
OIL-FREE TRANSPORT
(How I Learned to Stop Worrying and Love the Trolleybus and Trolleytruck)

NOTE

- THIS TALK COULD HAVE MANY TITLES; IT SEEKS TO ADDRESS SEVERAL ISSUES AT ONCE.

- The flow of the discussion, and the points intended are not always evident; for instance, you miss the high fives, the jokes, the rationale for interurban snail transport, zoning anecdotes regarding carfree parking, and why you should ignore most of the early graphs. To name a few. Ask me.

Ousting the Technofix:

Why Grid Connected Vehicles and Human Transport Have Far More to Offer than Biofuels, Hydrogen, and Hybrids

June 18, 2008

Jason N. Meggs
School of Public Health
Environmental Health Sciences Division
University of California at Berkeley

jmeggs@berkeley.edu
(510) 725-9991

Oil-free transport:

Best case scenarios for livable cities in the post cheap-oil era.

June 18, 2008

Jason N. Meggs
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jmeggs@berkeley.edu
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Trolleybuses:

A "forgotten mode" with major benefits for transitioning to a carfree city

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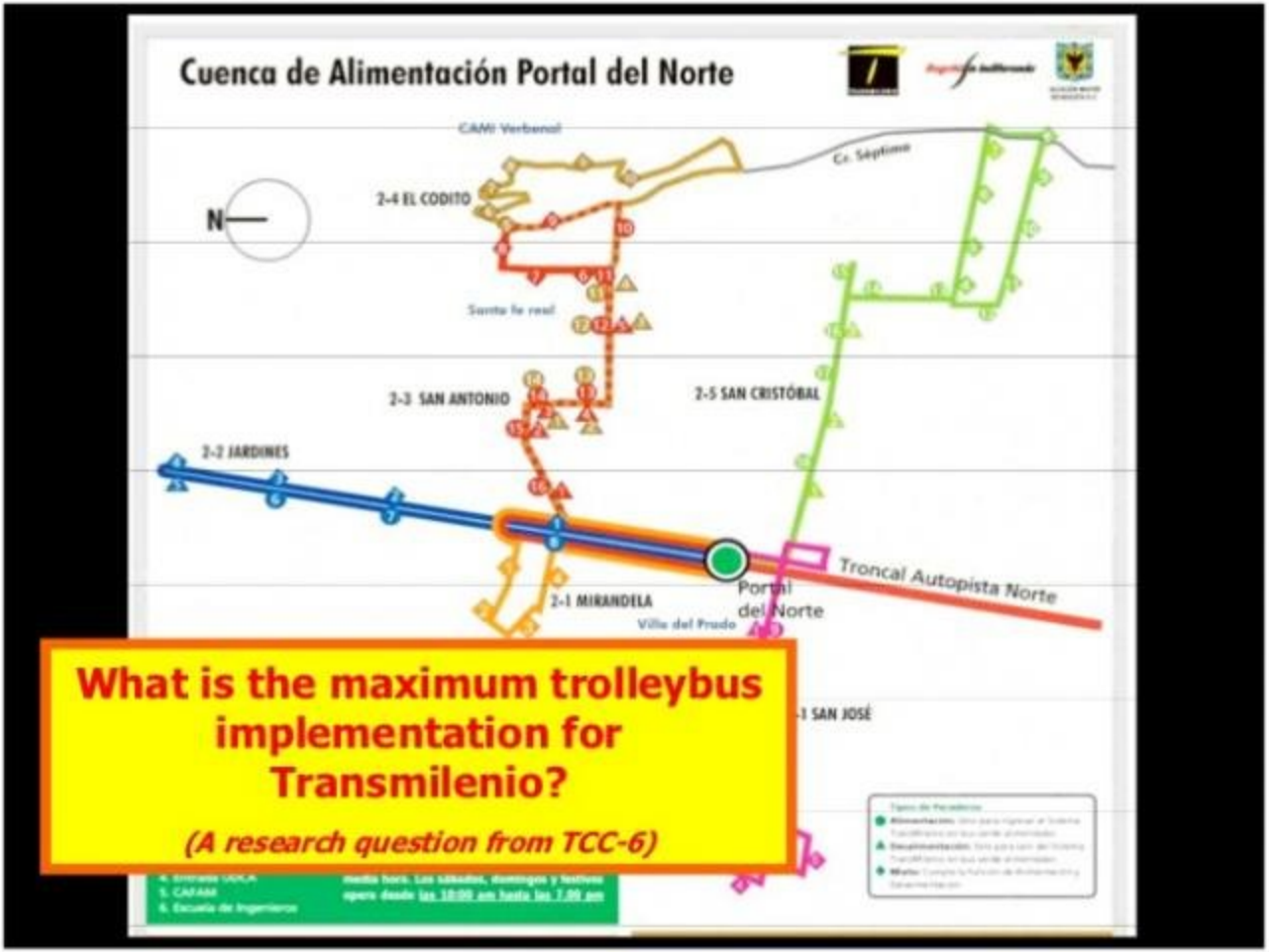
Cuenca de Alimentación Portal del Norte
CAMI Verbenal
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2-3 SAN ANTONIO
2-5 SAN CRISTÓBAL
2-2 JARDINES
Troncal Autopista Norte
Portal del Norte
2-1 MIRANDELA
Villa del Prado
-1 SAN JOSÉ
What is the maximum trolleybus implementation for Transmilenio?
(A research question from TCC-6)

