Communication

Cost effectiveness comparison of certain transportation measures to mitigate greenhouse gas emissions in San Diego County, California

Nilmini Silva-Send a,*, Scott Anders b, Andrew Narwold c

a Energy Policy Initiatives Center, University of San Diego, 5998 Alcala Park, San Diego, CA 92110, USA
b Energy Policy Initiatives Center, University of San Diego, USA
c School of Business, University of San Diego, USA

HIGHLIGHTS

- California local governments are driven by regulations to implement GHG policies.
- Cost effectiveness is not the main reason for policy priorities but stakeholder interest in cost is high.
- GHG and cost per metric ton of GHG abated for seven current road transport policies in San Diego are presented.
- Net costs are defined as costs and benefits to agency/city administration, to individuals and to employer without co-benefits and costs.
- These costs vary from negative to highly positive. Near net zero cost may or may not provide large GHG benefits.

Abstract

California’s overarching mandate to achieve 1990 levels of greenhouse gases (GHGs) in 2020 (AB 32, 2005), and the ensuing recent regulations (SB 375, CEQA updates) require local and regional governments to assess GHG mitigation policies, including on-road transportation. The regulations do not make cost-effectiveness a primary criteria for choosing measures but cost remains important to a variety of stakeholders.

This communication summarizes results from GHG and cost analysis for seven actual San Diego County road transportation policies: telecommute, vanpools, a bicycle strategy, an increase in mass transit use, parking policies (parking pricing, preferred parking for electric vehicles), an increased local fuel tax and speed harmonization (signal re-timing, roundabouts). Net costs are calculated as the sum of direct costs and benefits to the administering agency, the employer and the individual. Net costs per metric ton GHG abated vary greatly across measures, from negative to high positive (more than US $1000). We find that local GHG cost cannot be sensibly compared to other carbon or GHG policy costs outside the local context for a variety of reasons, but especially because measures have not been adopted primarily for carbon or GHG abatement potential or on the basis of cost effectiveness.

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1. Introduction

The Mckinsey Global Institute 1 global and national greenhouse gas (GHG) cost abatement curves and conclusion that “measures needed to stabilize emissions at 450 ppm have a net cost near zero” made headlines in 2007–2008. The Mckinsey study capped costs at 40 Euros per metric ton CO2e abated, and hoped to give policy makers an understanding of the impact and cost of measures “...should they choose to act” and assumed that countries would focus first on the cheapest measures. This, together with the Stern Review on the economics of climate change 2 led to similar discussions even at the local level.

In California, policy makers adopted mandatory GHG targets under Assembly Bill 32 (AB 32, 2005), which requires the state to reach 1990 GHG levels by 2020. The Scoping Plan for AB 32 then specified the measures expected to achieve these targets, including recommendations that local governments reduce GHG emissions from activities within their jurisdiction by about 15% below a chosen baseline year. California then enacted Senate Bill 375 (2010) 3 to reduce GHGs from personal vehicle use that is within the jurisdiction of regional transportation agencies. The San Diego Association of Governments (SANDAG), (2011a,b,c,d,e), the regional transportation and planning

* Corresponding author. Tel.: +1 619 260 2957; fax: +1 619 260 4753.
E-mail address: silvasend@sandiego.edu (N. Silva-Send).
1 Available at https://solutions.mckinsey.com/ClimateDesk/default.aspx.
3 Senate Bill 375 (2010).
agency became the first agency in the state subject to SB 375 and therefore explored measures to reduce GHGs from the transportation sector. A second mandatory state requirement came with the ‘Guidelines for GHG Planning’ (2010) under California’s Environmental Quality Act (CEQA) addressed to local governments. Thus cities must now implement GHG reduction measures upon update of their General Plans.

While these overarching targets, and the regulations that followed spurred local government into action, neither SB 375 nor the CEQA Guidelines require a cost analysis of the measures per se but state generally that “…a public agency has an obligation to balance a variety of public objectives, including economic, environmental and social factors…” and that policies should achieve GHG reductions “…if there is a feasible way to do so…” One interpretation of such statements is that “excessive” cost may make a GHG abatement measure infeasible.

