# UBC Steam to Hot Water Conversion

***IDEA Campus Conference 8-12th Feb 2016***

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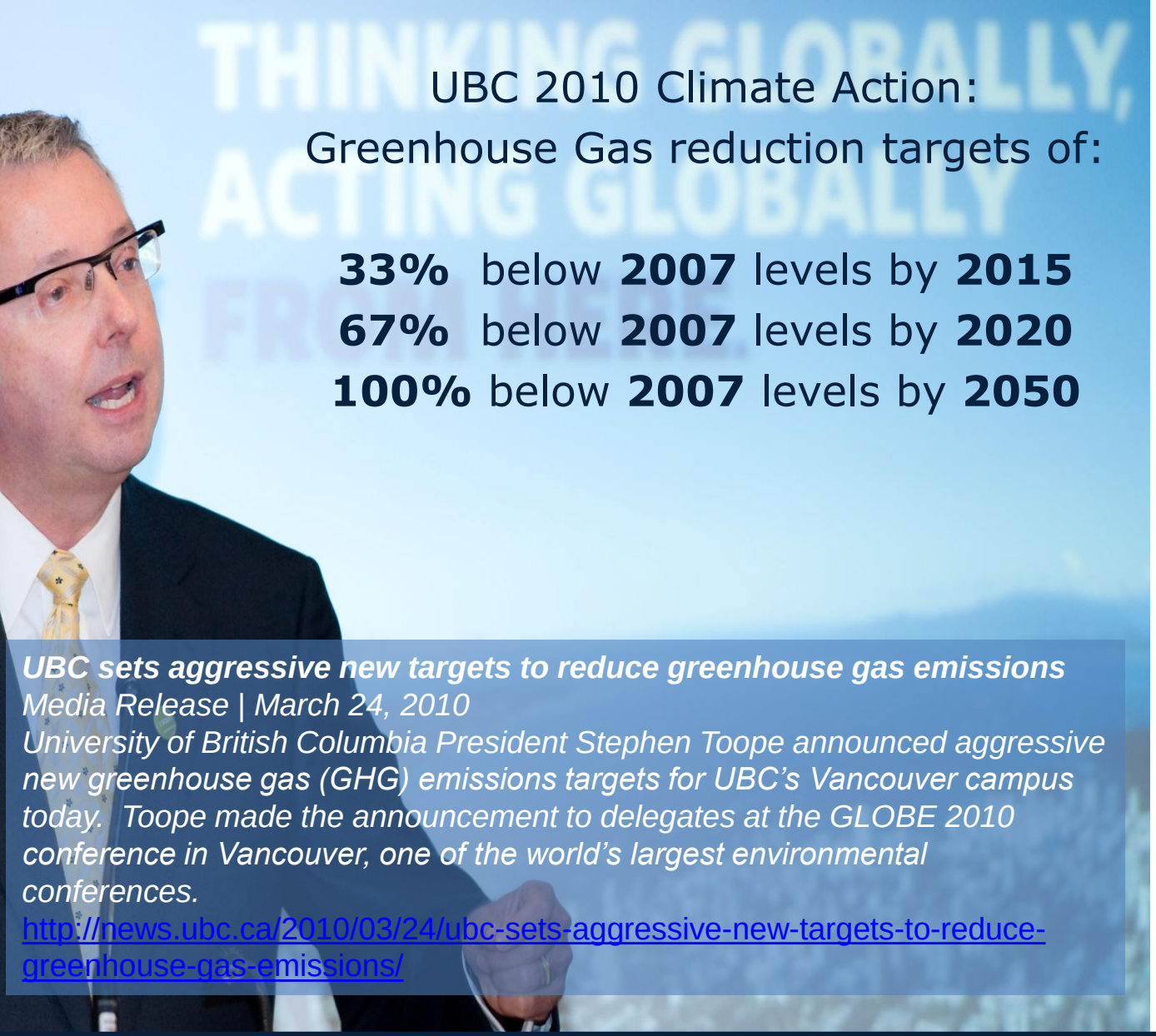
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

# The University of British Columbia

- 12 million sq.ft. of institutional & student Housing over 1,000 acres
- 1 million sq.ft. added since 2007
- Day time pop. ~ 65,000, with 30% continued growth expected over the next 20 years



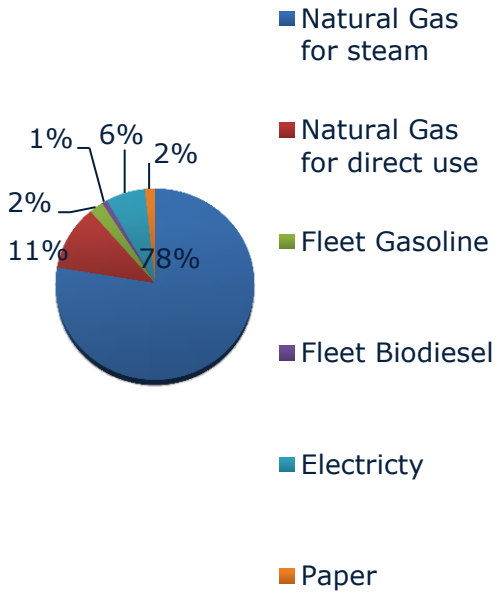

UBC 2010 Climate Action:
Greenhouse Gas reduction targets of:

