CHAPTER 2

Restore the Streetcar City

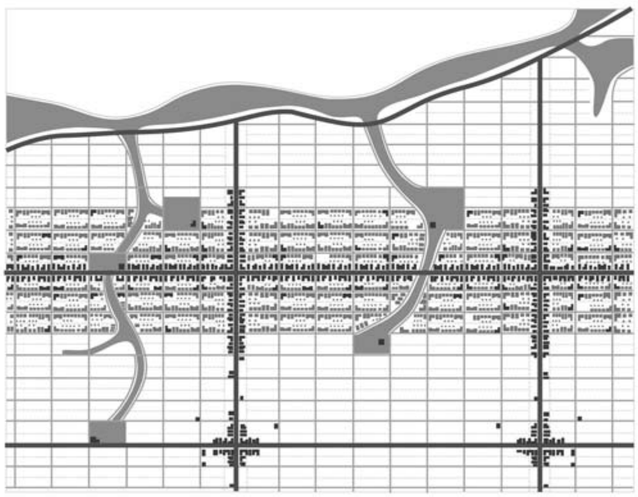


Figure 2.1. This diagram shows how the many components of a sustainable urban landscape work together in the streetcar city.

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 afterward, all but disappearing by 1990 in many fast-growing metropolitan areas.

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 walkable, transit accessible, and virtually pollution free while still dramatically extending the distance citizens could cover during the day.

The planning literature occasionally refers to the streetcar city pattern, but seldom is the streetcar city mentioned for enhancing human well-being or lauded 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, when most of the streetcars are gone. To ignore the fundamental architecture when retrofitting our urban regions for a more sustainable future will fail. It is like expecting pigs to fly or bad soil to grow rich crops. Accepting this premise, it may help 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.

[1]Between 1850 and 1900, horse-drawn and then electric streetcars enabled large numbers of upper- and middle-class commuters to move farther out of the city, eventually giving rise to residential enclaves organized around streetcar lines that were referred to as "streetcar suburbs" (Warner, 1962). By 1910, almost every American city with more than ten thousand 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 for several reasons that number had dropped to 17,911 by 1948 (Toronto Star, 1999).

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 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 is 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 as well as very similar bungalow buildings on the blocks immediately behind. As Mr. Campbell rides the streetcar farther 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. 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. Stepping into the project's show home, he is immediately surrounded by activity.

Carpenters and job supervisors waste no time inviting Mr. Campbell in, offering coffee and dropping him in a seat before the printed display of new homes. All the homes fit on the same size parcel or "lot", with the bungalow detached, single-family home the predominating style.

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.

The salesman 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. But we make enough on the houses to pay

Figure 2.2. Vancouver's Fourth Avenue streetcar line freshly installed. Streetcars were provided before roads were improved or land subdivided for homes, as a necessary precondition for development. Here is the scene a few years before these other urban features were built. (Source: Michael Kluckner, *Vancouver, The Way It Was*. North Vancouver: Whitecap Books, 1984).

Figure 2.3. Streetcars going over the Kitsilano trestle in 1909, west of the Granville trestle, which is now Granville Street Bridge. (Source: Vancouver Public Library)

[2]Early in the twentieth 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, to serve both commuters and local residents (Belzer and Autler, 2002, p. 4).

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. 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 of the lots are the same size even when the houses look 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-story 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.[3] 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."

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

Figure 2.4. Shown on Arbutus Street in Vancouver (1952), this streetcar is an example of the interurban type of vehicle that was used for longer trips and between rural communities in the Lower Mainland.

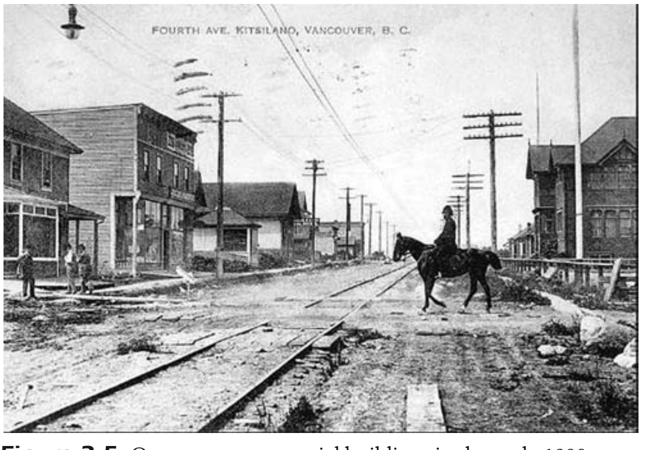


Figure 2.5. One-story commercial buildings in the early 1900s on Fourth Avenue, Vancouver.

Figure 2.6. Four-story mixed-use buildings now line block after block on Fourth Avenue in the Kitsilano District of Vancouver. Buildings of this scale were originally anticipated in the 1920s, when this area was built, but economic circumstances only became favorable for this type of building in the 1990s. All of the four-story buildings shown here were built after 1990.

[3]This is what is called "tax lots" or "taxpayer blocks," which refers to developers who built for low-density interim land uses, believing the land would eventually gain value and thus 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).

the main commercial street. Rather than ten years, it would take another eighty. First, the Great Depression froze economic activity; then World War II 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 Fourth Avenue be realized.

THE STREETCAR CITY AS A UNIFYING PRINCIPLE

The streetcar city principle is not about the streetcar itself; it is about the system of which that the streetcar is a part. It is 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) a diversity of housing types, (3) a five-minute walking distance to commercial services and transit, and (4) good jobs close to affordable homes.[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 parts of North American cities, such as Boston and Montreal. Classic streetcar cities, such as Dayton, 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, perfectly square 40-acre quarter rural parcels of the Land Ordinance Survey of 1795 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 commonly subdivided further into sixteen 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

[4]Vernez Moudon et al. (2006) found that environments associated with more walking were denser, had activities closer together, and had more sidewalks and smaller blocks. Handy (1993) found that residents living in traditional neighborhoods made two to four more walk or bike trips per week to neighborhood stores than those living in nearby areas that were served mainly by auto-oriented, strip retail establishments. Ewing, Haliyur, and Page (1994) found that sprawling suburban communities generated almost two thirds more per capita vehicle hours of travel than did 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. Streetcar city districts tend to have these attributes, thereby reducing vehicular travel and allowing for higher than normal public transit service (Hess and Ong, 2002).

