ENvision
INTELLIGENT ENERGY REDUCTION

Envision Energy Reduction Master Plan 2022-2030

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UNIVERSITY OF ALBERTA
FACILITIES AND OPERATIONS

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1. Introduction

The University of Alberta is a globally recognized leader in post-secondary education and research, and a leader in sustainability[1,2,3]. The university develops strategies to conserve resources, decrease the production of waste, minimize ecological footprints, decrease greenhouse gas emissions, and build a culture of sustainability at the institution and in the greater community of which it is a part. The university has demonstrated its commitment to energy efficiency and has made progress in recent years to advance a broad campus operational efficiency initiative.

The University of Alberta's Facilities and Operations (F&O) department is committed to reducing its impact on the environment and the energy management program has made substantial contributions to this effort for decades. The program was born during the energy crisis of the 1970s with a mandate to save on rising utility costs, but it has evolved since then into a robust, innovative, self-reliant and highly successful program. F&O has invested $85 million over 50 years to avoid an accumulated $430 million in utility costs and mitigate 2.8 million tonnes of GHG emissions.

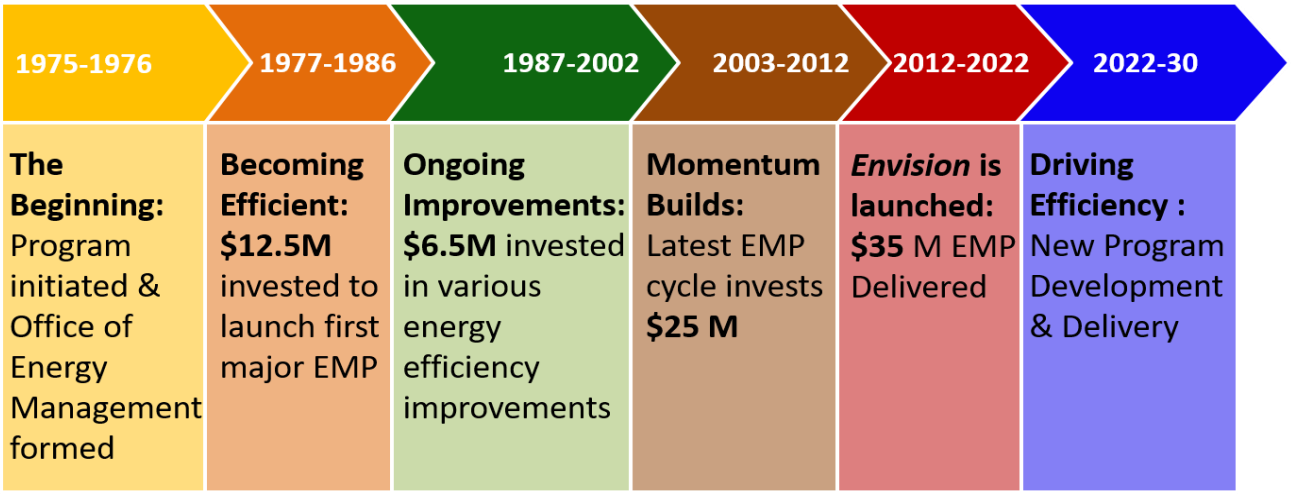

Figure 1. The Energy Management Program has grown steadily since its inception in 1975.

Today's *Envision: intelligent energy reduction* program is the main energy reduction program which seeks to go further, beyond low-hanging fruit to pioneer the implementation of new technologies in demand-based ventilation, renewable and alternative energy, and enterprise energy analytics. The university wants its facilities to be smart and adaptive so it can continue to provide excellent spaces for U of A students, staff and faculty to learn, research, work, live, and play.

[1] Times Higher Education World University Rankings https://www.timeshighereducation.com/world-university-rankings/university-of-alberta?ranking-dataset=133819. Accessed September 21, 2021.
[2] Maclean's University Rankings 2021. https://www.macleans.ca/education/university-rankings/canadas-best-universities-by-reputation-rankings-2021/. Accessed September 21, 2021.
[3] AASHE STARS Ratings. https://stars.aashe.org/institutions/participants-and-reports/?sort=rating. Accessed Sept-21, 2021.

This ***Envision*** **Energy Reduction Master Plan (EERMP)** provides an update on the current activities under *Envision* and highlights the program to the year 2030.

Setting the Stage for Continued Energy Reduction Success

Concerns about energy usage, environmental impacts, climate change, and increasing utility costs are increasingly adding pressure to realize still more significant energy reduction opportunities.

