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Article

Economic Analysis of Sustainable Transportation Transitions: Case Study of the University of Saskatchewan Ground Services Fleet

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Abstract: The global transport sector of the world economy contributes about 15% of the Greenhouse Gas (GHGs) emissions in the world today. The University of Saskatchewan has pursued the green energy transition over the years. They have spearheaded diverse sustainability projects and agendas, due to the importance of curbing climate change and advancing sustainability. The transport system in the university campus is one area of focus where the Sustainability Office plans to introduce some innovations, as a way of curbing GHG emissions while also advancing sustainability practice in the university campus. The study carried out an economic benefit analysis on the campus fleet (consisting of 91 ICE vehicles) to determine if it is economically or financially feasible to transition from Internal Combustion Engine (ICE) or PVs (Petrol Vehicles) to Electric Vehicles (EVs). The analysis used RETScreen Expert software for analyzing renewable energy technology projects. The variables of Payback Period (PBP), cash flow projections, savings made from transitioning (fuel cost savings and energy cost savings), Benefit-Cost-ratio, GHG emission reduction potential, etc. were analyzed. The findings revealed that the GHG emission from the campus fleet will be reduced by 100% (this will result in the removal of about 298.1 tCO_2 from the environment). Also, the fleet manager will save approximately $129,049 (88.9%) in fuel costs. Apart from these, the return on investment will be achieved in year 5 (all things being equal), but can be reduced to year 2 if the vehicles are put into constant and active use (eliminating most idle times. Also, the Sustainability Office will be making a GHG reduction revenue of $14,906.

Keywords: sustainability; transportation; fleet management; campus; university; renewable energy; energy transition

1. Introduction

The transport sector of the economy remains one of the critical sectors that has received attention over the years. In 2010 for example, 14% of the global GHG emission came from the transport sector of the global economy [1]. As of 2017, 23% of the global GHG emission came from transport [2]. This is understandable, knowing that 95% of the world's energy for transport comes from fossil fuels (mainly gasoline and diesel) [1]. In 2019, Canada contributed 1.5% of the global emission, of which 30% of Canada's total emission came from transport [3]. Seeing how critical the transport sector (mostly road transport) is, as it concerns GHG emission, it is now evident that sustainable solutions are needed to cut down the negative impact of these emissions and advance the sustainability of the environment, while also enhancing climate change mitigation. Lots of efforts are already being put into decarbonizing the road transport sector, even as scientists, researchers, and investors are all working together to make meaningful impacts. Major investments are already being made towards supporting sustainable road transport (the use of vehicles or automobiles in moving people, objects, and services from one place to another). One important innovation in decarbonizing road transport is the introduction of electric vehicles or simply called smart mobility in general terms.

The World Bank projects that the global market for smart mobility may hit over $150 billion within the next 5 years [4]. This actually aligns with the fact that automakers (like Tesla, Nissan,

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Volkswagen, and even several Chinese automakers- mostly start-ups) are in a tight race of developing the most affordable, safe, green, and efficient electric vehicles (EVs) within the coming years. Automakers such as Tesla, Nissan, GM, Mercedes, etc., are in stiff competition, and a few years from now, mind-blowing innovations and technological disruptions (as it concerns the design and production of EVs) are expected to occur in this sector. General Motors (GM) for example is committed to ending the production of diesel and gasoline cars by 2034, while budgeting about $27 billion dollars for the transition project [5]. All these may also be attributed to the projections that in the coming years, the demand for transport will grow exponentially, while the required financing will reach about $50 trillion by 2040 [6]. This explains what the future holds for sustainable transport and EVs, and why EVs are the vehicles of the future, being that they promote sustainability and help to reduce GHG emissions. Figure 1 explains the market size for smart mobility across the various regions of the world.

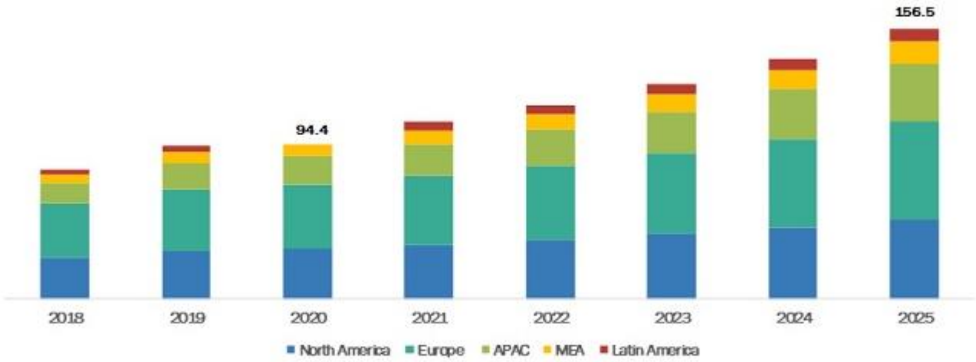

Figure 1. Smart Transportation Market, by region (in USD billion). Source: [4].

