Transplantation, Land Use, & Accessibility

ALLIANCE TO SAVE ENERGY
Using less. Doing more.

Alliance Commission on National Energy Efficiency Policy

JANUARY 2013

PREAMBLE

The Alliance Commission on National Energy Efficiency Policy (the Commission) was organized to study energy-efficiency policies, programs, and opportunities, and to make consensus recommendations on the next generation of domestic policies, programs, and practices to ensure that the U.S. can double its energy productivity (twice as much gross domestic product [GDP] from each unit of energy) from 2011 to 2030.

The work of the Commission will include an assessment of the current state of energy efficiency in the U.S. economy; a review and assessment of the best local, state, and national practices; and the development of a set of recommendations on policies and programs for the next administration and the 113th Congress to achieve the stated goal of doubling U.S. energy productivity by 2030.

This report, Transportation, Land Use and Accessibility, is one of seven research reports that assess the current state of efficiency within the economy and review the best local, state, and national practices. These assessments will be used to support and provide the technical basis for the Commission's efforts to develop a set of recommendations for doubling the nation's energy productivity. The other reports will address the following areas: history and business case of energy efficiency; residential and commercial buildings; manufacturing industry; power generation and smart grid; natural gas infrastructure; and systems integration.

To provide a comprehensive assessment to the Commission, the last report identified as "systems integration" will be a comprehensive analysis of the other research reports to identify common areas of consideration and areas of interdependency. It will also identify opportunities for the various sectors of the economy to work together.

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INTRODUCTION

The way we design and build our cities and regions has a significant impact on our ability to readily access the things we need and want, including jobs, services, recreation, friends, and family. The transportation infrastructure that overlays this landscape determines mobility choices, such as travel by car, plane, bus, rail, ships, bicycles, and foot. This infrastructure also provides the means to move goods from the point of production to the point of consumption—a primary driver of our global and local economies and our quality of life. The design and technology of vehicles themselves are also integral to personal mobility and freight transport, affecting cost and affordability, safety, convenience, environmental impact, and energy security and reliability.

Improving the energy performance of our transportation system will be essential to achieving the ACNEEP objective of doubling American energy productivity by 2030 relative to 2011. It will also be critical for advancing national economic productivity, prosperity, and quality-of-life while addressing important environmental and energy security challenges.

Many of the opportunities to improve energy productivity via transportation, land use, and accessibility are associated with providing more efficient choices for vehicles, housing, and transportation systems. This includes developing and deploying more energy efficient technologies for vehicles and infrastructure; enabling land-use and transportation planning and implementation that creates greater choice for resource-efficient housing, work, and transportation options; using information technologies to improve the efficient movement of goods, services, and people; providing alternatives to physical travel and transport; and changing pricing policies for transportation, parking, and insurance so that they better reflect true social costs of infrastructure, safety, traffic congestion, energy security, and the environment.

The potential offered by technology and integrated systems depends on the behavior of people. Individuals, businesses big and small, and the public sector need to be informed and motivated to contribute to greater energy productivity through their transport, mobility and accessibility choices. Better information will help them make better decisions about choosing vehicles, of locating their homes and businesses, of transport and shipping modes, of substituting communication for transportation, and other decisions. The human factor is crucial for success.

Some of the timeframes for transforming the U.S. mobility system can be long. New information technologies can be developed quickly, but widespread adoption may take years. Developing new vehicle models, for example, can take three to eight years. Introducing significantly new technologies can take longer still. Turnover of the light-duty vehicle can take 20 years, while medium- and heavy-duty vehicles, aircrafts, rail stocks, and water crafts are even longer lived. Some near-term options exist to enable shorter trips and provide options for mass transit, but bicycling, and walking, transforming cities and regions to be significantly more energy productive can take much longer because the infrastructure of buildings, roads, rails, and other structures are very long lived.

However, well-designed policies, technologies and strategies coupled with collaboration among federal, state, and local governments offer large potential to improve the energy productivity of our transportation, land use, and accessibility systems. Furthermore, they support robust economic development and business and employment opportunity; enhanced mobility choice and quality of life; and strengthened environmental protection and energy security. This research chapter summarizes these opportunities and their potential as well as some of the barriers to achieving that potential.

BACKGROUND DISCUSSION

The transportation sector of the American economy accounts for 28.1% of America's energy use and 71% of the nation's petroleum consumption.[1] Transportation energy consumption has grown as a percentage of total U.S. energy use—from 24.6% in 1973 to 28.1% in 2010—and continues to be primarily dependent on petroleum, with 93.2% of transportation energy coming from that source.[2] This makes transportation critical to pursuing companion national goals of strengthening energy productivity, environmental protection, and energy security.

Highway modes (automobiles, light trucks, and heavy trucks) account for 76% of American transportation energy use.[3] Aircraft are second at 9%, followed by water vessels at 5%, construction and agriculture at 4%, pipelines at 3%, and trains and buses at 3%.

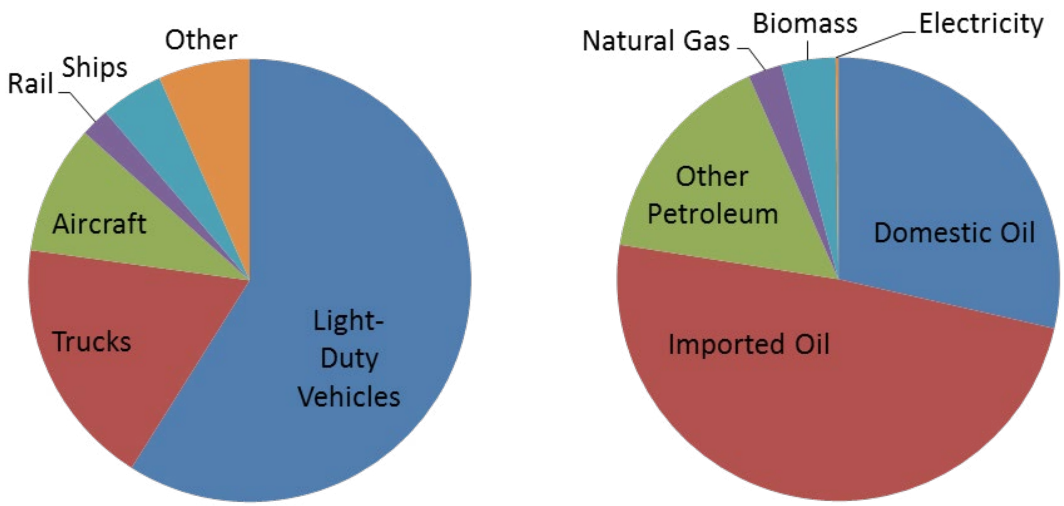

Figure 1. 2010 Energy use in the transportation sector by mode (left) and by source (right). Total for both charts is 27.4 quadrillion British Thermal Units (Btu). Source: Data adapted from Annual Energy Review 2011 (Energy Information Administration).

HISTORIC TRENDS IN TRANSPORTATION AND ENERGY

Between 1973 and 2007, vehicle miles traveled (VMT) for passenger vehicles in the United States grew by 168%. Data from the Federal Highway Administration shows that VMT growth began slowing in the early 2000s and then went down for the first time in 2008 and again in 2011, a significant break from historic trends.

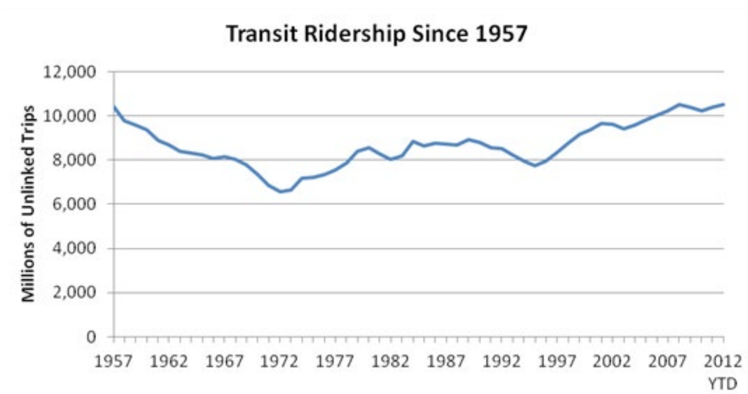

Figure 2. Transit Ridership Trends 1957-2012
Source: Dickens, "Transit Ridership Report" and American Public Transportation Association." 2012 Public Transportation Fact Book."

Meanwhile, public transportation ridership has increased significantly faster than population growth and VMT growth over the past fifteen years as better choices have become available, as populations grow in urban areas where transit options are more available, and as general popularity for transit strengthens. Transit ridership has grown back to levels that existed prior to the interstate highway era, and appears to be trending upward into the future. Intercity passenger rail ridership has seen similar increases. Figure 2 shows the current ridership-growth trend beginning in 1995. The current year, 2012, is expected to be very strong, with nationwide ridership up 5% year-to-date.

1 *Davis and Diegel, Transportation, 2-3; 1-23.*

2 *Davis and Diegel, Transportation, 2-3.*

3 *Aliprantis, "Electric Energy and Power Consumption."*

Air transportation, both passenger and freight, has grown considerably over the past three decades, with passenger miles up nearly 4.8% annually and air freight up 4.2% annually across that period.[4] Growth in energy consumption, however, has been far less, as load factors have increased and aircraft and their engines have become more fuel efficient. In recent years, passenger growth has been sluggish: there were fewer air boarding's in 2010 than in 2005.

Water is used for freight movement and recreation. Increasing size, better logistics, and sophisticated harbors, as well as better water dynamics and efficient engines have improved overall operational efficiency of water transport.

Rail is often the first choice of freight transport from harbors to regional hubs, where the last miles can be picked up by trucks. Freight rail has achieved nearly a 50% improvement in fuel efficiency, measured in British thermal units (Btu) per ton-mile, since 1980.[5] For passenger rail, numerous studies have shown that high-performance rail in critical transportation and economic development corridors can be a strategy for energy efficiency.

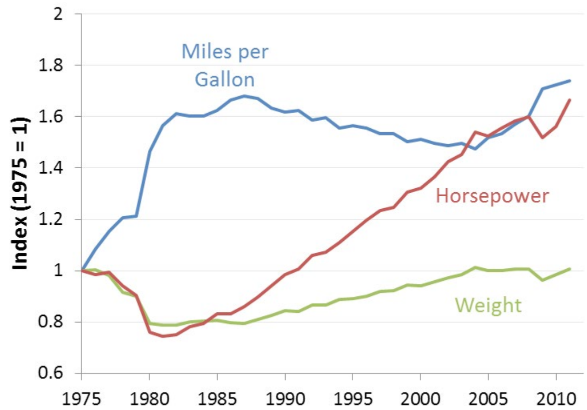

Figure 3. Trends in light-duty vehicle characteristics since 1970 fall into three epochs values in 1975: MPG = 13.1; Weight = 4060 lb.; HP = 137. Values in 2012: MPG = 22.8; Weight = 4084; HP = 228.

Source: "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011."

