UBC Steam to Hot Water Conversion

IDEA Main Conference 20-24th June 2016

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INTERNATIONAL DISTRICT ENERGY ASSOCIATION

The University of British Columbia

UBC 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

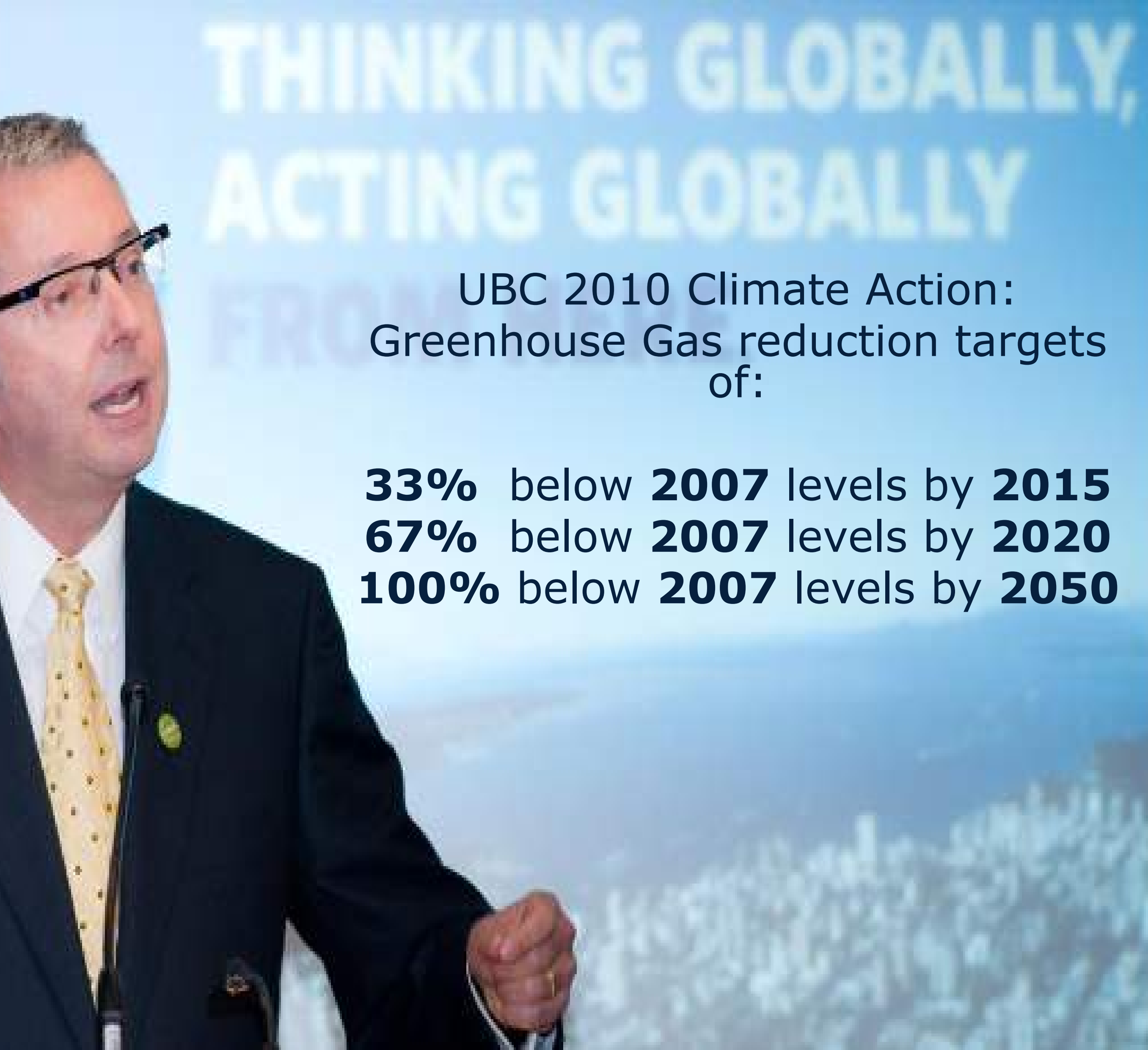
Background: Deferred Maintenance

UBC Powerhouse circa 1925

3rd permanent building on Campus

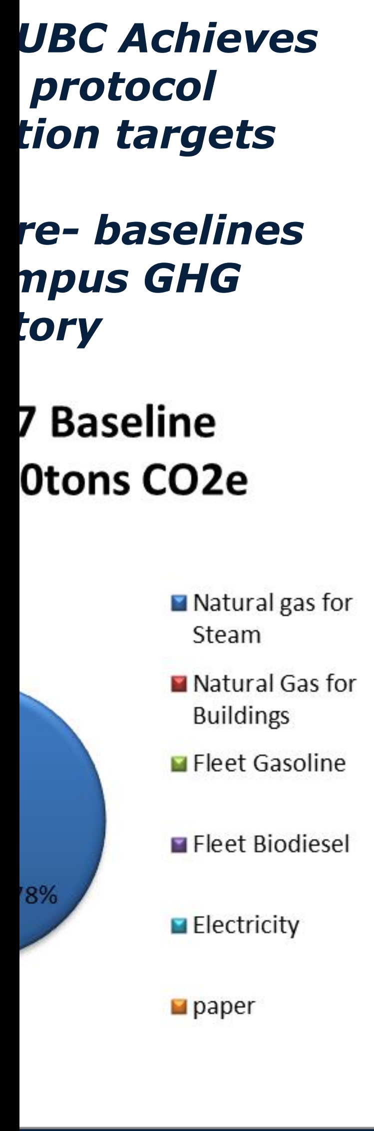
UBC Powerhouse 2015

- 2009 Powerhouse identified as No.1 Seismic Risk building on Campus
- 2010 VFA audits UBC Steam System with DM valued at $190M

