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AQUIFER THERMAL ENERGY STORAGE FOR THE BERLIN REICHSTAG BUILDING - NEW SEAT OF THE GERMAN PARLIAMENT

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ABSTRACT

According to the decision of the German Parliament, forward-looking, environmentally responsible, and examplary energetic concepts were to be implemented for the supply of energy to the Parliament buildings in the Spree river curve in Berlin, focusing on the high utilisation of the primary energy.
Vegetable-oil fired block type cogeneration units and the integration of one aquifer heat and cold store, respectively, are to make sure that 82 % of the electric work of the overall complex and even 90 % of the annual heat demand will be covered by power and heat cogeneration. The cold store – to be charged in particular with ambient winter cold – will cover 60 % of the cold demand in summer. Thus, the environment-benign combustion of bio-fuel plus the operation of the cold store will result in a 60 % reduction of CO_2 emission compared to conventional technical solutions.
At the time of the compilation of this manuscript, the system was in the phase of commissioning.

1. INTRODUCTION

In the Spree river curve located right in the middle of Berlin, the new buildings of the Parliament of the Federal Republic of Germany - grouped around the reconstructed and re-opened Reichstag building - are under construction now. For the four major complexes of buildings with the following energy demand:

- power 8,600 kW 19,500 MWh/a
- heat 12,500 kW 16,000 MWh/a
- cold 6,200 kW 2,800 MWh/a

an energy concept is being implemented which includes the combined production of power, heat and cold with highest possible primary energy utilisation.
The geological conditions on the site (cf. Figure 1) allow the integration of aquifer heat and cold stores in order to achieve this target, balancing in this way temporal discords of energy production and energy demand.

Basically, the system comprises:

- motor-driven heat and power cogeneration units in the basic load of the supply systems and simultaneous guarantee of stand-by power supply,
- use of methyl-esterified vegetable oil (MEVO), preferably for driving the block-type cogeneration units,
- coverage of the electric peak load from the network of the regional supplier,
- integration of two aquifer thermal energy stores for
    - seasonal shifting of the momentarily excessive waste heat of the cogeneration units,
    - utilisation of the winter ambient cold for the direct cooling of the buildings in summer, discharge of the refrigerating machinery waste heat and seasonal shifting into the winter season, when it will serve as heat source to heat pumps,
    - absorption-type refrigerating machines / heat pumps and DEC system driven by the waste heat of the cogeneration units.

2. ENERGY CONCEPTS

2.1 Principles of energy generation, storage and distribution

The energy concept focuses on the self-production of power based on block-type heat and power cogeneration units. The machines with a total electric capacity of 3,200 kW are operated according to the actual power demand.
The heat energy produced at the temperature level of 110 °C when generating power is for direct heat supply to the high-temperature (90 °C / 60 °C) and partly the low-temperature heating networks (45 °C / 30 °C) or for driving the refrigerating machines / heat pumps for the supply of cooling energy in summer and low-temperature heat in winter.
As the heat and power demand curves are not synchronous, there is from time to time - in particular in summer - produced surplus heat by the cogeneration units, and at other times, namely in winter, there is a gap in the coverage (cf. Figure 2). That is why the excessive waste heat of the cogeneration units is stored seasonally in a deep brine-bearing aquifer. The waste heat is fed into this heat store with a temperature of 70 °C and at a later date recovered with a temperature ranging from 65...20 °C. A major share of the recovered heat supplies the low-temperature section of the heating systems in direct heat exchange. More cooling down of the store is done by means of the absorption-type machines in the form of a heat pump transforming the heat to the temperature level of 45 °C.

There is another underground store integrated in the energy concept which is situated in a much lower depth, in the freshwater section. Primarily, this aquifer cold store is for cooling of the buildings.
The water contained in the cold store is cooled down in winter to minimum 5 °C. On one hand, this is done by charging the store with cold on days with low outside air temperatures via cooling towers. On the other hand, the cold store is - in the same way as described for the heat store - the source to the absorption-type heat pumps which absorb its heat, thus lowering its temperature.

The cold stored in winter in the above way feeds in summer the high-temperature cold systems of the buildings via heat exchangers at a temperature level of 16 °C / 19 °C.

The absorbers driven by hot water from the cogeneration units as described above feed principally the other low-temperature cold networks (6 °C / 12 °C).
The cooling demand of these refrigerating machines is covered by air coolers and the cold store, which is charged upon absorption of the cooling load from the high-temperature cold networks in direct heat exchange with the waste heat of the refrigerating machines up to the maximum temperature of 30 °C. In this way, the heat source to the heat pumps is formed again in the cold store for the next winter.