VEHICLE TECHNOLOGY SINCE THE 1970S

LIGHT-DUTY VEHICLES

Technology in transportation has improved steadily over the past 40 years, but these advances have not always included a focus on improving fuel economy. Between 1975 and the early 1980s, vehicle fuel economy improved dramatically in response to higher fuel prices and the new Corporate Average Fuel Economy (CAFE) regulations. This was achieved initially by reducing size, weight, and horsepower. After the 1980s, with fuel prices low again, fuel economy standards were left unchanged and new technology was applied to dramatically improve horsepower and increase size, weight, and other vehicle properties.[6] Also, the auto industry developed popular minivans and sport-utility vehicle (SUV) models that, along with pickup trucks, are classified as light trucks are subject to less stringent CAFE standards than are automobiles. Meanwhile, the distance driven per licensed driver increased from 10,000 miles per year in 1975 to 15,000 in 2005 before declining to 14,000 in 2010.[7]

NON-LIGHT-DUTY VEHICLES

All other transportation modes have improved fuel economy as new technologies were introduced. Since 1975, the fuel economy for trucks has improved more than 60%, with most of the improvement happening before 1995.[8] New commercial aircraft fuel intensity, in terms of energy use per seat-mile, has decreased by more than 50% since 1960.[9] The majority of this trend is attributed to improved engine efficiency. Freight rail has achieved a 50% improvement in fuel efficiency, measured in Btu per ton-mile since 1980.[10] Primary factors contributing to this improvement include changes in the traffic mix, improved locomotive technology, and increased payload weight.

4 *FAA, "Historical Passenger Enplanements at U.S. Airports."*

5 *Pew Center on Global Climate Change, "Freight Transportation," 2.*

6 *Environmental Protection Agency, "Light-Duty Automotive Technology."*

7 *Davis and Diegel, Transportation, 8-2.*

8 *Transportation Research Board, "Technologies and Approaches."*

9 *Rutherford and Zeinali, "ICCT Study Finds."*

10 *Association of American Railroads, "Title of the article."*

ANTICIPATED TRENDS

Assuming continuation of existing policy but no new policy, the following trends are projected by the U.S. Energy Information Administration (EIA) in its Annual Energy Outlook (AEO) 2012 Reference Case:

» Transportation energy use grows slowly in comparison with historic trend: Transportation sector energy consumption is projected to expand at an average annual rate of 0.1% from 2010 to 2035. Energy demand for aircraft is projected to increase by 11% in the same 25-year period. Higher incomes and moderate growth in fuel costs will encourage more personal air travel. The resulting increase in energy use will be offset by gains in aircraft fuel efficiency. The airfreight use of energy will grow as a result of export growth. Energy consumption for marine and rail travel also will increase as industrial output grows. The EIA's AEO 2012 reference case forecasts 1.2% annual growth in total light-duty-vehicle (LDV) miles, increasing VMT from 2,660 billion in 2011 to 3,583 billion in 2035.[11]

» CAFE and greenhouse gas emissions standards result in increased vehicle fuel economy: The introduction of CAFE standards, enacted in 1975, resulted in an increase in fuel economy for new cars and light trucks from 13.1 miles per gallon (mpg) in 1975 to 22.8 mpg in 2011. Projections are that mpg will reach 25.6 in 2015, 29.2 in 2020, and 30.9 in 2035.[12] The EIA reference case does not include the proposed new standards for 2017-2025, which will require new vehicles to achieve an average fuel economy of 54.5 mpg by 2025 based on combined city/highways tests (actual on-road fuel economy will be substantially lower).

» Travel demand for personal vehicles increases more slowly than in the past: In future years, several demographic forces, such as a population influx to cities, are likely to play a role in moderating the growth in VMT per licensed driver, despite the projected rise in real disposable income.

» Sales of alternative fuel, fuel-flexible, and hybrid vehicles rise: Light-duty vehicles that use diesel, alternative fuels, hybrid-electric, or all-electric systems will play an initially small but growing role in meeting more stringent emissions and fuel economy standards, as well as offering fuel savings in the midst of higher fuel prices.

Four factors are notable in assessing the energy impacts of transportation: (1) vehicle efficiency, (2) sources of fuels, (3) the number of miles the vehicles travel, and (4) the operational efficiency experienced during travel. Each of these factors is taken into account in the analysis of transportation/energy trends.

In addition, maximizing energy productivity in the transportation sector will require a combination of approaches at the federal, state, and local levels. A comprehensive plan would include a greater use of alternative fuels, land use policies, better traffic management/reduced traffic congestion, reduction of subsidies and cross-subsidies of travel to better reflect true cost, and a shift toward more energy-efficient travel, such as public transportation, walking, biking, and teleworking/ telepresence. In the next section we discuss the investment, technology, human behavior, and government actions that could improve energy productivity for transportation, community planning and mobility.

11 *EIA, "Annual Energy Outlook," 146.*

12 *Ibid.*

INVESTMENT

The opportunity for improvements in energy productivity of transportation and mobility access is significantly linked to public and private investment. Whether it is the development and sale of more efficient cars, trains, buses, ships, and planes; the growth of and transition to more resource-efficient communities and associated transportation infrastructure; or deployment of new information technologies that enhance or provide alternatives to travel, the investments from the public and private sector will shape the choices we have. Government policies at the federal, state, and local levels can have profound effects on the trajectory of public and private investment in the areas of research and development, demonstration, and commercial deployment.

The transportation system represents one of U.S. society's largest investments and is integral of our modern economy and lifestyle. It is so fundamental that it is difficult to estimate its economic impact because we cannot conceive of the counterfactual scenario—a world where we never built out our transportation system. Additionally, the transportation system and changes to it are challenging to assess from a cost-benefit perspective, because costs are borne by many parties and benefits take many forms. For example, public transportation has been shown to stimulate local development, increase land value, reduce traffic congestion, and improve health. However, it involves investment in land and dollars from federal, local, and individual parties.

U.S. investments in the system are made across many modes (personal vehicles, buses, trucks, rail, aircraft, and marine); take multiple forms (research and development, infrastructure, and vehicle investments); and are made through diverse agents (federal, state, local, business, and consumers). In addition to building, buying and maintaining transportation capital, we must produce, transport, and distribute the energy used to serve these modes. According to EIA, from 2005-2009, the United States spent $460-$690 billion per year on transportation energy, of which over 95% was for petroleum.[13]

From the perspective of energy productivity, quality infrastructure is important for two reasons: high-quality infrastructure of sufficient service capacity is an essential ingredient for economic growth, and inefficiency in infrastructure can impede mobility due to increases in traffic or other factors.

The following is a summary of recent investment in the areas of research and development (R&D) and commercial deployment. The examples included here are not comprehensive, but attempt to represent the overall investment picture. Spending varies from year to year, and 2007 was selected (except for R&D) where possible as the year for which the most data was available. For R&D, funding amounts can vary widely over years and so averages over several years are reported.

FEDERAL RESEARCH AND DEVELOPMENT

Most transportation-related R&D in the United States is either federally funded or funded by private companies for their own products. Federal research sources include the Department of Energy (DOE) (vehicles and fuels), Department of Transportation (DOT), Environmental Protection Agency (EPA), and National Aeronautics and Space Administration (NASA). A systematic review in 2001 by the National Academies of all research performed by the Office of Energy Efficiency and Renewable Energy found strong links between this R&D and the acceleration of dozens of advanced technologies to market.

The 2009 Recovery Act provided some additional one-time investments in transportation, including over $2 billion for vehicles (battery manufacturing) and about $800 million for biomass-derived fuels.[14] The Department of Defense (DOD) conducts extensive applied R&D, some of which may be relevant to the civilian transportation sector, including jet engines and batteries.[15] In the United States alone, automotive companies invested $16 billion in R&D in 2007.[16]

13 *U.S. Energy Information Association, "Annual Energy Review."*

14 *Canis, "Battery Manufacturing for Hybrid and Electric Vehicles: Policy Issues," 8; DOE, "Secretary Chu Announces Nearly $800 Million from Recovery Act to Accelerate Biofuels Research and Commercialization."*

15 *Sarewitz, "Energy Innovation at the Department of Defense," 19-21.*

16 *Hill et al., "Contribution of the Automotive Industry," 16.*

While the scope of the federal R&D programs is quite broad, some specific relevant examples include:

- DOE Vehicle Technologies
  - Increasing efficiency of conventional vehicle powertrain technology, including improved combustion, transmission, and lubricant technology
  - Lightweight materials with a goal of 50% reduction in body and chassis system weight by 2015 without sacrificing safety and performance[17]
  - Research on batteries, fuel cells, and electric drive trains to make e-drive vehicles competitive with conventional vehicles within a decade
- DOE SuperTruck Program to reduce Class 8 fuel consumption by 50% by 2015
- NASA on pre-commercial aircraft research, including more efficient engines and auxiliary power units
- DOD research on more efficient tactical and non-tactical vehicles

Federal, state, and local policies and investment in land-use and transportation infrastructure shape where and what types of private residential, commercial, and industrial development occurs. Increasingly, governments are realizing the benefits of integrating land-use and transportation planning at the regional level, which allows for more efficient availability of more efficient transportation choices and access to goods with shorter trips and less congestion, regional jobs/housing balance and economic development, and environmental protection. Additional savings can also be seen in the areas of waste, water, building operation, distribution, and others. All of this results in a lower cost to the public.

CASE STUDIES

» SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS, SUSTAINABLE COMMUNITIES STRATEGY

The Southern California Association of Governments (SCAG) comprises 191 cities and accounts for nearly half of California's population. To achieve the goals outlined in SB 375, California's Sustainable Communities and Climate Protection Act, SCAG focused on the integration of land-use development and transportation system planning for its 2012-2035 Sustainable Communities Strategy and Regional Transportation Plan (SCS/RTP).[18]

SCS/RTP STRATEGIES

The plan has four strategies: (1) focus new growth in existing population centers and along major transportation corridors, (2) use areas of mixed-use development and walkable communities, (3) target growth around existing planned transit stations, and (4) preserve open space and protect established residential areas. Of the total $260 billion planned for capital expenditures, 41% will go to transit, 7% to active transportation including biking and walking, and 33% for roads and highways.[19]

SCS/RTP BENEFITS

Some of the benefits of this plan include: (1) 9% per-capita reduction in passenger vehicle miles travelled, transportation energy use, and greenhouse gas (GHG) emissions by 2020 and 16% per-capita reduction by 2035, (2) savings of $5 billion in cumulative infrastructure costs to local governments, (3) savings of $1.5 billion per year in health costs, (4) 87% of jobs will be within 1/2of a mile of transit, (5) return on investment of $2.90 for every dollar invested in infrastructure, (6) double the number of households living near high-quality transit.[20]

17 *"Materials Technologies," 1.*

18 *California Environmental Protection Agency, "Technical Evaluation of the Greenhouse Gas Emission," 62.*

19 *California Environmental Protection Agency, "Technical Evaluation of the Greenhouse Gas Emission," i, 11, 92, 10.*

20 *Ibid., 9.*

» WEIGHING HOUSING AND TRANSPORTATION COSTS

When assessing affordability of housing, it is important to consider both housing and transportation costs. For example, a central-city neighborhood like Washington, D.C.'s Logan Circle neighborhood has higher housing costs than outlying neighborhoods in Prince George's and Loudoun County, with housing costs representing 32.4% versus 29.6% and 28.8% (respectively) of area median income (AMI). However, household transportation costs are much lower in Logan Circle—10.9% versus 18.7% or 20.8% of AMI, respectively, a savings of $5,000 to $6,000 per year. The net effect is a cost savings of over 6% of AMI.[21] The time saving effects of a shorter commute can also provide the benefit of a healthy lifestyle and increase quality of life.

