Chapter Two: Restore the Streetcar City

U.S. and Canadian cities built between 1880 and 1945 were streetcar cities.[1] It was a time, very brief in retrospect, when people walked a lot but could get great distances by hopping on streetcars. By 1950 this system was utterly overthrown, rendered obsolete by the market penetration of the private automobile. Both walking and transit use dropped dramatically after this, all but disappearing by 1990 in many fast growing metropolitan areas.

(Figure 2.1 in margin)

The collapse of that world constitutes a great loss, because the streetcar city form of urban development was a pattern that allowed the emerging middle class to live in single family homes, and was sustainable at the same time. Streetcar cities were walk able, transit accessible, and virtually pollution free, while still dramatically extending the distance citizens could cover during the day.

The planning literature occasionally makes reference to the streetcar city pattern, but seldom is it mentioned for enhancing human well being, or as a time when energy use per capita for transportation was a tiny fraction of what it is today. This is tragic, because the streetcar established the form of most U.S. and Canadian cities. That pattern still constitutes the very bones of our cities—even now that most of the streetcars are gone. To ignore the fundamental architecture when retrofitting our urban regions for a more sustainable future will fail. It's like expecting pigs to fly or bad soil to grow rich crops. Accepting this premise, it may be helpful to examine the forces that spawned this

distinctive urban pattern, and to understand which of these forces still persist. A “day in the life” story will start to reveal this genesis, and help us read more clearly what remains of this urban armature.

A Day in the Life

The year is 1922 and Mr. Campbell is house shopping. He has taken a job with Western Britannia Shipping Company in Vancouver and his family must relocate from Liverpool, England. He plans to take the new streetcar from his downtown hotel to explore a couple of new neighborhoods presently under development. A quick look at the map tells him that the new district of “Kitsilano”, southwest of the city center, might be a good bet. It is only a fifteen minute ride from his new office on the Fourth Avenue streetcar line and very close to the seashore, a plus for his young family. When he enters Kitsilano he finds construction everywhere. Carpenters are busy erecting one story commercial structures next to the streetcar line, and very similar bungalow buildings on the blocks immediately behind. As he rides the streetcar further into the district the buildings and active construction sites begin to be replaced by forest; the paved road gives way to gravel. Soon the only construction seems to be the streetcar tracks themselves, which are placed directly on the raw gravel. **(Figure 2.2 in margin near here or in text after para).** The streetcar line seems out of place in what appears to be raw wilderness. Taken aback by the wildness of the landscape, Mr. Campbell steps off the streetcar where a sign advertises the new Collingwood street development. Here things are more encouraging, as workers are laying new concrete sidewalks and asphalt roads **(Figure 2.3 in margin near here)**. Stepping into the project show home, he is immediately surrounded by activity.

Carpenters and job foremen waste no time inviting Mr. Campbell in, offering coffee and dropping him in a seat before the printed display of new homes. All the different styles fit on the same size lots, with the bungalow detached single family home style predominating.

Mr. Campbell has many questions, but getting to and from work every day is his most important concern.

"Well then sir, how do I know I can get downtown to my job from here dependably?" asks Mr. Campbell.

He smiles and says "Because we own the streetcar line of course![2] Naturally we had to put the streetcar in before we built the houses, and a pretty penny it cost too. But nobody will buy a house they can't get to will they? The streetcar lines have to be within a five minute walk of the house lots or we can't sell them. **(Figure 2.4 in margin near here)** But we make enough on the houses to pay off the cost. If we didn't we'd be out of business! But there have to be enough houses to sell per acre to make it all work out financially.[3] We have it down to a formula sir: eight houses to the acre give us enough profit to pay off the streetcar and enough customers close to the line to make the streetcar profitable too. That's why all the lots are the same size even when the houses look so different. You're a business man Mr. Campbell. I'm sure you understand, eh?" he says with a smile.

"But what of commercial establishments, sir?" asks Mr. Campbell with reserved formality, "Where will we buy our food, tools and clothing?"

"Oh all along Fourth Avenue sir. Don't worry! By this time next year it will be wall to wall shops. One storey ones at first to be sure; but when this neighborhood is fully developed we expect Fourth Avenue to be lined with substantial four and five story buildings to be proud of. Liverpool will have nothing on us! You'll always be just a couple of minutes from the corner pub. Anything else you need you can just hop on and off the streetcar to get it in a tic." **(Figure 2.5 in margin near here)**

Mr. Campbell was sold. He was overjoyed to be able to buy a freestanding home for his family, something only the very rich of Liverpool could afford. All of the promises the salesman made came true more quickly than Mr. Campbell imagined possible, with the single exception of the four story buildings on the main commercial street. Rather than ten years, it would take another 80. First, the great depression froze economic activity, then WWII redirected economic activity to the war effort. By the 1950s the economic pendulum had swung toward suburban development fueled by increasing car ownership. Not until the 1990s, during the decade of Vancouver's most intense densification, would the vision of four storey buildings lining both sides of Kitsilano's 4th Avenue be realized. **(Figure 2.6 in margin near here)**

Streetcar City as a Unifying Principle

The streetcar city principle is not about the streetcar itself, it is about the system that the streetcar is part of. It's about the sustainable relationship between land use, walking, and transportation that streetcar cities embody. The streetcar city principle combines at least four of the design rules discussed in the following chapters: 1) an interconnected street system, 2) different housing types in the same area, 3) a five-minute walking distance to commercial services and transit, and 4) good jobs close to home.[4] For this reason it is

offered as the first of the rules and as a "meta rule" for sustainable low carbon community development.

