Public Transportation Review

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Energy and Energy Policy

Public transportation has been a part of America ever since the first major cities began to form. It has always had the aim of being an efficient and convenient way to transport a large number of people throughout an area. In recent years, due to the onset of global warming and the need to reduce national reliance on foreign oil, public transportation has become an additional tool of domestic policy. The science of public transportation, as it relates to different fuels that are used and the efforts to use more environmentally friendly sources of energy, has changed in many ways over time. Also, there are some cities that have done a better job of using these resources, developing, and maintaining their public transportation systems over time. Through an understanding of the science of public transportation, and by examining two contrasting cities, one with dated infrastructure (Chicago) and one with newer infrastructure (Denver), we can show: what changes should be made to incorporate new ideas into existing infrastructures, what sort of ideas are beneficial to a system, how to plan for a new infrastructure and change existing systems in the necessary places like Chicago, and how to change public perceptions of mass transit in order to increase ridership.

Science of Public Transit

The science of public transportation is that of efficiency; how to get the most useful work done from a fuel source. Public transit primarily utilizes two fuels to move people: diesel and electricity. Electricity, while derived from coal, nuclear, or hydropower, will be thought of as fuel for the scope of this paper, as that is how it is considered from the perspective of public transit networks utilizing it. We begin with a side-by-side comparison of liquid fuels.

Fuel	BTU per 1 Gallon (3.79 Liters)	Density (kg/1000L)	Energy Density (BTU/Density)
Gasoline	125,000	737	45
Diesel	138,690	820-950	38-44
Ethanol	84,400	789	28

Gasohol	120,900	742	43
LNG (liquefied natural gas)	90,800	500	48

(Wisconsin DOA)(The Meter)(SIMetric)

We can see that the best fuel from an energy density standpoint is LNG. However, LNG has to be stored cryogenically, leading to more difficult engineering implementation. Compressed natural gas (CNG) is easier to store but has the disadvantage of lower energy density, due to its gaseous nature. CNG, which is a more common fuel source in public transit, is meaningless to compare to liquids, we instead must think in terms of weight. By pound, CNG produces 20,551 BTU vs. Gasoline at 44,643 BTU. With the implementation of Gasohol, customers must buy more fuel to derive the same amount of energy. Electricity is harder to compare side by side with the above fuels, but we do know 1 kilowatt-hour of electricity can produce 3,413 BTU.

With these values in mind, we must think in terms of how much energy it takes to move a person. This must be in context of a distance traveled, so we will assume a mile of travel.

Vehicle	Number in Use	Fuel Economy	Average Occupancy	Amount Fuel Used	Miles Travelled	Energy Intensity (BTU/person-miles)
Car	135,400,000	22.4 mpg	1.58	7.4983×10^{10} gallons	1.6819×10^{12}	3527
Light Truck	99,125,000	18.0 mpg	1.72	6.0662×10^{10} gallons	1.0881×10^{12}	4052
Bus	82,027	4.84 mpg	8.8	5.3385×10^{8} gallons	2.5822×10^{10}	3209
Heavy Rail	11,110	0.171mpkWh	22.3	3.7686×10^{9} kWh	6.4622×10^{8}	892
Light Rail	1,645	0.121mpkWh	24.5	5.7072×10^{8} kWh	6.9232×10^{7}	1148
Commuter Rail	6,392	N/A	31.2	7.6714×10^{7} gallons + $1.4836 \times$	3.0336×10^{7}	1653

				10^9 kWh		

Notes on Vehicles:

- Car: The major personal vehicle in the United States, average age 9.2 years
- Light Truck: Includes SUV's, mini-vans and full-sized vans, and two-axle trucks, average age 7.1 years
- Bus: Typically between 40' and 60', the next generation of buses can expect twice the average fuel economy, average age 7.5 years
- Heavy Rail: Electric trains with multiple cars such as the "L" in Chicago, restricted to tracks, average age 21.6 years
- Light Rail: Electric trolley and trams, restricted to tracks, average age 16.7 years
- Commuter Rail: Either electric or diesel, designed to go outside major metropolitan areas, for example the Metra, average age 18.2 years

The calculation for energy to move 1 person 1 mile is $\frac{Energy\ Expended\ from\ fuel(BTU)}{Vehicle\ Miles\ Traveled * Average\ Occupancy}$ which we then compare to the energy intensities the DOE lists in its Transportation Energy Data Book. Energy expended from fuel is, for cars, trucks, and buses, the gallons of fuel used multiplied by the BTU from those fuels. For the electric heavy and light rail, the number of kilowatt-hours is multiplied by 3413 BTU. Note that the DOE lists heavy and light rail together in its calculation of energy intensity.

