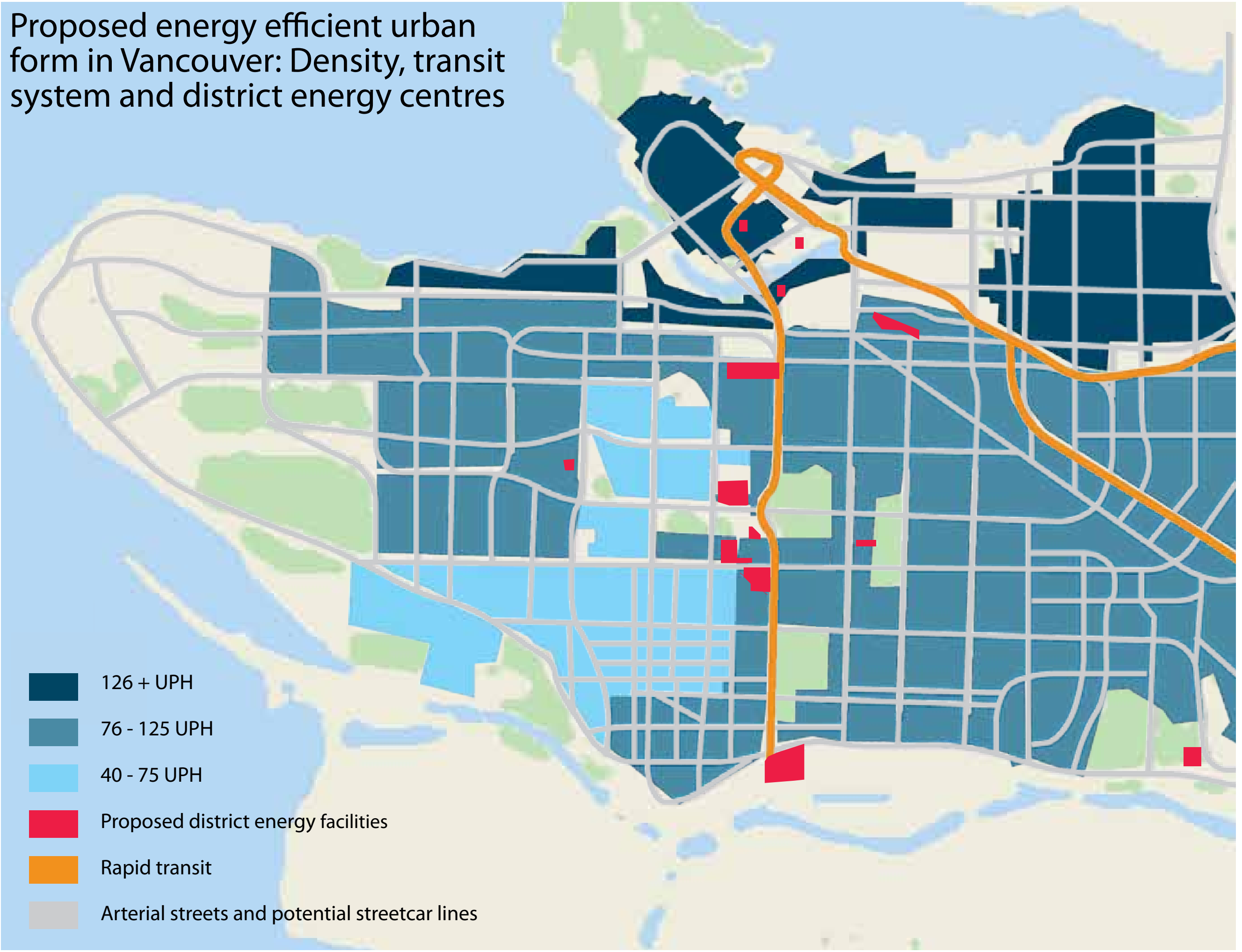
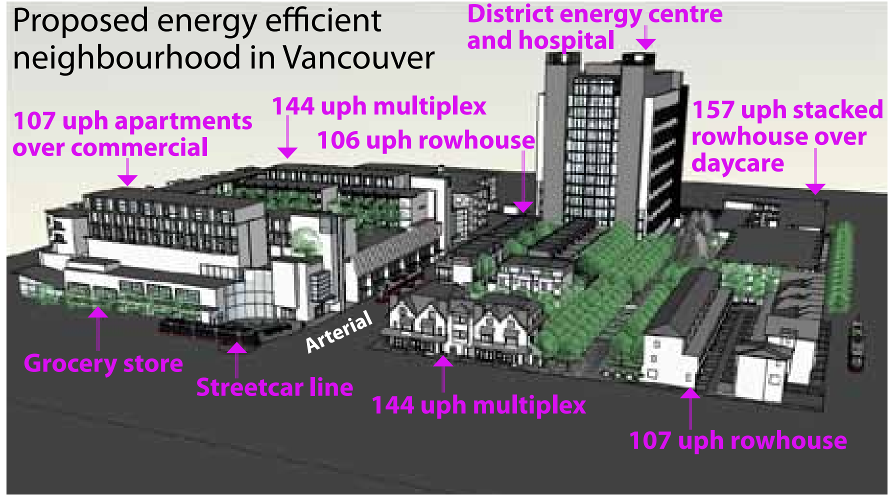


