April 2019

High Performance Water Management Program
3rd Party Verification of Water, Energy and Operational Cost Savings
With Benefits to the Houston Community

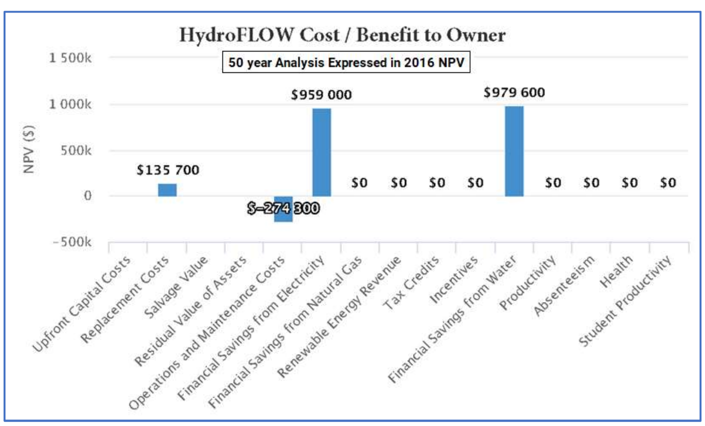
The following report was prepared by McMac Cx, who provides independent building commissioning project management, along with third party independent auditing of performance expectations in the built environment. McMac Cx carries the most current Commissioning Credentials, LEED Accredited Professional designation status and Sustainability Accounting Standards Board (SASB) Fundamentals of Sustainability Accounting (FSA) certification. McMac Cx has completed evaluations of numerous LEED Platinum and Gold buildings including the George W. Bush Presidential Library, Dallas TX, Mickey Leland Federal Building, Houston TX, BHP Billton Tower, Houston TX, the DOW Texas Innovation Center, Lake Jackson TX and many others.

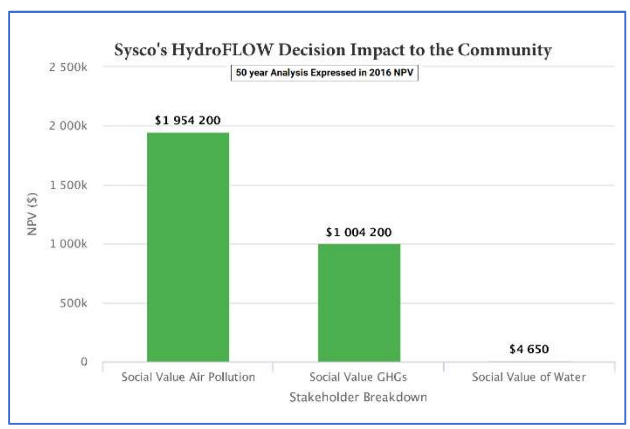
McMac Cx was engaged to quantify the performance outcomes of HydroTech Solutions' High-Performance Water Management program for **two 1,000-ton cooling towers** installed on the open loop condenser water system at a Fortune 100 Corporate Headquarters located in Houston, Texas, where the program has been active for nearly 3 years.

McMac Cx used the operating system's historical performance data over the past two years, together with Energy Model Simulation and our Autocase - Triple Bottom Line Cost Benefit Analysis (TBLCBA) to make their conclusions.

The Program's technology with digital measurement & verification allowed for **Annual Savings of**:

- Average annual fresh water use reduction of **4,341,024 gallons**, saving over **$19,600.00 annually** *(Simple Payback)*
- Average annual water Blow Down use reduction of **3,069,224 gallons**, saving over **$20,000.00 annually** *(Simple Payback)*
- 10% saving of electricity use by the cooling plant, equating to a **3.8% reduction in total energy consumption** or approximately **$34,500 annually** *(Simple Payback)*





The total benefits of the High-Performance Water Management program over the legacy system sees a positive Net Present Value (NPV) of $4,760,200. This NPV is framed in relation to the total Social, Environmental and Financial benefits realized by the Company, its employees and the surrounding community to which the Corporate Headquarters belongs.

Performance Outcome Verification and Social, Environmental and Financial Benefits of HydroTech Solutions High-Performance Water Management Program at [a Fortune 100] Corporate Headquarters in Houston, Texas

McMac Cx

Autocase BUILDINGS

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Date: **April 15, 2019**

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HydroTech Solutions High-Performance Water Management Program at
[a Fortune 100] Corporate Headquarters in Houston, Texas

One Page Overview

High Performance Buildings deploy technologies that improve systems efficiencies so that Facility Owners, Occupants, Operators and the Community benefit through cost saving, resource conservation, comfort, health, productivity increases, and reductions in pollution and Green House Gases. Upon its completion in 2008, a Fortune 100 Corporate Headquarters Campus became Houston's first LEED Gold certified property for New Construction. Since that time further system efficiency refinements have been implemented.

This report was prepared by McMac Cx, an Independent Third-Party Building Sustainability Best Practices Facilitation and Auditing firm and documents the benefits that have and will be realized by The Company's 2016 implantation of the HydroTech High Performance Water Management program technology at The Company's Houston Texas Corporate Headquarters complex.

The Company's Facilities Operations staff provided McMac Cx with two (2) full years of verified operating system performance data. McMac Cx used this historical data, as well as eQUEST™ Energy Model Simulation software and Autocase™ Triple Bottom Line Cost Benefit Analysis (TBL-CBA) economic modeling software to frame outcomes and conclusions.

This report utilizes a number of methodologies to illustrate the impact of this deployed technology. Simple life cycle payback data was chosen at times to provide simple framing around how this technology directly impacts energy or water cost savings. This simple, "financial only" impact is used when appropriate to communicate outcome data in a manner consistent with traditional meter read savings. For example, the following important simple payback outcomes result directly from captured data attributable to meter changes observed from HydroTech technology use during the 2016 and 2017 calendar years:

- The Company's annual potable water use reduction of 4,341,024 gallons, saving The Company$19,600 annually (Simple Payback).
- The Company's annual wastewater reduction of 3,069,224 gallons, saving $20,000 annually (Simple Payback).
- 10% electricity use reduction by the cooling plant, saving The Company $34,500 annually (Simple Payback.).

Illustrating simple lifecycle savings is an important first step in accounting for new technologies, but it falls short in capturing the complete opportunity. In order to account for the full Social, Environmental and Financial benefits available, McMac Cx utilized the Autocase™ Triple Bottom Line Cost Benefit Analysis (TBL-CBA) economic modeling software that incorporates simple payback savings and other important project specific economic, environmental and community data. Outcomes from Autocase™ are then framed in context to People, Planet and Profit benefits realized by The Company and our Community and compared to a baseline, which in this report is the legacy system technology that HydroTech replaced in 2016. Evaluating the total opportunities and impacts over the building's remaining fifty (50) year lifespan (2018 to 2066) and expressing these outcomes in monetary 2016 Net Present Value (NPV) dollars, presents a complete and clearer picture.

The total benefits, of the High-Performance Water Management program, realizes a positive 2016 Net Present Value (NPV) of $4,760,200 over the fifty (50) year expected building useful life, from 2016 to 2066. Outcomes are compared against the legacy system it replaces and framed in relation to the total Social, Environmental and Financial benefits realized by The Company, its employees and the surrounding community to which the The Company Corporate Headquarters belongs.

What follows is a breakdown and detailing of all inputs, outputs, methodologies and other background utilized to complete this analysis.

Executive Summary

McMac Cx has been engaged by HydroTech Solutions, to quantify the performance outcomes of the High-Performance Water Management program for two 1,000-ton cooling towers installed on the open loop condenser water system at a Fortune 100 (the Company) Corporate Headquarters located in Houston, Texas. This solution replaced a legacy Chemical Water Treatment Program as a means for the Company to reduce water consumption and associated costs, reduce or eliminate harsh chemicals and associated costs, decrease maintenance costs, minimize environmental impacts, increase the useful life of equipment and increase Central Plant energy efficiency. The High-Performance Water Management program includes HydroFLOW electronic water conditioning, internet-enabled sensors and meters for real-time measurement & verification to monitor and validate water and energy conservation.

The HydroTech Solutions High-Performance Water Management program has been in operation at the Company's Corporate Headquarters for over two (2) years. McMac Cx used the operating system's historical performance data over the past two years, together with Energy Model Simulation and our Autocase - Triple Bottom Line Cost Benefit Analysis (TBL-CBA) to make our conclusions.

The total benefits of the High-Performance Water Management program over the legacy system sees a positive Net Present Value (NPV) of $4,760,200.00. over a fifty (50) year expected building useful life, from 2016 to 2066. Outcomes are compared against the legacy system it replaces and framed in relation to the total Social, Environmental and Financial benefits realized by the Company, its employees and the surrounding community to which the Company's Corporate Headquarters belongs.

The Company Headquarters Facility Description

The Company's 595,600 square-foot Corporate Office Headquarters combines office and specialty-use space to form a two-tower Campus. With a focus on innovation, sustainable design, simplicity, and value, the Campus reflects The Company's corporate priorities of creating a high-quality workplace for its employees.
The Company's Corporate Headquarters Campus is sustainable at every level, from the landscape, site design, and energy efficiency to the ultimate consideration of the health and comfort of its occupants.
Several sustainable strategies helped the project achieve LEED Gold designation. The exterior sunshades and glazing modulate energy consumption and maximize natural light to improve energy efficiency while still maintaining access to daylight and views for occupants. An underfloor-air delivery system provides improved thermal comfort, better indoor air quality, reduced energy use, and greater flexibility for future office planning. Upon its completion in 2008, the Company Corporate Headquarters Campus became Houston's first LEED Gold certified property for New Construction.

The Company Corporate Social Responsibility

Paraphrasing the Company's 2018 Corporate Social Responsibility Report: The Company's Corporate Social Responsibility (CSR) strategy is based on the concept of materiality – the environmental, social, and governance (ESG) topics that reflect what stakeholders deem to be most important and/or that influence their decisions. The Company is committed to documenting progress through regular and transparent reporting practices, which were presented initially in their Fiscal Year 2018 Corporate Social Responsibility Report.

Deploying smart practices and better technology to reduce the energy intensity creates significant environmental benefits – and makes The Company's business more productive and efficient as well.
The Company is committed to creating positive change in their organization, the environment and the communities they serve, a commitment that ultimately enhances the value of their business. The Company's sustainability programs are based on sound science to ensure beneficial impact is greatest.

To ensure the highest level of regulatory compliance, The Company continues to expand on existing monitoring and training efforts. Water and air quality, solid and hazardous waste, storage tanks, spill prevention and control, as well as regulatory reporting compliance, are monitored through a compliance software system. Additionally, The Company utilizes an environmental risk ranking system for all Company facilities and has completed comprehensive environmental audits at 105 of our operating locations. Action plans were developed to address the audit findings, and identified issues were resolved.

The Company is carefully examining the benefits, costs, and opportunities of each approach to ensure that new solutions will deliver the environmental gains they seek. The Company's goal is to deploy energy efficiency measures that are the right ones not just for today, but for years to come. With more than 300 facilities across the Company enterprise, deploying technology and best practices at all locations is crucial to reaching their goals.

Triple Bottom Line Cost Benefit Analysis (TBL-CBA)

TBL-CBA is a framework for assessing the impacts of a design decision in today's dollar terms. It is an economic methodology used to aid in communication and decision making. The TBL-CBA economic business case framework uses best practice Life Cycle Cost Analysis (LCCA) and Cost Benefit Analysis (CBA) techniques to quantify and attribute dollar values to the impacts resulting from an investment.

