

## Portland Hybrid Electric Bus Project



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## Introduction

With the ever-rising need for a mass transit system, a clean, non-harmful, economical decision must be made as to what is to be done in the future. Humans inhabit cities across the planet. They also drive cars. The result of the human settlement in cities is traffic congestion, road damage, and pollution. One of the main purposes of mass transit is to cut down on the amount of cars driving during peak hours. Another purpose that comes with the decreased number of cars is pollution control. Carbon monoxide emissions from vehicles have become an issue in today's society. Buses and cars are major producer of carbon monoxide, so transportation must be adjusted. Carbon monoxide is one of the greenhouse gases, which may contribute to global warming. It is poisonous to warm-blooded animals (including humans), bonding to the hemoglobin found in blood, resulting in asphyxiation<sup>1</sup>. The main problem with carbon monoxide is pollution, though. The transit system must be looked at for one of the many possible solutions. One billion dollars has been allocated for this project. This is the approximate amount of money needed for the Westside light-rail project completed a few years ago. Shorter rail lines such as the airport and interstate light-rail projects obviously would cost less. There are, however, shortcomings to the light-rail system. This leads to the question of whether a better alternative exists. Where would this alternative come from if it is not used in Portland, a "clean" city? Scaling down the system for use on the road—or electric buses. While it is difficult to find purely electric cars currently, finding purely electric buses poses the same problem. It is not feasible to run power lines all around the Portland metro area to facilitate the needs of buses. Hybrid-electric buses are the best option. They run on power that is generated internally, they are cleaner than diesel buses, and they cost less than light rail. The affects on the environment

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<sup>1</sup> Microsoft Encarta Encyclopedia, 1999 edition.

also play a big part in this decision. Not only does pollution affect the environment, but also installation of a system that does not use current facilities requires destruction of some environment. Each option affects the environment in a different way. What follows is a study of the use of hybrid-electric buses for mass transit in Portland.

## **Purpose and Need**

To better understand the issues at hand today with transit in the Portland-Metro area, one needs to first look at its past. During the 1960s and 70s Portland began to go through significant changes. In this time the population nearly doubled from 656,000 to 1,030,000 and led to widespread suburban development with low densities and increasing the use and dependence of the automobile for single occupancy transportation to work. Increasing car use also caused escalating levels of traffic congestion, noise, and air pollution<sup>2</sup>.

As a solution to the problems associated with its growing population, the regional government implemented several new steps to check uncontrolled growth into Metro's farming and wilderness areas and curb the growing dependence on the automobile. In 1976 an urban growth boundary was enacted that prohibited or drastically limited development outside the boundary, while inside allowing for growth over the next twenty years.

In 1976 and 79 two separate interstate highway construction projects were scrapped and funds

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<sup>2</sup> <http://www.wri.org/wri/enved/suscom-portland.html>

of approximately \$500 million dollars were reallocated to other transportation projects<sup>3</sup>. Limits were put on an acceptable number of parking spaces in downtown Portland<sup>4</sup>. Both these steps were to discourage the use of single-occupancy vehicles as the main method of transportation to and from work and promote Tri-Met, the region's transit system. In September 1986, MAX light rail was added to the transit system as a faster, more efficient, and less polluting option for downtown commuters<sup>5</sup>.

For all these steps the Portland region has often been hailed as “a model of urban planning”<sup>6</sup>, which appears to be the only urban area “most consciously trying to shape itself as a new kind of American city”<sup>7</sup>, rather than becoming another sprawled out concrete city like Los Angeles. While the steps of the Portland metropolitan region sound good and perhaps are good when compared with cities such as Phoenix, Arizona<sup>8</sup>, they are far from being perfect and actually obscure several of the real facts about the region.

While the urban growth boundary has been successfully kept, with less than forty square miles added over the ten-year period from 1980 to 90, the population has actually been decentralizing from its Portland center. During the same time period the population grew over 14% but the core

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<sup>3</sup> Metro South/North DEIS- Chapter 1 February 1998

<sup>4</sup> <http://www.wri.org/wri/enved/suscom-portland.html>

<sup>5</sup> <http://www.tri-met.org/envfacts.htm>

<sup>6</sup> <http://demographia.com/dm-seapor.htm>

<sup>7</sup> <http://hannahsmac.magnet.fsu.edu/curg/PortlandHardlineManaging.html#Portland>

<sup>8</sup> <http://hannahsmac.magnet.fsu.edu/curg/UrbanSprawlinWesternUS.html>

city population actually decreased by almost two percent<sup>9</sup>. Within only six years, from 1989 to 95, the daily vehicle miles per capita increased by almost 15%<sup>10</sup>.

