District Energy in Cities Workshop: "Living the Dream" UBC Steam to Hot Water Conversion

IDEA Main Conference 20-24th June 2016

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

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The University of British Columbia

a place of mind

- 15 million sq.ft. of institutional & student Housing over 1,000 acres
- 1 million sq.ft. added since 2007
- Day time pop. ~65,000 i.e. 50,000 Students and 15,000 Faculty & Staff

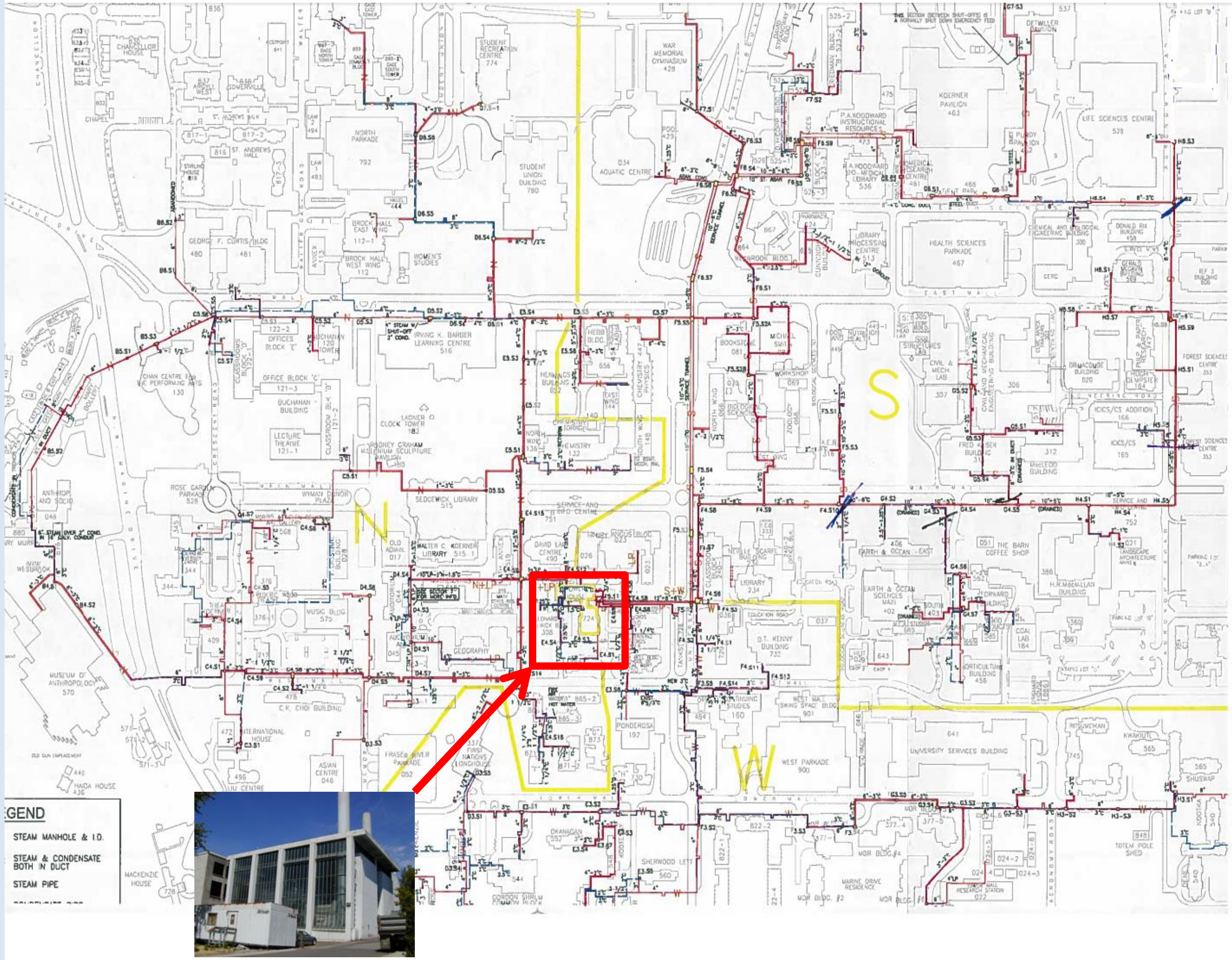
From Steam in 2010

2010 Summary

In continuous service for 85 years:

- 28km of Steam and condensate pipes (14 trench km's)
- 133* buildings on Steam
- 400,000lbs/hr capacity
- 250,000lb/hr peak
- 785,000,000lbs/year
- ~1,000,000GJ/year NG
- 78% of Campus GHG
- Overall system efficiency 60%

Includes UBC Hospital (local health authority, not UBC)



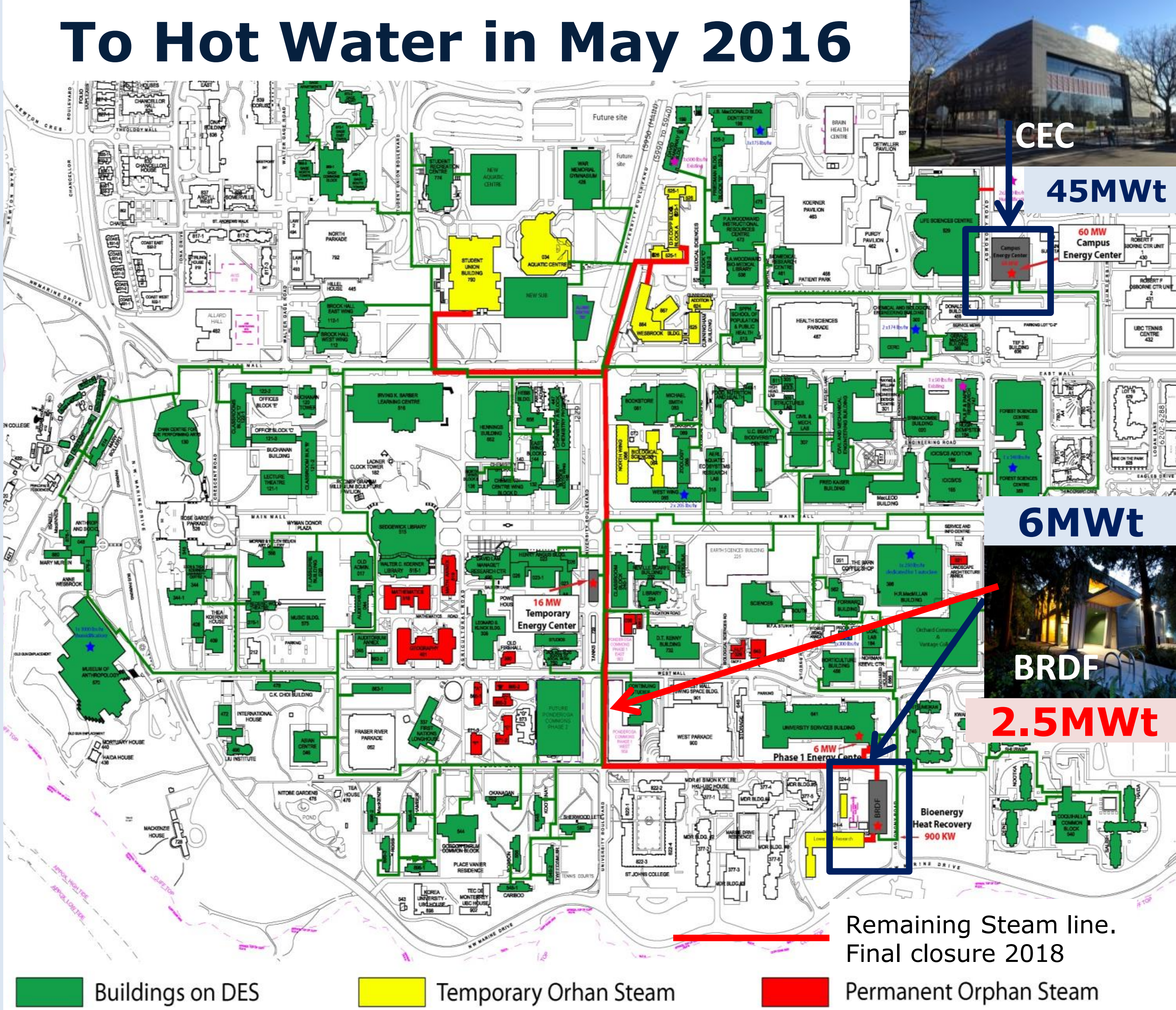
UBC Powerhouse

Steam Academic District Energy System Jan 2010

2016 Summary

- 22 kilometers of pre-insulated supply & return direct buried piping (11 trench km's)
- Commissioned a 45 MW Natural Gas fired (Current Capacity) Campus Energy Centre
- 115 building converted
- 14 buildings + 4 UBC Hospital Buildings not converted to hot water
- 12 research buildings with ongoing steam process loads requirements

To Hot Water in May 2016



Hot Water Academic District Energy System 2016

UBC Steam to Hot Water Project (STHW)

$88m, constructed over 5 Years, in 9 Phases

UBC STHW Project Lessons Learnt

Discussion points

- Business Case Assumptions
- What we missed
- What we got right
- Lesson learned and Adjustments made during the project
  - Technical
  - Assumptions
  - Financial
  - Organizational
  - Emergent information or unplanned
  - Initial scoping

BUSINESS CASE ASSUMPTIONS vs. ACTUAL TO DATE

Assumptions used to form 2010 business case:

- Capital Cost $88m CAD -> $92m
- Price of NG $5.22/GJ flat for 5 years, then up by 2% -> NG now ~$1.50/GJ
- Price of Carbon $55/tonne (or $2.75/GJ) -> Recent BC Government report recommends to rise ~$0.50/GJ per year until 2030
- Cost Avoidance ($7M PV) vs. Cost Savings ($20M PV) -> NG pricing currently impacting CA…
- Capital Avoidance ($34M PV).. VFA Audit ($190M vs. $42M) -> Business case was built on a Cap Avoidance inclusion in the funding. This did not happen. The gap in repayments has been made up by commodities savings due to other concurrent energy conservation programs.