Shown in table 1 is a survey comparison of the difference in transportation patterns in a central city location like Logan Circle and suburban locations like Prince George's County and Montgomery County.

According to National Capital Region Transportation Planning Board's release of its 2011 TPB Geographically-Focused Household Travel Survey:

Table 1. Transportation Pattern in Logan Circle vs. Prince George's County and Montgomery County

	Logan Circle[22]	**Prince George's County and Montgomery County[23]**
Residents living in apartments/ condominiums	85%	45%
Household average # of vehicles	0.65	1.55
Household average # of bicycles	0.82	1.21
Percentage of daily trips made by walking	56% (regional average is 9%)	23% (regional average is 9%)
Percentage of daily trips made by bicycle per household	10% (regional average is 0.6%)	2.4% (regional average is 0.6%)
Population density	37,100 people per sq. mile	11,000 people per sq. mile

Note: The densely populated urban neighborhood of Logan Circle experiences significantly higher usage rates of public transit, walking, and biking as modes of transportation as opposed to exurban areas like Prince George's and Montgomery counties, which experience higher rates of individual vehicle transportation.
Source: National Capital Region Transportation Planning Board, "2011 TPB Geographically-Focused Household Travel Survey."

The results of the survey demonstrate the importance of creating accessible transportation or infrastructure that accommodates pedestrians and bicycles in order to maximize efficient transportation patterns. Compact and diverse neighborhoods tend to encourage taking public transit, walking, biking, or using a mix of these methods to commute or make daily trips.

These results show a reduction in cost for Logan Circle households. But these savings are often not considered when a family that wants to live in Logan Circle is applying for a mortgage. Thus many families who prefer the (higher priced but lower total cost) housing cannot qualify for a loan, and must choose less efficient housing in outlying areas. Such policies create a vicious circle: neighborhoods such as Logan Circle have higher housing prices, in part because the market has too little supply compared to the demand, but more of such developments are impeded, because the buyers have trouble qualifying for loans and thus developers can only build for the higher income customer.

21 Center for Neighborhood Technology, "H+T Affordability Index," 1.

22 Griffiths, "2011 TPB," 7.

23 Ibid., 8.

TECHNOLOGY

The opportunities for new technology to contribute to energy productivity improvements are numerous and significant for all transportation modes. For the light-duty sector (cars and light trucks), new technologies have the potential to reduce energy demand by up to half, even with a projected increase in vehicle travel. Other vehicle sectors, including medium and heavy-duty freight and goods movement, have large energy savings potential and are also likely to see significant growth in service demand.

Technology-enabled systematic changes such as built environment strategies and shifts in travel mode have major potential benefits in economic development, cost effectiveness, maintenance costs, health, and traffic, while also providing significant energy savings. The following table summarizes the combined impact of expected service demand, the energy intensity potential, and use intensity potential by 2030.

Table 2. Combined impact of expected service demand, the energy intensity potential, and use intensity potential by 2030

Mode	Service Demand Growth in 2030 (baseline, % relative to 2005)	Energy Intensity Potential in 2030 (% reduction vs. baseline)	Use Intensity Potential in 2030 (% reduction vs. baseline)	Net Effect in 2030 (% change in energy demand relative to 2005)
LDV	+36%	33%	0% to 18%	-9% to -25%
M/HD Trucks	+41%	15% to 30%	3% to 5%	+16% to -6%
Aviation	+108%	30% to 40%	3% to 8%	+41% to +15%
Marine	+165%	40%	N/A	+59%
Rail	+33%	15%-17%	N/A	+13% to +10%

Note: Data adapted from Transportation Energy Futures

LIGHT-DUTY VEHICLE IMPROVEMENTS

Opportunities for continued improvement of combustion engines are significant through the use of improved combustion control, cylinder deactivation, continuously variable transmission, reduced friction, use of waste heat, etc. Currently, gasoline spark-ignition internal-combustion engines reach a thermal efficiency of about 25% on the highway – and this can only be reached wide-open throttle with lowest pumping losses. Diesels achieve thermal efficiencies closer to 35-45%.[24]

Improved lubricants can increase the efficiency of both new vehicles and the existing vehicle fleet by reducing engine friction. Impacts are likely to be a small percentage, but if applied to all vehicles, the impacts could be significant. Thermoelectric devices have the potential to convert engine waste heat to useful energy and can be used in concert with other improvements.

24 *Heavy Duty Diesel Engine Oil. "Fundamentals of Compression-Ignition Engines."*

WEIGHT REDUCTION

Significant improvements in fuel economy can be expected from strategies that focus on vehicle weight reduction. A 10% reduction in the weight of an internal combustion engine (ICE) vehicle can improve fuel economy some 6-8%.[25] DOE's Quadrennial Technology Review calls for a 40% reduction in vehicle weight through advanced design and materials by 2030. More than a dozen potential materials are known that could reduce vehicle weight, including high-strength steel, magnesium, titanium, and carbon fiber. Weight reduction has the potential to improve the efficiency of all types of vehicles, regardless of the powertrain technology.

The Corporate Average Fuel Economy regulations are the primary current driver of conventional engine technologies. The National Highway Traffic Association/EPA (NHTSA/EPA) joint rulemaking contains dozens of possible efficiency options in their cost/benefit analysis. New policies include feebates, which shift the externality costs to subsidize efficient vehicles at the expense of inefficient ones. This could ultimately encourage a shift to more efficient vehicles.

A primary barrier to new conventional engine technologies is the time for adoption, which can be quite long. From the introduction of a new technology, assuming it is successful, it takes 10-15 years to reach full market penetration for new vehicles and another 12-15 years to turn over the fleet.

DRIVETRAIN ELECTRIFICATION

Unlike internal combustion engines, which only convert about 17–21% of gasoline energy to power at the wheels, electric motors can convert about 59-63% of electrical energy that has been drawn from the grid into mechanical work, adjusting for inverter and gear reduction losses and parasitic losses.[26] The energy benefits of electric drive can be significant and enable a threefold improvement in vehicle efficiency as compared to conventional vehicles.[27]

Several electric-drivetrain technologies take advantage of this:

» Hybrid electric vehicle (HEV): HEVs use a combustion engine in addition to an electric motor. Series architecture HEVs use the engine to drive a generator that runs the motor, while parallel architecture HEVs have a direct connection between the engine and the drivetrain. All HEVs have a battery to store excess electricity. HEVs are commercially available today, and costs for hybrid batteries and components continue to come down. HEVs will also benefit from the conventional vehicle research and improvements described above.

» Battery electric vehicle (BEV): BEVs have no combustion engine at all but run only on a motor powered by a battery. Batteries in these vehicles are much larger than those used in HEVs. Commercially available BEVs today allow a driver to travel between 70 miles (Nissan Leaf) and nearly 250 miles (Tesla Roadster) on a single charge. Plug-in hybrid electric vehicles (PHEVs) retain the engine but have a large enough battery to travel under all electric power for short distances (about 10-40 miles) and can be charged from external electric sources between uses. The energy balance between electricity and gasoline for PHEVs depends on the usage patterns of the driver and the all-electric range of the vehicle. For both BEVs and PHEVs, the research challenge is the cost and energy density of the battery. The cost and quality of power electronics is also an important factor to take into consideration.

» Fuel cell vehicle (FCV): FCVs are essentially HEVs where the electricity is generated via a high-efficiency fuel cell powered by hydrogen (H2). This reaction produces only water, giving FCVs zero tailpipe emissions. There remain significant technical and economic challenges-- including addressing energy required to make, transport, and store hydrogen--to light-duty FCV application.

There are federal subsidies for these electric-drive vehicles (EV) in the form of tax credits up to $7500 and numerous efforts are underway at the federal, state, and local levels to encourage and facilitate advanced vehicle deployment. The federal CAFE and GHG standards provide significant incentives with advanced vehicles getting additional credit within the program. California, which has unique authority to set standards more stringent than the federal government (and which other states can opt to adopt), has a requirement that automakers produce approximately 15% of vehicle sales as qualifying zero-emission vehicles (ZEV) by 2025.[28]

25 *"Secretary Chu's Remarks at Detroit Economic Club -- As Prepared for Delivery."*

26 *US Department of Energy, "Electric Vehicles."*

27 *European Commission, "Clean Transport."*

28 *Union of Concerned Scientists, "Significant Progress."*

There are several potential barriers to deployment of electric-drive vehicles including higher upfront costs, consumer acceptance, and in the case of full BEVs and FCVs, additional infrastructure requirements. However, there are also opportunities for EVs, as electricity storage devices, to provide electric grid support (termed "ancillary services" by grid operators) and help level powers loads, which can enhance the efficiency of the electric grid operations through reduced line losses and more efficient dispatch of electric generating units. Additionally, for EVs, PHEVs, and FCVs, the overall life-cycle energy intensity of driving depends on the efficiency and method of electricity or H2 production.

NON-LIGHT-DUTY MODES

MEDIUM/HEAVY-DUTY VEHICLE FUEL ECONOMY

The EIA reference case projects a 56% increase in medium- and heavy-duty truck VMT between 2010 and 2035, representing an average annual increase of 1.8%.

For the engine and drivetrain, the overall improved diesel engine technologies in new trucks can reduce fuel consumption by 15-20% between 2020 and 2030.[29] Options include decreased engine friction, improved fuel injection, turbo-compounding, bottoming cycles, electrification of accessories, advanced combustion controls, and automated manual transmissions. Hybridization is also an option, but mainly for short-haul applications with frequent start/stop duty cycles.

Air drag can account for as much as 20% of fuel use for trucks that travel at highway speeds. The vast majority of tractors are already aerodynamically equipped and further improvements are estimated to improve overall fuel efficiency by 2-4%. If deployed, aerodynamic tractor-trailer devices can offer a fuel consumption decrease of 9-12% from 2015 to 2020. Rolling resistance can account for 30% of a truck's fuel use. The potential to save energy is large, however, with 1% vehicle fuel savings for every 3% reduction in rolling resistance. Replacing conventional dual tires with wide-base single tires can decrease fuel consumption by roughly 3%.[30]

To improve operational efficiency, a speed cap of 65 mph can reduce overall fuel use by 3-5% in long-haul combination trucks. Idle reduction can also save significant fuel, as approximately 7% of fuel is used during non-driving truck use. In long-haul Class 8 trucks, fuel costs rapidly dwarf capital costs, which improves the business case for efficiency technologies. For tractor-trailers, the breakeven price is approximate $1 per gallon. The fuel saving package include, in decreasing order of estimated cost effectiveness: low rolling-resistance wide-base single tires; transmission and driveline improvement; tractor and trailer aerodynamics improvement; engine improvement, including bottoming cycle; mild hybrid with idle reduction; and weight reduction through material substitution. For "vocational" trucks, such as trash collection vehicles, cement mixers, construction vehicles, and local deliveries, the order of cost-effectiveness of these measures differ due to different duty cycles (e.g., less high speed long distance travel but more slower speed local travel).

