2008 Rail~Volution

Evaluating Cost-Effectiveness of CO2 Emissions Abatement Transit Strategies

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October 29, 2008

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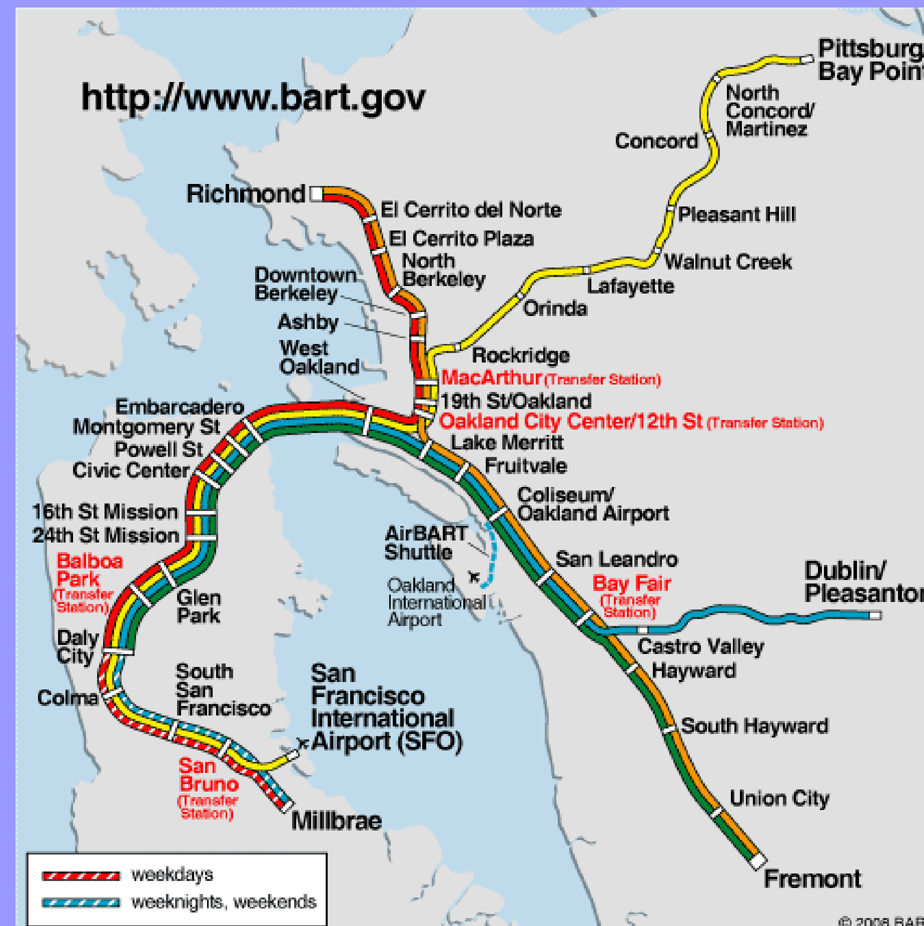
BART Basics

