A Vision of Energy Efficiency

2004 ACEEE Summer Study on Energy Efficiency in Buildings -- Asilomar, Pacific Grove CA

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ABSTRACT

This report shows how land use, transit service, nearby shopping, pedestrian amenities, autos and annual auto mileage vary widely across four typical existing communities. These cold statistics are supplemented by photos to convey a sense of what typical neighborhoods look like and how acceptable consumers find them. The variation in land coverage by concrete/asphalt and the water consumption across neighborhoods is shown to introduce a web-based calculator for all the above variables. The Location Efficient Mortgage research and its results are also described. Policy recommendations are presented.

Introduction

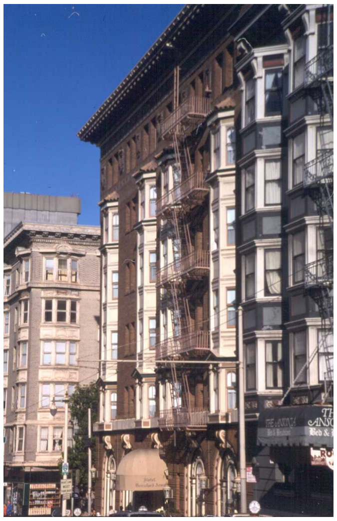
Neighborhood form impacts many aspects of energy and materials consumption, including auto ownership, driving, asphalt and concrete paving, building materials and heating and cooling energy, and water consumption. Smart Growth development can cut land, materials, water and energy consumption compared to sprawl development. Community Efficiency includes upon much more than mileage efficiency and building design. It begins with the design of the neighborhood itself, its density, provision of public transit, sidewalk and street design, proximity of job locations, and even simply allowing and promoting restaurants, groceries, pharmacies, hardware stores and child care in residential areas. Most communities in America have zoning which prohibits efficient communities. The examples herein are greyfields, or existing cities, which hold the most promise for community energy efficiency. However, they have strong implications for greenfield development.

Visioning Neighborhood Characteristics

Suburban sprawl development typically ranges from 1 to 5 households/residential acre (hh/res ac). Many neighborhoods prohibit sidewalks. Streets are generally wide, and their patterns often include cul-de-sacs, with collector streets connecting to through arterials. The resulting round-about route lengthens walking distances. Sprawl zoning prohibits neighborhood commercial development, so even a trip to the grocery for a bottle of milk often requires driving a freeway to a shopping center.

By contrast, in the North Beach area of San Francisco (including Russian, Nob and Telegraph Hills, and Chinatown and

Fisherman's Wharf), streets follow a rectilinear grid and are narrow; sidewalks are broad. Most buildings meet the sidewalk, and have small backyards. Buildings are multistory, mostly 3 or 4-story with a few to 30 stories. Street trees and nearby shopping are plentiful. Much neighborhood shopping is located on the ground floor of residential buildings. A three story over basement example, with no parking, is shown on the previous page. This is an example of 90 hh/res ac.



The densest census tract in the San Francisco Bay Area is shown on the left. This is a 3 by 4 block area just west of Union Square. Most buildings are 4 to 16 stories tall, with the tallest at 36 stories. The area contains abundant local shopping, 7 live theatres, fine hotels and cafes. It is over 500 hh/res ac, but only 15% of the land is residential land. There is very limited and expensive parking in the area.

San Pablo Avenue in El Cerrito CA is now a broad thorofare lined with parking lots, auto-oriented chain stores and abandoned buildings. Steve Price has conceptually transformed it, as shown shown below. Most present buildings are replaced by 2 and 3 story buildings, built to the sidewalk and featuring shopping on the ground floor. Wide sidewalks have been added, with street trees, and the roadway further narrowed by adding a broad center median with trees and light rail.