What this data shows is a population that is becoming increasingly decentralized from its center, Portland, and relying more on the automobile as single occupancy vehicles to travel further distances. As the population increases, so has employment, increasing by nearly 100 percent since the mid 1970s<sup>11</sup>. However the employment, that used to be centralized in the core of Portland, has shifted to outer areas of the metropolitan region<sup>12</sup>. As Tony Rufolo, a professor of Urban Studies and Planning at Portland State University, pointed to in a class presentation, this means the problem facing Portland's transit system today is catering to a growing, dispersed population that needs to travel to dispersed, decentralized businesses.

At costs of light rail construction being upwards of \$52 million a mile<sup>13</sup>, MAX light rail was supposed to contribute to a far better transit system with lines running along major traffic corridors into Portland, but it is rendered obsolete with the reasons mentioned above.

MAX light rail combined with Tri-Met buses does take a fairly significant number of automobiles, including single occupancy vehicles, off the road. While Tri-Met shows high

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<sup>9</sup> <http://demographia.com/dm-seapor.htm>

<sup>10</sup> <http://demographia.com/dm-seapor.htm>

<sup>11</sup> <http://www.tri-met.org/envfacts.htm>

<sup>12</sup> <http://hannahsmac.magnet.fsu.edu/curg/PortlandHardlineManaging.html#Portland>

<sup>13</sup> <http://www.tri-met.org/envfacts.htm>

numbers, Professor Rufolo pointed out the inaccuracy in reports due to the inclusion of bus/MAX transfers and juvenile riders in counting. Tri-Met's own reports show increases up to sixty percent in traffic at areas. This approximately matches the percentage of increase in population during the same period<sup>14</sup>, showing that ridership increase is not significant when compared to population growth.

One of the main reasons for commuting through the transit system is convenience, and as seen in class, the majority of people do not ride buses or MAX because it does not save time and is not conveniently located. As Professor Rufolo said, "People are willing to spend money for convenience and time," and use their cars.

Taking automobiles off the road for environmental reasons is one of the main reasons there is a transit system and one Tri-Met frequently promotes for ridership. Environmental benefit of transit is being threatened by use of Park and Rides, which combines the use of automobiles and transit. While it allows some to reach bus lines and reduce traffic, it also ends much of the environmental benefit of transit.

Nearly ninety percent of the emissions of an automobile are produced from the initial "cold" engine start<sup>15</sup>, so with any use, even Park and Ride conjunction with transit, a vast majority of the damage is done. The damage involved in vehicle emissions and use in general is quite wide and affects nearly every part of the environment.

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<sup>14</sup> Metro South/North DEIS- Chapter 1 February 1998

<sup>15</sup> <http://atlenv.ns.ec.gc.ca/epb/factsheets/drive.html>



In just one year the average automobile can produce up to:

- Two to three times its own weight in carbon dioxide<sup>16</sup>
- Nine pounds of hydrocarbons and a pound of particulates
- Five pounds volatile organic compounds and nitrous oxides
- Sixty-three pounds of carbon monoxide<sup>17</sup>

Carbon dioxide is a “greenhouse” gas that is believed to be a major contributor to global warming. Volatile organic compounds and nitrous oxides cause ground level ozone, or smog, which is not only causes an ugly brown haze over the region, but also is harmful to vegetation and humans<sup>18</sup>. Nitrous oxides are also a main factor in the production of acid rain, causing erosion, damaging lungs, and killing aquatic plants and animals<sup>19</sup>. Carbon monoxide is a poisonous gas that also contributes to smog and global warming.

Some of the other environmental hazards associated with automobiles include:

- Air conditioners-which contain CFCs that are harmful to the ozone.
- Gasoline-which includes several toxic substances, including a known cancer causing agent.
- Oil-one liter of engine oil can contaminate two million liters of water.
- Antifreeze-poisonous to humans and nearly all fish and wildlife.

