



# From Demonstration to Baseload

**IDEA Campus Conference 20-25<sup>th</sup> Feb 2017**

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# The University of British Columbia



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- 15 million sq.ft. of institutional & student Housing over 1,000 acres
- 1.5 million sq.ft. added since 2007, another ~2 million sq.ft. by 2030
- Day time pop. ~65,000 i.e. 50,000 Students and 15,000 Faculty & Staff



***UBC Powerhouse circa 1925  
3<sup>rd</sup> permanent building on Campus***

Aging Steam Infrastructure, with boiler renewal and capacity required.

VFA audits UBC Steam System with Deferred Maintenance valued at \$190M



UBC Powerhouse  
2015

# Background: Aging Steam Infrastructure

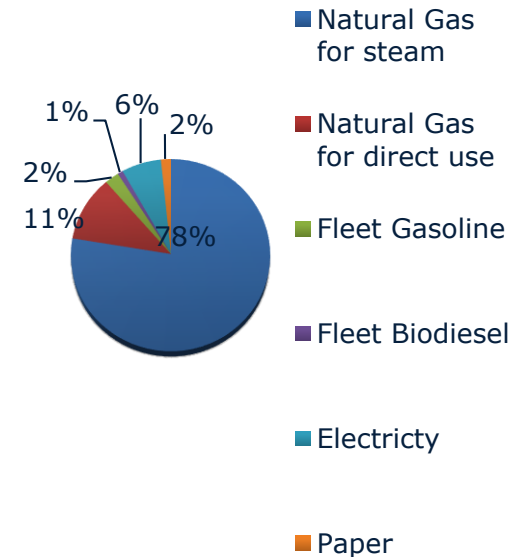
# UBC GHG Commitment Confirmed

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**

**2007 First  
Comprehensive  
campus GHG  
inventory**

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



## **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/>

# Background: CO2 Emissions Reduction Commitments



# ACHIEVING GHG AND ENERGY REDUCTION TARGETS

- Alternative Energy Campus wide feasibility study recommends a mix of options
- Out of these recommendations two main projects were developed:
  1. Convert UBC from a Steam to hot water DES (22% GHG reduction)
  2. Bioenergy Research Demonstration Facility (12% GHG Reduction)



Alternative Energy Feasibility Report  
For University of British Columbia

Phase Two – Step Three (Final)

Prepared For:  
UBC

The UBC Alternative Energy Sources Subcommittee  
c/o

Supply Management Department, GSAB  
2075 Wesbrook Mall, 1st Floor  
Vancouver BC V6T 1Z1

Prepared By:  
Stantec Consulting

1100 – 111 Dunsmuir Street  
Vancouver BC V6B 6A3  
604-696-8000

Principal in Charge: Hitesh Tailor

March 2010  
Updated June 2010



earthvoice strategies usitall



## Background: Alternative Energy Study



# BioEnergy Research Demonstration Facility (BRDF)

## Summary of Original Concept

- Biomass cogeneration demonstration project
- Building constructed from Canadian produced Cross Laminated Timber (CLT)
- LEED Gold
- A \$28M multi-partnership project (\$8.35m UBC)
- Thermal & Cogen Modes of operation
- 12% reduction of UBC CO<sub>2</sub> emissions
- “Campus as a Living Lab” collaboration between Faculty, Operations & Industry







**Construction:** Canadian Cross Laminated Timber (CLT) Locally Sourced and Manufactured in BC



# Original Project Roadmap

- Spring 2009 BRDF Concept devised
- Spring- Fall 2010 Public Engagement
- April 2010 UBC Board Approval
- Feb. 2011 Groundbreaking
- July 2012 Thermal Mode Commissioned
- Sept 2012 Grand Opening Ceremony
- Oct. 2012 CHP Mode Commissioned
- Nov. 2012 Full Operation