Life cycle cost analysis (LCCA) moves past just assessing the upfront costs when making a decision, and instead evaluates alternatives to purchase, own, operate, maintain and, finally, dispose of an investment. Cost benefit analysis (CBA) is a formal way of organizing the evidence on the key good and bad effects of project decisions. The objective may be to decide whether to proceed with the project, to see if the benefits justify the costs, to place a value on the project, or to decide which of various possible alternatives would be the most cost-effective.

TBL-CBA not only includes full LCCA for financial considerations, but also aids in the decision making process of CBA, by including the costs and benefits to the surrounding community and environment. Altogether, TBL-CBA is a comprehensive decision-making tool, that not only accounts for the tangible benefits, such as the financial costs over time, but also the intangible benefits, such as improved air quality or occupant health.

TBL-CBA is a formal way to compare different alternatives of the same project that may have impacts occurring in different years. Future impacts are then converted into a present-day dollar value using discounting. Autocase automatically factors in the time value of money through discounting and inflating, so the results you see are always in 2016 dollars. Autocase does this by using a 7% discount rate. Custom discount rates can be input the software to meet client accounting methodologies.

HydroFLOW High-Performance Water Management Program Description

HydroTech Solutions combined physical water conditioning with internet-enabled sensors and meters with a dashboard that presents real-time data along with data analytics so that water and energy conservation are monitored continuously. The HydroFLOW water conditioning crystalizes dissolved calcium and other ions into fine-grained suspended solids that cannot attach as scale on equipment and piping; enabling circulating water in the open loop system to be used for longer intervals with less water disposal and reduced fresh water demand.

The dashboard and analytics monitor conductivity, pH, make-up and blowdown volumes and provide summary performance reports for water consumption and cost savings. Measurement and verification of water usage is central to the program's value, as the monthly cost of the program is paid through ongoing cost savings of energy and water.

HydroFLOW Technology Description

HydroFLOW electronic water conditioners are powered by the patented Hydropath technology that produces a pulsed frequency causing dissolved calcium and magnesium to crystalize into suspended particles that cannot attach as scale. These environmentally-friendly devices have been distributed globally for over 20 years.

How Hydropath technology works

All open loop cooling towers work through rejecting heat from inside the building to the atmosphere via evaporation. Legacy cooling tower water treatment employs numerous chemicals to inhibit mineral scale accumulation, biofilm buildup and to sanitize the system. The scale inhibitor chemistry can only deter scaling so a low setting for the conductivity set-point is maintained, which results in frequent blowdown events into the sanitary sewer, with replenishment of fresh water and more chemistry. Millions of gallons of water are used in this process each year at the company's Corporate Headquarters.

The HydroFLOW (Hydropath) Technology uses a physical water conditioning technology that induces a signal to continuously condition the liquid solution throughout an entire open loop water system. This process treats water by inducing a robust yet harmless signal of 150kHz throughout the whole water loop. The circulating water inside of the pipe acts as a conduit which allows the signal to propagate and have effect throughout the water system, causing dissolved calcium and other ions to crystallize and in effect form scale on their seed crystals, which cannot attach to surfaces as scale.

The induction of the AC signal prevents scale and biofilm from accumulating inside plumbing systems and gradually removes existing deposits. The absence of scale and biofilm allows heat transfer to perform as designed with high efficiency in the cooling tower and chillers. This preventative action significantly reduces energy, chemical, water and maintenance costs which extends the service life of equipment and pipes.

Performance Outcome - Evaluation Details

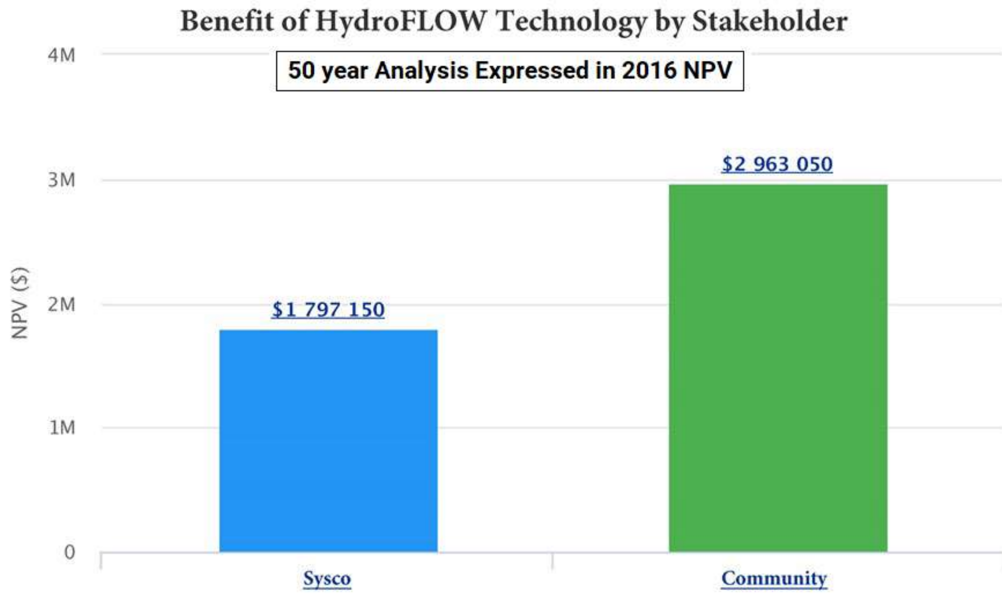
The High-Performance Water Management program with HydroFLOW technology has been in operation at the site for more than two years. Data for both pre and post installation of the HydroFLOW technology has been provided by HydroTech Solutions and by the Company's Facility Management staff. McMac Cx collected this data (2015, 2016, 2017 and 2018), compared it against projected performance Energy Models using the eQUEST – Quick Energy Simulation Tool version 3.65 and applied the Autocase materiality Triple Bottom Line – Cost Benefit Analysis software to identify alignment with the Company's Corporate Social Sustainability goals.

Outcomes

1. Total Social, Environmental and Financial benefit to the Company and our Community:

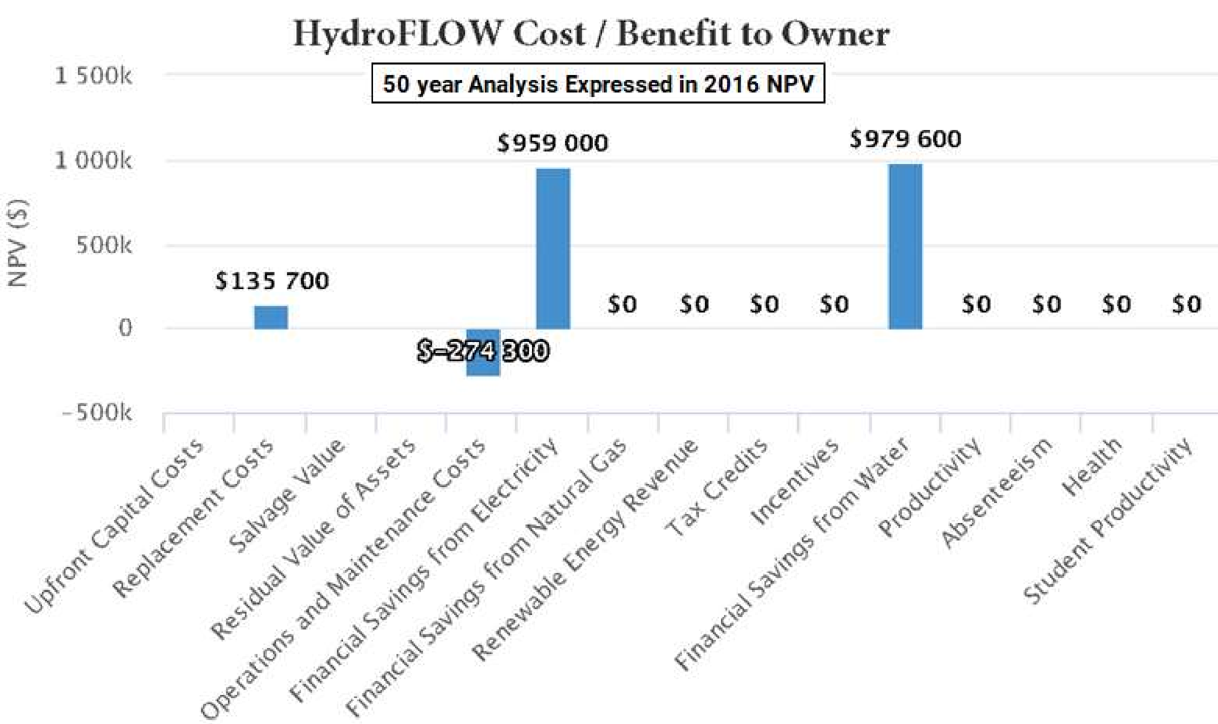
The materiality benefit of using HydroFLOW technology vs. legacy Chemical Treatment confirms a combined positive total social, environmental and financial benefit of $4,760,200.00, over the remaining fifty (50) year expected life (2016 to 2066) of the Company's Corporate Headquarters Campus. Figure 1 below breaks out benefits to the Company and benefits to our Community. Employees of the Company will also enjoy the positive benefits realized by the Community if they live within our geographic area.

Figure 1



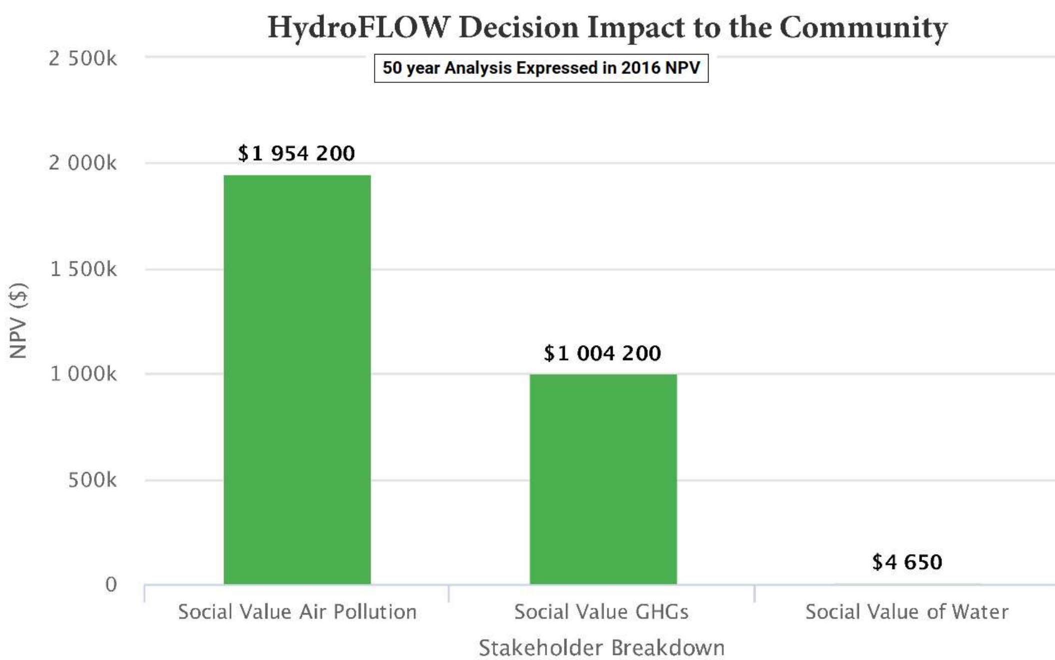
2. Benefit of HydroFLOW Technology by Cost/Benefit Type to Owner:

Benefits detailed in **Figure 2** below illustrate the breakout of those categories directly impacted by the HydroFLOW technology to the Company.