In the light of all these efforts, investments, and innovations, communities, cities, organizations, and nations are also working towards the full adoption of EVs. For instance, in June 2020, California enacted Advanced Clean Trucks (ACT) regulations, that is directed towards ensuring that manufacturers of trucks only sell zero-emission truck in an increasing rate (per annual sales), between 2024 to 2035 [7]. California by executive order expects that by 2035, only zero-emission compliant new passenger cars and light trucks will be sold in California [8]. Countries like Norway, Germany, France, Taiwan, India, United Kingdom, etc. have made commitments towards phasing out internal combustion engine (ICE) vehicles, even as cities such as Paris, Athens, Mexico City, Copenhagen, etc. have followed suit [9]. Businesses are not left out: over 600 companies with a total market cap of over $13 trillion dollars have signed on to the United Nations' Business Ambition for 1.5°C (a global coalition of United Nations agencies, businesses, and industry leaders that are committed to hitting the net-zero emission target by 2050) [10]. It is interesting to know that institutions such as universities across the globe are also at the forefront of combating climate change and advancing sustainability. Basically, universities play critical roles in championing sustainability through diverse means such as research and innovation, through their daily operations and diverse services [11].

Typical universities embody knowledge, innovation, and research, and are championing lots of initiatives geared towards advancing the cause of meeting the various decarbonization targets set globally. Thus, universities are setting up structures, projects, programs, and platforms that embody the concept of local actions that birth global impacts. They are also typical examples of organizations that are channeling different innovations and actions towards decarbonizing the environment.

Furthermore, university campuses are at the grassroots of innovation, research, and advancements, and as such, they are also championing diverse initiatives towards achieving global sustainability [12]. Therefore, the Sustainability Office of the University of Saskatchewan is a typical example of how universities set up structures to enhance sustainability and encourage innovation and research that is focused on climate change mitigation, while also creating platforms for discussions and actions that are focused on environmental sustainability and GHG mitigation.

The University of Saskatchewan – Dimensioning its decarbonization opportunities, challenges, and advantages.

Universities are knowledge centers for research, innovation, learning, and advancement of knowledge. They serve as incubation centers for most ideas that have changed the world. Over the years, most universities have triggered changes in their environment and around the world. This explains the importance of the role the universities play in championing global issues such as environmental sustainability, decarbonization of the environment, and sustainable energy and transport transitions. Universities are expected to play leadership roles in providing solutions to some of the issues facing societies today. Their strategy is hinged on the use of knowledge, innovations and, creativity to influence society, even as they help to birth new paradigms that enhance human lives and the advancement of society. A typical example is the Electric Vehicle Research Centre at the University of Toronto which was launched in 2016, where ground-breaking research into electric vehicles and batteries is being carried out [13]

It is also identified that there are some certain conditions or factors that help universities play their leadership role in the green revolution agenda. These factors help universities to scale up actions and impact at higher speed and effectiveness. Such factors include effective policy environment, adoption of the right strategies, raising and encouraging environmental advocates and ambassadors, creating awareness among staff and students as it concerns the importance of sustainability in preserving the future, and integrating sustainability practices into its daily operations (for example in its transportation system) [11]. Some of these factors are likely to distinguish a university campus in its sustainability drive.

University campuses represent the idea of local actions that produce global impact. Universities can act as living laboratories in developing ideas and innovations that trigger a paradigm shift in society and the economy. Typically, university campuses are usually communities that have buildings, laboratories, vehicles, energy supply systems, medical facilities, sports facilities, research centers, and the likes. All these represent what exists in the larger societies, hence, university campuses can leverage these operations and activities to demonstrate knowledge, rev up ideas and cause changes as it concerns climate change mitigation. In demonstrating this strategy, In 2020, the government of Canada through Natural Resource Canada gave $100,000 funding to the University of Guelph to install 20 EV chargers on campus, as a way of supporting Canada's ambition of achieving 100% passenger EV sales by 2040 in Canada [14] This further reinforces the role of universities in advancing decarbonization and climate change mitigation. Some of these actions have been demonstrated across the globe.

Across the world, several university campuses have championed sustainability initiatives (sustainable energy and transport transitions initiatives as well), and overall decarbonization of the environment. A typical example is the University of California, which has set itself as a leader and a shining example for others to follow, as it concerns climate change mitigation, environmental sustainability, and environmental policy and law [15]. The university has deployed diverse tools, projects, strategies, and programs toward bending the GHG emission curve and decarbonizing its campuses across its diverse operations [15].

For the University of Saskatchewan campus, the Sustainability Office is saddled to develop strategies and frameworks, while enhancing collaborative research on sustainability. They serve as platforms for interdisciplinary collaborations in research into diverse issues surrounding climate change, climate change mitigation, environmental sustainability, etc. Just like other campuses across Canada and North America, the Sustainability Office champions diverse programs, projects, and initiatives that tend to advance sustainability; while also coordinating various partnership initiatives (with government, research bodies, other organizations, and the private sector) that are focused on advancing sustainability in the university campus.