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

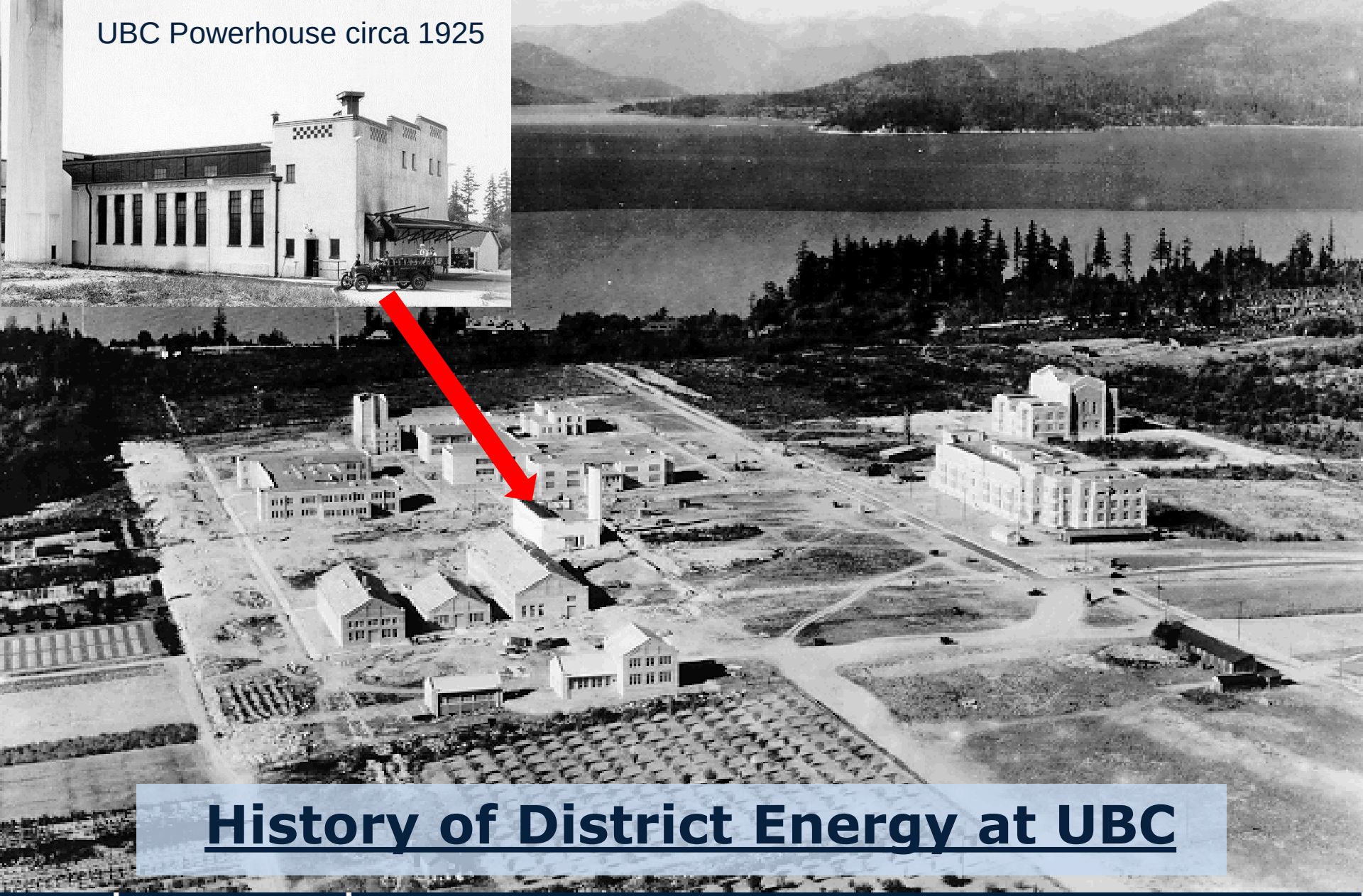
***UBC sets aggressive new targets to reduce greenhouse gas emissions***
*Media Release | March 24, 2010*
*University of British Columbia President Stephen Toope announced aggressive new greenhouse gas (GHG) emissions targets for UBC's Vancouver campus today. Toope made the announcement to delegates at the GLOBE 2010 conference in Vancouver, one of the world's largest environmental conferences.*
http://news.ubc.ca/2010/03/24/ubc-sets-aggressive-new-targets-to-reduce-greenhouse-gas-emissions/

- ***2007 UBC Achieves Kyoto protocol reduction targets***
- ***2007 re- baselines its campus GHG inventory***

