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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 Greenhouse Gas (GHG) emissions in the world today, and this must be drastically curbed. To reduce GHG emissions and achieve carbon neutrality, the University of Saskatchewan's Office of Sustainability has directed a green energy transition for the institution in recent years, leading diverse sustainability projects and agendas due to the importance of curbing climate change and advancing sustainability. However, there is a strong need to pursue deep decarbonization within the campus, and the university transport system is a critical operational area that the Sustainability Office has considered for decarbonization to achieve the net-zero agenda of the university. The motivation for this work stems from the directive of the Sustainability Office to transform the campus vehicle fleet as an identified area for curbing GHG emissions and meet the University agenda. This study was organized in partnership with the Sustainability Office and involved an economic benefit analysis of the campus fleet (consisting of 91 ICE vehicles) to determine if it was economically or financially feasible to transition from Internal Combustion Engines (ICEs) or PVs (Petrol Vehicles) to Electric Vehicles (EVs). The analysis used RETScreen Expert (a software for analyzing renewable energy technology projects) to model diverse transition scenarios. The variables of Payback Period (PBP), cash flow projections, savings made from transitioning (fuel cost savings and energy cost savings), benefit–cost ratio, and GHG emission reduction potential were analyzed. The findings revealed that the GHG emissions from the campus fleet could be reduced by 100%, resulting in the removal of 298.1 tCO_2 from the environment. The fleet manager could save $CAD 129,049 (88.9%) in fuel costs, and the return on investment could be achieved in year 5 but could be reduced to year 2 if the vehicles were put into constant and active use, eliminating idle times. Lastly, the Sustainability Office would achieve a GHG reduction revenue of CAD 14,906. These findings show that pursuing sustainable transport transitions in the transportation transition for a university campus is financially and economically viable and should be pursued vigorously. The contribution of this work provides examples and evidence to advance policy recommendations to aid the effective and efficient transitioning of the transportation sector, specifically for communities at the scale of university campuses.

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

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1. Introduction

The transport sector of the economy remains one of the critical sectors that has received attention over the years as it concerns decarbonization. In 2010 for example, 14% of the global GHG emissions came from the transport sector of the global economy [1]. As of 2017, 23% of the global GHG emissions 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 global emissions, of which 30% of Canada's total emissions came from the transport sector [3]. Seeing how critical the transport sector (mostly road transport) is, as it concerns GHG emissions, it is evident that sustainable solutions are needed to cut down the negative impact of these emissions and advance environmental sustainability, while also enhancing climate change mitigation and transport poverty reduction [4]. Because of this critical reality, efforts are already put into decarbonizing the road transport sector, even as scientists, researchers, and investors are working together to make meaningful impacts.

Major investments, policy changes, and innovations are being channeled toward supporting sustainable road transport transitions [5]. Moreover, one important innovation in decarbonizing road transport is the introduction of electric vehicles or smart mobility in general terms. The market for this innovation is growing rapidly, as seen from market reports.

For instance, the World Bank projects that the global market for smart mobility may hit over USD 150 billion within the next 5 years [6]. This clarifies why automakers (such as Tesla, Nissan, Volkswagen, and several Chinese automakers) are already in a tight race for developing the most affordable, safe, green, and efficient electric vehicles (EVs) within the coming years. Due to this stiff competition, automakers such as Tesla, Nissan, GM, Mercedes, and others are expected to invest massively in the design and production innovations for EVs, as this sector continues to experience growth and advancement. General Motors (GM), for example, is committed to ending the production of diesel and gasoline cars by 2034, while budgeting nearly USD 27 billion dollars for the transition project [7]. All these strategies and plans support the projections that, in the coming years, the demand for transport will grow exponentially, while the required financing will reach about USD 50 trillion by 2040 [8]. However, the reason for these huge investments is not just based on economics and market impact, but also on the importance of leveraging green transport transitions to achieve the carbon neutrality goal and attain a sustainable environment. To support this, Zhao et al. [9] carried out a study to ascertain the impact of green transportation in achieving carbon reduction in about thirty provinces in China between 2002 and 2017. The results indicated that adoption of EVs as a green transport system could significantly reduce carbon emissions. Furthermore, the findings revealed that the level of transition in each province influenced nearby provinces. In similar research carried out by Dioha et al. [10] and Tomsic et al. [11], studies have revealed that EV adoption can significantly reduce carbon emissions, reduce cost, and improve environmental sustainability. This emphasizes the importance of sustainable transport transitions in attaining net-zero goals and further suggests that EVs are the vehicles of the future due to their ability to promote sustainability and help reduce GHG emissions, as shown in Figure 1, which indicates the projected market for smart mobility across various regions.

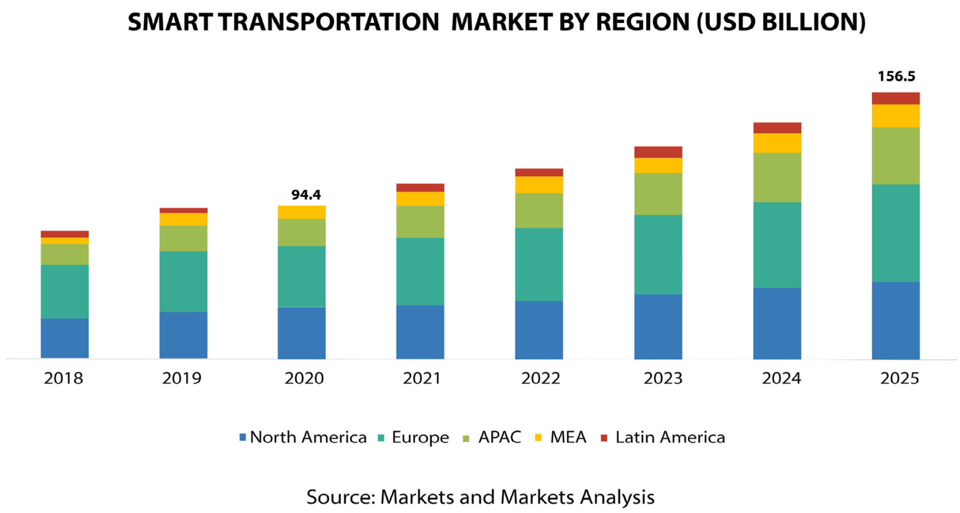

Figure 1. Smart transportation market by region (in USD billion). Source: [6]. Reprinted with permission from Ref. [6]. Copyright 2021, World Bank.