Over the years, the University of Saskatchewan has instituted diverse efforts to advance sustainability on the campus. The university is a signatory to the Climate Charter of Canadian Universities; a document that reinforces the commitment of Canadian universities to support the United Nations' 2050 net-zero emission target [16]. This shows the commitment and seriousness of

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the university towards curtailing or mitigating GHG emissions on campus, as part of its local actions. Also, the university initiated a strategic plan termed, The World the University Needs, a seven-year strategic plan that embodies diverse areas that require strategic improvements. Although the Strategic Plan does not embody sustainability as one of its five pillars, the goals and aspirations of the plan embody the principles of sustainability advancement, such as collaborations, boldness, innovations/curiosity, etc. [17]. It also plans to promote energy and environmental sustainability through its global citizenship and international community service agenda [17]. All these are plans and efforts of the University of Saskatchewan in achieving a zero-emission target on campus.

Furthermore, the university developed the 2019 GHG Emission Inventory, where it dimensioned how GHG is emitted and its diverse sources on the campus. From Figure 2 below, the fleet contributes 0.6% of GHG emissions on the university campus. It may seem little, but also significant when we consider the fact that it is categorized under direct emission, and the university has direct control over it. Therefore, the right action can help eliminate this. This is so important because the impact that such can create in the environment, mostly as it concerns public health may be too harmful in the long run.

The report suggests some remedies that can help to curb GHG emissions. One of such is fleet renewal. Hence, it is important to switch to more sustainable transport such as full adoption of EVs in the campus fleet. In the light of all these, it is obvious that the university has a good understanding of the challenges and therefore, is committed to resolving them, as we can see in the plan and the solution. The only visible gap is the right action in the right direction.

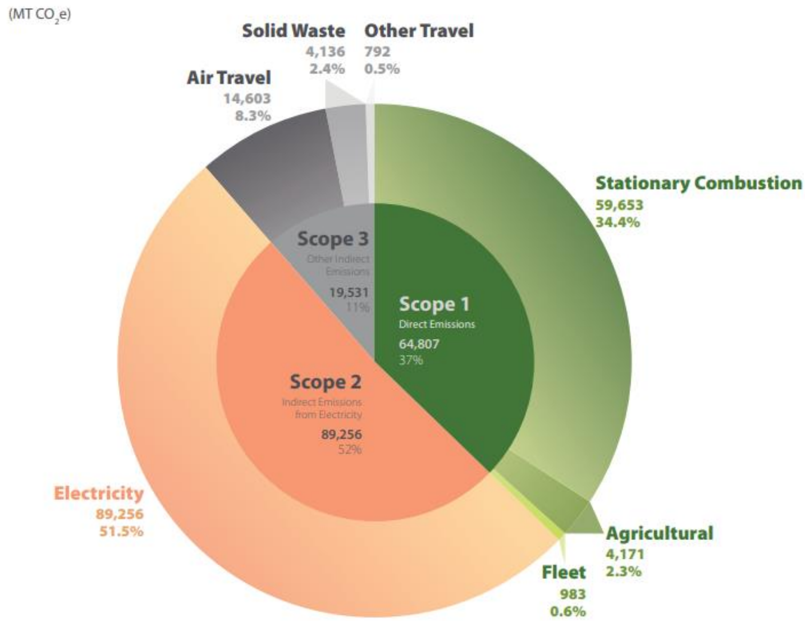

Figure 2. GHG emission by scope at the campus of the University of Saskatchewan. Source: [16].

Figure 3 shows some recommended solutions/strategies for curtailing GHG emission in the university campus. The recommendation is that the university should consider fleet renewal as solution for GHG emission mitigation.

Figure 3. Climate Action Plan Strategies and Initiatives recommended for the University of Saskatchewan, towards achieving GHG mitigation. Source: [16].

However, regarding green transportation on the campus, in 2013, AASHE (the Association for the Advancement for Sustainability in Higher Education) through its sustainability scoring/grading initiative termed STARS (Sustainability Tracking, Assessment and Rating System) program rated the University of Saskatchewan very low as it concerns the advancement of sustainable transport system: campus fleet, student commute modal split, and employee commute modal split. The report showed that only one vehicle out of 88 vehicles in the campus fleet was a full electric vehicle [18]. Comparing with the recent fleet data from the Sustainability Office, it's evident that little or no improvement has occurred in this area, hence, the urgent need to begin to implement sustainable transport initiatives (mostly as it concerns the adoption of EVs in the campus fleet) in the university campus. The impact of this will be far-reaching, not just in bagging good ratings but also in advancing sustainability practices in the campus and beyond.

The importance of EV adoption on campus cannot be overemphasized. Hence, this calls for quick actions.