Vehicle	DOE Energy Intensity (BTU/person-miles)	Calculated Energy Intensity (BTU/person-miles)	Percent Difference
Car	3512	3527	0.43
Light Truck (SUV, Van, etc.)	3944	4052	2.67
Bus	4235	3209	24.22
Heavy Rail	2784	892	67.96
Light Rail	2784	1148	58.87
Commuter Rail (Diesel and Electric)	2996	1653	44.82

Why do we have such stark contrasts between the calculated values and the values listed by the DOE? The DOE calculates its values by taking the total energy used and divides that by the number of total passenger miles. For buses, I calculated energy intensity solely based on Diesel fuel, as it is the primary (80%) of the fuel used in the fleet. For the electric vehicles, however, the DOE uses 10,339 BTU for every kilowatt-hour as opposed to 3,413 that I used. The DOE explains this change in value by saying: "This figure does not take into account the fact that electricity generation and distribution efficiency is approximately 33%. If generation and distribution efficiency are taken into account, 1 kWhr = 10,339 BTU" (286 DOE TED). The higher BTU here means that you need generate 10,339 BTU of electricity to get 3,413 BTU at the source. This rationale would be fine if it was applied to the various other fuels, both gasoline and diesel for instance, but the DOE does not take that into account. This causes the DOE to compare apples to oranges. Gasoline's total energy would be much different if the process of transporting the crude oil, cracking it, then distributing it to vendors was taken into account as well. It is thus more reasonable when examining public transit to consider electricity as a point fuel source, just as gasoline and diesel are. We will now examine the corresponding efficiency's.

Fuel	Point source BTU (per gallon)	Efficiency
Gasoline	125,000	86%
Diesel	138,690	90%
Ethanol	84,400	57%
Gasohol	120,900	83%
LNG (liquid natural gas)	90,800	91%
Electricity	3,413	33%

(Fuel_Prod_TOS GREET)

The processing efficiencies for liquid fuels are much better than for electricity. Not having to do an energy conversion from fuel to electricity is the big loser of energy for electricity. However, electricity generation has the upside of being non-reliant on foreign petroleum and can be generated from renewable sources. Ethanol is primarily derived from corn in the united states in

a process that is not nearly as efficient as the petro-chemicals and has negative social implications of using food for fuel.

The energy intensity of public transportation is lower than that of personal vehicles due to its inclusion of more riders per vehicle. Personal vehicles can easily bring their energy intensities down by simply filling up the vehicle with two or more people, thus beating the current average. The energy intensity tells us that it takes less energy to move a person via public transit than it does to move a person via a personal vehicle. This, in turn, means less energy is expended overall. We can also see this in terms of how different a car would have to be to compete with the energy intensities of public transit. Here we look at what changes to auto transit would be necessary to reduce its energy intensity to that of public transit. In real life, both average ridership and improvements in MPG would be used, but here we look at them held constant to each other for simplicity's sake.

Vehicle to compete with	Greater Average Ridership (holding MPG constant)	Average MPG Improvement (holding ridership constant)
Bus	+0.16	+2.2
Heavy Rail	+4.67	+66.3
Light Rail	+3.27	+46.5
Commuter Rail	+1.79	+25.5

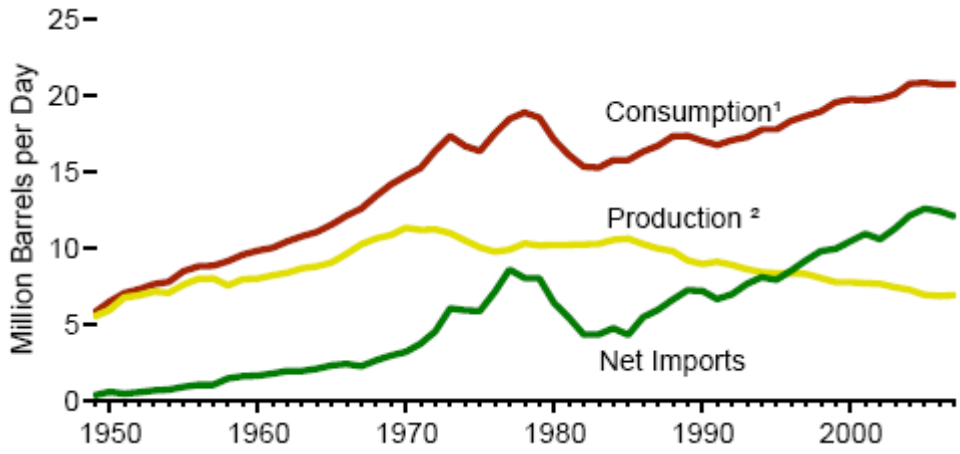
It is plain to see that gains in public transit come from moving more than one or two individuals at a time. Heavy adoption of carpooling or complete conversion to hybrid cars would be necessary to come close to the numbers for train public transit. The light truck has a harder time to come close to these numbers, as its energy intensity is higher than that of a car's.

National Security

As mentioned above, national security in terms on dependence of foreign oil has not always been the primary concern of security policy. Since the inception of the Interstate Highway System by President Eisenhower, the car has dominated the transportation of

individuals to and from their destinations. This system was designed for quicker troop deployment in time of war, and thus an integral piece of national security. It was assumed that our energy demands could be met within our immediate sphere of influence and the Cold War dominated the attention of the nation.