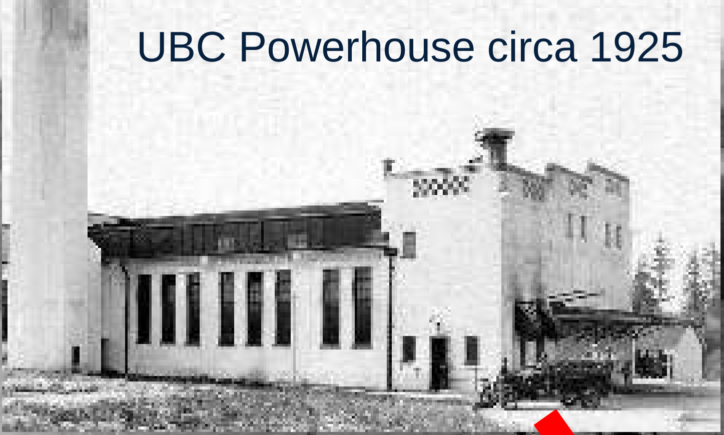


UBC 2010 Climate Action:
Greenhouse Gas reduction targets of:

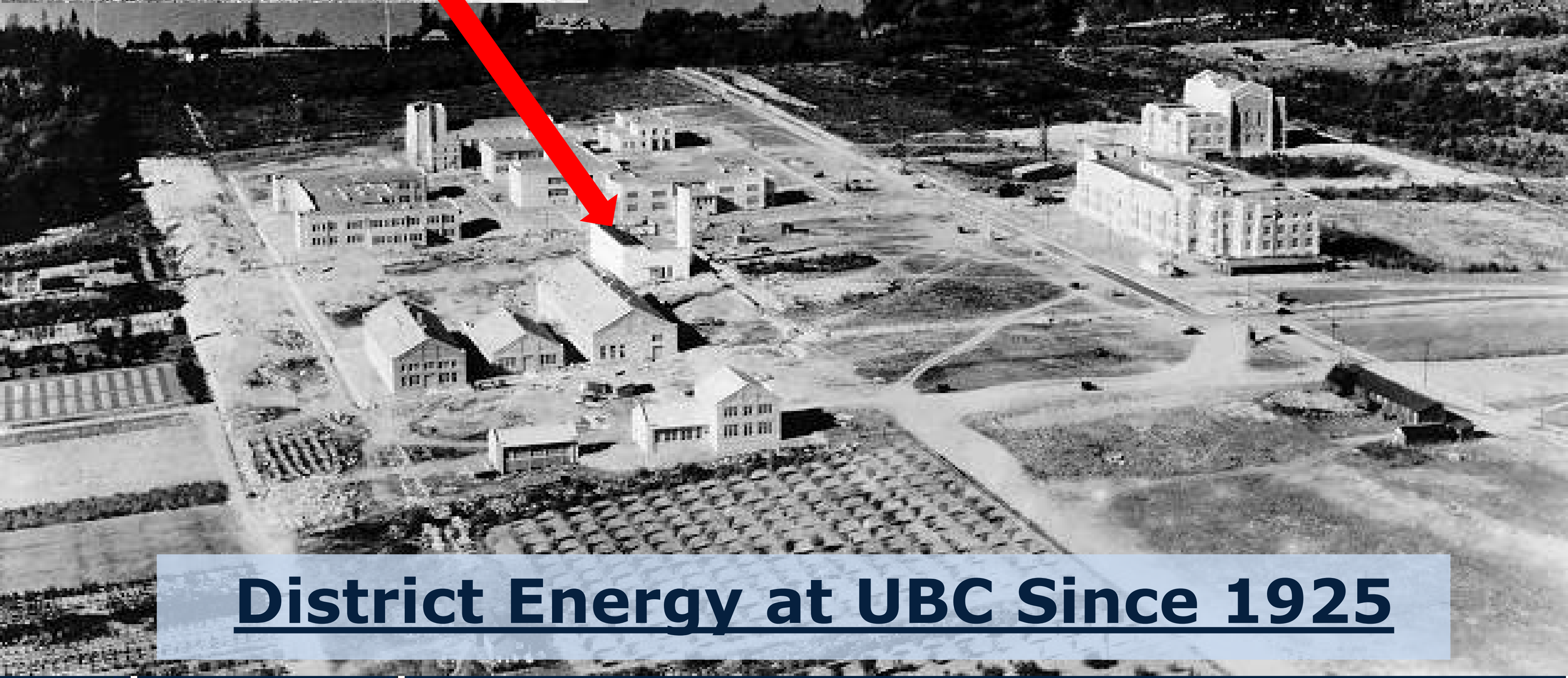
33% below **2007** levels by **2015**
67% below **2007** levels by **2020**
100% below **2007** levels by **2050**



Background: UBC GHG Commitment Confirmed



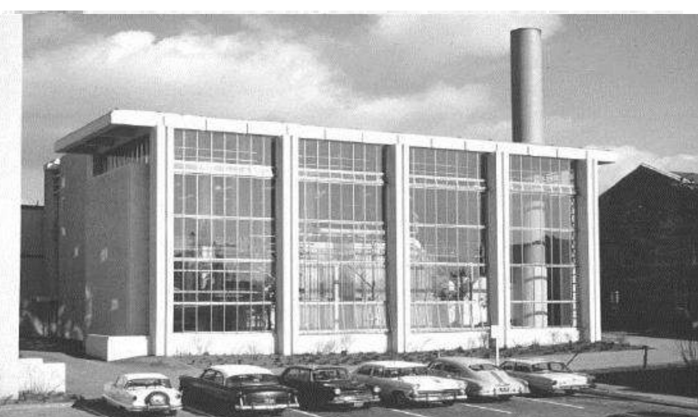
UBC Powerhouse circa 1925



District Energy at UBC Since 1925

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 (Fire)
- 2015 (July) Boilers 1 & 2 decommissioned



