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Case study: Experimental and numerical assessment of district heating supply for apartment complex

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INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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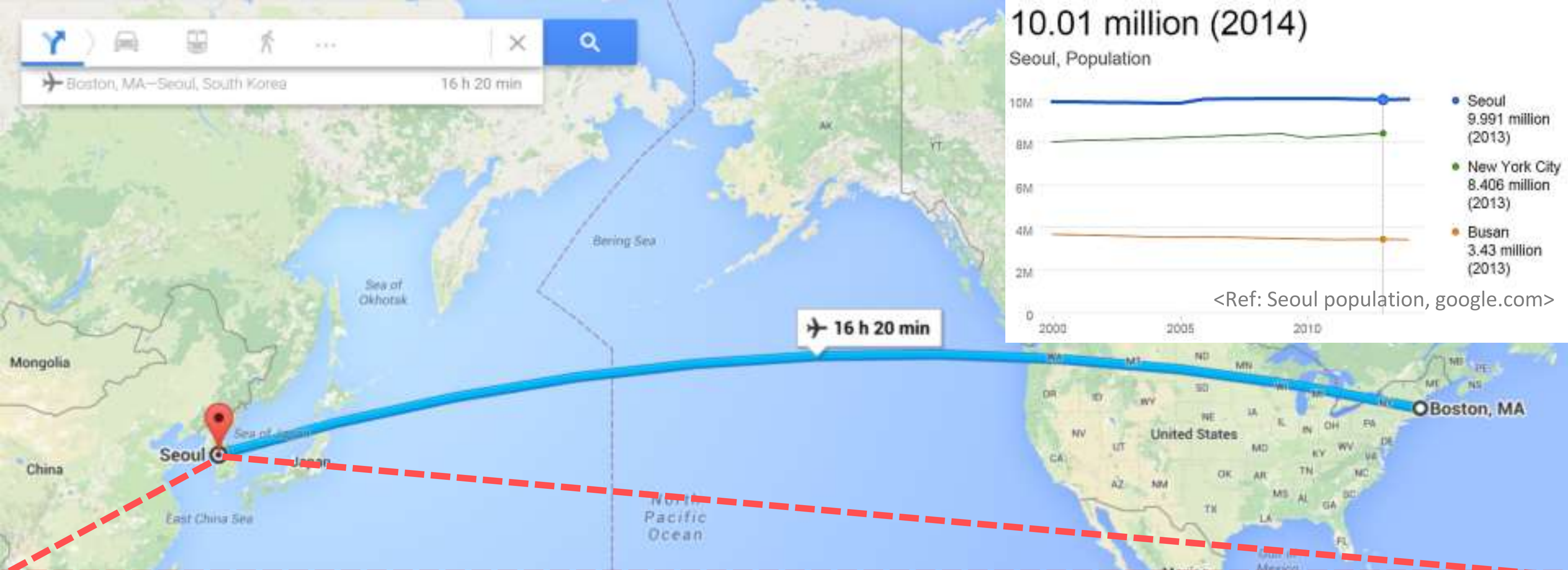
CONTENTS

Case study: Experimental and numerical assessment of district heating supply for apartment complex

Development industrial core energy technology

Contribute to national economic growth by developing and deploying industrial core energy technology



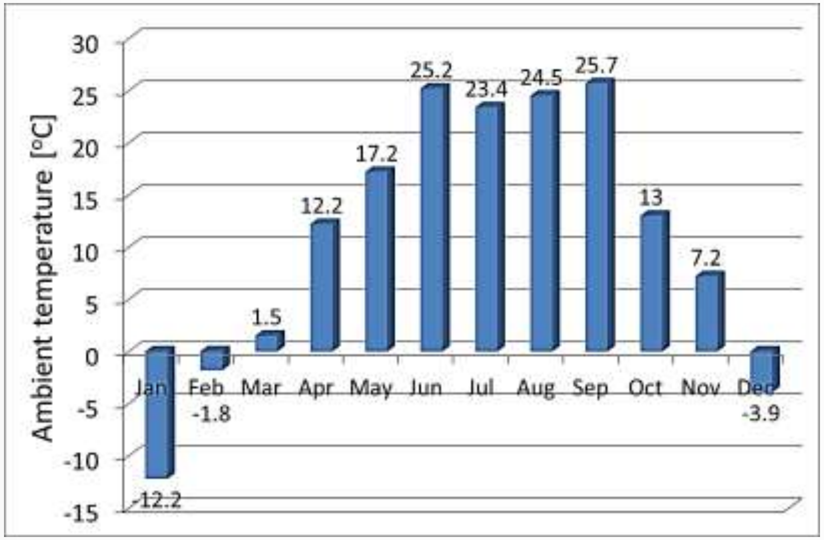
<Ref: Seoul population, google.com>

<Ref: Apartment complex in Seoul, hkviewn.wordpress.com>

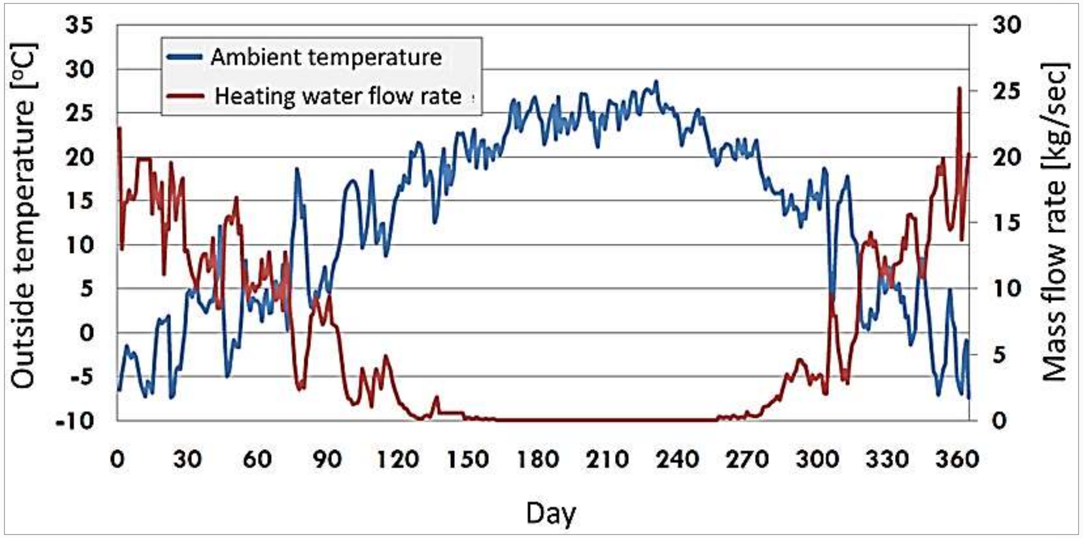
Current status

DH circumstances in South Korea

- **High heat demand density**
  - Several thousands household in an apartment complex
  - Higher than 46 m (150 ft) average height
- **Four distinct season**
  - No heating, only hot water demand in summer