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<sup>16</sup> <http://atlenv.ns.ec.gc.ca/epb/factsheets/drive.html>

<sup>17</sup> Metro South/North DEIS- Chapter 1 February 1998

<sup>18</sup> <http://atlenv.ns.ec.gc.ca/aeb/ssd/smog/smogfaq.html>

<sup>19</sup> <http://atlenv.ns.ec.gc.ca/epb/factsheets/drive.html>

The figures above are an average of all the various types and sizes of automobiles. Tri-Met claims that their diesel buses emit a third of the carbon monoxide per passenger mile than the average car<sup>20</sup>, what is left out of this statement is that this is true only when a bus is at a full carrying capacity of approximately ninety people. From my own experience, buses are full only in certain areas at certain times of the day. For example, the bus I take in the morning has on average six riders, only a small fraction of its capacity, so it is actually emitting more per passenger mile than even a single occupancy vehicle.

These are many of the problems plaguing today's transit system. So now, it is asked what can be done to improve the system and reduce the carbon monoxide emissions. Looking at the material that has been discussed in this section, inferences can be made on what steps need to be taken to produce a transit system that will solve this task.

A better transit system must first be able to reach all potential riders, managing new population growth, and be convenient and time saving to make them use transit rather than their automobiles. This would void the need for Park and Rides and reduce much of the emissions. A better transit system would significantly reduce traffic and negate any need for expansion of roadways. Finally, a better transit system would significantly reduce all the pollution and emissions associated with all automobiles and transit.

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<sup>20</sup> <http://www.tri-met.org/envfacts.htm>

## **Options at Hand**

### **Light Rail**

Light Rail, also known as MAX (Metro Area Express), certainly seems like an excellent way of solving many problems surrounding transportation and environmental concerns. In theory, this type of transportation can begin decreasing the amount of air pollution being currently put out by the gasoline-powered vehicles on the road. The pollution of air pertains to the concept of global warming, which is defined as an alteration of the chemical composition of the atmosphere through the buildup of greenhouse gases. The air pollution mainly consists of several deadly gases that are a result of burning fossil fuels. These gases include carbon dioxide, methane, and nitrous oxide. What makes these gases harmful to the environment is their ability to trap significant amounts of heat inside the atmosphere. Some effects of global warming include rising sea levels, shifting ranges of infectious diseases, and drastic habitat shifts for plants and animals.

Over the past few years the population of Portland and of its surrounding areas has increased dramatically, which also led to greater number of cars on the roads, and this is the leading cause of why the number of traffic jams has increased. This increase of the number of cars has also led to the increase in accidents on Portland's roads. Light Rail can help solving many of these traffic problems that plague the roads, highways, and freeways in Portland and the surrounding Metro areas.

These are the major problems that Portland is facing right now, and Light Rail sounds like a good

answer to them. However, light rail is not the only answer to these problems, and also may not be the most efficient or the least expensive. Other options of transportation include: electric vehicles/buses, hybrid electric vehicles/buses, trolley buses, and the current system, which includes the diesel buses.

### **Electric Vehicles/Buses**

An electric bus is a vehicle that uses a rechargeable battery for fuel instead of gasoline, diesel or other types of combustible fuels. This type of vehicle uses an electric motor instead of an internal combustion engine. In some applications, more than one motor is used to propel the vehicle. An electric bus is also very similar to a bus powered by a combustion engine in areas such as the chassis and the body design.

The energy used to power an electric bus is usually supplied from the rechargeable batteries to the motor controller, which is a device that controls the amount of power supplied to the electric drive motor(s) based on the position of the accelerator pedal. The electrical power supplied to the electric drive motor(s) is used to generate an electromotive force, which turns the shaft of the electric motor(s). This shaft is coupled to the wheels of the electric vehicle and causes movement either forward or reverse, depending on the direction the shaft is turning.

The refueling of an electric vehicle usually consists of plugging in the vehicle's charge plug into an outlet that is specifically designed for charging an electric vehicle. Recharging times vary, depending on the battery type, capacity and the voltage/current output of the charger. Most electric vehicles can be recharged in about 6 hours.

An electric vehicle or an electric bus has several advantages over vehicles that use internal combustion engines. An electric vehicle is very clean. There are no type of gaseous emissions and other problem pollutants such as oil, transmission fluid and radiator fluid.

The electric vehicles are also very efficient in terms of energy used. For every 100 units of fuel that are expended in an ICE (Internal Combustion Engine) vehicle, only 16 actually result in propulsion, making an ICE vehicle less than 20% efficient. An electric vehicle on the other hand converts virtually all of its fuel energy into usable power; it will use almost 85 units out 100 for driving the vehicle.