At the university specifically:

- Heavier energy demands are being placed on existing facilities with respect to occupancy and usage, and facilities are continually becoming more equipment intensive.
- Systems are required to run for longer hours including increased usage after normal hours to meet the increased demands being placed on facilities.
- Upgrading funds are not keeping pace with the decay of facilities. Facilities and systems are continually aging and decaying with subsequent loss of efficiency and increased energy consumption. With an ongoing deterioration of facilities, there is also a continual erosion of energy efficient operation strategies to solve immediate operating problems.
- Between 1990 and 2020, the university's building area increased by 54 per cent and its population by 54 per cent, with a substantial amount of building growth concentrated after the year 2005. The university has expanded its science and lab building space by 35 per cent since 2006 alone. Science and lab buildings are highly energy intensive and typically consume 2.5 times the amount of energy as an office/classroom space. The ongoing growth of the university and addition of new and energy intensive facilities over time increases the university's energy consumption, energy intensity, impact on the environment, and utility costs.

The university is not immune to utility rate increases and has no control over the world or local market forces that influence them. However, through vigilance in our energy conservation efforts we can exercise control over our energy consumption, thereby increasing the security and decreasing the cost of our utility bill and reducing our impact on the environment.

Additional cost-effective energy reductions can be made at the University of Alberta to address these issues and concerns. A continued and enhanced energy reduction program is necessary to keep our energy bill as low as cost-effectively feasible, to reduce our consumption of non-renewable resources, and minimize our environmental impact to best protect the long-term interests of the university and its facilities. Through its work, the *Envision* program can contribute to a secure energy future for the University of Alberta.

2. *Envision* Energy Reduction Master Plan (EERMP) Overview

Strategic Approach

The Energy Management and Sustainable Operations unit within Facilities and Operations is responsible for planning and implementing this EERMP. In this regard, EMSO's core objective is to reduce the university's utility consumption and greenhouse gas (GHG) emissions as much as

practical. EMSO strives to maintain the university's commitment to energy management and to ensure that:

- previous gains are built upon,
- energy bills are as low as practical,
- energy is used efficiently to reduce consumption of non-renewable resources,
- environmental impacts are reduced, and
- the university is developed and operated in a sustainable manner.

The university will take a three-pronged approach to implement its Climate Action Strategy, using the focus areas of Energy, Operations, and Teaching and Research as organizing categories. These categories allow the university to address its primary sources of GHG emissions, energy and operations, while pairing those efforts with an institution-wide commitment to integrate a climate lens throughout our teaching and research**,** truly living up to our promise of being the university for tomorrow.

The EERMP, focused primarily on energy, will assist in establishing the university as an innovative leader in addressing climate change and work towards reducing the university's greenhouse gas emissions by an additional 25,000 tonnes CO_2e by 2030 from 2022. The EERMP will focus on energy reduction goals and will help fulfill the goals of the University of Alberta's overall Climate Action Strategy (CAS). The EERMP will also integrate closely with the Master Energy Plan (MEP) under development by Utilities, targeting the District Energy System (DES) supplying the Greater Campus Area. EMSO continues to evolve, refine and implement the *Envision* program to adopt new technologies and approaches that advance energy efficiency at the U of A today, while continuously looking to the future and seeking out the most intelligent energy reduction solutions for generations to come.

The *Envision* program takes a strategic approach to energy management, organized into five focus areas:

1. Energy Efficiency and Reduction by Design
2. Recommissioning and Retrofitting
3. Continuous System Optimization
4. Greening the Supply
5. Education and Behaviour Change

1. Energy Efficiency and Reduction by Design

New buildings and major renovation projects present significant opportunities to infuse energy efficiency into a facility right from the beginning by using a total lifecycle approach. The level of foresight allowed by integrating energy management into early design phases means that everything from the building's envelope to its HVAC, lighting, and building control systems can be considered with a system lens and optimized through energy models. New designs also afford opportunities to leverage energy savings against a project's total cost, often enabling the implementation of new technologies that might otherwise be cost-prohibitive. Whenever these

projects exist, *Envision* seeks to maximize energy savings synergies with the overall project design and budget to make new facilities as efficient and advanced as possible.