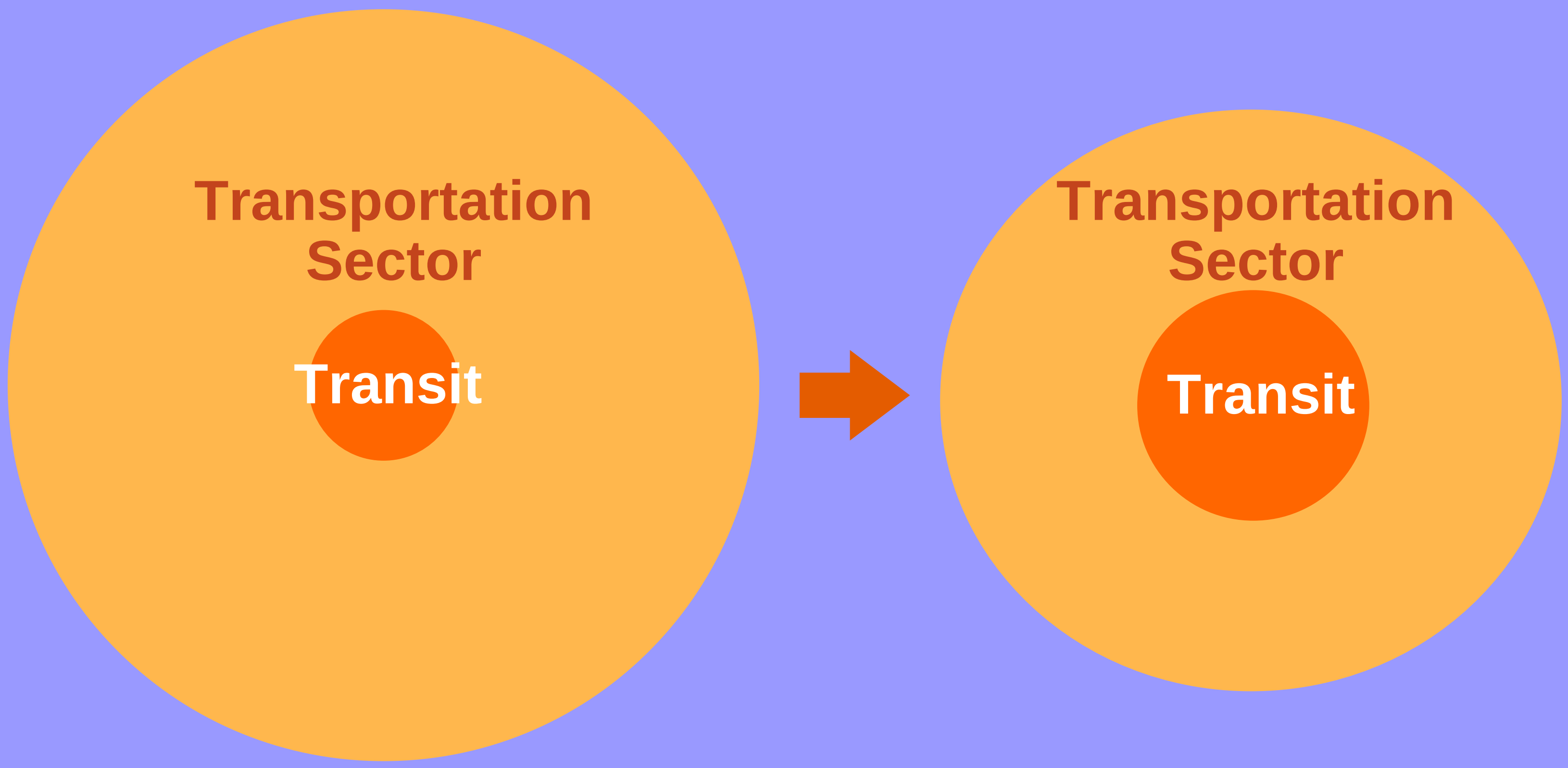
- Rapid transit system
- Trains all-electric; majority clean hydro power
- 104 miles
- 43 stations
- 360,000 daily riders
- 1.3 billion annual passenger miles



California Policy Context

- AB32 Global Warming Solutions Act (2006)
  - 1990 emissions levels by 2020
- Governor's Executive Order (2005)
  - 80% below 1990 emissions by 2050
- SB375 Sustainable Communities Strategy (2008)
  - Regional GHG Emission Targets for Autos / Light Trucks

