Transportation:
The Road More Traveled

San Bernardino Associated Governments

Ty Schuiling, Director of Planning & Programming

April 15, 2010
Sustainable Transportation

CHALLENGES:
- Growth and Congestion
- Freight Movement
- Air Quality & Environment
- Energy, Fuels, and Prices
- Transportation Finance
- Institutional Issues

SOLUTIONS: Our Next Steps
<table>
<thead>
<tr>
<th>Urban Area</th>
<th>Annual Delay Per Traveler</th>
<th>Travel Time Index</th>
<th>Wasted Fuel Per Traveler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007 Hours</td>
<td>Rank</td>
<td>Value</td>
</tr>
<tr>
<td><strong>Very Large (14 Areas)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles-Long Beach-Santa Ana, CA</td>
<td>51</td>
<td>1</td>
<td>1.37</td>
</tr>
<tr>
<td>Washington, DC-VA-MD</td>
<td>62</td>
<td>2</td>
<td>1.39</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>57</td>
<td>3</td>
<td>1.35</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>56</td>
<td>4</td>
<td>1.33</td>
</tr>
<tr>
<td>San Francisco-Oakland, CA</td>
<td>55</td>
<td>5</td>
<td>1.42</td>
</tr>
<tr>
<td>Dallas-Fort Worth-Arlington, TX</td>
<td>53</td>
<td>6</td>
<td>1.32</td>
</tr>
<tr>
<td>Detroit, MI</td>
<td>52</td>
<td>9</td>
<td>1.29</td>
</tr>
<tr>
<td>Miami, FL</td>
<td>47</td>
<td>11</td>
<td>1.37</td>
</tr>
<tr>
<td>New York-Newark, NY-NJ-CT</td>
<td>44</td>
<td>14</td>
<td>1.37</td>
</tr>
<tr>
<td>Phoenix, AZ</td>
<td>44</td>
<td>14</td>
<td>1.3</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>43</td>
<td>19</td>
<td>1.29</td>
</tr>
<tr>
<td>Boston, MA-NH-RI</td>
<td>43</td>
<td>19</td>
<td>1.26</td>
</tr>
<tr>
<td>Chicago, IL-IN</td>
<td>41</td>
<td>21</td>
<td>1.43</td>
</tr>
<tr>
<td>Philadelphia, PA-NJ-DE-MD</td>
<td>38</td>
<td>29</td>
<td>1.28</td>
</tr>
<tr>
<td><strong>Large 29 Areas</strong></td>
<td>35</td>
<td>1.23</td>
<td>24</td>
</tr>
<tr>
<td>San Jose, CA</td>
<td>53</td>
<td></td>
<td>1.36</td>
</tr>
<tr>
<td>Orlando, FL</td>
<td>53</td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>San Diego, CA</td>
<td>52</td>
<td></td>
<td>1.37</td>
</tr>
<tr>
<td>Tampa-St. Petersburg, FL</td>
<td>47</td>
<td></td>
<td>1.31</td>
</tr>
<tr>
<td>Denver-Aurora, CO</td>
<td>45</td>
<td></td>
<td>1.31</td>
</tr>
<tr>
<td>Riverside-San Bernardino, CA</td>
<td>44</td>
<td></td>
<td>1.36</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>44</td>
<td></td>
<td>1.31</td>
</tr>
</tbody>
</table>

Source: Texas Transportation Institute - 2009 Urban Mobility Report
## California’s Roads More Crowded Than Other States

<table>
<thead>
<tr>
<th>Rank (2003)</th>
<th>Urban Area</th>
<th>Miles Driven Per Highway Lane-Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Los Angeles-Long Beach-Santa Ana, CA</td>
<td>23,248</td>
</tr>
<tr>
<td>2</td>
<td>Riverside-San Bernardino, CA</td>
<td>21,429</td>
</tr>
<tr>
<td>3</td>
<td>San Francisco-Oakland, CA</td>
<td>20,242</td>
</tr>
<tr>
<td>4</td>
<td>Chicago, IL-IN</td>
<td>19,516</td>
</tr>
<tr>
<td>5</td>
<td>San Diego, CA</td>
<td>19,460</td>
</tr>
<tr>
<td>6</td>
<td>Sacramento, CA</td>
<td>19,303</td>
</tr>
<tr>
<td>7</td>
<td>Atlanta, GA</td>
<td>19,077</td>
</tr>
<tr>
<td>8</td>
<td>Miami, FL</td>
<td>19,057</td>
</tr>
<tr>
<td>9</td>
<td>Houston, TX</td>
<td>18,970</td>
</tr>
<tr>
<td>10</td>
<td>Oxnard-Ventura, CA</td>
<td>18,873</td>
</tr>
</tbody>
</table>

Source: California Travels – Legislative Analyst, 2007
SCAG Region…forecast growth like adding the cities of Chicago and Houston in next 25 years

SCAG Region 2035 Forecast
Population & Employment Growth (Millions)

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2035</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>18.6</td>
<td>23.8</td>
<td>28%</td>
</tr>
<tr>
<td>Employment</td>
<td>7.8</td>
<td>9.9</td>
<td>27%</td>
</tr>
</tbody>
</table>
Not just numbers: who are they?
Growth will be more Hispanic

SCAG Region Population Growth 2005-2025

Demographic data and analysis provided courtesy Frank Wen, SCAG
We will be older
SCAG Region Population Growth 2005-2025

Demographic data and analysis provided courtesy Frank Wen, SCAG
Household growth will be much older!

