Brunnshög project aims to minimize climate impacts:

- The world's largest low-temperature district heating system utilizes residual heat from the research facilities.
- The tramway from Lund Central Station to ESS provides low-carbon mobility.
- 92% of the buildings in Brunnshög have their own solar energy production.
- 92% of the apartment buildings offer carpool membership.
- Energy-efficient buildings help reduce the district's carbon footprint.

BALANCE

Balancing and compensating for the fertile arable land that disappears when the area is developed is one of the main tasks. Opportunities and methods for saving arable land and increasing biodiversity are investigated early on in the expansion process – the vision is for 30 per cent of exploited land to be restored to cultivable land in the future. Urban farming will become a natural and visible part of the urban environment in the project.

How the Brunnshög project aims to balance land use:
- Building densely and close to public transportation to optimize land use.
- 96% of the buildings offer the possibility of gardening on the property.
- Sweden's largest vacuum waste collection system provides space-efficient waste management.
- The public spaces incorporate edible plants, and instead of lawns, bushes and perennials will be planted in the common street areas.

MAXIMISE

Maximising sensations means focussing on the human and creating an environment where many people thrive. The physical design of the area is intended to make it easy for people to see each other and meet. Brunnshög wants to become a neighbourhood to be proud of, where it is as easy to find new acquaintances as it is to find a relaxing spot to linger.

How the Brunnshög project aims to maximize sensory experiences:
- Build the tramway and parks before the buildings.
- Diverse housing types including single-family, multi-family, architect-designed houses, and co-housing.
- A dialogue project to involve the people of Lund in the development of Brunnshög.
- Open stormwater management, where greenery provides blue benefits.
- The vacuum waste collection system enables streets designed for people rather than vehicles.

THE ONE-THIRD TARGET

A maximum of one third of all traffic to and from Brunnshög will be by car, at least two thirds will be by bike, on foot or public transport. This may not sound like an ambitious goal, but Brunnshög's close proximity to the E22 highway makes it more challenging to realize the vision of a car-free life. The ambition of the one-third objective is evident in several ways: streets and squares are planned with a focus on pedestrians and, at the same time, create environments that are exciting and stimulating to be in, the majority of residents are closer to the tram than to their car and there are strict requirements in place to guarantee ample bike parking.

MAIN REFERENCE(S)

- Lund NE/Brunnshög Vision och Mål [project vision], 2012 (in Swedish)
- Fördjupning av översiktsplanen för Lund NE/BRUNNSHÖG [comprehensive plan], 2013 (in Swedish)

