UBC BIOMASS EXPANSION PROJECT

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Single Owner
1000 acre campus

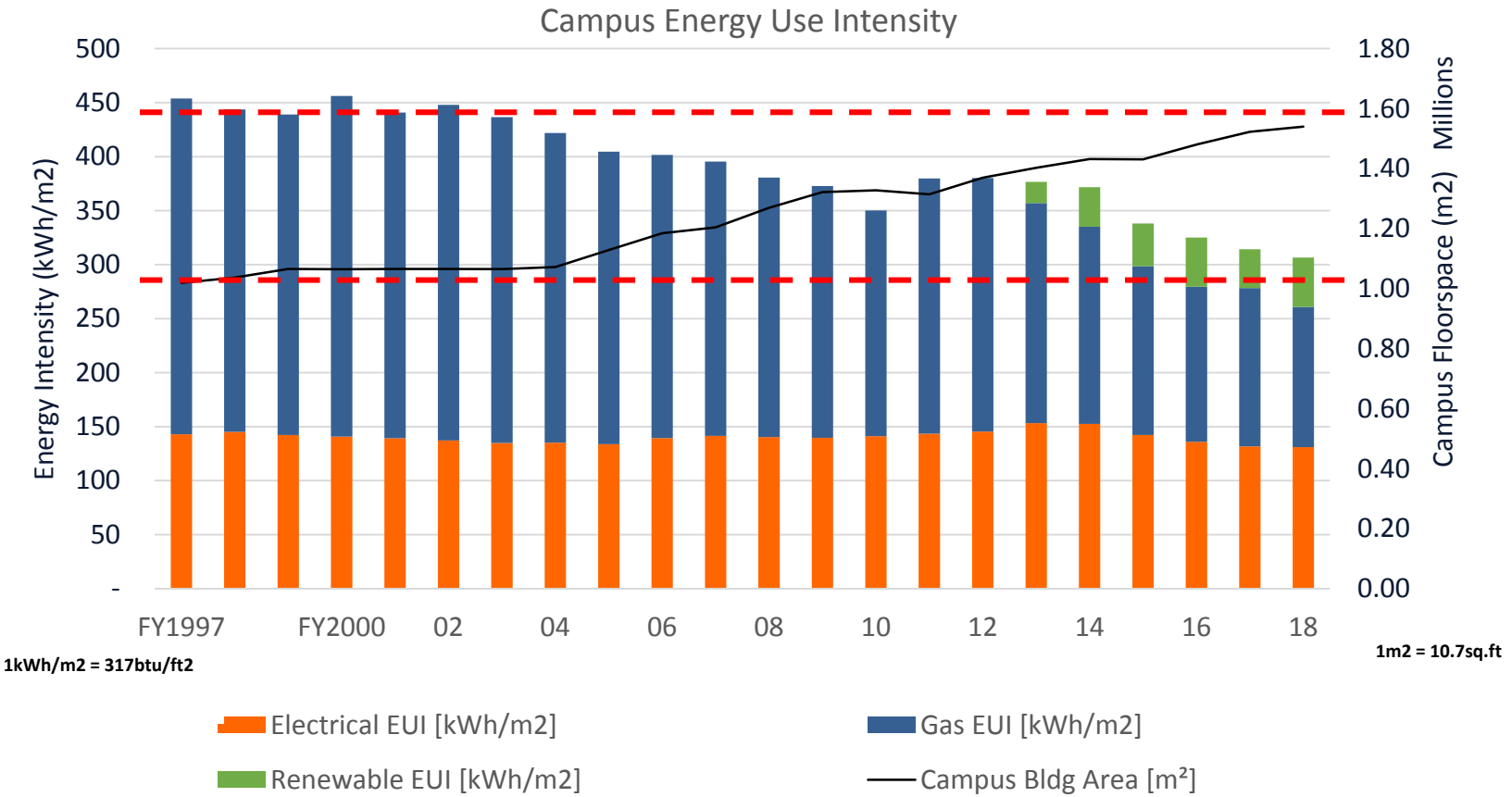
Day time population
69,000

17 million sq.ft. *of total floorspace*

Average annual growth of ***200,000 sq.ft.***

$54 million *annual Utility Budget*

UBC ENERGY USE INTENSITY WITH GROWTH

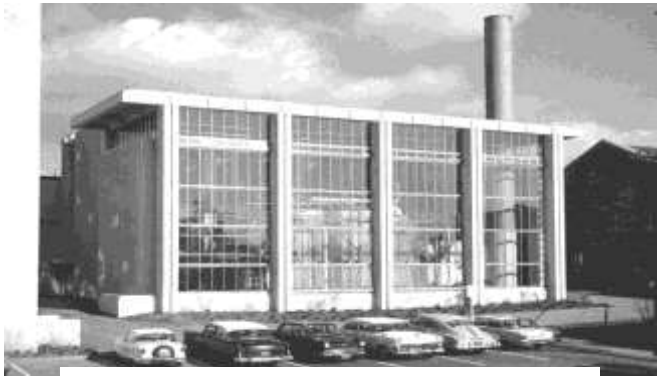


Brief history of District Energy at UBC
1925 - 2018

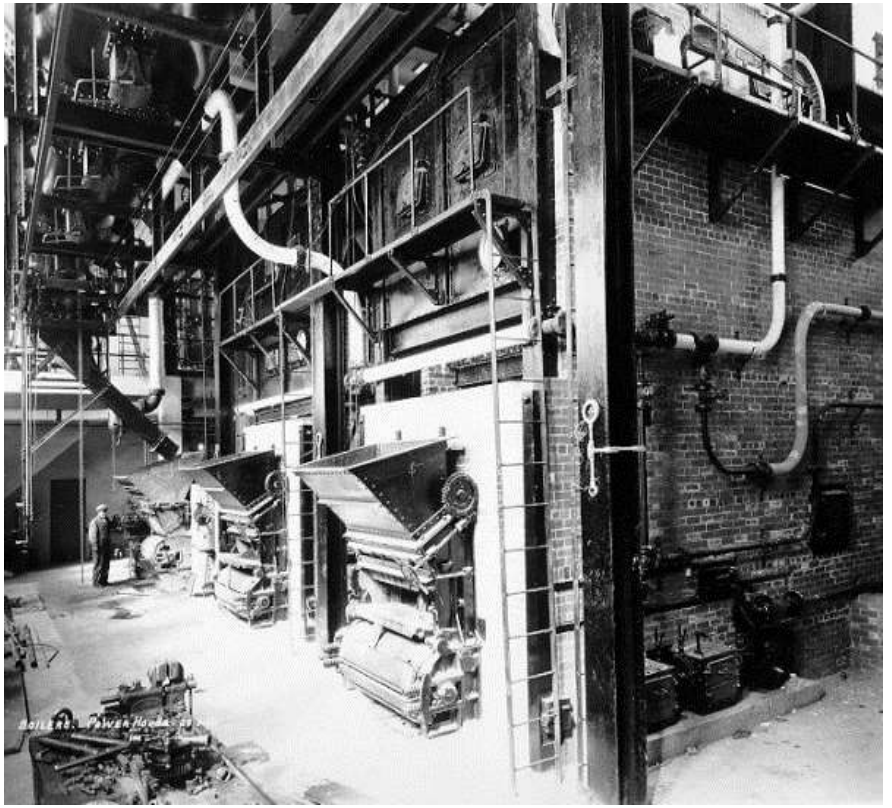
UBC Powerhouse circa 1925
3rd Permanent building
on campus

