Sustainable Transportation in Tennessee

January 2009

TDOT Go.

A report compiled and written by the TELA Class 2008

Tennessee Department of Transportation
Executive Leadership Academy
2008 Class Project

SUSTAINABLE TRANSPORTATION IN TENNESSEE:
STRATEGIES FOR ENERGY AND ENVIRONMENTAL SOLUTIONS

Submitted to:

Gerald F. Nicely
Commissioner – TDOT

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By the 2008 TELA Class

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ACKNOWLEDGMENTS

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We extend gratitude to our division directors and management who not only nominated us as TELA candidates, but also allowed us to participate in TELA activities above and beyond our normal work responsibilities. We thank our immediate supervisors who have allowed us time to participate in TELA.

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EXECUTIVE SUMMARY

Sustainable transportation has been defined in many ways by many people. But, for the purposes of this report we have developed the following definition: *Sustainable transportation means providing access and mobility across Tennessee in the most efficient and effective manner, while being a good steward of public funds and environmental resources, so that we meet the needs of today, without exhausting the resources needed by future generations.*

The sustainable transportation strategies here are just a starting point. And we hope TDOT will implement a program to promote the further development of sustainable transportation strategies and their implementation.

TDOT decision-makers will be able to use this report to "pull strategies from the sustainable transportation toolbox" and apply them to specific program areas. Cumulatively, this will help Tennesseans meet their transportation needs without compromising the ability of future generations to meet their own needs.

This report is organized into three broad categories: 1) Administrative Strategies, 2) Energy Conservation Strategies, and 3) Environmental Protection Strategies. Each strategy included in this report is achievable within the next two years. And the upfront implementation costs are shown with the cost key, as described on page 7. Most of these strategies actually save money over a period of time and the long term costs and benefits are discussed for each strategy. This Executive Summary provides an overview of our recommendations and the supporting justification for each recommendation is discussed in the body of the report.

As TDOT decision-makers evaluate strategies to reduce energy consumption and protect the environment, we believe flexible hours, four-day workweeks and limited telecommuting are viable solutions worthy of further consideration. We recommend that TDOT further evaluate the potential benefits (e.g., reduced wear-and-tear on roadways, reduced congestion, reduced mobile source emissions, reduced commute time, and reduced fuel consumption, etc.) of these strategies.

We believe TDOT should offer recycling through the State Employee Recycling Program at all our facilities where this service is available. Furthermore, we recommend the development of an environmental awareness program for TDOT employees to promote recycling and other strategies. Additionally, we suggest establishing a "Green Map" project that promotes environmental awareness and assists citizens in their quest for environmental resources (e.g., recycling centers, local farmers' markets, etc.).

We believe that reduced tunnel cleaning is a viable option to save money, with no impact on aesthetics or infrastructure integrity. One caveat to explore is that the roadways in the winter months will experience salt and/or brine treatment and a build-up of salt residue may occur. This build-up may be detrimental to the life expectancy of cement-based materials such as tile grout. Therefore, a monthly cleaning schedule from December through March may be necessary. We suggest TDOT conduct a study to conclusively determine the cost savings on a statewide level and any potential drawbacks.

We recommend that TDOT continue offering design plans in a digital format, as an option to printing. Additionally, we suggest that TDOT pursue plans to expand e-files to other program areas (e.g., File Net initiative). And we believe all data should be captured at the point-of-origin and transmitted electronically to other users, to avoid transcription errors and lost data, in addition to avoiding printing costs and saving time.

We recommend that TDOT establish an energy management team to develop a comprehensive plan for energy conservation strategies in TDOT buildings and leased facilities. More detail on green building strategies can be found in Appendix A of this report. Appendix A also includes a table outlining an implementation plan for energy management in TDOT facilities.

We recommend that when TDOT purchases new vehicles for our fleet that we should consider life-cycle costs and environmental benefits when making purchase decisions and not just initial purchase cost. Fuel use, emissions, maintenance costs and durability are all important factors to consider.

We recommend faithful and proactive vehicle maintenance of the TDOT fleet. Proper vehicle maintenance is an important part of any energy conservation program. Furthermore, we recommend that the halogen lights that are currently used on TDOT trucks for night work be replaced with LED lights.

As outlined in TDOT's fuel policy developed by the Environmental Policy Office, in order for TDOT to achieve the 20% reduction goal, it will be necessary to have the cooperation of staff at all levels across the state. TDOT headquarters and the region offices should designate a "champion" from each major program area to promote and track compliance with the petroleum reduction/displacement plan in their respective area. These champions should provide feedback and make recommendations for further reducing TDOT's petroleum consumption. Additionally, we recommend that TDOT continue its promotion of alternative fuels and Green Island Corridors, which have both been facilitated by TDOT's Environmental Policy Office.

TDOT should continue to actively pursue efforts to reduce mowing cycles along with the study and development of pilot projects, like the ones already underway, to further the Department's efforts to provide a sustainable landscape for Tennessee. The wildflower program is a low cost way to provide sustainable landscaping that is aesthetically pleasing and reduces mowing. TDOT should further investigate reducing the amount of right-of-way being mowed in order to maximize good stewardship of public funds. In addition, TDOT should begin a public awareness campaign to educate the public regarding naturalized right-of-way and reduced mowing, so the public can better understand TDOT's efforts to save money through energy conservation, while at the same time helping the environment.

We recommend TDOT consider promoting the following travel activity/ land use options:

1) Improve land use planning and development to reduce vehicle miles traveled,
2) Expand transit, bike, and pedestrian infrastructure,
3) Promote commuter choice/workplace travel demand management,
4) Improve multi-modal freight transportation, and
5) Increase transportation system efficiency.

Although intelligent transportation systems (ITS) are expensive, the investment pays big dividends. Effective and efficient communication of information is vital. Therefore, we recommend TDOT continue to support and expand the ITS program.

Greater emphasis should be placed on identifying streams and wetlands while developing the initial ecology report. Unfortunately, revisions during the right-of-way process cannot be entirely eliminated. However, revisions could be minimized if the mitigation design and acquisition processes were more closely aligned.

New regulations have stated a preference for wetland banks. Therefore, TDOT should be proactive and acquire sites to develop wetland banks.

Using bioretention to better manage stormwater runoff can be simple, yet very effective. We believe that TDOT should continue to build on its progress toward a comprehensive and sustainable approach to stormwater management in partnership with TDEC. These strategies can help improve water quality, reduce public health hazards and enhance communities.

We recommend that TDOT establish a sustainable transportation initiative and build a comprehensive program that puts TDOT in a position to lead by example in the following areas:

1) Energy efficiency, with a focus on building management and vehicle fleet management;
2) Planning policies and potential legislation that support Smart Growth;
3) Research opportunities for innovative transportation financing and public-private partnerships that support environmental and financial stewardship of public resources;
4) Internal and external environmental awareness in partnership with other agencies; and
5) Building on the success of proven strategies (e.g., alternative fuels, electronic data management, education and outreach, etc.) that are already underway at TDOT.

There are many stakeholders in our transportation system. And these stakeholders often seem to be adversarial and competing. However, the truth is that all the stakeholders desire an efficient and effective transportation system and the solutions to achieve this will likely require a mixture of visions for sustainable transportation. Ultimately, we believe for the budget to remain in the black we need to think green.

INTRODUCTION

PURPOSE OF REPORT

In June 2008, the Tennessee Department of Transportation (TDOT) Bureau Chiefs gave the TDOT Executive Leadership Academy (TELA) Class of 2008 the responsibility to research best practices for energy efficiency and environmental quality in the transportation sector and prepare this report that shows a sample of both large and small scale strategies that TDOT can implement, as a good steward of public resources (environmental and financial). This effort can be broadly characterized as a study in sustainable transportation.

Sustainable transportation has been defined in many ways by many people. But, for the purposes of this report we have developed the following definition: *Sustainable transportation means providing access and mobility across Tennessee in the most efficient and effective manner, while being a good steward of public funds and environmental resources, so that we meet the needs of today, without exhausting the resources needed by future generations.*

The objective of this study is to provide a sample of practical tools that can place TDOT in a position to lead by example and promote best practices as they relate to all aspects of transportation. This report illustrates a variety of strategies that establish a starting place for TDOT senior management, division directors and program managers from which to build a more comprehensive program to improve efficiency, protect the environment and save money.

The strategies included in this report are practical and achievable over the next several years. In fact, some are already in various stages of implementation. And we attempt to quantify the costs and the benefits of each strategy in such a way that this report might be useful during TDOT's budget development process.

COST KEY

Most of the strategies presented here actually save money over a period time; however, because of budgetary constraints, it is important to consider the upfront costs of initial implementation for each strategy. Therefore, TELA consulted with TDOT Finance Director Neal Ham, to develop the following cost key that gives an indication of the upfront investment necessary to implement each strategy. Costs and benefits of each strategy are discussed in more detail within the text, but the cost key is intended to serve as a quick reference for senior management when assessing the upfront costs.

$	This symbol represents no cost or insignificant cost ($0 - $10,000)
$$	This symbol represents low cost ($10,001 - $100,000)
$$$	This symbol represents moderate cost ($100,001 - $1,000,000)
$$$$	This symbol represents high cost ($1,000,001 and up)

ADMINISTRATIVE STRATEGIES

FLEXIBLE WORK SCHEDULES

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Introduction

According to the U.S. Department of Labor a flexible work schedule is one that deviates from the typical 9:00 a.m. to 5:00 p.m. or 40 hours per week schedule. Although the Department of Labor has mentioned flexible work schedules, the Fair Labor Standards Act does not address this issue and policies on flexibility largely remain between the employer and employee (Bureau of Labor 2008).

In 2004, the Bureau of Labor Statistics found that the number of workers on a flexible work schedule was over 27 million. This equals approximately 27% of the total workforce in the United States.

Flexible Work Schedules as an Emission Reduction Strategy

A flexible work schedule policy reduces the peak period of congestion and makes ridesharing and transit use more feasible according to a report from Alyssa Freas and Stuart Anderson with the Transportation Research Board (TRB). Fuel savings, emission reductions, and other benefits, can be achieved when employers allow managers to work with employees and develop a flexible work schedule to reduce vehicle miles traveled (VMT) or reduce idling in congestion by allowing employees to travel during off-peak hours (Freas, Alyssa, Anderson, and Stuart 2007).

According to the Victoria Transport Policy Institute (VTPI), an independent Canadian Research organization that studies transportation-related issues, several factors must be considered before implementing a flexible work schedule (Freas, et al. 2007).

Table 1: Common questions to ask when considering flexible work schedules

Which job categories are suitable?	How employee schedules will be determined?
What will be required of employees to qualify?	What will be required to change schedules?
What criteria would be needed to evaluate the performance of employees on alternative schedules?	How will management periodically review and evaluate the arrangement?

The VTPI points out that flexible work schedules may require changes in management practices. Managers would need to shift to more outcome-oriented management practices (i.e., evaluating employees based on their performance rather than simply the amount of time they spend at their desks). And managers must accept an increased use of electronic communication (e.g., e-mail or

video teleconferencing) to compensate for reduced face-to-face interaction, which makes this arrangement possible (Freas, et al. 2007).

Employees would also need to recognize that a flexible schedule is a privilege and not a right. Therefore, employees must always be responsive to the need to be physically present at all important meetings, as determined by management.

According to the Society for Human Resource Management, employers need to have a clear and concise policy before any flexible work schedule is implemented. Listed below are a few suggestions that should be included in a flexible work schedule policy (Pritchard 1998).

1) **Management rights clause:** The policy should make it clear that this is an optional benefit that can be discontinued at any time for any reason. However, efforts should be made to provide reasonable notice where possible (Pritchard 1998).
2) **Impact on paid holidays:** The policy should not conflict with existing holiday and leave allocation practices. It should clearly state what the impact will be on compressed workers if a holiday occurs during a compressed week. There should be equitable treatment so that participants receive the same time off and holiday pay as other workers receives. Some options include reverting to the regular schedule for any week or pay period in which a holiday is planned, offering an alternative floating holiday for compressed workers already scheduled to be off on a planned holiday, allowing compressed workers to rearrange their schedule during a holiday week to ensure they are appropriately compensated and granted holiday time off, etc (Pritchard 1998).
3) **Impact on paid leave:** Options will vary depending upon whether paid leave is allocated by the hour or by the day and should be consistent with existing paid leave policies and equitable for compressed workers and non-compressed workers (Pritchard 1998).
4) **Eligibility factors:** Will all jobs be eligible for compressed work or will it depend upon scheduling issues, staffing levels and supervision? The policy should clearly state who is eligible and ensure that the policy is fairly and consistently administered (Pritchard 1998).

Some advantages of implementing a flexible work schedule are:

1) Possibly improved morale.
2) Reduced commuting time for employees commuting during off-peak hours. This would also result in less congestion during peak hours, reduced fuel use and reduced emissions.
3) Increased coverage of office hours by staggering staff schedules to cover telephones and staff reception areas.
4) Reduced fuel costs to work units that use state vehicles such as survey crews, rail inspectors, and maintenance divisions in all Regions/Districts (Arlington 2008).

Current Practices

The Tennessee Department of Human Resources (DoHR) *Attendance and Leave Policies and Procedure* defines a flexible work schedule as "A work schedule which deviates from the normal 8:00 AM to 4:30 PM workday, but is still within general guidelines authorized in advance by an appointing authority."

This report addresses three different types of flexible work schedules. These include 1) flexible hours in a five day workweek, 2) a compressed workweek, and 3) limited telecommuting. Telecommuting is significantly different from flexible hours and the compressed workweek; therefore, it warrants consideration as a separate topic.

Examples of agencies within Tennessee state government that use flexible work schedules include, but are not limited to, the Tennessee Department of Environment and Conservation (TDEC), Finance and Administration (F&A) and the Board of Probation and Parole.

Flexible Hours: Some employees may wish to work an earlier or later schedule than the traditional 8:00 a.m. to 4:30 p.m. schedule, even if they work five days a week. The primary benefit would be to avoid rush-hour congestion, but it would also give employees the flexibility to manage their lives more effectively to accommodate other demands. This is a standard policy allowed under DoHR rules and is widely used throughout Tennessee state government.

Flexible Work Schedules can have several benefits: With over 43,000 state employees, if 20% (8,600 employees) commuted four days per week rather than five day per week and the average one-way commute was 20 miles; it would save 344,000 miles in one day. If these employees were allowed to avoid commuting just 44 days per year it would result in cleaner air for Tennessee through reduction of mobile source emissions annually by 16.40 tons of volatile organic compounds, 10.93 tons of NO_x, 141.87 tons of CO, 0.2 tons of particulate matter, 0.14 tons of SO_2, 1.68 tons of NH_3. This hypothetical example demonstrates that Tennesseans would have cleaner air to breathe and more time to enjoy it (TACIR 2008).

According to a study from the Tennessee Advisory Commission on Intergovernmental Relations (TACIR), there are financial savings through reduced fuel consumption if employees commute only four days per week rather than five (TACIR 2008).

Table 2: Savings by reducing weekly commute from 5 days per week to 4 days per week

TACIR Savings based on May 2008 Average Gas Price				
	Roundtrip miles to work	**Mile per gallon**	**Total gallons per week**	**$3.80 per gallon**
Employee A	70	33	2.12	$8.06
Employee B	12	25	0.48	1.82
Employee C	5	25	0.20	0.76
Employee D	60	15	4.00	15.20
Employee E	18	29	0.62	2.36
Employee F	20	25	0.80	3.04
Employee G	27	22	1.23	4.66
Employee H	12	26	0.46	1.75
Employee I	26	25	1.04	3.95
Weekly Total	**250**		**10.95**	**$41.61**
Annual Total	**13,000**		**569.44**	**$2,163.86**

(TACIR 2008)

Recommendations

TDOT faithfully conducts annual performance-based personnel evaluations. This progressive approach already promotes management of outcome and productivity, not management through general observation and assumptions. Therefore, the current personnel evaluation system easily lends itself to application in a flexible work schedule program. A flexible work schedule policy can be brief, but effective if given due consideration. The following is a hypothetical example of what a flexible work schedule policy might look like for a TDOT division.

Example Policy and Procedure Excerpt

> *The flexible work schedule is a privilege, not a right. Not every employee will qualify for this policy. And management may revoke any individual's flexible work schedule if it determines that work objectives are not being met in an effective manner.*
>
> *The center piece of this policy is "accountability." The burden of accountability will be on the employee who applies for a flexible work schedule. Every employee has a job plan with performance measures. The employee interested in applying for a flexible work schedule must use their individual job plan in consultation with their immediate supervisor to identify measureable deliverables for their work along with time lines for these deliverables.*
>
> *The employee must write a justification memorandum to their immediate supervisor requesting a flexible work schedule. The employee must outline the proposed schedule and identify how the supervisor can effectively oversee their performance.*
>
> *To receive approval for a proposed flexible work schedule, the employee's immediate supervisor and each manager in the employee's chain-of-command must approve the request. The Director of the Division will have final approval authority of the proposed flexible work schedule.*
>
> *The employee and their immediate supervisor will be accountable for evaluating the effectiveness of the flexible work schedule each year during the employee's annual performance review. This evaluation of the employee's flexible work schedule must be documented by the immediate supervisor in a memorandum to the Director of the Division, in addition to the annual performance review.*

We believe TDOT should encourage flexible work schedules and four-day workweek schedules.

TELECOMMUTING

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Introduction

This discussion is not a recommendation that TDOT necessarily adopt a telecommuting policy. Rather, this discussion is intended to provide a general overview of the telecommuting concept, as well as its potential benefits and challenges.

Telecommuting is a general term used to encompass all types of non-traditional work arrangements that move work to people rather than people to work. According to the definition provided by the Federal Highway Administration (FHWA), "telecommuting (sometimes referred to as teleworking) occurs when paid workers reduce their commute by carrying out all, or part of, their work away from their normal place of business, usually from home or a telework center." The objective of telecommuting is to move the work to the worker instead of moving the worker to work (FHWA 2005a).

Working from a remote location has been a part of the federal government workplace since the 1930s. With respect to the federal government, as early as 1934, the National Credit Union Administration (NCUA) allowed their credit union examiners to prepare reports at home, as NCUA did not provide office space for these employees (GSA 2000). In 1957, the U.S. Comptroller General approved salary payment to federal employees who worked at home. Such approval was granted on a case-by-case basis.

The ideas surrounding the modern concept telecommuting have their roots in the early 1970s, as technology allowed for the possibility of telecommuting. The terms "telecommuting" and "teleworking" were coined in 1973 by Jack Nilles, the Director of Interdisciplinary Studies at the University of Southern California. Trained as a physicist and engineer, Nilles began studying present and future impacts information technology has on the work force. Nilles wrote the original book on telecommuting, which is entitled *The Telecommunications-Transportation Trade Off* and has become known internationally as the "father of telecommunications" (JALA 2008).

Telecommuting is defined in pending federal legislation as "a work arrangement under which an employee regularly performs the duties and responsibilities of such employee's position, and other authorized activities, from home or another worksite removed from the employee's regular place of employment (Telework Improvements Act of 2008, H.R. 4106, 110th Cong. § 2 (2007)).

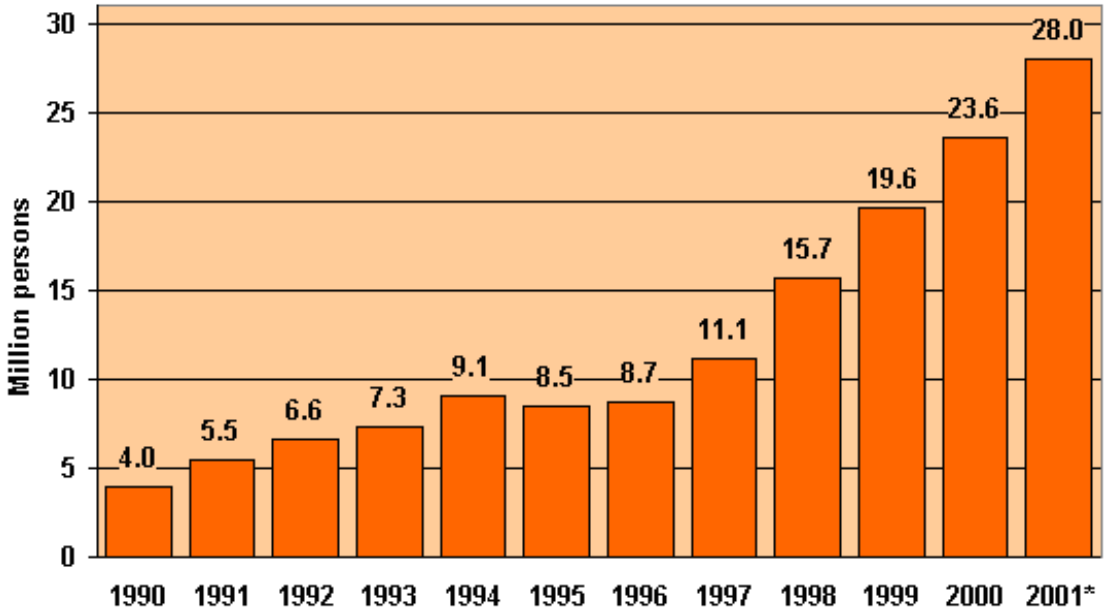
Current Practices

Telework has become a mainstream concept in today's employment market. According to the 2006 Gallup Work and Education Poll, 32% of adults in the United States who are employed

either full or part time have telecommuted to work (Gallup 2006). And recent statistics show that approximately 70% of Americans have Internet access in their homes (Abate 2008).

Current estimates of telecommuting range from 5-15% of the workforce, with 8-10% most probable (Pechan, et al. 2008). In 2003, the U.S. Department of Energy stated that between the years 1990 and 2001 the number of telecommuting adults in the United States increased from 4 million to 28 million (DOE 2003). Yet, some data suggest those telecommuting occasionally may be as high as 45 million (Abate 2008).

Figure 1: Number of workers telecommuting between 1990 and 2001



Today's federal government not only uses telecommuting, but has also implemented the concept of "flexiplace" working. Flexiplace is a term coined by Frank Schiff, former Vice President and Chief Economist for the Committee for Economic Development. Schiff's term encompasses not only work-at-home, but also such other flexible location arrangements as satellite work centers (Weiner and Stein 2005).

Telecommuting In Tennessee State Government

According to the Tennessee Advisory Commission on Intergovernmental Relations (TACIR), there is no clearinghouse or central source that maintains a list of agencies that allow or use telecommuting (TACIR 2008). However, research reveals that the Tennessee Department of Finance & Administration (F&A) has an established work at home policy. F&A created a formal telecommuting policy in 1998. Telework within F&A began as a pilot program with 11 participants. The F&A "Work At Home" Web site states, "the program continues to grow as we identify more areas where this approach is appropriate and beneficial to both the Department and the individual employee." Additionally the Human Resources Office of F&A created a policy manual that describes benefits of telecommuting, employee eligibility, and information regarding the telecommuter's status as a state employee.

In 2001, former Tennessee Governor Don Sundquist issued Executive Order # 27 that created the Governor's Interagency Energy Policy Work Group and Advisory Committee. Made up of representatives from each of Tennessee's departments as well as other interested organizations, the work group sought ways to incorporate policies within state agencies to conserve energy and conserve environmental resources. The work group focused on telecommuting as one of the key factors to help with energy issues. The Executive Order stated that the work group would evaluate the feasibility of increasing telecommuting opportunities at state offices across Tennessee to reduce energy needs at offices, decrease pollution and traffic congestion associated with daily commuting, and increase productivity and job satisfaction (Tenn. Exec. Order 27, 2001).

TDOT has also officially recognized the potential of telecommuting. TDOT's long range transportation plan envisions the future of Tennessee's transportation system for the next 25 years. The long range plan identified efforts in Travel Demand Management (TDM) that would reduce the need for expanded roadways while reducing congestion on existing roads. Specific items mentioned in the plan include carpool/vanpooling programs, telecommuting and flexible work schedules. The plan described the positive impacts of these strategies. In addition to avoiding the adverse impacts associated with widening a highway, these strategies can help improve air quality by reducing transportation-related emissions. Additionally, there may also be unquantifiable socioeconomic and quality of life benefits from reducing the number of person-hours spent in highway congestion (TDOT 2007).

Telecommuting in Other States

California: The State of California was the first state government to adopt a telecommuting policy. Between 1988 and 1990, a pilot project was established with 200 telecommuting state employees, 100 supervisors and 150 non-telecommuters in a control group. The pilot project was so successful that the California Legislature passed the State Employee Telecommuting Program in 1990, with amendments in 1994 (Fleming 2002).

