



# UBC Steam to Hot Water Conversion

*Evolving Energy Vancouver 7-10<sup>th</sup> Dec 2015*

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# The University of British Columbia



- 15 million sq.ft. of institutional & residential buildings over 1,000 acres
- Day time pop. ~ 65,000, with 30% growth expected over the next 20 years



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# Overview: UBC Steam to Hot Water Project (STHW)



**5 year, 10 phase, \$88 million project**

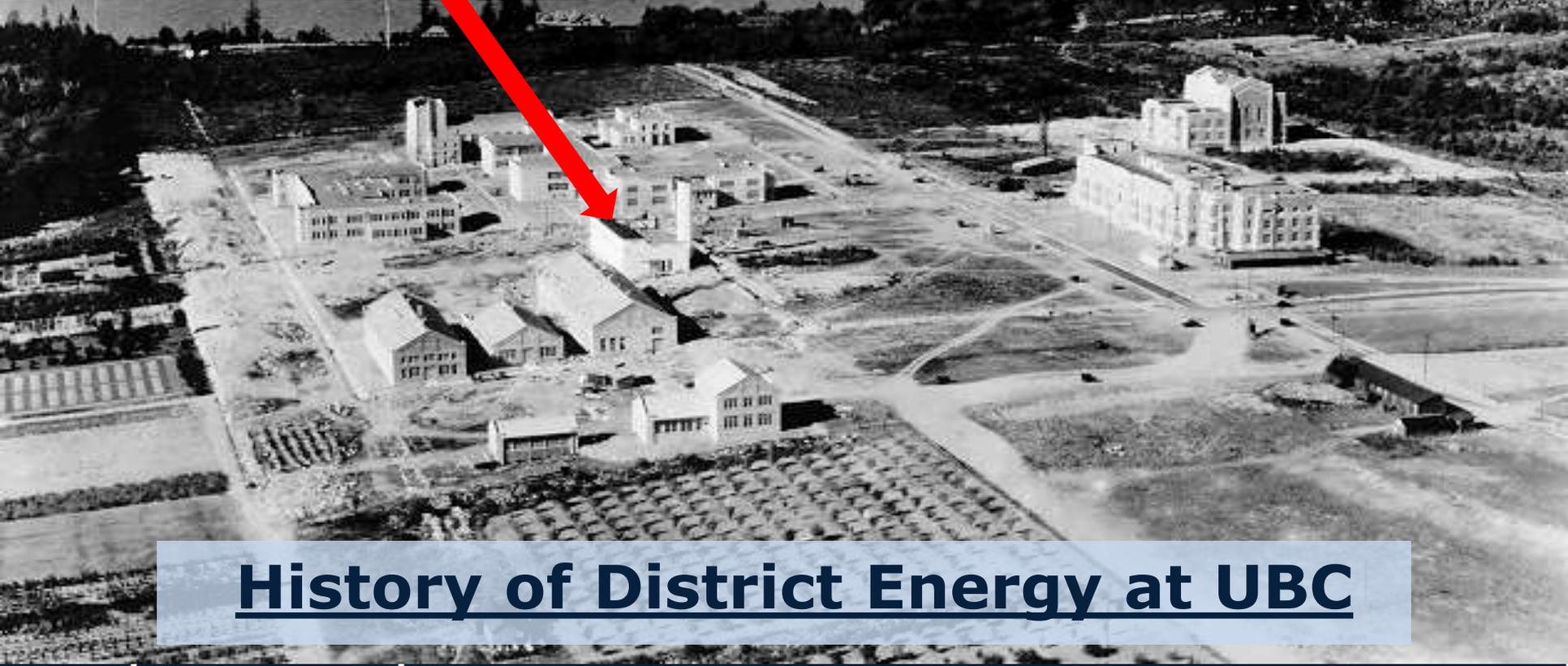
- 11 trench kilometers of pre-insulated supply & return direct buried piping
- 115 building conversions
- 45 MW Natural Gas fired Campus Energy Center
- 14 legacy buildings not converted to hot water
- 12 research buildings with ongoing steam process loads requirements



