
# Brock University

## Carbon Reduction Plan

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30 Years | ecosystem

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# Introduction

## Brock University's Response

Canada's emissions reduction and net-zero targets set an ambitious goal and Brock University has responded. These aggressive emissions reduction targets require a different kind of thinking. To outline a path towards this goal, Brock University collaborated with Ecosystem, building on previous efforts, to develop a "*Made for Brock University*" Carbon Reduction Plan (CRP or Plan).

## Breaking the Silos

Brock University's Carbon Reduction Plan supports the institution's short-, medium-, and long-term objectives and underlines the University's brand promise of overcoming barriers, igniting possibilities and life-changing breakthroughs that link every aspect of the institution. As such, this Plan was developed through consultative engagement with various stakeholders at Brock, including executive leadership, facilities professionals, energy management specialists, and capital development and finance experts to create a comprehensive approach that addresses operations, deferred maintenance, financial feasibility, procurement, academic engagement, and ultimately drive deeper value on the path towards carbon neutrality. The Plan's recommendations are backed by industry best practices and supported by comprehensive analysis using data-driven models.

## Roadmap to Achieve Carbon Neutrality

The following six "win strategy" actions are the backbone of Brock University's strategy to achieve carbon neutrality:

1. Transition on-site electricity production from natural gas to the Ontario low carbon electrical grid
2. Smart electrification of heating on campus to reduce fossil fuel (natural gas) use
3. Conservation by reducing campus buildings' wasted energy
4. Align end-of-life equipment and infrastructure replacement and renewal with the transition to maximize its economic value
5. Support transition delivery strategies with appropriate policies, standards, project procurement, and change management
6. Engage students in the process to support Brock University's well-established reputation for student-centred learning

## Strategic Pathway

Over the next three decades, Brock University must work to transform its energy system (central utility plant and buildings), from one that is energy intensive and powered by fossil fuels, to one that is more energy efficient and powered by clean electricity and renewable fuels. The assessment presented in the report indicates that the University has viable options to achieve this transformation. The design of each specific action will not only reduce greenhouse gas (GHG) emissions but also align with the University's goals and priorities including deferred maintenance and capital planning.

In addition, a strategic pathway to carbon neutrality by 2050 requires not only a change in utility infrastructure, but also a comprehensive set of policies, guidelines, green building standards, and procurement strategies to guide decision-making in ways that maximize value.

### Goals

- Academic engagment and alignment with Brocks' mission and brand
- Carbon reduction and energy efficiency on path to net-zero
- Capital planning & deferred maintenance alignment
- Optimize financial value and procurement approach

### Win Strategies

- Transition electricity production from natural gas to low carbon electrical grid
- Smart electrification of heating on campus to reduce fossil fuel use
- Conservation by reducing campus buildings' wasted energy
- Align infrastructure renewal with the transition to maximize its economic value
- Support transition delivery strategies with appropriate policies
- Engage students

### Path

- Stakeholder alignment and commitment
- Market sourced outcome-based implementation partner selection
- Validate KPI success

### Resources

#### People

- Project Manager
- Construction Manager
- Energy Manager
- Sustainability Manager
- Other stakeholders, etc.

#### Funding

- Internal funding and/or external financing
- $40 million for 75% carbon reduction by 2030
- Baseline year 2013

### ROI

- Positive NVP and optimal cost per GHG procurement selection criteria

**ALIGNMENT**

# Brock University's Carbon Reduction Plan At a Glance

Brock University

**Breaking Through - Overcoming Barriers, Igniting Possibilities**

### 1 Carbon Reduction Plan

- Target 75% carbon reduction by 2030 (2013 baseline year reduction)
- Net-zero by 2050

### 2 Supply Switch from Fossil Fuels to Clean Energy

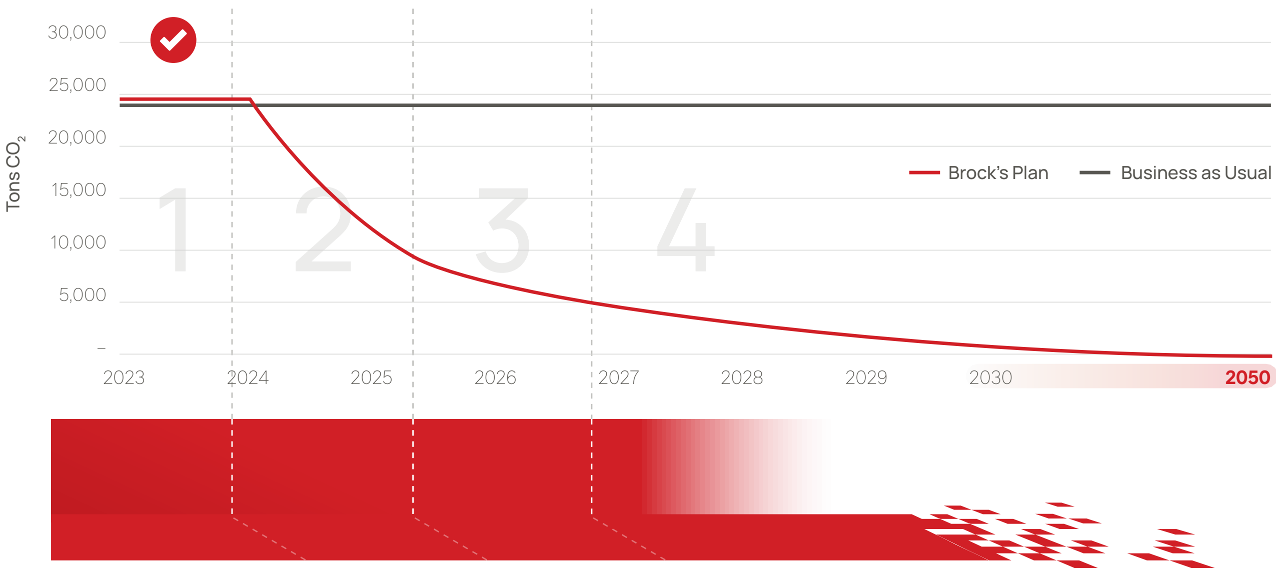
- Central Utility Plant conversion
- Mitigating rising utility cost

### 3 Energy Use Reduction

- Reduce building energy waste:
  - Legacy building upgrades
  - New buildings net-zero ready

### 4 Emerging Technologies Integration and Deep Building Retrofits

- Agile adoption of new and proven technologies
- Respond to changing regulatory and market opportunities
- Deep building retrofits




