ENvision
INTELLIGENT ENERGY REDUCTION

# Energy Reduction Master Plan 2017-2020

May 2017

UNIVERSITY OF ALBERTA
FACILITIES AND OPERATIONS

## Table of Contents

# 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 (FO) 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. FO has invested $80 million over 40 years to avoid an accumulated $380 million in utility costs and mitigate 2.3 million tonnes of GHG emissions.

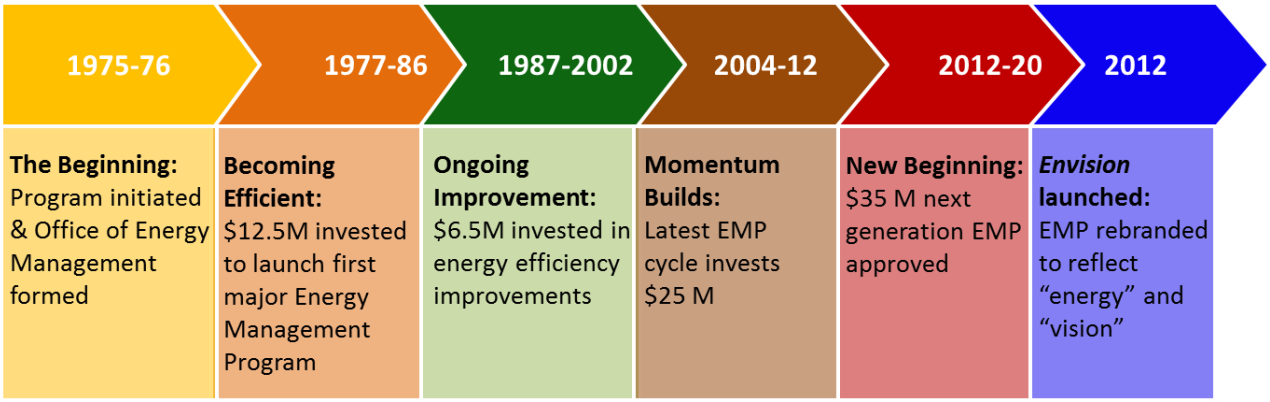


**Figure 1.** The Energy Management Program has grown steadily since its inception in 1975.

Today's *Envision: intelligent energy reduction* program 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 UAlberta students, staff and faculty to learn, research, work, live, and play.

## 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.

[1] Times Higher Education World University Rankings 2016. https://www.timeshighereducation.com/world-university-rankings/university-of-alberta?ranking-dataset=133819. Accessed January 15, 2016.
[2] Maclean's University Rankings 2016. http://www.macleans.ca/education/best-of-the-best-introducing-the-2016-macleans-university-rankings/. Accessed January 15, 2016.
[3] AASHE STARS Ratings. https://stars.aashe.org/institutions/participants-and-reports/?sort=rating. Accessed January 15, 2016.

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 2015, the university's building area increased by 56 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 increases utility costs.

We are not immune to utility rate increases and have 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.

Significant cost-effective energy reductions remain to 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. Energy Reduction Plan Overview

## Strategic Approach

The Energy Management and Sustainable Operations unit within Facilities and Operations is responsible for planning and implementing the energy management plan. 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.

With much reflection on past initiatives and successes, EMSO launched a new generation of the Energy Management Program in 2012. *Envision: Intelligent Energy Reduction* fuses energy and vision to reinvigorate and solidify the program's commitment to adopt new technologies and approaches that advance sustainability at UAlberta 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 that can be summarized into five tactics.

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 Facilities and Operations 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 larger scale implementations of these technologies as part of maintenance, renewal, alteration, and energy initiatives either singly or in concert.

## 3. Continuous System Optimization

Continuous system optimization is focused on making 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 already tackled. Three technologies in particular are being explored for implementation in the early phases of the *Envision* program: demand-based laboratory ventilation control, occupancy-based space ventilation, and energy analytics. These three technologies are described in more detail in Section 3 below.

## 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, wind, geothermal, 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 (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 770 kW of solar photovoltaics and 150 kW of solar thermal panels are already in various stages of completion as of spring 2017. These implementations also create opportunities for teaching, research, experiential learning, and the education and engagement of students, faculty, and staff.