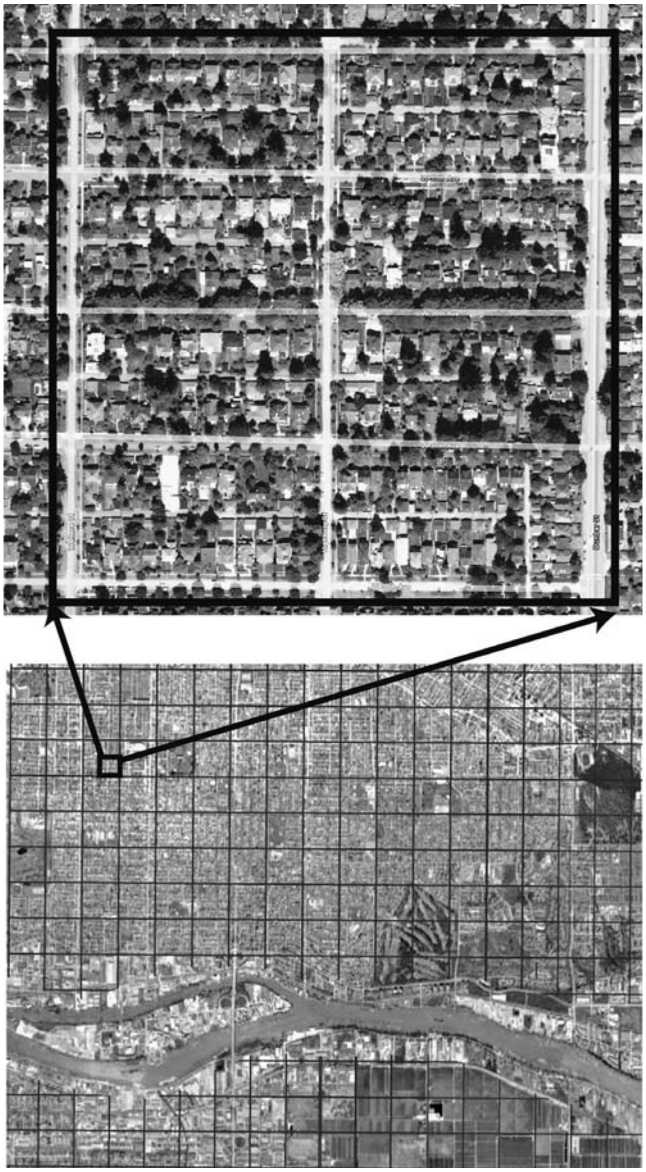


Figure 2.7. The grid overlay makes it clear that urban blocks were cut from the original agricultural pattern. The unaltered agricultural pattern in Richmond, British Columbia, shown near the bottom of photo, still retains this original pattern.

square was typically divided into eight equal 5-acre rectangles called "blocks," each block roughly 660 feet by 330 feet.

The Land Ordinance Survey had both political and practical goals. Thomas Jefferson, its author, believed that rendering the vast American continent into uniform squares would provide the ideal setting for the rural democracy he believed in so passionately.[5] Unlike the European feudal villages organized around manor houses, or the early New England towns 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 idealized by Jefferson. This same 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, courthouses, 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 nonhierarchical structure still bespeaks this democratic intention.

In conformance with the practical economics exposited in the "day in the life" story earlier, streetcar cities were built out at consistent densities of between seven and fourteen 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 line "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 (with a maximum quarter-mile distance to the nearest arterial). Typically, commercial services occupy the ground floor of most street-fronting buildings along both sides of the streetcar arterial.

In European or early American cities, civic life happened in nodes around key crossroads, such as the various five-corner "squares" of Boston, or around designated civic centers, such as the colonial commons of New England. In contrast, the civic life of the streetcar city extends along the entire line of the arterial and thus constitutes a uniquely American and Canadian social milieu. This begs the question: is this kind of linear space socially impoverished when compared to nodal urban spaces—

[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).

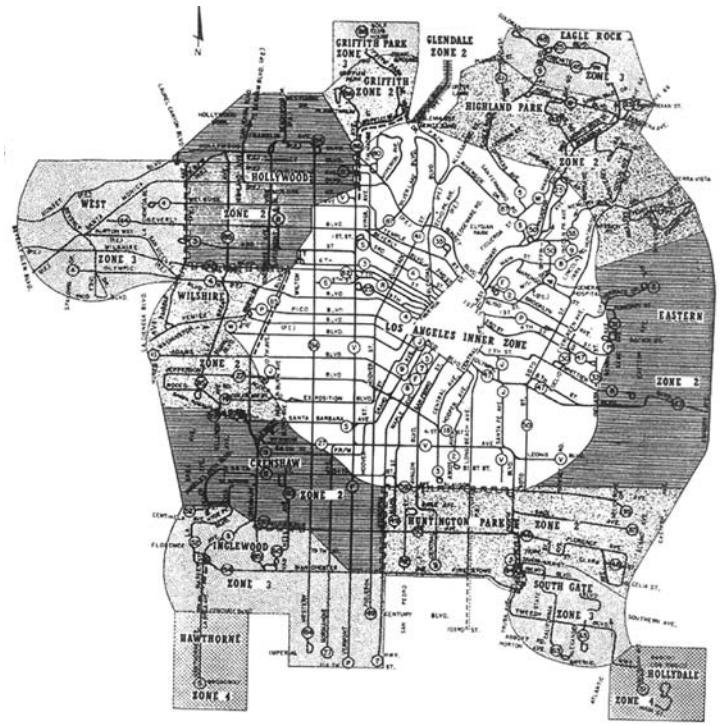


Figure 2.8. Historic streetcar routes in Los Angeles.

Figure 2.9. A typical Sunday afternoon on Broadway in Vancouver's Kitsilano District. The residential density on the surrounding streets is roughly fifteen dwelling units per gross acre.

spaces like Rockefeller Plaza in New York City and Boston Common in Boston.

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, almost 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 typically thronged with pedestrians, in numbers that rival the much higher density areas of New York City.