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UBC Powerhouse circa 1925



## History of District Energy at UBC

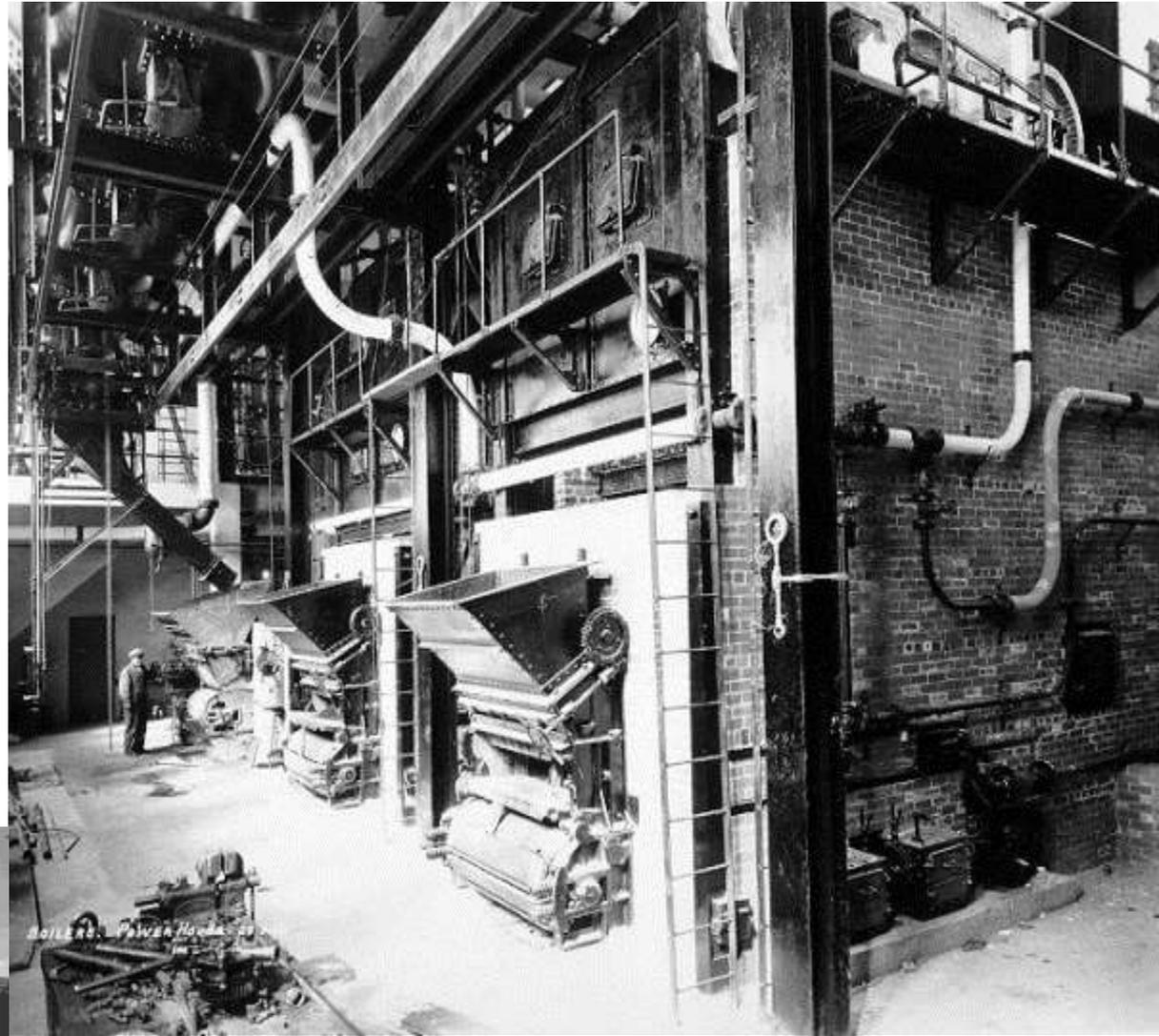


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# UBC Steam Powerhouse

- 1925: 3 original Boilers (Coal fired)
- 1950's Boilers 1, 2 & 3 replaced (FO)
- 1961 New wing added and Boiler 4 (NG) installed
- 1965 Boilers 1, 2 & 3 converted to NG
- 1969 Boiler 5 installed
- 1972 Boiler 3 decommissioned
- 2015 (July) Boilers 1 & 2 decommissioned

