ETH zürich

The energy of tomorrow

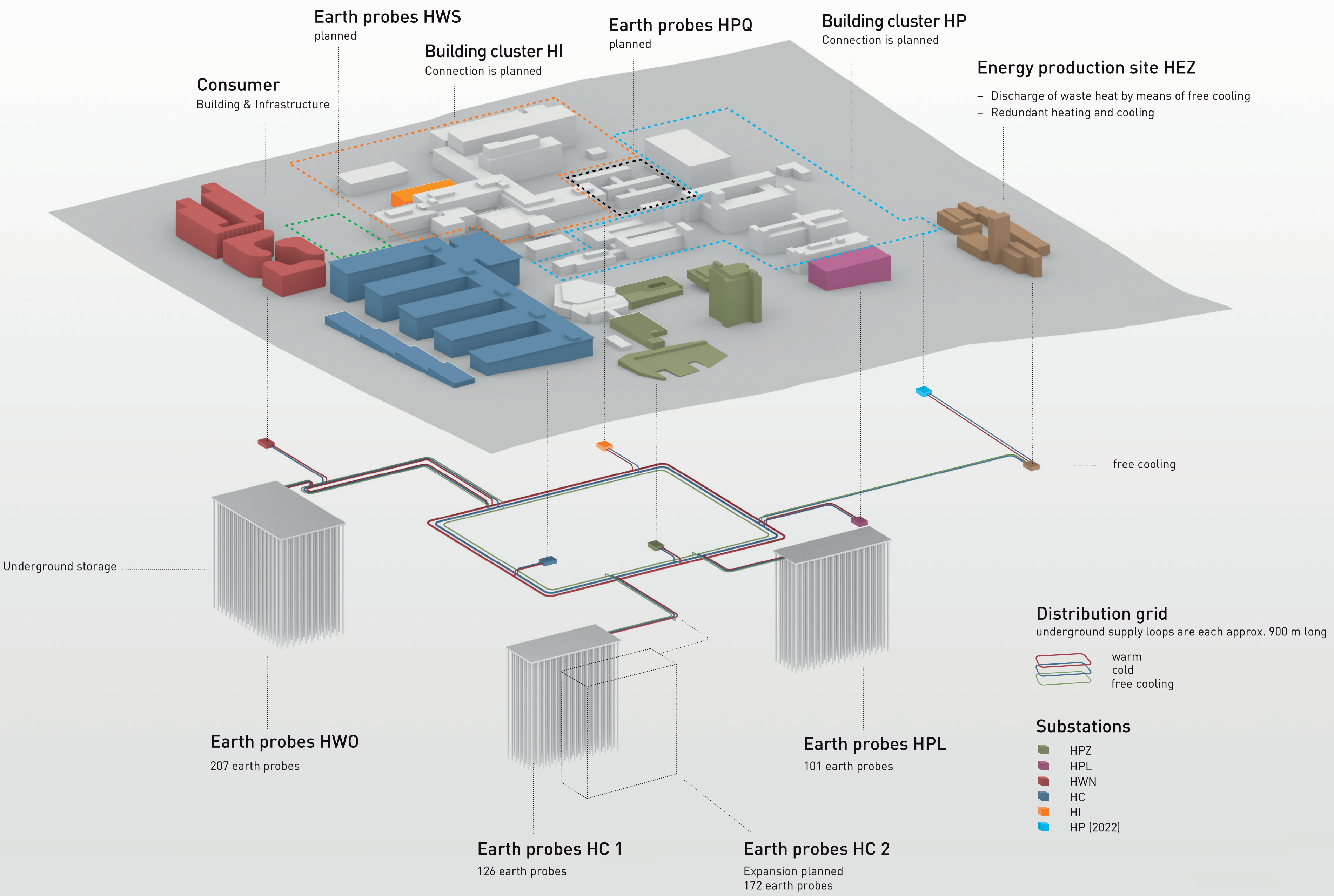
Anergy Grid Campus Hönggerberg – a dynamic underground storage system

Real Estate Management

ETH Zurich's Hönggerberg campus is almost a neighbourhood in its own right. Here, over 12,000 students and staff occupy more than 30 buildings and consume almost 77 gigawatt hours of energy (electricity and heat) per year, of which around 22 gigawatt hours are for heating alone. Until 10 years ago, heat was generated almost entirely from natural gas. In 2006, ETH Zurich's Executive Board set itself a target of a 50 percent reduction in the campus's CO_2 emissions by 2020. This represents a saving of 5,000 tonnes of CO_2 per year.