## Carbon Reduction Principles

**Breaking through Silos**

### Brock's Community Engagement

- Student experience
- Academic excellence
- Breaking through the silos

### Financial Sustainability

- NPV positive
- Maximize GHG per dollar
- Leveraging asset renewal capital

### Maximize Outcomes

- Efficient delivery of integrated design and implementation

### Accountability through Balanced Scorecard

- Carbon reduction
- Positive NPV
- Net deferred maintenance reduction

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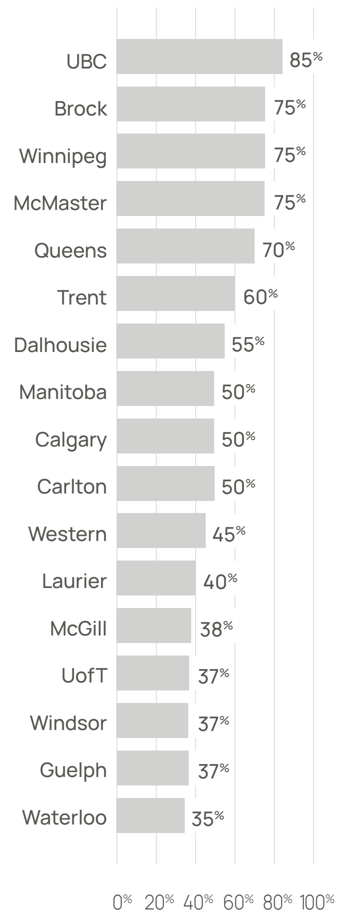
# Benchmarking Carbon Goals

The Government of Canada has set a goal to achieve net-zero emissions by 2050. To achieve this goal, the government is investing in multiple sectors, including higher education institutions. In alignment with the government, 75% of universities nation-wide and almost every major university in Ontario has set net-zero emissions goals by 2050. To meet this target, most universities have issued guidelines, roadmaps, or plans of action that often contain interim goals to significantly reduce carbon emissions on their campuses in the near future (2030). Universities in Canada are also taking action through "*Canada's Universities Action for Net Zero Initiative,*" to align its members on collaborating in all aspects of addressing climate change.

A common practice among higher education institutions is to set interim goals. Interim goals are important on the journey towards carbon neutrality for several reasons. Taking the first step towards lowering emissions and achieving interim goals often demonstrates that a significant portion of their carbon footprint can be eliminated with tested and practical measures at a reasonable cost. Similarly, Brock University can make a dramatic leap in a relatively short period of time which will lower Brock's operating costs and produce economic returns. The interim goal also provides accountability. Having interim goals to monitor progress is vital in keeping on track towards the final objective of carbon neutrality by 2050. For Brock, there is the added significance of setting and achieving this goal for Brock's branding, as well as the impact that ambitious and leading sustainability targets have on recruitment of both teachers and students. This is further elaborated in the next section on framing goals.

The following table shows selected higher education institutions and their stated interim carbon emissions reduction goals for 2030. It should be noted that Canada's emissions reduction target is 40% below 2005 levels by 2030.

Interim (2030) Carbon Emissions Reduction Goals



Many institutions have set interim goals for 2030. Universities in Ontario and elsewhere are investing in technologies such as heat recovery, battery storage, electrification, and more to achieve their goals. Their goals range anywhere from 35 to 85 percent reduction in emissions by 2030. Brock's achievements in infrastructure improvement over the past few years has placed the University in an advantageous position. Based on discussions with Brock's asset management and utility department and the stakeholder session held at Brock, a review of the installation and energy analysis shows that a carbon reduction goal of 75 percent by 2030 (baseline year 2013) is an ambitious and attainable target for Brock. This goal will place Brock at the forefront of sustainability on Canadian university campuses. The costs associated with such a project, along with the savings this reduction will provide, are in alignment with Brock's capabilities and needs. In addition, the added benefits of such a project aligns with Brock's visions and goals.

An ambitious carbon emissions reduction goal of 75 percent by 2030 is achievable at Brock

The table below summarizes the interim goals and 2050 GHG reduction goals of higher education institutions.

| | | | Interim Goals (2030) | 2050 |
|---|---|---|---|---|
| **College/University** | **Students** | **Year** | **%** | **100%** |
| Guelph | 24,400 | 2030 | 37% | Yes |
| Carleton | 19,600 | 2030 | 50% | Yes |
| Laurier | 16,700 | 2030 | 40% | Yes |
| Trent | 12,600 | 2030 | 3,800 $tCO_2$ remaining | Yes |
| Windsor | 10,200 | 2030 | 37% | No, 80% below 1990 |
| Queens | 23,600 | 2030 | 70% | 2040 |
| Waterloo | 34,700 | 2030 | 35% | Yes |
| UofT | 69,400 | 2030 | 37% | Yes, net positive |
| Western | 34,000 | 2030 | 45% | Yes |
| McMaster | 30,400 | 2030 | 75% | Yes |
| UBC | 44,000 | 2030 | 85% | 2035 |
| McGill | 39,700 | 2030 | 37.5% | 2040 |
| Calgary | 35,000 | 2030 | 50% | Yes |
| Winnipeg | 9,400 | 2030 | 75% | 2035 |
| Dalhousie | 20,200 | 2030 | 55% | Yes |

# Framing Goals

Brock's Carbon Reduction Plan requires strong long-term commitment and leadership from the University that will support action and coordination across multiple functions. It demands a shared vision, clear objectives, and a commitment to act.

To drive alignment and consensus, framing goal engagement sessions were facilitated by Ecosystem to discuss how to better support the drive towards carbon neutrality by 2050. The framing goals groups identified gaps, requirements, and desired outcomes that would advance a triple bottom line: social, environmental, and economic. When campus projects and operations follow these framing goals, they will be aligned with the carbon reduction vision.