SCAG Region Households Growth Age 2005-2025

Demographic data and analysis provided courtesy Frank Wen, SCAG
Huge Shift in Age of Population:
From wage-earners to retirees

1975 - 2000
- Under 20: 27.5%
- 21-64: 61.4%
- 65+: 11.1%

2000 - 2025
- Under 20: 31.4%
- 21-64: 38.9%
- 65+: 29.7%

Demographic data and analysis provided courtesy Frank Wen, SCAG
HH Income Before Taxes

Source: 2000 Consumer Expenditure Survey

Demographic data and analysis provided courtesy Frank Wen, SCAG
Personal Income Taxes Paid by Californians

Source: California State Controller's Office, based on data from the U.S. Census Bureau’s 1997 Current Population Survey courtesy Frank Wen
HH Average Annual Expenditures

Sales tax!

Source: 2000 Consumer Expenditure Survey

Demographic data and analysis provided courtesy Frank Wen, SCAG
Avg Government Service Expenses by age

Data and analysis provided courtesy Frank Wen, SCAG
Employment Growth Will Slow

<table>
<thead>
<tr>
<th>Average Growth Rate</th>
<th>Projected Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 - 2000</td>
<td>2010 - 2030</td>
</tr>
<tr>
<td>2.4%</td>
<td>0.7%</td>
</tr>
<tr>
<td>(156,000 jobs/yr)</td>
<td>(75,000 jobs/yr)</td>
</tr>
</tbody>
</table>

Data and analysis provided courtesy Frank Wen, SCAG
Driver Fatality Rates, 1996
(Per 100 Million VMT)

Male Drivers
Female Drivers
All Drivers

16-17
18-19
20-24
25-29
30-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Total

0
1
2
3
4
5
6
7
8
9
10
11
12

16-17: Male Drivers 2.5, Female Drivers 0.5, All Drivers 1.5
18-19: Male Drivers 1.8, Female Drivers 0.3, All Drivers 1.1
20-24: Male Drivers 1.2, Female Drivers 0.2, All Drivers 0.7
25-29: Male Drivers 1.0, Female Drivers 0.1, All Drivers 0.6
30-39: Male Drivers 0.8, Female Drivers 0.1, All Drivers 0.5
40-44: Male Drivers 0.6, Female Drivers 0.1, All Drivers 0.4
45-49: Male Drivers 0.4, Female Drivers 0.1, All Drivers 0.3
50-54: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
55-59: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
60-64: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
65-69: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
70-74: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
75-79: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
80-84: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
85+: Male Drivers 0.3, Female Drivers 0.1, All Drivers 0.2
Total: Male Drivers 6.0, Female Drivers 1.0, All Drivers 3.0
Household Growth 2000-2040

<table>
<thead>
<tr>
<th>US HH Type</th>
<th>Growth</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH Growth 54M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With children</td>
<td>7 M</td>
<td>14%</td>
</tr>
<tr>
<td>Without children</td>
<td>47 M</td>
<td>86%</td>
</tr>
<tr>
<td>Single/Other*</td>
<td>16 M</td>
<td>30%</td>
</tr>
</tbody>
</table>

*New single-person HHs double new HHs with children.*

Households are Changing

<table>
<thead>
<tr>
<th>Household Type</th>
<th>1960</th>
<th>2005</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH with Children</td>
<td>48%</td>
<td>32%</td>
<td>26%</td>
</tr>
<tr>
<td>HH without Children</td>
<td>52%</td>
<td>68%</td>
<td>74%</td>
</tr>
<tr>
<td>Single/Other HH</td>
<td>13%</td>
<td>31%</td>
<td>34%</td>
</tr>
</tbody>
</table>

Source: Arthur C. Nelson, Presidential Professor & Director of Metropolitan Research, University of Utah
Professor Arthur Nelson, Director of Metropolitan Research at the University of Utah:

The U.S. will have a likely surplus of 22 million large-lot homes—that’s houses built on a sixth of an acre or more—by 2025.

That's roughly 40 percent of the large-lot houses in existence today. Our housing policy has to be amended to reflect our changing preferences.
Indications from the demography:

• Reduction in per capita income tax and sales tax revenues (now the principal source of transportation funding!)

• Increased demand for small lot detached and attached residences, declining demand for large lot detached

• Increasing need for safer alternatives to the auto for aging population

• Probable end to increases in VMT per capita
GOODS MOVEMENT IN SOUTHERN CALIFORNIA
Intermodal Freight – Number 1

Double digit growth Impact on Ports

LA/ LongBeach/Ports
2006 Stats
• 14.8 M TEU’s
• 65% Transferred to Inland Ports

Source: US Department of Transportation
Drivers of International Trade

- Federal policy supports global trade
- Export manufacturing jobs to overseas sources of cheap labor
- Import manufactured goods from overseas
- Price of imported goods fails to internalize transportation, environmental, and social costs
The Transloading Advantage

Transloading of weekly shipments from Asia affords large, nation-wide retailers an 18-20% reduction in their total pipeline plus safety stock inventory compared to direct shipping.