The transformed neighborhood is about 60 hh/res ac if no surface parking is included. Adding it reduces density by about half. The surrounding neighborhood is now single family houses on small lots with some two story apartment buildings, averaging 9 hh/res ac. If the only change to the whole neighborhood is the transformation of the properties along San Pablo Avenue, the resulting density of the whole neighborhood would be 15 hh/res ac, or a 67% increase with no surface parking; or 12 hh/res ac with surface parking. This shows how simply adding smart growth along major through streets can increase neighborhood density. And how addition of parking decreases density.

Neighborhood Form Impacts Driving

Let's compare four typical neighborhoods that vary widely in compactness, convenience and driving. Density is the most important single measure of community efficiency. Table 1 shows the average density of these neighborhoods.

The San Francisco suburb of San Ramon is typical of sprawl. At 3.2 units per residential acre, San Ramon consumes three times as much land per household as the Rockridge neighborhood in north Oakland, California, 30 times as much land as North Beach, and 60 times as much as Manhattan. Consequently, Rockridge saves 68% of the land that would be required to house the same number of families in sprawl. North Beach saves 97% of that land, and Manhattan saves 98.5%: huge environmental benefits.

Table 1. Attributes of Four Typical Neighborhoods

	Sprawl San Ramon CA	Transit Village Rockridge Oakland CA	Urban Center North Beach San Francisco	Metro Center Manhattan
Res. Density (hh/res ac)	3.2	10	100	200
Transit (veh/hr nearby)	1	27	90	very high
Shopping (5 w/in 1/4 mi)	no homes	25% of homes	all homes	all homes
Pedestrian amenities	low	medium	high	high
Autos/capita	.79	.66	.28	.12
Auto miles/capita	10,591	6,455	2,759	1,145
Ann. household auto costs	$8,200	$5,030	$1,900	$800
Housing sales prices	$295/ft^2	$407/ft^2	$1,858/ft^2	higher

(Holtzclaw 1994; Newman & Kenworthy 1989; *San Francisco Chronicle* 2002 & 2003)

It’s very expensive to provide good public transit to sprawling areas, where riders are few and routes necessarily long and time-consuming. Consequently, San Ramon has only 1 bus per hour within a ¼ mile of the average home. That compares to 27, mostly BART trains, in Rockridge, 90 in San Francisco, and even higher service in Manhattan.

Since markets, drugstores, restaurants and the like are prohibited from sprawling residential neighborhoods, no homes in San Ramon have 5 such establishments within a quarter mile, while 25% in Rockridge do, and all homes in North Beach and Manhattan do. I live in the North Beach neighborhood of San Francisco, and have more than 700 restaurants within a 1 mile walk, and even more markets. That’s convenience.

Pedestrian amenities include the street grid, sidewalks, buildings built to the sidewalk and safe traffic. A rectilinear street pattern gives the pedestrian more route options and shorter routes, as well as more frequent intersections to slow traffic and allow safer street crossings. Narrower streets slow traffic and reduce crossing distances. Buildings built to the sidewalk can provide weather protection and interesting store windows, and don’t require crossing a parking lot to enter. San Ramon had low pedestrian conditions with few sidewalks. Rockridge provides medium conditions. Both North Beach and Manhattan have high pedestrian amenities. Density, local shopping, public transit and pedestrian amenities are crucial to reducing auto ownership and driving. Notice that they typically vary together.

Consequently, San Ramon residents require 0.79 cars per capita, according to the U.S. census. Rockridge has only 0.66, while North Beach has 0.28, 1/3 as many as San Ramon, and Manhattan has 0.12, 1/7 as much. The average San Ramon resident annually drives 10,590 miles, compared to 6,455 in Rockridge, 2,760 in North Beach, ¼ as much driving, fuel consumption and pollution, and 1,145 in Manhattan, 1/9 as much. Annual household auto expenses are $8,200 in San Ramon, $5,030 in Rockridge, $1,900 in North Beach and $800 in Manhattan.