The EPA and NHTSA finalized the first-ever heavy-duty vehicle fuel economy standards covering semi-trucks, heavy-duty pickups and vans, and vocational vehicles for model years 2014-2018 vehicles. The rule varies by class but will result in approximately a 20% improvement in truck fuel economy overall.[31] A number of different technologies may be deployed to meet these requirements.

TRANSIT BUSES

In aggregate, buses consume relatively little energy (1.5% of total non-LDV energy). However, this number will become more significant as automobile energy declines, as projected in this report, and as more buses are provided as part of its strategy. Most buses will benefit from improvements to diesel engines that also are used in trucks, and new buses being put into service are increasingly powered by compressed national gas (CNG) or other alternative fuels. Additionally, buses usually travel at low speeds with frequent stops and starts and will benefit from hybridization technology and regenerative braking. Even early hybrid technologies resulted in an average of 37% fuel economy improvement in real-world testing conditions.[32]

29 *Greszler, "Technologies and Policies," 138.*

30 *UGreszler, "Technologies and Policies," 139.*

31 *U.S. Environmental Protection Agency, "Paving the Way," 1.*

32 *Barnitt, "In-Use Performance Comparison," 1.*

TRAINS

The rail mode used 0.54 quadrillion Btu of energy in 2009, 4.1% of the combined non-LDV energy use. More than 80% of this is for Class I freight rail. Most of the remainder is for transit and commuter rail systems. While transit improvements may be important for reducing passenger vehicle demand, this summary focuses of freight rail.

Locomotive engines achieve 40% thermal efficiency, but 50-55% efficiency is attainable with a focused research effort, which would lower fuel consumption by 20%. Hybrid locomotives have been available for the last decade and are still under development and might reduce fuel consumption further.[33]

Positive train control (PTC) is an integrated system that monitors and controls train movements to prevent collisions, derailments, and casualties; it allows for denser train traffic. Fuel efficiency benefits can result from overall improved train movement efficiency, less stop-and-go, and higher average speeds. Rail lubrication applied after the locomotive has passed or cars with wheels that steer to match the curvature of the track can provide additional fuel savings. Lightweighting, such as by using aluminum rail cars, can further enhance the energy productivity of rail transport.

Electrification of rail could reduce emissions, but faces significant challenges. The effect on energy use would depend on the method of electric generation.

AIRCRAFT

Aviation currently consumes 16% of combined non-LDV mode energy. The Aerospace Forecast 2011-2031 by the Federal Aviation Administration (FAA) projects a 3.8% annual increase in revenue passenger miles between 2010 and 2030.[34]

Aircraft technology offers several approaches for improving energy efficiency:

- Engine Improvements: Opportunities include open rotor propulsion systems for short and medium flights, improved compressor operation, and geared turbofan engine. There are also German Aerospace Center (DLR) and Airbus experiments with fuel cell auxiliary engines, and some preliminary testing by DLR on solar powered planes.
- Weight Reduction: Composite materials are one of the most important advancements in new, more efficient aircraft such as the Boeing Dreamliner. Moving to higher ratios of composite or other advanced materials can improve efficiency.
- Aerodynamics: Winglets and riblets are near-term options for improving aerodynamics. Winglets are curved wingtips that disrupt vortices and reduce fuel consumption by up to 7%.[35] Riblets are small raised grooves that lower drag and could reduce fuel consumption by 1-3%.[36]
- Different designs: The proposed blended wing body designs, such as NASA's n + 3 aircraft, improve fuel efficiency by getting lift from the body of the plan as well as the wings. Strut-braced wings would allow longer, lighter wings, improving efficiency. Laminar flow control passively or actively manages the airflow to reduce drag.

Other aviation operational improvements will involve the communications, navigation, and surveillance (CNS) and air traffic management (ATM) systems. By just 2015, American and European airlines are expected to achieve 5% fuel savings through these improvements, and savings of 5-10% are expected in the medium term.[37] Full implementation of the delayed U.S. Next Generation Air Transportation System (NextGen) would simultaneously improve aviation energy productivity, reduce travel times and air traffic congestion, and improve safety. Also diversion of traffic from air to high-speed rail (HSR) should make a big difference because short flights that HSR would replace initially are less fuel economical and contribute more to congestion in the air and on the runways.

The 27-nation European Union (EU) decided in 2008 that aviation should be included within their emissions trading plan, including international flights travelling to or from EU countries. Emissions are capped at the average 2004-2006 level, with allowance trading since April 2012.

U.S. passenger aircraft lifespan is typically 20-25 years, but it can be as long as 35 years to completely replace a fleet.[38] On that same note, new aircraft development programs take approximately 7-10 years to develop. The slow turn-over of the aircraft fleet is a barrier to rapid improvement in energy productivity in this sector.

33 *Siemens, "CO2-saving locomotives," 2012.*

34 *U.S. Energy Information Association, "Annual Energy Review."*

35 *McCollum et al., "Greenhouse Gas Emissions," 38.*

36 *Mayer, "Low-Drag Surface," 1.*

37 *McCollum et al., "Greenhouse Emissions," 15-16.*

38 *Lee et al., "Historical and Future," 184.*

MARINE IMPROVEMENTS

According to the Energy Information Administration, international marine freight transport accounts for 80% of marine freight energy use and is projected to grow at an average annual rate of 5.3% between 2010 and 2035.[39] The reintroduction of sails to provide power assistance could supplement these technologies.[40] Improved hull design and more efficient engines and mechanical systems can enhance energy productivity. Operational improvements such as speed reduction, optimized routing, reduced port turnaround, voyage operation, and energy management systems could provide 10-50% energy savings.[41]

OTHER TRANSPORTATION MODES

Smaller energy uses are still critical components of the transportation system. Although rail and water transport (mostly freight) as well as pipelines garner a relatively small share of transportation energy use, this is partly due to their efficiency of transport. Direct intermodal comparisons of energy efficiency are challenging because the routes, commodities, and other parameters can vary greatly, but water and rail transport overall have much lower energy use per ton-mile of transport. In passenger transport, energy intensity is similar between passenger vehicles and air transport and generally better for bus or rail transport.[42]

INFORMATION AND COMMUNICATION TECHNOLOGY

Advanced information and communication technologies have transformed multiple sectors of the U.S. economy and is beginning to affect transportation. An American Council for an Energy Efficient Economy study identified three sorts of general opportunities. People-centered efficiency connects information on energy use to individuals, allowing them to make better money-saving decisions. Transportation-specific examples include driver feedback tools enabling easy, efficient driving and custom route guidance allowing for more efficient routing. Technology-centered efficiency allows automated systems to optimize energy use. For example, self-driving vehicles could dramatically change the way we travel. In transportation, smartphone applications allowing real-time bus or rail planning are already opening up these modes to users who previously found them too unpredictable. Teleconference and telework applications can reduce the need for commuting travel. The effects of these technologies on energy efficiency will be complex but could be significant.

TRANSPORT SYSTEM OPTIMIZATION

Another area for potential reductions in energy intensity lies in the optimization of the freight network. According to McKinsey and Company, the transportation of goods consumes around 15 million barrels of oil per day. Since this industry has few fuel substitutes for oil thus far, and oil prices are likely to continue to rise in the future, it is important to make investments in improving the efficiency in the system for goods transportation.[43] A 2010 Report to Congress by the U.S. Department of Transportation notes that there are clear energy efficiency and GHG emissions savings possible by "optimizing the design, construction, operation, and use of transportation networks."[44] For example, enforcing changes, such as lowering speed limits on national highways, would lower transportation greenhouse gas emissions by up to 2%.[45]

McKinsey and Company echoes the value of improving the transportation system, suggesting that opportunities in reducing costs – thereby improving the transportation system – are available for manufacturers, wholesalers, distributors, and carriers. In an on-going study on supply-chain energy efficiency, McKinsey created three energy cost scenarios with six potential areas for supply chain and transport asset energy savings. McKinsey estimates that in the medium oil price scenario, with oil at $100 a barrel, optimization of the transport system can lead to 38% fuel savings by 2020 from the 2006 baseline for freight transportation. Areas for improved efficiency include reducing the average transportation distance, adding variation to transportation modes, and addressing the usage of individual assets. In terms of individual assets, for example, the transport system can be improved through applying a maintenance regime, improving route planning, and reducing speed limits. Speed reduction of just 10% can lead to a

39 *U.S. Energy Information Administration, "Annual Energy Outlook," Table 36; calculation of internal freight as a percentage of total freight for 2012.*

40 *Kazim, "Dragon Freighter goes on Maiden Voyage."*

41 *Ibid.*

42 *U.S. Department of Transportation, "National Transportation Statistics," Table 4-20 4-21, 4-22, 4-24.*

43 *Meyer, "Increasing the energy efficiency of supply chains."*

44 *U.S. Department of Transportation, "Transportation's Role," ES-5.*

45 *Ibid.*

12-20% increase in energy efficiency. Reducing the average distance traveled in a supply chain can reduce energy consumption by 4% for the medium oil price scenario . This can be achieved by redesigning production and sourcing or reducing the density of warehouse locations to encourage road travel over air travel. Though there may be challenges to overcoming investment barriers, there are extensive opportunities for energy intensity reductions throughout the transportation system with clear economic and energy benefits.[46]

Intelligent transportations systems (ITS) are also arising as means to advance multiple transportation and mobility objectives, including reducing traffic congestion and travel time, enhancing transportation safety and security, and reducing air pollution as well as improving energy productivity. There are numerous components of ITS that can save energy, such as traffic signal optimization, variable speed limits, information feedback for drivers and transit passengers, and automated toll collection. Also, telematics – that is, combining information and communications technologies – are used by vehicle fleet operators to improve operational efficiency, leading to enhanced energy management as well as improved vehicle inventory management and maintenance and safety and security.

CASE STUDY

» NEW FUEL ECONOMY STANDARDS

When Henry Ford's Model T was released in 1908, its fuel economy was 13-21 mpg. Today's 6-cylinder Ford Explorer can travel 17 city mpg, 24 highway mpg, which is 20 combined mpg. Fuel efficiency has remained fairly stagnant for several decades with the availability and affordability of oil, but as energy security and environmental concerns have increased, so too has the need for greater fuel economy.