Reasons for a green transport system on campus:

Cost of maintenance

Regarding the cost of maintenance, it is believed that EVs are cheaper to maintain. Most parts of EVs are not movable, which helps to avoid wear and tear when compared with most ICE [19]. Also, there is no oil change, and the most vital parts such as the battery, motor, electronics, brakes (EVs have regenerative breaks, and may not require frequent repairs when compared with that of ICEs), don't require frequent servicing or change [19]. These are some of the economic and financial benefits of switching to an EV. Though a few people have argued that the maintenance cost in the real world may be high since EVs are relatively new and evolving [20].

Environmental and Public Health Significance

One of the ways of measuring the extent of the impact of GHG (expressed in dollars) is the Social Cost of Carbon (SCC); it measures the impact of one tonne of carbon in a given year and expressed in dollars [21]. SCC expresses in dollar terms what the world will be losing if quick action is not taken regarding the sustainability of the earth, while it also helps policymakers to have a clear picture of impending danger that may arise in the future [22]. One of the major challenges with ICEs is that they emit GHG and dangerous pollutants that affect the environment (health, biodiversity, air quality, etc.). This is a major concern and a strong case for the advocates of the green transport revolution. GHG is also a major culprit in global warming and climate change. Some of these emissions come with significant public health impacts.

Some of these health /medical challenges can be caused by carbon and pollutants from automobile exhaust pipes: cancer, respiratory diseases such as asthma, cardiovascular harm such as heart attack, as well as reproductive and developmental harm, and early death, etc. [19]. Children are most likely to be affected by the deleterious impact of pollution and GHG emission from fossil fuels

[23]. Some of the observable effects of climate change/GHG emission in children are heat-related illnesses, mental ill-health, physical trauma, malnutrition, infectious diseases, asthma, etc. [23].

Agriculture and Biodiversity Conservation

GHG emission and climate change can reduce crop yields, resulting in huge loss of billions of dollars, and causing food insecurity in the world. Warmer climates may affect crops and livestock, increase the susceptibility of crops to pathogens, and increase the chances of natural disasters to destroy so many farms and farm settlements [24]. This also affects biodiversity conservation.

Biodiversity conservation is also another concern when the issues of climate change prop up. The existence of many species of plants and animals is constantly being threatened as global temperatures increase and more GHG is emitted [25]. Therefore, an agriculture-dependent economy like that of Saskatchewan (a natural resource-rich province) cannot afford not to act; and in the long run, is expected to immensely benefit from climate change mitigation programs and actions. This can be achieved by pursuing a green revolution agenda, policies, and by deliberately reducing GHG emissions through its actions and laws as this will ultimately enhance sustainable food production in the region and help conserve and preserve species of plants and animals in the region.

Energy Security

The global oil market is a volatile one, and with the constant rising and falling of oil prices, it's risky to depend on oil for energy. In 2020, the world witnessed a strange event when the price of oil futures hit zero, and further went into a negative price zone for the first time in decades [26]. At this level, the revenue from sales of crude could not cover the production cost [27]. With this level of volatility, no nation should bank on oil for its continuous revenue flow (nations that largely rely on oil and gas revenues are worst exposed to the shocks in the global energy market).

In all, energy has become an essential part of daily living for institutions and communities. Hence, communities and institutions must plan to secure or shield themselves from the uncertainties or volatilities of the global energy market. Adopting EVs will help shield or protect the University of Saskatchewan from the vagaries of unstable oil and gas prices or shocks, while also helping the institution to save cost in terms of money spent in fueling and servicing (oiling).

Social Perspectives (Social Justice)

Considering the health and economic implications of transitioning to EVs, and how GHG emission causes harm to public health and the environment, one can say that GHG emission and climate change pose a serious risk to human life, and if it is the right of humans to have access to good health, life, and quality standard of living- a life that is free from any form of harm, torture or any form of stress or discomfort in the environment, then, there is need to approach climate change from the principles of social justice [28]. With this, it means that when nations, individuals, communities, and institutions take positive efforts towards curbing climate change and reducing GHG emission, they are preserving the rights of the people, and this will, in turn, increase the quality or standard of living not just in that particular environment, but also in the entire world (since climate change is a global issue).

2. Materials and Methods

2.1. Research Method

2.1.1. Data Collection and Data Cleaning

Fleet data (secondary data source) was supplied by the partner organization (the University of Saskatchewan) and was further worked on to suit the analysis and the analytical tool. Table 1 represents the clean dataset for the campus fleet: 91 ICEs exist in the fleet. 2 vehicles in the fleet use diesel as fuel, while 89 use gasoline.

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Table 1. Dataset for the University of Saskatchewan campus fleet. Source: the Sustainability Office of the University of Saskatchewan.