1925 - 2011 IT'S A STEAM WORLD

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 (NG) installed
1971: Boiler 3 Decommissioned
2011: Final full steam year; Installed Capacity **120 Megawatts** (410,000lbs), 232,000lbs peak load, 783,000,000lbs produced



UBC Powerhouse Expansion 1969



Boiler #1 circa 1925

2010-2012 New Construction

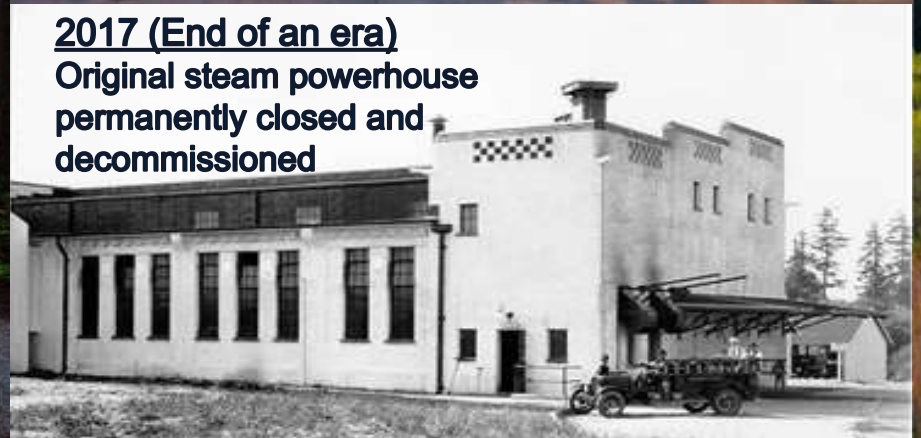
UBC constructs the BioEnergy Research Demonstration Facility (BRDF)

2012-2016 All change: UBC Goes Hot Water

UBC converts its entire steam district energy system to hot water and builds a new 45MW hot water boiler Campus Energy Centre (CEC)

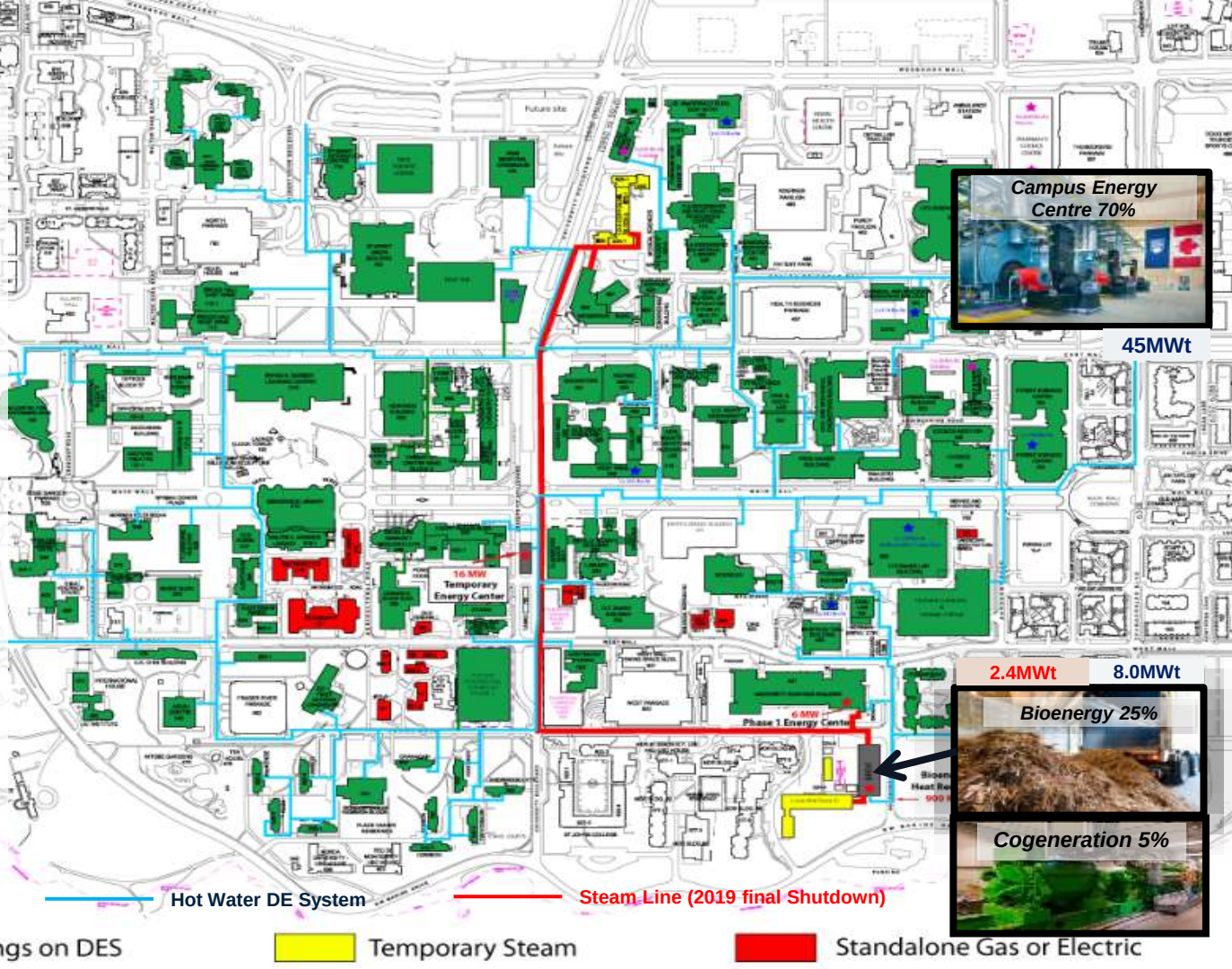
2017 (End of an era)

Original steam powerhouse permanently closed and decommissioned



2018 District Energy Summary

- 24km hot water DE supply and return piping laid to date
- CEC 45MWt installed Capacity
- BRDF 10.4MWt installed thermal capacity
- 120 buildings converted to Hot Water (and growing)
- Final steam line scheduled for closure in 2019 with demolition of D.H. Copp
- In 2016 UBC achieves a 34% absolute CO2 reduction from its 2007 baseline