DIMENSION 2

SPACE

GENERAL SPATIAL CHARACTERISTICS

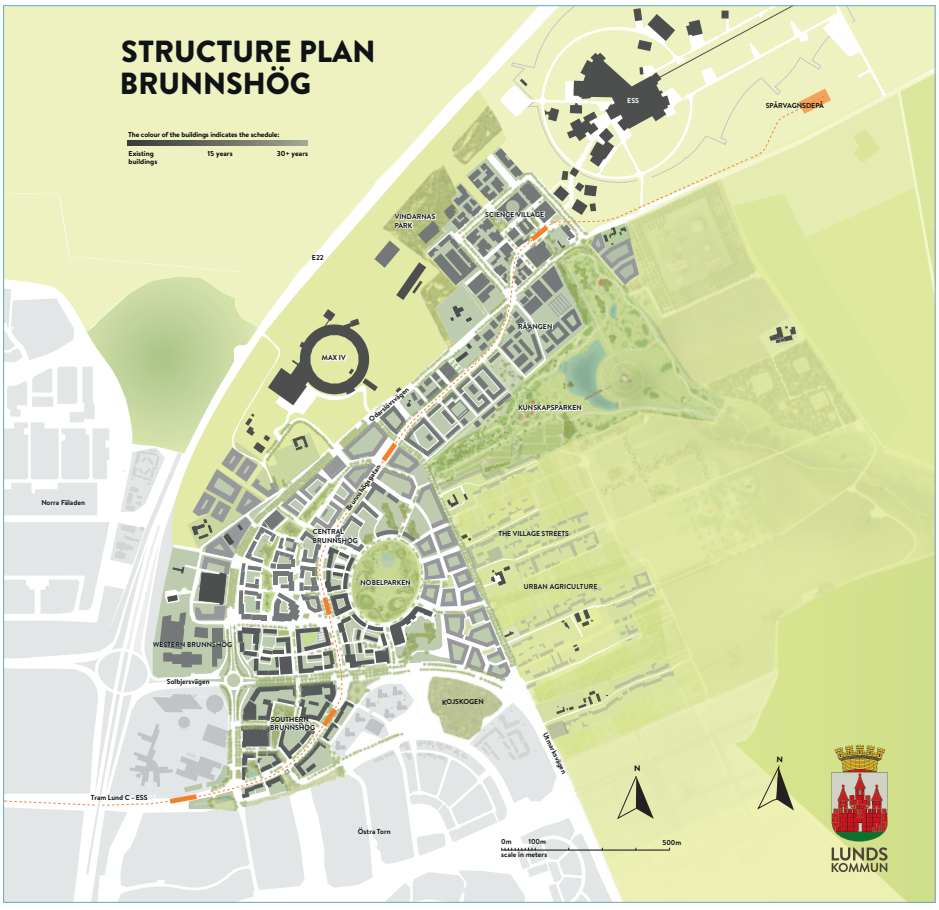

figure 2: map of Brunnshög (City of Lund)

The area of the Brunnshög project is located to the north-east of the city of Lund. Historically it was used for agriculture. The area was an old land reserve owned by the City of Lund for future development. A total of 225 hectares of land will be transformed into an urban living environment for the 40 000 people who will live and work in the district. Brunnshög is located about five kilometers from Lund city center. The journey by tram takes nine to fourteen minutes. The basic module of Brunnshög´s main street grid consists of two basic blocks, about 60 by 60 metres, with an internal green-blue thoroughfare between them. The public spaces encourage activity, spending time together and encountering neighbours. Although the neighbourhood is being expanded over a long period and is subdivided into several project areas, common spatial objectives have been formulated to bring coherence to the neighbourhood.

figure 3: map showing the location of Brunnshög in relation to Lund's city centre and main supra-local functions (City of Lund)

Places and activities are being created with a focus on the stimulation of social interaction between people in the neighbourhood. The Brunnshög planners hope this will contribute to strengthening people's well-being and happiness in the neighbourhood.
Parks and greenery is another focus point in the development of the district. Brunnshög´s big parks – Kunskapsparken and Nobelparken – were opened long before the buildings around them were built. There are several reasons for this: residents have access to great green environments that improve their quality of life, the greenery gets time to grow and the parks fulfil important stormwater management functions.

The planning in Brunnshög is based on the tramway, which runs from Lund Central Station through the entire Brunnshög neighbourhood to ESS. The street itself was designed to be as narrow as possible to encourage resident interactions, and it has a curved design - instead of a straight one - to minimize the effects of the windy conditions in Brunnshög. The benefits of the tramline are obvious – trams can transport a lot of people, they are environmentally friendly and do not release any emissions.

The tramline is a part of the one third target – a maximum of one third of traffic to and from Brunnshög will be in cars. To make this a reality, it requires more than just a tramway or good bicycle paths. To encourage more people to discover the benefits of a car-free life, environments must be built that are pleasant to be in. The planners intend to make it more enjoyable and inspiring to walk to the tramway or ride a bike compared to driving a car, so more people will choose sustainable transportation.

MAIN REFERENCE(S)

- Fördjupning av översiktsplanen för Lund NE/BRUNNSHÖG [comprehensive plan], 2013 (in Swedish)

BUILDING TYPOLOGY

figure 4: the Solbjerstorget square in southern Brunnshög (City of Lund)

figure 5: representation of a typical building block of Brunnshög (City of Lund)

figure 6: a completed part of the Brunnshög project (City of Lund)

The block format provides the prerequisites for various programmes and typologies, as well as flexibility for future changes to the plan. The varied buildings and planning of Lund´s medieval city centre —with its winding streets and broken sightlines—serves as a model. With a basic height of 4 to 5 floors, the buildings are of a suitable height to establish a connection between them, the streets are not too wide and are designed to encourage greeting acquaintances across the street, while the squares invite relaxation and social interactions. The neighbourhood is designed as a pedestrian-friendly environment which also provides the opportunity for smaller shops and services. The buildings are mixed, with different forms of tenure and housing, which enables more people to live and work in Brunnshög. In this way, the city wants to develop Brunnshög on 'a human scale' with close proximity between residents. The buildings are mixed, with different forms of ownership to allow more people to live and work in Brunnshög.

One of the reasons why the buildings can be kept relatively low is that a 36-story high-rise building will be built at Brunnshög Square - the district's hub and core. In addition to increasing the level of development in Brunnshög, the building will create the critical mass that is necessary to realise a vibrant, large square in the district.