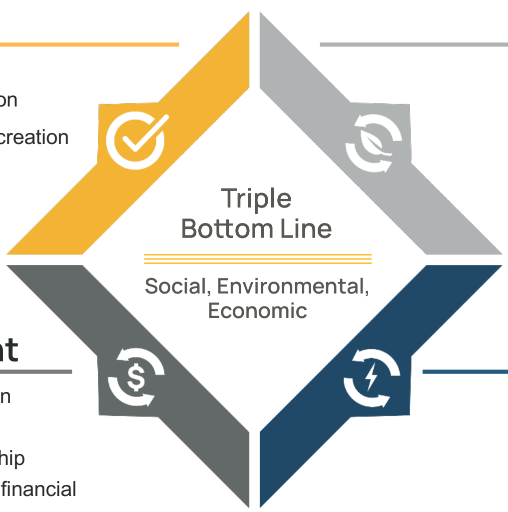
## Framing Goals towards 2050 Carbon Neutrality

### Academic Mission

- High quality teaching and learning environment to support Brock's mission
- Foster inclusion, engagement and cocreation with faculty and students
- Demonstrate project and results - No green washing

### Carbon Reduction

- Meeting higher education sector benchmarks
- Measurable and valid performance outcomes
- Realistic, cost effective, operable, sustainable both environmentally and economically
- 2030 actionable plan / 2050 aspirational goal
- Business continuity through multiple energy sources




### Financial/Procurement

- Enforce new KPI for project evaluation (cost per GHG, PB, NPV)
- Innovative procurement and partnership
- Financing/funding option's impact on financial performance

### Capital Planning

- Improve campus FCI
- Leverage 5 -10-year capital plan funding for strategic implementation
- Reusing and repurposing existing system supported by O&M training

# Vision

Brock University believes in creating a sustainable campus while promoting engagement amongst various stakeholders at the University, including its students. At the University, sustainability has been an ongoing effort in creating an environment where people are aware of the impact their choices have on energy consumption, water consumption, and greenhouse gas (GHG) emissions levels. From promoting carsharing and reusable water bottles to fair-trade initiatives and rainwater collection, Brock has implemented multiple initiatives and projects that positively impact its students and buildings, thereby making strides in reducing its environmental impact. These initiatives often lower utility and other costs, leading to cost savings that can be used to improve the University and student experience.

Brock is also coming off a successful multi-year sustainability effort achieved through the District Energy Efficiency Project (DEEP) which reduced the University's GHG emissions by 15%. Along with other initiatives, the project increased awareness while curbing GHG emissions. Some initiatives include a Campus Sustainability Dashboard, the Energy Conservation and Demand Management Plan, and other projects in the Niagara Region. These efforts have set the pace and momentum for Brock to move towards an aggressive carbon reduction plan that is bold, yet responsible and achievable. The goals set out in this Plan will bring Brock to the forefront of sustainable universities in Canada.

The Carbon Reduction Plan should be actionable in a way that allows Brock to coherently replace its assets (asset renewal), address its decarbonisation goals, design new buildings, futureproof its campus and ensure money is effectively allocated towards these goals. The Plan aligns with Brock's values while tackling these ambitious targets, helping promote recruitment at the University. Having one of the most sustainable campuses in Ontario will attract teachers and students from the province as well as from around the world.

Cost and return on investment (ROI) are very important to the University. Reducing operating expenses (OPEX) and renewing assets will push project feasibility and improve the bottom line. The Green and Sustainable aspects of the Plan is a large motivator for Brock employees and students. The Plan will highlight Brock's location and gold standard to differentiate the University from its peers. Keeping with the theme of sustainability, the Plan also takes advantage of existing infrastructure (reusing and repurposing assets).

The Plan also identifies interim steps towards a low carbon campus without restricting Brock from future technologies. Future consideration will be given to the changes that Brock will make to its campus and the available measures that will arise from technological advances. Brock will create intermediate goals and build projects now that will allow for subsequent actions to be taken in the future to reach net-zero emissions by 2050.

# Framing

## Carbon Goal

Brock's next step is to determine its interim carbon reduction goals. The carbon goals and objectives should meet higher education sector benchmarks. The goals of universities across Ontario and the nation are detailed in the previous section. The 2030 goals of other Universities range from ambitious to matching the minimum Province-wide goal of 37% reduction. Brock wants to define goals that include no carbon washing that have performance outcomes which are measurable and valid. The plan will be realistic, cost effective, operable, and sustainable both environmentally and economically. The 2030 goal will be an actionable plan with measures defined. While the 2050 goal is aspirational and leaves some space for future technology.

## Financial Evaluation Tools and Criteria

The financial performance of measures must be evaluated over the entire project lifecycle. As such, energy cost projection tools must be developed. The scenarios detailed in the measure scenarios section contain cost and savings results. The financial evaluation considers the costs associated with purchasing gas and electricity (operational expenses) as well as the capital costs to complete the defined savings measures (capital expenses). The viability of the projects is determined by weighing these costs and the cost of carbon against the savings that Brock will generate from the measures. Brock's combined heat and power (CHP) is under regulation (OBPS/ERP with assistance) for the cost of carbon. The real cost of carbon for Brock has certain intricacies due to the gas consumed for the CHP being considered differently than the carbon from the remaining gas load and from the grid. This is because a portion of the CHP gas is being used to make electricity.

These factors are modeled in certain financial evaluation tools which include the following KPIs: Cost per GHG (aligns with federal funding), payback (PB) using projected energy cost, and net present value (NPV) over the life of project.

## Business Continuity (Redundancy and Resiliency)

Brock University will use the existing Cogen as redundant and resilient equipment. The existing equipment will also be used to leverage low carbon solutions. The CHPs remaining operational will allow for a peak shaving measure to save money as shown in the scenario details. Multiple energy sources will bring more options to provide resiliency over the years and existing equipment can also be operated differently to provide OPEX resiliency and to extend equipment life. The district energy system (DES) is identified as a single point of failure and with asset renewal, the infrastructure will have added resiliency and increased life expectancy.

## Operations

Brock can achieve a campus with low carbon emissions and high energy efficiency. The operation of Brock's campus utility systems will change with the transformation to low carbon technologies and a campus-wide overhaul. The existing operations team is skilled, trained, and open to innovation and Ecosystem can assist in training the operations team to operate the equipment as designed to achieve maximum reductions and savings. The selection of the existing operation staff was based on capacity to learn, curiosity, and trainability which is beneficial when adapting to new equipment and procedures. The goal of the operation of the new system is to have motivated employees focused on the outcomes and purpose of the entire project and not only their day-to-day tasks.

## Financing

Brock University should analyze prospective capital improvement investments based on Brock's expected cash flow. It should be noted that building upgrades for carbon reduction and energy performance also generate cash flow. They reduce the cash flowing out to pay for energy consumption. In some circumstances, energy efficiency investments can also produce non-energy cash benefits, such as maintenance savings.

# Scenarios

This section presents the business-as-usual (BAU) scenario and two alternative scenarios that significantly reduce Brock's GHG emissions over the current BAU.