URBAN FORM AND THE PATTERN OF WALKING AND RIDING

Much has been made of the American Dream (or, in Canada, the Canadian Dream) of owning one's own home on its own lot. The dream was presumably realized after World War II

Figure 2.10. Original "town houses" in Boston, Massachusetts, a type typical of walking-distance cities built prior to the widespread use of the streetcar. (Credit: Gaither Limehouse Pratt)

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 United States 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 1800 and 2000, it appears that Americans always spent about twenty minutes on average getting to work—whether by foot, on streetcar, or in modern automobiles.[6] Residents of pre-transit Boston, 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, twenty-minute-walk circle. The need to keep everything within a one-mile walking distance in the more populous pre-streetcar walking cities required that the cities 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 in later, auto-dominated residential districts.[7] Beacon Hill in Boston is a good example of the very high density, four- and five-story walk-up neighborhoods characteristic of this time. These neighborhoods strongly resemble 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). This fourfold increase is actually much greater than it seems when you consider that this increases by sixteen times the area one can cover in twenty minutes. Thus, the same sixty thousand people who were compressed into one square mile could now be spread over sixteen square miles (lowering the density to four thousand 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 composed mostly of single-family homes on relatively small lots, with the bungalow house style predominating.

[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 time Americans spent driving to work was 25.1 minutes (U.S. Census Bureau, 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 and 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 and Sonstelie, 1992). Historically, people had much less indoor housing space than they do today, so higher average population densities could exist while the density of structures remained relatively low (Pushkarev and Zupan, 1977). However, allowing for modern space requirements (dwelling units ranging from one thousand to two thousand square feet with one parking space and one hundred square feet of open space per dwelling), Ellis (2004) found that four-story walk-up townhouses could still reach densities of 30 to 40 dwelling units per acre or 19,200 to 25,600 units per square mile. The benefits of this type of development have been studied by Cervero and Kockelman (1997), who found that compact, mixed-use, pedestrian-friendly designs can "degenerate" vehicle trips, reduce VMT per capita, and encourage nonmotorized travel.

[8]Even today, the built form of the Beacon Hill neighborhood supports almost ten thousand people within one half square mile (Beacon Hill Online, 2003). In comparison, streetcar suburbs in Cleveland historically supported population densities of around 500 to 1,200 people per half mile square, demonstrating the up to sixteenfold drop in density permitted by the streetcar access (Borchert, 1998).

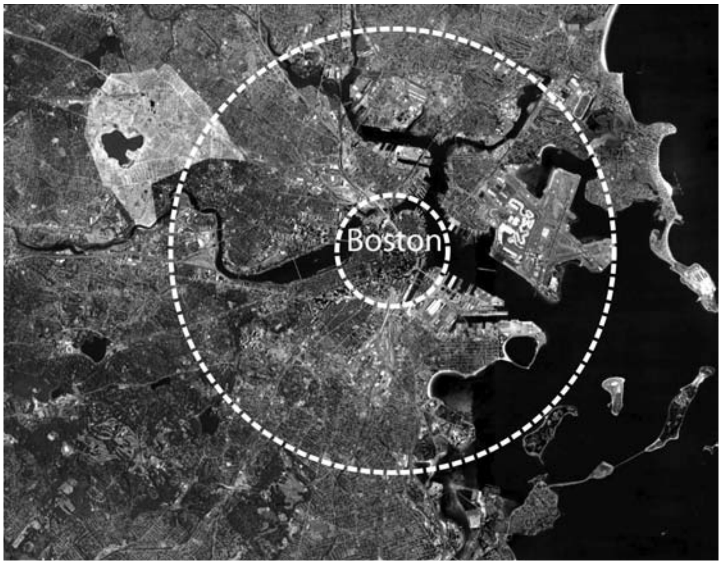


Figure 2.11. The smaller circle around downtown Boston represents the distance a person could walk in twenty minutes. The larger circle shows the distance a person could travel by taking a streetcar.

This pattern of density and land use, knitted together over large areas by the streetcar, could extend great distances. Thus, the streetcar city form allows detached housing within walking distance 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 home buyers for ground-oriented, detached dwellings, then the streetcar city is a proven prototype, uniquely suited to U.S. and Canadian cultural circumstances.

FORTY PERCENT STILL LIVE THERE

Close to half of urban residents in the United States 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

[9]In 2000, 80.3 percent of the total population in the United States lived in metropolitan areas (MAs): 30.3 percent in central cities and 50 percent in suburban areas (Hobbs and Stoops, 2002). This means that 40 percent of the total metropolitan population still lives in central cities. Central cities are defined as the largest city in an 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 an 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.

[10]Norman, McLean, and Kennedy (2006) conducted a life-cycle analysis of energy use and GHG 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 to 2.5, than was high-density urban core development. Ewing et al. (2007, pp.20) looked at the relationship among urban development, travel, and CO_2 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 CO_2 emissions from current trends by 7 to 10 percent as of 2050." Ten percent may seem small until one considers this 10 percent drop against what would most certainly be a large *increase* in GHG production if current trends continue. More dramatic differences are revealed in the work of the Center for Neighborhood Technology (CNT) in Minneapolis, where total per capita costs for transportation in former streetcar neighborhoods were less than half of what they were in third-ring suburbs, even when income disparities had been equalized. More recent analysis by the CNT in the New York metropolitan area has shown that overall GHG production per capita is roughly 200 percent less in Queens streetcar neighborhoods like Jackson Heights when compared to lower-density, auto-oriented areas such as Great Neck, New York, a community that is less than ten miles away (Center for Neighborhood Technology, 2009).

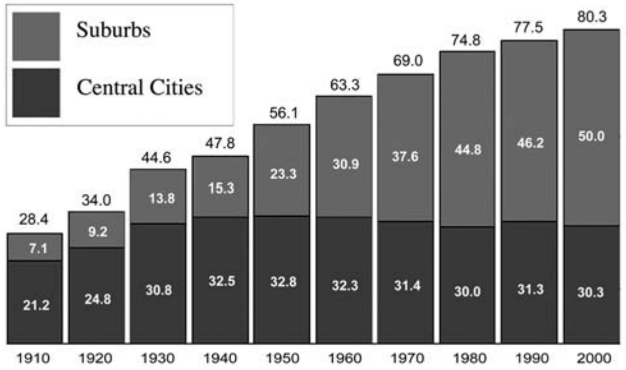


Figure 2.12. This table shows the percent of total population living in metropolitan areas and in their central cities and suburbs, 1910 to 2000. (Source: U.S. Census Bureau, dicennial census of population 1910 to 2000)