District Steam: Continuous Investment & Improvements

2005 3,650m trench new condensate return. 80% return

2004 Sofame Percotherm installed. Boiler efficiency raised from 70 to 78%

2006 New Low Nox burners and Burner Management System. Boiler efficiency raised from 78 to ~83%

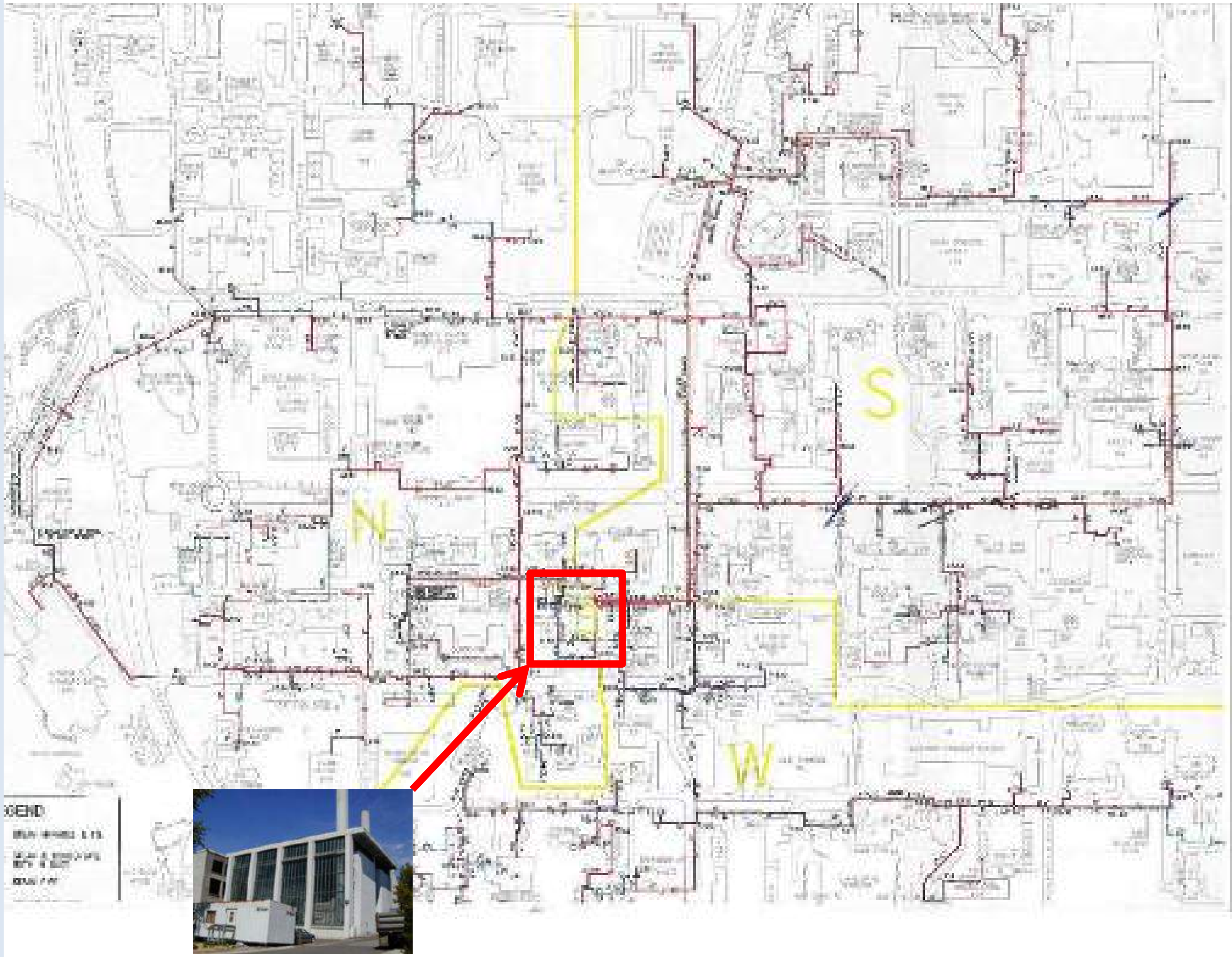
Steam as of January 2010

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

Steam System Efficiency

Powerhouse

Boilers + Sofame 89%

Deaerator + parasitic losses -9%

Steam & Condensate Distribution

Insulation losses + steam traps

Condensate 60-70% returned

Building/ End User

Shell & Tube heat exchangers

Steam traps + Hot water tanks losses

Plant = 80%

Distribution = 80%

End User = 90%

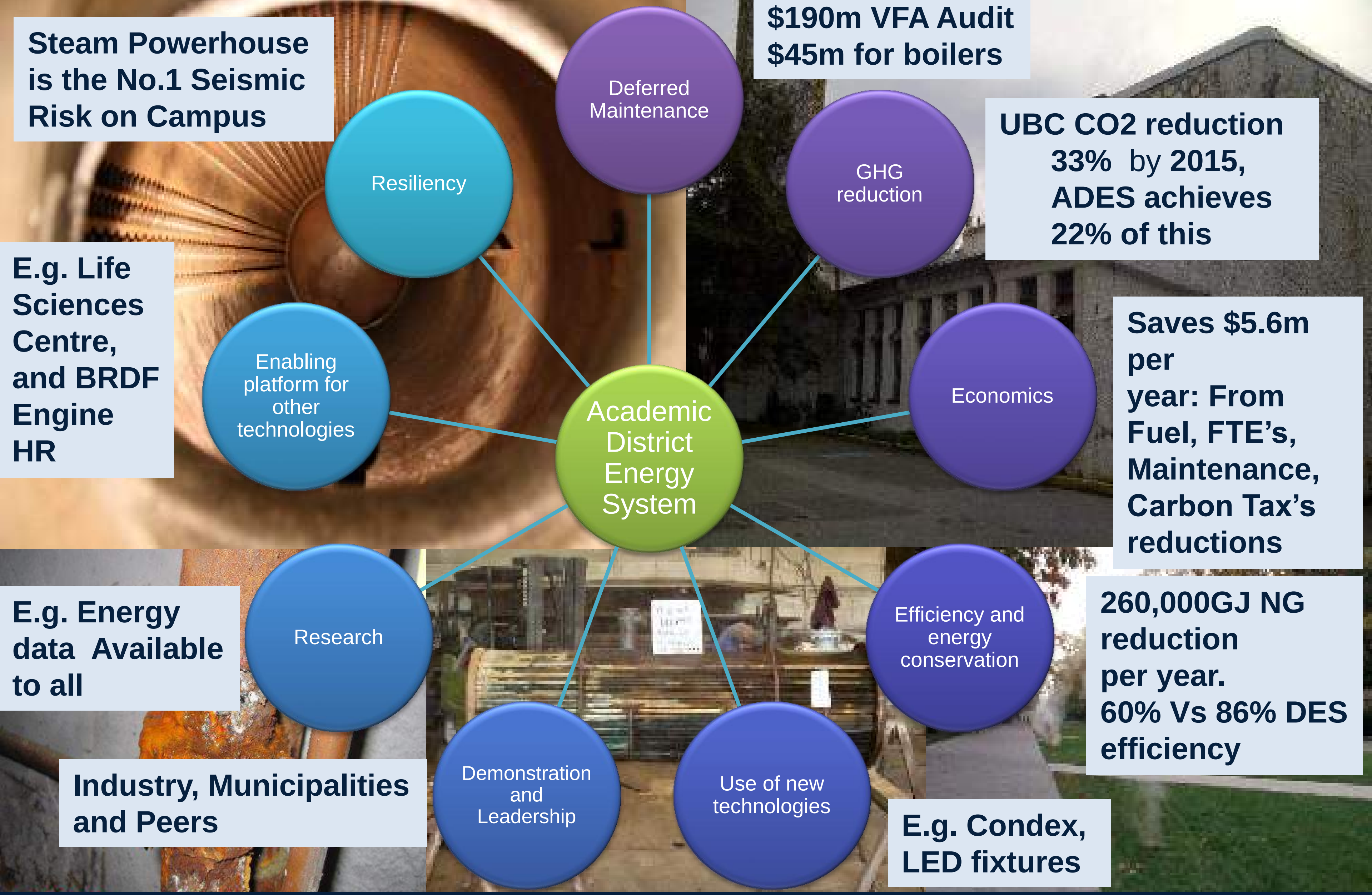
Overall Steam DES Efficiency = 80% x 80% x 90% = **60%**

UBC Steam To Hot Water (STHW) Project

Overview STHW Project

5 year, 9 phase, $88 million project

- 22 kilometers of pre-insulated supply & return direct buried piping (11 trench km's)
- 115 building conversions
- New 45 MW Natural Gas fired Campus Energy Centre (Current capacity)
- 14 legacy buildings not converted to hot water
- 12 research buildings with ongoing steam process loads requirements



