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

THOMAS LUND-HANSEN, REO
JOSHUA WAUTHY, UTILITY SYSTEMS SPECIALIST, UBC

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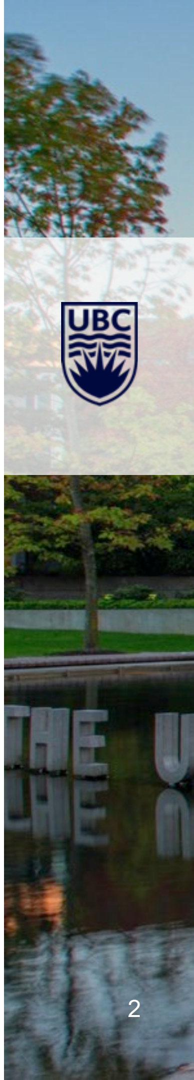
BACKGROUND

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.**

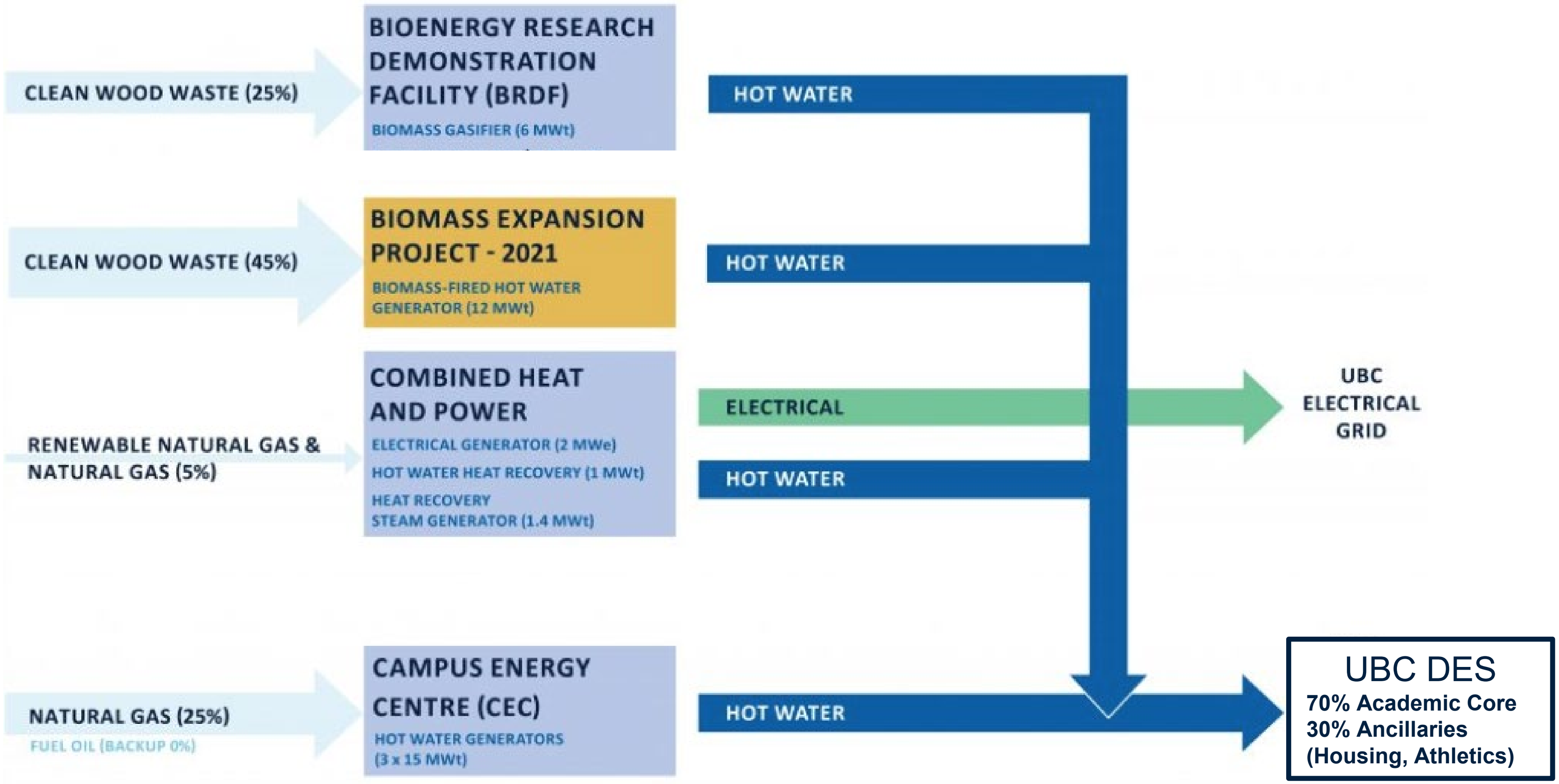
UBC transformed their district energy system to one of worlds leading medium temperature hot water system. Hydraulic modeling was a key component in this process and the real-time hydraulic modeling solution implemented in 2018 - in record time of just 3 months - has become **a strategic decision support 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.

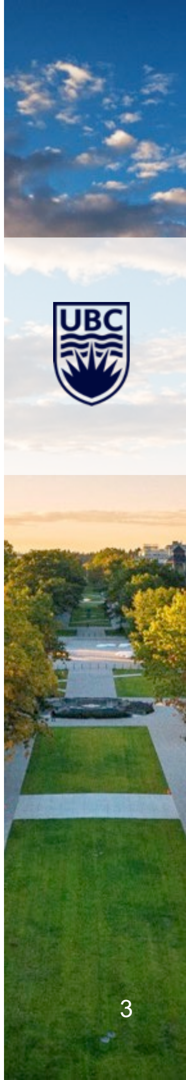
The investment of the real-time hydraulic modeling solution has provided readily available information that has aided in decision making while avoiding professional fees, **paying itself back in less than 24 months**.

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.