Ambient temperature in Seoul, 2010

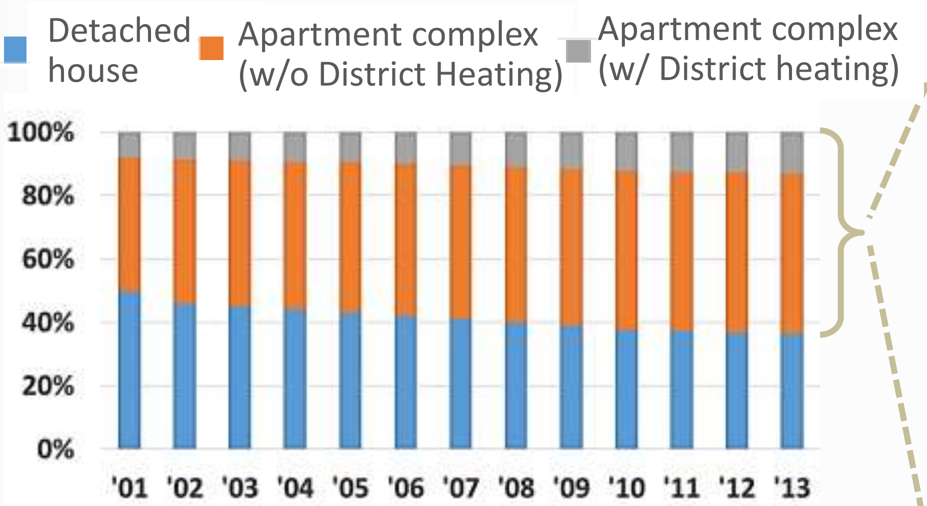


Year based heating demand in apartment complex

Current status

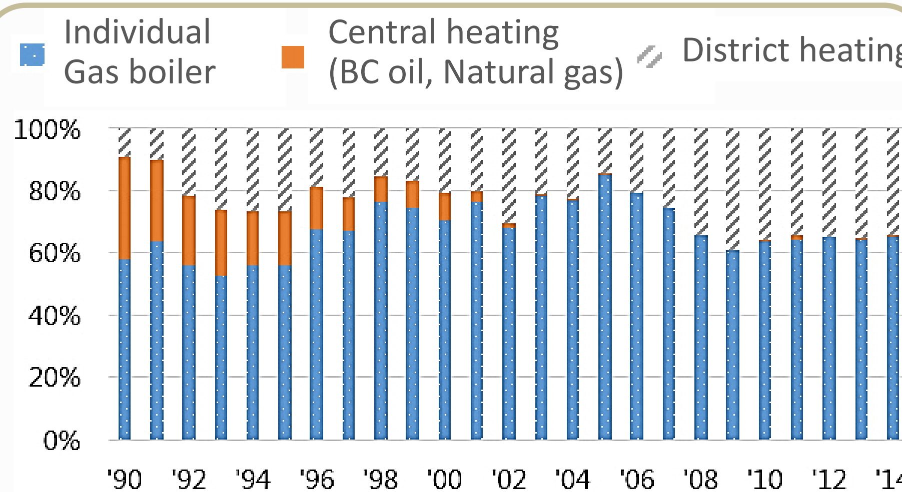
Heat supply in South Korea

- DH supply since 1985
- 2.3 million households are DH served (14.8 % market share, 2013)
- Retrofitting demand for old facilities over 20 years
- Changing demand from old central heating to DH



Residential type and heat market

<Ref: White paper, District energy supply 2014, KEMCO>



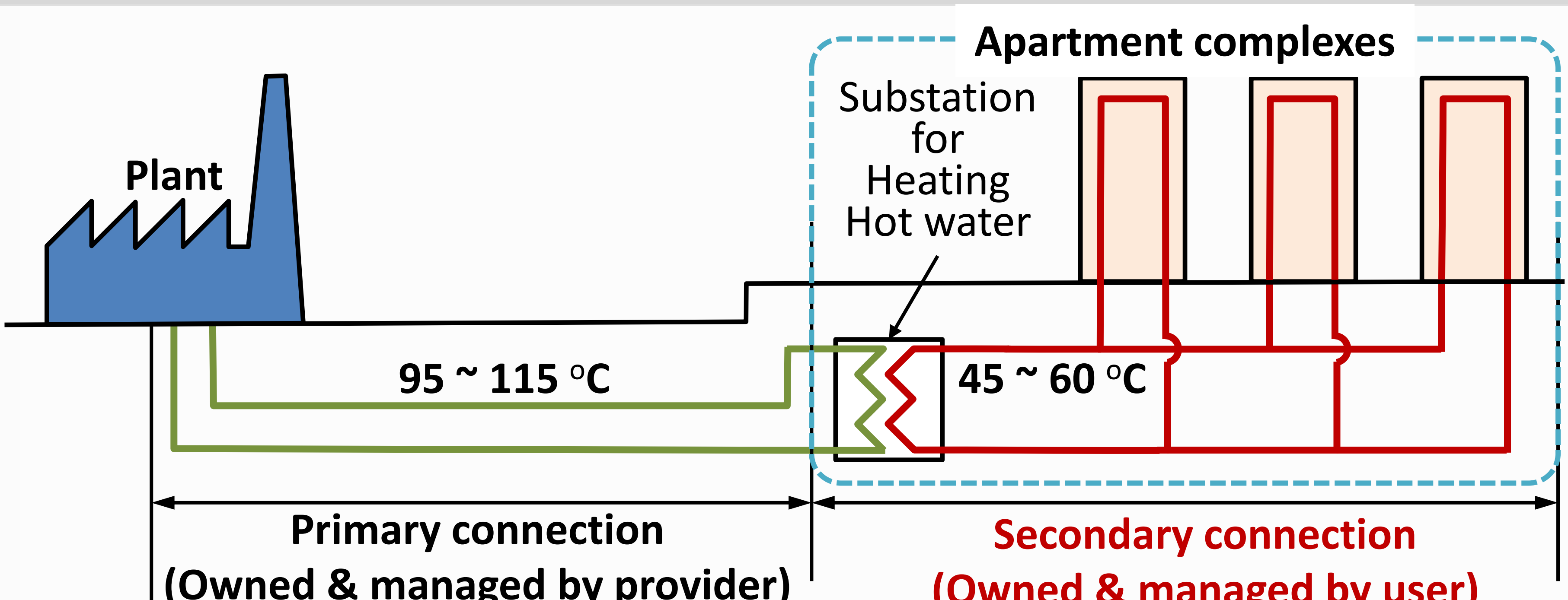
Year by year heating supply ratio of newly built apartment

<Ref: Real estate 114>

Current status

Our DH supply structure

- **Primary connection: Owned by DH provider, Well managed**
  - Single digit heat loss percentage
- **Secondary connection: Owned by user, Non-systematic managed**
  - Maintenance problem, Heat loss ?