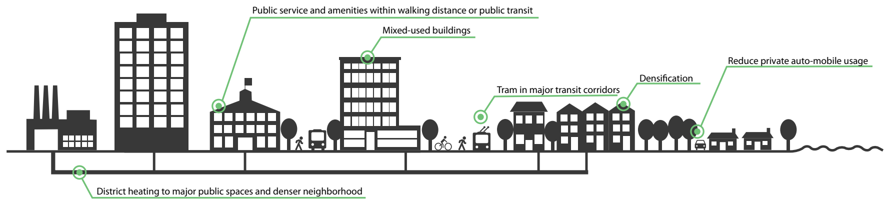
The undeniable link between energy and urban form must be considered when creating a set of strategies to guide the next 50 years of Vancouver's development towards an 80% reduction in Green House Gases (GHG). Energy (its use and its delivery) and built-form play a critical role in GHG emissions. The analysis in the subsequent sections of this chapter have resulted in some important conclusions that serve as important guiding strategies for the design of a 50 year plan. The diagrams on these pages synthesize the findings of this chapter, and are intended as initial design gestures. Density has emerged as an over arching theme in this chapter. Density allows for a decrease in car usage as well as an increase in the viability of efficient sustainable energy delivery. However, while the densification of Vancouver beyond its downtown core would allow it to reach the critical mass needed to provide district heating and adequate public transportation such as streetcars, there are important issues that need to be taken into consideration in order to utilize density in a more meaningful way. The proper distribution of density is important. Additionally, certain building forms, such as the ones illustrated on the diagrams on the facing page, are more energy efficient with lower embodied energy. The diagrams and conclusions in this chapter should serve as a toolkit for designing an energy efficient city.

Opposite:
Proposed energy efficient city diagram

Below, Top:
Proposed energy efficient neighbourhood in Vancouver

Below, Bottom:
Schematic section of an energy efficient, low carbon neighborhood in Vancouver





city form and ENERGY USE 2.0

TEAM MEMBERS: Rebecca Colter, Jia Cheng, Sam Mohamad- Khany, Sara Orchard, Niall MacRae

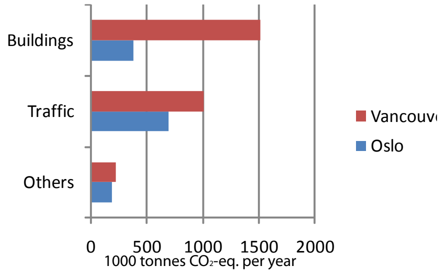
Design considerations for energy efficiency:
Vancouver can become more energy efficient with better transportation networks, intelligent built form and district energy centres

- Overall city form should have mixed use, high density and transit accessibility
- The most energy efficient built form is a four to six storey wood frame structure with energy smart technology
- Vancouver`s 80% reduction in GHGs would require transportation related energy consumption of no more than 9 giga-joules per capita per year
- Proximity to services and greater connectivity, particularly for sustainable modes of transportation (walking, cycling and streetcars) would allow for a reduction of transportation related energy.
- Move goods by rail into the city and encourage electrical freight cars in the future through proper infrastructure
- All buildings should be supplied by district energy

energy use

Lessons from Oslo's minus 50 plan. The city of Oslo leads the world in mitigating CO_2 emission and energy efficiency and can be used as a benchmark city to compare Vancouver's performance. The CO_2 emissions per capita in Oslo is 2.2 tonnes compared to 4.6 tonnes in Vancouver. The city has proposed to reduce total GHG emissions by 50%(1991-2030). Most emphasis in the mitigation plan is given to reducing oil-based heating and transportation.

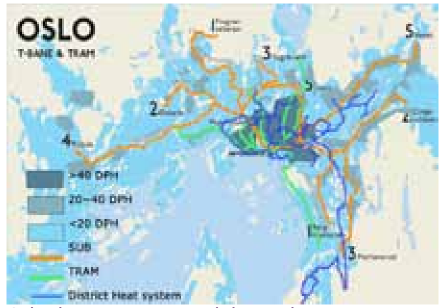
Vancouver and Oslo share a similar energy use and GHG emission pattern. Using the example of Oslo's minus 50 plan, the most effective way to achieve an 80 percent reduction in Vancouver's carbon emissions is to cut down GHG emissions from building heating and transportation. Providing district heating opportunities and efficient public transit at a regional and district scale are key strategies. However, a certain level of density would be necessary to make these services economically feasible. Generally the ideal density for district heating in Europe is over 50 UPH (units per hectare).



GHG emission by sectors

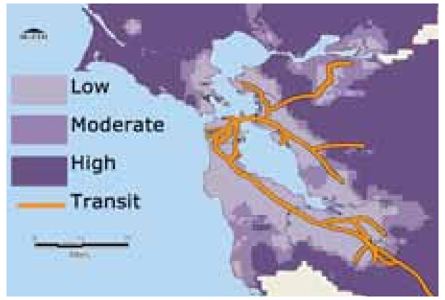
Over 80% of GHG emission from both cities come from buildings and traffic.

GHG emissions and city form. Studies in the San Francisco Bay area show that GHG emission per household reduces significantly in mixed-use, compact communities. When housing densities of 30-50 UPH are achieved, VMT (vehicle miles travelled) per household as well as the trip length reduce dramatically.