3. Benefit of HydroFLOW Technology by Cost/Benefit Type to Community:

Detailed in **Figure 3** below illustrate the breakout of those the Company's decision to adopt the High Performance Water Management program benefits our community.



4. HydroFLOW technology impact on controlling scaling on cooling tower and chiller heat exchangers:

The Company's Facility Team stated in interviews that the scaling on the heat exchangers of the cooling tower fill was reduced by at least 50% over that experienced with legacy chemical treatment. Scaling on the Chiller heat exchangers was shown to be minimal using both the legacy chemical treatment and HydroFLOW technology. The HydroFLOW technology is more effective overall in controlling scale while using significantly less chemicals.

5. Water quantity and cost saving to the Company:

Water saving and subsequent cost savings continue to be realized by the Company. It is projected that the cost to the Company, of bringing water to and from the Company's Corporate Headquarters will increase at approximately 5.9% annually. Water and cost savings are broken down into the following categories:

a. <u>Makeup Water</u> Evaporation of water from the cooling towers is part of the process through which heat is rejected from the building. Treated City of Houston potable water is used to replace this evaporated water. The HydroFLOW technology allows for an average annual potable water use reduction of **4,341,024 gallons**, saving The Company over **$19,600.00 annually** (*Simple Payback*). This potable water reduction also benefits the external community via a direct tax dollar expenditure reduction needed to maintain infrastructure of water treatment plants and distribution systems, cost of chemicals, cost of energy used at treatment plants and pumping stations and cost of labor. Additionally, the pollution and greenhouse gases averted by not producing the energy necessary to treat and pump this potable water to the Company, is a quantifiable benefit to the surrounding community, and is captured by Autocase as both Social and Environmental benefits.

b. Blow Down Water As evaporation occurs at the cooling towers, the level of concentration of materials that form scale on hot heat exchanger surfaces increases. An upper limit of this concentrated solution is monitored and when reached, the concentrated solution is “blown down” or released into the City of Houston Sanitary Sewer System. The HydroFLOW technology allows for an average annual wastewater Blow Down use reduction of **3,069,224 gallons**, saving The Company over **$20,000.00 annually** (*Simple Payback*).

This wastewater reduction also benefits the external community via a direct tax dollar expenditure reduction needed to maintain infrastructure of wastewater treatment plants and distribution systems, cost of chemicals, cost of energy used at treatment plants and pumping stations and cost of labor. Additionally, the pollution and greenhouse gases averted by not producing the energy necessary to treat and pump this potable water to the Company, is a quantifiable benefit to the surrounding community, that are captured by Autocase as both Social and Environmental benefits.

c. City of Houston – Evaporation Credit The City of Houston has created a program to incentivize the measurement of evaporated water from systems that cool buildings or process through evaporation from cooling towers. The goal is to allow the owner to measure and record the amount of evaporated water and receive credits for the “Sanitary Sewer Discharge” reduction. Since the water is evaporating, it is not going down the sanitary sewer to be treated at the wastewater treatment plant. Without the measurement data, the City of Houston assumes all the domestic water metered by the City of Houston coming into the building is also leaving the building and traveling to the City of Houston wastewater treatment plants. The HydroFLOW solution includes necessary metering to capture and document this data. Based on measured data, the Evaporation Credit puts approximately **$22,000.00** (*Simple Payback*) back in the Company’s water account annually.

6. Energy savings realized by the Company at the Central Plant:

No sub-metering exists on the cooling plant that would document changes in energy use realized by the HydroFLOW technology. The ability of heat exchanges to take the heat and reject it out of the building is significantly impacted by the reduction in scale and biofilm. Therefore, McMac Cx used the eQUEST Energy Model Simulation software to determine that the cooling plant accounts for approximately 35% of the Company’s Corporate Headquarters annual electricity consumption. Evidence would suggest that the HydroFLOW technology can consistently maintain the heat transfer within the system equal to a 10% saving of electricity use by the cooling plant. This equates to a **3.8% reduction in total energy** consumption or approximately **$34,500.00 annually** (*Simple Payback*).

7. Maintenance savings realized using HydroFLOW technology:

The Company’s Facility Team states that the HydroFLOW technology reduction in scaling and biofilm on the cooling towers results in approximately **$5,000** (*Simple Payback*) annual reduced maintenance costs.

8. Benefit of using no or less harmful chemicals:

a. Chemical cost reduction at the Company HQ:

The legacy chemical treatment solution, used prior to the deployment for the HydroFLOW technology in 2016, cost the Company approximately **$13,000.00 annually** (*Simple Payback*). These chemicals were used to prevent mineral scale buildup, biofilm buildup and to sanitize the system.

The HydroFLOW technology does require the use of a small amount of environmentally friendly biocide during the summer months. Within the **$60,534 .00** annual subscription service for the HydroTech Solutions High-Performance Water Management program is approximately **$1,500.00** for this biocide treatment. No onsite storage or handling of this solid chemical is required by the Company’s employees and the product is never applied or stored within the building envelope. The Company realizes an **annual chemical savings of $11,500.00** (*Simple Payback*).

b. Risk of storing hazardous chemicals inside the building envelope:

The chemicals used in the legacy treatment system were stored within the Company's Corporate Headquarters envelope. Even when all best practices of care are followed, a greater risk is present when harsh chemicals are stored onsite, either inside or outside the envelope vs. no harsh chemicals on site at all. The HydroFLOW technology utilizes an environmentally friendly biocide during summer months that is placed directly in the cooling tower basin outside the building envelope. Although McMac Cx has assigned no monetary value to this risk abatement in our analysis, the Company may be eligible for a reduction on their insurance coverage because of this risk reduction.

c. Cooling equipment life expectancy:

i. <u>Cooling Tower Heat Exchangers</u> Cooling tower heat exchangers should have a normal life expectancy of fifteen (15) years. The existing cooling tower heat exchangers were completely replaced in 2016 due to failure from excessive scaling and degradation in performance after only nine (9) years of service. Cooling towers are the most susceptible to reduced life through harsh chemicals use found in legacy water treatment systems, exposure to UV rays, water phase change and other environmental conditions. Reduced scaling and biofilm accumulation observed over the two years of HydroFLOW deployment should help the Company realize the full fifteen (15) years of useful life from the cooling tower heat exchangers.

ii. <u>Cooling Tower Frames & Motors</u> The cooling tower frames, motors, fans and basins are all susceptible to shorter life expectance when exposed to harsh chemicals and scale accumulation. It is reasonable that all of these items would last longer with the HydroFLOW technology's ability to reduce chemical use while preventing scale and biofilm accumulation.

iii. <u>Chiller Heat Exchangers</u> No difference in scaling seen on the chiller heat exchangers therefore life expectancies should be similar to the industry average of twenty-five (25) years.

9. Social, Environmental and Financial benefits to the Community of reduced water consumption:

The HydroFLOW technology reduces the burden to produce more potable water at the City of Houston Water Treatment facility by **4,341,024 gallons** annually while reducing the burden of treating chemical heavy sanitary sewer blow down water at the City of Houston Waste Water Facility by **3,069,224 gallons**.

Through use of the Autocase Triple Bottom Line Cost Benefit Analysis tool McMac Cx is able to calculate the social, environmental and financial benefit to both the Company and the community of these reductions. Since the City of Houston will treat less water to potable standards, pump less water to the Company's Corporate Headquarters, pump less blowdown water from the Company to the wastewater treatment facility, treat less water at the waste water facility and discharge less treated wastewater into our waterways, the Company and the community benefit. The materiality benefit to our community of reduced energy, air and water pollution, greenhouse gas emission and chemical discharge are cost benefits that the Company and our Community are realizing from water and energy savings with the HydroFlow technology.

Figure 4 below in illustrates direct energy production related benefits realized from water savings.

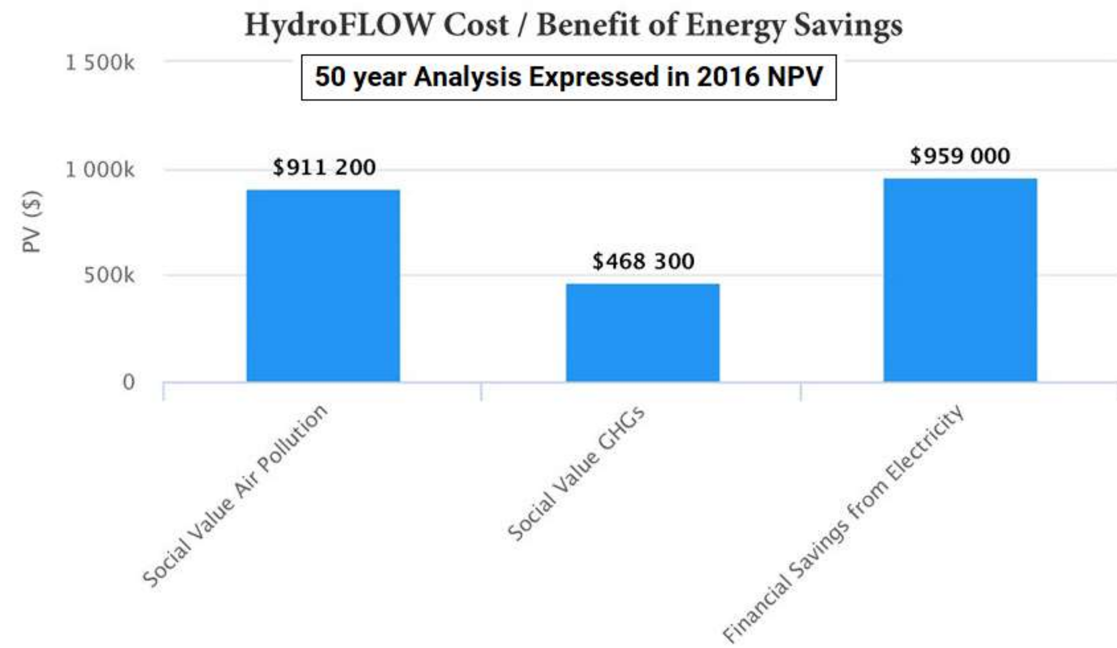
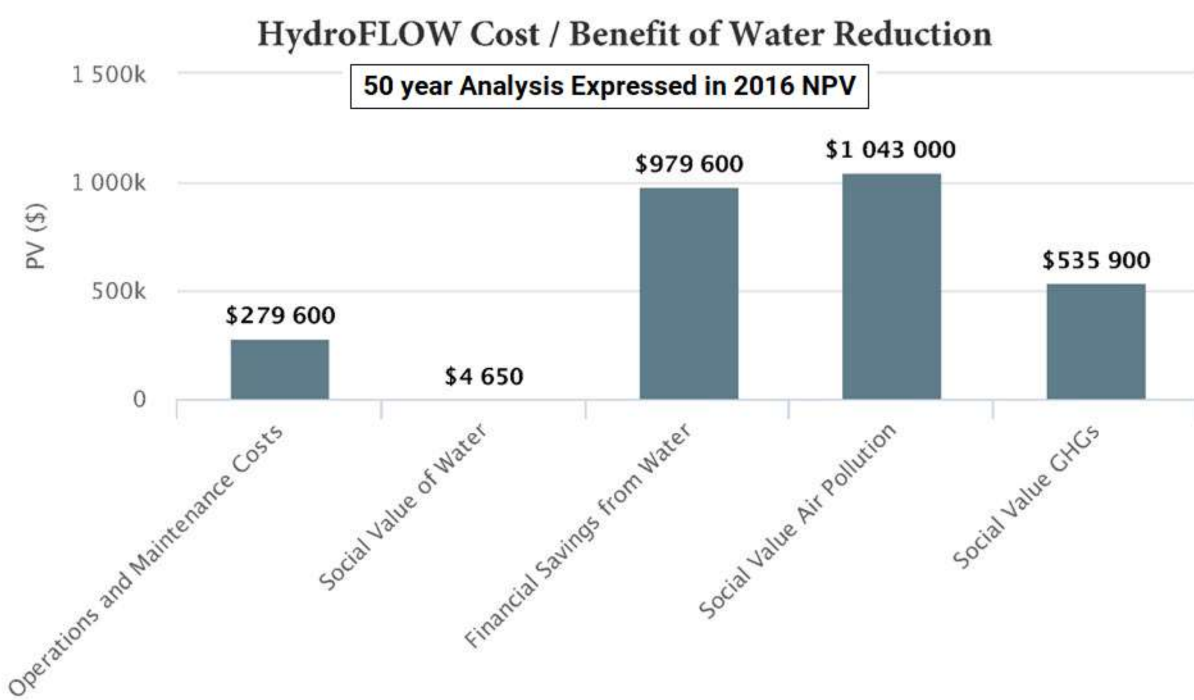