The Motivation for Change

Powerhouse

Boilers + Sofame 89%

Deaerator + parasitic losses -9%

Steam & Condensate Distribution

Insulation losses + steam traps

Condensate 60-70% returned

Building/ End User

Shell & Tube heat exchangers

Steam traps + Hot water tanks losses

Plant = 80% Distribution = 80% End User = 90%

Overall Steam DES Efficiency = 80% x 80% x 90% = **60%**

Campus Energy Centre

Boilers + Condensing economizer 88%

Supply & Return Piping

Insulation losses minimal

Return Water 100%

Building/ End User

Plate heat exchangers, cascaded with domestic. No DHW tanks required

Plant = 88% Distribution = 97% End User = 100%

Overall Hot Water DES Efficiency = 89% x 97% x 100% = **86%**

Steam Vs HW System Efficiency Comparison

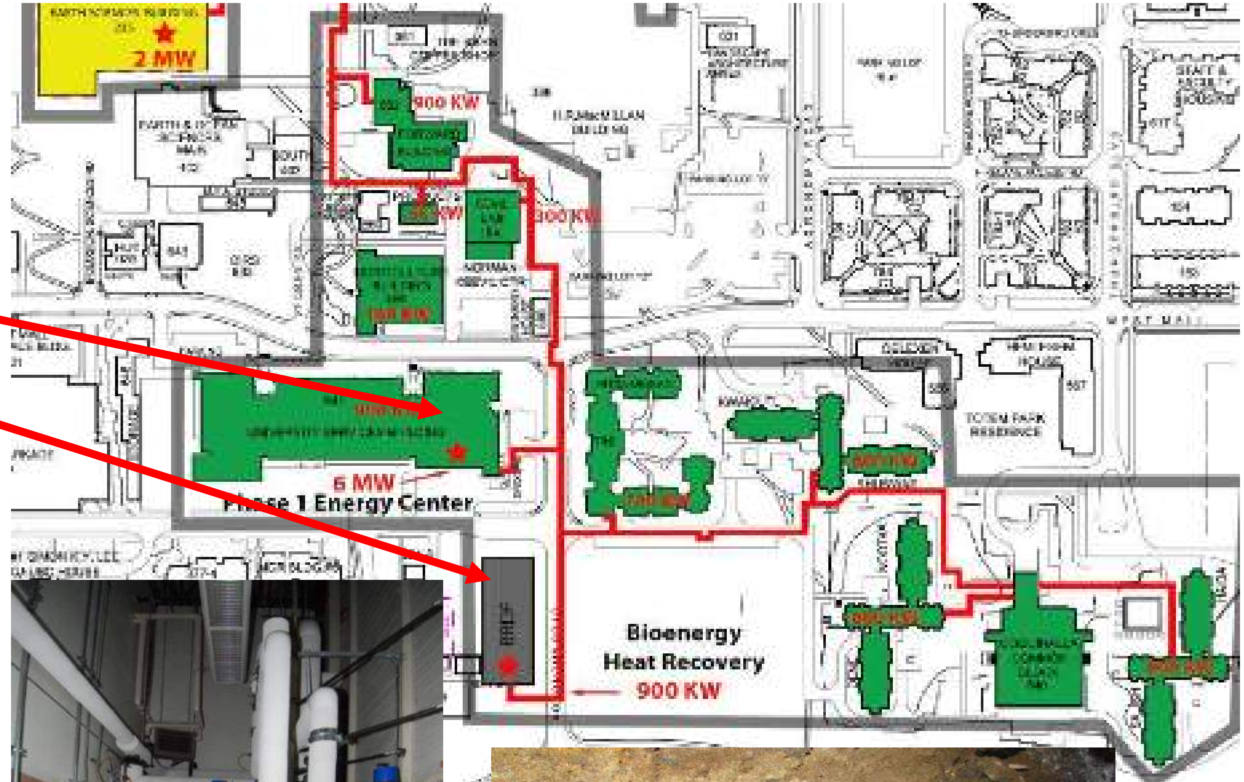
Project Risk Mitigation Strategy

- 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
  - 2013 Phase 4 CEC funding approved
  - 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