Basic Structure of the Streetcar City

Streetcar cities in North America have unique characteristics not found in European cities, or even in older US cities like New York and Boston. Classic streetcar cities, like Cleveland, Minneapolis, Seattle, Los Angeles, Edmonton, and Vancouver are all laid out in a gridiron, with streets generally orienting to the cardinal axes. The typical urban grid is formed by subdividing the original "Land Ordinance Survey of 1795" perfectly square 40 acre quarter rural parcels into urban blocks. Both U.S. and Canadian officials divided entire states and provinces into perfect one mile squares of 640 acres during this time. These mile squares were most often subdivided further into 16 equal quarter mile square 40 acre parcels. When nineteenth and early twentieth century cities were cut from this 40 acre rural quilt, each 40 acre square was most often evenly divided into eight equal five acre blocks (inclusive of street space) of roughly 660 feet by 330 feet. **(Figure 2.7 in margin near here)**

The Land Ordinance Survey had both political and a practical goals. Thomas Jefferson believed that rendering the vast American continent into uniform squares provided the ideal setting for the rural democracy he believed in so passionately.[5] Unlike the European feudal villages organized around manor houses, or early New England organized around churches, no position in the rural grid is elevated above any other. At the same time, all lands are equally available for character building husbandry and individual effort. The grid was therefore the ideal expression of the anti aristocratic,

personally entrepreneurial, and religiously neutral democracy imagined by the founding fathers. This same democratic lack of hierarchy adheres to urban districts that are cut from this democratic rural tapestry. In the urban gridiron, no streets terminate at palaces, churches, court houses, or the homes of the august. All views are into the infinite distance of the public landscape—into the country itself. Streetcar cities are organized around the main threads of this grid, and their non hierarchical structure still bespeaks of this democratic intention.

In conformance with the practical economics exposited in the "day in the life story" above, streetcar cities were built out at consistent densities of between 7 and 14 residential dwelling units per gross acre (gross acre meaning inclusive of street space). In streetcar city districts, most homes are located within a five minute walk (or a quarter mile) of the nearest streetcar stop. These stops lined "streetcar arterials". If most residents are to live within a five minute walk of a streetcar arterial, they must be no more than a half mile apart (maximum quarter mile distance to nearest arterial). Typically commercial services occupy the ground floor of most street-fronting buildings along both sides of the streetcar arterial. **(Figures 2.8 in margin near here)**

In European or early American cities, civic life happened in nodes around key crossroads, as at the various five corner "squares" of Boston, or around designated civic centers like the colonial commons of New England. In contrast, streetcar city civic life extends along the entire line of the arterial, and thus constitutes a uniquely American and Canadian social milieu. This begs the question: does this kind of linear social milieu operate at the expense of the more subtle social benefits of urban living most often ascribed to higher

density locations (such as the East and Greenwich Village in New York City whose rich street life was so poetically revealed by Jane Jacobs)?

No, it does not. Streetcar arterials can be amazingly rich in sense of place and civic life. Virtually all of the City of Vancouver's richest social settings are on streetcar arterials. While the high-rise neighborhoods of Vancouver are justifiably famous, it is also notable that virtually all of the rich street life of the downtown core still occurs on the streetcar arterials of Granville, Robson, Denman, and Davey Streets. Beyond the core lie miles and miles of very active streetcar arterials.. These streets are often thronged with pedestrians, in numbers that rival much higher density areas of New York City. **(Figure 2.9 in margin near here)**

The Pattern of Walking and Riding, and Urban Form

Much has been made of the American Dream (in Canada called the Canadian Dream not surprisingly) of owning your own home on its own lot. The Dream was presumably realized after WWII when the auto-oriented suburb was born. But the dream was actually realized two generations earlier in the Streetcar City. With the emergence of the streetcar, the radius within which urban residents in the U.S. and Canada could operate expanded dramatically. Prior to the streetcar, the radius of the average person's activities was proscribed by reasonable walking distance.

Despite great changes in transportation technology between 1850 and 2010, it appears that Americans have always spent about 20 minutes on average getting to work—no

matter it be largely on foot, on streetcar, or in modern automobiles. [6] Residents of pre-transit Boston, **(Figure 2.10 in margin near here)** for example, lived in a city that could be easily crossed on foot in less than a half hour, with most of the city confined within a one mile radius 20 minute walk circle. The need to keep everything within a one mile walking distance in the more populous pre streetcar walking cities required that they be quite dense by modern standards, with populations per square mile more than ten times higher than in later streetcar cities, and scores of times higher than later auto dominated residential districts.[7] Beacon Hill in Boston is a good example of the very high density four and five storey walk up neighborhoods characteristic of this time. These neighborhoods bear strong resemblance to even earlier cities including ancient Rome, itself dominated by house types and densities not unlike Beacon Hill.[8]

With the advent of the streetcar, the distance traveled in twenty minutes increased from one mile to four miles (assuming an average speed of ten miles per hour inclusive of stops and intersection waits). **(Figure 2.11 in margin near here)** This fourfold increase is actually much greater than it seems when you consider that this increases by 16 times the area one can cover in 20 minutes. Thus the same 60,000 people that were compressed into one square mile could now be spread over 16, (lowering density to 4,000 people per square mile) allowing much lower density housing while still maintaining easy access for workers across the service area. With the intense pressure to concentrate development partly relieved, houses could spread out, and the urban middle class could afford to buy detached homes. Thus most new streetcar city residential districts were comprised mostly of single family homes on relatively small lots, the bungalow house style predominating.

This pattern of density and land use, knitted together over large areas by the streetcar, could extend very great distances. Thus the streetcar city form allows detached housing within walking and short transit distance of jobs and services over very large metropolitan scale areas, all at very low energy demand while preserving traditional residential home types. If our challenge is to make North American cities more sustainable, by dramatically reducing their energy requirements and greenhouse gas (GHG) production, while not ignoring the desirability in the minds of most homebuyers for ground oriented detached dwellings, then the streetcar city form is a proven prototype, uniquely suited to American and Canadian cultural circumstances.