## Scenario Summary

| Scenario | GHG Emissions* | CAPEX | Savings OPEX |
|---|---|---|---|
| Business-as-usual (2022) | 23,008 | N/A | $0 |
| Scenario 1 | 5,752 (75%) | $38.5M | $2.5M |
| Scenario 2 | 3,278 (85%) | $98.7M | $3.5M |

* (Tonnes and % reduction vs BAU)

## Business-as-Usual Scenario

### Central Utilities Building

Currently, electricity is produced at Brock University's Central Utilities Building (CUB) using four Combined Heat and Power (CHP) generators. Brock produces around 72 percent of its own electricity. The remaining supply comes from the Ontario grid.

The CHP produces hot water that is used to provide campus building heating through the district heating system. A natural gas boiler is used to produce heat when the CHP cannot meet the heating demand, which typically happens in the winter.

Chilled water is produced primarily by an absorption chiller, which is fed from the CHP heat. An electrical centrifugal chiller is used to produce chilled water when the absorption chiller cannot meet the cooling demand, which typically happens during the summer months.

## District Energy System (DES)

The DES is the backbone of energy distribution from the CUB to the buildings. The distribution of thermal energy from the CUB to the campus building is done through a water-based system. The water-based system is comprised of a 4-pipe system (hot/chilled water pipes each with supply and return).

| Building | Cooling Capacity (Tonnes) | Heating Capacity (MBH) |
|---|---|---|
| Alan Earp Residence | – | – |
| Arthur Schmon Tower | – | 5,120 |
| Cairns Complex | 1,800 | 21,000 |
| Central Utilities Building | 2,600 | 14,650 |
| DeCew Residence | – | 7,000 |
| G&B Vallee Residence | – | – |
| Goodman School of Business | – | – |
| Inniskillin Hall | – | – |
| MCC – Block A | – | – |
| MCC – Block B/E | – | – |
| MCC – Block C/F | – | – |
| MCC – Block D/G | – | – |
| MCC – Block H | – | – |
| MCC – Block J | – | – |
| Plaza Building | 140 | 4,062 |
| Rankin Family Pavilion | – | – |
| Residence 8 | – | – |
| Robert SK Welch Hall | – | 1,840 |
| Scotiabank Hall | – | – |
| South Block | – | – |
| Student-Alumni Centre | – | 1,964 |
| Thistle Complex | – | 1,840 |
| Walker Sports – Field House | – | – |
| Walker Sports – Phys. Ed | – | – |
| **Totals:** | **4,540** | **57,476** |

## Satellite Plants

In addition to the CUB, there are additional satellite plants for heating and cooling. The Cairns Building and Plaza are the main satellite plants. Cairns houses boilers and chillers for its own demand. It is also connected to the DES. However, the building's system cannot currently exchange energy back into the DES. Both buildings do not currently operate with the DES. As a result, these buildings are still using natural gas.

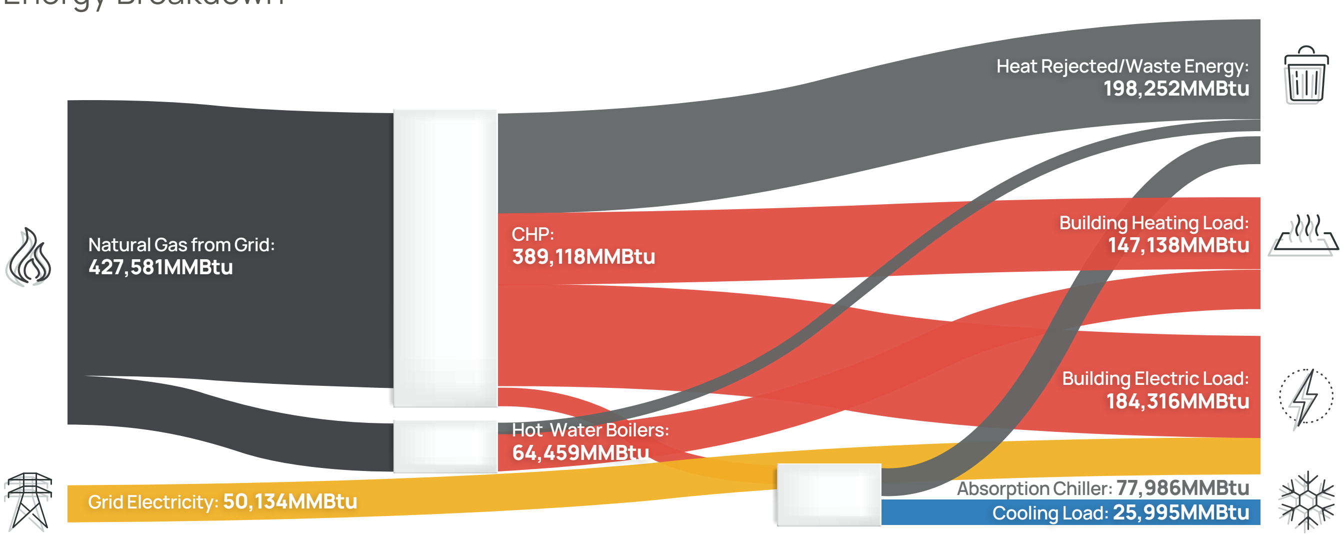
The overall description and operation mode of the system can be found in the following studies attached as **Appendix B**:

- Campus Chilled Water System Report - Chorley + Bisset
- Campus Hot Water System Report - Chorley + Bisset

## Energy Consumption on Campus

| BAU (2022) | CHP | Energy Consumption (Purchased) | Total Energy Consumption |
|---|---|---|---|
| Electricity (kWh) | 37,275,690 | 13,927,336 | **51,203,026** |
| Natural Gas ($m^3$) | 9,753,472 | **11,484,835** | 11,484,835 |

## Energy Breakdown



# Projected Scenario 1: 75% Carbon Reduction by 2030

As mentioned earlier in the introduction section of the Carbon Reduction Plan, Scenario 1 will achieve carbon reduction by doing the following:

1. Transition on-site electricity production over time from natural gas to the Ontario low carbon electrical grid.
2. Smart electrification of heating on campus to reduce fossil fuel (natural gas) use.
3. Conservation by reducing campus buildings' wasted energy.

## Central Utilities Building

In this scenario, clean Ontario grid electricity will be the primary source of electricity on site. The existing CHP will be reused and repurpose to reduce electrical cost. They will do so by reducing the Global Adjustment (GA) coincident peak. To maintain critical building operation, a battery or emergency generator will have to be installed on campus.

New central (CUB) and decentralized (Cairns) heat recovery chillers (HRC) will provide heating to the buildings. Heat recovery chillers will recover heat from the buildings (ventilation units and exhaust) and various processes (data center and fridges). The HRCs will provide hot water to the building using the DES. Electrical boilers and natural gas boilers will be used to ensure the heating campus demand is met during high demand times.