For the „storage“ of heat, the water is pumped off from the „cold“ side of the store, charged with heat (heat store: waste heat from the cogeneration units, cold store: waste heat from cooling and fed to the „warm“ side of the store at a distance of about 300 m. For „discharge“, the direction of flow of the respective system is reversed, i.e. water is pumped off from the „warm“ side of the store. Upon absorption of the heat from this water (heat store: direct heating or source to heat pump, cold store: cooling towers or source to heat pump), it is fed to the „cold“ side of the store.

The essential energy flows of the system are shown in Figures 3 and 4.

2.2 Energy store

In a depth of 285 to 3150 m below the Spree river curve, there is a sandstone layer with its pore spaces being filled with thermal water (mineralisation 29 g/l). This 29 m thick layer is covered by clay which separates it from the top layers. The hydraulic properties of this aquifer (heat store) allow the production of 100 m³/h of brine via each of the drilled deep wells, to heat it up to 70 °C, and to reinject it.
Moreover, there exist Quarternary / Tertiary water-bearing beds in a lower depth. The hydraulic conditions of these aquifers allow the production of 60 m³/h via one well and to reinject this amount, too. Totally, there were drilled six „warm“ and six „cold“ wells, including necessary redundancy. Operating parameters of the two aquifer thermal energy stores are given in Table 1.

2.3 Block-type heat and power cogeneration units

Power and heat are produced for the integrated energy supply system in two 1,600 kW cogeneration units, with one of them being installed in the Reichstag building. The module capacity is 400 kW_{el}. Combustion of methyl-esterified vegetable oil (bio-diesel) is done in modified diesel engines.
The total efficiency of the machines is almost as high as 90 %. Moreover, it was proven in the by now about 500 hours of operation of each module in the Reichstag building, that the flue gas cleaning equipment (SCR catalysts, soot filters) guarantees the observation of the maximum admissible emission values (nitrogen oxides 100 g/m³, dust 20 mg/m³, soot 10 mg/m³).

2.4 Heat pumps / refrigerating machines

Other than for high-temperature supply at the temperature level of 110 °C, for which there exists a central primary network for all buildings which is fed by the two cogeneration units and the peak-load boiler unit, a decentralised structure is established for the low-temperature heating and the cold supply networks. Basically, three single-stage absorption-type machines ($LiBr/H_2O$) with cooling capacities of 850 kW, 700 kW, and 400 kW produce low-temperature heat and cold. Each of the machines is connected with the thermal energy store in order to use it as a heat source or for discharge of the waste heat from refrigerating machinery operation.

3. CONCLUSIONS

With the implementation of the described concept it will be possible to produce 82 % of the electric work and even 90 % of the annual heat demand with block-type heat and power cogeneration units which cover 37 % of the electric peak load. From the cold store, i.e. predominantly from the winter ambient cold, 60 % of the cold demand in summer will be covered.
In the oral presentation of this paper, first experience gained from trial and normal operation - which were not yet analysed or available when elaborating the manuscript - will be described.