MAIN REFERENCES

- Kvalitetsriktlinjer Centrala Brunnshög [visual quality plan], 2017 (in Swedish)
- Dispositionsplan Centrala Brunnshög [structure plan], 2015 (in Swedish)
- Södra Brunnshög GestaltningsPM [design guidelines], 2016 (in Swedish)

DIMENSION 3

SOCIAL

SOCIO ECONOMIC PROFILE

Since most of the quarters are currently in the construction or planning phase, access to socio-economic data in Brunnshög is somewhat limited. As of 2023, approximately 1 600 people live in Brunnshög. Most of the inhabitants are 20 to 29 years old (42 %), which is higher than the rest of Lund. As a result, there are more single-resident households in Brunnshög than in Lund as a whole.

A MIXED DISTRICT

Brunnshög is being built with mixed functions in mind. In the planning of the neighborhood, the goal is to achieve a 50/50 distribution of owner-occupied and rental housing. Beyond this mix of ownership, apartment sizes will be allocated for both single occupants and large families. Currently, Brunnshög has a slight majority of rental housing, but due to upcoming land allocation competitions, the district will soon achieve an even distribution of privately-owned and rental housing. To create a pleasant urban environment, the cityscape must serve as a multi-functional environment with offices and businesses complementing residential areas. Several office buildings are currently being constructed in central Brunnshög in the future workplace area.

figure 7: a visualization of the envisaged atmosphere in the district (City of Lund)

ROOMS (+KITCHEN)	1	2	3	4	5+
Rental apartments	230	531	184	46	6
Co-operative housing (bostadsrätt)	88	300	154	132	37
Ownership (ägarlägenheter/äganderätt)	9	65	34	9	31

table 1 - estimated number of completed apartments by 2025

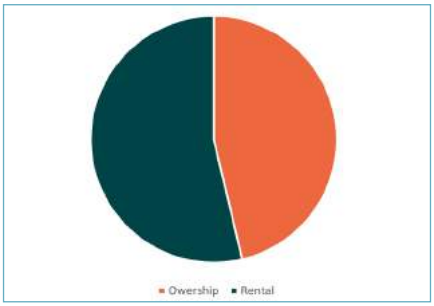

figure 8: distribution of rental and owner-occupied housing in Brunnshög (City of Lund)

A GLOBAL DISTRICT

The two research facilities and the companies already present in and around Brunnshög attract people from all over the world. This makes Brunnshög a global and multilingual districts. Among the 1 600 people currently living in Brunnshög, there are 79 different countries represented. The two most dominant nationalities (besides Swedish) are Chinese and Indian.

ENERGY-RELATED ASPECTS

NEW DISTRICT HEATING MODEL

The new district heating grid is designed as a low-temperature system.
This has several advantages: it means lower heat losses and it makes it possible to use new types of plastic piping. This makes it cheaper to build and operate and has resulted in a new pricing model with lower costs for residents.

DIMENSION 4

ENERGY
(AND OTHER METABOLIC FLOWS)

ENERGY FLOWS

LOW TEMPERATURE DISTRICT HEATING

District heating is the norm in all of Lund. In Brunnshög, a new and innovative system that utilises waste heat in a low-temperature (65°C) network is being constructed. Once finished, it will be the world's largest low-temperature heat network. Today, about 30 GWh of heat is generated by the MAX IV research facility. When ESS operating at its full potential, another 200 GWh of district heating will be available. The environmental performance of the district heating is very good: it's primary energy factor is below 0.04. The district heating network is owned and operated by Kraftringen, a municipally owned energy company based in Lund.

figure 9: the MAX IV research facility that provides residual heat to Brunnshög's district heating system. (City of Lund)

LOCAL ELECTRICITY PRODUCTION AND ENERGY-EFFICIENT HOUSINGHEATING

Most buildings have their own electricity production (mainly PV panels) and some have batteries for storage. Electricity that not used in Brunnshög is sold on the open market (Nordpool) to an electricity supplier. Additionally, all buildings in Brunnshög are new and must follow the current Swedish energy performance standards. In Brunnshög, most buildings perform better than the legal minimum requirements. The fact that energy performance is taken into account as a criterion in the competition for Brunnshög land purchases has resulted in the largest concentration of 'plus energy buildings' in Sweden. Moreover, the first climate neutral buildings (construction and operation) are now in the planning phase. This makes it possible for the buildings to maximise the use of the low-temperature district heating network.