What we missed

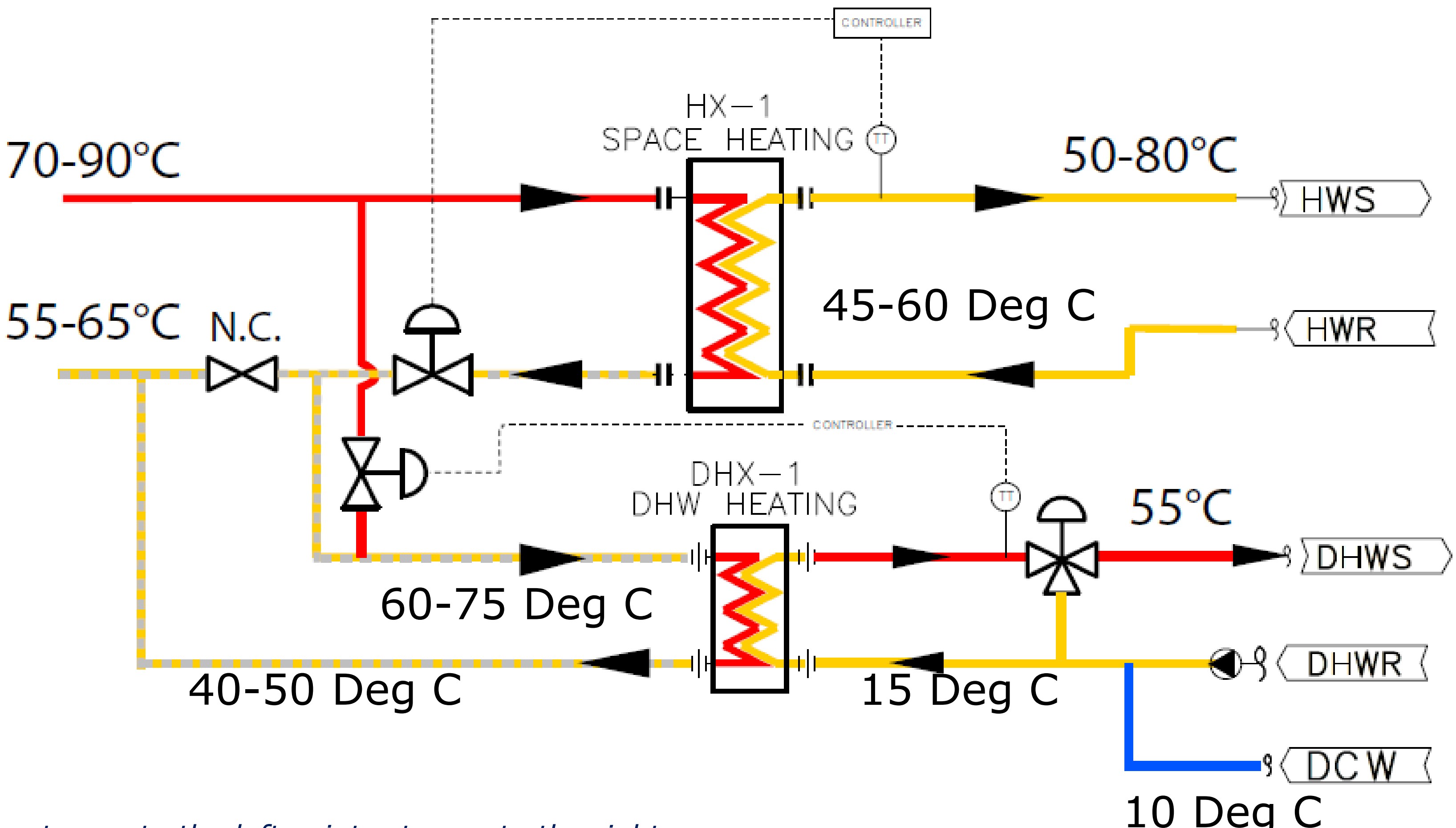
- 5 year construction period… what to do with new buildings coming on line when hot water (DES not ready) and yet shouldn't connect to steam DES.
- The other side of the meter… mechanical rooms now cold… Unexpected benefit and providing an extra ~5% savings.
- Powerhouse demolition costs $3.5 - $5.5m/still rising…….
- Process steam scoping… several labs and or process requirements were missed or not fully captured under original scoping
- Growth… we thought new buildings would be more energy efficient i.e. LEED/ Green buildings etc.

What we got right ☺

- Phase 1 pilot
  - Allowed for lessons learned to be incorporated into later phases
  - **Verified** costs estimates and energy/cost **savings**
  - Confirmed original business case assumptions e.g. existing steam piping was found to be very **poorly insulated**
- Carbon pricing (to date)
- Energy savings on pace for 280,000 GJ / year savings
- Links with public realm improvements and new construction
- New campus energy centre staffing requirements
- Lower operating temperature expected: Original supply planned for 90 deg C, we are now expecting nearer to 80 deg C in winter
- CEC has capacity future proofed to meet all expected future thermal load growth for the ADES and NDES (45MWt now to maximum potential build out of 110MWt)
- Open dialogue with peers e.g. Stanford, IDEA, local municipals etc.