Figure 5 below illustrates additional benefits realized from water savings.



10. Reduced risk from Cooling Tower Drift:

Cooling Tower "Drift "is defined as the water that is emitted along with the exhaust air of a cooling tower. The drift droplets that escape contain the same chemical, bacterial, and particulate matter of the circulating water from which they originate, and therefore, can cause negative effects on the surrounding environment and equipment. These drift droplets can cause health concerns, as well. A person can inhale these droplets and become seriously ill, which has recently been a headlining issue with Legionnaires' disease in several large cities. Drift is an unavoidable side effect of cooling tower performance. Drift is an environmental concern, because it allows potential hazards to unintentionally escape the cooling tower.

Calculation of Drift and the subsequent environmental and health impacts are difficult to model and predict. What is known is that the elimination of potential health hazards in the cooling tower water such as chemicals, bacteria and particulate matter is the best method to ensure that if Drift does occur, that there are no, or limited hazards to be carried into the surrounding environment. The HydroFLOW High-Performance Water Management program greatly minimizes these risks and provides accountability through accurate monitoring and documentation that all best practices are being utilized by the building team.

11. Benefits of continuous real time monitoring of all appropriate data by a third party:

The High Performance Water Management program is a subscription service where all upkeep, repair, and calibration are tied wirelessly to remote monitoring and data collection with a secure cloud-based dashboard that provides data analytics and alerts. Additional meters, sensors and periodic testing is being utilized over and above the legacy chemical treatment system it replaces.

The value of real time remote monitoring of system performance outcomes is expanding rapidly in the commercial building market. The Internet of Things, Artificial Intelligence, Sensor Technology and Cloud Based Analytics now assist Facility Management teams in their goal of providing buildings that are healthy, efficiency and productive places to live, learn, work and play.

The ability of the High-Performance Water Management program to perform self-diagnostics, supervised by knowledgeable building professions, is augmented further through monthly onsite visits by HydroTech professionals. During the summer months, water samples are taken to ensure that bacteria are not present in harmful numbers. This service has a direct impact on mitigating risk of hazardous drift that could negatively impacting the health of the Company's employees and the neighborhoods surrounding the Company's Corporate Headquarters.

Although no monetary value has been allocated to this risk abatement, the full monitoring services provided by HydroTech as an integral part of validating the performance of the HydroFLOW technology, along with quantifying conservation and cost savings. This fulfills the growing need for transparency in building operations and data storage confirmation through independent third-party professionals that best practices are being sustained. the Company may be able to reduce insurance costs as a result of this full-time monitoring.

Table of Pollutant Quantity Changes

The following table is a typical accounting by weight of Air Pollutant quantity reductions directly attributable to the use of HydroFLOW technology by the Company. This standard reporting methodology by weight is converted within Autocase to the Social and Environmental Benefits to our Community.

CO2e	-49,674 tonnes	$ 1,004,200	**Social Value GHGs**
SO2	-149,088 pounds	$ 97,603	**Social Value Air Pollution**
NOx	-51,659 pounds	$ 1,728,259	**Social Value Air Pollution**
VOC	-1,147.51 pounds	$ 337	**Social Value Air Pollution**
PM2.5	-4,635.28 pounds	$ 128,002	**Social Value Air Pollution**

Conclusion

The data collected over the past two years of HydroFLOW operation, clearly demonstrates the positive Financial benefit to the Company. When coupled with the Social and Environmental positive benefit realized by both the Company and our Community, the switch to the HydroFLOW technology demonstrates how good corporate decisions can have positive benefits beyond the property line.

Autocase Input Data

Project Timeline	Value	Unit
Operations Duration	50	Years
Advanced Inputs	**Value**	**Unit**
Discounting		
Project Discount Rate	7	%
Energy Costs		
Electricity Utility Cost	0.085	$/kWh
Natural Gas Utility Cost	11.464	$/MMBtu
Water Costs		
Water Utility Cost	0.0044	$/Gallon
Growth in Price of Water	2.53	%
Wastewater Utility Cost	0.0066	$/Gallon
Growth in Price of Wastewater	2.821	%
Social Costs		
Social Cost of Carbon (CO2e)	55.16	$/metric tonne
Social Cost NOx	15084.25	$/metric tonne
Social Cost SO2	92549.58	$/metric tonne
Social Cost VOCs	2344.97	$/metric tonne
Social Cost PM2.5	220469.6	$/metric tonne
Social Value of Groundwater	829.6	$/Acre-foot
Social Value of Surface Water	17.54	$/Acre-foot
Energy Emission Factors		
Electricity		
NOx emissions	298.464	Metric tonnes/Million MWh
SO2	861.372	Metric tonnes/Million MWh
VOCs	6.630	Metric tonnes/Million MWh
CO2e	632717.811	Metric tonnes/Million MWh
PM2.5	26.895	Metric tonnes/Million MWh
Natural Gas		
NOx emissions	54.787	Metric tonnes/Million MMBtu
SO2	0.267	Metric tonnes/Million MMBtu
VOCs	2.446	Metric tonnes/Million MMBtu
CO2e	53363.765	Metric tonnes/Million MMBtu
PM2.5	2.535	Metric tonnes/Million MMBtu
Occupant Inputs		
Average Annual Building Wage	80490.27	$/year
Utility and Property Inputs		
Average Property Value in City	250745	$
Source of Ground Water Used by Utility	0	%
Source of Surface Water Used by Utility	100	%
Utility Providers Estimate of Wastewater Usage (as a Percent of Water Charges)	100	%
Electricity Usage for Supply of Utility Water	194000	kWh/Million Gallons
Wastewater Treatment Process at Treatment Plant	Secondary	
Electricity Usage for Wastewater Treatment by Treatment Plant	2080	kWh/Million Gallons
Type of Storm Sewer System Connected to Site	MS4	
Percent of Storm Water Sent into Local Water Bodies	100	%
Percent Rainfall Leaving Site as Runoff (excluding on-site water capture)	100	%
Is wastewater being treated by an off-site wastewater treatment plant?	Yes	
Energy Analysis Type	Percent Reduction	

Case Study - Input Data Provided by the Company, HydroTech and eQUEST

Replacement Costs of Major Equipment					
Equipment Type	Number	Replacement Cost	Total	Lifespan Std	Lifespan HF
Cooling Tower Fill	2	$ 92,500	$ 185,000	9	15
Cooling Tower Frame	2	$ 125,000	$ 250,000	20	25

			Tower A 2017	Tower A 2018	Tower B 2017	Tower B 2018	Avg. Annual	
Building Size		638,661						
Occupancy		1200						
Visitors		400						
Average Annual Electric Costs 2017/2018	$	987,500						
Percentage Renewable		0%						
Cost of Electricity		0.095						
Annual Total Building Electricity (kWh)		20,921,000						
Annual Cost of Electricity		0.0827						
% Electricity used by CP		35%						
Annual Central Plant Energy Use (kWh)		7,322,350						
Cost CP Electricity	$	345,625						
10% CP Electricity Cost	$	34,564	2017	2018	2017	2018	Avg. Annual	
Average Annual Total Water Consumption (2016)	$	12,950,000						% Reduction from 2016
Average Water Saved (In) gal 2017/2018		4,341,024	1,838,301	1,921,421	2,171,097	2,170,512	4,341,024	34%
Average Cost Water Saved (In) 2017/2018	$	19,660	$ 7,905	$ 8,493	$ 9,336	$ 13,587	$ 19,660	% Reduction from 2015
Average Water Saved (Out) gal/yr 2017/2018		3,069,224	1,685,126	1,678,683	1,610,593	1,534,612	3,069,224	89%
Average Cost Water Saved (Out) 2017/2018	$	20,077	$ 10,246	$ 10,509	$ 9,792	$ 9,607	$ 20,077	
Unrealized COH Evaporation Credit 2017/2018	$	22,237	$ 12,168	$ 11,968	$ 10,253	$ 10,085	$ 22,237	
Pre HydroFlow Annual Chemical Treatment Cost	$	14,400						
2015 Blowdown Volume Total		3437300						
Annual Mainrenance Costs on Centra Plant Pre HF	$	15,000						
Annual Mainrenance Costs on Centra Plant Post HF	$	10,000						
Annual HydroFlow Service Subscription	$	60,534						
Legionella Risk Abatement Value	$	1,000.00						
Annual Cost to COH taxpayers of not treating wastewater	$	20,257						

HydroFLOW increases Cycles of Concentration from 3 to 9 and allows Water, Energy and Chemical Conservation

1,000 Ton Cooling Tower		At 3 Cycles	At 9 Cycles	
Recirculation rate of the cooling tower	(GPM)	3,000	3,000	(GPM)
Inlet water temperature of cooling tower	(F)	95	95	(F)
Outlet temperature	(F)	85	85	(F)
Wet Bulb temperature of the Area.	(F)	0	0	(F)
Expected cycles of concentration of cooling tower		3	9	
% of 24 hour period that the tower is in use	%	65%	65%	%
% of month that the tower is in use	%	75%	75%	%
% of year the tower is in use	%	75%	75%	%
Peak Evaporation	(GPM)	30	30	(GPM)
Peak Bleed	(GPM)	15	4	(GPM)
Peak Water Use	(GPM)	45	34	(GPM)
Range	(F)	10	10	(F)
Approach	(F)	7	7	(F)
Drift	(GPM)	0.30	0.30	(GPM)