The California telecommuting program is collaboration between the Department of Personnel Administration and the Department of General Services. The Personnel Department handles the human resource matters associated with telecommuters and the General Services Department deals with office space issues. One key factor in the success of California's program is the Telework Advisory Group that was created early in the planning process to serve as a forum for strategies and issues related to telecommuting. By 2002, California had 60 state agencies participating in the program with more than 7,000 state employees telecommuting. The California Transportation Department created a policy where local regional agencies are given the discretion to allow employees to telecommute (Fleming 2002).

The success of California's program spawned similar programs in Arizona, Colorado, Florida, Minnesota, Oregon, Virginia, and Washington based on the California model. Additionally, in 1992, former President George H.W. Bush incorporated telecommuting as part of the National Transportation Policy (Fleming 2002).

Connecticut: In 1998, the Connecticut Department of Transportation (CDOT) established "*Telecommute Connecticut!*" to encourage companies to allow employees to telecommute. The program provides technical information and assistance to employers considering allowing telecommuting in order to relieve traffic congestion (CDOT 2006).

Missouri: Effective July 1, 2008 the Missouri Department of Transportation (MoDOT) implemented a policy that would allow all qualified employees to telecommute. Their decision to allow an employee to telecommute would be based on time and cost effectiveness to conclude if a job that could be completed remotely without "diminishing quality, productivity, or level of service." The policy further stated that telecommuting did not change any official work policies already in place that telecommuting could be temporary or permanent, and the employee's supervisor continues to monitor their job performance. Additionally, MoDOT agreed to provide the employee with all necessary tools to perform their job other than a separate phone line, phone bills, or Internet usage bills, which would continue to be the employee's responsibility (MoDOT 2008).

Washington D.C.: Washington D.C. issued a new telecommuting policy on December 7, 2007. The policy allows eligible employees to telecommute "based on the needs of the organization and without diminishing employee performance." Each agency in the district is authorized to establish telecommuting for eligible employees. The policy also stipulates that unless special provisions are made telecommuting shall be limited to not more than 2 days per workweek (Washington D.C. 2006).

As advancing technology continues to provide workers with greater opportunities to work remotely, large corporations, as well as, small businesses are looking at both the positive and negative impacts of telecommuting on the workforce. Although corporations seem to be at the forefront, federal, state, and local governments have also begun considering telecommuting for employees whose physical location is not necessary to complete their jobs (Lillie 2001).

Benefits & Costs

Telecommuting is an option that could help reduce roadway wear-and-tear and congestion. Additionally, by reducing trips, telecommuting would reduce mobile source emissions. However, for telecommuting to be effective, the job should be a relatively independent work function that can rely on electronic information rather than face-to-face communications.

Like any change in the workforce culture, there are advantages and disadvantages in telecommuting. But, unlike most office policies, there are potential environmental benefits from a telecommuting program.

A recent University of Maryland study found the following:

- **50%** of workers travel more than **20 miles** to/from work
- **22%** of workers travel more than **40 miles** to/from work
- **10%** of workers travel more than **60 miles** to/from work

The American Electronics Association, a high-tech trade group, surmised that if every worker who could telecommute did so 1.6 days per week, at least 1.35 billion gallons of gasoline would be saved annually. The U.S. Environmental Protection Agency (EPA) has estimated that saving 1.35 billions of gas each year would decrease the amount of carbon dioxide (CO_2) in the atmosphere by 26 billion pounds (Abate 2008).

In a similar study in 2007, the Consumer Electronics Association found that if an additional 3.9 million people in the United States would work from home at least one day per week that by eliminating their average 22-mile commute for one day per week, 840 million gallons of gas could be saved, which is the equivalent to removing 2 million cars off the road each year. Given this information, the report suggested that if 53 million workers could telecommute that would be the equivalent of removing 27 million cars from the roads each year, effectively reducing CO_2 emissions by 1.6 billion tons each year (Mellor 2007).

In addition to individual companies recognizing the many benefits of telecommuting, the federal government has initiated legislation and guidance that provides incentives for telecommuting. Congress passed the National Telecommuting and Air Quality Act of 1999 to encourage companies and governments to allow employees to telecommute. The Act made provisions for an emissions credit trading and exchange system for employees that telecommute. Pilot programs were created in Washington D.C., Los Angeles, Philadelphia, Houston, and Chicago (FHWA 2008).

The Tennessee Supreme Court recognized the benefits of telecommuting in its unanimous decision in the Wait v. Travelers Indemnity Company of Illinois case (240 S.W.3d 220 (Tenn. 2007)). The Court recognized that employers often use telecommuting as a way to reduce overhead expenses. Similarly, employees enjoy many benefits of working at non-traditional worksites, such as reduced travel time. Furthermore, society benefits from telecommuting with reductions in traffic congestion and pollution. The Court goes further and quotes Carol Browner, former EPA administrator, "If 10% of the nation's workforce telecommuted one day a week, we would avoid the frustration of driving 24.4 million miles, breathe air with 12,963 tons less pollution, and conserve more than 1.2 million gallons of fuel each week."

In addition to the other benefits mentioned, there are financial and human resources benefits from a telecommuting program. Rapid changes in technology have made telecommuting much more feasible in today's workplace than in past years. As a result, it is now much cheaper for an employer to institute telework policies with the appropriate balance between the employees, management, and technology (Trumble, et al. 2006).

Potential telecommuting benefits to TDOT include:

1) Savings in office cost;
2) Potential productivity increases;
3) Reducing road congestion and infrastructure wear-and-tear;
4) Savings in relocation cost following a move or growth;
5) Improving air quality and other environmental benefits; and
6) Increasing levels of employee morale and loyalty.

These benefits improve the ability to recruit and maintain the best possible workforce, especially newer workers with a high expectation of a technology-forward workplace and any employee who values the work/life balance (USOPM 2006).

Despite these significant benefits, concerns remain with respect to telecommuting. Prior to the adoption of telework as a department-wide policy, there are some concerns that may bear consideration:

1) Workplace safety and liability – how safe is the environment in which the telecommuter is working? For example, what occurs if a telecommuter suffers an on-the-job injury at a home worksite?
2) The Tennessee Department of Labor Division of Occupational Safety and Health has issued a Tennessee Occupational Safety and Health Act (TOSHA) Instruction addressing compliance issues for home-based worksites (TDLWD 2000).
3) The Wait case indicates that employees injured at home-based worksites may be eligible for Worker's Compensation benefits under certain circumstances (Wait, 240 S.W.3d at 227).
4) Security of privileged and confidential information – for the telecommuter who handles sensitive information, all precautions must be taken to protect any confidential or proprietary information stored or accessed at telework locations.
5) Tracking hours worked – in light of the Fair Labor Standards Act (FLSA), management must decide how best to track any and all hours worked, especially those employees who are non-exempt and/or eligible to receive overtime pay.
6) Equality – a diverse number of employees should be eligible to telecommute, and not necessarily workers of a particular educational background, job area, or salary level. For example, the 2006 Gallup Poll shows that of all surveyed, 57% possessed a post-graduate education (Jones 2006).
7) Communication/interaction with non-telecommuting co-workers and management – Telecommuters can feel isolated from the office and should receive frequent opportunities to interact with co-workers and management. Telecommuters also take a risk in losing out on promotional opportunities as opposed to more visible colleagues in the office; therefore, it is crucial that these interaction opportunities take place for the telecommuter (Telecommuting 2008).

The following table provides a side-by-side comparison of some of the advantages and disadvantages of telecommuting.

Table 3: Advantages and Disadvantages of Telecommuting

Advantages for Workers (Johnson 1994)	**Disadvantages for Workers**	**Advantages for Employers**	**Disadvantages for Employers**
Decreased travel time and cost	Lack of social contacts with fellow co-workers	Decreased need for office space	May need to supply office equipment for remote location
Fewer interruptions in the work environment	Fewer face-to-face meetings	Decreased need for custodial services	Lack of understanding employees daily job tasks
Flexible work schedule	Longer working hours	Decrease in parking issues	Potential inadequate task management
Increased privacy	Lack of inter-office mail system & ad hoc communication	Increased employee satisfaction	Teleworkers that may lack discipline to devote time to work
Decreased work-related relocations		A job "perk" that will retain employees	
Conserving energy		Conserving energy	
Preserving the environment		Preserving the environment	
Allows employee freedom		Allows employee flexibility	
Improves productivity		Improves productivity	
Promotes safety—decreases possibility of traffic accidents			

Studies in Tennessee project that limited telecommuting could realistically reduce total urban VMT by 0.05-0.6%. An approximate doubling from current levels in telecommuting could be achieved, with a saturation increase of 9-44 percent above current levels, based on employer surveys from two different areas, and current telecommuting levels of approximately 10 percent at an average of 1.6 days per week. It is likely that public-sector programs or incentives will have little if any influence over adoption (aside from public employees themselves). Technology improvement, cultural shifts, and travel cost factors (e.g., price of gas, congestion, etc.) are likely to drive further private-sector adoption (Pechan, et al. 2008).

Recommendations

Funding is always a concern for any program. But, limited telecommuting would cost very little and might even save money for the employee and TDOT. However, if there were some up-front expenses federal funding could be available because telecommuting is one of several ways to reduce congestion and mobile source emissions in the air. Therefore, the Federal Highway

Administration (FHWA) supports telecommuting through the Congestion Mitigation and Air Quality (CMAQ) Improvement Program. CMAQ provides a flexible funding source for state and local governments to fund transportation projects and programs to help meet the requirements of the Clean Air Act (CAA) and its amendments. Eligible activities include travel demand management strategies, such as telecommuting options, traffic flow improvements, and public fleet conversions to cleaner fuels, among others (FHWA 2008).

CMAQ funds 80% of eligible projects costs and operates on a reimbursement basis. Eligible activities related to telecommuting include planning, technical and feasibility studies, training, coordination, marketing, and promotion of the program. Ineligible activities include purchasing equipment for employees who telecommute (FHWA 2008).

Nevertheless, TDOT does not generally pay for physical transportation to and from the physical work place and TDOT would not necessarily need to pay for telecommuting equipment to give employees access to the virtual work environment. In fact, in those circumstances where TDOT does pay for physical transportation (e.g., the employee bus pass or state vehicle) then those costs could be avoided on the days an employee telecommutes.

As TDOT decision-makers evaluate strategies to reduce energy consumption and protect the environment, we believe flexible hours, four-day workweeks and limited telecommuting are viable solutions worthy of further consideration. We recommend that TDOT further evaluate the potential benefits (e.g., reduced wear-and-tear on roadways, reduced congestion, reduced mobile source emissions, reduced commute time, and reduced fuel consumption, etc.) of telecommuting, flexible hours and compressed workweek strategies.

GENERAL RECYCLING

$ to $$

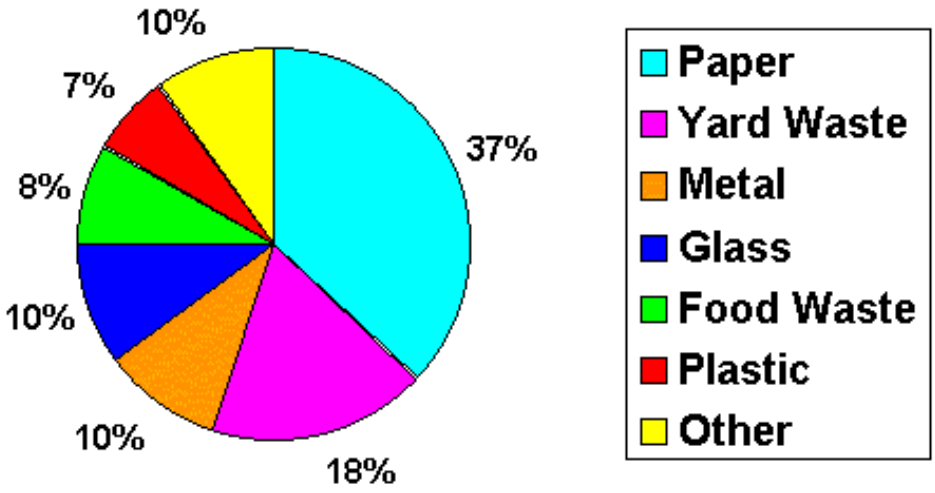
Introduction

It is common knowledge that recycling means less trash going to our landfills. However, the greatest environmental reasons for recycling are not related to landfills, but to the conservation of energy and natural resources and the prevention of pollution when a recycled material, rather than a raw material, is used to make a new product.

There are many benefits, both economical and environmental, to recycling,. A well-run program can cost less to operate than waste collection, landfill disposal and incineration. Recycling creates four jobs for every one job created in the waste management and disposal industries. On an individual level, recycling centers pay cash for their patrons' recyclables. In 2000, recycling and composting diverted nearly 70 million tons of material away from landfills and incinerators, doubling the amount from 1990 (34 million tons). By recycling, air and water benefit through a net reduction in major categories of air and water pollutants. According to information from the National Recycling Coalition, in the U.S., the processing of minerals contributes almost half of all reported toxic emissions from industry, sending 1.5 million tons of

pollution into the air and water each year. Recycling can significantly reduce these emissions. A national recycling rate of 30% reduces greenhouse gas emissions as much as removing nearly 25 million cars from the road. Recycling also conserves natural resources, such as timber, water and minerals. Clearly the benefits of recycling out weigh the costs (NRC 2008).

Figure 2: Composition of an Average Landfill



(EPA 2008a)

As shown in the figure above, paper and yard waste make up over 50% of landfill composition. Yard trimmings (which include but are not limited to cut grass, hedge or shrub trimmings, leaves and sticks) should never be bagged as trash. Cut grass is better left on a lawn so the nutrients are returned to the soil. All other trimmings should be reused through mulching, composting, or other landscaping. Recycling paper, plastic, glass and aluminum are just the beginning of what we, as a state, can do to help save energy, natural resources and reduce pollution. Every ton of paper that is recycled saves 17 trees, 6 gallons of water, 463 gallons of oil, 587 pounds of air pollution, 3.06 cubic yards of landfill space, and 4,000 kilowatt-hours of energy. Recycling one ton of plastic saves the equivalent of 1,000-2,000 gallons of gasoline. Making cars from recycled aluminum decreases related air pollution by 95%. Making paper from recycled materials generates 74% less air pollution and 35% less water pollution, and uses 64% less energy than making paper from virgin timber (NRC 2008).

By decreasing the need to extract and process new raw materials from the earth, recycling can eliminate the pollution associated with the first two stages of product development: material extraction and processing. Mineral extracting and processing pollute the air, land, and water with toxic materials, such as ammonia, carbon dioxide, carbon monoxide, methane, and sulfur dioxides. Recycling reduces, and in many cases eliminates, these pollutants. Recycling and composting can reduce greenhouse gases in several ways. Less energy is needed to make products from recyclables than from raw materials. Also, emissions are reduced from incinerators and landfills, which are the largest source of methane gas emissions in the U.S. The harvest of trees is slowed by recycling, thereby maintaining the carbon dioxide storage benefit provided by forests (NRC 2008).

Current Practices

Recycling in Tennessee State Government

Paper Products, etc.: In Tennessee government offices, recycle bins have become a standard piece of office equipment. Employees are encouraged to recycle office paper, aluminum cans, and plastic bottles. These recycling opportunities are provided to state employees through the State Employee Recycling Program (SERP). The SERP program allows state employees to recycle more than 70 tons of office paper per month which saves the state more than $2 million per month in landfill costs. Not only does recycling save the state money, it also provides the state with revenue for the Solid Waste Management Fund. Between 1990 and 2007, the recycling of mixed paper products provided the state with over $130,000 in revenue (TDEC 2008).

Figure 3: SERP Logo

As indicated in the following quote from the Tennessee Department of Environment and Conservation (TDEC), the State Employee Recycling Program has received national attention as the program expands throughout the state.

> *In fact, the SERP program in Tennessee has been so successful that they, along with the Tennessee Department of Environment and Conservation, received a State Government Partner of the Year Award from the U.S. Environmental Protection Agency in 2007. SERP received the award because of their efforts to expand the recycling program by adding nineteen new locations. Tennessee is one of only nine states to receive the award since its inception* (TDEC 2008).

This program should continue to expand and improve to maximize the benefits of recycling. Each state office building, garage, rest area, and state park should have plastic, aluminum, glass and paper recycling bins easily available and accessible. Each TDOT region could have recycling collection sites centrally located to provide access for all outlying TDOT facilities.

E-Waste: E-waste, or electronic waste, is waste of broken or unwanted electrical or electronic devices. Tennessee is also reducing major environmental hazards through "contract pick-ups," which are defined contracts to the lowest bidder that arrange disposal of harmful chemicals and waste. Computers, mobile phones, fax and copy machines, printers, televisions and stereo equipment make up a portion of all electronics used today. Most of the electronics we use today contain parts that remain useful long after the life of the equipment itself. The improper disposal of our electronics can pose a significant risk to the environment. Toxic substances such as lead, mercury, cadmium and polychlorinated biphenyls become an environmental concern when improper disposal of e-waste occurs (Environment-Green 2008).

Today's computers contain fire retardants in their plastics. This makes recycling difficult. The glass in the monitor contains lead and many of the components contain other toxic substances making proper disposal complicated and costly. The production of a more environmentally friendly computer is being developed in Japan. A computer that is specifically designed to be easily recycled as well as the usual toxic substances being substituted with more benign substances will hit the shelves soon (Environment-Green 2008).

E-waste is the fastest growing segment of the state's solid waste stream (TDEC 2008). Currently, The State of Tennessee disposes of its old equipment through surplus disposal procedures. Old equipment is auctioned off to the highest bidder, and broken equipment is sent to Unicor recycling company for processing. This process minimizes the state's e-waste and TDOT should continue to participate.

Tire Recycling: Tire recycling is the process of taking used tires that are no longer safe for the road and creating an entirely new product. Tires are produced to be durable and they take up a large amount of space. This is why most landfills will not accept tires. There is also the issue of methane emission when the tires begin to decompose.

Worn tires can be shredded and used for new purposes. Shredded or crumbled tires can be used for playground surfaces. There is also research underway for crumbled and shredded tires in roadway material. The newly created material is soft and durable. In 1998, TDOT used crumb rubber from scrap tires in modified hot-mix asphalt on two projects in west Tennessee. Both sections of roadway are seven miles in length and are located in Shelby and Dickson Counties. TDOT continues to monitor their durability in order to determine if this recycling technique could be used on other projects (TDEC 2008).

The shredded tire can also be used in landscaping. According to the Texas Natural Resources Commission, shredded tire mulch is a good substitute for wood mulch because it keeps soil moisture surrounding the plant while not attracting bugs and rodents (Texas Natural Resources Commission 2001). It lasts longer and does not require watering or cutting.

Current State of Tennessee government practice is for old tires to be returned to the company that furnishes new tires. It remains unknown if the tire companies have a recycling program, but TDOT could make this a contract requirement.

Motor Oil Recycling: Motor oil is another source of harmful waste to the environment. Approximately 1 gallon of improperly disposed motor oil could contaminate up to a million gallons of fresh water (TDEC 2008). TDOT's statewide maintenance contract is a pick-up service that collects all used motor oil for recycling. No expenses are incurred by TDOT and the contract produces revenue for the state. Although the dollar amount of revenue was not available in the most recent contract, it did specify that TDOT recycles over 40,000 gallons of oil each year (Enterprise Waste Oil Contract with the State of Tennessee 2007).

Recommendations

Overall, the State of Tennessee has already taken great strides in recycling. One other step the state can take to benefit employees is education on the subject. Seminars, pamphlets, brochures and speakers at monthly staff meetings are simple tactics to share facts and statistics on recycling. If individuals were aware of what a difference they could make to the environment, perhaps we could spread recycling from the workplace into the whole community. TDOT could include this type of educational effort through an internal environmental awareness program and TDOT could consider partnering with TDEC's State Employee Recycling Program.

We believe TDOT should offer recycling through the State Employee Recycling Program at all our facilities where this service is available. Furthermore, we recommend the development of an environmental awareness program for TDOT employees.

ENVIRONMENTAL AWARENESS PROGRAM

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Introduction

According to research by Deborah Gordon, Director of the Transportation Program at the Union of Concerned Scientists, there are three competing visions of sustainable transportation. These three strategies can be broadly categorized as 1) changing people, 2) changing technology, and 3) changing prices (Gordon 1995).

The first approach starts with the premise that we need to convince people to change the way they live. The primary objective of this approach is to reduce VMT by restructuring our society such that our needs (work, shopping, personal and social services, as well as, recreation) can be met in our local community by driving only short distances, or walking or biking near our homes. This behavior-based concept is called "access by proximity." Obviously, this approach would require a reassessment of our land use practices characterized by compact, multifunctional, pedestrian and bike friendly communities (Gordon 1995). According to a 2006 international study conducted by FHWA, entitled *Managing Travel Demand - Applying European Perspectives To U.S. Practice*, the primary motivation to move toward sustainable transportation practices in the United States is to address our energy needs, congestion and to a lesser extent, to protect the environment (FHWA 2006).

The second approach is based on applying technology to reduce the impact of transportation. This vision seeks to apply new and better technology to allow the transportation system to handle the current and future demand in a more efficient and effective manner without requiring individuals to make substantial changes to their behavior. Policies associated with this approach include cleaner, alternative-fueled vehicles; enhanced vehicle fuel economy; ultra-light composite vehicles powered by non-fossil fuels; demand-responsive public transit and ridesharing programs; intelligent transportation systems (ITS); and even telecommuting (Gordon 1995).

The third approach assumes that if we correctly include the true costs of transportation in the price of mobility that the market will solve our transportation problems. The current under-pricing of transportation service has resulted in over-consumption and a misallocation of resources. Pricing options to internalize true costs that are now treated as externalities by the consumer of transportation goods and services include taxes, subsidies, rebates, user fees, and marginal cost pricing.

If the true costs of the transportation system are factored into the cost of transportation goods and services then the consumers will be more likely to make choices that promote sustainable transportation. Additionally, the revenues generated through true pricing would be invested into those transportation services that are the most efficient and effective for society (Gordon 1995).

There are many stakeholders in our transportation system. And these stakeholders, like the three broad approaches described above, are often portrayed as adversarial and competing. However, the truth is that all the stakeholders desire an efficient and effective transportation system and the solutions to achieve this will likely require a mixture of all three visions of sustainable transportation (Gordon 1995). Yet, all paths to sustainable transportation begin with people; therefore, environmental awareness is of paramount importance.

Current Practices

TDOT is in the process of implementing a public education and outreach campaign in the areas of Tennessee that are not meeting air quality standards. The goal of the campaign is to increase public awareness and understanding of how transportation impacts air quality in Tennessee, particularly air pollution from cars and trucks.

The campaign will identify actions that everyone can take to reduce vehicle emissions and improve air quality. It will also attempt to motivate and persuade citizens to take action in their own lives to reduce air pollution from mobile sources. The campaign will be closely coordinated with Metropolitan Planning Organizations (MPOs), transit agencies, rideshare agencies, regional clean air partnerships, the Tennessee Department of Environment and Conservation, local air quality agencies, and alternative fuel Clean Cities coalitions.

This campaign could be extended to include a component targeted to state employees in general and TDOT employees specifically. Aspects of this program could include promoting greater awareness of alternative fuels (e.g., bio-diesel and E85) and energy conservation opportunities in the office environment.

Benefits & Costs

The public education and outreach campaign is in the early stage of implementation. The potential benefits and costs are still being defined. But, funds will include federal money through the Congestion Mitigation and Air Quality (CMAQ) program. Nevertheless, TDOT could implement an internal awareness campaign, at virtually no cost, with significant benefits. Such a program could also help TDOT reduce fuel consumption, as required by P.C. 489.

Recommendations

Internal Environmental Awareness Campaign

One-way an organization can encourage employees to reduce their carbon footprint is through education that encourages staff members to think environmentally. The information could be distributed via e-mail from TDOT's Communication Office. The components could include energy conservation in an office environment (e.g., powering down desktop computers, etc.) and environmentally friendly driving strategies (e.g., anti-idling, etc.). These strategies are discussed in more detail under the Green Building Management and Green Fleet Management sections of this report. Additionally, TDOT could facilitate public awareness through the use of existing Web-based Geographic Information Systems (GIS) technology.