Furthermore, the enormous impact of green transport illustrates why communities, cities, organizations, and nations are investing resources toward the full adoption of EVs. For instance, in June 2020, California enacted the Advanced Clean Trucks (ACT) regulations that is directed toward ensuring the manufacturers of trucks only sell zero-emission trucks at an increasing rate (per annual sales) between 2024 and 2035 [12]. Consequently, California, by executive order, expects that, by 2035, only zero-emission-compliant new passenger cars and light trucks will be sold in the state [13]. Moreover, countries such as Norway, Germany, France, Taiwan, India, and the United Kingdom have made commitments toward phasing out internal combustion engine (ICE) vehicles, even as cities such as Paris, Athens, Mexico City, and Copenhagen have followed suit [14]. Additionally, businesses and organizations are not left out: to date, approximately 600 companies totaling a market cap of over USD 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 [15]. Similarly, institutions such as universities across the globe are at the forefront of combating climate change and advancing sustainability.

Universities across the world are demonstrating the significance of local action in curbing GHG emissions. A typical example is the University of California, which has set itself as a leader and a shining example for others to follow through its concerns with climate change mitigation, environmental sustainability, and environmental policy and law [16]. Victor et al. [16] analyzed and dimensioned diverse projects and efforts of the University of California to decarbonize the campus. The various programs, projects, and operations designed to achieve sufficient carbon neutrality on the campus were captured and analyzed. Transport and energy were boldly highlighted as major sources of carbon emissions within the operational areas across its ten campuses. The research concluded by emphasizing the ecological consequences of not implementing a deep decarbonization agenda, as well as the ability of effective planning for mitigation and transition program results in successful investment in the long run due to cost savings over time.

Therefore, it is evident that universities play a critical role in championing sustainability through diverse means, such as research and innovation, as well as through their daily operations and different services [17]. Granted, many universities across Canada are championing many initiatives geared toward advancing the need to meet various decarbonization targets set globally. Typically, universities set up structures, projects, programs, and platforms that embody the concept of local actions that birth global impacts. A typical example is the Electric Vehicle Research Center at the University of Toronto, which was launched in 2016, where ground-breaking research into electric vehicles and batteries is carried out [18].

To further illustrate this, in 2020, the Government of Canada, through Natural Resource Canada, provided CAD 100,000 of funding to the University of Guelph to install twenty EV chargers on campus as a way of supporting Canada's ambition of achieving 100% passenger EV sales by 2040 [19]. This further reinforces the role of universities in advancing decarbonization and climate change mitigation, and some of these actions have been demonstrated across Canada and the globe.

In this case study, the University of Saskatchewan campus through the Sustainability Office, which is responsible for developing sustainability strategies and frameworks for the university, is promoting collaborative research on sustainability and climate change mitigation within the university campus. They serve as a platform for interdisciplinary collaborations in research on diverse issues surrounding climate change, climate change mitigation, and environmental sustainability, especially across the operational areas of the university. Similar to other university 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 governments, research bodies, other organizations, and the private sector) that are focused on advancing sustainability within the university campus [20]. However, the university has yet to witness deep decarbonization, and therefore, positions this research as essential.

Based on the principle that university campuses are at the forefront of innovation, research, and knowledge advancement and are always researching and innovating in order to achieve global sustainability and deep decarbonization [16,20], the University of Saskatchewan's Sustainability Office was established as a structure to facilitate and advance sustainability and deep decarbonization, encourage innovation, and design research initiatives focused on climate change mitigation, while also creating platforms for discussions and actions focused on environmental sustainability and GHG mitigation.

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

Over the years, the University of Saskatchewan has instituted and demonstrated diverse efforts to advance sustainability on the campus. For instance, 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 [21]. This shows the commitment and seriousness of the university toward curtailing and mitigating GHG emissions on campus as part of its local actions. In addition, 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, and curiosity [22]. It also plans to promote energy and environmental sustainability through its global citizenship and international community service agenda [22]. All these are plans and efforts of the University of Saskatchewan for achieving a zero-emission target on campus.

Additionally, the university developed the 2019 GHG Emission Inventory, where it dimensioned how GHG is emitted and its diverse sources on the campus. Figure 2 indicates that the campus fleet contributes 0.6% of the GHG emissions on the university campus. It may seem insignificant but considering that it is categorized under direct emissions that the university has direct control over, with the right action, this can be eliminated and can significantly impact health and wellbeing on campus and in the greater community, as it relates to public health in the long run. This report suggests some remedies that can help curb GHG emissions on the university campus, and one is fleet renewal [23]. This further demonstrates the importance of switching to more sustainable transport systems, such as the full adoption of EVs in the campus fleet.