A new dedicated chiller will have to be installed in the CUB to supplement the existing high efficiency 1,600-ton chiller. The existing absorption 1,000-ton chiller will be used only during GA peak events to minimize electrical input even further.

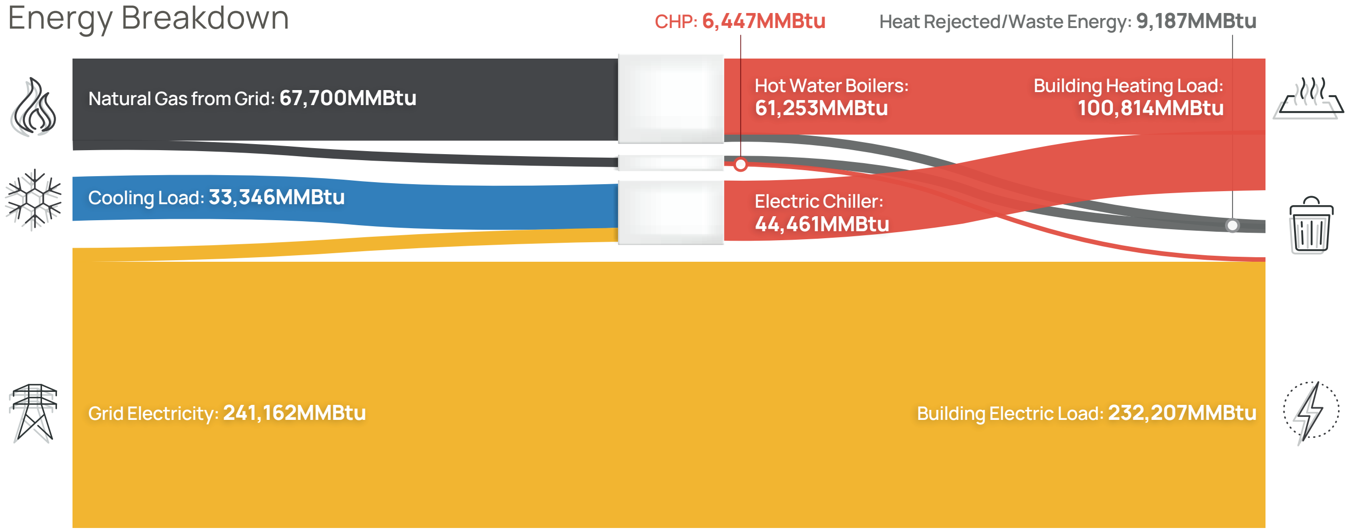
## District Energy System

In Scenario 1, DES will be extended / improved to minimize natural gas use in satellite locations on the campus, mainly in Cairns and Plaza building.

## Energy Consumption on Campus

| Scenerio 1 | CHP | Energy Consumption (Purchased) | Total Energy Consumption |
|---|---|---|---|
| Electricity (kWh) | 600,000 | 63,907,049 | **64,507,049** |
| Natural Gas ($m^3$) | 173,160 | **1,645,262** | 1,645,262 |

## Energy Breakdown




# Projected Scenario 2: 85% Carbon Reduction by 2030

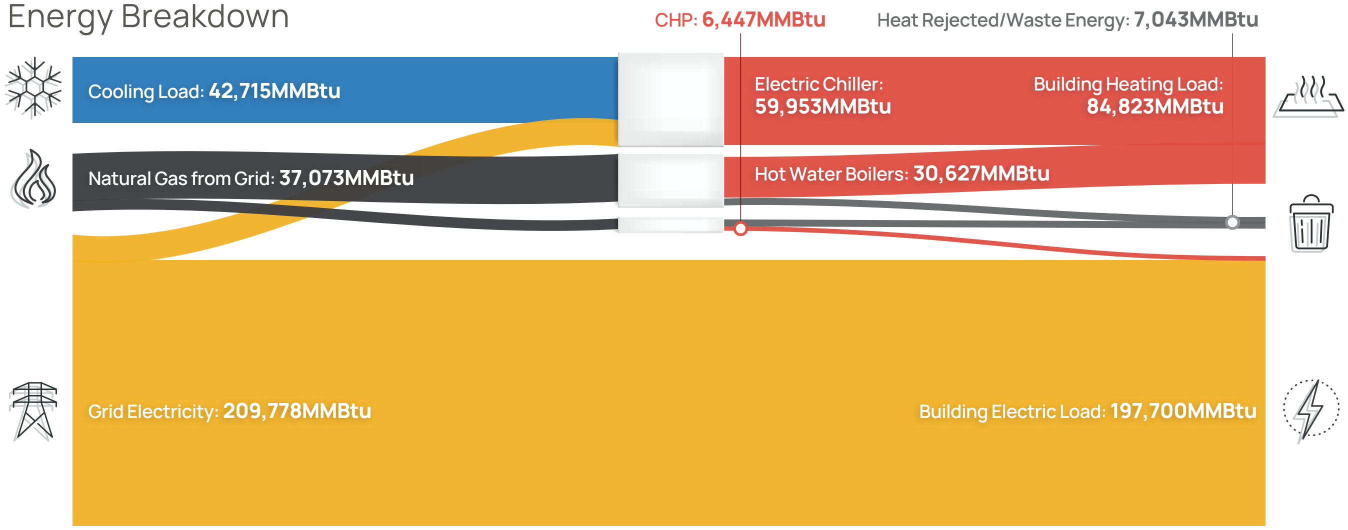
To reduce carbon emission even more aggressively, Scenario 2 will target energy conservation in the buildings through deep energy retrofit projects. The deep energy retrofit projects will target high intensity energy consumption building systems and aim to reduce energy consumption as a whole. This can be achieved through larger asset renewal projects focused on the following systems:

- Ventilation system modernization: Ventilation systems use a large portion of heat and electricity to operate. Ventilation system modernization (VAV, heat recovery, increase control, displacement ventilation) can have a significant impact on energy consumption and demand
- Lighting modernization: A complete LED lighting revamp coupled with occupancy and schedule controls
- Envelope improvement: Envelope improvement will ensure air tightness and reduce conduction. It will include projects such as window replacement, door replacement, roof and wall insulation, etc.
- Continuous recommissioning: A continuous process will ensure energy KPIs are maintained over time

## Energy Consumption on Campus

| Scenerio 2 | CHP | Energy Consumption (Purchased) | Total Energy Consumption |
|---|---|---|---|
| Electricity (kWh) | 600,000 | 54,320,992 | **54,920,992** |
| Natural Gas (m³) | 173,160 | **883,631** | 822,631 |

