3rd International Conference on
Smart Energy Systems and 4th Generation District Heating
12-13 September 2017 · National Museum · Copenhagen

The 1st application of 4th Generation District Heating in Japan, its outcomes and lessons

Sep. 12th, 2017

Hironao Matsubara, Tsuyoshi Yoshioka, Kanau Takahashi, Tetsunari Iida,

Institute for Sustainable Energy Policies, Tokyo, Japan

http://www.isep.or.jp/en

Jens Birch Jensen PlanEnergi, Denmark
http://planenergi.dk/

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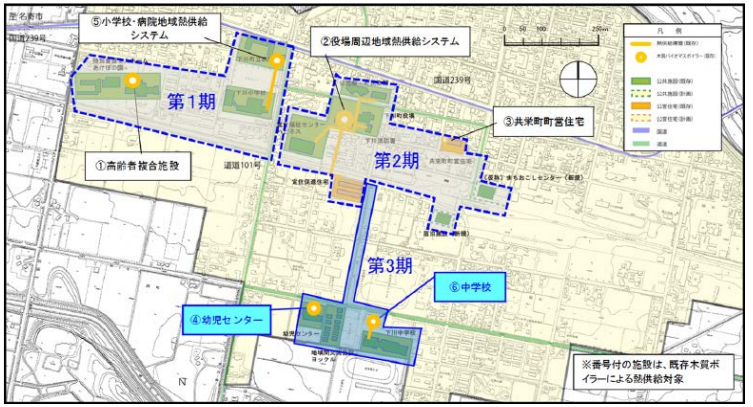
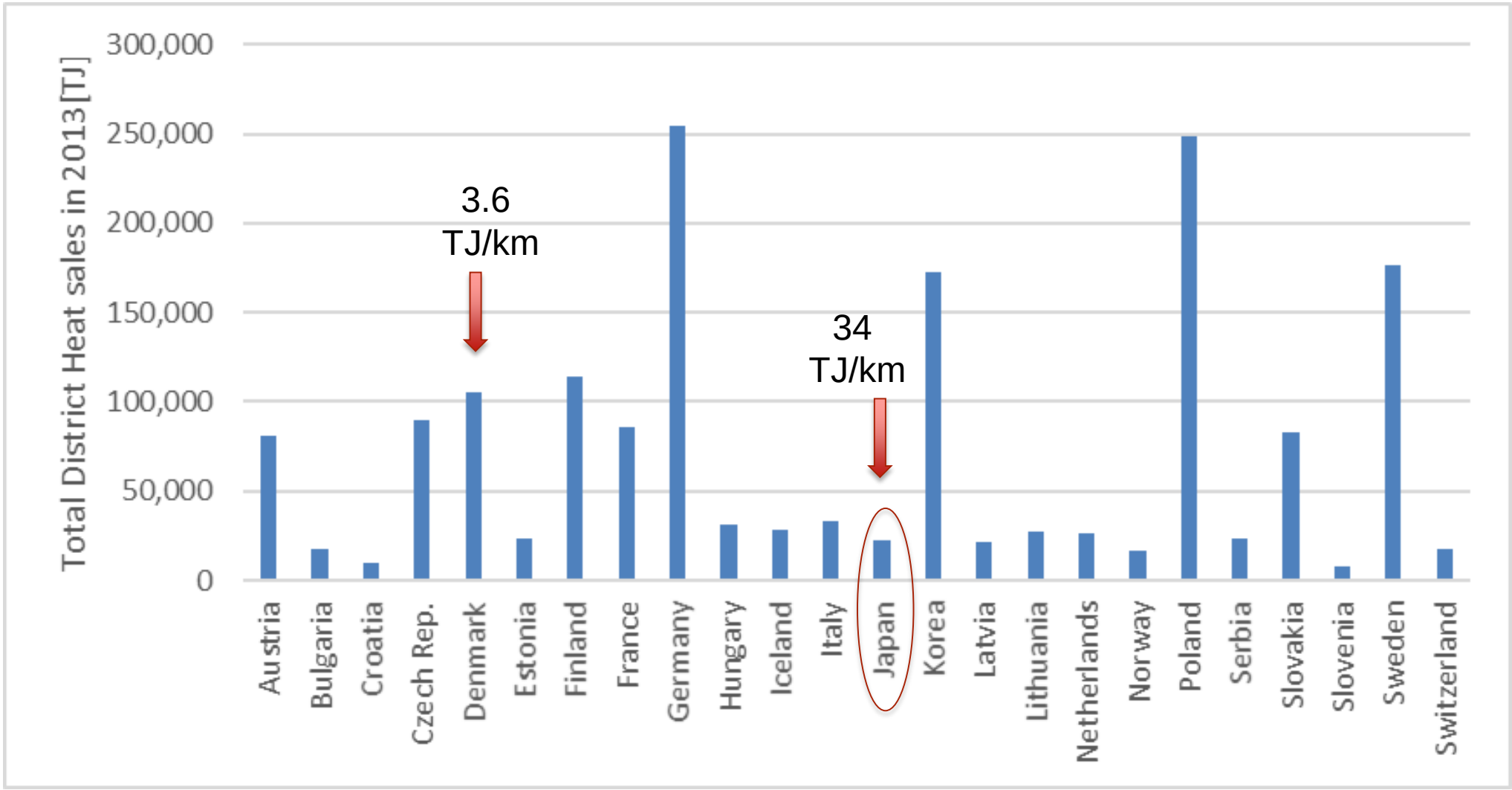


Status and Challenge of District Heating System in Japan
Comparison of Total District Heat Sales in each country (2013)

Market of district heating in Japan is very small as heavily populated country



Source: EUROHEAT&POWER Country by Country , 2015

Comparison of DH status between Denmark and Japan

- DH penetration in Denmark is 100 times larger than Japan in proportion to population
- Line Heat density of DH in Japan is 10 times larger than Denmark

Index	Denmark	Japan	Denmark/Japan
Population(2016)	5,710,000	127,000,000	0.04
Area	43,094 km2	377,972	0.11
Total District Heat sales in 2013	105,563 TJ/a	22,902 TJ/a	4.6
Annual District Heat sales turnover 2013	2,945 M EUR	1,103 M EUR	2.7
Trench length of DH pipeline 2013(2009)	29,000 (28,000) km	672（736）km	43 (38)
Number of District Heating systems	394	139	2.8
Line Heat Density	3.6 GJ/a m	34.1 GJ/a m	0.11
Penetration of DH	18.5 GJ/Capita	0.18 GJ/Capita	103
Price of heat	0.028 EUR/MJ	0.048 EUR/MJ	0.58