Although regulation focused on local governments does not make cost-effectiveness a primary criteria for choosing mitigation measures, the relative cost of such measures is important to a range of stakeholders. This paper presents estimates of GHG abatement costs for a selection of local transportation measures in place. We also compare these costs to other GHG policy costs and find that they cannot be sensibly compared outside of the local context.

2. Road transportation emissions in San Diego County

The road transportation category is the largest contributor of GHG gas emissions in the San Diego region, accounting for about 43% of the total in 2010 (Fig. 1). Tackling the emissions from on-road⁴ transportation is therefore necessary to achieve significant overall reductions in GHG emissions in the long run.

The 2020 projection for road transportation (Fig. 2) includes reductions to be achieved by federal and state technology-forcing measures in 2020⁵ as well as the California Energy Commission (CEC)’s forecast of about 11% of the passenger vehicle miles to be driven by electric vehicles (EVs) in 2020.⁶ While these measures provide the bulk of the reductions toward the 2020, AB 32 target local action is also needed to achieve longer term reductions.

We present GHG and cost analyses for seven local policy measures. Table 1 provides the key parameters of each policy.

2.1. Greenhouse gas abated method

GHG refers to the sum of CO₂, N₂O and CH₄ emissions expressed as CO₂ equivalent. Overall vehicle GHGs were obtained from the California transportation emissions model, EMFAC 2007. The GHGs abated by each measure were calculated on the basis of either vehicle miles traveled (VMT) that are avoided or fuel use avoided. Where policy measures lead to reduction in miles traveled, these avoided miles were converted to CO₂e using a CO₂e/mile emissions factor that accounts for fuel economy standards effects through 2016⁷. Note that improvement of fuel economy standards means it becomes more difficult for local

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⁴ As opposed to off-road transportation emissions.

⁵ These are California’s Pavley I (AB 1493) standards, which impose a 250 g/mile tailpipe emission standard for CO₂e, equivalent to 34.5 miles per gallon fuel economy, as in the federal Corporate Average Fuel Economy Standards (CAFE), and the California Low Carbon Fuel Standard, LCFS, which requires fuel suppliers to reduce the carbon intensity of the fuel by 10% from 2010 in 2020.

⁶ The CEC recently revised upwards its estimate of electric vehicle miles driven in 2020 to 17%; however, this paper still uses the older values.

⁷ The fuel economy standards have been improved again on August 28, 2012 but have not been taken into account for this communication. The new standards will be tailpipe emissions of 163 g/mile CO₂e, equivalent to 54.5 miles per gallon for new vehicles in 2025, if achieved purely by fuel economy changes. See http://www.epa.gov/oms/climate/regs-light-duty.htm#new1.
VMT reduction measures to achieve large GHG reductions. In contrast, if state and federal standards were not fully implemented as planned, the CO₂e/mile factor would be higher, and result in greater reductions from local VMT reduction measures.

Where the local policies, such as roundabouts, lead to reduction in fuel use, we convert fuel reductions to emissions avoided by applying a generic conversion factor of 0.009 CO₂e per gallon gasoline.8

The general assumptions for GHG calculations across all measures are shown in Table 2.

2.2. Cost analysis

While there are several approaches to cost effectiveness calculations, we estimate the overall net direct costs to society of a particular measure based on actual expenditures allocated to the measures as provided to us by the regional agency or City of San Diego. These net societal costs do not include benefits from air pollution savings, congestion reduction benefits, crash reduction benefits, or other ancillary co-benefits, except for mass transit, where some such costs are available in the literature for California. Therefore, except for mass transit, the net cost approximates the marginal cost, as elasticity relationships or equivalent are available to help scale the effect of the measure. For mass transit, the cost is an average annual as we have no estimate of the relationship of participation with expenditure. The two main assumptions for the cost analysis are that the price elasticity of gasoline is –0.3,9 and that the price of gasoline stays constant in 2010 real dollars, at $3.50 per gallon.10 Private sector cost is offset by private sector benefits and are not used in the cost calculations because it is assumed that the private sector costs are recovered by revenues and profits, and otherwise, the activity would not be undertaken.

Individual net cost calculations vary amongst measures but typical components of the estimates calculation are as follows:

Net cost = [Annualized or annual administrative costs] + [any annualized infrastructure costs] + [annual subsidy costs] + [(annual cost to individuals, such as vanpool fees)] + [benefits to individual in fuel savings and time] + [benefits to employer such as from telework]

More details of cost components for each measure are provided in Table 3.