Most TDOT employees read and send e-mail on a daily basis. According to Information Technology Operations Manager Mark D. Patterson, 2,920 TDOT employees possessed GroupWise e-mail access as of August 1, 2008. By attaching a simple statement to every email, such as a single environmental fact, TDOT will create awareness internally and externally with every email sent. This has the potential to be expanded statewide and could reach an infinite number of people outside the State of Tennessee. TDOT could implement this without any additional cost by using existing staff. Something as simple as the following could get employees and others to think more about the environment:

> *Thank you for considering the environmental impact of printing emails.*
>
> *Please consider the environment before printing this email.*

Web-based Green Map Project

This section is a summary and reproduction of an article written by Maggie Jones, ESRI, in the Summer 2008 edition of the *Environmental Observer*. TDOT already has all the necessary technology and in-house expertise to implement a similar program.

> Environmentally conscious members of the Westchester County Geographic Information System (GIS) group in New York State have found a way to facilitate global warming awareness in their community. They have created the online Green Map (http://greenmap.westchestergov.com/) that allows residents to visualize information about locations and activities that support green practices. For example, it shows citizens where they can dispose of used tires, in addition to other information.
>
> The map service utilizes ArcIMS software and technology from Green Map System, Inc. (GMS), an organization devoted to developing sustainable communities with mapmaking tools that increase citizen awareness of local conservation opportunities.

Westchester is a densely populated county neighboring New York City. With more than 900,000 residents, environmentally friendly practices are necessary for sustainable living. The county's interactive Green Map was launched as part of County Executive Andy Spano's Global Warming Task Force, whose mission is to create a countywide action plan to reduce greenhouse emissions and promote sustainable development through awareness and education.

The online map was created to help residents of all ages and backgrounds find resources that are available right in their own community. The Green Map project allows viewers to select the category they wish to see, such as bus stops, tire disposal sites, farmer's markets, or green buildings, to find the nearest and most accessible location for the resource they need. Users also have the option of viewing aerial imagery on the map.

Since the site is designed for easy navigation, users simply select the resources they wish to see labeled on the map, find the location most convenient for them, and zoom in until they can see the exact location (e.g., intersection or street name). Users can display or hide features on the map as well as find out more about anything that interests them just by clicking a link to source Web sites. Residents frequently visit the site to find the closest farmers' markets, cell phone recycling centers, and hazardous household chemical disposal sites. Additionally, citizens can locate facilities like parks and bike trails where they can enjoy the environment that they are working to protect.

The Web site also supplies community members with downloadable datasets for each of the categories represented on the map. The site was created to boost local awareness of and involvement in creation of a better environment and higher quality of life for everyone (Jones 2008).

For more information on the Green Map Project in Westchester, NY contact Cynthia Louie at 11c4@westchestergov.com. Additionally, Tennessee's Office for Information Resources (OIR), GIS Services Division has a new map website of Tennessee that is now available to the public. Visit http://tnmap.state.tn.us/viewer/map.aspx to learn more about this Tennessee site.

We recommend establishing a "Green Map" project that promotes environmental awareness and assists citizens in their quest for environmental resources (e.g., recycling centers, local farmer's market, etc.).

REDUCED FREQUENCY FOR TUNNEL CLEANING

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Introduction

In 2007, TDOT contracted the cleaning of five tunnels. The cleaning frequency schedules for all five tunnels were monthly. By reducing the cleaning frequencies to bi-monthly, you theoretically cut the cost in half.

Current Practices

In 2007, TDOT contracted the cleaning of five tunnels. A field trip was conducted on August 12, 2008 to one of these tunnels, the Henley Street tunnel in Knoxville. On this day, the tunnel was scheduled for cleaning. The purpose of the trip was to see the extent of grime build-up. The Henley Street tunnel walls are ceramic tiled. What was found on that day was that the residue was very minuscule and easily removable with the wipe of a finger. This is, of course, during a dry summer month and is not indicative of every month.

In 2007, the total contracted cost directly involved in cleaning the tunnels was $228,800, as illustrated in Table 4. A contractual cost item not directly involved in cleaning a tunnel is mobilization. Any potential transportation cost savings are generally considered low, and therefore are not considered in this example.

Table 4: TDOT Awarded Tunnel Cleaning Contracts 2007

Tunnel	Unit	Unit Price	Cost
McCallie Tunnel			
Cleaning	12	$ 2,500.00	$ 30,000.00
Maintenance of Traffic	12	$ 1,500.00	$ 18,000.00
Bachman Tunnel			
Cleaning	12	$ 2,500.00	$ 30,000.00
Maintenance of Traffic	12	$ 1,400.00	$ 16,800.00
Stringers Ridge Tunnel			
Cleaning	12	$ 1,850.00	$ 22,200.00
Maintenance of Traffic	12	$ 1,400.00	$ 16,800.00
Henley Street Tunnel			
Cleaning	12	$ 3,150.00	$ 37,800.00
Maintenance of Traffic	12	$ 1,400.00	$ 16,800.00
Thompson Lane Underpass			
Cleaning	12	$ 3,200.00	$ 38,400.00
Maintenance of Traffic	12	$ 1,000.00	$ 12,000.00
		TOTAL	$ 228,800.00

(TDOT 2008a)

Benefits and Costs

In 2007, costs totaled $228,800. Therefore, by cutting these direct costs in half, we realize an annual savings of approximately $114,400.

Recommendation

We believe that reduced tunnel cleaning is a viable option to save money, with no impact on aesthetics or infrastructure integrity. One caveat to explore is that the roadways in the winter months will experience salt and/or brine treatment and a build-up of salt residue may occur. This build-up may be detrimental to the life expectancy of cement-based materials such as tile grout. Therefore, a monthly cleaning schedule from December through March may be necessary. We suggest TDOT conduct a study to conclusively determine the cost savings on a statewide level and any potential drawbacks.

DIGITAL DESIGN PLANS

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Introduction

Distribution and submission of plans in a read-only electronic format by the Design Offices can reduce costs, as well as waste. Electronic plans include but are not limited to, Preliminary, Right-of-Way and Construction field reviews, Right-of-Way/Utility submittals, and final Construction submittals.

Current Practices

The Region 1 Design Office traditionally sends out approximately 10 full size sets of plans and 22 half-size sets of plans for each of the three types of field reviews (preliminary, right-of-way and construction). Right-of-Way submittals vary in quantity, but typically consist of approximately 26 full size sets and 20 half-size sets for an average project. For Final Construction, approximately 2 full size sets and 3 half-size sets are printed for submittal. In addition to these various printing milestones there are also Right-of-Way, Letting and Construction Revisions, prints for permitting and prints for grade approval requests, and several others. On large projects, a large amount of plans are printed. Batch printing is done by an independent contractor and in 2007; the Region 1 Design Office spent about $20,700 on printing of approximately 85,000 plan sheets. In addition to these printing costs, in-house printing, as well as, shipping through UPS or messenger mail is also a consideration.

Benefits & Costs

In a case study at the Croatian Institute of Civil Engineering, the investment in an electronic management system for plans reduced transaction time by 80%, increased productivity by 50%

and decreased processing time by 50%. At these rates, the Institute believes they will see a return on investment in excess of one million dollars over a year's time (Hoffer 2008).

Many of the plans printed and distributed throughout TDOT are not even used. They are thrown away, filed away, or lost. This is costly to the taxpayers as well as the environment.

Nearly 900 million trees are cut down every year to provide raw materials for paper for the U.S. In return, American offices throw away enough paper to build a twelve-foot-high wall from Los Angeles to New York City (Clean Air Council 2008).

Paper is costly, especially for the size of paper used for project plans. A full size plan sheet measures approximately 34" x 22" and a half size plan sheet measures approximately 17" x 11". A paperless office is a philosophy that work can be done with minimal paper. The idea is driven by a number of motivators including costs savings, productivity gains, and reduced environmental impact (Wikipedia 2008). The paperless office came into the forefront after a 1975 Business Week article titled "The Office of the Future." The article predicted that by 1990 most record handling would be electronic (Business Week 1975). Many of the Department's processes are now in an electronic format and plans processing should be a part of TDOT's electronic processes.

Other environmental factors support electronic distribution of plans. According to Jeffrey May, author of *My Office is Killing Me!: The Sick Building Survival Guide,* up to 30% of offices have mild indoor air quality problems and up to 10% of offices have significant problems. Large offices where windows cannot be opened, such as at the Region 1 Administration office, pose worse problems (May 2006). Region 1 Design currently uses a large scanner/copier for plans and other offices may also use a blueprint machine. One of the top 10 major indoor air contaminants is miscellaneous inorganic gases, which include ammonia, a major component of the blueprint machine (OSHA 2008). The large scale copiers can emit dust, ozone and other substances during their inking process, thus also reducing the indoor air quality (Hetes, Moore and Northeim 1995).

An electronic distribution of design plans will result in spending less money, producing less waste, increasing productivity and improving air quality. As a government agency, these factors are not only important to the organization, but to the people we serve, the citizens of Tennessee. Streamlining our process by using the available technology is a win-win situation for everyone.

Recommendations

Implementing electronic plans distribution improves communication, increases productivity, and saves money. Faster turnaround, fewer lost plans and immediate availability are additional benefits. An estimated 10% of company labor costs are on manual document management processes (Wilson 2008). We recommend that TDOT continue offering design plans in a digital format, as an option to printing. Additionally, we suggest that TDOT pursue plans to expand e-files to other program areas (e.g., File Net initiative). And we believe all data should be captured at the point-of-origin and transmitted electronically to other users, to avoid transcription errors and lost data, in addition to avoiding printing costs and saving time.

ENERGY CONSERVATION STRATEGIES

GREEN BUILDING MANAGEMENT

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Energy Efficiency Overview

On March 19, 2008, Governor Phil Bredesen signed Executive Order 54, establishing the Governor's Task Force on Energy Policy (TN Exec Order No. 54 (March 19, 2008)). The Task Force is charged with developing an energy plan to help state government become a leader in energy efficiency.

The task force will make recommendations to help Tennessee become a leader in energy efficiency and conservation through the use of alternative fuels and renewable energy sources, and the development of clean-energy technology. The Executive Order outlines four key goals and objectives:

1) Identify opportunities for state government to lead by example in energy efficiency and conservation, with an emphasis on building construction, facilities management and vehicle fleet administration;
2) Propose prospective policies, legislation, regulations or incentives to encourage statewide energy efficiency and conservation in the public and private sectors;
3) Determine possible public-private partnerships and collaborations to encourage research and development of clean-energy technology and increase economic development potential in the state's energy sector; and
4) Research strategies for expanding the use of alternative fuels and renewable energy sources to support the sustainability of Tennessee's environment.

TELA's overview of energy management strategies for buildings is intended to demonstrate the potential energy cost savings if building operating efficiency is maximized. Furthermore, we hope to provide a compelling vision of how TDOT might implement a successful energy management program in its building facilities in a manner that supports the Governor's goals.

Tennessee has a history of relatively low energy costs compared with other states. This means financial returns from implementing efficiency and conservation measures have been limited. States such as New York and California have higher energy costs and therefore this has motivated these states to be more aggressive in the area of energy conservation. Fortunately, Tennessee can benefit from the experiences of these other states, as we develop our own approach.

Energy efficiency and conservation of energy resources offer Tennessee the most cost-effective and most readily deployable method to manage its energy future. Tennessee state government has a significant role to play to increase implementation of energy efficiency and conservation measures by modeling the way for the public and the business communities.

Green Building Strategies

Computer Usage: Currently, TDOT leaves computers on at night for software updates. Updates are needed to keep our computers current with the latest software. However, computers use a great deal of energy even when they are not actively used. In fact, if the monitor displays a screensaver image then it is using an equivalent amount of energy to active use. The only way energy is saved is if the monitor is set to power-down and goes dark. With the LCD monitors we have now, a screensaver is not needed and should never be used because of the wasted energy.

Computers vary in the amount of energy watts they use, but a typical desktop personal computer (PC) with a 17-inch monitor requires about 165 watts per hour (130 watts for the computer and 35 watts for the monitor) (Dell 2006). If left on 24-hours a day, 7-days a week for one year, this computer will use 1,445,400 watt-hours. That is 165 watts × 24 hours × 365 days per year = 1,445,400 watt-hours or 1,445 kilowatt-hours. If it costs $0.049 per kilowatt-hour (kWh), we are paying $71 a year to run one computer (NES 2008).

TDOT has approximately 3,500 computers throughout all four Regions and at Headquarters in Nashville. The cost would be approximately $248,500 per year.

One option that can be used to conserve energy is the use of "hibernation" mode. This is designed to power off the computer after sitting idle for a certain number of hours. However, when the power is off updates cannot be installed.

The second option is for an update schedule to be implemented. Each TDOT region could designate a certain night of the week to leave all computers on for update installations. By reducing nighttime power uses of computers to only one night a week, a computer would use only 361 kilowatt-hours per year instead of using 1,445 kilowatt-hours annually. If the cost remains $0.049 per kWh, the same computer would only expend $18 a year in TDOT funds. When using this option, the savings will be $53 a year for one computer. If you multiply that by 3,500 the savings would be approximately $185,000. In light of the above, it is recommended that this is the safest and most economical of the two options and is the one TDOT should use.

Tankless Water Heaters: There are many state facilities throughout Tennessee. Each of those facilities, depending on their purpose, has at least one or two water heaters. These water heaters operate twenty-four hours a day seven days a week. The fact is most of those facilities are only occupied five days a week. All during this down time, water is continually being heated. Energy is being used to heat water that may not be used for days.

With tankless water heaters, energy is expended only when needed. The heaters take up less space and most often they can be installed closer to the faucets. This could possibly require less plumbing because the hot water line only runs from the water heater because it is closer to the faucet. Less water is wasted because the hot water is nearer to the faucet (assuming the heater is relocated).

While the initial cost may be more than that of a traditional water heater heating only the water needed saves more energy.

Solar Control Window Film: It is common knowledge that doors and windows are the two leading sources of energy loss in a building or home. Windows typically comprise 10 to 25% of an exterior wall area, and account for 25 to 50% of the heating and cooling needs, depending on the climate (EPA 2008b). Many technological improvements made in recent years that have advanced the insulating quality of windows including window and framing materials. Replacing outdated window units is often not a feasible option. The application of aftermarket window film is one cost-effective option used to increase energy efficiency of windows.

The practice of placing a plastic film on existing windows has been around since1966 when 3M patented and introduced its Scotchtint Film line. Window film today is now widely used in the automotive, residential, and commercial industry. Window films reduce the effects of solar rays to furnishings and excessive heat gain or loss; but also to change the architectural look, as well as increasing safety and security. The purpose of this strategy is to address only excessive building heat gain in the summer or loss in the winter.

There are many case studies where both private and government sector buildings are installing the film and realizing a significant cost savings. Obviously, the savings potential will vary depending on the existing amount (area) and type of glass, as well as whether it is single pane or double pane insulated.

Low-E film has the ability to reflect radiant heat. Low-E films block most solar heat gain while transmitting most visible light. Windows treated with Low-E film help in both the winter and summer, with little heat leakage coming inside on a hot summer day, or leaking outside in winter.

In Tennessee, we experience all four seasons with the effects of summer and winter affecting Tennesseans for the longest periods. The National Climatic Data Center reports heating and cooling degree-days for Tennessee averages about 4,000 and 1,300, respectively (NOAA 2008). Although there is more energy necessary for heating than cooling, both summer and winter seasons require a significant use of energy.

If you walked into a room with the film installed on the windows, you would hardly be able to notice it. The reduced glare will be your only hint; however, the reduction in your energy costs will be noticeable. Low-E properties work in reverse in the winter and keep heat indoors for year-round savings.

TDOT has facilities all over the state varying in architectural construction. The exterior construction of these facilities differ greatly, from glass facades of some regional offices, office towers of headquarters, log cabin Welcome Centers and permanent field office trailers, to name a few. Some of the existing facilities built within the last fifteen years may already have Low-E film or a factory installed coating. A survey of all TDOT owned facilities to determine which to retrofit is necessary.

We sought a cost-benefit analysis of an ideal existing building. The Field Offices building, a.k.a. Building C, at the Region 1 complex in Knoxville was selected as an ideal case study because of its relatively new architectural design/construction (built in 1995) with clear double-paned

insulated glass windows with blinds. Local Vista and 3M representatives independently interviewed and surveyed the Field Offices building; however, because the buildings in the complex are not metered separately for electricity use, it was not possible to calculate the energy savings. The Vista representative submitted a material and labor cost estimate of $6,700 to retrofit the east, south, and west facing building elevations. Nevertheless, both representatives did estimate a payback period of not less than five to six years for this particular building based on their local experiences.

Window film has an immediate energy cost savings, though the payback timetable for the capital investment can differ for a variety of reasons. The reason(s) would be independent to each building. Window blinds, when closed, do provide protection from heat gain or loss, but mostly provide UV protection. In a cost-benefit analysis, anticipated window blind use is considered. In construction where Low-E glass is installed, window blinds are often not installed because they offer little benefit. As mentioned above, a non-tangible benefit is the 'comfort' of the occupants working near a window.

A prudent approach may be to first survey existing TDOT facilities for a list of eligible buildings. Energy consultants are available and a possible resource to provide assistance to produce such a list. Once a list of facilities has been identified, a test site(s) can be selected for a cost-benefit analysis (Note: A prerequisite for a cost-benefit analysis requires each building site(s) be independently metered for its energy use). A window film type is selected; bid, installed, and then an annual follow up cost-benefit analysis for the actual savings would be made to determine just how soon there would be a payback. Decisions for further applications would be made based on the findings of the test site(s).

Benchmarking Energy Consumption

Since the early 1970s, a great deal of effort has been invested in institutional, commercial, and industrial facilities to reduce energy waste (Herzog 1997). Despite these efforts, a significant amount of energy is still wasted through inefficient operations.

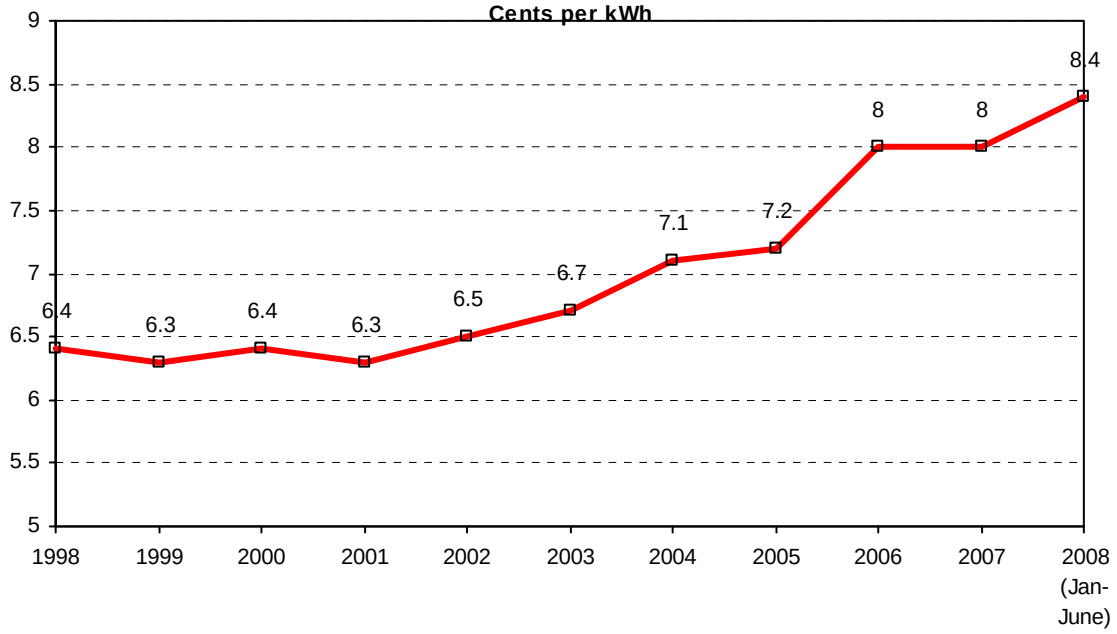
There are three fundamental components of a comprehensive process for conserving energy:

1) Efficient purchasing of energy products at the lowest available cost.
2) Efficient installation, maintenance and replacement of existing equipment with more energy efficient equipment when it is cost effective.
3) Efficient operation of equipment that consumes energy (Herzog 1997).

The most neglected of these is energy efficient operation of equipment. Fortunately, efficient operation of existing equipment requires a shift in thinking, but little capital. Many energy management programs are missing this component and thus they fail to achieve their full potential, even after investing funds and effort.

As indicated in Figure 4, energy costs are on the rise.

Figure 4: TVA
Commercial Price Trend



(EIA 2008a)

Because costs per unit of energy are on the rise and government budgets are getting tighter, it is imperative that TDOT and other state agencies maximize energy efficiency, as a part of sustainable financing efforts.

An energy consuming device is operated efficiently when it consumes only as much energy as is necessary to fulfill its intended function. This definition gives rise to important questions. First, is the energy-consuming device performing at its own optimal efficiency? Second, is the device's work necessary to achieve the desired result?

Office buildings are the single largest energy user in Tennessee's commercial sector and play a major role in efforts to increase energy efficiency. For example, in office buildings, the function of air handlers is to provide thermal comfort and ventilation for building occupants. An air handler is operating efficiently if it stays well tuned (i.e., no malfunctions causing unnecessary heating or cooling) and if it operates only when necessary to meet the needs of the occupants (i.e., no unnecessary night and weekend operation).

Tennessee state government does have a track record of successfully implementing energy management strategies for state office buildings. For example, the Andrew Jackson Building and the Rachel Jackson Building consumed 42% less energy after an efficiency retrofit project that was completed in 2004. As a result, the state now had $800,000 (in 2004) in annual energy savings with the project completion costs of $4 million (Governor's Task Force on Energy Policy 2008). If energy costs remained constant, this would result in a five year payback on the

initial investment. However, as energy costs continue to rise, the return on the initial investment accrues even more quickly.

The private sector has also recognized the value of energy efficient building management. Eastman Kodak, which is based in Tennessee, saved more than $8.6 million in operating costs in 2002 from its energy management efforts (Governor's Task Force on Energy Policy 2008).

Energy efficient building management combines an understanding of the technical systems of the building with common sense management procedures. Naturally, TDOT management will have a significant role in implementing this strategy and the first step in implementation would be to take the following actions.

1) Identify all people that have a roll in building operations and management.
2) Involve these individuals in establishing a protocol for efficient building management.
3) Establish a baseline and pattern of energy use through a monitoring program.
4) Apply the efficiency measures that are determined to be cost effective.
5) Continue the monitoring program and record the successes and short comings of the program.
6) Institute energy management accounting methods.
7) Designate an energy management team leader as the point of accountability.

The following principles should provide the framework for the policies and procedures for efficient building management.

1) Energy-efficient operation must be valued and those who implement successful efforts in this area should be recognized for their contribution.
2) Employees must be motivated to participate in the efforts.
3) Management must be willing to approach the program from a multi-functional perspective.
4) The cost savings must be included in the accounting process because a penny saved is equivalent to a penny earned and that value must be recognized.

Benchmarking establishes a baseline of data with which we can compare future data. Benchmarking is a mechanism that encourages building managers to improve building energy performance. The widespread use of benchmarking could lead to higher penetration of energy conservation and efficiency improvements.

Benchmarking supports energy conservation and efficiency programs in the following ways.

1) Benchmarking improves building managers' awareness of building performance:
   a. Identifies poorly performing buildings
   b. Provides baseline for measuring improvement in performance for all buildings
   c. Creates competition through comparison with like buildings
   d. Provides longitudinal trending in building performance
   e. Provides justification for building and equipment upgrades that could be paid through savings on future energy bills.

2) Delivering benchmarking is an important customer service and encourages participation in utility energy efficiency programs:
   a. Supports state and industry initiatives such as the Governor's Executive Order.
   b. Educates those who lack the knowledge and resources to meet their benchmark.
   c. Provides energy managers with an opportunity to report benchmarking results to employees and discuss energy efficiency opportunities.

3) An automated benchmarking system provides a platform for delivering building energy metrics to all employees.
   a. Building performance information could be made available to a large number of employees on a monthly basis with minimal effort.
   b. Other important metrics such as peak demand, water usage and carbon dioxide emissions could be added to benchmarking reports in the future.

Perhaps one of the best-known and most technically robust building energy benchmarking tools is the U.S. Environment Protection Agency (EPA) Energy Star Benchmarking Tool. This tool is unique and valuable initial screening tool available for building energy use analysis. The tool includes features to analyze building climate, building schedules, and building occupancy, as well as personal computers, ventilated garages, air-conditioning units, computer centers, and kitchen equipment.