Petroleum Overview:



(Energy Perspectives EIA)

During the 50's this seemed like a reasonable assumption as our consumption and production of petroleum kept up with each other well. However, past this point we see consumption outgrowing production, leading to heavier use of imported fuel. It is important to note that consumption and imports have a better correlation than consumption and production, we see production leveling off and then diminishing after the mid 80's. It has become a matter of national security to have energy balance between consumption and production in the US. We can see from the chart above that domestic production of petroleum has been falling. The projection of oil production in the US is expected to only grow modestly in the next ten years, and by no means dramatically becoming larger than imports. This means that to secure our current national interest of reducing imports of oil, we must voraciously cut into the consumption curve, through both efficiency as well as shifting away from petroleum as a major fuel source. As demonstrated

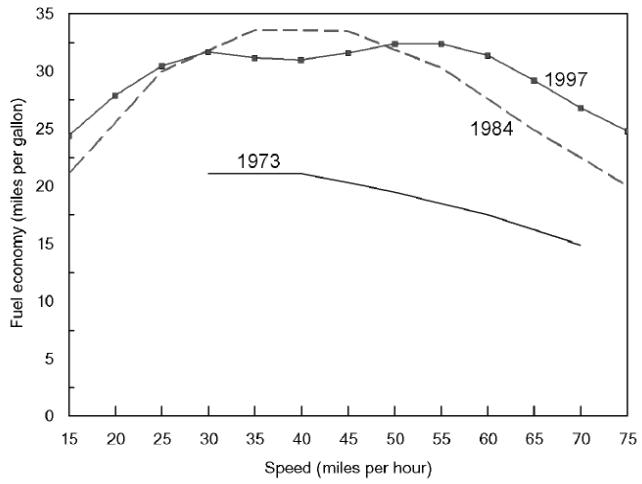
above, public transit allows for greater efficiency as well as the ability to shift away from petroleum as a fuel source.

Congestion

Congestion is a large source of economic loss in this country. It not only causes greater amounts of fuel to be used - with vehicles on the road longer and running at less efficient speeds - but it also causes a loss of productive time – a more abstract amount of loss but there nonetheless as we will discuss presently.

First we will look at operating efficiencies of internal combustion engines. Engine design improves over the years to give better efficiencies across a wider range of speeds, as shown below.

Figure 4.2. Fuel Economy by Speed, 1973, 1984, and 1997 Studies



We can see the changes over time of engine efficiencies, first by attempting to increase overall efficiency after the oil crisis of the 1970's, and then more recently to accommodate modern driving habits. The bimodal distribution of modern peaks seeks to get the best efficiencies at

highway cruising speeds as well as at city driving speeds. These fuel efficiencies are only at constant speeds, they do not account for acceleration.

Acceleration is always where the greatest loss of energy occurs when moving a vehicle. When a vehicle is moving, the major force acting on it is air resistance; the force you need to shove the air in front of you out of the way. However, when accelerating not only must you overcome the air resistance, but you also must build up the momentum of the vehicle, which requires a great deal more energy. This in turn means the engine has to work harder; you can look at your tachometer to see how many more revolutions the engine goes through during acceleration. This is why the stop and go traffic typically found in cities causes average MPG to be about ten less than driving on the highway (118 DOE TED). The fuel cost of congestion in the US was 2.9 billion gallons of fuel or $8.2 billion in 2007 (TTI 5). Congestion causes increased amount of stop and go traffic, as well as slower speeds in general, so it causes drivers to expend more energy. This increase in time on the roads not only causes greater energy expenditure, but also decreases in productivity.

Congestion leads to decreases in productivity in several ways. The most obvious are for those people interested in shipping or transportation. With greater congestion you have to have more delivery people because each individual takes longer to reach a destination and so can't accomplish as much. Transportation is similar; you must run more over-head to move people when they want to move. Congestion has a significant impact on all parts of the economy. Since the majority of American workers must travel to work, increased congestion means that they must spend more time on the road, cutting into personal time. Quantifying this is a difficult task, but the Texas Transportation Institute has stated that for the US, congestion causes 4.2 billion more hours on the road. They go on to give this extra time spent on the roads a price of $69.7

billion, or $16.60 lost for every extra hour of congestion (TTI). It's clear to see that congestion has very large effects on transportation efficiencies, and public transportation is one of the most effective ways to reduce congestion.

Public transportation works against congestion by fighting it at the source; it reduces the number of vehicles that must be on the road. The road has a fixed amount of space and there is an optimal number of vehicles to be on the road to be able to maintain efficient travel. Going beyond that number causes everyone to slow down: decreasing the fuel economy and increasing the amount of time on the road. Buses can hold many more people than a car can, reducing the number of vehicles on the roads; trains can hold even more people and eliminate use of roads altogether. It has been estimated that if public transit did not exist – and so every person took an individual vehicle - the nation would consume 340 million more gallons of gasoline and spend 541 million hours on the road, for a cost of $10.2 billion.

