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Abstract

The University of Michigan President Commission for Carbon Neutrality (PCCN) reports a goal of fully electrifying the transit bus system called Magic Blue Bus by 2035 as part of the wider goal of achieving carbon neutrality from scope 1 and scope 2 emissions by 2025. This will require the purchase of new battery electric buses (BEB) and the expansion of the current transit infrastructure to include charging facilities, all of which provide large upfront costs. The current method of financing the Magic Blue Buses includes grants and awards from Michigan Medicine. However, to attain a successful transition, more sustainable financing models must be set up. A Project Finance Model is proposed where the University becomes an off-taker of electric bus services through a lease agreement with a Special Purpose Vehicle (SPV) set up by Proterra. The University refinances the lease through proceeds from bond issuance in the capital market, revenues from the sale of carbon credits and the resale of excess electricity stored in the electric battery. A financial model is set up to calculate the Cost-Benefit analysis, Net Present Value (NPV), the Payback Period, and the Internal Rate of Return for the Project Finance Model. A sensitivity test is also carried out to determine the optimal interest rates that investors can charge on their capital. The work provides a model for assessing the cost feasibility of a transition to a BEB fleet at the University of Michigan, Ann Arbor campus by 2035.

Introduction

1. <u>Infrastructure As An Alternative Asset Class</u>

Infrastructure is defined as an object that possess the following characteristics, physical entity, medium to long shelf-life, indivisibility, and large initial capital expenditures requirements (Thierie, 2016). Infrastructure provides utility to its users and includes entities such as roads, bridges, courthouses, schools, transmission lines, and electrified bus fleets. Over the years, institutional investors such as pension funds have increased their investment in infrastructure as a viable investment play to hedge against market volatility (Blackrock, 2015; Poors, 2014).Nevertheless, these investments are inadequate, and private investors cite three reasons for the shortcomings in infrastructure funding namely the lack of investment vehicles in the space (Inderst, Private infrastructure finance and investment in Europe, 2013), unfavorable regulatory environment (Déau, 2011), and poorly established risk-reward profile of infrastructure investments (Thierie, 2016). Notwithstanding these drawbacks, institutional investors are apt to participate in infrastructure investing owing to the current low-yield environment (Della Croce R. S., 2011a; Della Croce, 2013; Inderst, 2013) as well as a higher sensitivity to risk honed following the aftermath of the 2008/2009 financial crisis (Della Croce R. S., 2011).

What makes infrastructure an asset class? Traditional asset classes in the market include bonds, equity, and real estate investment trusts (REITS) (Weber, 2016). The commonality shared between these asset classes are that they are capable of yielding additional monetary reward to the investor that can conversely result in losses. Infrastructure also share the above features, but it is unique as an asset class for exhibiting the following three additional characteristics: heterogeneity, illiquidity, and high initial capital expenditure(capex) (Thierie, 2016). Heterogeneity means that the return potential of an infrastructure investment is directly affected by the sector, geography and regulatory climate in which the infrastructure is used (Blackrock, 2015; Inderst, 2013; Russ, 2010). Illiquidity means that the asset class cannot be easily traded in the secondary market because infrastructure is a real asset i.e., a physical structure that is hard to move around (Bank, 2014a; Macquarie, 2014). High initial capex is required to build out an infrastructure, and this feature limits the number of investors that can participate in these markets to companies with large balance sheets e.g., pension funds, investment banks, sovereign wealth funds or ultrawealthy individuals, thus creating a pseudo-monopoly for this market (Panayiotou, 2014; Weisdorf, 2007; Bird, 2014). An additional argument for infrastructure as an attractive asset class is its disconnection with market cycles (Oyedele, 2014; Moss, 2014) exhibited by a low correlation with other traditional asset classes that track the market cycles closely e.g., equities (Peng, 2007; Inderst, Infrastructure as an asset class, 2010).

A common misconception that is worth clarifying is the difference between infrastructure and real estate. Although these two asset classes share many features, there are clear differences between them. Real estate does not always require a very high initial capex and can constitute a competitive market because the pool of investors is much wider than in the market for infrastructure. Furthermore, active management by investors are seen less in real estate markets than in infrastructure markets, and thus there is less potential to increase returns through this route. This implies that both infrastructure and real estate assets can co-exist in a diversified portfolio (Finkenzeller, 2010; Newell, 2008; Bank, 2014a). Infrastructure is not seen as a traditional asset class because of the features highlighted above, and increasingly data providers assign it as an alternative asset class (Inderst, Pension fund investment in infrastructure, 2009). Pension fund investment in infrastructure). This is because investments go into unlisted companies that participate in the infrastructure sector, or alternatively to infrastructure-based funds.

2. Investments in Infrastructure and the Performance of Infrastructure in the USA Today

There are two ways to invest in infrastructure, either through direct investments in infrastructure companies such as utilities or through indirect investments in fund managers that inculcate infrastructure-based companies in their investment portfolios (Inderst, Pension fund investment in infrastructure, 2009). Direct investments involve investments in infrastructure companies and infrastructure-based funds that are listed on a public stock exchange or held in the private funds. For privately held funds, pension management firms are often seen as the main investors and place capital in the hands of specialized funds such as hedge funds. The benefit of direct investments in infrastructure companies or infrastructure-based funds is the greater liquidity offered to retail investors, as they are able to cash out of such investments. Meanwhile, indirect investments offer a hands-off approach to investing as investors place their capital in the hands of an experienced fund manager. Nonetheless both approaches are still susceptible to losses.

The awareness of infrastructure as a potential alternative asset class by Investment Banks and Pension Funds in the US began in the year 2006 (Torrance, 2007a). However, there were already precedents elsewhere. For example, in Australia the financing and managing of public infrastructure was placed in the hands of the private sector following the bankruptcy of the state of Victoria in early 1990s (Torrance, 2007a). The delay in investments in infrastructure by private finance providers such as institutional investors has been brought about by a number of reasons namely, poor relationships between public and private fund providers, conflicts of interest in the transaction agreements e.g., while the financial service providers such as investment banks are in search of short-term opportunism, the institutional investors are looking for longer term commitments. These delays in infrastructure investment within the U.S is in part responsible for the poor performance of infrastructure when compared to other countries. According to a report card issued by the American Society of Civil Engineers (ASCE) every four years, infrastructure in the USA was given a grade of D+ in 2013 and 2017, however, there have been marginal improvements in the quality of infrastructure as shown by an overall grade of C- in ASCE's 2021 report card (ASCE, n.d.). Despite these improvements in infrastructure quality, the USA still ranks as no 13 for quality of infrastructure according to the World Economic Forum (WEF) 2019 Global Competitiveness report (WEF, 2019), even though it is ranked as number 2 overall for all aspects of the economy.

3. Electric Vehicles And The Trend Towards Renewable Energy Infrastructure

The use of electric vehicles (EVs) for everyday transportation began at the start of the 20th century. Japan led the way in this regard with the introduction of the Toyota Prius hybrid vehicle (Dijk, 2013). Between the periods 1997-2005, Toyota introduced the Prius I, II, and III to Japanese and California customers and presented some success by selling over 1 million vehicles worldwide from the period 1997-2005. However mainstream adoption of electric vehicles was slowed down by a high price tag and low driving ranges for electric batteries (Dijk, 2013). Other countries, particularly in Europe, began to deploy test pilot programs for large scale adoption of EVs at local towns, but such programs were not successful at winning over customers outside the pilot. For example, one pilot project worth noting was that launched by a French electric utility called EDF in the city of La Rochelle in France (Rupeka, 2018). This project involved the deployment of 2000 electric vehicles and helped raise the EV profile to residents within and outside the city and showcased data on the factors that affected customer acceptance of EVs. Legacy automobile companies dismissed electric vehicles as non-threatening at the initial stages because they operated their traditional vehicles with crude oil that was relatively easier to acquire (Oltra, 2009). Hence, these legacy companies spent more of their R&D money on improving processes for their Internal Combustion Engines (ICE) as evidenced by the relatively higher number of patents focused on ICE improvements than for innovations in battery and hybrid electric vehicle technologies (Oltra, 2009).

In the 21st century, electric vehicles have become more popular among consumers who belong to the millennial generation and are more environmentally conscious. The trend of greater customer acceptance of Battery Electric Vehicles (BEVs) has led to high market valuations for companies involved in the space such as the electric vehicle and clean energy company, Tesla and the Chinese designer and developer of electric cars, BYD (Li, 2018). There are a number of factors that have helped EVs become more mainstream in society and these include, favorable regulations such as grants for Research & Development(R&D) and subsides for capital expenditures (IEA, 2019), greater global awareness of the contributions of automobile carbon emissions to climate change, the idea of peak oil and the uncertainty of future oil prices (Mikael Höök., 2013; Heun, 2012), development of new battery technologies that are lighter with much higher density(IEA, 2019), and executions of new business models such as battery swapping that can help solve the “short-range” problem of electric vehicles (Kley, 2011). Despite these favorable trends, there are factors currently preventing the widescale adoption of electric vehicles including continuous R&D expenditure by incumbent companies on ICE improvements (Dijk, 2013), relatively higher upstream cost for manufacturing lithium ion batteries for EVs compared with the manufacturing of Internal Combustion Engines(ICE) (Hawkins, 2012), skepticism about the proof of concept for hybrid electric vehicles which has become more pronounced following the recent scandal with the hybrid automobile company called Nikola (Ludlow, 2020), and low rollout volume of supporting infrastructure for electric vehicles such as charging stations (Smith, 2019).

4. <u>The Market For Electric Vehicles</u>

The class of plug-in electric vehicles can be divided into Battery Electric Vehicles (BEV) and Plug-in hybrid electric vehicles (PHEV) (Wang, 2020), and the global EV market as of 2018 consisted of 2-wheelers, electric buses for human transport, light commercial vehicles for freight transport, and trucks. In 2018 the global total electric fleet was 5.1 million, with China (45%) and Europe (23%) providing the bulk of sales, while the United States supplied about 1.1 million electric vehicles to its roads (IEA, 2019). Meanwhile, the global count of electric buses was 460,000 in 2018, and the United States contributed only 6.5% of this total with little more than 300 electric buses added in 2018 (Reuters, 2017). Meanwhile China dominates the market, supplying 99% or roughly 455,400 electric buses in total (IEA, 2019).

In a study conducted by Noori(2016), battery electric vehicles (BEVs) were shown to cost the least for Maintenance and repair amongst a group of vehicle-types that include Internal Combustion Engine vehicles (ICEVs), and Hybrid Electric Vehicles (HEVs). However, BEVs also required the highest water consumption for manufacturing the battery. The same study also found that factors that can increase the adoption of BEVs include word of mouth, social acceptability and government subsidies, and predicts that if these factors are combined, BEV penetration could rise from 1.5% to as high as 26% by 2030 according to a model developed by the authors (Noori, 2016). Another study by the International Energy Agency (IEA) (IEA, 2019) stated that government policy are the main drivers for EV adoption, and these can take the form of fuel economy standards, new building requirements to inculcate charging infrastructure, and lower toll or parking fees for electric vehicles. A third study by Feng (2013) shows that BEVs become cost competitive with more lifetime miles driven i.e., above 12,000 miles per year and with a price reduction from its current level (Feng, 2013), however this will depend on innovations in electric battery development in the future. Notwithstanding the above factors that can increase the competitiveness of BEVs, there are three widely recognized obstacles for BEVs that limit their widescale adoption namely, high cost for electrical batteries, low energy density for batteries, infrequent charging infrastructure (Cowan, 1996).