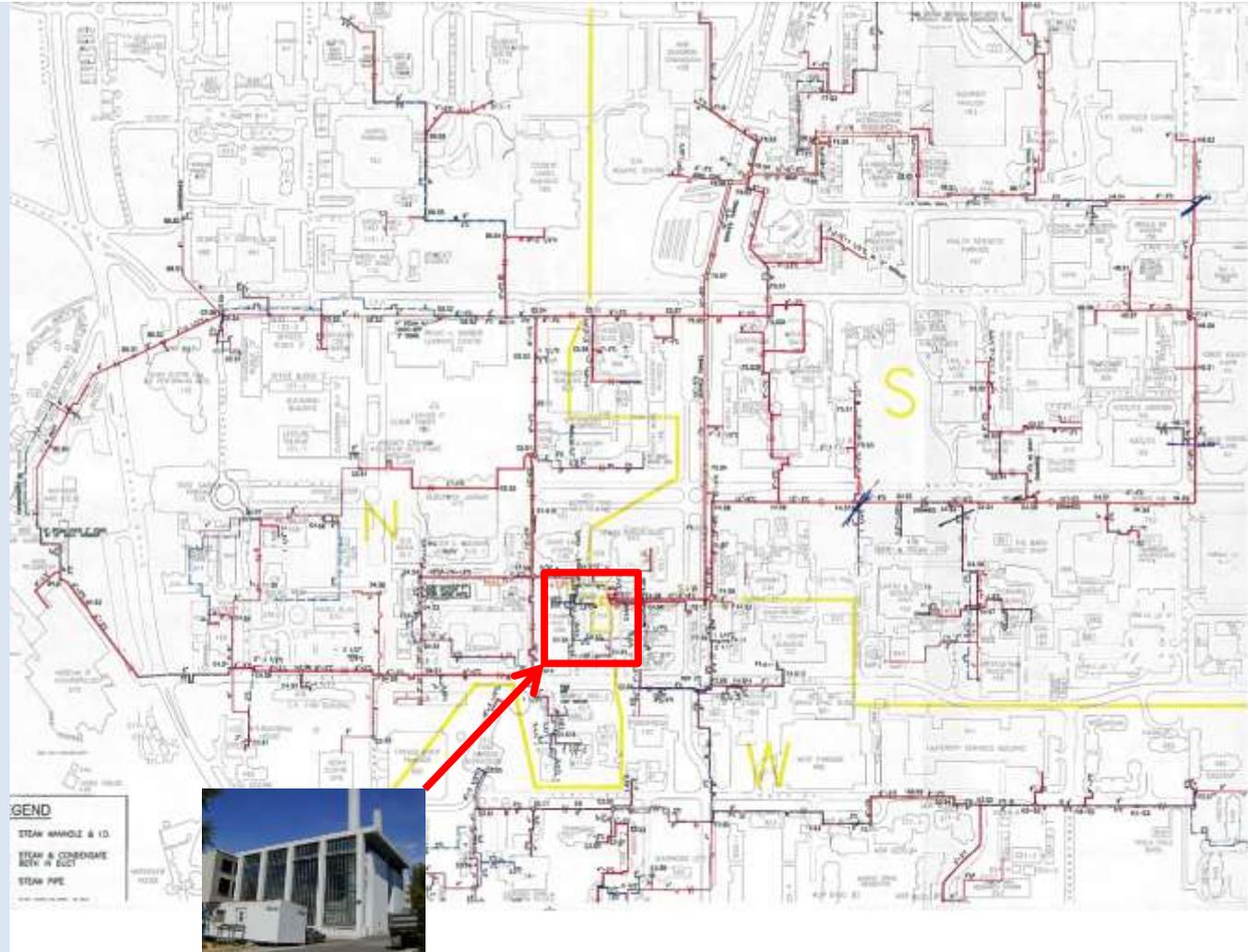


# UBC Steam District Energy System

## Summary

In continuous service for 90 years:

- 14km of Steam pipes
- 14km of condensate
- 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*



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# UBC STHW Project



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**No.1 Seismic Risk on Campus**