Construction  
May 2011



Construction  
Jan 2012



Construction  
May 2012

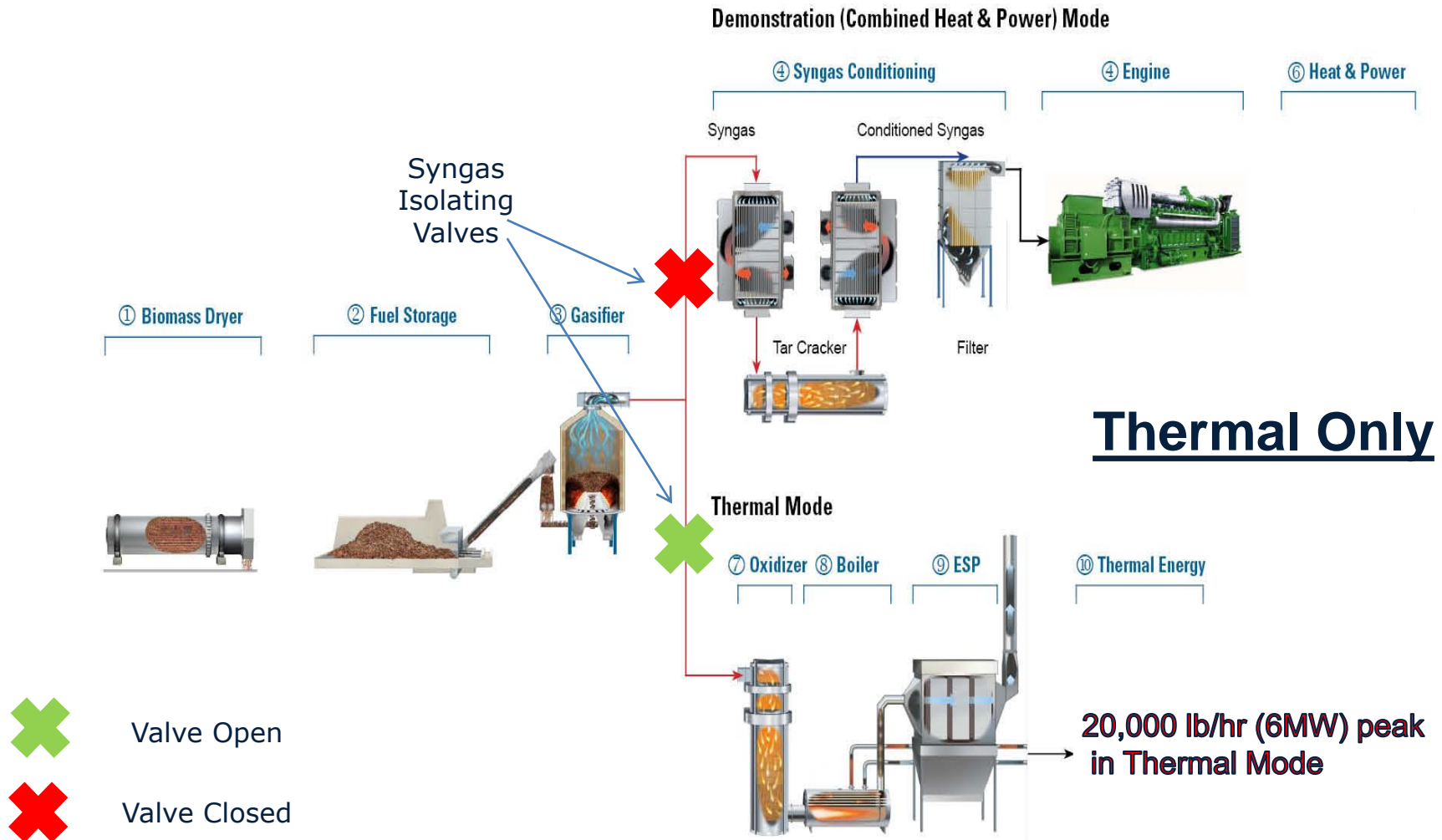


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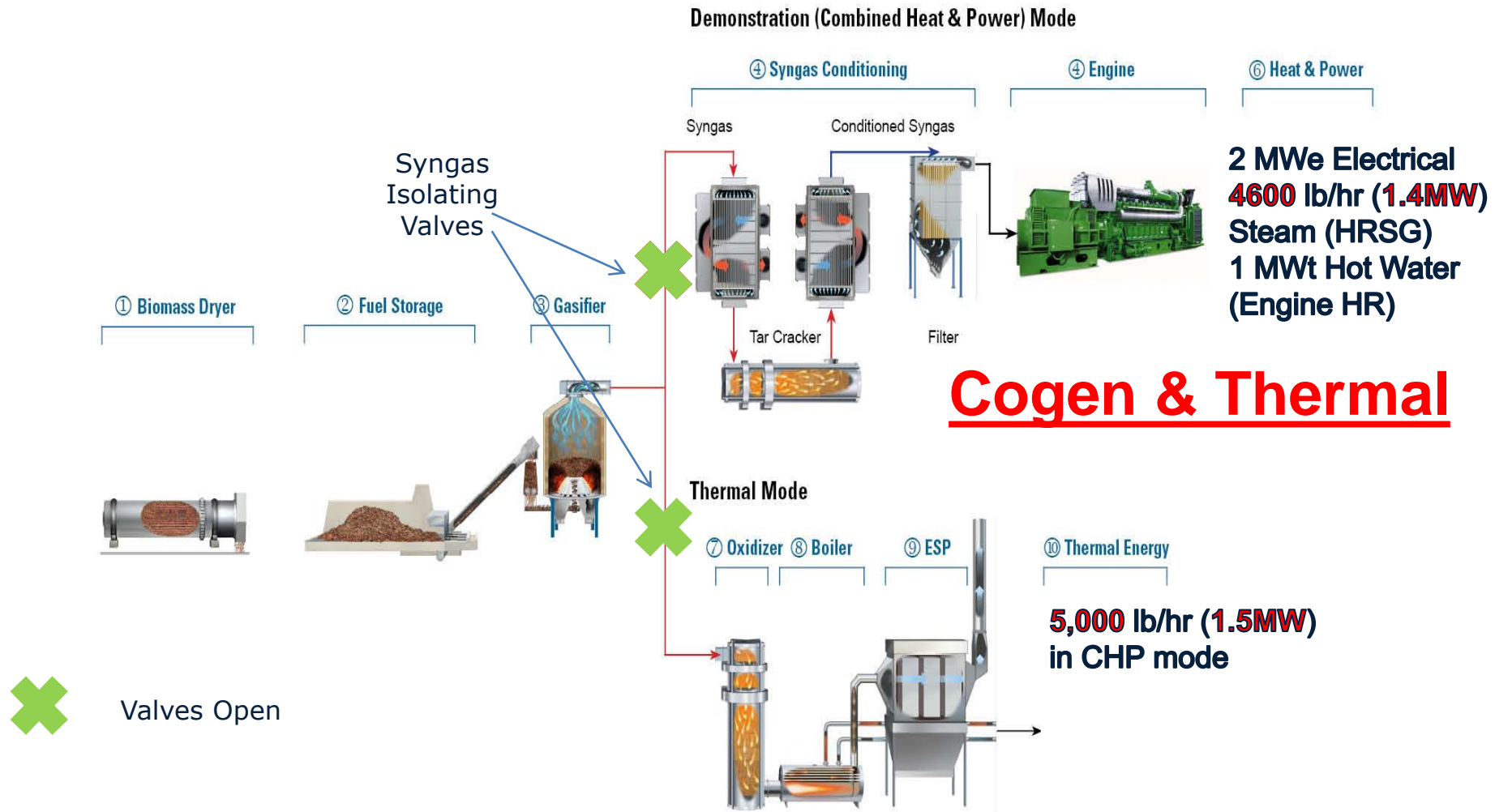
# SYSTEM SCHEMATIC



BRDF Original: Thermal Only Mode of Operation



# SYSTEM SCHEMATIC



BRDF Original: Combined Modes of Operation



# The Fuel: Biomass



- Fuel is ground & chipped waste wood:
  - Sawmill residuals
  - Furniture/carpentry offcuts
  - Municipal trimmings
  - Land clearing operations
- Delivery of 2-3 trucks per day for 12,500 dry tonnes per year.





# 1st Year



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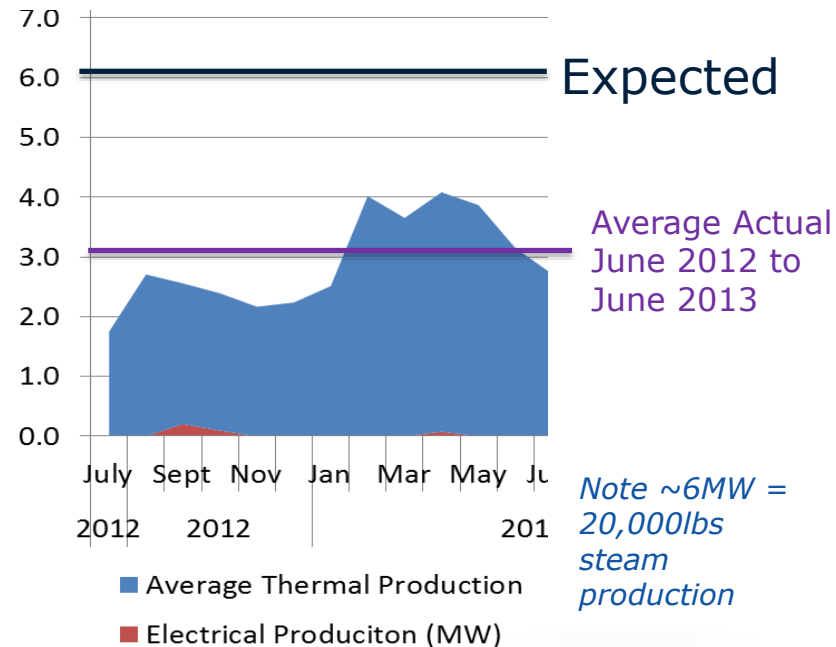
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# Successes