Figure 2.13. James Trowley presents a check to Twin City Rapid Transit company chief Fred Ossana as a streetcar burns behind them. National City Lines negotiated scores of contracts with transit agencies across the continent, requiring them to scrap their rail infrastructure as a precondition for attractive financial considerations. In 1960, Fred Ossana was convicted of fraud for activities associated with the conversion of Minneapolis streetcars to GM buses. (Source: Minneapolis collection, M3857)

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 certain. In 1949, the U.S. courts convicted National City Lines—a "transit" company owned outright by General Motors (GM), Firestone, and Phillips Petroleum—for conspiring to intentionally destroy streetcar systems in order to eliminate competition with the buses and cars GM produced. While it may seem impossible 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 remains. Only by perusing old photos can one sense the extent of the destruction.[11] Now, some sixty years later, elements of this system are being painfully replaced at great cost. The LA area Metrolink system has restored 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 and spatial characteristic of the streetcar city. This obvious fact has been ignored at best and derided at worst. 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 blithely sacrificed for parking lots. Yet, very few of us live within walking distance of a "node," whereas 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, has not been immune to this planning habit. The Vancouver region's consensus vision, the Livable Region Strategic Plan (LRSP), adopted in 1995, has several

[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" (Bianco, 1998, p. 10). 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).

Figure 2.14. Original streetcar routes highlighted in the Whittier Heights District of Seattle show the linear nature of a streetcar city.

key objectives, all laudable and pathbreaking. Two of the most important objectives are to create complete communities through "regional town center" nodes where people can live, recreate, and work close to home, and to link these complete communities by high-speed transit.

The regional town center nodes were identified on the LRSP map as relatively small nodes and were defined in the text as locations where jobs, homes, and commercial services were to be found at densities and intensities tens of times higher than surrounding districts. The plan was mute on the role of districts between the regional town centers, which constituted more than 80 percent of the urban landscape. These other areas were, and still are, the areas where most transit trips originate, where most jobs are located, and where most commercial services are

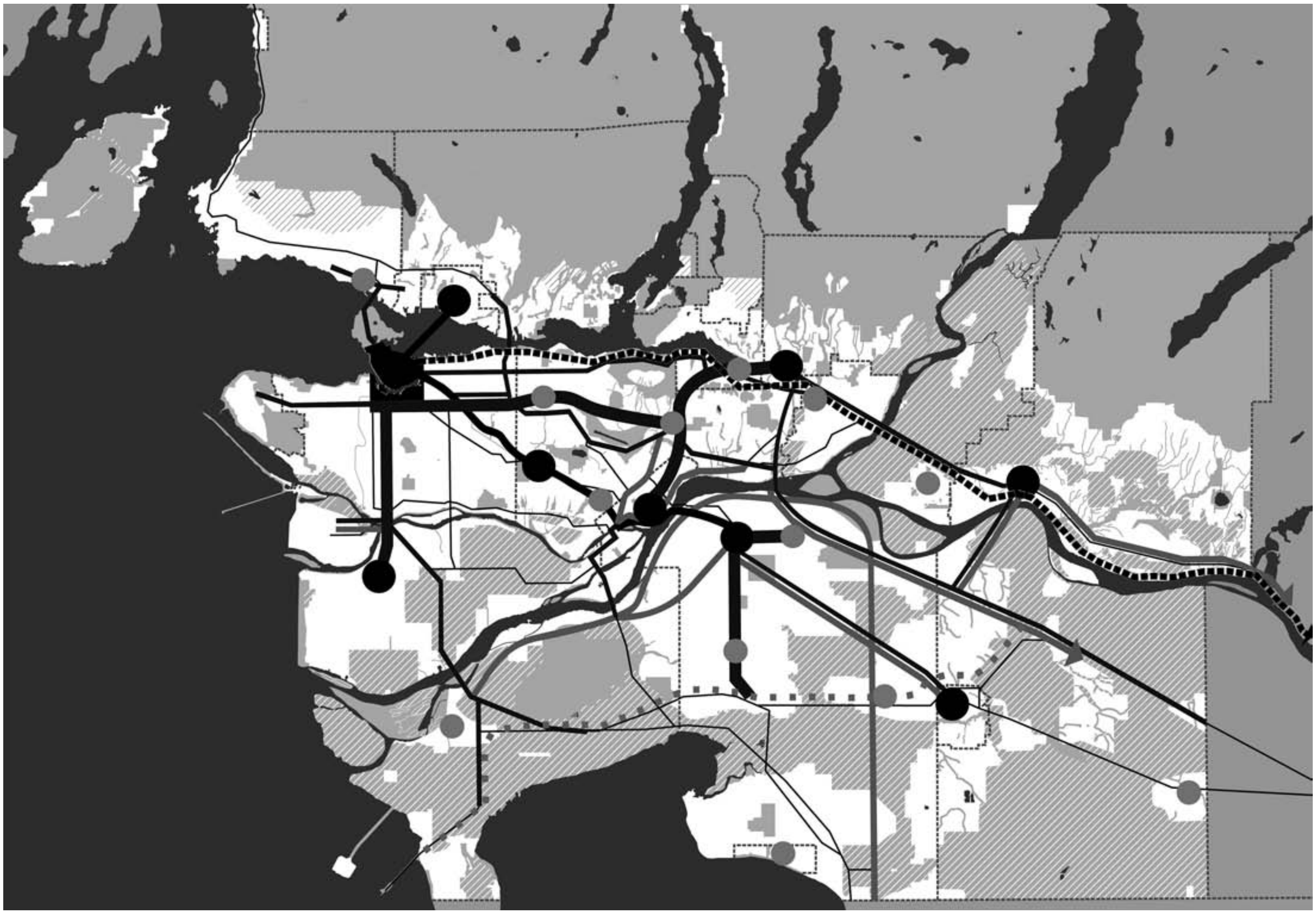


Figure 2.15. The Greater Vancouver Liveable Region Strategic Plan: Transportation and Town Centres.

to be found. The overemphasis on nodes led naturally to choosing a transit technology, the grade-separated "Skytrain" system (actually a scaled-down subway system), that was great for connecting the designated town center nodes but very poor at serving the streetcar city districts in between. Now, twenty-five years after the plan was first discussed, and fifteen 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 in this key respect by many of the region's authorities.