Assuming a 6% average error in nationwide one-week-ahead sales forecasts
Shares of Inbound Loaded Containers at West Coast Ports (TEUs)
Serving the Nation 2007: Local vs. Interregional Freight

Port of Oakland

LA-Long Beach Ports

Local

Out-of-region

TEUs (millions)

CA Goods Mvmt. Action Plan and SANBAG
Modal Market Segments (MCGMAP)

- Local Trucks: 23%
- Regional Trucks: 13%
- Intermodal Rail: 12%
- Off-Dock/Near-Dock: 20%
- On-Dock: 20%

*All percentages estimated based on 2005 data.*
1 billion sq ft of warehouses today

Where will the next .5B sq. ft. go?
Goods Movement Provides Economic Opportunity - Jobs

Blue Collar
Good Entry Level Pay
Defined Skill Ladder
On The Job Learning
Heavy Use of Information Technology
Has To Be In Southern California
Factors Impacting Cargo Projections for the San Pedro Bay Ports

- Reduction in transloading on the West Coast, and more intact movement of goods via the Panama Canal.
- Development of multiple import supply chains using ports on all three coasts.
- Growth in trade with regions such as Europe and Latin America that favor the East or Gulf Coast ports.
- Increased competition from West Coast ports
Key findings of the Leachman Port and Modal Elasticity Study are:

1. Inadequate landside freight capacity will strangle port growth absent major improvements

2. Failure to address landside congestion will cause diversion/loss of market share, and loss of logistics jobs
Daily Truck Traffic to/from LA/LB Ports will grow dramatically

Source: Gill V. Hicks Associates
California Railroad Freight Tonnage

Annual Million Gross Tons (MGT)

- 0 to 5
- 5 to 10
- 10 to 25
- 25 to 50
- 50 to 100

Source: BNSF Railway and Union Pacific Railroad
## Train Delays on Existing Trackage

<table>
<thead>
<tr>
<th>Year</th>
<th>Train Type</th>
<th>Average Delay per Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>BNSF Freight</td>
<td>31.9 minutes</td>
</tr>
<tr>
<td></td>
<td>UP Freight</td>
<td>30.4 minutes</td>
</tr>
</tbody>
</table>

## Forecast Train Delay

(Year 2000 passenger trains and no system capacity improvements)

<table>
<thead>
<tr>
<th>Year</th>
<th>Train Type</th>
<th>Average Delay per Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>BNSF Freight</td>
<td>206.3 minutes</td>
</tr>
<tr>
<td></td>
<td>UP Freight</td>
<td>196.9 minutes</td>
</tr>
</tbody>
</table>

Source: Leachman and Associates Mainline Rail Study for SCAG
## Intermodal Yard Capacity and Demand

(Millions of Lifts$^1$)

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2005</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Demand</td>
<td>3.27</td>
<td>4.29</td>
<td>6.95</td>
<td>15.01</td>
</tr>
<tr>
<td>Capacity</td>
<td>4.56</td>
<td>5.88$^2$</td>
<td>5.88</td>
<td>5.88</td>
</tr>
<tr>
<td>Surplus(+)Deficit (-)</td>
<td>+1.29</td>
<td>+1.59</td>
<td>-1.07</td>
<td>-9.13</td>
</tr>
</tbody>
</table>

$^1$ One lift = 1.85 TEUs

$^2$ BNSF’s Commerce facility to added 200,000 Dec. 2002 and Pier 400 added 1.12 million lifts 2004

Source: Gill V. Hicks and Associates
COMMUNITY AND ENVIRONMENTAL IMPACTS
Community Impacts of this freight: grade crossing delay...
Diesel Particulate Matter: Proximity Matters

Fine particle pollution at elementary schools and public facilities
PM2.5 Disproportionate Exposure
South Coast Air Basin

Population-Weighted Exposure Above NAAQS
Based on 2000-2002 AIRS Data

Rest of Nation
48%

South Coast
52%

Source: California Air Resources Board
Recent CARB Assessment of PM Health Effects

SCAB Cases/Year due to PM2.5 *

- Premature Deaths: 5,400
- Hospitalizations: 2,400
- Asthma & Lower Respiratory Symptoms: 140,000
- Lost Work Days: 980,000
- Minor Restricted Activity Days: 5,000,000

• 1999-2000 Air Quality Data

Source: California Air Resources Board
AQ : NOx Emissions Trend By Source Category and Carrying Capacity

- Off-Road
- On-Road
- Area
- Point

PM2.5 Carrying Capacity (443)
8-Hour Ozone Carrying Capacity (114)
2014 NOx Top Ten Source Categories

* Oceangoing vessels = 72
**RECLAIM: 300 largest stationary sources, including all refineries and power plants
2023 NOx Top Ten Source Categories

- Ships & Commercial Boats: 116
- Off-Road Equipment: 81
- Heavy-Duty Diesel Trucks: 78
- Aircraft: 29
- Locomotives: 28
- RECLAIM: 27
- Light-Duty Trucks: 23
- Residential Fuel Combustion: 21
- Light-Duty Passenger Cars: 17
- Heavy-Duty Gasoline Trucks: 17

* Oceangoing vessels = 103
Black Box & Other Challenges

• “Black box” of relatively undefined measures needed to attain the 8-hour ozone standard — 190 tons per day of NOx
  – greater than the total NOx “carrying capacity” of the region needed to attain the ozone standard,
  – greater than baseline emissions from trucks and locomotives combined

• New federal 24 hour PM2.5 standard will likely require ambient pollutant levels to be reduced by 49% from the levels that will be achieved by the current AQMP by 2019
“[The Basin] must reduce nitrogen oxide emissions by approximately two-thirds beyond the levels that will result from all the stringent rules adopted to date by federal, state and local agencies.