- **Best in class air emissions**  
(well below permitted levels and on par with Natural Gas)
- **1<sup>st</sup> LEED Gold facility made from BC CLT**
- **100+ of tours**
- **Achieved 2 MW electrical production using biomass engine grade syngas**
- **Strong engagement with faculty and students**

# Challenges

## Energy Production (MW)



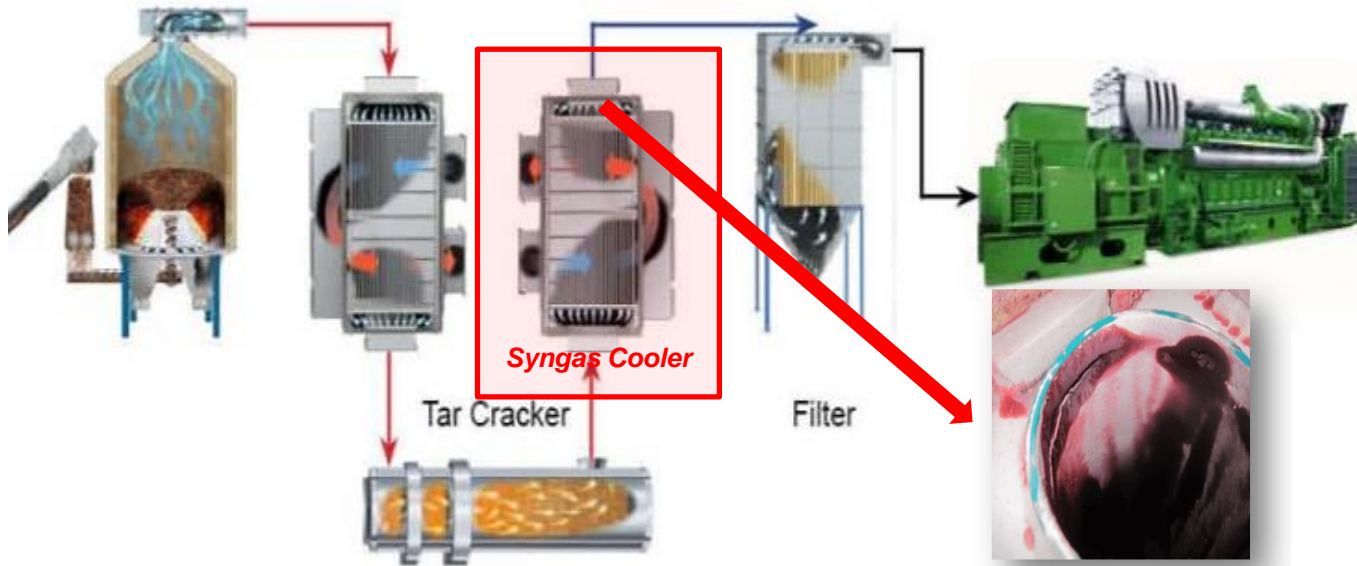
- Requires a higher fuel quality than expected (Needs ~30% MC)
- Higher operational costs than expected e.g. people, maintenance and materials
- CHP Downtime



# 1<sup>st</sup> Year of Operation (2012/13)



# CHP Performance Review with Biomass Syngas



## Successes

- CHP demonstration Trials: Fall 2012 and Spring 2013
- 406 hours of clean engine grade Syngas Produced
- 220MWh of Electrical Production
- Spawned multiple UBC Masters and PhD level research projects

## Challenges

- Material failures & reliability
- Increased Operational costs over base case to provide Cogen Operation:
  - No additional labour was accounted for Cogen Operations. It is a 5 day process with 2 man 24/7 operators to get the engine running.
  - Carbon annual costs of \$365k vs \$150k
  - Biomass moisture content less than 30%

# 2nd Year



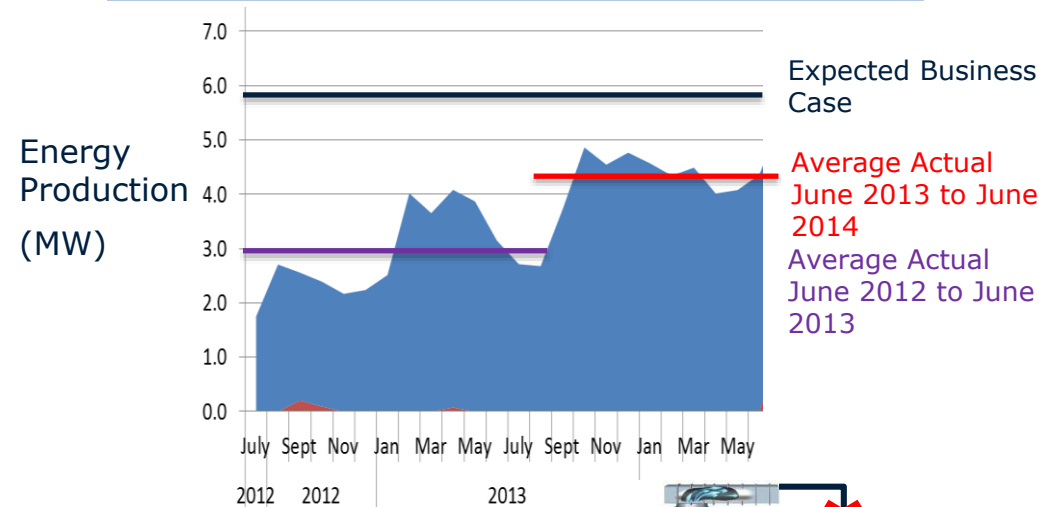
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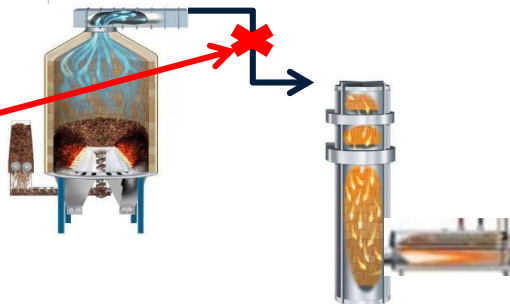