In July of 2012, the NTSHA and EPA finalized rules for fuel economy and greenhouse gas performance standards for passenger vehicles in the 2017-2025 model years. Raising the fleet-wide average fuel economy to 54.5 mpg by 2025 will save an estimated 12 billion barrels of oil[47] and will prevent 950 million metric tons of CO2 emissions from entering our atmosphere over the lifetime of vehicles sold between 2012-2016.[48]

By 2025, the standards are projected to save families an estimated $8,200 in fuel savings over the lifetime of a new vehicle, relative to the Model Year 2010 standard.[49] Cumulatively, consumers will save an estimated $1.7 trillion in real fuel costs over the life of their vehicles. For vehicles sold in just the 2012-2016 period, this measure will reduce petroleum consumption by an estimated 1.8 billion barrels petroleum and increase energy productivity by an estimated 5% compared to 2010.[50]

46 *Ibid.*

47 *Curtis, "President Obama Announces."*

48 *U.S. Environmental Protection Agency and U.S. Department of Transportation, "Light-Duty Vehicle Greenhouse Gas Emissions," 1-30.*

49 *The White House, "Driving Efficiency," 2.*

50 *U.S. Environmental Protection Agency and U.S. Department of Transportation, "Light-Duty Vehicle Greenhouse Gas Emissions," 1-30, 1-20.*

HUMAN BEHAVIOR

Travel occurs, of course, for a variety of purposes. According to the DOT Federal Highway Administration's 2009 National Household Travel Survey, there are eight main categories of travel. The travel shares are represented by purpose in the table below:

Table 3. Travel Shares of Eight Main Categories of Travel

Trip Purpose	Percentage of total trips
Work	15.6
Work-related business	3.1
Shopping	20.9
Family/Personal Errands	21.6
School or Church	9.6
Social and Recreational	27.5
Other	1.8
Total	**100.0**

Note: VMT growth has resulted in significant energy consumption. Bureau of Transportation Statistics data show that highway modes used 21,110 Btu in 2010, compared to 5,261 trillion Btu in 1960 (a more than fourfold increase).

Although VMT grew rapidly and steadily and significantly exceeded overall population growth for many decades, this trend has flattened in recent years. Data from the Federal Highway Administration shows that trends are slowing in the 2000s, and VMT actually went down for the first time in 2008, then stayed flat, and down again in 2011. The data show that national VMT in 2011 was less than it was seven years earlier (2004), a significant break from historic trends. The reasons behind these trends have not been researched adequately. The post-1973 trend may well be due to declining location efficiency in an era where most new development was in urban sprawl.

Changes to the historic patterns are the result of urbanization, new demographic trends, and growing popularity for a balanced transportation system with options and choices beyond travel by automobile.

Transportation planners had anticipated that VMT growth was inevitably bound to slow down following decades of rapid growth and with the peaking of certain influences such as the rise of two-income households. The big demographic change is the aging of the baby boomers, increasing numbers of households without children and the increasing proportion of minority and immigrant households, each of which typically have lower than average VMT. Urbanization and new travel behaviors among the Generation X and Generation Y cohorts are part of the explanation as well. Since 1995, VMT has grown by 21%, U.S. population has grown by 15%, and transit ridership has grown by 38%.

In his book The Option of Urbanism: Investing in a New American Dream, developer Christopher Leinberger describes and quantifies the pent-up demand for housing that is less oriented to automobile travel, and more suited to walking and public transportation. Local transportation and land-use practices and national transportation investment programs long favored the development of car-oriented communities. For example, local zoning laws and development practices often make it far easier for developers to build on a greenfield, or undeveloped plot of land, rather than to build in a built-up area. [51] In particular, local zoning limits maximum densities in almost all cases: it is rare for a minimum to be imposed. Lending practices by banks have typically favored development that is based on auto mobility. They continue to favor auto-focused developments where the price of the house is low while the costs of getting to it are high. Only recently has policy started to adapt to demands for a more balanced transportation system.

51 A site that has not been previously developed.

NEW REPORTS POINT TO THE NEED FOR A HOLISTIC APPROACH

The 2009 Moving Cooler report by Cambridge Systematics and the Urban Land Institute builds on the premise that the substantial gains in energy efficiency that result from innovations in technology will be offset by increases in travel, along with growth in the U.S. population. While this report focused on strategies to reduce emissions of greenhouse gases, its methodologies and conclusions are directly applicable to energy use.

The baseline is built on the annual rate of vehicle and fuel technology changes, consistent with forecasts of DOE in its Annual Energy Outlook and DOT's examination of alternative CAFE standards. Both of these analyses forecast substantial increases in the fuel efficiency of autos and light trucks during the next 20 or 30 years. The Moving Cooler baseline extrapolated these projections further to 2050, resulting in a projected doubling or greater of fleet fuel efficiency. These efficiency gains, however, are largely offset by an equally large increase in VMT, which is projected by these sources to grow by 82% during this period of time.[52]

Given this, a broad range of other strategies should be considered to reduce the energy impacts of transportation services. Moving Cooler examined the effectiveness of strategies that transportation agencies and policy makers can consider to complement and reinforce the improvements that technology can achieve. The study examined the effectiveness and costs of fifty of those types of strategies and combinations of those strategies. Particular strategies include:

» pricing and taxes,
» land use and smart growth,
» non-motorized transport,
» public transportation improvements,
» ride-sharing, car-sharing, and other commuting strategies,
» regulatory strategies,
» operational and intelligent transportation system (ITS) strategies,
» capacity expansion and bottleneck relief, and
» multi-modal freight sector strategies.[53]

The Moving Cooler report found that a combination of strategies would be most useful. For example, strategies such as congestion pricing or pay-as-you-drive insurance, which are associated with the true costs of driving and may discourage automobile trips, work best when connected to strategies that enhance public transportation and other mobility alternatives. Six of such bundles were analyzed in the report. In each case energy efficiencies would, however, involve considerable changes to current transportation systems and operations, travel behavior, land-use patterns, and public policy and regulations.[54]

The 2007 Growing Cooler report published by the Urban Land Institute provides evidence on the energy efficiencies of compact development, considers how compact development is likely to be received by consumers, and outlines policy changes that will make compact development possible. According to the report, consumers benefit from compact development and improved community planning by being able to easily access common needs, such as shops and schools, through means of walking or biking. Mixed used developments, by locating housing close to businesses and services, can therefore be used to replace single-use subdivisions or commercial spaces.[55] The street network can also be designed to be more efficient by interconnecting streets rather than ending with cul-de-sacs and adding convenient bike lanes, pedestrian access, and designated bus stops to individual streets making them more complete.[56] Lastly to shorten the distance between trips, homes can be built on smaller lots and commercial spaces such as offices and stores can be expanded upward rather than out. These compact development design elements combined not only shorten commutes and make transit services more convenient but also increase the economic viability of neighborhoods.[57]

52 Cambridge Systematics, "Moving Cooler," 79.
53 Ibid.
54 Cambridge Systematics, "Moving Cooler," 80.
55 Ibid., 52, 80.
56 Ibid.
57 Ibid.

This type of development has seen resurgence in recent years and goes by many names, including walkable communities, livable communities, and transit oriented developments (TODs). Infill and brownfield[58]developments put unused or underused parcels in previously developed areas to new uses, taking advantage of existing infrastructure and nearby destinations. Some developments called lifestyle centers are now replacing single-use shopping malls with open-air shopping on connected streets with housing and office space above stores. And many communities have rediscovered and revitalized their traditional town centers and downtowns, often adding more housing to the mix.

The 2011 Growing Wealthier report found a strong and growing market trend for homes and businesses in walkable communities with transportation options beyond the car. The report showed that strategies commonly referred to as smart growth and TOD are in step with forward-looking trends (among these are economic, urbanization, demographic, energy efficiency, environmental, affordability, and public choice trends). The report also shows that growth in VMT is not a prerequisite for GDP growth, as was once thought to be the case. Steve Winkelman, author of the report and director of transportation and adaptation programs for the Center for Clean Air Policy made this observation: "It is interesting to note that from 1998-2008, knowledge and service-oriented economic sectors such as information, finance, real estate and health care were responsible for more than two-thirds of GDP growth, while extracting, manufacturing, transporting and selling physical goods generated less than one-third of GDP growth over that period. In the previous decade, these more physically intensive sectors contributed more than half of all GDP growth."[59]

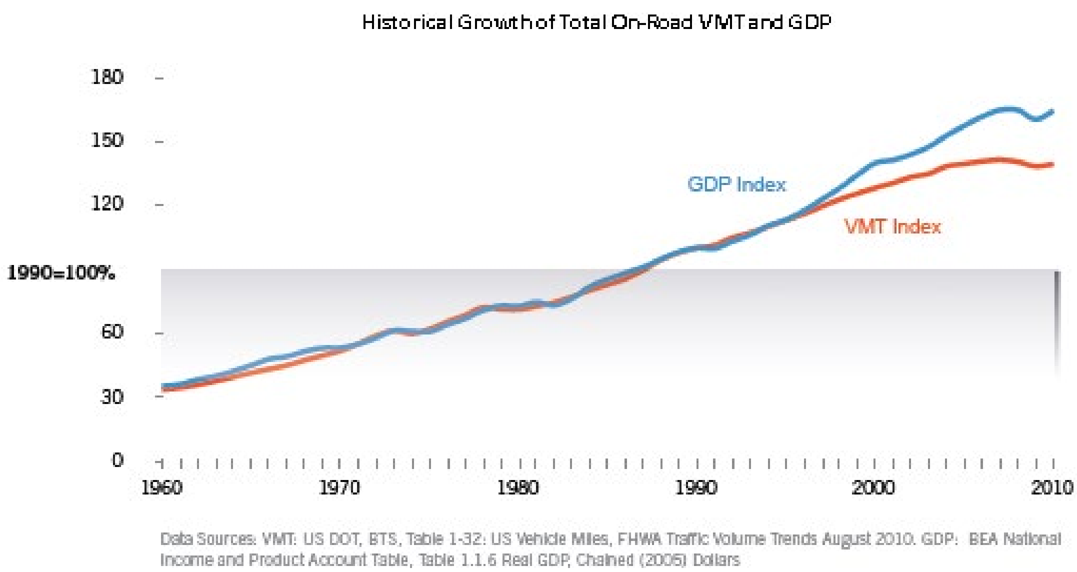

Figure 4. Historical Growth of Total On-Road VMT and GDP.[60] *A 2010 report titled Analysis of Policies to Reduce Oil Consumption and Greenhouse Gas Emissions from the U.S. Transportation Sector, by Harvard's Kennedy School, concluded that the key to obtaining significant improvements in transportation-related energy efficiencies is to increase the cost of driving so that it reflects its full societal costs and provides people accessible alternatives*[61]*. Data gathered from focus groups by Public Opinion Strategies on behalf of the Natural Resources Defense Council found that, overwhelmingly, participants said they would like to drive less. This poll found that over 55% of participants would like to drive less, but nearly 72% said that they had no choice in how much they drive.*[62]

58 *According to EPA, a brownfield is real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.*

59 *Leonhardt, "Growing Without Driving."*

60 *Kooshian and Winkelman, "Growing Wealthier," 28.*

61 *Morrow and Gallagher, "Analysis of Policies," 2.*

62 *Metz and Weigel, "Key Findings," 1.*

INDIVIDUAL AND CORPORATE COMMITMENTS TO ENERGY EFFICIENCY AND ENVIRONMENTAL SUSTAINABILITY

Energy efficiency and environmental sustainability are the product of many choices people make each day. Because people are inclined to make the best and logical choices based on the options and information they have, it is a function of government and responsibility of society overall to ensure the proper decision-making framework. Points to consider include the following:

» An example of a corporate commitment to energy efficiency would be to provide employees with commuter benefit programs. Many employers provide free parking or paid/subsidized parking for their employees but do not always extend similar benefits to employees who use public transportation.