This “black box” of needed but unidentified control measures includes over 200 tons of Nox reductions, an amount that exceeds the region’s entire federal ozone standard “carrying capacity” [of 114 tons]

The …Air Quality Management Plan thus identifies non-combustion zero-emission transport technologies as a potential means to fill the black box.”

To achieve federal clean air standards, the SCAB has little choice but to achieve zero and near-zero emission vehicle penetration far beyond levels consistent with ARB’s EMFAC model (which is also used for SB375 GHG calculations). Doing so would effectively negate VMT as an air quality/GHG issue except for entrained road dust (PM10).
Exceedence of critical loads of nitrogen deposition in red, where negative impacts to ecosystems occur due to excess N inputs.

Critical Load issues include:

- Increased invasive plant density and production
- Increased fuel load
- Increased threat of fire frequency and intensity
- Loss of habitat for native species
- Groundwater nitrate

Invasive grasses carry fire

University of California, Riverside
Need for Near Zero Emission Technologies

• Even full fleet turnover to 2010 truck standards and to the Tier 4 locomotive standards proposed by USEPA will not provide sufficient reductions.

• Additional emission reductions — over and above the control measures the agencies have been able to identify for inclusion in plans to date — will have to be implemented.
Air Toxics: Modeled Cancer Risk (Excluding Diesel)
MATES III Modeled Estimated Risk (With Diesel)
### CARB Health Risk Assessments

**Estimated Potential Cancer Risks for BNSF San Bernardino Rail Yard**

<table>
<thead>
<tr>
<th>Sources</th>
<th>Diesel PM Emissions (tons per year)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Diesel PM Emissions</td>
<td></td>
</tr>
<tr>
<td>Locomotives</td>
<td>10.6</td>
<td>48%</td>
</tr>
<tr>
<td>Line Hauls</td>
<td>6.13</td>
<td>28%</td>
</tr>
<tr>
<td>Switchers</td>
<td>4.06</td>
<td>18%</td>
</tr>
<tr>
<td>Fueling</td>
<td>0.39</td>
<td>2%</td>
</tr>
<tr>
<td>On-Road Trucks and Vehicles</td>
<td>4.35</td>
<td>20%</td>
</tr>
<tr>
<td>Cargo Handling Equipment</td>
<td>3.65</td>
<td>17%</td>
</tr>
<tr>
<td>Off-Road Equipment</td>
<td>3.35</td>
<td>15%</td>
</tr>
<tr>
<td>Stationary Sources</td>
<td>0.09</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>22</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: Draft ARB Health Risk Assessment for the BNSF San Bernardino Railyard
Freight Challenges Summarized

- Finance – requires new funding, users and beneficiaries must contribute
- Environment – timely AQ attainment despite 2x increase in shipping & freight throughput and other land-use/transportation resource conflicts
- Performance – assure infrastructure benefits
- Communities – Involvement in decision-making and developing effective, meaningful mitigation [leading to] acceptance and support essential to progress
- Institutions – clarify implementation responsibilities, state & federal recognition
- Implementation – in one decade, not three
But do we attack the air quality problem in effective ways?

SB 375 – 3-5% (?) reduction in GHG from changed land use patterns, new urban design, and enhanced transit
% VMT Reduction by Individual Measures, 10 yr, 20 yr, 30 yr, 40 yr

FIGURE 1 Box Plots of Single Policy VKT Reductions by Time Horizon

From Rodier (2008), UC Berkeley for the 2009 TRB
### Technology?

<table>
<thead>
<tr>
<th>Emission Standard</th>
<th>2004 Chevrolet Malibu</th>
<th>2004 Toyota Prius</th>
<th>Savings</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA Emission Standard</td>
<td>Tier 2 Bin 8</td>
<td>SULEV II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Methane Organic Gases (grams)</td>
<td>1,527</td>
<td>122</td>
<td>1,405</td>
<td>92%</td>
</tr>
<tr>
<td>Carbon Monoxide (grams)</td>
<td>51,303</td>
<td>12,215</td>
<td>39,088</td>
<td>76%</td>
</tr>
<tr>
<td>Nitrogen Oxides (grams)</td>
<td>2,443</td>
<td>244</td>
<td>2,199</td>
<td>90%</td>
</tr>
<tr>
<td>Particulate Matter (grams)</td>
<td>244</td>
<td>122</td>
<td>122</td>
<td>50%</td>
</tr>
<tr>
<td>Carbon Dioxide (lbs)</td>
<td>10,470</td>
<td>5,330</td>
<td>5,140</td>
<td>49%</td>
</tr>
<tr>
<td>EPA Fuel Economy (city/hwy)</td>
<td>24/34</td>
<td>60/51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPA Fuel Economy (combined)</td>
<td>28</td>
<td>55</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Fuel Consumed Annually (gallons)</td>
<td>436</td>
<td>222</td>
<td>214</td>
<td>49%</td>
</tr>
</tbody>
</table>

**Notes**

1. Based on 12,215 annual mileage.
2. Data obtained from Smog Forming Pollutants Chart, EPA Green Vehicle Guide: [www.epa.gov/autoemissions/0-10chart.htm](http://www.epa.gov/autoemissions/0-10chart.htm)
5. Assumes 55% city driving and 45% highway driving.