# Successes

- **33% lift in thermal energy production**
- **Employee engagement**
- **200's + tours**
- **Multiple Research projects ongoing**



Moisture Content  
consistent ~30%



# Challenges

- Economic:
  - Lower than expected natural gas prices
  - Loss of electrical revenue
  - Lower than expected thermal production
- Loss of Electrical production to reduce UBC's Peak electrical demand exposure
- Desire to make use of stranded assets without compromising research or GHG objectives



## 2<sup>nd</sup> Year of Operation (2013/14)

# Moving Forwards 2014/15

## *“A New Direction”*

### Separate out CHP from Biomass

- Provide reliable engine uptime and electrical generation
- That improves the business case and cash flow
- Provides a firm (N-1) 2.4MW thermal capacity
- Aligns with UBC's Climate Action Plan and GHG targets
- And continues Academic research opportunities



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# Separate Fuel Sources Utilizes the full installed capacity at BRDF and provides firm thermal supply

Renewable  
Natural Gas



Engine & HRSG

2 MW Electrical  
4600 lb/hr (1.4MW) Steam from HRSG  
1 MW Hot Water HR

Biomass  
Syngas



Biomass Gasifier



Steam Boiler

AND

Steam  
→ 20,000 lb/hr (6MW) peak

# Benefit of Better Use of Capacity

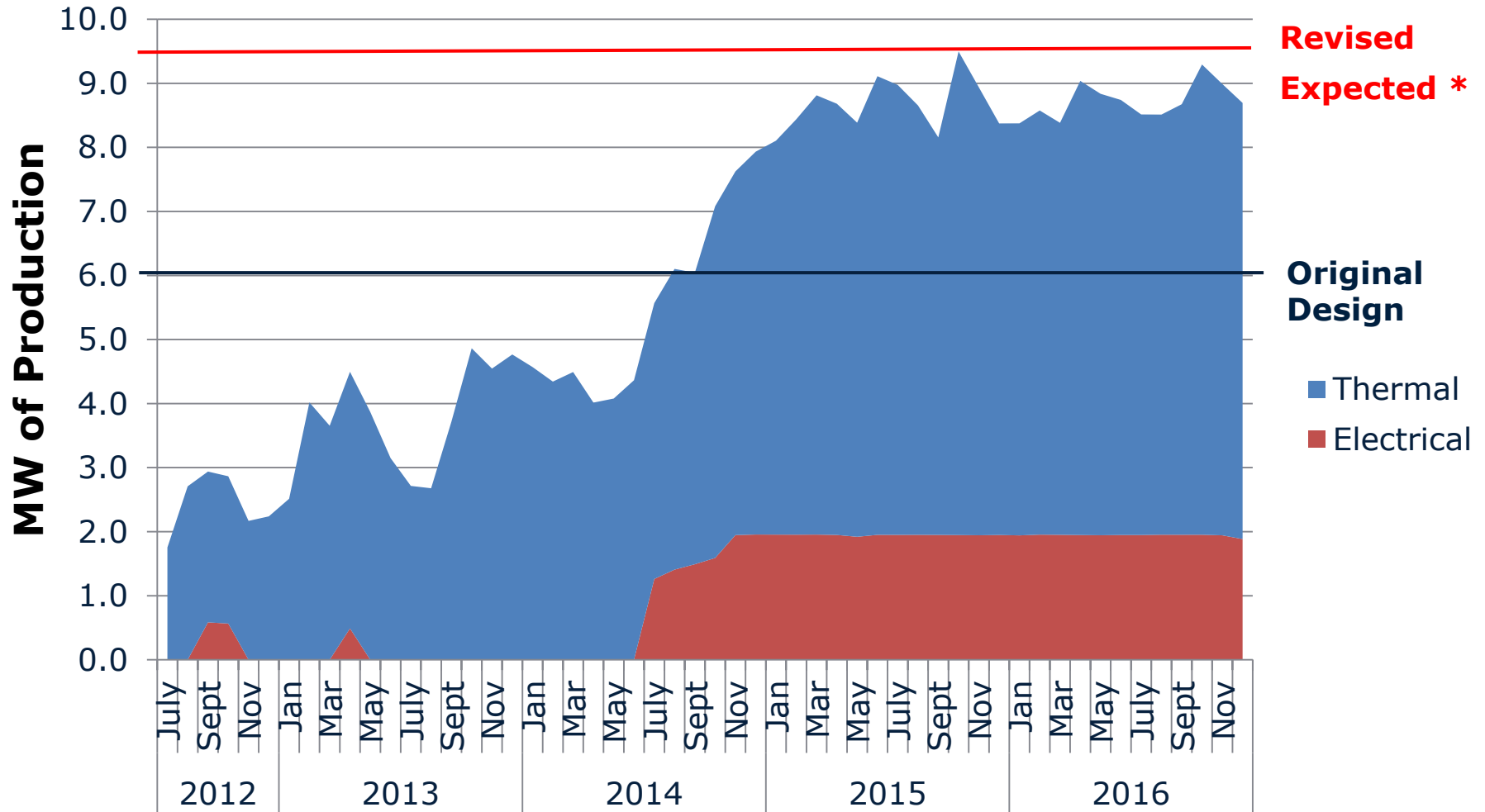
BRDF	Biomass Thermal	Biomass Cogen	Biomass Thermal & RNG Cogen
Steam Boiler	6.0 MWt (20,000lbs)	1.5 MWt (5,000lbs)	6.0 MWt (20,000lbs)
Heat Recovery Steam Generator (HRSG)	-	1.4 MWt (4,600lbs)	1.4 MWt (4,600lbs)
Hot Water Engine Heat Recovery	-	1 MWt	1 MWt
Electrical Energy	-	2 MWe	2 MWe
<b>TOTAL</b>	<b>6 MW</b>	<b>5.9 MW</b>	<b>10.4 MW</b>

*Note 1MWt = 3,412lbs steam*





# BRDF Average Monthly Production - By Energy Type



\* Slightly reduced output from previous total due to parasitic loads e.g.DA, trace heating etc.