**\$180m VFA Audit  
\$45m for boilers**

**UBC CO2 reduction  
33% by 2015,  
ADES achieves  
22% of this**

**Saves \$5.6m  
per  
year: By  
Fuel, FTE's,  
Maintenance,  
Carbon Tax's  
reductions**

**E.g. New SUB  
Solar Thermal**



Deferred  
Maintenance

GHG  
reduction

Economics

Enabling  
platform for  
other  
technologies

**Industry  
and Peers**

Leadership

Demonstration  
of new  
technologies

Research

**E.g. Condex**

Sustainability  
& energy  
conservation

Resiliency

**ADES**

**240,000GJ  
NG  
reduction  
per year.  
60% Vs  
87% DES  
efficiency**

**E.g. Energy  
data Available  
to all**

# **STHW: The Motivation for Change**

# Project Risk Mitigation Strategy

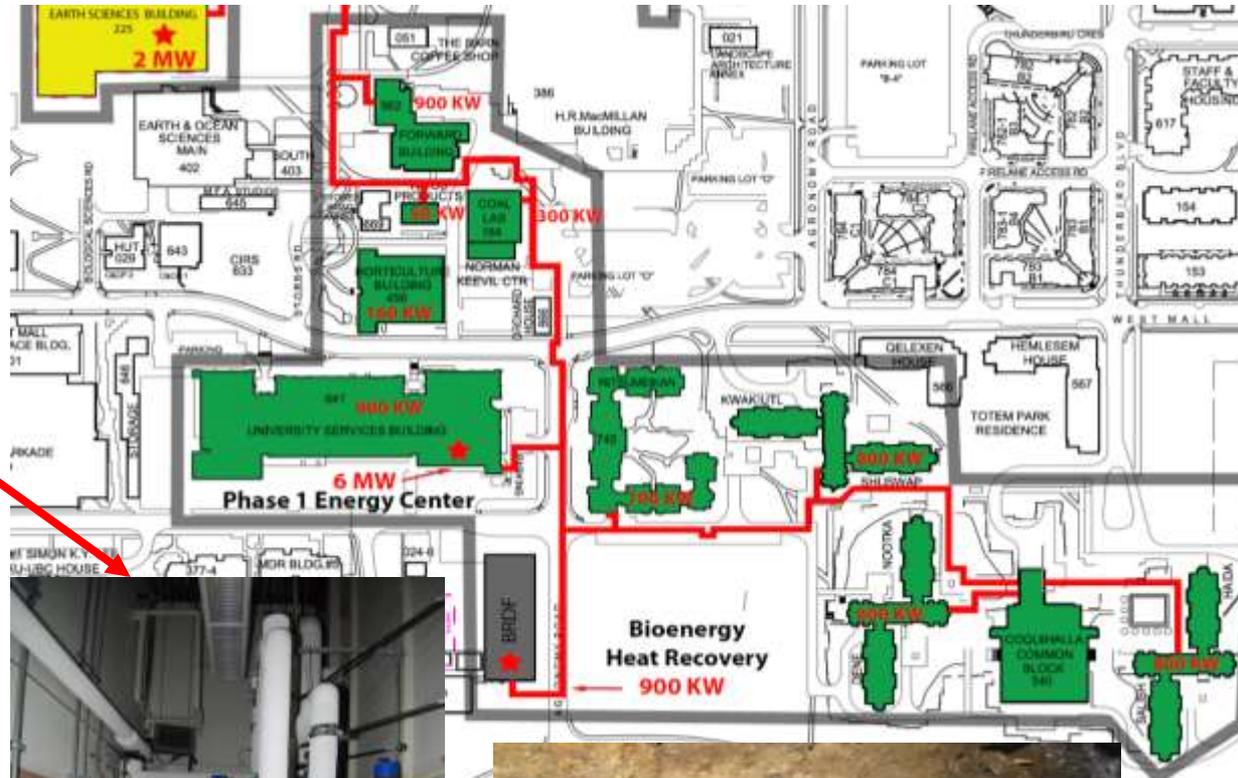
- 2011 Board of Governors (BOG) approves the \$88m project in principle and deploys the following strategy:
  - A step by step approach with main funding approval contingent upon the pilot or phase 1 performance evaluation and verification.
  - Stop NO Go or Off ramp options available up to phase 4 i.e. the construction funding approval for the CEC:
- Timeline
  - 2011 Funding approval for phase 1 to provide proof of concept
  - 2012 Approve funding phase 2 & 3
    - Verified phase 1 performance (off ramp option; *not taken*)
  - 2013 Phase 4 CEC funding approved (last chance to off ramp; *not taken*)
  - 2013 Phase 5-10 full funding approved