**Emission Standard Key**: Vehicles meeting the Federal Tier 2 Bin 8 standard produce: 4.2 g/mi of CO, 0.02 g/mi of particulate matter, 0.2 g/mi of NOx, and 0.125 g/mi of non-methane organic gases. Vehicles meeting California’s SULEV II (Super Ultra Low Emissions Vehicle) standard produce: 1.0 g/mi of CO, 0.01 g/mi of particulate matter, 0.02 g/mi of NOx, and 0.01 g/mi of non-methane organic gases.
AIR QUALITY STRATEGIES
for transportation sources

More effective

Clean technologies (EVs, plug-in hybrids): 90%+ reductions in emissions per vehicle

Pricing (increased gas tax, VMT fees, congestion pricing): 10%+ reductions in VMT in < 5 years

Land use change: possibly 4% in VMT over 20 years (per Rodier)

Transit: 3% (?) in VMT over 20 years (per Rodier)

Infrastructure investment: little, for mobility

Less effective

Note: Less effective strategies (e.g. land use and transit) can be more effective if combined with pricing and clean technologies
ENERGY – an Economy Powered by Fossil Fuels

Mathematical relations involved in the complete cycle of production of any exhaustible resource

from Hubbert, M. King (1956), Pub. No. 95,
Shell Development Co. Exploration and Production Research Division
Uses of Petroleum

1973

- Transportation
- Industrial
- Commercial
- Residential
- Electrical power

2004

- Transportation
- Electrical power
- Commercial
- Residential
- Industri
Hubbert linearization of US lower 48 production

US Petroleum Production 1954 to 2006

By Geographic Location

US Crude oil production vs drilling activity

Oil Production Drops Even as Drilling Increases
American oil production rose for over 100 years until 1970, then began an intractable decline. With prices rising, companies are drilling more.

Upstream production costs per barrel of oil equivalent

Notes: Costs are the quotient of costs and reserve additions for each three-year period. BOE = Barrels of oil equivalent.
Source: Energy Information Administration, Form EIA-28 (Financial Reporting System).
Oil producing countries past peak production, 2007

Source: IHS 2006; PEMEX, petrobras; NPD, DTI, ENS(Dk), NEB, RRC, US-EIA, January 2007
Forecast: LBST estimate, 25 January 2007
Oil production from the Majors, 1997 to 2007

Compilation by Energy Watch Group 2007
History of petroleum discoveries (proven + probable) versus production

Crude oil + NGL / Condensate

[Gb per year]

Largest oil field (Saudi Arabia)

2nd largest oil field (Kuwait)

1st oil crisis (1973)

2nd oil crisis (1979)

Production

Legend
- Onshore
- Deep water

IHS Energy, 2005
The world consumes two barrels of oil for every barrel discovered.

So is this something you should be worried about?
Hubbert linearization of world production

It took us 125 years to use the first trillion barrels of oil. We’ll use the next trillion in 30.

So why should you care?

Energy will be one of the defining issues of this century: one thing is clear— the era of easy oil is over. What we all do next will determine how well we meet the energy needs of the entire world in this century and beyond.

Demand is soaring like never before. As populations grow and economies take off, nations in the developing world are enjoying the benefits of a lifestyle that requires increasing amounts of energy. In fact, some say that in 20 years the world will consume 50% more oil than it does today. At the same time, many of the world’s oil and gas fields are maturing. As new energy discoveries are mainly occurring in places where resources are difficult to extract, physically, economically, and, even politically, when growing demand meets tighter supplies, the result is more competition for the same resources.

We can wait until a crisis forces us to do something. Or we can commit to working together and start by asking the tough questions: How do we meet the energy needs of the developing world and those of industrialized nations? What role will renewables and alternative energies play? What is the best way to protect our environment? How do we accelerate our conservation efforts? Whatever actions we take, we must look not just to next year, but to the next 50 years.

At Chevron, we believe that innovation, collaboration and conservation are the cornerstones on which to build this new world. We cannot do this alone. Corporations, governments and every citizen of this planet must be part of the solution as surely as they are part of the problem. We call upon scientists and educators, politicians and policy-makers, environmentalists, leaders of industry and each one of you to be part of reshaping the next era of energy.
Oil + natural gas production profiles based on data through 2006

Source: Association for the Study of Peak Oil and Gas, most recently reproduced in Newsletter No. 85, January 2008
The Shape of Future Petroleum Production

- oil buyer's market
- seller's market

ANNUAL OIL PRODUCTION (BILLIONS OF BARRELS)

- WORLD
- WORLD OUTSIDE PERSIAN GULF
- PERSIAN GULF
- U.S. AND CANADA
- FORMER SOVIET UNION
- U.K. AND NORWAY

Here we are today!