# BRDF Integration with UBC Steam to Hot Water Project



Concurrent to the BRDF project, UBC has been undertaking an \$88m, 9 phase, Steam to Hot water conversion project: Academic District Energy System (ADES)



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**Steam  
Powerhouse**

## **TEC Summary**

- **Commissioned Jan 2014**
- **Allowed 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**
- **BRDF only, supplied steam for summer 2015. Powerhouse Shutdown**
- **TEC in Reserve November 2015**

**TEC (Jan 2014)**



**New HW feeder pipe line Fall 2013**

**Main UBC Steam feeder line**

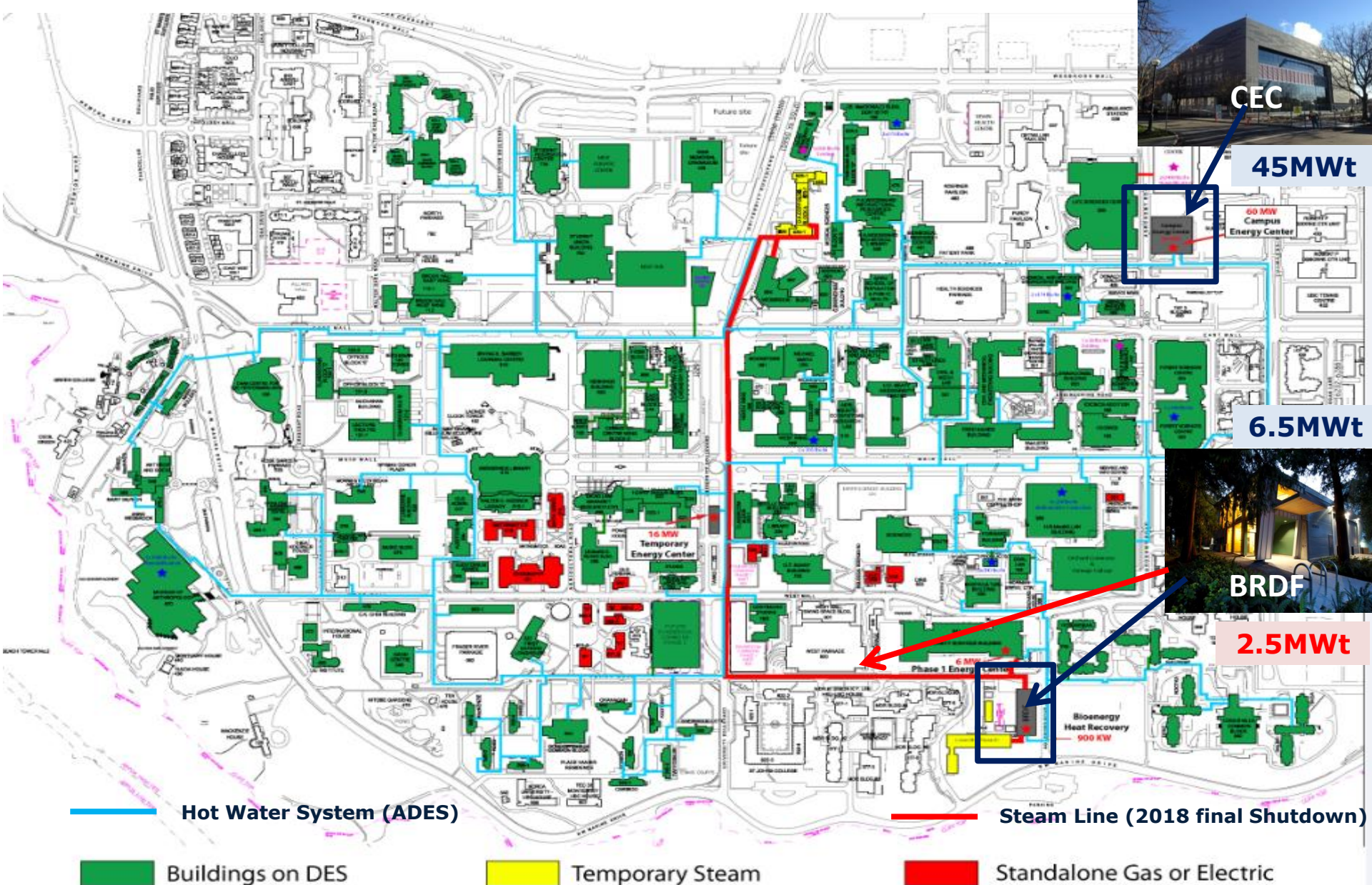
**From BRDF feeder line**

**BRDF**



**BRDF and The ADES Temporary Energy Center (TEC)**



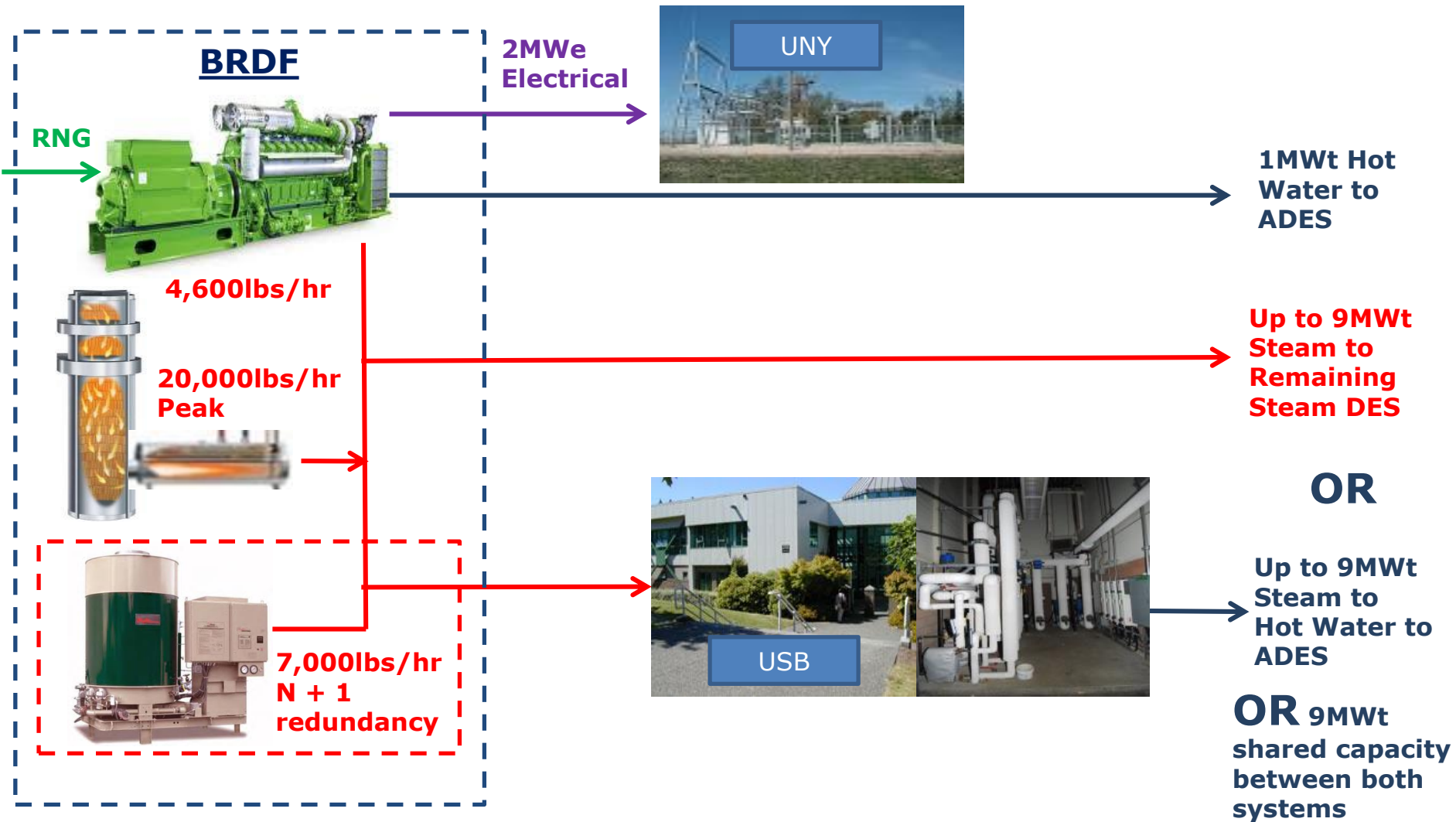


