SEPTEMBER 20, 2023

STRATEGIC ENERGY MASTER PLAN – 2023 UPDATE

PREPARED BY:

ENERGY TEAM

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Executive Summary:

In line with UBC's Climate Emergency Declaration, UBCO is pursuing a greenhouse gas (GHG) emissions reduction target of **65% below 2013 levels by 2030**, based on *gross* GHG values as per Climate Action Plan (CAP). Energy Team has been tasked with developing appropriate policies and guidelines that assist in meeting long-term campus energy and carbon goals.

The 2023 update of the Strategic Energy Master Plan (SEMP) is a comprehensive integration of diverse initiatives aimed at advancing our high-level energy strategy. This update is in alignment with our goal to reach a future state with a view of modernization, renewal, and growth to meet current and future energy needs in line with UBC Okanagan's goals and resilience. Following are the various initiatives integrated under the 2023 edition of SEMP:

- Utilities tracking and forecasting (campus future utility needs and costs)
- Demand-Side Management (energy efficiency and optimization)
- Building Energy Targets (targets for net-positive ready buildings)
- Decarbonization with targets from the CAP (Climate Action Plan)
- Campus Growth (Buildings and FTE)
- Renewal and Modernization

In recent years, the UBCO Energy Team transitioned from heavy reliance on external consultants to establishing an internal expertise in energy and data analysis, KPI reporting, and BMS improvement. This strategic shift has yielded significant benefits, including cost savings, improved control, faster response times, knowledge retention, customization capabilities, long-term planning, and increased adaptability to changing energy dynamics. While some of the work is still being outsourced to meet external funding partner requirements, our in-house capabilities have allowed us to conduct thorough energy evaluations, monitor performance indicators, and optimize our BMS, resulting in Net Present Value (NPV) of $600,000 for a $400,000 investment, in addition to external energy efficiency benefits of $500,000. This strategy positions UBCO to make well-informed decisions, drive down operational costs, and effectively align our energy management strategies with our overarching sustainability objectives.

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Following are the recommended cost-effective strategies as per Strategic Energy Master Plan 2023:

1. Add 1 MW CO_2 ASHP (Benefits: meet decarbonization targets, capacity increases, future proofing)
2. Increase demand side reduction program to $500k per year due to better ROI and achieve required CAP targets
3. Retrofits/Modernization/Stranded Loads should be scheduled in alignment with DE strategy to minimize future capital costs
4. Periodically update the Strategic Energy Master Plan (SEMP) to stay aligned with technological advancements, evolving regulations, market trends, and environmental goals.