TRANSPORT REVOLUTIONS

MOVING PEOPLE AND FREIGHT WITHOUT OIL

Richard Gilbert and Anthony Perl


ONE
LESS
CAR


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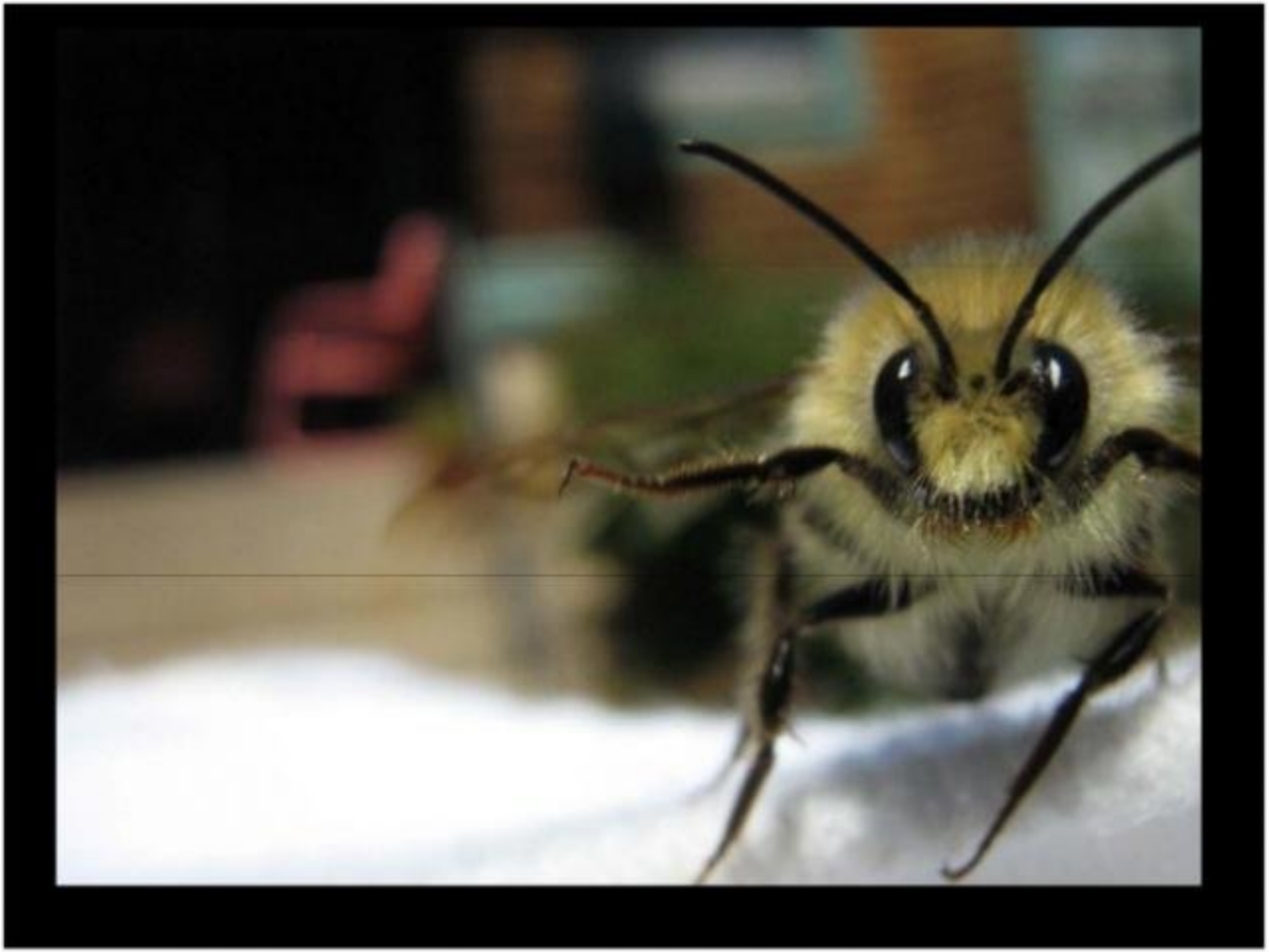
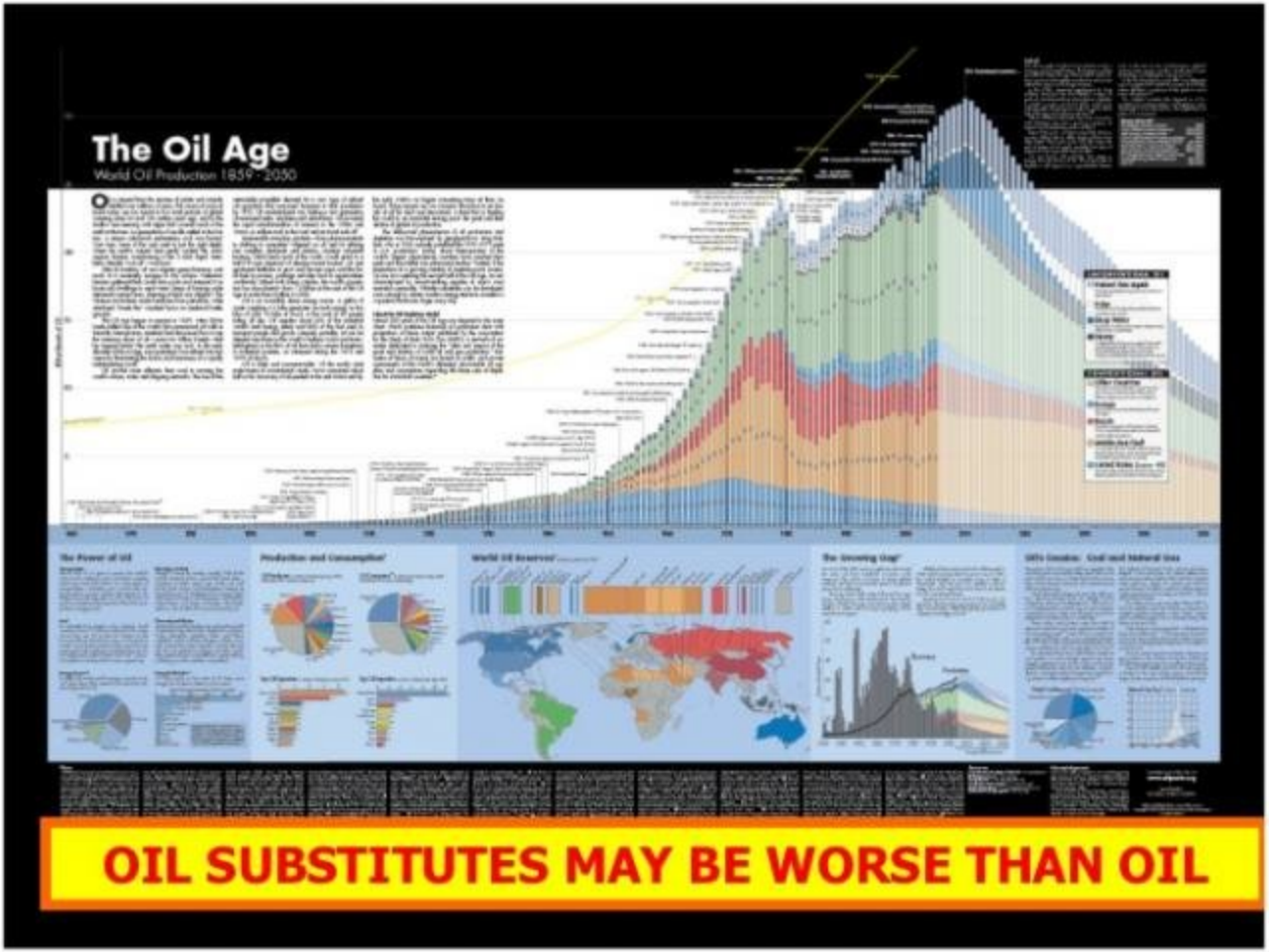
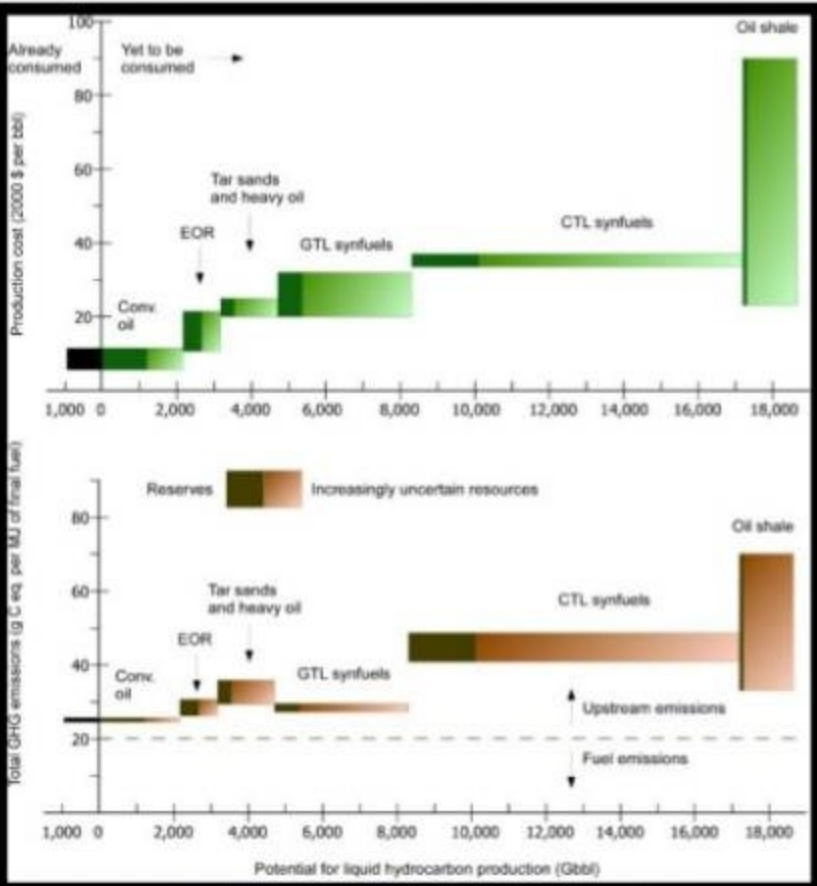


That is to remind us
that cities can be
vibrant, livable, alive.

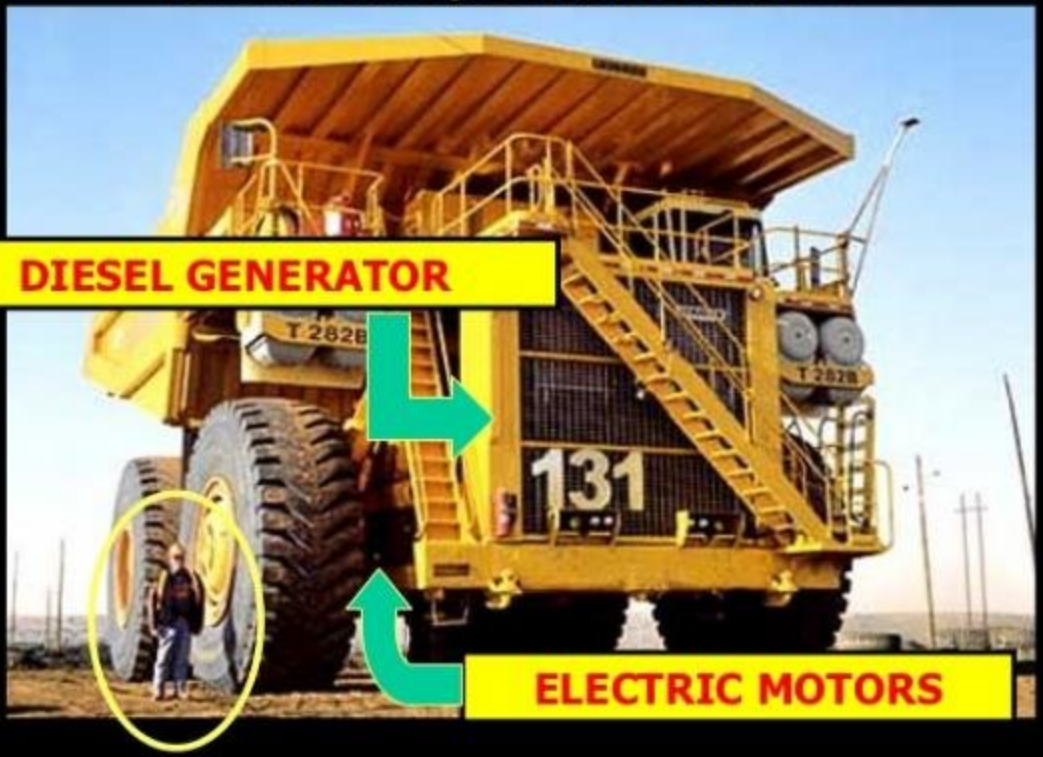
THE REALITY IS DIRE


The Oil Age
World Oil Production 1859 - 2030
OIL SUBSTITUTES MAY BE WORSE THAN OIL



Farrell & Brandt, 2006, *Risks of the Oil Transition.*

The full weight of the machine is 592 tons. Length - 14,5 meters; width - 8,8 meters; height - 7,4 meters. Lifts 363 tons.