5. Value proposition for investing in Electric Vehicles for market participants

Adoption of electric vehicles can provide benefits to society. One benefit is a total reduction of global CO_2 emissions ($MtCO_2$.eq) when compared with Internal Combustion Engine (ICE) powered vehicles, according to a policy-based forecast proposed by the IEA called the New Policies Scenario, electric vehicles are set to have well-to-wheel(W-T-W) savings of CO_2 emissions of 220 $MtCO_2$.eq when compared with ICE vehicles by 2030 (IEA, 2019). A more ambitious forecast called the EV30@30 which aims to have Electric Vehicles attain a 30% market share across all modes of transport by 2030 forecast the same 220 $MtCO_2$.eq CO_2 emissions savings contingent on a parallel shift to decarbonize the electrical power grid (IEA, 2019).

The other value proposition for electric vehicles is the role it can play in the inclusion of renewable energy sources into the grid. Renewable energy sources such as solar energy and wind energy are intermittent, which means that they are not available 24/7 to consumers and may sometime fail to meet peak consumer demand (Suberu, 2014), hence there has to be a way to store some of the excess energy generated from these variable sources. Electric vehicles can mediate this by providing ancillary services such as load balancing (IEA, 2019), this involves storing the excess energy in batteries and supplying the grid with this reserve energy when the peak consumer demand cannot be covered by the amount of solar and wind energy generated at the time.

Methods

1. Case Study: Electrifying the University of Michigan, Ann Arbor Magic-Bus Fleet using a Project Finance model with a special purpose vehicle (SPV).

Current Transit System at the University of Michigan

The current transit system at the University of Michigan comprises of a total of 56 buses. This comprises a combination of 27 diesel-powered buses and 29 hybrid-electrical buses. These transport systems are called Blue Buses or Magic buses or M-buses and are used to move students, faculty and staff along 12 routes.[1] [2] The 12 routes are further divided into Campus-focused routes and Michigan Medicine-focused routes and while the Campus-focused routes run every day with a combined schedule from 6:30 AM to 3:10 AM, the Michigan Medicine-focused routes only run during weekdays with a combined schedule from 5:15 AM to 1:07 AM (LTP, 2021). The operations of the Magic Buses are managed by the Logistics, Transportation & Parking (LTP) department, within the Facilities and Operations Division at the University of Michigan.

The Presidents Commission for Carbon Neutrality (PCCN) at the University of Michigan is tasked with the mandate of coming up with strategies for which the University of Michigan can achieve Carbon Neutrality for Scope 1 and Scope 2 emissions by 2025(or earlier for scope 2 emissions), offsets included, across all 3 campuses. According to the final report put forth by this commission in 2021 (PCCN, 2021), one of the key elements to achieving the goals mentioned above is to "Fully decarbonize U-M's transit system, vehicle fleet (buses, trucks, and automobiles), and maintenance equipment" (PCCN, 2021). The transit system that contributes the most emission within the U of M Ann Arbor campus is the Blue Buses or M-Buses, and the commission has set out to fully electrify the Blue Bus fleet by 2035. There has recently been an attempt to showcase why transitioning to an all-electric fleet will be beneficial for the University of Michigan in achieving its carbon neutrality goals by comparing the lifetime costs and emission impact of BEB buses and traditional diesel buses (Sun, 2021). However, this report stops at highlighting the capital requirements for achieving this feat. This thesis intends to go one step further by proposing a project finance model that can help achieve the transition to an all-electric Blue Bus fleet system at the University of Michigan Ann Arbor campus.

2. Value proposition for choosing an electric bus system over a diesel-powered or hybrid bus system- Comparing performance on the basis of costs and emission intensities

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[1] The EV with the longest range as of 2020 is the Tesla Model Y with a range of 316 miles and this is far above the EV with the second longest range, the Chevrolet Bolt EV which has a range of 259 miles with a single charge[1]. There have been projects to increase the ranges of EVs in the USA such as the US Department of Energy's Vehicle Technology Office (VTO) Batteries, Charging and Electric Vehicles Program which aims to increase the vehicle range to 300 miles per charge

[2] The 12 routes are divided into Campus focused routes and Michigan Medicine focused routes. The Campus focused routes include: Campus connector, Bursley-Baits loop, Green Road-NW5 loop, Northwood loop, Oxford-Markley loop, Stadium-Diag loop. The Michigan Medicine focused routes include: MedExpress, Wall Street-NIB, Wall Street Express, Crisler Express, and Glazier Express.

The value proposition for fully electrifying the transit bus fleet at the University of Michigan, Ann Arbor campus include,

1. Reduced operation and maintenance cost over the 12-year lifetime of each 40-foot bus.
2. Reduced greenhouse gas (GHG) emissions which contributes to the PCCN's goal of reaching carbon neutrality for scope 1 emissions by 2025.
3. Additional educational and economic opportunities to students, faculty and staff at the University of Michigan, Ann Arbor through the establishment of an internal carbon market that mirrors the Carbon Charge program established and employed at Yale University (Yale, 2016). The carbon charge program at Yale University employed a carbon price of $40/metric-ton of CO_2, which is lower than the estimates for the 2020 Social Cost of Carbon (SCC) with a 3% discount rate (Government).[3]

3. Cost-Benefit Analysis of moving from diesel-powered and hybrid electric buses to fully electrical buses

Investors and regulators of public infrastructure projects such as a public transit system consider certain metrics before deciding on whether to approve of these projects. One popular metric is the Benefit-Cost Analysis for the project. A benefit-cost analysis was carried out on two different deployment scenarios for the electrification of the Magic-Bus system at the University of Michigan, as outlined in (Sun, 2021). It should be noted that the University's LTP department replaces four transit buses every year, hence efforts to electrify the bus fleet will involve buying new electric buses with each replacement cycle. The first scenario, which will be referred to as *Fast-Deployment*, involves replacing all four diesel buses with battery electric buses, while the second scenario, which will be referred to as *Slow-Deployment*, involves replacing all four diesel buses with two battery electric buses and two diesel buses. The assumptions in the Benefit-Cost Analysis come from an economic study previously performed by the PCCN Mobility Electrification sub-group (Sun, 2021). The current research is seen as a continuation from this rigorous study as well as a method to validate the previous findings. Assumptions that are not found in the Sun(2021) paper are referenced in the table. The major assumptions employed are shown in the **table 1** below.

Table 1: Assumptions made in the Cost-Benefit analysis

ASSUMPTIONS			
Item	Value	Units	Justification/Comments

[3] https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf. Technical document from the US Federal Government interagency working group on the Social Cost of Carbon.

Lease period	7	years	Lower than the Average lifetime of the transit buses (12 years) according to LTP
Discount rate	2.9%	%	Interest rate on University of Michigan issued Bond as of 2020 (pwc, 2020), which is taken as the Weighted Average Cost of Capital (WACC).
Price per diesel bus	450000	$	Price that Gillig charges for the 40-inch transit buses
Price per battery electric bus	760000	$	The number cited in the Sun, J-J et al., 2020 study (Sun, 2021).
Maintenance Cost per Diesel bus	1.29	$/mile	Provided in the appendix of Sun, J.J et al., 2020 study (Sun, 2021).
Maintenance Cost per Electric bus	0.79	$/mile	Provided in the table B2 of the Sun, J.J et al., 2020 study and is based on an NREL study done on the Foothill Transit Agency (FTA) in the Greater Los Angeles Area (Sun, 2021).
Annual Miles	31250	mi/vehicle	This value represents the Annual Miles for a commuter that normally drives a 20+ mile range to work/school in a 200-day year as mentioned in the Sun, J-J et al study (Sun, 2021).
Total number of chargers needed in switching to all-electric buses	1088	L2 type chargers	This value was calculated for commuters within the 20+ miles commuting range as mentioned in the Sun, J-J et al study (Sun, 2021).
Maintenance cost of chargers	200	$/3 years	
Capital cost per EV charging unit	1550	$/unit	There are 2 ports per charging unit (Sun, 2021).
Capital cost per charging pedestal	1895	$/pedestal	There are 2 charging units per pedestal (Sun, 2021).
Cost for Charger Installation	2305	$/installment	This includes cost for labor materials, permits and electricity capacity upgrades
Number of pedestals	544	pedestals	As mentioned in the Sun, J-J et al., 2020 study (Sun, 2021).
CO2 emission factor for Diesel buses	11	kgCO2/gal	As mentioned in table B4 in the Sun, J-J et al., 2020 study (Sun, 2021).
CO2 emission factor for electrical buses	0.27	kgCO2/kWh	As mentioned in table B4 in the Sun, J-J et al., 2020 study (Sun, 2021).
Vehicle efficiency for diesel bus	4.18	mpg	As mentioned in the Sun, J-J et al study (Sun, 2021).
Vehicle efficiency for battery electric buses	2.62	kWh/mile	As mentioned in the Sun, J-J et al study (Sun, 2021).

Carbon Price	50	$Mt/CO2	This was the assumed number stated in the Carbon Pricing section of the U of M's PCCN Carbon Neutrality final report (pp 162 under "financial consideration") (PCCN, 2021).
Number of commuters	10877	vehicles	This number represents all vehicles in the 20+ miles category as seen in Sun, J-J et al., 2020[50]. An assumption is made that there is 1 passenger per vehicle commuting every day.
Annual Fuel Cost savings with Battery Electric Buses	1175.64	$/commuter	This is assuming that the university provides free charging for all electric vehicles
EV efficiency	2.1	kWh/mile	Assumed to be Proterra's ZX5 battery with maximum operating efficiency (Proterra, Accessed 2021)
Charges per day	2	Full battery charges	1.5 charges required on average to meet the full daily schedule for the Magic Blue buses, but the value was rounded up to a whole number.
Number of days driven per year	200	Working days	The Magic Blue buses are only in operation 200 days per year according to the Sun J,J et al paper (Sun, 2021).
Electricity rate	0.086	$/kWh	This is the retail rate that the Central Power Plant charges internal departments for electricity use (Witter, Accessed 2020) [4]
Lifetime of a Battery Electric Bus	12	Years	Reported by the NREL VICE-BEB model study (Johnson, 2020)

To calculate the result for the Cost-Benefit analysis equation, incremental pair-wise comparisons were performed between *Fast-Deployment*, *Slow-Deployment* and a *Do-nothing* scenario. The formula was given as $\Delta(B_2 - B_1)/\Delta(C_2 - C_1)$, where $\Delta(B_2 - B_1)$ is the difference between the total benefits of the challenger or more expensive alternative ($_2$) and the defender or less expensive alternative ($_1$) while $\Delta(C_2 - C_1)$ is the difference between the total costs of the challenger or more expensive alternative ($_2$) and the defender or less expensive alternative ($_1$).

[4] This value is based on the utility enterprise rates for FY20 and FY21 as reported by University of Michigan facilities and operations. https://utilities.fo.umich.edu/services/energy-utilities/business-services/utility-rates/.

As long as the $\Delta(B_2 - B_1)/\Delta(C_2 - C_1)$ ratio is greater than one, the challenger alternative is preferred. However, if the $\Delta B/\Delta C$ ratio is less than one, then the defender alternative is preferred.

The total costs for each alternative include the upfront cost for the Battery Electric Buses (BEB), the maintenance cost for the BEB, the upfront cost for the charging infrastructure (units, pedestal and installation), the maintenance cost of the batteries, and the electricity cost for charging the batteries without DTE subsidy. Defining the total benefits for each scenario proved to be challenging as there is difficulty in putting a $ value to intangible benefits (White, 2012). However, for this analysis it was assumed that the total benefits will be the sum of the Annual Fuel saving ($) across the twelve-year lifetime of a bus, and the value of Annual CO_2 emissions abated ($) across the same twelve-year lifetime of a bus using a carbon price of $50/Mt$CO_2$ as proposed by the PCCN report, see **table 1** above.