But do consumers want to live in these denser neighborhoods? Economists tell us the best measure of the value of a product is its sales price. The average 2002 – 2003 sales price of housing was $\$295/ft^2$ in San Ramon, $\$407/ft^2$ in Rockridge, $\$1,858/ft^2$ in North Beach, and probably higher in Manhattan. Residents of Rockridge pay 40% more than the residents of upscale suburb San Ramon; while the residents of North Beach pay over 6 times as much. Most of the higher cost of North Beach housing is due to higher "land cost," which increases to bring the final price to what the buyer will pay. Thus the market says location efficiency is popular. If much more location efficient housing were built the greater supply should bring down market prices, making them more affordable. So, the market is there to expand present location efficient neighborhoods, and build more such communities.

The Location Efficient Mortgage® Study of Auto Ownership and Driving

To explore auto use relationships in more detail, our Institute for Location Efficiency (an enterprise of the Center for Neighborhood Technology, Natural Resources Defense Council and Surface Transportation Policy Project) studied all the neighborhoods in the Chicago, Los Angeles and San Francisco metropolitan areas. This Location Efficient Mortgage® study of nearly 3000 neighborhoods showed that more compact urban neighborhoods are more convenient, and trips are much shorter so that residents walk, bike and take transit more. High density areas also have more shopping and better public transit service. We found the same pattern of more driving at lower densities in all three regions (Holtzclaw, et al. 2002).

These three metro areas differ widely in topography, one flat and two mountainous. One rustbelt, one sunbelt and the other a West Coast area that fancies itself European. Yet, the plot of annual driving against density looks almost identical, see Figure 1. In low density sprawling areas, below 5 hh/res ac, families in each area drive 20,000 to 30,000 miles annually. At 100 hh/res ac, families drive less than 5,000 miles.

We know single adults and families with children drive more than seniors. Yet, as Figure 2 shows, retired families in sprawl drive 30 to 40 miles daily, compared to only 10 to 15 for single adults or families with children living at 100 hh/res ac. This analysis used the Metropolitan Transportation Commission's Household Travel Survey. Density predicts our driving better than our stage of life.

Figure 1. Driving in Three Metropolitan Areas

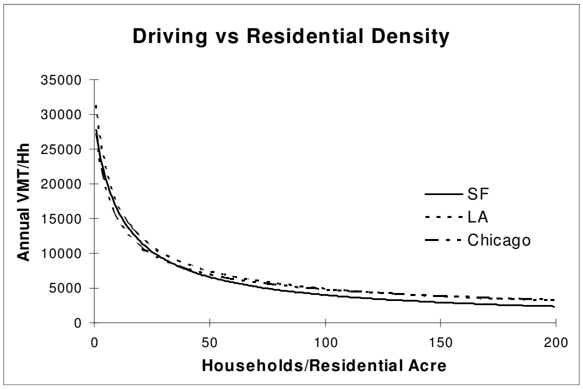
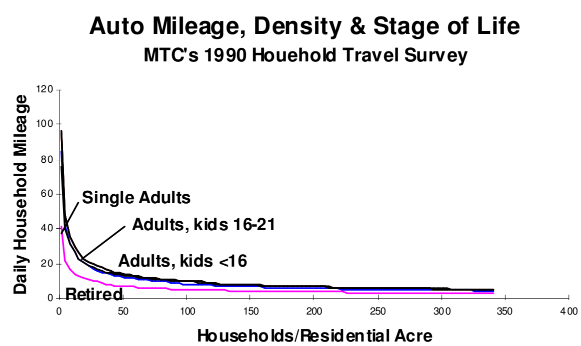


Figure 2. Driving by Stage of Life



Similarly, larger households need to drive more. Aggregating the data for the three metro areas gives Figure 3. Indeed, larger households drive more, but even smaller households living in sprawl drive 20,000 – 30,000 miles annually compared to the 8,000 miles driven by a large family living at 100 hh/res ac.