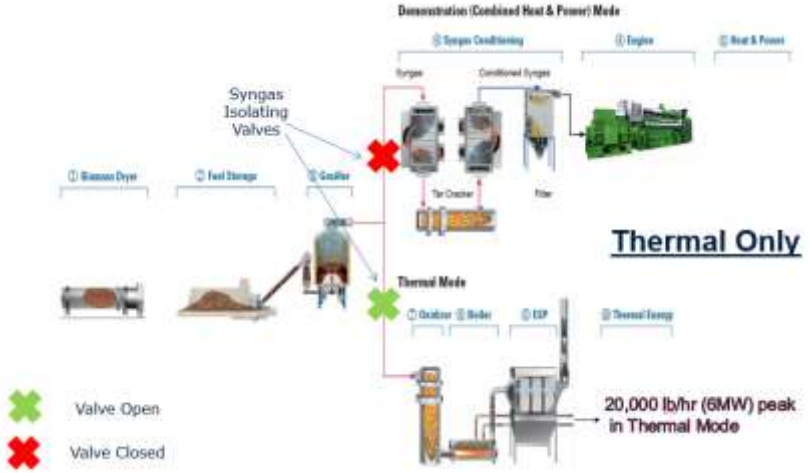
OPERATING A HOT WATER VS STEAM DISTRICT ENERGY SYSTEM

	Steam (2007)	Hot Water (2017)
Floor space	9.5 million square feet	9.7 million square feet
Plant Efficiency	80%	87%
Distribution Efficiency	75%	97%
Installed Capacity	**120MWt** (410MMBTU/hr)	**55.4MWt** (189MMBTU/hr)
Winter Peak	**73MWt** (250MMBTU/hr)	**44MWt** (150MMBTU/hr)
Summer Min. Load	**7.6MWt** (26MMBTU/hr)	**3MWt** (10MMBTU/hr)
Annual Thermal Energy	**242GWh** (830,000MMBTU)	**129GWh** (440,000MMBTU)
Water (Makeup & Quenching)	270,000,000 liters (9,535,000cft)	130,000 liters (4,590cft)
FTE	33	18
Regulatory	1st Class Plant	4th Class Plant
Carbon	50,000 tCO2e	27,000 tCO2e
% Renewable	0%	31%

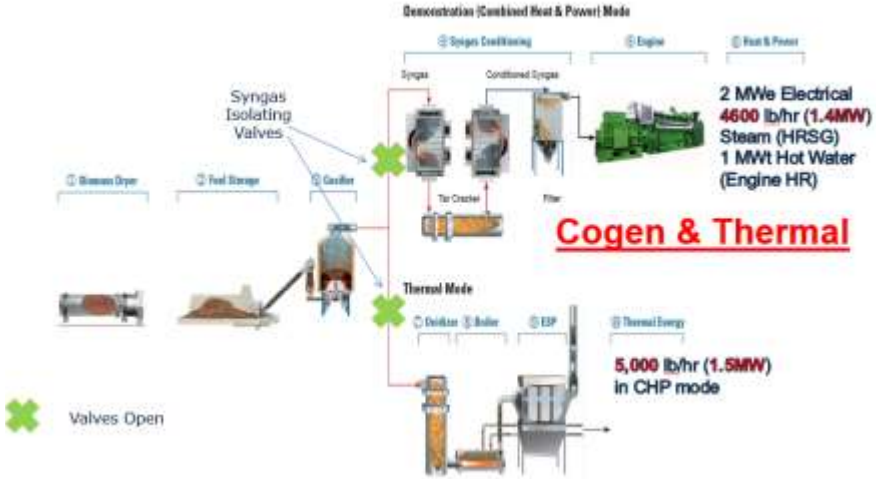
As Completed June 2012

- LEED Gold Certified
- Constructed using Canadian cross laminated timber (CLT)
- $28.5m CAD
- Social license demonstration
- Two modes of operation Biomass (Thermal only) or a Cogen/Biomass (Thermal) mix
- 12% GHG reduction

2012 ORIGINAL MODES OF OPERATION



Thermal Mode 6MWt

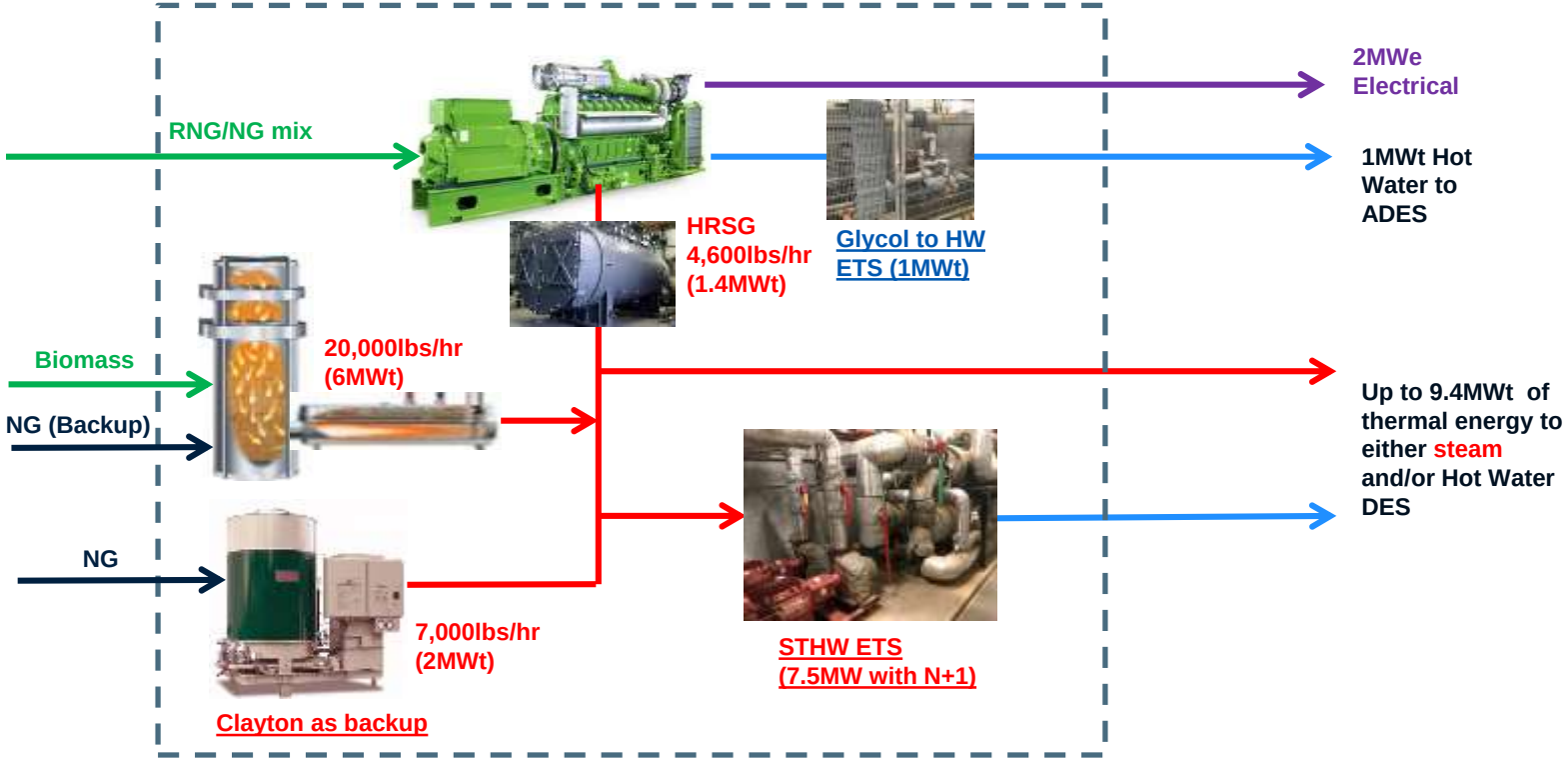


Cogen Mode 5.9MW (total)