3. Results and discussion

Table 4 summarizes the costs per metric ton of GHG abated for the 7 policy measures. The cost across these measures range from negative to highly positive. We do not provide cost ranges for each measure because we have used actual or planned input cost components and results reflect current policy. Based on these actual policy designs and cost components, the telecommute policy, the speed harmonization measures and the vanpool policy as currently designed and as currently operated have negative costs.11 A fuel tax is close to zero net cost while parking policies, mass transit and the bicycle strategy have increasing positive costs based on current participation rates and design.

None of the policies are enacted purely for GHG or carbon mitigation but have been selected from among existing policies or removed from their previous policy context (air pollution, traffic congestion) in order to demonstrate the ability to also reduce GHGs, an existing benefit that was not quantified in the past, or required. Thus the cost effectiveness results can be considered conservative as a GHG policy tool alone.

8 Environmental Protection Agency, XXX. This involves an uncalculated inherent error due to the fact that the gasoline is no longer pure gasoline but E10, a mixture of 10% ethanol and 90% gasoline.


10 We are assuming this as the real, not nominal, price in 2010 $s and the real price is held steady at $3.50 /gallon. See http://www.sandiego.edu/epic/data_center/feature_archive.php?PriceGasoline which shows that the real price has not risen above $3.50 in 2010 $s from 1919 to 2008.

11 The effect the level of commute miles avoided has on the cost per metric ton is as follows: commute miles avoided: 25, 40, 50, 75, 100; cost ($/metric ton CO₂e: 348, 87, 0, –16, –174, respectively, with the price of gasoline per gallon held constant at $3.50 (2010). The policy would become cost-ineffective if the commute avoided is less than about 50 miles. If the real price of gasoline increases, the break-even point occurs at a lower commuter distance avoided.

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Table 3

General assumptions for greenhouse gas emissions calculations, road transportation policies, San Diego County, California.

The GHG emissions of the private vehicle fleet are composed of emissions from passenger cars and light duty trucks up to 8500 lbs. These are the two categories affected by state and federal fuel economy mandates. The GHG emissions are derived from the Series 12 local VMT input data, obtained from SANDAG in 2010, with the EMFAC 2007 model. This provides VMT from 2008 to 2010 with forecasts for 2020. Annual values were linearly interpolated.

The CO₂/E/VMT factor used for policy measures that affect VMT is 4.014E-04 metric tons CO₂e/mile, reflecting the high percentage of light duty vehicles in the private fleet. The average commute distance in 2010 was 25 miles per day, according to SANDAG. This is assumed constant through 2020. The rebound effect is not taken into account. However, previous research has shown that this is not more than about a 3% increase in VMT (Silva-Send, 2009). Greater errors may arise from uncertainties in the forecasts based on uncertainties in the past forecasts for our region for VMT, of the order 8%.

Based on analysis carried out by author of historical SANDAG forecasts every four years since 1974.

Table 3

Local GHG mitigation road policy cost components, San Diego County, California.

(a) Telecommute policy
A telecommuting employee avoids the cost of the typical daily commute, 25 miles, in a single occupant vehicle. Benefits to the employer—greater productivity, reduced administrative costs due to reduced office space needs, reduced relocation costs, reduced absenteeism—have been estimated and are included. Other benefits that may be enjoyed such as tax benefits, family benefits, independence and flexibility are not included. Administrative costs to the agency are included. The additional energy cost of working at home or nearby is not included.

(b) Vanpool policy
The regional vanpool policy consists of subsidizing private operators that offer this service. Costs include: monthly subsidies of $400/month per operator by the agency, agency administrative costs, and monthly fees of $120 to individuals. Benefits accrue to individuals from reduced fuel use in single occupant vehicles. An increase in the cost of the monthly subsidy would be offset by a decrease in the user monthly fee. In general, the variable that makes this policy cost effective (i.e., a negative cost in terms of dollars per metric ton ($/MT)) is the daily avoided miles in a single occupant vehicle. For our county, with these cost/benefit parameters, we estimate achieving near zero net cost per metric ton at about over 50 miles daily commute avoided.