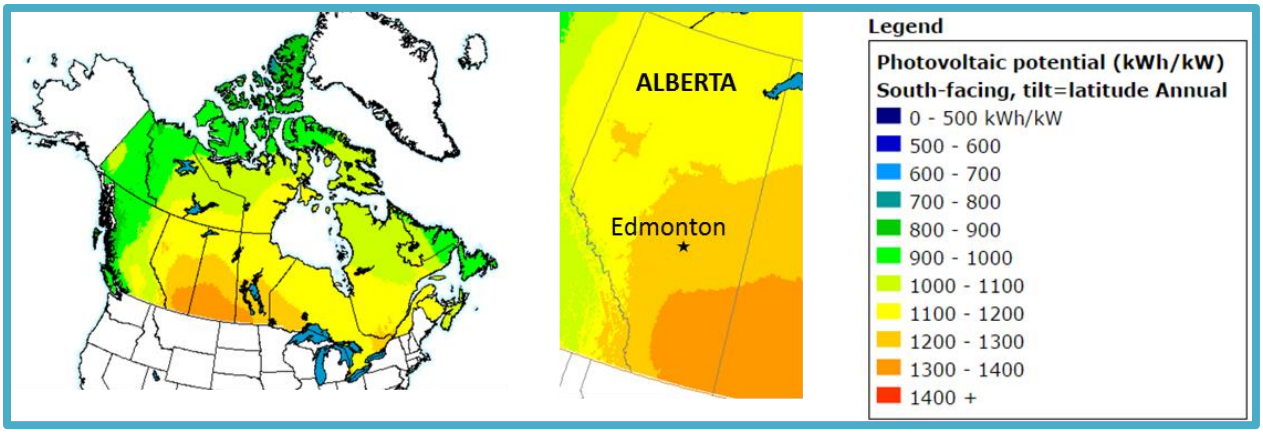


**Figure 2.** Annual photovoltaic potential in Alberta and Canada. (Natural Resources Canada[4])

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

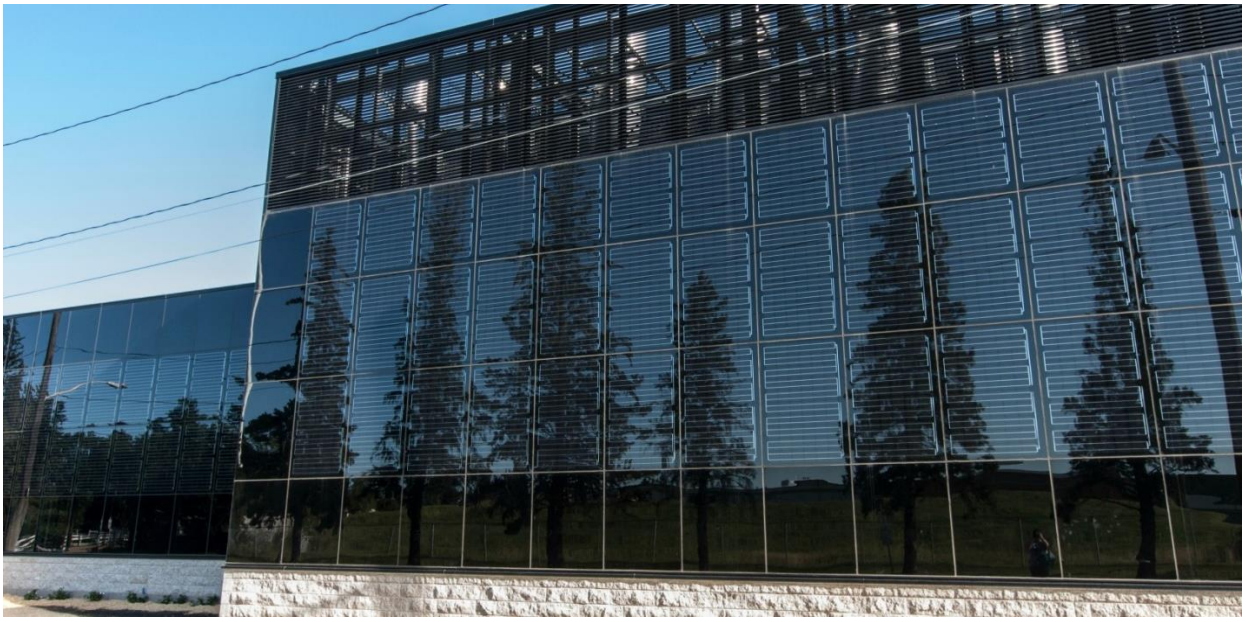

**Figure 3.** Building-integrated solar PV at the Medical Isotope and Cyclotron Facility.

## 5. Education and Behaviour Change

While *Envision* largely focuses on infrastructure changes to directly reduce energy use by campus facilities, a holistic approach to energy reduction and sustainability must also address people's knowledge, attitudes and behaviours. Education and empowerment to encourage positive behaviour change can lead to further reductions in energy use and more responsible university citizens. In collaboration with the Office of Sustainability, campus-wide education, awareness, engagement, and behaviour change programs are planned and in progress. Some examples of these initiatives are listed below.

- The Green Labs program targets behaviour and infrastructure changes within lab settings.
- The Shut the Sash project encourages people to be safe and save energy by shutting VAV fume-hood sashes when not in use.
- 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 will be 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.

**2016-2020 Sustainability Plan**

In addition to the strategic approach of the program itself, *Envision* will advance the greater campus sustainability initiative and aligns with several goals and strategies within the new Sustainability Plan for the university. The following goals and strategies are copied directly from the plan, for reference.

**Goal 2.4:** Integrate sustainability into curriculum and academic programming in ways that foster critical, interdisciplinary, long-term and systems thinking on sustainability.

> **Strategy b.** Facilitate the use of university campuses, field stations, research facilities and demonstration projects for sustainability research, teaching and practice