## Phase 1 Summary

# Phase 1 Pilot Project

- 1,100 trench meters of District Piping System (DPS) laid
- 13 buildings converted
- Connection for BRDF HR (1MW)
- Successfully repurposed the existing oversized heat exchangers at USB (5MW).
- Subsequently becomes the USB Energy Center (USBEC) (6MW total) (USB + BRDF HR)
- Phases 1 completed on budget and on time
- Concurrently 1km of steam lines decommissioned (insulation worse than expected)
- **Confirmed Phase 1 energy savings of 12,000 GJ's NG and 600 tonnes of CO2 emissions**



# Bridging the Energy gap to the CEC

- Phase 1, 2 & 3 converted 17 buildings to Hot Water and laid 4 trench km's of DPS.
- USBEC at maximum capacity after phase 3
- Phase 4 the CEC was a two year build
  - What about the remaining 98 buildings?
- Another energy source(s) was needed
  - Learning from the USBEC concept, a new Temporary Energy Center (TEC) was developed:



- 2 x 7.5MW Steam to Hot Water Heat Exchangers (15MWt total)
- The TEC + USBEC gave a total 23MWt capacity for the system whilst the CEC was being built which enabled further building change overs to occur



# ***Campus Energy Centre***

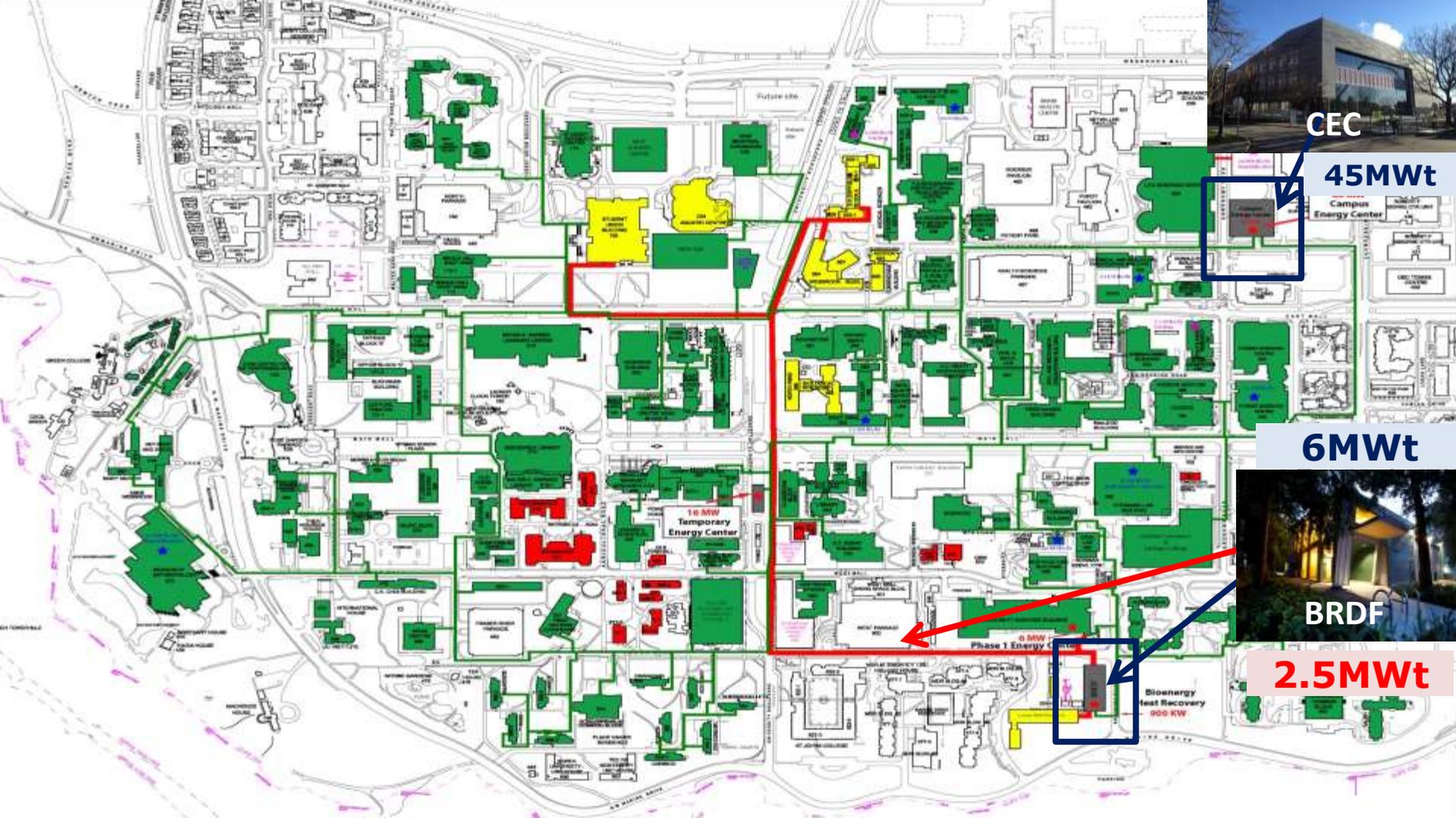
***In Service November 20<sup>th</sup>, 2015***