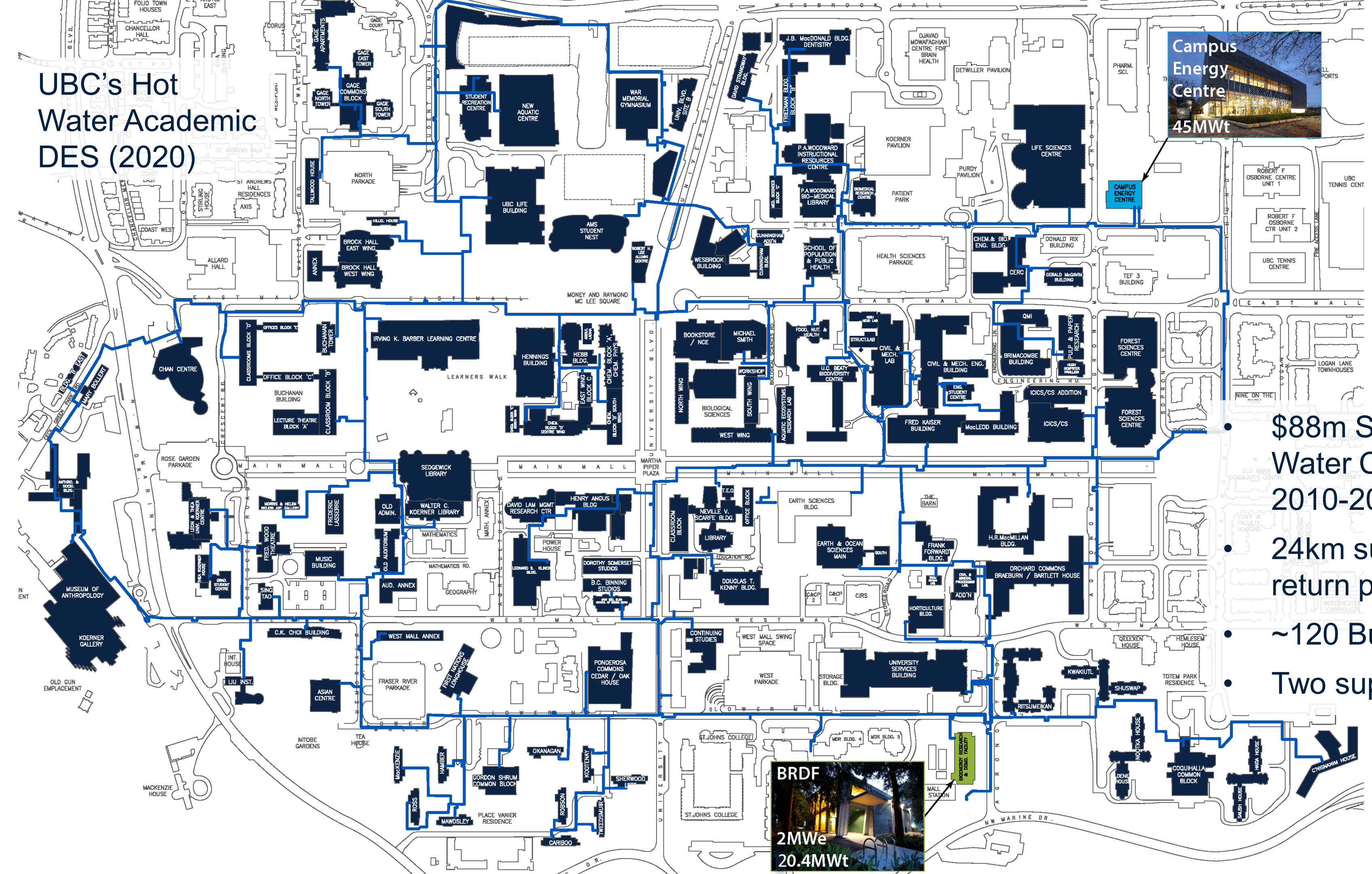


UBC DISTRICT ENERGY SYSTEM - 2021



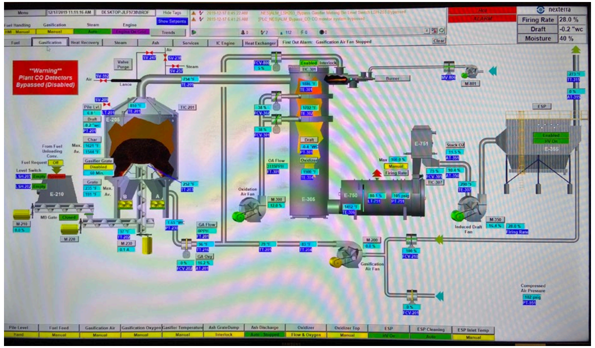


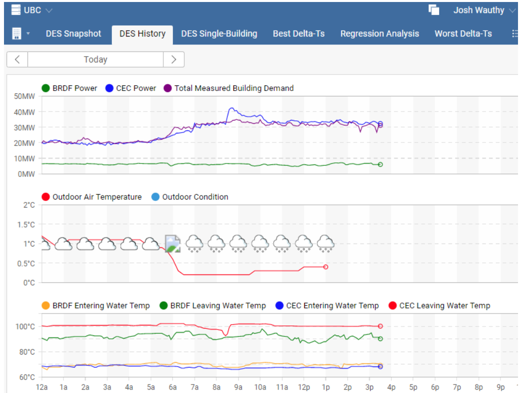
UBC's Hot Water Academic DES (2020)



- $88m Steam to Hot Water Conversion 2010-2017
- 24km supply and return piping
- ~120 Buildings
- Two supply plants

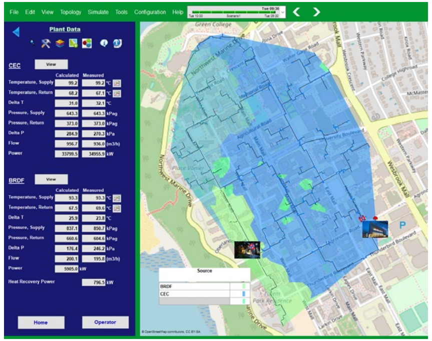
HOW IS UBC MONITORING THIS $88 MILLION INVESTMENT?