The Anergy Grid – a dynamic underground storage system – will massively reduce the central heat and cold production in the energy production site HEZ in the long run and make a significant contribution to achieving the above goals. This is achieved by an intelligent networking of heating sources and sinks in combination with a seasonal shift. In this way the fossil energy demand and thus the CO_2 emissions are reduced. Simultaneously a stabilisation of the heating demand is realised by means of a technical and construction efficiency increase. The cooling demand can also be stabilised in medium term, but it increases again due to the new buildings.

ETH Zurich, Campus Hönggerberg
Anergy Grid



Anergy Grid
Campus Hönggerberg

Since 2013 the Anergy Grid at Campus Hönggerberg is in operation and being continuously expanded. In the year 2019 the system consists of three underground storages and five substations, which supply 14 buildings with heat and cold. Three further underground storages and an additional substation are planned to assure that new and renovated buildings can be supplied from the Anergy Grid.

Energy flows
If a substation requires heat, it is supplied from one of the other clusters or underground storages via the grid. If there is waste heat in a cluster, which cannot be directly used in the associated buildings, it is – depending on the operating mode – directly used by other clusters or stored in the underground storage, where it is available for later use.
The temperature level of the water-bearing warm supply loop varies between 8°C and 22°C, the water in the cold supply loop is four Kelvin lower. It is the objective to keep the temperature level in the storages low in May (end of the heating period - 8°C/4°C), in order to maximise the cooling capacity for summer. At the end of September – after the regeneration of the underground storages – the grid has the highest temperatures (22°C/18°C), what allows an efficient heat production in the following heating seasons.
A substation covers the heating and cooling demand of an associated building cluster by means of heat pumps and exchangers. The most efficient type of operation is the autonomous operation, which works without the Anergy Grid and mostly occurs in the transition period. Incurring cold from the heat pumps can then be used in the same substation directly for covering the cooling in air conditioning or for pre-cooling of laboratory cooling water. If a surplus or deficit of heat is present, the Anergy Grid compensates it.
The ideal operation is defined by the continuously prepared energy balance and assures the respective requirements to the superordinate control system. Under consideration of the energy and performance balances a continuous expansion of the grid as well as a flexible adjustment to changing requirements take place. The chosen hydraulics has the decisive benefit that the total system is only active in case of a cooling or heating requirement and that only then water is circulating in the distribution grid.

Operation
Based on the continuous monitoring of the overall system and comprehensive plausibility checks of the relevant dataset, the first operating years have been evaluated. In 2016 the coverage of energy requirements was at 81 per cent for the useful heating demand and at 87 per cent for the useful cold demand. The remaining amount was conventionally covered via redundancy from the energy central in the HEZ building. It is the objective, to increase the coverage ratio of the Anergy Grid in the associated buildings to 90 per cent.

Development
In the final expansion stage the Anergy Grid will cover a large part of the heating and cooling demand of Campus Hönggerberg. Possible external consumers (e.g. residential building) and sources of waste heat (e.g. a new data centre) can be integrated into the energy concept after prior inspection. The cooling demand is depictured in figure 1 (development cooling demand). Since 2016 the cooling coverage from the Anergy Grid significantly increased due to the inclusion of the HC-Cluster. With the planned expansions the total cooling demands will most likely exceed 25 GWh in the year 2026 and will further approximate the absolute heating demand. Such a starting situation is ideal for dynamically operated networks or areas and confirms the selected and pursued strategy.

CO_2 emissions
ETH Zurich is aiming to eliminate at least 80 per cent of CO_2 emissions or 8,000 tonnes of CO_2 per year by 2040 (relative to the base year 2006).