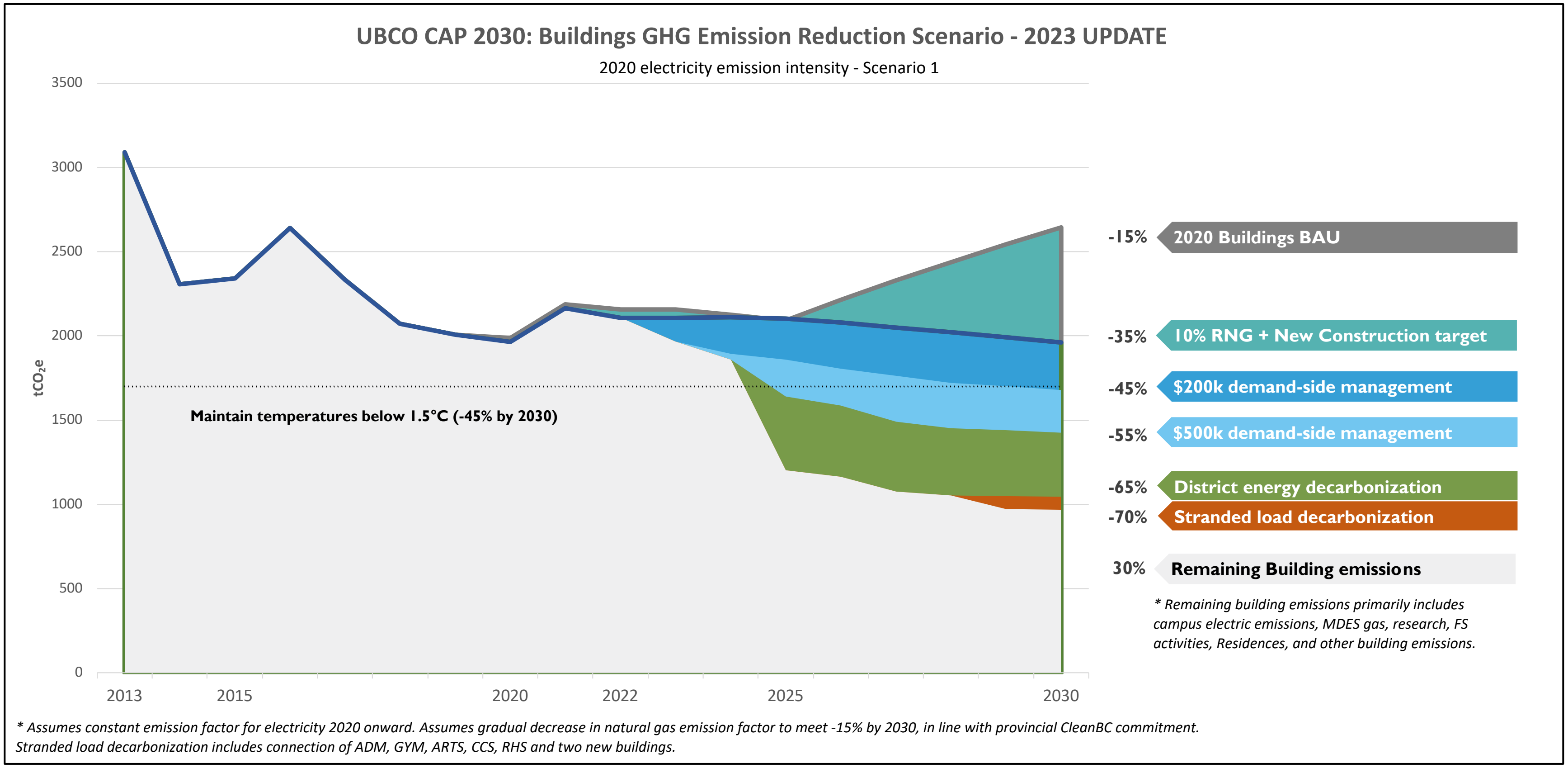

Figure 1: Potential Building GHG Emissions Reduction (updated July 2023)

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Figure 1 above presents an update to the building GHG emissions reduction scenario under Climate Action Plan (CAP) 2030. The strategies under CAP 2030 included partial decarbonization of the central plant, implementing projects that will reduce energy demand, and connecting select existing buildings to central energy supply systems (district energy).

The 2023 update to CAP 2030 highlights the criticality of each of the energy strategies in achieving the CAP 2030 emissions reduction target of 65% below 2013 levels by 2030.

- **10% RNG procurement:** In line with CAP 2030 plan, 10% RNG is being procured to decarbonize critical gas-fired research equipment. RNG procurement is temporarily paused for 2-3 years in light of shifting financial priorities.
- **New Construction energy target:** Implementation of building energy performance targets remains one of the most cost-effective strategies for reducing future carbon emissions, effectively guiding the emissions profile on a downward trajectory.
- **$200k demand-side management (DSM) program:** For existing buildings, prioritizing energy efficiency and optimization represents the foundational steps towards sustainability and resource conservation, yielding a net-positive value (NPV) of $1.8 million with an annual funding of $200k till 2030. DSM program reduces the liabilities for future utility and carbon costs while also minimizing the upfront investment required to transition to cleaner energy sources.
- **$500k demand-side management program:** Increasing the annual funding for demand-side program from $200k to $500k results in a net-positive value of $2.5 million. While a $300k yearly increment in DSM funding produces a relatively modest NPV boost, its importance lies in sustained benefits over 15 years and is crucial for achieving CAP 2030 targets. In lieu of increased funding, a strategic recommendation is to reinvest external incentives received from DSM projects to expedite the advancement of the demand-side management program.
- **District energy decarbonization:** Due to BC's clean electricity grid, electrification is the best strategy for decarbonization for UBCO campus. A key strategy in decarbonizing UBCO's core operations is the expansion of central plant using low carbon energy equipment (air source heat pumps). The newly proposed CO_2 heat pump solution enhances system efficiency, performs effectively at colder temperatures, and offers scalability and modularity for future energy needs.
- **Retrofit/ Modernization/ Stranded load:** Retrofits, Modernization, and Stranded Load connection should be strategically scheduled in alignment with our District Energy (DE) strategy to minimize capital costs while ensuring long-term sustainability. Future renewal and modernization costs are unavoidable. As per the DE strategy, hybrid cluster plant approach, featuring Zone-scale heat pumps for generating and distributing hot and chilled water via a 4-pipe system to buildings in a cluster, not only represents a lower-cost strategy for the campus but also stands as the most effective approach for achieving our carbon emission reduction goals.