Vehicle Type	FLEET	TYPE	STATE	FUEL	Litre	Avg km travelled	kW/h	Litre/ 100Km
2001 CHEVROLET S-10 1/4 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	342	2,407	3184.94	14.2
2002 DODGE ST2500 4X2 QUAD CAB WITH VAN BODY	FLEET	TRUCK	ACTIVE	Gasoline	942	4,400	8772.55	21.4
2002 FORD E150 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	328	1,795	3054.56	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	419	2,291	3902.02	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	298	1,627	2775.18	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	290	1,583	2700.68	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	305	1,669	2840.37	18.3
2002 FORD SUPER DUTY F-450 REGULAR CHASSIS CAB 4 X	FLEET	TRUCK	ACTIVE	Gasoline	735	7,002	6844.83	10.5
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	382	2,034	3557.45	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	521	2,770	4851.91	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	418	2,225	3892.7	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	582	3,094	5419.98	18.8
2004 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	254	1,458	2365.42	17.4
2004 FORD E150 VAN	FLEET	VAN	ACTIVE	Gasoline	170	974	1583.16	17.4
2004 FORD E150 VAN	FLEET	VAN	ACTIVE	Gasoline	258	1,483	2402.67	17.4
2004 GMC EXPRESS COMMERCIAL CUTAWAY VAN	FLEET	VAN	ACTIVE	Gasoline	440	2,416	4097.58	18.2
2005 CHEV HD SILVERADO 3/4 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	613	3,294	5708.68	18.6
2005 CHEV SILVERADO 1 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	614	3,303	5717.99	18.6
2006 CHEV EXPRESS CARGO 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	287	1,579	2672.74	18.2
2006 CHEV EXPRESS CARGO 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	690	3,790	6425.76	18.2
2006 DODGE DAKOTA CLUB CAB TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	240	1,570	2235.05	15.3
2006 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	264	1,500	2458.55	17.6
2007 DODGE CARAVAN CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	468	3,418	4358.34	13.7
2007 FORD E150 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	219	1,182	2039.48	18.5
2007 FORD FREESTAR VAN	FLEET	VAN	ACTIVE	Gasoline	80	512	745.012	15.6
2007 STERLING ACTERRA 3 TON DUMP TRUCK	FLEET	TRUCK	ACTIVE	Diesel	1,373	4,429		31.8
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	293	1,863	2728.62	15.7
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	511	3,255	4758.78	15.7
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	637	4,058	5932.18	15.7
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	106	675	987.145	15.7
k2008 CHEV UPLANDER	FLEET	VAN	ACTIVE	Gasoline	61	414	568.07	14.7
2008 FORD 1/4 TON RANGER XL TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	627	4,934	5839.06	12.7
2008 STERLINE 360 COE30 CAB & CHASSIS	FLEET	TRUCK	ACTIVE	Diesel	929	2,921		31.8
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	656	4,175	6109.12	15.7
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	199	1,269	1853.23	15.7
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	485	3,089	4516.65	15.7
2009 CHEV EXPRESS 1500 1/2 TON PASSENGER VAN	FLEET	VAN	ACTIVE	Gasoline	185	1,175	1722.85	15.7
2009 CHEV SILVERADO 3500HD 1-TON TRUCK (SANDER)	FLEET	TRUCK	ACTIVE	Gasoline	1,048	6,675	9759.69	15.7
2009 CHEV UPLANDER	FLEET	VAN	ACTIVE	Gasoline	465	3,165	4330.4	14.7
2009 CHEV UPLANDER	FLEET	VAN	ACTIVE	Gasoline	56	379	521.51	14.7
2009 CHEV UPLANDER	FLEET	VAN	ACTIVE	Gasoline	118	802	1098.89	14.7
2009 JOHN DEERE 4X4 GATOR	FLEET	UTILITY	ACTIVE	Gasoline	135	378	1257.21	35.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	809	5,154	7533.96	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	335	2,132	3119.75	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	427	2,722	3976.52	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	351	2,236	3268.75	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	168	1,070	1564.53	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	86	546	800.89	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	1,658	10,561	15440.4	15.7

