University of British Columbia (UBC) Case study: Use of Real-Time Hydraulic Modeling

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BACKGROUND
This presentation is a University of British Columbia case study how UBC, based on real-time distribution system hydraulic modeling, gained detailed control of the operation, system optimization path, system expansion, system bottle necks, among others of their hot water based district energy system, to monitor their CAD $88 million investment.

UBC transformed their district energy system to one of worlds leading medium temperature hot water system. Hydraulic modeling was a key component in this process and the real-time hydraulic modeling solution implemented in 2018 - in record time of just 3 months - has become a strategic decision support tool. Offline and Real-time hydraulic modeling is used for the day-to-day operational management, troubleshooting, engineering, planning for changes and additions of new buildings, distribution system piping and plant capacity.

The investment of the real-time hydraulic modeling solution has provided readily available information that has aided in decision making while avoiding professional fees, paying itself back in less than 24 months. This presentation is a hands-on experience and includes demo to serve as an inspiration for all utilities interested in transforming their energy systems and to improve the efficiency of their energy systems.
UBC DISTRICT ENERGY SYSTEM - 2021

CLEAN WOOD WASTE (25%)
- BIOENERGY RESEARCH DEMONSTRATION FACILITY (BRDF)
  - BIOMASS GASIFIER (6 MWt)

CLEAN WOOD WASTE (45%)
- BIOMASS EXPANSION PROJECT - 2021
  - BIOMASS- FIRED HOT WATER GENERATOR (12 MWt)

RENEWABLE NATURAL GAS & NATURAL GAS (5%)
- COMBINED HEAT AND POWER
  - ELECTRICAL GENERATOR (2 MWe)
  - HOT WATER HEAT RECOVERY (1 MWt)
  - HEAT RECOVERY STEAM GENERATOR (1.4 MWt)

NATURAL GAS (25%)
- FUEL OIL (BACKUP 0%)
- CAMPUS ENERGY CENTRE (CEC)
  - HOT WATER GENERATORS (3 x 15 MWt)

UBC ELECTRICAL GRID

- HOT WATER
- ELECTRICAL
- HOT WATER

UBC DES
70% Academic Core
30% Ancillaries
(Housing, Athletics)
UBC’s Hot Water Academic DES (2020)

- $88m Steam to Hot Water Conversion 2010-2017
- 24km supply and return piping
- ~120 Buildings
- Two supply plants
HOW IS UBC MONITORING THIS $88 MILLION INVESTMENT?

DES meters in all buildings trended alongside plant scada & field data collected and stored into a unified historian database for analytics.

Leak detection system

Termis real-time model
TERMIS IMPLEMENTATION

• Spring of 2018 - 3 months
• High level of buy-in and support from all levels
• IT resources
• Required an all around effort to integrate plant and building data into the Termis background databases
• IT resources
• Staff training on data administration as well as model use
• Ongoing model & data management, IT infrastructure upgrades, ongoing calibration to reflect reality
MODELING – WHAT AND WHY

Industry preferred District Energy management software which models the whole district system (plant, piping, consumer)

- Hydraulic and thermal model that performs calculations of flow, pressures, losses, temperatures, velocities, gradients for every single pipe
- Developed in Denmark and implemented worldwide
- Both offline and real-time configurations
- Provides ability to observe and manage performance of the whole system
- “Eyes” on your whole district energy system
- SI units

- Planning and Design
- Optimization & Efficiency
- Operational & KPI tracking
Real-Time Dynamic Modeling versus Static Modeling
Elimination of the "black hole syndrome" and guess work

Scalable solution starting simple and adding functionality on a solid platform:

1. **Static**: How it should work
   1. Limited to a specific point in time
   2. Post analyses labor intensive

2. **Real Time**: Facts-Calibration
   1. Control Room and Field Operations monitoring and diagnostics
   2. Immediate Optimization of pressures, flows, temperature, losses, and equipment wear and tear
   3. Cost

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**Distribution System Piping**
- 30%