Current status

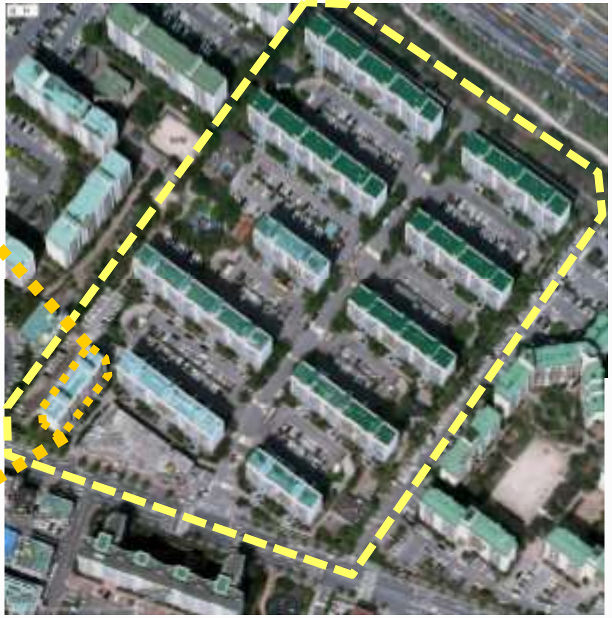
Secondary connection: Over 20 years old DH facility in apartment

Project overview

Retrofitting & assessment of DH supply

- Research grant was awarded by KDHC (Korea District Heating Cooperation)
- Retrofitting DH facilities of an old apartment building (since 1993)
- Extensive yearly data(Temp, flow rate, heat) records for assessment
- Small (1 bldg.) & Large (11 bldg.) scale numerical modeling and analysis

1 building, 60 households



11 buildings, 990 households

Project overview

Project description: Key features

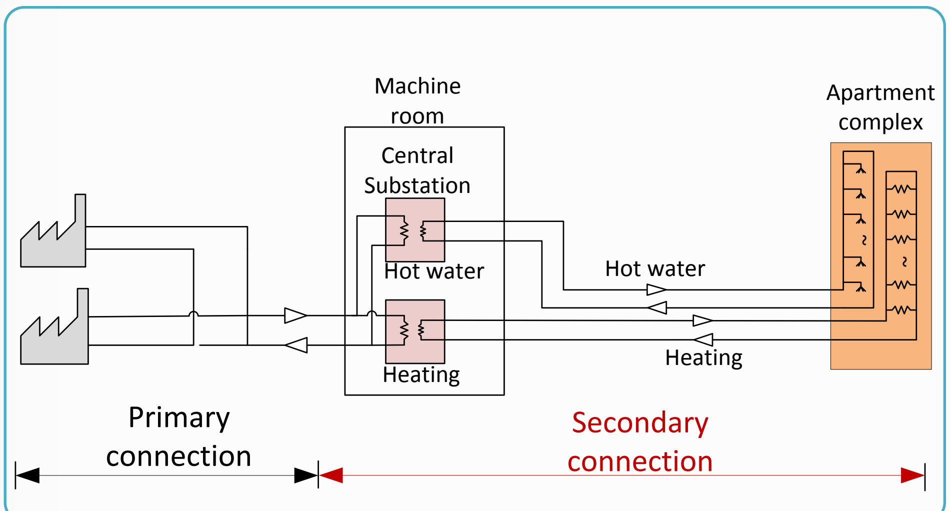
- **Heat saving: Reducing the number of pipes**
- **PEX pipe: Flexible pipe installation for easy retrofitting**
- **Space saving: Compact substation hiding under the kitchen sink**
- **Remote heat metering: AMR and monitoring wall pad for every household**

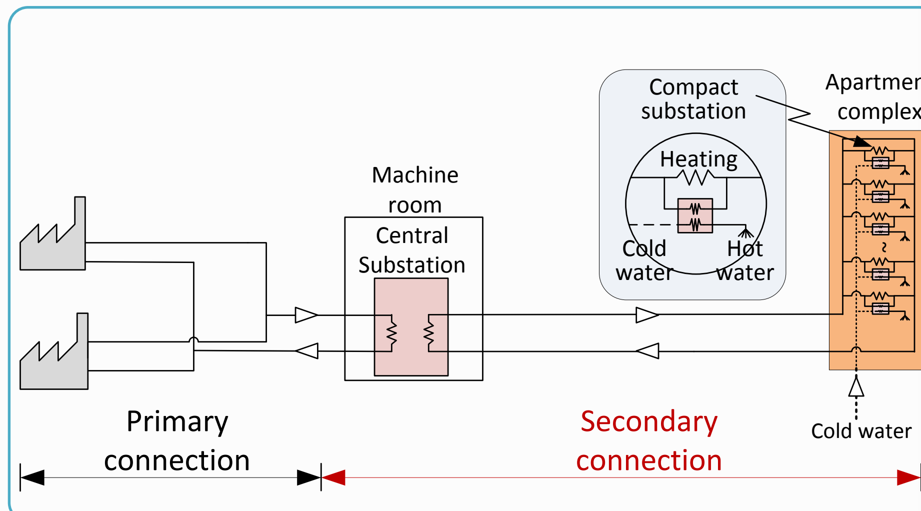

<Ref: BRUGG PEX pipes>

Project overview

System design: Reducing pipes

- **Our conventional DH piping system: 2 for heating, 2 for hot water**
- **Reducing pipes and distributed substation for hot water produce**
  - PROS: Reducing heat loss, Saving space inside building & machine room
  - CONS: Compact substation at each household, occupying space at home





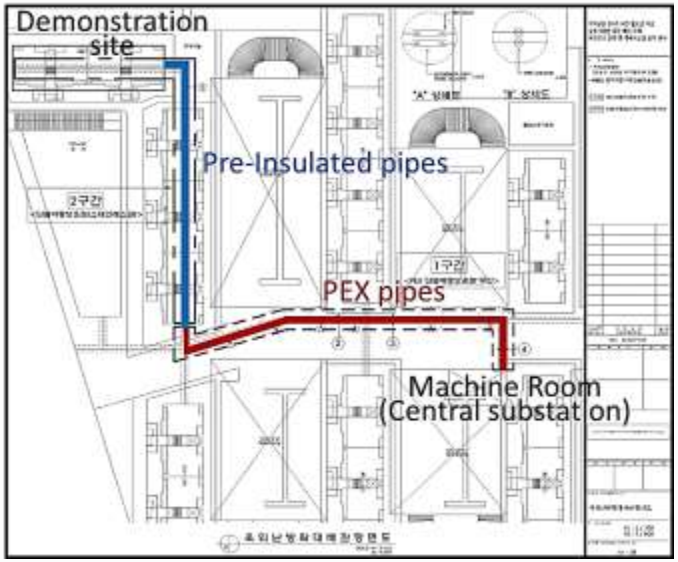
OLD: 4 pipes in secondary connection (Conventional DH system)