**2007 Baseline is 61,090 tons Co2 equivalent**




# Background: UBC GHG Commitment Confirmed




# History of District Energy at UBC


1925


1945

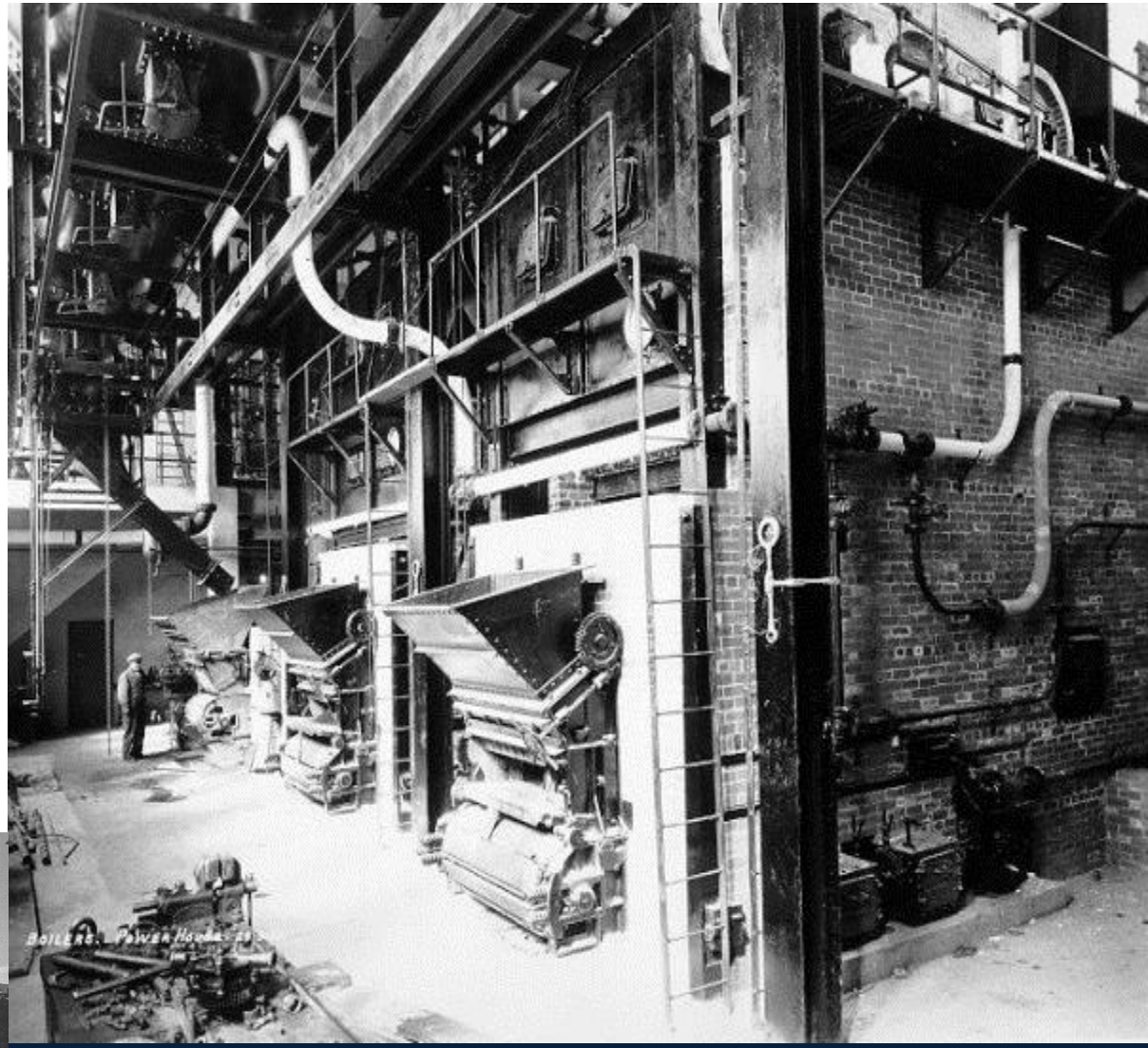

1958

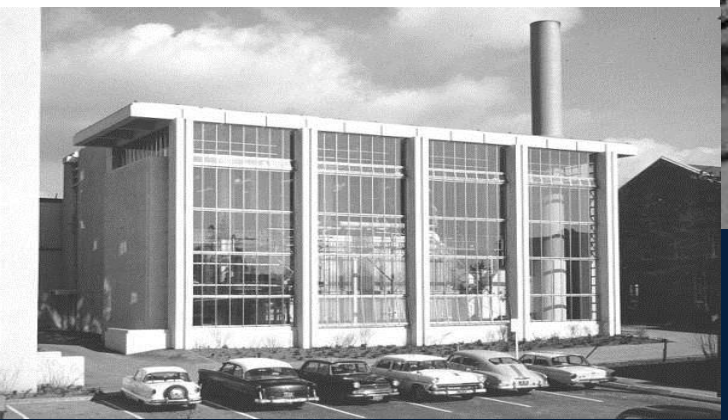

1973


2012

# 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





# 1950's to 1970's Campus Growth

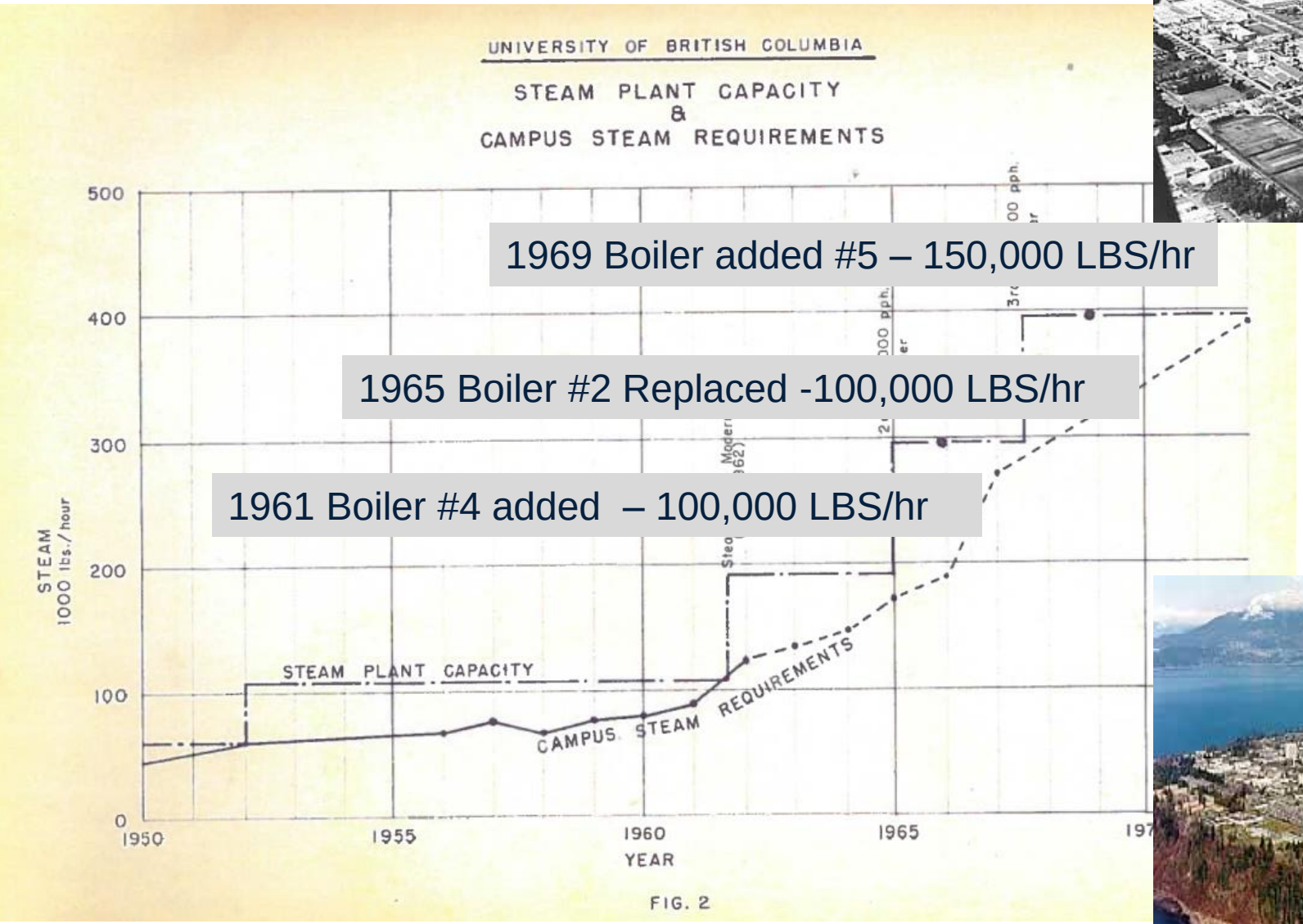



FIG. 2

1969 Boiler added #5 – 150,000 LBS/hr

1965 Boiler #2 Replaced -100,000 LBS/hr

1961 Boiler #4 added – 100,000 LBS/hr