Source: EUROHEAT&POWER Country by Country , 2015

Market of District Heating and other energy business in Japan

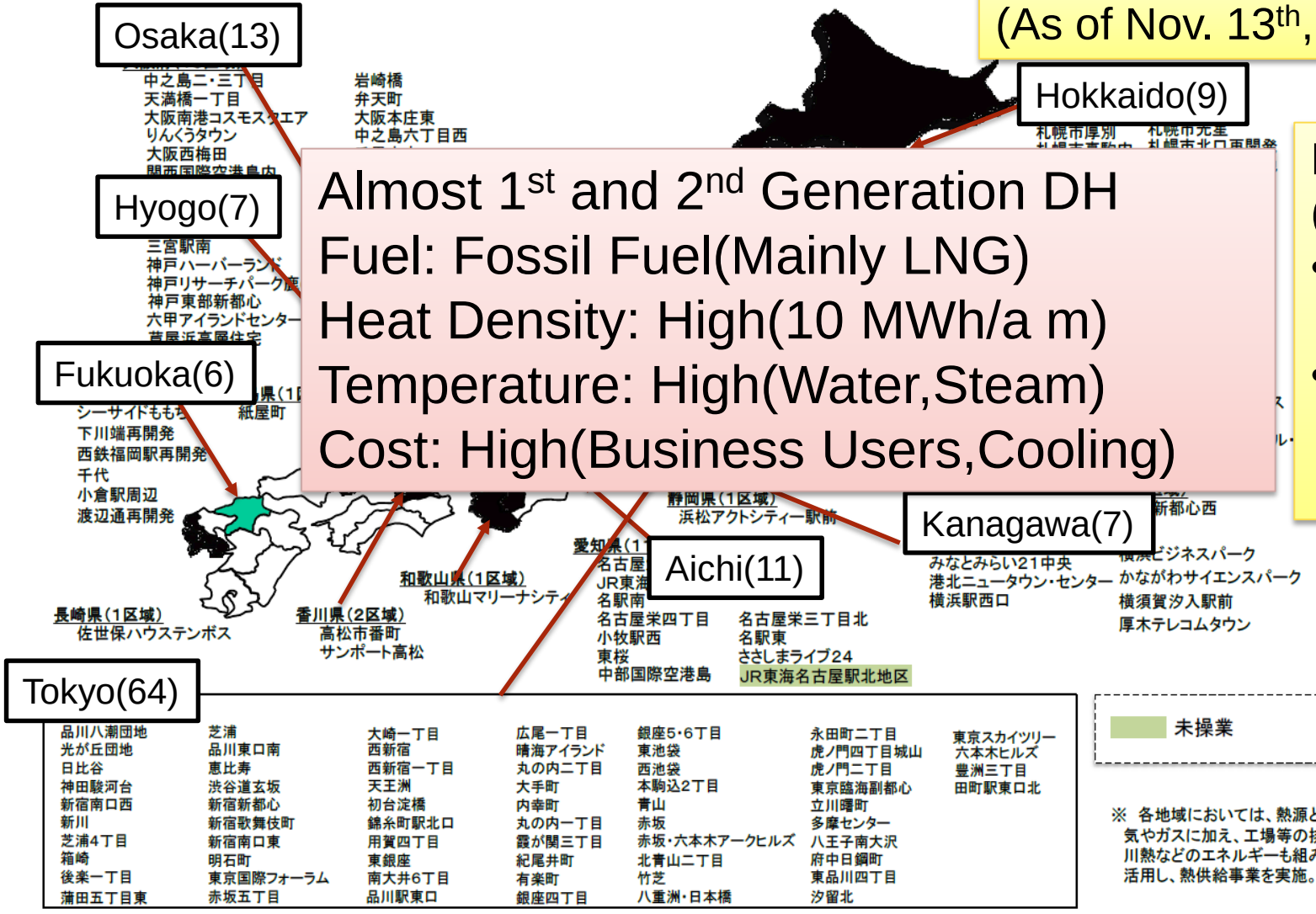
Market of District Heating is very small in comparison with gas market in heating sector of Japan.

	Electricity Market	Gas Market	District Heat Market	Gas/ DH
Liberalization period	FY2016	FY2017	FY2016	
Supply Area(Share of land area)	100%	5.7%	0.01%	570
Number of consumers	84 million	29 million	36,000	805
Annual Sales Turnover	16 Trillion JPY	3.7 Trillion JPY	145 Billion JPY	25
Total No. of Employee	130,000	32,400	2300	14
No. of Employee in each area	13,000	155	17	9
Data Year	FY2012	FY2012	FY2013	
Notes	10 Big Utilities Over 400 retail Sales Company	Not including LPG	77 Companies, 138 Regions	

Source: METI

Status and Challenge of District Heating System in Japan
Operators of District Heating System in Japan

77 Companies, 138 Regions
(As of Nov. 13th, 2014)



Almost 1st and 2nd Generation DH
Fuel: Fossil Fuel(Mainly LNG)
Heat Density: High(10 MWh/a m)
Temperature: High(Water,Steam)
Cost: High(Business Users,Cooling)

District Heating (Regulated):

- More than two supply points.
- Large Scale(Min. Output 21GJ/h)

Output:
more than 5.8MW
Almost by Fossil Fuel

Source: METI

Application designs of District Heating System in Japan

Case2: Ogata Village

- Rice Husk Boiler
- Location and size of the Boiler
- Coverage of Heat demand by biomass
- Spec and Cost of Piping Network