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

File Edit View Topology Simulate Tools Configuration Help

Tue 09:30 Tue 10:00 Scenario1 Tue 09:30

Plant Data

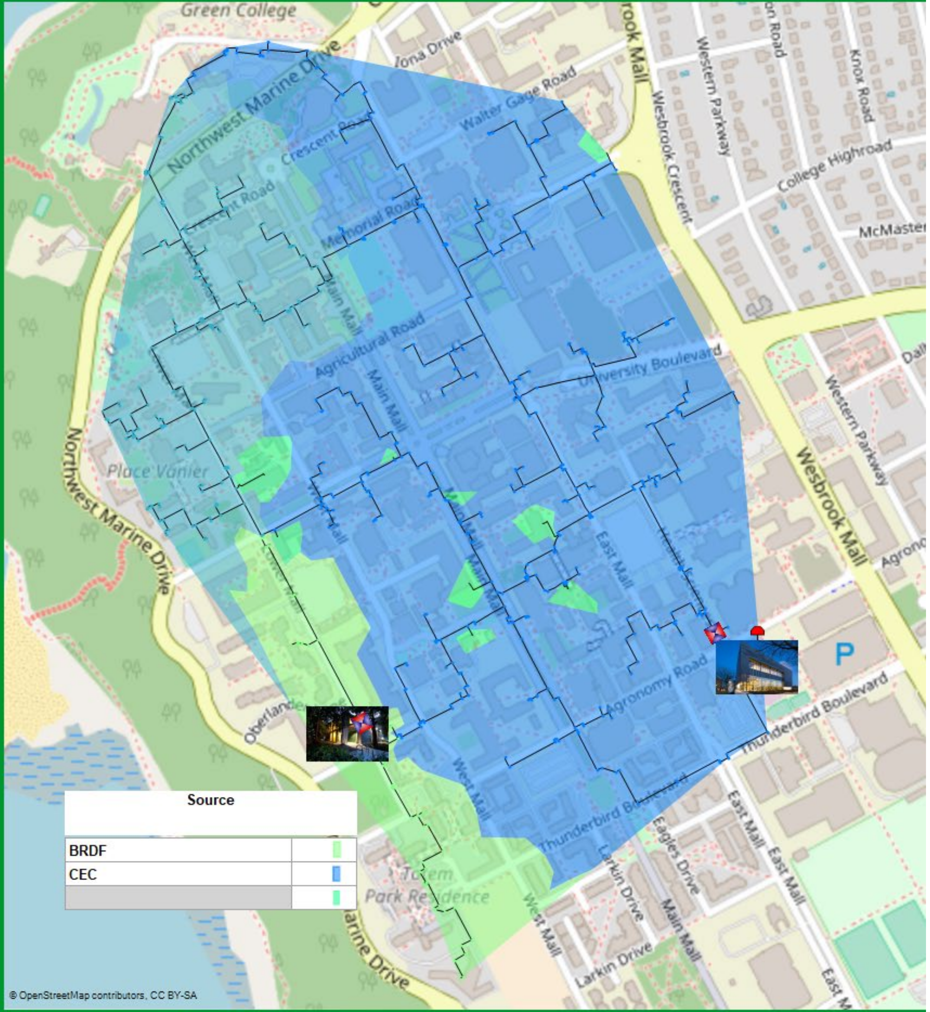
CEC View

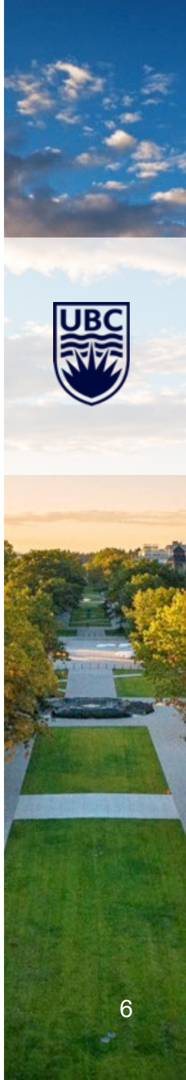
	Calculated	Measured	
Temperature, Supply	99.2	99.2	°C
Temperature, Return	68.2	67.1	°C
Delta T	31.0	32.1	°C
Pressure, Supply	643.3	643.3	kPag
Pressure, Return	373.0	373.0	kPag
Delta P	284.9	270.3	kPa
Flow	956.7	936.0	(m3/h)
Power	33799.5	34955.9	kW

BRDF View

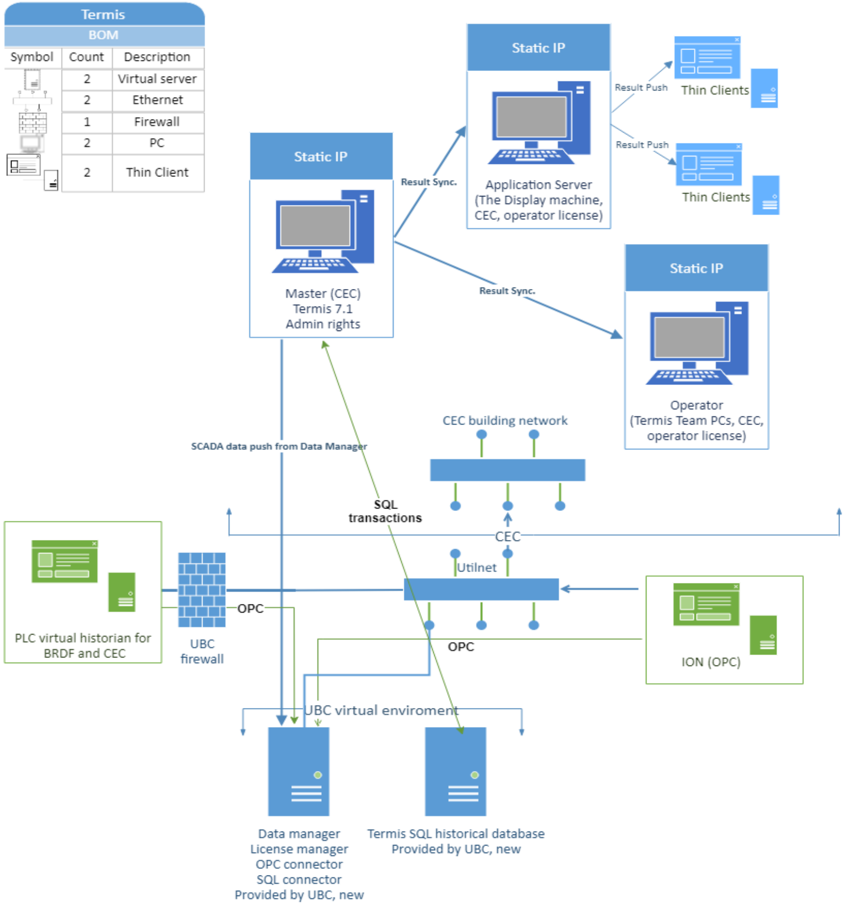
	Calculated	Measured	
Temperature, Supply	93.3	93.3	°C
Temperature, Return	67.5	69.6	°C
Delta T	25.9	23.8	°C
Pressure, Supply	837.1	850.7	kPag
Pressure, Return	660.6	604.6	kPag
Delta P	176.4	246.2	kPa
Flow	200.1	195.8	(m3/h)
Power	5905.0 kW		
Heat Recovery Power		796.5	kW

Home Operator



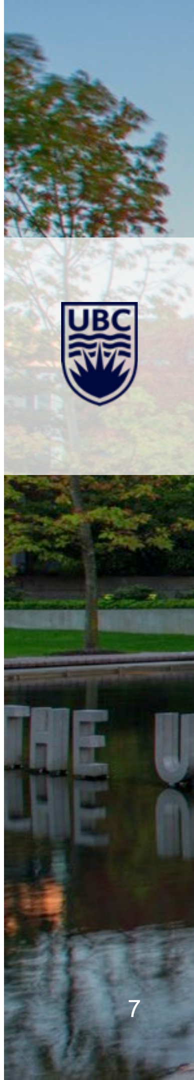


TERMIS IMPLEMENTATION



- 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

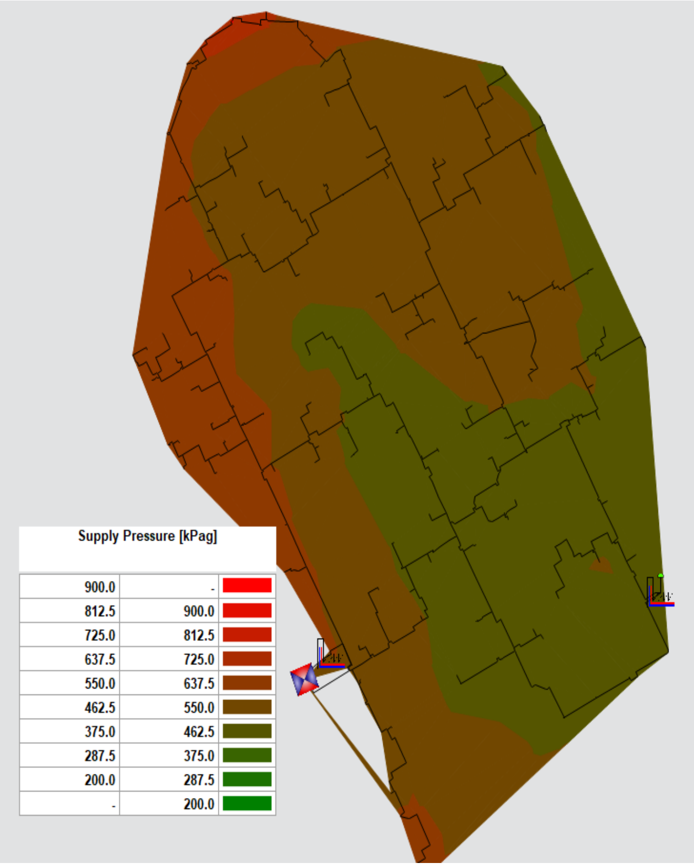
- Ongoing model & data management, IT infrastructure upgrades, ongoing calibration to reflect reality