2. Recommissioning and Retrofitting

With nearly 1.5 million square meters of existing building space, facility maintenance, renewal and alteration projects are perhaps the most frequent chance for *Envision* to seek energy savings opportunities, in conjunction with other facility system upgrades. This allows the optimization of available funding and an efficient use of resources to mutual benefit. This has been an ongoing practice of EMSO and has resulted in strong working relationships and collaborations within FO that *Envision* will continue to foster. These collaborations have also resulted in the piloting and testing of new technologies and approaches to gain experience with them (e.g. higher efficiency fans, ventilation, cooling, and fume hood/exhaust systems). These pilot projects have set the stage for future, large scale implementations of these technologies as part of maintenance, renewal, alteration, and energy initiatives.

3. Continuous System Optimization

Continuous system optimization makes dynamic changes to operating practices over time using data gathered during regular operation. This could involve reviewing utility data, making seasonal changes in response to occupancy changes in summer months, or adjusting temperature set points to adapt to changing outdoor air temperatures and other ongoing commissioning practices that ensure as little energy is wasted as possible. System optimization is becoming a particularly exciting area of energy management with the advent of several new technologies that enhance the ability to monitor facilities in real time and better automate system changes. This approach is an especially important way to maximize energy savings once equipment upgrades and efficiency projects are implemented. Three technologies in particular are being implemented in the *Envision* program: demand-based laboratory ventilation control, occupancy-based space ventilation, and energy analytics.

4. Greening the Supply

The production of renewable energy on site is an important additional strategy to reduce the environmental impact of the energy that is still required after maximizing energy reduction through efficiency and optimization initiatives. Some of the technologies under consideration are solar thermal, solar PV, energy storage and fuel cells. Solar photovoltaics (PV) offer particularly good potential for generating renewable electricity on site because of Edmonton's high number of sunny days each year, resulting in high solar PV potential (Figure 2). Although the cost of solar energy products is still high, it is steadily decreasing and this will allow an increased focus on the implementation of renewable energy technologies in the later parts of the *Envision* program. Meanwhile, *Envision* will undertake a series of projects to test, gain experience, and demonstrate various renewable energy technologies. Nearly 1,487 kW of solar photovoltaics and 150 kW of solar thermal panels are already in various stages of completion as of fall 2021. These implementations also create opportunities for teaching, research, experiential learning, and the education and engagement of students, faculty, and staff.

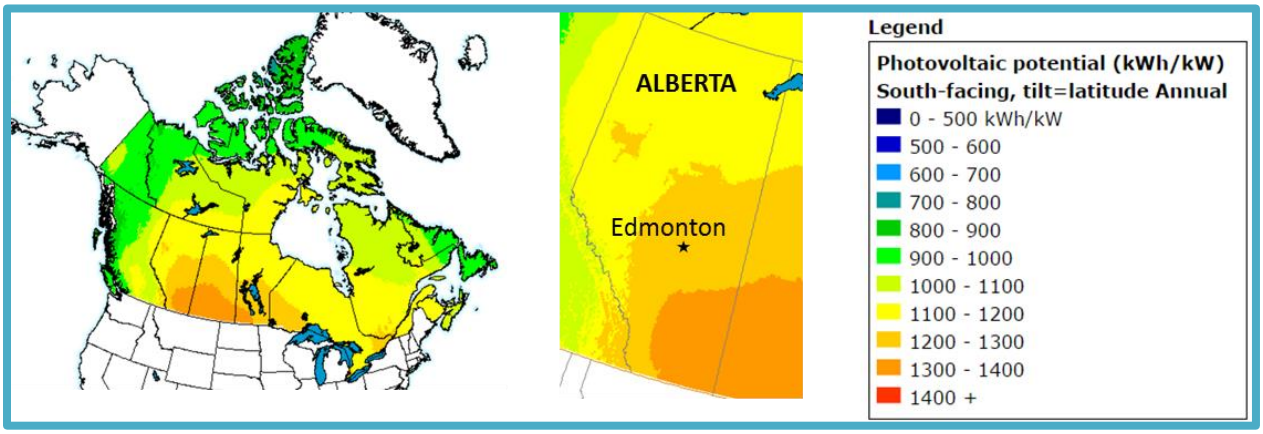

Figure 2. Annual photovoltaic potential in Alberta and Canada. (Natural Resources Canada[4])