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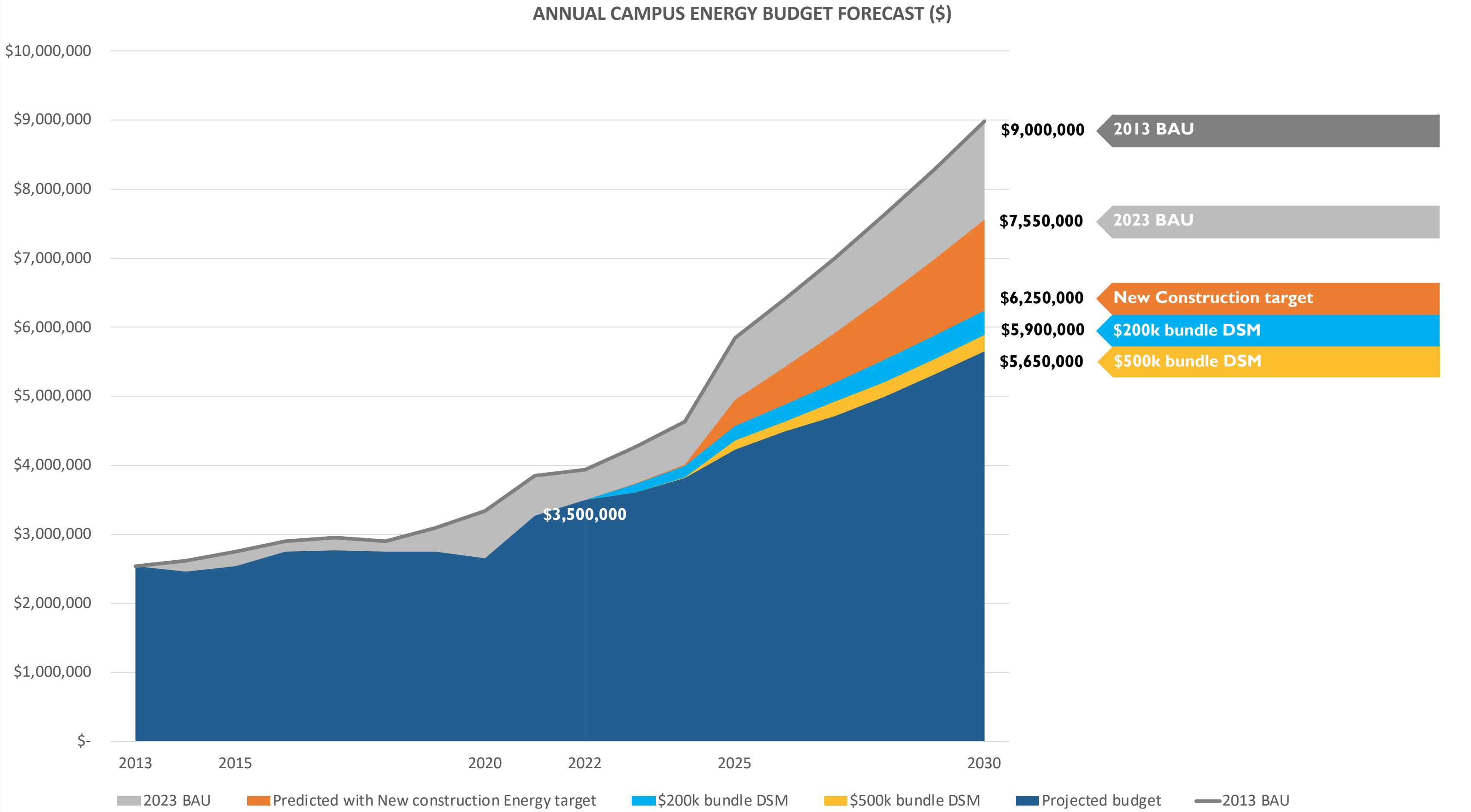
Energy Budget forecast:



**2013 BAU scenario is the baseline as per CAP 2030 target*
**2023 BAU scenario shows without DSM measures, and higher energy performing buildings, energy budget would increase to $7.5 million from current $3.5 million.*

Figure 2: Energy budget forecast 2013 – 2030

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In Figure 2, we present an overview of the utility budget progress from 2013 until the present, with a glimpse into the potential trajectory through 2030. This projection takes into account the impact of higher-performing buildings and demand-side measures (DSM). Notably, the 2023 Business-As-Usual (BAU) scenario reveals the stark contrast that would exist without the implementation of DSM measures and the adoption of more energy-efficient building practices.

In the absence of these measures, our analysis indicates that the energy budget would surge from its current level of $3.5 million to $7.5 million in 2030. It is worth noting that while the annual savings achieved by increasing DSM funding by $300k annually amounts to $250k, the true significance lies in the sustained benefits these measures promise over the course of 15 years. By prioritizing these initiatives, we can not only mitigate the immediate budgetary impact but also pave the way for long-term financial stability, energy efficiency, and sustainability. This underscores the prudent nature of investing in DSM measures, ensuring not just short-term gains, but also a more resilient and cost-effective energy future for years to come.

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Demand-side management program:

By optimizing energy usage, encouraging efficiency, and promoting sustainable practices on campus, DSM programs help mitigate climate change while saving costs and resources. Table 1 below presents an 8-year plan compiled from identified DSM projects under a $200k DSM program. These figures provide an estimate for short-term potential energy and GHG emissions savings.

Table 1: 8-year DSM plan summary for $200k program

Funding year	Net Project cost	Annual savings $	GHG tCO2e	NPV
FY21-22	$125,200	$28,839	22	$100,884
FY22-23	$222,245	$67,374	86	$529,120
FY23-24	$236,000	$109,134	142	$594,148
FY24-25	$200,000	$22,710	75	$266,400
FY25-26	$220,000	$16,144	35	$143,378
FY26-27	$250,000	$12,242	33	$63,019
FY27-28	$250,000	$13,470	28	$36,180
FY28-29	$200,000	$26,534	20	$311,633

Increasing investment in a demand-side management program from $200k to $500k is crucial as it empowers us to significantly boost energy efficiency, reduce carbon emissions, and enhance overall sustainability. This increased funding allows us to capitalize on cost-effective measures and technologies. Table 2 below presents an 8-year plan compiled from identified DSM projects under a $500k DSM program.

Table 2: 8-year DSM plan summary for $500k program

Funding year	Net Project cost	Annual savings $	GHG tCO2e	NPV
FY21-22	$125,200	$28,839	22	$100,884
FY22-23	$222,245	$67,374	86	$529,120
FY23-24	$236,000	$109,134	142	$594,148
FY24-25	$332,500	$33,184	106	$394,682
FY25-26	$870,000	$86,238	228	$985,158

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FY26-27	$350,000	$16,984	39	$18,798
FY27-28	$750,000	$51,282	90	$348,881
FY28-29	$615,000	$21,392	25	-$144,117

Relying solely on demand-side management is insufficient to reach the CAP 2030 targets. To effectively meet the 2030 targets, it is imperative to incorporate a degree of fuel-shifting. This means transitioning to cleaner energy sources or technologies to complement demand-side efforts, ensuring a more holistic and sustainable approach towards achieving the desired environmental goals.