(c) Local fuel tax
The county has the ability to increase the local fuel tax to a certain extent. The following components of the pump price of gasoline were used for the cost estimate with a price elasticity of 0.3: Federal fuel tax ($): 0.184; California fuel tax ($): 0.180; underground storage tank fee ($): 0.02; local sales tax 8.75% (less county fuel tax) ($): 0.215; County tax amount (1.25%, $): 0.36fnb; The total taxes and fees are $0.635.

(d) Mass transit
Mass transit costs are based on SANDAG’s estimates to increase the commuter mode share from 5.3% in 2010 (all day) to 7.8% in 2020. The cost to achieve the new percentage is the additional cost incurred by SANDAG for transit compared with the previous period. Thus for 2020, the cost to achieve 7.8% is the additional expenditure during 2010–2020, compared with what had already been spent in 1999–2010. The fuel saved by individuals not using private vehicles for the average commute distance of 25 miles is removed from the SANDAG costs. SANDAG capital and O&M costs are net of revenues from bus fares.

(e) Parking management policies
Parking fee strategy
Increasing residential and commercial parking fees has been shown to decrease the use of vehicles by increasing the cost of driving. Parking fee increases and the resulting GHG reductions are based on best estimates of the number of parking spaces in the metropolitan area over which the city has jurisdiction. The miles avoided by introducing a parking fee depends on the magnitude of the price increase, response of drivers, availability of cheaper parking options nearby, and the availability of other modes of getting to the same place. Despite these variabilities, parking pricing reduces commuter VMT in metropolitan area by 0.1–0.3%. (Litman, Parking Pricing).

It is assumed that user parking fees are offset by this same revenue to the city, making this a revenue neutral measure, except for minimal administrative costs for the city to operate the system.

Preferred parking for electric vehicles
A policy to reserve 10% of the total parking spaces for electric vehicles incurs regular operation and maintenance (O&M) and administrative costs for a local government.

Enforcement costs are assumed offset by parking fees.

(f) Bicycle strategy
Costs were based on SANDAG’s estimates of the cost for Class I and II bicycle lanesfind; per square mile in the region. As per the Moving Cooler report, only Class I and II lanes are likely to promote bicycle commuting. Fuel savings by individuals are based on the equivalent of 8 miles per day avoided by use of a conventional vehicle, as assumed by SANDAG. The CO₂e/mile factor used for all measures does not reflect the fact that use of a private vehicle for short distances is less efficient than that for the average commute distance of 25 miles.

(g) Speed harmonization measures
Signal retiming
By harmonizing and coordinating speeds along major highways in place of dynamic controls, traffic light retiming reduces emissions and crash damages. The cost per signal retiming is based on a comprehensive local SANDAG study of 1993 that assessed the potential for signal retiming in the region. Low and high costs for installation and engineering costs were provided in that report and the high estimates were used for this paper. Capital costs are assumed offset by individual fuel savings.

Roundabouts
Like synchronized traffic lights, roundabouts at intersections in place of stop signs or traffic signals reduces emissions and crash damages (Varhelyi). A local feasibility and implementation analysis for roundabouts in La Jolla, San Diego (2007) was used as the cost basis for this measure. Capital costs for roundabouts are offset over their lifetime by fuel savings.

§§§ See http://legacy.signonsandiego.com/uniontrib/20080601/news_1n1pkmain.html for typical enforcement, administrative costs and fines revenues estimates in the city of San Diego.
§§§§ Class I is a dedicated path separated from other traffic. Class II is a lane separated from traffic generally by a white line in California. In a study of over 30 cities in 2003, Dill and Carr (2003), found that for a city with population > 250,000, each additional mile of Type 2 bicycle lanes per square mile is associated with a one percent increase in bicycle commuting. This is the elasticity used in our calculations.
Table 4
Cost estimates per metric ton of on-road transportation policies, San Diego County, California.

<table>
<thead>
<tr>
<th>Transportation Policy Measure</th>
<th>Cost (2010 $s/MT CO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecommute</td>
<td>1715</td>
</tr>
<tr>
<td>Speed harmonizing; signal re-timing/roundabouts</td>
<td>456/340</td>
</tr>
<tr>
<td>Vanpools</td>
<td>162</td>
</tr>
<tr>
<td>Fuel tax</td>
<td>0</td>
</tr>
<tr>
<td>Parking policies: parking fees/preferred parking for electric vehicles</td>
<td>98/761</td>
</tr>
<tr>
<td>Mass transit with health co-benefits</td>
<td>2607/74</td>
</tr>
<tr>
<td>Bicycle strategy</td>
<td>37,811</td>
</tr>
</tbody>
</table>

Fig. 3. Vanpool policy GHG abatement cost per metric ton based on a varying commute distances avoided, target year 2020, San Diego County, California.