Source: http://www.autolenta.com.ua/rating/Avtogiganty-chast-1-Nazvalsja-gruzom-polezai-v-Liebherr-T-282-B/


SKY 9
LIVE
BREAKING NEWS
BURBANK
KCAL 9

Lifecycle Analyses Usually Ignore the TOTAL Transport System and often ignore many of the externalities.

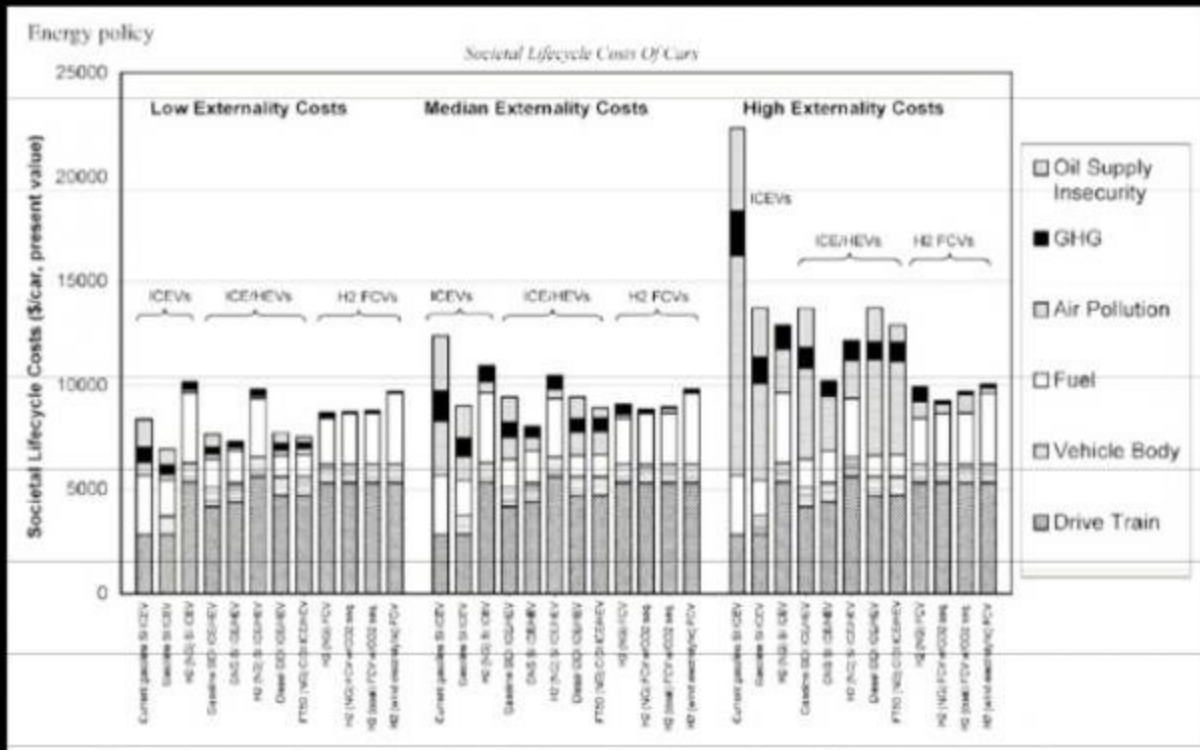


Fig. 2. Lifecycle costs for cars with alternative fuel/engine options and low, median, and high estimates of externality costs.

Societal lifecycle costs of cars with alternative fuels/engines

Ogden et al. Energy Policy 32 (2004) 7–27

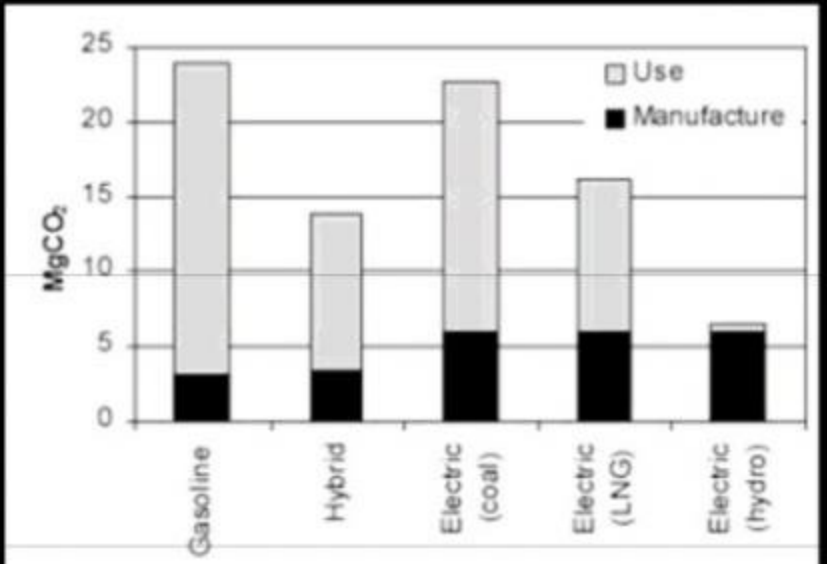


Figure 1 - Total carbon dioxide emissions over the lifetimes of gasoline, hybrid, and electric cars. The electric car is shown three times, with differing use energies depending on the method of generating electricity: coal, liquified natural gas, or hydroelectric.

Source URL:
http://www.ilea.org/lcas/taharaetal2001.html

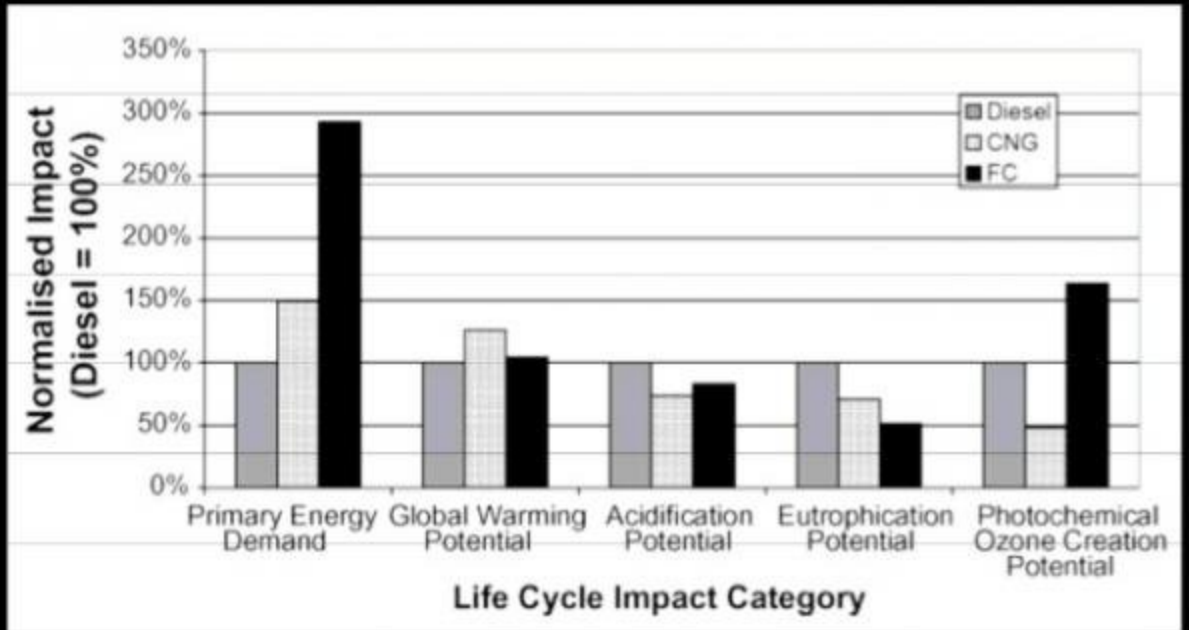
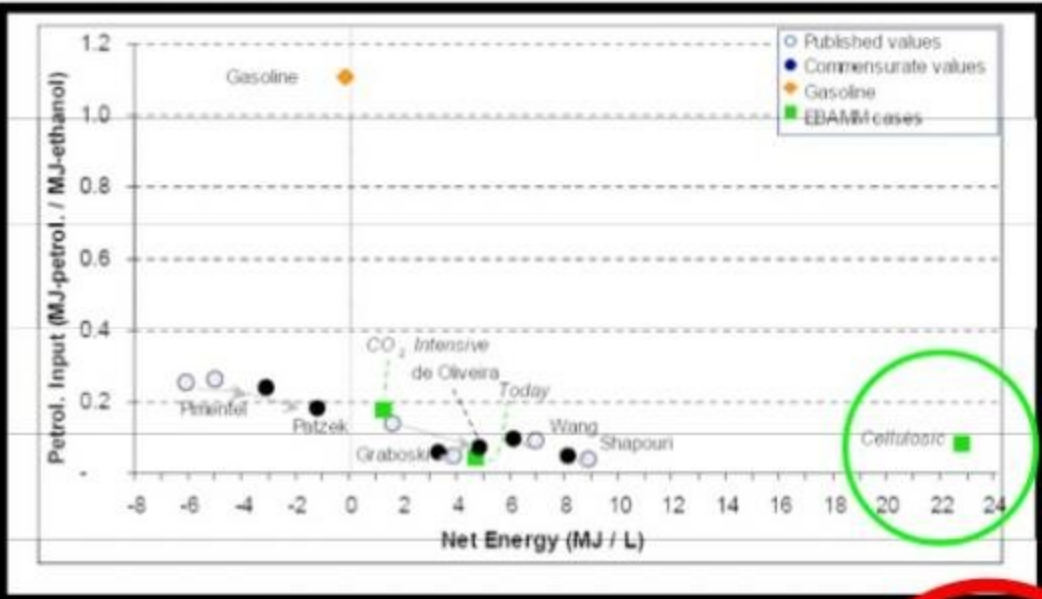


Fig. 3. Life-cycle impact assessment results. Bars normalized to set the reference diesel system at 100%.