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District Energy decarbonization

A key strategy in decarbonizing UBCO's core operations cost-effectively is the expansion of central plant using low carbon energy equipment (air source heat pumps). These heat pumps would be used to address the base load heating requirements instead of gas boilers which would only be used during peak heating demand (during the coldest months). Continuing to use gas boilers to handle peak heating loads results in reduced capital costs for Air-Source heat pumps and enables significant decarbonization with a relatively modest equipment size.

To decarbonize the District Energy system, original proposal in 2021 involved a phased approach using two successive phases of air source heat pumps (using R410a refrigerant). Each of these decarbonization phases was designed with a thermal capacity of 700 kW, with an estimated cost of $4M for the first phase.

However, since then, we have acquired updated information concerning the phasing out of refrigerants utilized in the originally designated equipment. While replacement refrigerants are available, they generally exhibit lower performance levels, carry a potential risk of being phased out themselves, and also introduce the possibility of per- and polyfluoroalkyl substances (PFAs), which could pose significant long-term environmental hazards.

The newly proposed CO_2 air source heat pump solution not only addresses environmental concerns linked to conventional refrigerants but also provides significant improvements in efficiency and operational flexibility. UBCO's low-temperature district energy system (5th generation district energy network) provides a unique opportunity and novel application for CO_2 refrigerant-based Air-source heat pump. While the novelty of this application may introduce some institutional risk, it's important to recognize that CO_2 heat pump technology has a well-established history, primarily in industrial and refrigeration applications.

Furthermore, the use of CO_2 air source heat pumps is supported by the presence of local supplier and servicing companies with specialized training for maintenance tasks, ensuring reliable and convenient support. Additionally, it's worth highlighting that these projects are eligible for external energy efficiency rebates, offering potential savings in the range of $500,000.

Our analysis indicates that implementing the proposed CO_2 heat pump solution will drive 700 tCO_2e reduction (30% of total campus GHG emissions) in campus emissions compared to 500 tCO_2e in the original proposal. In addition, the CO_2 heat pump solution offers an expanded cooling capacity of 250 tons, which is equivalent to the combined cooling needs of the ICI building and two newly constructed residence buildings of the same size as the Skeena building. Implementing this solution would lead to a deferral of the

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need for a fluid cooler for these three new buildings. The flexibility of the CO_2 heat pump system allows it to adjust capacity based on changing heating and cooling demands and ensures scalability and modularity, allowing for easy expansion or modifications to meet future energy needs.

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Stranded load decarbonization

As per High-Level Campus Carbon Energy Strategy, Hybrid cluster plant approach (Zone-scale heat pumps generating and distributing hot and chilled water via a 4-pipe system) was identified as the most cost-effective solution for the campus. This approach not only aligns with UBC's carbon reduction objectives but also simplifies building operations, enhances resilience, and lays the groundwork for integrating waste heat, renewable energy, and other low-carbon energy sources in the future. The strategy is key to accelerate decarbonization of our core operations in support of UBC's Climate Emergency Declaration and emerging CAP 2030.

The cluster is considered to be a low-risk endeavor due to its simple scalable design with the unique feature being additional mechanical space provisions to support future building retrofits and new builds as they happen. This strategy eliminates need for large outdoor mechanical equipment, provides equipment redundancy and improves system resiliency.