NEW: Reducing pipes & Compact substations

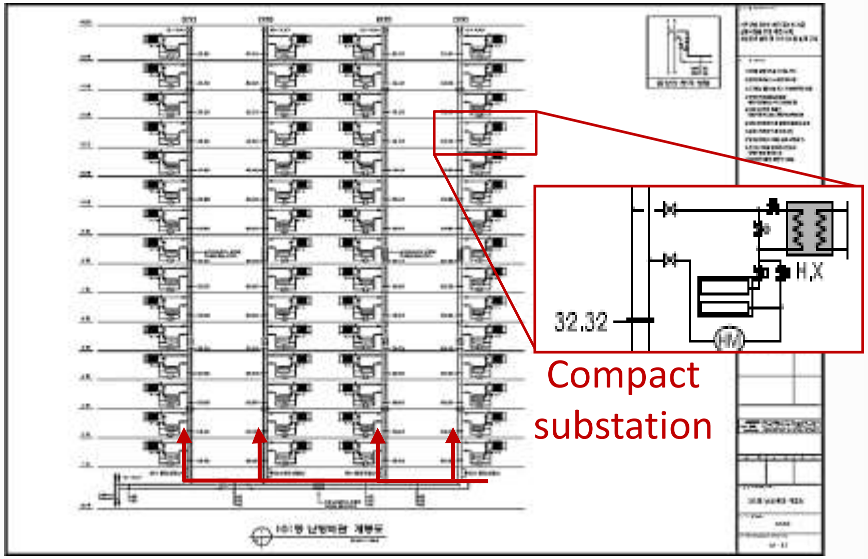
Project overview

Pipe system and substation design

- **Length of pipelines: Horizontal line 430 m (1410 ft), Vertical riser 230 m (755 ft)**
  - The most distant building from the machine room
- **Easy retrofit installation: PEX pipe**
- **Hot water produce: Cascade type compact substation at home**



Horizontal pipeline
from machine room to demonstration site

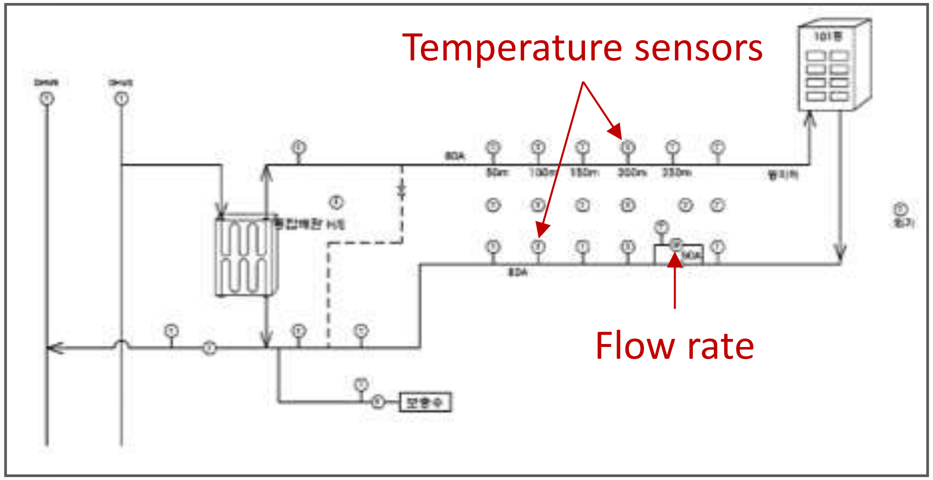


Vertical riser pipeline
& Compact substation

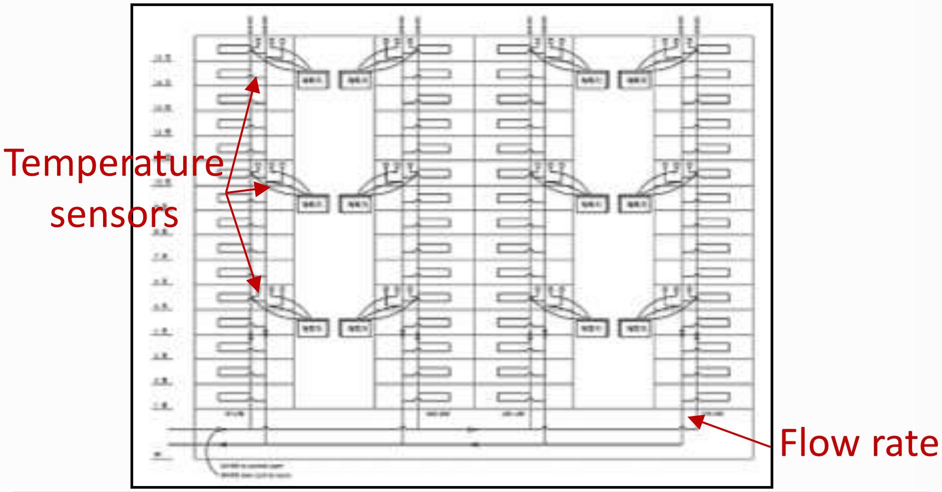
Project overview

Measurement system

- **Horizontal pipes**
  - Supply/return temp (Every 50 m) & flow rate (Primary/Secondary)
- **Vertical riser pipes**
  - Supply/return temp (High/Mid/Low location) & flow rate at each line
- **Households**
  - Heating supply/return temp. & flow rate, Hot water temp. Heat usage



Horizontal pipeline measurement



Vertical riser pipeline measurement

Installation

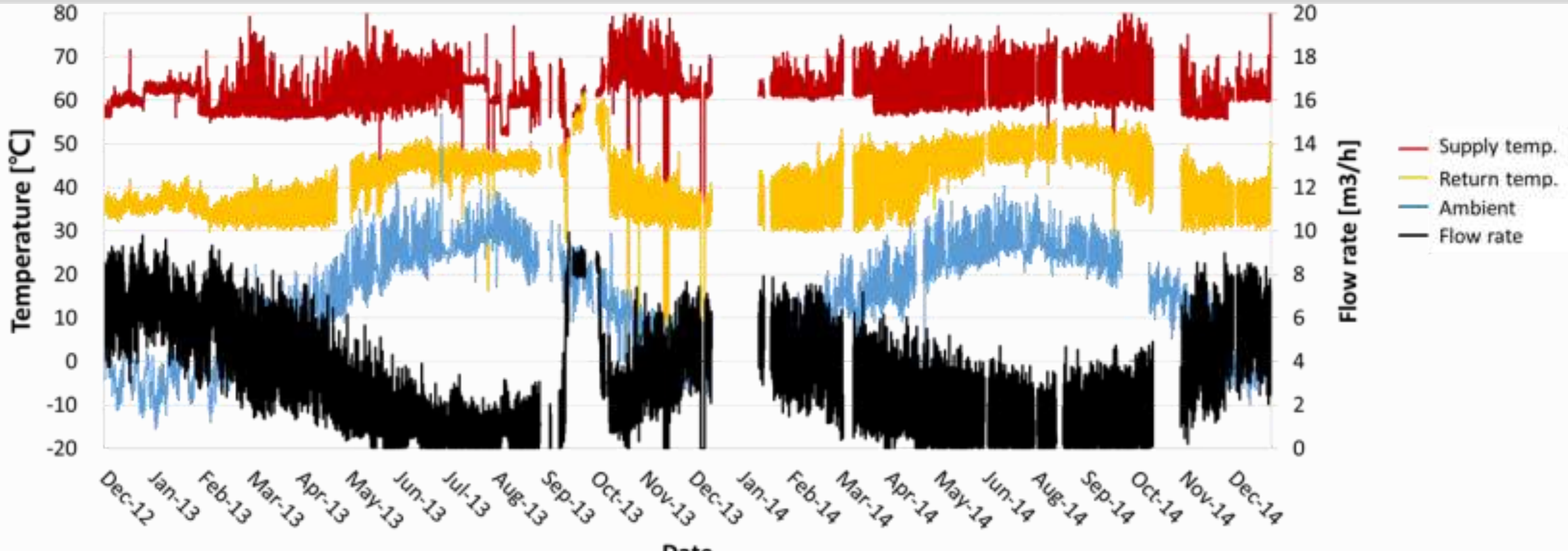
Before

After

Experimental assessment

Data collection in machine room

- **Data collection since Dec. 2012 till present**
- **Daily/Monthly/Yearly basis trend monitoring the heat usage**
- **Various test were conducted**
  - Supply temperature optimization
  - Flow rate control optimization

