



# The building level substation – the innovation of district heating system

Kari Sipilä | Arto Nuorkivi | Jorma Pietiläinen



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## Preface

The Manual comprises the aspects as outlined in the Table of Contents to follow. The Manual is based on the request of the Ministry of Housing, Urban and Rural Development (MoHURD) on Dec. 2, 2014 to the Finnish VTT and Tekes delegation to support the national Heating Reform by providing guidance to building level substation (BLS) implementation from institutional, economic and operational point of view.

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The attachment of the Manual offers a comparison of the practice in DH between China and Finland.

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## List of symbols

<b>Abbreviation</b> 缩写	<b>In English</b> 英文	<b>In Chinese</b> 中文
BLS	Building level substation	楼宇换热站
CHP	Combined heat and power plant	热电厂
DH	District heating	区域供热
DHW	Domestic hot water	生活热水
EU	European Union	欧盟
GS	Group substation	集中换热站
HoB	Heat only boiler plant	锅炉房
SCADA	System for Computerized Automation and Data Acquisition	计算机自动化及数据采集系统
SH	Space heating	室内供暖

# 1. Concept of BLS

## 1.1 What is BLS?

The building level substation (BLS) is suggested here as an innovation to the DH sector development in China. But what is BLS and what would it change? Introduction of the BLS would provide obvious benefits in improved energy efficiency and living comfort, but it also faces institutional barriers to overcome. In the following, the CHP concept will be described, and the economic, institutional and technical issues associated to BLS will be addressed.



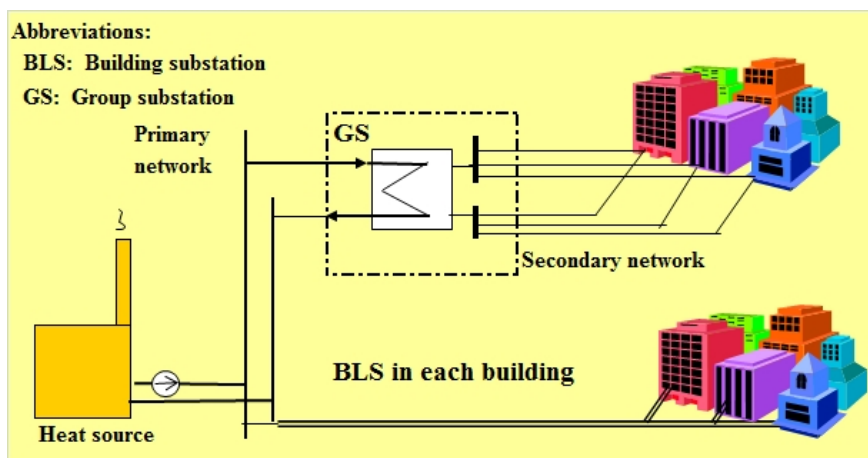
**Figure 1. Building level substations (BLS) with capacity of about 10 000 m<sup>2</sup> each in the factory ready for shipment to Chengde, Hebei Province, China.**

In Fig. 1 a number of BLS units wait for the delivery to China. The BLS units were installed in the city of Chengde, under co-financing of the grant from the Global Environmental Facility administrated by the World Bank.

The Figure below illustrates the difference in the substation culture between China and Finland. In China, the substation serves 20–30 buildings through the secondary



underground network, whereas in Finland, the primary network extends to the building basement where the BLS is connected to the indoor piping.



**Figure 2. The network structures of the traditional group substation (GS) in China and the building level substation (BLS) in Finland.**

Typically, the BLS capacity is below 15 000 m<sup>2</sup> of heated area equal up to 1 MW. The BLS units are prefabricated compact products that are designed, manufactured and tested at the factory ready for transportation to the construction site, where the complete BLS unit will be mounted to the floor, connected to the existing indoor piping of heating and water, the remote communication facilities as well as to power supplies of the building.

The BLS as an integrated plate heat exchange unit shall be prefabricated and assembled and successfully tested both hydraulically and electrically in the factory already to meet the high functional and low noise requirements, and if he so wishes, at the presence of the Borrower's representative. Its base and brazed structures should have sufficient intensity and stability.

## 1.2 Heating Products of BLS

Traditionally, only room space heating is used in Chinese DH. In other world, also domestic hot water is often integrated to DH. Introduction of BLS makes it possible to complement the DH with DHW afterwards at low incremental costs: a small heat exchanger and a small circulation pump as well as connection to the existing DHW and city water piping are needed.

### 1.3 Physical Dimensions of BLS

The substations require room space depending on the size. Below a few examples are given about the substations of various capacities.

**Table 1. Examples of physical sizes of real substations.**

<b>SUBSTATION</b>	<b>DIMENSIONS length x width x height mm</b>	<b>Floor area substation m2</b>
WEIHAI 0,2 MW	1500x600x1600	0,9
ULAN BATAR 0,4MW	2000x1000x1600	2,0
HARBIN 1MW	2500x2000x2300	5,0
BAOTOU 7MW	3000x4000x2300	12,0
YANJI 9 MW	6500x4000x2400	26,0
YANJI 13 MW	6000x3800x2300	22,8
QINHUANGDAO 14MW	7000x4000x2300	28,0
YANJI 17MW	6600x3900x2300	25,7

The maximum physical dimensions of the BLS is given below in order to make it feasible to transfer the BLS to the final operation site, and to use as little room space as possible but to be easy to maintain anyway.

**Table 2. Physical dimensions of BLS to design the room space needed in the building (mm).**

<b>Capacity</b>	<b>Length</b>	<b>Breadth</b>	<b>Height</b>
≤200 kW	1500	700	1600
≤400 kW	1700	750	1650
≤600 kW	1800	800	1700
≤800 kW	1900	850	1800
≤1000 kW	2000	900	1800
≤1200 kW	2200	950	1900

The room size of the BLS should be large enough to leave at least 1 m on each side of the substation space free to walk and work.

The main components of the BLS are:

- Plate heat exchangers, the number depending on the types of heat consumptions such as space heating, DHW and ventilation.
- Heat meter
- A safety valve is in the secondary side to protect against high pressures.
- The circulation pump with control system
- A water flow sensor in the make-up water supply
- Temperature control components together with communication
- Circulation pump with frequency converter
- Pump box
- Shut-off valves
- Strainers

As the BLS product will be transferred as one integral unit from the factory to the final operation site without any disassembling/reassembling in between, there is no risk of noise or excess consumption of electricity, heat and room space, but the operation will be silent and optimal in the building.

The BLS can be carried through the normal doors of some 2.1 m high and 0.9 m breadth to the final operation site in the building.

There is no international standard about the BLS for the time being but the “Guidelines for District Heating Substations” issued by Euroheat&Power, e.g. the DH association in Europe, in October 2008. The guidelines are downloadable from the link: <http://euroheat.org/Technical-guidelines-28.aspx>

## **1.4 BLS supports Heating Reform**

To the Heating Sector Reform the BLS introduction offers essential advantages such as:

- Each building gets exactly the heat it needs.
- Heat control inside the rooms works better when the heat supply is controlled for the particular building in the BLS.
- A professional body, the DH company, will be responsible for the heat supply quality until the building entrance, not only to the GS.
- Heat losses (inside and outside the building) can be allocated unambiguously to either consumer or supplier. The building internal heat losses are clearly the responsibility of the customer, e.g. the building owner.

- Heat metering can be organized at low cost on building level.
- Thus, heat tariffs can be clearly defined: covering the costs of supplying heat up to the substation, either before or behind the heat exchanger of the BLS.
- Serial production is much more possible with BLS, thus providing lower investment costs than with tailored GS units.
- BLS with primary network connection is flexible for expansion: every new building will be equipped with a BLS whereas in a GS system a new building may either require capacity to be added to the GS or the secondary networks or such excess capacity had to be reserved in the design phase already, both being costly.
- Low return temperature due to tuned functioning of the BLS according to the heating needs of the particular building will be achieved, which improves the overall economy of the DH/CHP system.

## **1.5 Manufacturing BLS**

The BLS shall be manufactured and tested at the factory as one integral unit, which then will be transported to the final site to be connected to the building and DH infrastructure.