Life-cycle assessment of diesel, natural gas and hydrogen fuel cell bus transportation systems

Ally J, Pryor T. JOURNAL OF POWER SOURCES, Volume: 170 Issue: 2 Pages: 401-411. JUL 10 2007



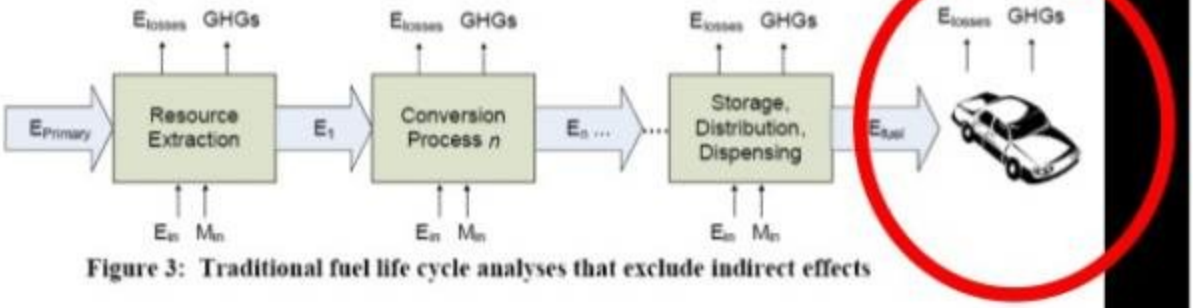


Figure 3: Traditional fuel life cycle analyses that exclude indirect effects


FUEL
EVERYTHING ELSE

Electricity and Mass Transport

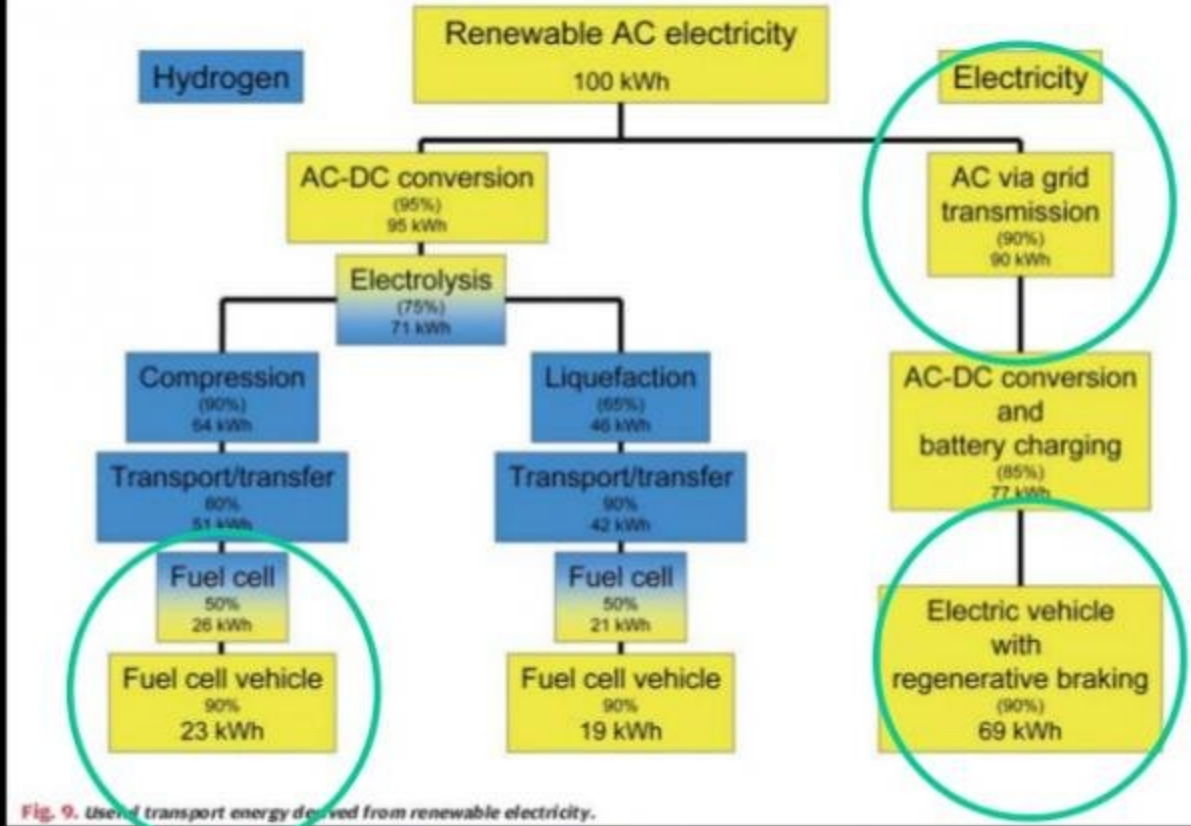


Fig. 9. Useful transport energy derived from renewable electricity.

Bossel, 2005. Does a Hydrogen Economy Make Sense? http://www.efcf.com/reports/E21.pdf

Direct Electric Drive

(Grid-Connected Vehicles, GCVs)

Key Points

- Electricity is a universal medium of exchange, it can come from many renewable sources
- Air and noise pollution can be greatly reduced
- Energy can be recaptured by braking (30-70%)
- Higher torque at outset (power & acceleration), means faster trips, fewer vehicles & drivers
- Direct connection to grid is most efficient
- High capacity transit changes the urban form, increases walking & biking, reduces driving

Source: http://www.autolenta.com.ua/rating/Avtogiganty-chast-1-Nazvalsja-gruzom-polezai-v-Liebherr-T-282-B/

TROLLEYS

Source: http://www.tbus.org.uk/uitp5.jpg

Clean, Quiet, Fast, Efficient, Long-lived

TROLLEYS AROUND THE WORLD

	systems	vehicles
Austria	4	131
Belgium	1	20
France	6	199
Germany	3	104
Greece	2	350
Italy	14	388
Netherlands	1	48
Norway	1	15
Portugal	1	20
Switzerland	15	618
totals	48	1893

	systems	vehicles
East Europe	64	4482
West Europe	48	1893
Eurasia	189	26666
North America	9	1926
South America	13	828
Africa	0	0
Australasia	1	60
Asia	39	4810
totals	363	40665

Source: http://www.tbus.org.uk/article.htm

(On the street AC Transit FC: 16,329 kg.)

Table 2
General bus specifications

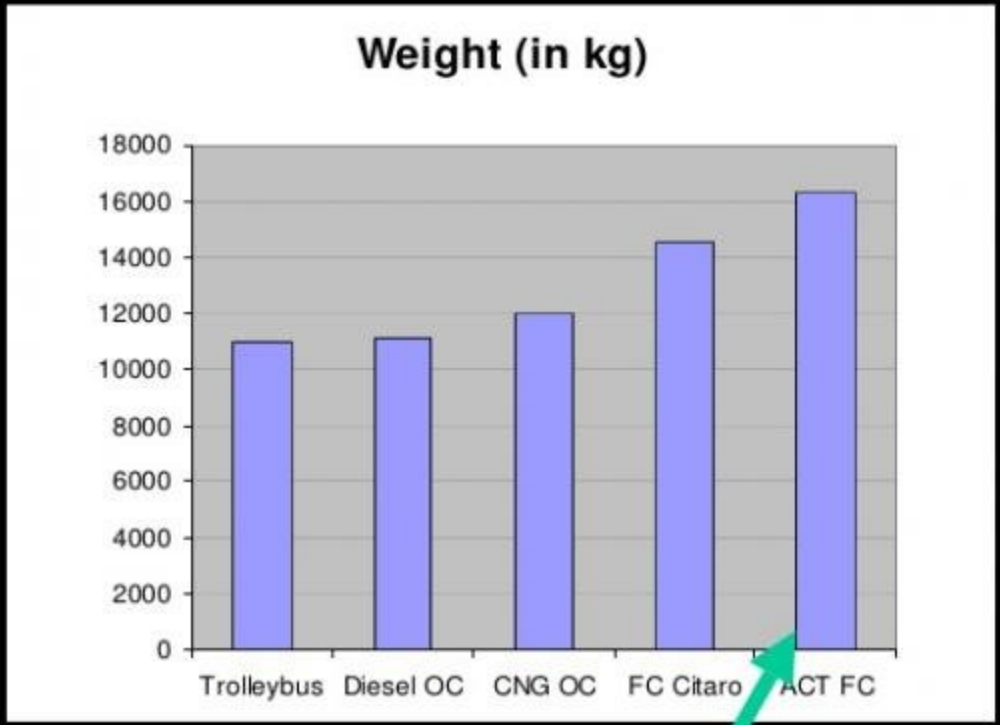
Specification	Diesel OC 500 [45]	CNG OC 500 [45]	FC Citaro [46]
Engine	Mercedes Benz OM 457 hLA	Mercedes Benz M 447 hLAG	Ballard HY-205 fuel cell engine
Chassis	Flat-ladder steel frame	Flat-ladder steel frame	Steel space-frame
Body	Volgren extruded aluminium	Volgren extruded aluminium	
Empty vehicle mass (kg)	11,100	11,950	14,500
Passenger capacity [47]	75	59	59
Engine power (kW)	185	185	205
Maximum torque (Nm)	1,100	1,050	1,050
Approx. range (km) [48]	450	350	250