The Energy Star assessment provides a user with a clear evaluation methodology, hopefully encouraging building owners to perform retrofits or improve operation to ensure that a building reaches an efficient target through the following three step process.

1) Determine annual use of each fuel by summing monthly utility bills.
2) Determine total annual energy use of all fuels and energy use intensity (EUI) of the building.
3) Using building EUI, comparing with similar buildings or more efficient than this building.

Portable data loggers are diagnostic monitoring tools for energy efficient building operation. These are used on short notice and on a temporary basis to measure the building energy efficiency program.

The loggers and the associated software are user friendly and ideal for the gathering and subsequent presentation of energy environmental data. They are reliable products for measuring energy consumption. They are also used to measure temperature, humidity, voltage, and contact closures to determine the energy efficiency and comfort levels in occupied buildings.

In addition to portable data loggers, energy metering and sub-metering systems are powerful tools. Metering is a valuable tool for improving management of electrical energy, and for improving efficiency. There are many reasons why facilities should incorporate sub-metering into their energy management strategies. These include the ability to verify the accuracy of utility bills, the ability to allocate energy costs to specific organizations (providing motivation to do better), and more accurate troubleshooting of electrical system problems, among others.

The first step in improving energy efficiency is to understand of where, how, and how much energy is used. Accurate information is the foundation of effective management. Moreover, it is important to understand how much energy is consumed at the individual building-level, at the campus-level, and at the agency-level (i.e., TDOT).

Once energy use is benchmarked and energy use patterns are tracked then TDOT will be in a position to implement efficient energy management strategies. The following outline illustrates the variety of opportunities that TDOT has to implement efficient energy management strategies throughout the department.

1) Building Envelope
    a. Reduce heat conduction through ceilings and roofs
    b. Reduce solar heat gain through roofs
    c. Reduce heat conduction through walls
    d. Reduce heat conduction through floors
    e. Control solar heat gain through glazing areas
    f. Reduce infiltration

2) HVAC Systems Ventilation
    a. Improve chiller efficiency
    b. Improve AC or heat pump efficiency
    c. Reduce energy used for tempering
    d. Use energy-efficient cooling systems

3) HVAC Distribution Systems Energy Loss
    a. Reduce system flow rates
    b. Reduce system resistance

4) Water Heating Systems
    a. Reduce hot water loads
    b. Reduce hot water heating system losses
    c. Use energy-efficient water heating systems

5) Lighting
    a. Reduce illumination requirements
    b. Install energy-efficient lighting systems
    c. Use day lighting

6) Energy Load Management Systems
    a. Reduce peak power demand
    b. Install energy-efficient motors

7) Energy Management Control Systems and Metering

8) Information Technology Systems
   a. Energy Star compliant equipment inventory
   b. Centralized PC power management strategy

9) Data center/server operations assessment

10) Water Conservation
   a. Public information and education programs
   b. Distribution system audits, leak detection repair
   c. Water efficient landscape
   d. Toilets and urinals
   e. Faucets and showerheads
   f. Single-pass cooling systems
   g. Miscellaneous high water-using processes
   h. Water reuse and recycling

11) New Energy Savings Technology Applications
   a. Solar power
   b. Wind power

We recommend that TDOT establish an energy management team to develop an implement plan for energy conservation strategies in TDOT buildings and leased facilities. More detail on green building strategies can be found in Appendix A of this report. Appendix A also includes a table outlining an implementation plan for energy management in TDOT facilities.

GREEN FLEET MANAGEMENT

$ to $$$

Introduction

On September 26, 2008, Commissioner Nicely, in his weekly "Friday e-mail" address, explained the importance of fleet management and fuel conservation. According to Commissioner Nicely, "TDOT's fuel costs during the month of July 2008 were $1.25 million dollars. TDOT's on-road and off-road vehicles consumed over 145,000 gallons of gasoline and 170,242 gallons of diesel.

"By 2010, state agencies with large fleets like TDOT are mandated to reduce the use of petroleum by 20%, by displacing some of the petroleum usage with cleaner, renewable fuels. With over 3,000 on-road vehicles, TDOT is already working to reduce the use of petroleum and increase the use of biofuels. During July 2008 TDOT used 656 gallons of E-85 and 18,431 gallons of biodiesel, which helps to offset our petroleum consumption. However, as stewards of public funds, we must all help reduce TDOT's consumption."

Current Practices

Currently, Public Chapter 489 requires all state agencies, universities, and community colleges to reduce or displace motor vehicle fleet use of petroleum products by 20 percent by January 1, 2010 (T.C.A. Section 4-22-101, *et seq.*). Building on this initiative, Tennessee agencies could maximize the use of non-petroleum, renewable fuel, or other low emission fuels for state fleets, by planning and setting higher goals (Pechan, et al. 2008).

For example, in New York's 2003 *Recommendation for Reducing New York State Greenhouse Gas Emissions* (CCAP 2003), one of the recommendations was to expand the use of biodiesel in New York by starting with state fleets. At the time, biodiesel was already available at service stations in New York, and the New York State Energy Research and Development Authority had a number of pilot projects for both light- and heavy-duty fleet vehicles. The biodiesel recommendation expanded on the pilot projects by calling for a contract for enough additional B20 to supply the entire state fleet of diesel vehicles. It also recommended using biodiesel in marine ferries, as well as in all passenger marine vessels and freight vessels. It called for New York to develop biodiesel infrastructure and storage facilities as a pilot project. Other actions recommended include: funding pilot programs for B20 use in high-mileage local government and private-sector fleets such as school buses, garbage trucks, and delivery vehicles; and create similar pilot programs for using B20 in mail delivery trucks and transit buses (Pechan, et al. 2008).

In 2005, Governor George E. Pataki of New York State issued an Executive Order requiring all state agencies and public authorities to increase their purchase and use of biofuels for heating their facilities and fueling their vehicles. This biofuels initiative also would increase the production of biofuels in the state (N.Y. Exec Order No. 142 (November 21, 2005)).

On June 18, 2008, New York Governor David A. Paterson, continued Executive Order 142, directing state agencies, and authorities to diversify fuel and heating oil supplies through the use of biofuels in state vehicles and buildings (___ N.Y. Reg ___ (June 18, 2008) (Exec. Order No. 9)).

A Michigan stakeholder group is considering an advanced vehicle technology mitigation option. Their preliminary plan is to create a market for plug-in electric hybrid vehicles (PHEVs) with modern high energy density battery technology and to encourage PHEV applications to public transportation sectors, with a goal of obtaining 5 percent total market penetration of new vehicle sales by 2025. They want to use this PHEV market to encourage Michigan-based battery research and development. The option also would make available loans and subsidies to municipalities, local governments, waste management organizations, etc., to encourage more rapid adoption of hybrid vehicles by fleets offering public services (transit agencies, schools, and refuse companies) with a goal of achieving a 15 percent increase in hybrid use by 2020 in this sector. Michigan is also considering providing funding through tax incentives for the research and development of freight vehicle efficiency improvements (CCS 2008).

Public Chapter 489 (T.C.A. Section 4-22-101, *et seq.*) passed by the Tennessee General Assembly and signed by Governor Bredesen in June 2007, requires all state agencies, public universities and community colleges with state-owned fleets consisting of more than ten vehicles to increase the use of alternative fuels, synthetic lubricants, and fuel-efficient, low-emission vehicles. Public Chapter 489 requires that by January 1, 2010, each agency to reduce and/or displace at least 20 percent of the petroleum products consumed compared to a 2006 baseline. Agency plans were to be implemented by January 1, 2008, and starting in 2008 each agency was to submit an annual analysis of the plan.

TDOT's Environmental Policy Office developed the Department's compliance strategy and the first analysis of its implementation was submitted to the Comptroller.

Table 5: TDOT Petroleum Consumption Baseline Data

Calendar Year 2006	
	Gallons / year
Diesel	1,618,690
Gasoline	1,646,029
Motor Oil	5,149
Total	3,269,868
Reduction Goal (20% of 2006 Total)	**653,977**

TDOT expects to achieve most of its required petroleum reduction/displacement through the use of biofuels (B20 and E85). Other actions that will provide small incremental reductions include the use of synthetic oils or lubricants and the purchase of hybrid-electric or fuel-efficient vehicles through the Department's vehicle replacement program. Additionally, the strategy calls for the development and implementation of an aggressive and universal anti-idling policy to eliminate all unnecessary idling by TDOT vehicles. The details of TDOT's Petroleum Reduction/Displacement Plan can be reviewed by contacting TDOT's Environmental Policy Office.

Benefits & Costs

Petroleum Reduction/Displacement Plan

Table 6 lists 2006 fuel consumption numbers by major program area and the projected number of gallons that each program area will strive to reduce. Fuel reductions/displacement will contribute to an overall TDOT reduction goal of 20% from the 2006 baseline consumption of petroleum. Other agency-wide actions being implemented will also provide small incremental reductions that will contribute to the overall reduction goal, including the use of synthetic oils or lubricants in gasoline vehicles, conserving fuel through idle reduction and conservation practices, and purchasing more fuel-efficient vehicles.

Table 6: TDOT On-road Vehicle Petroleum Consumption in 2006 by Program Area

Division	Unleaded	20% Reduction	Jan 2010 Budget	Diesel	20% Reduction	Jan 2010 Budget	E85	B20	Total Fuel	%
Commissioner	4,047.4	809.5	3,238.0	0.0	0.0	0.0	0.0	0.0	4,047.4	0.12%
Administration	34,971.0	7,194.2	28,776.8	253.5	50.7	202.8	650.3	0.0	36,874.8	1.10%
Engineering	44,781.6	8,956.3	35,825.3	6,578.3	1,315.7	5,262.6	0.0	0.0	51,359.9	1.53%
Environment	51,037.0	10,207.4	40,829.6	0.0	0.0	0.0	33.0	0.0	51,070.0	1.52%
Field Engineering	446,964.6	89,392.9	357,571.6	73,296.3	14,659.3	58,637.0	140.1	2,627.9	523,028.8	15.61%
Construction	617,558.6	123,511.7	494,046.9	0.0	0.0	0.0	0.0	0.0	617,558.6	18.44%
Maintenance	365,031.9	73,006.4	292,025.5	1,505,519.0	301,103.8	1,204,415.2	0.0	79,495.5	1,950,046.4	58.22%
Garage	80,636.7	16,127.3	64,509.4	33,042.9	6,608.6	26,434.4	0.0	2,037.9	115,717.5	3.45%
Total	**1,646,028.8**	**329,205.8**	**1,316,823.0**	**1,618,690.0**	**323,738.0**	**1,294,952.0**	**823.4**	**84,161.3**	**3,349,703.5**	**100.0%**

Other Initiatives

The U.S. EPA's SmartWay program promotes vehicle upgrade kits. A variety of fuel- and emissions-saving technologies, typically consisting of engine idle reduction technology, LRR tires, improved aerodynamics, and exhaust after-treatment devices. In tests, these kits can reduce fuel consumption by 10 percent to 15 percent, saving more than $8,000 in fuel costs annually. They also reduce pollution: CO_2 and NO_x emissions are cut 10 percent to15 percent, and when a kit includes an exhaust after-treatment device, particulate matter (PM) emissions are reduced by 25 percent to 90 percent (NC CAPAG 2008).

Recommendations

Vehicle Purchasing Policy

The EPA SmartWay program is a voluntary partnership between various freight industry sectors and EPA that establishes incentives for fuel efficiency improvements and mobile source emissions reductions (EPA 2007a). The program has three primary components: creating partnerships, reducing all unnecessary engine idling, and increasing the efficiency and use of rail and intermodal operations

TDOT is an affiliate member of EPA's SmartWay Transport Partnership. TDOT should enact vehicle procurement policies and utilize the SmartWay Upgrade kits that would result in lower-emitting vehicle fleets (Pechan, et al. 2008).

We recommend that when TDOT purchases new vehicles for our fleet that we should consider life-cycle costs and environmental benefits when making purchase decisions and not just initial purchase cost. Fuel use, emissions, maintenance costs and durability are all important factors to consider.

This option would build on Tennessee's existing Energy-Efficient Vehicle Acquisition Requirement, in which state fleets are encouraged to meet the goal of at least 30 percent of newly purchased motor vehicles be energy-efficient (DOE 2007). Tennessee state agencies that have already incorporated low-emitting vehicles in their fleets include the Department of General Services and the Department of Transportation (BioTenn 2006).

Advanced Vehicle Technology

TDOT could lead a Tennessee state government initiative creating a policy that seeks to expand the development and use of more efficient vehicle design and/or hybrid propulsion systems. This might expand a market for series plug-in electric hybrid vehicles (PHEVs) with modern lithium-ion battery technology, which is due out in 2010, and encourage similar applications to other transportation sectors, such as public transportation, delivery, public services, etc. (Pechan, et al. 2008).

Vehicle Maintenance

We recommend faithful and proactive vehicle maintenance of the TDOT fleet. Proper vehicle maintenance is an important part of any energy conservation program. According to the Weather Channel, if all U.S. cars had proper tire pressure it would save 100 million barrels of oil each year. Correctly aligned tires also contribute to fuel economy. (Weather Channel 2008). With a fleet size of over 3,000 on-road vehicles, small efforts such as maintaining proper tire pressure can have a big impact for virtually no cost.

Keeping an engine properly tuned can save you up to 165 gallons of gas per year. Checking spark plugs, oxygen sensors, air filters, hoses and belts are a few examples of maintenance that can result in potential savings of over $400 annually (EIA 2007).

Thicker than required, engine oil will reduce your gas mileage, because it takes more energy to push through thick oil than it does through thinner oil (Weather Channel 2008). TDOT should review the owner's manual of each vehicle and make certain that the recommended viscosity is used.

Little Effort – Big Results

We recommend incorporating a "Green Driving" component into the Environmental Awareness initiative described earlier in this report. Other small changes of our mindset can produce positive results for the environment and the bottom-line. For example, carrying around an extra 100 pounds in the car reduces fuel economy by up to two percent. Employees should take only what they need and be sure to place luggage inside instead of in the trunk or on the roof to minimize drag and maximize your mileage (Weather Channel 2008).

Aggressive driving wastes fuel, not to mention increases stress and accidents. Rapid acceleration and braking reduces gas mileage and can burn an extra 125 gallons of gas per year (Weather Channel 2008).

In highway travel, exceeding the speed limit by a mere five mph results in an average fuel economy loss of six percent. And idling can be just as wasteful as speeding. Idling for more than 10 seconds uses more gas and emits more pollution than restarting the car (Weather Channel 2008).

There are also simple seasonal considerations that can make driving more efficient. The best way to warm up a car in winter months is to drive it. When the temperature is below freezing, give it 30 seconds to warm-up and then drive it smoothly. In the summer, air conditioning can decrease your fuel efficiency by as much as 12 percent in stop-and-go traffic, so consider cracking the windows. At high speeds, driving with the windows open can decrease the overall efficiency of the vehicle. At higher speeds, employees can use the vents to get a good air flow and on the hottest days we should still keep the air conditioner on low (Weather Channel 2008).

Alternative Fuels

Tennessee should continue to promote an increase the market penetration of biofuels in the state – offsetting fossil fuel use with the production of soybeans and corn to produce biodiesel and ethanol fuels. Replacing gasoline with ethanol can reduce some emissions. Using biodiesel instead of conventional diesel reduces also reduces some emissions (Pechan, et al. 2008).

Tennessee already has an Alternative Fuels Working Group in place, which was charged with developing a state alternative fuels strategy. Tennessee state agencies have been involved in promoting and using alternative fuels. For example, TDOT is working to assist retail station owners with infrastructure to dispense E85 and B20 through the Biofuel Green Island Corridor Grant project (BioTenn 2006). TDOT has awarded 190 grants to retail fuel stations, totaling more than $485,792. In addition, Governor Bredesen has made $1.5 million available to establish refueling sites no more than 100 miles apart along highways and major highway corridors (TDOT 2008b).

In addition, the University of Tennessee is also collaborating with the Oak Ridge National Laboratory on the Biofuels Initiative, which is a state sponsored plan to decrease Tennessee's dependency on foreign oil, while simultaneously increasing rural economic development and domestic energy production within Tennessee (UT 2008). Plans include constructing a pilot bio-refinery to demonstrate and refine biofuels production technology (Pechan, et al. 2008).

Since Tennessee already has initiatives to switch to alternative fuels, any new initiatives should focus on increased market penetration of these alternatives. For example, North Carolina's biofuels strategy seeks to replace 25 percent of gasoline and 20 percent of diesel with biofuels by year 2025. They plan on accomplishing these goals through a mixture of renewable fuel standards, financial incentives, outreach, and market-based mechanism (NC CAPAG 2008).

Truck Safety Lighting

Most of the Department of Transportation work trucks that have safety lights on them use halogen rotating warning lights. These lights pull 20 amps of power (Public Safety Equipment, Inc. 2008). When a crew is working in an area where warning lights are needed, the driver must leave the truck idle, else the battery goes dead. During a trip from Nashville to Cookeville, a state truck used three gallons of gas with the engine turning 2100 rotations per minute (rpm). When idling, that same truck turns 700 rotations per minute (rpm). Therefore, a truck left idle for one hour will use one gallon of gas. The amount of CO_2 produced for this hour is 9.0 kg.

There are two ways to avoid this. One suggestion is to operate the safety lights without idling the engine. The driver should go to the truck every two or three hours and run the engine to charge the battery. The other option is to use safety lights made with Light Emitting Diodes (LED). These lights use only 0.3 amps of power and will not drain the truck battery during a day of work (Whelen 2008).

Given these options, it is recommended that the halogen lights that are currently used should be replaced with LED lighting. The cost savings in the long run will outweigh the initial cost of converting the lights. Any new vehicle should only have LED lights installed.

Petroleum Reduction/Displacement Plan

In order for TDOT to achieve the 20% reduction goal, it will be necessary to have the cooperation of staff at all levels across the state. TDOT headquarters and the region offices should designate a "champion" from each major program area to promote and track compliance with the Petroleum Reduction/Displacement Plan in their respective area. These champions should provide feedback and make recommendations for further reducing TDOT's petroleum consumption.

REDUCED MOWING VIA LANDSCAPE DESIGN

$$ to $$$

Introduction

Sustainable Landscaping is the process of planting native species along roadways that reduce or prevent pollution, conserve natural resources, require less maintenance, and increase the aesthetic value of the area by providing a sense of place for local residents and the traveling public (King County Solid Waste Division 2007).

Initiatives in Sustainable Landscaping

Native Vegetation: The use of plants that are indigenous to the region allows for the greatest likelihood of subsistence with the least amount of maintenance required. Because the plants are local, they easily adapt to the soil and climate. The use of native vegetation also provides travelers with a sense of place and adds aesthetic appeal to the region. Unlike non-native, ornamental plans, native plants are also less likely to harm other native plants in the area adjacent to the roadway if the plants multiply. Just as the use of native vegetation benefits local plant life, it also sustains the local wildlife by providing indigenous animals with plants typically found in their diet and provides them with a known type of shelter (Welker and Green 2008).

Naturalized Mowing: A more economically friendly policy could include a naturalized mowing policy. This area could be as small as the clear zone, which is determined by the highway characteristics, or it could be a set distance from the road itself. For the purposes of this report, we will use 30 feet as a guideline. This would provide plenty of distance from the highway so as not to interfere with sight distance or vehicle recovery in any instance. This area would still be mowed at a frequency of 4 times per year. The remainder of the right-of-way would be allowed to naturalize, or grow to full height. It would be mowed once per season in order to keep trees from getting to a size that they would require further maintenance.

Federal Guidelines

In 1995, the Office of the Federal Environmental Executive issued guidance on "Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds." The guidance also applied to federally-funded projects that have landscaping components. As many of TDOT's projects are federally funded, this guidance would apply (Office of the Federal Environmental Executive; Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds, 60 Fed. Reg. 40,837 (August 10, 1995)).

Essentially, the federal guidance "is intended to promote principles of 'sustainable landscape design and management' which recognizes the interconnection of natural resources, human resources, site design, building design, energy management, water supply, waste prevention, and facility maintenance and operation" (Id.). The guidance dealt primarily with five issues that could help implement sustainable landscaping practices. These issues were not meant to be comprehensive and agencies were encouraged to build upon them to create sustainable landscaping practices that fit their area. The five principles discussed in the federal register were:

1) Use Regionally Native Plants for Landscaping: Regionally native plants provide people with a specific sense of place as well as require less maintenance which would reduce the cost of mowing, pesticides, and watering. Agencies should take care in selection of plants that meet the biological needs of the area, require minimal care, use less water, and need less fertilizer or pesticide.
2) Design, Use or Promote Construction Practices that Minimize Adverse Effects to the Natural Habitat: this provides for an overall planning, engineering, and construction approach with the natural habitat of the area in mind.
3) Seek to Prevent Pollution: Sustainable landscaping would reduce the need for pesticides and fertilizers by using native vegetation that can withstand the area's climate. When pesticides are necessary, the agency will use "chemical management practices which reduce or eliminate pollution associated with the use of chemical fertilizers and pesticides."
4) Implement Water and Energy Efficient Practices: the guidance recommended reduced irrigation and the use of recycled or reclaimed water. By taking these steps the energy needed to pump water and the water resources could be spared. The agency should also consider the existing vegetation and topography of the project area.
5) Create Outdoor Demonstration Projects: these are meant to promote public awareness about environmentally sensitive areas (Federal Environmental Executive Guidance 1995; and EPA 2008c).

Sustainable Landscape Practices in Other States

Arkansas: In 2003, Arkansas Department of Transportation began an initiative to break the mowing schedule based on high maintenance zones and transition zones. On roads with a wide right-of-way, a natural zone was created that would never be mowed in order to better accommodate wildlife (Moore 2003).

Kansas: The Kansas Department of Transportation (KDOT) in cooperation with the Kansas Department of Wildlife and Parks, Kansas Department of Agriculture, and the Audubon Society of Kansas created an initiative to save and restore the prairies of the state. KDOT begins with the roadside landscape by introducing two seed mixes into their plantings rather than one. The first seed mix is for standard grasses on the shoulders of the road. The second seed mix is used on the natural areas beyond the shoulders. This mix consists of native species that reduce the need for mowing while enhancing the landscape with colorful wildflowers. With the two new seed mixes, KDOT only mows areas with native plants once every 2 to 3 years. This allows for a natural wildlife habitat to build up and saves time and fuel for the department (Shields n.d.).

Nebraska: Nebraska has maintained a policy of planting native grasses since the 1960s. However, a more recent initiative introduced two types of seed mixes. The area within fifteen feet of the pavement is planted with shorter grasses that NDOT keeps mowed to five inches in height. The secondary area contains taller native grasses and wild flowers. Nebraska has a mowing policy for the secondary area that consists of mowing three times per year for two years to control the growth of weeds. Once the plantings reach maturity, the area is mowed once every five years and the mowing is staggered so only one side of the road is mowed each year in order to maintain the wildlife habitat in the area (Thompson 2000).

Texas: Texas Department of Transportation has implemented a policy of strip mowing which allows native grasses and wildflowers to emerge. Additionally, TXDOT has issued a directive to mow around all blooming wildflowers (Hughes 1998).

Current Practices

The following information indicates TDOT's mowing and landscaping schedules based on information from 2005.

July 2005:		
Length of Roadways:	State Routes:	13,077 miles
	Interstates:	1,073 miles
Mowing Schedule:	State Routes	3 times per year
	Rural Interstates	4 times per year
	Urban Interstates	6 times per year
	Inner loop of Nashville	1 time per week
Cost of mowing:	$36.00 per acre	(Houston 2008)

TDOT is currently assessing pilot programs in Region 2 and Region 3 that would reduce mowing in the right-of-way (Doran 2008). Additionally, TDOT has hired a landscape design firm to create a landscaping policy that could possibly be adopted by the Department. This policy would dovetail with TDOT's current mowing policy that takes air quality into consideration during the peak mowing season.

Projects Currently Underway

Region 2 (Chattanooga Area) Pilot Project: Chemicals are being applied to sections of the right-of-way that would eliminate weeds and suppress the growth of grasses. TDOT has reduced the number of times this section is being mowed. According to early reports, the number of required mowing events has been reduced. However, this project is still in the very early stages and more time will need to elapse before TDOT can learn the full success of this project.

Region 3 (Nashville Area) Pilot Project: TDOT has used wet blade technology that applies the chemicals directly to the plant in order to reduce the risk of chemical mishaps. Results similar to Region 2 have been indicated.