At present, there are not many manufacturers of BLS in China, but as BLS becoming more common based on the pilots financed by the World Bank, for instance, it is certain that the numerous heat exchanger manufactures currently operating in China will add BLS to their product mix. This transition from imported to local manufacturing has happened in many other imported products before already: plate heat exchangers, fluidized bed boilers, frequency control of pumps, etc. that used to be imported but which now are mainly of Chinese origin. The same will happen with BLS after the prevailing barriers have been phased out.

## 2. Global Trends with Substations

### 2.1 BLS Worldwide

The trend elsewhere in the world appears to either stay with BLS or to convert GS towards BLS as presented in the Table below.

**Table 3. Countries with main practice on substations.**

<b>Common practice</b>	<b>List of countries</b>
Countries using GS	Belarus, China, Denmark, Romania, Russia, Ukraine
Countries using BLS	Austria, Bulgaria, Canada, Croatia, Czech Republic, Estonia, Finland, France, Germany, Italy, Norway, Serbia, Sweden, Switzerland, United Kingdom, USA
<b>Countries in transition</b>	
Countries moving from GS to BLS	Poland, Hungary, Lithuania,
Countries moving from BLS to GS	There are NONE.

A number of countries use BLS already, and some of the countries are turning from GS to BLS. Nevertheless, none are moving other way round from BLS to GS.

In some cases, such as Russia and Denmark, for instance, not only group substations and even direct connections are used but also BLS.

The heat exchangers of space heating can be either mountable, when opening and remounting of the heat exchanger plates is possible, or brazed, when the entire heat exchanger has to be replaced if broken or leaking. The latter brazed ones are reliable and much cheaper and smaller than the mountable ones, thus having had gained market dominance in the world, as presented in Table below.

**Table 4. Countries using mountable or brazed heat exchangers in SH circuits.**

Heat exchanger type in space heating	Countries
Only mountable	China
Brazed	Austria, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Norway, Serbia, Sweden, Switzerland, United Kingdom, USA
Both brazed and mountable	Belarus, Russia, Ukraine

## 2.2 BLS in Finland

DH in Finland has been awarded as the best DH system in the world with full five stars by the IEA, the International Energy Agency, mainly because of high level of integration and energy efficiency. Moreover, the DH and district cooling systems of Helsinki have been awarded as the best practice in the world by the IEA and the Euroheat & Power a number of times, for instance, Paris, France, 2009 and latest in New York 2013.

In Finland, the customer is always the building owner, never the individual apartment. Each building has its own substation (BLS) separating the responsibility border of the DH company and the building owner. The BLS is owned by the customer.

Apart from China, the BLS in Finland supplies heat both for SH and DHW. Therefore, there are always at least two heat exchangers and controllers in each substation, sometimes the third one for air conditioning.

Finland is a small country with the population of only 5.5 million and the territory of some 300 000 km<sup>2</sup>, but located in the north with the highest heating requirements prevailing in Europe. The outdoor temperature used as the design basis of the DH systems ranges from -25°C in the south to -35°C in the north of Finland. Therefore, the heating systems have to be both reliable and adequate. The reliability of the DH supplies to the customers amounts to as high as 99.98% of the calendar time, and those less than 2 hours a year, the customer does not usually even recognize any break as the heat energy accumulated to the buildings and pipelines compensates the impacts. The Finnish Energy Industry Technology Association recommends that the back-up boiler capacity shall be sized to allow less than 10% lack of capacity in production for maximum 6 hours period at a time, when largest unit is out of operation and winter peak demand exist. The network and booster pump stations must be designed that not any customer is allowed to stay totally out of heat more than 3 hours. This recommendation takes into account the heat demand pattern and heat storage characteristics of buildings and DH networks as well as separated heat storages in some DH-systems.

Despite of northern location, the DH sales to customers, including both DHW and SH, amounted to 38 kWh/m<sup>3</sup> of heated volume in year 2014 on average. The value has been constantly declining due to energy efficiency improvements in the existing

buildings and the new buildings being more or less passive or zero energy buildings already.

Moreover in Finland, DH has had to operate on the competitive market without much public support, which has made DH highly economic to be successful on the heating market. As competitors of DH during the past decades, oil and electric heating and lately individual heat pumps have appeared. Today, the half of the population is with DH, about 75% of DH produced by highly efficient CHP and the fuel mix ranging from fossil fuels to the constantly increasing share of renewable energy sources.

Most DH companies in Finland are owned by the municipalities. There are two main reasons to the municipal ownership such as (i) heating is local activity serving only the local people, which makes the governmental involvement unnecessary, and (ii) DH together with CHP is a profitable business to the owner, even though both electricity and heat function on open markets. As an example, the DH and CHP company of Helsinki, the capital of Finland, generated €250 million profit with €900 million turnover in year 2014. A good share of the profit was used by the city as the owner to fund city development in favor of its citizens.

The DH industry by itself is not regulated in Finland, but the same customer right protection procedures apply to DH as to any other commercial product available on the market such as food, electric appliances, house renting, etc. Because of DH is regionally in a dominant market position due to DH share of 90% and more of the local heat market, the Finnish Energy Market Authority follows the pricing of DH companies that the heat price is not over sized including a fair profit. Due to competition on the market, the competitiveness and customer satisfaction, both constantly monitored by the DH companies, are the driving forces of DH management in the whole country.

The BLS is a rather standard product in Finland, but not officially standardized. The association Finnish Energy Industries<sup>1</sup> issues recommendations to its member companies, both utilities and manufacturers, about required water quality, substation structures, heat tariff systems, etc. The recommendations are not mandatory, but as the companies themselves have participated in preparing the recommendations, the recommendations are implemented in practice. Therefore, the DH systems in Finland both technically, institutionally and economically are rather uniform as designed, operated and maintained according to the mutually agreed recommendations. The association is based on voluntary membership of the energy companies in Finland. In practice, most DH companies are members of the Finnish Energy Industries as they benefit from lobbying with the government, participation in development work and information exchange.

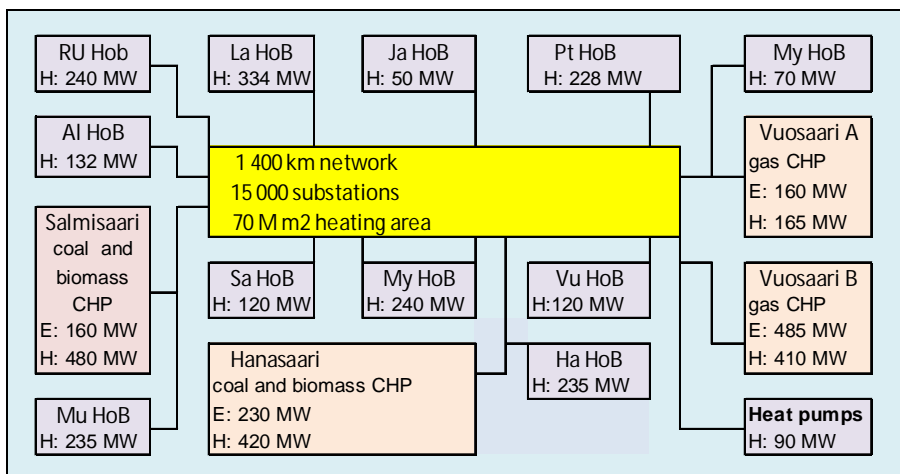
The DH system is operated all year round because of continuous DHW supply, but SH is needed in the heating season only. All year round operation guarantees also better condition and reliability of DH systems compared to 3–4 months shut-down mode of the DH systems a year.

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<sup>1</sup> [www.energia.fi](http://www.energia.fi)

The connected buildings can switch on/off their heating individually as needed, because the DH system is in operation at all times.

An example of a Finnish DH system is given in the Fig. below. In the city of Helsinki, the capital of Finland, some 92% of the building stock is connected to the DH. About 90% of the DH energy is produced by the CHP plants Vuosaari, Salmisaari and Hanasaari and the balance of 8% by the large heat only boilers (HoB) spread in the city area. The CHP energy is high as a base production even though the heat production capacities of CHP and the other sources are almost even, 1250 MW from CHP and 1350 MW from the HoBs and large heat pumps. The annual efficiency of the heat production is about 90% which is very high in the international context. The heat losses of the DH network are 6% of the annual heat production. The water losses of the DH systems are as low as some 0.08% of the circulation water flow on average.