The results from the Benefit-Cost Analysis are presented in the tables below

Table 2: Benefit: Cost ratio analysis for fast deployment compared to do-nothing

Δ(B2 – B1)/Δ(C2 – C1) Analysis excluding the cost of issuing bonds	
Alternative 1(Fast-Deployment) vs Do Nothing	
$\Delta C = \Delta C_{(\text{do nothing})} - \Delta C_{(\text{fast deployment})}$	$ 88,291,389.63
$\Delta B = \Delta B_{(\text{do-nothing})} - \Delta B_{(\text{fast deployment})}$	$ (141,578,634.72)
$\Delta B/\Delta C$	-1.60
Interpretation of the Cost-Benefit analysis	The pairwise comparison has a B/C ratio < 1, therefore fast deployment(defender) is better than the do-nothing(challenger) approach.

Table 3: Benefit : Cost ratio analysis for fast deployment compared to slow deployment

Δ(B2 – B1)/Δ(C2 – C1) Analysis	
Alternative 1(Fast-Deployment) vs Alternative 2(Slow Deployment)	
$\Delta C = \Delta C_{(\text{slow-deployment})} - \Delta C_{(\text{fast-deployment})}$	$ 3,439,137.08
$\Delta B = \Delta B_{(\text{slow-deployment})} - \Delta B_{(\text{fast-deployment})}$	$ (370,911.62)
$\Delta B/\Delta C$	-0.11
Interpretation of the Cost-Benefit analysis	The pairwise comparison has a B/C ratio < 1, therefore fast deployment (defender) is better than slow deployment(challenger).

The incremental cost-benefit analysis began with a comparison between a “do nothing” approach (challenger or more expensive alternative) and a fast deployment approach (defender or less expensive alternative). A “do nothing” approach represents a situation where the University of Michigan, Ann Arbor campus continues to replace 4 old diesel or diesel-hybrid buses each year with 4 new diesel hybrid buses. The value for the Benefit:Cost ratio for this comparison was -1.60, and since this is less than 1, the challenger alternative (do nothing) is rejected, and the defender alternative (fast deployment) is chosen. The second incremental cost-benefit analysis was between a slow deployment approach (new challenger or more expensive scenario) and a fast deployment approach (defender or less expensive scenario). The value for the Benefit:Cost ratio for this comparison was -0.11, and since this is less than one, the challenger alternative (*slow deployment*) is rejected, and the defender alternative (*fast deployment*) is chosen. Overall, *fast deployment* is the best option from a benefit: cost ratio standpoint.

Table 4: Comparison of a Benefit - Cost analysis for a do-nothing approach, fast deployment, and slow deployment

Scenario	Benefit	Cost	Benefit - Cost
Do nothing	$ 0	$ 132,343,303.89	$ (132,343,303.89)
Fast Deployment (Scenario 1)	$ 141,578,634.72	$ 44,051,914.26	$97,526,720.46
Slow Deployment (Scenario 2)	$141,207,723.10	$47,491,051.34	$93,716,671.76

The above table shows that the scenario with the highest value of Benefit – Cost is the *fast deployment* ($97,526,720.46) followed by the *slow deployment* ($93,716,671.76), meanwhile the *do-nothing* approach has the lowest benefit – cost value of $93,716,671.76. Overall, fast deployment is still the best option from a benefit - cost standpoint.

It is worth noting that the interpretation of the Benefit-Cost analysis in this study is subject to some factors of uncertainty which includes, the choice of discount rate, the reference point of the stakeholder assessing the costs and benefits of the project (i.e., there are different viewpoints for what constitutes costs and benefits for university users, investors and project developers), the choice of what constitutes as “benefit” in the analysis (White, 2012). For this case study, the point of view of users of the bus system is taken, using a 2.9 % interest rate (**see table 1**), while taking the CO_2 emissions abated ($) and diesel fuel cost saved ($) in switching to BEB as the metrics to calculate the “benefits”.

4. Assessing the feasibility of the project for the Special Purpose Vehicle - Net Present Value (NPV) calculations and Payback Period for Investors.

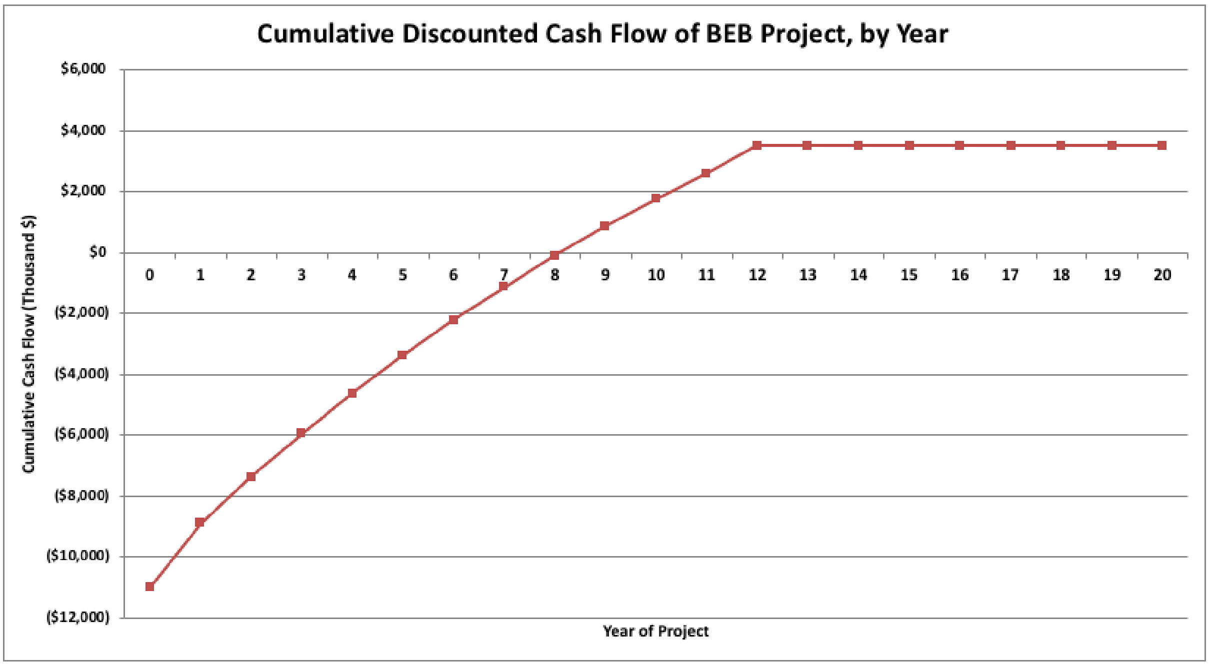
The previous section showed that fast-deployment of BEBs presents the best path for the University of Michigan, Ann Arbor from a cost-benefit standpoint. However, before the Special Purpose Vehicle or Project Company can offer a lease contract, it has to determine whether the revenue from running the project with the University of Michigan, Ann Arbor outweighs the cost. In this context, the "costs" for the project company include the principal and interest payments on public and private loans from banks and private equity, management fees for setting up the SPV, contract fees with the Engineering, Procurement and Services (EPS) contractors i.e., Gillig, and dividend payments to the equity sponsor i.e., Proterra.

One way to access the feasibility of the project is by determining the Net Present Value (NPV) and the Discounted Payback Period for the project. The Net Present Value is the total cashflow generated throughout the lifetime of the project and discounted to present day dollar values (Hinman, 1997). It includes both the cash inflows into and the cash outflows from the project. Meanwhile, the Payback Period is the minimum time in years needed to return investor capital. To calculate the Net Present Value and Payback period to investors for this project, the Vehicle and Infrastructure Cash-Flow Evaluation Model for Battery Electric Buses (VICE-BEB) developed by researchers at the National Renewable Energy Laboratory (NREL) was used (Johnson, 2020). Input data in the default form of the Model was substituted with specific data for the University of Michigan, Ann Arbor based on the Economic Analysis for electrifying the transit fleet described by (Sun, 2021). The results are shown below.

Table 5: Net Present value and discounted payback period for Scenario 1(Fast Deployment) with the discount rate set at the commercial lending rate of 7%

OUTPUTS		
Net Present Value	$3,530,301	USD
Discounted Payback Period	8.6	Years
Simple Payback Period	6.5	Years

Figure 1: Graph showing Annual Net Present Value (NPV) of cash flows for Scenario 1(Fast Deployment) with the discount rate set at the commercial lending rate of 7%



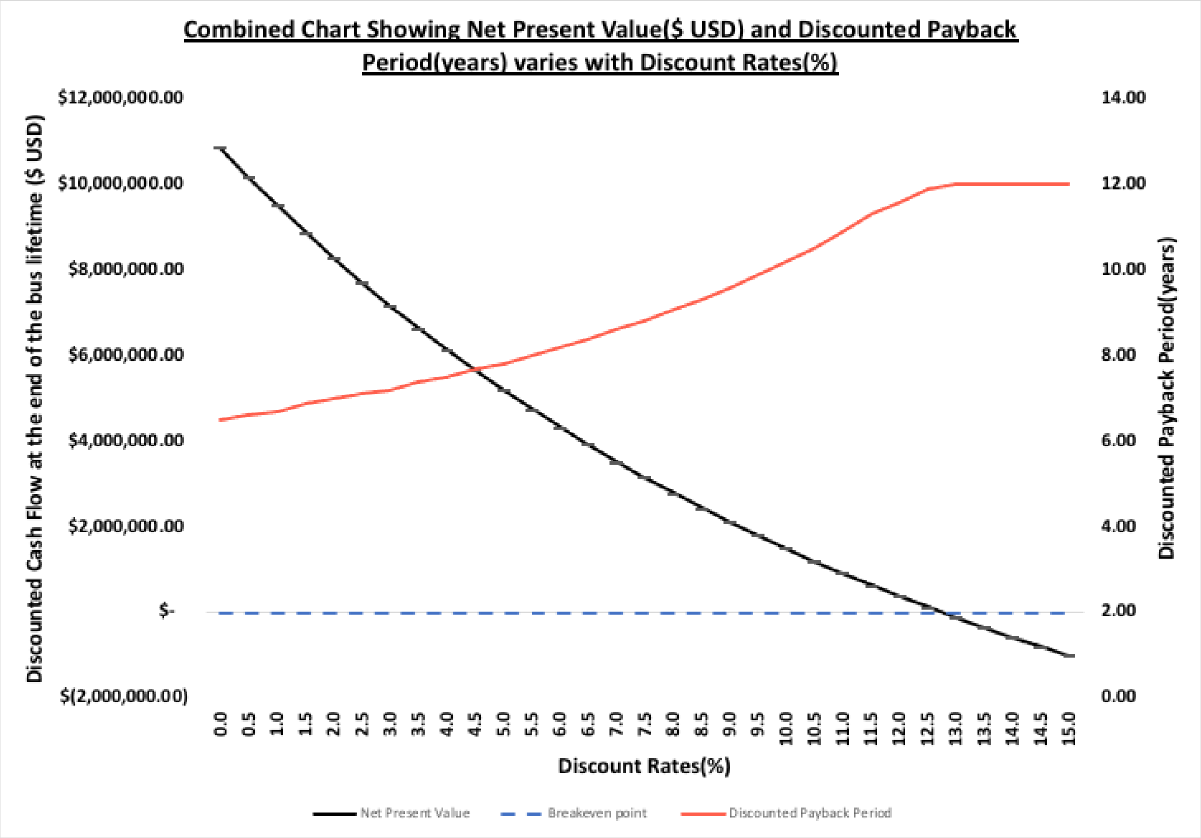
From table 5, the model predicts that if the discount rate is set at the commercial lending rate of 7%, the discounted payback period for fast deployment is 8.6 years and the NPV at the end of the twelve-year lifetime of the bus is $3,530,301. In lay terms, the model predicts that if the project company incurs a weighted average cost of capital (WACC) of 7% and sets up a lease agreement with U of M as an off-taker, they are able to pay back the initial capital borrowed from investors roughly nine years into project operations. Furthermore, at the end of the lifetime of these leased buses, the project company will have a net positive cash flow of $3,530,301 in today's dollars.