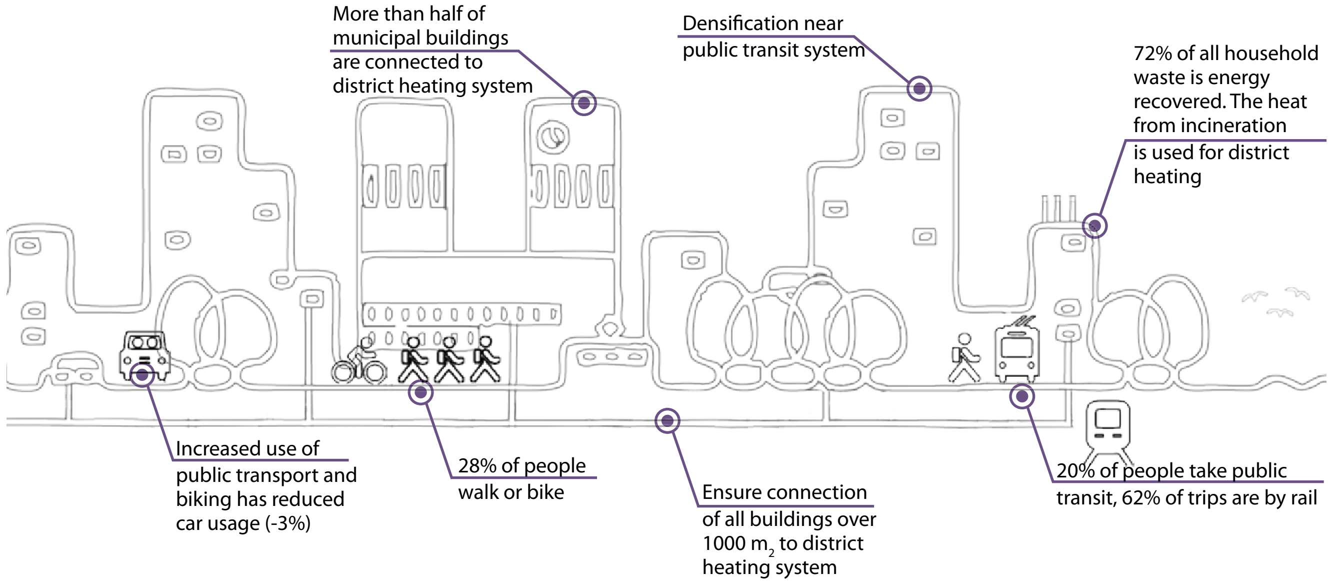


Oslo density, transit and district heating map

88 % of the population has easy access to the public transport system.



Bay area transit-related GHG emission trend



Oslo's GHG mitigation approaches

Top:
Vancouver density map (Dwellings per Hectare)

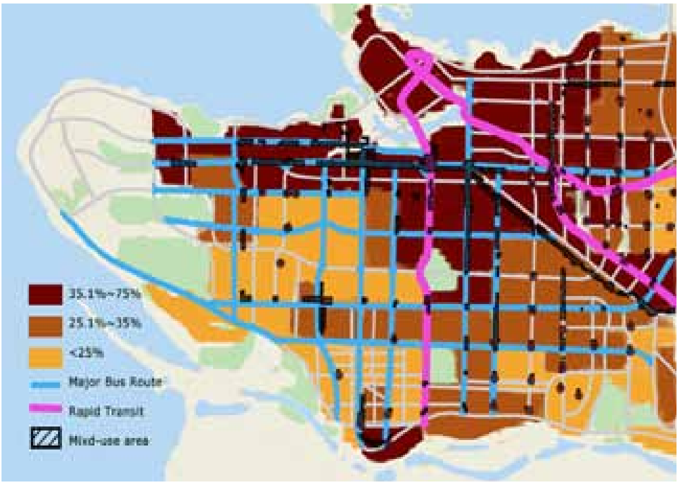
Large portions of the city fail to reach the optimal density for effective district heating and public transit.

Middle:
Vancouver GHG Emission Map (Total emissions per person per year)

People living in areas with higher density emit fewer GHG compared to those who live in low density areas.

Bottom:
Share of commuters using transit/bike/walk

People living in compact, mixed-use communities drive less.



city form and
ENERGY USE
at the district and regional scale

2.1

TEAM MEMBER: Jia Cheng

Design considerations for energy use:

3-D vision of future Density+Diversity+Design =Sustainability

Higher density, mixed used neighbourhoods with easy access to public transport systems have higher energy efficiency and lower GHG emissions. To achieve the goal of an 80% reduction in GHG emissions in 2050, Vancouver has to achieve higher density in major neighborhoods, increase diversity in land use, and introduce design strategies for efficient energy use.

- Cut down GHG emissions in building heating and transportation
- Provide district heating to public buildings and neighbourhoods that achieve a density of 50 UPH
- Design mixed-use communities: work, shop, play near home or near public transit (within 5~10min walking distance)
- Switch to a transit mode with higher efficiency and clean energy

References:
http://www.ssb.no/english/municipalities/0301
http://www.metrovancouver.org/about/statistics/Pages/CensusBulletins.aspx
http://vancouver.ca/
http://www.oslo.kommune.no/
www.miljo.oslo.kommune.no/.../1%20Oslo%20miljøpris/Siemens%20oslo%20event%20(2).pdf

low density | mid density | high density

Current building practice

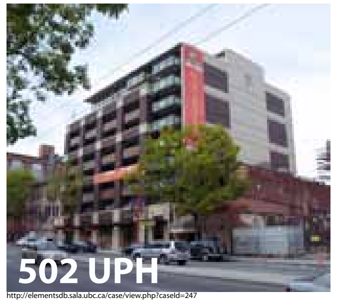
GOOD

31000 kWh/yr

http://elementsdb.sala.ubc.ca/case/view.php?caseId=155

4000 kWh/yr

http://elementsdb.sala.ubc.ca/case/view.php?caseId=257



7000 kWh/yr

http://elementsdb.sala.ubc.ca/case/view.php?caseId=247

Current building practice in Vancouver could be more energy efficient. Detached single family homes use the most energy, followed by high rises and then low rise buildings. Energy smart appliances, materials and glazing techniques are often used, although energy intelligent building policy should be enforced to encourage lower energy consumption.

Energy efficient building practice

BETTER

3000 kWh/yr

http://www.jetsongreen.com/2009/09/marken-passive-leed-platinum-home.html

2925 kWh/yr

http://inhabitat.com/2010/06/30/stylish-super-efficient-swiss-home-wins-the-2010-passivhaus-award/

Net Zero

http://s3.amazonaws.com/gbb/pictures/1214/featured/SEFC_Net_Zero.jpg?1266101909

Energy efficient building practices featured in the examples above include passive vertical ventilation systems, capillary mat radiant heating systems, solar thermal array systems, green roofs, geothermal systems, rainwater harvesting, greywater recycling, and constructed with low-VOC materials.