An electric vehicle is also quiet. Since the engine is electric the vehicle operates at a virtually silent rate. This will also reduce much noise pollution in a growing city like Portland.

### **Hybrid-Electric Vehicles (HEV)/Buses**

An electric hybrid vehicle uses two different energy sources. This is a system designed to utilize either clean diesel engines, alternative fuels engines, gas turbines or fuel cells in conjunction with batteries.

The conventional combustion engines are very inefficient, using only 16% of the liquid fuel to propel the vehicle. The heat emitted in the combustion process wastes the majority of the energy while frictional losses from the hundreds of moving parts in the engine, transmission and the mechanical connection to the drive wheels consumes the rest. The electric hybrid vehicles on the other hand are designed with energy efficiency in mind.

The main sources of energy used in the most common HEV today are batteries. A battery contains no moving parts. The only energy wasted is a very small amount of heat during the

course of a discharge cycle. As previously mentioned, hybrid electric vehicles utilize two different energy sources. Batteries are usually the main energy supplier for the vehicle and an auxiliary engine that burns gasoline, diesel fuel, or alternative fuels such as methanol, ethanol, or compressed natural gas provides the auxiliary power. In some cases, the reverse is true with the batteries providing back up power during times of high-energy demand.

A hybrid electric vehicle is also able to utilize energy produced by its back up engine, when the vehicle is not moving. Storing the energy produced during inactivity in the battery pack does this. Additionally HEV can recover 10% or more of the energy consumed in propelling the vehicle during deceleration by reversing the direction of current flow from the drive motors. The motors become generators and energy is placed back into the battery by a process known as regenerative braking.

A hybrid electric vehicle also has its advantages over an ICE vehicle. HEV is able to operate nearly twice as efficiently as traditional internal combustion vehicles. A hybrid vehicle can also travel twice the distance of a conventional vehicle on the same amount of energy. Overall it provides the equivalent power, range, cost and safety of a conventional vehicle, while reducing fuel costs and harmful emissions.

**Trolley Buses**

Trolley buses are propelled by electric motors that receive their power from an overhead wire system. These are full-size buses that run on rubber tires and steered the same way other buses are.

The system begins with electrical rectifier substations, which convert normal alternating current (a-c) electricity from the grid to direct current (d-c) at 6000 to 700 volts. The power is connected to twin wires suspended about 18 feet above the street, with a positive and a negative wire spaced 24 inches apart. Two current collectors, or trolley poles, are mounted side-by-side on the roof of the vehicle, and each pole can swivel both vertically and horizontally. Springs push the pole upward to keep the collector shoe in contact with its wire. The shoes also swivel, so the bus can deviate about 12 feet from the wires to load passengers at the curb or get around stopped vehicles.

The trolley buses basically have the same advantages over the ICE vehicles as the electric buses do with only one exception, the trolley buses can run nonstop because the energy is continuously being fed to them. And the only disadvantage of having trolley buses is that it is very expensive to install the system of wires and to maintain them.

**Diesel Buses**

The diesel buses are vehicles propelled by internal combustion engines, which use liquid fuel. The burning of this fuel produces harmful gases, which contribute to global warming.

The internal combustion engine is also very inefficient, using only 16% of fuel to propel the vehicle. Also seem very inefficient when compared to the electric engines that use more than 80% of energy to propel the vehicle. The diesel buses are also loud, contributing to the noise pollution as well as to the air pollution.

Since these buses are powered by diesel, most of the costs in operating them go towards purchasing this fuel. Also due to the fact that an internal combustion engine has many parts, the buses are often in need of almost daily maintenance, which also add to the costs of operation.

Overall, the diesel bus is the least efficient alternative to light rail. It does not provide any advantages over the electric buses. The disadvantages actually outweigh the advantages in this case.

With several different alternatives to Light Rail, only one seems to fit all the categories and needs, and that is the electric bus. Overall this type of transportation is very clean, has good range, the comforts, and the safety of any conventional bus, but also is the least expensive, especially when compared to the costs of installing the light rail system or the system of wires for the trolley buses.