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# 2015 BRDF Further Thermal Capacity Added: 7kpph (~2MWt) Clayton Boiler



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- **Separate thermal and Cogen Steam Processes: Units 1 & 2 (6MW & 1.4MW steam respectively)**
- **7kpph (2MW) steam boiler added 2015: Unit 3**
- **BRDF now has 3.4MW (11kpph) thermal (steam) redundancy**
- **And 1MW Hot Water from Engine Heat Recovery**



**BRDF Has Now Transitioned From a Demonstration Project to UBC's Thermal Baseload Facility**



# 2017 What's Next for BRDF?



Research and Biomass Production Expansion

# Current Plant Layout: Original Biomass & Syngas Clean up Technology

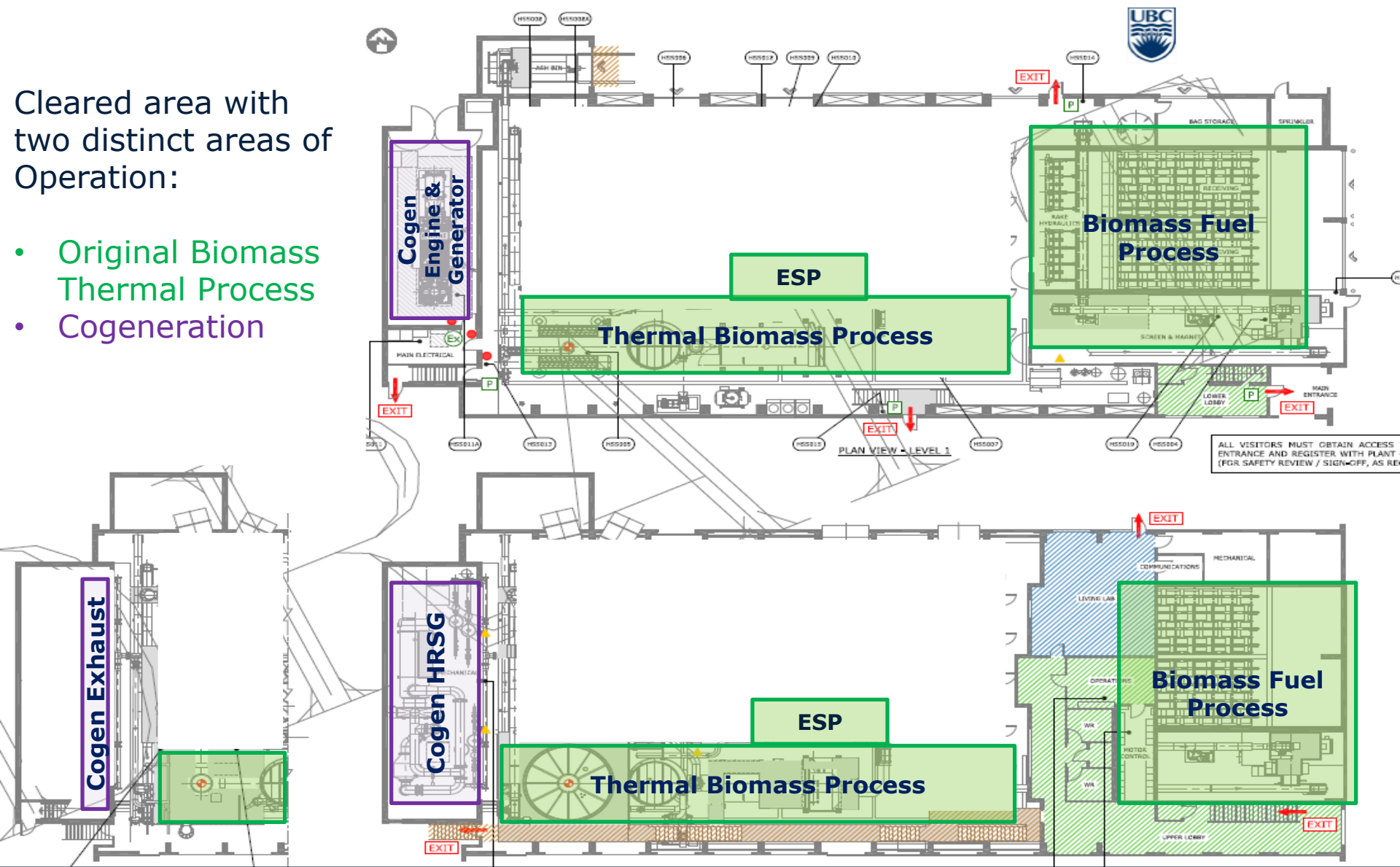


Original Syngas Cleanup Equipment to be Removed



Cleared area with two distinct areas of Operation:

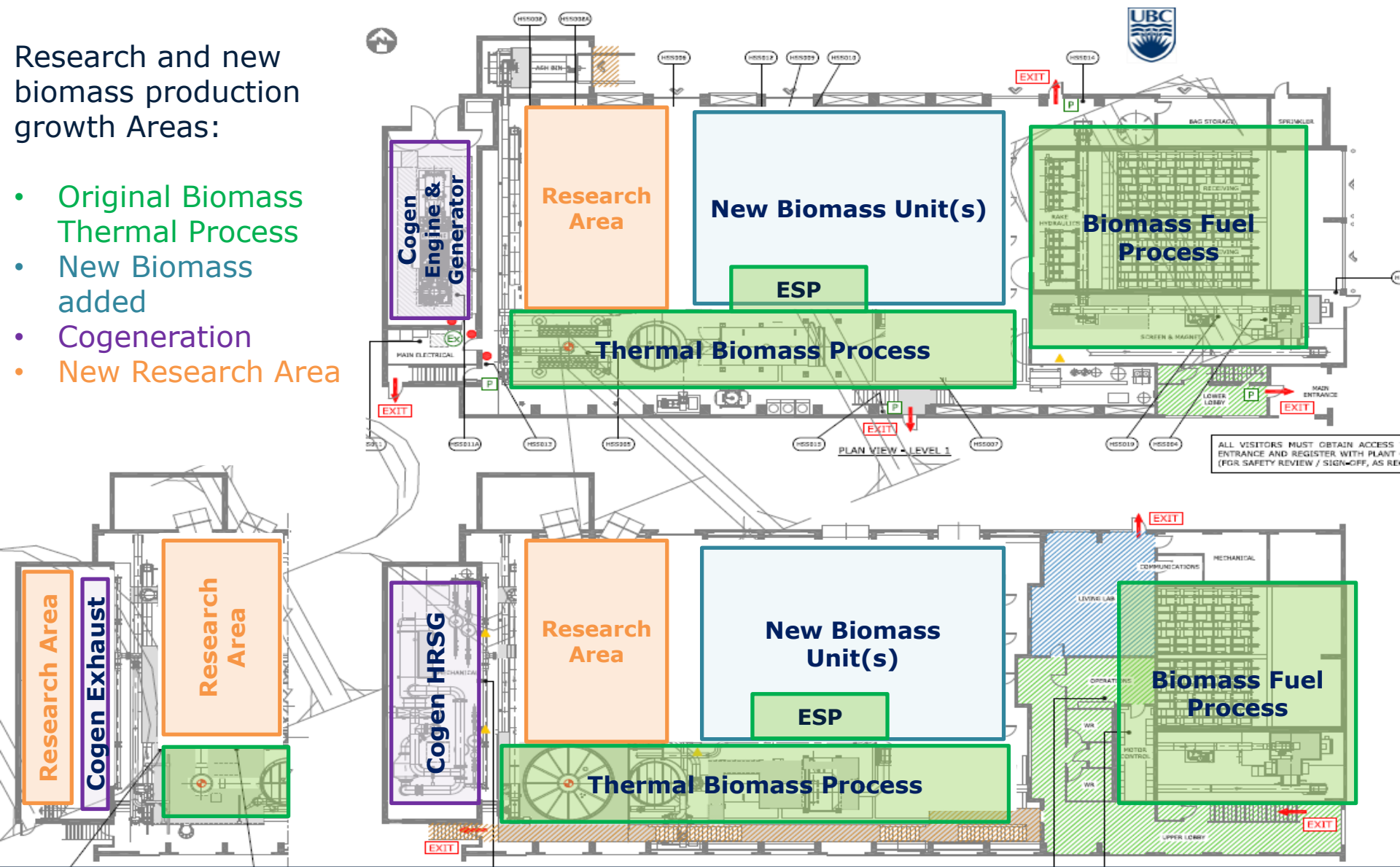
- Original Biomass Thermal Process
- Cogeneration



Proposed Clean Site Layout: Original Biomass and Cogen Units Only

Research and new biomass production growth Areas:

- Original Biomass Thermal Process
- New Biomass added
- Cogeneration
- New Research Area



Repurposed Site: With Future Research Areas and Biomass Production Expansion Zones