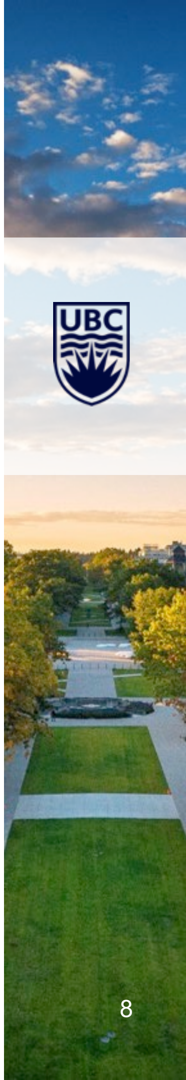
MODELING – WHAT AND WHY

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**



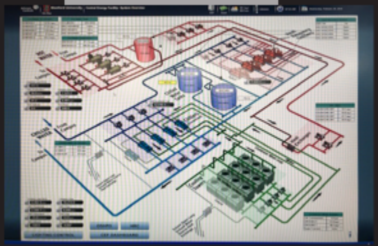
Real-Time Dynamic Modeling versus Static Modeling

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

SCADA



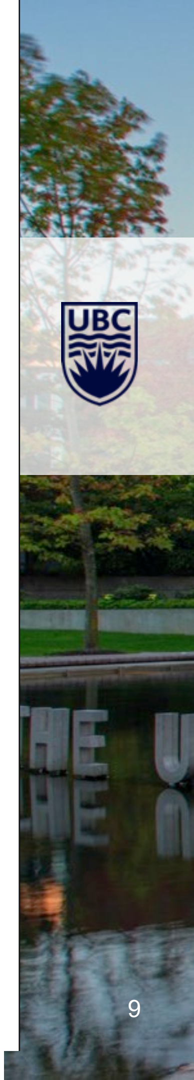
Termis

Investment: Plants and ETS/Buildings

70%

Distribution System Piping

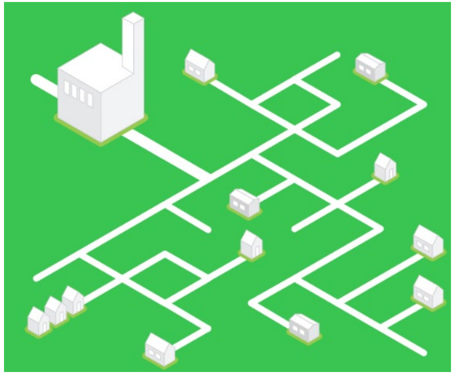
30%



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



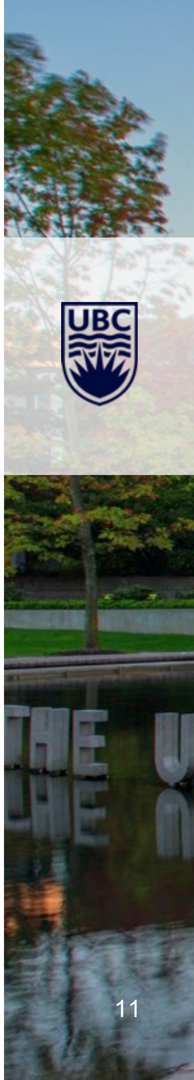
BENEFITS OF REAL-TIME MODELING

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

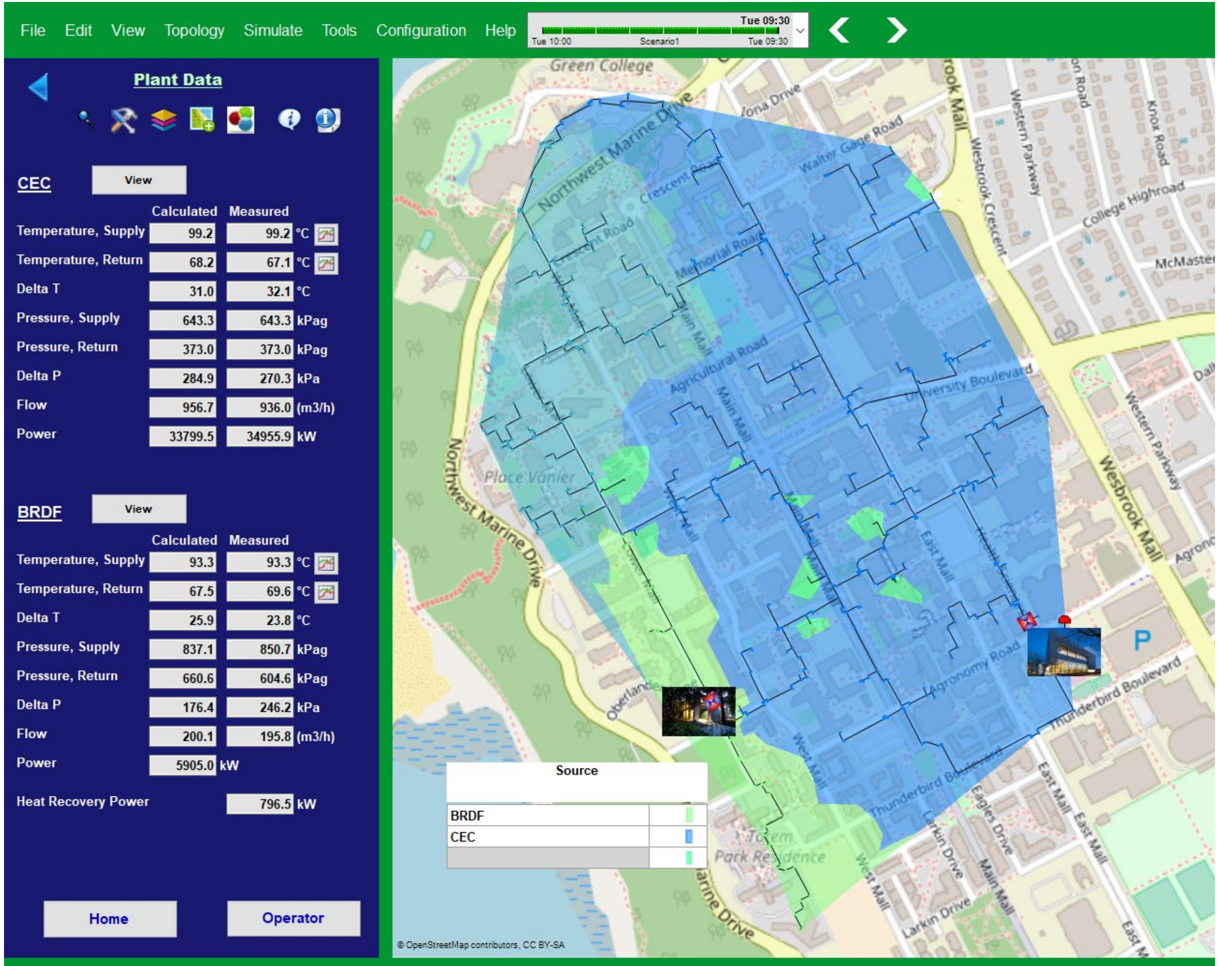
- Detect abnormalities in operation
- Measurement & meter validation
- Track KPIs such as system thermal losses etc