2018 Three Energy Units Installed

1. 6MWt Biomass Gasification technology with firetube boiler
    1. NG back up burner capable of up to 3MWt for redundancy
2. 2MWe Cogen Engine, with 1.4MWt HRSG and 1MWt Engine HR
3. 2MWt Clayton NG Boiler provides redundancy

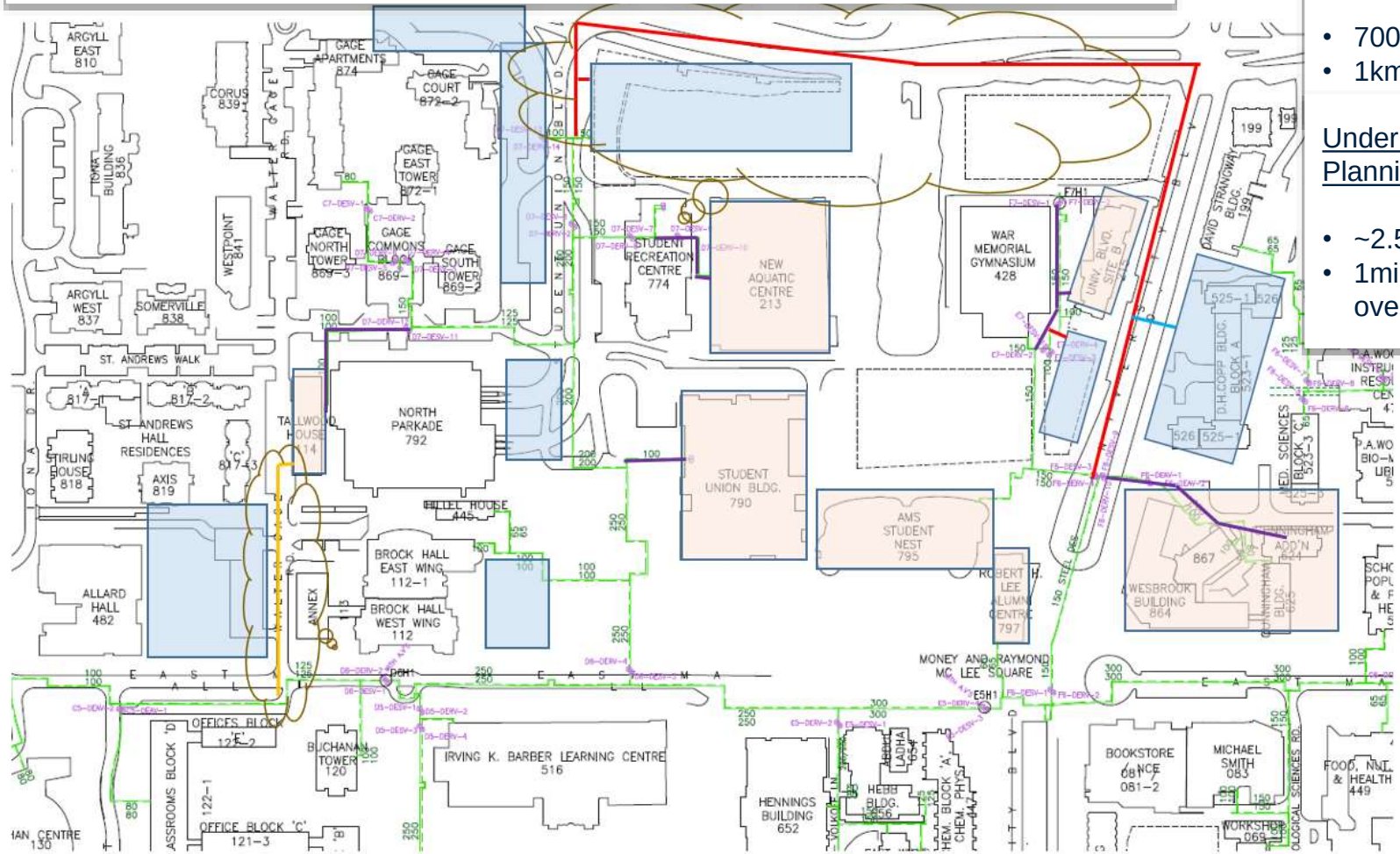
2018 BIOENERGY FACILITY CURRENT CAPACITY



BRDF Process Arrangement

WHAT'S NEXT–
A GROWING DE SYSTEM

DE GROWTH SINCE 2016 AND IN PLANNING



Completed since 2016:

- 700ksq.ft added
- 1km trench DPS laid

Under Construction or in Planning:

- ~2.5km DPS
- 1million sq.ft planned over next 3 years

TO MEET NEW DE GROWTH, NEW THERMAL CAPACITY IS NEEDED

After analysis to meet DE growth needs for the next 10 years, a minimum 12MWt of new boiler capacity needs to be added to meet new thermal demand and maintain N+1 redundancy.

Note this is needed in conjunction with building recommissioning and performance optimizations (demand side measures).

Options:

Option 1: Add NG Boiler at CEC (BAU)	
Pros	Con's
Lower Cap Cost	Increases GHG (CO2) emissions
Lower life cycle Maintenance costs	Increases fuel life cycle commodity costs
Simple to operate	Increases dependency on NG, less fuel resiliency
No increase in truck traffic	Not in aligned with UBC Climate Action Plan (CAP) or Sustainability objectives

Option 2: Add a new Biomass Boiler at BRDF	
Pros	Con's
Significantly reduces UBC's GHG (CO2) emissions	Higher cap Cost
Increases fuel diversity & fuel resiliency	higher life cycle maintenance costs
Reduces fuel life cycle commodity costs	increase truck traffic over BAU
Fully aligned with UBCs CAP and sustainability objectives	more complex to operate
CEC shuts down for ~70% of the year	
Positive business case over BAU ($1.3m/yr)	

Decision:

After due consideration UBC's Board of Governors approves in principle the expansion of UBC's Biomass boiler capacity and the installation of a new 12MWt hot water boiler at the BRDF.

NEW BIOMASS CAPACITY

- New 12MW Biomass Hot Water boiler to be installed at the BRDF
- AFS Energy Systems selected and currently in detailed design
- To be operational by Fall of 2020
- $18.2m CAD cap cost, with annual cost savings of $1.3 million vs NG boiler BAU
- Further reduction of ~13,000 tCO_2/yr of carbon
- Biomass will now produce ~67-71% of UBC total annual thermal district energy load requirements
- UBC's DE system will be low carbon/renewably fueled.

BUSINESS CASE AND THE TECHNOLOGY: ARGUABLY THAT WAS THE EASY PART ☺…, WHAT ABOUT THE SITE AND OTHER PROJECT DRIVERS/ CHALLENGES?

The approval process and business case was based on the premise of repurposing the existing BRDF site footprint i.e. so no building expansion. This constrained the ultimate boiler size to 12MWt.

Additionally 2,500sq.ft of the original 20,000sq.ft process hall floorspace has been given over to a new high head research laboratory for Faculty & Researchers

Also there is a need to ensure the increased truck traffic does not increase unloading time on site over the previous operation, and also resolves a long standing issue of blocking the current footpath and some street access.

The High head lab removes the original biomass fuel storage silo, so new storage needs to be included.