- Built for 4 boilers with 3 initially installed: 3x15MWt Natural gas/#2 diesel boilers
  - 4<sup>th</sup> Boiler required by 2020
- LEED Gold Certified
- Built using Canadian cross laminated timber (CLT)
- \$24m CAD and on budget
- Delayed by 1 month on a 2 year build
- Designed for future expansion to match UBC thermal load growth profile:
  - Each boiler bay is sized for 4 x 22MW boilers (88MWt)
  - Site chosen to allow for a Cogeneration Phase 2 expansion
  - Total capacity: CEC phase 1 + Cogeneration phase 2 at maximum build out will be 110MWt and 25MWe



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**CEC**  
**45MWt**

**6MWt**

**BRDF**

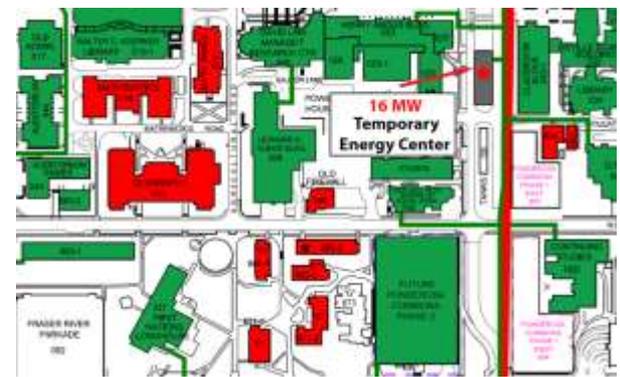
**2.5MWt**

- Buildings on DES
- Temporary Orphan Steam
- Permanent Orphan Steam
- Existing Buildings with gas boilers
- ★ New Process Steam Boiler
- ★ Existing Process Steam Boiler

# Academic District Energy System Dec 2015

# Permanent Orphan Steam Buildings

The original 1930's buildings were directly heated by steam on their secondary sides. There were 8 buildings remaining in this category and they were deemed to be too cost prohibitive to convert to hot water:



## Original Project Scope:

- 8 x 1930's buildings converted to electric baseboard



However, during the 5 year project, 7 buildings that were due for demolition were reprioritized by the university and kept:

## Additional Scope:

- 1 x 1930's building: HW boiler installed and existing steam radiators were repurposed to use Hot Water
- 3 x 1960's buildings were on an existing small hydronic distribution grid with an original primary STHW Hex supplying this mini HW district. We replaced the STHW Hex with a new HW boiler.
- 2 x 1960's buildings using a forced air system. Here we replaced the original AHU steam coils with NG coils