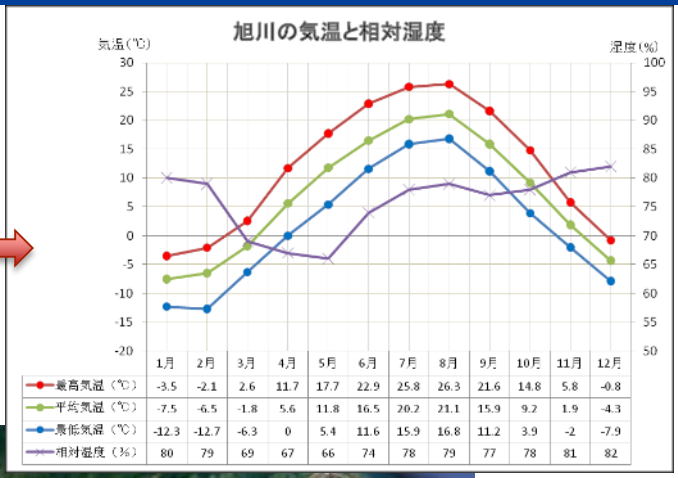
Case1: Shimokawa Town

- CHP operated by wood pellet
- Heat Storage
- Coverage of Heat demand with DH and existing biomass boiler
- Spec and Cost of Piping Network

http://frame-illust.com/?p=10210

Case1:
Shomokawa Town in Hokkaido, Japan

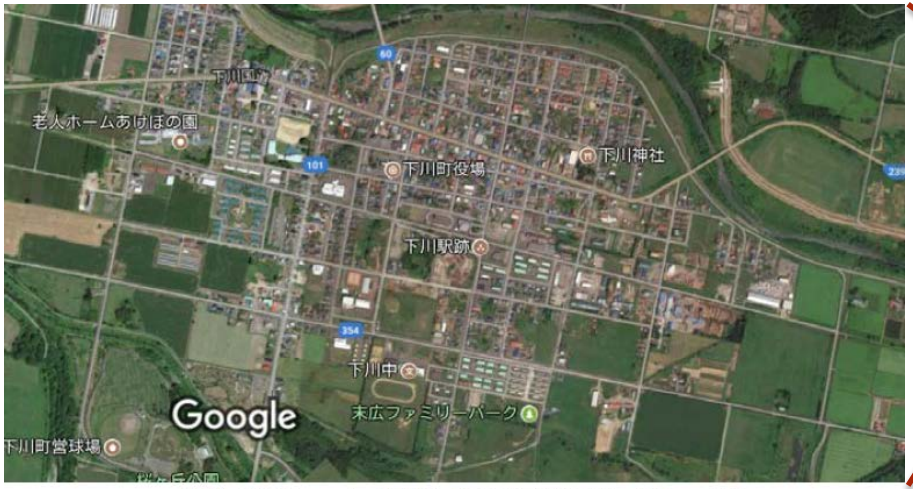
- **Population : 3,468 (June, 2015)**
- **Total Area: 64,420ha**
- **Peak Temp. : Summer 30℃、Winter －30℃**
- **Average Temp. : Summer 21℃、Winter -7.5℃**
- **Forest area : 88% of town**
- **Agricultural Area : 6% of town**

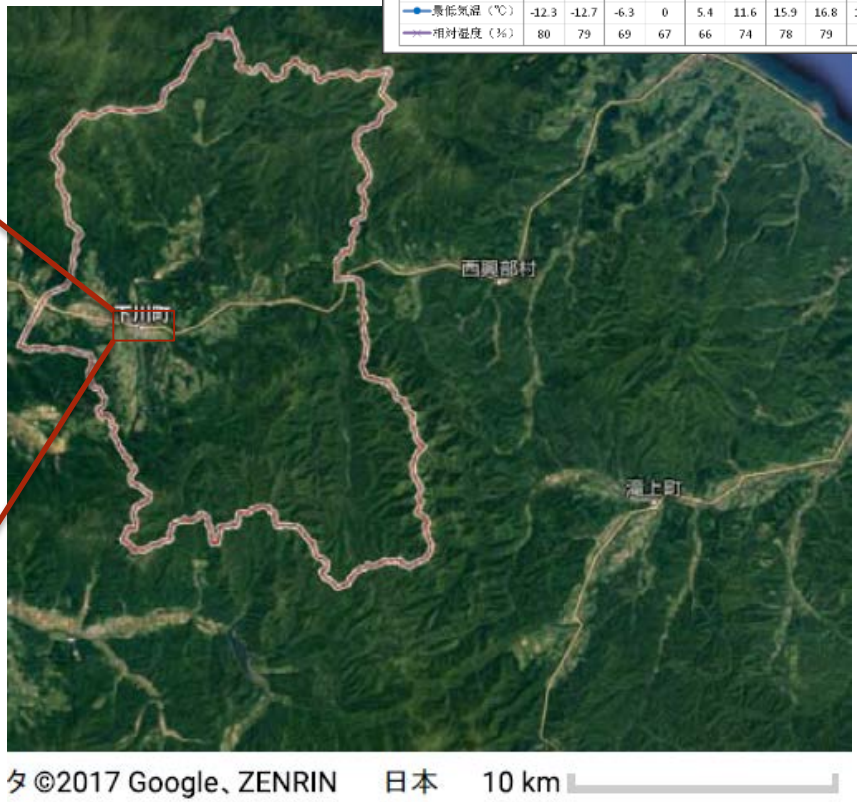


	1月	2月	3月	4月	5月	6月	7月	8月	9月	10月	11月	12月
最高気温（℃）	-3.5	-2.1	2.6	11.7	17.7	22.9	25.8	26.3	21.6	14.8	5.8	-0.8
平均気温（℃）	-7.5	-6.5	-1.8	5.6	11.8	16.5	20.2	21.1	15.9	9.2	1.9	-4.3
最低気温（℃）	-12.3	-12.7	-6.3	0	5.4	11.6	15.9	16.8	11.2	3.9	-2	-7.9
相対湿度（%）	80	79	69	67	66	74	78	79	77	78	81	82