Forty Percent Still Live There

Close to half of urban residents in the U.S. and Canada live in districts once served by the streetcar.[9] In these neighborhoods, alternatives to the car are still available and buildings are inherently more energy efficient (due to shared walls, wind protection, and smaller average unit sizes). [10] Most of these districts are still pedestrian and transit friendly, although with rare exception the streetcar and interurban rail lines that once served them have been removed (Toronto is a rare example of a city where the streetcar lines remain largely intact). While there is much debate about what precipitated the demise of North America's streetcar and interurban systems, one thing is beyond debate. In 1949 the U.S. courts convicted National City Lines—a "transit" company owned outright by GM, Firestone, and Phillips Petroleum— for conspiring to intentionally destroy streetcar systems for the purpose of eliminating competition with the buses and cars GM produced.

While it may seem impossible for us to envision today, Los Angeles once had the largest and most extensive system of streetcars and interurban lines in the world. In a few short years this system was completely dismantled by National City Lines, at the same time that an enormous effort to lace the LA region with freeways was launched. Today no hint of this original streetcar fabric can be experienced. Only by perusing the old photos can one sense the extent of the destruction.[11] **(Figure 2.13 in margin near here)** Now some 60 years later, elements of this system are being painfully replaced at great cost. The LA area Metrolink system restores some of the historic interurban lines while inner city surface light rail lines have replaced a small fraction of the former streetcar system.

Continuous Linear Corridors, Not Stand Alone Nodes

Linear public space is the defining social/spatial characteristic of the streetcar city. This obvious fact has been ignored at best or derided at worst. **(Figure 2.14 in margin near here)** Most planning, urban design, and economic development experts favor strategies that ignore corridors in favor of discrete and identifiable places, key urban "nodes" in planning terms. Their plans focus most often on an identified "downtown" or a key transportation locus, while the thousands of miles of early Twentieth century streetcar arterials are either allowed to languish or are blithely sacrificed for parking lots. Yet very few of us live within walking distance of a "node", while most of us live within a reasonable walk of a corridor, however gruesome it may now be. The Vancouver region, for all of its notable successes, is not immune to this planning habit. The Vancouver region's consensus vision, the Livable Region Strategic Plan (LRSP) adopted in 1995, has several key objectives, all laudable and path breaking. Two of the most important are to create complete communities "regional town center" nodes where people can live

recreate and work close to home, and to link these complete communities by high speed transit. **(Figure 2.15 in margin near here)**

The Regional Town Centre nodes were identified on the LRSP map as relatively small nodes, and defined in the text as locations where jobs, homes, and commercial services were to be found at densities and intensities scores of times higher than surrounding districts. The plan was mute on the role of districts between the regional town centers, which constituted certainly more than 80% of the urban landscape. These other areas were and still are the areas where most transit trips originate, were and still are the areas where most jobs are located, and were and still are the areas where most commercial services are to be found. The overemphasis on nodes led naturally to choosing a transit technology, the grade separated “Skytrain” system (a scaled down subway system in actual fact), that was great for connecting the designated town center nodes, but very poor at serving the streetcar city districts in between. Now nearly 25 years after the plan was first discussed, and 15 years after it was officially adopted, certain results are clear. While high-density high-rise housing has been attracted to some of the regional town center nodes, attracting jobs has proven much more difficult. The plan is thus considered a “failure” by many of the regions authorities in this key respect.

The Province is now investing in controversial freeway expansion to “fix the failed plan”. The BC Minister of Transportation justified the project, in part, by noting that job targets for the regional town center nodes were not met, that job growth was outside the centers, and thus not reachable by the new transit system. Consequently more freeway lane miles and more freeway bridges were required to serve this presumably random job

distribution. Now the region finds itself having invested billions in a system that cannot fully integrate with the underlying armature of the region, its streetcar arterials, nor do these town center nodes have the gravitational strength to pull jobs away from these arterials. But these jobs did not escape the region, they just ended up close to the same former streetcar and interurban corridors that the plan ignored.[12]

Vancouver has been damaged by its mistake, but mistakes made elsewhere have done much greater harm. At least Vancouver had the sense to designate more than just one center node in the region. Other North American regions were not so fortunate. Most other metro areas have devoted infinite transit resources into getting people from the edges of the region where they presume everyone lives, to a single urban center where they presume everyone works. Neither presumption is correct. Traditional downtowns have been losing percent share of total metropolitan regional jobs for over a century. Since the streetcar took hold, jobs have been migrating out of traditional center city nodes to other parts of the urban metroplex, trending towards an eventual balance between jobs located in the center of the region and jobs located in its outer districts (see chapter 4). But an urge to support the traditional downtown locus, and a not always successful attempt to draw suburban commuters out of their cars, has convinced transit officials to consistently spend all of their resources on hub and spoke systems to support jobs that are not there. In the most extreme cases, of which there are far too many, this leads to an exclusively and profoundly hierarchical (one center, everything else edge) “hub and spoke” system of transit, antithetical to the original homogonous (no center, no edges) North American streetcar grid. Hub and spoke systems, as the name suggests, have a

single hub location, always a traditional downtown node, served by a set of “spoke” lines that run out through first ring former streetcar districts to second and third ring suburbs. Metropolitan regions as diverse as Minneapolis, Houston, and Denver have fallen into this hub and spoke trap. They have expended billions on new grade separated “light” rail systems that only get you to traditional downtowns, and cannot conveniently move you in any other direction. Meanwhile the numerous freeway ring roads in these places operate for the cars much like the streetcar and interurban grids of yore, allowing car owners access in any direction in a way prohibited to rail transit users.