## **Financial Analysis**

July of last year, five hybrid buses were bought and authorized to run in Portland Oregon. They are to be delivered by December 2000<sup>21</sup>. Only a small number of hybrid buses are being tested

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<sup>21</sup> <http://www.oregonlive.com/news/99/07/st072909.html>

around the country. Today, there are about 200 electric and hybrid buses operating all over the U.S. The largest buses systems have impacted the city's economy in which they run positively. Chattanooga, Tennessee was one of the first cities to invest in hybrid buses and electric vehicles. Chattanooga has a reputation as a leader in its strong development in mass transit due to its use of electric and hybrid buses. Chattanooga is well known throughout the world for leading the way to the use of electric powered vehicles<sup>22</sup>.

Hybrid buses at this time almost twice the price of a diesel-powered bus by some manufacturers. The hybrid buses tend to average around \$550,000, although one manufacturer offered a bus for a significantly lower price of \$400,000<sup>23</sup>. A diesel bus has an average price of \$280,000, significantly lower than that of a hybrid bus. However, the cost of maintaining hybrid buses is much lower than the cost of maintaining diesel buses. Another important fact to keep in mind is that, just as other new innovations arrive on the market, hybrid buses are expensive because they are a new technology. As more cities start adapting hybrid buses to their transit system, the price of the buses will fall.

Currently the cost of maintaining a hybrid bus is not lower than maintaining a diesel bus. Again, as prices fall for hybrid buses, the life-cycle cost will decrease as well. We should also take into consideration that the life cycle costs are compared to diesel or gasoline buses. A hybrid bus life cycle is significantly lower in costs when compared to fuel buses (including infrastructure costs). Maintenance costs will normally be much lower in that the buses are properly maintained

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<sup>22</sup> <http://www.etvi.org/General/Benefits%20of%20Electric%20Buses.html>

<sup>23</sup> <http://www.oregister.com/community/features/1998/growth/transportation/hybrid030w.shtml>

(this includes replacement batteries). Cost reduction mainly incorporates the reduction in the amount of lubricants, antifreeze, transmission fluid, oil, etc. Also, of the three major propulsion components: motor, controller, and batteries, only the batteries need to be maintained. Hybrid buses also save money on fuel.

Because they use electricity to power them most of the time, depending on local electricity rates, "fuel" can be up to sixty-six percent less than diesel or gasoline buses. This factor can really help our economy by reducing the demand for to import as much oil. Brakes also require less maintenance. Regenerative breaking uses the kinetic energy of the bus to generate energy and helps to slow the bus down while minimizing use of the brakes. Hence, break replacement becomes more scarce an event. Mr. Jim McDowell, Director of Advanced Engineering at Nova BUS, had some very optimistic words to say: "Long term technical objectives for this project included reducing operating costs and emissions while improving performance, reliability and maintainability. This is a welcome success!" (Referring to the sale of five hybrid buses to the New York Transit Authority<sup>24</sup>). Nova BUS is confident that this technology will be widespread in the future.

Another area that hybrid buses are bound to have a financial impact is environmentally. If air pollution significantly decreases, the government will have to spend less money trying to fix air pollution. Cars and trucks make up two-thirds of the transportation emission problem. In the United States, our vehicles alone contribute more carbon dioxide to the air than most other small

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<sup>24</sup> <http://www.novabuses.com/Bulletin/english/Edition.asp?EdID=46>

countries emit from all their sources combined<sup>25</sup>. So getting people out of their vehicles and onto a bus and providing efficient vehicles powered by renewable fuel share are both high priorities. With around 200 million cars on the road, electric and hybrid buses probably will not have a tremendous impact on the reduction of air pollution right away. However, people perceptually see that it does, placing a higher value on public transit systems, causing an increase in riders and a decrease in cars on the road. Diesel buses, even when superbly maintained, leave behind a recognizable trail of diesel exhaust. In many cases with public transit systems, issues with vehicle exhaust reach board level and, sometimes, even city hall! Electric vehicles are emission free, reducing pollution by over ninety-eight percent, while hybrid buses cut down on pollution significantly too. The Orion hybrid-electric buses operating in New York on diesel fuel are cleaner than those buses that operate on compressed natural gas<sup>26</sup>.