Source: JMA

Center of Shimokawa Town



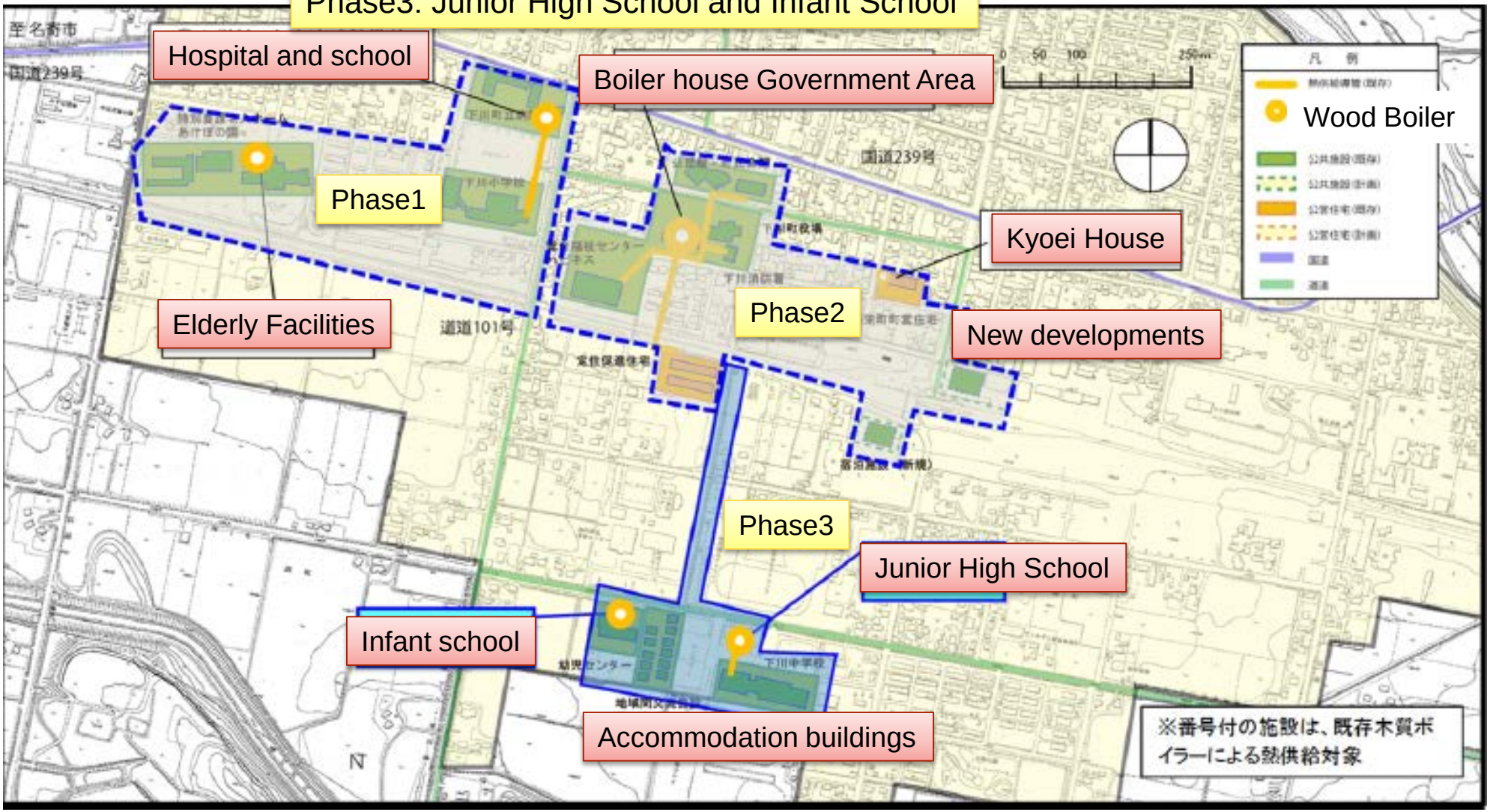


Case1: Shimokawa Town
Design Area of District Heating

Phase1: Elderly Facilitires, Hospital and school

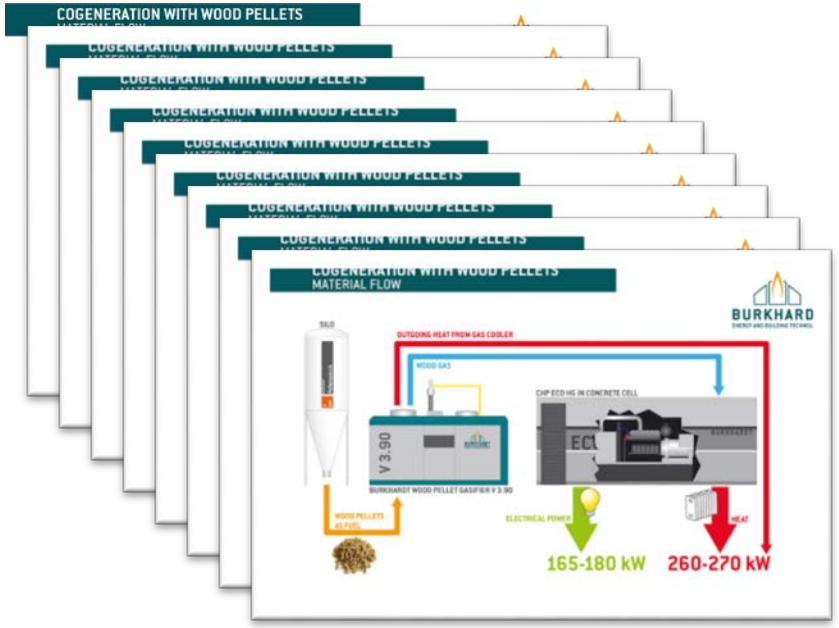
Phase2: Government Area and Kyoei House

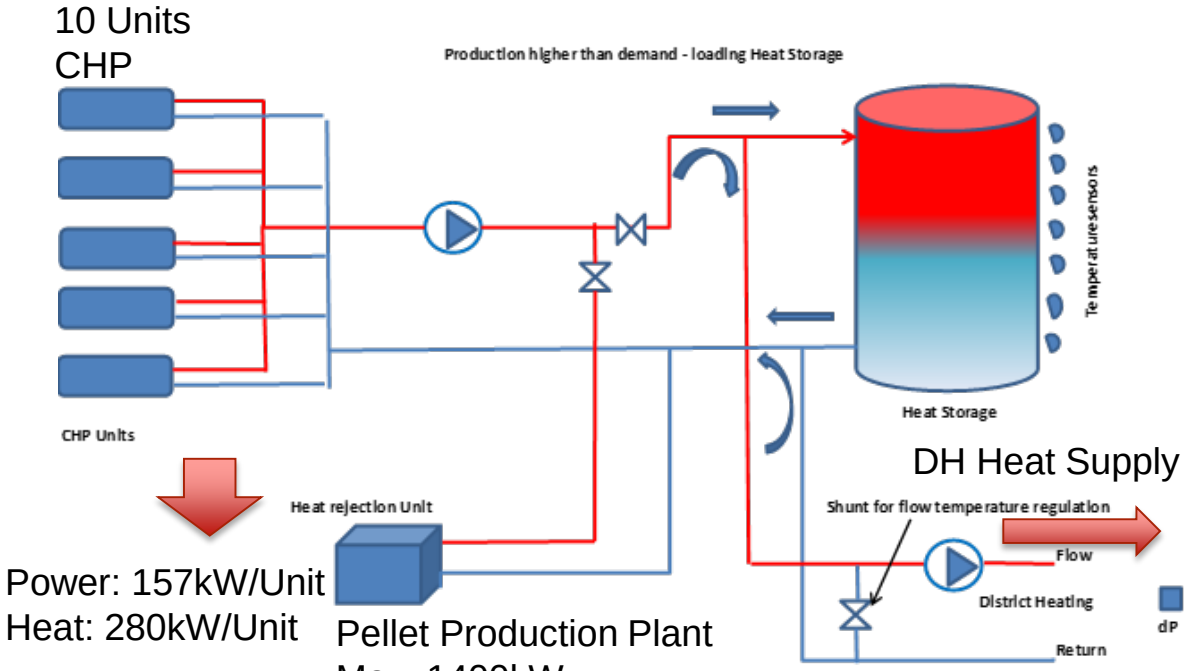
Phase3: Junior High School and Infant School