**Figure 3. The various types of heat sources are interconnected to one integral ring-type DH network in the city of Helsinki, Finland (2015). All 15 000 substation units are BLS.**

VTT has developed in co-operation with Helen a *Kopti* software system to help optimally operate the energy production system in Helsinki. Fuel consumption, capacity operation, including energy storing and unit annual service break time are optimized. Electricity trade in Nordic electricity trade market and local heat trade are also included in the systems operation.

Helen has automated customer information system collecting electricity and heat consumption data from remote read meters (ARM) at consumers, issues the customer electricity and heat bills according to the collected data. The data information system gives also to customer his own measured consumption history information in hourly/months level, if the customer wishes to have it.



## 2.3 Customer Connection Procedure in Finland

In Finland, the building owner is always the customer of DH, never the individual apartment. Therefore, the apartment level heat metering even being very rare and if possibly exists, is only used to allocate the total heat bill of the building to the apartment owners.

All buildings connected to the DH network have a BLS installed in the building basement to control the supply temperature and to measure the heat energy consumption of the building. Measuring consumption at the building level allows the heat supplier to issue the energy bills based on the actual consumption and the customer to monitor and control their heat consumption.

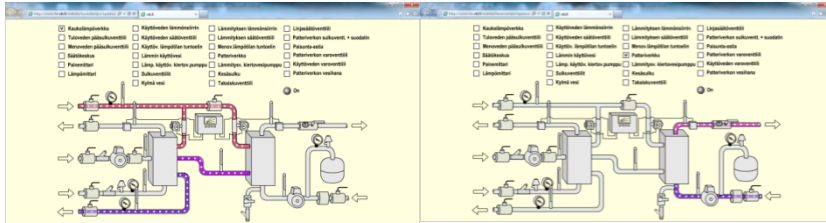
The process of joining a building property to the existing DH network and installing a BLS in the case of Turku Energia, typical to Finland in general, is described in the following steps:

1. Turku Energia (TE) carries out a technical and economic assessment on the property's connection readiness to the DH network (location of the property, other possible customers in the area, etc.). TE builds and covers the costs of the main DH network and the connecting pipe from the main network to the planned BLS in the building. The customer pays the fee for joining the network. The fee is based on the agreed heat capacity, either in terms of kW or m<sup>3</sup>/h of ordered DH water flow.
2. Based on the assessment, TE estimates the initial costs and submits a heat sales offer to the customer. The initial offer includes:
  - Agreed water flow
  - BLS's location in the building and the requirements for the room space of the BLS
    - Estimated annual heat consumption (MWh)
  - Fees for joining the network (€)
  - Network user fee per annum (€/year)
  - Expert's fee for gathering necessary information to make the offer
  - A list of certified heat subcontractors is also provided to the potential client as the client (building owner) is responsible for the indoor installations.

TE makes the cost estimate for the above mentioned equipment and services. The costs are paid by the customer once the customer approves the offer.

3. The customer estimates the investment costs within the building property needed to join the network. The expenses of the property, the surface work, insulation work in the building etc. are covered by the customer. The customer accepts / declines the offer. TE goes through the offer with the customer before the offer is accepted.

4. The property owner and TE agree on the heat distribution point, and both parties sign the heat distribution agreement. The heat distribution point divides the ownership and responsibilities of the maintenance etc. The heat supplier (TE) is responsible for the equipment from the heat source to the distribution point (left chart), the customer from the distribution point to the radiators in the property (right chart).



**Figure 4. Borders of heat delivery in Finland**

(source: <http://www.rte.vtt.fi/webdia/kaukolampo/opastus/animaatio/kaukol3.swf>)

5. The customer submits the DH connection plan to TE for approval  
The DH connection plan has to be designed to meet the building's heat energy and capacity needs. The plan is drawn and designed by a professional technical designer. The information shown in the plan is used e.g. to define the agreed capacity and water flow, to estimate the energy consumption, etc. The plan is handed to TE for inspection and approval.
6. The customer chooses the subcontractor for installing the BLS  
TE purchases and installs the heat meter, heat supplier's shut-off valves and the strainer. The customer purchases the BLS. The BLS has to be installed and connected to the TE's network by the subcontractor certified by TE. A list of certified heat subcontractors that have proven to have sufficient expertise and experiences is maintained by TE.
7. Checking of the installed DH equipment.  
TE conducts the installation check to make sure the equipment and the installation fill the technical requirements before the start of heat distribution.
8. Heat distribution starts.
9. Operations test and final check of the equipment. Guidance will be provided by TE to the customer on how to use and maintain the BLS and the indoor heating system.

## **3. Expected Benefits of BLS Compared to GS**

### **3.1 General Benefits**

There are several reasons to believe that the BLS is competitive, and even superior to the traditional GS in future, in China.

The required number of small BLS units themselves alone are more costly than the GS alone indeed, but including replacement of the multi-pipe secondary network with primary 2-piping and with more optimal pipeline layout often makes the total investments of the BLS option lower than the traditional one with GS and multi-pipe secondary networks.

The arguments supporting BLS introduction in China are as follows:

- Eliminating the underground secondary network which is bothered by poor water quality and strong corrosion;
- Optimal layout of network as the GS is not needed in the middle of the residential area anymore;
- Easier installation of primary network in the middle of buildings as it requires much less land area than the traditional secondary piping consisting of 2–6 pipes installed in parallel depending on whether up to 12, 24 or 36 floor buildings are concerned;
- Electricity savings in pumping in BLS as the water flow of the primary network is 70–80% smaller than that of the secondary flow of GS;
- Make-up water savings as the water losses are better controlled on the building than on a region basis;
- Heat energy savings as the temperature control will be closer to the customer than in traditional group substations;
- Improved heat comfort at the customer apartment as the heating conditions are more stable, because the temperature control is closer to the customer than in the traditional GS case.
- Reduced return water temperature on the primary side thanks to optimized circulation inside the buildings, which improves the power-to-heat rate of the CHP, reduces the need of pumping as the water flow is smaller and reduces heat losses of the network.

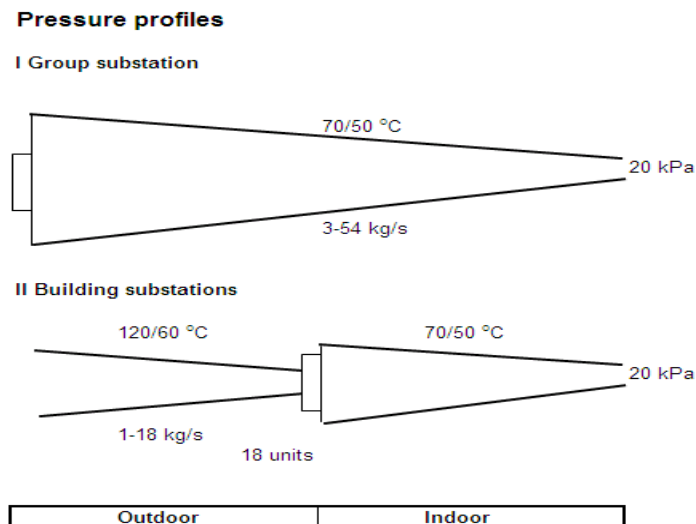
- Flexibility in extension of the building stock in case the area will be gradually built in accordance of people moving in, and not the entire district at once and having a number of apartments empty

### 3.2 Reduced Pumping

There are two issues related to DH circulation pumping to be discussed here.

First, in China it is common, according to the studies of Tsinghua University, that the DH pumps are oversized. Too powerful pumps cause many problems such as noise and cavitation (pump inlet pressure too low), for instance, the latter cavitation being a reason to frequent damage of pump bearings. As the real BLS is optimized and completed in the factory already, there are no such risks.

Second, in the drawing below, the pumping efficiency improvement due to the BLS introduction is illustrated. While secondary network is converted to primary network, the total water flow falls as much as 60% to 80%, which consequently reduce the need of pumping, and thus the associated electricity consumption. The water flow fall is often more drastic than in the drawing, as in practice the secondary water temperature differences are 15°C and 10°C for radiator and floor heating systems at highest, respectively. Having both types of heating in a building, the design follows the floor heating temperatures, this giving the maximum temperature difference of only 10°C.