Influent Conductivity (µS/cm):	450
Circulating Conductivity (µS/cm):	1,500
Blowdown Set Point (µS/cm):	2,000
Targeted Set Point (µS/cm):	**4,000**

Estimated Utility Costs		
Water (per 1,000 gal)	Make-Up	$4.33
	Sewer	$6.14
Electricity	(per kWh) total	$0.085
	kW per Ton	0.65
Chemicals	(per Month)	$600.00

Cooling System Water Use

Water Use	At 3 Cycles Maximum Make Up	At 3 Cycles Maximum Blowdown	At 9 Cycles Maximum Make Up	At 9 Cycles Maximum Blowdown
Daily Gallons	42,401	14,040	31,871	3,510
Monthly Gallons	954,018	320,288	727,053	80,072
Yearly Gallons	8,586,162	2,882,588	6,543,474	720,647

Estimated Water Conservation At 9 Cycles

Water Volume Conserved	Maximum Make Up	Maximum Blowdown
Daily Gallons	10,530	10,530
Monthly Gallons	226,965	240,216
Yearly Gallons	2,042,688	2,161,941

Estimated Water, Energy and Cost Savings

	Water Savings: Make up Water (Gallons)	Blowdown Water (Gallons)	Total Water Savings	Water Cost Savings
Daily	10,530	10,530	21,060	$110
Monthly	226,965	240,216	467,181	$2,458
Annual	2,042,688	2,161,941	4,204,629	$22,119

Energy Savings (@10%) Current Cost	10% Savings
$689.52	$68.95
$12,618	$1,262
$90,851	$9,085

Estimated Annual Water Conservation
2,161,941
Gallons

Estimated Annual Energy Conservation
$9,085

About McMac Cx

McMac Cx, an Independent Third-Party Building Sustainability Best Practices Auditing firm.

McMac Cx provides world class Triple Bottom Line Cost Benefit Analysis Modeling, Alignment of Corporate Environmental, Social and Governance (ESG) expectations with Faciality Operations, Building Data Cloud Analytics and Independent Building Environmental Quality verification via Internet of Things Sensor Technology for ongoing operations verification, and Full Project Design, Construction and Operations Commissioning.

McMac Cx carries the most current Commissioning Credentials, LEED and WELL Building Standard Accredited Professional designation and Fundamentals of Sustainability Accounting (FSA) certification through the Sustainability Accounting Standards Board (SASB).

McMac Cx has completed Design, Sustainability and Commissioning Consulting Services on many iconic LEED projects in Texas including the LEED Platinum George W. Bush Presidential Library, Dallas TX, LEED Platinum Mickey Leland Federal Building, Houston TX, LEED Gold BHP Billiton Tower, Houston TX, and the LEED Gold DOW Innovation Center and Laboratories in Lake Jackson TX to name a few.

McMac Cx was formed to bring together the tools and Partners needed to break down barriers currently preventing the adoption of proven off-the-shelf technologies and best practices. The ultimate goal is to allow all Projects Team Stakeholders the opportunity to evaluate the full Social, Environmental and Financial benefit of each project decision so that the places we create to live, learn, work and play are as healthy, efficient and productive as possible.

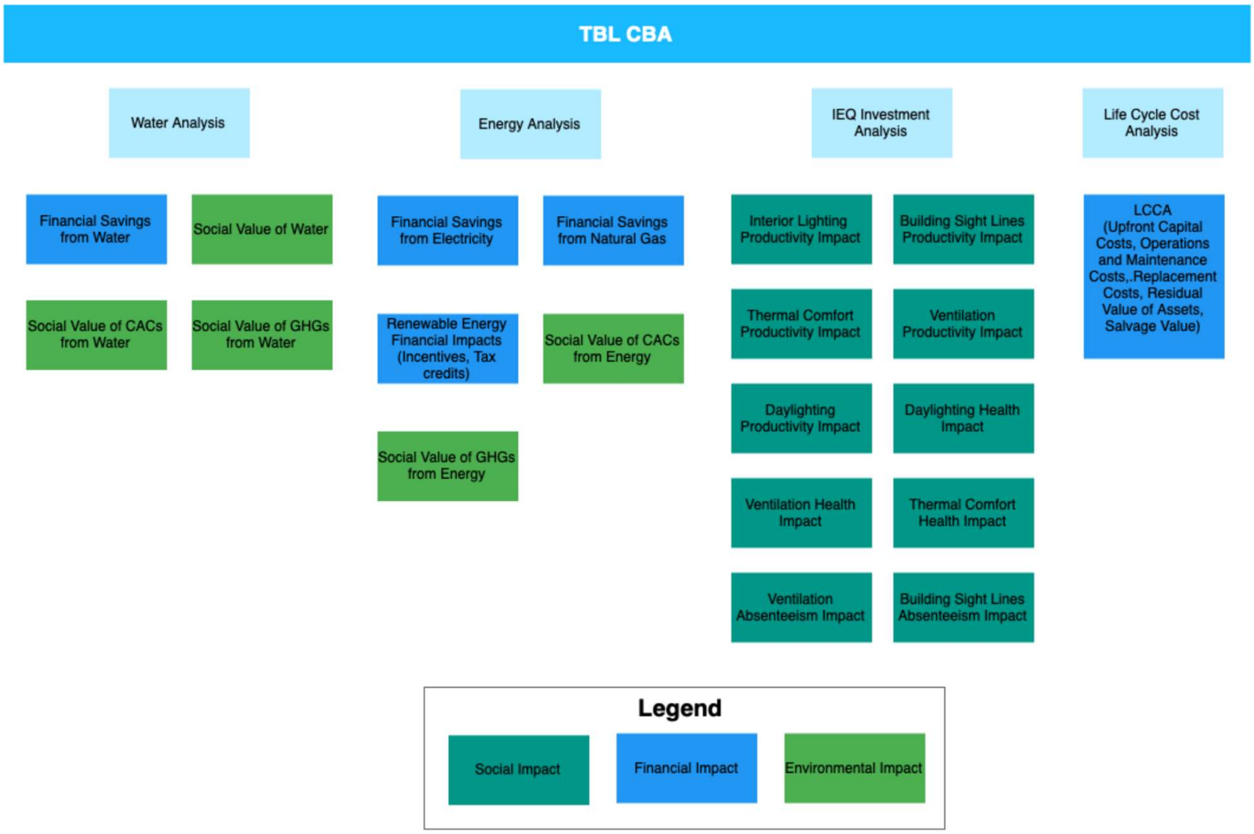
The President and Founder of McMac Cx, David MacLean, believes that in order for change to happen, we need to be engaged with our community. To this end Mr. MacLean has been intimately engaged in advocacy, education and promotion of the US Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) rating system, holding numerous leadership roles at the USGBC Texas Chapter Board level and Past Chair of the USGBC Texas Gulf Coast Region over the past fifteen (15) years.

Mr. MacLean donates over 30% of his billable time to helping public and non-profit organizations knock down the barriers they face when adopting proven sustainable best practices.
Mr. MacLean is currently:

- Chair of the USGBC Texas Sustainable Communities – Best Practice Leaders Committee,
- Chair of the ASHRAE Houston Chapter Commissioning Committee,
- Chair of the Standards & Policy Committee - Cities Connection Children to Nature – Houston, and
- Member of the City of Houston – Climate Action Plan – Building Optimization Committee.

Methodologies

Included in this section is a detailed description of the methodologies employed when Autocase generates results based on user inputs. These methodology descriptions contain the sources used, data relied upon, and structural diagrams where helpful.



Indoor Environmental Quality

The indoor environmental quality of a space greatly affects those who are occupants of that space. Autocase recognizes these impacts through three impact (benefit) categories: Productivity, Absenteeism, and Health. For occupants who are expected to be working in a space, productivity impacts can be calculated for those individuals, based on the interior of the space and design. Similarly, the benefit of an employee being absent from work less, is a second way that Autocase translates the benefits of improved indoor environment quality. This is strongly related to the health of that individual, and acts as a proxy for individual health. Related to absenteeism is the health cost impact. This benefit is the broader health costs that individuals may bear for being sick at work (outside of the cost of being absent). Together, these three impacts can translate the benefits of improved indoor environmental quality into changing dollar value metrics that reflect the benefit of various design decisions.

Other occupants outside of employees may be in a space and enjoy the benefits of that space. Another occupant type that Autocase analyzes is students in primary, middle and secondary schools.

Heating, Ventilation, and Air Conditioning (HVAC)

Heating, Ventilation and Air Conditioning investment decisions can play a large part in improving indoor environmental quality. These considerations can be broken down into two categories: Thermal Comfort and Ventilation. There is also an energy and cost impact, but
that is covered later in the Energy Investment and LCCA sections.

Default Values for HVAC

The defaulted ventilation rate in the base case is determined by the type of building. This value is assumed by using ASHRAE sourced default ventilation rates separated by building type.

Default Values for Building Sight Lines

Autocase defaults the base case building's quality views, for the designs to be compared against. The base case default assumptions are that 100% of employees will have a view rating with minimal outdoor views and minimal indoor biophilia. Specifically, for both quality views and indoor biophilia, the assumed base case view rating is 1 out of 10 on a scale where 1 is minimal views and plants, and 10 is maximum views and plants. Users are encouraged to change this value to match their base case scenario.

Life Cycle Cost Analysis (LCCA)

Life Cycle Cost Analyses (LCCA) evaluates the total cost of ownership over the life of a building in order to compare the cost-effectiveness of design options. It is usually conducted in the early design phase of a project, as it offers an opportunity to amend designs to reduce life cycle costs.

Upfront Capital Costs

Upfront capital costs are the initial costs incurred during the construction period. Cost items can include the purchase of assets, systems, and any other materials during construction, including labor costs for installation. Upfront capital costs in each design case are compared to the base case. Positive incremental upfront capital cost in the results implies that the design was less costly than the base case. For example, for HVAC investments, upfront capital costs may include a furnace, ductwork, and thermostats. These components may be compared to a less efficient system in the base case.

Replacement Costs

Replacement costs refer to the costs required to replace an asset or system during the specified life of a building (or study period). An asset may be replaced multiple times over the life of a building/study period. The replacement cost may cost more, less, or the same as the upfront capital costs of the asset. For instance, a furnace, part of an HVAC investment, may only have a useful life of 20 years, therefore must be replaced throughout the life of the building if the study period is longer than the useful life.

Residual Value

The residual value of an asset or investment refers to the financial benefit arising at the end of the life of a building or study period, for any assets with a remaining useful life. Autocase calculates residual values using straight-line depreciation. If, for example, a furnace still has useful life remaining at the end of the life of the building or study period, a residual value will be applied.

Salvage Value

The salvage value is the financial benefit associated with the disposal of assets at the end of their useful life. For instance, at the end of the useful life of a furnace, there may be a financial benefit from the scrap metal in the unit.

Non-Utility Operations and Maintenance Costs

Non-utility operations and maintenance (O&M) costs include all costs associated with operating, repairing, upgrading and/or recommissioning investments over the course of an investment's useful life but exclude any costs from utilities. These costs include preventative measures and anticipated repairs to extend the useful life of materials and equipment. For example, to keep a furnace in proper working order, filters must be changed as part of preventative maintenance performed over the life of the asset.