What we got right ☺

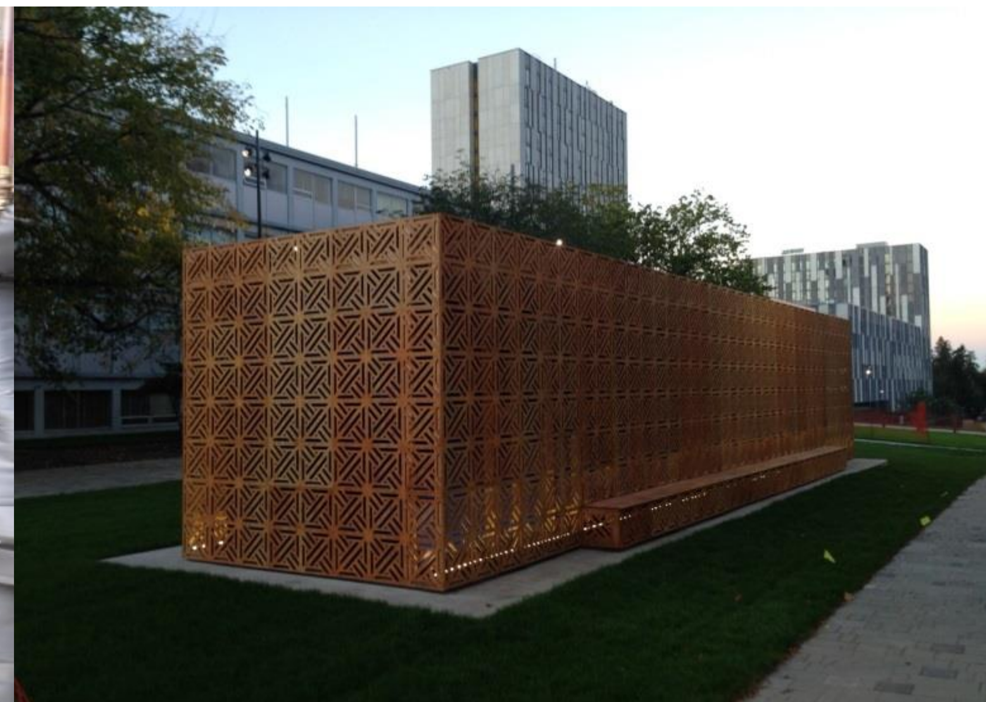
- Phase 1 Energy Transfer Station (ETS) simple schematic **cascading** design for domestic hot water



Summer temps to the left, winter temps to the right

Lessons learned and adjustments made during the project

- Installation of the temporary Energy Centre
  - Developing a TEC and the use of existing steam to hot water HEX’s, allowed for the early energization of the DPS and for 80 building conversions to be completed prior to Campus Energy Centre coming into service.