Transit's Role in Transport Sector



Current Greenhouse Gas Emissions

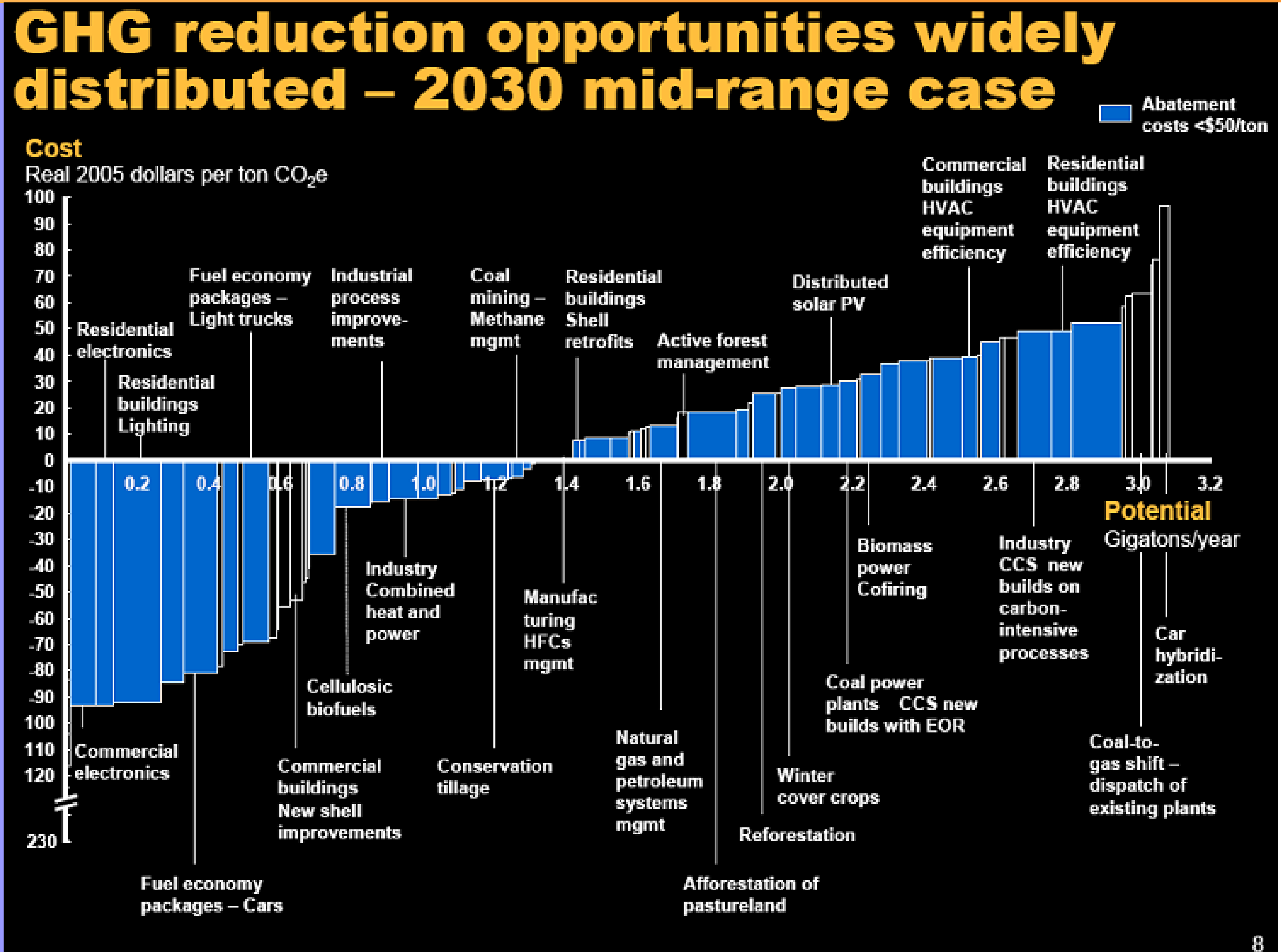
Future Greenhouse Gas Emissions

BART Greenhouse Gas Policy Work

1. State / Federal Policy & Regulation
2. GHG Inventory / Footprint
3. Carbon Markets
4. Partnerships
5. Climate Action Plan (scoping)
6. Cost-Effectiveness

CO2 Emissions Abatement Transit Strategies

McKinsey – Economy Wide Study



Source: "Reducing US Greenhouse Gas Emissions: How Much at What Cost?" McKinsey and Company, December 5, 2007

Sense of Urgency

"What we do in the next **10-20 years** can have a profound effect on the climate in the second half of the century and in the next."