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2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	344	2,188	3203.57	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	398	2,532	3706.45	15.7
2010 CHEV SILVERADO 3500HD 1 TON FLAT DECK TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	1,717	10,935	15989.9	15.7
2010 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	1,158	8,452	10784.1	13.7
2011 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	608	3,873	5662.11	15.7
2011 CHEV SILVERADO 2500HD	FLEET	TRUCK	ACTIVE	Gasoline	771	4,912	7180.08	15.7
2011 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	186	1,358	1732.16	13.7
2011 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	209	1,524	1946.35	13.7
2011 JOHN DEERE HPX GATOR	FLEET	UTILITY	ACTIVE	Gasoline	158	443	1471.4	35.7
2011 JOHN DEERE HPX GATOR	FLEET	UTILITY	ACTIVE	Gasoline	291	815	2709.99	35.7
2012 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	379	2,417	3529.51	15.7
2012 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	407	2,968	3790.26	13.7
2012 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	366	2,674	3408.44	13.7
2012 FORD TRANSIT CONNECT	FLEET	VAN	ACTIVE	Gasoline	519	4,432	4833.29	11.7
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	517	2,889	4814.66	17.9
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	287	1,603	2672.74	17.9
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	614	3,428	5717.99	17.9
2013 FORD F550 XL (BUCKET TRUCK)	FLEET	TRUCK	ACTIVE	Gasoline	1,024	5,222	9536.19	19.6
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	567	3,318	5280.29	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	205	1,199	1909.1	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	521	3,048	4851.91	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	797	4,663	7422.21	17.1
2014 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	334	2,441	3110.44	13.7
2014 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	218	1,591	1992.92	13.7
2014 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	441	2,490	4106.89	17.7
2014 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	201	1,134	1871.85	17.7
2014 FORD TRANSIT CONNECT CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	264	2,446	2458.55	10.8
2015 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	242	1,763	2253.67	13.7
2015 JOHN DEERE 4 X 2 GATOR (TEST LM0025 SEPT 30/15)	FLEET	UTILITY	ACTIVE	Gasoline	11	34	102.44	32
2016 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	1,817	8,261	16921.2	22
2016 CHEVROLET COLORADO CREW CAB	FLEET	TRUCK	ACTIVE	Gasoline	769	6,463	7161.46	11.9
2016 CHEVROLET COLORADO CREW CAB	FLEET	TRUCK	ACTIVE	Gasoline	1,130	9,498	10523.3	11.9
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	15	110	139.69	13.7
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	319	2,331	2970.75	13.7
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	78	566	726.39	13.7
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	1,113	8,122	13.7	13.7
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	357	2,604	3324.63	13.7
2017 Chev Express 2500 Cargo Van	FLEET	VAN	ACTIVE	Gasoline	313	1,435	2914.87	21.8
2017 Chev Silverado 1500	FLEET	TRUCK	ACTIVE	Gasoline	704	4,818	6556.13	14.6
2017 Ford F150	FLEET	TRUCK	ACTIVE	Gasoline	889	7,285	8278.98	12.2
2017 Ford Transit	FLEET	VAN	ACTIVE	Gasoline	477	4,011	4442.15	11.9
2018 Chev Silverado 1500	FLEET	TRUCK	ACTIVE	Gasoline	866	5,934	8064.79	14.6

Fuel Type	**Total Fuel Usage in 2020, Liters**	**Number of Vehicles**
Gasoline	39,842	89
Diesel	2,302	2

From the number of liters supplied, the average kilometer traveled in a year was calculated using the fuel consumption rating expressed in Liter/100Kilometers.

The data on fuel consumption rating was derived from the government of Canada website [29]

Liter of fuel used or issued = L (expressed in liters)

Fuel consumption rating of the ICE = Y (expressed in liter/100Km). This is unique for each vehicle model or spec.

Number of kilometers covered by the ICE (expressed in kilometers) = Z

Hence Z (number of kilometers covered by a particular vehicle in the fleet) = L*100/Y = Average kilometer traveled by a particular vehicle in the fleet.

Note that this is based on the assumption that the vehicles have not lost their minimum efficiency as of the time of calculation.

2.2. Modelling using RETScreen Expert

The RETScreen® Clean Energy Management Software is a renewable energy technology software developed by the government of Canada for modeling diverse renewable energy projects. The software is effective for planning, implementation, monitoring, and reporting renewable energy projects of diverse scales [30]. The premium version of this software is called, RETScreen Expert. This version was deployed during the course of this project.

2.2.1. Brief Description of RETScreen Expert

RETScreen Expert has some interesting features that make it unique for renewable energy feasibility analysis while considering location, cost (financial and economic factors), risk, technology, and other important factors or variables that may be useful in renewable energy technology (RET) assessment or study.

Diverse projects can be analyzed using the RETScreen Expert software. Such projects are centered on these modules:

- Power Plants
- Power, Heating, Cooling
- Industrial
- Commercial/Institutional
- Residential
- Agriculture
- Individual Measure
- Transportation
- User-Defined.

Our analysis was centered on the Transport Module. A feasibility analysis was centered on Location, Energy, Cost, and Finance, within the transportation module.

In analyzing energy under the transportation module, diverse variables such as vehicle type, distance covered, fuel type, fuel consumption, the amount saved on transitioning to the renewable energy transport system, efficiency, and cost are considered. With this, one can easily infer/predict performance and also have an idea of the feasibility of the project.

Location: with the help of satellite data, RETScreen can pick global locations and pick up the weather data and all essential data for such locations.

In terms of finance and economics, the cost is quite an important factor or variable. Majorly because it determines how feasible the project may be, and how investors, banks, and the users will perceive the viability of the project.

3. Results

This model has captured some key parameters that determine the viability of a project like this. One of such is the cash flow. Granted, it's observed that despite the huge capital outlay (initial cost of purchase) required for this project, a positive cash flow of $72,054 was realized in year 1 of the project. This shows the strong viability of this project. Although, when the cumulative cash flow is considered, the project seems to yield positive cash flow in year 5, which is also a good one for a project of this type.