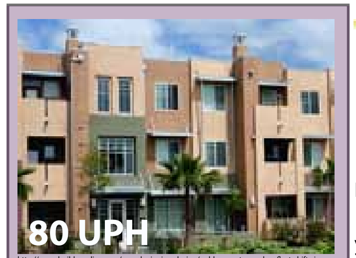
Energy production building practice

- Best examples for energy efficient buildings in Vancouver

BEST

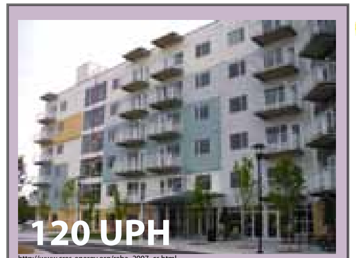
Net Zero

http://www.sabmagazine.com/blog/wp-content/uploads/2009/07/riverdale_ph01.jpg



Produces 142 kWh/yr

http://www.builderonline.com/award-winning-design/gold-nugget-awards-reflect-shifts-in-housing-landscape.aspx?rssLink=Gold+Nugget

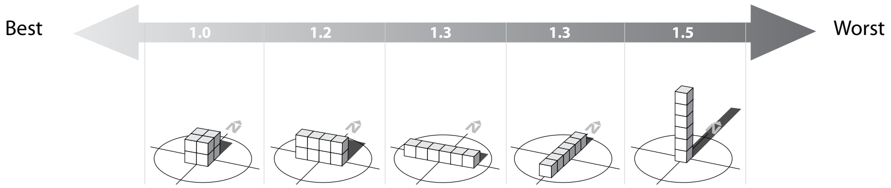


Produces 34,382 kWh/yr

http://www.cres-energy.org/reba_2007_cs.html

Energy producing buildings are now able to generate enough energy to cover the building's annual needs plus sell energy back to the grid. Efficient techniques include solar photovoltaic array systems, solar hot water heating system, passive solar gain, cleansing storm water, reducing water use, recycling construction waste, and educating residents on energy smart behaviour.

Effect of envelope to volume ratio on energy efficiency



City of Vancouver Passive Design Toolkit - Best Practices - November 2008

The BC Energy Plan Targets:

New single family and row house residential buildings	Achieve an EnerGuide for New Houses rating of 80 by 2010, reducing average energy consumption in new homes by 32%.
New multi-unit residential buildings	Achieve energy performance of 25% better than Model National Energy Code for Building by 2010, reducing average energy consumption by 37%.
Existing single family and row house residential buildings	Reduce the energy consumption in 12% of existing buildings by an average of 17% by 2010.
Existing multi-unit residential buildings	Reduce the energy consumption in 16% of existing buildings by an average of 9% by 2010.
New industrial, commercial and institutional buildings	Achieve energy performance 25% better than Model National Energy Code for Building by 2010 and reduce the average energy consumption by 20%.
Existing industrial, commercial and institutional buildings	Reduce the energy consumption in 20% of existing buildings by an average of 14% by 2010.

http://www.saveenergynow.ca/bcenergyplan

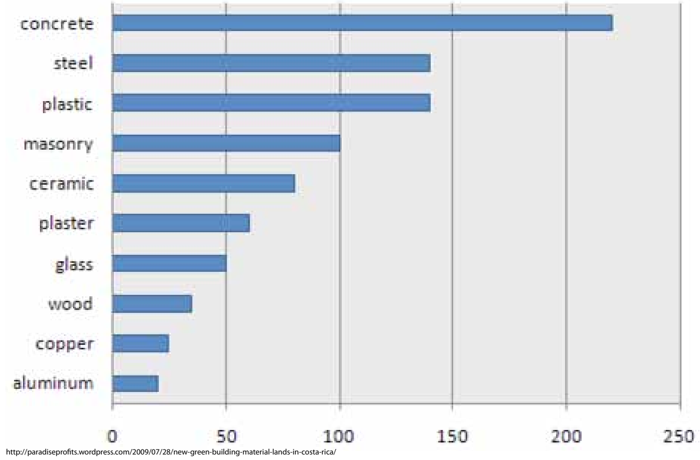
city form and BUILDING ENERGY use at the neighborhood, block and parcel scale 2.2

TEAM MEMBER: Rebecca Colter

Design considerations for energy efficient buildings and neighbourhoods:
Wood framed, mid rise, compact buildings are the most efficient

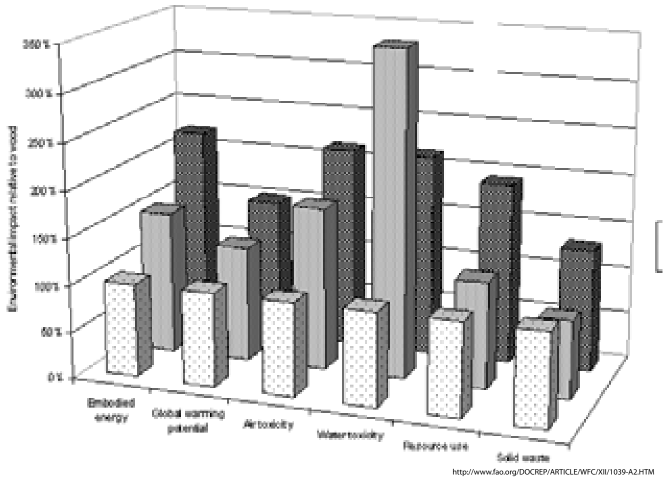
- Wood has the lowest embodied energy of conventional building materials
- Compact, 4-6 story buildings have the best energy efficiency
- Wood buildings sequester carbon and are better for the environment than steel and concrete