Environmental Impact

Transportation has multiple effects on the environment that are not solely based on the emissions of the vehicle (or the power source in the case of electric vehicles). The construction of a vehicle is a major undertaking making use of steel, plastic, and electronics, all energy intensive products. However, the energy costs of producing a vehicle are spread out over the vehicles lifespan. Instead we will explore the amount of CO_2 produced during the use of a vehicle, as transit, and not manufacturing, is the subject of this paper.

We will begin by examining the amount of CO_2 released by burning an energy-equivalent amount of fuel, in comparison to one gallon of gasoline; we do this to ensure a fair comparison.

Fuel	Equivalent Energy Amount	CO_2 Released (lb)
Gasoline	1 gallon	18.75
Diesel	0.90 gallon	21.14
Ethanol	1.48 gallons	18.63

Coal	12.91 lb	47.18
CNG	6.08 lb	16.66
LNG	1.37 gallon	15.71

We can see that natural gas, either compressed or liquefied, is the best as far as release of CO_2 is concerned. Coal is the clearly elephant in the room; it produces over twice as much CO_2 as any of the liquid fuels. For public transit that utilizes electricity, it must then look to sources that are not coal if it wishes to seriously cut into its "production" of CO_2.

The estimation of energy costs to produce a vehicle is beyond the scope of this paper; we can observe the lifetime of vehicles to see for what amount of time these energy costs are spread out.

Vehicle	Average Age (2006) (in years)
Car	9.2
Light Truck	6.8
Bus	7.5
Commuter Rail	18.2
Heavy Rail	21.6
Light Rail	16.7

(78 DOE TED) (31 APTA)

The age of a car can be a double-edged sword: while you spread out the energy used in construction over a longer period of time to get a better yearly energy intensity, you also lose the advantage of having a newer car, with its better fuel efficiency. Cars and light trucks have been steadily improving their fuel efficiencies. Cars have annually improved 1.4% since 1970, but only 0.6% since 1996 (88 DOE TED). Similarly, light trucks have improved 1.6% since 1970, but only 0.5% since 1996 (89 DOE TED).

Chicagoland Transportation

Public Transportation in Chicago has existed since 1892 in one form or another. It was originally composed of multiple independent companies building rail service to downtown from the surrounding area. It originally consisted of 4 rail companies that were merged into the

Chicago Rapid Transit Company in 1924. This company continued until after WWII when in 1947 the Chicago Transit Authority was created. The CTA began by becoming cost effective, cutting non-economical stations and routes. However, by the end of the 1960's, it could no longer keep up with the burgeoning auto industry and in 1970 the CTA could not cover its expenses with the fares it collected. This turning point in the CTA's history would foreshadow the future of public transit in Chicago.

The 1970 census brought with it the data showing that the outlying counties outside of the city limits had surpassed the city's population. To cover the costs of transit, the Regional Transit Authority was created in 1974 to not only service the outlying counties with public transit, but to also govern the taxation of all the associated counties. This had to be passed by referendum, and won by a slim margin. Residents of the collar counties of Chicago protested against additional taxes that would be implemented while the residents of Chicago were happy to get money from others to pay for their transit. Paying for transit beyond the use of fare collection continues to this day, with money coming from both a state and national level. 1990 signaled a large overhaul of public transit. The various "L" lines were renamed and the entirely new Orange Line was conceived. There was also major restoration of the Green Line, and in general the CTA was overhauled in terms of capital investments. Currently, the CTA is in the process of increasing fares by $0.25 a ride due to several factors, including no increase for inflation in the past 10 years, the implementation of seniors riding free, as well as increases in fuel and power costs. This increase will not bring parity to the fare-box revenues and the expenditures the CTA makes.

The CTA is a large organization with a budget of over $1.2 billion every year. "The CTA operates the nation's second largest public transportation system and covers the City of Chicago

and 40 surrounding suburbs. On an average weekday, 1.6 million rides are taken on the CTA. CTA has approximately 2,000 buses that operate over 154 routes and 2,273 route miles. Buses provide about 1 million passenger trips a day and serve more than 12,000 posted bus stops. CTA's 1,190 rapid transit cars operate over eight routes and 222 miles of track. CTA trains provide about 500,000 customer trips each day and serve 144 stations." (http://www.transitchicago.com/welcome/overview.html).

Now that we have seen the national statistics, it is important to think in terms that are more comprehensible and closer to home for the reader. Getting an idea of the efficiencies of bus and rail transit in a major metropolitan area is much easier than it is to get that idea from a national average. We will examine two metropolitan areas, Chicago and Denver, in order to look at public transit from two ends of the spectrum. Chicago has a long tradition of public transit and but has seen urban sprawl and the rise of suburbia. Denver is not as large a city and has made a concerted effort to contain its sprawl. We will begin by comparing the energy intensities of the bus and rail of each city to the national averages. We'll again be looking at energy intensity, BTU per person-mile.