## Energy Breakdown

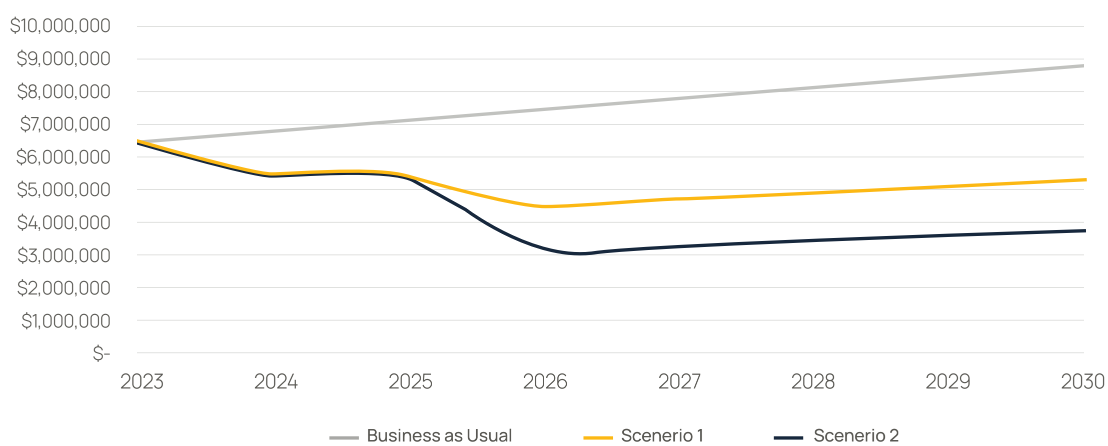



# Scenarios Comparison

The above scenarios will have different impacts on Brock University's OPEX and GHG emissions. In addition, these scenarios require different level of investments.

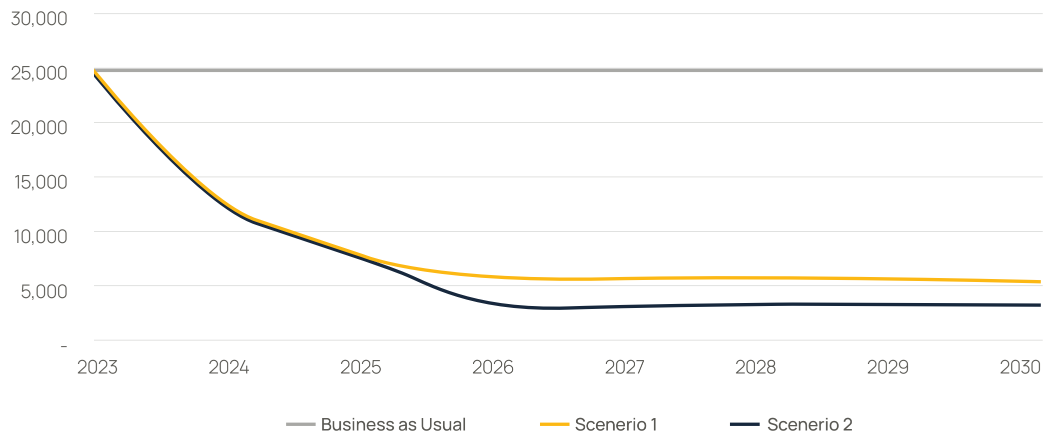
## OPEX Impact

OPEX savings from the different scenarios will result from a reduction in consumption (mainly natural gas), carbon pricing, and Global Adjustment. The table below shows the OPEX costs of all scenarios.



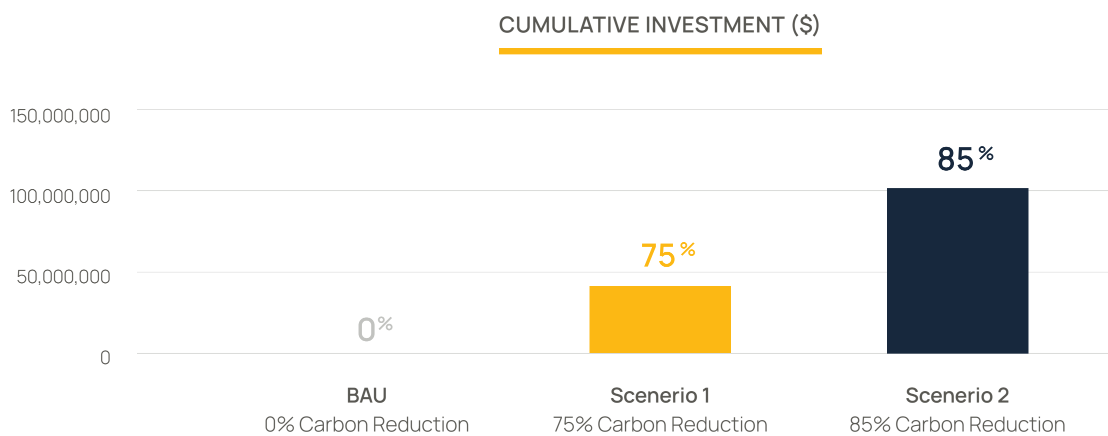
## GHG Emissions Impact

GHG emissions reduction from the different scenarios will result from the transition to the Ontario low carbon electrical grid and smart electrification of heating.




## Investment Analysis

Cost per GHG is maximized in Scenario 1; it is also the scenario with the best payback period.




## Conclusion

Given Brock University's framing goals, we recommend **Scenario 1: 75% Carbon Reduction** as the 2030 interim carbon reduction goal, for the following reasons:

- Carbon reduction exceeds higher education sector benchmarks
- Scenario 1 meets new KPIs for project evaluation (Cost per GHG, PB, NPV)
- Realistic, cost effective, operable, and sustainable (environmentally and economically)

# Alternative Energy Sources

Decarbonization challenges can be overcome with a combination of conventional and alternative measures to lower emissions and energy consumption. While there is no single silver bullet to tackling net-zero goals, the alternative energy sources listed below can significantly propel Brock towards net-zero carbon. As technologies are further developed and their costs are lowered, these measures can be implemented to push Brock University to the finish line.