Landscape Design Manual: In 2005, TDOT hired a landscape consulting firm to study the need for a comprehensive landscape program that can be used throughout the state. The consultant began with an on-line survey of community leaders throughout the state, asking them about the benefits of a more uniform landscaping program. The majority of the respondents stated that they would boost community pride, increase economic development, improve resident's quality of life, and increase tourism. Public meetings were held throughout the state and participants stated the same things (Lose 2008).

The draft Landscape Design Manual was submitted for review by TDOT officials in July 2008. The manual is meant to provide "a new process for designing and maintaining roadway environments with respect to the roadway character, the surrounding landscape, cost variables, maintenance resources, safety and time" (Lose 2008).

Tennessee Wildflower Program: The Tennessee Wildflower Program has been one of the most beloved programs implemented by TDOT in recent years. The program plants wildflowers along roadways throughout the state and are often dedicated to our nation's veterans. Begun in 1998, the program is paid for primarily through the federally funded Transportation Enhancement Program. The federal government pays eighty percent of the cost and the state pays the remaining twenty percent (TDOT 2003).

In 2003, Commissioner Gerald Nicely announced changes to the Wildflower Program that benefited both the environment and state taxpayers. TDOT would no longer use methyl bromide to treat wildflowers because the federal government had mandated that this expensive chemical would no longer be used by 2005. However, TDOT chose to phase out the use of the chemical prior to the 2005 deadline. After the removal of the chemical, TDOT can plant over 800 acres of wildflowers for a total cost of $28,000 in state funding (TDOT 2003).

Mowing Policy and Air Quality: TDOT has a policy where the mowing contractor suspends all mowing in the non-attainment counties on days when the ozone rate and $PM_{2.5}$ rate are in the Orange Level leading to an Air Quality Action or Alert day. Mowing will not begin again until the air quality falls below the Orange Level.

Table 7: The Non-Attainment Counties where mowing is currently suspended on Air Quality Action or Alert Days

Ozone	**$PM_{2.5}$**
Memphis—Shelby County	
Clarksville—Montgomery County	
Nashville—Davidson, Rutherford, Sumner, Wilson and Williamson	
Chattanooga—Hamilton and Meigs	Hamilton
Knoxville—Anderson, Blount, Jefferson, Knox, Loudon, and Sevier	Anderson, Blount, Knox, Loudon, and Roane
Great Smoky Mountains—Blount, Cocke, and Sevier	
Tri-Cities—Hawkins and Sullivan	

Benefits & Costs

Naturalized Mowing in the Right-of-Way: As of 2005, TDOT spent $36 per acre toward keeping the right-of-way mowed along state routes. The current policy is to mow all of the land that is accessible for the mowers (Houston 2008). If the Department adopted a more naturalized landscaping approach for projects that fit within the previously discussed framework, there is an opportunity to save money on mowing costs throughout the year. Although these savings would vary by project, the following charts and information illustrate potential savings for a typical project on a state route in Middle Tennessee.

As an example, we will use the contract for SR-386 in Sumner County. This is a fairly typical section of road for TDOT where some sections of right-of-way are very wide. There are some places where we currently mow over cut sections that are well out of sight of motorists. The following charts demonstrate the monetary savings on this project alone.

Table 8: TDOT's Current Mowing Practices on State Route 386

County	**Route**	**Location**	**Miles**	**Acres**	**Mowing Events**	**Total Acres**
Sumner	SR-386	Davidson line to SR-6	13.52	335.12	4	1340.48

Table 9: Reduced Mowing Proposal

County	**Route**	**Location**	**Miles**	**Acres**	**Mowing Events**	**Total Acres**
Sumner	SR-386	Davidson line to SR-6	13.52	49.16	4	196.64
				285.96	1	285.96
Total						482.60

Following this proposed method of mowing would save (482.60 ÷ 1340.48) × 100 = 36% of mowing costs. If considered on a case-by-case basis, TDOT could save significant money, energy, and time by reducing the amount and frequency of right-of-way mowing.

The monetary savings would be (Mowing Area × Mowing Events × $36 per acre) = Total cost per acre. Following this proposed method of mowing would save 482.60/1340.48 x 100 = 36% of mowing costs. The cost savings of reducing the amount of right-of-way being mowed on a yearly basis for one 13.52 mile stretch of roadway would total approximately $30,883.

Furthermore, less time spent on mowers means less chance of accidents and an increase in safety. Though the savings amount will vary from project to project, it can easily be seen from this one project that a large monetary savings can be made with this proposal.

There is a possibility that some motorists will not like the appearance of the naturalized area more than 30' from the roadway. It may not appear as "neat" to them so TDOT may field some complaints about this. However, the monetary savings and the increased safety are well worth this small negative factor.

Recommendations

Landscape Design Manual: TDOT is currently making significant strides in better design of the landscapes found along Tennessee's roadways. The draft Landscape Design Manual illustrates excellent ways to utilize sustainable landscaping while at the same time balancing the needs and desires of local stakeholders. TDOT should continue to actively pursue efforts to reduce mowing cycles along with the study and development of pilot projects, like the ones already underway, to further the department's efforts to provide a sustainable landscape for Tennessee.

Naturalized Mowing in the Right-of-Way: TDOT should further investigate reducing the amount of right-of-way being mowed in order to maximize the use of public funds. In addition, TDOT should begin a public awareness campaign to educate the public regarding naturalized right-of-way and reduced mowing. Although some motorists may dislike the natural look of the right-of-way, by providing them with the reasons behind reduced mowing, they can better understand TDOT's efforts to save energy while at the same time helping the environment.

ENVIRONMENTAL PROTECTION STRATEGIES

TRAVEL DEMAND MANAGEMENT

$$ to $$$$

Introduction

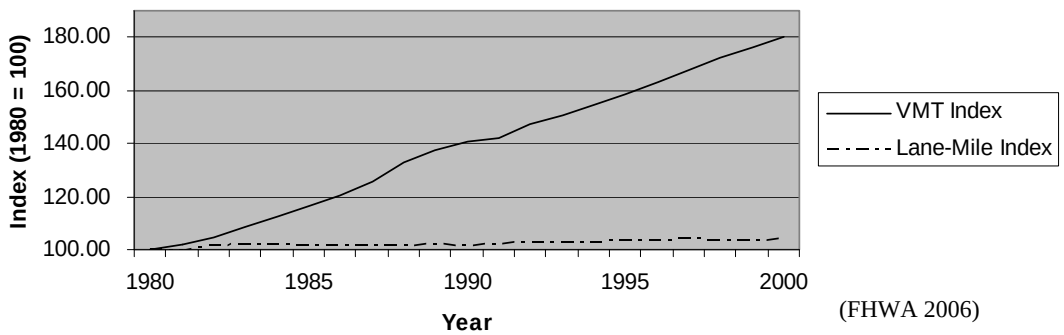
TDOT's mission is to plan, implement, maintain and manage an integrated transportation system for the movement of people and products, with emphasis on quality, safety, efficiency and the environment. According to TDOT Commissioner Gerald Nicely, "TDOT is committed to practicing four basic values as we serve the citizens of Tennessee: 1) communication, 2) accountability, 3) consistency and 4) integrity." To do any less, would not be sustainable because the citizens of Tennessee expect, deserve, and demand a transportation system that meets the mobility needs of today, while being protective of resources (financial and environmental) in a manner such that we can confidently meet the needs of tomorrow. Therefore we must address the significant costs associated with traffic congestion and managing our transportation network.

Consider the following information from the Texas Transportation Institute's 2007 Urban Mobility Report, based on 2005 national data:

- Drivers, in 85 urban areas studied around the U.S., experienced 4.2 billion hours of delay annually.
- This delay, in the 85 urban areas, wasted 2.9 billion gallons of fuel.
- The cost in wasted time and fuel was $78 billion per year (Schrank 2007).

Similar costs in time, fuel and money are typical throughout the United States (Schrank 2007). Yet, we cannot simply build our way out of the congestion problem. The following 2006 FHWA figure illustrates the problem. As demonstrated by the historical growth in vehicle miles traveled (VMT) compared to the flat growth in lane-miles, we must focus our efforts on managing travel demand.

Figure 5: **Change in VMT and Lane-Miles**

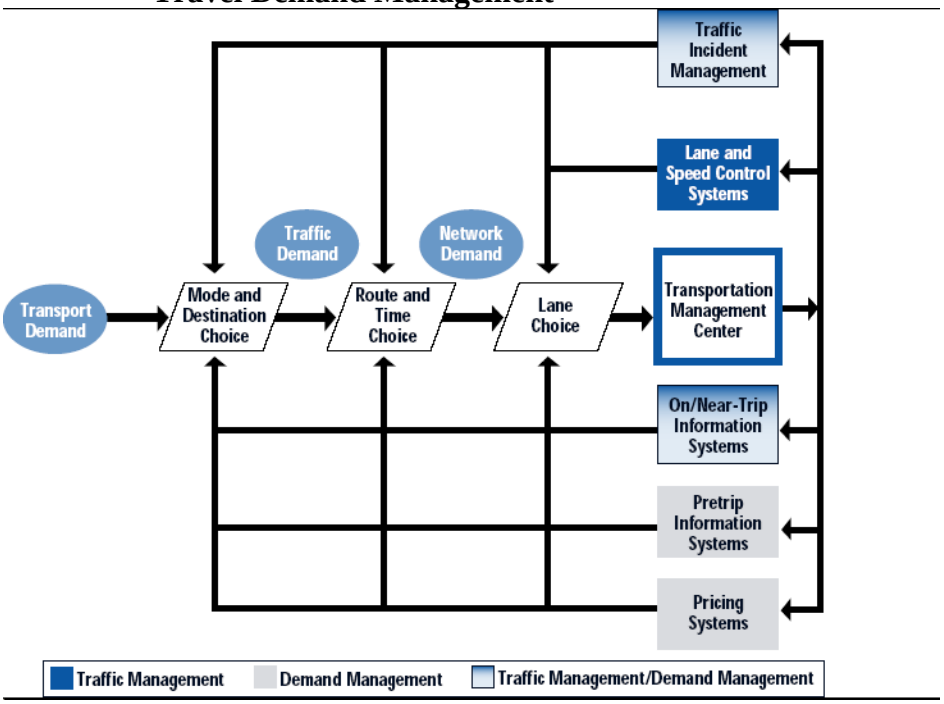


(FHWA 2006)

In the broadest sense, travel demand management (TDM) can be defined as providing travelers with dynamic, timely information on routes and road conditions, while also providing viable, convenient alternatives (e.g., rail, bus, car/van-pool, bike, compressed work week, telecommute and Internet access options, etc.) to conventional single-occupancy vehicle trips to improve travel efficiency and in some cases reduce the need to travel. Managing travel demand is about providing travelers with choices, such as work location, route, time of travel and mode of travel.

However, before we attempt to manage travel demand, we must consider the distinction between traffic management and travel demand management. As illustrated in the following conceptual diagram that FHWA adapted from a Dutch model, traffic management is managing vehicles that are on the road; whereas, travel demand management is managing people before they decide to put a vehicle on the road by offering viable alternatives to a conventional trip. And some of these areas, like information systems, overlap to cover aspects of both traffic demand management and travel demand management.

Figure 6: Diagram of Traffic Demand Management and Travel Demand Management



(FHWA 2006)

Ultimately, the goal of our transportation network must be to facilitate public access to the destinations, resources, and information they are seeking. The desire for access is the driving force behind travel demand.

In some cases, access can be provided through means other than physical mobility. For example, if the public is seeking access to information then they could potentially obtain this through technology, like the Internet, without generating a physical trip on the transportation network. When physical access to a site is needed then the objective is to facilitate the movement of people and goods, not the movement of automobiles per se.

In many cases, public transit is a viable option. Yet, we assume that people generally value the freedom and independence that are available through using a personal vehicle. Therefore, a transit option must be integrated into a larger travel demand reduction strategy.

For example, we should consider a mixture of automobile access control, special facilities (e.g., rail and bus rapid transit stations), and special lanes (e.g., bike lanes, HOV and HOT lanes, etc.), and improved transit facilities, in addition to market-based, travel pricing strategies (e.g., congestion fees and tax credits) and land use strategies to promote transit oriented density (TOD).

In addition to costs associated with traffic congestion, there are many challenges that face TDOT. These challenges include budget constraints and environmental protection. Fortunately, sustainable transportation strategies are often "green on both sides of the issue." Sustainable transportation strategies, as demonstrated in this report, are usually green for the bottom line and green for the environment. Even though not every sustainable transportation strategy saves money, many do. And in most cases, we hope to create a synergy between financial savings and environmental protection through improved energy efficiency to achieve objectives in both areas.

Even though integrating efficiencies into the transportation system does save energy and therefore money, it can result in an overall negative impact to TDOT's budget because much of our funding is based on fuel taxes. Thus, strategies that seek to reduce VMT, to promote fuel efficiency and to provide alternative fuels as a means to reduced mobile sources emissions and reduce our dependence on foreign oil imports can also result in less revenue for TDOT under the current funding structure.

Additionally, there are concerns beyond budgetary constraints such as water resource protection and land conservation issues associated with transportation projects, in addition to regional and local air pollution prevention and even global climate change. These issues all present challenges that must be simultaneously addressed by transportation agencies.

Air quality issues, as a function of mobile source emissions, are the environmental issues most closely related to energy efficiency. Thus, efforts to reduce fuel consumption through travel demand management strategies provide the connection between energy conservation and environmental stewardship.

According to the U.S. Office of Technology Assessment, it became clear in 1988 that many metropolitan regions in the United States would not be able to meet federal Clean Air Act requirements for emissions reductions without significant reductions in vehicle miles traveled.

Several types of modest TDM strategies have been deployed throughout the nation. However, these strategies reduce VMT by only a few percentage points over a decade and this will not offset the impact of VMT for most regions in the United States. Thus, this is the time to consider implementing measures such as market-based, travel pricing strategies and land use strategies that support transit, walking and bicycling, which so far have gone untested in the United States (Johnston and Ceerla 1995).

Current Practices

One of the most popular approaches that states are using to reduce VMT is implementing Smart Growth and land-use planning/ development strategies. These strategies include bundling mixed-use developments into a single project, integrating project development into the land use planning process, and including transit oriented density with multi-modal options (e.g., bus, train, bike and walk options) (Pechan, et al. 2008).

Due to the variety and overlapping nature of these strategies, different states focus on different features of these strategies. The options included in these Smart Growth strategies include infill, densification, and brownfield redevelopment, mixed-use and transit oriented development, smart growth planning, modeling, open space protection, and expanded transit infrastructure and service. The results of these strategies vary widely depending on the effort and magnitude of the strategies adopted by each state (Pechan, et al. 2008).

Tennessee Forecasts

Analysis shows that the transportation sector accounted for 31 percent of Tennessee's gross greenhouse gas (GHG) emissions in 2005. This is higher than the national average, where 27 percent of total GHG emissions come from the transportation sector. On-road vehicles accounted for 83 percent of total transportation sector GHG emissions in 2005. Transportation emissions have increased by 42 percent since 1990, which is more than double the emissions growth seen across Tennessee as a whole (18 percent). The business-as-usual forecast for Tennessee shows that emissions from the transportation sector are expected to account for 37 percent of the state's GHG emissions in 2025 (Pechan, et al. 2008).

Activities in Tennessee accounted for approximately 148 MMt of *gross* CO_2e emissions (consumption basis) in 2005, an amount equal to about 2.0 percent of total U.S. gross GHG emissions (based on 2005 U.S. data) (EPA 2007b). And Tennessee's gross GHG emissions are rising at a faster rate than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Tennessee's gross GHG emissions increased by about 18 percent between 1990 and 2005, while national emissions rose by 16 percent from 1990 to 2005. The growth in Tennessee's emissions from 1990 to 2005 is primarily associated with the electricity consumption and transportation sectors (Pechan, et al. 2008).

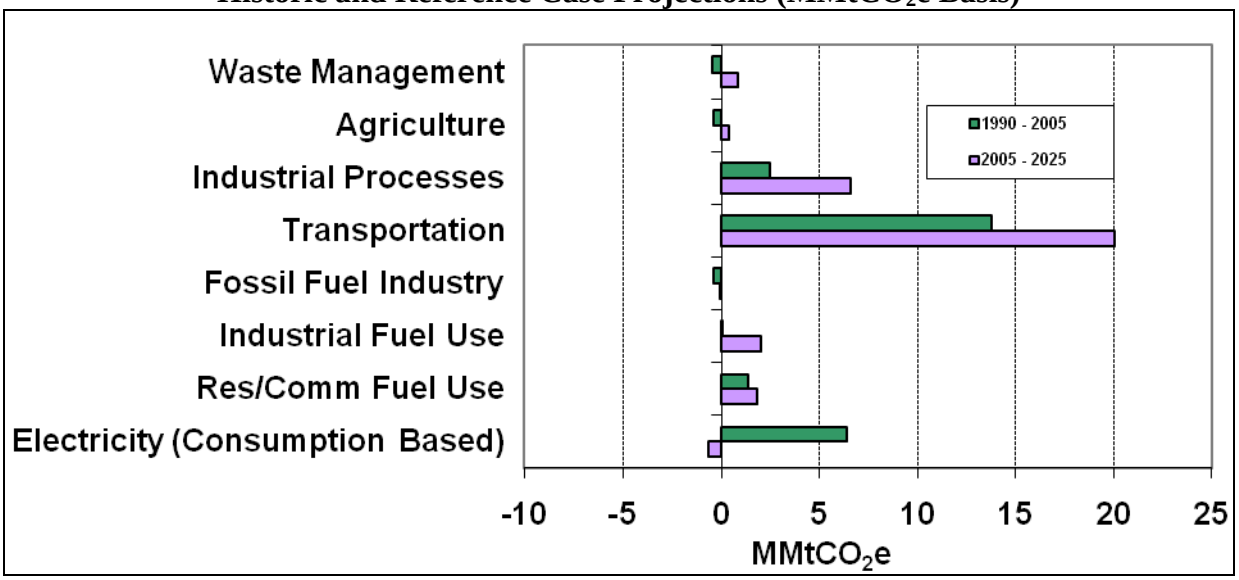
Transportation is one the largest GHG source sectors in Tennessee. The transportation sector includes light- and heavy-duty on-road vehicles, aircraft, rail engines, and marine engines. CO_2 accounted for about 97 percent of the transportation sector's GHG emissions in 1990 and is projected to increase to about 98 percent of transportation GHG emissions by 2025. Most of the remaining GHG emissions from the transportation sector are due to N_2O emissions from gasoline engines (Pechan, et al. 2008).

TDOT recognizes the Tennessee population is projected to increase 32 percent between 2005 and 2030 (TDOT 2005). Significant growth in transportation infrastructure will be required to accommodate this increase. However, this also presents an opportunity to grow in an efficient

manner, and move towards a more sustainable transportation infrastructure, where increasing population densities allow for reduced VMT (Pechan, et al. 2008).

As shown in Figure 7, the transportation sector is projected to be the largest contributor to future emissions growth in Tennessee, followed by industrial processes.

Figure 7: Sector Contributions to Gross Emissions Growth in Tennessee, 1990-2025 Historic and Reference Case Projections ($MMtCO_2e$ Basis)



(Pechan, et al. 2008)

Table 10 shows the estimated VMT in the State of Tennessee for 1990, 2005 and 2025.

Table 10: Tennessee VMT Estimates (millions of miles)

Vehicle Type	1990	2005	2025
Heavy-Duty Diesel Vehicle	3,044	4,709	8,827
Heavy-Duty Gasoline Vehicle	684	696	887
Light-Duty Diesel Truck	346	716	2,337
Light Duty-Diesel Vehicle	294	215	702
Light-Duty Gasoline Truck	12,046	23,777	35,295
Light-Duty Gasoline Vehicle	30,107	40,349	59,894
Motorcycle	189	242	359
Total	46,710	70,704	108,301

Table 11 shows estimated VMT growth rates used for the 2005-2025 period.

Table 11: Tennessee VMT Compound Annual Growth Rates

Vehicle Type	1990-2005	2005-2025
Heavy-Duty Diesel Vehicle	2.95%	3.19%
Heavy-Duty Gasoline Vehicle	0.12%	1.22%
Light-Duty Diesel Truck	4.96%	6.09%
Light-Duty Diesel Vehicle	-2.07%	6.09%
Light-Duty Gasoline Truck	4.64%	1.99%
Light-Duty Gasoline Vehicle	1.97%	1.99%
Motorcycle	1.65%	1.99%
Total VMT	2.80%	2.15%

(Pechan, et al. 2008)

Sample of Other States

Montana has a package of Smart Growth policies and incentives that sets a goal to reach a VMT reduction of 3 to 11 percent below the 2020 baseline. Arizona's goal is to reduce growth in VMT from passenger vehicles by 2 to 11 percent in the years 2007-2020. And South Carolina seeks to stabilize per capita VMT at the 2005 levels by 2010. Many of these states plan on using market incentives, funding technical assistance programs, rule-making, and a host of other mechanisms to reach their goals. Efforts in implementing these Smart Growth and land-use planning strategies involve all levels of the government, including local, county, school district, regional and state. Another key variable in estimating emission reductions from land use planning strategies is determining how the new policies differ from those already planned in an area (Pechan, et al. 2008).

Other strategies targeted at VMT and trip reduction include Commuter Benefits programs and automobile insurance based on distance driven. Commuter Benefits include reducing the amount of free or subsidized parking; providing paid or pre-tax transit passes or mode-neutral transportation allowances; guaranteeing rides home for non-drive-alones; providing bicycle parking and employee lockers; providing telecommuting programs; and converting employee ID cards to transit passes. If enough employers offer a Commuter Benefits program at the workplace, some mobile source emissions can be reduced by 1 to 6 percent due to increased use of transit, ride-sharing, and non-motorized transportation. Commuter benefits programs have very favorable cost effectiveness rankings. However, they also rely on investing capital in transit programs that provide non-sport utility vehicle travel alternatives to commuters (Pechan, et al. 2008).

South Carolina has implemented an "Improved Development Patterns" mitigation option to reduce emissions. The goal of their policy is to stabilize statewide VMT at today's levels by 2010 (2010 ceiling) by working with local governments. Each local government in South Carolina would be free to implement land use tools that it determines are best suited for managing VMT within its respective jurisdiction. Such tools would be designed to promote more efficient development patterns by encouraging and promoting highly connected street

networks, higher residential and employment densities, and mixed land uses in new and existing development. South Carolina's policy stresses that coordination with transportation agencies and MPOs would be necessary (SC CECAC 2008).

South Carolina's option also describes specific state actions for carrying out the policy. These include:

1) Requiring all counties in South Carolina to establish planning commissions and to work with those commissions to prepare and implement comprehensive plans that reduce and/or stabilize VMT within their jurisdictions (at a minimum, versus the baseline).

2) Expanding state incentives for brownfield redevelopment in South Carolina. These incentives could include grants or loans, with preferences given to projects that meet sustainable development principles.

3) Requiring planning commissions to assess the impact of their comprehensive plans on mobile source emissions.

4) Reestablishing the Division of Regional Development and providing adequate funding for the division to meet its responsibilities under the law.

5) Expanding state incentives for conservation, such as by improving the tax credits for conservation easements.

6) Increasing the amount of funding for the South Carolina Conservation Bank and the South Carolina Heritage Trust program.

7) Providing state incentives and resources to encourage planning and implementation of plans.

Florida provides an example of a state DOT promoting local and regional initiative to affect land use patterns. FDOT has supported the development of regional visioning and scenario planning throughout the state through technical assistance including staff resources, modeling, etc., and its transit division has developed resources and conducted outreach to promote transit-oriented development. Coordinating state transportation investment policies with regional growth objectives is another important action that TDOT could take to promote more efficient land use patterns.

Local Government Programs

In addition to actions that have been taken at the state and national level, a large number of local areas have become active in developing climate action plans, quantifying local GHG emission inventories, and taking actions to reduce GHG emissions. Several organizations exist to assist local governments in developing and pursuing these plans. One of the most notable of these organizations is International Council for Local Environmental Initiatives (ICLEI)-Local Governments for Sustainability. This organization was founded in 1990 and is an international membership association of local governments dedicated to climate protection and local

sustainability. ICLEI provides technical consulting, training, and information services to build capacity, share knowledge, and support local governments in the implementation of sustainable development at the local level in an effective and cost-efficient way. Currently, 864 cities, towns, and counties are full members of ICLEI. ICLEI members from the State of Tennessee include Chattanooga, Gatlinburg, Knoxville, and Signal Mountain (Pechan, et al. 2008).