1958

1973


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

1997 Sofame Percotherm installed. Boiler efficiency raised from 70 to 78%

2004 New Low Nox burners and Burner Management System. Boiler efficiency raised from 78 to ~83%

# District Steam: Continuous Investment & Improvements

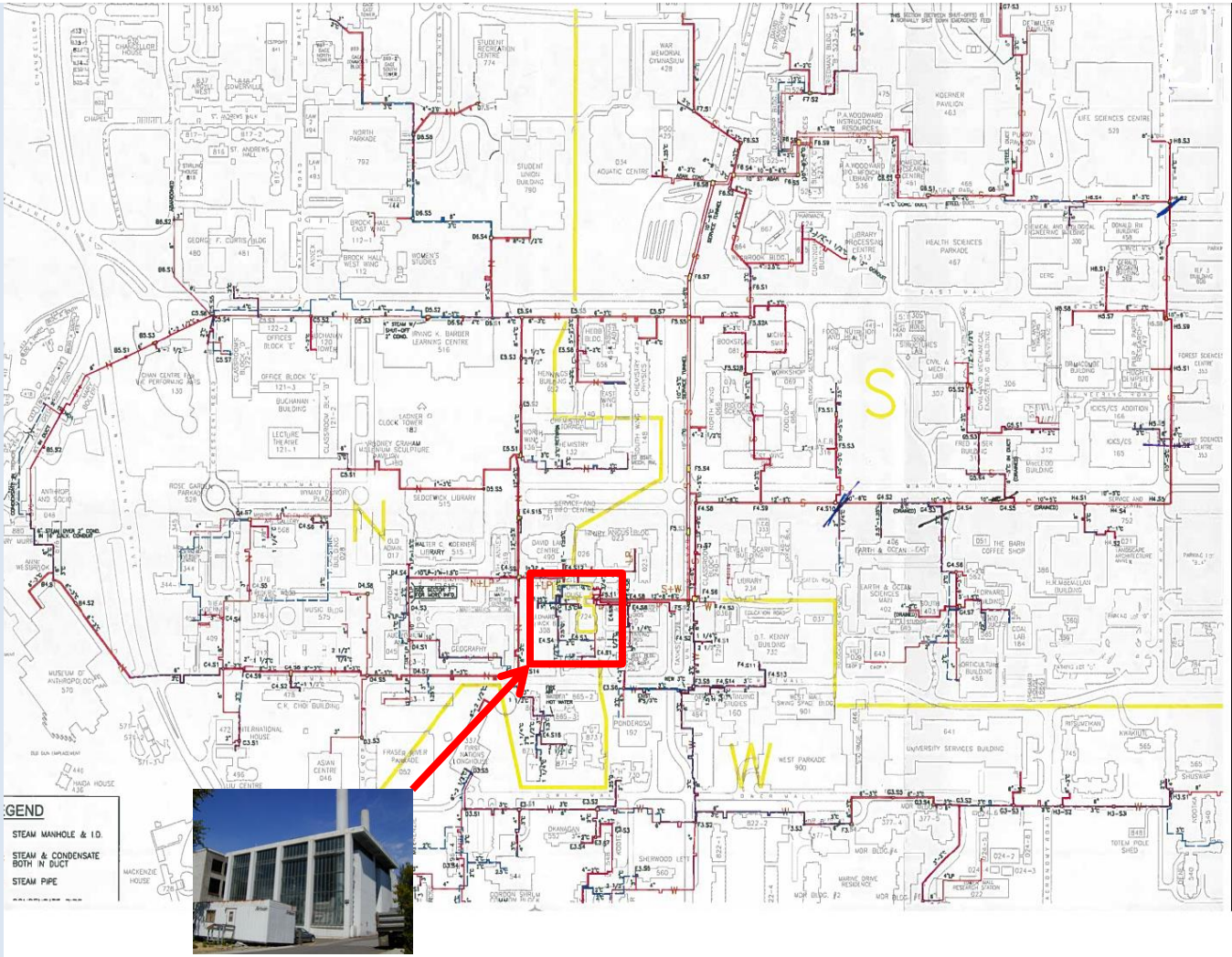
# UBC Steam District Energy System

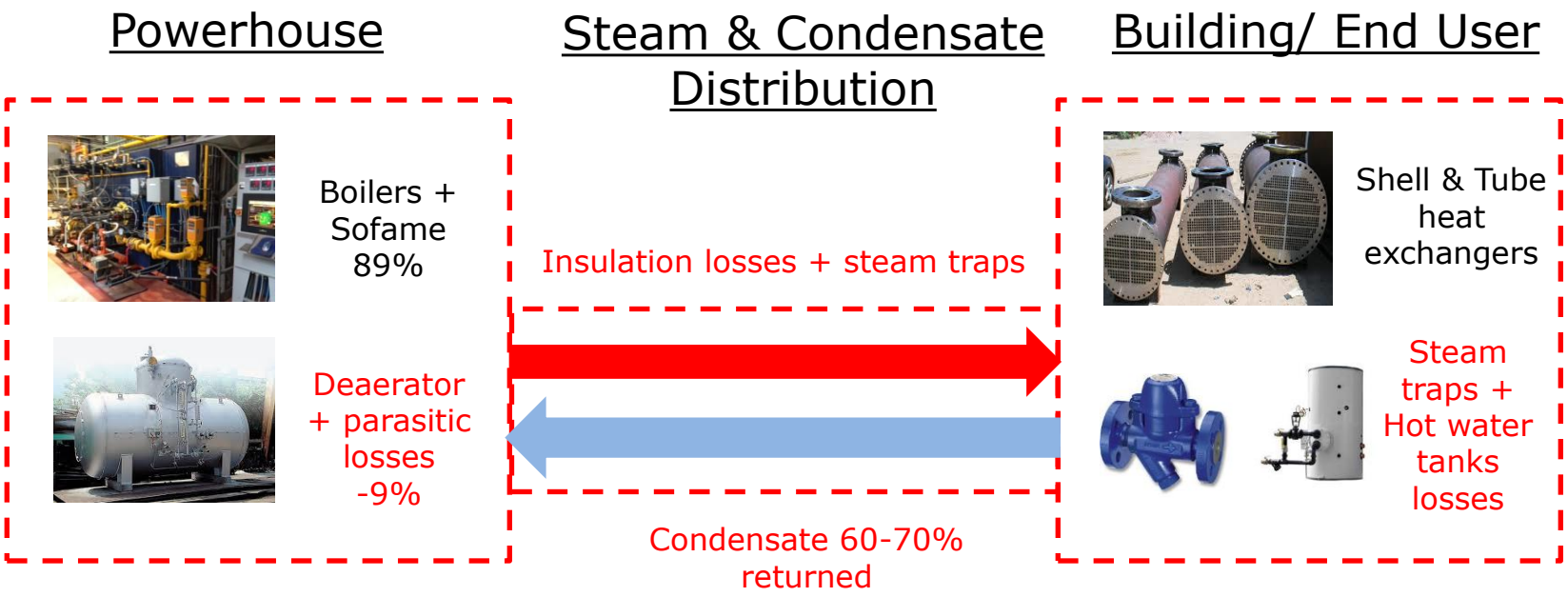
## 2014 Summary

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*