Nicholas Stern, The Stern Review
Chief Economist World Bank (2000-2003)

STERN review
ON THE ECONOMICS OF CLIMATE CHANGE

Analysis Considerations

- Sense of Urgency: “Early Actions”
- BART Early Action Strategies:
  - Service Frequency
  - Station Access
  - Fares
  - Marketing
- Other BART Strategies
- Transportation Sector Strategies

Additional Considerations

- Did not compare to roadway investments
- Did not examine life-cycle costs
- Only analyzed GHG emissions
- Transit projects have multiple objectives that need to be balanced
- Capacity improvements hard to quantify
- Considered "transit multiplier" for some investments (shorter trips, more walk/bike)
- Considered public costs, not private costs

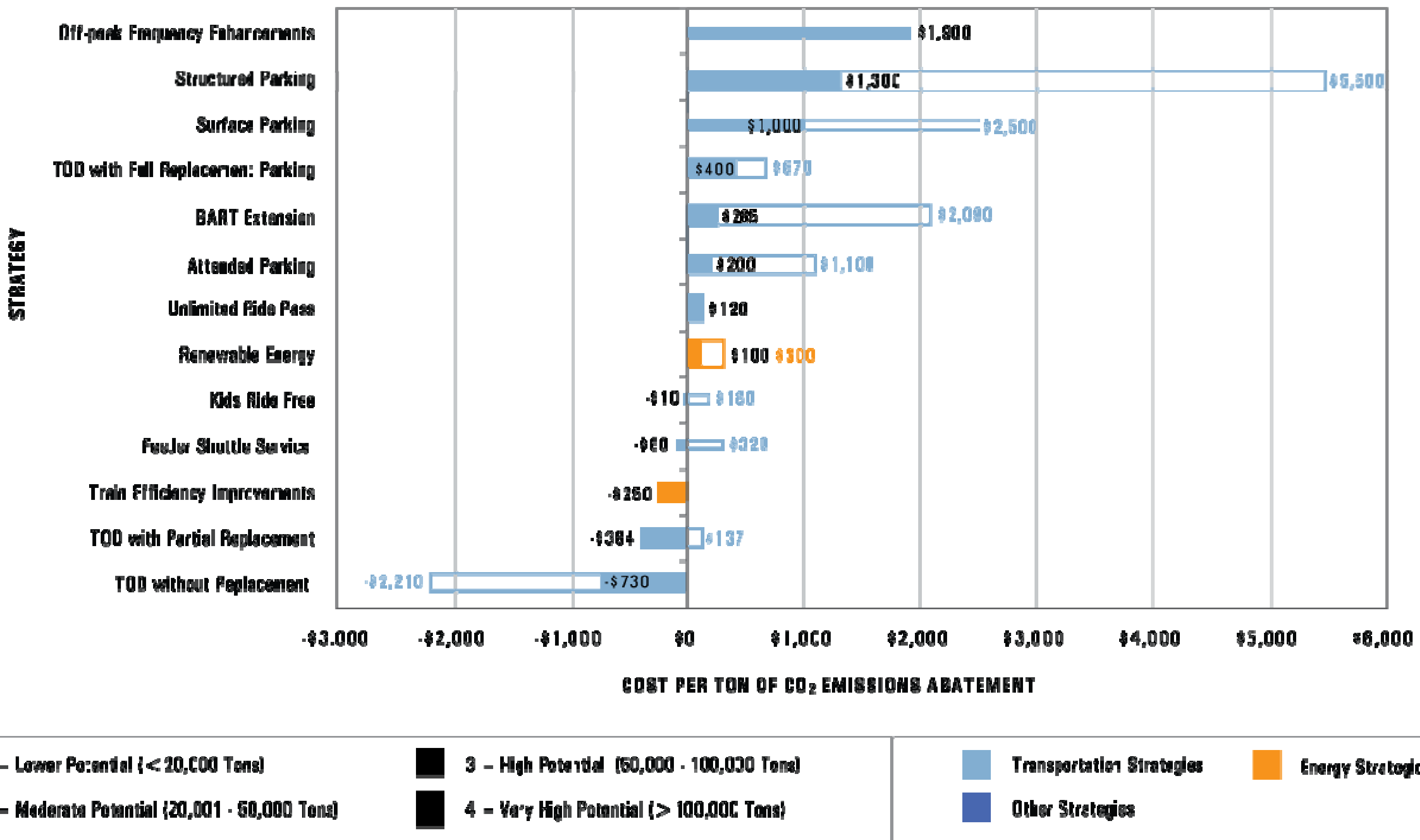
Assumptions

- Existing transit capacity
- Average BART trip = 13 miles
- BART 2/3 clean hydroelectricity
- Average BART trip = 14% of GHG of equivalent auto trip.
- Average auto drive access = 3.8 miles

CO2 Emissions Abatement Transit Strategies

Cost-Effectiveness Comparison

Cost per Metric Ton of CO_2 Emissions Abatement (Bart Strategy)



Service: Off-Peak Frequency

- BART improved off-peak frequencies (evening and Sundays) in FY08
- More frequent transit service can attract travelers out of their cars.
- Considered additional costs for traction power and rolling stock
- BART's recent off-peak frequency enhancements lower system productivity; not cost effective for CO_2 abatement alone.

Improve off-peak frequency

Emissions Reduced:	1,000 Metric tons per year