The province is now investing in controversial freeway expansion to, in the words of former British Columbia minister of transportation Kenneth Falcon, "fix the failed plan." The minister 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 one center node in the region. Other North American regions were not so fortunate. Officials in most other metropolitan areas have devoted infinite transit resources to 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 percentage 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 toward 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 capital expansion 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, which is antithetical to the original homogenous (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,

[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 (+17,300, 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, Belausteguigoitia, Fryer, and Straatsma, 2006).

and Denver have fallen into this hub-and-spoke trap. They have expended billions on new at grade and grade-separated "light" rail systems that only get users to traditional downtowns and cannot conveniently move them 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 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 which 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 United States 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 needed are close at hand. A trip that is five miles on a streetcar moving fifteen miles per hour takes a lot less time than a twenty-five-mile trip on a heavy commuter rail moving at forty miles per hour.

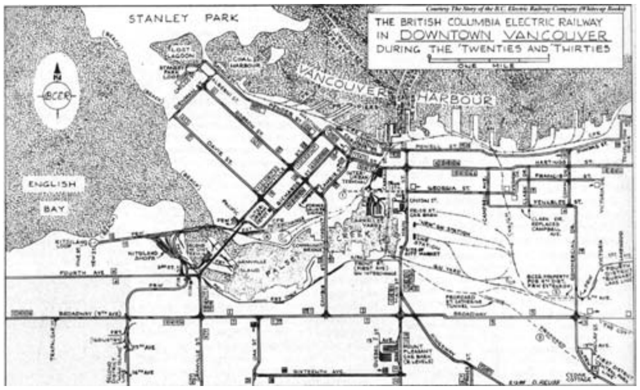
The common complaint that streetcars and buses cannot move at high speeds through urban streets is thus a red herring. It is not how fast you are going but how far you are trying to go. The streetcar city concept works in metropolitan regions where the average trip distance is a short one. Average vehicle-miles traveled (VMT) per day has been increasing for decades. This trend must be reversed. No sustainable region strategy can ever succeed that presumes 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 costs more and produces as much carbon per passenger as a fully loaded Prius. Getting people onto transit will not help defeat global warming 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 that favor short trips over long ones seem an obvious part of the solution. Inexpensive short-haul zero carbon transit vehicles, such as trolley buses and especially streetcars, are a likely feature 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 U.S. city to have made a serious effort to restore its 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, and commercial 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]

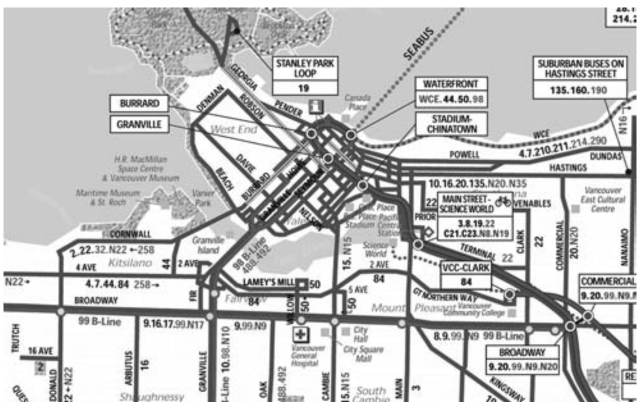
Other regions should follow Portland's example. Wherever the original streetcar city fabric is still in place, planners should reenforce that structure with transit investments. Citizens and officials in most U.S. and Canadian cities need only search archives for historical maps to discover exactly where these systems existed and how amazingly extensive they were. 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 will hasten the day when average VMT drops to sustainable levels. It also restores the universally accessible and democratically nonhierarchical regional system that is the defining characteristic of U.S. 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 one half to one mile, a legacy of the Land Ordinance Survey, and should support a transit system

[13]In the United States, 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.



(a)



(b)

Figure 2.16. The map of Vancouver's historic streetcar lines (a) matches up with existing transit routes (b) in Vancouver. (Source: Henry Ewert, *The Story of BC Electric Railway Company* (North Vancouver: Whitecap Books, 1986; Translink 2008)

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 urban region. Complete communities are communities where one needs to travel far less during the average day than is standard now; they are cities that dramatically reverse our ever increasing demand for transport.

BUSES, STREETCARS, LIGHT RAIL TRANSIT, AND SUBWAYS

When National City Lines disassembled the Los Angeles streetcar systems, they marshaled strong arguments in favor of rubber-tired buses (Bauer, 1939). 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, it is said. They are on rails, so if one gets stuck the whole system gets stuck. Streetcar vehicles cost more than buses. Buses do not need overhead wires to run. Buses do the same job as streetcars but do a lot more too. These arguments are often enough to end the matter. But let's approach the question from a different angle. It is not a question of buses versus streetcars, really. Since most metro areas are now investing in some form of rail transit, it is a question of what kind of rail transit makes the most sense: lightweight streetcar, medium-weight light rail transit (LRT), or heavyweight Skytrain or subway technology.

It is generally agreed 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 be used only 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 (Metropolitan Area Express) line, operates like a large streetcar in the center city, moving at slower speeds on crowded streets.[14] But once out of

[14]Portland's 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 States' second most ridden standalone light rail system, behind only San Diego.

the small downtown area, it operates as a grade-separated system with a dedicated right-of-way, widely spaced stations, and travel speeds of up to sixty miles per hour, similar to many other hub-and-spoke commuter rail systems.

Given these speed demands, Portland-style MAX technology costs a lot, about $50 million per two-way mile to build. Fully grade-separated systems, such as 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 to 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.[15] Officials in Portland were initially inclined to give up, but they didn't. They still needed a system to serve the northwest 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 there still manufacture them. A Czech company, Skoda Transportation, was able to provide the components of a system that could be installed, including rolling stock, for $20 million 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 was not that. The system is cheap because while it can run in dedicated rights-of-way at speeds of fifty miles per hour, 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 it does on the Green Line in Boston. The vehicles are so light that streets and bridges do not need to be rebuilt to support them. On regular streets, all that is needed is a twelve-inch-thick concrete pad within which to set rails. Aside from the pad construction, the street and the businesses that line it are not disrupted.