» Transportation systems themselves need to adopt best practices in energy efficiency and resource conservation. Temperature and lighting systems, optimal temperature and lighting settings, recycling, and energy-efficient operations and maintenance practices are among the many examples. Many transportation organizations and local government entities have signed commitments to adhere to sustainability practices. Better information technology will help. Systems are being developed that can provide instant information on the cheapest, quickest, and most energy-efficient way to get door-to-door. Live, eat, and work locally: Locally sourced goods to cut down transportation costs; use web/phone-based meetings rather than drive/fly to meetings; driving schools teach how to get more miles per gallon.

WORKING AT HOME AND SHOPPING FROM HOME

Working at home has been an area of consistent increase for over thirty years in virtually every area of the country. There is perhaps a romanticized notion of those who work at home—the author, the systems programmer—whereas the statistics indicate a more mundane world. Professional occupations in the work-at-home field are heavily represented in business management and financial services.

Telecommunications have been a major force in allowing people to work and shop from home, and it is apparent that people with high-speed internet, email, and cell phones do their work or shopping from wherever they may be—home or elsewhere. Those who work or shop from home do not use the energy required for those trips, including transportation infrastructure and services.

The forces of technology aid the freedom to work at home and to live farther from the nominal workplace. Although the extent to which people will stay at home and use electronic communication to interact with their coworkers is unclear, it is clear that these technologies permit the occasional day at home for workers, and an occasional purchase from home, and this could have an impact on energy consumption and traffic congestion. Of course, in the longer term, this could promote living farther away, as would any change that reduces the penalties of distance, and the trip patterns of telecommuters needs to be better understood. Furthermore home energy use may increase as people shift from office to home during the day. This is an area where additional research would be helpful in understanding the net energy impacts, given land-use implications, relative energy consumption, implications for goods movement and similar factors. These options add to the variability of the traffic flow, which will be an increasing factor in the future. Whether this will be an improvement to traffic patterns is unclear, but the expansion of freedom of choice to live, work, and shop where we want has to be seen as a positive factor socially, economically, and possibly in energy productivity.

CASE STUDIES

» PORTLAND'S GREEN DIVIDEND

Due to a combination of factors, including efficient land-use patterns and a transportation system that provides alternatives to automobiles, Portland, Oregon's population of about 2 million people are estimated, on average, drive nearly four miles less per day than the populations of in similarly sized cities do, 20.3 miles compared to 24.3 miles.[63]

At an average fuel economy of approximately 20 mpg, Portland residents consume 400,000 fewer gallons of gasoline per day, save $1.1 billion dollars per year on fuel costs, and reduce greenhouse gases by about 1.4 million tons per year.[64]

Portland's Green Dividend extends to public transportation and biking as well; its citizens are seven times as likely to commute by bike and twice as likely to take public transit than the national average. The savings from spending less on transportation are distributed to other spending that helps to stimulate the local economy.

» MINNEAPOLIS ANTI-IDLING VEHICLE ORDINANCE

In 2008 the Minneapolis City Council adopted the Anti-Idling Vehicle Ordinance to minimize the time that vehicles idle. The ordinance restricts idling by gasoline and diesel powered vehicles to 3 consecutive minutes per hour, allowing up to 5 minutes for commercial vehicles and 30 minutes for loading and unloading. Exceptions are made for health and safety concerns, including for emergency vehicles and for private vehicles during extreme temperatures. The city instituted a $200 fine for violating the ordinance.[65]

The city implemented the policy through consumer education campaigns that linked idling to unnecessary emissions and costs.

- On average, cars burn more than half a gallon of fuel for every hour spent idling.
- Ten seconds of idling uses more fuel than restarting the car.
- Minimizing idling helps decrease air pollution, protects human health, and improves engine performance.
- A car that reduces five minutes of unnecessary idling daily will save 10-20 gallons of gasoline or 30 to 60 dollars annually.[66]

ACHIEVEMENTS

Data from the case study provided by the Minneapolis Police Department on its fleet showed:

- a 16% reduction in total fuel consumption from 2009 to 2010;
- annual cost savings of $280,000;
- idle hours per vehicle decrease by more than 280 hours (or 25%) from 2009 through 2010; and
- projections suggested that if similar idling improvements took place across the department's entire fleet, they would have saved 60,000 gallons or $158,000 from 2009-2010. [67]

» CAR SHARING

Car sharing provides consumers easy access to a variety of vehicles without requiring ownership. Typical programs charge a monthly or annual subscription fee plus a rental rate on an hourly basis. Studies on car-sharing programs in North America show that car sharing can reduce vehicle travel, greenhouse emissions, and vehicles ownership. For example, Martin and Shaheen of the Mineta Transportation Institute showed that car-sharing members reduce GHG emissions by 0.58-0.84 tons CO2-equivalent per household per year, and that vehicle ownership drops by nearly half, from 0.47 to 0.24 vehicles per household.[68] Due to their central control and propensity to park at designated locations, car-sharing organizations also provide the opportunity to introduce new vehicle types like battery electric and other alternative fueled vehicles.[69]

63 Cortright, "Portland's Green Dividend," 4.

64 Cortright, "Portland's Green Dividend," 2,3.

65 American Council for an Energy-Efficient Economy (ACEEE), "Minneapolis Anti-Idling Vehicle Ordinance,"1.

66 Hinkle et al., "Anti-Idling Primer."

67 ACEEE, "Minneapolis Anti-Idling Vehicle Ordinance," 1; The ACEEE notes that while this drop was influenced by a number of factors, including the number of vehicles and miles driven, there is evidence showing that a portion of this savings is from decreased idling.

68 Martin and Shaheen, "Greenhouse Gas Emission Impacts," 3.

69 Martin and Shaheen, "The Impact of Carsharing," 24.

GOVERNMENT

All levels of government including federal, state, regional, and local levels have a unique ability to affect energy productivity in the United States. Governmental and quasi-governmental bodies (often with independent bonding authority) at state, regional, and local levels also directly build and operate many types of transportation facilities, infrastructures and services, including roads, bridges and tunnels, ports and airports, and public transit. The federal government has responsibilities for operating and maintaining various parts of the aviation and waterborne transportation system, such as air traffic control and maritime aids to navigation. The federal government) also financially supports state and local transportation facilities, such as via a surface transportation trust fund funded by motor fuel taxes.

In the field of community planning and transportation, methods can range from local zoning to DOT design standards to regional grant programs. Triggers at each level of government can affect efficiency in different ways such as funding, standards, model guidance, and implementation. Government can also implement measures to increase energy efficiency and performance across operations with minimum energy performance required.

From 2000 to 2025, the United States is expected to convert 18.8 million acres of land to build 26.5 million homes and 26.5 billion square feet of nonresidential space. This will require $190 billion of investment in water and sewer infrastructure alone to accommodate the additional 18 billion gallons of pumped water. If inter- and intra-county land-use planning methods are pursued, 150 million gallons of water and sewer could be saved per day.[70]

FEDERAL GOVERNMENT

A main influencer that the federal government has across the United States is the agency appropriation decisions from the DOT, Housing and Urban Development (HUD), EPA, DOE, Department of Agriculture, DOD, and others. Some of these agencies (HUD, DOT, EPA) make up the Partnership for Sustainable Communities, which is working to promote efficient regional planning. The federal government can also establish enabling legislation to allow states to implement or create law; impose and enact administrative or agency; as well as set requirements for its own operation.

The federal government also operates a fleet of more than 600,000 civilian and non-tactical military vehicles, which consumes more than 380 million gallon of gasoline equivalents each year. Several laws and executive orders are stimulating agencies to reduce vehicle miles traveled, increase fleet fuel efficiency, and increase use of alternative fuels.[71]

EXECUTIVE ORDER 13514

The presidential administration recently enacted Executive Order 13514 that requires agencies to meet a number of energy, water, and waste reduction targets, including a 30% reduction in vehicle fleet petroleum use by 2020.[72]

RELEVANT POLICIES:

The recently enacted Moving Ahead for Progress in the 21st Century (MAP-21) federal transportation bill includes a new requirement for regions to adopt “performance based planning.”[73] Metropolitan Planning Organizations (MPOs) are required to establish performance targets that address issues such as safety and state of good repair of their transit systems. Perhaps this is step one to performance targets that can be more transformative in nature. Policy goals such as energy-efficient personal mobility would help direct transportation investments to more energy efficient outcomes.

In the planning process for federal transportation investments, MPOs are required to take into account numerous planning factors. Energy efficiency and the long-term energy implications of transportation investments are conspicuous in their absence as planning factors. Planning factors could include energy-related considerations.

70 *Burchell and Mukherji, “Conventional Development Versus Managed Growth,” 1536.*

71 *U.S. Department of Energy, “Federal Fleet Program Overview,” page.*

72 *Council on Environmental Quality, “Federal Leadership.”*

73 *Federal Highway Administration, “moving Ahead for Progress.”*

Federal, state, and local governments could lead by example in the location efficiency of public buildings. To the greatest degree practical, public buildings could be located in places accessible by walking, biking, and public transportation, and not be located in places nor designed in ways that favors automobile transport and discourages (or precludes) other options.

The federal government could set a standard as an energy-sensitive employer by offering employees transit commuter benefits, in all regions of the country, as an incentive for energy-efficient commuting. Federal tax laws could be amended to establish consistent tax treatment of employer-provided transit commuter benefits programs, as are allowed for employer-provided parking benefits. Currently, federal tax laws limits transit benefits to a significantly lower amount than is permitted for parking.

U.S. DOT could consider new procedures to allow the use of lighter passenger rail equipment that meets or exceeds safety requirements yet will also allow for more energy-efficient operations.

STATE GOVERNMENT

Individual states can have significant power when it comes to efficiency in transportation and our communities. States are in the position to distribute both federal and state funding to regional and local governments for the purposes of implementing federal or state legislation. States also have the ability to enact enabling legislation for local and regional governments. There are also state regulations that impact tax rates, the economy, and the environment.

REGIONAL GOVERNMENT

Regional government entities usually facilitate the development of transportation systems and connect local networks through transit and highway planning; they also assist in enforcement of DOT regulations and distribute federal and state funding for these systems. Increasingly, regional air-quality management district's engage in the support of more energy-efficient transportation networks that focus on reducing pollution. Regional governments usually do not have specific land-use authority and function primarily as a collaborative body of local governments that conducts planning and receives and distributes federal and state funding.

A successful regional example is California's Sustainable Communities and Climate Protection Act, or SB 375. This legislation uses an incentive-based approach to use transportation and land-use planning to reduce energy usage.