**Goal 3.2:** Establish the university as an innovative leader in addressing climate change and work towards reducing the university's greenhouse gas emissions to 17% below 2005 levels by 2020.

> **Strategy c.** Implement innovations, upgrades, preventative maintenance and best practices in energy management, climate change mitigation and environmental protection.
> **Strategy e.** Complete the next $35 million five year Energy Management Program *Envision*.
> **Strategy f.** Create an energy use reduction plan informed by the Envision program that outlines baseline energy use and sets reduction targets to be reached by the year 2025.

## Scope of the Energy Reduction Plan

The University of Alberta has five campuses and several research stations. This plan focuses on the campuses and research stations that are directly operated and maintained by the university's Facilities and Operations (FO) department, as well as some Ancillary Services (AS) facilities.

| Campuses | Research Stations |
|---|---|
| North Campus | Ellerslie Research Station |
| South Campus | Kinsella Research Station |
| Augustana Campus | Meanook Research Station |
| Campus Saint-Jean | Devon Research Station |

**Key Collaborations**

The Energy Management and Sustainable Operations (EMSO) unit within FO is responsible for the implementation of *Envision* but EMSO does not work in isolation. The success of the *Envision* program and its strategic approach require constant and productive collaboration with other units within FO including:

- **Operations and Maintenance**
- **Planning and Project Delivery**
- **Utilities**
- **Ancillary Services**
- **Office of Sustainability**

## Energy Reduction Goal

| Target | Year |
|---|---|
| **Overall energy intensity 8.5% below 2016/17 levels** | **2020** |
| **770 kW renewable energy installed** | **2020** |
| **450 kW alternative energy installed** | **2020** |
| **210,000 GJe Total Energy Reduction from 2016/17** | **2020** |

# Greening the Supply Highlights

With an average number of 321 days and 2299 hours of sunshine each year, solar energy technologies are a key part of the greening of UAlberta's energy supply.