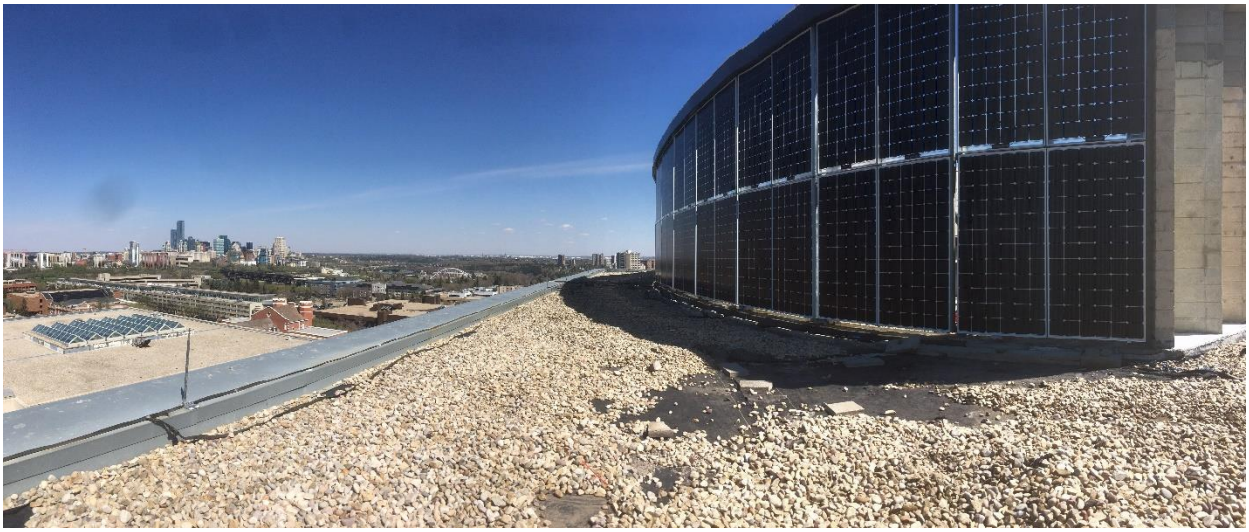

Figure 3. The Education Centre South bifacial solar PV installation acts as a screen for the mechanical penthouse.

5. Education, Research and Behaviour Change

While *Envision* largely focuses on infrastructure changes to reduce the energy demands of all campus facilities, a holistic approach to energy reduction and sustainability must also address peoples' knowledge, attitudes and behaviours. Education, research and empowerment to encourage positive behaviour change can lead to further reductions in energy use and more responsible university citizens. In collaboration with the Sustainability Council (SC), campus-wide education, awareness, engagement, and behaviour change programs are planned and in progress. Some examples of initiatives run by EMSO and/or the SC are listed below:

- **Campus as a Living Lab (CALL)** research projects use the university's campus as a testing ground for sustainability solutions. These projects connect the classroom to the real world, enabling students to find the solutions and generate the data that we need to build a better world—the work that University of Alberta academics are doing every day.

[4] PV Potential and Insolation. Natural Resources Canada. http://pv.nrcan.gc.ca. Accessed January 15, 2016.

- **Campus Sustainability Grants** fund projects that use a campus-focused lens to improve operations and practices, advance the stewardship of our natural environment, conduct collaborative research in sustainability, encourage integrated and collaborative solutions to sustainability problems, or advance a culture of sustainability on our campuses. Up to $50,000 per major project is available.
- **Sustainability Scholars** was founded by the University of Alberta and the City of Edmonton. Since 2015, it has grown to include close to a dozen municipal, corporate and institutional partners. These partnerships create unparalleled opportunity for graduate students to share their ideas and innovations, and to also learn best practices from working professionals. The program was designed to develop University of Alberta graduate students' professional aptitudes, especially in sustainability-related career fields. Scholars have worked on climate action plans, energy improvements in affordable housing, wildlife tracking, groundbreaking energy storage, green building standards, and more. These projects enable our graduate students to apply their hard-earned knowledge to real-world challenges. As a result, real progress to shift the Edmonton area toward sustainability and climate resilience has been made.
- The **Shut the Sash** project encourages people to be safe and save significant energy when fume hoods are not in use.
- **Green Spaces** lets students and staff integrate sustainable practices into both work and living space at the University of Alberta. Events, Labs, Offices, Food Vendors and Residences can earn Bronze, Silver, or Gold certification for adopting sustainable practices.
- **Flip the Switch** stickers on light switches remind building occupants to turn off the lights when leaving a room.
- **Building Dashboards** in buildings with renewable energy installations will educate people about the real-time resource use of campus buildings.
- **FigBytes** is an online platform that is used to maintain the university's greenhouse gas inventory, as well as track and report progress towards GHG reduction and other sustainable operations goals.

Figure 4. Flip the Switch sticker, Shut the Sash mobile, and sample page from FigBytes online dashboard.