Cost:	$2,000 per ton
Max Potential:	BART system, 1,000 metric tons per year

Access: Feeder Shuttles

- Shuttle programs can bridge the last mile to destinations and reduce the need for new parking.
- Employers may contribute part of the cost of operation.
- Including new fare revenue generated for BART, feeder shuttles can be revenue positive under the right conditions.

Feeder Shuttle Access

Emissions Reduced (Metric Tons)	3,600
Annual Cost	-$150,000 to $570,000
Cost Efficiency ($ per metric ton)	-$80 to $320
Max Potential (Metric Tons)	3,600

CO2 Emissions Abatement Transit Strategies

Access: Commuter Park-n-Ride

- More parking may allow more people to access a BART station by car; shorter auto trips.
- Capital costs are very high.
- Cost effectiveness low.

BART Station Parking

Surface Parking	
Emissions Reduced:	240 to 431 Metric Tons per Project
Cost:	$520 to $1,400 per ton
Max Potential:	4,800 to 8,600 Metric Tons (Projects at 20 BART Stations)
Structured Parking	
Emissions Reduced:	700 to 1,200 Metric Tons per Project
Cost:	$2,204 to $4,700 per ton
Max Potential:	14,400 to 25,900 Metric Tons (Projects at 20 BART Stations)
Attended Parking (In Structure)	
Emissions Reduced:	800 to 1,400 Metric tons per Project
Cost:	$2,200 to $4,700 per ton
Max Potential:	15,300 to 27,600 Metric Tons (Projects at 20 BART Stations)

Fares: Special Promotions

- Fare programs have the potential to encourage off-peak ridership.
- Could be cost-effective way to reduce emissions. Requires further study and possibly outside funding.