In Europe, streetcar and tram systems are being expanded much faster than heavier rail systems, gradually replacing buses on heavily used urban arterials.[16] They provide a much

(a)
(b)

Figure 2.17. Photo (a) shows a "light" rail Portland MAX vehicle operating like a streetcar in the foreground with a true light rail streetcar in the background. Photo (b) shows Portland's MAX line outside of the central city, where it travels large distances more typical of a light rail system. (Credit: available under the Creative Commons Attribution 2.5 License)

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

[16]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, including 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/

smoother ride for elderly people than do buses. With an aging demographic in which those over age sixty-five will soon constitute more than 33 percent of the population, a 200 percent increase over today, this is a key factor. Body balance is compromised as one ages. Unsteady rides on rubber-wheeled vehicles and buses that are hard to mount and stand in become increasingly difficult after age fifty-five, and almost impossible past age seventy-five. Low-floor streetcars are mountable at grade and are free of any lateral or orbital rocking motion.

Streetcars are always electric and thus generate no GHG direct emissions, and very low indirect 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 $1.23 per passenger-mile compared with $1.62 per passenger-mile for diesel buses.[17] The GHG consequences of this choice are much more dramatic. Diesel buses produce almost 200 grams of CO_2 per passenger-mile, whereas modern trams produce between 0.45 grams and 23.4 grams per passenger-mile (depending on electricity source). More details on these cost and energy relationships follow.

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.[18] 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.[19] 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.

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 World War II; however, more recently many cities in the United Kingdom and France have been reintroducing streetcars from scratch, after having had no light rail or tramway for more than a generation (Hyden and Pharoah, 2002).

[17]The average cost of new light rail construction in North America is $35 million/mile, excluding Seattle, whose $179 million/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). The streetcar line in Tampa, Florida, was built for $13.7 million, and the one 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 forty-foot transit bus costs between $0.4 and $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 for buses, primarily because of their higher capacity per driver. 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 twenty-five years, while that of transit buses is only seventeen 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 (Condon and Dow, 2009).

[18]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 in investment (Ohland, 2004).

[19]Hovee & Company, LLC, "Portland Streetcar Development Impacts" (2005), in *Portland Streetcar Loop Project Environmental Assessment* (January 2008).

Most attribute this impressive increase in investment to the presence of the streetcar line. 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 the site. These developers, the same ones who had created the highly successful streetcar serving Pearl District, knew from experience how important the streetcar is to success. If the free market tells us anything at all in this case, it is that the economics of the streetcar, when the value of new investment is included, is much more cost effective than an investment in rubber-wheeled diesel buses or heavy transit.

CARS, BUSES, STREETCAR, OR HEAVY RAIL? CASE STUDY OF THE BROADWAY CORRIDOR IN VANCOUVER

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 (UBC). Broadway has always been a good street for transit, even after the streetcars were removed. All of the density and access features described earlier in this chapter are found there. The corridor has a continuous band of commercial spaces for most of its length that are within short walks of residential densities greater than fifteen dwelling units per acre to ensure 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 buses with three- to five-minute headways. More than half of all trips on the corridor now are by bus, with over sixty thousand passenger trips per day.[20] Very frequent bus service has reinforced 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 in some portions curb lanes are transit only during peak hours. 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.

[20] G. Leicester, *Implementation of Transit Priority on Broadway Corridor*, prepared for GVTA Board of Directors (2006).

The buses on Broadway work very well; if they were never upgraded to streetcars, it would not be end of the world. But the corridor, because of its high ridership, is a candidate for substantial new transit investments. Using a modest amount of proposed funds to restore streetcars to Broadway makes good sense. Streetcars will reduce pollution, better accommodate infirm and elderly passengers, add capacity, provide everyone a more comfortable ride, cost less per passenger-mile over the long run than is being spent now, and attract investment where it is most desired.

WHAT IS THE OPTIMAL TRANSIT SYSTEM?

What evidence exists that streetcars are more cost effective over the long term than either rapid bus transit, which the corridor has, or heavier "rapid" transit, such as the Skytrain, which is being proposed? To get a useful answer to this question, it must be further asked: Cost effective for what? Over what distance? To serve what land uses? The question quickly becomes complicated. It helps to start by asking what the optimal relationship is between land use and transit, and what transit mode would best support this optimum state. Similarly, how do an increasingly uncertain oil supply and rising concern over GHG 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 one hundred years. 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 at UBC compiled the information needed 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.[21]

First, shorter trips. It does us no good to shift car trips to transit if average transit trips become longer and longer over time. Eventually, energy and resource reductions will be eaten up by increased vehicle-miles traveled per person on these new

[21]The full bulletin, summarized below, can be downloaded at http://www.sxd.sala.ubc.ca/8_research/sxd_FRB07Transport.pdf.

transit vehicles. If shorter vehicle trips are the long-term goal, what then is the best option to achieve this goal? In traditional streetcar neighborhoods, local buses and streetcars extend the walk trip, allowing frequent on and off stops for trip chaining, and accommodating typically short trips to work or to shop when compared to other modes. Thus, the walk trip is the mainstay mode of movement in streetcar neighborhoods, with the streetcar itself acting as a sort of pedestrian accelerator, extending the reach of the walk trip.[22]

While both buses and streetcars are effective ways to extend the walk trip, streetcars are much more energy efficient than diesel buses and even somewhat better than electric trolley buses.[23] Electrically powered vehicles also give the flexibility to incorporate "green" sources of energy into the mix—electricity from hydro, wind, or solar power that could, in time, completely eliminate carbon emissions from the transit sector. But even streetcars that get their energy from coal-burning power plants generate far less GHG per passenger mile than do diesel buses, as electric vehicles are far more efficient in converting carbon energy into motive force than are internal combustion engines.[24]

The capital costs for transportation modes such as streetcar, LRT, and Skytrain are relatively easy to determine because the large initial investment to build the transportation infrastructure (tracks, platforms, stations, and so forth) is generally tied directly to the project.[25] However, many costs associated with the use of personal automobiles, local bus service, and to a lesser extent bus rapid transit and trolleybuses are more difficult to determine because they operate on existing roadways, the construction and maintenance of which are not included in most cost calculations for these modes. For this reason, external costs that begin to place a value on the land and resources dedicated to automobile infrastructure are necessary to accurately represent the true costs of the system. Estimates for the capital and external costs per passenger-mile for each transportation mode are show in figure 2.20.