If jobs cannot, or perhaps should not, be confined to a single or even multiple high intensity urban nodes, then a regional transit strategy suited to this circumstance is required. The streetcar and interurban transit strategy that worked in the past, and that spawned the still dominant land use and movement patterns extant in most metro areas, is such a strategy. Transportation and land use choices can still be made that promote complete communities across broad swaths of urban landscape without compelling Herculean daily drives or very long trips on transit. No sustainability strategy can ever work that assumes all people will be crossing entire regions twice a day to do their daily business. Traditional streetcar cities were characterized by high mobility, but not unlimited mobility. Statistics still indicate that the average trip in both the US and Canada on buses and by Streetcar is short. This is because buses and streetcars tend to operate well in areas where distances are short and the things you need are close at hand. A trip that is five miles on a streetcar moving 15 mph takes a lot less time than a 25 mile trip on a heavy commuter rail moving at 40. The common complaint that streetcars and buses

can’t move at high speeds through urban streets is thus a red herring. It’s not how fast you are going but how far you are trying to go. The streetcar city concept works in metropolitan regions where the average trip distance is a short one. Average vehicle miles traveled (VMT) per day has been increasing for decades. This must be reversed. No sustainable region strategy can ever succeed if we presume an infinite increase in the average daily demand for transportation, no matter what the mode. Accepting that the decades long increase in average VMT must drop, then the rationale for the streetcar city is ever more compelling. Trips by transit are not free. A passenger mile on the average diesel bus produces as much carbon per passenger as a fully loaded Prius. It won’t help us defeat global warming by getting people onto transit unless we can find a way to radically decrease the average daily demand for motorized travel of any kind, and the per mile GHG consequences of each trip. Community districts that are complete and favor short trips over long ones seem an obvious part of the solution. Inexpensive short haul transit vehicles, like trolley busses, but especially streetcars, are a likely features of a low energy, low-travel demand solution.

Precious few cities seem to “get it” in this respect. Portland, again, is the exception. Portland is the only US city to have made a serious effort to restore their streetcar system. The results could not be more promising. Jobs, housing, and new commercial services are flocking to the line, making the community that much more complete, and thus incrementally reducing aggregate per capita trip demand. In Portland, jobs, housing, clubs, commercials services, are coming closer together. A ten minute ride on the

Portland Streetcar gets you where you want to go. Its speed between these points is irrelevant.[13]

Other regions should follow the Portland example. Wherever the original streetcar city fabric is still in place, planners should re-enforce that structure with transit investments. Citizens and officials in most US and Canadian cities need only search archives for historical maps to realize exactly where these systems existed, and how amazingly extensive they were. **(Figure 2.16a and b in margin near here)**Transit investment should then shift back to fund modern tram systems using the same alignments of the former streetcars, rather than, or at least in addition to, hugely expensive long distance grade separated systems. A gradual reinvestment in these traditional lines will provide strong stimulus to the kind of urban re-investment in mixed use so dramatically demonstrated in Portland, and hasten the day when average VMT drops to sustainable levels. It also restores the universally accessible and democratically non hierarchical regional system that is the defining characteristic of US and Canadian regional cities, a characteristic that we have sadly lost sight of but that it is not too late to recover.

Citizens and officials in newer suburbs should examine the essential street structure of their arterials, almost always a grid with increments of either .5 to one mile, a legacy of the Land Ordinance Survey, and support a transit system that best serves local trips along these lines. To do otherwise is to consistently disadvantage their own community interests. This is particularly important if one accepts that “complete communities” should be a feature of any sustainable city. Complete communities are communities

where one needs to travel far less during the average day than we do now – cities that dramatically reverse our ever increasing demand for transport.

Buses, Streetcars, LRT and Subways

When National City Lines disassembled the Los Angeles streetcar systems, they marshaled strong arguments in favor of rubber-tired buses.[14] They argued that initial capital costs for streetcars were much higher, and that the cost of operating buses per vehicle mile was at that time half the cost of operating streetcars. Many of the arguments they used then are still used when streetcar systems are proposed today. Streetcars are inflexible, they say. They are on rails so if one gets stuck the whole system gets stuck. Streetcar vehicles cost more than busses. Buses don't need overhead wires to run them. Buses do the same job as streetcars but do a lot more too.[15] These arguments are often sufficient to end the matter. But let's approach the question from a different angle. It's not a question of busses or streetcar really. It's a question of what kind of rail transit makes the most sense: buses, lightweight streetcar, medium weight light rail transit (LRT), or heavy weight Skytrain or subway technology

There is general agreement that rail systems are a good thing, and that they should be a major part of any region's transportation expenditure. But until very recently rail funding could only be used for traditional hub and spoke type transit systems, using grade separated LRT technology. To call these systems "light" is a misnomer. They are heavy rapid transit systems that cost many billions to construct. Portland's regional hub and spoke commuter system, the MAX line, operates like a large streetcar in the center city, moving at slower speeds on crowded streets.[16] **[Figures 2.17 in margin near here]** But

once out of the downtown it operates as a grade separated system with a dedicated right of way, widely spaced stations and travel speeds of up to 60mph, in a manner characteristic of a myriad of other similar hub and spoke style commuter rail systems.