Vehicle	National (BTU/person-mile)	Chicago (2006) (BTU/person-mile)	Denver (2007) (BTU/person-mile)
Bus	3209	1846	1950
Rail	892	923	1888

(CTA 75,77) (RTD 9)

These values are rough estimates based on average pricing throughout the year in question. Only Denver listed the amount of diesel it used, and neither city listed the number of kilowatt-hours used in providing service, they only gave prices. Also, the cities only give the number of miles their vehicles travel, but nothing about the number of people, either in the form of total people-miles or as average ridership. This made calculations of the average number of riders difficult, so

it was assumed that these numbers were similar to national numbers. It is likely that the light rail in Denver has better average ridership, and would explain this discrepancy.

The Chicago public transportation is a good example of a system that has been in place for many years, but may be in some need of an upgrade in order to cope with the higher demand for mass transit as a result of increasing fuel prices and environmental concerns. There are many cities that have different and innovative ideas in their transportation system and the city of Chicago could learn valuable lessons from some of these other metropolises in a search for ways to upgrade its transportation infrastructure. Cities in the western United States, many of which were not founded until many years after Chicago had already become a booming metropolitan area, tend to have newer, more efficient, and further advanced systems of transportation in use. They have gone though intense planning stages in order to find out what will work best for their specific region, and in an effort to find the newest, best technologies to give themselves the most modern, cost effective, and environmentally friendly mass transit infrastructure possible. Specifically, the city of Denver, Colorado has made a determined effort to build a transportation system with new technologies and ideas in order to best suit the needs of the inhabitants of the area, is constantly improving upon itself to make the system better, and can be used as a possible example of one of the directions the city of Chicago could go in order to modernize its mass transit system for the future.

The Denver Transportation System

The regulating body of the Denver transit system, their version of the CTA, is called the Regional Transportation District (RTD), which was established in 1969. The system consists of light rail train lines, commuter train lines, and a bus system. It is a smaller system than the one in Chicago, however, covering a 2,331 square mile area, with transit options covering a distance

of 166,571 miles a day. Presently this covers forty municipalities in six different counties surrounding the Denver area. It is estimated that there are about 2.6 million people with easy access to the RTD infrastructure, and about 313,000 people use it every day, or approximately 13% of the people who have the option of using the system. The whole network has an operating budget of about $450 million, which comes from fare revenue, local taxes (specifically sales tax), and federal grants (www.rtd-denver.com/). While the ridership is significantly lower in Denver than it is in Chicago, this is merely a reflection of the difference in population size between the two areas. In fact, there is a higher percentage of people that use public transportation in Denver than in Chicago, meaning that the mass transit system in Denver is in some way more attractive to individuals in the area. By looking at the ways in which transportation infrastructure actually works, one can gain a greater understanding of why the Denver system may be more appealing, and what can perhaps be done to improve the way Chicago manages its mass transit.

There are many differences between the bus system in Chicago and the one in Denver. Denver's bus system has about 1,000 buses in its fleet, much smaller than that of Chicago (RTD Facts, 2008). The Regional Transportation District, however, has taken many steps to encourage more people to ride the bus than the city of Chicago has. In Denver, for instance, there are bus lines that run directly from the suburbs into the city, and are allowed to use special lanes in order to avoid traffic congestion, where people can then either walk, take another bus, or use the light rail system in order to arrive at their final destinations. There is also a great push for convenience with 179 daily bus routes, and increases in the number of vehicles by up to 40% on some routes during peak usage times (www.rtd-denver.com/). The convenience of the bus system is not the only attractive thing about it, however, as the RTD has taken steps to make

people feel like they are doing something good for the community by using a mass transit vehicle instead of their cars.

While the buses in Chicago operate primarily on regular diesel fuel, the Regional Transportation District has made an effort to find better alternatives. The buses that are used in Denver operate on an "ultra low sulfur" diesel fuel that contains 95% less sulfur than the regular diesel fuel used by buses in Chicago (Clean Air Facts, 2007). The RTD is also in the process of upgrading all of their buses to those with advanced emissions devices, which currently make up about half the fleet. "These buses are equipped with an exhaust gas recirculation (EGR) valve to reduce oxides of nitrogen emissions, a particulate filter to capture the particulate matter emissions, an oxidation catalyst to reduce CO, HC and particulate matter emissions, and a variable geometry turbocharger to improve the overall efficiency of the combustion process (Clean Air Facts, 2007)." The RTD takes many of these actions in an effort to self-regulate and minimize its environmental effects. Emissions are such a concern for the RTD that they use standards that are two times higher than those required by law in the state of Colorado. These actions make a dramatic difference in the amount of pollution that is put into the air by buses and may appeal to those people who want to ride the bus in order to try and make a difference in the environmental movement, making the whole system even more attractive to people who have the option of using it.