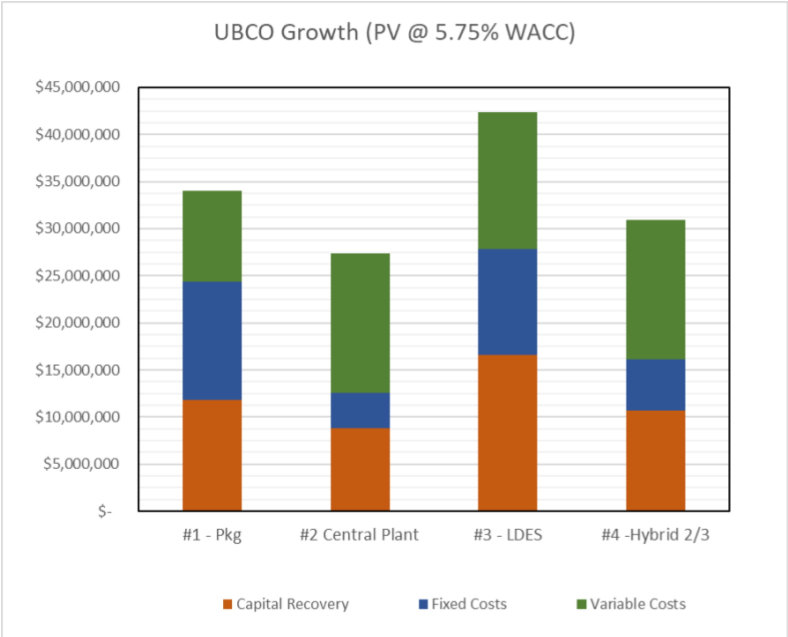

Figure 3: High-Level Campus Carbon Energy Strategy outcome

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Figure 3 above illustrates the present value costs associated with the new infrastructure growth across the four alternatives. It's important to note that despite the substantial upfront investment required for the in-ground 4-pipe infrastructure of the hybrid cluster plant system, this strategy was found to be the most cost-effective option. This cost advantage stems from the diversity and redundancy inherent in a centralized system, which ultimately leads to a reduction in the overall installed capacity. Moreover, the utilization of centralized cluster plant equipment will streamline maintenance processes and contribute to a decrease in ongoing operation and maintenance (O&M) expenses.

This approach holds true for all building types across the campus, including residences. As per Residence cluster plant study conducted in 2023, the anticipated costs for installing packaged Air Source Heat Pumps (ASHPs) in all four Residence buildings (Skeena, Purcell, and the two new residences) are projected to be at least 20% higher when compared to the cluster plant option. This cost disparity can be attributed to the economies of scale realized through the cluster plant approach, as well as the ability to employ simpler and more efficient equipment within this system. In conclusion, Retrofits/Modernization/Stranded Loads should be scheduled in alignment with DE strategy to minimize capital costs.

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Conclusion

In conclusion, the 2023 update of the Strategic Energy Master Plan (SEMP) for UBCO presents a comprehensive and forward-looking approach to address the institution's ambitious greenhouse gas (GHG) emissions reduction target of 65% below 2013 levels by 2030. The plan incorporates a range of strategic initiatives, including demand-side management, decarbonization efforts, and district energy improvements.

The recommended cost-effective strategies outlined in the plan offer a practical roadmap towards achieving these goals. These strategies include the adoption of CO_2 air source heat pumps (ASHPs), increased funding for demand-side management programs, and a focus on retrofitting and modernizing campus infrastructure. These measures not only align with UBC's commitment to sustainability but also demonstrate significant cost savings and long-term benefits.

Furthermore, the plan underlines the importance of transitioning to cleaner energy sources, such as the CO_2 heat pump solution, to complement demand-side efforts effectively. It also emphasizes the significance of decarbonizing the District Energy system and adopting a hybrid cluster plant approach to optimize efficiency, reduce emissions, and ensure long-term sustainability.

Overall, the 2023 Strategic Energy Master Plan provides a clear and pragmatic pathway for UBCO to meet its carbon reduction targets while simultaneously enhancing energy efficiency, financial stability, and environmental sustainability for years to come. This strategic approach not only aligns with UBC's Climate Emergency Declaration but also sets a precedent for responsible energy management in educational institutions.

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Appendix

FY23-24 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
C1-I	FY23-24	FIP ASC occupancy sensor-based DCV [occupancy sensors]	2,677	541,344	$61,000	$85,436	135	8	$575,308
C2-I	FY23-24	EME RCx	134	261,164	$75,000	$23,697	7	5	$37,753
C3-S	FY23-24	Study: District Energy optimization (Cooling tower and boiler efficiency improvement)	0	0	$30,000		0		
C4-S	FY23-24	Study: Conversion of high temp terminal to low temp + ARTS CV TO VAV	0	0	$30,000		0		
C5-S	FY23-24	Study: People counter for lecture theatre with spaces >50 [4 spaces identified FIP 121, LIB 305, SCI 247, COM 201] [dedicated unit for the whole space, intermittent occupancy]	0	0	$20,000	$0	0		
C6-I	FY23-24	EME HRV3 occupancy sensor replacement demand-controlled ventilation	TBD	TBD	$20,000	$0	-	8	($18,913)