Life-cycle assessment of diesel, natural gas and hydrogen fuel cell bus transportation systems
Ally J, Pryor T. JOURNAL OF POWER SOURCES, Volume: 170 Issue: 2 Pages: 401-411. JUL 10 2007

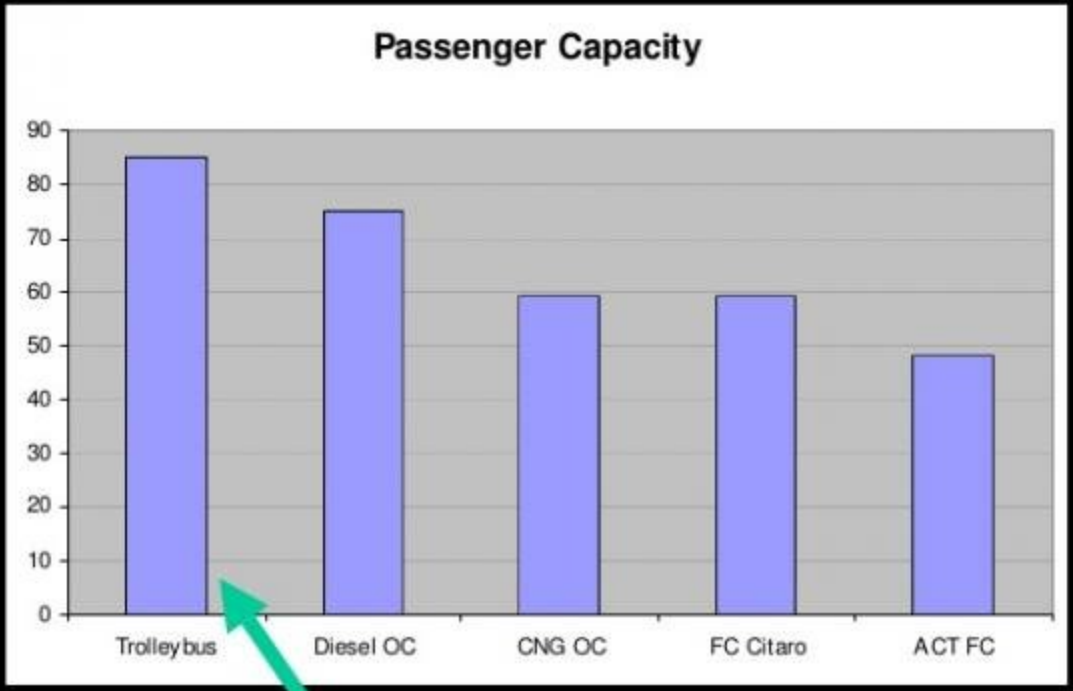
Technical Data

Nominal voltage: 600 Vss and/or 750 Vss +20%-30%
Maximum speed: 70 km/hour
Total car length: 11560 mm
Car width: 2500 mm
Car height: 3364 mm
Floor level in the front: 360 mm
rear: 560 mm
Number of seats: 27 passengers
Number of standing places (5 persons/m2): 58 passengers
Total capacity: 85 passengers
Operating weight: 11000 kg
Driving motor: direct-current series four-pole motor
with foreign ventilation
Permanent motor capacity: 140 kW at 600 V
150 kW at 750 V
Average acceleration (0-40 km, operating weight): 1.3 m/s2
Maximum climbing ability: 15 %
Internal noisiness: 78 dB (A)
External noisiness: 78 dB (A)

Source: http://www.iee.cas.cz/power/tr21.htm

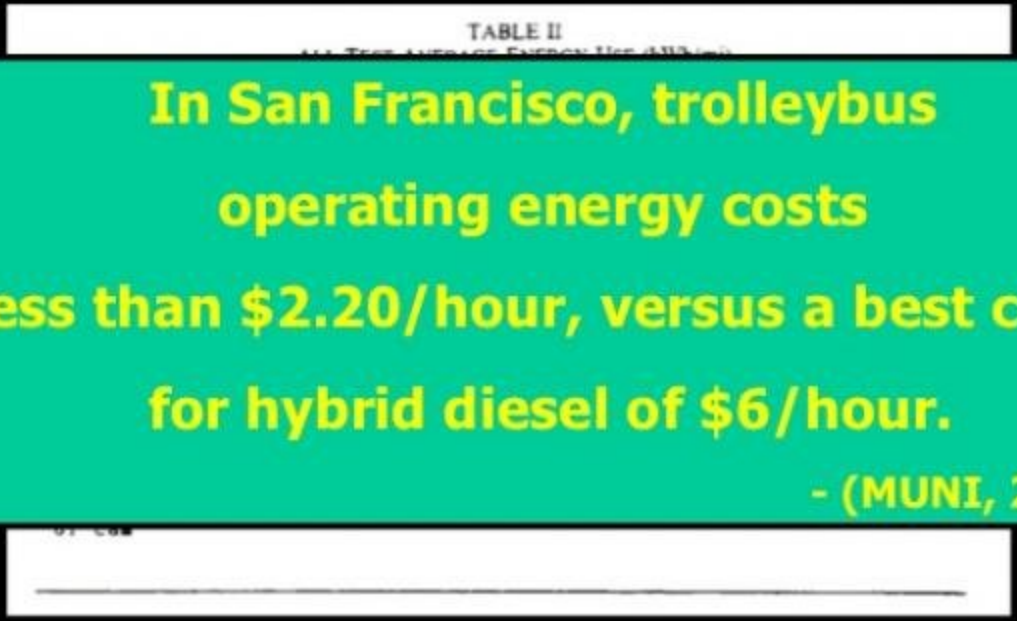


(AC Transit FC: 16,329 kg. 48% heavier than a Trolleybus!)



(Trolleybus: 77% more people carried than AC Transit Hydrogen Fuel Cell bus!)

Energy & Economic Efficiency



In San Francisco, trolleybus operating energy costs less than $2.20/hour, versus a best case for hybrid diesel of $6/hour.

- (MUNI, 2006)

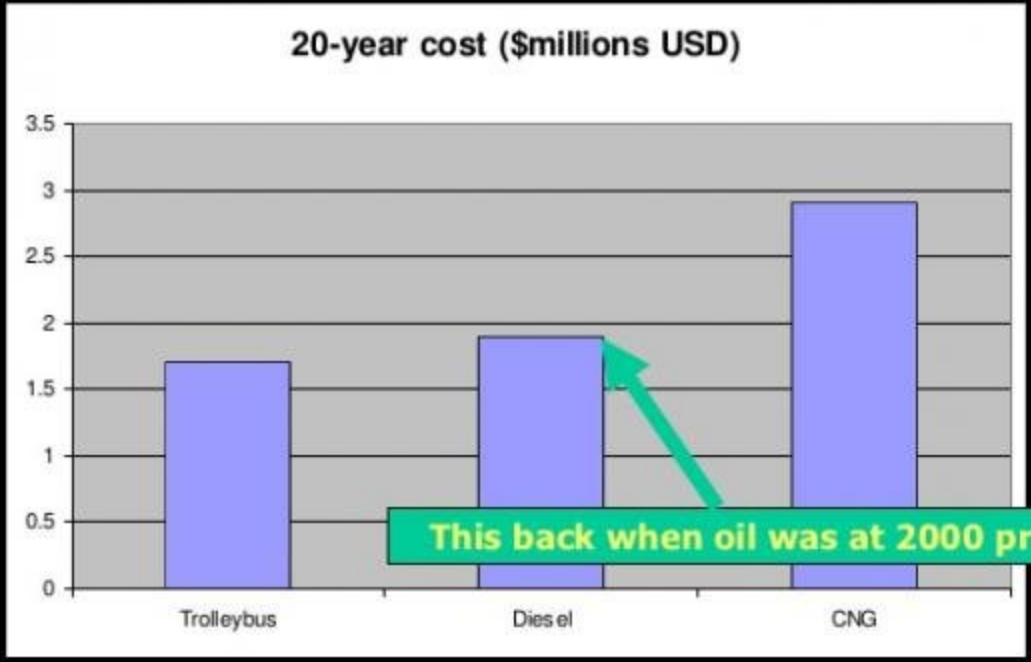
San Francisco MUNI trolleybus propulsion tests: The results. Turner, D.B., De Guzman, F.I., 1986. **Vehicular Technology, IEEE Transactions on**, Volume: 35, Issue: 3, pages: 118- 131

Ridership Increases

Ridership increases, Seattle and San Francisco, Booz, Allen & Hamilton, Trolleybus Study for RTC and LACTC, 1992, Wil Teunissen, 2004, Salzburg AG, 2004

Total Cost Reduced

(Not including health and environmental costs!)