Not only has the Regional Transportation District already taken many steps to minimize the environmental impacts of mass transit on the environment in their area, but they are constantly looking for ways to improve their system in order to further reduce emissions and perhaps even limit our reliance on foreign oil. The RTD has run several alternative fuel experiments in the past, running vehicles on propane, methanol, and natural gas. As a result, the

RTD found compressed natural gas to be $0.43 more expensive per mile than diesel fuel, and methanol fuel to be $0.53 more expensive per mile (http://www.rtd-denver.com/). Despite these findings, the RTD elected to begin incorporating buses that run on compressed natural gas in a hybrid configuration into its system. There are currently 36 of these buses, which use a 2.5-liter engine to charge batteries inside the bus while running on natural gas, and the bus switches over to use the electrical power when the batteries are charged. These buses can carry over 100 people and essentially use as much energy as a Toyota Prius (Clean Air Facts, 2007). More recently, the RTD concluded an experiment with the National Renewable Energy Lab than involved running buses on biofuel. Through these efforts, it is clear that the RTD is trying to limit the amount of foreign oil that we are using, focusing on experimenting with technologies that utilize domestic products, thereby making the bus system in Denver more appealing to people interested in limiting our oil intake in an effort to increase our national security, even though the bus system may be more expensive to run as a result.

Not only does the Denver area have a more advanced and attractive bus system than the Chicago Transit Authority, but they also have a light rail train infrastructure that is second to none. There are currently six different train lines that run to the downtown Denver area, which reach as far as Littleton and Lincoln, Colorado, and service the University of Colorado as well as many sporting events venues and other attractions in the downtown vicinity (http://www.rtd-denver.com/). While there are six lines, there are only three different districts that are currently served by the light rail service, namely the southeast, southwest, and downtown districts. The light rail service has 91 vehicles and 37 stations at the present time, with the time between trains being no longer than five minutes and much shorter during high volume travel times, at many of these stations (RTD Facts, 2008). These trains operate off of overhead electrical power that

comes from power lines and runs through a conductor into the engine of the vehicle itself. There is no need for a diesel engine, as is necessary for commuter trains like the ones that service the Chicago area, and all necessary power can come from any source of electricity (Central Corridor Light Rail Train Facts, 2007). This type of a train system offers many advantages over the infrastructures that are used in other areas, such as Chicago.

When compared to the Chicago train infrastructure, there are many reasons why the Denver system is more appealing. One advantage of the Denver light rail system is that the trains do not have to share their tracks with any freight train traffic. One of the major reasons for delays and unreliability among Chicago commuter trains (Metra) is the interference of freight train traffic. Without having to worry about freight traffic, the light rail trains in Denver rarely have a problem staying on schedule. Because of the fact that the trains operate on overhead power lines, there is also an advantage in that the energy source to operate them does not have to come from an oil-based fuel. The trains can take draw energy from any source of electricity, such as coal or wind power, reducing the amount of foreign oil that is necessary to operate the system. The lower reliance on foreign oil can help to increase our national security, and people may be more inclined to take trains because of this detail. Because of these facts, the train system in Denver is more popular than the one in Chicago, but the benefits of the Denver public transportation system are more than just advantages over Chicago in terms of convenience, reliability, and the appealing nature of working to increase national security and reduce pollution, by using them.

Unlike Chicago, Denver has devoted a great amount of resources to the public transportation system and is constantly working to innovate and make it better. In 2005, Denver set out to expand its public transportation system when it implemented its “12-year plan to build

a comprehensive, integrated region-wide transit network that will provide a reliable and safe system, enhance mobility and respond to the growing transportation needs within the eight-county Regional Transportation District," know as the FasTracks plan (FasTracks Facts, 2007). With this plan, the RTD is taking the ideas that are working well and expanding them to other districts. Specifically, there will be 122 miles of new rail lines, 18 miles of Bus Rapid Transit, and 57 new transit stations (FasTracks Facts, 2007). The new rail lines and Bus Rapid Transit Lanes, which are highway bus lanes that allow buses to avoid highway congestion, will offer the convenience and reliability of mass transit in their commutes to thousands of additional people. The FasTracks plan also takes convenient features that were found to be very popular and is further expanding them in new and existing districts. For example, 31 new park-n-rides, places where people can park/drop off their cars and then take public transit, will provide 21,000 new parking spaces for people who wish to use public transportation (FasTrack Facts, 2007). While the FasTracks plan is currently somewhat over budget and some of the construction projects have been temporarily stalled, the plan goes to show that Denver has put more of an effort into maintaining, upgrading, and expanding its public transportation system than Chicago has.

The City of Denver is also trying to incorporate public transportation into its development as a whole. As a part of the FasTracks plan, the city is working to encourage Transit Oriented Development (TOD) throughout the metropolitan area. This is a type of development that reduces urban sprawl by pushing for compact designs in the layouts of new areas that are focused on making sure people are never more than ten minutes away from some form of mass transit (Transit Oriented Development Facts, 2008). This will work to reduce urban sprawl in an effort to balance current needs with future growth predictions, as it is expected that the population of the Denver area will increase by nearly 50 percent in the next 25

years (Transit Oriented Development Facts, 2008). The plan also encourages building near mass transit in already established areas, as well as in currently uninhabited places, by offering tax breaks to those that do so (Transit Oriented Development Facts, 2008). TOD is a major undertaking by the city that shows just how dedicated it actually is to the mass transit system that is being developed, and is a project that could be used by the City of Chicago to encourage better development patterns that are focused on allowing people to utilize public transportation in certain areas.