Forecasted production

Previous rollovers

Actual production

A

B

C

Source: US Geological Survey Open File Report 00-320
Economic Scenarios for an Age of Declining EROI's

[Energy Return on (Energy) Invested]

Energy and GDP
- Global Energy – GDP correlations
- An advanced model
- Transfers of energy in products and services
- A chicken and egg question
- The price of energy

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The price differences between human labor and fossil fuels are breathtaking

Fossil energy is significantly cheaper than energy from human labor (and renewables from solar inputs like photovoltaics, wind, etc.):

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>US$ cost of 1kWh energy input (2005 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil at long term median price ($15/bbl)</td>
<td>$0.01</td>
</tr>
<tr>
<td>Oil at long term avg price ($28/bbl)</td>
<td>$0.02</td>
</tr>
<tr>
<td>Oil today ($70/bbl)</td>
<td>$0.04</td>
</tr>
<tr>
<td>Electricity from coal (US ex power plant) 2009</td>
<td>$0.03</td>
</tr>
<tr>
<td>Low cost solar (ex-power plant) 2009</td>
<td>$0.35</td>
</tr>
<tr>
<td>Humans (Bangladesh)*</td>
<td>$1.75</td>
</tr>
<tr>
<td>Humans (global average)*</td>
<td>$13.66</td>
</tr>
<tr>
<td>Humans (United States)*</td>
<td>$60.84</td>
</tr>
</tbody>
</table>

Fossil energy use provides wealth from past solar inputs

- Even very inefficient use of fossil fuels creates a surplus, as this energy provides abundant capacity unavailable (and unaffordable) from humans

- An increase in energy consumption leads to a higher standard of living due to increased outputs

* Human labor cost was derived from the energy-GDP model (pages 6-9), attributing GDP not used for energy purchases to human labor using the following approach: A full year of primary energy input (calorific food intake of a human) represents 365 x 2kWh x $60.94 per kWh = $44,486. Cross-check: U.S. median full time worker income for 2007 was reported as $43,460. © IIER 2009
Over the past decades, our fossil energy sources have become less efficient

Independent of the arrival of “Peak Oil”, increasing amounts of upfront energy are required to explore the next new units of energy

The concept of EROI (Energy Return on (Energy) Investment) describes this as: Energy Units Gained from one Energy Unit Used

A change of EROIs from 80:1 to 20:1 (current estimate for global oil production) equals a “salary increase” of physical work from oil by a factor of almost 4, significantly reducing benefits to our economy

▸ With this change of contributions from energy, economic growth becomes increasingly difficult as more and more output is used for energy generation

Results might be very different compared to most people’s expectations

Every time we see refueled growth
- this will be curtailed by growing energy prices
- leading to a shrinking economy
- and another commodity (and energy) price crash

Key effects
- A downward trajectory
- Reduced readiness to invest (including investments into energy technology and exploration)
- Even fewer available resources
U.S. Fuel Economy for New Light-Duty Vehicles

1975–2004 Model Years Sales-Weighted Horsepower and MPG

Sources: Environmental Protection Agency; Energy Information Administration
International Fuel Economy Comparison

Comparison of fleet average fuel economy and GHG emission standards for new-sale light-duty vehicles

Source: UC Berkeley
Graph courtesy of Kei Koizumi, White House Office of Science and Technology Policy
Energy Efficiency

Energy produced (kinetic) per energy input (chemical or electrical)

Upper efficiency limits of various technologies:

- Steam/external combustion: 10% single expansion, 25% multiple
- Gasoline (internal combustion): 37%
- Diesel (internal combustion): 50%+
- Electric: 80 – 90%+, higher horsepowers more efficient
- Electric generation: 50%+ simple, 90% with cogeneration

Various sources
No. 1. Riverside-San Bernardino, Calif.

$7.61 Per Commuter Per Day

There's no big mystery as to why drivers in these "Inland Empire" cities are hit worst at the pump. Not only are gas prices $3.91 per gallon, some of the highest in the country, but cities like Riverside and San Bernardino grew as part of the Los Angeles sprawl, where residents accepted the trade-off of cheaper housing for longer commutes. Add to the mix 49 hours of annual delays and the fact that 81% of commuters are driving alone, and Riverside-San Bernardino commuters slog through an already lengthy commute at low speeds and with low fuel efficiency.

Matt Woolsey, Forbes.com, May 7, 2008. Based on May 1, 2008 gas prices
“So now we know: The price point is $4. At $3 a gallon, Americans just grin and bear it, suck it up, and, while complaining profusely, keep driving like crazy. At $4, it is a world transformed. Americans become rational creatures. Mass transit ridership is at a 50-year high. Driving is down 4 percent…

Hybrids and compacts are flying off the lots. SUV sales are in free fall.”

CHARLES KRAUTHAMMER, Pulitzer Prize-winning syndicated columnist, June 7, 2008
"Right now we have enough information to officially call it a trend," said Federal Highway Administration spokesman Doug Hecox. According to the survey, drivers started staying off the roads in droves last November. In March, the miles driven on U.S. highways fell 4.3% from March 2007.

Steve Chawkins and Martin Zimmerman, Los Angeles Times Staff Writers, May 24, 2008
A quicker ride?

Road sensor data show some average commute times during rush hour in April were shorter than a year earlier. Rush hour is considered to be from 5 to 10 a.m. and from 3 to 8 p.m. Motorists may experience longer trip times during peak periods.