Embodied energy of common building materials

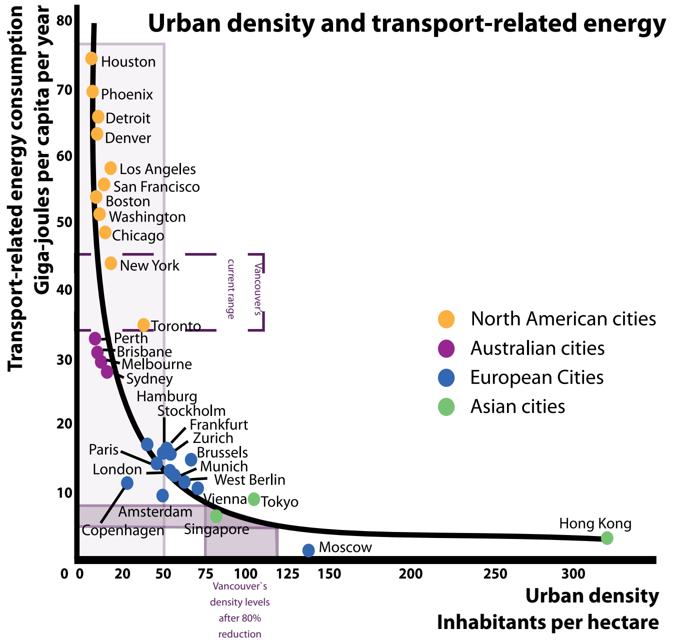


http://paradiseprofits.wordpress.com/2009/07/28/new-green-building-material-lands-in-costa-rica/

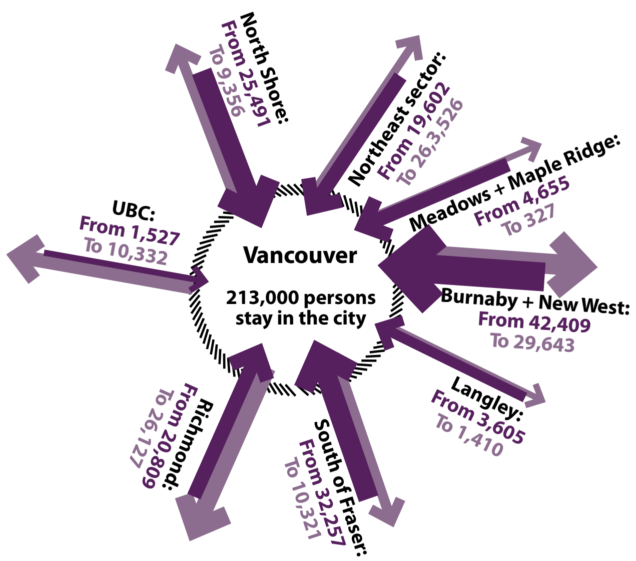
Environmental impacts of wood, steel + concrete

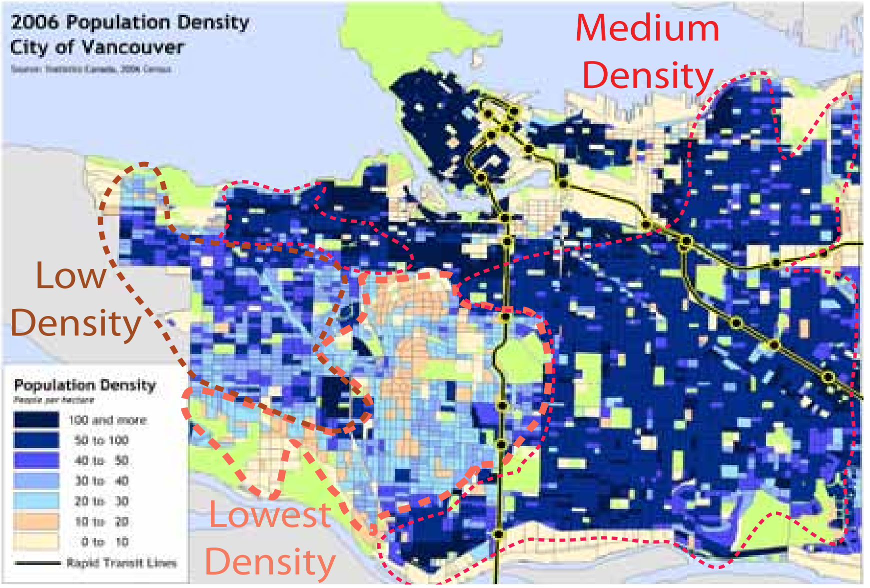


http://www.fao.org/DOCREP/ARTICLE/WFC/XII/1039-A2.HTM

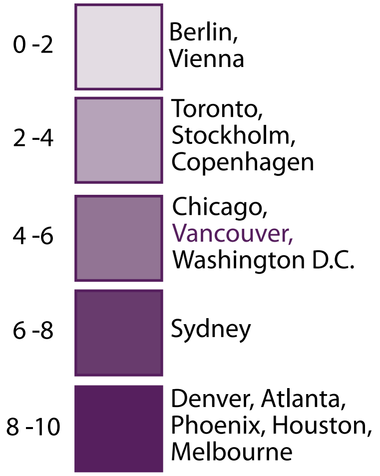


Commute Pattern, Vancouver and rest of Metro Vancouver, 2006





Road Length Per Capita (Meters/person)



If Vancouver is going to cut its GHG emissions by 80%, it needs to decrease its transportation energy consumption from its current levels of 35 to 45 giga-joules per capita to roughly 7 to 9 giga-joules per capita per year. In order to achieve this, Vancouver should aim for density levels of around 75 to 125 people per hectare (pph).

For an efficient transportation system, based on the streetcar model, a more uniform distribution of density across the city is recommended. Therefore, as illustrated on the opposite page, areas of low density need to catch up to these higher levels. This increase in density will support increased proximity of residents to services and a more connected transportation system. These strategies will play an important role in achieving lower energy consumption and GHG emissions.