- Successfully repurposed the existing oversized heat exchangers at USB (5MW).
- Connection for BRDF HR (1MW)
- Subsequently becomes the USB Energy Center (USBEC) (6MW total) (USB + BRDF HR)
- Phases 1 completed on budget and on time
- Concurrently 1km of trench steam lines decommissioned (insulation worse than expected)
- **Confirmed Phase 1 energy savings of 12,000 GJ's NG and 600 tonnes of CO2 emissions**

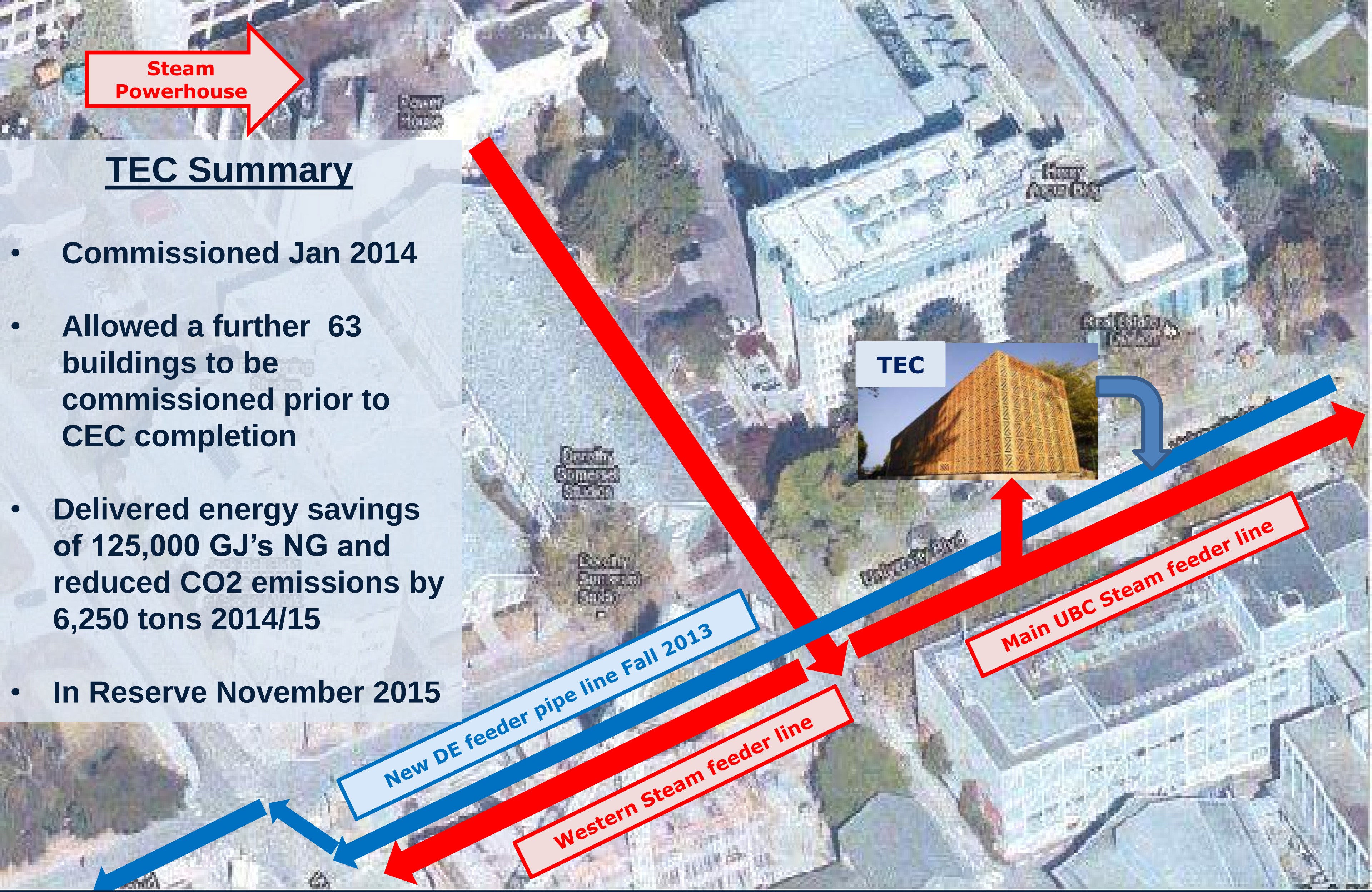


Bridging the Energy gap to the CEC

- Phase 1, 2 & 3 converted 17 buildings and laid 4 trench km’s of DPS.
- USBEC at maximum peak capacity after phase 3
- Phase 4: the CEC was a two year build
- A Temporary Energy Centre (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

TEC Summary

- Commissioned Jan 2014
- Allowed a further 63 buildings to be commissioned prior to CEC completion
- Delivered energy savings of 125,000 GJ's NG and reduced CO2 emissions by 6,250 tons 2014/15
- In Reserve November 2015



Siting the Temporary Energy Centre (TEC)

Campus Energy Centre (CEC)