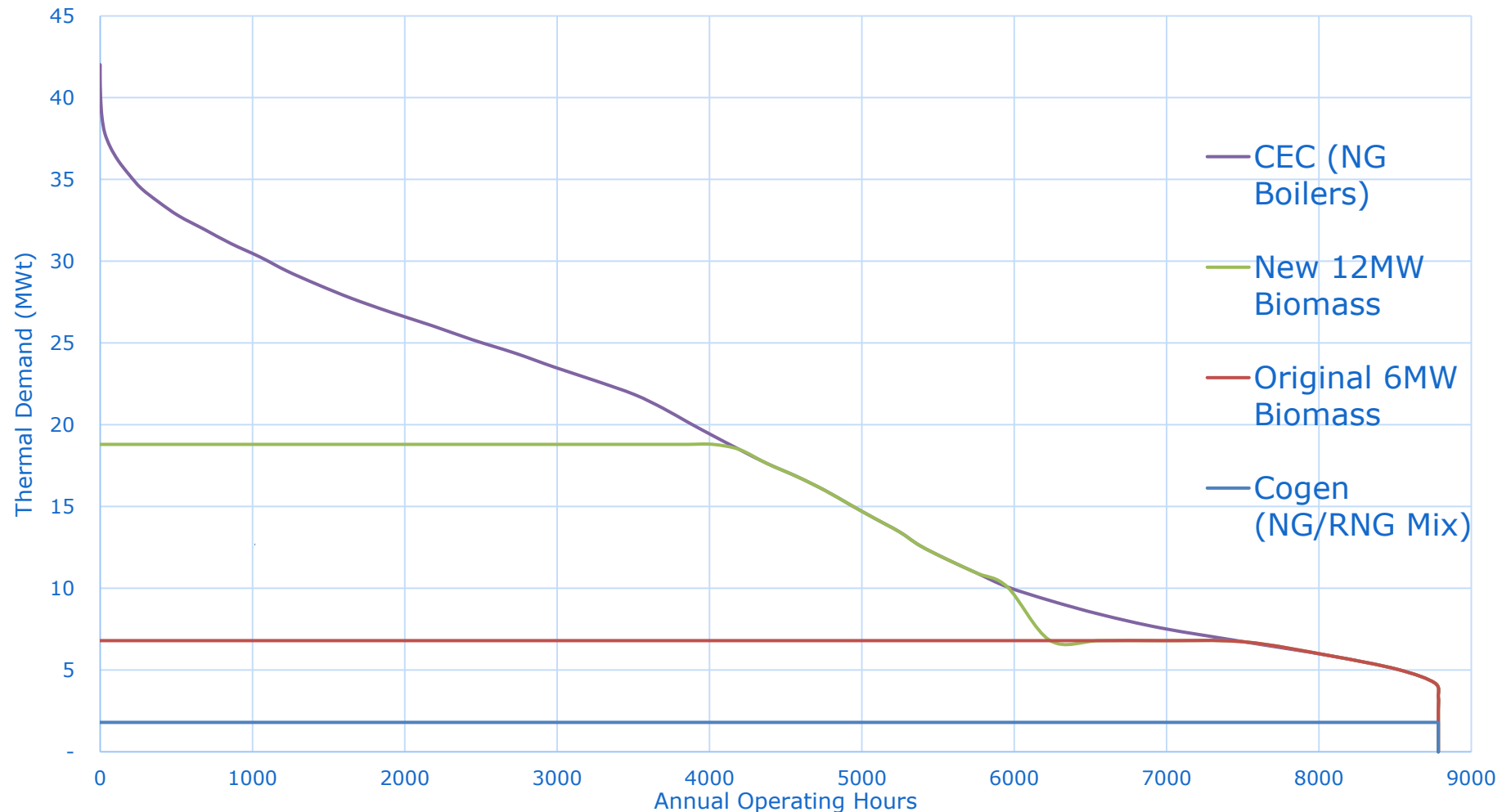


# New Biomass Capacity

- We are planning to add an additional 12MW Biomass Hot Water Boiler
- To come on line by late 2018 early 2019
- Biomass will now produce ~60% of UBC total annual Thermal load requirements



# UBC Thermal Load Profile with New Biomass



*Currently ~25% annual thermal production now supplied by BRDF*

*Future capacity increase; could be up to 60% of UBC's annual thermal production by Renewable fuels*

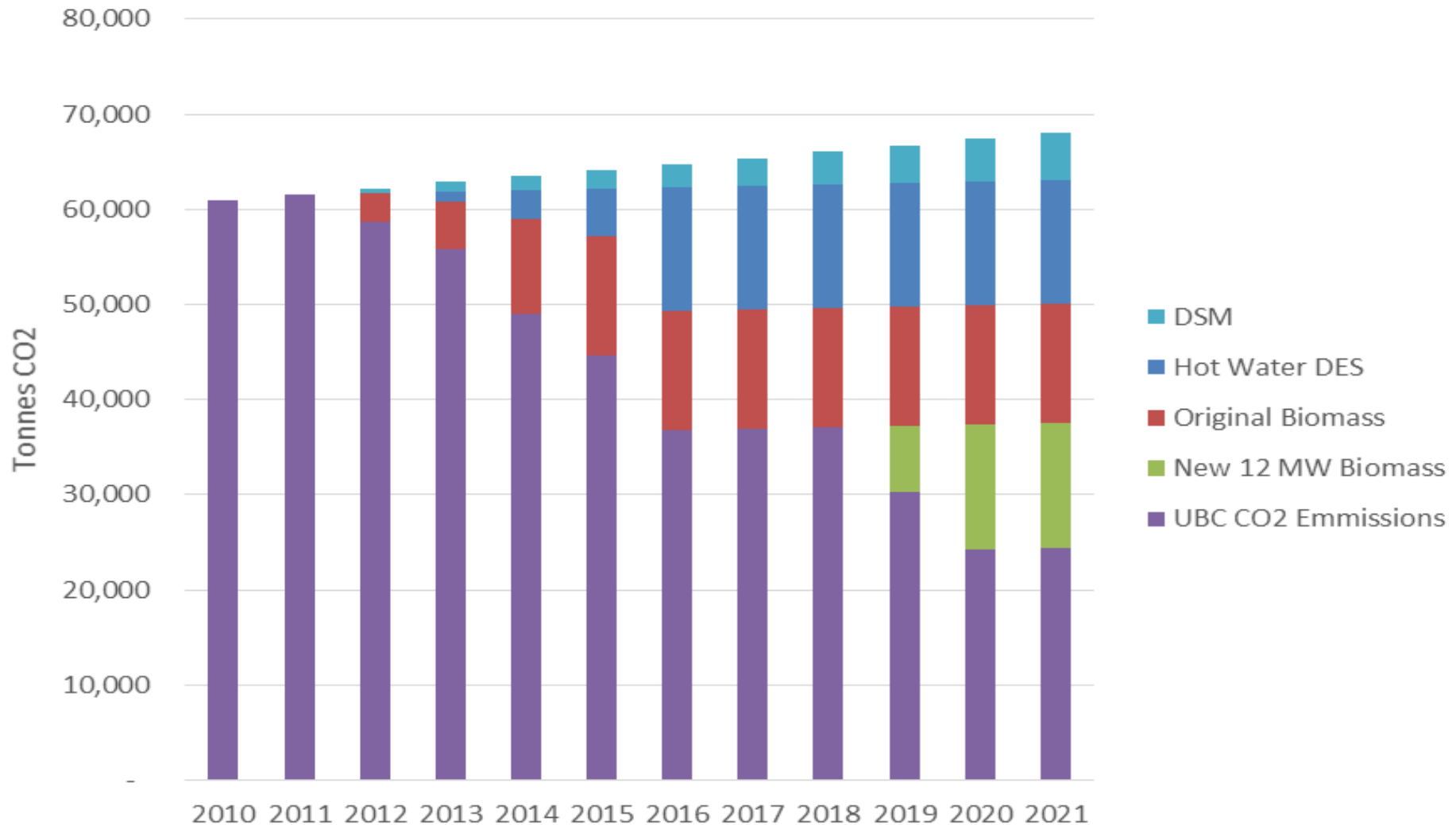


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## UBC CO2 Emission Reductions



*UBC would achieve ~61% CO2 reduction by 2020 from 2007 baseline, with new biomass addition*

**UBC GHG Emissions Profile:  
Active & Planned Projects**

# Conclusions to Date

- CHP fuelled with Biomass produced Syngas was successfully demonstrated and proven
- BRDF now performs as the baseload District Energy thermal energy generation unit and produces up to 25% of annual thermal production
- BRDF only provides all thermal production for the summer season
- Separation of Thermal and Cogen Processes has provided:
  - Combined ~8MW's thermal capacity & with fuel diversification
  - Provides 3.4MWt firm (N-1) thermal capacity
  - Provides 2MWe reliable power production
- BRDF currently reduces UBC's GHG emissions by ~18%.
- UBC continues to benefit from in-kind world attention to BRDF through sustainability agendas, tours (~700+), CLL and ongoing research, including new research laboratory space to be added.







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