***** Cluster: Building group, which is supplied by a substation.

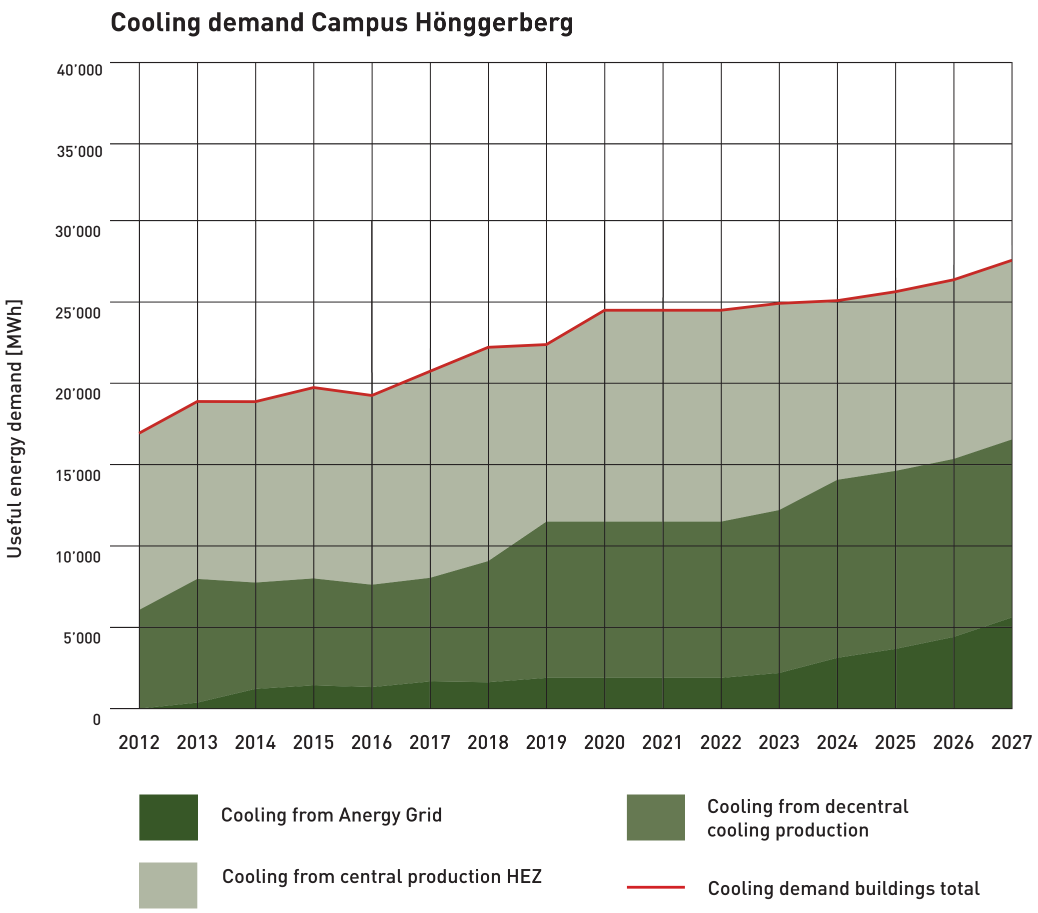


Figure 1 shows that the share of the central cooling production continuously decreases and in return the share of the cooling demand from decentralised cooling production and from the Anergy Grid increases continuously.