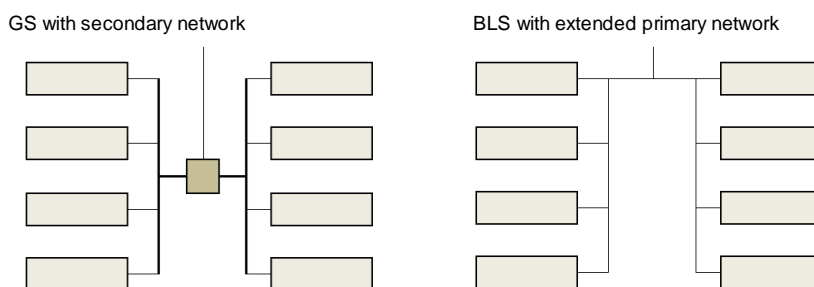
**Figure 5. Comparison of water flows in GS and BLS cases. In the GS case the water flow is three times the water flow of the BLS case, which is the reason to excess pumping and high costs of electricity associated with GS.**

All in all, the life cycle costs of BLS with extended primary network during 20 years to come make BLS very competitive to the traditional GS having troublesome secondary networks.

The network layout can be better optimized when having BLS instead of the traditional GS as illustrated in Fig. 6 below. The GS is often in the middle of the connected buildings, which causes some pipes to follow the route back to the buildings that the primary network had already passed by. Moreover, installing two primary pipes is more flexible than 2–6 secondary pipes in between the densely constructed buildings and other technical infrastructure already in the ground, telecommunication and electric cabling, water and sewage piping.

### 3.3 Optimal Underground Piping

Introduction of BLS will both reduce the diameter and geographical length of the underground network, often also the number of the pipes to be installed. The reduced length is based on the new layout of the pipes as illustrated in Fig. 6 below.



**Figure 6. BLS helps reduce the piping route length.**

As the water flow in the secondary network is large requiring several and large pipes, the BLS introduction will reduce the diameter and number of the pipelines when converting the secondary to the primary network. Reduced diameter implies lower investment costs on piping, usually the network being the largest component of the DH fixed assets.

The BLS will likely cause energy savings in the buildings as the temperature control is building specific and can be tuned according to the heating behavior of the particular building. This cannot be done with the traditional GS which serves 10–20 buildings collectively, and the heating quality needs to be adjusted to the most critical building, while the others will receive excess heat from time to time.

### 3.4 Improved Energy Efficiency

Some of the experiences from the heat energy savings after having had converted the GS to BLS have been:

- In Central Europe, conversion of old GS systems to modern BLS systems has reduced heat consumption by 15% on average, thus making DH more energy efficient and competitive on the market.
- In Weihai, Shandong, there have been indications that BLS systems use heat energy 12% less than GS systems.
- In Chengde, there are indications that the BLS saves 11% of the heat consumption compared with GS<sup>2</sup>.

Remote communication may provide benefits in reduced maintenance and energy consumption.

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<sup>2</sup> District Heating 6/2014

## **4. Ownership and Cost Sharing**

### **4.1 Property Borders**

Traditionally, when constructing a new DH system in China, the heating company is responsible for the primary network and the GS, whereas the real estate developer for the secondary network and the indoor heating installations. Now, introduction of the BLS would change the responsibility border, and the associated cost allocation.

- The heating company should extend the primary network from the avoided GS up to the building entrances.
- The real estate developer does not need to install the underground secondary network but should install the BLS into building basements where room space should be reserved for BLS.

### **4.2 Ownership of BLS**

Currently in China, the developer would be responsible for financing the BLS if implemented. The responsibility of operating should be with the DH company as there is no market yet specific to operation and maintenance of the BLS outside the DH company. Therefore, the DH company would have the know-how to maintain the BLS and interest in it as well, because the technical performance of the substation, both BLS and GS, reflects to economy of the entire DH system.

The BLS ownership could be transferred from the developer, or the customer, to the DH company as is currently done with secondary networks already.

In Europe, the ownership of the BLS varies even in a country. Either the DH company or the heat customer can be the BLS owner.

Regardless who the owner is, the authorized customer representative, the property management company, should have access to the BLS room to tune the BLS operation according to the building specific needs.

### **4.3 Cost Sharing**

Based on the calculations and experiences, the costs of the two parties do not change much, when the BLS system will be chosen instead of the traditional GS system in a new construction area. Therefore, there seems not to be any substantial financial barrier to introduce BLS. Rather the problem seems to be how to find room space in the building to install the BLS. Sometimes, as in Weihai, Shandong province, the BLS units were installed in separate steel plate covered boxes near to the heated buildings.

Nevertheless, the investment cost sharing between the DH company and the developer should be clear. The current responsibilities seem simple and fair: The DH company invests in primary network extension to the room of the BLS and the developer invests in the BLS and the indoor heating system.

In Europe various cost sharing ways are applied, even in one company. The customer may choose whether he wishes to own the substation or not. If yes, his annual payments to the DH company will be lower than if the DH company would own the BLS.



## **5. Institutional Barriers to be Addressed**

### **5.1 Slow Commissioning of BLS**

There have been BLS units in operation for several years in various parts of China, but still very little analyzed information is available on their real performance in terms of energy efficiency.

So far, there have been challenges to commission and analyze BLS in China due to institutional resistance, which has been seen in the following forms:

- The BLS changes the responsibility border between the parties, the DH company and the real estate developer. The parties do not see an incentive to work over the traditional border to facilitate BLS.
- The technical design institute has little or no experience in the BLS concept, its design, requirements and benefits. Therefore, it rather designs traditional solutions.
- DH operators have had little or no trust in the independent and automatic operation of the BLS, but the automation may have been switched off and the BLS has been operated manually. Therefore, the collected data is not completely relevant for analyses.
- The DH companies, after the international financing is over, have not always shown interest in recording and giving metered data for the analysis to be carried out by an external body.

### **5.2 No Competition at Present**

In China, there is no competition in the DH sector as the customers are more or less obliged to connect DH. Nevertheless, in Europe and America the DH companies need to be competitive on the market at all times, and if not, a customer may switch to other heating modes, and new customers will not connect any more.

Lack of competition does not provide strong incentives to the DH company to take care of the heating quality and costs of the customer.

### **5.3 Different Interest of DH Company and Developer**

An institutional barrier concerns the interest of the heating company and the developer:

- Heating company may wish to minimize the life cycle costs as it will be responsible for operation of the system in the future. Given that, the operation costs including water, heat and electricity losses as well as repair costs are important to run the business. The lower the costs are, the higher the profit would be unless the regulator distributes the cost savings to the end-user tariffs.
- Real estate developer wishes to sell the apartments at high profit. Therefore, it tries to minimize the investment cost related to heat supply, thus often yielding to poor materials and poor construction quality.

Then, after the building has been commissioned, usually the heating company has to take over the operation of the secondary network, the construction of which was out of the company's quality control.

### **5.4 Lump-sum Tariff**

The heat customer, paying a lump sum for DH regardless the quality and energy he has received, is not interested in energy saving.

The DH company having a constant cash flow, based on the lump sum tariff, has an incentive to minimize the fuel costs as a means to gain profit. From time to time, this may compromise the heating quality of the customers. The customers being at the far end of the distribution network suffer more for the inadequate heating quality whereas the other ones being closer to the heat source, the GS, may have even excess heat to be ventilated out from the windows. Typically, there prevails imbalance of heating quality in the secondary networks at present.

## 6. Technical Issues

### 6.1 Make-up Water

There are three alternatives to supply make-up water to the indoor heating system, as follows:

- First, city water will be taken and stored in an open basin and softened before supply to the heating system. The water storage basin and the softening system need relatively much room space which is costly. On the other hand, the price of the city water is lower than the price of the treated primary network water.
- Second, the primary network water can be tapped to the indoor heating system. As the treated water is relatively more expensive, the water management in the indoor heating systems should be good: no water losses and expansion tank.
- Third, the city water is taken directly from the city water network and led to the indoor heating system without any open air basin. Typically in Europe and America, mainly this third alternative is used which leads to make-up water savings.

### 6.2 Expansion Compensation

Based on water physics, both water volume and density change along with the temperature variations. At present, the expansion is compensated by the overflow valve. As the pressure increases, the valve opens and releases excess water to the sewage or the open-type make-up water tank.

In China for the time being, the water losses in the secondary side are so high that there is no possibility to closed water circulation in the secondary side. Make-up water flow is constant ranging from 1 to 3% of the secondary circulation water flow.

As the BLS will become more common, and the make-up water flow will substantially reduce, expansion tanks can be installed to the BLS. In such a way, the water losses will reduce even more, and almost vanish. Thus, the indoor piping system would become a closed loop without constant make-up water need.