Given these speed demands, Portland style MAX technology costs a lot, approximately 50 million dollars per two way mile to build. Fully grade separated systems like the Vancouver Skytrain system cost four times as much: 200 million or more per two way mile. In the mid 1990s, Tri-Country Metropolitan Transportation District (TriMet) planned a north south MAX line to complete the basic hub and spoke system. The new line would have run from Downtown Portland, serve the north side of the city, before connecting across the Columbia river to the City of Vancouver, Washington. Voter approval via a referendum was required to authorize the substantial local cost share. The bond measure was narrowly defeated, constituting a major setback for transit in the region.[17] Officials in Portland were initially inclined to give up, but didn't. They still needed a system to serve the north part of the city so they cast about for more affordable alternatives. What they found was modern streetcar technology. Europe had never abandoned streetcars and many companies still manufacture them there. A Czech company, Skoda Transportation, was able to provide the components of a system that could be installed, including rolling stock, for 20 million dollars per two way mile – only one fifth the cost per mile compared to MAX technology and one tenth the cost of Skytrain. Why so cheap? Car size was the same as Skytrain so it wasn't that. The system is cheap because while it can run in dedicated right of ways at speeds of 50 mph it can also very easily run on existing street rights of way. It can either share lane space with

cars as it does in Portland or move faster on dedicated lanes in the center of streets as does the Green Line in Boston. The vehicles are so light that streets and bridges do not need reconstruction to support them. On regular streets, all that is needed is a 12 foot concrete pad within which to set rails. Otherwise the street is not disrupted, nor are the businesses that may line it.

In Europe, streetcar or tram systems are being expanded much faster than heavier rail systems, gradually replacing buses on heavily used urban arterials.[18] They provide a much smoother ride than buses for elderly. With an aging demographic where those over 65 years old will soon constitute over 33% of the population, a 200% increase over today, this is a key factor. Body balance is compromised as we age. Unsteady rides on rubber wheeled vehicles and buses that are hard to mount and stand in are increasingly difficult after age 55, and almost impossible past 75. Low floor streetcars are mountable at grade and are free of any lateral rocking motion.

Streetcars are always electric and thus generate little to no GHG emissions. Finally and most compellingly they are cheaper than buses when all costs are considered over the useful life of the system. Over the life cycle period, tram systems cost $.90 per passenger mile compared with $1.05 per passenger mile for diesel busses.[19] The GHG consequences of this choice are much more dramatic. Diesel busses produce 50grams of CO2 per passenger mile while modern trams produce between zero grams and 5 grams per passenger mile (depending on electricity source). More details on these cost and energy relationships are provided below.

Streetcar as an Urban Investment

Most discussions of streetcar focus solely on transit issues, but the implications are much wider. Streetcars stimulate investment and buses don't. This has been powerfully demonstrated in Portland where the introduction of a modern streetcar line spurred the high density development that helped the City of Portland recoup construction costs through significantly increased tax revenues. [20] Between 1997 and 2005 the density of development immediately adjacent to the new streetcar line increased dramatically. Within two blocks of the streetcar line $2.28 billion was invested, representing over 7,200 new residential units and 4.6 million square feet of additional commercial space; even more impressive, new development within only one block of the streetcar line accounted for 55 percent of all new development within the City's core.[21] To put this in perspective, prior to construction of the new streetcar line, land located within one block of the proposed route captured only 19 percent of all development. Most attribute this impressive increase in investment to the presence of streetcar. Developers for the new South Waterfront development at the other end of the downtown from the Pearl District would not proceed before the city guaranteed to extend the streetcar line to their site. This developer, the same ones who had developed the highly successful Pearl District, knew from experience how important the streetcar was to success. If the free market is telling us anything at all in this case it is that the economics of streetcar, when the value of new investment is included, is much more cost effective than an investment in rubber wheeled diesel busses or heavy transit.

Cars, Buses, Streetcar, or Heavy Rail? The Broadway Corridor in Vancouver Case Study

[Figure 2.18]

Broadway is the dominant east west corridor in Vancouver, running from its eastern border at Boundary Street to its western border at the campus of the University of British Columbia. Broadway has always been a good street for transit, even after the streetcars were removed. All of the density and access features described above are found there. It has a continuous band of commercial spaces for most of its length, and residential densities within short walks of greater than 15 dwelling units per acre to insure a steady stream of riders and customers on foot.

Residents who live near Broadway can survive without a car. Many of the residents along the corridor are students at UBC, who have always enjoyed a one seat ride to school on busses with three to five minute headways. More than half of all trips on the corridor now are by bus, over 60,000 passenger trips per day.[22] Very frequent bus service has re-enforced the function of the Broadway corridor even without the streetcar in place. Buses are both local, stopping every second block, and express, stopping every one to two miles. The street has no dedicated bus lanes although curb lanes are transit only during peak hours in some portions. Walkable districts, sufficient density, three minute headways, hop-on-hop-off access to commercial services, and five minute walking distance to destinations at both ends of the trip all contribute synergistically.

The buses on Broadway work very well, and if they were never upgraded to streetcars much worse things could happen. But the corridor, due to high ridership, is a candidate for substantial new transit investments. Using a modest amount of proposed funds to restore streetcars to Broadway is eminently sensible. Streetcars will reduce pollution, better accommodate the infirm and the elderly, add capacity, provide everyone a more comfortable ride, cost less per passenger mile over the long run than they are spending now, and attract investment where you most want it.

What is the Optimal Transit System?

What is the evidence that streetcars are more cost effective over the long term than either rapid bus transit, which the corridor has, or heavier "rapid" transit like the Skytrain, which is being proposed? Well, cost effective for what? Over what distance? To serve what land uses? The question becomes quickly very complicated. To answer this question it is helpful to ask what the optimal relationship is between land use and transit, and what transit mode would best support this optimum state. Similarly, how does an increasingly uncertain oil supply and rising concern over greenhouse gas emissions factor into our long term transportation planning? Investment decisions made in Vancouver and elsewhere over the next ten years will determine land use and transportation patterns that will last for the next hundred. How can we choose the system that helps create the kind of energy, cost and low GHG region that the future demands?