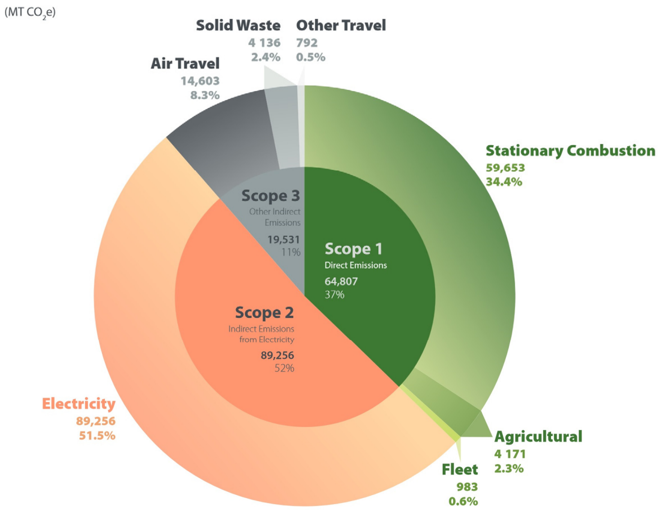

Figure 2. GHG emissions by scope on the campus of the University of Saskatchewan. Source: [23].

Figure 3 provides categories of recommended solutions and strategies for curtailing GHG emissions on the university campus. The recommendation is that the university should consider fleet renewal as a solution for GHG emission mitigation.

Figure 3. Climate action plan strategies and initiatives recommended for the University of Saskatchewan toward achieving GHG mitigation. Source: [21].

However, regarding green transportation on the campus, in 2013, the AASHE (Association for the Advancement for Sustainability in Higher Education) through its sustainability scoring and grading initiative termed STARS (Sustainability Tracking, Assessment and Rating System) rated the University of Saskatchewan very low as it concerned the advancement of a sustainable transport system for the following: 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 [24]. Compared with the recent fleet data from the Sustainability Office, it is evident that little or no improvement has occurred in this area. Hence, there is an urgent need to begin to implement sustainable transport initiatives (mostly as it concerns the adoption of EVs in the campus fleet) in the university community. The impact of this can be far-reaching, not just in positive ratings, but in advancing sustainability practices on the campus. In fact, the importance of EV adoption on campus cannot be overemphasized.

It is obvious that the university has a good understanding of the challenges and is committed to resolving them, as shown in the plan and the solution. However, it lacks the right action in the right direction. Thus, it is important that the economic feasibility of transitioning to a more sustainable transport system is first tested, modeled, and configured into policy. This is the motivation for this research, in which the following research objectives are established:

The research objectives of this study include the following:

- To underscore the importance of transitioning to sustainable transport systems through an extensive review of previous research works and works of literature bordering on transport and energy transitions and to review the role of other universities in Canada and North America in advancing sustainability on campuses as a bottom-up approach to advancing global sustainability practices.
- To critically examine transitioning to a sustainable or green transportation system at the University of Saskatchewan campus with respect to feasibility, attainability, efficiency, and most importantly, economic and financial viability.
- To determine the best option based on an economic benefit analysis of transitioning the vehicle fleet to EVs from PVs at the University of Saskatchewan campus considering model of EV, cost efficiency, and ease of use that is best suitable, efficient, and adaptable.

- To make sensible data-based policy recommendations that can help the University and the Sustainability Office implement programs and projects that support regenerative transport systems and initiatives, while providing research-based knowledge and insights for further studies and policy formulations, as well as awareness and education on sustainability and evidenced-based insights on the importance of adopting sustainable living, particularly in transportation.

Furthermore, this research is also expected to provide recommendations to the Sustainability Office of the University of Saskatchewan in line with the findings. The outcome may be useful for the continuous study of transportation transitions and how they can be implemented, not just by the university campus, but by other communities, cities, businesses, and governments around the world, as the importance of green transportation adoption is comprehensively explained and understood.

Reasons for a Green Transport System on Campus

Generally, the basic reasons communities adopt green transport transitions are related to concerns of health, environment, safety, economy, and social justice.

Cost of maintenance

The economic and financial benefits of switching to electric vehicles indicate that, in general, EVs are more affordable to maintain since conventional parts of internal combustion engines (ICEs) are not needed, particularly those that require service due to mechanical wear and tear [25]. Specifically, EVs do not require oil changes, and their most vital parts, such as the battery, motor, electronics, and regenerative brakes, do not require frequent servicing or changes [25]. However, some arguments exist that maintenance cost in the real world may be high since EVs are relatively new and evolving [26].

Environmental and Public Health Significance

One of the ways of measuring the extent of the impact of GHG (expressed in USD) is the Social Cost of Carbon (SCC); it measures the impact of one ton of carbon in a given year and is expressed in USD [27]. SCC expresses in USD terms what the world will be losing if quick action is not taken regarding carbon emissions, while it also helps policymakers to have a clear picture of impending danger that may arise in the future [28]. One of the major challenges with ICEs is that they emit GHGs and dangerous pollutants that affect the environment (health, biodiversity, air quality, etc.). This is a major concern and a strong case for advocates of the green transportation revolution. A study conducted by Zaman et al. [29] demonstrated how transport- and logistics-induced carbon emissions could create a negative impact on healthcare by increasing the overall healthcare expenditure and budget in a country due to carbon-induced transportation, which creates dangerous emissions and creates a negative impact on public health. This study demonstrated that this could also impair development, deteriorate environmental quality, and negatively impact the carbon neutrality agenda. Therefore, it is important to know that green transportation can help reduce climate vulnerability and improve healthcare by reducing related expenses.

Some health and medical challenges that can be caused by carbon and pollutants from automobile exhaust pipes include cancer, respiratory diseases (such as asthma), cardiovascular harm (such as heart attacks), reproductive and developmental harm, and early death [30]. Children are most likely to be affected by the deleterious impact of pollution and GHG emissions from fossil fuels [31]. Some of the observable effects of climate change and GHG emissions in children are heat-related illnesses, mental health illnesses, physical trauma, malnutrition, infectious diseases, and asthma, for example [31].