### 6.3 One- or Two Way Control

In China, the communication functions in two-ways. Measured data can be collected both into controller of the substation or remotely to the control center. The control center may locate either at the main heat source or at the headquarters of the DH company. Second, by means of remote control system, the operator can remote manipulate the set values of the pumps and valves at the substation, thus bypassing the local automation of the substation.

Moreover, if the number of the substations is high, the operator staff is not able to manage the substations other than relying on the electronic automation systems functioning in the substations already.

In China, there have been examples that the set value manipulation, while bypassing the automation of the substation, has caused excess heating costs.

While analyzing the remote metered data, the operator can identify those substations in which the measured data seem abnormal, and if so, send a maintenance staff to check the substation functioning. Such indicators of abnormal operation compared to measured data from the other substations are, for instance:

- The difference of supply and return temperature is very low, which may indicate there is excess pumping in the secondary side. This can be corrected by reduced pumping.
- The make-up water losses are high. Either there is a leakage to be repaired or the customer illegally taps water for his own needs.
- Heat consumption is high/low per heated area, which indicates there is a need to adjust the temperature values of the control systems of the substation.
- Alarms of unexpected events of doubtful data

### 6.4 Heat Exchanger Design

Often the rubber sealed heat exchangers are undersized, which is one reason to small temperature difference on the secondary side. Another reason is excess pumping caused by too powerful pumps.

In order to have the heat exchangers adequately sized, there is a non-profit standardization institute AHRI based in the USA. AHRI is the only third party heat exchanger verification institute in the world. Most international heat exchanger manufacturers are members of AHRI.

AHRI Standard 400 is a global standard stipulating the verification of thermal performance of liquid-to-liquid heat exchangers.



**Figure 7. Label and contact information of AHRI.**

AHRI uses the “AHRI Liquid To Liquid Heat Exchangers (LLHE) Certification Program” to verify the heat exchanger performance.

The manufacturers are forced to deliver their heat exchanger design software programs to AHRI. Whenever there is any doubt the heat exchanger does not meet the required temperature values, AHRI can be asked to test the particular heat exchanger. The costs of the testing shall be paid by the manufacturer in case the heat exchangers failed, or the requestor, if the heat exchanger met the set requirements.

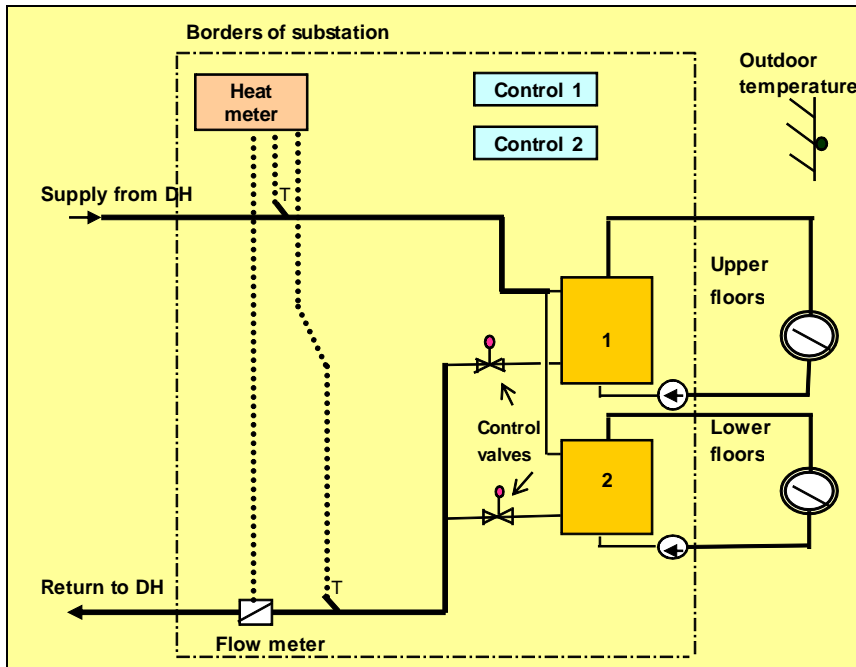
## **6.5 Heat Meter Reading Combined with Remote Controlling**

Regular heat meter reading is vital in case consumption based billing is used. In China, the consumption based billing is still to expand outside the already existing pilot cities.

As ways to collect metered heat consumption, the following options are available:

- Automatic remote reading through the SCADA
- Mobile remote reading by means of car driving in the neighborhood of the buildings
- Manual recording on the paper cards that the customer shall fill-in and mail to the DH company at the end of each month.

Consumption based billing is used 100% in the EU, North-America, and South-Korea on the building level. Apartment level metering is rarely applied as billing as there are both excess costs and inaccuracies related to apartment level heat metering. Those apartment level meters already existing are often used to allocate the heat consumption of the building to the apartments. Specific heat cost allocators are used often to allocate the heating costs of the building to the apartments.



**Figure 8. The BLS for up to 24 floors in building with two heat exchangers and control systems, one for floors 1–12 and the other one for 13–24. More heat exchangers and control systems can be added if more floors exist in the particular building. No changes in the primary network are needed.**

The main components of the BLS comprise the heat exchanger (orange color) separating the primary and the secondary water networks, the temperature control valves (pink), outdoor temperature controller (light blue) and the heat energy meter (light red) with two temperature sensors and one water flow sensor. The water flow sensor is installed in the return pipe on the primary side.

The substation automation is the same in GS and BLS, but with in BLS it works more accurately as being specific to the individual building. The automation regulates the heat supply by means of two measurements, as follows:

- The outdoor temperature measurement tells to the temperature controller how much heat is needed.
- The supply temperature of the secondary/indoor piping tells to the controller how much heat is currently supplied to the buildings or buildings.
- The controller regulates the control valve by opening if more heat is need and throttling if less heating is needed.

The automation system shall be tuned according to the requirements of the connected heat load. Basically, the tuning is very simple: The set value of the supply

water temperature will be given respective both to the outdoor temperature starting the heating, let us say +17°C, and the nominal design temperature, let us say –20°C. The supply water temperature set values depend linearly on the actual outdoor temperature.

As an ECO-function, the circulation pump may stop temporarily when the outdoor temperature is very high, usually in day time during sunny spring and autumn.

The flow sensor of the heat energy meter should be installed in primary side of the BLS either:

- in to the return pipe where the water temperature is more stable than in the primary side, and the meter reading therefore more accurate as used in Finland; or,
- on the supply side in case the water losses inside the building are relatively high as often in China, and there is a need to charge the water losses in the heating bill at least in some extent.

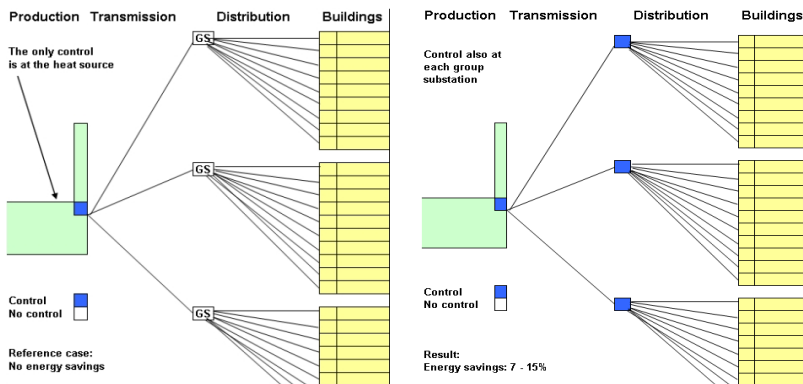
## 6.6 Automation

The old DH system scheme is illustrated in Fig. 9 left below having had prevailed in the past in China and Russia. There was neither control at GS nor in buildings, but only manual temperature control at the heat source. The old case is used here as the reference case with zero energy savings.