A research bulletin completed by the Design Centre for Sustainability compiled the information necessary to begin to answer these questions. The results are organized in the context of three basic sustainability principles; (1) shorter trips are better than longer trips, (2) low carbon is better than high carbon, and (3) choose what is most affordable over the long term.[23]

If shorter vehicle trips are the goal, what is the best transit option? In traditional streetcar neighborhoods local buses and streetcars extend the walk trip, making frequent stops and short trips, therefore acting as pedestrian accelerators.[24]

While both buses and streetcars are effective ways to extend the walk trip, streetcars are inherently more energy efficient than both diesel and trolley buses. Streetcars perform better than even electric trolley buses because they lose less energy to frictional resistance than rubber wheeled vehicles and they are capable of much higher passenger capacities.[25] Streetcars can carry between 70% and 150% more people than the average low floor bus making streetcar operators more than twice as productive per hour as a diesel or trolley bus driver.

Due in large part to the energy efficiency of the electric motor, the energy cost for electrically powered transportation is dramatically cheaper per passenger mile than in gasoline or diesel powered vehicles.[26] Electricity also comes with the flexibility to incorporate ‘green’ sources of energy such as hydro, wind or solar that can eliminate carbon emissions from the transportation sector.[27]

To make a sound comparison between the long term costs associated with each transportation mode we incorporated initial capital and construction costs, amortization costs, on-going operation and maintenance expenses, energy use and carbon offsets to come up with a final cost comparison. Carbon offsets were calculated using the market price of carbon traded in the European Emissions Trading scheme in December 2008 ($49 per ton). The latest analysis by New Carbon Finance predicts that prices will increase to more than $72 per ton by 2012 (New Carbon Finance, 2008). The following chart shows the final cost comparison between transportation modes. **[Figure 2.22 in margin near here]**

In the future the gap between electric and fossil fuel powered transportation modes is expected to widen even more dramatically. The vast majority of projections for the next 50 years predict rising fuel prices as global economies expand and competition for finite oil reserves increases. Assuming that future gasoline and diesel prices rise to $10.00 per gallon and the price of electricity doubles, the difference in energy cost per passenger-mile between a tram and a Ford Explorer skyrockets from 16 to 41 cents. The difference between a tram and an articulated diesel bus increases from two cents to five cents per passenger mile**. [Figure 2.23 in margin near here]**

Conclusion

It is important to note that the benefits of streetcar city development don't come solely from the construction of a streetcar system itself. The streetcar city concept is systemic

and necessarily incorporates an integrated conception of community structure and movement demands. When applied to low-density suburban developments modern streetcars are doomed to low ridership and anemic cost recovery.[28] The Streetcar City Principle is thus about more than just the vehicle, about more than the track. It's about a balance between density, land use, connectivity, transit vehicles, and the public realm. The streetcar city concept is compatible with single family homes yet can be served by transit. It assures that walking will be a part of the everyday experience for most residents and provides mobility for the infirm. It has been shown to induce substantial shifts away from auto use to transit use and can conceivably be introduced into suburban contexts.[29] It has also been shown to dramatically increase investment in a way that neither buses nor expensive subway lines can. It is compatible with the trend to increasingly dispersed job sites and seems to be the form that best achieves "complete community" goals. The Streetcar City principle, whether manifest with or without steel wheeled vehicles, is a viable and amply precedented form for what must by 2050 become dramatically more sustainable urban regions. Other sustainable city concepts that presume extremely high density urban areas linked by rapid regional subway systems seem inconceivably at odds with the existing fabric of both pre war and post war urban landscapes, and beyond our ability to pay for. At the other extreme, assuming that some technological fix like the hydrogen car will allow us to continue sprawling our cities into the infinite future seems even more delusional. Part of the therapy for the sickness of our cities must be a clear eyed recognition of the status of the physical body of the city as it is, and a physical therapy calibrated to its specific capacity for a healthier future. The physical body of our regions was and still is the streetcar city pattern. The Streetcar City principle is intended

to both provide simple insight into our condition, and a clear set of strategies that have proven themselves for decades.

[1] Between 1850 and 1900 horse-drawn and then electric streetcars enabled large numbers of upper and middle class commuters to move further out of the city eventually giving rise to residential enclaves organized around streetcar lines referred to as “streetcar suburbs” (Warner 1962). By 1910 almost every American city with more than 10,000 people had one or more streetcar lines and per capita transit ridership peaked in 1920 at about 287 annual rides per urban resident (American Transit Association 2006). In 1917 there were 72,911 streetcars in service in the United States but due to a number of factors that number had dropped to 17,911 by 1948 (Toronto Star 1999).

[2] Early in the 20th century “streetcar lines and their adjacent residential communities were typically developed by a single owner who built transit to add value to the residential development by providing a link between jobs in an urban center and housing at the periphery” Private developers built transit to serve their developments and as part of this formula small retail outlets were often built in clusters around streetcar stops, both to serve commuters and local residents (Belzer & Autler 2002).

[3] This is what is called “tax lots” or “taxpayer blocks” and it refers to developers who built for low density interim land uses on land believing it would eventually gain value therefore making more permanent commercial buildings worth their while. The low density buildings produced enough revenue to pay taxes and essentially held the land for future development. (Rowe 1991).

[4] Vernez Moudon et al. (2006) found that environments associated with more walking were denser, had activities closer together, and more sidewalks and smaller blocks. Handy (1993) found that residents living in traditional neighborhoods made two to four more walk/bike trips per week to neighborhood stores than those living in nearby areas that were served mainly by auto-oriented, strip retail establishments. Ewing et al (1994) found that sprawling suburban communities generated almost two-thirds more per capita vehicle hours of travel than the ‘traditional city.’ Neighborhoods that have gridded streets, convenient transit access and destinations such as stores and services within walking distance result in shorter trips, many of which can be achieved by walking or biking (Hess & Ong 2002). Streetcar suburbs tend to have these attributes therefore reducing vehicular travel and allowing for higher than normal public transit service (Hess & Ong 2002).