It should be noted that setting the WACC at 7% may be an underestimation. The choice to do so is assuming that the project company raises the capital to pay for the electric buses and charging infrastructure from one commercial lender e.g., a commercial bank which charges a single rate that equals the current commercial lending rate. However, the Project company and its partners (equity sponsor and EPS partners) could seek to raise capital from multiple sources e.g., loans from commercial banks, investment from private equity firms, and each source could charge a different premium on their capital. Such a scenario will increase the WACC for the project company to a value higher than 7%, and thus negatively impact the NPV and discounted payback period. To buffer for this effect, a sensitivity analysis will be carried out next to determine how the NPV and discounted payback period varies with changes to discount rates. This will serve as a guide for the project company and its partners on an acceptable WACC value when seeking capital.

5. Sensitivity Analysis to highlight best-case and worse-case scenario from operations on the project.

To conduct the sensitivity analysis, discount rates ranging from 0% to 15% were selected with an increment of 0.5%. This range accounts for the full gamut of typical commercial lending rates (Gellerman, 2021), and places the current assumed discount rate of 7% at the midpoint, thus allowing the project company to roughly predict what the NPV and discounted payback period will be with a given WACC. The result from this sensitivity analysis is shown in **Figure 2**.

Figure 2: Combined graph showing the Net Present Value (NPV) in $USD of cash flows at the end of the lifetime of the bus and discounted payback periods for *Fast Deployment* given a range of discount rates (%) from 0% to 15%. Primary y-axis (LHS) shows the overall NPV ($ USD) for the project and the pattern is shown with a black trendline. Secondary y-axis (RHS) shows the Discounted Payback Period (years) for the project and the pattern is shown with an orange trendline. The blue dashed line represents the breakeven point for the project, when the NPV ($USD) becomes zero.

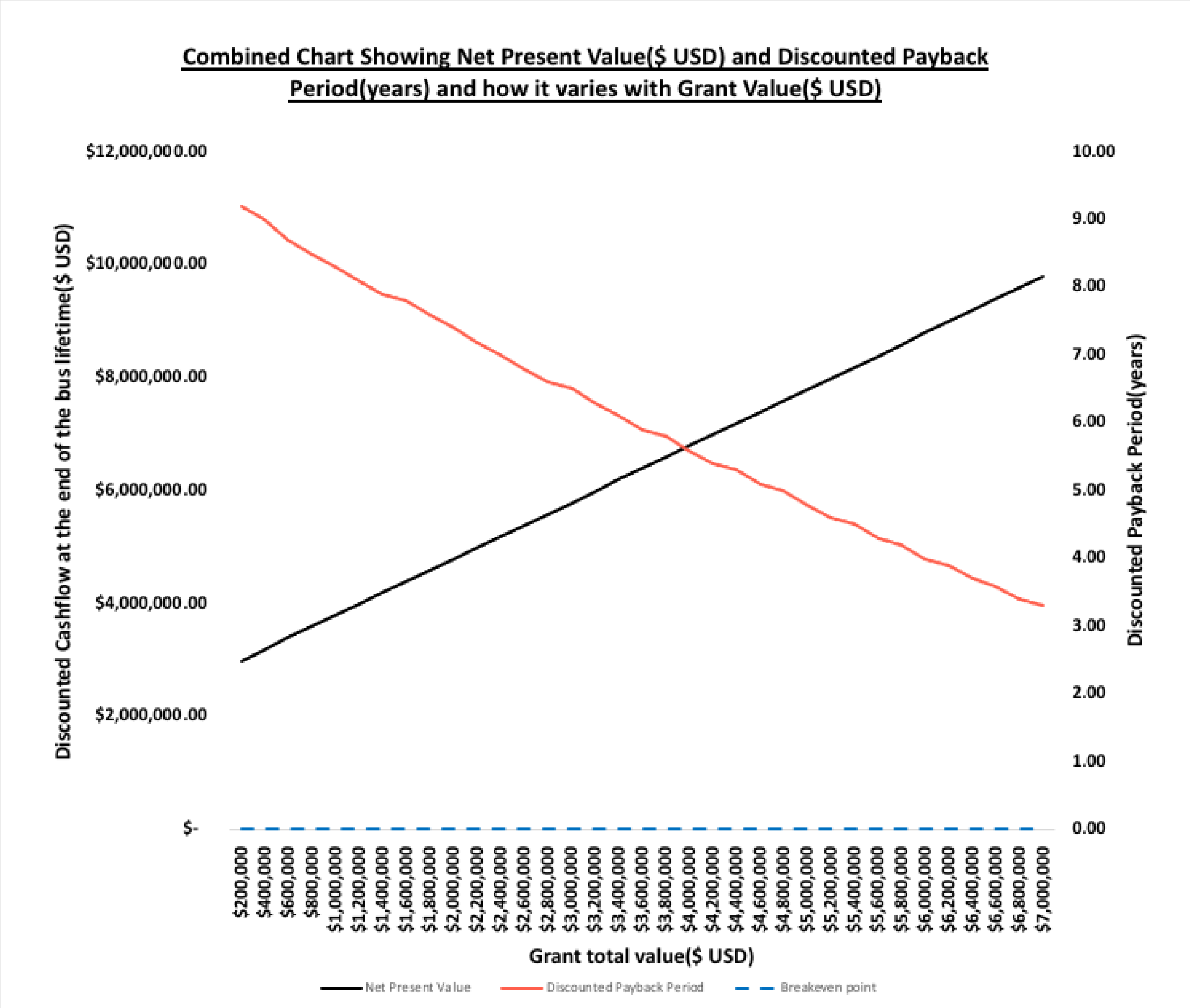


The combined chart above suggests that the project company can attain a positive Net Present Value (NPV) as long as the discount rate remains below 13%. Furthermore, investors can expect to receive the payback for their initial capital within the lifetime of the project i.e., twelve years as long as the discount rate remains at or below 13%. The implications for this result are to provide a rough guide to the project company on the maximum allowed WACC for financing the project in order to break even or yield net positive cash flows at the end of the project. In this case, the total WACC should not exceed the rate of 13%.

Aside from the Discount Rate, another parameter that can influence the cash flows of the project company are the grants it receives to subsidize the upfront costs of operating the electric bus service. To determine a baseline grant value for the NREL VICE-BEB model, William McAllister, a General Manger at the Logistics Transport and Procurement (LTP) department within the University of Michigan was consulted. The LTP department applies to a number of federal grants each year to purchase new transit buses, one of which is the low or no emission vehicles grant program administered by the Federal Transit Authority (FTA). This program provides funding to state and local government authorities for zero-emission buses as well as supporting infrastructure such as electrical chargers (FTA, FTA Low or No Emission Vehicle Program, 2021). The LTP department applied unsuccessfully for a grant in 2020, however William McAllister stated that another grant application for $741,303.45 will be sent on behalf of the University in 2021 to help purchase two 40-foot electric buses. Thus, $741,303.45 was used the baseline grant value in the NREL VICE-BEB model. Because grant funding can effectively reduce the cost of the project for the project company, a sensitivity analysis was carried out to determine how the grant value in US dollars affects the NPV and discounted payback period for the project in delivering its electric bus services.

To determine the range of grant amounts needed to use as independent variables in the sensitivity analysis, data from the FTA's low or no emission vehicles grant program showing each individual grant awarded to all projects since the beginning of the program in 2016 were assembled (FTA, FTA Low or No Emission Vehicle Program Grant Amounts, Accessed 2021).The total value awarded from the grant program to date is $409,349,017.00, which are broken down to 202 individual grants ranging from the highest grant value of $7,074,310 to the lowest grant value of $284,759. Therefore, the input independent variables in the sensitivity analysis ranged from $200,000 to $7,000,000, and the corresponding NPV and discounted payback period were recorded. The results are shown in **Figure 3**.

Figure 3: Combined graph showing the Net Present Value (NPV) in $USD of Cash Flows for Scenario 1



<u>Notes:</u> Scenario 1 (*Fast Deployment*) at the end of the lifetime of the bus and discounted payback periods for given a range of total grant value ($ USD) from $200,000 to $7,000,000. Primary y-axis (LHS) shows the overall NPV ($ USD) for the project and the pattern is shown with a black trendline. Secondary y-axis (RHS) shows the Discounted Payback Period (years) for the project and the pattern is shown with an orange trendline. The blue dashed line represents the breakeven point for the project, when the NPV ($USD) becomes zero

Figure 3 suggests that the project company can attain a positive Net Present Value (NPV) when the total grant falls in between $200,000 and $7,000,000. Furthermore, investors can expect to receive full payback on their initial investment within the lifetime of the project. However, a higher total grant value results in a faster discounted payback period. Therefore, the results serve as a rough guide for the project company when seeking grant funding to help subsidize the cost of the project in a way that yields a positive NPV at the end of the project life. In this case, the total value of grant sought by the project company should not go below $200,000.

6. Proposals for Investment vehicle to finance electric bus system- Special Purpose Vehicles or Special Purpose Entities (SPVs or SPE).

Special Purpose Vehicles (SPV) or Special Purpose Entities (SPE) are standalone entities (project companies) that are created for a specific purpose or commercial activity. They are a form of project finance commonly used to reduce the financial risk of the originators (Gorton, 2006). The major forms of an SPV are a trust, a partnership, a limited liability company, and a corporation (Gorton, 2006).

The central object of a trust based SPV is the project company which is established to perform a particular function or deliver a narrow set of commercial activity stipulated in a legal agreement document. This project company could be a subsidiary of a parent company, or an orphan company (Gorton, 2006).

The main players of an SPV are the originators/sponsors of the project company, the project company, the construction and operation and maintenance (O&M) companies, the off- takers of the output from the project, the investors which includes both equity investors and debt investors, the facilitators who help issue securities of the project company to the secondary markets, and finally individual investors in the secondary market that purchase the securities.

Transactions in a Project Finance Model

Figure 4: Organization of stakeholders and transaction in a Project Finance model
(*Adapted from Weber, B et al. 2016. Chapter 6: Project Finance, pp310)*

