

Case Studies of the Greening of Public Transit:

Metro Transit

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Metro Transit of King County (Seattle) traces its transit history back to the 1850s, when ferry boat service across the Puget Sound began. A variety of privately owned streetcar companies operated during the nineteenth century, and in 1914 the first city-owned streetcar line went into service. During the Depression the financial status of the city-run streetcars became precarious, and the city reorganized the system as the Seattle Transit System, which quickly tore up the rail lines and put in trackless trolleys and buses. In 1972 Seattle Transit merged with another system, Metropolitan Transit, to become Metro Transit. As of 2005 the agency has a fleet of about 1,400 vehicles, and it serves 100 million riders per year.¹

In the late 1980s Metro Transit built a 1.3-mile transit tunnel to ease congestion in the downtown area. Because voters had not approved rail transit, the tunnel used dual mode buses that could convert from diesel to electric power when they were inside the tunnel. In 2004 hybrid buses began replacing the dual mode buses in the tunnel. Metro Transit worked with General Motors/Allison to reprogram the hybrid buses so that they could run on “hush mode” within the portions of the tunnel between the underground stations. The hush mode utilizes mostly electricity and has minimal fuel consumption and emissions, so that air quality within the station equals ambient conditions even

though the tunnel is heavily used by buses. In 1990 the county's voters approved light rail, and in 2000 the transit agency worked out a plan to convert the tunnel to add light-rail vehicle use. The hybrid buses and light rail cars will eventually run together in the tunnel; however, the long-term plan is to phase out bus use in the tunnel as light-rail traffic increases.

Metro Transit attracted national attention for a large order of hybrid-electric diesel buses in 2003. The purchase of 213 buses for Metro Transit and another 22 for its partner Sound Transit gave the Seattle area the distinction of having the largest fleet of sixty-foot hybrids in the country (New York may have the largest fleet of forty-foot hybrids). In June, 2004, when the hybrids began operation, the city won an award as a National Clean Bus Leader from the Environmental and Energy Study Institute (ESSI). Each hybrid bus cost \$645,000, or about \$200,000 more than a standard diesel bus, and federal funds helped cover the marginal cost of about twenty-five of the new buses.²

I interviewed Jim Boon, the manager of vehicle maintenance, a section manager for the county government. Mr. Boon has been with the county for twenty-three years and has worked the entire time in vehicle maintenance, with the exception of a few years when he worked on other projects. He is very happy with the performance of the new hybrids. The buses utilize a parallel drive, which is a heavy-duty system that can operate on a range of urban streets. The buses perform well from slow city streets to the highways and from flat terrain to the many hills around Seattle.

As Boon explained, "The hybrids work better than the diesel buses on the hills, because they have much more torque. They're using the electric motors in the drive units and the battery energy, so they far outperform a conventional bus. They're also

phenomenally reliable. In the transit industry, we measure reliability as miles between trouble calls, or breakdowns in revenue service. The whole hybrid bus fleet is operating at over 6,000 miles between breakdowns, and that's incredible for a new technology. You just don't take this level of sophisticated technology out of the box and get great performance and high reliability. This is a very pleasant experience."

He added that before Metro Transit signed the contract for the large order, it bought a bus to test: "We wrote a bus spec for a sixty-foot bus, and we bought it. We ran it twenty hours a day, seven days a week, for almost six months. My goal was to get a year's worth of wear as fast as I could. We operated on regular routes but filled the bus with tanks of water that represented 130% capacity load, and we had a dozen drivers who worked on shifts. Our goal was to hit 37,000 miles, and we actually went to 47,000 miles. We monitored everything about the bus: oil, tires, brakes. When we finished, we took the hybrid drive unit out and flew it back to the factory. I went with two other guys, and we tore it apart. It didn't have any wear on it. It doesn't have a torque converter or an integral retarder, so it has no temperature swings and runs cool."

I asked if he was able to figure out if the savings on maintenance and fuel economy justify the extra cost of \$200,000, and he replied, "We keep a bus for twelve years. I'll probably keep this bus for fourteen to sixteen years. Our initial cost model showed that with labor, fuel, and maintenance, we thought we'd get our money back in about eight years, and we're well on target to do that. Because of the reduced maintenance, we reduced our mechanic workforce about 10%, which is about twenty-four positions. We don't need as much staff in the parts department and rebuild center. We eliminated a truck driver because we're not hauling as many parts from building to

building. All of the sudden we were able to shed a huge portion of the operating cost and labor.”