Agriculture and Biodiversity Conservation

GHG emissions and climate change can reduce crop yields, resulting in huge losses of billions of USD, causing food insecurity around 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 many farms and farm settlements [32]. This also affects biodiversity and conservation.

Biodiversity and conservation are concerns related to climate change. The existence of many species of plants and animals is constantly threatened as global temperatures increase and more GHGs are emitted [33]. Therefore, an agriculture-dependent economy such as that of Saskatchewan (a natural-resource-rich province) is an example of potential biodiversity risk and, in the long run, can expect to immensely benefit from climate change mitigation programs and actions. This can be achieved by pursuing a green revolution agenda, enacting sustainability policies, and deliberately reducing GHG emissions through actions and laws, as this can 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 volatile, and with the constant rising and falling of oil prices, it is risky to depend on oil for energy. In 2020, the world witnessed a peculiar event when the price of oil futures hit zero and further went into a negative price zone for the first time in decades [34]. At this level, the revenue from sales of crude could not cover the production cost [35]. With this level of volatility, no nation should bank on oil for its continuous revenue flow, as nations that largely rely on oil and gas revenues carry the greatest risk exposure to shocks in the global energy market.

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 can help shield and protect university campuses from the vagaries of unstable oil and gas prices or shocks, while also helping institutions save cost in terms of money spent on fueling and servicing.

Social Perspectives and Justice

Considering the health and economic implications of transitioning to EVs and the ability of GHG emissions to cause harm to public health and the environment, evidently GHG emissions and climate change pose a serious risk to human life. Given the right of humans to have access to good health and a quality standard of living, as well as a life that is free from any form of harm, torture, unnecessary stress, or discomfort in the environment, there is a need to approach climate change from the principles of social justice [36]. With this, it means that, when nations, individuals, communities, and institutions take positive efforts toward curbing climate change and reducing GHG emissions, they are preserving the rights of the people, and this, in turn, increases the quality or standard of living, not just in that environment, but also in the entire world since climate change is a global issue.

However, the importance of sustainable transport transitions and the adoption of a sustainable transportation system requires policymakers and administrators to understand the feasibility and the sustainability of such projects over a period of time. Therefore, it is imperative that an economic analysis of such a project is carried out to determine the feasibility, efficiency, sustainability, ability to implement, and effectiveness of such projects for a given time and location. Thus, this research aims to provides answers to very pressing questions on the feasibility of such projects and initiatives.

This research critically examines transitioning to a green transport system at the University of Saskatchewan as a case study to determine if such projects are economically feasible, attainable, efficient, and financially viable. Therefore, the basic questions that the research aims to answer are as follows:

Research Questions

1. Will sustainable transport transition in the University of Saskatchewan have any significant impact on environmental sustainability?
2. Is sustainable transport transition at the University of Saskatchewan viable?
3. What are the major quantitative factors that determine the economic feasibility of sustainable transport transitions at the University of Saskatchewan?

2. Materials and Methods

2.1. Research Method and Data

Meetings with the Office of Sustainability at the University of Saskatchewan provided a background understanding of the challenges and goals of the project. Fleet data (secondary data source) were supplied by the University of Saskatchewan Sustainability Office. The data were cleaned to suit the analysis and the analytical tool. Table 1 represents the clean dataset for the campus fleet: 91 ICEs existed in the fleet, and 2 vehicles in the fleet used diesel as fuel, while 89 used gasoline. The data on the vehicle fleet were used in the RETSCREEN analysis program to determine the options for transport transition. The data are presented in Table 1.

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 Traveled	kW/h	L/100 km
2001 CHEVROLET S-10 1/4 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	342	2407	3184.94	14.2
2002 DODGE ST2500 4X2 QUAD CAB WITH VAN BODY	FLEET	TRUCK	ACTIVE	Gasoline	942	4400	8772.55	21.4
2002 FORD E150 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	328	1795	3054.56	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	419	2291	3902.02	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	298	1627	2775.18	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	290	1583	2700.68	18.3
2002 FORD E152 CARGO VAN PACKAGE	FLEET	VAN	ACTIVE	Gasoline	305	1669	2840.37	18.3
2002 FORD SUPER DUTY F-450 REGULAR CHASSIS CAB 4 X	FLEET	TRUCK	ACTIVE	Gasoline	735	7002	6844.83	10.5
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	382	2034	3557.45	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	521	2770	4851.91	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	418	2225	3892.7	18.8
2003 FORD E152 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	582	3094	5419.98	18.8
2004 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	254	1458	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	1483	2402.67	17.4
2004 GMC EXPRESS COMMERCIAL CUTAWAY VAN	FLEET	VAN	ACTIVE	Gasoline	440	2416	4097.58	18.2
2005 CHEV HD SILVERADO 3/4 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	613	3294	5708.68	18.6
2005 CHEV SILVERADO 1 TON TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	614	3303	5717.99	18.6
2006 CHEV EXPRESS CARGO 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	287	1579	2672.74	18.2
2006 CHEV EXPRESS CARGO 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	690	3790	6425.76	18.2
2006 DODGE DAKOTA CLUB CAB TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	240	1570	2235.05	15.3
2006 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	264	1500	2458.55	17.6