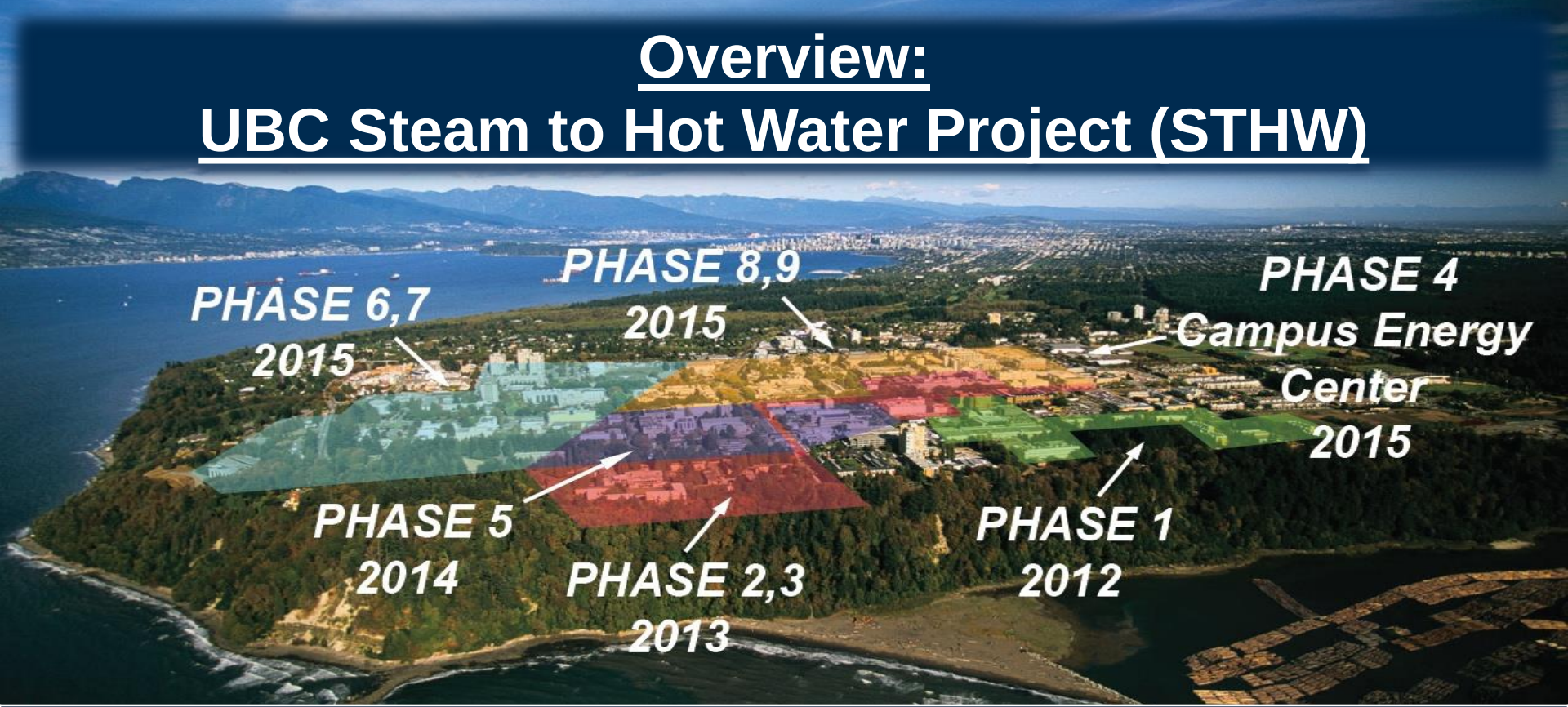

Plant = 80%  Distribution = 80%  End User = 90%

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

# Steam System Efficiency

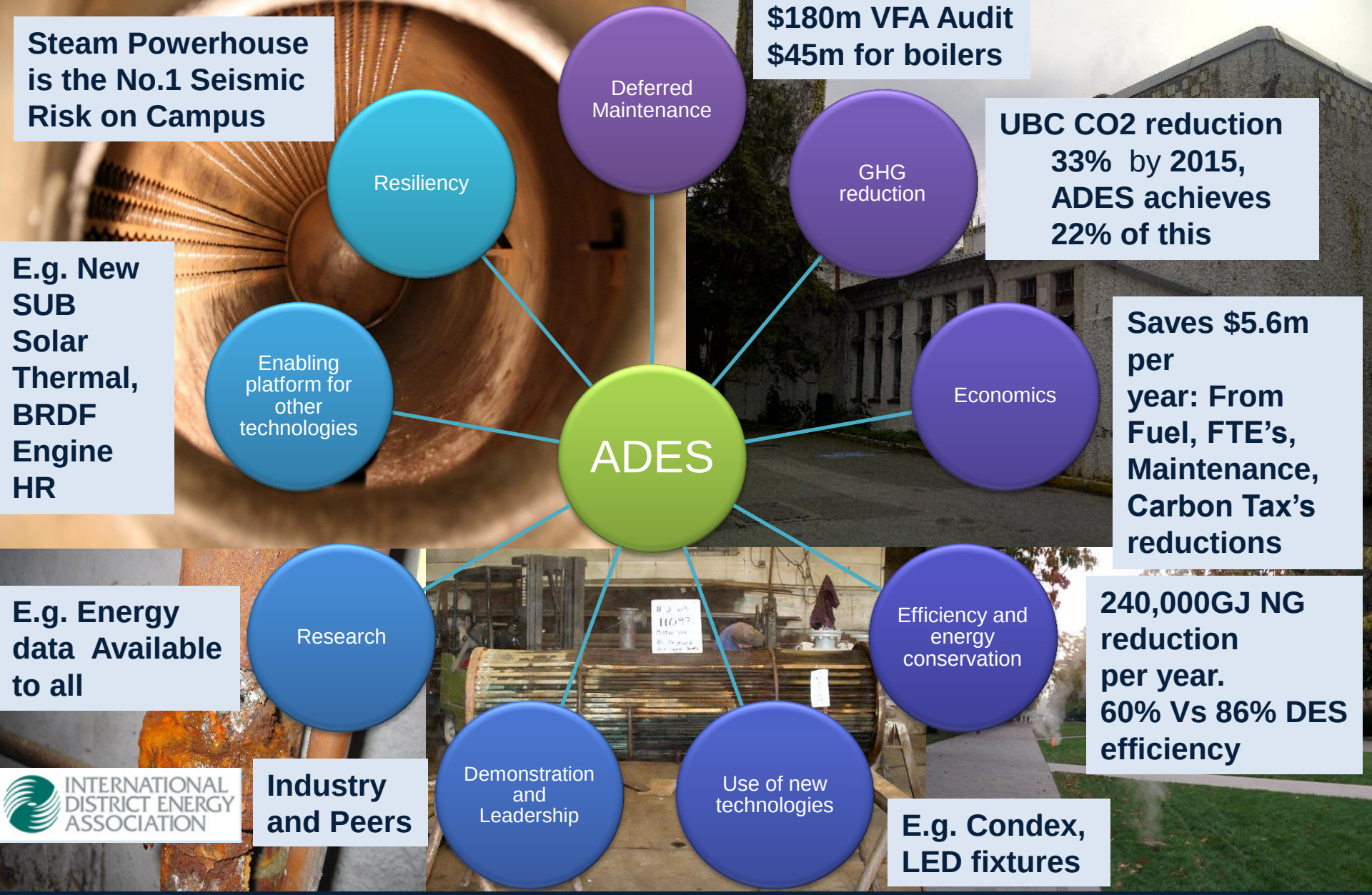
# UBC STHW Project

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




**5 year, 9 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




# STHW: 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 Center

Boilers + Condensing economizer 89%

## Supply & Return Piping

Insulation losses minimal