As for fuel economy, he went on to describe their experience: “When we started, we didn’t have any particular ideas in mind about what our fuel improvement would be. We were looking at the overall ownership package. Fuel was one component, maintenance another, other consumables such as replacement oil and disposal of oil, and brake wear. People ignore brake wear in urban environments as a source of particulate matter (PM) and pollution. Because the PM from brakes is larger and heavier particulate, it gets down in the streets, and other vehicles blow it around. People ingest it, and people with asthma really struggle with it. So we were looking at a number of issues, but to stay focused on fuel, in the beginning we hoped to get a 20% savings over the buses that we were replacing. We need to compare the hybrid with a similarly built bus with the same engine and a conventionally built drive train. We have conventional articulated buses and hybrid buses with identical engines; they’re built on the same production line on the same purchase order. When we look at the identical buses, with one hybrid and the other conventional, we get about a 50% improvement. That’s the good news.

The bad news is that in 2004, when the federal government implemented the emissions standards for the engine we’re using, fuel economy went down. We are getting about 2.6 miles per gallon on a conventional bus, and we’re getting about four on a hybrid. Prior to the implementation of the emissions standards, I was getting four miles per gallon on the older conventional buses.”

Boon went on to explain how it could happen that adding the hybrid technology has only resulted in a relative savings of fuel, but not an absolute savings. He needed to back up and explain the history of the Clean Air Act, which was first passed in 1963 and then modified again in subsequent decades. The early versions of the Clean Air Act focused on emissions and air quality, not technology design. As Boon explained, “In the 1980s the Clean Air Act gave tailpipe emissions standards, then it handed the problem to the engine manufacturers and told them to figure it out. . Although they were part of the problem, they were only one element of the solution. Today emissions are managed three ways: fuel formulation, combustion technology within the engine, and exhaust after treatment at the tailpipe. It’s now a three-legged stool, and we’re getting somewhere. We reduced sulfur content and went to ultra-low sulfur diesel. Originally the limit was 5,000 ppm (parts per million); in the mid to late 1980s it was decreased to about 500 ppm, and in 2006 it will go down to 15ppm. In 2004 the Environmental Protection Agency also implemented a rule reducing both NO_x (nitrous oxide) and PM. If NO_x are up, you can get PM down, and if PM comes up, you can reduce NO_x, but because NO_x is a gas, you can’t capture it at the tailpipe. The way to reduce NO_x is to lower the combustion temperature, but in doing so, more fuel is used. So you blow the excess PM out the exhaust and trap it in the diesel catalytic particulate filter, catalyze it into ash, and blow clean air out the tail pipe. That reduces emissions, but we have to burn more fuel to do it. That’s why we get terrible fuel economy. In 2007 the NO_x/PM levels go down again, and again in 2010. One promising technology to reduce NO_x is urea injection. They’ll spray urea—which is what farmers use to reduce nitrogen in the soil—into the exhaust stream, and that will neutralize the NO_x as it comes down the tailpipe.”

Because biodiesel results in increased NO_x, I asked if the changes had implications for their use of biodiesel, but he was only aware that various people were trying to figure out additives to reduce the NO_x in biodiesel. Metro Transit's experience with biodiesel is very recent. It's current use of B5, a 5% biodiesel blend, was funded by Seattle City Light, the city's publicly owned municipal electricity department, through its environmental mitigation program. The program was set up because the city has established a goal of making Seattle City Light a net zero emissions electricity provider (see the case study of Seattle City Light). To achieve the goal, the city's electricity department purchases carbon offset credits for the small part of its energy supply that is coming from fossil fuel sources. Biodiesel is considered carbon neutral because the carbon released on burning the fuel is recaptured by plants that are grown to create the fuel. Because Metro Transit consumes about ten million gallons of diesel fuel per year, the purchase of 5% (or 500,000 gallons) for its entire fleet will help spur the biodiesel industry in Washington state.³

Boon was careful to explain that although the purchase of biodiesel may be valuable for its carbon credits and its impact on the developing biodiesel industry in the state, the use of biodiesel did not have emissions benefits for his transit system. "Biodiesel has some appeal for older engines, and the transit industry has some engines that are twenty years old. It has some appeal if people are just trying to clean up the black smoke. We don't have that problem. I don't have any buses older than 1995. Our average fleet age is 5.5 years. When we went to ultra-low sulfur diesel, we retrofitted about 500 or 600 buses with diesel particulate filters, and our hybrids all have diesel particulate filters. Our buses are so clean that, in our mind, there's no emissions gain

with biodiesel. Our PM is .01. We're 90% under the standard. We're as clean as a natural gas vehicle, and we're not putting out the same level of greenhouse gases."