## Hydrogen

### Description

Hydrogen will likely be an energy source in the future. It can be used as a fuel to power Cogens, boilers, or fuel cells. Hydrogen can also be produced from different sources.

| Energy Source | GHG Emissions |
|---|---|
| Natural gas reforming | Medium |
| Coal | High |
| Electrolysis from renewable power | Low |
| Electrolysis from nuclear power | Low |

The decarbonization merits of hydrogen comes from its source as shown in the above table. Currently, hydrogen is produced as a byproduct of natural gas reforming. This source of hydrogen production has an emission factor higher than natural gas. In order to consider hydrogen as a green energy source, it must be generated through electrolysis powered through renewable or nuclear electricity. Green electrolysis may be available in the future (OPG-Atura). Pending an award of federal funding, this facility can be commissioned as soon as early 2024. It is currently unclear how hydrogen will be distributed in the future.

## Technical Feasibility

Hydrogen mix can be used in the existing CHP pending modifications. The existing Brock CHP can accept up to 25 percent hydrogen mix.

### Engine Modification

To enable a hydrogen and natural gas mixture, the following modifications to the engine must be made:

- Seal - all seals in the engine must be hydrogen compatible
- Gas train
- Gas injection
- Software change

### Safety

Hydrogen is a highly flammable gas that has no colour (even when burning) and no odor. Therefore, the following safety modifications and labelling is required:

- Flame arrestor
- Warning labels

Hydrogen contains around 30 percent less energy per volume compared with natural gas. Because of this difference in energy content, using hydrogen in existing CHP units will result in a decrease in electrical power output as well as heat output.

## Savings

Hydrogen costs compared to other energy sources are summarized in the table below. Since the cost of hydrogen is 18 times more expensive than natural gas and 9 times more expensive than Electricity, using hydrogen would be more costly currently.

| Energy Source | $/GJ |
|---|---|
| Natural gas | 5 |
| Electricity (Class A) | 10 |
| Hydrogen | 90 |

### Impact on GHG

Available sources of hydrogen is presently more carbon intensive than natural gas and thus has a negative impact on GHG emissions.

### Cost per GHG

The cost of all necessary modifications to the engine, storage tank, and safety items were not provided but is currently costly. On the other hand, the GHG reduction impact is also negative at a minimum (15 percent more GHG emissions). Therefore, the cost per GHG reduction is defined as high or even detrimental.

## Renewable Electricity On-Site (Solar PV, Wind)

### Description

Renewable electricity can be produced by using solar PV and / or wind power sources. Solar PV transforms sun energy into electricity.

### Technical Feasibility

Each square meter of existing solar PV technology can produce up to 1,100 kWh. Therefore, to produce 100 percent of Brock's electricity, it would take 46,500 $m^2$ of Solar PV and electricity storage solutions. In addition, Canadian weather conditions such as snow and light intensity can decrease its efficiency. Furthermore, corrosion and maintenance issues can impact the efficacy of this solution.

### Savings

The cost of installing a solar PV system can vary based on multiple factors, such as system size, equipment quality, installation complexity, and local market conditions. Over the past decade, the cost of solar PV systems has significantly declined due to technological advancements, economies of scale, and increased competition in the solar industry. The cost is typically measured in dollars per watt (or kilowatt) of installed capacity.

Renewable electricity production could become a source of revenue for the University as well. However, due to the availability / variability of production, the renewable electricity will be charged at the following rates:

- Electricity Class A range: $0.03/kWh to $0.1/ kWh

With a relatively high cost of installation and low revenue generation opportunities, renewable electricity installation has a long payback period of around 20 to 30 years.

### Impact on GHG

Brock's GHG emissions comes mainly from natural gas combustion. Therefore, renewable electricity will have minimal impact on Brock's overall emissions.

### Cost per GHG

The costs associated with renewable electricity is summarized in the table below. The cost per GHG of solar PV is enormous and therefore not recommended to reduce GHG emissions.

| | | |
|---|---|---|
| **Cost of Solar PV ($/kW)** | 2,000 to 3,000 | A |
| **Annual production per kW (kWh/yr)** | 1,100 | B |
| **Savings ($/yr)** | 100 | C |
| **Payback (yr)** | 20-30 | A/C |
| **GHG savings (tonnes)** | 0.033 | D |
| **Cost per GHG ($/GHG)** | 75,750 | A/D |

## Geothermal

### Description

Geo-exchange systems are one of the most efficient alternatives to fossil fuels for building heating after heat recovery. It uses the ground thermal capacity to store and recover heat when heating or cooling is required by the building. Combined with the high efficiency of a high-performance heat pump, the energy used to recover heat is multiplied several times to fulfill thermal needs.

### Technical Feasibility

A geo-exchange system is a very reliable source that is generally designed for a very long lifespan with minimal maintenance requirements. Its implementation reduces the stress on the other heating and cooling components of the system, which may result in lower operation cost. Brock U sits on bedrock which is significantly less expensive to drill and more conductive than soft ground. As technologies further develop and costs to implement go down in the future, this could be an option for Brock. To further explore this option, It would be worthwhile to conduct a feasibility study to identify locations, costs, etc.

## Savings

The dollar savings for such a system are very modest because of the current price of natural gas ($7/GJ) when compared to electricity ($49/GJ), which is seven times more expensive. This measure focuses mainly on achieving GHG reduction goals but may result in an increase in heating energy cost. The geo-exchange system will also result in a modest reduction of cooling electricity use.

## Impact on GHG

The geo-exchange system will yield significant natural gas and GHG emissions reduction. A geothermal heat pump is a constant source of renewable energy that would otherwise come from less clean sources such as burning natural gas. This results in a high number of tonnes of GHG saved.

## Cost per GHG

Geo-thermal exchange systems require extensive upfront costs. There is a cost to survey the land to find a suitable place to install the system. Depending on the results of the survey, there may be limited areas of viability for the system. The costs of a geo-exchange system include the following:

- Drilling and piping
- Landscaping
- Heat pump

These costs result in a low $/GHG but a high payback period. To be effective both on GHG impact and payback period, the geo-exchange solution must be coupled with a mix of technologies such as heat recovery chillers, electrical boilers, and air-sourced-heat pumps. The costs associated with a geothermal system is summarized in the table below.

| | | |
|---|---|---|
| **Cost of Geothermal ($/kW)** | 6,500 to 7,500 | A |
| **Annual production per kW (kWh/yr)** | 6,570 | B |
| **Savings ($/yr)** | 150 | C |
| **Payback (yr)** | 45 | A/C |
| **GHG savings (tonnes)** | 18 | D |
| **Cost per GHG ($/GHG)** | 390 | A/D |