In the area of climate mitigation, ICLEI assists local governments through the Cities for Climate Protection (CCP) program. This program assists cities in adopting policies and implementing quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability.

The CCP program includes the following five milestones for the local governments in this program:

1) Conduct a baseline emissions inventory and forecast.
2) Adopt an emissions reduction target for the forecast year.
3) Develop a Local Action Plan.
4) Implement policies and measures.
5) Monitor and verify results.

Memphis, Tennessee is a participant in the CCP program.

In addition to the CCP program, U.S. mayors have developed a Climate Protection Agreement. By February 2008, over 800 mayors from the United States and Puerto Rico had signed this agreement. The mayors who have signed this agreement have committed to taking the following actions:

1) Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns;
2) Urge their state governments, and the Federal Government, to enact policies and programs to meet or beat the GHG emission reduction target suggested for the United States in the Kyoto Protocol – 7 percent reduction from 1990 levels by 2012; and
3) Urge the U.S. Congress to pass the bipartisan GHG reduction legislation, which would establish a national emission trading system.

In Tennessee, mayors of the following cities have signed this agreement: Chattanooga, Cookeville, Crossville, Franklin, Knoxville, Shelby County, Nashville, and Signal Mountain.

Several of the Tennessee cities have already begun the process of quantifying GHG emissions in their communities, including the contribution of the local governments to the GHG inventories, and are implementing measures to begin reducing GHG emissions. For example, the City of Chattanooga has replaced incandescent bulbs in all traffic signals to LED lights, purchased 12 hybrid vehicles, and switched all diesel vehicles to 20 percent biodiesel (B20). Additionally the City is experimenting with a new product called “Green Asphalt.” This asphalt contains up to 50 percent locally recycled asphalt product and requires less heat,

reducing heating costs and emissions in paving projects. The City of Knoxville will be investing in energy efficient LED lights to replace the incandescent bulbs in the city's traffic signals. The mayor of the City of Nashville has noted the following actions that are already in place:

1) The purchase of six hybrid buses at the Metropolitan Transit Authority;
2) Public Works signal optimization program and the replacement of incandescent traffic lights with LEDs;
3) Sustainable building features at parks facilities, including a green roof, waterless urinals and geothermal heating; and
4) Leadership in Energy and Environmental Design building standards adopted for the construction and renovation of Metro buildings.

Benefits & Costs

Business-as-usual, which allows VMT, fuel consumption, mobile source emissions and urban sprawl to grow indefinitely is not sustainable. Likewise, the current funding structure for transportation infrastructure is not sustainable. The problem is exacerbated because if fuel consumption is reduced significantly then the revenue from the fuel tax would be eroded even more quickly.

Additionally, other facets of the problem, like federal regulations, oil/fuel market dynamics, advances in vehicle technology, and alternative fuels all factor into the equation. It will be imperative to find the balance between energy conservation and environmental protection on the one hand and adequate funding on the other. But, the number of variables and unknowns will make this a challenging endeavor.

Transportation Funding in Tennessee

TDOT's current annual budget is one billion, thirty million, two hundred thousand dollars ($1,030,200,000). This funding is derived from the following sources:

- State Gas Tax - $278.4M
  21.4 cents/gal (split with state general fund, cities and counties)

- State Diesel Tax - $135.4M
  18.4 cents/gal

- State Vehicle Registration Fees - $214.4M (split with state general fund and other state entities)

- Other - $402M

Over the last six months, revenue from the fuel tax on gasoline and diesel has been trending downward as VMT, and therefore fuel consumption, declined. There is significant interest by a variety of stakeholders in finding an alternative to the fuel tax for transportation funding.

However, there are several options being considered to make adjustments under current funding structure. These include:

1) Increase in gas tax (1 cent = $30.5M of which TDOT would receive $18M per year)
2) Increase in diesel tax (1 cent = $11M of which TDOT would receive $8M per year)
3) Increase in motor vehicle registration ($1 increase on 5M registered vehicles = $5M)

If there were a five-cent increase in gasoline tax, it would generate $146.5 million. Under the current funding structure this amount would be distributed as follows:

- $87.9 million (60%) to TDOT
- $55.7 million (38%) to cities/counties
- $2.9 million (2%) to the State General Fund

Because of the importance of the fuel tax in financing highway programs, highway agencies are interested in projections of fuel economy and motor vehicle technological developments. Improvement in fuel economy would create pressure for the federal government and the states to raise fuel tax rates and/or curtail highway spending (TRB 2006).

In addition, in the absence of changes in the user fee system, expanded use of vehicles that do not consume taxed liquid fuels would reduce revenues. And the states anticipate that lawmakers will consider promoting introduction of alternative fuels and technology through highway user tax breaks such as the break gasohol received until 2006 (TRB 2006).

The projections suggest that fuel economy improvements of 15 to 25 percent for new light-duty vehicles would be practical within the next 10 to 20 years, without the need for technical breakthroughs and without downsizing or vehicle price increases that would seriously affect the vehicle market or driving habits. If such new-vehicle efficiency improvements were attained, the improvement in light-duty vehicle fleet fuel economy would be 10 to 20 percent by 2025 (TRB 2006).

None of the projections foresees important use of vehicles not powered by gasoline, diesel, or ethanol blends before 2025. For example, they do not project significant market shares for hydrogen-fueled cars or electric vehicles with batteries charged from electric power lines. Thus, vehicles foreseen to be in use in 2025 will be subject to existing fuel taxes (TRB 2006).

Studies of the connection between fuel price and the motor vehicle market all conclude that no likely fuel price increase or technology development in the period to 2025 will have a dramatic market effect on fleet average fuel economy by 2025. The implication of the projections in these studies is that if fundamental changes in fuel economy, fuel price, or engine technology occur in the next several decades, they are more likely to be the result of government intervention than energy market developments (TRB 2006).

Fuel Price Effects

As fuel prices rose during 2008 due to market dynamics, we did see a dip in VMT. Naturally, this had an adverse impact on fuel tax revenue. However, fuel prices have now receded and this may be the time to consider restructuring the fuel tax in Tennessee.

Historically per-mile vehicle operating costs declined during most of the 20th century, due to increased vehicle reliability (and less frequent repairs), increased vehicle fuel efficiency and declining real fuel prices. However, fuel prices are predicted to increase during the 21st century as demand grows and production peaks. Thus, rising energy prices probably will cause modest mileage reductions during the foreseeable future (Litman 2006).

Gasoline price increases in 1979 and 1980 led to purchases of more fuel-efficient vehicles. Although the consumer response to gasoline price increases is now smaller than it was then, lower gasoline consumption is now being seen due to a combination of more fuel-efficient vehicles and reduced VMT as fuel prices continue to rise (EIA 2008b).

A 2004 study found that a 10 percent increase in fuel price would reduce the volume of traffic by approximately 1 percent within a year, and about 3 percent over the next 5 years. In addition, the amount of fuel consumed would fall by approximately 2.5 percent within a year, eventually leading to a 6 percent reduction over the next five years (Goodwin, et al. 2004).

This occurs because fuel consumption is relatively inelastic towards increases in price in the short term, but more responsive to price increases over the long run. Options for immediately reducing fuel use are limited, involving only cutting out non-essential trips or making greater use of the currently available transit system. In the longer term, there are more options available to reduce fuel consumption. People concerned with saving energy can organize carpooling, use a more efficient vehicle, or change locations to avoid the need to travel. In addition, higher fuel prices mean mass transit becomes more cost-effective, and the government can help expand these options to meet increased demand.

There have been numerous other studies indicating that vehicle miles traveled are not very responsive to changes in fuel cost. These studies typically found that a 10 percent increase in cost per mile traveled will result in a 1-2 percent reduction in VMT (Greene 1998).

Because this reduction is so small, estimates of rising fuel costs are typically not factored into estimates of VMT in the United States. So, if Tennessee passed a modest increase to the existing fuel tax, it would probably have very little impact on fuel consumption.

Vehicle Technology

Seventeen states have adopted, or announced their intention to adopt, the California Clean Car standards (Pew Center 2008). The standards require automobile manufacturers to reduce GHG emissions from new passenger cars and light trucks beginning in 2009. Automakers have a phase-in period of 8 years to comply, so that by 2016, a 30 percent reduction in GHG emissions from new vehicles can be achieved. In light of the recent federal CAFE standard, which

establishes a 35-mpg requirement for all new cars and light-duty trucks by 2020, EPA has denied California's waiver to implement its proposed Clean Car regulations. California and 15 other states have since sued EPA to have the decision overturned (Barringer 2008).

Apart from the California GHG standard adoption issue, states have focused their other vehicle technology decisions on state programs to purchase vehicle technologies that are lower carbon emissions per mile than conventional technologies. Such initiatives are underway in California, New York, and Washington. For example, Washington's Heavy-Duty Vehicle Reduction Measure seeks to reduce diesel emissions and the use of conventional diesel fuel in the public and private sectors through promotion and deployment programs for a variety of technologies and practices (WA CAT 2008). These technologies include more fuel efficient technologies for trucks, replacement of freight handling equipment with battery-electric and hybrid-electric equipment, reduced fuel use in ferries through engine modifications, shore power, and waste heat recovery. Washington also plans on accelerating and integrating plug-in hybrid electric vehicles (PHEVs) use by creating incentives and integrating PHEVs with other energy systems (Pechan, et al. 2008).

Alternative Vehicle Fuels

Some states are proposing major initiatives to reduce the carbon intensity in vehicle fuels include setting low carbon fuel standards and methods to increase the use of alternative fuels. Thirty-seven states already provide incentives promoting ethanol production and use; these include states that border Tennessee: Arkansas, Mississippi, Kentucky, North Carolina, and Virginia. Nine states have also introduced their own renewable fuels standard (RFS) with ethanol mandates (Pew Center 2008).

California is the first state to establish a Low-Carbon Fuel Standard (LCFS). Its goal is to reduce the "carbon intensity" of California's vehicle fuel by at least 10 percent by 2020. Carbon intensity refers to GHG emissions per unit of energy, in units such as grams of CO_2e per Btu, used to power a vehicle (CARB 2007). The LCFS would require all fuel providers in the state to ensure the mix of fuel they sell meets, on average, a declining standard for GHG emissions. Other states, such as South Carolina, Minnesota, and Washington have also included the California LCFS goals into their mitigation plans. The potential GHG emission reductions resulting from this strategy is high – approximately 6 to 9 percent of total 2020 transportation emissions in all states. But the cost per ton CO_2e reduced can also be relatively high (Pechan, et al. 2008).

Other fuels-related programs being adopted by states target increased use of specific fuel alternatives to conventional gasoline and diesel. The estimated GHG reductions from increasing alternative fuel use, as well as the cost effectiveness, differ widely from state to state. This is due to the wide variety of alternative fuels strategies.

For example, New Mexico's Alternative Fuels Use plan involves expanding the availability and use of alternative fuels, hybrid vehicles, low-speed vehicles, and zero emission vehicles (ZEVs). New Mexico's plan is estimated to reduce 8 percent of New Mexico's transportation GHG emissions by 2020 (Pechan, et al. 2008).

Arizona, on the other hand, has a Biodiesel Implementation strategy that seeks to increase market penetration of biodiesel fuels only. This strategy is estimated to reduce 2 percent of Arizona's 2020 transportation GHG emissions (Pechan, et al. 2008).

State goals for alternative fuel market penetration vary widely. For example, North Carolina proposed a phase-in goal for its biofuels implementation, replacing an increasing percentage of gasoline and diesel with ethanol and biodiesel by specific target years as shown in Table 12.

Table 12: North Carolina Goal Levels and Timing for Biofuels Implementation

Phase	Year	Percentage of Gasoline to be Replaced by Biofuels	Percentage of Diesel to be Replaced by Biofuels
1	2010	10% (E10 equivalent)	5% (B5 equivalent)
2	2015	15% (E15 equivalent)	10% (B10 equivalent)
3	2020	20% (E20 equivalent)	15% (B15 equivalent)
4	2025	25% (E25 equivalent)	20% (B20 equivalent)

(NC CAPAG 2008)

The plan is to use a combination of renewable fuels standards, financial incentives, outreach, and market-based mechanisms to reach the goals. In order to maximize the benefit of biofuels, North Carolina's Climate Action Plan also includes proposals to provide incentives for in-state biodiesel and ethanol production. Because feedstocks used to produce biodiesel and ethanol are made from crops, these strategies are being coordinated with strategies to reduce agriculture sector GHG emissions. Linking agriculture GHG reduction strategies (especially in the areas of biofuel production) with transportation strategies is characteristic of many state climate mitigation strategies (Pechan, et al. 2008).

The estimated cost effectiveness of alternative fuel use strategies also varies from state to state. States that have large urban populations and limited agriculture acreage tend to have higher mitigation costs, while states located in the Midwest and agricultural regions tend to have lower costs associated with biofuels. The quantification of costs associated with this strategy is more uncertain (than other strategies) and relies on numerous assumptions; therefore, some states have not made any cost estimates for their alternative fuels programs (Pechan, et al. 2008).

Surface Transportation Reauthorization

Work already has started on the next round of surface transportation legislation, extending SAFETEA-LU, and is expected to be a high Congressional priority during 2009. It is possible that during this same period, Congress will be simultaneously considering major climate change legislation. It is almost certain that climate change will be an important consideration in any new surface transportation legislation along with funding, congestion, intermodal freight, and other considerations (Pechan, et al. 2008).

Therefore, an important question is the manner in which climate change could be introduced into new transportation legislation. Three potentially less controversial ways are to explicitly define climate change as one of the listed planning factors, extend or modify the time horizon of long

range transportation plans so that the 50 and 100-year time frames typically associated with climate change science are taken into consideration, and including a range of climate change adaptation activities such as planning, new materials, stormwater runoff and drainage, and changes in design standards (Pechan, et al. 2008).

It is possible that additional measures could be proposed as part of either climate change or surface transportation legislation. For example, environmental groups are concerned that existing proposed climate change legislation does not adequately address issues associated with growth of VMT. In response, a Green TEA proposal has been developed by the Center for Clean Air Policy (CCAP), Environmental Defense Fund (EDF), and the Surface Transportation Policy Project (STPP) that includes proposals aimed at reducing GHG emissions from mobile sources and the rate of VMT growth (Pechan, et al. 2008).

More controversial options that are still "on-the-table" for consideration include tying transportation funding to energy, GHG, and VMT reductions; incorporating scenario analyses and visioning into transportation planning; strengthening the linkage between land use and transportation planning; increased funding for energy efficient transportation alternatives; encouraging location-efficient development (e.g., smart growth, transit oriented development); creating a GHG conformity process; and eliminating the blanket eligibility of traffic flow improvement projects for Congestion Mitigation and Air Quality (CMAQ) federal funding (Pechan, et al. 2008).

It is far too early to know how many, if any, of these environmental proposals will receive major consideration. However, it is likely that climate change will be an important element of any new surface transportation legislation.

While climate change has emerged as a major policy issue, considerable uncertainty remains as to how this will be reflected in transportation planning, project development, construction, maintenance, operations, and other transportation decision-making. Leadership, at present, is being taken at the state and local-levels of government rather than at the federal-level. Furthermore, this leadership is occurring primarily from within the environmental community, with a far lower-level of involvement from transportation agencies. As demonstrated by the initiatives described in this section, this means that the transportation-related agenda is being established by a combination of environmental groups and the work being done in support of state climate change action plans. This is resulting in the establishment of GHG reduction goals and, by implication, associated goals for reducing VMT, such as those adopted in Washington State. This may lead to the analysis of GHG emissions as part of transportation plans, programs, and projects and proposals to extend the Clean Air Act's transportation air quality conformity provision to include GHG reductions (Pechan, et al. 2008).

Nearly two-thirds of the states have developed, or in the process of developing, a state climate action plan (or the equivalent) to reduce mobile source emissions. About one half of these plans have been developed via a stakeholder-based consensus building process. These state initiatives to reduce mobile source emissions include improving vehicle fuel efficiency, replacing conventional gasoline and diesel with lower-carbon fuels, switching to lower-emission means of travel, and various strategies to increase vehicle operation efficiency (Pechan, et al. 2008).

North Carolina and South Carolina are two states near Tennessee that have developed effective emission reduction strategies for the transportation sector. The following tables show proposed mobile source emission reduction strategies for North Carolina and South Carolina. North Carolina has established a Climate Action Plan Advisory Group (CAPAG) to develop further recommendations to reduce emissions (NC CAPAG 2008).

Table 13: North Carolina Transportation and Land Use Strategies

Mitigation Option	CO_2e Reductions			Net Present Value 2008-2020 (Millions $)	Cost-Effectiveness ($/t$CO_2e$)
	2010	2020	2008-2020 Total		
Land Development Planning	2.6	8.0	58.2	Net savings	
Multi-Modal Transportation and Promotion	3.7	5.8	52.4	-1,300	-25
Surcharges to Raise Revenue	1.2	2.2	15.7	-1,800	-117
Rebates/Feebates to Change Fleet Mix	0	<0.5	2.8	*Not quantified*	-40 to +10
Truck Stop Electrification	Included in other strategy			*Net savings*	
Tailpipe GHG Standards	0	8.1	44.5	-1,690	-38
Biofuels Bundle	1.9	4.5	35.4	*Not quantified*	
Procure Efficient Fleets	Included in other strategy				
Idle Reduction/Elimination Policies	0.1	0.2	2.2	-6	-4
Diesel Retrofits	0.3	2.2	13.5	*Not quantified*	
PAYD	2.3	5.3	42.0	*Expected net savings*	
Advanced Technology Incentives	*Not quantified*				
Buses – Clean Fuels	Included in other strategy				
Sector Total After Adjusting for Overlaps	11.1	25.5	232.3	*Not quantified*	
Reductions from Recent Actions	0	0	0	0	0
Sector Total Plus Recent Policy Actions	11.1	25.5	232.3	*Not quantified*	

(NC CAPAG 2008)

These recommendations are the result of a stakeholder process involving more than 40 members representing a broad range of interests and expertise in North Carolina. They worked together with state agencies and the Center for Climate Strategies (CCS) to reach consensus on the recommended options. The majority (8) of the 13 recommendations have unanimous consent, while the rest have the support of the supermajority (Pechan, et al. 2008).

These mitigation recommendations could lead to emission reductions from North Carolina's reference case projections of 25.5 $MMtCO_2e$ per year by 2020. The cumulative savings from these reductions can reach 232 $MMtCO_2e$ from 2008 through 2020, and the net cost savings can reach $4.3 billion to the North Carolina economy through the year 2020 on a net present value basis. The weighted average cost of saved carbon from the mitigation options for which quantitative estimates of both costs and savings were prepared was –$19 per metric ton of CO_2e (NC CAPAG 2008).

South Carolina established a Climate, Energy & Commerce Advisory Committee (CECAC) to develop a set of recommended policy options to reduce South Carolina's GHG emissions (SC CECAC 2008). The CECAC comprises a diverse group of stakeholders who bring broad perspective and expertise to the topic of climate change in South Carolina. The CECAC has just recently (May 2008) completed the stakeholder process and the final set of recommendations to reduce transportation sector emissions are shown in Table 14, below.

Table 14: South Carolina Transportation and Land Use Strategies

Policy Option		Emission Reductions ($MMtCO_2e$) 2012	2020	Total 2008–2020	Net Present Value 2008–2020 (Millions $)	Cost-Effectiveness ($/tCO_2e$)
Adopt California Clean Car Standards		0.21	1.14	7.04	–$323 –$1,598	–$46 – $227
Transportation System Management		0.01	0.04	0.22	< $0	< $0
Tax Credits for Efficient Vehicles		0.02	0.12	0.68	$244	$359
Improve Development Patterns		0.41	2.31	14.02	< $0	< $0
Transit & Bike-Pedestrian [Incorporates other]		0.02	0.02	0.22	-$1	-$1
Transit & Bike-Pedestrian						
Alternative-Fuel Infrastructure		0.02	0.24	0.77	$54	$70
Diesel Engine Emission Reductions and Fuel Efficiency Improvements	Efficiency Improvements	0.03	0.19	0.96	–$110	–$114
	Biodiesel	0.05	0.38	1.95	–$291 –$319	–$15 – $164
Stricter Enforcement of Speed Limits		0.10	0.12	1.18	NQ	NQ
Make Full Use of Congestion Mitigation and Air Quality Improvement (CMAQ) Funds		*Not quantified*				
Commuter Choice and Commuter Benefits Programs		0.12	0.43	2.63	–$631	–$240
Low-GHG Fuel Standard		0.38	3.67	17.89	$20 –$3,276	$1 – $183
Rail		*Not quantified*				

(SC CECAC 2008)

Recommendations

As suggested by Pechan & Associates, Inc., we recommend TDOT consider promoting the following travel activity/land use options:

1) Improve land use planning and development to reduce VMT,
2) Expand transit, bike, and pedestrian infrastructure,
3) Promote Commuter Choice/workplace TDM,
4) Improve intermodal freight transportation, and
5) Increase transportation system efficiency.

Improve Land Use Planning and Development to Reduce VMT

The location and design of development have substantial impacts on mobile source emissions, and growth in Tennessee could be accommodated in a variety of ways that might reduce growth in VMT. For example, infill and brownfield developments produce less vehicle travel and emissions than development on lower-density exurban or greenfield locations (Pechan, et al. 2008).

Households and workers in areas with higher density and mixed uses take shorter trips and use more alternatives to automobile travel. Brownfields are one type of infill location – commercial or industrial properties that are abandoned, or are not being fully used because of actual or perceived environmental contamination. Greyfields, another type of infill and redevelopment opportunity, are the declining commercial strips left behind by 1960s-style commercial development, characterized by seas of parking and cheap one-story buildings that are difficult to reuse. Communities from Nashville to Raleigh, North Carolina have capitalized on these underutilized and relatively centrally located sites to create new mixed-use urban villages with traditional, walkable street networks and a rich mix of retail, office, and residential uses (SC CECAC 2008).

Additionally, infrastructure and service boundaries are essentially policies that concentrate infrastructure and services, such as roads, schools, water, and sewer, in areas where growth is desired. Such policies reduce both the extent of sprawl and the cost of providing infrastructure and services (SC CECAC 2008).

Tennessee currently has land use policies in place to improve its transportation system. The Tennessee General Assembly passed a Growth Policy Statute, Public Chapter 1101, in May 1998, that sets out goals to develop compact urban and growth areas. But with large Tennessee cities projected to grow rapidly between 2000 and 2030 (Clarksville at 60 percent, Knoxville at 27 percent, and Nashville at 21 percent), land use planning and development can be improved in ways to reduce VMT growth (TDOT 2005).

Expand Transit, Bicycle, and Pedestrian Infrastructure

Tennessee should consider expanding infrastructure and programs to increase transit ridership, carpooling, bicycling, and walking. This would reduce VMT (fewer vehicle trips and shorter trip

distances) and associated emissions. This strategy helps reduce congestion, lower the cost of transportation in the long run, improve air quality, and improve communities (Pechan, et al. 2008).

Currently, TDOT has a SmartCommute website encouraging alternative ways to commute, including walking, bicycling, passenger rail, public transit and ridesharing. TDOT's Long Range Transportation Plan also recognizes the opportunities in mass transit in Tennessee and lays out a bicycle and pedestrian plan in detail, as well as a plan to expand public transportation. TDOT also has programs and projects in place to improve bike and pedestrian paths, but more can be done in these areas (TDOT 2005).

For example, South Carolina's climate action plan also includes a similar strategy to expand their transit, bicycle, and pedestrian infrastructure. They plan to implement their goal of enabling "personal trip making to move from single-occupant vehicles to lower-emitting transportation options" by:

1) Implementing a state multimodal transportation plan, including the statewide transit plan, which South Carolina DOT is adopted in early 2008. This includes 1.75 cents per gallon to fund transit, in the event the gas user fee is increased.

2) Creating a new state mass transit aid program to fund 50 percent of the annual operating costs of mass transit systems in South Carolina, to be administered by South Carolina DOT. Require South Carolina DOT to audit both the financial records of each aid recipient annually and the performance (efficiency and effectiveness) of each aid recipient every 5 years.

3) Creating a new state mass transit aid program, to be administered by South Carolina DOT, to fund 90 percent of the costs of mass transit projects designed to test and evaluate the costs and benefits of innovative ways for the state's mass transit systems to provide mobility. SCDOT plans to encourage the deployment of innovative technologies.