**Solar PV Projects Completed**

- **23 kW** Medical Isotope and Cyclotron Facility
- **122 kW** Jeanne and Peter Lougheed Performing Arts Centre (Augustana)
- **23 kW** Physical Activity and Wellness (PAW) Centre
- **10 kW** ALES Atrium
- **60 kW** Chemical/Materials Engineering Building
- **90 kW** Forum Building (Augustana)
- **35 kW** Jeanne and Peter Lougheed Performing Arts Centre Expansion (Augustana)
- **90 kW** Donadeo Innovation Centre for Engineering
- **3.5 kW** Miquelon Lake Research Station
- **90 kW** ECV Residence

**Solar Thermal Projects Completed**

- **13 kW** solar thermal, Forum Building Augustana Campus
- **133 kW** of solar thermal at the Physical Activity and Wellness (PAW) Centre

**Solar PV Projects in Progress**

- **15 kW** R. E. Phillips Building
- **50 kW** Electrical and Computer Engineering Research Facility and the Engineering Teaching and Learning Complex (ECERF/ETLC)
- **TBD (50-250 kW)** Universiade Pavilion

**Solar Thermal Projects in Progress**

- **10 kW** expansion of the solar thermal system at Augustana Campus' Forum Building

**770 kW of renewable energy capacity complete or in progress**

**Figure 5.** Artistic rendering of the PAW Centre, with solar thermal (top left) and solar PV (solar shade), courtesy of Group 2 Architecture.

# 3. Implementation to 2020

## Description of Technologies

The *Envision* plan 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. The following sections describe both traditional and new measures, a list that will no doubt be expanded before the lifetime of this plan is complete.

### Typical Implementation Measures

The following list represents several well-established implementation measures that can be utilized. These measures are similar to those used by the energy management program in the past.

- ✓ HVAC Load Reduction Technology
- ✓ Lighting system upgrades and retrofits
- ✓ Fan system upgrades
- ✓ Upgrades and improvements in efficiency to heating, ventilating, and air-conditioning systems
- ✓ Re-commissioning and system optimization
- ✓ Fume hood replacements and controls upgrades
- ✓ High efficiency motor replacements
- ✓ Waste heat recovery systems (air and water)
- ✓ Variable speed drive installations (fans and pumps)
- ✓ Controls systems modifications and upgrades
- ✓ Automation of building room controls
- ✓ Piping and equipment insulation
- ✓ Building envelope sealing and upgrades
- ✓ Micro-steam turbines (CHP)

**New Technologies and Implementation Options**

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

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

Each of these initiatives, outlined briefly below, is expected to significantly reduce the university's energy consumption, energy intensity, greenhouse gas emissions, and utility costs.

**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 their air with outside air 8-10 times an hour, 24 hours a day, seven days a week. In addition to the energy required to supply and exhaust these large quantities of air, substantial amounts of energy are also expended to heat or cool and condition this 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 dewpoint 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.

The continuous monitoring and analysis process also inherently facilitates real time commissioning that allows system degradation to be easily observed 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., 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. It is anticipated that improvements will fall into multiple categories including:

- 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.

## Implementation Phases 1 to 3

Phases 1 and 2 of the *Envision* program are complete. Feasibility studies and Design continue for Phase 3, with several projects in construction and completed.

**Table 1. Phase 1 Projects**

| Building | Project | Progress | Energy Savings Predicted |
|---|---|---|---|
| **Augustana Residence** | Lighting retrofit | Completed | **79,000 GJe TOTAL** |
| **Jeanne and Peter Lougheed Performing Arts Centre (Camrose)** | Energy efficiencies and renewable energy | Completed | |
| **PAW Centre** | Energy efficiencies and renewable energy | Completed | |
| **Katz Building** | Demand-based laboratory ventilation | Completed | |
| **South Academic Building** | Window replacement | Completed | |
| **Car parks** | Lighting retrofits | In construction | |

**Table 2. Phase 2 Projects**

| Building | Project | Progress | Energy Savings Predicted |
|---|---|---|---|
| **CCIS** | DBV, HVAC / Mechanical | Completed | **78,000 GJe TOTAL** |
| **Li Ka Shing** | DBV, HVAC / Mechanical | Completed | |
| **RTF** | Lighting retrofit | Completed | |
| **ECV Infill Residences** | Energy efficiency measures | Completed | |
| **Peter Lougheed Leadership College** | Energy efficiency measures | Completed | |
| **Agri-Food Discovery Place** | DBV, HVAC upgrades | In Design | |
| **NREF** | DBV, HVAC upgrades | Completed | |