Fig. 4. Mass transit abatement cost with and without health benefits, target year 2020, San Diego County, California.

Fig. 5. Greenhouse gas abatement costs for seven measures, target year 2020, San Diego County, California.

Fig. 6. Greenhouse gas reduction amounts for seven measures, target year 2020, San Diego County, California.

Fig. 7. Greenhouse gas abatement costs for six measures, target year 2020, not including the bicycle strategy, San Diego County, California.

Fig. 8. Greenhouse gas reduction amounts for six measures, target year 2020, not including the bicycle strategy, San Diego County, California.
It is clear that the design of the policy will affect the cost and the GHG abated. As currently designed, the vanpool policy, for example, is cost effective but if the commute distance avoided were to change to below about 60 daily miles, the policy is likely to become less cost effective for GHG abatement alone (Fig. 3). Similarly, if the price of gasoline rose and/or the monthly incentive is changed the vanpool policy’s cost effectiveness will change.

Some policies become specially cost effective upon increasing participation rates, such as mass transit, where cost effectiveness will be reached either upon significant participation rates, or at relatively low participation rates if ancillary benefits such as health benefits are included (Fig. 4).

It is important to recognize that while the cost per metric ton indicates the effectiveness of a measure in economic terms, this should ideally be balanced against the magnitude of the GHGs avoided, and/or against the total absolute cost of a measure. Therefore, Figs. 5–8 show the results of the analysis in terms of cost per metric tons and separately as GHG abated. Fig. 7 is the same as Fig. 5 without the bicycle strategy, the cost of which skews the other results. When Fig. 5 is considered in conjunction with Fig. 6, or Fig. 7 in conjunction with Fig. 8, the cost of the region-wide telecommute, signal re-timing, roundabouts and vanpool policies as designed is low, and the GHG abated is also relatively low (less than 0.15 million metric tons CO2e); in contrast the fuel tax and parking fees provide significant GHG abatement (greater than 0.25 million metric tons CO2e) at low cost while mass transit also provides significant GHG abatement at higher cost.

How do these carbon mitigation costs compare with other GHG or carbon policy mitigation costs and is there any value in comparing estimates? Certainly, some of the local transportation mitigation costs are higher than the costs capped at 40€/ton CO2 in 2008 up from €106/ton CO2 in 2008 up from €43/ton CO2 in 1991.12 This range reflects policies implemented largely for the sake of GHG and carbon mitigation and not, as in San Diego, policies that collaterally have been shown to mitigate GHGs. Unless measures are implemented largely for carbon or GHG abatement, comparing local abatement costs per metric ton outside of this context is of little value. Therefore, while abatement costs are useful for comparative and background policy information purposes, they are less meaningful in the local planning context.

4. Conclusion

We have presented results of 7 actual road transportation policies in San Diego county that abate GHGs and their costs in target year 2020. As currently designed, these policies have a large range in cost effectiveness, with 4 measures having negative (net savings) or near zero costs, and 3 measures with low to high net costs. For some measures, such as increase in mass transit use, net cost can easily switch to near zero, even with planned and expected participation rates if co-benefits such as air pollution avoidance are included. On the other hand, bicycle policy costs are high per ton of GHG abated, unless participation rates or commute distance were to increase to unrealistically high levels. Nonetheless, this is a desirable policy for the quality of life, an issue that the San Diego region touts.

Our local transportation measures are implemented not based on an up-front cost analysis with range of inputs and they are not based on GHG reduction potential or priority. Therefore comparisons of costs per metric ton GHG abated with those of other GHG or carbon mitigation policies, let alone with the capped costs of the McKinsey study, are of little value because those other carbon pricing measures are implemented primarily for the purpose of achieving GHG reduction. In our region, at this time, such an analysis provides a useful but only post-assessment of the GHG cost effectiveness of policies that have been implemented anyway.

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12 EU hails airline emissions tax success, the Guardian, May 15, 2012.