Source: http://www.tbus.org.uk/article.htm

The only practicable way to compare alternative trolleybus and diesel proposals is by whole life benefit costing methods. In 1999 Vancouver reported in conjunction with proposals to renew and expand their trolleybus fleet that the expected costs per vehicle over a 20 year period were in C$ millions 1.7 for diesel, 1.9 for trolley and 2.9 for compressed natural gas [CNG]. These figures are costs and exclude benefits such as increased trolleybus ridership or environmental benefits. [Figures from article by Millar, Brown and the author in July 2000 'Buses' magazine].

Looking at cost - benefits, TfL expects trolleybuses to show a 14% greater cost benefit for ELT over diesels. This figure does not attempt to quantify environmental benefits of trolleybuses such as health costs. The Swedish report mentioned earlier estimated the 'social cost' of emissions of a diesel bus over trolleybus at about £6K / year / vehicle.

Source: http://www.tbus.org.uk/article.htm

HEALTH

HEALTH

- Air pollution eliminated locally (except for tires)
- Noise pollution greatly reduced
- Promotes switch to walking and bicycling
- No evidence found of EMF effects
- Global Warming: compounded reductions

Trolley Bus is best for GHG Reduction and Air Pollution

Pollution comparison diesel bus/trolleybus

Pollution	Local Emission		Global Emission		
	articulated-diesel bus g/km	articulated-trolleybus g/km	articulated-diesel bus g/km	articulated trolleybus (*) g/km	articulated trolley. (**) g/km
SO^2	1.07	0	1.7	0.86	0.43
NO^2	23.6	0	24.2	1.31	0.66
Dust particles	0.47	0	0.5	0.25	0.13
CO	4.58	0	4.8	0.61	0.31
CO^2	1204	0	1314	912	456

(*) power generated by thermal electric stations
(**) power generated by hydroelectric stations
Source: P. G. Brandl, "Obus mit positiven Perspektiven", Nahverkehr, 9/2001

Plus reduction of many other pollutants.

NOISE: a killer

85 dBA is generally considered hearing damage level.

10 dbA is roughly 10* difference in pressure hitting ear

Most buses are over 85 dBA, trolleybuses are generally 78 dBA. SF new hybrid diesels surprisingly loud.

Federal policies of Reagan era disallow transit agencies to specify noise as criteria, gutted nascent EPA noise control. Thus the only solution is to specify a quieter technology like trolleybuses.

SLEEP:

Transit Particularly Important as Operates Late at Night

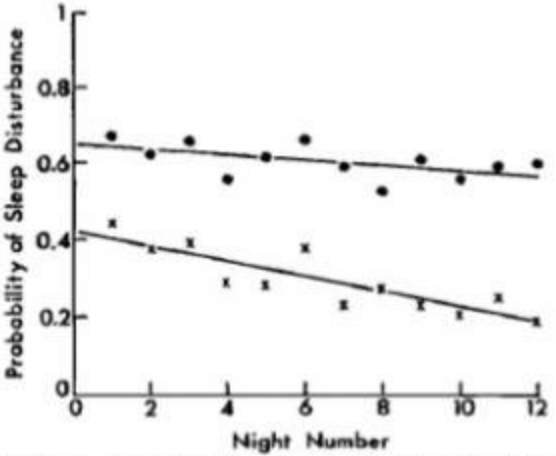


FIG. 1. Adaptation of sleep disturbance with time. The top set of points shows the probability of shift in sleep level due to truck noises with peak *A*-weighted levels of 65 dB presented 8–20 times per night, every other night for 12 nights for all 17 subjects. The lower set of points shows the corresponding probability of waking. The lines are linear regression lines.

G. J. Thiessen and A. C. Lapointe: Effect of truck noise on sleep

Electric Bus is Quietest

(Comparison with Diesel and Light Rail)

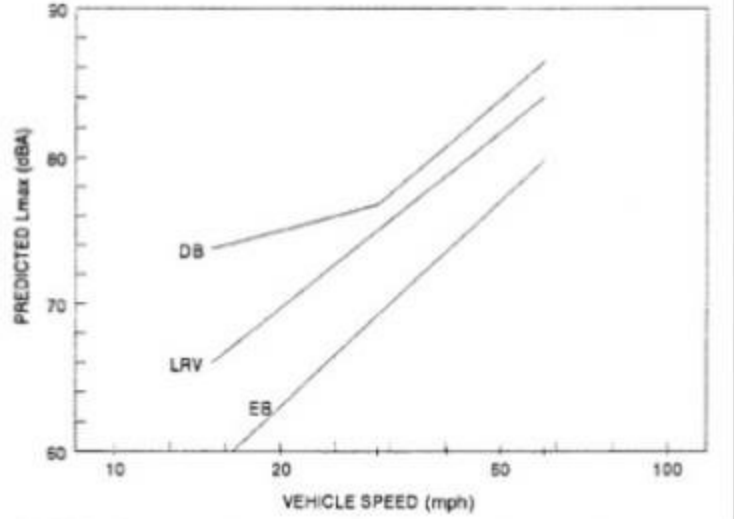


FIGURE 8 Transitway vehicle noise emissions (passby maximum sound levels (L_{max}) at 15.25 m (50 ft) from centerline of at-grade guideway for light rail vehicle (LRV) on tie-end-ballast track, diesel bus (DB), and electric bus (EB)). (1 mph = 1.61 km/h.)

Comparison of Light Rail and Bus Transit Noise Impact Estimates per Federal and Industry Criteria

Michael A. Staiano. 2001. Transportation Research Record 1756 45. *Paper No. 01-2938*

Ischemic Heart Disease:

Dose-response curve from multiple studies

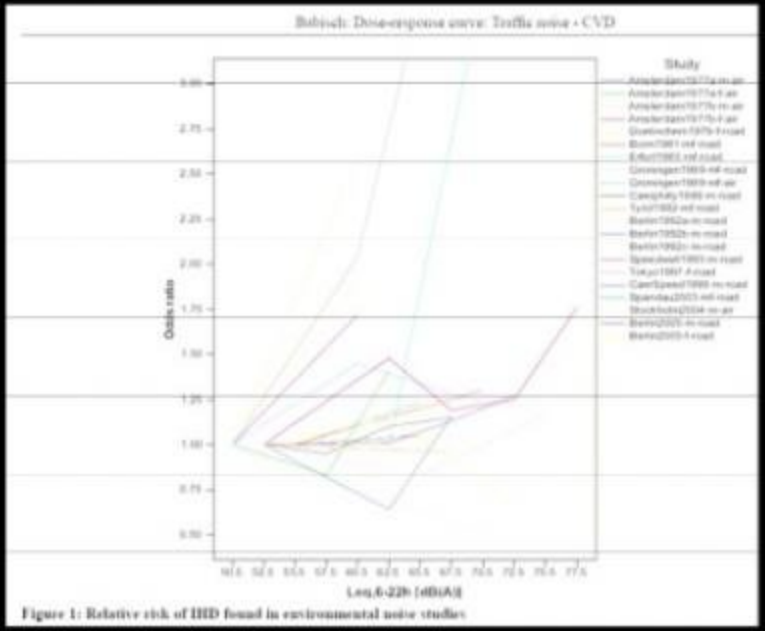


Figure 1: Relative risk of IHD found in environmental noise studies

Road traffic noise and cardiovascular risk. Wolfgang Babisch. 2008.