On the whole, the transportation system in Denver has many advantages over the one used in Chicago and many lessons could be learned from its example. By running its light rail service on tracks that do not have freight train traffic, the system is much more reliable in that delays are a rarity. The Denver system has also taken many steps to increase convenience that could easily be added into Chicago's infrastructure. The buses have their own special lanes to drive in on the highways so they do not have to sit in traffic, something that would be an excellent option if Chicago bus service were to be extended further into the suburbs considering the amount of congestion that is present. The park-n-ride feature also serves as a good way to convince people that the transit system is a convenient alternative, as they are given a designated place to leave their cars when they use a transportation option. Park-n-rides are not currently used in Chicago on a large scale, but when people know that they have a convenient place to leave their cars they may be more convinced to leave them behind. The Denver system is also more attractive because of the concerted effort that has been made to reduce emissions and decrease the use of foreign oil. Electric trains, buses that run on compressed natural gas, and the use of engines with increased efficiency that run on low sulfur diesel fuel work to reduce the damage that is done to the environment by public transportation and reduces the amount of

imported oil that is actually used, making people feel that by taking mass transit they are in some way making a difference. Finally, Denver has been constantly experimenting with new ideas and is always working to make improvements in its transit system, oftentimes making transportation a central part of its plans. With a few simple changes and more of a dedication to its transit infrastructure, Chicago could easily work to model itself more in a way that is similar to Denver, making public transportation better and more attractive to potential customers.

Metropolitan Planning Organizations

Before Chicago can make its transportation system more like the Denver system, it is necessary to figure out what the best way of going about this is. Unlike Denver, which has a relatively new transportation system, Chicago will need to work around its present infrastructure in order to upgrade and improve it instead of starting over from scratch. The inconveniences that would occur because of the shear number of people who use the current transit system, as well as the economic toll of tearing everything up and starting with a clean slate would be impossible to deal with. Instead, Chicago needs to work with what it already has in place and decide upon the best way to add new features without causing too much disruption to the current road and rail network. Many other cities, both in the United States and around the world, have been able to change their transit systems for the better in order to make them more appealing to people. In making changes, Chicago will also need to do things to change the public perception of mass transit in order to make people want to use it on a regular basis. There is no point, after all, in making improvements to the system if they do not result in an increase in the number of people that use it. Several cities, Denver included, have approached this problem through the use of their Metropolitan Planning Organizations (MPO's), which are federally required organizations that oversee transportation planning in cities with populations greater than 50,000, and bring

different members of the community together in an effort to find what will work best for that region and how the changes can most easily be implemented.

Metropolitan Planning Organizations are especially popular and powerful in cities in the western United States that are still developing, but there is no reason to think that they cannot also be used more effectively in older cities as well. With rising prices of oil and the realization that there is an ever-increasing need for better public transportation systems, MPO's have become integral to some areas that are trying to make plans for their transit systems. The goal of MPO's is to in some way find a way to bring about collective governance of an area without fully being a governmental institution. An MPO is made up of community members, business leaders, and government officials who all live or work in the area that is under discussion (Vogel and Nezelkewicz, 2002). Ideally, these people will cooperate and develop a plan that satisfies as many of the demands that are being made as possible. More often than not, MPO's are able to find a way to compromise everyone's wants and develop some sort of plan for changing the current system for the better. The most successful MPO's have many similar characteristics with each other, namely: competent staffs, effective leadership, aggressive public involvement programs, an efficient process, a cooperative relationship with the state department of transportation, accountability, and perhaps most importantly they have a regional ethos (Goetz, Dempsey, and Larson, 2002). An MPO with those characteristics, if used in Chicago, would undoubtedly be able to come up with some ideas and plans for the Chicago mass transit system that would be improvements, but it would be necessary for the political cronyism that has been present when planning government projects to be disregarded in order to allow the MPO to come up with the best plan possible without any input from other sources.

While Metropolitan Planning Organizations are federally mandated for all major cities, some are more effective than others. The MPO in Chicago was actually one of the first to be developed in the country, with the hope that it would help to streamline the planning process. But the political nature of Chicago made it very difficult for the MPO to actually exercise any power, and it was actually combined with a number of other organizations, becoming a bureaucratic mess (Lillibridge, 1950). It also lacks many of the characteristics listed above that are present in good MPO's, like accountability and the presence of an efficient process. Denver, on the other hand, has kept its MPO separate from all other organizations, leaving it entirely dedicated to transportation planning, and a greater amount of successful planning has been observed because of it (Goetz, Dempsey, and Larson, 2002). The first step Chicago should take in making its transportation system better and more attractive to riders is to form an MPO that will be entirely dedicated to transportation planning and coming up with new ideas and improvements for the Chicago transportation system.