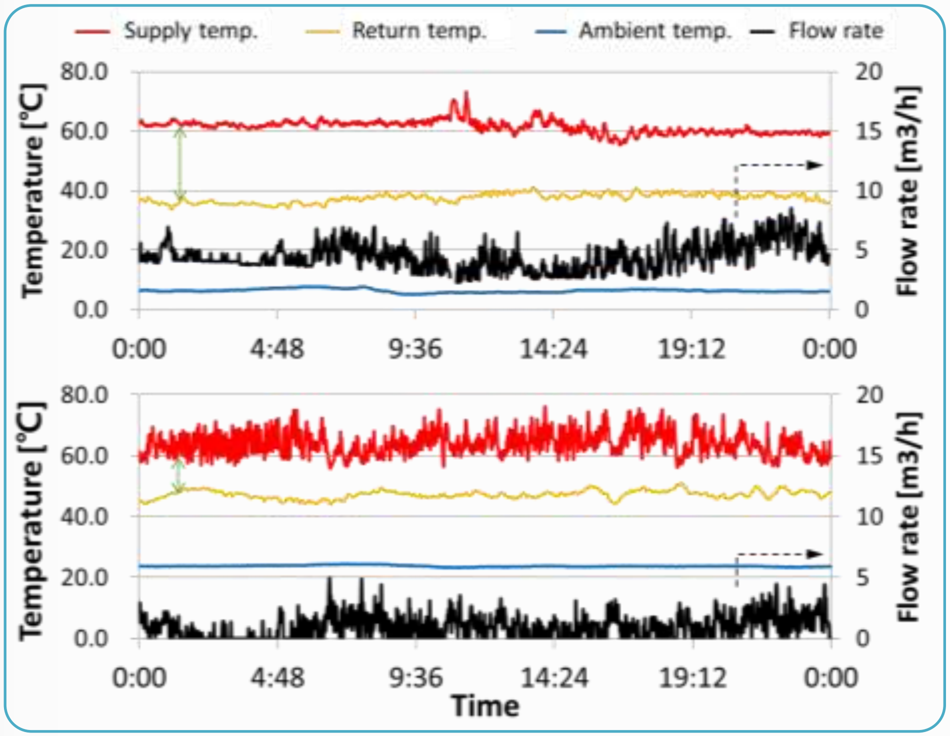


Heat usage trend for two years (minute interval)

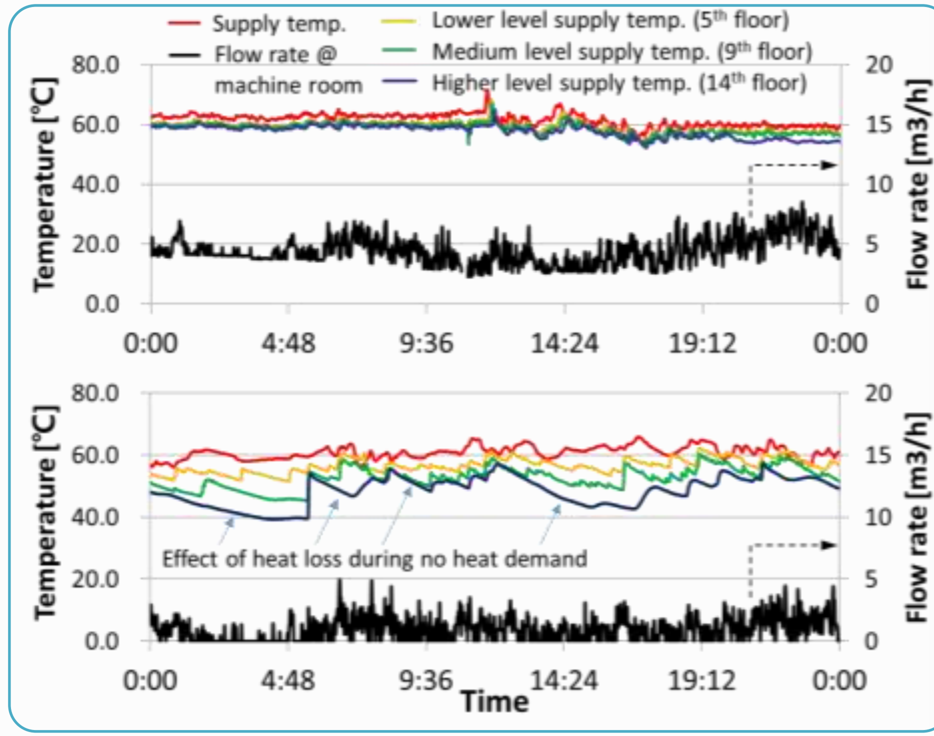
Experimental assessment

Data collection in pipelines

- **Detailed information such as temp. profile / heat demand pattern**



Horizontal pipeline daily trend
(UP: Winter, DOWN: Summer)