There are two types of O&M costs: annual and variable. Annual O&M costs are incurred each year during the life of the building (or study period) and may escalate if real costs increase over the study period. Escalation rates are capture growth beyond general inflation (i.e. costs increase every year by the rate of inflation; these cost increases should not be included). Variable O&M costs are those that occur sporadically throughout the study period. If for example, a cost of $200 is incurred in 2020, 2030, and 2035, one cost will be included in this section and "add a new cost" to your LCCA analysis for the other costs in the future.

Energy Investments

Energy usage can be affected by almost any design decision. Autocase itself does not prepare energy simulations, but rather works in tandem with the energy information available at your stage of the project. In this regard, there are three ways to enter energy information into the software:

Energy simulation data: If you have completed an energy simulation, enter the resulting EUI values for your building. Autocase will automatically compare these values to a base case building, which is based off of the Commercial Buildings Energy Consumption Survey ("CBECS"), which you can override if you prefer.
Percent reduction target: Great for early stage design planning - if the project is potentially hitting the Architecture 2030 energy reduction goals, or a net zero energy building, simply enter the percent reduction goal as compared to the baseline. Again, Autocase automatically compare these values to a base case building, which is based off of the CBECS, which you can override if you prefer.

Feature by feature: If your project is assessing the difference between one energy related feature and another - for example two different lighting fixture options - Autocase allows you to simply enter the individual features you would like to analyze, and attribute them to the investment category they belong to (e.g., Lighting). You can enter their energy usage data compared to a base feature, for example, energy star vs. not energy star fixture.

In Autocase, energy impacts can come from (i) more efficient building features, or (ii) renewable energy. (There is also an energy impact from reduced water usage, but that is covered in the Water Investments section.) The impacts of reducing energy consumption include:

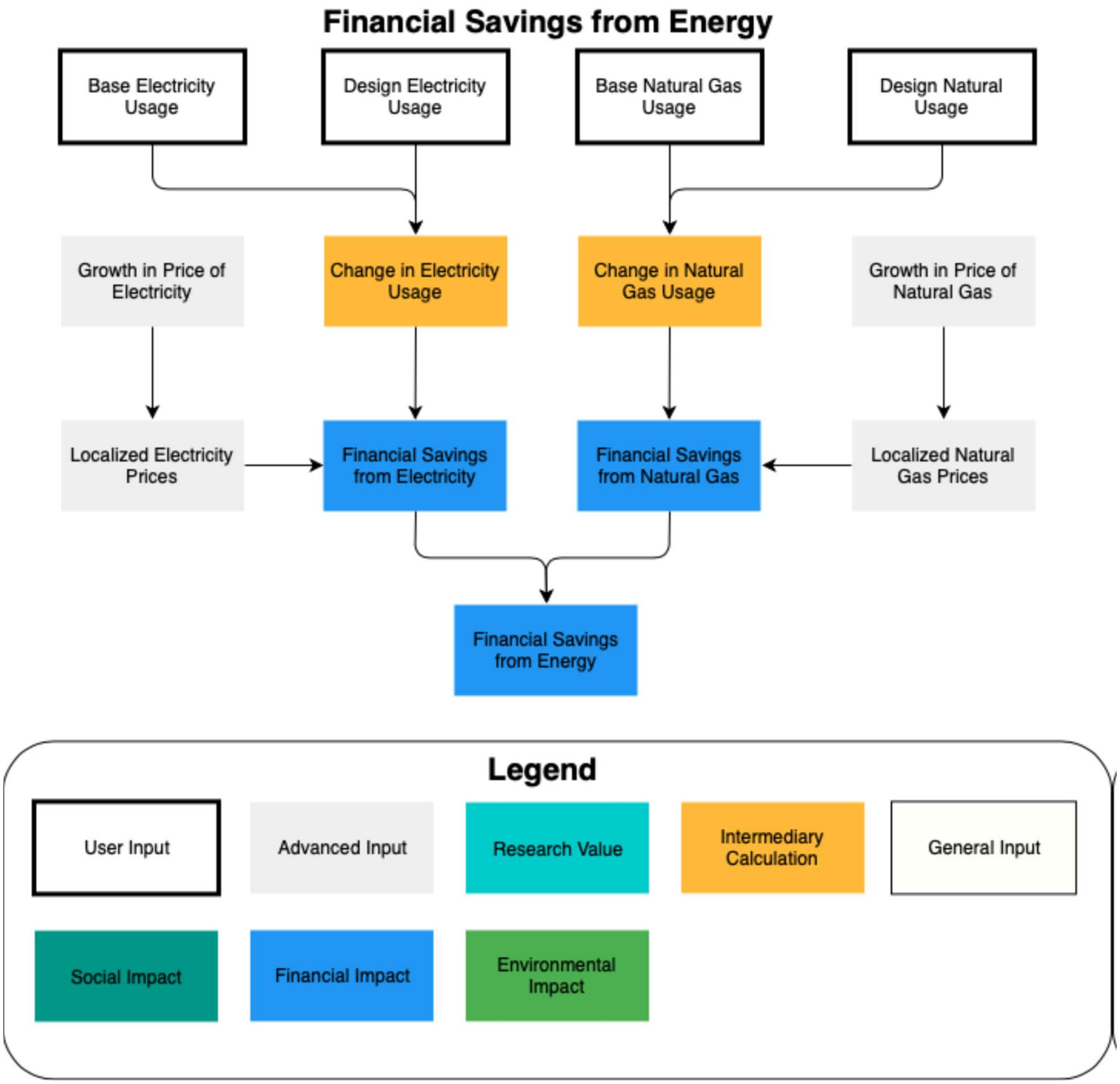
a. Reduced carbon emissions
b. Reduced air pollution
c. Tax credits
d. Utility incentives
e. Financial utility cost savings
f. Revenue if renewable energy is sold to the grid

Energy Efficiencies

Changes in electricity and natural gas consumption may have the following impacts: (i) utility costs; (ii) greenhouse gas emissions (GHGs); and (iii) air pollution. Ways to reduce energy consumption from the grid include: (i) investing in energy efficient technologies; and/or (ii) on-site renewable energy production.

Financial Savings

Lower dependency on energy from the grid in the design case may generate financial benefits due to cost savings. Autocase estimates the financial savings from a project using local utility prices from the Energy Information Administration for US cities and from local utilities for Canadian cities. Any upfront capital costs and/or ongoing non-utility operations & maintenance costs associated with energy investments should be recorded in the Life Cycle Cost Analysis. Autocase forecasts energy prices for the US and Canada using estimates from the EIA and National Energy Board respectively. The EIA and NEB provide energy price forecasts up to the year 2050 across a variety of high and low macroeconomic conditions such as fluctuating oil prices, economic growth, and technological progress.



Air Pollutants from Energy Efficiencies

Reducing energy consumption from the grid (in the design case compared to the base case) may generate social benefits from reduced air pollution being emitted. For each unit of energy produced and used, air pollution emissions are released into the atmosphere, quantified using emission factors. The social benefit from reducing air pollution emissions is monetized by applying the social cost of each air pollutant to the respective amount of that air pollutant reduced.

Autocase calculates the societal benefit for the following air pollutants: NOx, SO2, PM2.5, and VOC. Non-baseload, location-specific emission factors per unit of electricity are gathered from National Emissions Inventory in the U.S and Air Pollutant Emission Inventory in Canada (U.S. Environmental Protection Agency, 2014; Environment Canada, 2015). Emission factors for natural gas combustion for U.S. and Canada are gathered from the United States Environmental Protection Agency (EPA, 1998).

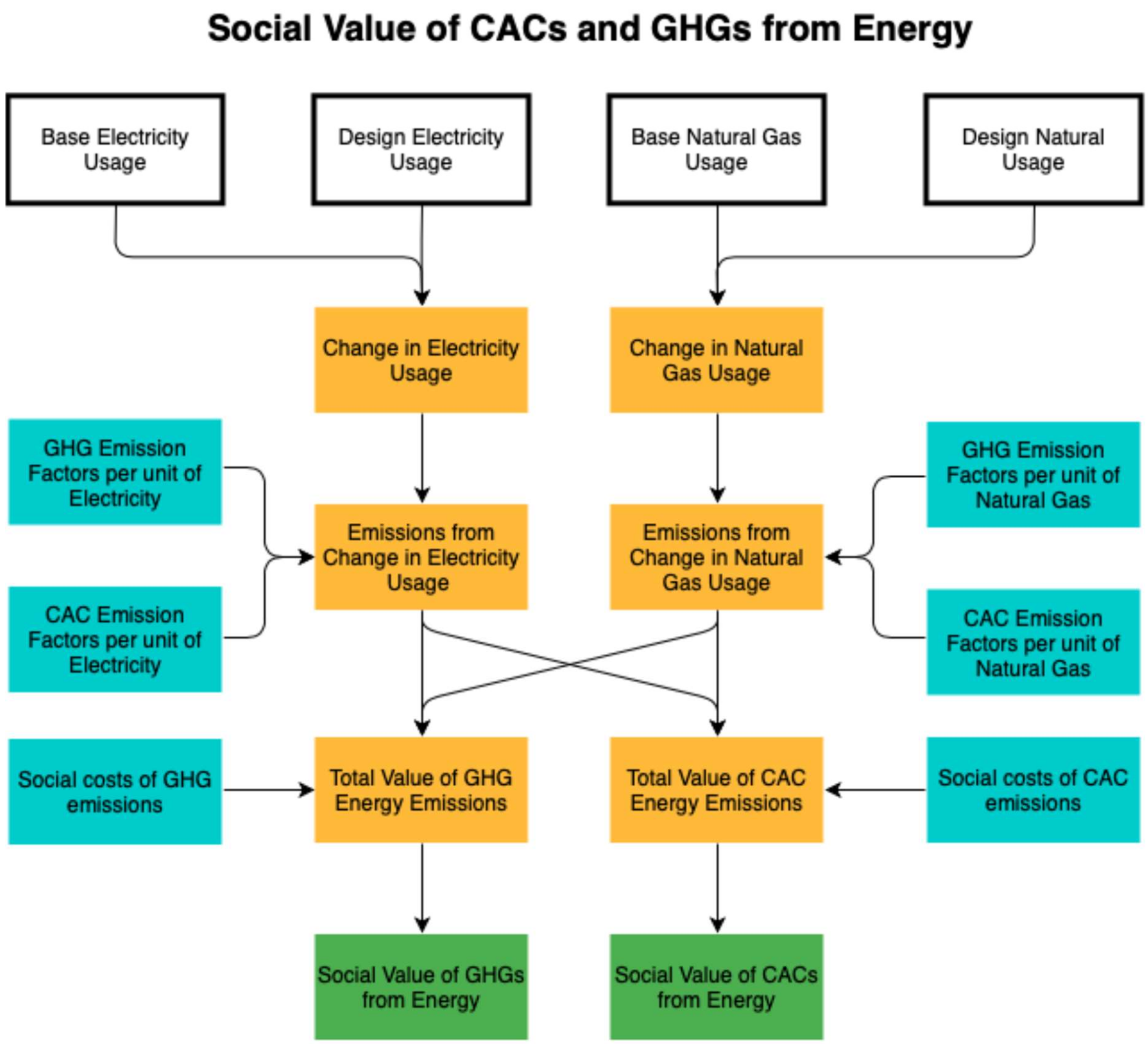
Greenhouse Gas Emissions (GHGs) from Energy Efficiencies

Reducing energy consumption from the grid may also reduce GHG emissions, thereby generating societal benefits. For each unit of energy produced and used, GHGs emissions are released into the atmosphere, quantified using emission factors. The social benefit of reduced GHGs is monetized by applying the social cost of carbon to the amount of carbon dioxide equivalent emissions reduced.