4) Creating a new state mass transit aid program, to be administered by South Carolina DOT, to fund 50 percent of the nonfederal share of capital improvement projects of the state's mass transit system. Design all facility renovation or new facility construction projects funded under this program to meet appropriate Leadership in Energy and Environmental Design™ (LEED) standards promulgated by the U.S. Green Building Council.

5) Creating a new state program to aid communities in the retrofitting of pedestrian and bicycle infrastructure that was frequently omitted from the mid-1940s to the mid-1990s. This could be stand-alone funding or designated to combine with existing Federal programs, such as Transportation Enhancements, Safe Routes to Schools, and others.

Commuter Choice/Workplace TDM

The goal of Tennessee's Transportation Alternatives Community Assistance (TACA) Program is to encourage and facilitate wider use of transportation alternatives in air quality nonattainment

areas. This program works with local governments and businesses in selected nonattainment area communities to initiate and sustain modal shifts from single-occupant vehicle trips to transportation alternatives, including carpools, vanpools, public transit, walking, bicycling and telecommuting. This is accomplished by sharing the most current TDM strategies and information on commute transportation benefits via multi-employer workshops, single-employer in-person meetings, conference call presentations, and outreach materials. By reducing VMT the program should result in reduced mobile source emissions as well as criteria pollutants (Pechan, et al. 2008).

TDOT could more aggressively pursue the promotion of commuter choice/workplace TDM strategies within the state by expanding this program. EPA's Best Workplaces for Commuters program (now operated by the Center for Urban Transportation Research) provides one such model. The program worked with local and regional TDM organizations to provide targeted outreach to employers well as national recognition for employers that adopted a set of defined commuter choice "best practices." A further expansion of this program could include providing financial incentives to further encourage employers to offer financial incentives (such as subsidized transit passes or parking cash-out) for alternative modes. New Jersey DOT is an example of a state agency that has taken a lead in promoting alternative commute modes (Pechan, et al. 2008).

Expanded Transit Infrastructure, Incentives and Marketing

VMT increased by 100 percent between 1980 and 2000, while population only increased 25 percent over the same period (TDOT 2005). This trend is seen nationwide, although Tennessee's per capita VMT growth is higher than that of the nation as a whole (Ewing, et al. 2007). Reducing per capita VMT is an essential part of controlling transportation fuel use and emissions in the state, and in order to achieve this, viable transportation alternatives must be offered. Expanded transit infrastructure and services will help provide fuel efficient, low-carbon transportation options to all Tennessee residents (Pechan, et al. 2008).

Key elements that would likely be present in a more aggressive transit infrastructure program would include: further efforts to integrate Tennessee's transportation infrastructure to make vehicle, rail, aircraft, bicycle and pedestrian modes of travel more compatible, increased local efforts to reduce VMT per capita, and aggressive actions to encourage rail, bus, bike and pedestrian options (Pechan, et al. 2008).

Smart Growth/Land-Use Planning/Development Strategies

Due to the overlapping nature of these strategies and different states focusing on different features within these strategies, the potential mobile source emission reductions can vary. Infill, densification, and brownfield redevelopment help to increase population density, and reduce the need for expanded transit infrastructure. Transit-oriented development can be similarly valuable, by developing communities with a variety of transit options available. Smart growth planning, modeling, and tools will help to integrate different elements of the transportation system. Clarksville, Nashville, and Memphis are all projected to grow by more than 50,000 residents

between 2005 and 2025 (UT 2003). This type of growth provides the opportunity for effective state and municipal policies to have a significant impact (Pechan, et al. 2008).

Targeted open space protection can have benefits in terms of reducing the urban heating effect (buildings and asphalt absorb more heat than most plants) as well as providing carbon sequestration through plant life and aesthetic benefits to the community. The Tennessee Department of Agriculture has an existing urban forestry program with the goals of setting up local urban forestry programs in municipalities across the state, and providing educational and technical expertise to support urban forestry programs (TDAg 2008). The mobile source emission reduction potentials for these development strategies vary widely, depending on the effort and magnitude of the strategies adopted by each state.

South Carolina's Climate Change Advisory Group recommended that legislation be passed requiring all South Carolina counties to create plans to stabilize VMT in their jurisdiction (CECAC 2008). Other recommendations included brownfield redevelopment, and open space protection (Pechan, et al. 2008).

Congestion Pricing

Alleviating congestion is one of the points of emphasis of Tennessee's 25-year transportation plan. The plan calls for $840 million over the next ten years to help reduce congestion in the state (TDOT 2005). Of this funding, over 92 percent is allocated towards maintaining and expanding Tennessee's roadways. While this undoubtedly plays an important role in alleviating congestion in the state, it is likely that other approaches might also be an effective part of this effort (Pechan, et al. 2008).

Tolls or other user charges can fluctuate with congestion levels (congestion pricing). The goal of congestion pricing is to set up a direct economic relationship between the total costs and benefits of personal travel decisions. Congestion pricing accounts for the increased environmental and economic costs of traveling on congested roads. This can be used to provide a further incentive to avoid traveling on heavily congested roads. Various forms of VMT-based user fees can also help to discourage unnecessary automobile use. Pricing revenues can be used to fund transit and other transportation alternatives within a corridor or region. Factors that make congestion pricing more effective include: high population density, widely available transportation alternatives, and consistent hours of peak congestion (Pechan, et al. 2008).

Fuel Tax Revenue Implications

Developments in motor vehicle fuel economy and propulsion technology could affect the viability of the present transportation finance scheme in three ways. First, maintaining constant revenue per vehicle mile would require raising cents-per-gallon fuel tax rates if average fuel economy improves. Second, some technologies do not consume the fuels that are now within the highway user tax scheme. Finally, lawmakers may decide to provide incentives for adoption of new technologies in the form of lower user fee payments (e.g., the lower federal excise tax rate paid on gasohol than on gasoline before 2005) (TRB 2006).

If fuel price increases are great enough to drive significant fuel economy improvements and reduced travel (reduced VMT) could combine to reduce fuel tax revenue. Maintaining constant revenue per vehicle mile after a 15 percent decrease in gallons per mile would require a 17.6 percent increase in the combined average federal and state gasoline tax rate, about $0.07 per gallon (in 2002 dollars), or increases in other user fees. With fuel prices falling due to market dynamics, now may be the time to consider increasing the current fuel tax and indexing the tax to some measure of growth or cost to adjust the fuel tax for inflation. This would offer an opportunity to achieve funding objectives at the same time we pursue policies to conserve energy and protect the environment. States using indexing include Kentucky, Florida, Iowa, Maine, New York, North Carolina (TRB 2006).

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

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Introduction

Intelligent Transportation Systems (ITS) is a concept generated by the U.S. Department of Transportation (DOT). The federal ITS program is based on the fundamental principle of intelligent vehicles, intelligent infrastructure, and the creation of an intelligent transportation system, through which all components are integrated. The systems are implemented at state Department of Transportation (DOT) levels, yet the federal investments will be directed at targets of opportunity that have the potential for significant payoff and major incentives, such as, improving traveler safety, mobility, and productivity while decreasing travel congestion. These objectives of opportunity will include both the infrastructure and vehicles, but to will focus on the *integration* between vehicles and infrastructure, between modes of transportation, and between state Departments of Transportation and the Federal Highway Administration (FHWA) (DOT 2008).

ITS improves transportation safety and mobility and enhances productivity through the use of advanced communications technologies. The system encompasses a broad range of wireless and wire line communications-based information and electronics technologies. When integrated into the transportation system's infrastructure, and in vehicles themselves, these technologies relieve congestion, improve safety and enhance American productivity. ITS is made up of 16 types of technology based system applications. These systems are divided into 13 intelligent infrastructure systems and 3 intelligent vehicle systems (DOT 2008).

Intelligent Infrastructure

1) Arterial management systems include several sub-components. One sub-component is traffic and infrastructure surveillance by the use of closed circuit television cameras (CCTV) and speed sensors to monitor traffic flow. Another is traffic control which includes measures to provide transit signal priority, emergency vehicle preemption, adaptive signal phasing and network control, variable speed limits due to weather or congestion conditions, and bicycle

and pedestrian actuated signals. Another sub-component is lane and parking management for High Occupancy Vehicle (HOV) facilities, reversible flow lanes, data collection, and pricing. The next is information dissemination by the use of dynamic message signs (DMS), in-vehicle systems (IVS), such as, a device capable of displaying traveler information, and highway advisory radio stations (HAR). The final sub component to arterial management is enforcement of speed and stop/yield regulations.

2) Freeway management systems are similar to arterial management for traffic and infrastructure surveillance, lane management, and information dissemination. This is different because freeways encompass ramp control, meaning ramp metering, ramp closures, and allocating priority access. This also broadens the scope for enforcement. Freeway management includes not only speed enforcement on the freeway system, but also HOV lane and ramp meter enforcement.

3) The transit management systems sub-components are safety and security, transportation demand management, fleet management, and again information dissemination. Safety and security includes transit in-vehicle and transit facility surveillance, employee credentialing, such as, photo identification, and remote vehicle disabling. Transportation demand management includes ride sharing/matching, dynamic routing/scheduling, and service coordination. Fleet management includes automatic vehicle location (AVL) and computer aided dispatch (CAD), maintenance, and planning. For transit management, information can be disseminated via internet, wireless connections, and by telephone.

4) Incident management systems involve surveillance and detection, mobilization and response, information dissemination, and clearance and recovery. Surveillance and detection includes sensors and other means of detection that include various types of traffic detectors, still imaging or video surveillance, location information from wireless enhanced 911 (E-911) phone calls, information from Mayday or automated collision notification (ACN) systems, and incidents reported by travelers via roadside call boxes, or mobile phones. Mobilization and response includes AVL/CAD, response routing, and motorist assistance patrols. Motorist assistance patrols are now frequently incorporated into traffic management systems. These patrols, called HELP trucks specifically for the state of Tennessee, typically consist of specially equipped vehicles and trained staff that can assist stranded motorists, help clear minor incidents, and assist with the safe management of traffic around major incident scenes.

5) Emergency management systems include hazardous materials (HAZMAT) management, emergency medical services, and response and recovery. HAZMAT management involves tracking, detection, driver authentication, and route planning. Vehicle-mounted hardware provides the capability to track HAZMAT shipments and support the notification of management centers when a shipment deviates from its intended route. Emergency medical services involve advanced ACN and telemedicine. Telemedicine systems provide a link between responding ambulances and nearby emergency medical facilities, enabling doctors to advise emergency medical personnel regarding patient treatment en route to the hospital. Response and recovery involves early warning systems, response management, evacuation and re-entry management, and emergency traveler information.

6) Electronic payment systems have broadened their scope to toll collection, transit fare payment, and parking fee payment. A bar coded "smart card" can be incorporated as a multi-use payment system. Multi-use payment systems can make transit payment more convenient. Payment for bus, rail, and other public or private sector goods and services can be made using transit fare cards at terminal gates, or on check-out counters and phone booths of participating merchants located near transit stations. Multi-use systems may also incorporate the ability to pay highway tolls with the same card.

7) Traveler information systems involve pre-trip information, en route information, and tourism and special events notification. Pre-trip, travelers can gather information from DOT internet websites, radio and TV alerts, or travel information kiosks. En route, travelers can gather information by calling 511, the national roadway and weather condition telephone system, or by stopping at travel rest stops. Tennessee adopted the 511 program in August 2006.

8) Information management is data archiving. Data archiving is the collection, storage and distribution of ITS data for transportation planning, administration, policy, operation, safety analyses, and research. Data archiving systems make use of a variety of software, database, and electronic data storage technologies.

9) Crash prevention and safety involves warning systems for highway-rail crossings, dangerous intersections, pedestrian walkways, bicycle crossings and shared lane areas, and wild animal crossing alerts. Crash prevention and safety also involves road geometry warning systems for ramp rollover, curve speed warning, downhill speed warning, run-away truck detention areas, and truck over-height/over-width warnings.

10) Roadway operations and maintenance (O&M) systems include information dissemination, asset management, and work zone management. The most common way information is disseminated for O&M is via portable programmable digital message signs and HAR. Several applications help state DOTs with asset management, including fleet tracking applications such as automated vehicle location and computer aided dispatch systems, as well as handheld computers supporting data entry and reporting from the field. Work zone management involves all these aspects: temporary traffic management, temporary incident management, lane control, variable speed limits, speed enforcement, intrusion detection for sensitive areas of the jobsite, and road closure management.

11) Road weather management includes surveillance, monitoring and prediction, information dissemination, traffic control, and response and treatment. Surveillance, monitoring, and prediction blanket pavement conditions, atmospheric conditions, such as, fog alerts, tornados, and heavy precipitation, and managing water levels. Information is disseminated by DMSs or by calls to 511. Response and treatment refers to fixed winter and mobile winter maintenance like anti-icing chemicals and salt trucks.

12) Commercial vehicle operations involve credentials administration, safety assurance, electronic screening for border clearance and weight restrictions, carrier operations and fleet management, and security operations. Credentials administration refers to electronic funding for registration fees, fee payment, electronic registration, and permitting. Safety information

exchange programs assist the safe operation of commercial vehicles, providing inspectors with electronic access to carrier and vehicle safety information from previous inspections. ITS can be used to ensure the security of motor carriers. Asset tracking can improve the safety and security of drivers and vehicles by installing technologies that can monitor the location and condition of fleet assets, such as, trailers, cabs, and trucks, in real-time.

13) Intermodal freight systems can utilize ITS for freight tracking, asset tracking, freight terminal processes, freight-highway connector systems, and for the international border crossing processes. ITS freight terminal processes can improve the efficiency of freight transfers or freight storage by activating transponder tags to track cargo containers within the terminal as they are processed and sealed for transfer or storage. ITS applications that optimize traffic control and coordinate transfers near intermodal ports of entry can streamline increased freight movement on the nation's freight highway connector system (DOT 2008).

Intelligent Vehicles

Collision avoidance systems include intersection collision warnings, obstacle detection, lane change assistance, lane departure warnings, roll-over warnings which are intended for large freight trucks, road departure, forward collision, and rear impact warnings. ITS assists in collision notification by utilizing closed circuit televisions (CCTVs) dynamic message systems DMSs, and radar detection systems (RDS). They are used to monitor traffic flow and congestion. Driver assistance systems include navigation/route guidance, driver communication with other drivers or dispatchers, vision enhancement, object detection, adaptive cruise control, intelligent speed control, lane keeping assistance, roll stability control, precision docking, coupling and decoupling where multiple buses or train cars can link together for similar routes, and lastly, on-board monitoring (DOT 2008).

Intelligent Vehicles in Other States

Collision Avoidance: The National Highway Traffic Safety Administration (NHSTA) modeled a study that indicated on-board vehicle collision warning systems would be effective in 42% of rear-end crashes where the lead vehicle decelerated and 75% effective where the lead vehicle was stationary. The Federal Transit Administration (FTA) priced bus side-mounted ultrasonic sensors and on-board computers at $2,600 per bus.

Collision Notification: In New York, automatic collision notification (ACN) systems in urban and suburban areas were studied to estimate response time. Vehicles with ACN had an average notification of an incident time less than one minute and no longer than two minutes, while vehicles without ACN waited an average of three minutes. In the event of a collision, seconds make a world of difference. Aftermarket ACN devices can cost as little as $400 and as much as $2000 with a monthly service fee of about $20.

Driver Assistance: In a NHTSA field test, participants ranked adaptive cruise control over the conventional cruise control systems. The adaptive cruise includes throttle modulation and down shifting, not braking, to maintain preset headways. Results showed that with adaptive cruise, fewer risky lane changes in response to slow traffic where made (RITA 2007).

Current Practices

TDOT is currently is the process of integrating ITS highway management into the major cities in Tennessee, including, Nashville, Chattanooga, Knoxville, and Memphis. Other than ITS, the Tennessee is also currently implementing several traveler assistance programs, such as TDOT HELP, I-75 Fog Detection and Warning System, and the 511 telephone service. The following table shows the total number of motorists assists offered by TDOT HELP statewide since July 1999 through 2005.

Assist	Amount
Tagged Abandoned Vehichles	85,755
Changed Tires	71,558
Provided Traffic Control	162,116
Provided Fuel (2 Gallon Max.)	47,899
Debris Removed from Lanes	39,992
Relocated from Travel Lanes	34,398
Provided 1st Aid	3,283
TOTAL	**445,001**

Table 15: Average number of Assists by TDOT help Trucks July 1999 through 2005

This is an average of 65,000 assists per year and nearly 180 per day. Assuming the percentage of assists is equal for each of the four major Tennessee cities, these totals about 45 assists per day per city. Table 16 shows the total number of assists provided by the TDOT HELP program for just the City of Memphis from June 2000-2005 (TDOT 2006a).

Assist	Amount
Tagged Abandoned Vehichles	30,528
Changed Tires	24,472
Provided Traffic Control	17,657
Provided Fuel (2 Gallon Max.)	14,720
Debris Removed from Lanes	8,605
Relocated from Travel Lanes	5,829
Provided 1st Aid	908
TOTAL	**102,719**

Table 16: TDOT HELP Program Assists in Memphis, June 2000 to June 2005

As previously mentioned, TDOT launched a 511 reporting system as part of a national effort to provide motorist information in August 2006. Tennessee 511 features the following: one-stop resource for statewide travel and road conditions; easy to

remember telephone number; easy to use voice-activated system; and information about statewide conditions allowing for efficient trip planning. 511 signs are posted on all Tennessee interstates to inform the traveling public that the service is available (TDOT 2006b).

Since the addition of TN 511, nearly a quarter million calls have been made, the amount increasing each month due to the ease and recognition of its use. In August 2006 63,485 calls were made; September 2006 had 67,505 calls; and October 2006 had 71,156 calls. 36,419 calls where made in the first week alone. Following are some more TN 511 facts from the first week of use:

1) The average length of call was 1 minute 50 seconds;
2) On average, 217 people called TN 511 per hour;
3) The percent of people seeking traffic information was 90.5%;
4) The percent of callers seeking weather information was 13.34% (some callers wanted weather and traffic);
5) 354 callers asked to be transferred to other states;
6) The ratio of complaints to calls was one out of every 3310.

Memphis SmartWay System: Memphis's system is also known as Memphis TDOT SmartWay. The system includes two separate projects, the Early Deployment Project (EDP) and the Memphis Major Phase SmartWay Project.

Design for the early deployment phase began in the fall of 2003. Construction began in August 2004 and was completed on June 11th, 2005. The project focuses on the I-40 and I-55 Mississippi River bridges and West Memphis, Arkansas. These areas are heavily traveled at 116,000 Average Daily Traffic (ADT). The project includes 25 CCTV cameras and 3 DMSs. Communications between the devices is an all wireless digital microwave operating at 5.8 GHz and are manufactured by Proxim. There are communications wireless link towers located at the I-55 and I-40 weigh stations in Arkansas, the Tennessee State Office Building located in downtown Memphis, and at the TDOT HELP Dispatch Office. Wireless communications were used for the EDP because of the flat terrain, convenience of location (there is up to 10 miles between wireless devices due to some being located in Arkansas), the availability of large downtown buildings, and the reduced cost versus a fiber/conduit option. For the EDP, fiber/conduit would have cost $3 million, whereas the wireless cost only $800,000 (Chester 2006).

The second phase Memphis TDOT SmartWay project was let in July 2005 and was finished November 2008. The system has a 3 year on-call maintenance contract following a 6 month system burn-in phase. It encompasses 83 miles around Memphis, including the I-240 loop, I-55 from Arkansas to Mississippi state lines, Bill Morris Parkway to Hacks Cross Road, and I-40 to Canada Road. It is currently one of the largest single contract ITS projects in the United States. The estimated cost minus the cost of a new Transportation Management Center (TMC) building is $35 million. The project has added more devices to the already existing EDP wireless network and several more fiber/conduit linked devices. Fiber/conduit had to be used for TDOT SmartWay because the project boundaries are too large and costly for an entire wireless system. The fiber and conduit cost alone were $7 million. The project added 39 more DMSs totaling 42

for the entire system, and will add 90 more cameras for a total of 115. Also included were 354 RDSs, mostly strictly radar detection and some with video detection which can be used for collecting traffic data, and 16 full coverage HAR transmission sites.

TDOT is on the cutting edge of intelligent transportation technology in an attempt to benefit travelers' safety, mobility, convenience, efficiency, and productivity. It is up to other state DOTs, the general public, and our nation's government to continue to push the safety of transportation systems. We have an obligation to ourselves and others to keep each other as safe as possible while utilizing the roadways that have been provided.

Benefits & Costs

The ITS concept can be explained through a benefits versus cost format. This section will cover some examples of benefits and costs from participating state DOT ITS systems across the nation for each of the 13 intelligent infrastructure components and the 3 intelligent vehicle components.

Arterial Management for New York's DOT (NYSDOT): To improve the air quality in downtown Syracuse and Onondaga County, the NYSDOT installed a computerized traffic signal system and optimized the signal timing for 145 intersections. The prevailing benefit was mobility, resulting in a reduction of total delay experienced by vehicles during the A.M. peak, mid-day peak, and P.M. peak periods by 14-19%. The total installation cost of the 145 intersections was $8,316,000.

Freeway Management for Utah's DOT: Mail-back questionnaires were sent to 428 drivers living near major freeways to assess the impacts of posting travel delays and traffic information on variable message signs (VMSs) statewide. The prevailing benefit was customer satisfaction based off 221 returned questionnaires with results indicating, 15% of travelers used the information more than 5 times a month to adjust travel routes year-round. The total cost of 69 VMSs in Utah cost $15.25 million with an annual operating cost of $21,960.

Transit Management for Acadia National Park in Maine and Seattle, Washington: At Acadia, electronic message signs were installed to inform visitors of updated bus arrival and departure times at three poplar tourist attractions. Ninety percent (90%) of the surveyed park visitors said that the transit information was extremely beneficial, increasing customer satisfaction. In Seattle, at Bellevue and Northgate Transit Centers a TransitWatch system provides transit riders with bus arrival/departure times, bay numbers, an expected actual departure times for all bus routes using the transfer center. The total cost of TransitWatch was $722,877 in 1998 with an annual O&M cost of $179,652.

Incident Management: Freeway service patrols, such as TDOT HELP, in Minneapolis-St. Paul, Minnesota; Denver, Colorado; and Northwest Indiana documented an average annual delay savings of $1.5 million, benefiting mobility, through reductions of incident duration and related congestion. Michigan DOT (MDOT) implemented a freeway courtesy patrol (FCP) in the Detroit, MI area as part of the larger freeway incident management program. The cost to operate the FCP in 2003 was $2.5 million.

Emergency Management for San Antonio, Texas: Customer satisfaction is boosted due to the use of the LifeLink project which enables emergency room doctors to communicate with Emergency Medical Technicians (EMTs) using two-way video, audio, and data sharing. The Combined Transportation, Emergency and Communication Center (CTECC) is a multi-agency partnership between the Texas DOT (TxDOT) Austin District, Travis County, City of Austin, and the Capital Metro Transportation Authority that handles and delegates 911 calls, CAD, and AVL. The approximate CTECC equipment cost is $5 million.

Electronic Payment: Three European transportation/commercial projects have utilized smart cards as a payment system for public transit, shops, libraries, swimming pool access, and other city provided services. Customer satisfaction ranges from 71-87% for the smart cards. The Washington Metro Area Transit Authority (WMATA) is expanding the capability of their contact-free smart card system, SmarTrip, by linking it to multiple bus and rail fare collection systems. A Regional Customer Service Center (RCSC) is used to perform cross-jurisdictional management and distribution. The 2003 cost to deploy RCSC was $25.5 million and the annual O&M is $3.45 million.

Traveler Information for Montana DOT: Through surveys provided by the Greater Yellowstone Regional Traveler and Weather Information System (GYRTWIS) those that dialed 511 for travel assistance, 81% were highly satisfied and indicated that they had changed travel planes at least once as a result of the information provided. The 511 traveler information system is just part of the GRYTWIS, which also encompasses Amber, Homeland Security, and General Transportation alerts. It cost $188,000 to deploy GYRTWIS in 2003 with annual operating cost of $195,453.

Information Management for Nevada DOT: In efforts to increase efficiency, Nevada DOT has implemented Freeway and Arterial System of Transportation (FAST) central software. The software provides a fully automated freeway Management system and can receive, collect, archive, summarize, and generate data. The software cost $4.225 million in 2000 for design and development.