Table 1. *Cont.*

Vehicle Type	Fleet	Type	State	Fuel	Litre	Avg km Traveled	kW/h	L/100 km
2007 DODGE CARAVAN CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	468	3418	4358.34	13.7
2007 FORD E150 1/2 TON VAN	FLEET	VAN	ACTIVE	Gasoline	219	1182	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	1373	4429		31.8
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	293	1863	2728.62	15.7
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	511	3255	4758.78	15.7
2008 CHEV EXPRESS 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	637	4058	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	4934	5839.06	12.7
2008 STERLINE 360 COE30 CAB & CHASSIS	FLEET	TRUCK	ACTIVE	Diesel	929	2921		31.8
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	656	4175	6109.12	15.7
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	199	1269	1853.23	15.7
2009 CHEV EXPRESS 1500 1/2 TON CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	485	3089	4516.65	15.7
2009 CHEV EXPRESS 1500 1/2 TON PASSENGER VAN	FLEET	VAN	ACTIVE	Gasoline	185	1175	1722.85	15.7
2009 CHEV SILVERADO 3500HD 1-TON TRUCK (SANDER)	FLEET	TRUCK	ACTIVE	Gasoline	1048	6675	9759.69	15.7
2009 CHEV UPLANDER	FLEET	VAN	ACTIVE	Gasoline	465	3165	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	5154	7533.96	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	335	2132	3119.75	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	427	2722	3976.52	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	351	2236	3268.75	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	168	1070	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	1658	10,561	15,440.4	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	344	2188	3203.57	15.7
2010 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	398	2532	3706.45	15.7

Table 1. *Cont.*

Vehicle Type	Fleet	Type	State	Fuel	Litre	Avg km Traveled	kW/h	L/100 km
2010 CHEV SILVERADO 3500HD 1 TON FLAT DECK TRUCK	FLEET	TRUCK	ACTIVE	Gasoline	1717	10,935	15,989.9	15.7
2010 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	1158	8452	10,784.1	13.7
2011 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	608	3873	5662.11	15.7
2011 CHEV SILVERADO 2500HD	FLEET	TRUCK	ACTIVE	Gasoline	771	4912	7180.08	15.7
2011 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	186	1358	1732.16	13.7
2011 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	209	1524	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	2417	3529.51	15.7
2012 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	407	2968	3790.26	13.7
2012 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	366	2674	3408.44	13.7
2012 FORD TRANSIT CONNECT	FLEET	VAN	ACTIVE	Gasoline	519	4432	4833.29	11.7
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	517	2889	4814.66	17.9
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	287	1603	2672.74	17.9
2013 FORD E 150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	614	3428	5717.99	17.9
2013 FORD F550 XL (BUCKET TRUCK)	FLEET	TRUCK	ACTIVE	Gasoline	1024	5222	9536.19	19.6
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	567	3318	5280.29	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	205	1199	1909.1	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	521	3048	4851.91	17.1
2014 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	797	4663	7422.21	17.1
2014 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	334	2441	3110.44	13.7
2014 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	218	1591	1992.92	13.7
2014 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	441	2490	4106.89	17.7
2014 FORD E150 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	201	1134	1871.85	17.7
2014 FORD TRANSIT CONNECT CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	264	2446	2458.55	10.8
2015 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	242	1763	2253.67	13.7
2015 JOHN DEERE 4X2 GATOR (TEST LM0025 SEPT 30/15)	FLEET	UTILITY	ACTIVE	Gasoline	11	34	102.44	32

Table 1. *Cont.*

Vehicle Type	Fleet	Type	State	Fuel	Litre	Avg km Traveled	kW/h	L/100 km
2016 CHEV EXPRESS 1500 CARGO VAN	FLEET	VAN	ACTIVE	Gasoline	1817	8261	16,921.2	22
2016 CHEVROLET COLORADO CREW CAB	FLEET	TRUCK	ACTIVE	Gasoline	769	6463	7161.46	11.9
2016 CHEVROLET COLORADO CREW CAB	FLEET	TRUCK	ACTIVE	Gasoline	1130	9498	10,523.3	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	1113	8122	13.7	13.7
2016 DODGE GRAND CARAVAN	FLEET	VAN	ACTIVE	Gasoline	357	2604	3324.63	13.7
2017 Chev Express 2500 Cargo Van	FLEET	VAN	ACTIVE	Gasoline	313	1435	2914.87	21.8
2017 Chev Silverado 1500	FLEET	TRUCK	ACTIVE	Gasoline	704	4818	6556.13	14.6
2017 Ford F150	FLEET	TRUCK	ACTIVE	Gasoline	889	7285	8278.98	12.2
2017 Ford Transit	FLEET	VAN	ACTIVE	Gasoline	477	4011	4442.15	11.9
2018 Chev Silverado 1500	FLEET	TRUCK	ACTIVE	Gasoline	866	5934	8064.79	14.6
Fuel Type		**Total Fuel Usage in 2020, Liters**		**Number of Vehicles**				
Gasoline		39,842		89				
Diesel		2302		2				

Assumptions related to the data included the following:

- From the number of liters supplied, the average kilometer traveled in a year was calculated using a fuel consumption rating expressed in Liter/100 km.
- The data on fuel consumption rating were derived from the government of Canada's website [37].
- A liter of fuel used or issued = L (expressed in liters).
- The fuel consumption rating of an ICE = Y (expressed in liter/100 km). This was unique for each vehicle model.
- The number of kilometers covered by an ICE (expressed in kilometers) = Z.
- Hence, Z (number of kilometers covered by a particular vehicle in the fleet) = L×100/Y = average kilometers traveled by a particular vehicle in the fleet.
- This assumed that the vehicles did not lose their minimum efficiency as of the time of calculation.

2.2. Modeling Using RETScreen Expert

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 [38]. The premium version of this software is called RETScreen Expert. This version was used for this analysis.