Noise *& Health, January-March 2008, Volume 10*

Myocardial Infarction:

Dose-response curve from multiple studies

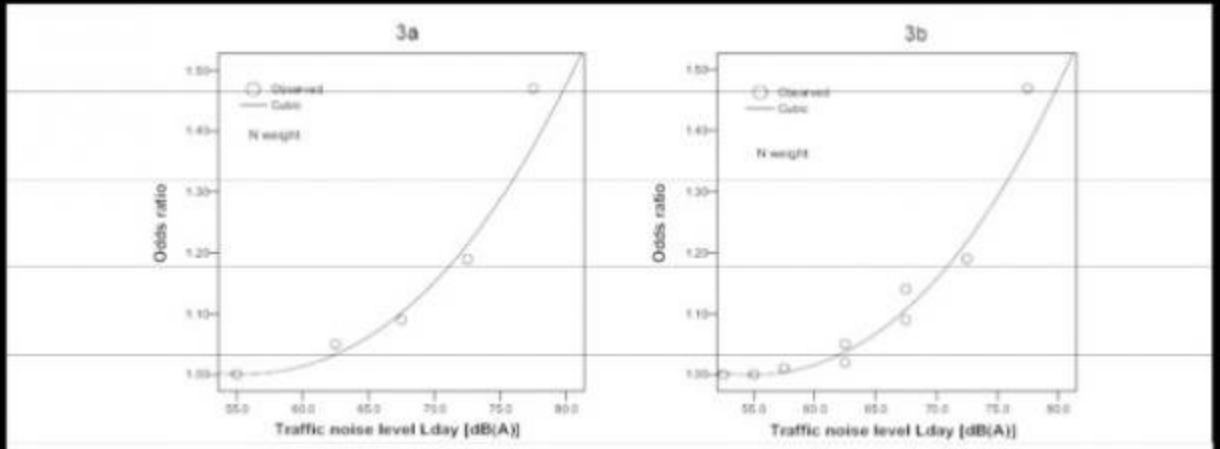


Figure 3 (a-b): Polynomial fits of the exposure-response relationship between road traffic noise and myocardial infarction. The left graph (3a) refers case-control or cohort studies (analytic studies), the right graph (3b) to cross-sectional, case-control or cohort studies (descriptive and analytic studies)

Summary for two descriptive and five analytical studies.
Babisch, 2008. **Road traffic noise and cardiovascular risk.**

Noise & Health, January-March 2008, Volume 10

Hypertension and Noise :

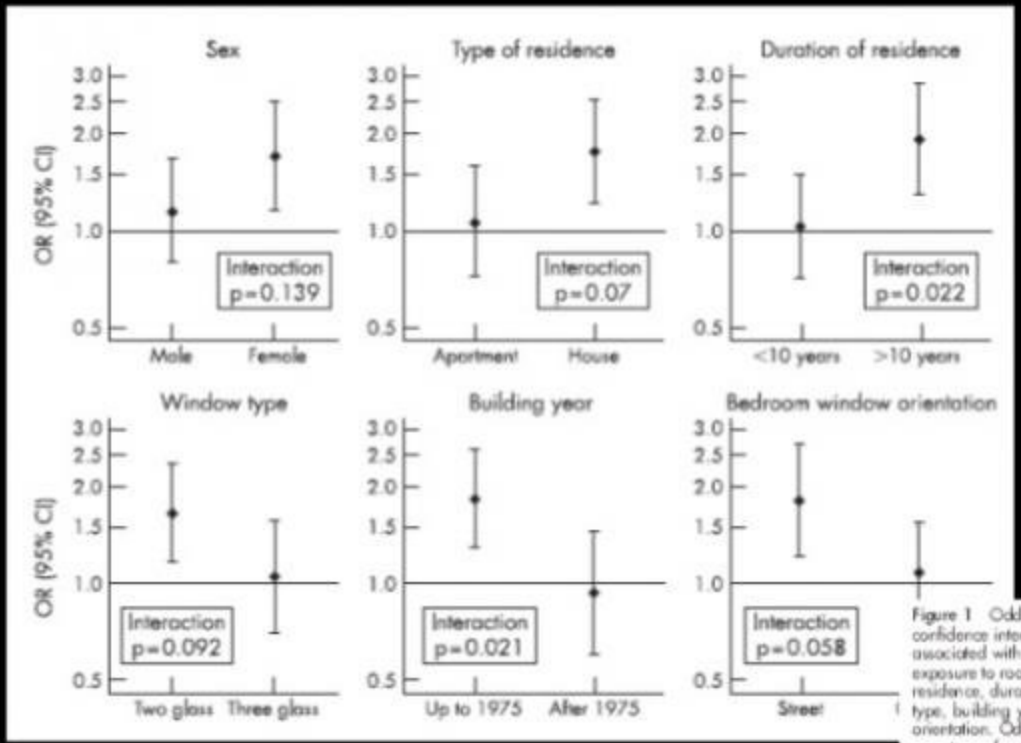
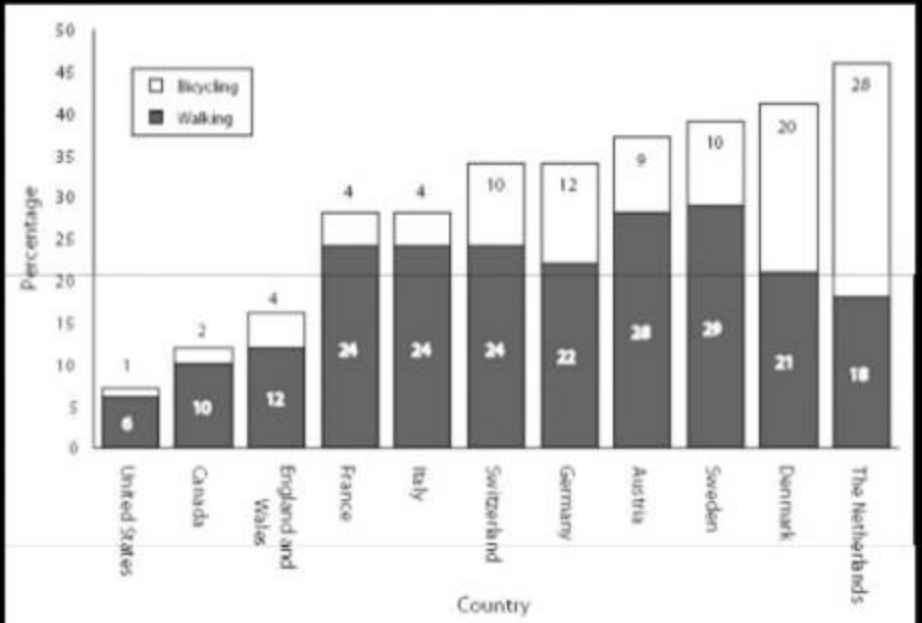


Figure 1 Odds ratios (OR) and 95% confidence intervals (CI) for hypertension associated with a 5 dB(A) increase in exposure to road traffic noise by sex, type of residence, duration of residence, window type, building year and bedroom window orientation. Odds ratios were adjusted for age, type of residence, occupation, smoking status and number of cigarettes.

Human Power Increases

GCV systems lead to more walking and bicycling, an additional health & sustainability benefit.

This provides an additional argument for their implementation.

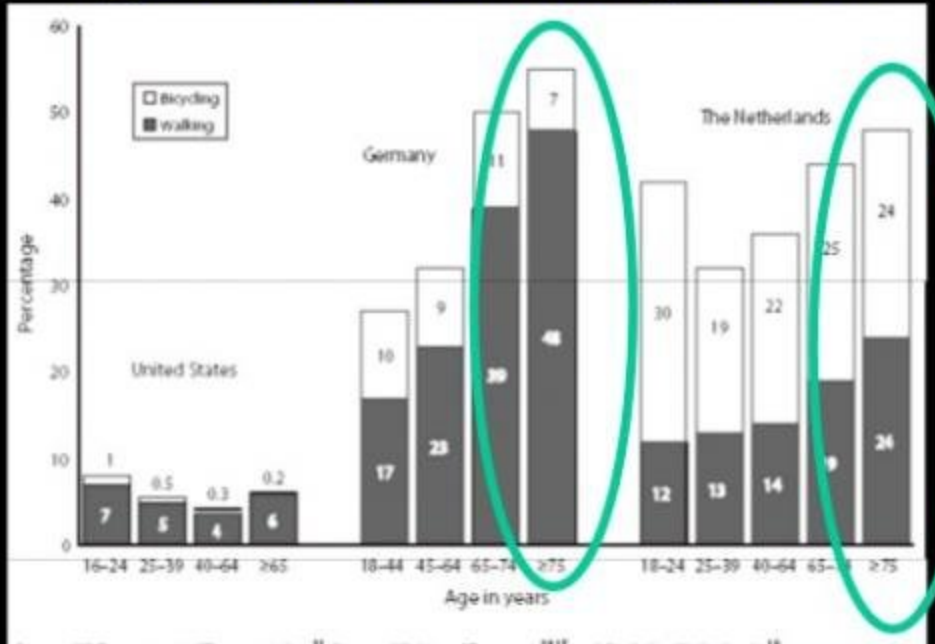


Note. Modal split distributions for different countries are not fully comparable owing to differences in trip definitions, survey methodologies, and urban area boundaries. The distributions given here are intended to show the approximate differences among countries and should not be used for exact comparisons.
Source. Transportation Research Board,[29] Table 2-2, p. 30.

FIGURE 1—Percentage of trips in urban areas made by walking and bicycling in North America and Europe, 1995.

Pucher & Dijkstra, 2003. Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany. American Journal of Public Health

Age is not the limiting factor.



Source. US Department of Transportation,[11] German Ministry of Transport,[14,15] and Statistics Netherlands.[19]

FIGURE 2—Percentage of trips in urban areas made by walking and bicycling in the United States, Germany, and The Netherlands, by age group, 1995.

Pucher & Dijkstra, 2003. Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany. American Journal of Public Health

- In the USA, bicycle advocates frequently hear the objection, "Not everyone can ride a bicycle," and "Old people cannot ride."

- This argument is quite insulting, misleading and quite harmful; it is particularly important to provide an environment where all feel safe to ride, particularly for the young and old.

Participation in regular, moderate physical activity can delay functional decline. It can reduce the onset of chronic diseases among both healthy and chronically ill older people.