<table>
<thead>
<tr>
<th>Morning route</th>
<th>Travel time (in minutes)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Clarita to Los Angeles</td>
<td>45.1</td>
<td>43.7</td>
</tr>
<tr>
<td>Thousand Oaks to Los Angeles</td>
<td>56.7</td>
<td>55.7</td>
</tr>
<tr>
<td>Riverside to Ontario</td>
<td>41.5</td>
<td>36.2</td>
</tr>
<tr>
<td>Corona to Ontario</td>
<td>16.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Anaheim to Irvine</td>
<td>24.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Fontana to Pasadena</td>
<td>56.8</td>
<td>54.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Afternoon route</th>
<th>Travel time (in minutes)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles to Santa Clarita</td>
<td>46.1</td>
<td>44.8</td>
</tr>
<tr>
<td>Riverside to Ontario</td>
<td>40.7</td>
<td>37.8</td>
</tr>
<tr>
<td>Ontario to Riverside</td>
<td>43.8</td>
<td>37.2</td>
</tr>
<tr>
<td>Anaheim to Irvine</td>
<td>17.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Irvine to Anaheim</td>
<td>32.9</td>
<td>27.7</td>
</tr>
</tbody>
</table>

Source: Freeway Performance Measurement System.
Graphics reporting by Steve Hymon
When driving seemed almost free, we maintained that we couldn’t build our way out of congestion…

But $4 gas eased congestion in ways we hadn’t seen in 30 years.

Do we prefer payment in dollars or in delay?
Transportation Finance

In case your understanding of transportation funding is a bit shaky...

Transportation Funding in California - Overview

- Fuel Tax
  - California 18 cents/gal, Gas & Diesel
- Truck Weight Fee
- Federal
  - 16.4 cents/gal. Gas
  - 24.4 cents/gal. Diesel
- Federal Transit
  - Admin.
- State Highway Account
- Transportation Investment Plan
  - State Transportation Assistance
- Local Sales Tax
  - 1/4% Local Sales Tax for transportation
  - 4.75% Sales Tax on Diesel Fuel
- Sales Tax
  - 5% State Sales Tax on Automotive Fuel
- Motor License Fees
  - Vehicle License Fee
  - 1.5% Vehicle Property Tax
  - Motor Vehicle Account
- Vehicle Registration & Driver's License Fee
  - License Fee
  - Inspection Fee
  - Disability Fee
  - Special Education Fee

Accomplishments:
- CHP: California Highway Patrol
- CMMD: Congestion Mitigation and Air Quality
- DMV: Department of Motor Vehicles
- EIR: Environmental Impact Report
- FHWA: Federal Highway Administration
- FSP: freeway Service Patrol
- ITA: Federal Transit Administration
- NBBN: Bridge Replacement
- PCA: Public Transportation Account
- RPA: Rural Planning Assistance
- RSTP: Regional Surface Transportation Program
- RTC: Regional Transportation Commission
- SCRTD: Santa Cruz Metropolitan Transit District
- SHOPP: State Highway Operations & Protection Program
- STP: State Transportation Improvement Program
- TCAP: Traffic Congestion Relief Program
- TDA: Transportation Development Act

State Highway Account
- Federal Highway Trust Fund
- California Local
- Federal
- Local
- State
- Transfers
- California State Travel Program
- Public Transportation Account (PTA)
- Vehicle License Fee
- Inspection Fee
- Disability Fee
- Special Education Fee

Transfers:
- Federal
  - FTA: Federal Transit Administration
- State
  - California State Travel Program
- Local
  - City of Los Angeles
- County
  - City of San Diego
- State
  - California State Travel Program
- Local
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In Transportation Investment Fund
- Revenue from local sales tax on gasoline will be divided between city/county roads (46%), the PTA (24%), and the STP (30%). Prior to FY 2018, funds are first taken off the top to fund TCBP projects. When "local emergencies" are declared, funds sometimes have been diverted from General Fund for non-transportation programs. 1st year of program funds came from General Fund.
Sources for Transportation Funds 1993-94

Total Funding $10.2 Billion

State $4.5 Billion
Federal $3.0 Billion
Local $2.7 Billion

Other $360
Motor Vehicle Fees $1,125
Gas Tax $3,015

Local Tax Revenues $1,431
Passenger Fares $675
Local Grants $594

Source: California Legislative Analyst's Office, 1995
California Transportation Revenue Sources (1999-2000)

Local Funds 49%

State Funds 29%

Federal Funds 22%

The [Federal] Highway Account … is projected to have a negative balance by the President’s Budget estimates in 2009 …
Purchasing power of fuel tax is < ½ what it was in the 60’s

California Fuel Tax Revenue Per Million Vehicle Miles Traveled

Source: Caltrans, California Transportation Plan to 2025
State gasoline tax has not kept pace with travel
Source: California Travels – Legislative Analyst, 2007
- California now spends $0.40 on the dollar ($2B for every $5B annual need) to maintain and operate its state highway system

- California Local Governments now spend $0.50 on the dollar ($3.5B for every $7B in annual need) on the local street system
State Funding Summary

• Major decline in purchasing power of gas tax

• Sales tax on gas (Prop 42) a major boost, but may be borrowed to address California Budget deficit

• Prop 1B a major boost, but funds are subject to appropriations in California Budget and are subject to state’s ability to sell bonds