Brief Description of RETScreen Expert

RETScreen Expert enables a renewable energy feasibility analysis while considering location, cost (financial and economic factors), risk, technology, and other important factors or variables useful in renewable energy technology (RET) assessment or study.

Diverse projects can be analyzed using RETScreen Expert software, including projects focused on the following modules:

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

This analysis used the Transport Module. A feasibility analysis was focused 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, amount saved on transitioning to a renewable energy transport system, efficiency, and cost were considered. The results provided outcomes of the system and provided the feasibility of the project.

With the use of satellite data, RETScreen could provide global locations and weather data, which were essential for the location-based analysis.

The financial and economic analysis was an important factor or variable, as it determined how feasible the project was and how investors, banks, and users would perceive the viability of the project.

2.3. Parameters and Variables in Analysis

Fuel Cost Savings: We implemented the average retail gas price in Saskatoon, and the value was set to CAD 1.2/L [39].

GHG Reduction Credit: This was set at CAD 20 for 2019, with an annually increase of CAD 10/annum until it reached CAD 50/t/kgCO_2 by 2022 [40]. The Government of Canada plans to increase the carbon price to CAD 170 per metric ton by 2030, which may bring gas prices to more than 38 Canadian cents within the next 10 years [41]. Thus, this increased carbon levy would result in a reduced payback period of 2 years, and the university would increase earnings from the GHG reduction credit. Considering these variables, the proposed solution was viable, with great prospects to meet targets and objectives.

Road-Use Fee: Considering that Saskatchewan Province is proposing charging CAD 150 as the road-use fee on all EVs, this cost variable was considered in the analysis [42]. This fee is charged as cost of highway maintenance by the Saskatchewan government. This resulted in a total cost of CAD 12,750.

Federal Incentives: A CAD 5000 federal government incentive for EV purchases was considered as a credit [40]. This produced total incentives and grants of CAD 425,000.

Initial Cost: Considering all these, an initial cost of CAD 2,867,750 was required to switch to EVs, and this sum was expected to be financed at 3%/annum. There is a possibility of achieving zero-interest financing in Canada. For instance, the Canadian government has budgeted CAD 15 billion for green projects and initiatives that enhance decarbonization channeled through the Canada Infrastructure Bank [43]. This project could be financed through such an arrangement or 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 was a measure of the changes in the cost of fuel in Saskatchewan. Escalation rate measured the degree of change in the price of a particular good or service. It was calculated by subtracting the initial cost from the present cost, dividing by the initial cost, and multiplying by 100.

For Saskatchewan in 2020 [39], it was calculated thus:

Starting price as of January 2020 = CAD 1.296
Closing price as of December 2020 = CAD 1.396
Hence, escalation price was $(1.396 - 1.296)/1.296 = 0.077 \times 100 = 7.7\%$

Inflation Rate: We took the 2020 average inflation rate in Saskatchewan to be 0.62% [44]. This value was used to model this project as it concerned inflation.

O&M Savings: The total savings as it concerned O&M (Operating and Maintenance) cost when switching to an EV over the lifecycle (which varied and depended on EV type, as well as other factors) of that EV was CAD 4600 [45].

Debt Interest Rate: The debt interest rate was set at 3%. However, the average debt rate in Canada is between 3% and 6% for a good credit rating, and there are possibilities of having a 0% discount, mostly for manufacturers who want to attract more buyers [43].

Debt Term: This was the duration for servicing the debt before total pay down. This was set to 4 years, which is usually the conventional debt term for vehicle finance lease.

Debt Ratio: This was the percentage (60%) of the total debt that the financier would contribute, while the University of Saskatchewan would finance 40%.

3. Results and Findings

The model in this study featured key parameters that determined the viability of such a project: cash flow, payback period, internal rate of return, net present value, total annual savings, reduction in energy and fuel costs, GHG emissions removed in tons of CO_2, and benefit–cost ratio. The results are presented.

Despite the significant capital outlay (initial cost of purchase) required for this project, a positive cash flow of CAD 72,054 was realized in year 1 of the project. This indicates the strong viability of this project. However, when the cumulative cash flow was considered, the project yielded a positive cash flow in year 5, which is also a reasonable positive result for a project of this type. The cash flow parameter is shown in Figure 4.

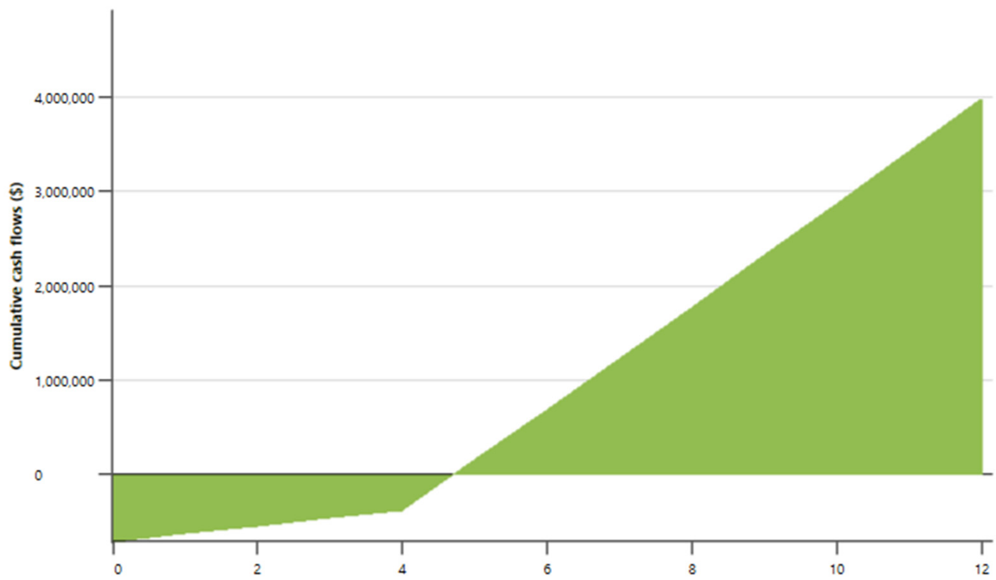

Figure 4. Graphical representation of cash flow model for the project (RETScreen).