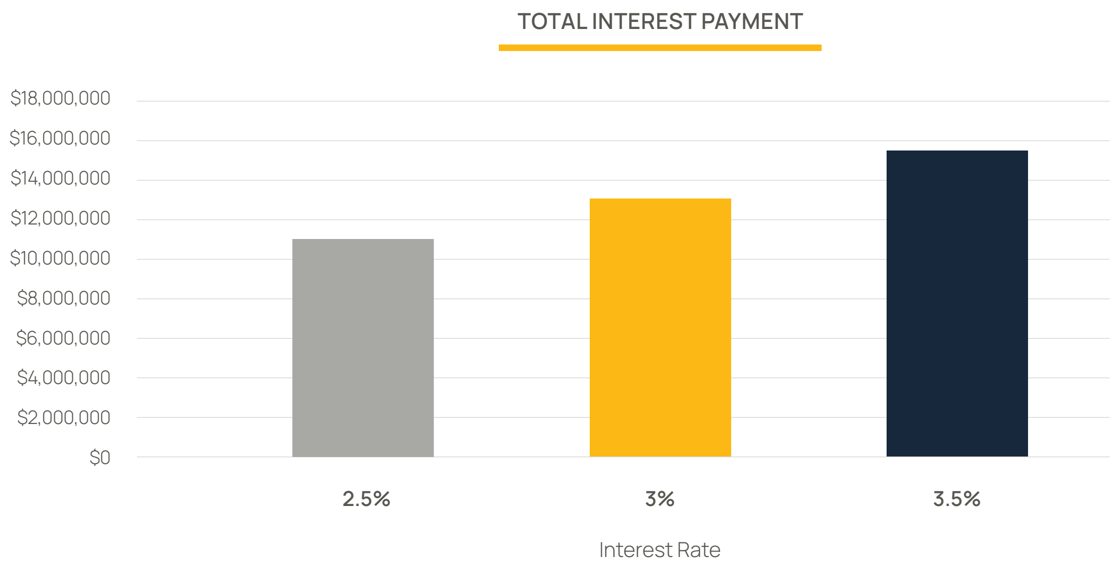
# Funding

Ambitious decarbonization projects require a significant amount of investment. Typically, decarbonization projects are either internally funded (with an acceptable internal rate of return) or financed through an external lender. Regardless of the source (internal funding or external financing), the marginal return for decarbonization / energy cost reduction should be considered in the decision making process when considering interim goals. The assumption is that with technological advances in the coming years, the marginal return will increase to make the remaining / complete decarbonization efforts economically feasible.

In the past 2 years, Canada Infrastructure Bank (CIB) has and continues to provide financing paths for large decarbonization projects. Currently, it provides the most competitive financing rate in the market. For projects where GHG emissions are reduced by at least 50 percent, the most favorable CIB interest rate currently stands at approximately 3 percent.

## Financing

The simulation below shows the difference in financing costs for a $40M project over a 20-year reimbursement period. It should be noted that the difference in total interest payments between a 2.5% to 3.5% interest rate is approximately $4,700,000.



# Procurement Strategy and Project Delivery

A better understanding on procurement and project delivery options would prepare Brock University for subsequent implementation phases. As part of a strategic path towards carbon reduction, the right procurement and project delivery methodology can mitigate cost and performance risk in the delivery of high-performance green equipment and systems while supporting the transition to a low-carbon campus.

For the best delivery of the framing goals outcomes, we recommend that Brock University adopt an outcomes-based approach project delivery method focused on energy-performance outcomes and risk mitigation. In its simplest form, this approach uses a firm-fixed price design-build-commission contract (such as the Canadian CCDC-14) with guaranteed energy performance. This is coupled with a value-based procurement strategy in which value is measured by alignment with all the required standards and by optimizing energy use intensity, GHG, and NPV.

The benefit of a fixed-price design-build delivery strategy is the avoidance of the standard 5-20% cost premium associated with high-performance building construction and renovation delivered using a traditional design-bid-build (DBB) methodology and ensures the highest level of performance post-project [1]. Most recently, this approach has been used with leading Canadian higher education institutions to implement similar aggressive decarbonization projects.

DBB-delivered green-certified buildings and renovations do not always deliver deep operational savings from lower energy use and simplified systems. Research has found that only 50 percent of sampled certified buildings were able to achieve an EPA Energy Star score of 75 or higher (meaning they are better than 75 percent of comparable, non-certified buildings), while 25 percent also had scores under 50 (NBI and USGBC). [2]

This methodology should apply to all projects with sufficient scope and complexity where the general contractor can be held accountable for performance. Smaller projects may be delivered using other contract types but must include provisions for compliance with the adopted standards.

Since a prescriptive method will carry a cost premium, we highly encourage expanding the project scope to whole-buildings or whole-systems whenever possible. This can sometimes also be accomplished by grouping several projects together.[3]

During procurement, the request for proposal (RFP) process should establish the overall objectives and problems the University is facing and clearly define the desired outcomes (framing goals) in a measurable manner. Brock can then decide on the specifics of its bidding process. Ecosystem recommends that a design firm prepare a preliminary design that meets Brock's requirements to a conceptual or schematic design level to provide roughly +/- 25 percent cost estimates. Bidders are then invited to propose alternatives or improvements to the base project, delivering greater innovation and uncovering additional value as measured through the life-cycle-cost-analysis (LCCA) tool.

## References


- [1] Kung, Feitau., Leach, Matt., Pless, Shanti. (2014, September). "*Cost Control Strategies for Zero Energy Buildings – High Performance Design and Construction on a Budget*" pp. 7,14, 21-26. How-to Guide: This publication from the US DOE / NREL dispels the myth that high-performance buildings / major renovations can only be delivered at a cost premium. The guide out-lines a strategy from procurement, design and delivery of high-performance buildings on typical construction budgets.
- [2] Frankel, Mark., Turner, Cathy. (2008, March 4) "*Energy Performance of LEED for New Construction Buildings*" pp. 3-5. Final Report: Prepared by the New Buildings Institute and funded by the USGBC with support from the US EPA, this report looks at the post-occupancy energy performance, in terms of EUI, of 121 LEED-certified buildings and contrasts with CBECS to evaluate EUI performance vs non-certified buildings and compares actual EUI results vs the design intent. As most of these projects were delivered via a design-bid-build methodology, it shows the large discrepancy between design intent and actual performance and the relative underperformance of many compared to non-certified buildings. These results highlight the diversity in actual performance when energy performance is not a key contractual deliverable.
- [3] Kung, Feitau., Leach, Matt., Pless, Shanti. (2014, September). "*Cost Control Strategies for Zero Energy Buildings – High Performance Design and Construction on a Budget*" pp. 7,14, 21-26.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