# Process Steam Loads

- Sterilization:
  - 12 buildings required steam for process loads e.g. autoclaves and cage washers
    - Electric steam generators used for isolated loads <100 KW's
    - Gas steam boilers required for 2 buildings with significant steam loads
- Humidification:
  - 6 Buildings required steam for humidification
  - Museums, Rare books, animal care
- 3 steam Absorption chillers replaced
- Kitchens:
  - 2 aging dishwashers replaced
  - 3 Steam kettles



# Things we would do differently

- Better communications and engagement for stakeholders around campus disruptions
- Work year round from the “get go” (first three years was summer DPS work only)
- Regular communication for project team **crucial** The PM(s) and owners group need to meet regularly
- If multi year project, plan from the start for temporary energy center solutions
- Better scoping of Orphan and Process steam needs
- Include a larger contingency in the project budget (minimum 10%)

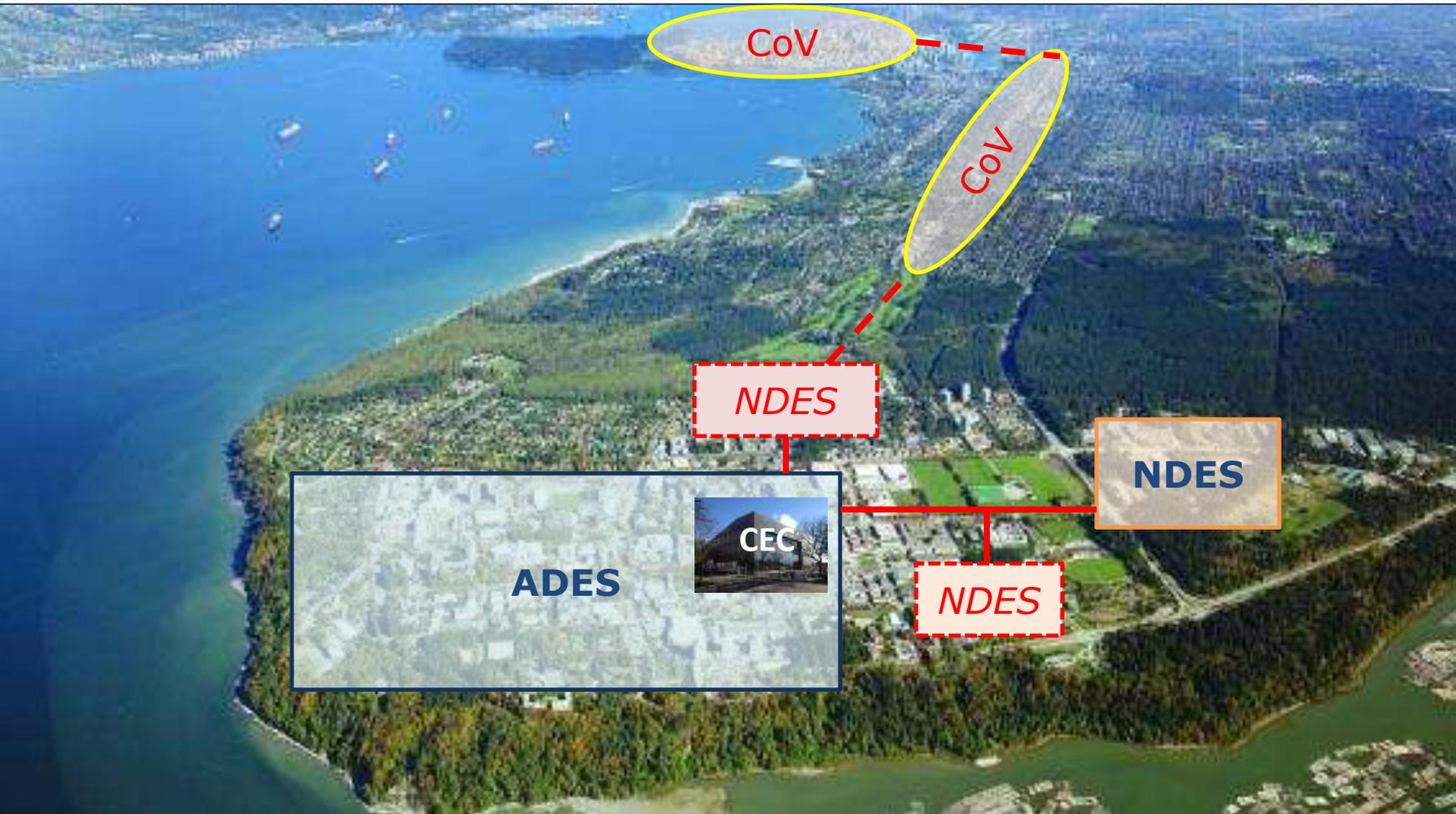


# Things we did right

- Phased implementation allowed for technical and cost control lessons learned to be incorporated into future phases
- Consistent Owner Engagement
  - Dedicated design team and management oversight
  - Operations group fully embraced the concept and allocated consistent FTE resource
- Consistent project management
  - UBC Project Services
- Consistent consultant(s) and contractor teams
- Kept Consistent Scope:
  - We did not add redundancy if there was non before (unless there was another driver or need for)