Non-baseload, location-specific emissions factors for carbon-dioxide equivalent emissions per unit of electricity are gathered from eGRID in the U.S and Facility GHG Emissions by Province/Territory in Canada (U.S. Environmental Protection Agency, 2014; Canada's Official Greenhouse Gas Inventory). Emission factors for natural gas combustion for U.S. and Canada are gathered from the United States Environmental Protection Agency (EPA, 1998).

Social Value of GHGs

Reducing energy consumption from the grid may also reduce GHG emissions, thereby generating societal benefits. For each unit of energy produced and used, GHGs emissions are released into the atmosphere, quantified using emission factors. The social benefit of reduced GHGs is monetized by applying the social cost of carbon to the amount of carbon dioxide equivalent emissions reduced. The social cost of carbon in the U.S is from the Interagency Working Group on Social Cost of Greenhouse Gases (August 2016). Canada has its own estimates based off models used for the social cost of carbon in the U.S. The social cost of carbon is a conservative estimate of the negative effects of climate change. The cost of carbon pollution is an estimate of the damages - of the economic cost of the health, agricultural losses, property flooding and the value of ecosystem services. The estimates, and there are many estimates, are conservative because they do not yet capture all of the identified impacts of rising levels of CO2 in the atmosphere.



Default Values for Energy Efficiencies

Default electricity and natural gas usage for this building are populated by combining:

g. the square footage of the building;
h. the size of the building (square footage); and
i. the location of the building.

The default information is from CBECS Energy Usage defaults are for both electricity and natural gas usage. Autocase has a database of average electricity and natural gas prices by city. Prices for the U.S. are collected by state from the U.S. Energy Information Administration and by municipality from municipal electric utility websites for Canada. If a user has more accurate prices for their project, it is encouraged to override this input in order to get more representative results.

Renewable Energy Production

Renewable energy produced on-site, whether it comes from solar, wind, or hydro sources, has the following impacts:

j. Financial benefits
k. Tax credits
l. Utility incentives
m. Renewable energy revenue
n. Environmental benefits
o. Reduced criteria air contaminants
p. Reduced greenhouse gas emissions

Tax Credits

Governments may provide tax credits to encourage building owners to invest in on-site renewable energy production. These tax credits are financial benefits realized for a user-defined length of time, beginning at the start of operations.

Utility Incentives

Local utilities may offer incentives to building owners to invest in the on-site production of renewable energy. These financial incentives are collected for a user-defined length of time, starting at the beginning of operations.

Renewable Energy Revenue

On-site renewable energy production may not only be used on-site, but also sold to the grid. The revenue received from selling renewable energy is calculated based on the amount of energy sold to the grid and the local price paid for renewable energy inputted by the user.

Air Pollutants and Renewable Energy

Renewable energy production may be sold to the grid. When this occurs, it generates social benefits as the grid becomes cleaner by being partially offset by renewable energy. The social benefit from renewable energy is monetized by applying the social cost to each air pollutant to the respective amount of that air pollutant reduced. Non-baseload, location-specific emission factors per unit of electricity (for NOx, SO2, PM2.5, and VOC) are gathered from National Emissions Inventory in the U.S and Air Pollutant Emission Inventory in Canada (U.S. Environmental Protection Agency, 2014; Environment Canada, 2015).

Greenhouse Gas Emissions (GHGs) and Renewable Energy

Similar to air pollution, the sale of on-site produced renewable energy can also facilitate the reduction of carbon emissions, thereby generating social benefits. The social benefit from renewable energy is monetized by applying the social cost of carbon dioxide equivalents (CO2e) to the total amount of CO2e emissions reduced. Non-baseload, location-specific emissions factors for carbon-dioxide equivalent emissions per unit of electricity are gathered from eGRID in the U.S and Facility GHG Emissions by Province/Territory in Canada (U.S. Environmental Protection Agency, 2014; Environment Canada, 2015) .

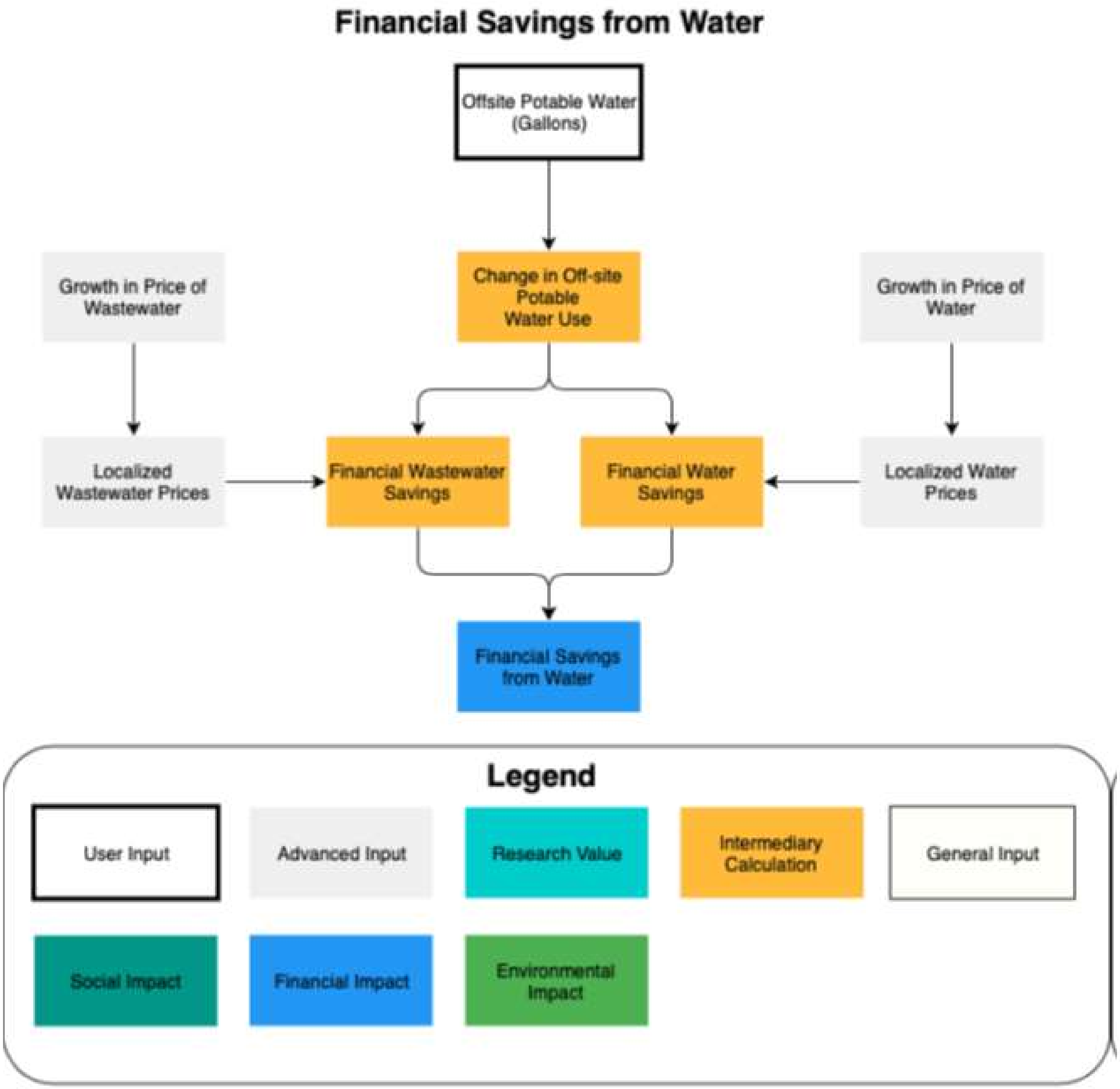
Water Investments

Autocase evaluates the impacts of building design on water, ground water, stream water, aquifers, the energy used to treat and distribute water, wastewater, and the financial utility costs of water. Autocase can analyze efficiencies from:

q. More efficient water features within the building, such as taps and toilets,
r. Graywater reuse, and
s. Rainwater harvesting.

Financial Savings

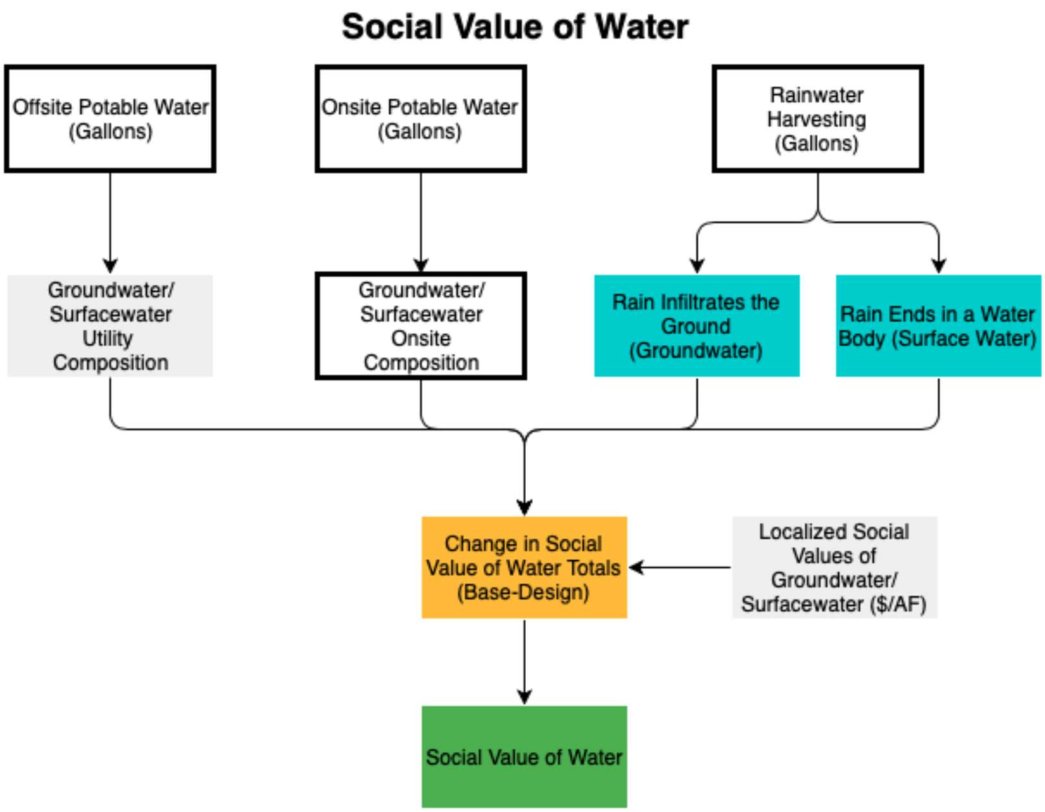
Local water and wastewater prices, collected from American Water Works Association (2014) and Environment and Climate Change Canada (2009), are used to estimate the financial savings of reducing utility water and wastewater. Growth rates are applied water and wastewater prices to forecast real growth in prices over the study period. These growth rates are forecasted using American Water Works Association (2014) historical price growth.