ELECTRICITY IMPORTED TO THE DISTRICT

Additional demand is met by imported electricity and each property owner or tenant can choose their own provider. The electricity grid is owned by Kraftringen.

OTHER METABOLIC FLOWS

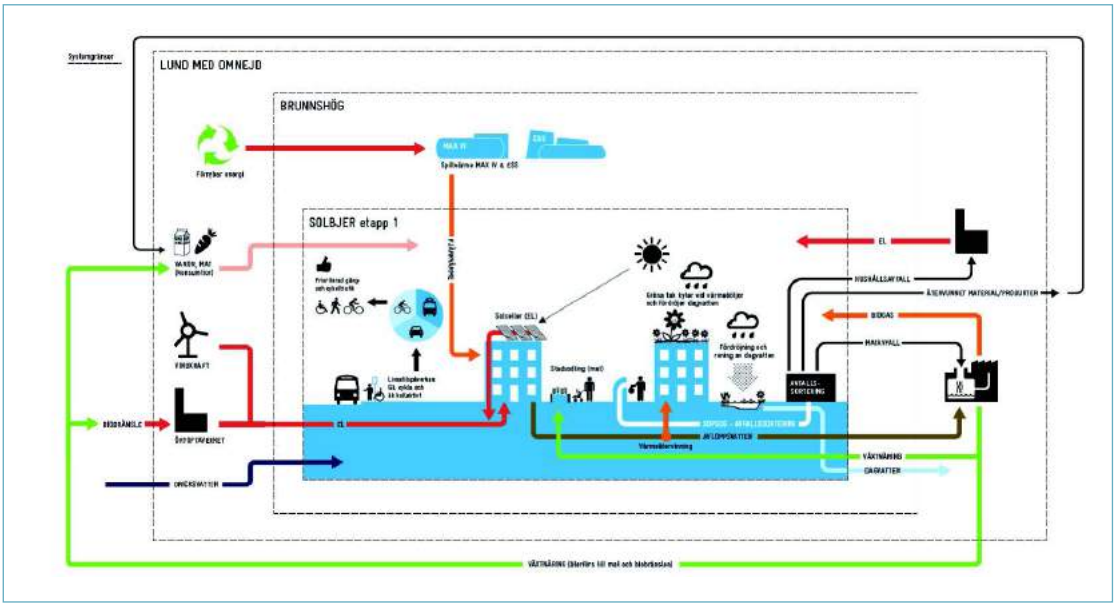

figure 10: schematic representation of energy and other metabolic flows in Brunnshög (City of Lund)

SOLID WASTE

Solid waste is collected locally in eight fractions: four by a vacuum waste collection system and four by large underground waste storage containers. Other types of waste can be taken to recycling centres. All waste is transported to Malmö for treatment (less than 20 km from Lund). Food waste becomes biogas and biofertilizer. Metal, cardboard, paper, and plastic is recycled mainly as materials. The residual fraction of waste is incinerated to generate electricity and district heating in Malmö. The waste is collected by the city's sanitation department (Lunds *renhållningsverk*). After collection, it is transferred to Sysav in Malmö. Sysav is owned by 14 municipalities in southern Scania with Lund as the second largest owner.

SEWAGE

The sewage system in Brunnshög is connected to a wastewater treatment plant in southern Lund. The generated sludge is used to produce biogas. This system is owned and operated by VA Syd, a company owned by six municipalities with Lund as the second largest owner.

DIMENSION 5

GOVERNANCE AND POLICY CONTEXT

PROJECT'S GOVERNANCE STRUCTURE

The Brunnshög project is a cross-departmental project led by the City of Lund. It was initiated to promote the development of the two research facilities (MAX IV and ESS). Together with several other stakeholders, the city used the development of these facilities as an opportunity to develop a highly ambitious sustainable district in Brunnshög.

The city of Lund owns the land in Brunnshög until construction begins. To build in Brunnshög, interested developers must win a land allocation competition. In these competitions, the developer proposals are assessed on several criteria including sustainability, energy solutions, and cost.

Before a construction project is initiated, there is a dialogue between the city of Lund and the developer. This dialogue results in a document that describes Brunnshög's sustainability goals and the role of the city of Lund. It also contains proposals for how the developer can work with the sustainability goals. The activities the developer then chooses are summarised in an action program.