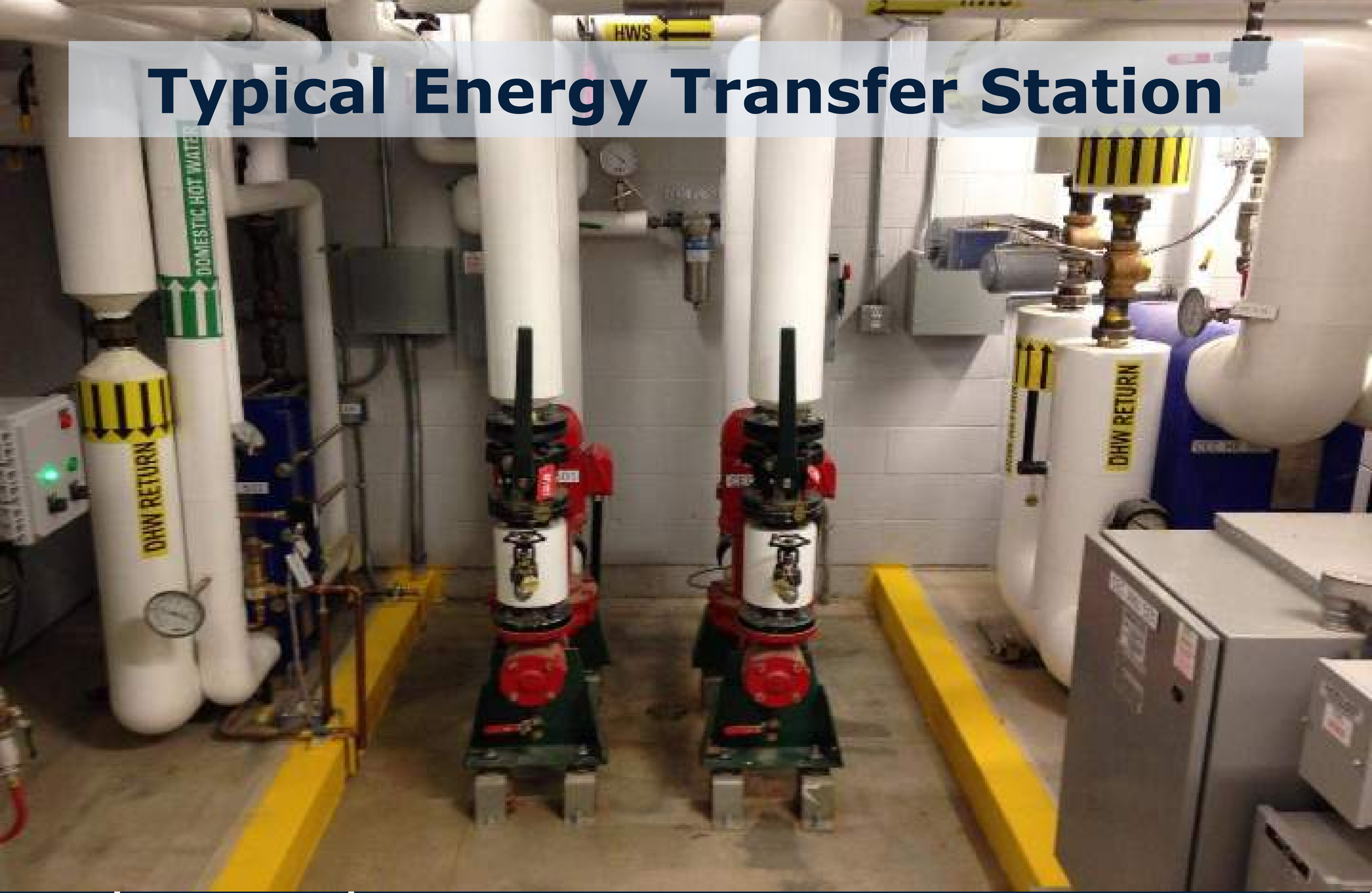
In Service November 20th, 2015

- LEED Gold Certified
- Constructed using Canadian cross laminated timber (CLT)
- $24m CAD

- Built for 4 boilers
- Initial Installation 3x15MWt Natural gas/#2 diesel boilers (45MWt)
- To match UBC thermal load growth profile over next 20 years:
  - 4th Boiler planning required by 2020
  - Each boiler bay is sized for 4 x 22MW boilers (88MWt) ultimate expansion