The next consideration is ongoing operation and maintenance expense. Figure 2.21 shows these costs, together with the capital and external costs. Energy costs are isolated from the operating expenses and shown separately according to present energy costs for each mode as well as the future increase in energy

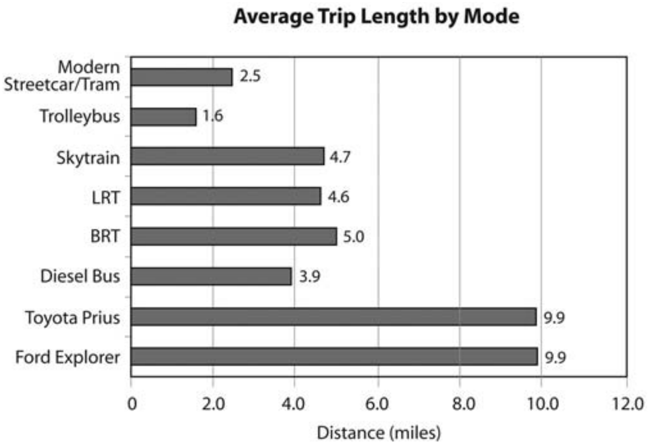


Figure 2.18. Average trip length by transportation mode. Data from APTA, 2009; Buehler et al., 2009; IBI Group, 2003.

[22]This hypothesis is borne out by data that shows that North American districts still served by streetcar or electric trolley buses or both exhibit shorter average trip lengths than other modes (2.5 and 1.6 miles, respectively). On the other hand, the average daily trip length in a personal automobile in the United States is 9.9 miles (15.9 km). Other trip length averages across the United States were found to be 3.9 miles (6.3 km) for local bus, 5.0 miles (8.0 km) for bus rapid transit, and 4.6 miles (7.4 km) for light rail transit (American Public Transportation Association, 2009; Buehler, Pucher, and Kunert, 2009; IBI Group, 2003). These values are represented in figure 2.18.

[23]According to Strickland (2008), internal combustion engines typically convert, at best, one third of their energy into useful work while electric motors generally have energy efficiencies of 80 to 90 percent. In addition, rail vehicles lose less energy to frictional resistance than do rubber-wheeled vehicles, and they are typically capable of much higher passenger capacities.

[24]Although the Design Centre for Sustainability's research bulletin focused primarily on the carbon emissions from the actual movement of vehicles, significant carbon emissions are also associated with vehicle manufacturing and maintenance, infrastructure construction, and fuel production. Recent research by Chester (2008) provides some insight into this question. He found that life-cycle greenhouse gas emissions are 47 to 65 percent larger than for tailpipe emissions from automobiles, 43 percent larger than for buses, and 39 to 150 percent for rail (streetcars, with their minimal construction requirements, would be on the lower end of this range, while Skytrain would be on the higher end) (Chester, 2008).

[25]To make a sound comparison of the long-term aggregate costs per passenger-mile associated with each transportation mode, we incorporated capital costs associated with acquiring the vehicles and constructing the infrastructure necessary to support them. The total cost was then amortized over the expected life of the system, and this annualized cost was divided by the actual annual passenger-miles recorded by various transit authorities for each mode.

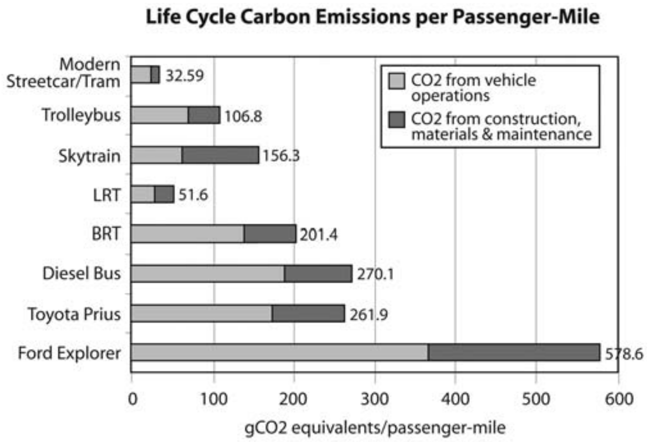


Figure 2.19. Carbon emissions per passenger-mile when electricity source is coal. (Source: Strickland, 2008; U.S. Environmental Protection Agency, 2005; Spadaro, Langlois, and Hamilton, 2000)

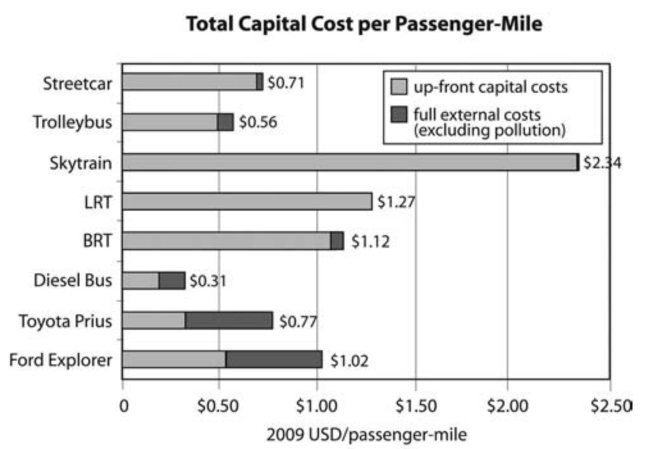


Figure 2.20. Total capital cost per passenger-mile by mode. Capital costs were calculated using construction costs and/or vehicle costs amortized over the expected life of the system. This annualized cost was then divided by the annual passenger-miles reported for each mode. Data from American Automobile Association, 2009; Translink, 2008; TTC, 2007; IBI Group, 2003; National Transit Database, 1998–2007; Portland Bureau of Transportation and Portland Streetcar Inc., 2008; Buchanan, 2008.

costs that can be expected as nonrenewable fuels such as oil become more scarce. Using full external costs (excluding the very difficult to assess costs associated with air and water pollution caused by transport), the Toyota Prius scores best per passenger-mile, with a total cost of $1.09, followed by the streetcar at $1.23. Even with negligible energy costs, the Vancouver-area Skytrain system is by far the most expensive, at $2.66 per passenger-mile.

The results shown in figure 2.21 show the cost of moving one person one mile. This kind of calculation tends to favor modes of transportation that typically travel longer distances. But since shorter trips are, in the context of this argument, more sustainable, it is useful to also look at the cost per average trip. Low average trip distance is a marker for a more sustainable district, as it indicates that the relationship between mode and land use has been optimized. Conversely, low costs per mile gain us nothing if the relationship between mode and land use is such that all trips are unnecessarily long.