ACTORS

CITY OF LUND

The development of Brunnshög draws upon expertise from several departments at the City of Lund. The shared mission is to refine the land holdings of the municipality to create a district at the forefront of urban development. The team includes a project manager, architect, land development engineers, landscape architects, planners, traffic planners, utility coordinators, communication specialists, and a project coordinator.

THE MUNICIPAL COMPANIES AND THE BRUNNSHÖG CONTRACT

To encourage developers to invest in Brunnshög, the city needs to define its role. Thus, the city and its municipal companies created the Brunnshög Contract, an agreement between the city of Lund, Lunds Renhållningsverk, Kraftringen and VA Syd describing the infrastructure networks in Brunnshög (energy, water, sewage and solid waste). The purpose is to create efficient and sustainable supply systems for a neighborhood with very ambitious goals. The world's largest low temperature district heating network and one of Sweden's largest waste vacuum systems have emerged from this contract.

DEVELOPERS IN BRUNNSHÖG

Today, about 30 developers have built, are building, or are planning to build in Brunnshög. A developer is granted a building right by winning a land allocation competition. In the competitions, the project that has the highest quality is proposed as the winner. Sustainability has been a consistent criteria in all land allocation competitions in Brunnshög, but contractors have also won land allocation on grounds such as architectural quality or their bid price. Through this method, the city will ensure that Brunnshög is at the forefront of testing new innovations and promoting sustainable construction.

By combining the testing of new innovations with sustainable construction, Brunnshög hopes to become a model for other areas and cities in promoting technological advances while simultaneously reducing environmental impacts. The city also hopes to attract researchers, innovators, and companies to this dynamic and sustainable environment.

MAIN REFERENCES

- Brunnshögskontraktet [Brunnshög Contract],2013 (in Swedish)
- Hållbarhetsöverenskommelse [development contract], 2020 (in Swedish)

POLICY CONTEXT

The ambitions for the district were established in a program that was agreed upon by local politicians in June 2012. The adopted 'vision goals' are ambitious and are intended to stimulate innovation and to be revised and updated in the coming years. The sustainability goals for Brunnshög are based on the principles of minimizing, balancing, and maximizing, namely:

- **Minimize climate impacts**
- **Balance the good earth**
- **Maximize experiences**

Brunnshög has a development period of at least 40 years, a timeframe that means specific 'stage goals' need to be continuously adjusted as the world changes. Since these vision goals are ambitious and difficult to achieve, they have to be realised in a much longer timeframe than the stage goals. With today's technologies and practices, they are likely to be impossible to reach and will require new methods, innovations, and a strong will by all stakeholders.
The vision goals should inspire and bring stakeholders together to think and act differently. The vision goals need to encourage stakeholders to abandon "business as usual" practices. Broad collaborations between all stakeholders are necessary to achieve the vision goals. The stakeholders recognize that there is a gap between the current situation and the vision for the district. Regular follow-ups and an iterative collaboration model involving the city, university, and business sector can gradually enable progress towards the vision goals. The vision goals are not just inspiring descriptions of a desired future but are quantified. It is provocative to concretize the vision, but it is hoped that this can also provide a foundation for an important discussion about what is possible, impossible, desirable, and credible.

STAGE GOALS

To fulfil the vision goals, all stakeholders need to make their utmost effort starting from the initial stages. The goals are divided into concrete, measurable, and trackable objectives for each construction stage. The requirements will become higher with each step as technologies are developed and lessons are learned from previous stages.
Before each new stage, common goals are established. Once the stage is completed, an evaluation phase follows. The formulation of goals for upcoming stages occurs through an iterative process, where lessons learned from previous stages are taken into account. A crucial part of the evaluation involves the identification of specific development needs. Innovations will be necessary to achieve the various goals, and the process will also generate new ideas. In this way, the area will both attract and generate innovations.
Since the district will be developed over a long time period, there are ample opportunities to evaluate behaviours, i.e., the opportunities for the residents to make sustainable living choices. This is of central importance for the district to successfully achieve its vision goals.

MAIN REFERENCES

- Hållbarhet i Brunnshög [sustainability goals], 2022 (in Swedish)
- Lund NE/Brunnshög Vision och Mål [project vision], 2012 (in Swedish)

FOCUS

PARKS AND INFRASTRUCTURE FIRST

Traditionally, urban development projects in Sweden focus on constructing buildings first, with infrastructure and parks coming later. In Brunnshög, the opposite was done. The creation of the parks and the construction of a tramway was prioritized over the development of the surrounding buildings. As a result, the very first project inaugurated in the Brunnshög project area was the southern Brunnshög neighborhood park, Gryningsparken.

figure 11: the tramway that links Brunnshög to Lund's city centre and serves as the backbone for its development. (City of Lund)

By establishing the tramway, residents living in Brunnshög have access to high-quality public transportation from the first day they move in. At the same time, it provides stability for future developers in Brunnshög, as a tramway is a permanent fixture and not easily relocated compared to, for example, a bus line. The tramway between Lund Central and ESS opened in December 2020.