Figure 3. Driving by Household Size

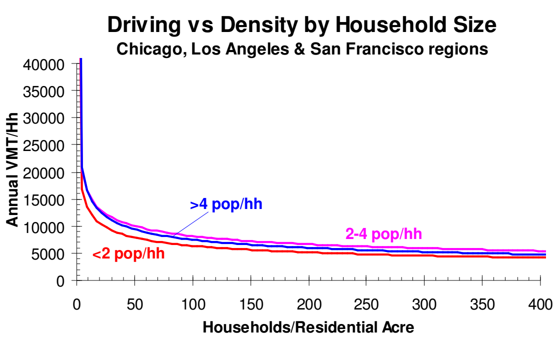
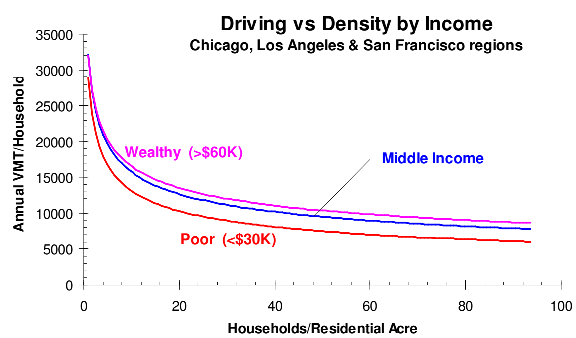


Figure 4. Driving by Household Income

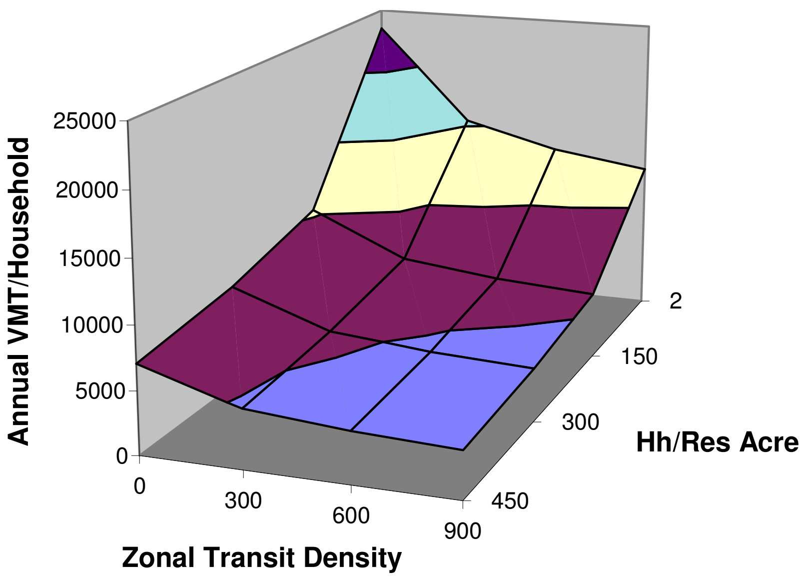


The poor drive less than the middle class or wealthy, as shown in Figure 4. But poor families living in sprawl still have to drive 20,000 – 30,000 miles annually. That's much more than the 10,000 miles driven by wealthier households living at 100 hh/res ac.

The Location Efficient Mortgage study developed a set of equations to predict auto ownership, driving per car and driving per household for each of the three metro areas. The nearly 3000 neighborhoods gave us huge degrees of freedom. Yet, these equations predict 79 to 96% of the variation in household auto ownership and driving between neighborhoods--using their density, household income and size, transit service and pedestrian/bicycle friendliness.

Using the equations for the San Francisco Bay Area, Figure 5 shows the annual driving of households with the regional average income and size. This family living at 2 hh/res ac with no public transit will drive about 25,000 miles (the high point on the graph). As transit service increases, with no change in density (follow the curve to the right), driving decreases. Similarly, as density increases even with no transit service (follow the curve to the left), driving falls off even faster. The near point in the curve shows that this family living in a dense area (450 hh/res ac) with high transit service will drive only 3,000 or 4,000 miles. But the curve also shows that a given modest increase in density or transit service will reduce driving more for those living in the lowest density and transit neighborhoods.