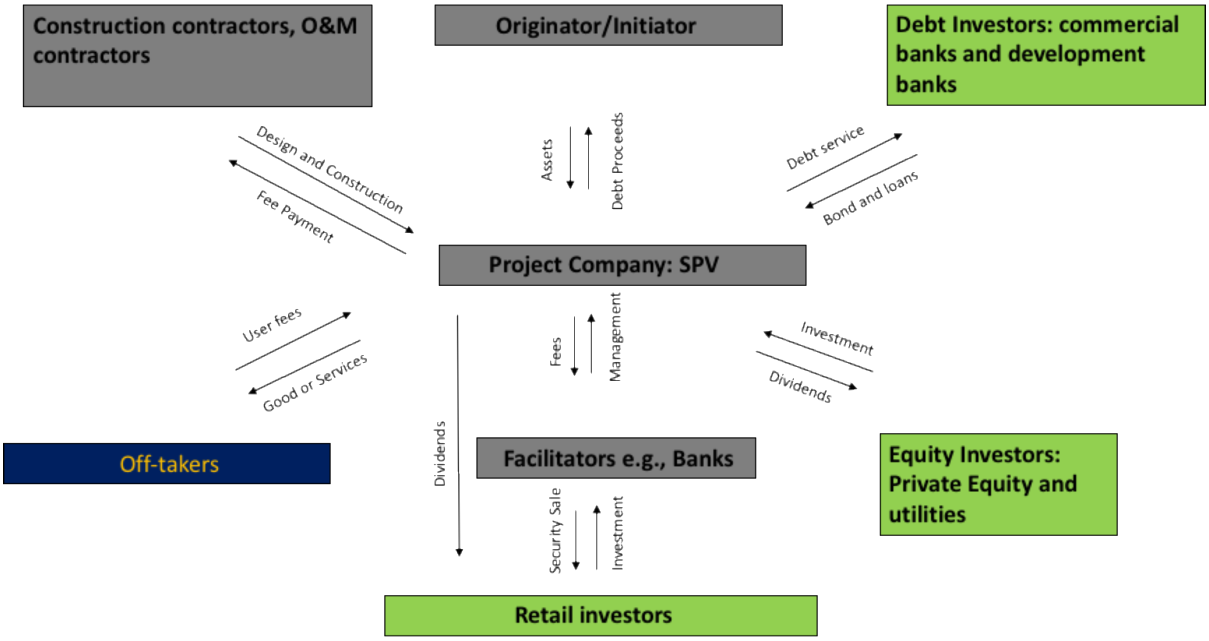


Figure 4 shows the transactions that occur in the SPV. The project company sits at the center of the project finance model, and above them are the project sponsors which can include the parent company or a syndicate of companies. The parent company sells off assets to the project company and cannot offer these assets to creditors as collateral in the advent of a bankruptcy. The construction companies and O&M companies assist with the development of the assets up until the operation stage by providing their in-house expertise in return for fee payments. These services can also be bundled and provided by a single contractor. The off takers are the customers of the project company and they receive a good or service in exchange for service payments that count as revenue to the project company. The investors provide financing for the project companies and are generally divided into two kinds of investors, namely debt investor and equity investor. Debt investors provide loans with interest charges and tend to be commercial banks and development banks. Equity investors on the other hand provide equity capital and shareholder loans. They are roughly divided into strategic investors and financial investors. While the strategic investors provide capital to a project company with the hopes of adding value in the future of their underlying business e.g., expanding to a new geography, the financial investors are mostly concerned with attaining a good return on their investments and thus provide short term capital. Common examples of strategic investors are utilities and insurance companies, while financial investors include sovereign wealth funds (Weber, Chapter 6: Project Finance, 2016). The proceeds from the product or service offered by the project company are used to pay back investors. However, if these returning cash flows are insufficient to repay investors their principal and interest, the project company can raise cash through the secondary markets with facilitators structuring and selling financial instruments such as bonds or Senior notes in exchange for a management fee. These facilitators include investment banks, rating agencies, and commercial banks and their roles are divided into the actual structuring of the security (investment banks), the rating of these securities (rating agencies), and the enforcement of the contracts between the issuer and the buyers of these securities (commercial banks) (CFI, Accessed 2021; Peristiani, 2012). Finally, we have the investors in the secondary markets which are mainly individual or retail investors that purchase these securities issued by the investment bank.

Participation in the secondary markets acts as a hedge for debt refinancing and provide liquidity to the project company to help pay back the principal and interest. The process begins with the pooling of receivables (expected cash from the sale of an asset) from the project company such as credit card receivables, lease agreements, licensing rights etc. and grouping these receivables into tranches that reflect the riskiness of the assets in each group. These tranches, which are a type of security, are sometimes called notes, and they are named Senior notes, Mezzanine notes, and Junior notes in descending order of riskiness. It is common practice for the project company to hire investment banks to help structure these securities and issue them in the capital market in exchange for fee payments. Once issued by investment bankers, retail investors on the secondary market pay to acquire these debt securities that are backed by revenue contracts and receive dividends in exchange. The proceeds from these sales are used to acquire more receivables in a revolving pool, and only after a pre-determined amortization period will the excess cash be used to pay back the principal and interest rate to the debt investors or banks (Gorton, 2006).

The running of an SPV involve both opportunities and challenges. Advantages of an SPV includes off-balance sheet accounting, project efficiency due to various in-house expertise, and spreading of risk amongst the different types of investors. SPVs provide certain benefits to the originators, one of which is off-balance sheet accounting. Off balance sheet accounting is when the revenue received, and debt incurred by the project company are not recorded on the balance sheet of the originators. This is advantageous when the project company does not receive enough revenue from its operations to pay back debt. Thus, the deficit is not recorded on the balance sheet of the originators and poor performance of the project company does not affect the credibility of the originators. Another benefit SPVs provide the originators is the protection of the assets sold to the SPV if the originator becomes bankrupt. In such a situation, creditors of the parent company cannot claim the assets sold to the SPV as collateral and as a consequence the investors for the SPV experience less legal risks.

Moving away from benefits gained by the originators, SPVs also have the advantage of increased access to expertise from participating firms in managing the project throughout its lifetime. Such help comes mainly from strategic investors who provide long term capital and have it in their best interest to see the project succeed and the assets appreciate over the entire period of the project operation. These incentives offer a stronger push for project efficiency than having a public organization as a watchdog to ensure an acceptable quality of project operations.

The final benefit of an SPV is the ability to spread the risks of the project amongst the sponsor parties that are best suited to handle it. Asides from bankruptcy risk, there are other risks that accrue to any type of project such as risk from unfavorable government regulation, legal risk for land ownership, interest rate risk and exchange rate risk. These risks are allocated to the stakeholder in figure 4 above best suited to handle them. For example, the regulatory and legal risk will be allocated to the parent company which is expected to use its lobbying power and political influence to win key concessions for the project company, likewise the interest rates and exchange rates risks that occur through changes in variable interest rates and changes in local currency are allocated to the debt investors (commercial banks) so that they can use their expertise to avoid these risks (Weber, Chapter 5: Risks, 2016).

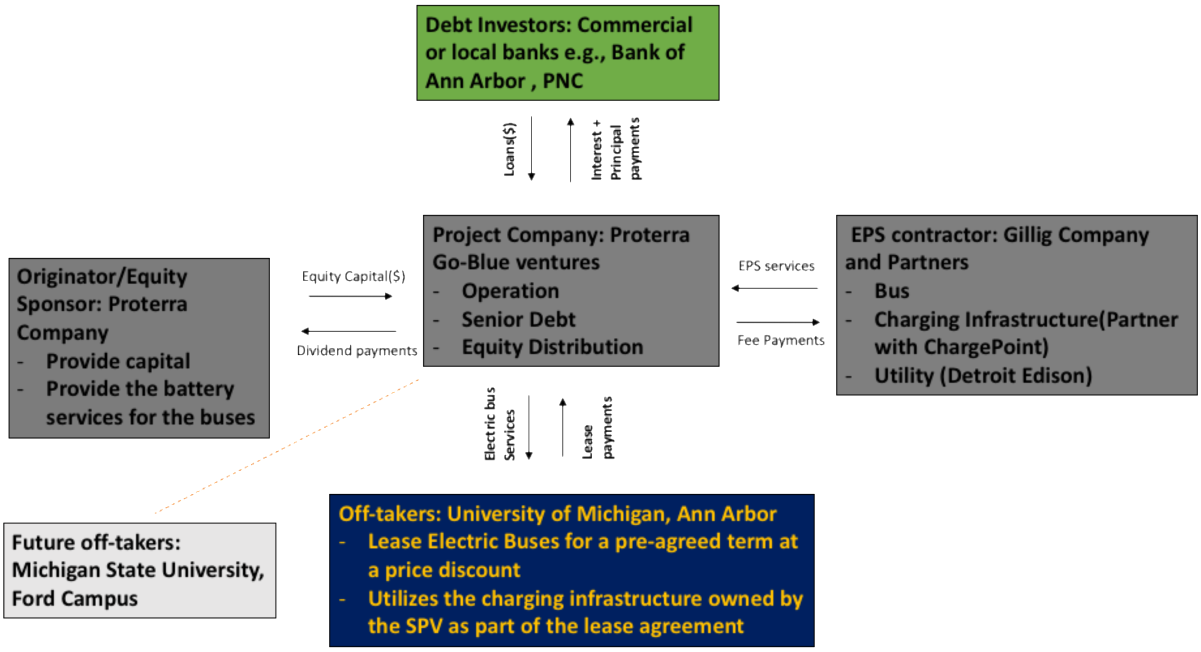
On the contrary, the major risks of an SPV include over-forecasting of expected revenues from the project which can lead to default in paying back the debt financing, a complex structure that has numerous financial stakeholders, the problem of contrarian incentives amongst stakeholders e.g., while strategic investors are in for the long-term, financial investors are chasing short term returns, and finally the absence of fiduciary responsibility.

Discussion

1. The SPV structure for providing electric bus services to the University of Michigan, Ann Arbor

The previous section gave a brief description of what Special Purpose Vehicles were as well as a discussion of its pros and cons. The following section will take these concepts and apply it to the Magic Blue Bus system at the University of Michigan. The aim of this section is to design an SPV that will allow the University to assume the role of an off-taker of the electric bus services that the Project company provides. The structure of this SPV is shown in figure 6.

Figure 6: Organization of the Special Purpose Vehicle (SPV)



Notes: The University of Michigan acts as an off-taker of the electric bus services provided by the Project Company, Proterra Go-Blue! ventures. Other stakeholders involved in the SPV are also shown. The smaller black arrows show the type and direction of payments made to each stakeholder, the larger black arrows show debt repayment, the dotted orange line represents a path for potential expansion of the customer base following a pilot phase with the University of Michigan, Ann Arbor.

Figure 6 provides an outline of all the stakeholders that are involved in the Special Purpose Vehicle. The focal point for this Project Finance Model is the Project Company called Proterra Go-Blue ventures. Proterra is an automotive and energy storage company that has pioneered the battery leasing model in North America (Stromsta, 2019; John, 2021). They represent the originator for the SPV and the main equity sponsor for the project company. Proterra was chosen as the originator because of the strides it has made to reduce the upfront cost for purchasing battery electric buses and will be supportive of the University of Michigan's PCCN mandate to roll out all electric buses by 2035. In this model it is assumed that Proterra will provide the electric batteries for these buses.

Another key stakeholder in the SPV is the Engineering, Procurement and Services (EPS) contractor, Gillig. Gillig is the second largest transit bus manufacturer in the United States (Gillig , Accessed 2021), as well as the current vendors for the University of Michigan's transit Blue Magic buses.[5] The California based company has a breadth of experience in the transit mobility space and can provide its industry connections to pull together contracts from the charging infrastructure providers such as ChargePoint and the chosen utility company DTE. Furthermore, Gillig is also a manufacturer of 40-foot battery electric buses and can sell these buses without batteries to the project company while also providing operations and maintenance services. In the proposed model, Gillig will be partnering with Proterra in delivering the infrastructure to support the battery electric bus provided to Proterra Go-Blue! ventures, and while both California based companies are currently seen as rivals in providing these services, Gillig has the opportunity to forge a new partnership that can lower the costs of producing BEB (as the batteries for their buses will be produced by Proterra) while expanding their EV rollouts into more geographies within the United States. The role that Gillig plays as the main EPS contractor reduces the financial and management risks to Proterra Go-Blue! ventures of having multiple stakeholder transactions.

The final stakeholder in the day-to-day running of the SPV is the U of M which acts as the sole off-taker in the pilot phase of the project. The U of M will receive the electric bus services provided by the project company for a given number of years in exchange for annual lease payments. These services include the use of the BEB to transport students via the normal routes and schedules for the Magic Blue Buses, access to charging infrastructure provided by Proterra Go-Blue! ventures, access to regular operations and maintenance provided by the EPS contractors via the project company. The main advantage of this arrangement is the reduced upfront cost to the U of M in purchasing brand new BEB and charging infrastructure, thus accelerating the roll-out of BEB by the U of M in line with the PCCN carbon neutrality goals.

Debt investors and future off takers are also included in the SPV model. The Debt investors are commercial banks such as Ann Arbor, and they provide Proterra Go-Blue with loans to help with the purchase of the electric buses and supporting infrastructure from their equity sponsors and EPS contractors. A detailed analysis of the agreement between Proterra Go-Blue! and Bank of Ann Arbor is beyond the scope of this research. However, the project company should be reminded that the safety buffer for the WACC should not exceed 13% in order for the cash flows to break even (see Fig 2).