Case1: Shimokawa Town
Heat Source(CHP) of District Heating system

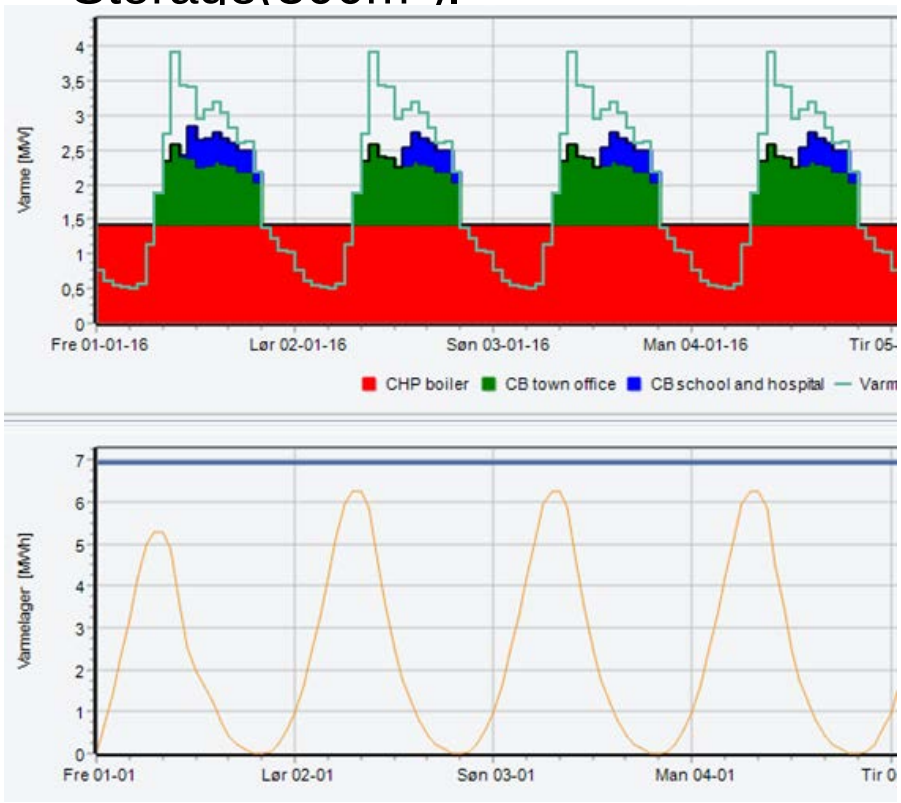
- Total heat production for external use is 2800 kW. Hereof a maximum of 1400 kW is used for the pellet production plant. The surplus heat depends on the ambient temperature, wood chip temperature and humidity of the material.
- District Heating Network for utilization of surplus heat(minimum 1400kW) from CHP Plant to heating and domestic hot water heating
- Utilization of existing boiler plants for peak and reserve capacity

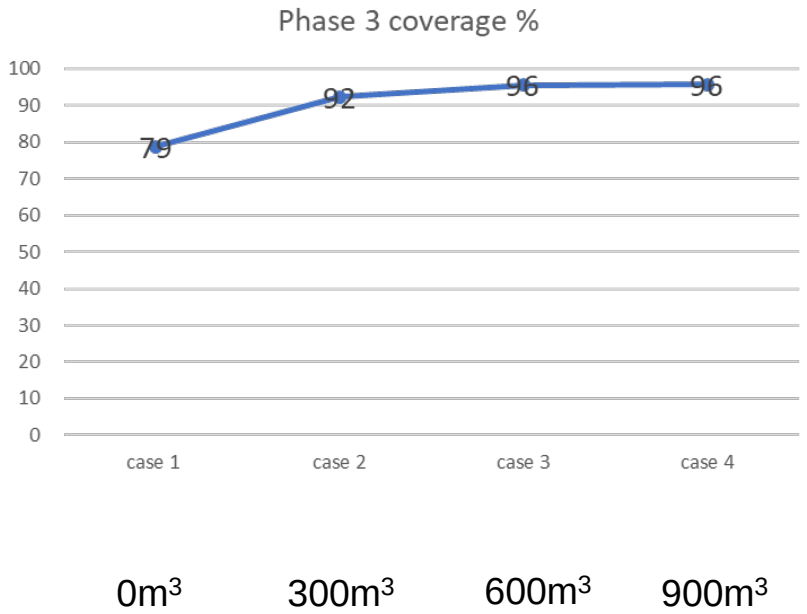




Case1: Shimokawa town
Design of Heat Storage

- Separation of operational control for heat production and heat consumption
- Storage of surplus heat production for periods with larger consumption than production (i.e. peak supply)
- Reserve capacity on stops or failures of the production units.
- Peak heat demand is 3900 kW. Up to 3000 kW it is covered by CHP and Heat Storage(300m^3).