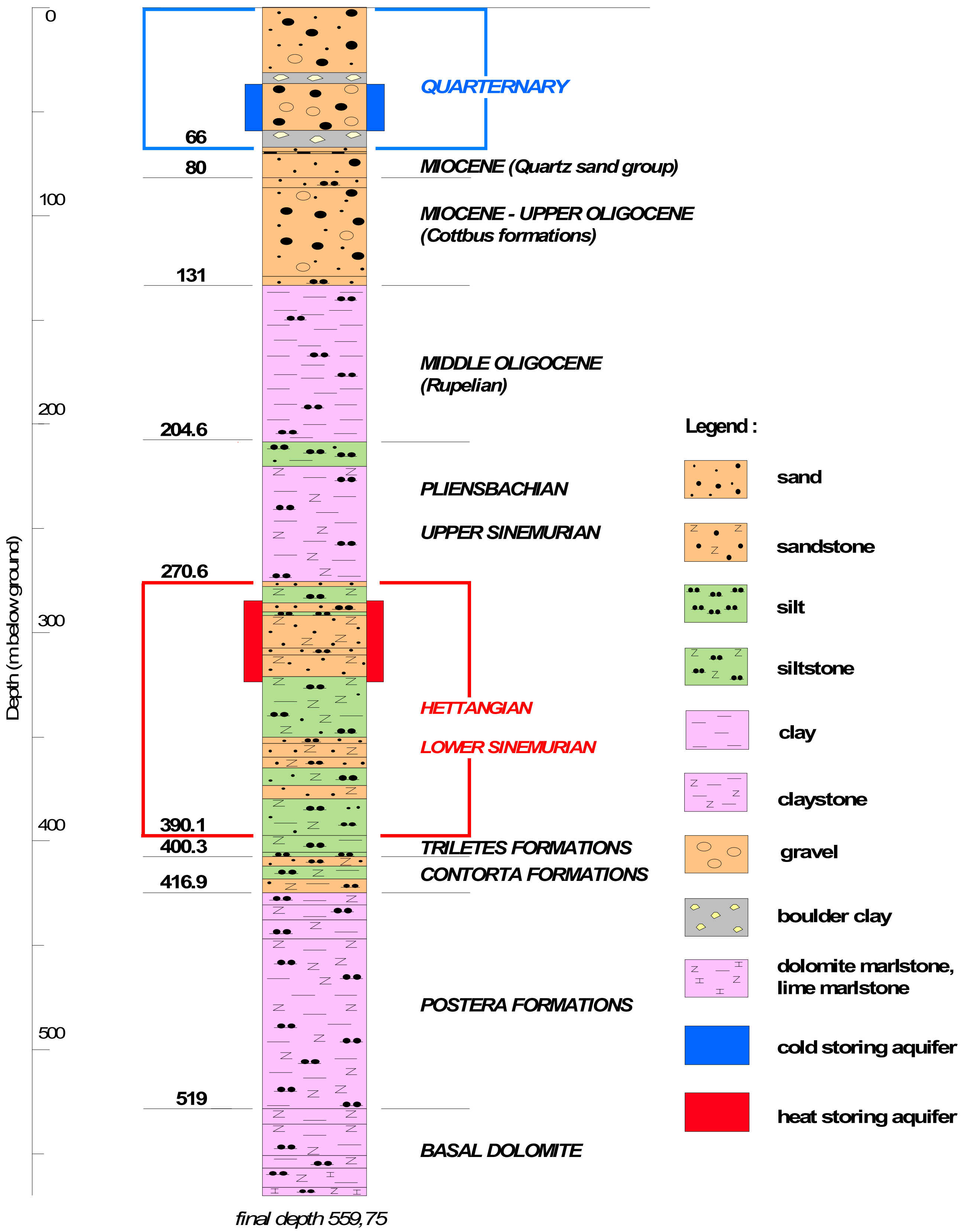

Figure 1. Geological profile on the site

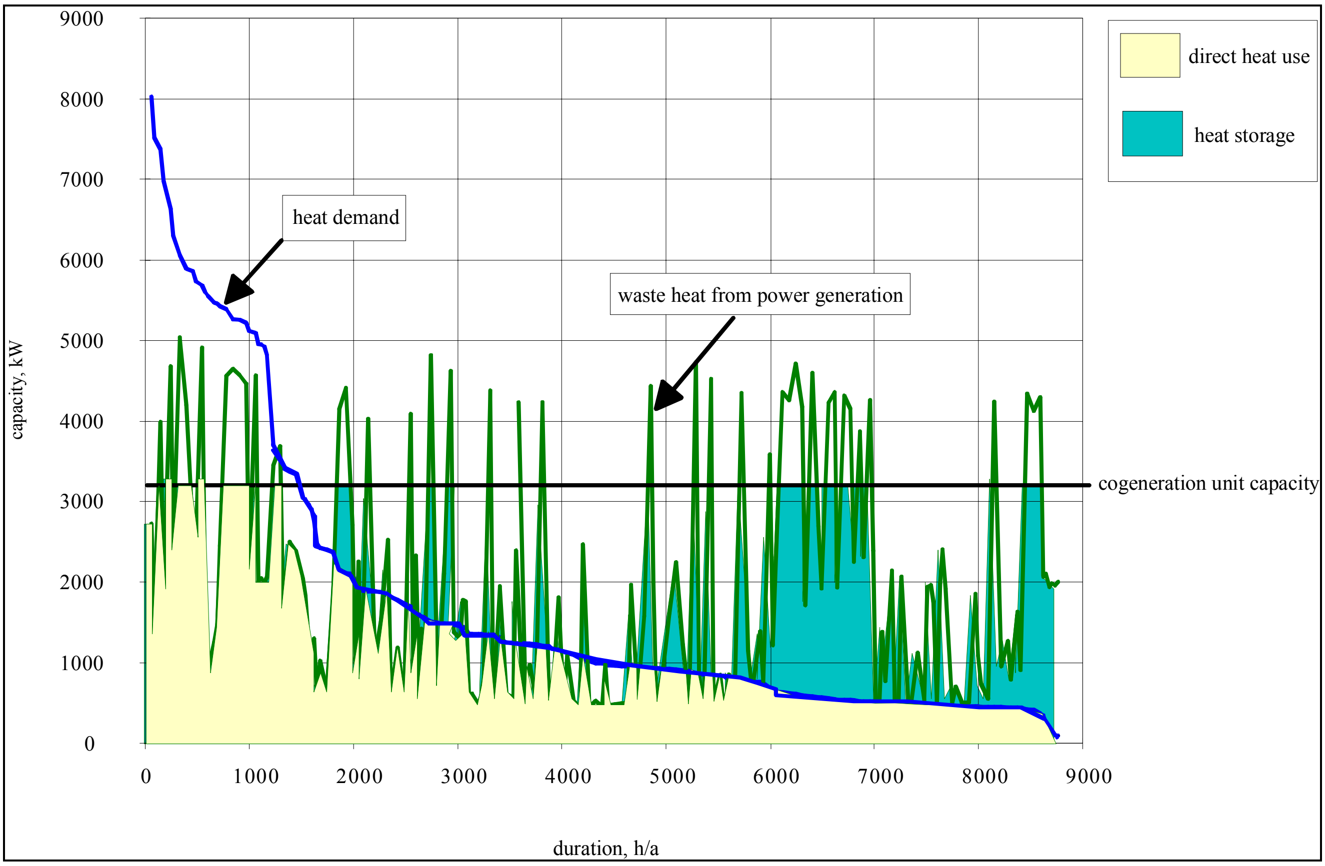

Figure 2. Effects of heat storage, demonstrated with the example of the ranged demand curve for heat and the respective time-parallel power demand curve

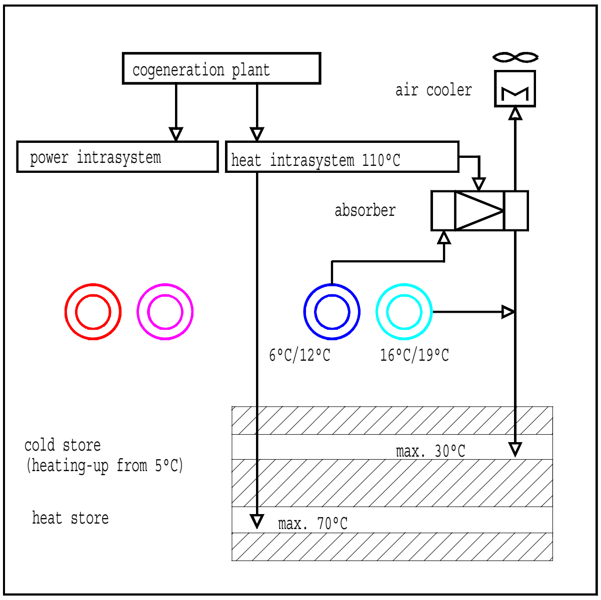

Figure 3. Heat flows in summer operation

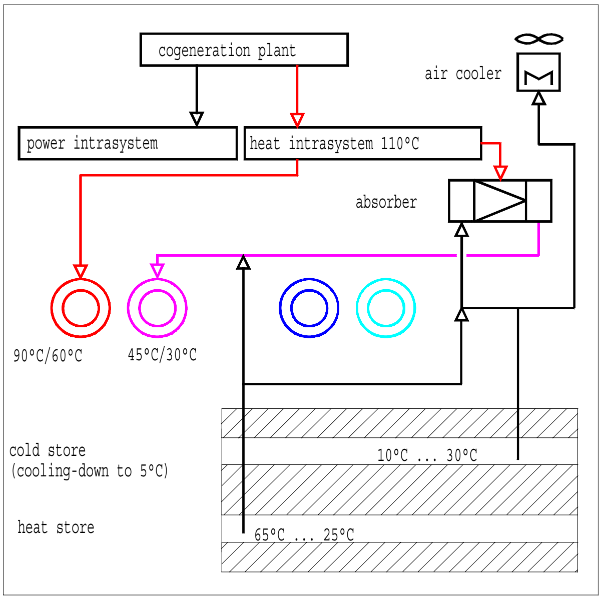

Figure 4. Heat flows in winter operation

Table 1.
Operating parameters of the heat store:

summer operation (charging with heat)	**dimensioning parameters**
medium production temperature	25°C
injection temperature	70°C
charged amount of heat	2,650 MWh/a
winter operation (discharging of heat)	**dimensioning parameters**
production temperature	65°C ... 25°C
medium injection temperature	30°C
discharged amount of heat	2,050 MWh/a

operating parameters of the cold store:

summer operation (discharging of cold)	**dimensioning parameters**
production temperature	6 ... 10°C
injection temperature	15 ... 30°C
discharged amount of cold (incl. absorber cooling)	3,950 MWh/a
winter operation (charging with cold)	**dimensioning parameters**
medium production temperature	22°C
injection temperature	5 °C
charged amount of cold	4,250 MWh/a