Kids Ride Free

Emissions Reduced (Metric Tons)	1,500[4]
Annual Cost	-$20,400 to $286,000
Cost Efficiency (per metric ton)	-$10 to $185

Unlimited Ride Passes

Emissions Reduced (Metric Tons)	85,000
Annual Cost	$10,000,000
Cost Efficiency ($ per metric ton)	$120
Max Potential (Metric Tons)	85,000

Marketing

- Marketing programs may include either BART advertising on its own or investing in outreach programs run by other agencies.
- TravelChoice outreach has been successful and cost effective at attracting people to transit.
- Return on Investment varies widely for BART's own marketing projects.

TravelChoice Outreach

Emissions Reduced:	6,600 Metric tons per year for 10,000 households
Cost:	$60 per ton.
Max Potential:	66,000 metric tons per year (100,000 households)

Energy: Expand to 100% Renewable

- BART power already 2/3rds hydroelectric.
- Replace energy from fossil fuels with emissions-free renewable energy eliminates CO_2 emissions.
- Questionable whether sufficient reliable, baseline green power can be acquired.

BART Power Supply

Emissions Reduced:	72,000 Metric tons
Cost:	$110 per ton
Max Potential:	72,000 Metric tons

CO2 Emissions Abatement Transit Strategies

Energy: Train Efficiency Improvements

- Improvements to BART train car efficiency were identified in a recent PG&E audit
- Could reduce the energy needed for trains by more than half: **-$250 per ton/CO2**

	Electricity Savings (kW/h/ Year)	Initial Cost
Use Ultracapacitors for Regenerative Braking Energy Storage	82,948,688	$88,038,753
Use Permanent Magnet (PM) Motors for Car Propulsion	38,905,029	$51,344,198
Install Variable Frequency Drives on HVAC Supply Fans	3,206,292	$1,475,000
Direct Cooler Air to the Inlet of HVAC Condensers	1,717,819	$100,000
Optimize Outside Air Intake into Cars	1,444,334	$847,793
Install Daylight Controls on the Fluorescent Lamps	837,433	$2,820,270
Install Higher Efficiency HVAC Units on C Cars and New Cars	413,021	$632,177

Source: Energy Efficiency Assessment of Bay Area Rapid Transit (BART) Train Cars. Prepared by BASE Energy, Inc. for Pacific Gas and Electric, March 2007.

CO2 Emissions Abatement Transit Strategies

Land Use: TOD

- Two benefits for CO_2: Attracts passengers to BART and creates residential developments that encourage walking, biking, and short trips.
- Bay Area TOD residents generate half VMT compared to regional average
- Revenue-positive: can maximize value of BART property.
- Wide range of cost effectiveness, depending on station and replacement parking requirements.

BART Station Transit Oriented Development

TOD with full replacement parking	
Emissions Reduced:	800 to 2,000 Metric Tons per Project
Cost:	$480 to $770 per ton
Max Potential:	16,000 to 40,000 Metric Tons (Projects at 20 BART Stations)
TOD with partial replacement parking	
Emissions Reduced:	900 to 2,500 Metric Tons per Project
Cost:	Negative $400 to positive $148 per ton
Max Potential:	19,000 to 50,000 Metric Tons (Projects at 20 BART Stations)
TOD without replacement parking:	
Emissions Reduced:	650 to 2,300 Metric Tons per Project
Cost:	Negative $600 to negative $1,400 per ton
Max Potential:	13,000 to 46,000 Metric Tons (Projects at 20 BART Stations)

BART Extensions

- Extending BART attract new passengers; some may currently take long auto trips.
- <u>Extensions in isolation</u> have very high capital costs, and lower productivity may mean that extensions may not be cost effective for CO2 abatement.
- Extensions <u>effectiveness significantly improves</u> when considering the <u>“transit multiplier”</u> where transit enables a more compact land use pattern (shorter trips, more walk/bike).

BART Extensions	
Emissions Reduced:	30,000 Metric tons; 79,000 including land use impacts
Cost:	$2,000 per ton; $285 per ton including land use impacts
Max Potential:	Not Estimated.