FY24-25 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
D1-I	FY24-25	People counter for lecture theatre with spaces >50 [4 spaces identified FIP 121, LIB 305, SCI 247, COM 201, GYM basketball space]	TBD	TBD	$12,500	$0	0	15	($11,820)
D2-I	FY24-25	SCI lab exhaust heat recovery	1,500		$200,000	$22,710	75	20	$266,400

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D3-I	FY24-25	District Energy optimization (Cooling tower and boiler efficiency improvement)	631	11,042	$70,000	$10,474	32	20	$140,102
D4-S	FY24-25	Study: EME Strobic heat recovery	0	0	$25,000	$0	0	20	
D5-S	FY24-25	Study: MUA AHU DCV: Units running 24x7 and/or not utilizing CO2 sensors. [5 units: ASC MUA2, FIP MUA1, FIP MUA2, SCI AHU7, SCI AHU8]	0	0	$25,000	$0	0	20	
D6-I	FY24-25	ADM AHU 4 serves Exec rooms - SAT reset	TBD	TBD	$0	$0	0	20	TBD

FY25-26 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
E1-I	FY25-26	LIB building recommissioning	65	56,560	$100,000	$5,670	3	20	$3,276
E2-S	FY25-26	Study: EME high head lab DCV			$20,000	$0	0	20	
E3-S	FY25-26	Study: SCI Aircuity phase 2 DCV			$20,000	$0	0	20	
E4-I	FY25-26	Conversion of high temp terminal to low temp + ARTS CV TO VAV	0		$0	$0	0	20	$0
E5-I	FY25-26	Adjust DE system SWT using machine learning in collaboration with Researchers	444	24,268	$100,000	$8,729	22	20	$80,401
E6-I	FY25-26	EME Strobic heat recovery	1,060		$350,000	$16,049	53	20	$7,996

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E7-I	FY25-26	MUA AHU DCV: Units running 24x7 and/or not utilizing CO2 sensors. [5 units: ASC MUA2, FIP MUA1, FIP MUA2, SCI AHU7, SCI AHU8] - investigate internally	3,000	125,000	$250,000	$55,790	150	20	$893,485
E8-S	FY25-26	Study: Dedicated heat pump for Gym DHW			$30,000	$0	0	20	

FY26-27 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
F1-I	FY26-27	Endotherm for Hydronic Heating/Cooling Systems - may be pilot in one building (MWO), medium term	220	2,200	$100,000	$3,513	11	20	($17,382)
F2-I	FY26-27	EME high head lab DCV	TBD	TBD	$0	$0	0	20	TBD
F3-I	FY26-27	SCI Aircuity phase 2 DCV	550	62,000	$250,000	$13,470	28	20	$36,180

FY27-28 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
G1-I	FY27-28	ART AHU1 AHU2 heat recovery (revisit this project, potential decarbonization project)	500		$350,000	$7,570	25	20	($153,682)
G2-I	FY27-28	ASC Invivo Aircuity	TBD	TBD	$0	$0	0	20	TBD
G3-I	FY27-28	ASC building recommissioning	265	133,799	$100,000	$15,108	14	20	$194,132
G4-I	FY27-28	GYM building recommissioning - delay	115	45,696	$100,000	$5,530	6	20	$12,702

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G5-I	FY27-28	FIP building recommissioning	130	114,059	$100,000	$11,426	7	20	$117,501
G6-I	FY27-28	Dedicated heat pump for Gym DHW	769		$100,000	$11,648	38	20	$178,229

FY28-29 DSM bundle

ECM#	Funding year	Measure	Natural gas savings GJ	Electric savings kWh	Net Project cost	Annual savings $	GHG tCO2e	EUL	NPV
H1-I	FY28-29	ARTS LIB SCI ADM GYM LDES cooling load transfer - based on 4-pipe *(Project part of stranded load decarbonization, additional benefits other than energy savings)*	TBD	TBD	$0	$0	0	20	TBD
H2-I	FY28-29	ADM building recommissioning	132	65,116	$50,000	$7,395	7	20	$99,810
H3-I	FY28-29	UNC building recommissioning	110	101,200	$50,000	$10,060	6	20	$145,996