"EYES ON OUR SYSTEM" AND ENGAGING WITH OUR COMMUNITY

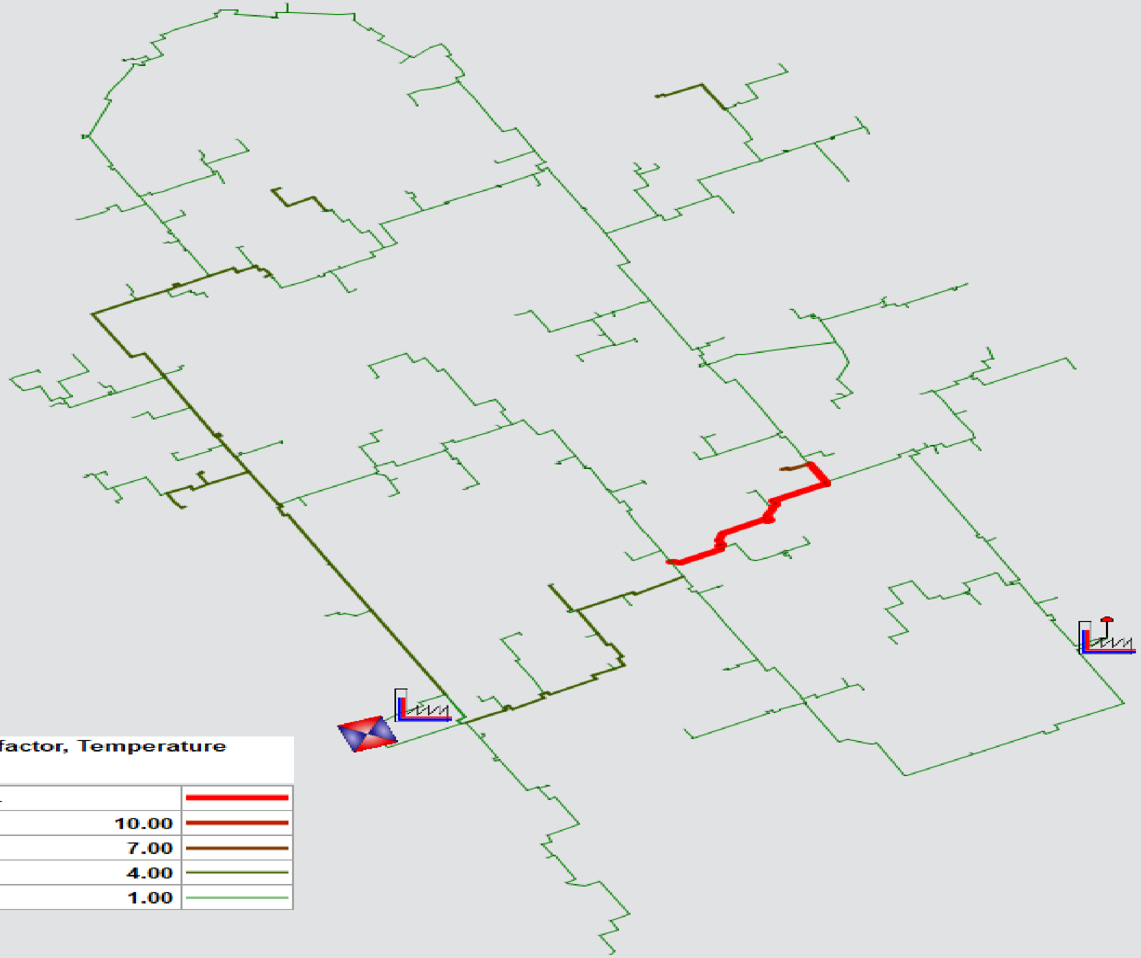
- Telling UBC Steam to Hot Water and Bioenergy Plant story
- Shows UBC's DES in real time
- Shows amount of energy supply with natural gas & biomass