Improves DES fuel resiliency

Lastly and likely the most challenging…. To transition the crews and change the operation profile of the CEC and BRDF

CLEARING OUT THE ORIGINAL PLANT REDUNDANT EQUIPMENT

By removing the original syngas clean up equipment used for the engine, this frees up approx. 60% of the current floor space

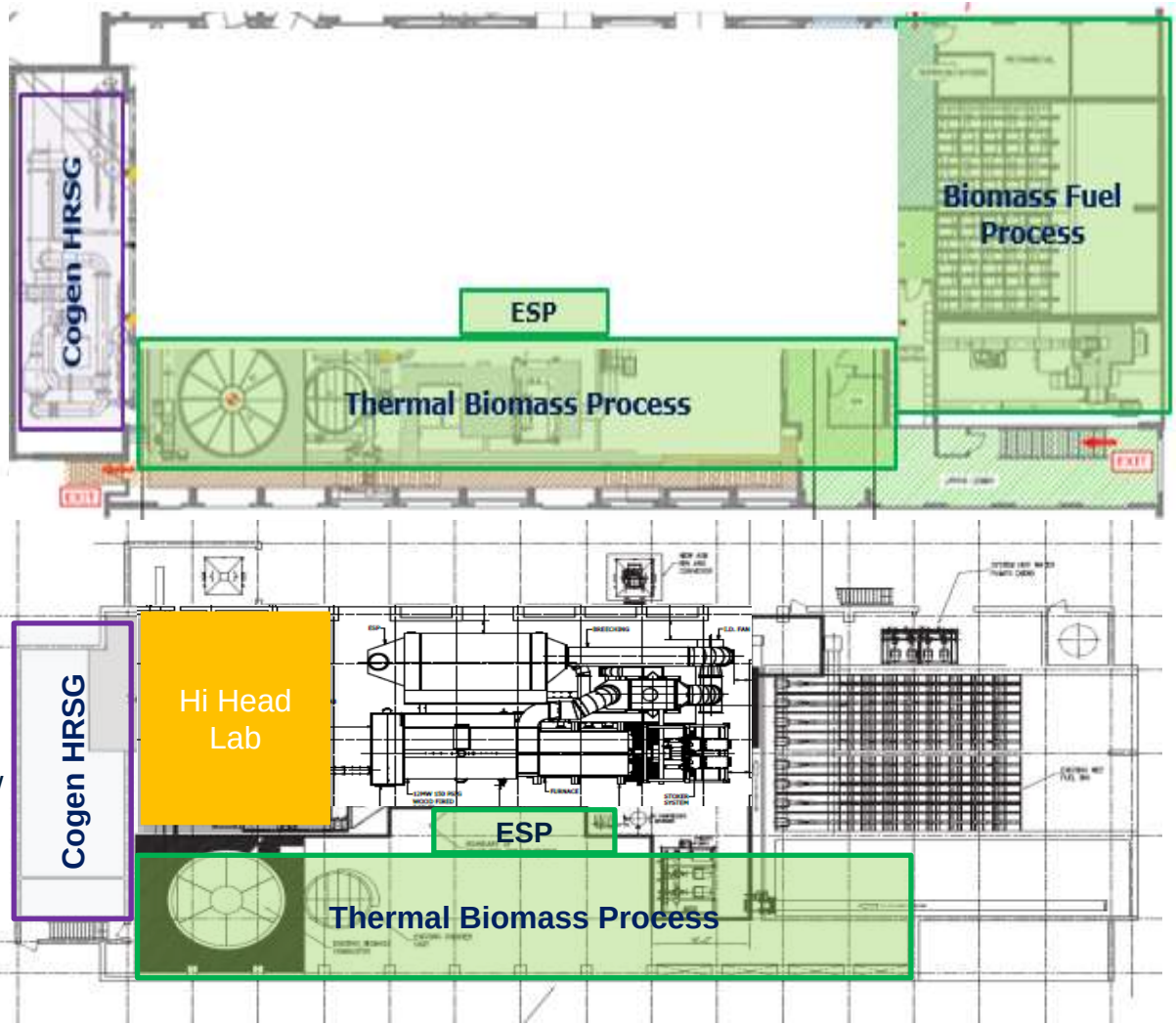
FREED UP SPACE

The Wood Silo and Syngas Clean up Process equipment is cleared out

The existing biomass & Cogen operational areas remain in service:

- Biomass Thermal Process
- Cogeneration

Planned use of the freed up floorspace will encompass the new boiler the and the new high head laboratory



FUEL UNLOADING

Current:

Trucks back in and

Can partially block

Path and road for up

to 3 hours per day

Plan:

Install new fast speed

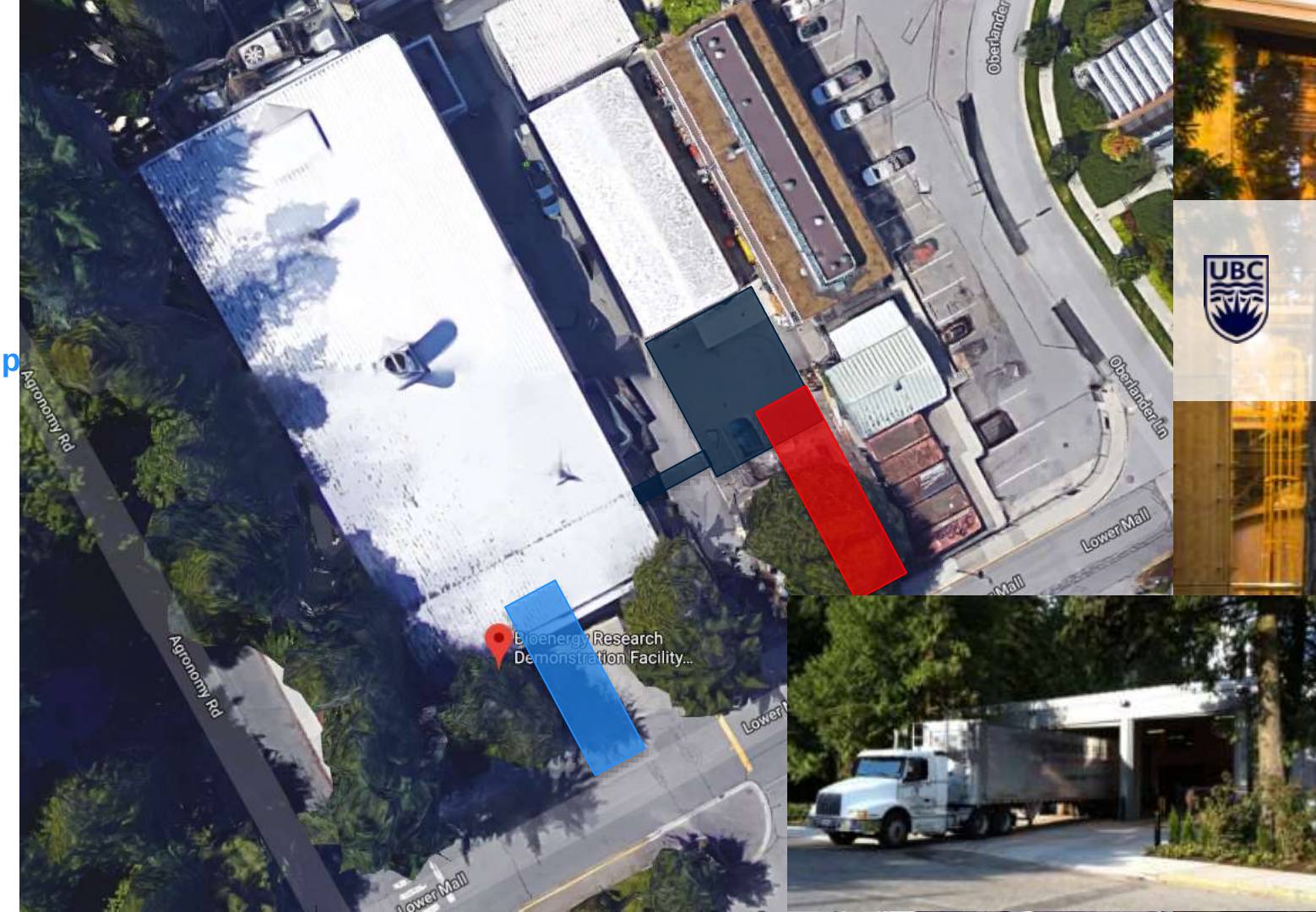
Unloading bay and

overhead conveyor

Trucks:

Now unload fully off

Street and pavement

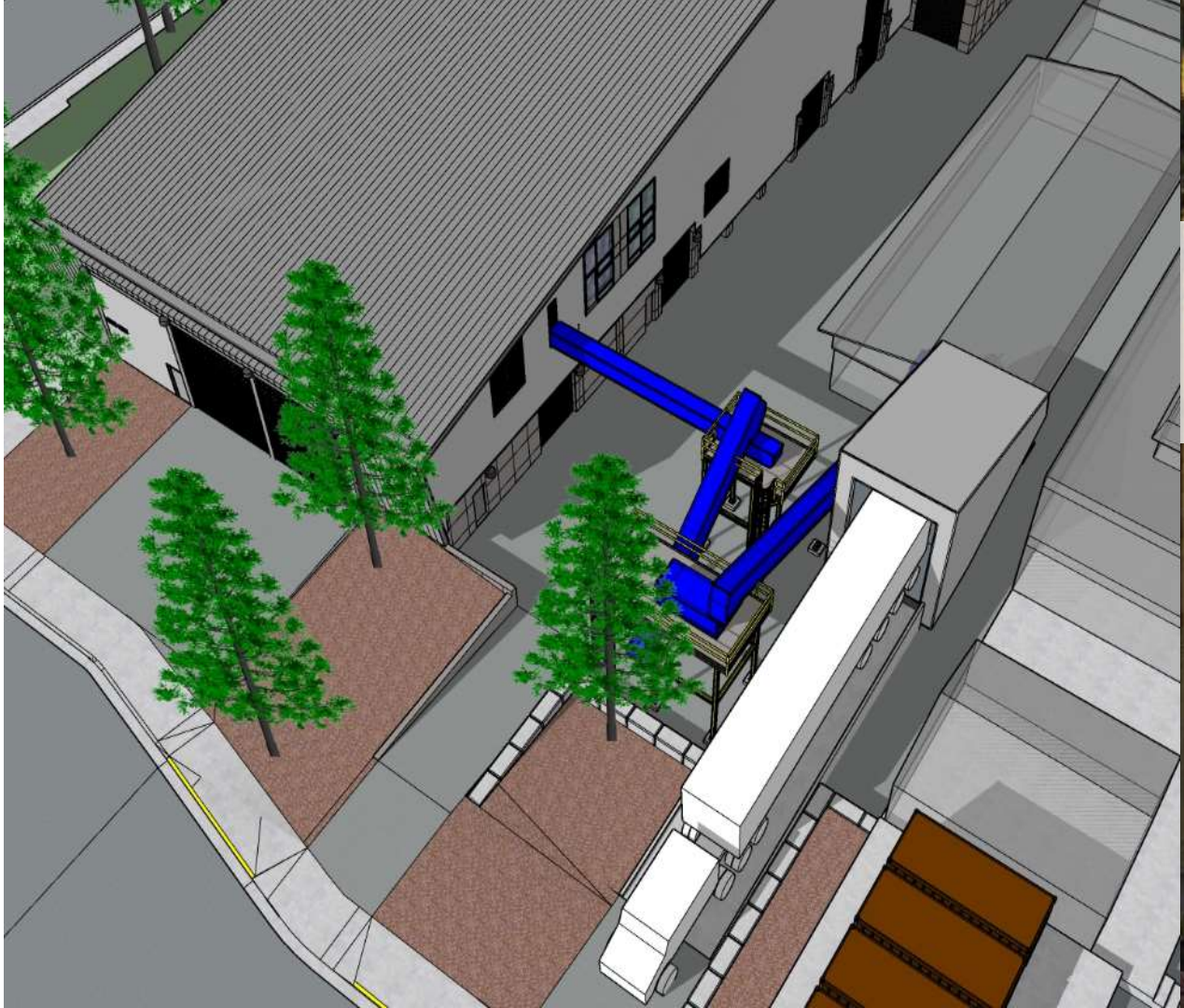


CONCEPT LAYOUT

New fuel unloading system, will unload a 53’ truck/trailer in under 15 minutes

Up to 9 trucks per day peak winter load demand

All trucks unloaded in under 3 hours

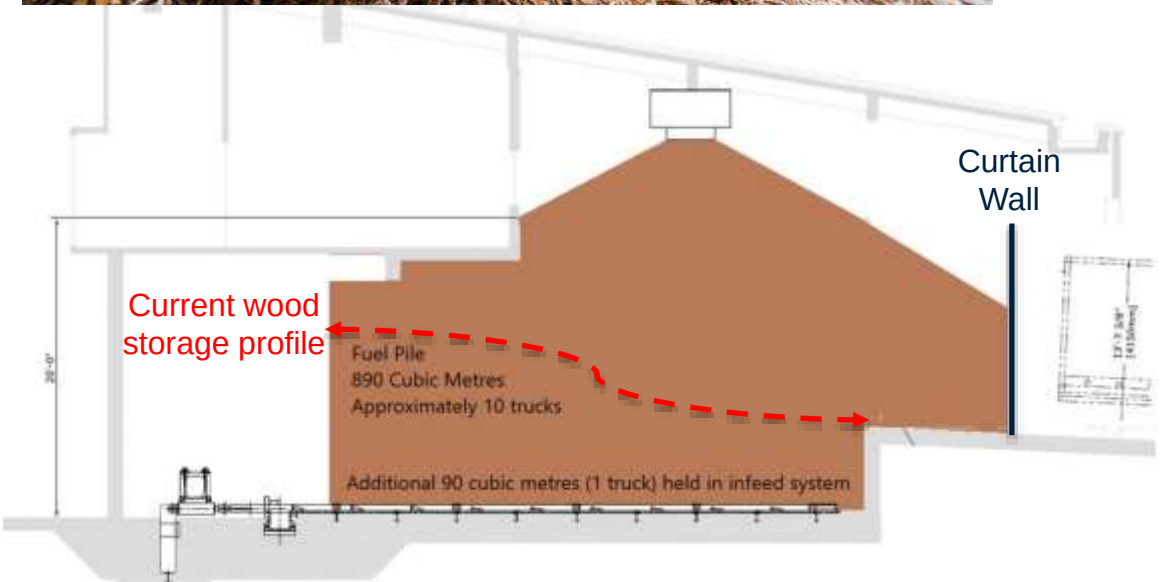


FUEL STORAGE

The red dashed lines shows the current loading bay profile. The bays currently store up to approx. 2 truck loads. The existing wood silo can hold a further 3 trucks.
This enough for 24 hours peak demand

By overhead filling and adding a new curtain wall, we increase the storage capacity of the loading bay, to the equivalent of 11 truck loads.