Scope of the *Envision* Energy Reduction Master Plan

The University of Alberta has several campus and research stations. This plan focuses on the campuses and research stations that are directly operated and maintained by the F&O department.

Campuses	Research Stations
North Campus	Kinsella Research Station
South Campus	University of Alberta Botanic Gardens
Augustana Campus	Augustana Miquelon Lake Research Station
Campus Saint-Jean	

Key Collaborations

EMSO is responsible for the implementation of *Envision* and all other operational sustainability and GHG reduction activities, but EMSO does not work in isolation. The success of EMSO programs require constant collaboration with other departments within FO and beyond including:

- **Asset Management and Operations**
- **Integrated Planning and Partnerships**
- **Utilities**
- **Campus Services**
- **Support and Recreation Services**
- **Sustainability Council**
- **Multiple Faculties**

EERMP Goals

Target	Year
Overall energy intensity 15% below 2019/20 levels	**2030**
2,500 kW renewable energy installed	**2030**
495 kW alternative energy installed	**2030**
350,000 GJe Total Energy Reduction from 2022	**2030**
25,000 tonnes CO_2e reductions from 2022	**2030**

Figure 5. Lister Residence – Mackenzie Hall's solar PV provides electricity and shade to reduce heat gain from the hall's sunny south exposure.

Greening the Supply

2735 kW of renewable and alternative energy capacity complete or in progress					
Campus	**Building**	**Project Description**	**Technology**	**Installed Capacity**	**Status**
Augustana Campus	Augustana Miquelon Lake Research Station	Rooftop solar PV	Solar PV	4 kW	Complete
	Forum Building	Rooftop solar PV	Solar PV	90 kW	Complete
		Rooftop solar thermal	Solar Thermal	13 kW	Complete
	Jeanne and Peter Lougheed Performing Arts Centre	Rooftop solar PV	Solar PV	35 kW	Complete
		Theatre fly tower, building integrated solar PV	Solar PV	122 kW	Complete
Campus Saint-Jean	Pavillon McMahon	Rooftop solar PV	Solar PV	30 kW	Complete
North Campus	Agriculture/Forestry Centre	ALES Atrium glazing-integrated solar PV	Solar PV	10 kW	Complete
	Chemical/Materials Engineering Building	Rooftop solar PV	Solar PV	60 kW	In Progress
	Dentistry/Pharmacy Building	Rooftop solar PV	Solar PV	232 kW	In Progress
	Donadeo Innovation Centre for Engineering	Rooftop solar PV	Solar PV	90 kW	In Progress
	ECERF/ETLC	Rooftop solar PV	Solar PV	45 kW	Complete
	Education Centre South	Rooftop vertical screen, bifacial solar PV	Solar PV	44 kW	Complete
	Li Ka Shing Back Pressure Turbine	Back pressure turbine	CHP	250 kW	Complete
	Lister - Henday Hall	Wall-mount & solar PV shade	Solar PV	120 kW	Complete
	Lister - Kelsey Hall	Wall-mount & solar PV shade	Solar PV	120 kW	In Progress
	Lister - Mackenzie Hall	Wall-mount & solar PV shade	Solar PV	120 kW	Complete
	Morrison Structural Engineering Lab	Rooftop solar PV	Solar PV	50 kW	In Progress
	Nîpisîy House	Rooftop solar PV	Solar PV	90 kW	Complete
	Physical Activity and Wellness (PAW) Centre	Wall-mount solar PV shade	Solar PV	23 kW	Complete
		Rooftop solar thermal	Solar Thermal	133 kW	Complete
	R.E. Phillips Building	Rooftop solar PV	Solar PV	15 kW	In Progress
	Myer Horowitz Theatre (SUB)	theatre fly tower building-integrated solar PV	Solar PV	180 kW	In Progress
	Universiade Pavilion	Wall-mount & rooftop solar PV	Solar PV	500 kW	In Progress
South Campus	Agri-Foods Discovery Place	Combined heat & power unit	CHP	55 kW	Complete
	Dairy Research & Technology Centre	Rooftop solar PV	Solar PV	90 kW	Complete
	Medical Isotope and Cyclotron Facility	Building-integrated solar PV	Solar PV	23 kW	Complete
	Saville Community Sports Centre	Combined heat & power unit	CHP	80 kW	Complete
	Swine Research & Technology Centre	Combined heat & power unit	CHP	75 kW	Complete
U of A Botanic Garden	Greenhouse	Combined heat & power unit	CHP	35 kW	Complete

3. Implementation to 2030

Description of Technologies

The EERMP seeks to utilize a combination of more traditional, well-established methods to improve energy efficiency and reduce consumption, as well as explore, test, and take advantage of new technologies as they arise and are feasible. Wherever possible, *Envision* also strives to involve students and researchers in the exploration of new technologies, thereby benefiting both the academy and the operations of the institution. Each stage of the reduction plan's implementation will involve conducting detailed energy auditing and analysis to determine the most cost-effective energy reduction measures in each facility.