VISUALIZATION & DASHBOARDS: TWO PLANTS IN OPERATION



SINGLE PLANT IN OPERATION

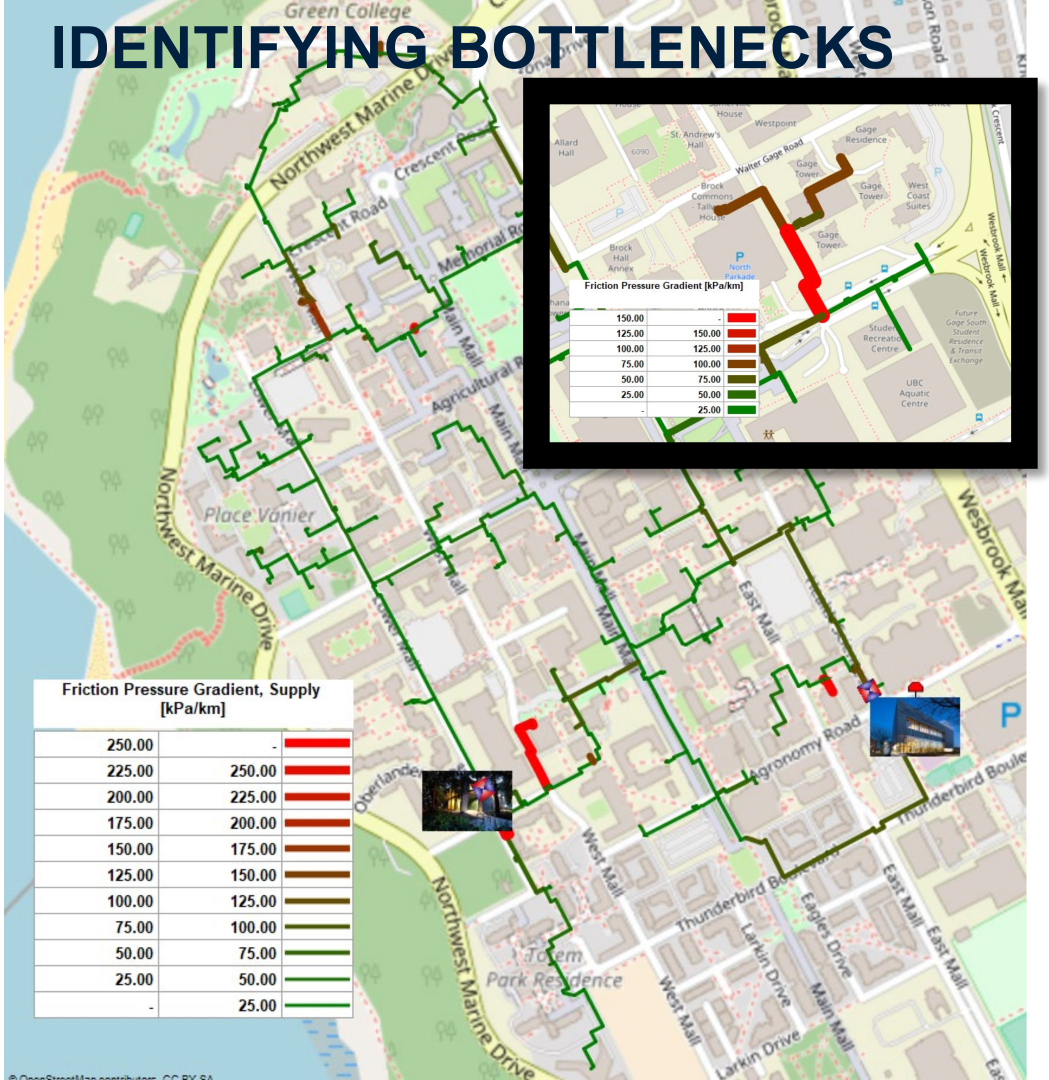
TEMPERATURE MODE

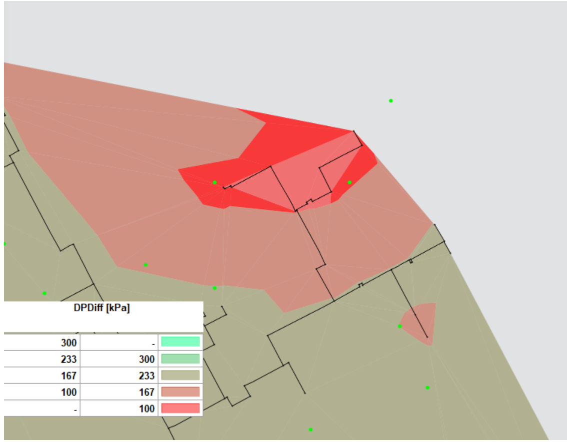


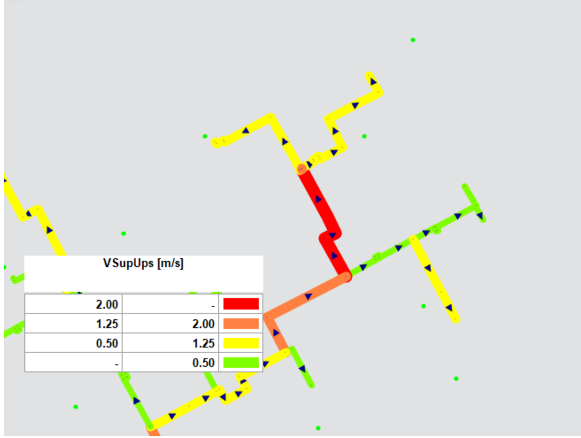
Calibration factor, Temperature

10.00	-	
7.00	10.00	
4.00	7.00	
1.00	4.00	
-	1.00	

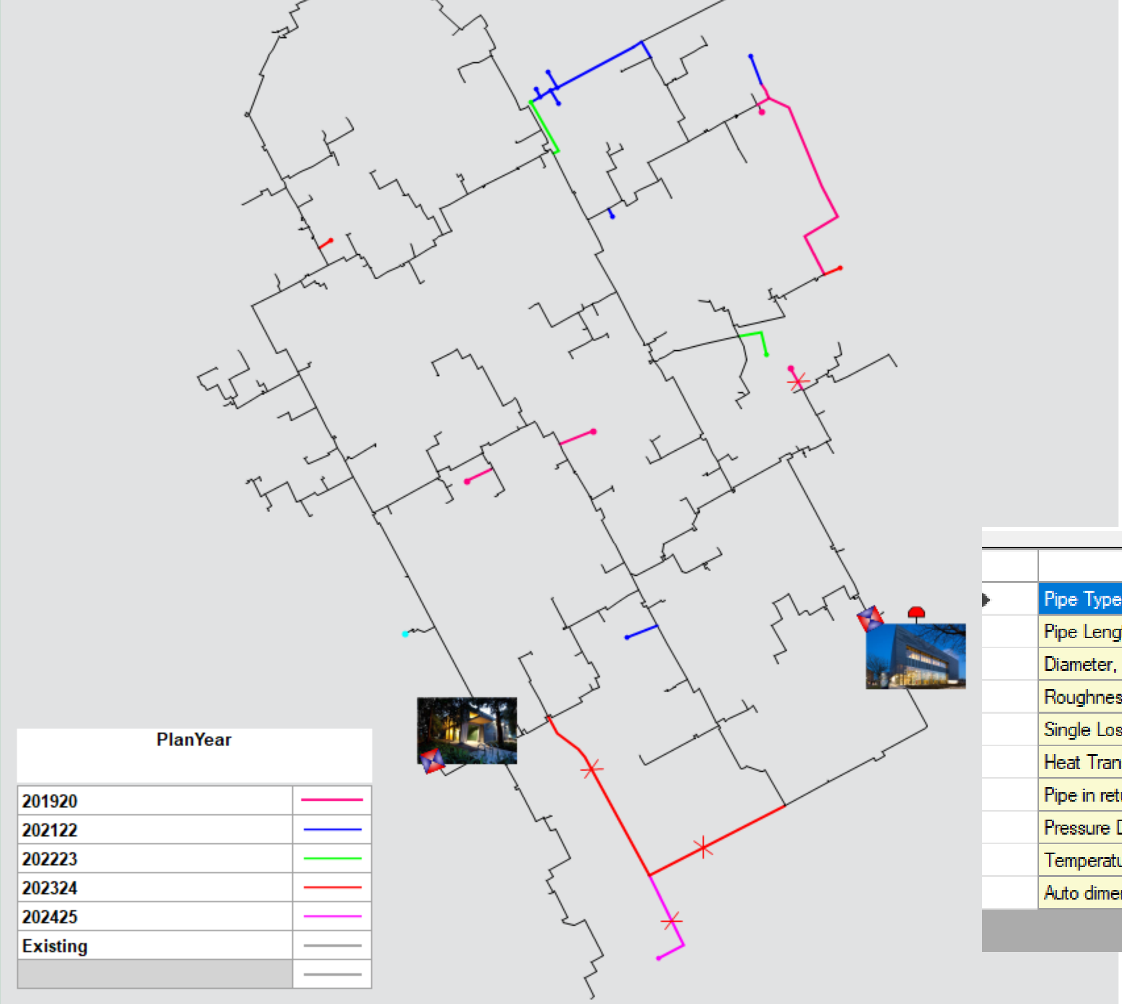
IDENTIFYING BOTTLENECKS







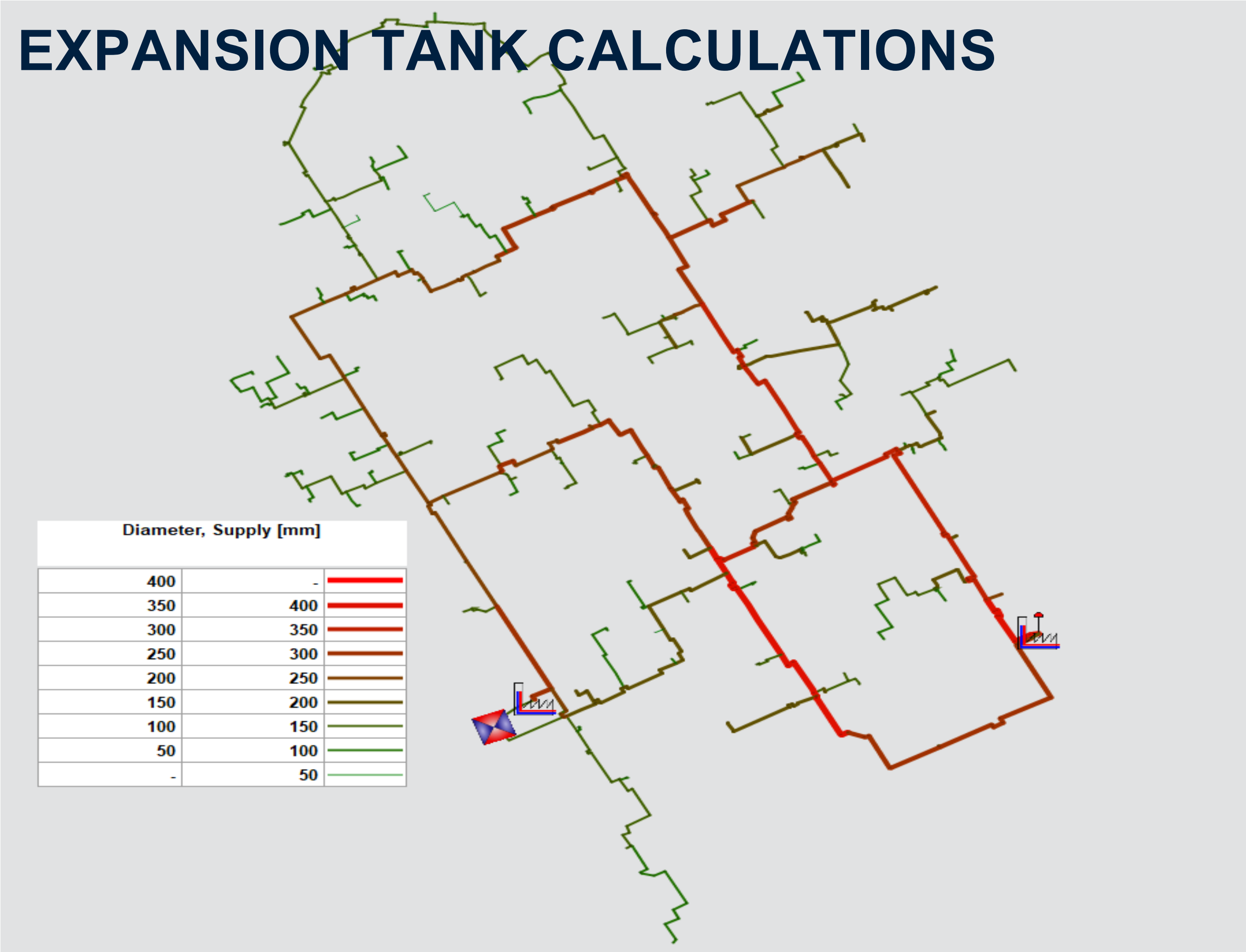
FUTURE EXPANSION & PIPE SIZING MODELING



	*	500	399	387	68
Pipe Type, Return		D70.3	D82.5	D160.3	D160.3
Pipe Length, Return [m]		1.4	1.9	12.7	9
Diameter, Return [mm]		70.3000	82.5000	160.3000	160.30
Roughness, Return [mm]		0.05	0.05	0.05	0.
Single Loss, Return		0	0	0	
Heat Transfer Coeff., Return [W/m/K]		0.26	0.27	0.39	0.