To many Americans electric vehicles represent the future. Range, infrastructure, and economic base of the United States growth in personal electric vehicles will most likely be slower than many of us would like to see. As sales of electric vehicles are limited to the Far West or the Southwest, the closest most of us will come to an electric vehicle will be riding an electric or hybrid-electric bus. The short-term growth of electric vehicles lies in fleet operations such as transit systems. Because of the buses "futuristic appeal", and are clean and quiet, they attract riders who would not normally ride the public transit. Transit systems throughout the country have discovered that the operation of electric and/or hybrid-electric buses does increase ridership. A good example of this can be seen in Miami's case. For many years Miami has been a hub of

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<sup>25</sup> <http://www.ucsusa.org/transportation/cleantransit.html>

<sup>26</sup> <http://www.etvi.org/General/Benefits%20of%20Electric%20Buses.html>

traffic. Forty-foot buses operated on Miami's beach, a very congested area. Ridership of the public transit system was limited. This was probably the worst case on all of the East Coast. When electric buses were introduced in 1998, ridership demand became unmanageable. During the first twelve months, the electric buses carried over 1.5 million passengers; thus making the highest ridership on electric buses ever in U.S. history. In July 1999 Miami Beach TMA established a fare on the "electrowave". Ridership for that year was projected to be 1.2 million<sup>27</sup>. An important detail that also helped the Miami's situation is that the low floors on these buses speeds up boarding which becomes vital in heavy traffic<sup>28</sup>. Santa Barbara, California, and Chattanooga, Tennessee are two other cities with an excellent electric bus system. They were estimated to carry one million passengers each in the year of 1999, which is a dramatic increase from the pre-electric period<sup>29</sup>.

The operation of a hybrid-electric bus system can, to a certain measure, change the transit systems, and how they are viewed by outside organizations. This is due to the decrease of noise, pollution, and fuel costs. Electric and hybrid-electric buses also have the ability to create plenty of free publicity. When demonstrations of an electric bus took place in Knoxville, Tennessee, the Tennessee department of transportation and the Electric Transportation Vehicle Institute received plenty of attention. The demonstration was covered on three television stations, five different radio stations, a national broadcast, and the local newspaper four different times. The local transit system could not have paid for that kind of publicity, in which they had just

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<sup>27</sup> <http://www.etvi.org/General/Benefits%20of%20Electric%20Buses.html>

<sup>28</sup> <http://www.oregonlive.com/news/99/07/st072909.html>

<sup>29</sup> <http://www.etvi.org/General/Benefits%20of%20Electric%20Buses.html>

received for free, in four years. Hybrid-electric buses also save money in advertisement and public relations. Electric buses have and will continue to gain immediate support from elected officials, the riding public, and news agencies<sup>30</sup>.

It is evident that hybrid-electric and electric buses will dominate in the future. It is in Oregon's best interest to provide funding in which we can move ahead and grasp this new technology. With sixty million dollars we could purchase at least 12 new buses. It is certainly in Oregon's best interest to start replacing our old buses with new hybrid buses. The last two that Portland's Tri-Met purchased actually cost us no more than the regular price of two diesel fueled buses due to the manufacturer being late in delivering the buses. So the penalty of the manufacturer brought the price back down for us<sup>31</sup>. As we do this, as said before, we will continue to see prices of these buses fall, as life-cycle costs will fall as well. As time passes, we will start to see a return on the money we invested in the hybrid bus system.

## **Environmental Impact**

In the movie Highlander 2: The Quickening, which was released in the very early 90s, by the year 1999 the ozone layer has been almost completely destroyed and people are dying left and right from the intense rays of the sun. A group of scientists then covers the earth with a protective shield that leaves the earth in a state of darkness. The year 1999 has come and gone and we are a far cry from being in such a state of distress. Although we are not in too much danger of losing

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<sup>30</sup> <http://www.etvi.org/General/Benefits%20of%20Electric%20Buses.html>

<sup>31</sup> <http://www.oregonlive.com/news/99/07/st072909.html>

the services of the ozone layer, the increasing amount of pollution generated can be a threat to future generations. As transportation is one of the most essential parts of our daily life, there is no place better to begin in cutting back the level of pollution being emitted into the atmosphere. Another important thing to consider is that environmental effects are not just based on pollution. It is also important to consider any vegetation or wildlife that could be affected by the expansion of existing public transportation. Even if the amount of pollution emitted into the atmosphere could be greatly reduced, if the expansion destroyed wetlands, vegetation, or animals' home, it could not be considered environmentally efficient.