CO_2 Emissions Abatement Transit Strategies

Dealing with Transit Capacity

- In the coming decades BART will increasingly face capacity challenges for peak-hour, peak direction travel.
- The analysis does not account for the additional costs from the need to add capacity.
- Some strategies, such as fare incentives and TOD, tend to generate off-peak ridership.

CO2 Emissions Abatement Transit Strategies

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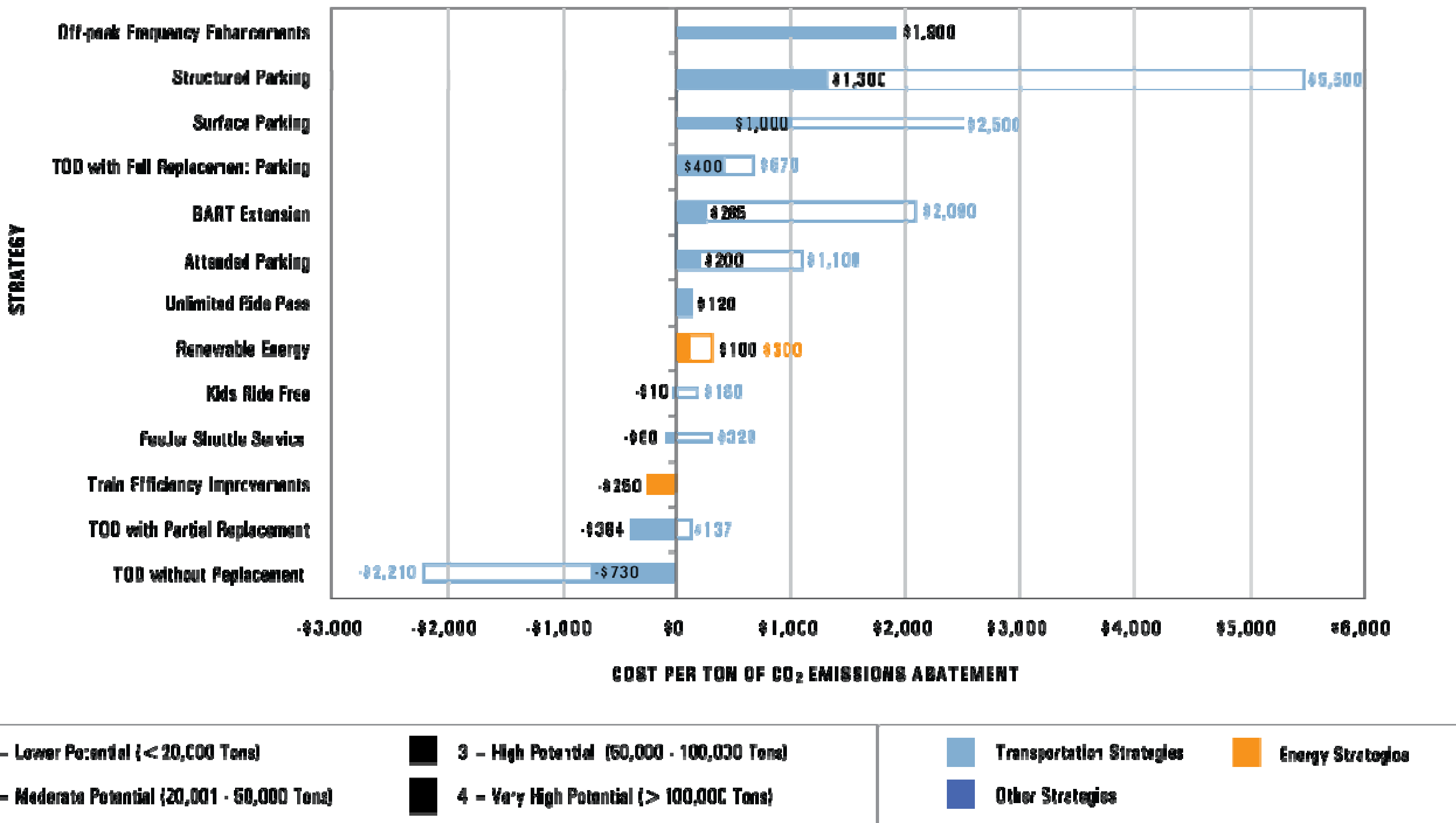