This is enough for 12 hours storage on a peak winter thermal load day at full thermal production.

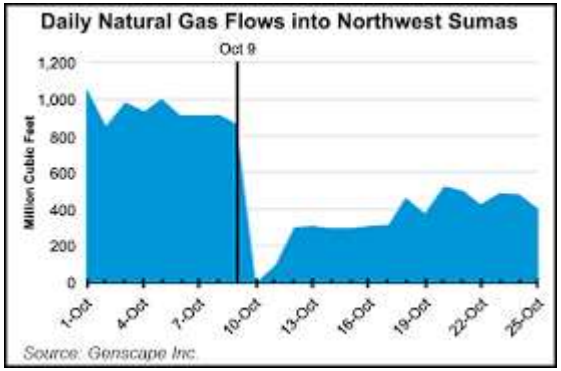


DISTRICT ENERGY SYSTEM (DES) FUEL RESILIENCY

2011: DES (steam): 100% NG, Fuel Oil (FO) back up

2018: DES (hot water): 70% CEC NG (FO back up), 25% BRDF Biomass (NG back up), 5% Biogas (RNG)

October 2018: Enbridge T South NG Line 'blows'. Lower Mainland NG supplies 100% loss



Shell Energy North America

Indicative Price Update

Tuesday, February 12, 2019

BC Next Day	
Sumas (USD/MMBtu)	$ 40.00
Sumas (CAD/GJ)	$ 50.26
Station 2 (CAD/GJ)	$ 2.97

Fuel Pricing during the loss of NG: FO was ~$30/GJ vs $3.25/GJ for Biomass

2020 (Plan): DES: ~70% BRDF Biomass (NG back up), 25% CEC NG (FO back up)*, 5% Biogas

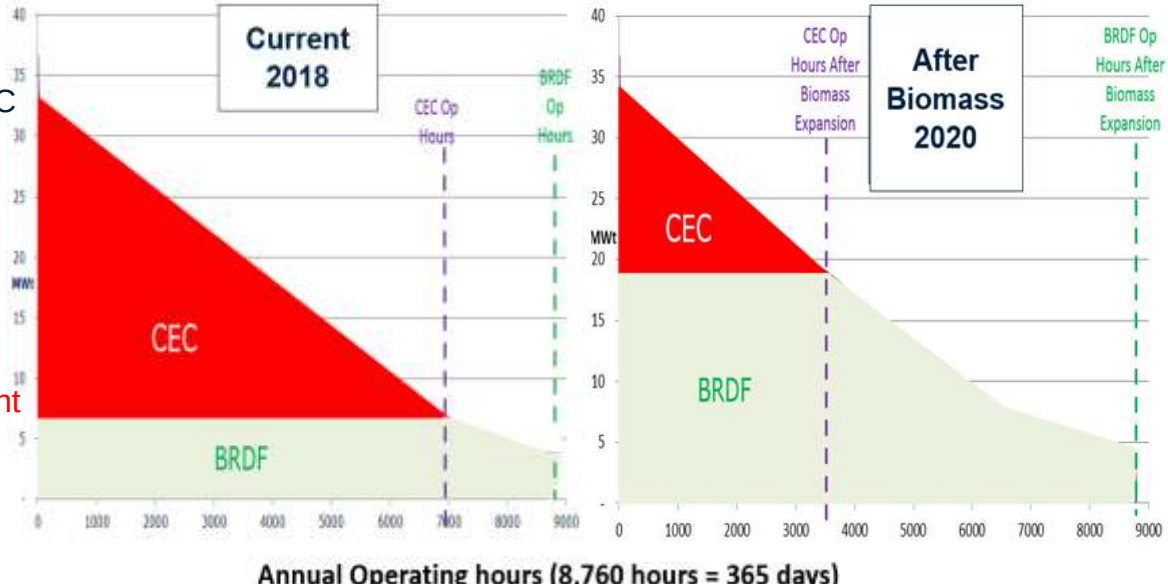
** Note CEC NG can pick up full campus thermal production under emergency. Fuel resiliency in depth*

OPERATORS AND PLANT OPERATIONS

Currently both the BRDF and CEC are 24/7 year round operations. Each site has a crew complement of 6 operators.

The BRDF is ‘baseloaded’ and operates the full year round, while the CEC provides peaking and has an annual shutdown from mid June through to September. The plant remains staffed, but is ‘locked out’ and in maintenance only.

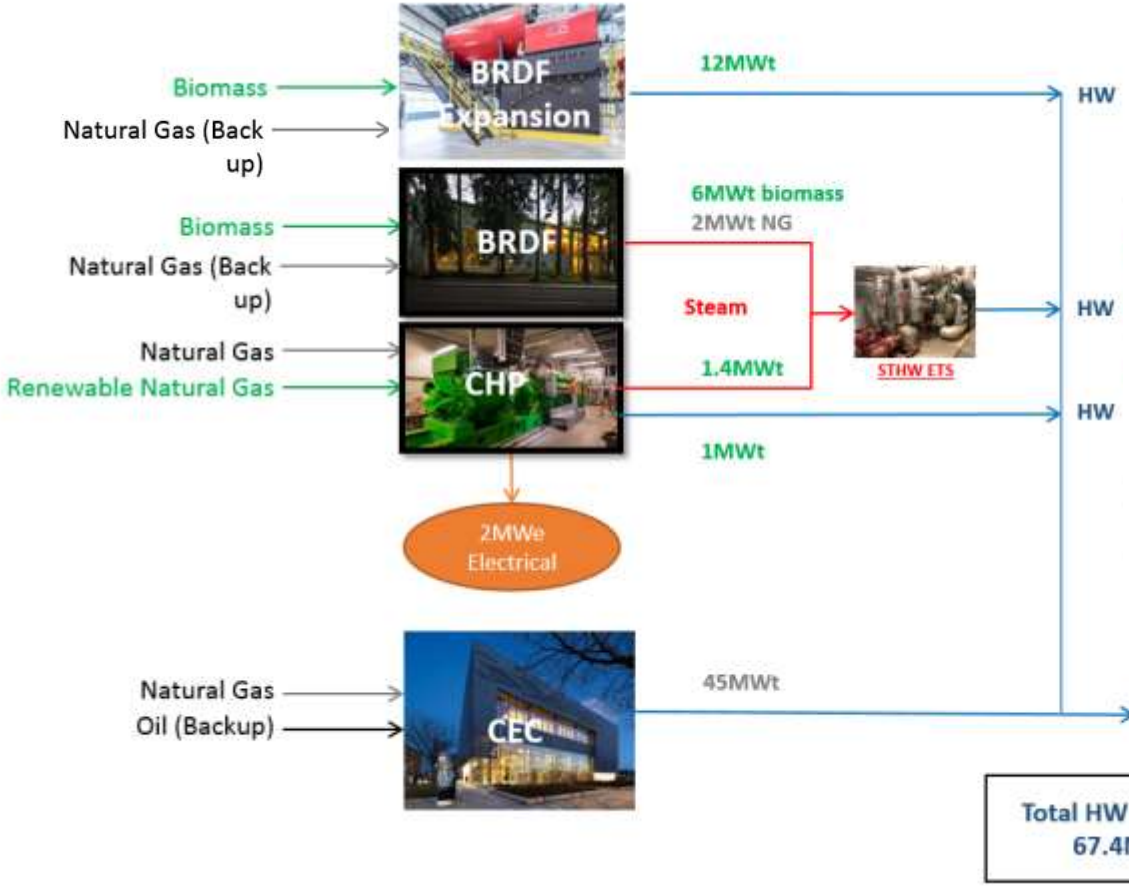
However, with the addition of the new boiler this will significantly increase the operational production at the BRDF while decreasing production at the CEC Consequently increasing the CEC annual shutdown period.