The most important job that MPO's have is to try and develop a regional ethos for their areas. Specifically MPO's look at the traffic congestion, air pollution, and urban sprawl that is occurring in their areas, and try to formulate a plan that will solve these problems for that area, in a way that fits into the regional way of thinking (Goetz, Dempsey, and Larson, 2002). It is apparent that the same type of infrastructure will not work for every city in the world, so the formulation of a regional plan by MPO's is an essential process when formulating any type of new arrangements. This is especially true for the city of Chicago. Because Chicago has a very old infrastructure that has been relatively unchanged, the MPO would have to decide how they could make changes and improvements on top of the existing system. Any MPO to be used in the City of Chicago should start with a development of a clear regional ethos, as there are a lot of

problems that would be very unique when looking to upgrade this old and dated system, that will lead to a more efficient transportation system that people will want to ride.

While it is important for any Metropolitan Planning Organization to have a clear regional ethos, the one used in Chicago could still look to a place like Denver for ideas on how to improve. Denver, for example, has incorporated high-speed bus lanes into its highway system so that the people riding them will not have to wait in rush hour traffic. Chicago has a well-developed highway system that can be used to go just about anywhere in the downtown area, and the incorporation of new bus lanes would not be overly difficult to include. This would be a relatively quick way to build on the existing infrastructure, and has been proven to increase ridership in other areas. Because of the popularity of light rail systems in places like Denver and other west coast cities, a Chicago MPO should also look into incorporating a new train infrastructure into its regional ethos. This would be more difficult to build on top of the existing system, but by bringing together community members, government officials, and businesses that operate in the field of public transportation, the MPO should work to find a way to try and include a new idea like this into the system. Ideas that have been successful in other places would be an easy way for a Chicago MPO to start thinking about ways to make improvements.

A Chicago Metropolitan Planning Organization should also think about ways to increase ridership on the transportation system that goes beyond simply making improvements. The London version of the MPO has taken up a method called the “sticks and carrots” approach. Increasing the use of alternative modes of transportation, according to a report on the system, requires “sticks (e.g., ecotaxes and other market-based instruments, a much less car-friendly streetscape) and carrots (e.g., integration of public transport and bikes/pedestrians, secure bike parking and cycle routes, employer incentive schemes, and employer mileage allowances for

transit use) (Batterbury, 2003)." In other words, regulatory bodies need to work to coerce people to use public transportation and rely less on their cars, which could possibly be done in Chicago by increasing toll prices or implementing a gas tax. At the same time, there needs to be a system of rewarding people or making them feel good about taking public transportation, which in Chicago could be done by starting an advertising campaign about the benefits of public transportation on the environment, by incorporating conveniences like the park-n-ride feature in Denver, or through state tax breaks for people that take public transportation. It is not enough for a Chicago MPO to make improvements to the system, but they also have to work to convince people to use the system.

Costs and Benefits

Giving more power to the Metropolitan Planning Organization in Chicago and allowing it to make drastic changes would go a long way towards improving the system and making it more like the successful system that is used in Denver. Undoubtedly, however, such an endeavor would be expensive. While these projects may cost a lot of money up front, there would also be a great amount of benefits that come out of them. The yearly cost of public transportation in the United States is $42.7 billion, $12.4 billion in capital costs and $30.3 billion in operating costs. While these figures are high, when one looks at the big picture it appears that mass transit actually saves people money in the long run, even now when major cities like Chicago have old, inefficient systems. Public transportation annually saves $10.2 billion because of congestion reduction, due to the fact that people waste less fuel while idling or moving slowly in traffic, and also saves 9.4669×10^8 gallons of gas, or using today's prices $1.77 billion. Based on 2001 statistics, 7,803,000 people use public transit regularly. This is only 5% of the work force, and a reasonable lower bound, as we have seen significant increases in the amount of public transit

used in the past few years. This typically means that these people are in a public transit household, not needing a car for each person. Based on savings from not having a car, estimated at about $5,586 annually per person according to the American Automobile Association, this saves another $43.6 billion. Public transportation also keeps 2.6 million tons of carbon dioxide from being produced, a savings of about $530 million according to European carbon dioxide market prices. When all the benefits are added together and the costs subtracted, there is a net benefit of $15.9 billion annually in the United States. If Chicago were to make improvements to its transportation infrastructure, therefore, it would make back the money that was put into the system based on the cost to benefits calculations for the United States as a whole. It could also be assumed that the city would actually make even more money, as a more efficient and convenient system would attract more customers and make the benefits even higher.

Mass transit has a long history in this country, and there are many goals that it sets out to accomplish. Public transportation aims to be an efficient way to move people around, helps to minimize negative environmental impacts, works to decrease United States dependency on foreign oil, while at the same time is designed in a way that is attractive to and convenient for people to use. Some places, like Denver, have done a better job of reaching these goals than other places, such as Chicago. By working to make its planning process better, through the redesign of its Metropolitan Planning Organization, Chicago should be able to incorporate new ideas fairly easily into its transportation system that will let it reap more of the benefits of public transportation like Denver is doing. Public transportation is an excellent resource, and more needs to be done to convince people in the Chicago area to use it. The decrepit infrastructure that is presently being used will not be able to meet the needs of the region forever, and the sooner it is upgraded the earlier Chicago will be able to reduce its pollution, help to increase

national security, and save money due to the economic benefits that arise out of public transportation.

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