The simple payback period could be achieved within 4.6 years, and an equity payback period could be realized within 4.7 years. These results indicate that the project could pay back its initial cost within 5 years. However, this was expected to be less if the EVs were put into active use (minimizing idle times as reasonably as possible).

The IRR (internal rate of return) typifies the growth rate that a project or investment is expected to generate in a year or, simply, what the investment returns. The higher the IRR, the more viable the project. With an IRR of over 30%, this project was expected to be viable. The resulting NPV (net present value), which expressed the time value of money (TVM) of the project was positive. As such, a positive NPV meant a viable project.

The total annual savings for this project were CAD 160,140. This represented significant savings for the University of Saskatchewan. These savings were a result from fuel cost savings of CAD 145,234 and GHG reduction revenue of CAD 14,906 (this could be higher if the proposed policy of carbon price of CAD 170/tCO_2 was considered, which is a policy that is expected to come into effect by 2030) [46]. Thus, this project could reduce energy consumption by 85.7% and fuel cost by 88.9%. The financial impact and savings for the fleet were significant.

Furthermore, the significant impact of the project related to decarbonization indicates that it would remove 298 tCO_2/year from the campus, and in 12 years it would remove 3577 tCO_2 of carbon from the campus. Considering the effect of CO_2 on the environment (public health impact), as well as its contribution to climate change and global warming, it is evident that the impact of this project would be substantial.

Moreover, the Benefit–Cost Ratio (BCR) of the project was 3.7, indicating that the benefit of this project was greater than the cost: a BCR value of more than one (1) is a clear indication that that a project is viable, and the benefit is greater than the cost of the project.

Therefore, considering the key parameters, the transition to the EV fleet was viable. This result supports the findings of Kinsella et al. [47] in analyzing the viability of adopting EVs in a transportation service company in Ireland using a cost–benefit analysis (CBA) method. Their findings showed that EV adoption in a fleet would significantly reduce carbon emission, reduce energy and operational costs, and increase efficiency.

These results provided responses to the research questions in this study by indicating that a sustainable transport transition at the University of Saskatchewan campus was viable, attainable, and significant. The parameters highlighted above elaborated on such findings.

Simple Payback Period (PBP)

The simple payback period was 5.3 years. Although for an EV the ideal payback period is between 2 and 3 years, this is more realizable for EVs that are high-mileage-driven (active usage for Bolt and Lyft services, for example) [48]. Thus, the fleet manager could achieve a quick PBP if the EVs were put in more active use. This means that fewer vehicles could be purchased so that the available vehicles could be put into maximum active use. Note that these were variables that could be changed to suit a particular scenario or model.

4. Result Discussion

From the analysis, this project appeared viable within 5 years. The cumulative cash flow became positive in the first year. The Payback Period (PBP) occurred within 5 years. The Benefit–Cost Ratio (BCR) was 3.7, which signifies that the project had a positive net present value (NPV) and implied that the benefit of the project outweighed cost. This finding aligns with the findings of Kinsella et al. [47] in dimensioning the cost–benefit impact of transitioning to a green transportation system. In addition, the IRR (internal rate of return) represented the returns that the investment should make in a year. An IRR of 30.9% indicates that the project was potentially profitable. The NPV for this project was positive, which also supports that the project was profitable and valuable. The annual lifecycle savings were CAD 312,498, and the GHG reduction revenue was CAD 14,906 in 4 years.

Given these positive results, the Sustainability Office, the campus, and the entire university community would benefit from this project, indicating that this project should be vigorously pursued.

Regarding the substantial initial cost, which could be perceived as a challenge, engaging a credit provider or financier that could finance the project, particularly with zero-interest rates, would further increase the profitability of the project. Furthermore, leveraging funds from the government, as well as grants from international agencies, would offset the initial investment required for the project. Since the government has made diverse grants and funds for green projects available, projects of this scope should consider these sources of funds before corporate loans or credits, which are usually costlier. This would help reduce the cost of paying back the loans, reduce the payback period, increase the cash flow, and generally enhance the profitability of the project, as well as the BCR of the project. A typical fund to be considered is offered by the federal government through the Canada Infrastructure Bank [45].

One key recommendation is that the vehicles in the fleet should be put into more active use (covering higher mileage), as this would help reduce the payback period to 2 years, thereby creating more benefits for the project [48].

The money earned from carbon credits, as well as the quantity of GHGs that this project would remove from the environment, (298 tCO_2), indicate that this project was feasible and viable, and it should be implemented.