LOCAL GOVERNMENT

Cities, counties, and towns have local land-use planning, some with taxing authority to protect and enhance the health, safety, and welfare of its citizens and its services. Local governments can promote, regulate, create standards, impose taxes, and work collaboratively with other local governments to promote a more efficient regional economy. These governments can pursue energy efficiency through the development of policy and strategies including incentives; regulations that can include zoning, standards, and codes for infrastructure construction; and enforcement of building codes. Local government has a responsibility to facilitate community connectivity, appropriate zoning, real estate development, information technology (IT), and infrastructure investment including water, waste, and partnerships with other utilities. Since the implementation of the American Recovery and Reinvestment Act (ARRA), there has been a significant increase in the development and implementation of community energy plans.

ENERGY PRODUCTIVE GROWTH PATTERNS

All levels of government should consider the full cost of different types of development and what they mean to manage more resource-efficient growth patterns. According to a study published in the American Journal of Public Health by Burchell and Mukherji, strategically managing growth can conserve resources without impeding traditional development methods. The study, "Conventional Development Versus Managed Growth: The Costs of Sprawl," focuses mainly on the increased need to build roads and water/sewer delivery and treatment facilities as development moves beyond the city limits.[74]

74 *Burchell and Mukherji, "Conventional Development Versus Managed Growth".*

FISCAL BENEFITS OF USING EXISTING INFRASTRUCTURE

Burchell and Mukherji cited the advantages of focusing development in areas with excess service capacity rather than investing in areas that would also need new infrastructure. Real estate costs tend to increase as a function of conventional development that requires building new roads, expanding sewer and water delivery, and building power generation or expanding transmission lines. Developing areas that already have roads and water systems can generate greater long-term fiscal benefits and savings in operating costs, however allocating funds for increases in costs associated with upgrading existing systems can be challenging.[75]

METHODS FOR ENCOURAGING RESOURCE EFFICIENT GROWTH

Several opportunities exist to encourage resource-efficient growth:

1. Redirecting growth into urban centers by creating an urban growth boundary, and/or limiting external growth to a small area or county while protecting other suburban areas
2. Providing incentives for urban infill and/or ensuring that development properly covers its full costs, including externality costs
3. Including efficiency metrics in regional performance-based planning activities
4. Providing regions greater control and flexibility to fund transportation systems that offer choices including transit, biking, and walking

There is also a connection between road expansion and induced exurban growth. The costs of this expansion is large, $927 billion, to provide an additional 2 million lane-miles from 2000-2025. A managed-growth scenario would reduce this to $817 billion for 1.9 million lane-miles of growth, creating savings of $110 billion.[76]

75 *Ibid., 1534.*

76 *Ibid, 1538.*

OPPORTUNITIES AND BARRIERS

The opportunities for energy productivity gains in the areas of community planning and mobility are large, however so are the barriers. The following table enumerates some of the key opportunities, barriers, and potential solutions identified by the research team.

Table 4. Transportation Sector Opportunities, Barriers and Potential Solutions for Energy Efficiency

OPPORTUNITIES	BARRIERS	POTENTIAL SOLUTIONS[77]
Passenger vehicle efficiency	Perceived lack of consumer demand for high-efficiency vehicles	Monetary and nonmonetary incentives for efficient vehicle purchase (e.g., pollution pricing, high occupancy vehicle (HOV) access, feebates)
	Lack of infrastructure for ultra-high-efficiency vehicles including electric and fuel cell vehicles	Fed/state/local incentives and permitting for charging and hydrogen infrastructure, low carbon fuel standards
	Weak signals to industry for continued investment	Fuel economy standards, R&D funding/incentives
Medium-/Heavy-duty truck/bus efficiency	Market acceptance	Monetary and nonmonetary incentives for vehicle purchase
	Weak signals to industry for continued investment	Fuel economy/engine efficiency standards, R&D funding/incentives
	Long development time for new products, slow turnover	Incentives and regulations for Smartway-type technologies, depreciation and other tax incentives
Air/ship travel efficiency	Long development time for new products, slow turnover	Pricing signals, depreciation/tax measures, improved routing, R&D for better materials/aero improvements/auxiliary power units Speed NextGen air traffic control implementation. Engine (including hybrid), hull, mechanical systems, shore power efficiency for marine vessels.
Better transit	Lack of transit-oriented development and supporting infrastructure, consumer awareness	System expansion, service promotion, service improvements, employer/employee cost sharing Dedicated revenues (some areas have portion of sales tax to transit and such) Planning, TOD, location-efficiency consideration, etc.
More resource-efficient land use and transport infrastructure	Lack of coordination among regional/local governments, lack of financial/technical resources for planning	Planning grants for regional planning, performance- based infrastructure funding and targets. Location-efficient government buildings
	Lack of funding/flexibility to fund transit, bike, walk infrastructure	More flexibility to MPOs and locals to fund non-auto infrastructure Dedicated revenues accommodations (sidewalks, pedestrian signals, bike paths, bus stop/shelter, etc.)
Improved transportation system efficiency	Lack of information, funding, need for alternatives	Funding and assistance for traffic management, real-time traffic/routing information, adjusted speed limits
Information technology	Complexity of integrating information, consumer awareness	Automated systems, smartphone applications, teleconference/telework applications ITS, telematics
Encourage more efficient travel choices overall	Lack of proper price signals, equity concerns	Pricing strategies that reflect true cost of travel (fuel tax, carbon dioxide (CO2) tax, VMT fee, pay as you drive (PAYD) , congestion pricing, parking)
New efficient technologies, policies, and strategies across all opportunities	Lack of R&D funding, insufficient scientists, engineers, etc. with appropriate skills	Increased public R&D and incentives for private R&D, science, technology, engineering and mathematics (STEM) education/training improvements, international engagement

CONCLUSION

The ability to move people and goods efficiently and effectively is central to our economy and our way of life. Within the areas of transportation and mobility, significant potential exists for reducing energy consumption and saving consumers and businesses money - money that can then be reinvested in the domestic economy, a double bonus for energy productivity. To achieve its potential, a variety of strategies and policies will be required at the federal, state, and local level, as well as sustained investment over many years from both the public and private sectors.

With strategic policy and investment support, we will continue to see the improvement of existing technologies for light-, medium-, and heavy-duty vehicles. These improvements will take the form of more efficient combustion engines, transmissions, lighter weight materials, and better aerodynamics. We will also see the electrification of the vehicle drivetrain, including vehicles capable of being plugged in to the power grid or fueled with alternative fuels like hydrogen, which have the potential for dramatic lifecycle efficiency improvements. We can also expect various energy productivity technological advances for non-road transportation, including rail, aviation, and maritime transportation. Many of these will improve economic and operational performance and can enhance safety, security, and environmental performance.

The information and communication technology revolution will also have growing effects on transportation efficiency. Already, there is significant computing power in vehicles that help efficiently control engines and electrical and mechanical systems. Intelligent transportation systems, routing and logistic software, next generation air traffic control, fleet management telematics, and other opportunities grow to simultaneously improve energy productivity, economic performance, relieve traffic congestion, mitigate pollution, and enhance safety and security.

For land use and transportation systems, the use of greater coordination in regional and local planning, funding for transit, biking and walking, and development of more resource efficient communities provide a huge opportunity to reduce energy and other social costs (congestions, pollution, etc.). Doing this well will also enhance communities and the quality of life in them. This requires that we continue to find creative and flexible funding mechanisms for infrastructure and make it easier to build diverse and mixed-use communities that the market is indicating are already in high demand.

By pursuing a holistic approach that includes new vehicles, new fuels, advanced infrastructure, and new ways of planning and implementing land use and transportation development at multiple scales, we can set the course for a substantial gains in energy productivity and enjoy the environmental, economic, and quality of life benefits that come with it.

ACRONYMS AND FIGURES

AB – Assembly Bill

ACEEE - American Council for an Energy-Efficient Economy

AEO – Annual Energy Outlook

AMI – Area Medium Income

APTA – American Public Transportation Association

ARRA – America Recovery and Reinvestment Act

ATM – Air Traffic Management

BEV – Battery Electric Vehicles

BTU – British Thermal Units

CAFE – Corporate Average Fuel Economy

CEII – Community Energy Partnership

CHP – Combined Heat and Power

CNG – Compressed Natural Gas

CNS – Communications, Navigation, and Surveillance

CO2 – Carbon Dioxide

DLR – German Aerospace Center

DOD – Department of Defense

DOE – Department of Energy

DOT – Department of Transportation

EIA – Energy Information Administration

EPA – Environmental Protection Agency

EU – European Union

EV – Electric-Drive Vehicle

FAA – Federal Aviation Administration

FCV – Fuel Cell Vehicle

FY – Fiscal Year

GDP – Gross Domestic Product

GHG – Greenhouse Gas

H2 - Hydrogen

HEV – Hybrid Electric Vehicles

HOV – High Occupancy Vehicle

HSR – High-Speed Rail

HUD – Housing and Urban Development

ICE – Internal Combustion Engine

IT – Information Technology

ITS – Intelligent Transportation Systems

LDV – Light-Duty-Vehicle

MAP-21 – Moving Ahead for Progress in the 21st Century

MPG – Miles Per Gallon

MPH – Miles per Hour

MPO – Metropolitan Planning Organizations

NASA – National Aeronautics and Space Administration

NEXTGEN – Next Generation Air Transportation System

NHTSA/EPA – National Highway Traffic Safety Administration

PAYD – Pay As You Drive

PHEV – Plug-in Hybrid Electric Vehicles

PTC – Positive Train Control

R&D – Research and Development

SCAG – Southern California Association of Governments

SCS/RTP – Sustainable Communities Strategy and Regional Transportation

SEP – Strategic Energy Plan

STEM – Science, Technology, Engineering and Mathematics

SUV – Sport-Utility Vehicle

TOD – Transit Oriented Development

VMT – Vehicle Miles Traveled

ZEV – Zero-Emission Vehicle

Figures:

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APPENDIX: ADDITIONAL CASE STUDIES

CASE STUDY: AB32 – GLOBAL WARMING SOLUTIONS ACT OF 2006

In 2006 the California legislature passed Assembly Bill (AB) 32, the Global Warming Solutions Act of 2006, which requires a reduction in greenhouse gas emissions to 1990 levels by 2020 and an 80% reduction below 1990 levels by 2050.[77]

Meeting AB32 targets will require decreasing emissions 30% from the levels currently projected for 2020, which equates to a CO2 emission reduction of about 4 tons per person.[78] Key strategies to reach these targets include:[79]