Finally, we must recognize the role of Vancouver as the centre of the region, with a considerable number of people commuting to and from the city on a daily basis. This requires a strategy for public transportation connecting the city to its surroundings.

Opposite, top:
Left: There is a strong correlation between urban density (pph) and the amount of energy used (giga-joules per capita per year) due to transportation. Cities tend to cluster around the same range due to their similar urban form.

Right: It is important to recognize the influx of population to the city during 24 hours. (Source: City of Vancouver, http://vancouver.ca/commsvcs/planning/census/2006/popdensity.pdf, 2006, City of Vancouver, *Social Indicators & Trends Report, 2009*)

Opposite, bottom:
While the downtown core is quite dense the rest of Vancouver is less so. (Source: City of Vancouver, http://vancouver.ca/commsvcs/planning/census/2006/popdensity.pdf, 2006, City of Vancouver, *Social Indicators & Trends Report, 2009*)

Right: As a symptom of car dependency, there is generally more road length per capita in North American cities than in more compact European cities. (Source: Newman et Kenworthy, 1989, *Atlas Environment du Monde Diplomatique* , The Neptis Foundation, "Metropolitan poster")

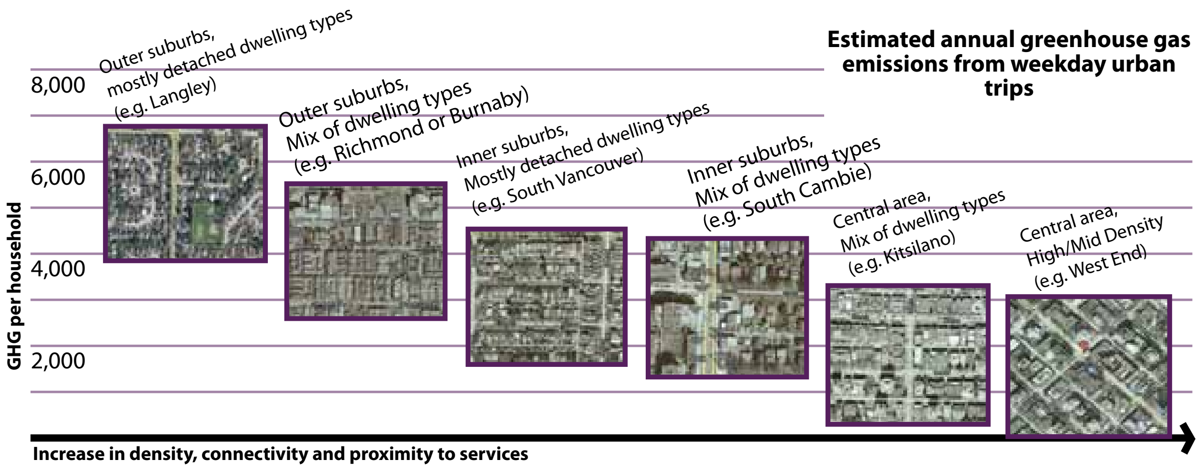
Below:
As density, connectivity and proximity to services increases, GHG emissions per household decreases. (Source: Canada Mortgage and Housing Corporation Travel Tool, 2001 Census data Corporation Travel Tool, 2001 Census data)

city form and energy use for
TRANSPORTATION 2.3

TEAM MEMBER: Sam Mohamad- Khany

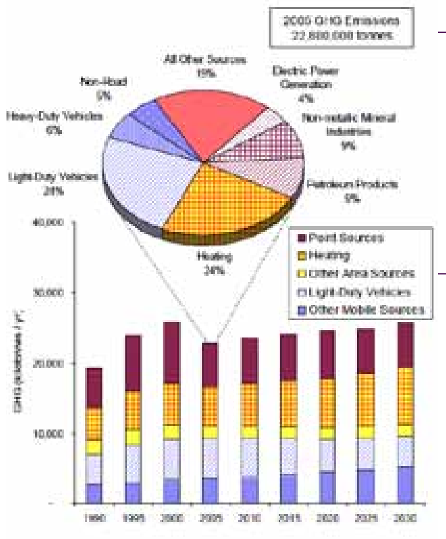
Design considerations for energy use and transportation:
There is a strong correlation between density, city form and energy use for transportation.

- Households in denser urban patterns - within 75 to 150 pph - consume significantly less transport related energy.
- Population density distribution in Vancouver is currently uneven, with areas of optimal density and areas of very low density.
- Higher density and increased connectivity will help reduce transportation-related energy consumption.



Goods movement in the minus 80 city requires an large shift in logistical thinking. Increases in density and mixed-use development will require an increase in the ability to move goods into and throughout the city. Currently, goods transport within the city is the most energy intensive segment of point-to-point goods movement. Heavy- and light- duty trucks account for the highest GHG emission totals and vehicle kilometers travelled (VKT) of all modes of freight transportation. The greatest portion of those totals occur within the metro area.

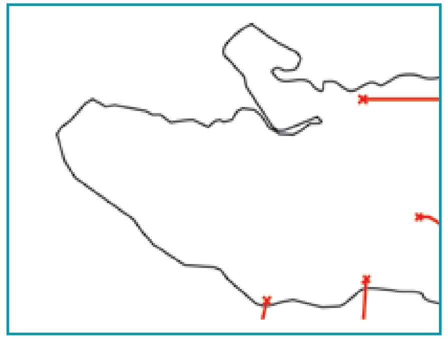
Lower mainland data shows that roughly 56% of light truck trips and 40% of heavy truck trips run between retail, residential, warehouse, and service land uses. Improving logistical synergies and moving away from internal combustion (IC) vehicles for the short-range round-trip needs of urban goods movement is essential in the minus 80 city.