CO2 Emissions Abatement Transit Strategies

Potential Impacts

	Lower Potential (<20,000 Tons)	Moderate Potential (20,001 - 50,000 Tons)	High Potential (50,000 - 100,000 Tons)	Very High Potential (>100,000 Tons)
Very Expensive (>$800/Ton)	Parking (Surface); BART Frequency enhancements;	Parking (Structured and attended); BART Extensions (without Land-use changes).		
Expensive (>$100/Ton)		TOD with full parking replacement.	Electricity(Hydro + Renewables), BART Extensions (with Land-use changes).	Unlimited Ride Pass
Inexpensive (<$100/Ton)	"Kids Ride Free"		TravelChoice	Station Area Planning
Revenue Neutral ($0/Ton)	Feeder shuttle service	Carsharing; Indirect Source Review Policy		Employee-paid parking
Revenue Generating (<$0/Ton)		TOD with partial parking replacement	Train Efficiency Improvements	
Strongly Revenue Generating (<-$1000/Ton)	Market-Priced Curb Parking	TOD without parking replacement		Roadway Congestion Pricing

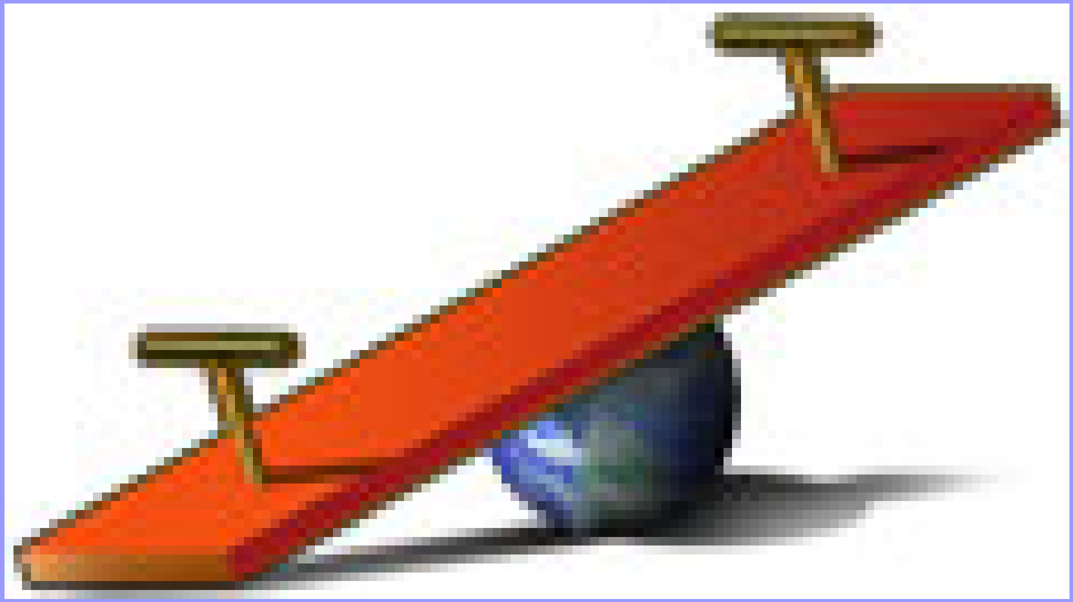
Findings

Most cost-effective strategies:

- Fill empty seats
- Transit multiplier
- Energy strategies competitive
- Co-benefits

Finding the Right Balance

- Reduce VMT = Grow transit ridership
- Greener Transit



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