Figure 5. Impact of Density and Transit on Driving in the San Francisco Bay Area



Collateral Efficiencies of Compact Development

Not only is transportation more efficient in the dense areas, but other types of consumption are reduced too. Twenty years ago (Phillips and Gnaizda 1980) compared a run-of-the-mill apartment house on Nob Hill in the North Beach area with a state-of-the-art energy conserving houses in Davis, California. They found that residents of the sprawling area consumed much more land, construction materials, water and energy than urban residents, see Table 2. More comparisons are available at www.sflcv.org/density.

Thirty-five times as much natural habitat and farmland is lost to development in sprawl as on Nob Hill. Five times as much copper pipe (and wiring) are needed in the sprawl development. Four times as much lumber, but perhaps only twice the total building materials, are needed for the sprawl houses. But 15 times as much asphalt or concrete are required for the streets and driveways. More use of construction materials means more logging, mines and pollution. Scott Bernstein reports that “two-thirds of the weight of new materials entering the economy are for construction” (Bernstein 1999).

Seventy times as much water is required in sprawl, much of it for watering lawns. Davis has hotter summers, and accounting for that reduces the difference to perhaps 35 times as much.

More water use requires more dams and lowers stream flow. More driving requires more drilling, tankers and refining, emitting more pollution and global warming gases.

Despite their award-winning energy efficient design, the sprawl houses used 5 times as much heating and cooling energy. Thanks to exposing much more roof, walls and windows to the sun, rain and winds. Multi-family units share walls to conserve energy. Accounting for Davis' harsher climate could reduce that difference by half.

Table 2. **Urban vs. Suburban Materials and Energy Use**

Suburban homes use	* 5x the copper pipe	as a typical Nob Hill apartment
(Davis, CA)	* 35x the land	(San Francisco)
	* 15x the pavement	
	* 4x the lumber	
	* mail carrier travels 300x as far	
	* 70x as much water	
	* 5x as much heating	
	* 4x as much driving	

(Phillips & Gnaizda 1980)

Conclusions

The above data show that the construction of dense, beautiful, convenient urban areas – Smart Growth – can save building, utility and roadway construction materials by virtue of their density. Shared foundations, roofs and walls, shorter utility runs and less pavement could cut use of construction materials by half or more. Savings construction materials cuts logging, mining, manufacturing, transport and installation, saving energy, pollution and global warming gas emissions.

The convenience of such areas to jobs, local shopping and recreation, combined with safe attractive pedestrian ways, increases walking and transit use, reducing auto ownership and driving. Dense, convenient areas like North Beach in San Francisco cut auto ownership by 2/3 compared to households in sprawl, and cut driving by ¾, reducing fuel consumption, air pollution and global warming gas emissions by ¾. The reduction in driving will cut highway construction, further saving construction materials.

References

Bernstein, Scott. 1999. "Using the Hidden Assets of America's Communities and Regions to Ensure Sustainable Communities." For The Symposium on the Future of Local Government in Michigan. Michigan Municipal League Foundation.

Holtzclaw, John. 1994. Using Residential Patterns and Transit to Decrease Auto Dependence and Costs. San Francisco, CA: Natural Resources Defense Council.

Holtzclaw, John, Robert Clear, Hank Dittmar, David Goldstein and Peter Haas. 2002. "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use---Studies in Chicago, Los Angeles and San Francisco." *Transportation Planning and Technology*, Vol. 25(1), pp 1-27. March.

Newman, Peter and Jeffrey Kenworthy. 1989. *Cities and Automobile Dependence: An International Sourcebook.* Aldershot UK: Gower Publishing.

Phillips, Michael and Robert Gnaizda. 1980. "New Age Doctrine Is Out To Lunch on Three Issues: Villages, Recycling and Democracy." *CoEvolution Quarterly*. Summer.

______. 2002 & 2003. Sunday Real Estate housing sales summaries. *San Francisco Chronicle.* San Francisco, CA.