Metro Vancouver 2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast, Executive Summary, *December 2007*

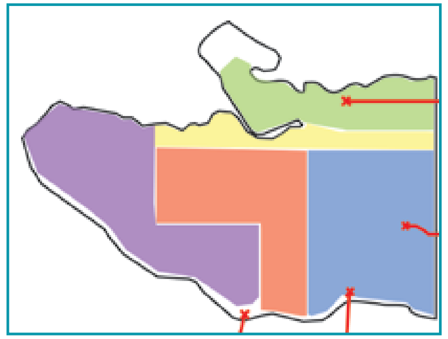
Goal 1. Limit VKT for heavy duty commercial trucks

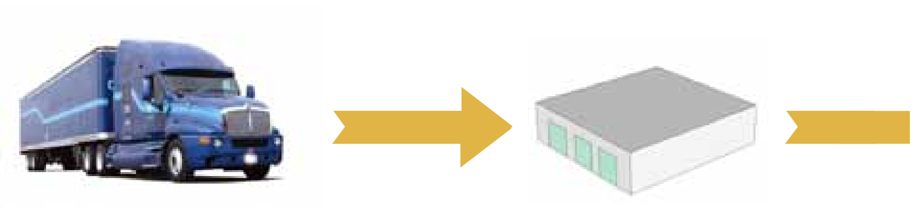
Method: Heavy trucks deliver freight and goods to large scale consolidation centers on the metro periphery.



Goal 2. Create a more efficient off-loading scheme

Method: Large district consolidation centers provide a centralized off-loading location for trucks and provide processing and sorting space for delivery catchment.



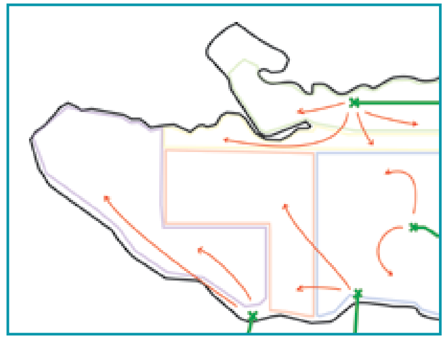


Reduction of heavy truck emissions depend on prioritizing them in city periphery access and limiting city interior access.

District consolidation centres make sense for merchants and businesses in compact mixed-use developments and improve the efficiency of goods movement. Centres receive, consolidate and store shipments and inventory of medium-sized, non-perishable goods. Combining deliveries and return shipments to and from multiple stores will ensure two-way-full loads and maximum efficiency.

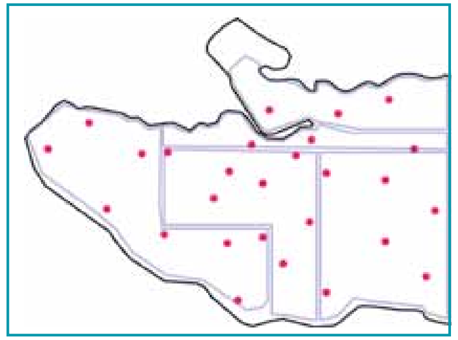
Goal 3. Minimize VKT for light duty internal combustion vehicles within the metro area

Method: Short range electric light- and heavy-duty trucks are utilized for delivery and goods transport within the city.



Goal 4: Create more efficient delivery schemes for residential and commercial addresses

Method: Neighborhood commercial consolidation centers increase the efficiency of commercial goods shipping, warehousing and recieving. Neighborhood large parcel pick -up centers or lockers reduce the need for door-to-door delivery services.



Average trip frequency in the region is 10 trips/day for light trucks and 8 trips/day for heavy trucks. Average trip length is 8.5 km for light trucks and 15.8 km for heavy trucks. At these distances, fully electric trucks could handle the bulk of goods movement needs within the city.

Smaller scale consolidation centers have shown reduction of 50% VKT for commercial centers in European pilot studies.
Residential door-to-door deliveries are unnecessary in a highly walkable city. Large package drop off at a centralized neighborhood location allows delivery vehicles to minimize their VKT, idling, and travel on small residential streets.

movement of GOODS in the minus 80 city

2.4

TEAM MEMBER: Niall MacRae

Design considerations for the movement of goods:
Improved goods movement logistics and delivery modes minimize GHG emissions despite increased goods movement demand in a more dense Vancouver.

- Reduce the VkmT totals of light- and heavy-duty vehicles associated with goods movement in the city.
- Move away from GHG producing modes of goods transport within the city.
- Increase the efficiency of goods movement to neighborhood businesses and commercial areas.
- Decrease the neccesity for door-to-door residential delivery.