There are successful precedents to the proposed SPV model (Miles, 2014). In a nearly identical project enacted in 2014 in Milton Keynes, England, a "Special Purpose Enabling Company" called Electric Fleet Integrated Services Ltd was formed through a joint venture between Mitsui and Arup. The project company obtained electric buses and charging infrastructure from their chosen

[5] This information was gotten from an email exchange with Mr. William McAllister, a General Manager in the Logistics, Transportation and Parking (LTP) division at the University of Michigan. The LTP department is in charge of the daily operations of all the Blue Magic Buses.

EPS contractors and leased these buses out to municipal transit authorities. Because the project company was a direct customer to the EPS contractors, it was able to reduce the technology and business risks for the off takers. In another similar project in Montgomery Maryland, a twelve-year lease agreement between the suburban Maryland district and Highland Electric Transportation is set up (Kaplan, 2021). Highland, which is a Boston Based company, will buy these buses from Thomas Built Buses in North Carolina and rent it out to the district transport authorities. The annual lease payment is $1.3 million and will cover charging of the batteries, operations and maintenance and training for the drivers of these buses. The successful implementation of the aforementioned project finance model provides some confidence that the same outcome can be replicated at the U of M.

2. Financing the lease payments

The U of M is able to experience reduced upfront cost by acting as an off-taker and providing lease payments for battery electric bus services from the project company, Proterra Go-Blue! ventures. However, it is also important to propose a structure for the lease contract, and to determine if the University is able to achieve timely payments of the lease throughout the contract period. This section looks at one possible model for the lease contract, as well as the sources of revenue available to the U of M in paying back the lease. Furthermore, it determines the Internal Rate of Return and the Debt Service Coverage Ratio for the University as an indicator for its ability to pay back the lease over the life of the project.

Structure of the lease contract

The model for the lease contract between the U of M and Proterra Go-Blue! ventures includes a seven-year lease agreement, with fixed annual lease payments of 8% of the total upfront cost for the 40-foot BEB and full payment for additional charging infrastructure services[6]. A pro-rata of 8% was selected because it represents the typical leasing rate for transit electric buses reported in other case studies involving Proterra and Park City Transit in California, as well as Generate Capital and BYD's joint venture called Green Transportation Leasing LLC created in 2018 with operations in California (Lui, 2019; Pyper, 2018). The lease contract comes with a bundle of four new buses added per year in line with the *fast deployment* scenario, depot charging on all charging infrastructure owned by Proterra Go-Blue! ventures at no additional cost, regular repair and maintenance services for all buses, the rights to customize the electric buses to match the University's previous Magic Blue Bus designs, and

[6] This includes the physical infrastructure and the electricity supplied by the utility. Recall that the Providers of the Charging Infrastructure (ChargePoint) and the electricity providers to the chargers (DTE) does not deal directly with the University but arranges a contract with the EPS providers for the SPV, Gillig.

the rights to resell the excess electricity stored in the battery to internal departmental buildings on campus.

Revenue sources for the University of Michigan, Ann Arbor

The revenue pool to pay back Proterra Go-Blue! ventures is proposed to come from two sources, sale of carbon credits and resale of excess electricity in the batteries to internal departments on campus. The sale of carbon credits is based on the premise that the use of the battery electric transit buses will result in abatement of CO_2 (eq) when compared with traditional diesel buses or hybrid diesel buses[7]. If we consider the carbon price of $50/metric-tons of CO_2 (eq) proposed by the University of Michigan Carbon Neutrality final report (PCCN, 2021), the dollar value of annual carbon abatement (kg CO_2 eq) can be found over the 7-year lease agreement. The result of this analysis is shown in **table 6.**

Table 6: Dollar value of Carbon Abated by the University of Michigan

Carbon Credit Revenue Calculations								
Year	2021	2022	2023	2024	2025	2026	2027	2028
Total Annual Carbon Footprint (kg CO2e) from scenario-1 (fast deployment)	3947368	3706846	3466324	3225801	2985279	2744757	2504234	2263712
Total Annual Carbon Footprint (kg CO2e) from a do-nothing scenario	3947368	3947368	3947368	3947368	3947368	3947368	3947368	3947368
Carbon Savings (kg CO2e)	-	240522	481045	721567	962089	1202612	1443134	1683657
Carbon Credit value ($) Non-discounted	$ -	$ 12,026	$ 24,052	$ 36,078	$ 48,104	$ 60,131	$ 72,157	$ 84,183
Carbon Credit value ($) Discounted	**$ -**	**$ 11,687**	**$ 22,716**	**$ 33,113**	**$ 42,907**	**$ 52,122**	**$ 60,783**	**$ 68,915**

Notes: Dollar values of carbon abated from the lease agreement with the project company over the seven-year pilot lifetime with a $50/metric-ton of CO_2 (eq) carbon price

From table 6, the Total Annual Carbon footprint is calculated from the equation, **Total Annual Carbon Footprint (kg CO_2eq) = Number of Diesel buses in the fleet * 1/vehicle efficiency of diesel buses(mpg) * Annual miles travelled(mi/vehicle) * CO_2 emission factor for diesel buses(kgCO_2/gal) + CO_2 emission factor for electric buses(kgCO_2/kWh) * vehicle efficiency for an electric bus(kWh/mile) * Annual miles travelled(mi/vehicle) * number of**

[7] The total CO_2 (eq) emissions from all types of transit buses (diesel, hybrid or battery electric) is heavily dependent on the composition of resources used to power the electric grid, and to reap the full environmental benefits of a transition to battery electric transit buses, the electricity produced to charge the BEB has to come from cleaner renewable energy sources.

electric buses. The assumptions for the values of all these factors can be seen in table 1, except for the number of diesel buses and electric buses which were determined based on *fast deployment* scenario discussed previously (Sun, 2021).

The previous section laid out a possible structure for the lease contract that included providing the off taker with the rights to resell excess battery capacity from the electric buses to departmental buildings within the University. The process of internal energy supply is not new and has already been practiced by the U of M's Electrical Engineering and Computer Science (EECS) department, where the heat released from running the Heating Ventilation and Air Conditioning (HVAC) systems is used to provide geothermal energy to power three EECS buildings (Newman, 2017). If these rights are granted, the University can generate revenue from the internal resale of excess electricity from the leased buses and use the revenue to help pay back the lease for the buses. Work was done to estimate the annual revenue that can be gotten from resale of excess electricity from the leased buses in the fleet over the lifetime of the project shown in table 7.

Table 7: Annual revenue from excess electricity resales to internal departments at the University of Michigan

Electricity Sales revenue								
Year	2021	2022	2023	2024	2025	2026	2027	2028
Number of EV buses in fleet from scenario 1(fast deployment)	0	4	8	12	16	20	24	28
Total annual value of excess capacity in battery($/year) Non-discounted	$ -	$ 8,385.00	$ 16,770.00	$ 25,155.00	$ 33,540.00	$ 41,925.00	$ 50,310.00	$ 58,695.00
Total annual value of excess capacity in battery($/year) Discounted		**$ 8,149**	**$ 15,838**	**$ 23,088**	**$ 29,916**	**$ 36,341**	**$ 42,380**	**$ 48,050**

Notes: over the 7-year pilot lifetime with a $0.086/kWh electricity rate.

The assumptions made in table 7 were that the 225kWh battery capacity for each electric bus will need two full charges per day to meet daily operational demands given an EV efficiency of 2.1 kWh/mile which represents the battery efficiency for Proterra's ZX5 batteries (Proterra, Accessed 2021). The Battery Capacity used per day is calculated by the formula, **Daily Battery Capacity utilized= EV efficiency (kWh/mile) * Annual miles driven/days driven per year(mile)**. Furthermore, the leftover capacity following a day's operation that can be resold internally is given by the formula, **Daily Excess Battery Capacity= Battery Capacity (225 kWh) * No of charges per day (2) – Daily**

Battery Capacity utilized (328.125 kWh). If the LTP department resells the excess electricity at same rate as the average utility enterprise rates for FY 2020 and FY 2021, the predicted revenue profile across the seven-year lease period is shown in the final row on table 7. The predicted total annual revenue from the electric bus services across the seven-year lifetime of the lease contract are shown in table 8, alongside with the total cost for the lifetime of the bus (i.e., twelve years). The profit is found by subtracting the total annual revenue by the total annual cost. The values in table 8 show that the U of M is unable to make a profit throughout the lifetime of the lease because the total annual cost is much larger than the total annual revenues, hence the U of M ought to look for other sources of revenue to pay back the lease to Proterra Go-Blue! ventures. Two possible solution to the shortage of funds for lease payments are the issuing of municipal bonds by U of M, and the establishment of a Revolving Energy Fund(REF) that provides grants to the LTP (PCCN, 2021).

Table 8: Total Annual revenue for the University of Michigan

Year	2021	2022	2023	2024	2025	2026	2027	2028
Total Revenue ($, non-discounted)	**$ -**	**$ 11,695,339**	**$ 22,731,465**	**$ 33,136,246**	**$ 42,936,503**	**$ 52,158,045**	**$ 60,825,709**	**$ 68,963,388**
Total Cost ($, non-discounted)	$ 6,598,450	$ 20,411	$ 40,822	$ 61,233	$ 81,644	$ 102,056	$ 122,467	$ 142,878
Profit ($)	$ (6,598,450)	$ (2,787,339)	$ (2,947,628)	$ (3,108,117)	$ (3,268,206)	$ (3,428,494)	$ (3,588,983)	$ (3,749,072)

Notes: Revenue over the 7-year pilot lifetime. Calculated by the sum of revenue from the Carbon Price and Resale of excess electricity

University bond sales and grant awards as a buffer for revenue undershoot

Revenue estimates in the previous section relies on there being a carbon market already established with a carbon price of $50/metric-ton CO_2 (eq). It also relies on the success of the University in selling all the excess battery capacity back to internal departmental buildings at the current utility enterprise rate of $0.086/kWh. If any of these assumptions are violated, or the revenues are not able to cover the cost as seen in the previous section, it becomes necessary to develop alternative revenue sources to pay back the lease, some of these alternative sources of cash are, issuing of bonds, receipt of University grants, and advertisement fees charged to local businesses.

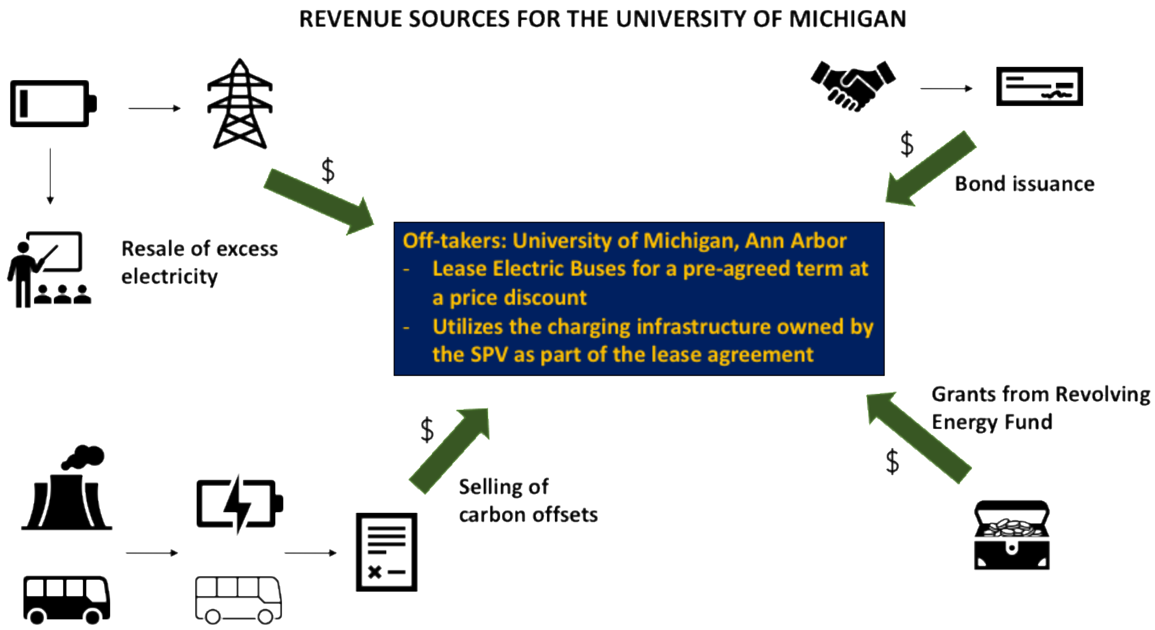
The U of M is an active participant in the bond market, as evidenced by a total bond issuance of $998 million of general revenue bonds in 2020, and $277 million of general revenue bonds in 2019 (pwc, 2020). These bond proceeds are used to finance capital intensive projects, pay back current debt and are kept for other administrative uses. The U of M also has a good credit rating in the bond market and has attained the highest bond ratings for both the S&P Global ratings (AAA) and Moody's credit ratings (Aaa) as a result of its reputation, the quality of its students it attracts, the volume of annual student enrollment, and its strong balance sheet (pwc, 2020). The average interest rate charged on bonds issued by the University is 2.9%. The project finance model in this paper proposes that the University issues bonds with at a fixed rate of 2.9% to investors to help pay back the lease during years where actual revenues undershoots forecasts.