A very interesting parameter to be considered again in this project is the payback period. The simple payback period will be achieved within 4.6 years, and an equity payback period will be realized within 4.7 years. This is also a good result for this type of project. It means that the project can pay back its initial cost within 5 years. Although, this is expected to be lesser if the EVs are put into active use (minimizing idle times as much as possible).

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Considering the IRR (internal rate of return), this typifies the growth rate that a project or investment is expected to generate in a year, or simply put the investment returns. The higher the IRR, the more viable the project. With an IRR of over 30%, this project is expected to be a viable one. Also, considering the NPV (net present value), which expresses, the time value of money (TVM), it can be seen that the NPV of the project is positive. As such a positive NPV means a viable project.

Another interesting parameter is the total annual savings and revenue. For this project, it stands at $160,140. This represents huge savings for the University of Saskatchewan. This savings results from fuel cost savings of $145,234, and GHG reduction revenue of $14,906 (this may be higher if the proposed policy of carbon price of $170/tCO_2$ is considered (this policy is expected to come into effect by 2030) [31]. In all, this project will reduce energy consumption by 85.7%, and fuel cost by 88.9%. This is huge when you consider the impact it will create on the financials/savings of the fleet manager.

Furthermore, a great consideration as it concerns the significant impact of the projects is that this project will take out 298 tCO_2/year from the campus. And in 12 years it will take out 3,577 tCO_2 of carbon from the campus. Considering the effect of CO_2 in the environment (public health impact), as well as its contribution to climate change and global warming, it is so clear that the impact of this project will be enormous.

In all, looking at the Benefit-Cost- Ratio (BCR) of the project, which is 3.7, it clearly shows that the benefit of this project is much bigger than the cost: a BCR value of more than one (1) is a clear indication that that project is viable, and its benefit is bigger than the cost of the project.

Therefore, looking at all these key parameters, it can be concluded that the project is viable.

Highlights of Key Parameters/Variables

Fuel Cost Savings: considering the average retail gas price in Saskatoon to be CAD 1.2 [32] switching to EVs will save the fleet manager $129,049 in total savings (please see attached RETScreen report).

GHG Reduction Credit: this has been set at $20 for 2019, and to annually increase by $10/annum till it reaches $50/t/kgCO2 by 2022 [33]. The Prime Minister of Canada, Justin Trudeau, also plans to hike carbon price to C$170 per metric ton by 2030, which may bring gas price to more than 38 Canadian cents within the next 10 years [31]. Hence, when we further insert this hike in carbon levy into our model, we could have a payback period reduced to 2 years, and the university earning more from the GHG reduction credit. Overall, in the long run, when we put all these variables into consideration, the project stands out as a viable project with great prospects.

Road-Use Fee: considering that Saskatchewan Province will be charging $150 as the road-use fee on all EVs (this is expected to kick in by October 2021), this is one of the cost elements considered in the model [34]. This fee is charged as cost of highway maintenance by the Saskatchewan government. This results in a total cost of $12,750

Federal Incentives: also, a $5,000 federal government incentive on EV purchase was considered as a credit [35]. This produces total incentives and grants of $425,000.

Initial Cost: considering all these, an initial cost of $2,867,750 is required to switch to EVs, and this sum is expected to be financed at 3 %/annum. There is a possibility of getting zero-interest financing in Canada. For instance, the Canadian government has budgeted C$15 billion for green projects/initiatives that enhance decarbonization, and this is being channeled through the Canada Infrastructure Bank [31]. This project can be financed through such an arrangement, or even through a blended finance structure (a mix of corporate debt and subsidized credit from development finance institutions (DFIs) or grants).

Fuel Escalation Rate:

Fuel escalation rate is a measure of the changes in the cost of fuel in Saskatchewan. Escalation rate measures the degree of change in the price of a particular good or service. It is calculated by subtracting the initial cost from the present cost, divided by the initial cost, and multiplied by 100.

For Saskatchewan in 2020 [32] it was calculated thus:

Starting price as of January 2020 = 1.261

Closing price as of December 2020 = 1.32

Hence, escalation price is 1.32-1.211/1.211 = 0.059*100 = 9%

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Inflation Rate: taking the 2020 average inflation rate in Saskatchewan to be 0.62% [36]. This value is used to model this project as it concerns inflation.

O&M Savings: the total savings as it concerns O&M (Operating and Maintenance) cost when switching to an EV over the lifecycle (which varies and depends on the EV type as well as other factors) of that EV is $4,600 [37].

Debt Interest Rate: the debt interest rate is set at 3%; though the average debt rate in Canada is between 3% and 6% for someone who has a good credit rating, and there are possibilities of having a 0% discount, mostly for manufacturers who want to attract more buyers [38].