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



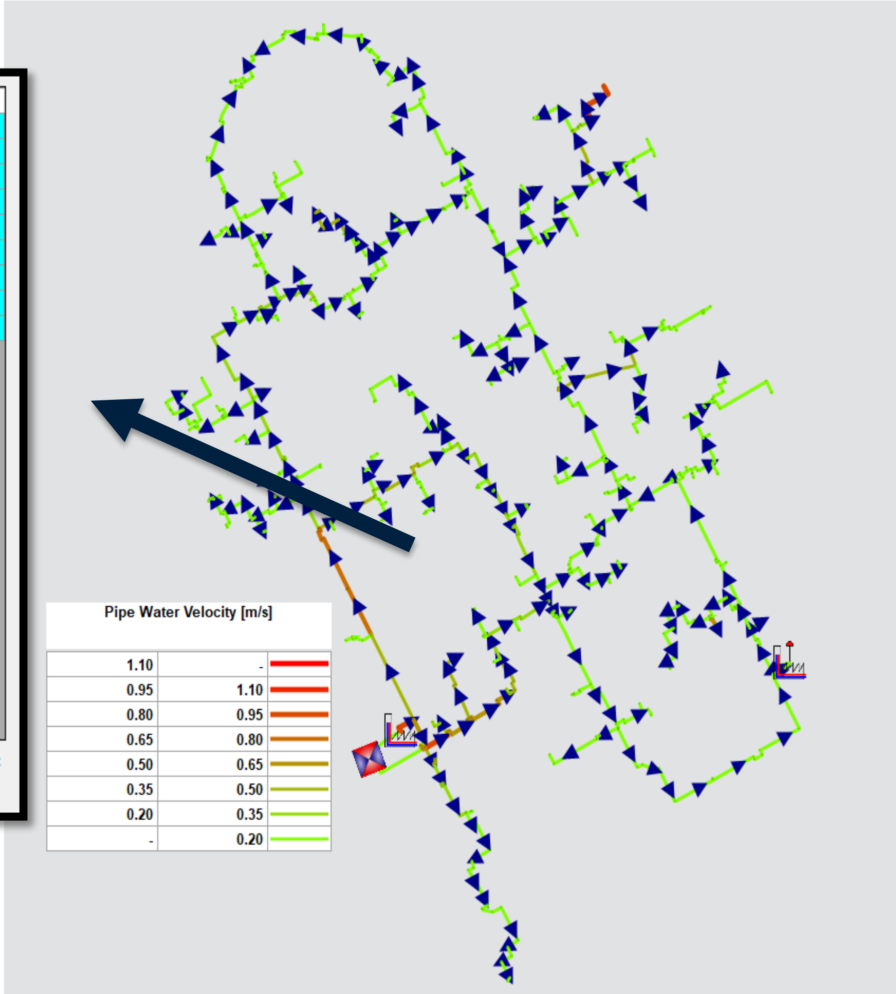
PIPE LINE VELOCITY & WATER FLOW DIRECTION

- Scenario1
  - Pipe
    - Results
    - System
    - Geometry
    - Additional Info
    - Data, Supply
    - Data, Return
    - Results, Supply
    - Results, Return
    - Show
    - Adaption
    - Measurements
    - KPI

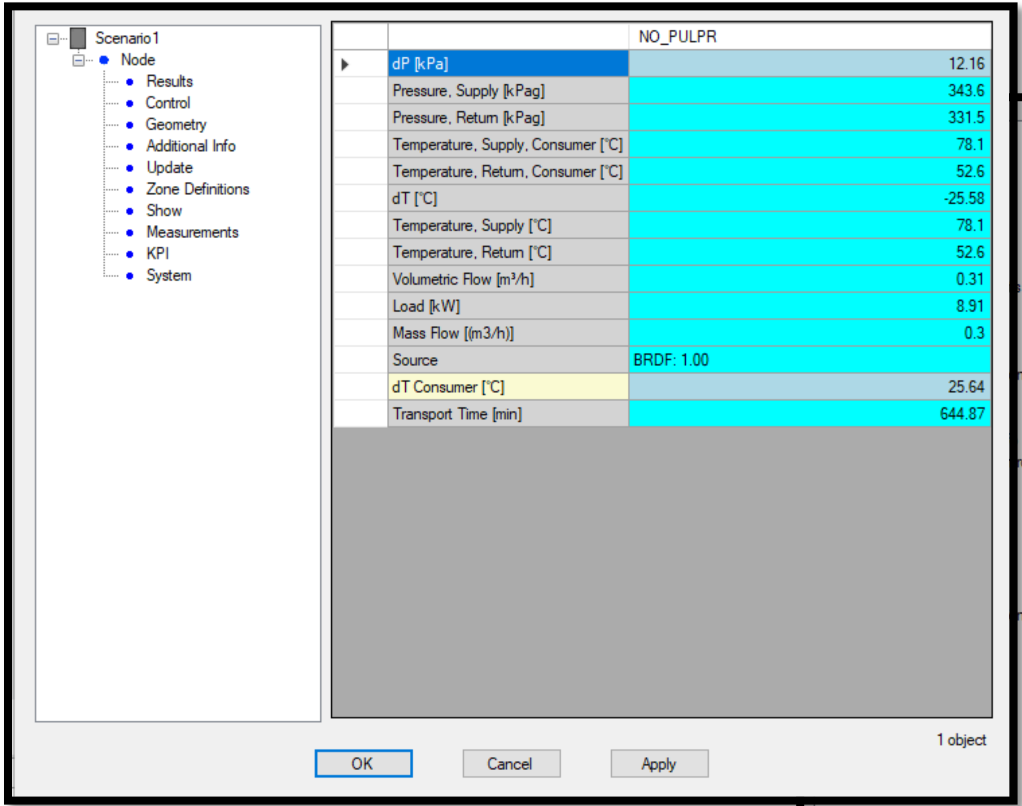
	154
Pressure, Ups., Return [kPag]	466.6
Pressure, Dws., Return [kPag]	449.1
Friction Pressure Gradient, Return [kPa/km]	6.45
Mass Flow, Ups., Return [(m3/h)]	87.3
Volumetric Flow, Ups., Return [m³/h]	89.08
Velocity, Ups., Return [m/s]	0.46
Temperature, Ups., Return [°C]	65.0
Temperature, Dws., Return [°C]	65.1
Relative heat loss, Return [W/m]	-23.38