• SHOPP funded at $2.1B per year vs $5B per year need; pay me now or pay me later?
Local Funding:

- Measure I
- Development Impact Fees
- Cities
Commissioners

Mary Peters Secretary of Transportation — Chairperson
Jack Schenendorf Of Counsel, Covington & Burling — Vice Chair
Frank Busalacchi Wisconsin Secretary of Transportation
Maria Cino Deputy Secretary of Transportation
Rick Geddes Director of Undergraduate Studies, Cornell University
Steve Heminger Executive Director, Metropolitan Transportation Commission
Frank McArdle General Contractors Association of New York
Steve Odland Chairman and CEO, Office Depot
Patrick Quinn Chairman, American Trucking Association
Matt Rose CEO, Burlington Northern Santa Fe Railroad
Tom Skancke CEO, The Skancke Company
Paul Weyrich Chairman and CEO, Free Congress Foundation
Federal Reauthorization

### Findings of the Federal 1909 Commission

[SAFETEA-LU]

#### Current Funding for Capital Expenditures by Source and Mode

<table>
<thead>
<tr>
<th>Source</th>
<th>Highway</th>
<th>Transit</th>
<th>Intercity Pass Rail</th>
<th>Freight Rail</th>
<th>All Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Funding</td>
<td>75.1</td>
<td>11.8</td>
<td>0.6</td>
<td>13.8</td>
<td>102.7</td>
</tr>
<tr>
<td>Federal</td>
<td>32.1</td>
<td>4.6</td>
<td>0.5</td>
<td>13.8</td>
<td>38.4</td>
</tr>
<tr>
<td>State and Local</td>
<td>37.7</td>
<td>7.2</td>
<td>0.1</td>
<td>12.4</td>
<td>46.6</td>
</tr>
<tr>
<td>Tolls/Private</td>
<td>5.4</td>
<td></td>
<td></td>
<td>12.4</td>
<td>17.8</td>
</tr>
</tbody>
</table>
Annual National Funding Gap

Source: Section 1909 Commission
To address this investment shortfall by providing the traditional federal share of 40% of total transportation capital funding, the federal fuel tax needs to be raised by 25-40 cents per gallon. This rate increase should be indexed to the construction cost index and phased in over a period of years.
The deployment of peak-hour “congestion pricing” on Interstate highways in major metropolitan areas should be permitted, provided that revenues generated by this strategy are restricted to transportation purposes in the travel corridors where the fees are imposed.
Public-Private Partnerships should be encouraged as a means of attracting additional private investment to the surface transportation system, provided that conditions are included to protect the public interest and the movement of interstate commerce.
What is this information in combination telling us, and how can it best be used to influence public policy?
TAKEAWAYS:

Demography:
- Reduction in average per capita income tax and sales tax revenues
- Small labor force supporting large aging and very young populations
- Need for safer transport alternatives for the aging population

Housing and Land Use:
- Increased demand for small lot detached and attached residences
- Declining demand for large lot detached
- Trend toward compaction of non-residential uses driven by increasing transport costs

Energy:
- Petroleum production may be 60% of today’s by 2040, natural gas will decline more slowly
- Significant near-term reductions in EROI from limitations on fossil fuel production
- Need intense focus on development of energy alternatives
- Near-term need for energy-efficient (not just fuel efficient) technologies to reduce demand
Freight Movement:

- Mere doubling of freight in 20 years versus tripling in 15 isn’t much relief
- Need for dedicated clean technology freight corridors between ports and warehousing/distribution districts, and from there to intermodal facilities
- Potential may exist to reverse geographic expansion of SoCal logistics system, with substantial benefits – but only with clean technologies
- Need rail electrification, new technologies are being advanced by Ports and AQMD
- As above, container fees, diesel fuel tax increases needed to fund freight movement solutions
TAKEAWAYS #3

Transportation Finance:

- Re-establish fee-for-use concept in transportation finance to affect demand
- Need to double annual nationwide transportation investment if only to operate and preserve existing system (1909 Commission)
- Need to *triple* investment if fee-for-use not re-established
- Gas tax increase the most obvious and technically easy first step. Would:
  - Pay to preserve, operate, improve system
  - Reduce demand (VMT reduction = GHG & pollutant reduction)
  - Incentivize fuel efficiency and fleet transformation
  - Promote energy independence
  - Continue to be a viable revenue source for 10-20 years
- VMT fee or similar revenue source needed within 10 years
- Container fees, diesel fuel tax increases needed to fund freight movement solutions
TAKEAWAYS #4

Air Quality:

- Emission reductions from mobile sources are key to healthy air
- Attainment of federal AQ standards in the SCAB require zero/near zero technologies, *all modes, in 1-2 decades*
- Fuel tax increases would help incentivize transformation
- Transparency essential, no more “black boxes”

Greenhouse Gases:

- Technologic transformation needed for clean air profoundly reduce GHG’s as well
- Gas tax increase and pricing measures would provide far more significant near-term results than other options
- Demographic factors and energy constraints will drive land use in directions consistent with SB375.

All of the above are consistent with migration away from internal combustion of fossil fuels and improved EROI!
Are our plans aligned with these factors?

The good news::
THE CHALLENGES ARE IMMENSE, BUT PREFERRED RESPONSES TO THEM ARE REMARKABLY SYNERGISTIC