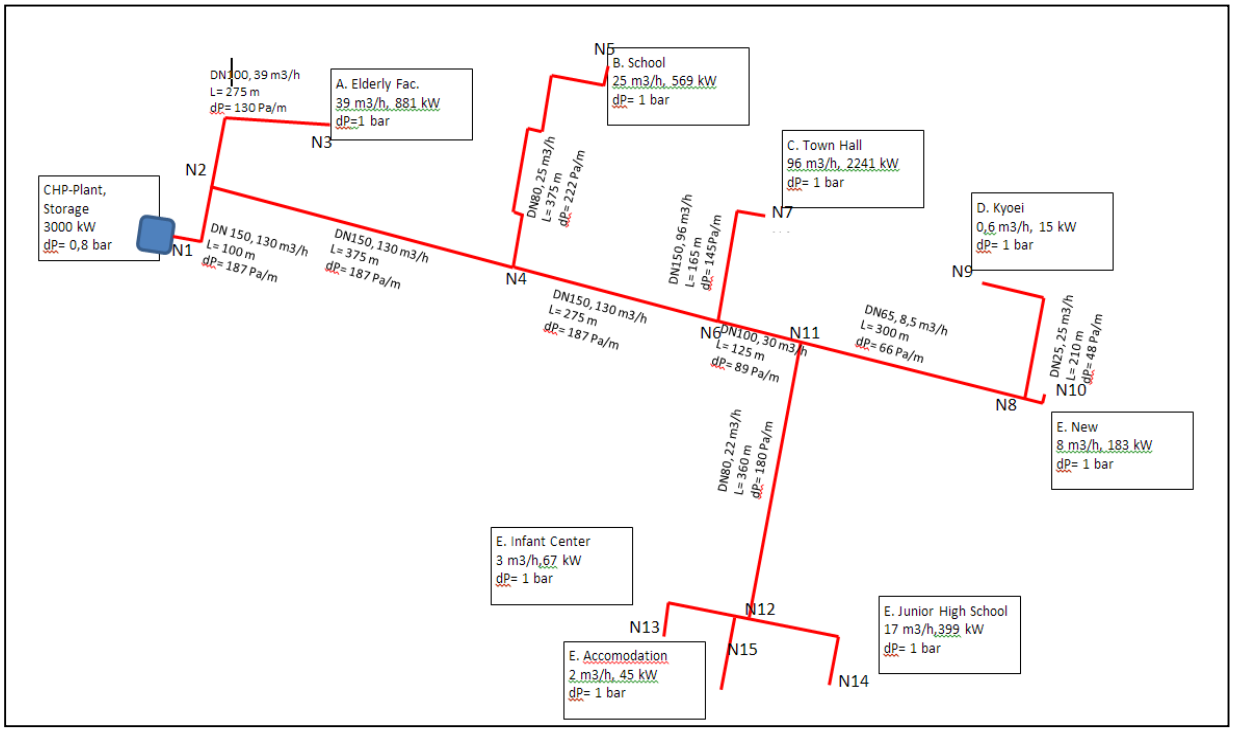




Phase 3, Tank Volume:300m3

Case1: Shimokawa Town
District Heating network Layout(Phase3)

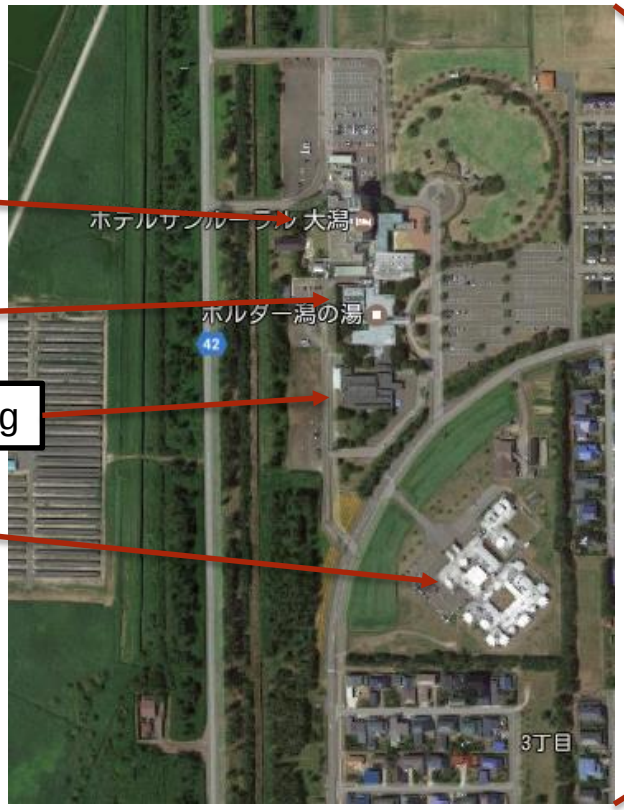
- DH network design for the peak demand is made at a low temperature difference of 20 ℃ and relatively high temperature(80℃) for supply because of operating condition for existing biomass boiler and demand side heating system for mainly public building. Design of 4th generation DH will be adopted in future expansion of the network because of lower heat density for wide residential area.
- Pressure loss and velocity in the network is maximized to 200 Pa/m and 2 m/s. The maximum pressure drop and flow speed is determined from the cost of investment vs. cost of operation (power consumptions costs).



Peak demand: 3.9MW
Peak supply: 3.0MW
Storage: 300m3
DH Cover rate: 93%
Supply Temp.: 80℃
Return Temp.: 60℃
Max Pipe Diameter: DN150
Length of Pipeline: 3.0km
Max. Pressure Drop: 200 Pa/m
Max. Flow Velocity: 2 m/2
Annual Heat Supply: 13 TJ/a
Line Heat Density: 4.4 GJ/a m

Case2: Ogata Village
Ogata Village in Akita, Japan

- **Population : 3206 (As of Sep. 2017)**
- **Households: 1103**
- **Total Area: 170 km²**
- **Average Temp. : Summer 24 ℃、Winter 0 ℃**
- **Forest area : almost 0% of town**
- **Agricultural Area : almost 100% of town**



Case2: Ogata Village
Background of designing DH system

Ogata Village is planning the implementation of a local Energy Supply system consisting of:

- Rice husk Boiler Plant for production of District heating
- District Heating Network for utilization of heat from Boiler Plant to heating and domestic hot water heating for 4 consumer buildings
- Utilization of existing boiler plants for peak and reserve capacity

The district heating system will in phase 1 provide hot water distribution from the Boiler Plant to a number of existing boiler houses:

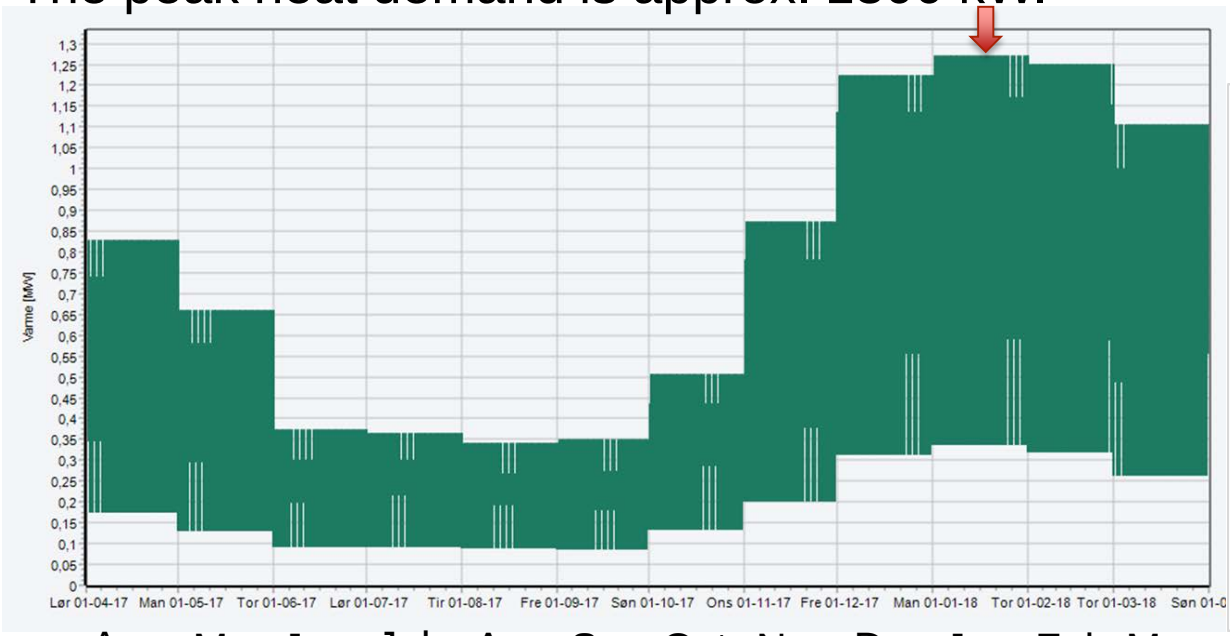
- Sunrural Hotel
- Polder Hot Spring
- Social Welfare Building
- Nursing Home

The district heating system is designed for the possible future extension of the system.

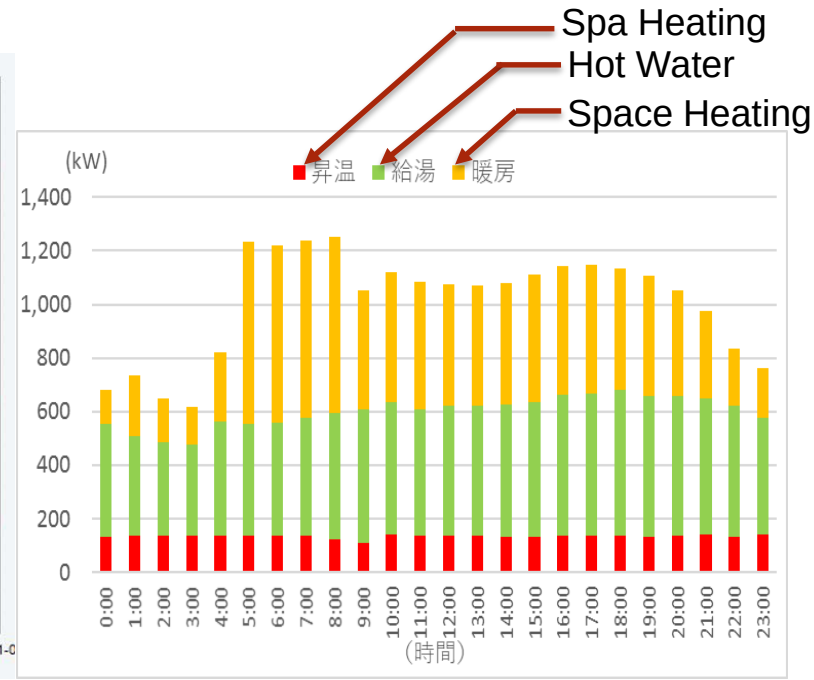
Case2: Ogata Village
Heat Demand of the facilities in the center of the Village

Facility	Heating Spa	Hot Water	Space Cooling	Space Heating	Annual Demand
SunRural Hotel	Heating Oil Boiler 733kW + 733kW		Oil Absorption HP x 3 Cooling:352kW, Heating:422kW		Oil:268 kL/yr
Polder Hot Spring	Heating Oil Boiler 581kW, 581kW, 350kW		Oil Absorption HP x 2 Cooling: 211kW, Heating 253kW		Oil:330 kL/yr
Fureai Social Welfare Building	Heating Oil Boiler 291kW		Oil Absorption HP Cooling 246kW, Heating 295kW		Oil: 54 kL/yr
Hidamari Nursing Home	Electrical Heater 89kW and 17kW		Electrical HP(Air) Each Room Electrical Floor Heating		382 MWh/yr

The peak heat demand is approx. 1300 kW.



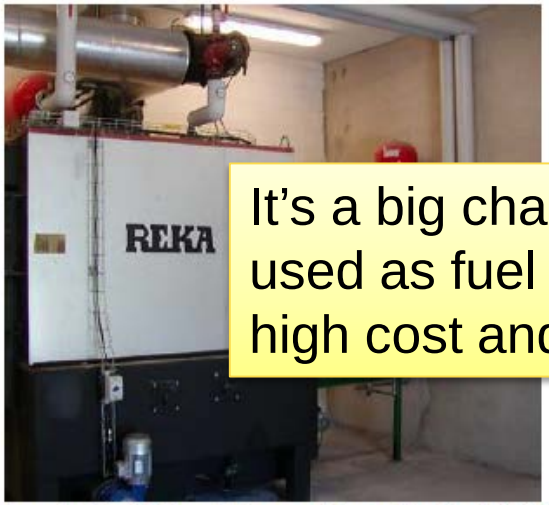
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar



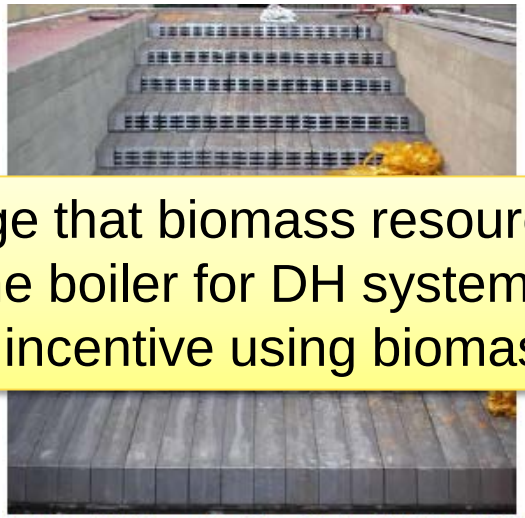
One day in January(peak demand)

Case2: Ogata Village
Rice husk as a fuel of Biomass Boiler

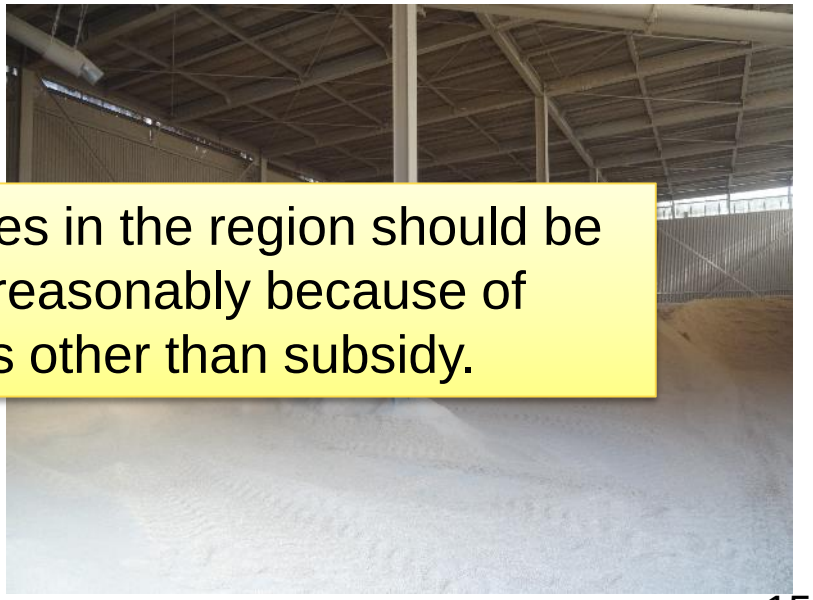
- Total production of Rice Husk is 11,000 ton/year in Ogata Village
- Almost 4,000 ton Rice Husk is treated in the Rice center of the village.
- Rice husk contains 20%wt ash, mainly Silica which has risk of crystallization.
- Burning test of rice husk is needed by the biomass boiler to avoid crystallization.



Picture 2: Bio Boiler, stoker, grate and boiler (REKA HKRST)



Picture 3: Moveable Step Grate (REKA HKRST)



It's a big challenge that biomass resources in the region should be used as fuel of the boiler for DH system reasonably because of high cost and no incentive using biomass other than subsidy.

Case2: Ogata Village
Comparison of Networks Design for District Heating

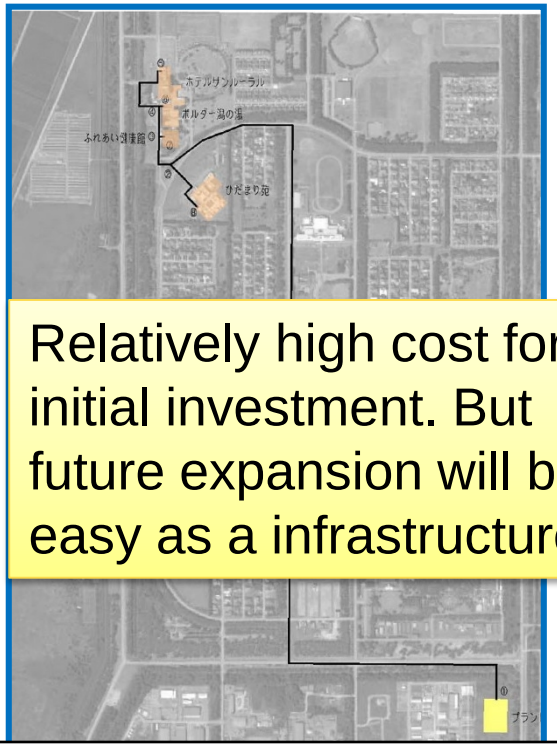
Case A:
Near by Consumer

Relatively low cost for initial investment. But in future expansion of DH, more investment will be needed

Case B:
Source of Hot Spring

Lowest cost for initial investment. But Future expansion of DH will be difficult.

Case C:
Near by Rice Center



Relatively high cost for initial investment. But future expansion will be easy as a infrastructure.

Heating Hot Spring, Hot water, Space heating	Demand：Heating of Hot spring、Hotwater	Demand：Heating Hot Spring, Hot Water, Space Heating
Boiler：1400kW(700kW × 2)	Boiler: 500kW	Boiler：1400kW(700kW × 2)
Total length of pipe：840m , Heat Storage 10t × 2	Pipe：existing pipe of Hot Spring	Total length of pipe：3200m , Heat Storage: 10t × 2
Rice Husk: 2,347ton/year	Rice Husk: 1,148ton/year	Rice Husk: 2,478ton/year (No Transport)
Initial Investment：511 Million JPY	Initial Investment：204 million JPY	Initial Investment：916 million JPY

Conclusions and recommendations

- DH is so minor for energy supply system in Japan. Almost 1st and 2nd generation DH system are adopted using fossil fuels(mainly gas) , high supply temperature and low temperature difference because of high heat density in urban area. Concept of 4DH should be known by policy maker, specialist and business operator of DH system.
- In this situation, application designs trying to adopt 4DH concept was made in two regions, Shimokawa Town(Hokkaido) and Ogata Village(Tohoku). As a result, adopting 4DH concept is found difficulty because of several hurdles of existing heat supply system.
- For adopting 4DH concept to DH system in Japan, heat policy and research plan should be revised in the future. And reformation of existing DH system in design and implementation level will be needed.

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Thank you !

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