1 object

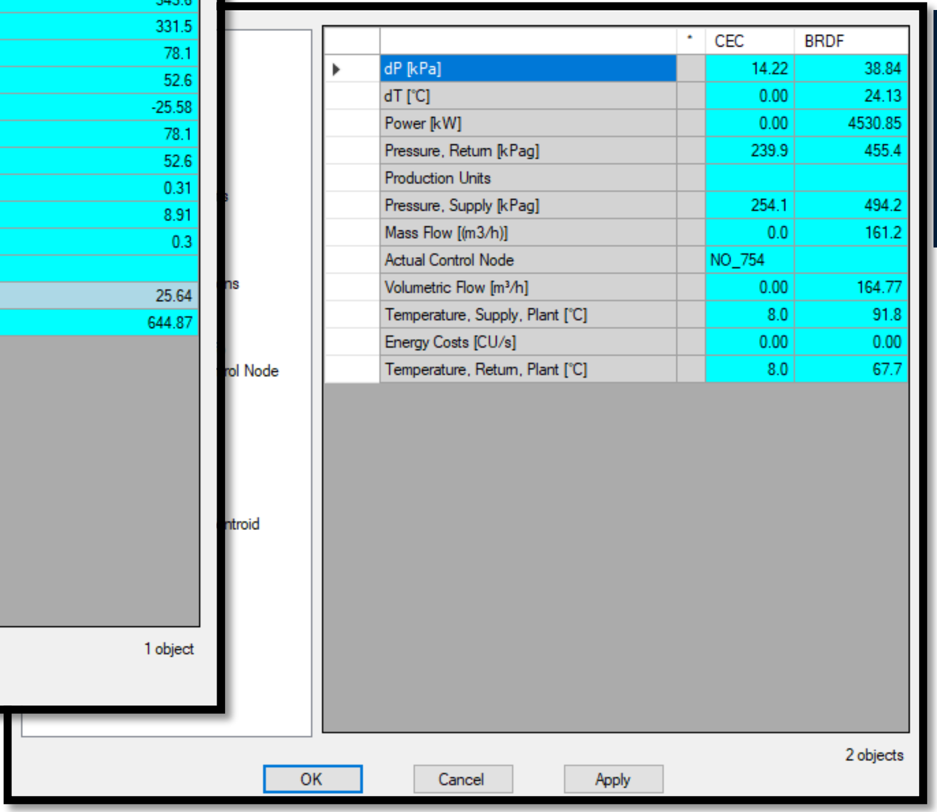
OK Cancel Apply



SAMPLE BUILDING & PLANT DATA



	NO_PULPR
dP [kPa]	12.16
Pressure, Supply [kPag]	343.6
Pressure, Return [kPag]	331.5
Temperature, Supply, Consumer [°C]	78.1
Temperature, Return, Consumer [°C]	52.6
dT [°C]	-25.58
Temperature, Supply [°C]	78.1
Temperature, Return [°C]	52.6
Volumetric Flow [m³/h]	0.31
Load [kW]	8.91
Mass Flow [(m3/h)]	0.3
Source	BRDF: 1.00
dT Consumer [°C]	25.64
Transport Time [min]	644.87

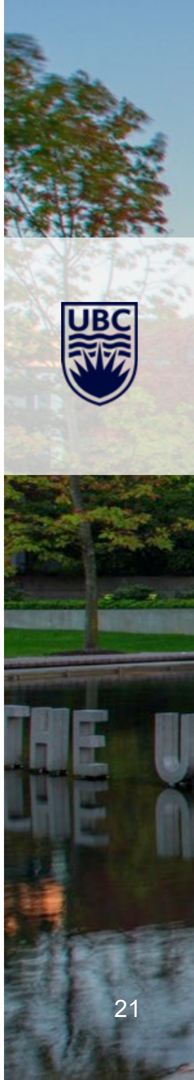


	*	CEC	BRDF
dP [kPa]		14.22	38.84
dT [°C]		0.00	24.13
Power [kW]		0.00	4530.85
Pressure, Return [kPag]		239.9	455.4
Production Units			
Pressure, Supply [kPag]		254.1	494.2
Mass Flow [(m3/h)]		0.0	161.2
Actual Control Node		NO_754	
Volumetric Flow [m³/h]		0.00	164.77
Temperature, Supply, Plant [°C]		8.0	91.8
Energy Costs [CU/s]		0.00	0.00
Temperature, Return, Plant [°C]		8.0	67.7

EXAMPLES OF USE

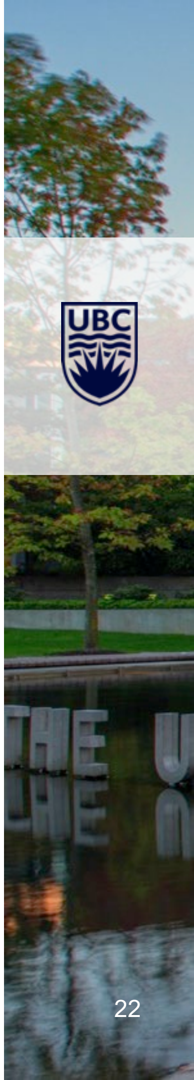
1. What-If scenarios of plant capacity from 2019-2025 including DT impact,
2. What-If scenarios of Max and Min demand (Tsup = 75 C),
3. What-If scenarios of pumping requirements for adding the BDRF 12 MWt plant,
4. What-If scenarios of use of booster pump,
5. What-If scenarios of use of control valves,
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

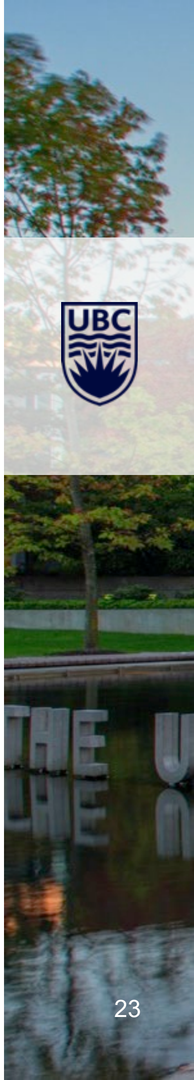
- Have a system like Termis to aid original design of the system to identify future scenarios and bottle necks.
- Suggest to have model during design stages of DES to use the offline model right away to check consultants work during implementation of new system
- Dedicated resources for daily check-in 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

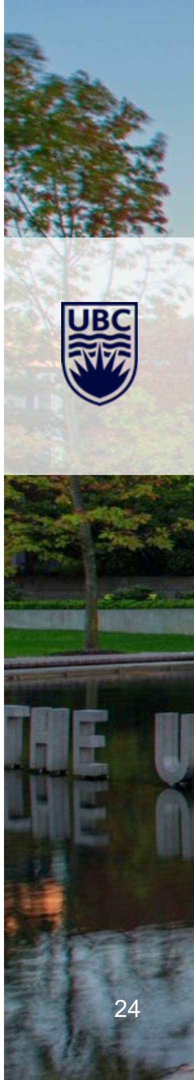
UBC is monitoring and managing the $88 million energy transformation investment:

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?

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Joshua Wauthy, UBC

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