When I asked if they had any plans to shift to higher levels of biodiesel, such as B20, Boon replied, "B20 is about the breakpoint for what we know we can burn reliably. Engine manufacturers look at B5 as a fuel additive, and they look at B20 as a fuel form. They say that if we ever have problems with our fuel system, they'll void the warranty if they trace it back to biodiesel as the source. However, the biggest problem with biodiesel is the cost. Around here B100 costs about \$3.00 per gallon, and there are enough people around here using biodiesel that sometimes we can't get it. It's not an inconvenience, because we can just use regular diesel, but it shows that the B100 suppliers are not where they need to be. They need to get in the market and become a force."

Historically, King County also looked at compressed natural gas (CNG) as an option during the early to mid 1990s, but ultimately the county decided not to go that route. The reasoning behind the decision not to convert, both from a technical and economic perspective, are of general interest, because some transit agencies made the decision to convert. As Boon explained, "In the 1990s everybody was getting a full-court press from the gas lobby. To the gas companies, a bus consumed an amount of natural gas equal to about sixteen houses, and if you multiply that by the size of a transit fleet, it was like adding a new city. We were a huge new market at a time when their market had flattened out. They were competing with oil and electricity and barely making progress. At the time the gas companies were also willing to put up several hundred thousand dollars to help offset the compressor station costs, and the federal government had

demonstration grant money available. Some transit agencies didn't have capital money for new buses, so it was a way for them to buy buses.

“Also in the early 1990's we were getting ready to buy about 360 new buses, and the gas company tried to convince the county council that we should buy all compressed natural gas buses. We were concerned with the amount of time that it would take to fuel 360 buses with natural gas. We only have from about 11pm to 4am to service our vehicles and get them back on the road. If we were to extend that to the fleet of 1200 to 1400 vehicles, they couldn't supply us with enough gas. There weren't enough hours in the night, and the compressor stations would have had to be huge. The gas supply lines were too small, and they would have had to bring in bigger lines; however, they were unable to share in the cost. To level the flow on their distribution system, the gas company wanted us to fuel in the middle of the day and the middle of the night, but not one or the other, because we'd strain the system and we'd be sucking pilot lights out of people's furnaces. They couldn't supply the gas. I have seven locations throughout King County, and it was a monstrous problem to get the gas to every one of them in the volumes we needed at the time of day we needed.

“So I said, ‘Why don't we look at liquified natural gas?’ but the gas company said that wouldn't work. I said, ‘Why not? Gas is gas. It's coming out of the pipe.’ Following that approach we could have bought gas off the main line and bought it up in Canada, then we could have liquified it and trucked it in, but the local gas company would have lost the business. I said, ‘As soon as it hits the engine and is reformulated from liquid to vapor, gas is gas.’ The infrastructure impacts for LNG wouldn't have been as bad, but there were still huge facility impacts. A lot of our bus barns were built in the mid 1970s,

and they were built for diesel equipment maintenance or heavier-than-air fuel vehicles. When you introduce lighter-than-air gas vehicles in the maintenance shops, you have the capacity to have gas migrate in the shops and offices, go up into the light fixtures, go in the walls, and get into the telephones. In a perfect situation the phone could ring and blow up. So we brought in some consultants, and they estimated that we would need to spend \$50 million (1990 dollars) to retrofit our facilities to make them safe to work in with lighter-than-air gas. The incremental cost on the vehicles was another \$45 million to go out and build up the fleet to natural gas. We were looking at almost \$100 million.

“However, the county council said to go ahead and do it. We signed the contract and ordered 360 LNG buses and began engineering and design for our fueling facilities, but within six months, there was an election. The Republicans were voted out of office, and the Democrats took over. They said that if we had \$100 million—and we had to borrow most of it—we were better off taking the cleanest available technology off the shelf, putting more service on the street, and having people get out of their cars. They said, ‘Follow that path.’ That was in 1992, and we haven’t looked back. We fired the consultants and cancelled the contracts for the fueling facilities and new LNG buses.”

Today, the environmental advantages of CNG are much weaker than they were in the mid 1990s, because the technology and fuel for diesel has improved. As Boon commented, “I’m not an expert, but I believe the greenhouse gas emissions are cleaner in hybrid diesel than in CNG buses. The PM for both are below detectable levels.” He added that more information about the emissions levels for the new hybrids is under development: “The Environmental Protection Agency is now developing a test protocol for hybrids to measure emissions. I am testing both a new, 2004 conventional bus and a

sixty-foot hybrid back at the National Renewable Energy Laboratory in Colorado. When the report comes out, it will be the first side-by-side data.”