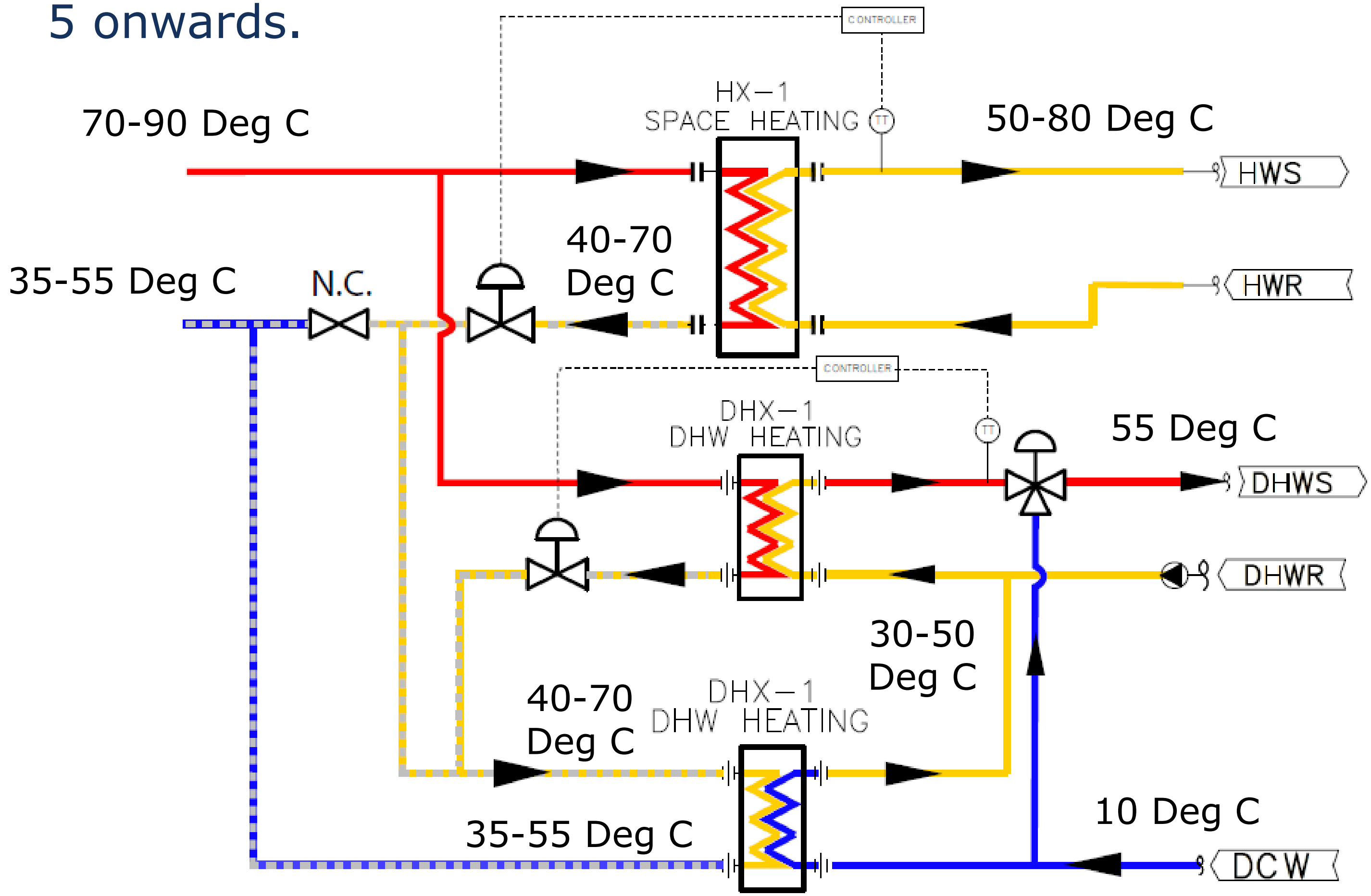


Lessons learned and adjustments made during the project cont'd

- Staff Transition plan:
  - Business case originally planned for contract staff to operate CEC before moving crews across i.e. +6 temp staff for up to 1 year.
  - Alternative strategy was developed:
    1. Powerhouse was 2 x Operators 24/7
    2. Negotiated with local safety authority to reduce manning requirement to 1 x Op 24/7 (this was achieved by a 50% capacity reduction at Powerhouse via permanent decommissioning of 2 x main boilers)
    3. Concurrent Union negotiation to agree to new PH requirements
    4. This freed up the second operator position to move to CEC, which is also 1 x Op 24/7
    5. Upon final closure of Powerhouse (Mar 2017) remaining staff either retire, packages or alternate employment at UBC
  - This new strategy has saved over $1m in transitional staff coverage

Lessons learned and adjustments made during the project cont'd

- Improved Energy Transfer Station (ETS) cascading design, Phase 5 onwards.



http://www.technicalguidelines.ubc.ca/Division_23/UBC_DPS-ETS_Design_Basis_6March2014.pdf