Return Water 100%

## Building/ End User

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

Plant = 89% Distribution = 97% End User = 100%

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

# Steam Vs HW System Efficiency Comparison

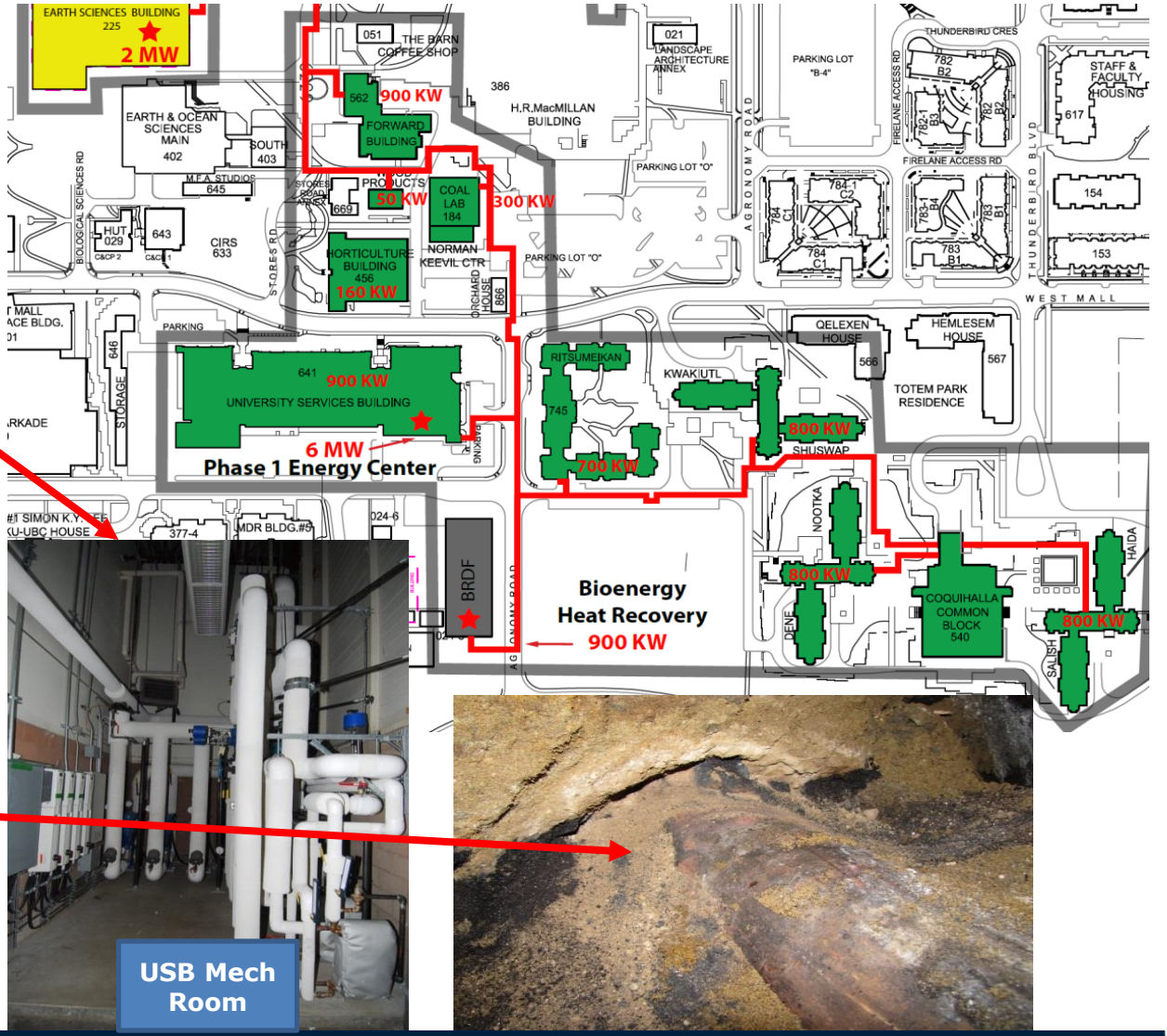
# Project Risk Mitigation Strategy

- 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

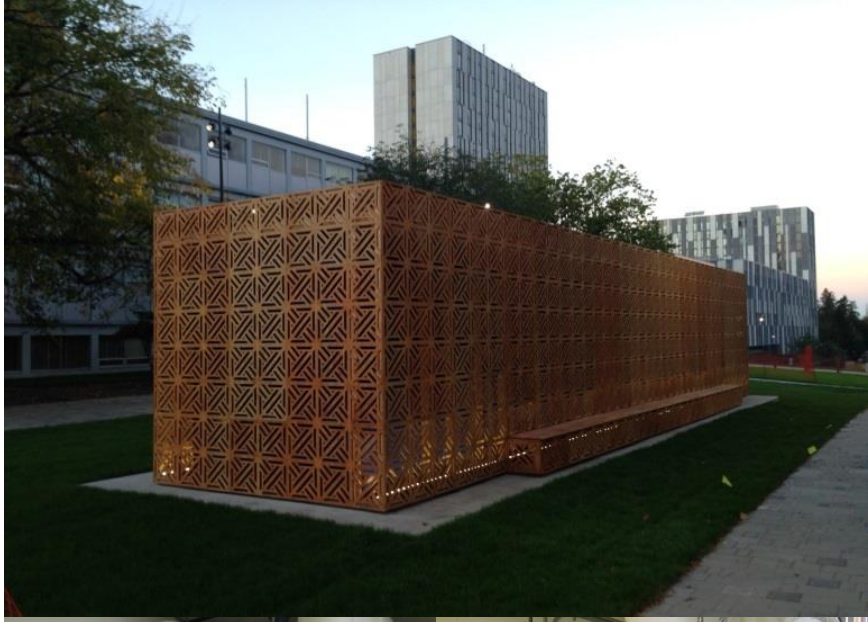
# Phase 1 Pilot Project

## Phase 1 Summary

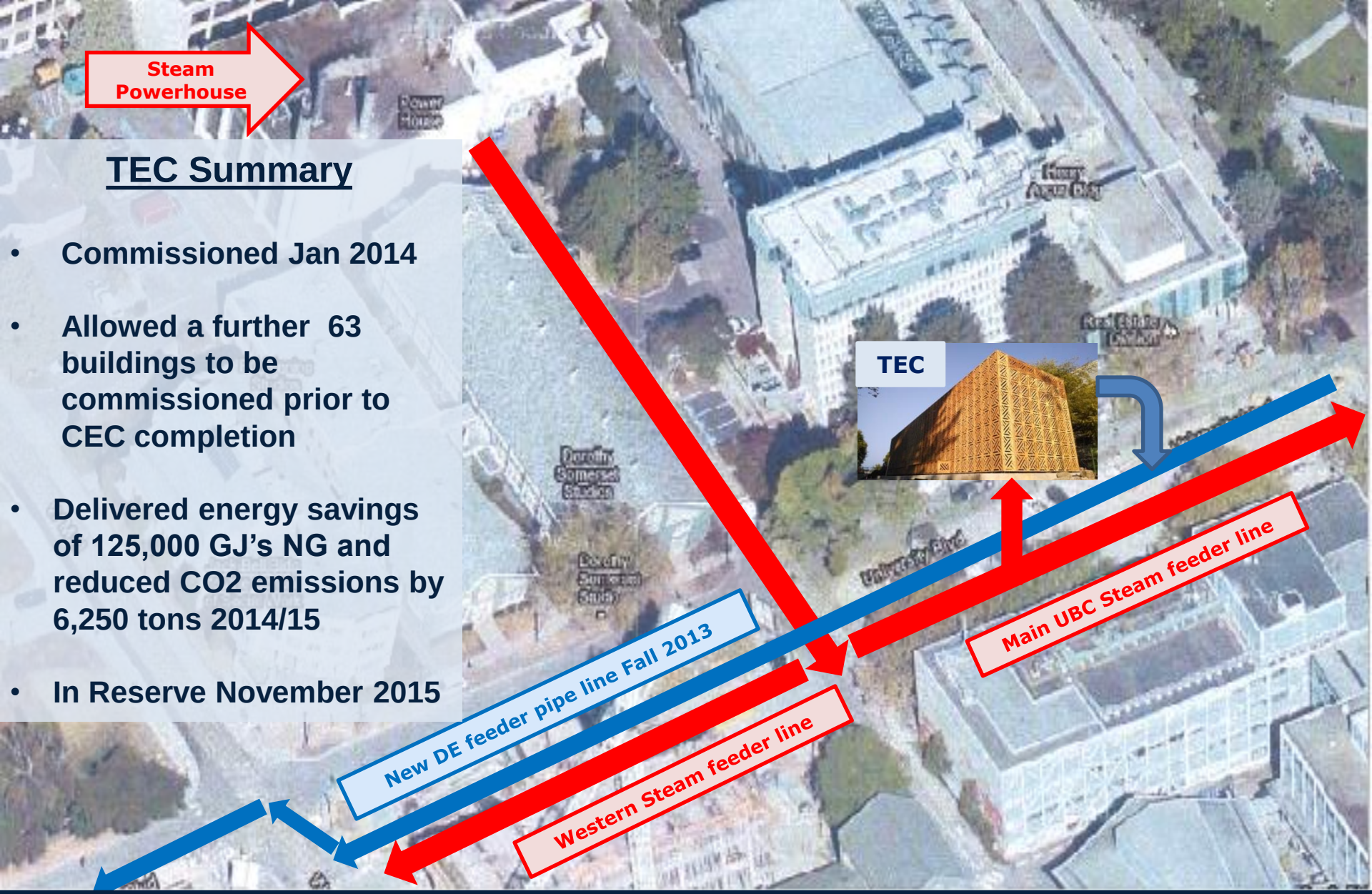
- 1,100 trench meters of District Piping System (DPS) laid
- 13 buildings converted
- Connection for BRDF HR (1MW)
- Successfully repurposed the existing oversized heat exchangers at USB (5MW).
- Subsequently becomes the USB Energy Center (USBEC) (6MW total) (USB + BRDF HR)
- Phases 1 completed on budget 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**



- Phase 1, 2 & 3 converted 17 buildings to Hot Water and laid 4 trench km's of DPS.
- USBEC was 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