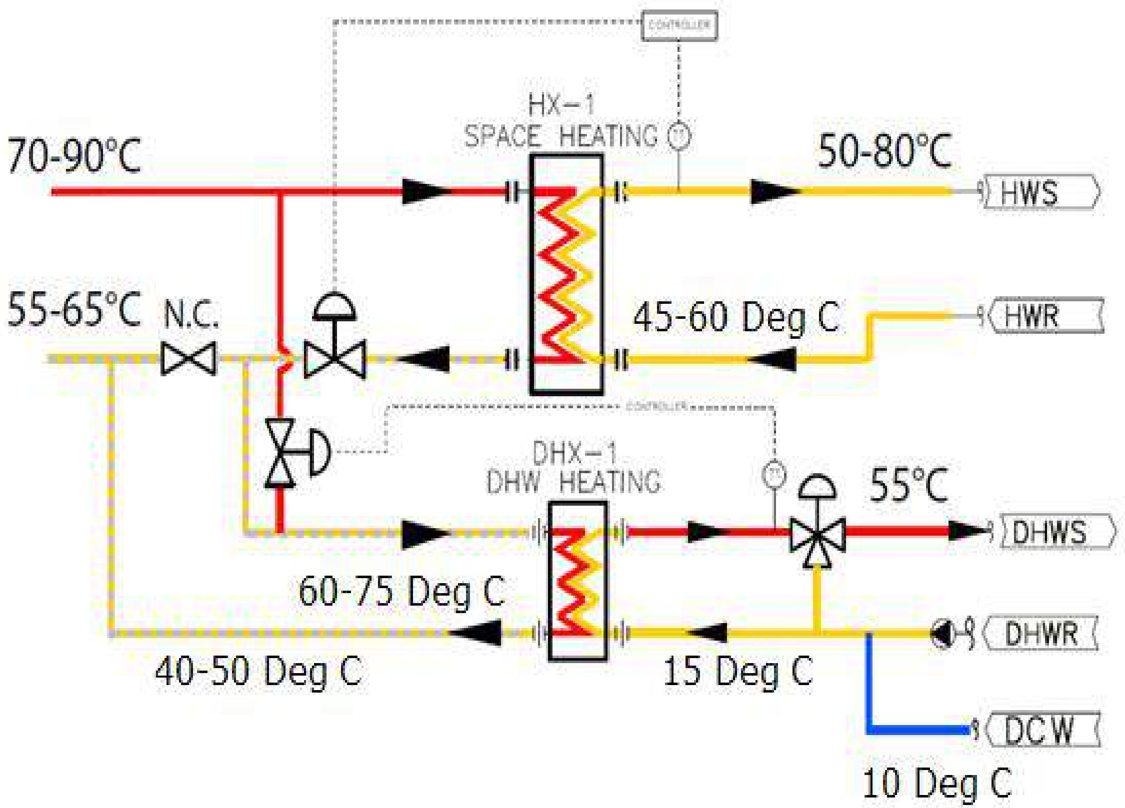
- Cogeneration Option:
  - Site chosen to allow for a Cogeneration Phase 2 expansion
  - Total potential CEC capacity: CEC phase 1 + Cogeneration phase 2 at maximum build out will be 110MWt and 25MWe

Typical Energy Transfer Station



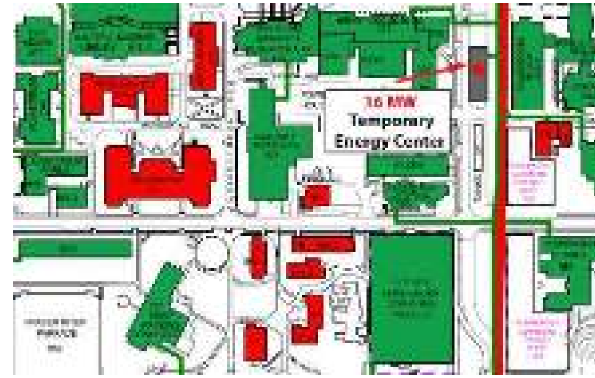
Energy Transfer Stations (ETS)

- Typical Phase 1 cascaded ETS schematic design



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

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:

<u>Original Project Scope:</u>

- 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:

<u>Additional Scope:</u>

- 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

- 12 buildings with sterilization requirements (Autoclaves, cage washers)

- 6 buildings require steam for humidification
  Most researchers already had clean steam generators
- 3 x Steam absorption chillers replaced
- Kitchens – Dishwashers and steam kettles