With respect to the parks, the residents and workers in Brunnshög have access to large green areas from day one. Additionally, the parks have time to mature and grow. Moreover, the parks play an important stormwater management role. Without having the parks in place, certain parts of Brunnshög cannot be developed. The green recreational spaces thus serve a crucial function as 'blue' infrastructure.

The larger parks in Brunnshög have already been inaugurated. The 3.8-hectare Nobelparken was completed in the summer of 2021 and the 21-hectareKunskapsparken that connects Brunnshög to its rural surroundings was inaugurated in the summer of 2022.

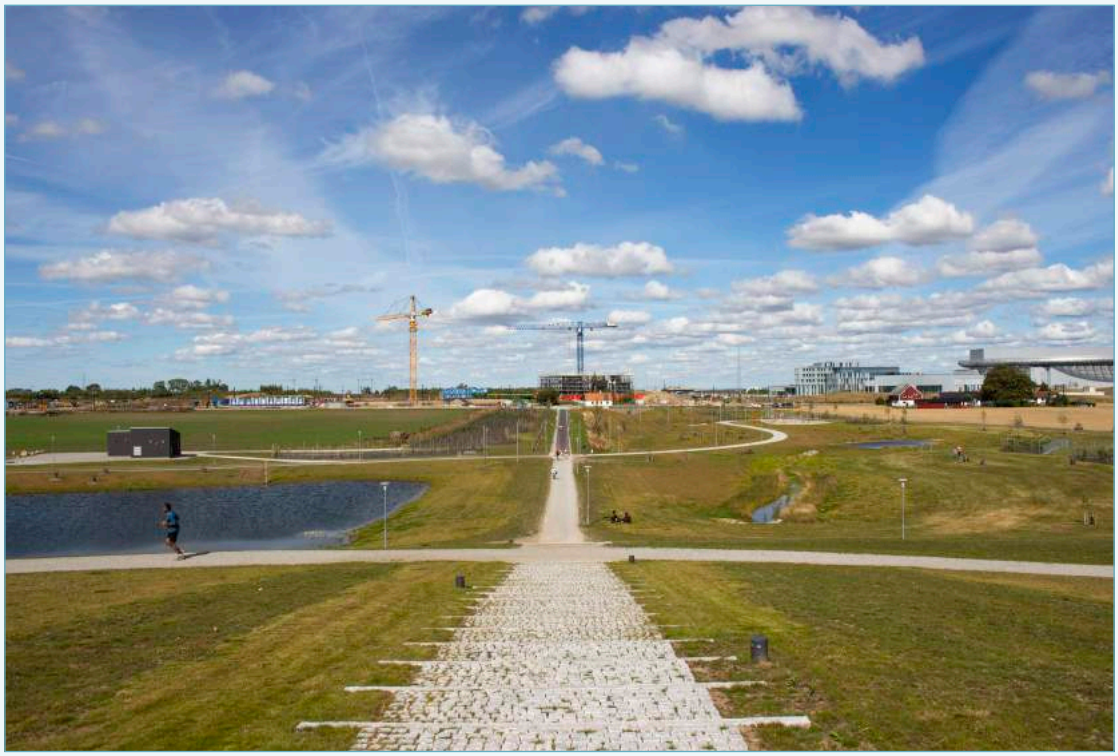

figure 12: Brunnshög's Kunskapsparken (City of Lund)

Not all of Brunnshög's advanced infrastructure is visible. The underground includes the world's largest low-temperature district heating network powered entirely by the excess heat from MAX IV and ESS. The system could actually provide heating for ten fully developed Brunnshög areas. Sweden's largest waste vacuum system is also located underground.

Plastic, cardboard, food, and household waste are transported at speeds of 70 km/h to a central waste center. This eliminates trips for large garbage trucks, reducing traffic-related environmental impacts and allowing for the creation of more intimate and pleasant streets. The low-temperature district heating network was inaugurated in 2019, and the waste vacuum system became operational in 2022. This infrastructure was designed through close collaboration early in the development of Brunnshög.

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