The PCCN proposed the formation of a Revolving Energy Fund (REF) across the three U of M campuses as part of the solution for full decarbonization (PCCN, 2021). The REF is a pool of money set aside for projects that encourage energy conservation and decarbonization and was a spin-off idea from the Billion Dollar Green Challenge that involves fifty-eight institutions of higher education as well as a number of non-profit organizations (Sustainable Endowments Institute, Accessed 2021). The PCCN report asserts that the REF represents a solution of medium difficulty to the U of M and proposes a minimum of $25 million to be set aside for the REF at the Ann Arbor campus. Furthermore, a group called Voices for Carbon Neutrality (VCN), which comprises of University faculty and alumni leaders have come forward in support of this recommendation and go a step further to suggest that the REF will serve as down payment for a more comprehensive funding scheme for decarbonization[8]. The lease contract for battery electric buses between the U of M and Proterra Go-Blue! ventures qualifies for a project that encourages better energy management with reduced emissions within the U of M as shown in table 6, and the LTP division can apply to receive annual grants from the REF to help pay back the lease.

Overall, the proposed revenue schema that the U of M can utilize to pay back the lease is represented in fig 7.

Figure 7: The revenue scheme for the University of Michigan

[8] Letter by Voices for Carbon Neutrality (VCN) providing feedback on the PCCN annual report.



The revenue schema and lifetime costs for the lease contract were shown earlier, however in order to convince the head of the Operations and Facilities at the U of M that accepting the lease contract provides net benefits with low risks, estimates for the Present Worth (PW), the internal rate of return (IRR) and the debt service coverage ratio (DSCR) will need to be shown. The difference between the analysis that follows, and the analysis done in table 8 is that the current cash flows will be discounted based on an assumed Weighted Average Cost of Capital (WACC) of 2.9% (cost to the University for issuing bonds). Also, the debt from bond sales and the issuance management premiums will be added to the total costs for the project. Finally, a total grant amount of $741,303.45[9] will be provided by the REF to subsize the lease contract payments. All the assumptions for modelling the cash flow for the University of Michigan are presented in table 9, and the key output metrics of interest to decision makers at the University are presented in table 10.

Table 9: Assumptions for the Discounted Cash Flow Analysis for the University of Michigan, Ann Arbor campus over the seven-year lease pilot lifetime

Assumptions			
Parameter	Value	Unit	Comments

[9] Recall that the $741,303.45 was the total grant proposal that the LTP department was going to send to the Federal Transit Authority (FTA) Low or No Emissions Vehicle grant program in the summer of 2021 to purchase two brand new hybrid transit buses. The annual leases costs much less than this amount, and the REF can provide this same amount of money as a one-time grant to help offset the cost of the lease payment over the seven-year lifetime of the contract.

Fraction of funding from bonds	1	No units	N/A
Annual Bond Yield rate	2.9	%	The bond payments involve fixed interest payments to the bondholders by the university each year, and a balloon payment at the end of the 7-year planning horizon (pwc, 2020)
Number of coupon payments received by the bondholder	7	Payments	Annual payments made
Income tax rate	21	%	The current regime change in federal administration may result in an increase in this value
Planning Horizon	7	years	
Cost of issuing bonds	1.949	%	This value was gotten from University of Michigan's FY 20 Complete Financial Statement On page 5, it states that the total bond proceeds for FY2020 was $1026 million, and from that the cost of debt issuance was $2 million. This gives a % of total debt proceeds of 2/1026= 0.1949 or 1.949%. These costs include management fees to the banks that help issue the bonds on the market.

Table 10: Present Worth ($) at the end of the seven-year lease period, Internal Rate of Return (IRR) value (%), and the Debt Service Coverage Ratio (DSCR) from the Discounted Cash Flow Analysis

Parameter	**Value**	**Unit**
Present Worth	(87,813,465)	$
IRR	N/A	%
DSCR	0.01	No unit

Notes: These are some of the key metrics for decision makers at the University of Michigan in determining the financial feasibility of a lease contract with the project company

Table 10 shows that the project undertaking by the U of M would result in present worth of – $87,813,465. Furthermore, the DCF did not report an IRR because the cash flows before taxes were all negative throughout the lease periods, and it will take a very small rate to break even. This is not encouraging for decision makers because the IRR is smaller than the assumed WACC of 2.9%, which makes the project unprofitable. Finally, the predicted DSCR value of 0.01 suggests that the University is not able to cover the lease payments for the electric bus services with the potential returns from the project. Overall, all three financial metrics suggest that the lease contract between the U of M and Proterra Go-Blue! ventures will not be financially feasible unless there are additional sources of revenue to support the lease payment, or there are substantial cost reductions over the life of the lease.

Risks and Opportunities

The project finance model proposed contain certain risks and opportunities for added benefits, and while the risks include some of the common risks highlighted in (Weber, Chapter 5: Risks, 2016), the opportunities arise from strategies employed to manage these risks. There are technological risks, policy risks and business risks to be managed. The technology risks arise because Proterra Go-Blue! ventures obtain all of its buses from Proterra. Therefore, if Proterra fails to innovate its battery technology as fast as other market competitors, Proterra Go-Blue! ventures can miss out on the additional cost savings such innovation can create. Furthermore, if Proterra experiences a hold-up in the manufacturing of its EV buses, Proterra Go-Blue! will have to wait until the manufacturing issues are resolved, and this can lead to logistical challenges for the U of M LTP department. To manage this risk, Proterra Go-Blue! ventures should create calls for business proposals to a wide range of electric bus producers and select the vendors that is most innovative amongst various competitors. The policy risk arises if the internal carbon price is not instituted by the U of M or nationally. The revenue scheme relies on a functioning carbon market with a preset carbon price of $50/metric ton. However, the PCCN proposes a gradual increase in carbon price by $10/metric ton across years before the final price of $50/metric ton is met. Such a stepwise policy will mean reduced revenue from those seen in the model and will result in greater losses from the project over the lease period. This risk can be managed by Proterra Go-Blue! ventures engaging in carbon credit trade with companies or institutions in states with an active carbon market e.g., California, as the U of M slowly ramps up its price of carbon. The final risk is the business risk, and this affects the revenues that can be gotten from the resale of electricity back to the grid. Business risk arises because of demand response and how it impacts the retail rate of electricity. During a summers day when demand is high, the LTP could potentially charge higher rates for selling electricity back to internal building. Conversely, during summer evenings when demand is low, the LTP may not be able to charge as high a price or make profit from resale of electricity to internal buildings. To manage the business risk, the U of M can institute a fixed retail rates for their resale of electricity which is not affected by demand responses.

Conclusion and next steps

Financial limitations present a challenge for institutions in adopting innovative solutions that results in positive impacts for the environment such as reduced CO_2 emissions(kg). The U of M has made an effort to bring forth innovative solutions to help it each carbon neutrality by the establishment of the President's Commission for Carbon Neutrality (PCCN). The PCCN earlier released a detailed report on what it will take for the University to achieve its goal of carbon Neutrality for Scope 1 and Scope 2 emissions by 2025(or earlier for scope 2 emissions, offsets included) across all 3 campuses. Within this report are proposals to fully electrify the transit Magic Blue Bus fleet at the U of M. A follow-up study by Sun(2021) showed a cost-benefit analysis comparison between a *fast deployment* and *slow deployment* strategy for fully electrifying the forty-eight Magic Blue Bus fleet. This is in line with the cost-benefit analysis in this study which shows that *fast deployment* is the most cost-effective deployment strategy. This study goes one step further by proposing a financial model for a *fast deploymen*t scenario using a Special Purpose Vehicle set up by Proterra Go-Blue! ventures, with Gillig and partners as EPS contractors, and the U of M as an off taker of electric bus services. In this model, Proterra Go-Blue! ventures will lease the buses to the University of Michigan over a seven-year period. The University will pay back the lease using revenue from carbon credit sales and internal resale of excess electricity from batteries, with bond issuance and funding from the proposed Revolving Energy Fund (REF) acting as a reserve for when annual revenue undershoots forecasts. A discounted cash flow (DCF) analysis was performed to determine the financial feasibility of the project and estimates for the Present Worth of about negative $87 million was calculated. Furthermore, the Internal Rate of Return was less than the Weighed Average Cost of Capital. In addition, the Debt Service Coverage ratio was 0.01 which suggested that the revenue from the project would not be able to cover the debt. All of these metrics suggest that the project finance model will not be feasible and attractive to investors unless additional sources of revenue and substantial cost reductions are seen.

The main risk for the project finance model is that the stakeholders presented may not agree to the terms of the lease contract or may not want to work with a competitor in delivering the electric bus service. However, the model is configurable, and the choice of stakeholder can be replaced with parties that see a business opportunity in the SPV. Furthermore, assumptions of an internal carbon market and a Revolving Energy Fund are subject to the University taking action on these recommendations provided by the PCCN in their annual report, and there is a risk that neither proposals will be enacted by University authorities.

The actionable next steps for the U of M are to engage Proterra and Gillig in conversations on the proposed project finance model to see if they would be willing to collaborate in the forming the SPV. Through these conversations, the U of M should set clear expectation about dealing solely with the project company as an off taker of electric bus services, while the project company negotiates with the EPS contractors, Gillig and partners, on behalf of U of M. Furthermore, the University should push for the rights to resell excess battery capacity back to internal buildings as a way to generate revenue for the lease payments. The LTP department should collaborate with the PCCN in advocating for an internal carbon price pilot scheme at the U of M using similar strategies employed at Yale University (Yale, 2016). A detailed analysis on the carbon abatement from a hybrid bus when compared with a BEB should be performed to achieve more accurate data of carbon savings. This analysis should include the impact of improvements in battery technology on the total amount of CO_2(eq) in kg abated from a BEB. In addition, Proterra Go-Blue! ventures should be informed that the project finance model provides the possibility of having other higher educational institutions as off takers (see fig 6) e.g., Michigan State and Ford University, thus creating an electric bus transit corridor which could bring more stable cash flows.

Bibliography

ASCE. (n.d.). *ASCE Report Card for 2021*. Retrieved from https://infrastructurereportcard.org/.

Bank, D. (2014a). *European infrastructure update.* Technical report.

Bird, R. L. (2014). Infrastructure: real assets and real returns. *Eur.Financ.Manag.20(4)*, 802-824.

Blackrock. (2015). *Infrastructure rising: An asset class takes shape.* Blackrock.