One of the most important factors of public transportation, when it is used effectively is that it potentially can keep people from driving their cars so much by providing convenient and affordable means of traveling. Even though many users of public transportation are youths who do not have a driver's license, it does keep them from having to ask parents for rides, thus reducing the number of vehicles on the road. However, getting kids to use public transportation is a lot easier than asking or expecting adults who love their cars, to give them up and ride on a sometimes very crowded and stuffy bus or max train surrounded by strangers. This is really not a whole lot different than being in traffic, however at least when an individual is in their car they can listen to tunes, they might have air conditioning, and they are guaranteed a seat. Not only that but driving is a lot more fun than just standing or sitting around waiting for your stop.

When determining which form of public transportation to expand with the \$1 billion, it is not only important to determine which one is most environmentally efficient, but also which one will be most likely used by the public. If one form of public transportation were only slightly less

environmentally efficient than another, but would be used by more people, then overall it would probably be the better choice. Environmental efficiency is not only determined by the pollution each method itself causes, but also by the number of people who opt to not drive their cars and instead use public transportation.

The first option to consider is the expansion of the already existing MAX light rail. There are two qualities of the MAX that are extremely attractive. The first is that the MAX itself does not give off any emissions whatsoever; it is purely run by electricity. The second attractive quality is that when out of the downtown area where there are many traffic lights, it is not impeded whatsoever by traffic. However, the MAX does have its negative qualities as well. The first is its mobility; more or less the MAX only goes in a straight line that runs east to west from Gresham to Hillsboro. People that do not live close to the MAX, even if it is an efficient way to travel, are more likely to find more convenient means of transportation.

In order to expand the MAX from North to South as some would like, new tracks would have to be laid, and this would then mean clearing away area, some of which would include the natural environment in order to lay the new tracks. There are several areas that would be affected by this North/South expansion, all of which will now be covered. The first segment to discuss is the Clackamas Regional Center Segment. The expansion here would cause loss of grassland north of CTC and loss of deciduous trees both north and South of CTC. This expansion would also interrupt a minor travel corridor for wildlife and north of CTC would extend culvert for fisheries. For the East Milwaukie Segment along both Railroad Avenue and Highway 224 there would be a loss of shrubs and deciduous trees, a loss of habitat for wildlife, and increased runoff for fisheries.

For the Milwaukie Regional Center Segment along the Main Street/Tillamook Branch Line there would be a loss of mixed forest and loss of mitigation planted tree, a loss of habitat for wildlife, and increased runoff for fisheries. There would be a loss of grassland and extended culvert for fisheries caused by the McLoughlin Boulevard Segment, and from the South Willamette River Crossing Segment there would be a permanent vegetation clearing, an impact on a wildlife travel corridor, and piers in water that would effect fisheries. From the North Portland Segment there would be Vegetation loss due to bridge shadow both along I-5 and Interstate Avenue and increased runoff and piers in water that would affect fisheries from the Hayden Island Segment. The only two areas of the proposed expansion that would not have an effect on the environment are the Downtown Portland Segment and the Eliot Segment<sup>32</sup>.

Although it seems there would be an extremely negative effect on the natural environment because of MAX expansion it is not quite as bad as it sounds. All the segments combined would impact less than 20 acres altogether of the natural environment<sup>33</sup>. However, even a North/South line would not greatly increase the mobility of the MAX as it would still be going in a straight line, only instead of going East to West it would be going North to South. Provided the North/South expansion did increase the number of people using the MAX, improvements in traffic congestion could be expected in certain areas and also a deduction in CO concentrations. However, none of them seem to make a big enough difference to be worth spending \$1 billion on an expansion<sup>34</sup>.

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<sup>32</sup> The entire above paragraph from Table 5.6-2 of the South/North DEIS Ch. 5, Feb. 1998

<sup>33</sup> Table 5.6-3 South/North DEIS Ch. 5, 5-55, Feb. 1998

<sup>34</sup> Tables 5.4-1,2 South/North 5-39, Feb. 1998

The second option is the increase of the number of current Tri-Met busses. An increase in the number of buses would allow busses to arrive at stops more frequently, expand upon the locations the buses travel to, and hopefully increase the number of people who ride the bus, as it would become more convenient to ride. There are four possible types of expansions of the Tri-Met bus system. The first is the purchase of traditional diesel fuel buses; the second is the purchase of busses that run on natural gas; the third is to purchase buses that run solely on electricity; and the fourth and best option, the hybrid-electric vehicles or HEVs.