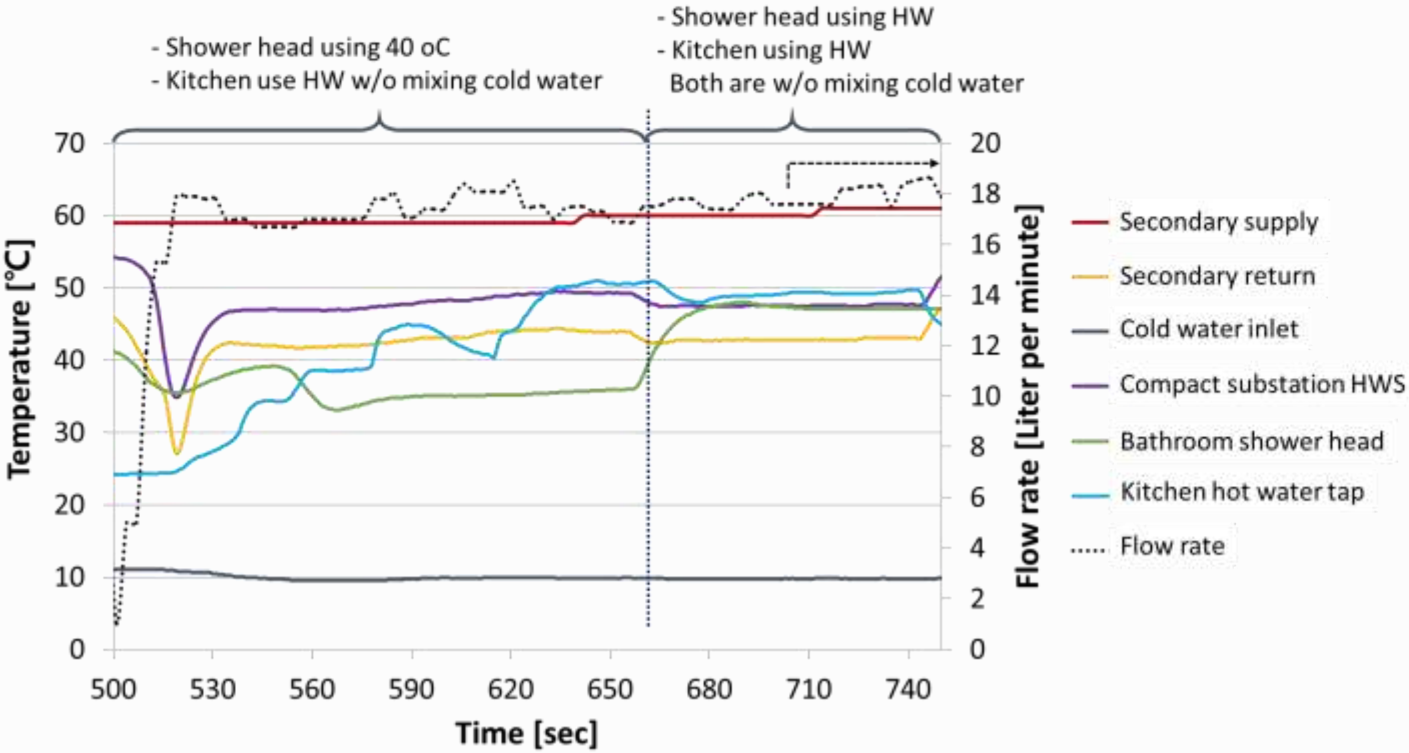


Vertical pipeline daily trend
(UP: Winter, DOWN: Summer)

Experimental assessment

Data collection in households

- **Detailed information from household heat usage** (Permitted measurement for householders)
  - Data gathering from AMR heat meter system & compact substation

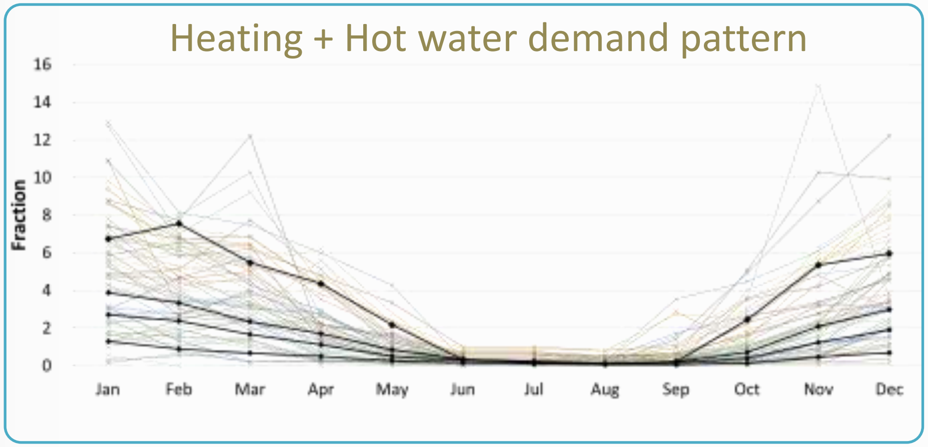


Dynamic behavior of household Hot water usage

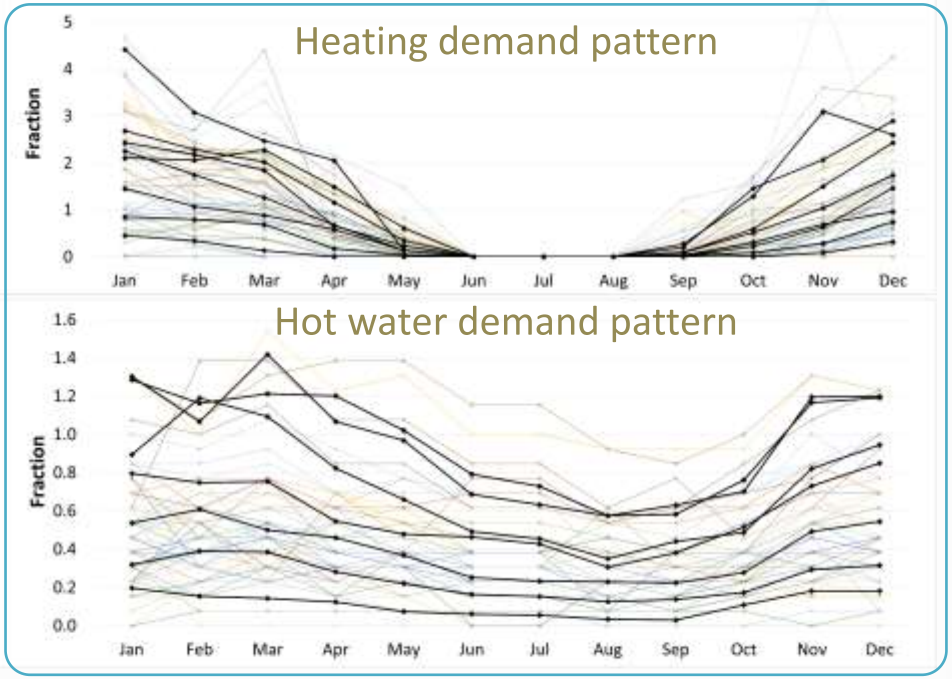
Numerical assessment

DH system modeling: Heat demand pattern

- **From heat usage data collection, heat demand patterns were produced**
  - AMR heat meter data collection from experiment
  - Previous heating bill analysis