[5] Jefferson even went so far as to sketch a pure grid plan for the District of Columbia. How seriously his plan was considered is not known. George Washington hired Charles L’Enfant who produced the complex multi-axis plan that was ultimately built. Jefferson was not supportive of L’Enfant’s plan, but was overruled by Washington (Linklater 2002; Kite 1970; Malone 1948).

[6]In the 1990s the average commute time began to increase and is now up 18 percent from its historic norm with almost 10 million Americans driving more than an hour to work, an increase of 50 percent between 1990 and 2000 (Siegel 2006). In 2007 the average distance Americans drove to work was 25.1 minutes (US Bureau of the Census (ACS) 2005-2007).

[7] Historically, walk up tenements allowed for compact, high density, walkable cities. Ancient Rome reached urban densities of 95,000 people per square mile of built up land while Manhattan reached a peak of 130,000 around 1910 (Pushkarev & Zupan 1977). In 1880, 45 percent of all adult male workers employed in Philadelphia lived within one mile of the central business district and 96 percent lived within six miles (Gin & Sonstelie 1992). Historically, people had much less indoor housing space than we do today so higher average population densities could exist while the density of structures remained relatively low (Pushkarev & Zupan 1977). However, allowing for modern space requirements (dwelling units ranging from 1,000 – 2,000 square feet with one parking space and 100 square feet of open space per dwelling), Ellis (2004) found that four story walk-up townhouses could still reach densities of 30-40 dwelling units per acre or 19,200-25,600 per square mile. The benefits of this type of development have been studied by Cervero & Kockelman (1997) who found that compact, mixed-use, pedestrian-friendly designs can ‘degenerate’ vehicle trips, reduce vehicle miles traveled per capita and encourage non-motorized travel.

[8] Even today the built form of the Beacon Hill neighborhood supports almost 10,000 people within one half square mile (Beacon Hill Online, 2003). In comparison, streetcar suburbs in Cleveland historically supported population densities of around 2,000-5,000 people per square mile demonstrating the approximately 16 fold drop in density permitted by the streetcar access (Borchert 1998).

[9] In 2000, 80.3% of the total population in the United States lived in Metropolitan Areas (MAs): 30.3% in central cities and 50% in suburban areas (Hobbs and Stoops 2002). This means that 40% of the total metropolitan population still lives in central cities. Central cities are defined as the largest city in a Metropolitan Area (MA) with additional cities qualifying if specified requirements are met concerning both population size and employment to residence ratios of at least 0.75. Suburbs are the areas inside a MA but outside the central city (Hobbs and Stoops 2002). Central cities have substantially higher densities than their suburbs and are the closest approximation to traditional streetcar cities for which census data is available. **(Insert Figure 2.12)**

[10] Norman et al. (2006) conducted a life-cycle analysis of energy use and greenhouse gas emissions for high and low residential density that included the construction materials for infrastructure, building operations and transportation. They found that low density suburban development was more energy and greenhouse gas intensive by a factor of 2.0-2.5 than high density urban core development. Ewing et al. (2007) looked at the relationship between urban development, travel and CO2 emitted by motor vehicles. They found that “the evidence on land use and driving shows that compact development will reduce the need to drive between 20 and 40 percent, as compared with development

on the outer suburban edge with isolated homes, workplaces, and other destinations…smart growth could, by itself, reduce total transportation-related CO2 emissions from current trends by 7 to 10 percent as of 2050."

[11] National City Lines (NCL) was organized in 1936 "for the purposes of taking over the controlling interest in certain operating companies engaged in city bus transportation and overland bus transportation". In 1939, when NCL needed additional funds to expand their enterprise they approached General Motors for financing. GM agreed to buy stock from NCL at prices in excess of the prevailing market price under the condition that NCL would refrain from purchasing equipment not using gasoline or diesel fuel (Bianco 1998).

[12] The number of people whose usual place of work was in the City of Vancouver rose by 6 percent between 2001 and 2006 compared to an increase of 9.7 percent in the peripheral municipalities (Statistics Canada 2006). The fastest growing peripheral municipalities in terms of jobs were Surrey (+ 17,3000 or 17 percent), Burnaby (+ 7,000 or 6.5 percent), Langley (+ 6,400 or 18.5 percent) and Coquitlam (+ 5,800 or 17.2 percent).The business parks in Metro Vancouver are often located close to residential areas, services and transit. Instead of being inherently disconnected from the urban fabric it is the physical site design and single-use zoning that frustrates connectivity, explodes distances between amenities and generally makes for an unwalkable, auto-dominated environment (Condon et al. 2006)

[13] In the US it was only after the effort of Congressman Earl Blumenauer of Portland and his congressional supporters that federal transit monies could be used to support

shorter range, lower speed, and much cheaper streetcar systems. Prior to that, Portland had to pay the entire cost of the first phase of its streetcar system with local funds.

[14] Bauer, John. 1939. The street railways struggle against traffic losses. *Public Utilities Fortnightly* 23: 209-17 *In* as cited in Ortner & Wachs 1979

[15] The majority of European cities rebuilt or upgraded their streetcar systems following World War II in response to "lower automobile ownership, a lack of domestic petroleum resources, plentiful electricity and a desire to not allow automobile usage to disturb the traditional economic and social patterns of these centuries-old cities" (Gormick 2004). A few large cities like Stockholm, Rotterdam, and Milan built heavy rail but most decided to restore or upgrade their streetcar services instead (Black 1993). In 1975 there were 310 cities in the world with streetcar/LRT systems in operation including most West European nations and Japan (Diamant et al. 1976). Great Britain and France were two notable exceptions to this trend in Europe. Very few tram lines survived in these countries after WWII however, more recently many cities in the United Kingdom and France are reintroducing streetcars from scratch, having had no light rail or tramway for more than a generation (Hyden and Pharoah 2002).