  - Essentially we replaced equivalent steam for Hot Water ETS's only i.e. we did not fix existing secondary side issues e.g. HVAC / BMS, unless it was part of the scope and or synergized with outside funding, then the economies of scale made a lot of sense to achieve "more bang for buck". E.g. Steam absorption chillers replaced by Smardt Heat recovery chillers



# What Next for DES at UBC?



# Conclusions to Date

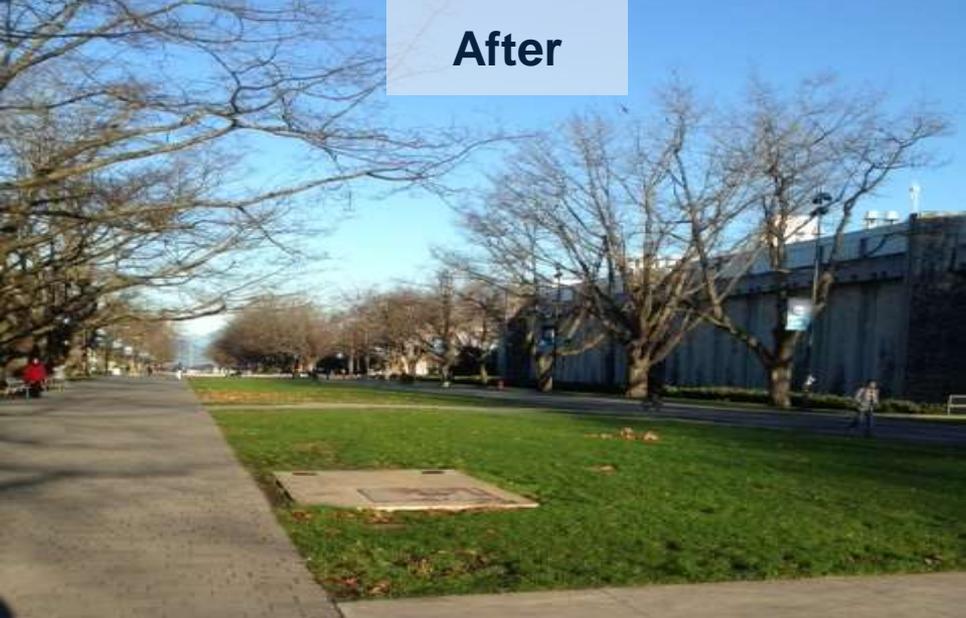
- Project is ~95%+ complete on schedule and expected to come in at most 2% above original budget (set 5 years ago). *Note project only carried a 5% contingency.*
- Phased implementation:
  - Allowed for lessons learned in earlier phases to be incorporated into later phases
  - **Verified** costs estimates and delivered energy and cost **savings** from phase 1 onwards
  - Confirmed original business case assumptions e.g. existing steam piping was found to be very **poorly insulated**
- Developing a TEC and use of existing steam to hot water HEX's, allowed for the early energization of the DPS and for 85 building conversions, prior to Campus Energy Center coming into service.
- Energy reduction targets are on track and likely to exceed forecasts
- STHW on target to achieve a ~22% GHG reduction as expected by end 2015
- CEC has expandability to meet all future thermal load growth for the ADES and NDES



Before



After



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Main Mall Nov 2015



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