**Table 3. Phase 3 Projects**

| Building | Project | Progress | Energy Savings Predicted |
|---|---|---|---|
| **Agriculture-Forestry Building** | Pump system VSDs and controls | In Construction | **75,000 GJe TOTAL** |
| **Biological Sciences** | Pump system VSDs and controls / Water | In Construction | |
| **Campus Saint-Jean** | HVAC / Mechanical Optimization | Completed | |
| **Augustana Campus** | HVAC / Mechanical Optimization and PV | Completed | |
| **General Services Building** | Domestic water reduction | Completed | |
| **Medical Sciences** | Pump system VSDs and controls / Steam / PRV | In Construction | |
| **Earth Sciences Building** | DBV, HVAC / Mechanical upgrades | Design / Development | |
| **Agri-Foods, Saville, Swine Research, Devonian Greenhouses** | CHP Installations | In Construction | |
| **Edmonton Waste Management Centre** | Partnership waste-to-energy project to build high solids anaerobic digestion facility HSADF | Completion 2017/18 | |

## Tentative Priority Projects, Phases 4 to 5

Phases 4 and 5 will be the remaining two of the accelerated 5-Phase $35 million program. While much of the feasibility work and choices of specific projects have not yet been completed, the following table outlines some tentative priorities in line with other FO priorities for the next few years.

**Table 4. Phases 4 and 5 Tentative Priority Projects**

| Building | Project | Progress | Energy Savings Predicted |
|---|---|---|---|
| **Business Building** | HVAC/Mechanical optimization, people counters, HVAC load reduction, VAV box conversion | Design / Development | **135,000 GJe TOTAL** |
| **Chemistry Complex** | Lab renewals, DBV upgrades utilizing | In Construction | |

| | | | |
|---|---|---|---|
| | dynamic barrier fume hoods. Central system upgrades | | |
| **Cameron Library** | Total facility renewal, envelope upgrades, alternative and renewable energy | Design / Development | |
| **Pavilion** | Total envelope upgrade, alternative and renewable energy | Design / Development | |
| **HMRC** | Lab renewals, DBV upgrades, fume hood replacements, central systems | Design / Development | |
| **Various** | Deployment of Enterprise Energy Analytics | Design / Development | |
| **Agriculture Forestry** | Lab renewals, DBV upgrades, fume hood replacements, central systems | Design / Development | |
| **Various** | Water efficiency upgrades | Design / Development | |
| **Various** | Solar PV / Alternative energy deployments | Design / Development | |

## 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 for its community members, 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

Primary Contact:
Michael Versteege, P.Eng, LEED AP
Manager, Energy Management and Sustainable Operations
Email: mike.versteege@ualberta.ca
Phone: 780-492-4024

Acknowledgements
Shannon Leblanc, MSc, BSc
Sustainability Coordinator, Energy Management and Sustainable Operations

# 6. Appendices

## Appendix A – Past Projects Summary

| Building Name | Project Description | Annual Utility Savings ($) | Annual Energy Savings (GJe) | Annual GHG Savings (metric tonnes $CO_2$ equivalent) |
|---|---|---|---|---|
| **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 | | | |

| Building Name | Project Description | Annual Utility Savings ($) | Annual Energy Savings (GJe) | Annual GHG Savings (metric tonnes $CO_2$ equivalent) |
|---|---|---|---|---|
| HUB | VFDs | | | |
| 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 | | | |
| Htg. Plant, Corridor & | LED lighting | | | |

| Building Name | Project Description | Annual Utility Savings ($) | Annual Energy Savings (GJe) | Annual GHG Savings (metric tonnes $CO_2$ equivalent) |
|---|---|---|---|---|
| Ext | | | | |
| Li Ka Shing (HRIF) | Steam turbine | | | |
| SUB | Ventilation optimization | | | |
| Timms Centre | Lighting | | | |
| Various | Audits and studies | | | |
| **YEAR 7** | | | | |
| Campus wide | Lighting controls | | | |
| Clinical Sciences | Lighting | | | |
| Ed South | Window tinting | | | |
| GSB | Rad heating / AHU optimization | | | |
| Li Ka Shing (HRIF) Level 4 | Controls | **$465,000** | **41,800** | **3,940** |
| 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 2017/18.