Typical Implementation Measures

The following list represents several well-established implementation measures that will be executed. These measures are similar to those used by the energy management program in the past (Refer to Appendix A for a list of past projects from the Energy Management Program 2003 to 2012).

- ✓ HVAC Load Reduction Technology
- ✓ Lighting system upgrades and retrofits. LED Street lighting. Human Centric Lighting.
- ✓ Fan system upgrades. Fan-wall technology.
- ✓ Upgrades and improvements in efficiency to heating, ventilating, and air-conditioning systems
- ✓ Re-commissioning and system optimization
- ✓ Fume hood replacements and controls upgrades for demand based controls
- ✓ High efficiency motor replacements
- ✓ Waste heat recovery systems (air and water)
- ✓ Variable speed drive installations (fans and pumps)
- ✓ Controls systems modifications and upgrades. Advanced analytics and AI technology.
- ✓ Automation of building room controls
- ✓ Piping and equipment insulation
- ✓ Building envelope sealing and upgrades
- ✓ Micro-steam combined heat and power (CHP) turbines

New Technologies and Implementation Options

In addition to the traditional energy reduction measures identified above, several new focus areas are in various stages of exploration and implementation.

- ✓ Demand-based ventilation (DBV) laboratory control
- ✓ Occupancy-based space ventilation
- ✓ Energy analytics

Each of the following initiatives, outlined briefly below, will address deferred maintenance; significantly reduce the university's energy consumption, energy intensity, greenhouse gas emissions, and utility costs. The *Envision* program will continue demonstration activities

exploring the long-term potential of emerging technology and techniques under a campus as a living lab program.

Demand-Based Ventilation (DBV) Laboratory Control

Laboratory environments consume significant amounts of energy, typically twice the amount of energy as an office/classroom space. Labs are often programmed to exchange 100% of the conditioned air with outside air 8-10 times an hour, 24/7. In addition to the energy required to supply and exhaust the large volumes of air, a substantial amount of energy is used to heat, cool and condition the fresh outside air.

DBV control technology is an integrated sensing, control, and optimization solution that reduces building energy and operating expenses while maintaining indoor environmental quality. The system continuously monitors and analyses the facility's air, detecting parameters such as total volatile organic compounds (TVOCs), particulates, carbon dioxide, carbon monoxide, temperature, and dew-point temperature. The system then dynamically reduces air change rates when the air is clean, often the majority of the time, and raises the rates when pollutants are sensed to maintain indoor environmental quality and safety.

The continuous monitoring and analysis process also inherently facilitates real time commissioning that allows system degradation to be easily identified and corrected, maintaining long-term energy savings. Actionable system information that helps to quickly address issues when they arise results in better management of the facility, tracking of airside energy use, and improvement in lab management and safety.

Occupancy Based Space Ventilation

Occupancy based space ventilation determines real-time space occupancy levels using people counters and then through integration with the building automation system, triggers real-time and dynamic control of the space ventilation systems. Fan operation, fan speed, levels of ventilation and fresh air are thereby based on the actual number of occupants in a space rather than on levels required for the maximum potential number of occupants at all times.

Capturing occupancy trends over time also allows operations staff to better understand actual space utilization, optimize ventilation system operation and implement energy efficient strategies. Overall this responsive system results in reduced fan power requirements, reduced energy used to heat or cool fresh air, increased air quality and occupant comfort, and reduced operating and maintenance costs.

Energy Analytics

The energy analytics initiative will employ an Enterprise Energy Information Management System (EEIMS) to improve facilities management and develop a long-term strategy for energy cost reduction through efficiency gains in heating, ventilating, and air-conditioning (HVAC) systems.

The EEIMS will consolidate various real-time and historical energy related data sources (e.g., weather data, energy consumption, costs, building automation system information, control and

monitoring points) into a data warehouse, analyze and normalize the data for subsequent processing, thereby providing a platform for analytics tools to easily access the data and obtain usable information. This information is categorized, stored and analyzed to provide a series of functions that include energy usage history, benchmarking, recognition of anomalies, display on dashboards, fault diagnostics and detection.