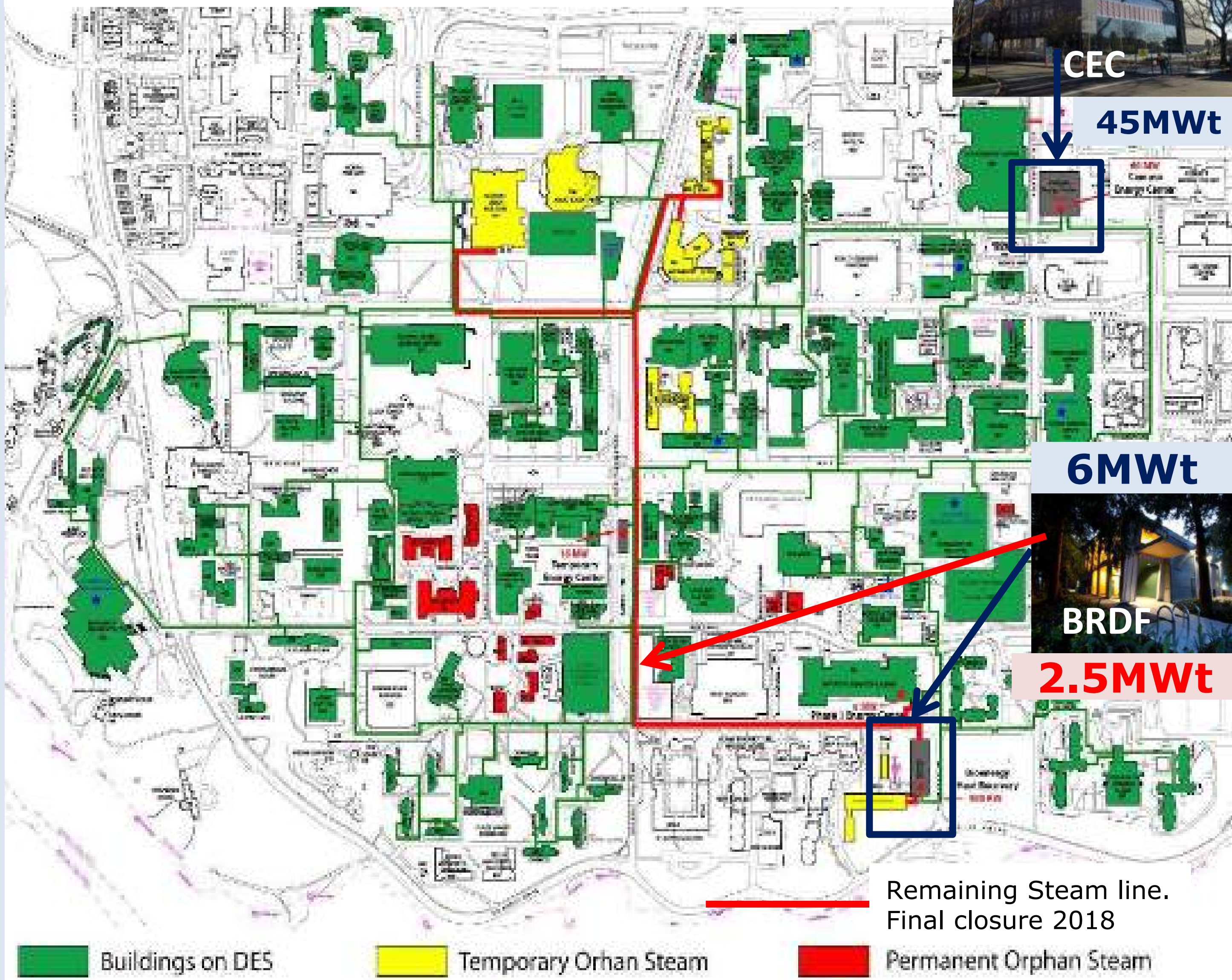
Things we would do differently

- Earlier assessment and full scoping of orphan buildings and process steam requirements
- Work year round from the get go (first three years were summer only)
- Dedicated owner team (HW Process Engineer hired year 3)
- Improved communications for campus stakeholders on disruptions
- Regular communication for project team crucial
- The temporary energy centre was essential (we should have done it earlier)

2016 Summary

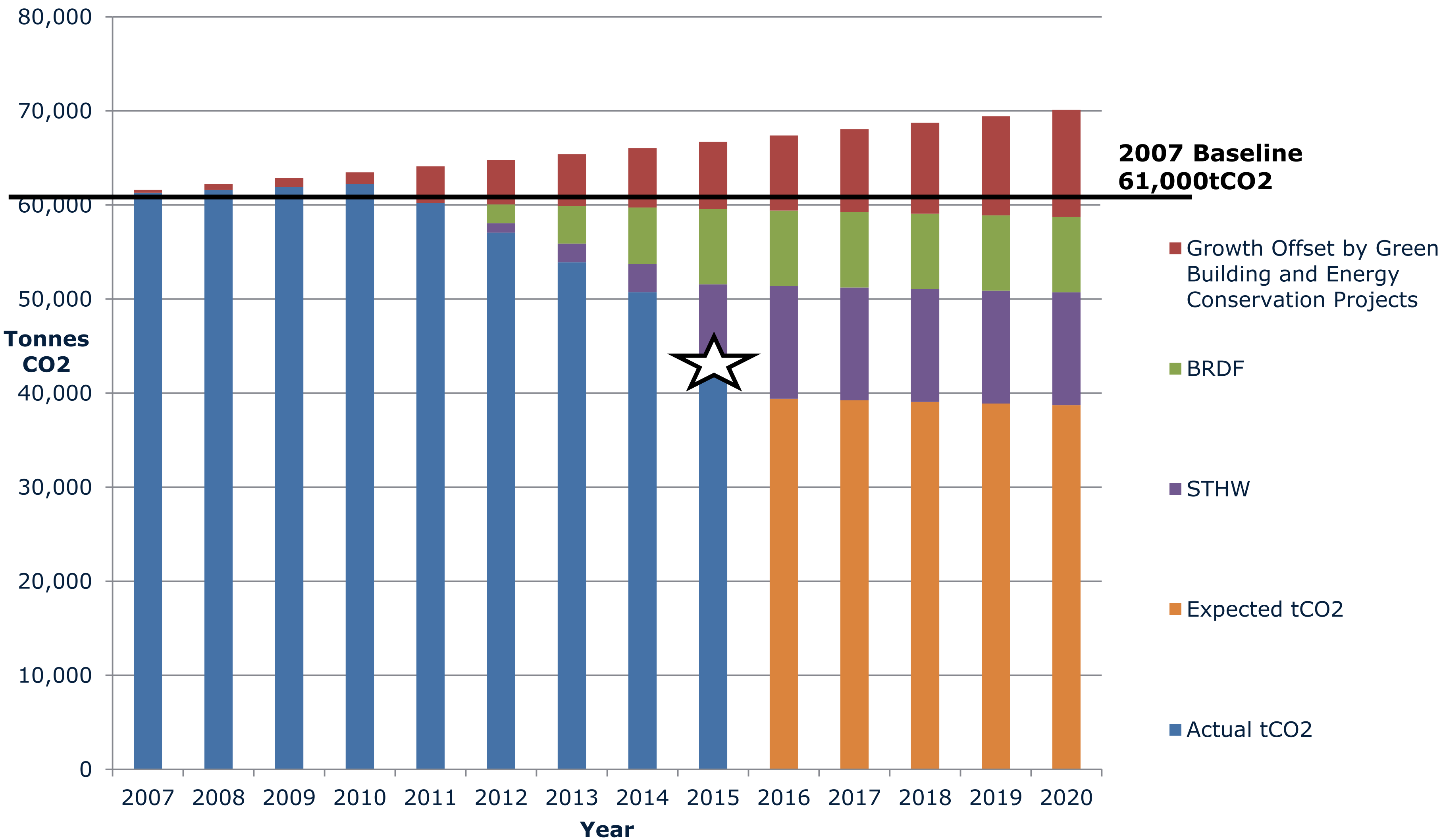
- 22 kilometers of piping (11 trench km's)
- CEC commissioned 45MW peaking Capacity
- BRDF ~8MW's provides thermal baseload and all summer thermal production needs
- 115 building converted
- 14 buildings + 4 UBC Hospital Buildings not converted to hot water
- 12 research buildings with steam process loads requirements

Hot Water in May 2016



Academic District Energy System

UBC CO2 Emissions Post Projects



2015: UBC Achieves 18,300ton CO2e or 30% GHG Reduction from 2007 baseline, despite a 7% growth in campus buildings

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
- Developing a TEC and the use of existing steam to hot water HEX's, allowed for energization of the DPS and for 80 building conversions to be completed prior to Campus Energy Centre coming into service.
- Energy reduction targets achieved and now expected to exceed forecasts in 2016
- **UBC Achieves a 30% GHG reduction 2015, new expectation could be closer to 40% 2016**
- CEC has expandability 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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