- **Cap-and-trade program:** covers 85% of emissions including electricity, industry, transportation, residential, and commercial use of natural gas
- **Electricity and Energy:** improves appliance efficiency standards including:
  - Target of 33% of electricity from renewables by 2020
  - Increased use of combined heat and power
  - Solar roofs and solar hot water heating
  - Green buildings
  - Water efficiency
- **High Global Warming Potential Gases**
  - Capture refrigerants by removing them from an appliance and storing them in certified recovery containers[80]
  - Capture other high global warming potential gases already in use, such as capturing methane emissions in municipal solid waste landfills[81]
  - Introduce leak-resistant equipment[82]
- **Agriculture**
  - More efficient agricultural equipment, and improve efficiency of fuel and water use
  - GHG reductions from manure digesters at dairies
  - Address GHG impacts on crop and livestock productivity
- **Transportation:**
  - 30% reduction in GHG vehicle emissions by 2016 followed by further reductions in 2017
  - Decrease carbon intensive vehicle fuels 10% by 2020
  - SB 375, which was passed in 2008, requires the California Air Resources Board to develop regional transportation-specific GHG reduction goals[83]
  - California also passed AB 118, a clean transportation program that includes funding for a hybrid vehicle rebate program targeted at medium- and heavy-duty vehicles [84]
    - The goal is to reduce the high up-front costs associated with the purchase of high efficiency vehicles.
    - Rebates are likely to range from $20,000 to $40,000

77 *California Labor Federation, "AB 32 Proposed Implementation."*
78 *California Environmental Protection Agency, "California's Climate Plan" "California's Climate Plan"*
79 *Ibid.*
80 *California Environmental Protection Agency, "Proposed Regulation Order," 9-10.*
81 *California Environmental Protection Agency, "Landfill Methane."*
82 *Stouffer, "California Global Warming," 2.*
83 *ACEEE, "Transportation System Efficiency Policies"*
84 *Ibid.*

- **Industry**
  - Target the 800 largest sources of emissions including the cement industry and the high carbon dioxide emissions from heating cement mix[85]
  - Audit the largest industrial sources of GHG emissions to identify opportunities for GHG reductions
- **Forestry**: projects will address forest sequestration and voluntary reductions
- **Waste and Recycling**: target methane reductions at landfills

BENEFITS

Since 1975 California's energy efficiency policies have saved $56 billion and are expected to save another $23 billion by 2013.[86]

CASE STUDY: SAN DIEGO REGIONAL COMPREHENSIVE PLAN

Developed in 2004, the San Diego Regional Comprehensive plan helps manage growth while preserving resources and limiting sprawl. The plan uses smart growth principles, including transportation and planning initiatives to help develop sustainably.[87] Under the plan, local governments worked to identify priority areas close to existing transportation infrastructure, which were then eligible for grants for planning and infrastructure projects.[88]

The Regional Comprehensive Plan is also being used to help the city comply with California's recently passed SB375 law, which requires metropolitan areas to develop sustainable strategies to meet GHG reduction targets through land use, transportation, and housing planning initiatives.[89]

ACHIEVEMENTS

The Regional Comprehensive Plan has increased transit ridership and the development of homes in smart growth areas. Achievements include:

- an increase in homes built in smart growth areas from 37% in 2004-2005 to 44% in 2008-2009;
- increased regional transit ridership from 89 million in 2004 to 104 million in 2009;
- decreased commuting travel time on every major roadway between 2005 and 2009; [90]
- an extension of the San Diego Trolley from Santee, Old Town through Mission Valley to San Diego State University and La Mesa;[91]
- opening the COASTER Commuter rail between Oceanside and San Diego; and
- connection of Oceanside and Escondido by the SPRINTER light rail.[92]

PROJECTED BENEFITS

While the Regional Comprehensive Plan Monitoring Report does not include information on emissions reductions, the San Diego Association of Governments is preparing a 2050 Regional Transportation Plan based in part on the regional comprehensive plan (RCP). The 2050 Regional Transportation Plan projects:

- a 13% reduction in per capita carbon dioxide emissions from passenger vehicles from 2005 levels by 2020 and 18% reduction by 2035;
- projects will exceed SB375 targets by 7% and 13%, respectively; and
- a decrease in fuel consumption per day per capita from 1.45 gallons in 2008 to 0.89 gallons in 2050.[93]

85 *Kramer, "Why AB32 Goes After the Cement Industry."*
86 *California Public Utilities and Commission and California Energy Commission, "Highest Priority Resource."*
87 *ACEEE, "San Diego Regional."*
88 *Ibid.*
89 *Ibid.*
90 *85 Sandag, "Regional Comprehensive," 5, 6, 9.*
91 *Sandag, "Green Line Trolley."*
92 *Sandag, "Regional Comprehensive," 12, 14.*
93 *Sandag,"Board of Directors Agenda"*

CASE STUDY: ENVISION UTAH

Launched in 1997, Envision Utah uses the expertise of various community stakeholders, such as conservationists, business owners, government officials, residents, developers, and others, to build more sustainable communities.

POTENTIAL SAVINGS WITH QUALITY GROWTH

Envision Utah (2000) found that a regional "quality growth scenario" would add $1.5 billion over twenty years in public transit spending, but save $3.5 billion in regional road costs, for a net savings of $2 billion. A quality growth strategy would also save 171 square miles of land by 2020 and would yield a net savings of $4.5 billion in water, sewer, transportation, and infrastructure development.[94]

CREATING SUSTAINABLE COMMUNITIES

A major endeavor of Envision Utah is to provide a framework for communities to become more sustainable and energy efficient. The framework explores various options that aid communities in achieving more sustainable energy usage, such as addressing local barriers to greater efficiency (i.e., financing or funding), creating an energy advisory committee that holds regular meetings, creating an energy task force, supporting policies that help utilities provide efficiency services, and drafting an energy plan to hold the community accountable to its goals.

BUILDING EFFICIENCY AND LAND-USE

Envision Utah also advocates building efficiency and more effective zoning policies within communities, such as Salt Lake City, through programs like the High Performance Building taskforce and by recommending more flexible building permits and regulations in order to streamline the implementation of energy efficiency strategies. The organization also promotes better understanding of building codes and standards through education in order to enforce the codes and standards.[95]

CASE STUDY: SANTA MONICA – STRATEGIC ENERGY PLAN

One of the first local efficiency policies in Santa Monica's energy history is its Strategic Energy Plan (SEP), which was developed in 1999 to address rising concerns of public health, environmental sustainability, resource depletion, and economic development.[96]

From 2000-2004, the SEP created several outcomes:

- It spent $513,000 to retrofit eight schools and district headquarters with efficient lighting and energy management systems. Savings are estimated at $93,000 annually in electricity costs.
- Through a Community Energy Partnership under the SEP, 1,657 home and 60 businesses were retrofitted with efficiency measures, and savings are expected to surpass $1.5 million.
- It created new energy performance standards for new and existing structures that have increased energy performance overall.
- Through a partnership with Southern California Edison, Santa Monica's City Council, Community Corporation of Santa Monica, and the Energy Coalition, it constructed a 44-unit affordable housing project called Colorado Court. The project has a natural gas conversion rate of 70%, compared to the conventional rate of about 30%. This adds up to approximately $6,000 in savings on natural gas and electricity within the facility annually.

COMMUNITY ENERGY INDEPENDENCE INITIATIVE

Santa Monica's major energy efficiency programs have expanded during the Community Energy Independence Initiative (CEII), which began in 2005 as a framework to achieve net-zero electricity imports by 2020 by means of efficiency and domestic clean-electricity generation.[97] In Santa Monica, energy efficiency endeavors are combined with solar energy programs within the organization Solar Santa Monica. The city government is also one of sixty-nine local governments nationwide participating in Local Governments for Sustainability.[98]

94 *U.S. Department of Transportation "Toolbox for Regional Policy."*

95 *Envision Utah, "Energy Efficiency."*

96 *"Santa Monica's Community Energy."*

97 *Solar Santa Monica, "Solar Santa Monica Third Annual Report," 7.*

98 *ICLEI, "Santa Monica Launches."*

GOALS OF CEII

The overall goal is to create 150 MW of efficient, renewable, "clean distributed generation." [99] Since Solar Santa Monica was established in 2006, its energy efficiency division has mainly focused on making existing homes and businesses more efficient. The Community Energy Independence Initiative began in 2006 as a two-year demonstration project to highlight greater efficiency within fifty of the city's buildings: thirty-five residences and small businesses, ten commercial buildings, and five municipal buildings.[100] The program is meant to fully develop over a twenty-year span in order to spread energy efficiency throughout the city.

Potential Benefits of CEII by 2020

- Overall savings of 38% in electricity
- Overall savings of 34% in natural gas consumption[101]
- Potential to created self "self-contained 'micro' power grids" that would be more efficient and less prone to power outages
- Installation of more combined heat and power (CHP) systems to achieve 70-80% efficiency in end-use consumption rather than the conventional 30-40%[102]

RESULTS OF CEII

To address financing and budgeting, one of the most pressing barriers of implementing energy efficiency, Solar Santa Monica and its partner EcoMotion promoted a citywide program in 2009 in which preferential financing was given to all eligible property owners for up to 100% of costs for permanent energy efficiency fixtures.[103] Also in 2009, Solar Santa Monica compiled and published a comprehensive listing of energy efficiency service and upgrade contractors.[104]

In the first two years of implementation in the first fifty demonstration buildings, CEII achieved:

- $375,863 in energy costs savings and
- 430 tons of carbon dioxide (CO_2) were abated.

To fund CEII, Santa Monica's City Council contributed approximately $200,000 in fiscal year (FY) 2005-2006, $440,000 in FY 2006-2007, and approximately $322,000 in FY 2007-2008. These are one-time expenditures that pay back over time in energy savings and resource benefits.[105]

CASE STUDY: GREENWAY APP – ABOLISHING URBAN TRAFFIC JAMS AND HALVING AVERAGE JOURNEY TIME

In 2012, the start-up Greenway won Microsoft's Imagine Cup in Sydney, Australia for a navigation assistance app for smartphones that generates the best route for any individual given all other individuals' routes. In simulations, if Greenway is used by at least 10% of traffic participants, this app managed to reduced average inner-city travel time by half and cancelled out traffic jams, while saving up to 20% in fuel. Greenway is currently prototyping in Hannover and Munich with local taxi-fleet and logistics firms. The start-up is improving its technology with localized services (e.g., next parking spot) in conjunction with Stanford University.[106]

Considering the adverse urban traffic effects of noise and pollution, such a technology is not only reducing travel time and fuel consumption but also reduces inner city noise and improves air quality.

99 Solar Santa Monica, "Solar Santa Monica Third Annual Report," 7.
100 Solar Santa Monica, "Solar Santa Monica: A City Approach," Slide 24.
101 LACCD Sustainable Building Program, "Santa Monica," Slide 10.
102 City Staff of Santa Monica, "Recommendation to Conceptually Approve," 4.
103 Solar Santa Monica, "Solar Santa Monica Third Annual Report," 6.
104 Ibid.
105 Perkins and Munves "Conceptual Approval of a Santa Monica Community Energy Independence Initiative and Authorization to Implement a Two-Year Demonstration Project."
106 "About Greenway"; Metz, "An App that Could Stop Traffic."

Using less. Doing more.

The Alliance to Save Energy promotes energy efficiency worldwide to achieve a healthier economy, a cleaner environment, and greater energy security. Founded in 1977, the Alliance to Save Energy is a non-profit coalition of business, government, environmental, and consumer leaders.

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