2 pipeline modeling

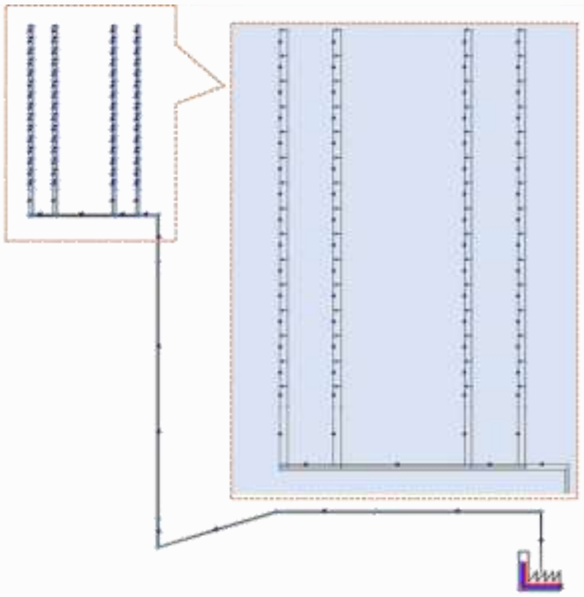


4 pipeline modeling

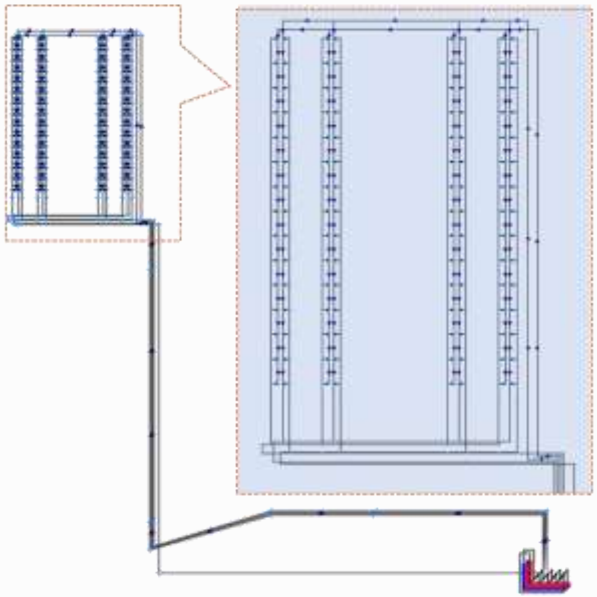
Numerical assessment

DH system modeling: Network design

- **Network structure modeling by TERMIS (Schneider Electric)**
- **2 pipeline (after retrofitting) & 4 pipeline (before retrofitting) were designed**
- **Boundary conditions: Dimensions & Experimental values**
  - Pipe dimension, Material properties, Heat demand, Ambient condition



2 pipeline modeling for an apartment

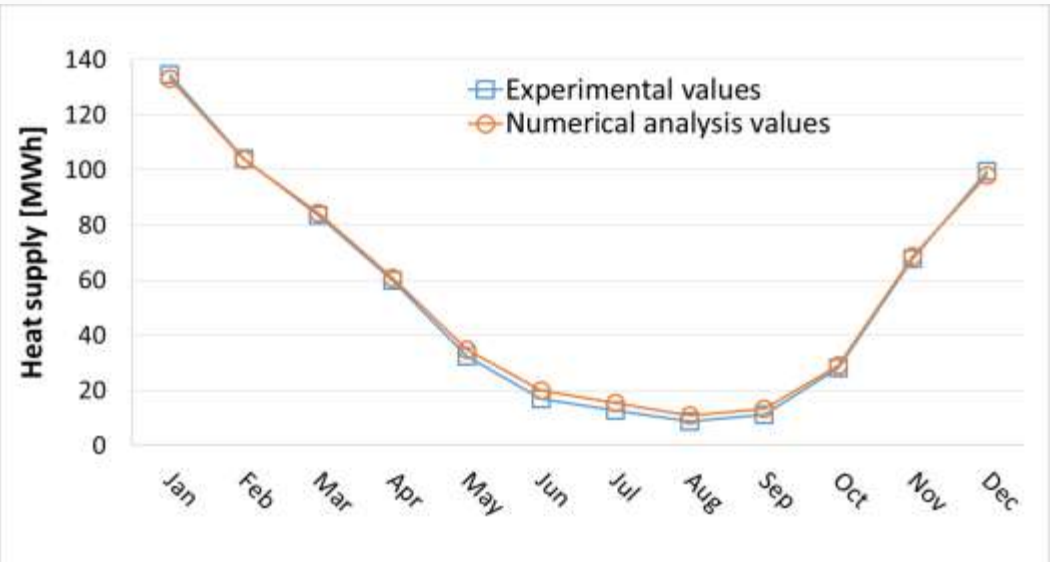


4 pipeline modeling for an apartment

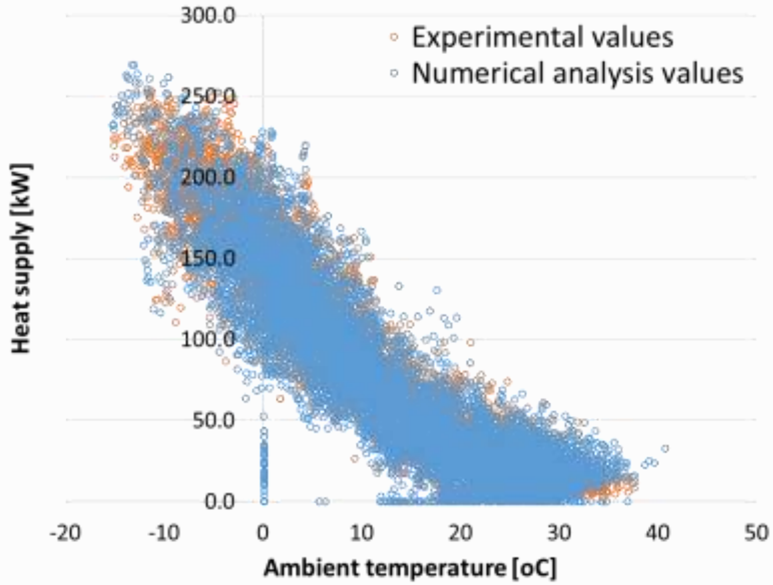
Numerical assessment

Data comparison between experiment and numerical analysis

- **Numerical simulation shows good match with measurement**
- **Various analysis and optimal estimation can be made based on these model**
  - Optimal supply temperature for heat loss reduction
  - Various parameters: Changing circumstances, Pipe parameters, Aging effect..



Heat supply comparison

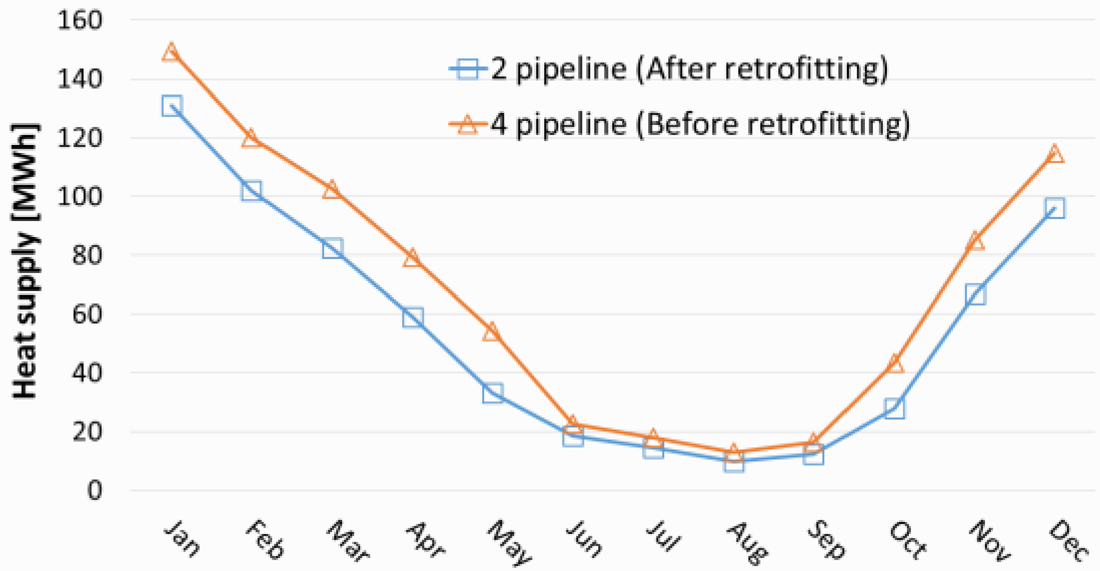


Heat supply to ambient temp. dependency

Numerical assessment

Effect on retrofitting

- **Heat saving effect was investigated**
- **4 pipeline model is still under construction**
- **Retrofitting to 2 pipeline system expects over 25% heat saving**
  - When supply temperature decrease 5 °C, over 10 % heat saving is expected