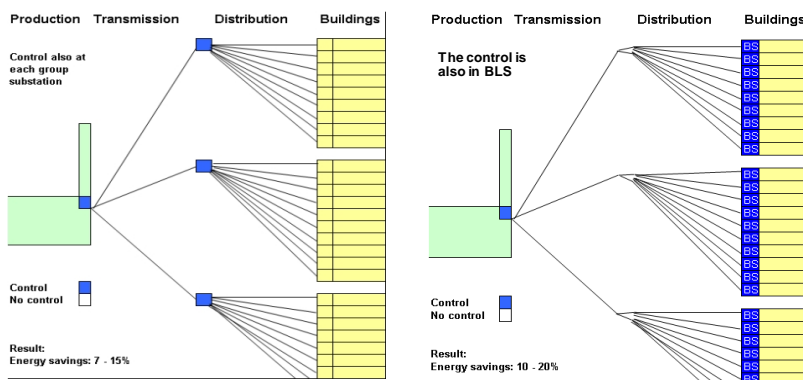
The current practice in China is to equip the GS with temperature control systems (right), which save 7–15% heat energy compared to the old practice with no control at all. The GS controls the supply temperature of the secondary network according to the outdoor temperature. Those buildings being close to the GS may receive excess heat whereas the others being at the end of the network less than needed as the secondary network may not be in balance at all times.

The heat energy savings mentioned in the Figures assume that the required room temperature is the same in all cases.

The closer the temperature control is to the customer, the more accurate is the control quality for the end-user at the apartment. Based on the accurate control, the problems with over and under heating of apartments will substantially fade, thus reducing heat losses in buildings.



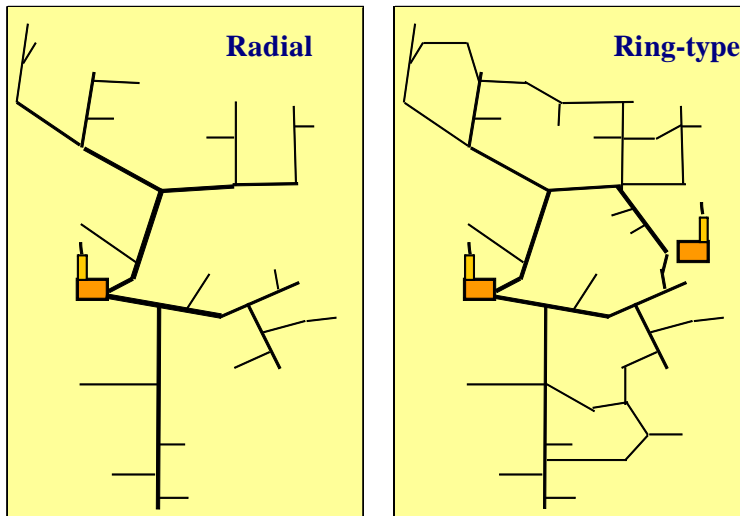
**Figure 9. Reference case with manual control at heat source only (left) and the current Chinese practice to have the automatic temperature control at each GS (right). The energy savings of the automatic GS reach from 7% to 15% relative to the reference case. The blue squares indicate temperature control whereas the white squares without such control.**



**Figure 10. The GS (left) is replaced by BLS (right). Simultaneously, the temperature control has moved from GS to each BLS, where the temperature control can be tuned to reflect the behavior of the particular building. The heat energy savings range from 10 to 20% compared to the reference case.**

In China, as in all countries in the world, people want to have a constant improvement on the living quality. It may mean better or more food, better possibilities to travel, larger variety of entertainment, etc. Improving quality of heating is certainly one of those trends of wanting. The heating quality means that room temperatures must stay adequate and stable to meet the increasing requirements of living comfort. To meet the requirements, the BLS offers a response better than the current GS.





**Figure 11. One heat source per network in the radial (China) versus two or more heat sources in the ring-type network (Finland).**

The ring-type primary network becomes possible when all substations, regardless whether GS or BLS type, are equipped with temperature control. The temperature control makes the substations automatic and independent. In practice this means that the substation functions if there is adequate pressure different on the primary side, about 1 bar (0.1 MPa), and the supply temperature is on the level required by the actual outdoor temperature. Thus, the automatic substation is independent on the direction from where the heat comes to the substation. Therefore, the substation can be connected to a ring (e.g. a loop) of the primary network having two possible directions to receive heat. Two directions improve the reliability of heat supply compared to the radial type. Moreover, the looped network allows economic load dispatch which sets the CHP to be a base heat source and the HoBs to remain as peak and back-up heat sources, as demonstrated in the Helsinki example above.

A new requirement shows up when the DH network operation will be converted from the radial to ring-type operation. Hydraulic analysis of ring-type networks is not possible any more to be carried out by manual calculation but the analysis requires a sophisticated software designed for ring-type network analyses.

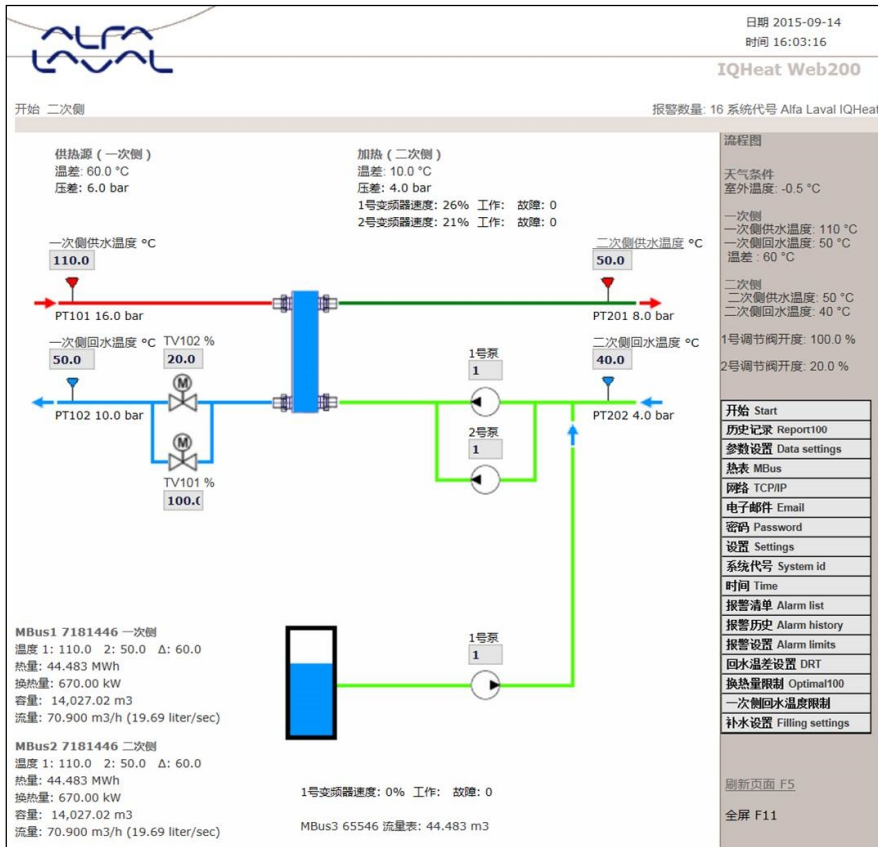


Figure 12. Control screen of substation.

## 6.7 IT Tools for Optimization

Appropriate software helps district heating companies improve energy efficiency, increase security of supply and save on costs. Two internationally used software tools of Enoro are mentioned here.

Enoro's GRADES Heating software is a network calculation and simulation tool that is used to improve overall network design and operation. The graphical user interface includes a map view for visual network design and simulation calculations. When the design of a DH network must be changed – for example to add BLS units, heating consumers, or network areas – GRADES Heating helps find the optimal new network dimensioning (sizing for pipes, pumps and valves), to increase energy efficiency and save on costs without reducing security of supply. In daily DH operations, GRADES Heating can be used to evaluate different scenarios to find the best network operation plan for the coming days.

The GENERIS energy information system provides a measurement data warehouse for the centralized management of all measurement data measured from DH networks. Collection of measurement data from as many network locations as possible provides valuable information about the status and dynamics of the entire DH network. In addition, measurement data can be used to improve the accuracy of network simulations. When GENERIS is also given data about the costs of heat production (e.g. production plants and fuel costs) and about sales models (i.e. sales contracts and tariffs), the system will provide the heating company with a complete and detailed overview of their entire heating business as a basis for planning future business operations.