Busses, regardless of what type are already a positive investment. One of the most important aspects is that because buses drive on roads there is no need to damage the natural environment because of expansion necessities. For the city of Portland, currently 26% of downtown employees take the buss to work, a daily average of 164,000 car trips are taken off the road, and the average Tri-Met bus uses 1/3 less carbon monoxide per passenger mile than the average car<sup>35</sup>. This is using traditional busses that have been modified so that they already emit 90% fewer particulates and nitric oxides than they did 10 years ago and run on what is called “clean diesel” fuel which has reduced sulfur emitted by 90%<sup>36</sup>. Based on this information alone it is clear that the environment would benefit from the expansion of the Tri-Met bus system. Add busses that ran more frequently and expanded routes and the increase in the number of users of Tri-Met buses that would lead to a further decrease in the number of cars on the road would be imminent.

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<sup>35</sup> <http://www.tri-met.org/envfacts.htm>

<sup>36</sup> <http://www.tri-met.org/envfacts.htm>

A sort of icing on the cake of this bus expansion would be if the buses used were HEVs. Tri-Met is currently already looking into the use of these vehicles but currently cannot afford their use because of the expense<sup>37</sup>. The advantages of using HEVs are numerous. With HEVs batteries are the main energy suppliers for the vehicle and an auxiliary engine that burns gas or alternative fuels provides the auxiliary power. An HEV can use as little as 50% of the energy of a conventional vehicle, which means that it could travel twice the distance using the same amount of energy. Also unlike conventional vehicles, which continue to use energy while idling, an HEV can store the energy produced into the battery pack while idling, thus saving even more energy<sup>38</sup>.

One of the best examples of an HEV Transit Bus is the Thunder Volt TB40-H. It is a forty-foot bus that is capable of meeting the 10-12 year life cycles of buses on urban routes with peak power ratings of up to 300 horsepower. These busses can go up to 400 miles between each charging of the batteries, and also has the ability to operate in all-electric modes that result in zero emissions during periods of low power usage. Because of its lighter weight and engine power it has better acceleration and hill climbing ability than conventional buses and competing electric and HEV buses. Another benefit of these busses is that they offer an extremely quiet and comfortable ride<sup>39</sup>.

By expanding the Tri-Met bus system there would be an almost certain increase in the number of riders which would lead to a reduction in the number of cars on the road and a decrease in the

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<sup>37</sup> <http://www.tri-met.org/envfacts.htm>

<sup>38</sup> <http://www.etvi.org/Just%20the%20Facts/Hybrid%20-%20JTF%20RIGHT.htm>

<sup>39</sup> [http://www.isecorp.com/40\\_foot\\_transit\\_buses.htm](http://www.isecorp.com/40_foot_transit_buses.htm)

pollution emitted into the air. The best part would be that the natural environment would not be negatively effected in any way because of the expansion and all wetlands, grasslands, trees, wildlife, fisheries would remain unaffected. One last interesting fact to leave with, is that for each commuter who leaves their car at home in order to use Tri-Met for just one year spares us and the planet from 68 pounds of pollutants<sup>40</sup>. That has potential to really add up.

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<sup>40</sup> <http://www.tri-met.org/envfacts.htm>

## **Conclusions**

While hybrid electric buses may be the way of the future, the system would not be immediately implemented. The purchase of a few buses a year would eventually result in the full implementation. There are over 700 buses in Tri-Met's fleet, that is more than the current number of hybrid electric buses running in the country. It will take a while to complete, but it will be more beneficial. The current mass transit system will have to be revamped in the future. Traffic congestion, air pollution, and road conditions will make this necessary. Standards on emissions may change, so new propulsion systems will be needed. Hybrid electric vehicles operate cleaner than their purely internal combustion counterparts. This option is cheaper than putting in a new light rail line, plus has more advantages. The environment is not harmed by construction in new areas, and the buses can go to different locations besides the one track. Hopefully, reduced carbon monoxide emissions will result from the revamped transit system. It will all depend on ridership. People will have to ride the transit system to make it work. If more the system is made more convenient, there is a higher chance of attracting new users. A cleaner, quieter system may also help in this. Eventually, Portland could be at the forefront of a cleaner, more efficient transit system. The light rail lines have helped, but using hybrid electric buses will be better. Many people do not even like the MAX who live here. They prefer buses, or in some cases driving. Revamping the system would be beneficial to the city of Portland in the long run, even if the pinnacle of the system is still a ways away.

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