# Bridging the Energy gap to the CEC




## 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 Center (TEC)

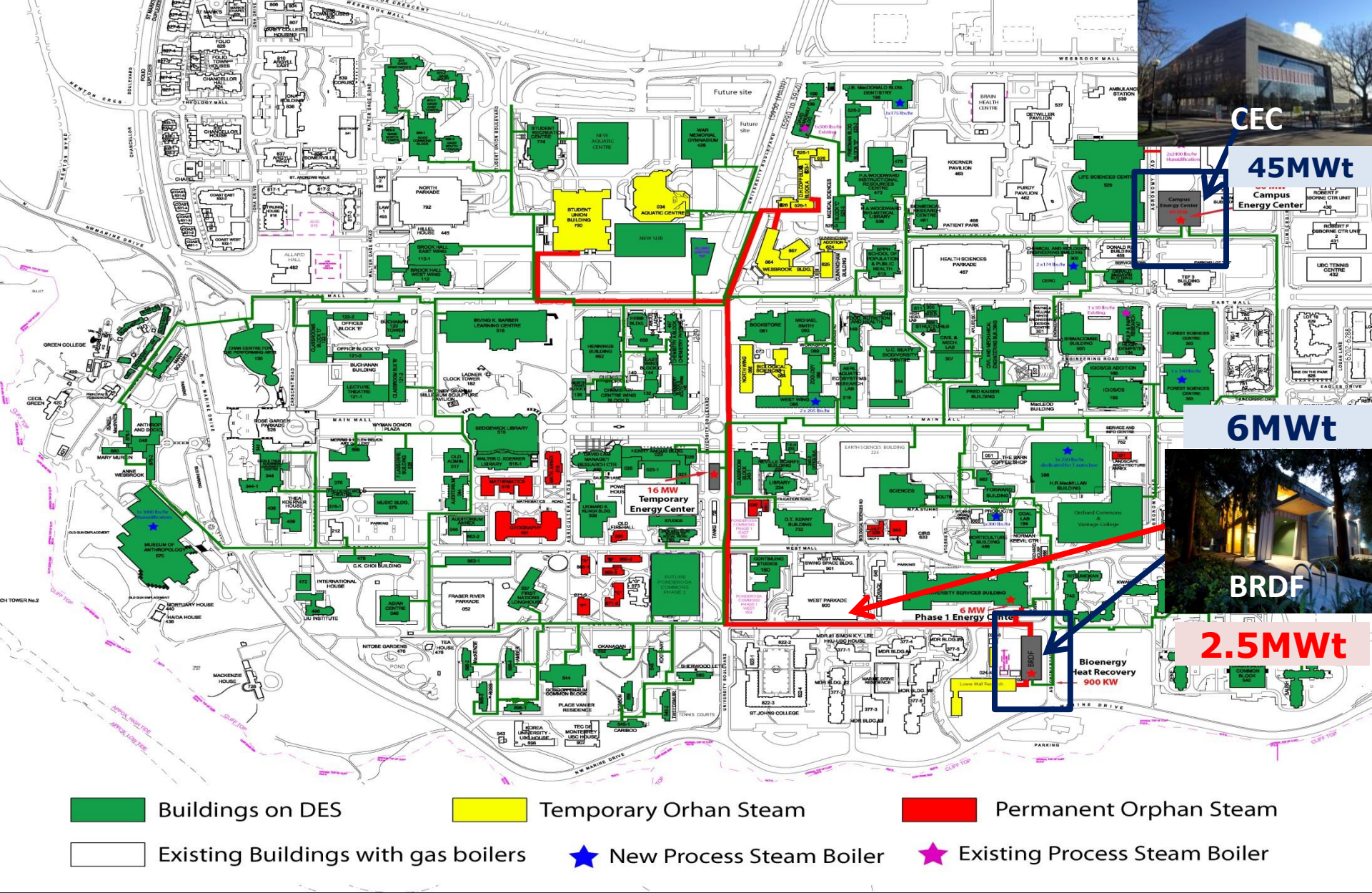
# Campus Energy Centre

## *In Service November 20th, 2015*

- Built for 4 boilers with 3 initially installed: 3x15MWt Natural gas/#2 diesel boilers
  - 4th 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

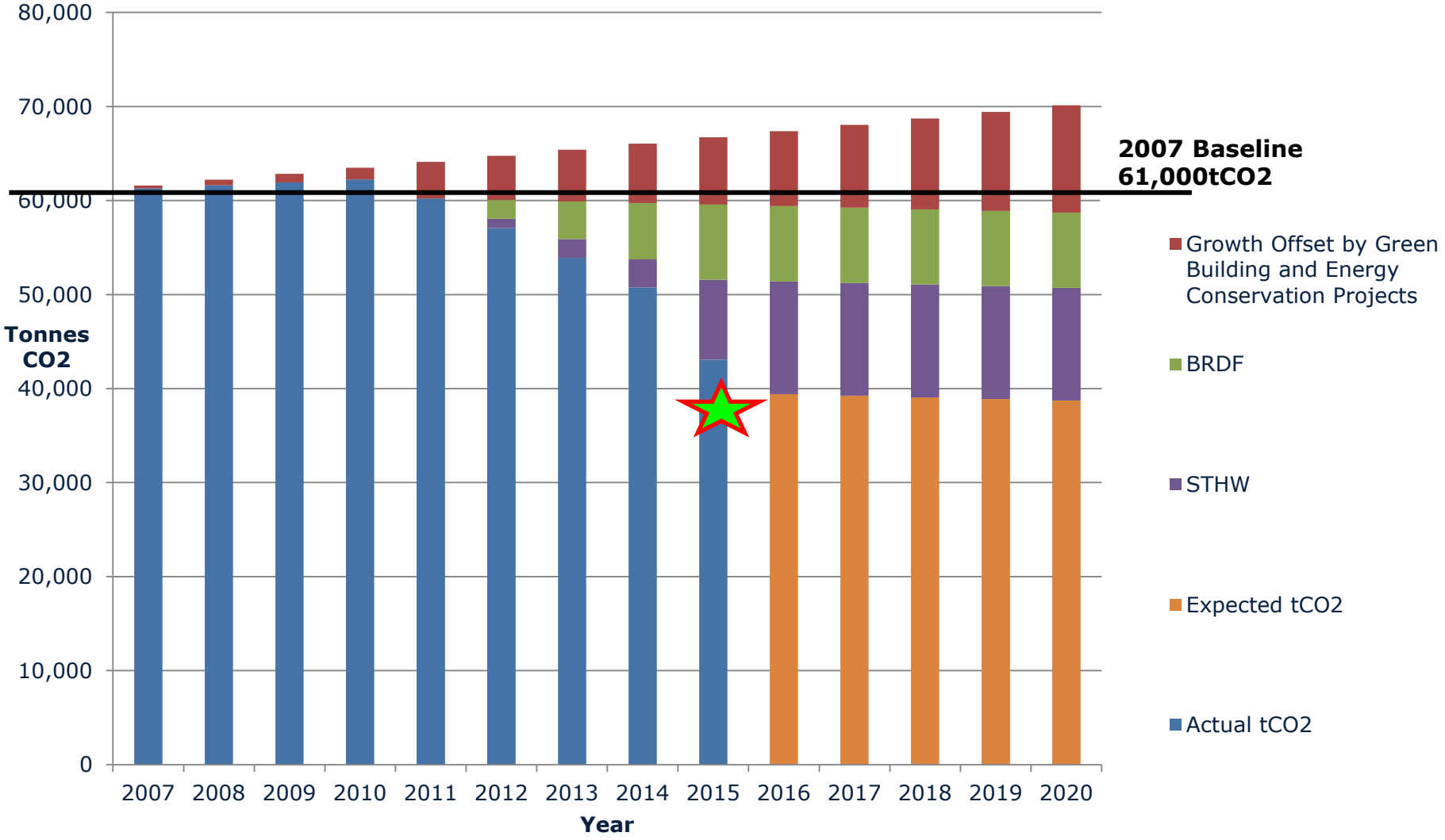
# Process Steam Loads

- 12 buildings with sterilization requirements (Autoclaves, cage washers)
- 6 buildings require steam for humidification Most researchers already had clean steam generators
- Absorption chillers (3) required replacement
- Kitchens – Dishwashers (2) and steam kettles (3)


# Academic District Energy System Dec 2015

# UBC CO2
# Emissions Post Projects




**2015: UBC Achieves 30% GHG Reduction from 2007 baseline, despite 10% campus growth**

# Things we would do differently

- Earlier assessment of orphan steam requirements.
- Work year round (first three years was summer only)
- Improved communications for campus stakeholders on disruptions
- Regular communication for project team crucial
- The temporary energy centre was essential (would have done it earlier)

# What Next for DES at UBC?

# Conclusions to Date

- Project ~97% complete on schedule and coming in on budget
- 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 the use of existing steam to hot water HEX's, allowed for the early energization of the DPS and for 85 building conversions to be completed prior to Campus Energy Center coming into service.
- Energy reduction targets achieved and now expected to exceed forecasts  in 2016
- **UBC Achieves a 30% GHG reduction in 2015**
- CEC has expandability to meet all future thermal load growth for the ADES and NDES

Before Conversion

After Conversion

Main Mall Oct 2014

Main Mall Nov 2015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