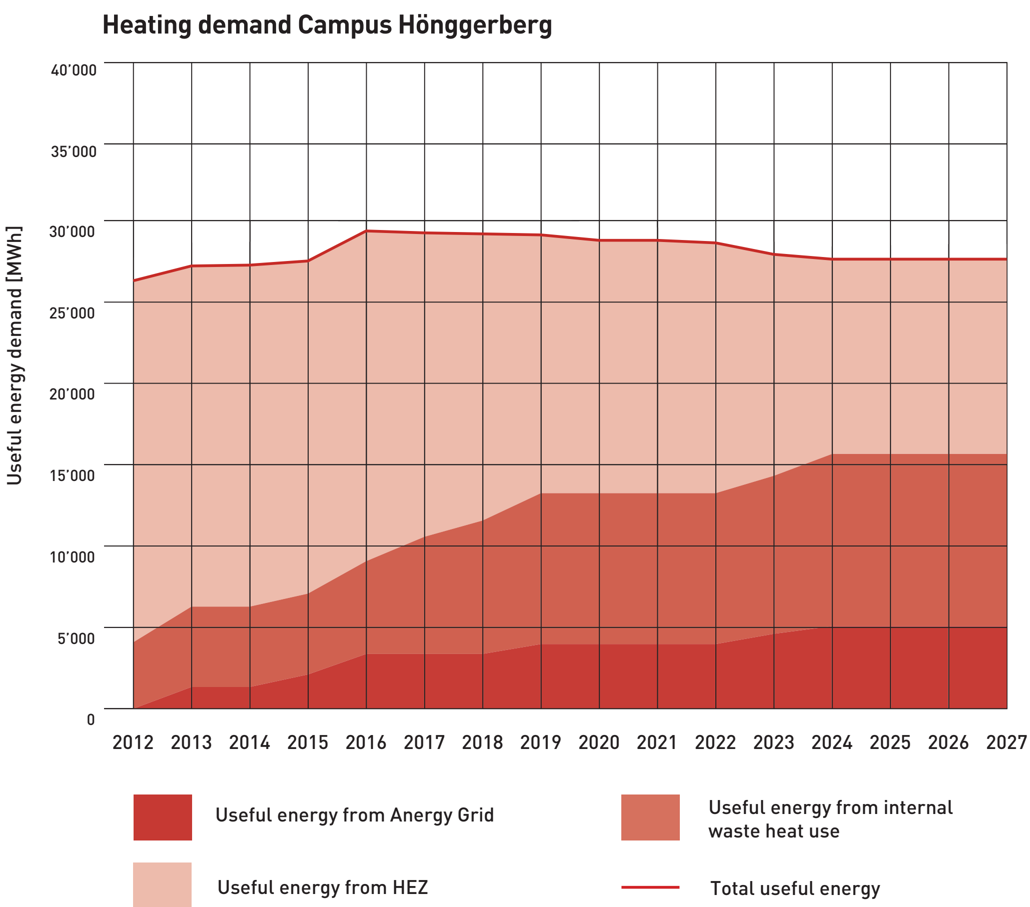


Figure 2 shows that the amount of central gas heating (useful energy from HEZ) continuously decreases and in return the share of internal waste heat use and Anergy Grid increases.

Key figures [1]

	COP [2] Coefficient of Performance	JAZ [3] Annual COP
Heating		
Substation HPZ	7.5	6.2
Substation HPL	7.7	6.2
Substation HWN	7.8	5.8
Useful heating and cooling [4]		
Substation HC	6.9	–

	EER [5] Energy efficiency ratio	JAZ [3] Annual COP
Cooling		
Substation HPZ	36.5 *	12.8 ** (incl. HEZ)
Substation HPL	33.0 *	9.7 ** (incl. HEZ)
Substation HWN	22.1 * (only air conditioning AC)	–

Max. heating output WP/KM [6]	6,5 MW ***
Max. cooling output WP/KM [6]	5,3 MW ***
Earth probes (Borehole heat exchanger)	
Amount of probes	431 (status as of 2019)
Amount of probe meters	86’200 m (200 m/probe)
Max. performance	5.2 MW *** (at 60 Watt/m)
Nom. performance	3.0 MW *** (at 35 Watt/m)

1 Key figures from the year 2018 for substations HPZ, HPL, HWN. The substation HI went into operation in December 2019. No measured values are available yet.

2 The COP defines the thermal efficiency of heat pumps. It defines the ratio of the heat supplied by the machine to the absorbed drive power (electricity).

3 The annual COP contains additional to the power input (accord. to COP) also the auxiliary energies (circulator pumps, valve drives, cooler units etc.).

4 Combined coefficient of performance for useful heat and cooling; In contrast to other substations, the HC cluster actively generates cooling. The substation is either in combination mode or pure cooling mode. The value corresponds to October 2019 (average value of the months January – October 2019).

5 For a cooling system the term EER (Energy Efficiency Ratio) is used. EER is a performance number of a cooling unit.

6 Heating pump/cooling unit

* Direct cooling via Anergy Grid including pumping energy.

** Incl. cooling supply from HEZ (heating station Hönggerberg); the plain annual COP value of the substation is actually higher.

*** Megawatts

Contact

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