One other area of note is that Metro Transit has also provided national leadership in its programs and efforts to get people to shift from single-passenger commutes to alternative forms of transit. In addition to making public transit as attractive as possible, Metro Transit has developed ridesharing programs. Its Regional Ridematch System is a large database that matches drivers and riders for carpooling and vanpooling. The VanPool program is the oldest and largest of public transit programs of this type in the country. Metro Transit provides guidelines and support to people who wish to organize a van pool, then it trains the driver and a bookkeeper, and finally it loans them a van. The driver rides for free, the bookkeeper collects the fees for Metro Transit, and the van is allowed to use high-occupancy diamond lanes on the highways.⁴

Equity and Sustainability

Because transit agencies have limited funds, they often face the equity-sustainability trade-off when making decisions about investing in projects that green the fleet and those that would develop more transit lines or keep fares down. When I asked if such issues had emerged at Metro Transit, Boon replied, “We faced that issue when we took the lead in moving to ultra-low sulfur diesel and putting on the diesel particulate filters. We funded that out of our pocket, without any grant money. The question emerged, because people who get on the bus don’t know what’s in the fuel tank. They’re just happy that it’s on time and that it takes them where they want they go. We’re trying to do a little bit of both without raising the fares.

“We work to make the public aware that we believe strongly that we want our buses to be as clean as they can be using available technology. We’re not doing a lot of R&D work with fancy fuels. It was luck that cars led the way in terms of educating the public about how green hybrids are, and then we ended up buying the hybrid buses. We happened to be in the right place in the right time, and the press and public picked up on it. Letters poured in from the local community, and there were articles in the press saying that we had finally done something smart.”

Another equity-sustainability issue that at this point may be unique to Seattle is threat of job loss that occurs when a transit agency converts to hybrid. As discussed above, the hybrids are so much more reliable than the conventional buses that if the changes are not implemented carefully, maintenance workers can risk losing their jobs. However, Boon was careful to avoid this problem. As he explained, “I went to the union a year and a half before we got the buses. I said, ‘Here’s what my testing and cost model show.’ The way I calculate for labor is in units of labor hours needed per thousand miles on the road. I said, ‘Right now my old fleet is using about twelve hours for every thousand miles, and I think the hybrid is going to come in around nine hours. That represents in the worst case about thirty employees, but probably about twenty to twenty-four, so we need to partner to tell the employees up front that we can work our way through it.’ Over that eighteen month period, we leveraged every vacancy that we could, and no one went out the door.”

Another equity issue that may be unique to Seattle is the governance structure of Metro Transit. When the organization was originally formed in 1972 from the merger of the city and suburban transit systems, it was set up as a municipal corporation. As Boon

described, “We had a council with forty-two people that included citizens and mayors from throughout the county. You would think that they couldn’t reach a decision, but they did a great job. However, as the county grew, the demographics shifted, and in 1990 there was a court case that claimed we no longer had equitable representation. The judge ruled that we were in violation of the one-person, one-vote rule. To fix the problem, the transit system was merged into the county government, which was already structured to meet the one-person, one-vote rule by its very definition. That was completed in January, 1996. We’re now governed by the county council of thirteen, who are all elected officials, and the county executive.”

Policy Issues and Recommendations

One policy issue that sometimes emerges in urban transit systems is the decision to invest money in existing bus lines versus rail. In some cities, rail transit has been accused of siphoning money to commuter lines at the expense of bus lines that are more heavily used by low-income residents. Seattle is currently in the process of building light rail; however, light rail is under the jurisdiction of another agency. Boon was aware of some of the issues that had emerged in other cities, such as Los Angeles and Atlanta, and he noted, “Rail is very expensive. It gets a lot of attention and is glitzy, and buses aren’t fun anymore. However, we’re two separate agencies with separate funding sources, and we have no way to comingle funds.” Although Seattle’s experience of negotiating rail versus bus transit is still very much in the formative stage, the decision to have the two set up as separate agencies may allow the bus system more room to continue to grow and prosper.

Another policy issue, and really the main one from Boon's point of view, is the need for more support from the federal government. As he explained, "When we first started the hybrid program, there was no state or federal funding. It was our feeling that if we wanted to show a reduction in emissions and fuel consumption, the federal government should help reduce that \$200,000 delta that we were paying per bus. We did get a \$5 million earmark, but that was from our senator, who earmarked the funds in the transportation budget. The entire purchase was \$160 to \$170 million, so \$5 million doesn't buy that much. We're just not seeing the support from the Federal Transit Administration. We hear that they're happy that we're doing this, but they're not offering to help. They offered a lot of subsidies and grants for natural gas, but they haven't done the same for hybrids." Even Seattle, which is a national leader in the green of urban transit, can only do so much without badly needed federal support.

Based on an interview by David Hess of Jim Boon, June 7, 2005.

Web site: <http://transit.metrokc.gov>

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