Lessons learned and adjustments made during the project cont'd

- In year 3: We went from summer only to year round construction/ implementation
  - 4 DPS construction crews
  - 2 ETS construction companies
- 3 different approvals from the Board (not 9)
  - Phase 4 approval CEC "all in from this point"
- Project governance / execution alignment

  The Original Owner department demerged 2 years into project. EWS retains project implementation, but post project completion:
  - EWS department has DPS and CEC
  - BO department has ETS (buildings) and process steam equipment
- Pre-purchased district energy pipe
  - 2012 CN rail strike leaves DPS stuck in Montreal for 6 weeks
  - Strong CAD vs Euro

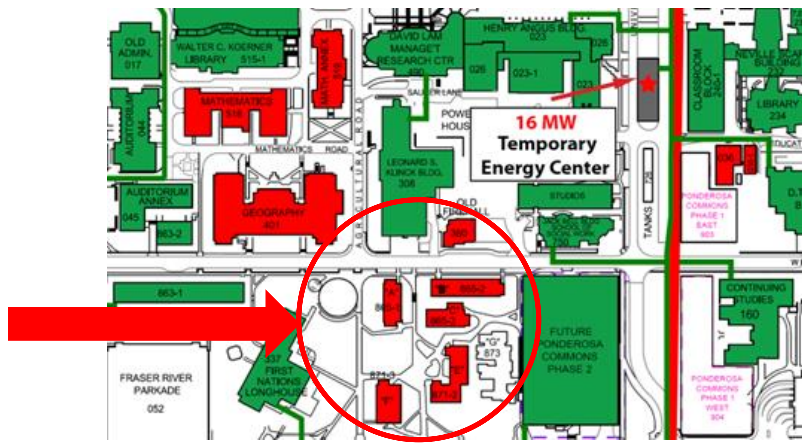
Lessons learned or adjustments made during the project cont'd

- Allowed buildings with pending major renovation projects post DES project to remain on steam.
  - Several buildings either awaiting renew programs or scheduled demolitions delayed.

- Modified later phases to accommodate new building construction
  - Ponderosa II; student housing project (1,000 bed)
  - Orphan Commons: Student Housing and academic joint project (1,000 bed)

Lessons learned or adjustments made during the project cont'd

- Several buildings originally planned for demolition during the project now had to be incorporated into the DES plan and or new orphan steam projects developed to compensate for UBC capital planning changes



- BC Government switches from HST to PST/GST taxation; a $1M impact

Lessons learned or adjustments made during the project cont'd

- Process steam scoping
  - The earlier assumptions or missed equipment in original scoping identified led to standardization of equipment selection
- Communication plan refined
  - PM's, Communications, C&CP, Facilities Managers fully engaged to give continuous updates to community e.g. road closures, classroom & laboratory interruptions etc., etc…
- Project Management team
  - PM's increased from 1 to 5 by end of the project
- Team Meetings
  - Weekly meeting between PM's, key owner group and associated post project owner groups
- AVED funding
  - At approx 23:59 in the project timeline... $7m BC Government funding came in

Conclusions to Date

- Phased implementation:
  - Allowed for lessons learned in earlier phases to be incorporated into later phases
  - **Verified** capital costs and delivered energy and cost **savings** from phase 1 onwards
  - Pre purchasing of the DPS enabled significant savings and reduced material delivery risk
- The TEC allowed for energization of the DPS and for 80 building conversions prior to the Campus Energy Centre coming into service.
- Staff transition and change management plans achieved
- Energy reduction targets achieved and now expected to exceed business case forecasts in 2016
- **UBC Achieved a 30% GHG reduction by 2015, expected to approach 40% by end 2016**
- CEC built to meet all future thermal load growth for the ADES and NDES
- 14 separate UBC departments, 18 different consultants and contractors firms: Altogether over 3,000 people worked on the ADES project

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