[16] Portland's Metropolitan Area Express (MAX) system is one of the most successful light rail systems in North America. According to the American Public Transportation Association's Ridership Report (2007), Portland's MAX system accommodates 104,300 daily trips and is the United State's second most ridden standalone light rail system, second only to San Diego.

[17] In 1996 Oregon voters rejected a $375 million transportation package that would have funded the north-south light rail project as well as a 9 mile extension from Vancouver to Hazel Dell by a vote of 53 percent to 46 percent (Metro 2007). Although the measure failed state-wide, it was approved by a majority of voters within the TriMet service area (Metro 2007).

[18] The majority of European cities rebuilt or upgraded their streetcar systems following World War II in response to "lower automobile ownership, a lack of domestic petroleum resources, plentiful electricity and a desire to not allow automobile usage to disturb the traditional economic and social patterns of these centuries-old cities" (Gormick 2004). A few large cities like Stockholm, Rotterdam, and Milan built heavy rail but most decided to restore or upgrade their streetcar services instead (Black 1993). In 1975 there were 310 cities in the world with streetcar/LRT systems in operation including most West European nations and Japan (Diamant et al. 1976). Great Britain and France were two notable exceptions to this trend in Europe. Very few tram lines survived in these countries after WWII however, more recently many cities in the United Kingdom and France are reintroducing streetcars from scratch, having had no light rail or tramway for more than a generation (Hyden and Pharoah 2002).

[19] The average cost of new light rail construction in North America is $35million/mile, excluding Seattle whose $179million/mile price tag is well outside of the norm (Light Rail Now 2002). This calculation includes new streetcar systems which are significantly less expensive. Portland's modern streetcar line was constructed for $12.4 million/mile (although some sources have it at $16.4 million/mile (Light Rail Now 2002)). Tampa,

Florida's was built for $13.7million and the streetcar line in Little Rock, Arkansas was built for $7.1 million/mile (Weyrich and Lind 2002). The typical price for a modern streetcar vehicle is in the range of $3 to $3.5 million while a 40-foot transit bus costs between $0.4 to $0.5 million and articulated buses range between $0.6 and $0.9 million. Higher vehicle costs for streetcars can be partly offset by increased efficiency in operating costs. In most cases, the operating cost per boarding rider for light rail and streetcars is significantly lower than buses, primarily due to their higher capacity. For example, the operating cost per rider trip for buses in St. Louis is $2.49 while for light rail it is only $1.32 (Lyndon 2007). Streetcars also have a service life of 25 years while transit buses only have 17 years (City of Vancouver 2006). For detailed notes on the life cycle costs per passenger-mile quoted in the main text, see Foundation Research Bulletin No.7: A Cost Comparison of Transportation Modes, 2009).

[20] Cervero (2007) cites the streetcar system as a major driving force in the development of the Pearl District in Portland which now has an average density of 120 units per acre net, the highest in Portland. The streetcar has stimulated housing and transportation in the area as well as an estimated 1.3 billion dollars in investment (Ohland 2004).

[21] Hovee & Company, LLC. 2005. Portland Streetcar Development Impacts. *In* Portland Streetcar Loop Project Environmental Assessment, January 2008.

[22] Leicester, G. 2006. Implementation of Transit Priority on Broadway Corridor. Prepared for GVTA Board of Directors.

[23] The full bulletin, summarized below, can be downloaded at http://www.sxd.sala.ubc.ca/8_research/sxd_FRB07_cost.pdf.

[24] This hypothesis is born out by data that shows that North American districts still served by streetcar and \ electric trolley buses exhibit shorter average trip lengths than other modes. A review of the literature found the average trip length in a personal automobile in Vancouver, BC is around 12 km (TSI Consultants, 2001). In the United States trip length by mode was found to be 6.3km for local bus, 11.6km for BRT, 7.4km for LRT, 2.6km for Trolleybus and 2.9km for Streetcar (American Public Transportation Association, 2008). These values are represented in the graph below. **[Insert Figure 2.19]**

[25] According to Strickland (2008) internal combustion engines typically convert, at best, 1/3 of their energy into useful work while electric motors generally have energy efficiencies of 80-90%.

[26] The following graph has been compiled by averaging typical and maximum passenger capacities for various transportation modes (Strickland, 2008; City of Vancouver 2006; URS Corporation, 2008; The Urban Transportation Monitor, 2001). **[Insert Figure 2.20]**

[27] Converting energy efficiency numbers provided by Strickland (2008) into kilowatt hours/mile we found that the energy efficiency of a modern streetcar was approximately 24 passenger-miles per kilowatt hour while trolleybus was 11.1, Skytrain was 11.6, articulated diesel bus was 6, diesel bus was 4.5, a Toyota Prius was 1.5, and a Ford

Explorer was only 0.7 passenger-miles per kilowatt hour (all figures for typical capacity). The graph below shows the final cost comparisons of the various transportation modes. The cost per passenger ranges from 0.5 cents per passenger-mile for a modern streetcar to 16.8 cents for a Ford Explorer (at typical capacity). **[Insert Figure 2.21]**

[28] Gormick, Greg (2004) The Streetcar Renaissance: it's background and benefits. A research report for the St. Clair Avenue Transit Improvements Environmental Assessment Study" On Track Consulting. Available online: http://www.toronto.ca/wes/techservices/involved/transportation/st_clair_w_transit/pdf/report/streetcar_renaissance.pdf

[29] Litman (2006) found that "cities with large, well-established rail systems have significantly higher per capita transit ridership, lower average per capita vehicle ownership and annual mileage, less traffic congestion, lower traffic death rates, lower consumer expenditures on transportation, and higher transit service cost recovery than otherwise comparable cities with less or no rail transit service." Studies have found that 30 percent of residents moving into Portland's new transit oriented development own fewer cars than they did at their previous home, and 69 percent use public transit more often than they did in their previous community (Podobnik 2002; Switzer 2003).