Facility engineering, maintenance, and operations staff can then perform in-depth diagnostics, engineering analysis, and monitoring to develop actionable strategies in a small fraction of the time it took with earlier methods.

The goal is to gain a better understanding of the real-time and historical trending through use of rule-based engines and analytics tools that can define key areas of improvement that will fall into multiple categories:

- Scheduling improvements
- System optimizations
- Energy load shedding, and/or shifting strategies
- Maintenance process improvements including deferred maintenance and predictive maintenance versus scheduled maintenance
- Predicting energy cost deviations versus usage
- Identifying usage patterns, anomalies, and identifying system process adjustments for greater optimization.

The EEIMS will help to identify areas to improve energy and operational efficiency, enhance operational and management effectiveness, improve building performance, save energy, systematically improve occupant comfort, lower maintenance costs, measure and verify results, and allow deployment of internal and external maintenance and operations resources in a proactive and efficient manner.

Envision Status and future roadmap (2012-2030)

2012 to 2021 Progress	**2021/22 to 2030 Future programming**
$35M Total *Envision* Investment 75 % Complete to 2020/21 26,700 tonnes CO_2e avoided annually to 2020/21 $4.5M utility cost avoided annually to 2020/21	***Envision* is expanded** Additional 25,000 tonnes CO_2e avoided annually by 2030 Additional $3M utility cost avoidance by 2030

Table 1. Completed *Envision* Projects (2012-2020)

Building	Project	Progress	Energy Savings Realized
Augustana Residence	LED lighting retrofit	Completed	**210,000 GJe TOTAL**
Jeanne and Peter Lougheed Performing Arts Centre (Augustana)	Energy efficiencies and renewable energy	Completed	
Physical Activity and Wellness (PAW) Centre	Energy efficiencies and renewable energy	Completed	
Katz Centre for Pharmacy and Health Research	Demand-based laboratory ventilation	Completed	
South Academic Building	Window replacement	Completed	
Car parks (All)	Lighting retrofits	Completed	
CCIS	DBV, HVAC / Mechanical	Completed	
Li Ka Shing	DBV, HVAC / Mechanical	Completed	
Research Transition Facility	LED lighting retrofit	Completed	
Nîpisîy House	Energy efficiency measures	Completed	
Peter Lougheed Hall	Energy efficiency measures	Completed	
Natural Resources Engineering Facility (NREF)	DBV, HVAC upgrades	Completed	
Agriculture/Forestry Building	Pump system VSDs and controls	Completed	
Biological Sciences Centre	Pump system VSDs and controls / Water	Completed	
Campus Saint-Jean	HVAC / Mechanical Optimization and PV	Completed	
Augustana Campus	HVAC / Mechanical Optimization and PV	Completed	
General Services Building	Domestic water reduction	Completed	
Medical Sciences Building	Pump system VSDs and controls / Steam	Completed	
Agri-Foods Discovery Place	CHP Installation	Completed	
Dairy Research & Technology Centre	CHP Installation	Completed	
Saville Community Sports Centre	CHP Installation	Completed	
Swine Research & Technology Centre	CHP Installation	Completed	
U of A Botanic Garden Greenhouse	CHP Installation	Completed	
Edmonton Waste Management Centre	Partnership project high solids anaerobic digestion facility HSADF	Completed	

Implementation Plan (2022-2030)

Tentative Priority Projects

While many of the feasibility studies, concept work and choices of specific projects have been completed, the following table outlines tentative priorities in line with other FO priorities.

Table 4. Tentative Priority Projects

Building	Project	Progress	Energy Savings Predicted
Alberta School of Business	HVAC/Mechanical optimization, people counters, HVAC load reduction, VAV box conversion	Design / Development	**135,000 GJe TOTAL**
Biological Sciences Centre	Lab renewals, DBV upgrades utilizing dynamic barrier fume hoods. Central system upgrades	Design / Development / Implement	
National Institute for Nanotechnology (NINT)	Lab renewals, DBV upgrades, LED Retrofits, Chilled water optimization.	Design / Development	
Chemical/Materials Engineering Building (CMEB)	Lab DBV upgrades	Design / Development	
Universiade Pavilion	Total envelope upgrade, alternative and renewable energy	Design / Development	
Various	Deployment of Enterprise Energy Analytics	Design / Development / Implementation	
Various	Exhaust Stack / Exhaust Fan optimizations in several Laboratory Facilties	Design / Development	
Agriculture/Forestry Centre	Lab renewals, DBV upgrades, fume hood replacements, central systems	Design / Development / Implementation	
Various	Water efficiency upgrades	Design / Development / Implement	
Various	Solar PV / Alternative energy deployments	Design / Development / Implement	

4. Conclusion

The *Envision* program will continue its work to reduce the impact of the University of Alberta's facilities on the environment, enhance the teaching, research and study spaces, and seek opportunities to advance industry practices and research in the area of energy management for the betterment of the entire university and the communities in which it is a part.