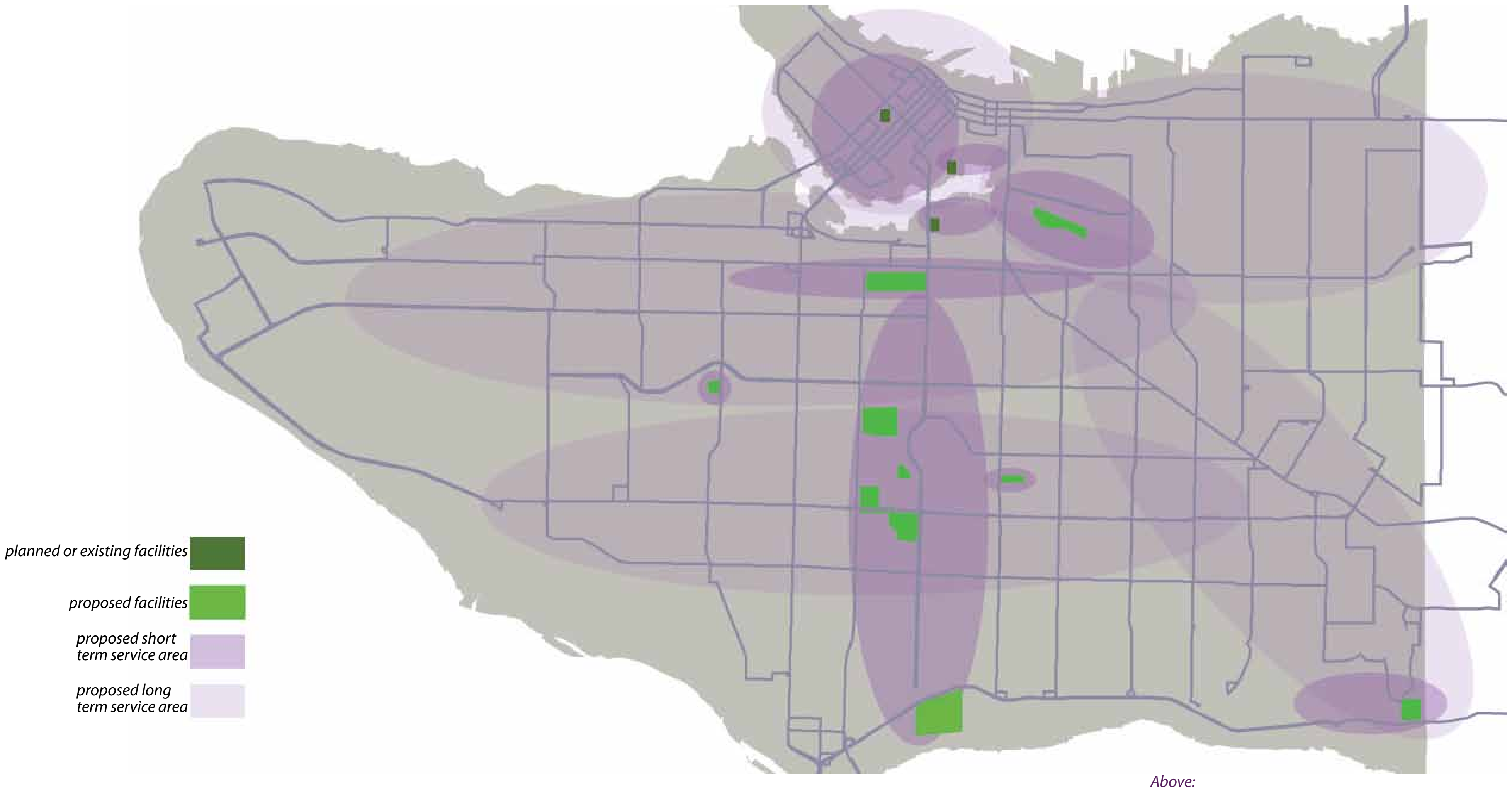
District energy is the centralized production of heating and/or electricity for a neighbourhood or community.[3] With the pressing need to reduce carbon emissions from energy use, district energy presents itself as a low carbon alternative.

Fuel sources for district energy systems often dictate the type of energy provided. For example, incineration often co-generates, providing both heat and electricity. An example of the breadth of fuel sources include:

- Solid wood, pulp and paper residues
- Municipal wastewater
- Municipal solid waste
- Agricultural residues
- Geothermal
- Biomass
- Ocean
- Solar and wind for back-up energy

Systems can also be engineered to be flexible in their use of fuel and are often easily retrofitted to newer technology. Many systems now have solar or wind power as backup to limit the use of other fuel sources.[3] Once a facility is built it is easier to expand the reaches of the system. Facilities also do not have to be limited to serving a neighbourhood scale, sometimes only one district energy facility is needed to service an entire city.[4]

In Vancouver, the District Energy strategy has been to evaluate existing buildings with excess energy and/or already existing district energy systems. Feasibility is based on the economic cost recovery of the system. Currently district energy is economically feasible in neighbourhoods with higher densities and a mix of uses. The potential expansion of the systems into lower density neighbourhoods is primarily dependent on the costs of doing so.[4]



Above:
Potential for future district energy in Vancouver based primarily on using existing infrastructure.

Opposite (from left to right):
Proposed geothermal district energy Germany (Image: http://www.hafencity.com/en/concepts/clean-thermal-energy-for-a-new-part-of-town.html)

Biomass district energy facility in Hartford, New York (Image: http://www.schooldesigner.com/Architects/CSArch-Architecture-l-Engineering-l-Construction-Management/Elements/)Alternative-Energy-Plant.asp

Notes

1 Morris, Pierce. "In the Pipeline: District Energy and Green Building" *Environmental Building News*. (2007) 16 no. 3
2 Energy Saving Trust. "The applicability of district heating for new dwellings" (2008) www.energysavingtrust.org.uk/housing (accessed October 17, 2010)
3 Province of British Columbia. "District Energy Infrastructure" *BC Climate Action Toolkit*. (2010) http://www.toolkit.bc.ca/tool/district-energy-systems (accessed October 8, 2010)
4 Baber, Chris. "City of Vancouver District Energy Strategy",. Phone Conversation, October 15, 2010.

DISTRICT ENERGY 2.5

low carbon energy of the future

TEAM MEMBER: Sara Orchard

Design considerations for the role of district energy:
It is realistic to envision the widespread use of district energy sources in Vancouver.

- Find potential in existing facilities with excess heat and/or existing district heating systems, for example industrial facilities, and hospitals.
- District energy is economically feasible when it serves a higher density neighbourhood. Mixed use areas are optimal because energy use is distributed throughout the day. Although technically feasible at any density, a minimum of 50-60 units per hectare is in general currently economically feasible.[1,2]
- When built with flexibility in mind systems are easily retrofitted to use the most appropriate fuel source. Similarly, when economic conditions are favorable for expansion into lower density neighbourhoods existing facilities can be utilized.
- Implement in higher density, mixed use areas first, for example along arterials in Vancouver context, before lower density ones