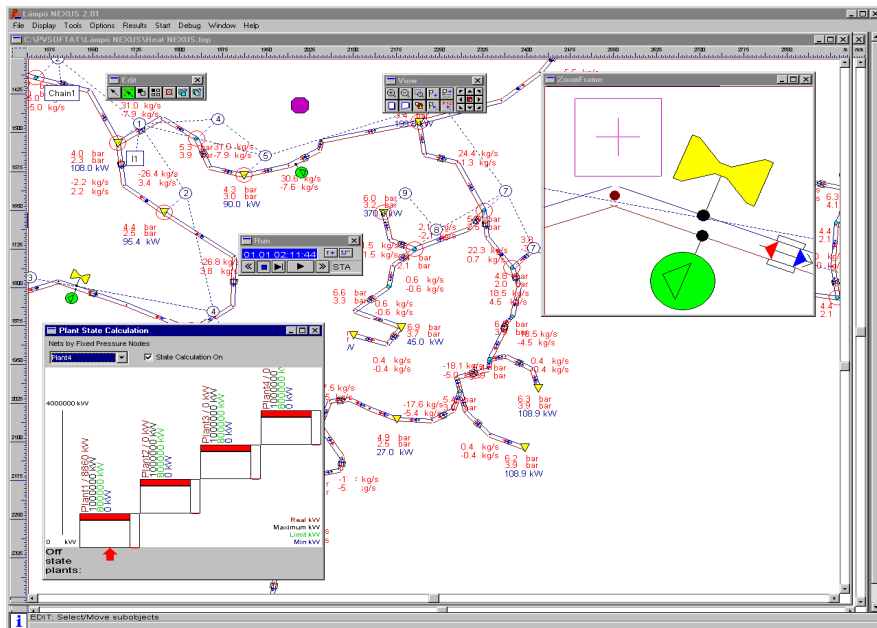


Figure 13. Example of looped network optimization with GRADES software.

## 6.8 Noise

The BLS units are silent as they are both designed and tested in the factory already to be installed in the living environment not to disturb anybody. The smallest substations can be installed in the living rooms, when the substations are apartment level substations, as show in Picture below.

The noise level of BLS is below 35 dB, which is mainly caused by the water flowing in the pipes. Also some little noise comes from the controller as it is knocking when doing the controlling work. As wet pumps are used, the pumps are silent and noiseless.



**Figure 14. Two apartment level substations for 150 m<sup>2</sup> (left) and 300 m<sup>2</sup> (right) heated areas including both DHW and SH services.**

## **6.9 Safety**

The BLS is equipped with an excess pressure valve, e.g. a safety valve, which releases the excess pressure out of the BLS and the DH system.

The high pressure and temperature up to some 10 bar and 120°C, respectively, can temporarily prevail in the primary network in the entrance of the substation. The pipes are from steel usually of PN16, which is designed for normal use in 16 bar pressure.

If problems occur, they start with small leakages in seams, which will be detected by the moist sensor located in the substation room or by the visual inspection regularly, once a week, for instance, carried out by the operation staff in the substation room.

## Annex 1: Sino-Fin Comparison of DH

The main differences between Finland, and typical to many countries in the EU, and China are collected to the table below.

Table 5. Comparison.

<b>Issue</b>	<b>China</b>	<b>Finland</b>
Climatic conditions	35–55° Latitude; -10...-35°C minimum temperature	60–70° latitude; -25...-35°C minimum temperature
New building code	New buildings with 50% energy reduction from the 1980-1982 building code	Low energy buildings from 2012 on
Status of DH	Strongly expanding 13–18% /a	Rather saturated market, 1%/a growth
Products of DH	Only room heating; DH system runs during heating season only (5–7 months); DHW usually with solar collectors	Both room and DHW heating: DH runs all year round
Type of room heating	Either radiator or floor heating	Radiator heating mainly
Heat metering	Rather common in group substations already, but rarely in buildings	Always in buildings
Number of enterprises	Several per city (In Tianjin used be 420 DH companies 10 years ago)	Usually one DH company per city but not regulated by anybody
Heat tariffs	Fixed Yuan/m <sup>2</sup>	Two tier tariffs based on metered heat consumption
Basis of heat billing	Building norms	Metered heat consumption

Heat distribution	DH company delivers via primary network to group substations, from which further on via secondary networks to buildings	DH company delivers via primary network directly to the buildings, where building level substations
DH sector regulation	Strictly regulated, socially motivated	Almost no regulation but market based business
Specific heat consumption	100–200 kWh/m <sup>2</sup>	130 kWh/m <sup>2</sup> including domestic hot water 130 kWh/m <sup>2</sup>
Quality of heating services	No heating in early autumn and late spring, sometimes inadequate room temperatures in winter (World Bank customer surveys)	Comfortable heating services all year round, customers are highly satisfied according to the surveys carried out.
Type of networks	Branched: one heat source per network	Looped: several heat sources in one network
Expected lifetime of the network pipelines	10–30 years. The main problem is the corrosion in the secondary networks 10–30年。	Longer than 50 years. At present, only 0.5% of the networks country wide are replaced annually (equals to 200 years lifetime)
Circulation water losses	The water losses are typical high 1–3% of the water flow.	Water losses are low: 0.08% of the water flow.
Circulation water quality	Water quality is poor and corrosive in the secondary side.	Good quality of water and no corrosion.
Heat production	About 35% from huge CHP plants and the rest 65% from coal fired water boilers of 29 to 64 MW and a little from industrial processes	70% from CHP, 30% from industry and heat only boiler sources
Heat production capacity	About 100% of peak load, no back up	120..200% of peak load including back-up
Fuel	More than 95% domestic coal	Mix of bio mass (31% in 2014), natural gas (22%), coal (24%), peat (13%); oil (3%), waste heat and other (7%)
Corporate structure	CHP state owned, DH city owned, secondary networks owned by customers	DH and CHP mainly city owned in one company, no secondary networks
DH company	Operation and maintenance focused utilities	Full scale business units

## **Annex 2: Substation for connecting the building to heating networks**

### **Integrated meter section**

Prefabricated meter section, integrated in the substation  
Complete for metering of energy, except meter.  
Vertical meter section with 10X before and 5X meter-DN after, in straight line  
Pressure class PN 16 (or PN 25 bar)  
Connection DN 50

### **Consisting of:**

Strainer with draining valve  
Thermometers 0–160°C  
2-point metering of pressure and differential pressure over strainer.  
Manometer in return line 16 bar.  
Temperature sensor connection DN15  
Dummy flow meter threaded DN32 L=260 mm  
Draining valve in return pipe  
Connection for letting off air DN15 in supply line

### **Heat exchanger system**

Unit including programmable computerized control equipment. Unit is delivered mounted, wired and fully functional.

1. Heat exchanger system
2. Computerized programmable controller
3. Options to Controller

#### **1. Heat exchanger system**

Unit for heating of heating circuits. Stainless acid proof steel in heat exchangers.

Unit made and marked according to PED 97/23.

Prefabricated Heat Exchanger Unit,

Weight about: 180 kg

Unit equipped with sensors for measuring of temperature of incoming primary and secondary media.

Sensors replace thermometers for temperature reading.

Primary supply equipped with a summer shut off valve for Heating 1

Needed deaeration connections included and drainings with sealed flush valves.

The heat exchanger is insulated with CFC-free PU-foam, with an ABS surface. The insulation is easy to mount and dismount.

Steel pipes in the system are painted.

**Heating 1** secondary side with:

- Ball valve in return pipe

- Balancing valve in supply line DN80

- Safety pressure relief valve, DN25, 6.0 bar

- Filling of secondary side of type EN1717 EA.

- Connection for expansion line DN25

- Strainer in return line

Manometer for pressure and differential pressure reading 3 points, 0–6 bar

*Circulation pump*

- Flow 6.09 l/s, lifting height 85 kPa

The pump has alarm signal, is prepared for external on/ off control, and has control input for 0–10V.

External pipe connection DN80

## **2. Computerised controller**

Hardware is mounted in an electrical cabinet. It includes applications and functions for control and monitoring of the heating unit.

Controller has an inbuilt display, and can even in simplest version communicate via WEB, OPC and ModBus both RTU and IP, without options and add-ons. A modem port is also included.

M-Bus, Lon, advanced WEB, BacNet and other options included in delivery are listed under 3. - options below.

Controller can be integrated and communicate with most Building Management Systems (BMS) and supports open communication standard like TCP/IP OPC and LON.

Optional communication module can be installed also afterwards, not needed to be part of initial delivery. The software can be replaced by use of the inbuilt SD-card reader.

Controller shall be completely installed, programmed and wired. Basic function of hardware and software, as well as sensors, actuators, pump control functions shall be tested before shipment.