Debt Term: this is the duration for servicing the debt before total pay down. This is stated as 4 years (which is usually the conventional debt term for vehicle finance lease)

Debt Ratio: this entails and implies the percentage (60%) of the total debt that the financier will be contributing, while the University of Saskatchewan will finance 40%.

Cash Flow: Figure 4 shows that positive cash flows are observable from year 5, though cumulative cash flow comes to positive from year 1

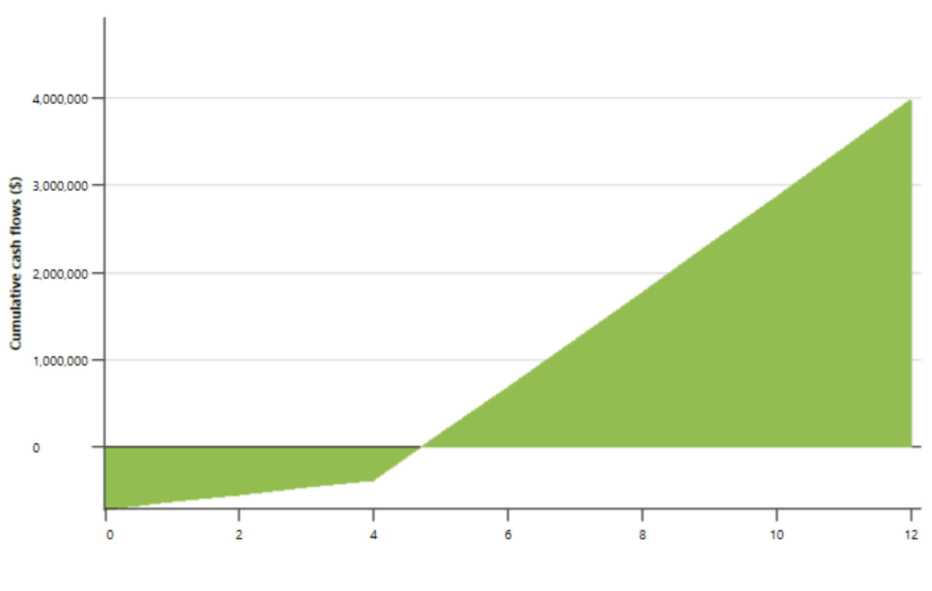

Figure 4. a graphical representation of cash flow model for the project.

Simple Payback Period (PBP)

The simple payback period is at 5.3 years. Although for an EV, the ideal payback period is between 2 to 3 years, this is more realizable for EVs that are high-mileage driven (active usage for Bolt and Lyft services for example) [39]. So, the fleet manager can achieve quick PBP if he plans to put the EVs in more active use. This means that few vehicles can be purchased so that the available vehicles can be put into maximum/more active use.

Note that these are variables that can be changed/altered to suit a particular scenario or model.

4. Discussion

From the analysis, we can see that it is a profitable investment/venture, seeing that our financial ratios are looking good, and the project should be ''in the money'' within 5 years. For instance, the cumulative cash flow became positive in the first year. Also, the PBP kicked in within 5 years. The Benefit-Cost- Ratio (BCR) is 3.7 being higher than one, which signifies that the project has a positive net present value- NPV. This shows that the benefit of the project far outweighs its cost implications. Also, the IRR (internal rate of return) represents the returns that the investment should make in a year. An IRR of 30.9% is a good one. This, therefore, proves that the project is a profitable one. The NPV for this project is positive, and as such, the project is profitable. Annual lifecycle savings is $312,498. Also, GHG reduction revenue is $14,906 in 4 years.

With these parameters pointing northwards, the Sustainability Office, the campus, and the entire university community will benefit immensely from this project, and as such, this project should be vigorously pursued.

Regarding the huge initial cost, which could be a major challenge, it is recommended that engaging a credit provider or financier that can finance the entire project with the Sustainability Office not having to make any equity contribution will be most ideal. This will reduce the initial burden of contributing so much equity. Also, it will be most profitable and appropriate to source for financiers who offer zero interest rates. This will further increase the profitability of the project.

One important consideration that should also be made regarding the huge initial capital outlay and the cost of the initial project capital, is leveraging cheap funds from the government, as well as grants. Since the government has made available diverse grants and cheap funds for green projects, the Sustainability Office should consider these cheap sources of funds before thinking of corporate loans or credits, which are usually costlier. This will help reduce the burden of paying back the loans, reducing the payback period, increasing cash flow, and generally enhancing the profitability of the project and the BCR of the project. A typical fund to be considered is that being offered by the federal government through the Canada Infrastructure Bank [31].

One key recommendation is that the vehicles in the fleet should be put into more active use (covering higher mileage), as this will help reduce the payback period to 2 years, thereby creating more benefits for the project [39].

Looking at the money saved from fuel, and the money earned from carbon credits, as well as the quantity of carbon, this project will remove global carbon emissions (298 tonnes),which indicates that this project is feasible and viable, and thus, should be implemented.

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