The cost per average trip for each mode is shown in figure 2.22. In this scenario, the transportation modes encouraging land uses that support shorter trips (trolleybus and streetcar) are significantly more cost effective than modes that facilitate more spread out land use patterns (that is, modes designed for high-speed, long-distance trips).

It is important to note that the benefits of streetcar city development do not 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 absent a comprehensive urban infill strategy, modern streetcars are doomed to low ridership and anemic cost recovery (Gormick, 2004). The streetcar city principle is thus about more than just the vehicle, more than just the track. It is about a balance among 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 ensures that walking will be a part of the everyday experience for most residents and provides mobility for infirm users. It has been shown to induce substantial shifts away from auto use to transit use and can conceivably be introduced into suburban contexts.[26] It has also been shown to dramatically in-

[26]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 that 69 percent use public transit more often than they did in their previous community (Podobnik, 2002; Switzer, 2003).

crease investment in a way that neither buses nor expensive subway lines can. It is compatible with the trend toward 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 prewar and postwar urban landscapes, and beyond our ability to afford. At the other extreme, assuming that some technological fix, such as the hydrogen car, will allow us to continue sprawling our cities into the infinite future seems even more delusional. To heal our sick cities, we must recognize the physical body of the city for what it is and implement 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 provide both simple insight into our condition and a clear set of strategies that have proven themselves for decades.

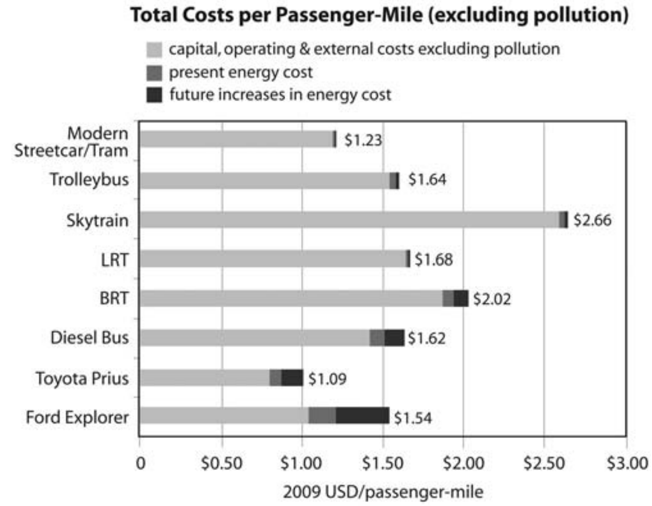


Figure 2.21. Total cost per passenger-mile. The total cost per passenger-mile was calculated by adding the capital, external, operating, and energy costs for each mode.

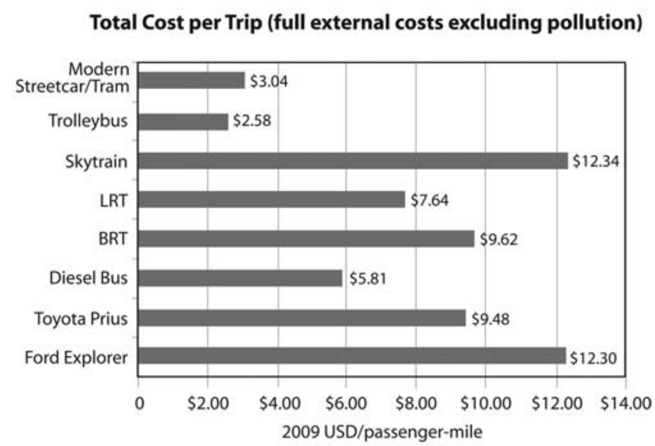


Figure 2.22. Total cost per trip. The total cost per trip was calculated by multiplying the cost per passenger-mile by the average trip length for each mode.

CHAPTER 3

Design an Interconnected Street System

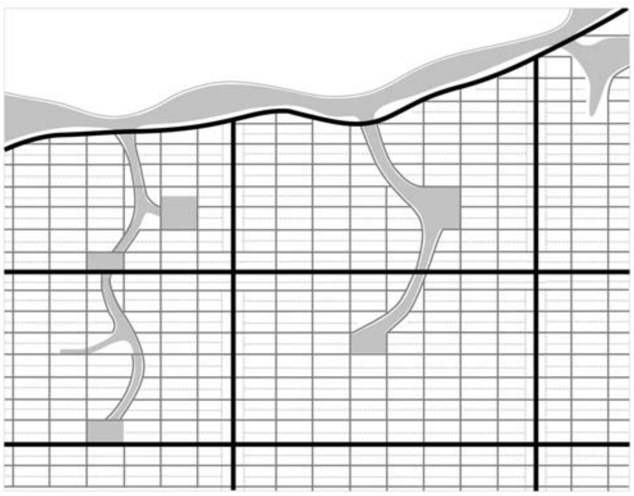


Figure 3.1. Interconnected streets are a vital part of a sustainable community. This diagram shows a rectilinear grid, but many variations are available. Curved, axial, and informal grids are all workable.

Street systems either maximize connectivity or frustrate it. North American neighborhoods built prior to 1950 were rich in connectivity, as evidenced by the relatively high number of street intersections per square mile typically found there.[1] Interconnected street systems provide more than one path to reach surrounding major streets. In most interconnected street networks, two types of streets predominate: narrow residential streets and arterial streets. In this book, for reasons explained in chapter 2, we call these arterial streets in interconnected networks "streetcar" arterials.

On the other end of the spectrum are the post–World War II suburban cul-de-sac systems, where dead end streets predominate and offer only one path from home to surrounding suburban arterials. This cul-de-sac–dominated system can be characterized as dendritic, or "treelike," the opposite of the web of connections found in interconnected systems. Streets in this system all branch out from the main "trunk," which in Canadian and U.S. cities is usually the freeway. Attached to the main trunk of the freeway are the major "branches," which are the feeder suburban arterial streets or minor highways. These large branches then give access to the next category down the tree, the "minor branches," which are the collector streets. Collector streets then connect to the "twigs and branch tips" of the system, the residential streets and dead-end cul-de-sacs.

The major advantages of the interconnected system are that it makes all trips as short as possible, allows pedestrians and bikes to flow through the system without inconvenience, and relieves congestion by providing many alternate routes to the same destination. The major disadvantages of the interconnected street system are that no homes are completely cut off

[1]A gridiron street system typically has a greater number of intersections per square unit area than a dendritic street system.