5. Research Implications

This research reinforced the importance of transitioning from petrol vehicles to electric vehicles (EVs) since about 298 tCO_2 would be taken out of the environment annually. Ultimately, this had both long- and short-term positive impacts on the environment and supports the findings of Zhao et al. [9] and Dioha et al. [10] regarding the carbon reduction potential of switching to EVs. Furthermore, CAD 312,498 would be saved annually, which demonstrated the viability of transitioning to a more sustainable transport system. This then established that this research may be useful to policymakers, governments, and industry leaders for quantifying the impact of sustainable transport transitions. It can serve as science-based proof for policymakers, law makers, and community leaders to demonstrate the importance of advancing sustainability across communities and organizations in the world. For instance, the benefit–cost ratio demonstrated that the benefit of adopting a green transport system was tangible, quantifiable, and reasonable. Ultimately, this may serve as motivation for other universities, communities, and policymakers regarding the adoption of EVs as a way of advancing sustainable practices across communities and in the transition of transportation systems. This research further exemplified how finances can be a veritable tool in promoting environmental sustainability and climate change mitigation. It, therefore, illustrated that not just finance, but the right finance (in terms of structure and form), would help substantiate and increase the viability of sustainable transport transitions. This research supported the importance of government laws and economic and financial policies as enablers of sustainable transport transitions. For instance, the carbon credit policy and other government incentives could boost the possibilities of EV adoption. In addition, government incentives on EV purchases would encourage increased conversion to EVs.

Consequently, modeling sustainable transport transitions, mostly as it concerns the financial and economic implications of green transport adoption, is important for scholarly activities. This research contributed to the appreciation of the dimensions of finance, economics, and technology as they concern green transportation transitions and sustainability, generally. However, this research could be further expanded to cover the social aspect of sustainable transport transitions by analyzing the various social factors that could affect the adoption of EVs, to go beyond financial, economic, and technological factors and consider how culture, religion, lifestyle, and other social factors would affect the adoption of a green transport system.

This research provided a better understanding of the significance of climate financing in sustainability advancement for policymakers, researchers, and financiers to ascertain the point of optimal efficiency in transitioning from PVs to EVs, mostly with respect to technology, economics, and finance.

6. Policy Implications

This research identified the importance of decarbonizing the transport sector and examined the economic and financial benefits of the process. For instance, decarbonizing the campus fleet of the University of Saskatchewan would enhance fleet efficiency, save costs, mitigate GHG emissions, encourage biodiversity, and improve environmental sustainability. Therefore, these are the major policy recommendations based on the findings of this research:

- There is a strong need for policymakers to quickly adopt green transportation to promote environmental sustainability and help to mitigate the emission of GHGs and other related adverse effects.
- Finance has a critical role in achieving decarbonization and environmental sustainability [49], especially in achieving carbon neutrality in the transport sector of the economy. Hence, policymakers should design efficient and effective finance mechanisms and structures that boost and speed up transition processes.
- Since finance is a veritable tool in advancing climate change mitigation, DFIs, multilateral agencies, venture capital firms, governments, and other important institutions should come together to implement effective-impact financing programs that can help communities and organizations achieve goals of deep decarbonization, mostly as they concern the transport sector. A green transport transition is a long-term investment, and affordable and patient capital sources should be provided to fund this important investment.
- Improvement in technology is a critical factor for consideration in achieving an efficient transition program [50]. Policymakers should build policies around the manufacturing of efficient, affordable, and durable EVs, as this can lead to speedy adoption of EVs not just by organizations or communities but also by individuals. This may further expand the impact of green transportation.
- GHG emissions affect almost every aspect of livelihood, health, agriculture, economy, and security; hence, there is a need to adopt, implement, and enforce critical policies around sustainable transport transitions, as this can speed up the achievement of the net-zero goal. This is also in line with the findings of Tomsic et al. [11].
- Innovation is key to the achievement of a sustainable transport initiative. Policymakers should design programs that support and boost innovation, mostly as it concerns the application and the advancement of renewable transport and energy research. This is a critical factor that can enhance deep decarbonization of the environment. For example, there is a need to fund research on battery development, EV manufacturing, and GHG emissions reduction, as examples. This is a significant investment that will pay substantial returns in the long run.

Generally, considering the critical information that this research provided, the Sustainability Office of the University of Saskatchewan can properly plan and understand the importance of switching to EVs, even as they design policies and programs that advance sustainability practices on the campus. This result is a model that other institutions and communities of similar scale and applicability can reference.

Overall, this research demonstrated that sustainable transport transitions could positively impact the environment, birth new sustainability paradigms, and serve as a significant investment with a long-term significance (cost- and energy-saving investments). The significance of this research is highly valuable to environmental, economic, and financial policy, as well as social policy design and implementation. Therefore, implementing sustainable transport transition policies within the framework of this research is highly relevant in curbing GHG emissions, enhancing climate change mitigation, and advancing sustainability and Environmental Social Governance (ESG) across university campuses, communities, and organizations across the globe. Most significantly, this research can aid and encourage communities, organizations, and policymakers to design sustainability and ESG policy roadmaps, especially as they concern green transport adoption.

7. Conclusions

This research demonstrated that implementing sustainable transport transitions could be of great significance across campuses, communities, and organizations, particularly with fleet vehicles. This could help promote environmental sustainability, improve environmental health, enhance biodiversity and conservation, save cost, unlock capital, and build a more sustainable world. Therefore, it is expected that universities are an ideal setting to begin the energy transition of fleet vehicles for campus communities, such as the University of Saskatchewan demonstrated. The key lessons learned indicated that the implementation of sustainable transport transition principles defined in this research could provide a pathway to reap the dividends of green transport transitions: a better and healthier environment, reduced cost of fleet management, attaining energy security, high ranking in sustainability and ESG adoption among other universities, biodiversity and conservation, and GHG emissions reduction. The limitations of this research include that a single-location case study in central Canada was used, as well as that funding mechanisms and industry directives to enable the transport transition were beyond the scope of this analysis.

Overall, this research demonstrated that sustainable transport transition on the University of Saskatchewan Campus was economically feasible and financially viable and, as such, should be vigorously pursued and implemented by the Sustainability Office. In addition, it could encourage other campuses, governments, organizations, and communities around the world to adopt this initiative to achieve their net-zero goals and reap the long-term benefits of this critical investment.

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