## **Control functions**

### *Heating*

Outdoor compensated heating supply temperature is used. An outdoor sensor and a heating curve determines the wanted supply temperature of the heating supply. The heating curve is a 5 points curve + min and max value, adjustable at different temperatures.

### *ECO-function heating*

Need- based control of control valves and pumps. At warm outside temperature all control valves closes, and the pump stops. Pump and valve exercise is performed at adjustable times.

### **The controller shall be always prepared for the following functions:**

Reading of pulses from energy meter and/ or cold water meter.

Limiting/ control of difference between the primary return and the secondary return temperatures. When this difference is too high, this function limits the opening of the control valve, in order not to use more than necessary capacity and limit primary flow.

Limiting of return temperature primary side. Different settings depending on season. Capacity or flow limitation.

## **Alarm functions**

Controller has alarms for temperature deviations, sensor faults, pump alarms and external alarm inputs. Alarm message can be sent as E-Mail or SMS if unit is connected to internet, or via an optional Modem.

## **Commissioning**

Startup is made according to instructions in the manual in the shipping documentation. Support available via .(contact of the manufacturer).

## **3. Options included in delivery**

These options are ordered and is part of the delivery:

### **- Advanced webserver**

Advanced WEB- function, built in web server. Gives a graphical interface over the units functions. A large memory holds historical data ( >20 years!) that can be presented in the user interface. All settings, optimizations and alarm handling can be made via this user interface. No licenses, no programs needed, no web-hotels etc. Only a PC with a web browser program is needed. Internet connection on both the Controller and the PC is needed.

Alarms as SMS to mobile phones via TCP/IP is prepares, as well as e-mail alarm. A report function shall be included in Controller. It is a function monitoring system for historical data of the unit. The Report component shall have several loggers,

with different time horizons. In the user interface can be monitored 1, 2, 3 or 8 days of values in a graph, or as values in a table.

It shall be possible to download all stored data since the Controller was started up every 10 minutes a value-set is saved. This data shall be accessible in an Excel file automatically created on demand.

The electrical cabinet shall be prepared with a 2 meter TCP/IP network cable, that should be connected to the internet-supplier's network socket. Internet connection, subscription and socket are not part of this delivery.

#### **-Meter value communication**

Transmitting of meter values from energy meter and/ or cold water meter with M-Bus. Values gathered from the energy meter are volume, energy, capacity, flow and temperatures.

#### **-Pressure sensor 0–10 bar**

Pressure sensor 0–10bar, output 0–10V (24V AC supply) for measuring of pressure in secondary side heating.

#### **Design data:**

Available differential pressure min:	100 kPa
Pressure Norm PN 16 (or PN 25) <i>Heating 1</i>	
Capacity	500 kW
Temperature	120-63.8 / 60-80 °C
Flow	2.24 / 6.09 l/s
Pressure drop	2 / 14 kPa

#### **Control equipment:**

Controller	
Heating 1	
Temperature sensor	QAZ21.5220-150
Sec. return sensor	QAD21/209
Prim. Return sensor	QAD21/209
Outdoor sensor	QAC 22
2-way control valve 16.00, 25 kPa	VVF53 DN40 Kvs
Actuator	SKD 60
<i>Sensors primary side</i>	
Sensor primary return	QAD21/209
Sensor primary supply	QAD21/209

Control equipment with sensors and actuators are internally wired. Outdoor sensor is supplied but not wired. Commissioning not included.

Supplied pumps are electrically wired. For 1-phase pumps for heating >6 A, Hot Water Circulation pumps > 2 A, double pumps and all 3-phase pumps only alarm and control wiring is made. Electrical main supply for pumps must then be done on site according to local regulations.

### TECHNICAL SPECIFICATION TABLE

<b>HEAT EXCHANGERS</b>		<b>Unit</b>		<b>Heating 1</b>		
Manufacturer						
Type						
Load		kW		500		
				<b>Prim.</b>	<b>Sec.</b>	
Temperature		°C		120-63.8	60-80	
Flow		l/s		2.24	6.09	
Pressure drop		kPa		2	14	
PED - category				Cat 1		
Material				AISI 316		
<b>Control equipment</b>				<b>Heating 1</b>		
Manufacturer						
Controller						
Control Valve						
Flow		l/s		2.24		
Pressure drop		kPa		25		
Size / kvs		DN/kvs		40/16.00		
Actuator				SKD 60		
Control signal/Voltage		V		24V / 0-10V		
<b>PUMPS</b>				<b>Heating 1</b>		
Manufacturer						
Type						
Flow		l/s		6.09		
Head		kPa		70		
Power / Current		W / A		769/ 3.38		
Voltage		V		230, 1 phase		
<b>NETWORK, EXPANSION- AND SAFETY EQUIPMENT</b>				<b>Heating 1</b>		
Network volume / lifting head for network		l/kPa		/ 50		
Expansion tank volume / prepressure		l/kPa		/		
Safety valve size / relief pressure		DN/bar		DN25/6.0		
<b>SECONDARY SIDE PIPE EQUIPMENT</b>				<b>Heating 1</b>		
Pressure drop		kPa				
<b>PIPE SIZES</b>						
District heating flow/return				DN50		
Heating flow-return, pressure drop for pipes and components				DN80		

<b>OPTIONAL COMPONENTS:</b>	<b>Measurements and calculation values</b>
Balancing valve for heating / Pressure Drop (kPa)	
Manometer module for heating / secondaryside	3 points, 0–6 bar
Filling H1	
Summer Shut Off Valve Heating1	
Painting of steel Pipes	
Pressure sensor 0-10 bar, 0-10 V, 24V AC IQ Web200 ( Incl. WEBServer, Report, E-mail alarm) IQ Meter 200 ( M-Bus, meter communication)	
<b>ADDITIONAL INFORMATION:</b> Temperatures read from control center.	
PED-category for substation Cat 1	
Calculated available differential pressure of primary heating network min 100 kPa /max 600 kPa	
Integrated meter section with inlet strainer, sensor pockets and thermometers. Vertical return line with meter dummyThreaded, DN 32, 260 mm.Pressure metering in 3 points, 16 bar.	

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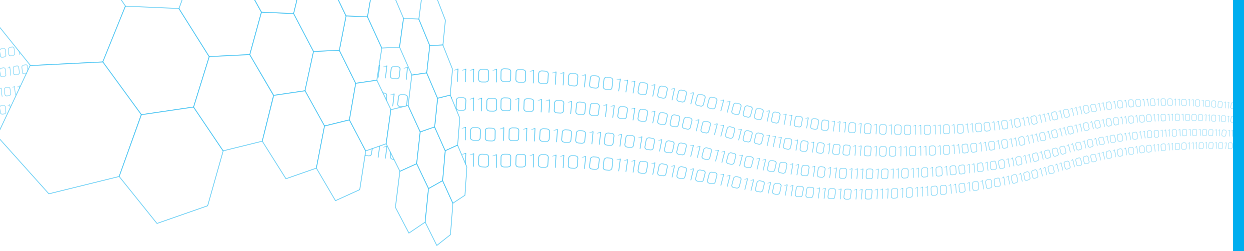


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Title	<b>Building level substation – the innovation of district heating system</b>
Author(s)	Kari Sipilä, Arto Nuorkivi & Jorma Pietiläinen
Abstract	<p>The building level substation (BLS) is suggested here as an innovation to the District Heating (DH) sector development in China. Introduction of the BLS would provide obvious benefits in improved energy efficiency and living comfort, but it also faces institutional barriers to overcome. CHP concept will be described, and the economic, institutional and technical issues associated to BLS will be addressed.</p> <p>The BLS units are prefabricated compact products that are designed, manufactured and tested at the factory ready for transportation to the construction site, where the complete BLS unit will be mounted to the floor, connected to the existing indoor piping of heating and water, the remote communication facilities as well as to power supplies of the building.</p> <p>The BLS as an integrated plate heat exchange unit shall be prefabricated and assembled and successfully tested both hydraulically and electrically in the factory already to meet the high functional and low noise requirements, and if he so wishes, at the presence of the Borrower's representative. Its base and brazed structures should have sufficient intensity and stability.</p> <p>Domestic hot water (DHW) can also be integrated to DH. BLS makes it possible to complement the DH with DHW afterwards at low incremental costs: a small heat exchanger and a small circulation pump as well as connection to the existing DHW and city water piping are needed.</p>
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## **The building level substation – the innovation of district heating system**

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