- World Health Organization, 2002,

A PHYSICALLY ACTIVE LIFE THROUGH EVERYDAY TRANSPORT WITH A SPECIAL FOCUS ON CHILDREN AND OLDER PEOPLE)

PREVENTS DISABILITY

Most people can ride a bicycle (up to 99% of adults) and those who can't, benefit from bicycling and its infrastructure in many ways. Special bicycles exist for people with disabilities and bicycle planning provides better accomodations for wheelchair use in general.

The benefits of bicycling were estimated to be twenty times the risks by Mayer Hillman of the British Medical Association.

Injury and fatality risks are usually given as rate per distance traveled. This is improper; it should be done by time spent traveling or by the # events accomplished, as different modes are "apples and oranges." When reassessed bicycling and walking are seen much less risky.

Health Impact Analysis:

A strategy for requiring trolleybuses.

Health arguments are increasingly powerful in policy decisions.

Key lever in legal processes (e.g., environmental review).

Element B. Sustainable Transportation (ST)

Objective ST.1: Decrease private motor vehicles trips and miles traveled

Health-based Rationale (references forthcoming)

- Location-efficient growth can allow for population and job growth without increases in VMT which is directly proportional to gasoline consumption, vehicle emissions, pedestrian injury rate, hearing, environmental noise exposure, physical inactivity, lower social cohesion
- Respiratory disease (air pollution); pedestrian injury, sleep disturbance, annoyance, speech impairment, hypertension (noise); exposure to environmental contamination due to fuel and oil spills, air emissions, etc.
- Link physical activity and health outcomes (ie CVD, stroke, cancer) as well as costs that are saved from the prevention of these diseases

Established Standards

- HP 2010 Objective 22.14: Increase the proportion of trips made by walking.
- HP 2010 Objective 22.15: Increase the proportion of trips made by bicycling

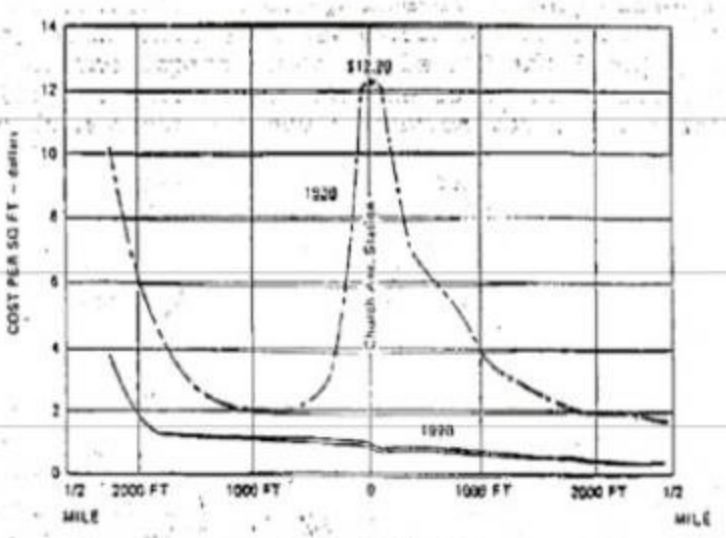
Key Indicators	Development Targets
a. Vehicle miles traveled per San Francisco resident (SF drivers only) b. Aggregate regional vehicle miles traveled	Development results in regional contributions to vehicle miles traveled (VMT) as: • Min: 20% below standard area trip generation rate for type and size of project • Benchmark: 30% below area trip generation rate • Max: --
c. Vehicle trips per resident	Development results in vehicle trips that are: • Min: 20% below standard area trip generation rate for type and size of project • Benchmark: 30% below area trip generation rate • Max: --
d. Proportion of commute trips made by walking or biking	Development results in: • Min: 10% increase in trips made by walking or biking • Benchmark: : 20% increase in trips made by walking or biking • Max: 50% increase in trips made by walking or biking
e. Proportion of commute trips made by public transit	Development results in: • Min: 10% increase in the trips made by public transportation • Benchmark: 20% increase in the trips made by public transportation • Max: 50% increase in the trips made by public transportation

DRAFT

http://www.sfdph.org/phes/enchia/HDMT/2006_08_14_Draft_HDMT.pdf

Urban Effects of Trolleys

- Incentivize Density
  - Fewer cars & better infrastructure efficiency
- Increase transit ridership
- Increase walking/biking
- Vibration and weight reduced
  - less road & sewer damage
- Can be transitional to light rail
- Can take on cargo burden



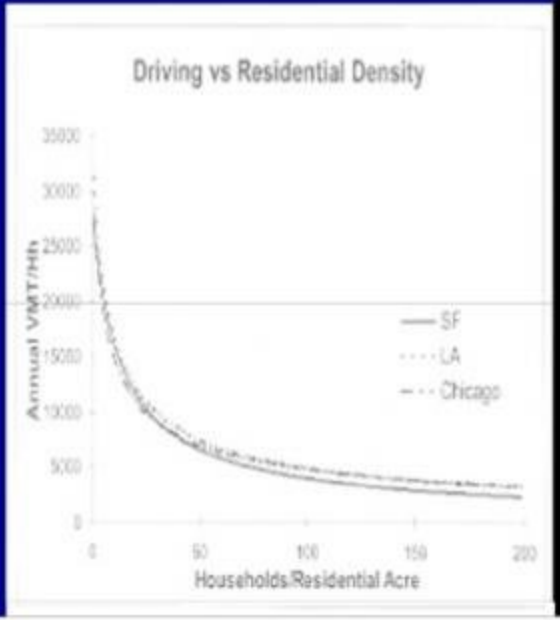
Classic Study: Church Street, Brooklyn, NY

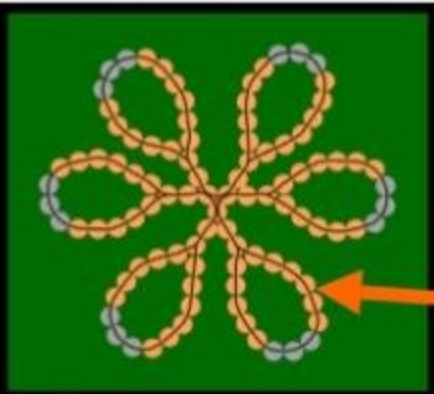
Source: Harbridge House, **The Economic and Social Impact of Investments in Public Transit** (1973), p. 43 (citing E. Law, "Real Estate and Population Growth along Rapid Transit Lines in the City of New York," **The Municipal Engineers Journal**, Vol. 21, 1935).

Slide from Prof. Robert Cervero, UC Berkeley, CP 213, Fall 2007.

Less Density = More Driving

More Trolleys = Less Driving





	1 unit
Population	12,000
Diameter	2500 ft.
Area	112 acres
Building Footprint	40 %
Number of Stories	4
Floor Area Ratio	1.5
Average Street Width	25 ft.
Building Depth	30 ft.
Courtyard Width	130 ft.
Walking Time to Transport	5 min.

Districts

Source: Joel Crawford, Carfree.com

San Francisco

Hypothetical Car-free San Francisco Topography

Environmental Benefits of a Carfree San Francisco

LAND SAVINGS:

80% restored

Personal Automotive Transportation Emissions (EIO-LCA):

27% of total San Francisco MT CO_2

Commercial Automotive Transportation Emissions (EIO-LCA):

2% of total San Francisco MT $C0_2$

39% of total San Francisco MT CO

15% of total San Francisco MT NOx

8% of total San Francisco MT VOC

AND MUCH MORE!

Source: Meggs and Broome, UC Berkeley, 2006

Electric Trolley Trucks For Cargo, Sharing Overhead Lines

- Trolley trucks exist, used in Russia.
- Delivery was the norm before the car, still common in other countries.
- Pairs well with local bicycle/foot distribution.
- Delivery is much more energy efficient.
- Studies currently underway for cargo capacity on BART trains from SFO.
- Overhead lines amortize nicerly with increased usage.
- Urban trucks are major source of noise & air pollution

Source: Wikipedia Commons (1954 conversion in Kharkiv, Ukraine)

Source: Wikipedia Commons: Freight Trolleybuses in Saint-Petersburg
(Sept. 19, 2006)

Bicycle Cargo:

Capable of pairing with trolley trucks and trains

Picture the Escher City:

Take cargo to tops of hills for distribution.

Source: Joel Crawford, Carfree.com

Summary: Trolley Bus and Truck Benefits versus Diesel

- Faster, last longer, more economical, riders prefer
- Major health benefits (less noise, vibration & air pollution; less driving, more walking & bicycling)
- Electricity from Renewables; GHG reductions
- More torque; *better for hills and heavy loads*
- Cost of wire infrastructure amortizes well with higher use, can phase to light rail
- Can send some freight at night, when transit and energy demands are lowest
- Highly efficient (5-10% loss from plant to mechanical energy, *plus* regenerative braking)
- *Vehicles last roughly 2X as long, need less service*

Finally

There are crisis opportunities ahead, when we will have policy windows to make good versus bad choices. The current resistance to carfree cities and ending dependence on oil will be at a high point of openness to change. If we are not ready at those moments we will lose them, and terrible commitments of dwindling resources will be made instead. You can bet the oil & car interests know this. The carfree movement needs to develop proposals now that are ready for those opportunities.

Jason N. Meggs
School of Public Health
Environmental Health Sciences Division
University of California at Berkeley

jmeggs@berkeley.edu
(510) 725-9991