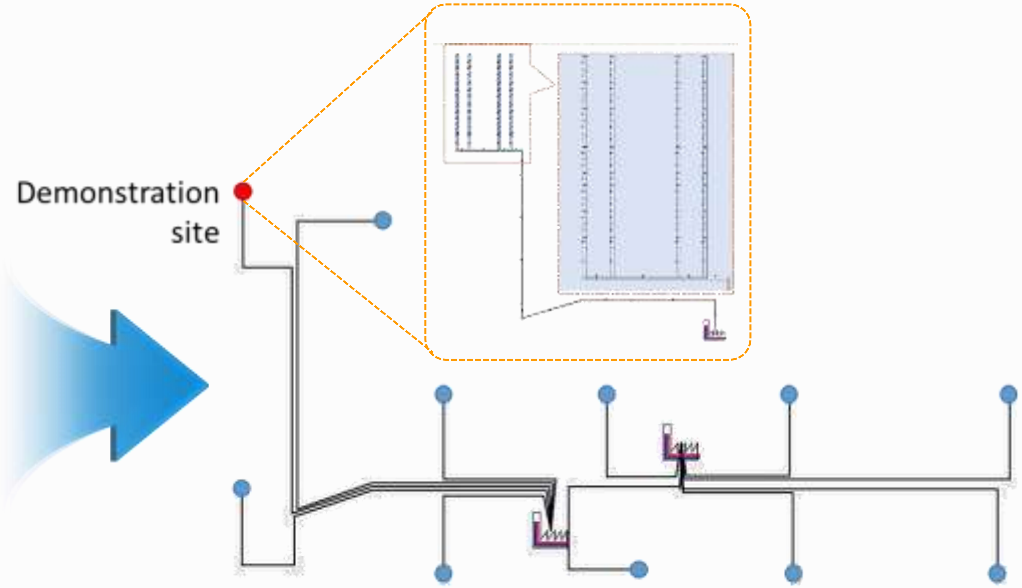
Comparison before and after retrofitting

Numerical assessment

Expanded DH system modeling

- **Expanded modeling for apartment complex (11 buildings, 990 households)**
- **Whole retrofitting was assumed for estimating heat saving**
- **A building was simplified as a single node**

GIS layout for apartment complex

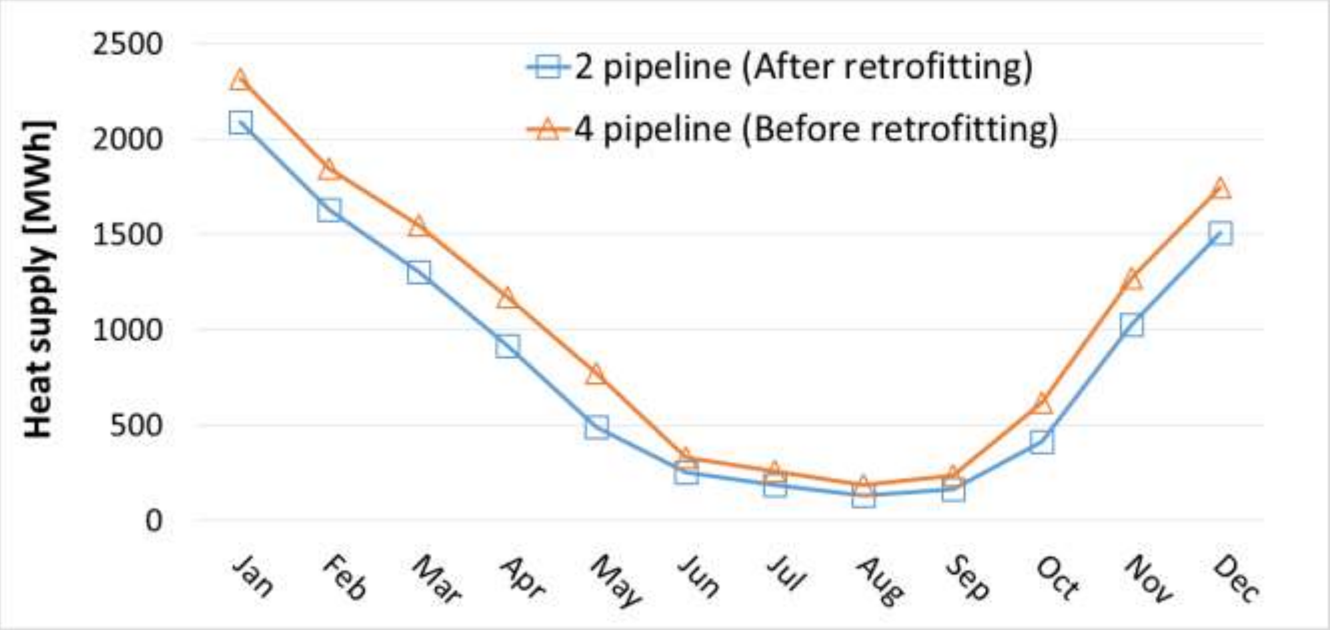


Extended network model for apartment complex
(11 buildings, 990 households)

Numerical assessment

Expanded DH system modeling

- **Expanded modeling for an apartment complex (11 buildings, 990 households)**
- **Retrofitting to 2 pipeline system expects over 16% heat saving**
- **Modeling and considerations are improving**



Expanded modeling result before and after retrofitting

Summary

Experimental and numerical assessment for DH

- **Retrofitting DH facilities of an old apartment building**
  - Heat saving: Reducing the number of pipes
  - PEX pipe: Flexible pipe installation for easy retrofitting
  - Space saving: Compact substation hiding under the kitchen sink
  - Remote heat metering: AMR and monitoring wall pad for every household
- **Extensive yearly data (Temp, flow rate, heat usage) record for assessment**
  - Temperature, Flow rate, Heat usage measurement
  - Data collection in machine room, pipelines, households per minutes
  - Heat demand patterns were produced
- **Small (1 bldg.) & Large (11 bldg.) scale numerical modeling and analysis**
  - 2 pipeline & 4 pipeline model are constructed
  - Various heat saving effects were investigated

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Acknowledgement

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תודה
Dankie
Gracias
Спасибо
شكراً
Merci
Takk
Köszönjük
Terima kasih
Grazie
Dziękujemy
Dėkojame
Ďakujeme
Vielen Dank
Paldies
Kiitos
Täname teid
谢谢
Thank You
Tak
感謝您
Obrigado
Teşekkür Ederiz
감사합니다
Σας Ευχαριστούμ
ขอบคุณ
Bedankt
Děkujeme vám
ありがとうございます
Tack
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