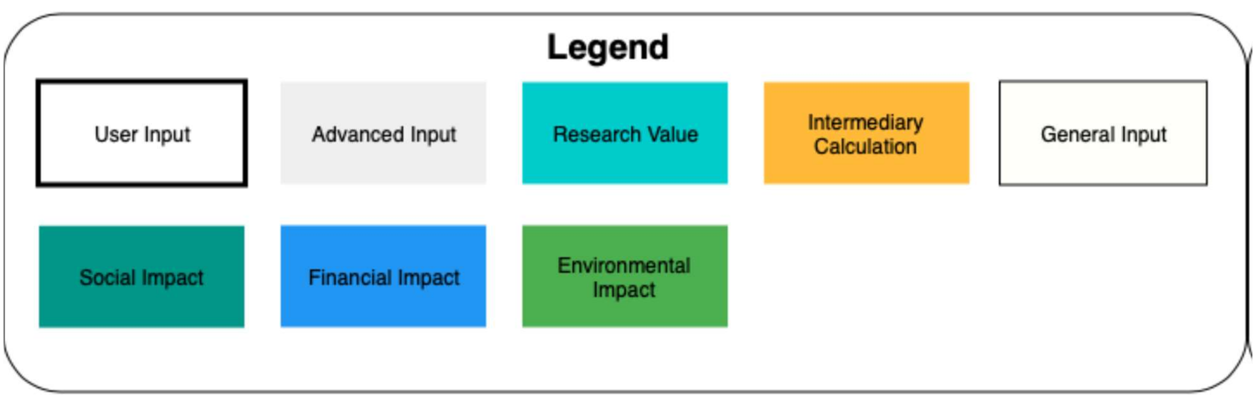

Financial Savings from Water
Offsite Potable Water (Gallons)
Growth in Price of Wastewater
Change in Off-site Potable Water Use
Growth in Price of Water
Localized Wastewater Prices
Financial Wastewater Savings
Financial Water Savings
Localized Water Prices
Financial Savings from Water
Legend
User Input
Advanced Input
Research Value
Intermediary Calculation
General Input
Social Impact
Financial Impact
Environmental Impact

Social Value of Water

A social value of water will be applied to any water taken out of the water table. For instance, using water from a utility or capturing water from a well will imply water being taken out of the water table or a body of water, and a corresponding social value of water will be applied.

Reducing the amount of water consumed from a utility or a well will realize a benefit to society in terms of the social value of water. Autocase uses the research conducted by United States Geographical Survey Water Survey (2010) and Environment Canada Municipal Water Use Report (2009) to allocate groundwater-surface water proportions for cities in the software.

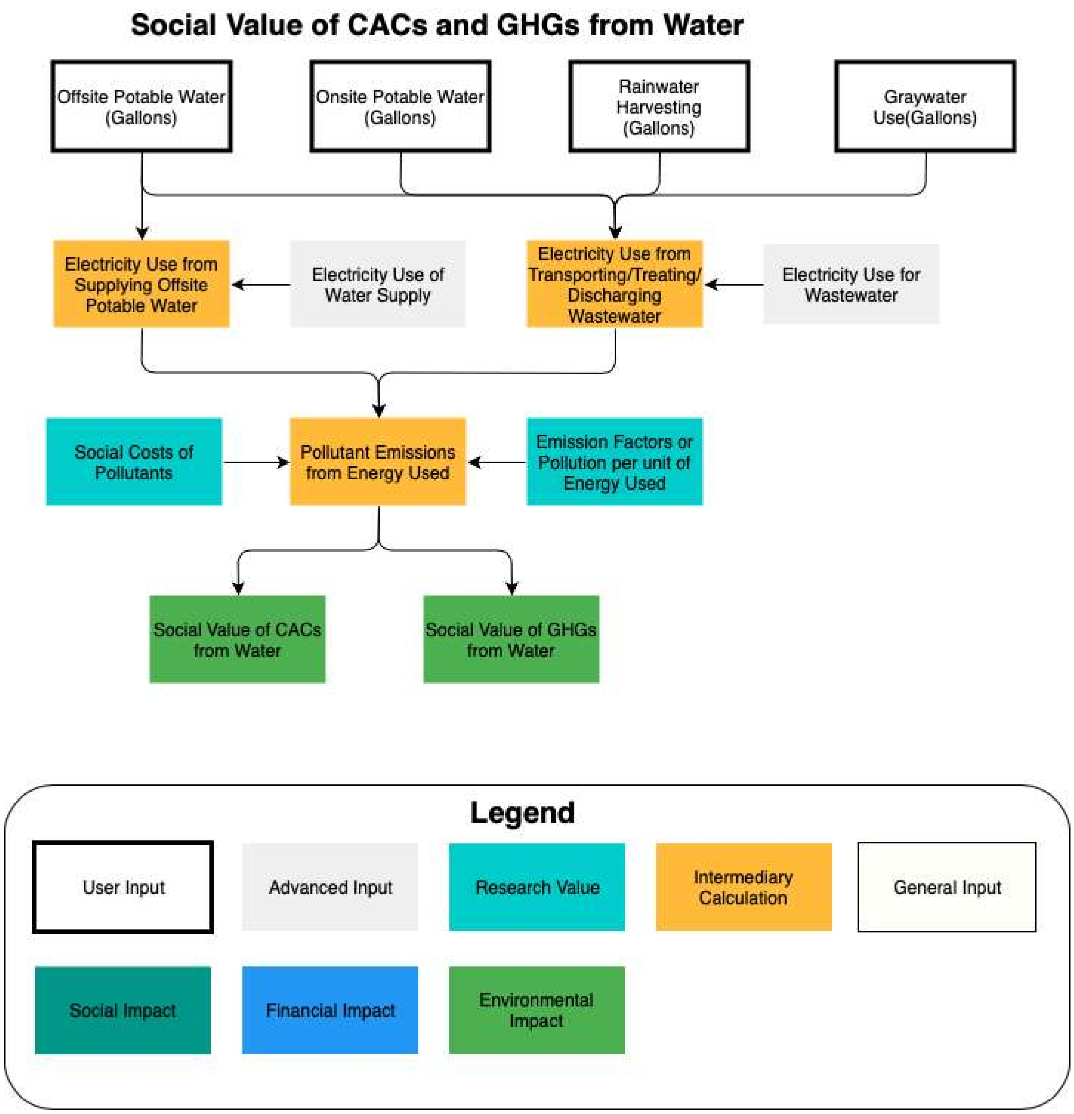




Air Pollutants and Greenhouse Gases (GHGs) and Water Efficiencies

Water supplied by a utility as well as wastewater treated by a wastewater treatment plant require significant energy use. Using emission factors and the amount of offset energy from the grid, the societal benefit is monetized by applying the social cost to each air pollutant, including: NOx, SO2, PM2.5, and VOC.

Autocase uses information on energy intensities from the Water Research Foundation and Electrical Power Research Institute (2013) .Non-baseload, location-specific emission factors per unit of electricity are gathered from eGRID and National Emissions Inventory in the U.S and Air Pollutant Emission Inventory in Canada.



Default Values for Water Efficiencies

The default water usage is populated by combining the square footage of the building and the average utility water usage per square foot of the building type separated by region and building type found from CBECS Water Usage defaults Autocase defaults to city-specific water cost estimates using American Water Works Association's Water and Wastewater Survey (2014) for US cities, and Environment Canada's Municipal Water Pricing Data (2009) for Canadian cities.

Glossary

Base and Alternate Cases

The cost benefit analysis in Autocase must be run relative to a base case. The proposed project is the alternative. There are a number of circumstances in which questions about the base case are asked in Autocase.

Benefit Cost Ratio (BCR) The benefit cost ratio (BCR) is – as it sounds – benefits divided by costs. The BCR is an efficiency indicator that explains how much benefit the project creates for every dollar of cost spent on the project. If the budget is constrained, a higher benefit cost ratio is preferred due to every dollar of investment cost being worth more in benefit. The calculation includes salvage values, residual values of an investment, renewable energy revenues, tax credits, incentives, and all social and environmental benefits as “benefits” (for the numerator). Similarly, financial impacts excluding salvage value and residual value in addition to electricity and natural gas costs, are considered “costs” and are in the denominator.

A BCR > 1 means that more than $1 of benefit is generated for every $1 in cost, thus representing good value for money.

A BCR < 1 means that the costs associated with that design are higher than the benefits.

Cost Benefit Analysis (CBA)

Cost benefit analysis is a formal way of organizing the evidence on the key good and bad effects of projects. The objective may be to decide whether to proceed with the project, to see if the benefits justify the costs, to place a value on the project, or to decide which of various possible alternatives would be the most cost-effective.

To compare different projects or alternatives of the same project that may have impacts occurring in different years, discounting is used to convert future benefits and costs to a current year perspective. The standard criterion for deciding whether a project can be justified is whether the net present value (NPV) is positive. The NPV is the discounted monetized value of expected net benefits (i.e., benefits minus costs).

Cost Benefit Analysis Best Practice

The following section sets forth the manner in which Autocase follows best practices in CBA. Autocase has been designed such that it uses and follows general principles outlined in guidance from the US Federal Government around cost benefit analysis, including Office of Management and Budget (OMB) Circular A-94, the document which provides guidance on US federal government CBAs. Below are more detailed explanations of a number of key concepts from federal guidance.

Discounted Payback Period (DPP)

The financial discounted payback period determines the time it takes to pay back the initial upfront investment. In Autocase, only the financial impacts are included in this calculation, and not the social or environmental. The smaller the number, the quicker the payback.

Discounting

The default discount rate used in Autocase is equal to the Social Opportunity Cost of Capital, or 7.0%. The social discount rate can be thought of as measuring a time preference for the present over the future and an opportunity cost that using resources today means that they are not invested for use later. The time preference can also be thought of as being composed of a pure time preference and a premium for the uncertainty that benefits and costs in future will materialize. We have decided in Autocase to follow the U.S. Federal Government guidance and use a 7% real discount rate.

Impacts vs. Benefits and Costs

Autocase calculates the economic benefit or value of a project. It does not calculate economic impact (jobs created, GDP, and income created). The reason is that impacts are a poor measure of value. While these statistics may have value to some, there are more reliable and impartial statistics for measuring welfare or value.

Life Cycle Cost Analysis (LCCA)

Life cycle cost analysis (LCCA) moves past just assessing the upfront costs when making a decision, and instead evaluates alternatives to purchase, own, operate, maintain and, finally, dispose of an investment, when each is equally appropriate to be implemented on technical grounds.

Net Present Value (NPV)

NPV is the present value of benefits net of present value of costs over the project’s entire life – it is the projected future cash flows over 50 years which are discounted to current dollars, essentially showing the entire value of the project over 50 years in today’s dollars. TBL-NPV is the principal measure of a capital investment’s economic worth:

TBL-NPV > 0, means benefits are larger than costs.

TBL-NPV < 0, means costs are larger than benefits.

Return on Investment (ROI)

The return on investment (“ROI”) can indicate whether capital is returning more than was spent on the investment. A high ROI means the investment's gains were significantly higher than its costs.