5. Acknowledgements

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Appendices

Appendix A – Energy Management Program, Past Projects Summary (2003-2012)

Building Name	Project Description	Annual Utility Savings ($)	Annual Energy Savings (GJe)	Annual GHG Savings (tonnes CO_2e)
YEAR 1				
Agriculture-Forestry	Growth chambers	**$650,000**	**69,000**	**5,300**
Biological Sciences	Lighting			
Biological Sciences	VFD			
Cameron Library	VFD			
Education Carpark	VFD			
Extension	Classroom lighting			
Exterior	Lighting			
General Services Building	4th floor lighting			
GSB	VFD			
Humanities	VFD			
Ice Arena	Heat recovery			
Law Building	Lighting			
Materials Mgmt	Lighting			
Mechanical Engineering	VFD			
Rutherford Library North	VFD			
Various	Audits and studies			
YEAR 2				
Ag/Forestry	Lighting	**$565,000**	**60,800**	**4,700**
Ag/Forestry	Greenhouse lighting			
Arts Building	Lighting			
Earth Sciences	Lighting			
Exterior	Lighting			
Medical Sciences	Lighting			
Rutherford North	Lighting			
Various	Audits and studies			
YEAR 3				
Biological Sciences	VFDs	**$525,000**	**56,600**	**4,350**
CCIS-II NLT	VSD			
Clare Drake Arena	Ice controls			
ERS F75 Poultry Research	Lighting			
Extension Centre	Lighting			
Exterior	Lighting			
H. M. Tory	Lighting			
HUB	VFDs			

Building Name	Project Description	Annual Utility Savings ($)	Annual Energy Savings (GJe)	Annual GHG Savings (tonnes CO_2e)
Humanities	Lighting			
Pavilion	Lighting			
Van Vliet Centre E & W	Lighting			
Various	Audits and studies			
YEAR 4				
Agriculture/Forestry	Heat recovery	**$565,000**	**61,100**	**4,700**
Biological Science	Cage washer			
Chemistry East	Lighting			
Chemistry West	Heat recovery			
Corbett Hall	Lighting			
Fine Arts	Lighting			
General Services	Lighting			
GSB Mechanical	HVAC optimization			
Student's Union	Lighting			
Tory, Humanities, GSB	Window tinting			
Various	Audits and studies			
YEAR 5				
Admin	Lighting	**$433,000**	**46,900**	**3,330**
CAB	Window film			
Chemistry West V-Wing	AHU			
Education North	Lighting			
Education South	Lighting			
GSB	Condenser removal / heat recovery			
HUB Main Floor	Lighting			
Industrial Design Studio	Lighting			
Mechanical Engineering	Lighting			
Morrison Structural	Lighting			
RCMS	Lighting			
RTF	Lighting			
Various	Audits and studies			
YEAR 6				
Augustana Campus	Lighting	**$355,000**	**39,400**	**4,130**
Bio Sciences	Heat recovery			
CSJ Campus	Lighting			
Environmental Engineering	Lighting			
HMRC	Lighting			

Building Name	Project Description	Annual Utility Savings ($)	Annual Energy Savings (GJe)	Annual GHG Savings (tonnes CO_2e)
Htg. Plant, Corridor & Ext	LED lighting			
Li Ka Shing (HRIF)	Steam turbine			
SUB	Ventilation optimization			
Timms Centre	Lighting			
Various	Audits and studies			
YEAR 7				
Campus wide	Lighting controls	**$465,000**	**41,800**	**3,940**
Clinical Sciences	Lighting			
Ed South	Window tinting			
GSB	Rad heating / AHU optimization			
Li Ka Shing (HRIF) Level 4	Controls			
Med. Sciences	Heat recovery			
Multi-AHU	VSD and Controls			
SAB	Window glazing			
Various	Solar PV projects			
PROGRAM TOTAL:		**$3,558,000**	**375,600**	**30,450**

Notes:

1. Energy savings are based on the University of Alberta Utilities Department cost forecast for electricity, steam and chilled water in 2020/21.