CFI. (Accessed 2021). *Rating Agencies: Evaluating the creditworthiness of debt issuing companies and organizations*. Retrieved from https://corporatefinanceinstitute.com/resources/knowledge/finance/rating-agency/

Cowan, R. a. (1996). Escaping Lock-In: The Case for the Electric Vehicle. *Technological forecasting and Social Change 53(1)*, 61-79.

Déau, T. 2.-t. (2011). How to foster investments in long-term assets such as infrastructure. *OECD J. Finance. Marketing Trends*, 1.

Della Croce, R. a. (2013). Institutional investors and infrastructure financing. *Wor. Pap. Financ. Insur. Priv. Pensions 36.*

Della Croce, R. S. (2011). Promoting longer-term investment by institutional investors: Selected issues and policies. *OECD J.Finance.Mark.Trends* .

Della Croce, R. S. (2011a). Pension funds investment in infrastructure: a survey. *OECD, International Futures Programme Project on Strategic Transport Infrastructure to 2030.*

Dijk, M. a. (2013). The emergence of an electric mobility trajectory. *Energy Policy 52,* 135-145.

Feng, W. a. (2013). An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market. *Transportation Research Part C: Emerging Technologies 26*, 135-145.

Finkenzeller, K. D. (2010). Infrastructure: a new dimension of real estate? An asset allocation analysis. *J. Prop. Invest. Financ. 28(4)*, 263-274.

FTA. (2021). *FTA Low or No Emission Vehicle Program*. Retrieved from https://www.transit.dot.gov/funding/grants/lowno

FTA. (Accessed 2021). Retrieved from FTA Low or No Emission Vehicle Program Grant Amounts: https://www.transit.dot.gov/funding/grants/lowno

Gellerman, E. (2021). *Commercial Lending rates in the United States as of 2021*. Retrieved from https://www.valuepenguin.com/average-commercial-real-estate-loan-rates.

Gillig . (Accessed 2021). *Home page*. Retrieved from https://www.gillig.com/company

Gorton, G. a. (2006). Chapter 12: Special Purpose Vehicles and Securitization. In *Risk of Financial Institutions* (pp. 549-602). National Bureau of Economic Research Conference Report.

Government, U. F. (n.d.). *Technical document from the US Federal Government interagency working group on the Social Cost of Carbon.* US Federal Government interagency working group on the Social Cost of Carbon.

Hawkins, T. S.-B. (2012). Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles. *Journal of Industrial Ecology 17*, 53-64.

Heun, M. a. (2012). Energy return on Energy Invested(EROI), oil prices and energy transitions. *Energy Policy 40*, 147-158.

Hinman, N. a. (1997). Net present value analysis to select public R&D programs and valuate expected private sector participation. *Applied Biochemistry and Biotechnology 63-65*, 599-607.

IEA. (2019). *Global EV outlook 2019: Scaling up the transition to electric mobility.*

Inderst, G. (2009). Pension fund investment in infrastructure. *OECD Working Papers on Insurance and Private Pensions, No 32*.

Inderst, G. (2010). Infrastructure as an asset class. *EIB Pap. 15(1)*.

Inderst, G. (2013). Private infrastructure finance and investment in Europe. *EIB Working Paper*.

John, J. S. (2021, January 12). *Proterra Set To Take Heavy-Duty Electric Vehicle Business Public via SPAC Transaction Proterra makes EV transit buses, plus drivetrains, batteries and charging systems for growing heavy-duty electric transport market.* Retrieved from https://www.greentechmedia.com/articles/read/proterra-to-take-electric-vehicle-drivetrain-business-public-via-spac-transaction

Johnson, C. N. (2020). *Financial Analysis of Battery Electric Transit Buses.* Golden, CO: National Renewable Energy Laboratory.

Kaplan, S. M. (2021, February 24). *A lesson in electric school buses Montgomery County school board seals deal to get 300 of the buses*. Retrieved from https://www.washingtonpost.com/climate-solutions/2021/02/24/climate-solutions-electric-schoolbuses/

Kley, F. L. (2011). New business models for electric cars- A holistic approach. *Energy Policy 39*, 3392-3403.

Li, X. L. (2018). New entrants versus establishers in China and US electric vehicle marketplace: a comparative analysis. *Asia Pacific Business Review 25*.

LTP. (2021). Retrieved from https://ltp.umich.edu/campus-transit/routes-and-schedules/.

Ludlow, E. (2020, September). "Nikola Falls as Short Seller Accuses EV Maker of "Deception". *Bloomberg Hyperdrive*, pp.

https://www.bloomberg.com/news/articles/2020-09-10/nikola-declines-as-short-seller-accuses-ev-maker-of-deception.

Lui, D. (2019). *The U.S. Electric Bus Transition: An Analysis of Funding and Financing Mechanisms.* Masters Project Document from the Nicholas School of the Environment of Duke University.

Macquarie. (2014). *Inflation-linked infrastructure debt: Unlocking the barriers to pension scheme investment.* Technical report .

Mikael Höök., a. X. (2013). Depletion of fossil fuels and anthropogenic climate change- A review. *Energy Policy 52*, 797-809.

Miles, J. a. (2014). Developing a viable electric bus service: The Milton Keynes demonstration project. *Research in Transport Economics 48,* 357-363.

Moss, A. (2014). Infrastructure investment: Combining listed with unlisted. *Consilia Capital Technical report*.

Newell, G. a. (2008). The role of U.S. infrastructure in investment portfolios. *J.Real Estate Portf. Manag.14(1),* 21-32.

Newman, D. (2017, September 21). *Using University of Michigan buildings as batteries:How a building's thermal energy can help the power grid accommodate more renewable energy sources*. Retrieved from https://ece.engin.umich.edu/stories/using-university-of-michigan-buildings-as-batteries

Noori, M. a. (2016). Development of an agent-based model for regional market penetration projections for electric vehicles in the United States. *Energy 96*, 215-230.

Oltra, V. a. (2009). Variety of technological trajectories in low emission vehicles (LEVs): A patent data analysis. *Journal of Cleaner Production 17(2),* 201-203.

Oyedele, J. A. (2014). Performance of global listed infrastructure investment in a mixed asset portfolio. *J.Prop.Res. 31(1),* 1-25.

Panayiotou, A. a. (2014). Attracting private sector participation in infrastructure investment: the UK case. *Public Money Management 34(6),* 425-431.

PCCN. (2021). *PCCN final report for Carbon Neutrality at the University of Michigan*. Retrieved from http://sustainability.umich.edu/media/files/U-M-Carbon-Neutrality-Final-Report-2021.pdf

Peng, H. a. (2007). The significance of infrastructure in investment portfolios. *Conference Paper, Pacific Rim Real Estate Society Conference.*

Peristiani, N. C. (2012). *Federal Reserve Bank of New York Economic Policy Review*.

Poors, S. &. (2014). *Global Infrastructure: How to fill a $500 billion hole.* Standard's & Poors.

Proterra. (Accessed 2021). *Proterra ZX5 40 Foot Bus Platform Specification*. Retrieved from https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-40-Foot-Bus-U.S..pdf pwc. (2020). *Complete 2020 Annual report for the FY 2020 at the University of Michigan*. Retrieved from https://2020.annualreport.umich.edu/uploads/fy20-complete-financial-statements.pdf

Pyper, J. (2018, July 12). *BYD and Generate Capital Take the 'Messiness' Out of Deploying Electric Buses The $200 million leasing program will help lower upfront costs and could open up opportunities for second-life batteries.* Retrieved from https://www.greentechmedia.com/articles/read/byd-and-generate-capital-launch-a-200m-electric-bus-leasing-program

Reuters. (2017). U.S. transit agencies cautious on electric buses despite bold forecasts. *Reuters*, pp. https://www.reuters.com/article/us-transportation-buses-electric-analysi/u-s-transit-agencies-cautious-on-electric-buses-despite-bold-forecasts-idUSKBN1E60GS.

Rupeka, M. (2018). *What Drives Innovation and How Its Relevance is Established. A Perspective on Electric Vehicle Promotion in La Rochelle and Gothenburg: 1989-2000.*

Russ, D. T. (2010). Can infrastructure investing enhance portfolio efficiency? *Credit Suisse Asset Management*.

Smith, S. S. (2019). *Powering the future of mobility: How the electric power sector can prepare for its critical role in the new transportation ecosystem.* Deloitte Center for Energy Solutions.

Stromsta, K.-E. (2019, April 16). *Proterra Rolls Out $200 Million Electric Bus Battery Leasing Program With Mitsui Electric buses require more upfront investment than their diesel counterparts. Or at least they used to.* Retrieved from https://www.greentechmedia.com/articles/read/proterra-rolls-out-bus-battery-leasing-program-with-mitsui

Suberu, M. Y. (2014). Energy Storage Systems for Renewable Energy Power Sector Integration and Mitigation of Intermittency. *Renewable and Sustainable Energy Review 35*, 499-514.

Sun, J. H. (2021). Mobility Electrification at the University of Michigan: A Report Developed for and Supported by the U-M President's Commission on Carbon Neutrality. https://doi.org/1.

Sustainable Endowments Institute. (Accessed 2021). *The Billion Dollar Green Challenge Save Energy. Grow Money.* Retrieved from http://greenbillion.org/wp-content/uploads/2011/10/TheChallenge-OnePageSummary.pdf

Thierie, W. a. (2016). The characteristics of infrastructure as an investment class. *Financial Market Portfolio Management* , 277 -297.

Torrance, M. I. (2007a). The power of Governance in Financial Relationships: Governing Tensions in Exotic Infrastructure Territory. *Growth and Change, 38*, 671-695.

Wang, M. a. (2020). Deployment of plug-in electric vehicles in China and the USA: issues and opportunities, forward. *Mitigation and Adaptation Strategies for Global Change 25*, 285-288.

Weber, B. S.-B. (2016). Chapter 5: Risks. In *Infrastructure as an Asset Class 2nd edition* (pp. 259-291).

Weber, B. S.-B. (2016). Chapter 6: Project Finance. In *Infrastructure as an Asset Class 2nd edition* (pp. 295-324).

WEF. (2019). *WEF 2019 Global Competitiveness report.* http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf.

Weisdorf, M. C.-2. (2007). Infrastructure: a growing real return asset class. *CFA Inst. Conf. Proc. Q. 24(3),* 17 -27.

White, J. C. (2012). Chapter 14: Economic Analysis in the Public and Regulated Sectors. In J. C. White, *Principles of Engineering Economic Analysis 6th Edition* (pp. 683-703).

Witter, J. (Accessed 2020). Retrieved from https://utilities.fo.umich.edu/services/energy-utilities/business-services/utility-rates/

Yale. (2016). *White paper of the result of the pilot project for Yale's Carbon Tax.*

Appendix

Financial Model for Proterra Go-Blue! ventures

Discounted Cash Flow for the University of Michigan Lease Payments

Abbreviations

BEVs= Battery Electric Vehicles
EVs= Electric Vehicles
BEB=Battery Electric Buses
ASCE= American Society of Civil Engineers
WEF= World Economic Forum
ICE= Internal Combustion Engine
HEV= Hybrid Electric Vehicles
PHEV= Plug-In Hybrid Electric Vehicles
IEA= International Energy Agency
PCCN= Presidents Commission for Carbon Neutrality
GHG= Greenhouse gases
SCC= Social Cost of Carbon
CBA- Cost Benefit Analysis
WACC= Weighted Average Cost of Capital
SPV= Special Purpose Vehicle
VICE-BEB= Vehicle and Infrastructure Cash-Flow Evaluation Model for Battery Electric Buses
NREL= National Renewable Energy Laboratory
FDA= Federal Transit Authority
LTP= Logistics, Transportation and Procurement
O&M= Operations and Maintenance
U of M= University of Michigan, Ann Arbor