Outcome:

To adjust for the changes in operations it will require the BRDF to become a 2 person 24/7 operation. The CEC will become a satellite plant when in service, and no longer 24/7 site staffed. *(Net zero change in FTE’s, but a new operating pattern and staff/ union agreement is required).*

2020 UBC ENERGY PRODUCTION, FUEL DIVERSITY & CO2



2020 Stats

- 239,000 GJ's NG
- 110,000 GJ's RNG
- ~25,000 BDT Biomass
- ~71% Renewable
- 80% System Efficiency
- 11,950 tCO2* (~75% emission reduction)

Note over the last decade

- *30% increase in floor space*
- *35% more students*

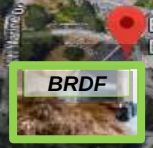
UBC 2011 Stat's

- *1,000,000 GJ's NG*
- *100% NG*
- *60% System Efficiency*
- *50,000 tCO2**

** Note DES emissions only*

CONCLUSION

- Biomass expansion increases BRDF production to ~67-71% of all UBC district energy thermal requirements.
- UBC DES becomes a low carbon district energy system(<60tCO2/MWh)
- Biomass expansion matches UBC buildings & thermal load growth profiles. It enables n+1 thermal redundancy for next 10 years.
- Biomass Expansion allows UBC to meet its 2020 GHG targets
- Biomass expansion allows commodity price stability, while improves availability and diversity of fuel sources
- Expected $1.3m in operational savings per year



QUESTIONS

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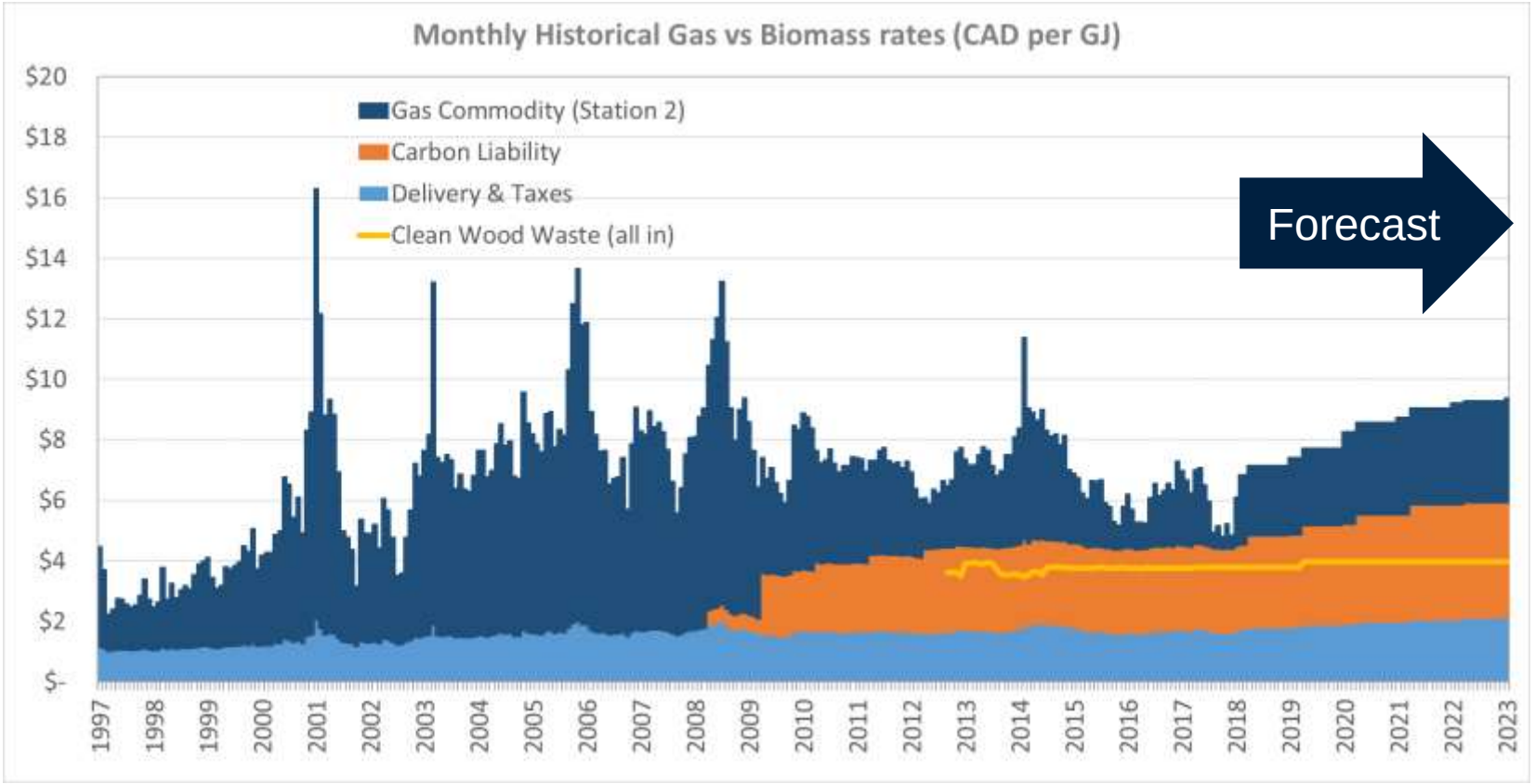
Note a few additional biomass fuel information slides attached after the presentation

Biomass

Biomass – Clean Waste Wood

- Fuel is ground & chipped waste wood:
  - Sawmill residuals
  - Furniture/carpentry/lumberyard waste
  - Municipal trimmings
  - Land clearing operations
- Fuel Spec
  - 3” minus, <10% fines, <2% dust
  - 5-40% MC, <3% Ash
  - No paint, chemicals, glues etc.

Why Biomass? Price Stability



Why Biomass – Local & Available

- Region produces 1 million tonnes of wood waste annually
- Sawmills, Secondary Processors, C&D, Land Clearing, trimmings
- Only half is used
- UBC currently uses 10,000 tonnes per year or 1% of total supply, pushed up to 2% when expanded