**Investment: Plants and ETS/Buildings**
- 70%
BENEFITS OF REAL-TIME MODELING

Planning and Design

• Decision Support Information to the management, operation, maintenance, planning, design and commissioning of thermal energy networks
• Pipe sizing for new network extensions / buildings
• Design pipes, pumps, valves
• Evaluation of control schemes “As-Is” and planned changes
• Plan outages and valving off parts of the system
• Perform “What-if” scenarios – Feasibility studies, Energy Master Plan
BENEFITS OF REAL-TIME MODELING

Optimization & Efficiency
- Optimize pressure, temperature, flow, velocity
- Identify areas of high pressure/heat loss in the network
- Load forecasting and Demand analysis
- Supply and return pressure and temp optimization
- Electricity and thermal optimization

Operation Monitoring
- Detect abnormalities in operation
- Measurement & meter validation
- Track KPIs such as system thermal losses etc
“EYES ON OUR SYSTEM” AND ENGAGING WITH OUR COMMUNITY

- Telling UBC Steam to Hot Water and Bioenergy Plant story
- Shows UBC’s DES in real time
- Shows amount of energy supply with natural gas & biomass
VISUALIZATION & DASHBOARD: TWO PLANTS IN OPERATION
SINGLE PLANT IN OPERATION
TEMPERATURE MODE
IDENTIFYING BOTTLENECKS

Friction Pressure Gradient, Supply [kPa/km]

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FUTURE EXPANSION & PIPE SIZING MODELING

PlanYear
201920
202122
202223
202324
202425
Existing

Pipe Type, Return
D70
D82.5
D160.3
D160.3

Pipe Length, Return [m]
1.4
1.9
12.7

Diameter, Return [mm]
70 3000
82.5 3000
160 3000
160 3000

Roughness, Return [mm]
0.05
0.05
0.05

Single Loss, Return
0
0
0

Heat Transfer Coeff., Return [W/m²K]
0.26
0.27
0.33

Pipe in return does not exists

Pressure Drop Correction, Return
1
1
1

Temperature Drop Correction, Return
1
1
1

Auto dimension return

UBC
PIPE VOLUME, THERMAL STORAGE, & EXPANSION TANK CALCULATIONS
SAMPLE BUILDING & PLANT DATA
EXAMPLES OF USE

1. What-If scenarios of plant capacity from 2019-2025 including DT impact,
2. What-If scenarios of Max and Min demand (Tsup = 75 C),
3. What-If scenarios of pumping requirements for adding the BDRF 12 MWt plant,
4. What-If scenarios of use of booster pump,
5. What-If scenarios of use of control valves,
6. Initial assessment of plant supply temperature and pumping pressures.
7. Thermal storage
8. Early stages of modeling potential district cooling system nodes

DEMO
LESSON LEARN/CHALLENGES

• Have a system like Termis to aid original design of the system to identify future scenarios and bottle necks.
• Suggest to have model during design stages of DES to use the offline model right away to check consultants work during implementation of new system.
• Dedicated resources for daily check-in to ensure a healthy system.
• People communication is important: Receive plans, potential system upgrades, communication with IT (ie server upgrade = lost data)
• High level buy in
CONCLUSIONS AND NEXT STEPS

UBC is monitoring and managing the $88 million energy transformation investment:

• Improving planning, design, operational conditions by Dynamic Live Real-Time modeling
  • Real capacity and capability versus design
  • Improving / maintaining dT at a high level
  • Dispatch strategy to ensure low dP to minimize pumping
  • Management of piping losses, identify system bottlenecks
  • Measurements; accuracy watch-dog and location
  • Managing campus building expansions by applying loads from existing Building System
  • Managing valves and by-passes
  • Visual overview
CONCLUSIONS AND NEXT STEPS

UBC is monitoring and managing the $88 million energy transformation investment:

Next steps 2020-21:

**Phase 6:**
Enable management, operational, and maintenance staff to use the Termis System Thin Client HMI (View Only) as well as tablet and smartphone devices.

**Phase 7:**
Study of optimization and efficiency opportunities of dynamic supply pressure and supply temperature reset in real-time modeling advisory mode. In addition study the benefits and savings of load forecasting based production scheduling.

**Phase 8:**
Potential implementation of the recommendations of Phase 7
Thank you! Questions?