Crash Prevention and Safety: In Baltimore, Maryland, installation of a "second train coming" warning system at light rail transit crossings increased safety and led to a reduction of 26% of vehicles crossing the tracks during the slight delay between two consecutive trains. In Groton, Connecticut, a four-quadrant gate with automatic train stop system was deployed in 2001. The system included four-quadrant gates to deter vehicles from attempting to cross as trains approached, and six inductive loop vehicle detectors to pick up track obstructions. This is tied to an in-cab signaling system for the train engineer and an automated stopping system. The entire system cost $977,000.

Roadway Operations and Maintenance: Traveler mobility was benefited in Albuquerque, New Mexico when the implementation of motorist assistance patrols and temporary traffic management reduced average incident clearance times by 44% during a major freeway construction project. MDOT spent $2.4 million in 2001 to construct a temporary traffic management system (TTMS) for a downtown Lansing project. The system included 17 CCTVs and 12 DMSs.

Road Weather Management for Washington State DOT (WSDOT): WSDOT installed a system in the rural region of Spokane to collect and share weather and road conditions, border crossing status, and other relevant information to commercial truck drivers, the public, and WSDOT maintenance. Nearly 95% of surveyed users agreed the information helped them avoid travel delays. Their system cost approximately $200,000 for environmental sensor stations (ESS) and HARs.

Commercial Vehicle Operations: Three motor carriers surveyed during the Commercial Vehicle Information System and Network (CVISN) model deployment indicated that electronic credentialing reduced paperwork and saved them and average of 68% on credentialing costs, increasing productivity. In addition, motor carriers were able to commission new vehicles 60% faster by printing their own paperwork and not being restricted to conventional mail delivery. This CVISN system cost Kentucky $935,906 and Maryland $464,802.

Intermodal Freight: To improve efficiency and productivity in Chicago, Illinois and New York, New York, an electronic supply chain system implemented smart-card devices to automate manual paper-based cargo data transfers. The time required for airports to accept deliveries reduced by 3 minutes per shipment, and was reduced by 4 minutes per shipment for manufacture received cargo. Another way to track fleet trailer cargo would be by integrated global positioning systems (GPS), which cost about $800 per trailer (RITA 2007).

NaviGAtor: As previously mentioned, the ITS systems are constructed, operated, and managed at the state DOT level. Georgia was one state involved in the ITS conception. Their system, operated and maintained by the Georgia Department of Transportation (GDOT), is known as the NaviGAtor, and was first operational in 1996. The majority of the devices cover over 153 centerline miles of Atlanta's metro freeway system. The transportation mission statement of NaviGAtor is: *The Transportation Management Center is committed to enhancing travel safety and transportation efficiency by managing incidents, controlling traffic, and providing accurate information to the traveling public* (GDOT 2008).

Table 17: Components of NaviGAtor

Components of NaviGAtor	Number of Components
CCTV Cameras	341
Ramp Detectors	9
VDS Cameras	1361
Radar Detectors	46
Changeable message Signs (CMS)	97
Weather Stations	48
HEROs (GADOT's equivalent to TDOT HELP trucks)	48
Transportation Management Center (TMC): Mission Statement:	1

In a study conducted in 2005, GDOT quantified the incidents attributable to the NaviGAtor management program. Quantified were the benefits related to incident delay savings, reduced fuel consumption, improved air quality, reduced secondary crashes, and motorist assistance. Results revealed that the average duration of an incident without NaviGAtor lasted 67 minutes; while with the aid of the ITS system, the overall duration was reduced by an average of 21 minutes.

The following is a synopsis of the annual benefits derived from Georgia's NaviGAtor system's incident management program between May 2003 and April 2004:

SAFETY: 467 secondary crashes eliminated per year;
MOBILITY: 7,254,495 vehicle-hours of incident-delay eliminated per year;
CUSTOMER SATISFACTION: 49,051 motorist assists provided to travelers per year;
ENVIRONMENTAL: 2,904.91 tons of emissions eliminated per year and 6,830,625 gallons of fuel saved per year
BENEFIT/COST RATIO: 4:1; $187,232,045(benefit savings)/ $42,552,737.50 (construction cost) = 4.4:1 ratio for one year (GDOT 2008)

Table 18: NaviGAtor Environmental Impact

Emission Reduced	Amount (tons/year)
Hydrocarbon (HC)	186.27
Carbon Monoxide (CO)	2,457.01
Nitrous Oxide (NOx)	261.63
Fuel Saved	**Amount (gallons/year)**
Leaded/Unleaded	5,172,455
Diesel	1,658,170

Table 19: NaviGAtor Benefits and Costs

Benefit Measure	Annual Cost Savings
Incident Delay Savings	$152,053,180
Reduced Emissions	$20,243,009
Reduced Fuel Consumption	$10,365,969
Reduced Secondary Crashes	$1,614,564
Motorist Assistance	$2,955,323
TOTAL	**$187,232,045**

Recommendations

TDOT has developed and implemented an ITS called "TDOT SmartWay." There are nine components of Tennessee's SmartWay: Roadway Traffic Sensors, Camera Video Surveillance, Dynamic Message Signs, HELP Freeway Service Patrols, Transportation Management Centers, Incident Management, Construction Information, TDOT SmartWay Information System, and

Information on Weather-Related Road Conditions. Tennessee should consider further improvements to its SmartWay (Pechan, et al. 2008).

For example, Maryland is currently considering a Transportation Technologies option that includes ITS management as a part of their mitigation strategy (MCCC 2008). Maryland's option contains a list of transportation system management policies to develop, refine, and implement, which include:

1) Active traffic management: The real-time variable control of speed, lane movement, and traveler information within a corridor can improve traffic flow in the corridors where it is applied.

2) Traffic management center(s): Provides centralized data collection, analysis, and real-time management of the transportation system. System management decisions are based on in-road detectors, video monitoring, trend analysis, and incident detection.

3) Traffic signal synchronization: The timing and operations of the traffic signal operations are synchronized to provide an efficient flow or prioritization of traffic, increasing the efficient operations of the corridor and reducing unwarranted idling at intersections. The system can also provide priority for transit and emergency vehicles.

4) Managed lanes and dynamic roadway and full corridor pricing: Managed lanes are lane(s) which have special operational characteristics and restrictions that are intended to manage the operations of the lane(s). Management of the facility is typically a combination of physical design, which limits access and regulation, and may include pricing.

5) Smart parking systems.

6) Bus signal priority.

TDOT should optimize the timing of individual traffic signals and coordinating control of traffic signals along a corridor or network. Many jurisdictions do not routinely update or optimize their traffic signal timing or have not implemented adaptive coordination systems. One source estimates that over 75 percent of the 260,000 traffic signals in the U.S. could be improved by updating equipment or by simply adjusting and updating the timing plans. In addition to working to optimize signal systems under TDOT control, TDOT could provide a set-aside of state transportation funding granted to local jurisdictions for the purposes of signal timing and coordination, and/or support regional management and operations committees that jointly set coordination policies and advocate jurisdictional coordination (Pechan, et al. 2008).

Although ITS is expensive, the investment pays big dividends. Effective and efficient communication of information is vital. Therefore, we recommend TDOT continue to support and expand the ITS program.

WETLAND AND STREAM MITIGATION STRATEGIES

$$ to $$$

Introduction

As long as TDOT continues constructing and maintaining transportation infrastructure, wetland and stream mitigation will continue to be a prominent consideration for the transportation sector. Proposed transportation improvements traversing wetlands and streams must comply with permitting requirements of the Clean Water Act Section 404 (33 U.S.C. § 1344, 2002). In addition to federal requirements, the Tennessee Water Control Quality Act of 1977 considers streams and wetlands "waters of the state," and other state permitting requirements must be met before certain ground disturbing activities commence (Tenn. Code Ann. § 69-3-108(b), 2000). The following describes the present TDOT processes of stream and wetland compensatory mitigation then mitigation strategies are proposed for consideration.

Current Practices

TDOT is committed to compliance with state and federal statutes for the protection of wetlands and water resources. And TDOT will provide off-setting compensation for any permanent loss to water resources that might occur in the course of project implementation.

Mitigation refers to an action done to lessen the severity of another action. As it pertains to wetlands and streams, mitigation takes the form of an ecological benefit. Mitigation is performed with the intent of offsetting unavoidable alterations and damage to wetlands and streams due to construction impacts, and to compensate for any permanent loss.

Present Mitigation Planning: The planning of proposed transportation projects begins when TDOT recognizes the need for a transportation improvement. Depending upon the project scope, public impact of the proposed project is formally studied by the TDOT Planning Division, and sometimes the TDOT Long Range Planning Division will study the project. Standardized procedures to determine the required scope of environmental study for a given project have been adopted and are found in the *Tennessee Environmental Procedures Manual* (TDOT 2007)

The TDOT Planning Division produces the Transportation Planning Report (TPR). Among other topics covered in the TPR, a very preliminary examination of unavoidable environmental impacts is documented. Following TPR development, an in depth environmental impact study is documented by the TDOT Environmental Division NEPA Documentation Office. This office is responsible for preparation of the National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) report (TDOT 2007).

Present Mitigation Permitting: Following planning document authorization, the TDOT Environmental Division Natural Resources Office is responsible for initially preparing the project Ecology Report, which is forwarded to the NEPA Documentation Office to prepare the project Environmental Assessment (EA), EIS, or Categorical Exclusion (CE). Following further

project development, the Natural Resources Office reviews the project once again and prepares the Environmental Boundaries Mitigation Design (EBMD) document. The EBMD identifies and quantifies wetlands and streams impacted along the site prior to construction, and makes further mitigation design recommendations (Williams 2008).

Many permits must be issued prior to contract letting of a transportation project, but where wetland and stream mitigation is required, two specific environmental permits must include the proposed mitigation design. These permits are the 404 Permit and the Aquatic Resource Alteration Permit (ARAP).

The U.S. Army Corps of Engineers has authority to administer wetland and stream mitigation on behalf of the Federal government. The Corps issues what is commonly known as a 404 Permit to authorize this mitigation. The term 404 refers to Section 404 of the Clean Water Act (CWA), which among other things, designates the Corps responsible for issuing permits authorizing construction fill placement upon wetlands or stream altering operations (33 U.S.C. § 1344, 2006).

In addition to permit requirements imposed by the Corps, wetland and stream mitigation also requires an Aquatic Resource Alteration Permit (ARAP). The ARAP is issued by Tennessee Department of Environment and Conservation (TDEC) and the state's requirements are more stringent than federal regulations; therefore, an ARAP may be required even where a federal 404 permit might not. An ARAP permit is required for projects physically altering surface waters of the state (T.C.A. §69-3-108, 2000). Nevertheless, TDEC and the Corps must come to an agreement on the project mitigation design.

Recommendations

Staff Consistency: For a variety of reasons, the environmental compliance regulatory agencies have experienced turnover in the past. Retaining a qualified environmental staff long-term would pay dividends.

The transportation planning, development, and design process is a long and deliberate effort. In the period of time taken to push a single project from planning to contract letting, it is common for several different ecologists, from multiple agencies, to have worked on that same project. The decisions made by these individual professionals during the ecological design may be qualitative and subjective, or based on definitions and regulations that have changed. For a variety of reasons the project ecology could actually change during the time duration of the project, or regulations change how resource features are defined and / or regulated. If an ecological project decision is modified by the current project ecological professional, the project schedule is delayed or at least tightened. Modifications to the ecological project report can increase total design costs.

Ecological Review: Greater emphasis should be placed on identifying streams and wetlands while developing the initial ecology report. Proposed easement designs required for streams and wetlands mitigation are less standardized than easement designs prepared by the Design Division for proposed rights-of-way.

Collaboration between the Environmental Division and the Design Division should occur during earlier stages of the Program/Project/Resource Management System (PPRM) schedule. Potential mitigation design strategies should be discussed earlier in the project schedule. This collaboration could delay holding the Right-Of-Way (ROW) field review, but the overall project schedule should prove to be more realistic.

EBMD Submittal: Presently, streams and wetlands are identified in the ecology report (PPRM Activity 210). More detailed studies are conducted and impacted quantities are determined in the Environmental Boundaries Mitigation Design (EBMD) document. Oftentimes, the EBMD document submittal to the Design Division occurs after the ROW Field Review, finalization of ROW Plans, or distribution of final ROW Plans' PPRM milestones.

If the EBMD is submitted following the distribution of final ROW Plans, and the mitigation design requires additional property acquisition, then extensive Design Division person-hours are required to modify the ROW plans, and a ROW Revision submittal is necessary. The additional property must be acquired in the form of an S-tract, requiring more costly site visits and further negotiation between the ROW Division and the landowner. Furthermore, TDOT could appear ill-prepared to the landowner by seeking additional property. Unfortunately, ROW revisions cannot be entirely eliminated. Revisions could, in this particular type case, be minimized if the mitigation design and acquisition processes were more closely aligned. Moreover, the present PPRM process should strictly followed at all times.

It is worthy of note, a number of these issues are discussed in the Tennessee Environmental Streamlining Agreement (TESA). Further information on TESA is available at http://www.tdot.state.tn.us/tesa/default.htm (Williams 2008).

Mitigated Area Reduction Strategies

Alignment Shift: New alignments should carefully be considered during the NEPA document phase. Certain elements of the TDOT Context Sensitive Solutions program, such as allowing the local leadership and the public decide the location of the improvement, is sometimes in conflict with the Clean Water Act Section 404's documented goal of no wetlands net loss.

Existing roadway alignments that follow the path of streams are frequently in need of improvement or repair. Shifting the proposed alignment centerline further from the existing stream, and into a flood bank, adds green value through minimizing the impact to the stream or wetland. This alignment shift causes higher construction costs because of greater cut volume and/or the need for earth retaining structures.

Retaining Walls and Reinforced Soil Slopes: Increasing the steepness of the side slope of a fill section is a direct approach to reducing the size of the embankment footprint and minimizing the disturbance of the wetland and stream area. Steep side slopes are generally not designed for use on new highways because of high maintenance costs and safety issues. Guardrail is generally required on slopes steeper than 3:1. If project requirements are to minimize environmental

impact at any and all costs, retaining walls and reinforced soil slopes would be an alternative to consider.

Wetland Banking Strategies

New regulations have stated a preference for wetland banks. Therefore, TDOT should be proactive and acquire sites to develop wetland banks.

The U.S. Army Corps of Engineers and the Environmental Protection Agency (EPA) have issued regulations governing compensatory mitigation for activities authorized by 404 Permits issued by the Department of the Army. The new mitigation regulations went into provisionary effect June 9, 2008 (33 CFR § 325 and 332, 40 CFR § 230 (2008)).

The regulations establish a preference hierarchy for mitigation options, and the preferred option is mitigation bank credits. The credits are ideally in place before the activity is permitted. In-lieu fee program credits are the second preferred mitigation option, while permittee-responsible mitigation is the third preferred option (33 CFR § 325 and 332, 40 CFR § 230 (2008)). Permittee-responsible mitigation is defined as the owner of the permit is responsible for carrying out the success of the mitigation, where success is generally determined by a governmental agency.

Although costly, there is merit in discouraging permittee-responsible mitigation in favor of mitigation banking. There are common problems inherent in implementing a wetland or stream mitigation project. Tree planting appears to be a common form of restoration, establishment, and enhancement mitigation. The thriving trees receive much competition from other native tree species. Cultivation for the desired tree plantings should consist of appropriate mowing and practical design. Cultivation by means of herbicides can be successful, but there are many seasonal limitations. Drought conditions will hinder desired tree plantings. Beaver dams may inundate the site and prevent the growth of the desired trees. Oftentimes, the desired trees and seedlings are destroyed by wildlife as food forage (Timms 2008).

Stream Mitigation Strategies

Enhance Streams on Existing Rights-of-Way (ROW): TDOT should consider restoring and enhancing the aquatic resources available in degraded roadside streams, adjacent to many isolated low-volume state roads. This restoration and enhancement could be applied in exchange for environmental resource credits from TDEC. This would require an ecological study to identify the locations of degraded streams.

Enhance Streams Beyond ROW: TDOT should consider restoring and enhancing the aquatic resources available in degraded streams that are beyond but adjacent to the state ROW in exchange for environmental resource credits from TDEC. TDOT routinely provides stream mitigation enhancements for bridge replacement projects right up to the state ROW. Beyond the ROW, the stream sometimes reverts to a degraded state (Smith 2008). As the ROW Division office is required to approach the landowner to acquire proposed ROW, the acquisition of proposed stream mitigation could be accomplished concurrently.

Mitigation and Governing

Eminent Domain Condemnation: TDOT's Legal Division should continue monitoring the judicial outcomes of mitigation eminent domain condemnation proceedings. It does not appear TDOT has placed, or will ever place, priority on acquiring mitigation sites through eminent domain condemnation. The majority of wetland mitigation properties have been standard, bargained-for-exchange real estate transactions between the landowner and the state. (Williams 2008).

Recently, a study in Middle Tennessee was conducted that located sites which were conducive to wetland mitigation. Fifteen sites were identified, but none of the landowners were interested in converting their cultivated property into wetland (Williams 2008). It should be noted that in summer 2008, there was a heavy market demand for agricultural commodities.

The New Compensatory Mitigation Regulations: TDOT should persuade TDEC to continue allowing existing compensatory permittee-responsible mitigation through restoration, enhancement, and establishment. The Compensatory Mitigation for Losses of Aquatic Resources statute went into effect June 9, 2008. The rule establishes a documented preference for mitigation bank credits, then in-lieu fee program credits, then finally permittee-responsible compensation (33 CFR § 325 and 332, 40 CFR § 230 (2008)). Most TDOT responsible mitigation is permittee-responsible type mitigation. If enforced on the state level as the most recent Corps and EPA mitigation regulations appear to imply, this rule will surely create an increased demand for mitigation bank credits. An increased demand for wetland bank credits, without creating an accompanying increased supply of wetland banks, could likely cause a dramatic increase in wetland mitigation costs in the future.

STORMWATER BIORETENTION DESIGNS

$$ to $$$

Introduction

Stormwater runoff occurs when precipitation flows over the land or other surfaces, such as pavements, rather than soaking into the ground. This can be a problem because the runoff can pick up debris, chemicals and other pollutants as it flows into the storm sewer system. Most storm sewer systems do not have mechanisms for treating the runoff, thus anything entering the system will flow into the natural water sources.

Urban and suburban runoff is the second most prevalent source of water quality impairment in the nation's estuaries and the fourth most prevalent source of impairment in lakes (NRDC 2001). The polluted stormwater can have many adverse effects including ecological damage and public health hazards (Lehner, Cameron, and Frank 1999). Communities are beginning to recognize this runoff issue as critical. One way that TDOT can take action to control runoff is by using stormwater management measures such as bioretention.

Bioretention is a practice which utilizes soil and plants to remove pollutants from stormwater runoff (EPA 1999). Methods include vegetated swales or basins and stormwater planters. Bioretention can reduce some of the adverse effects as well as enhance communities (New Jersey EPD 2004). Many designs and retrofits are geared toward low impact development (LID) approaches.

LID is the culmination of all our thinking about how to modify the nature of development in order to maintain natural ecological function (Hager 2003). In other words, LID is a means to manage stormwater to reduce impacts on ecology, the environment and the community.

TDOT can take advantage of some of these methods to control runoff at select sites. Little space is needed, making LID well suited for urban and suburban areas (Stormwater 2008).

Current Practices

One example of bioretention is a simple stormwater planter used to capture pavement runoff. The city of Portland, Oregon used this idea in its first "Green Street Project." Planters were used to capture runoff from approximately 7,500 square feet of roadway pavement. This allowed for treatment and filtration of the water. The project construction cost was approximately $39,000. Thus, with limited spending, the city was able to reduce peak flows by at least 70%, increase water quality and add aesthetically pleasing elements to the streetscape. Please see below a photograph illustrating the Green Street Project (Portland Bureau of Environmental Services 2008).

Figure 8: Portland Green Street Project

Like Portland, Fairfax County, Virginia has been a leader in promoting better stormwater management. At the Mount Vernon Recreation Center site, they constructed vegetated swales and bioretention basins with underground storage to alleviate flooding and decrease phosphorus concentration in the runoff. Please see below photographs illustrating Fairfax County's efforts (Fairfax County 2006).

Figure 9: Fairfax County bioretention basins with underground storage

Fairfax County provides a great example of what organizations can do to protect the environment and has been recognized and awarded by the U.S. Environmental Protection Agency (EPA) for its efforts (Wasteworld Online 2007).

Benefits & Costs

The design or retrofitting of selected stormwater systems to better manage runoff, specifically, by means of bioretention could benefit TDOT both economically and environmentally. The cost of LID projects are site specific, but case studies and pilot programs are proving at least a 25% reduction in costs for site development, stormwater fees and maintenance for residential development (Urban Design Tools 2008).

Recommendations

Bioretention measures to treat runoff from about 0.5 acre costs approximately $6,500. Potential pollutant removal rates are approximately 90% for total suspended solids, organics and bacteria and at least 70% for phosphorus (EPA 1999). Removing these amounts of pollutants is important for the quality of our lakes and streams. Phosphorus is a concern because it promotes weed and algae growth. Aquatic plants and algae produce oxygen (O_2) during the day and consume it at night. Generally, O_2 production exceeds consumption. Only under conditions where an algae bloom is excessive, due to organic enrichment of the water, and then dies off suddenly or if day-time temperatures are so high that the O_2 carrying capacity of the water is decreased is this a problem. Bacteria can cause public health hazards. Bacteria counts from urban runoff are up to 40 times higher than the health standard for swimming (City of Waupan 2008).

Using bioretention to better manage runoff can be simple, yet very effective. The citizens of Tennessee are becoming more environmentally aware and it is recommended that a sustainable approach to stormwater management would be a step in the right direction for TDOT. These strategies can help improve water quality, reduce public health hazards and enhance communities.

CONCLUSION

The concepts presented in this report are not new, but there is a new urgency to sustainable transportation and sustainable funding for transportation. Based on this study of challenges and solutions, we have arrived at some conclusions that we believe to be fundamental truths.

We cannot build our way out of congestion. There is a synergy between financial savings and environmental protection through energy efficiency policies. Multi-modal options and intelligent transportation systems (ITS) are vital to effective traffic management, while congestion pricing and incorporating the full cost of transportation into the market are key elements in reducing travel demand.

No one strategy will provide a sustainable transportation system. The strategies outlined in this report will work best if applied together. And all strategies should be viewed in the context of land use planning and public behavior influenced by market dynamics. For example, if public transit (e.g., commuter rail or public bus) is going to be a viable option then we must encourage transit oriented density (TOD) in our land use planning. Intelligent transportation systems are powerful tools; however, operational needs must drive the deployment of technology.

Innovative financing must be a reality if we are going to maintain a safe and efficient transportation network. Public-private partnerships and tolling are examples of innovative financing strategies that must be explored during this era of limited funding and growing needs if we are going to continue funding capital transportation projects and existing transportation infrastructure maintenance because the fuel-tax model alone is not a sustainable funding source.

We recommend that TDOT establish a sustainable transportation initiative and build a comprehensive program that puts TDOT in a position to lead by example in the following areas:

1) Facilitating energy efficiency, with a focus on building management and vehicle fleet management;
2) Identifying planning policies and potential legislation that supports Smart Growth;
3) Researching opportunities for innovative transportation financing and public-private partnerships that support environmental and financial stewardship of public resources;
4) Promoting internal and external environmental awareness; and
5) Encouraging the continuation of the successful strategies (e.g., alternative fuels, electronic data management, etc.) that are already underway at TDOT.

The first step toward a comprehensive sustainable transportation strategy would be an endorsement of these goals by senior management. The next step would be to refine our objectives and identify the various stakeholders in the process. We would then need to benchmark our current status in these areas. Then we need to develop an implementation strategy and track our progress toward the goals.

There could be a variety of ways to organize a comprehensive, sustainable transportation initiative. The program could be organized as a standing committee with representatives from each of TDOT's major program areas. Another option might be to establish the initiative within

the Office of Strategic Planning or a special program in the Commissioner's Office with oversight by the Bureau Chiefs.

Making the choice to have a sustainable transportation system will require more courage and political capital than monetary capital. However, choosing between a sustainable transportation system and a crumbling network is not really a choice; it is an imperative action and true leadership requires some risk and the investment of political capital. Change does not happen without leadership and we need leaders within this agency to champion the concept of sustainable transportation and facilitate a paradigm shift. Ultimately, if we want our budget to remain in the black then we must think green!

APPENDICES

Appendix A: TDOT Building Energy Management

Potential Action Areas for TDOT's Existing buildings

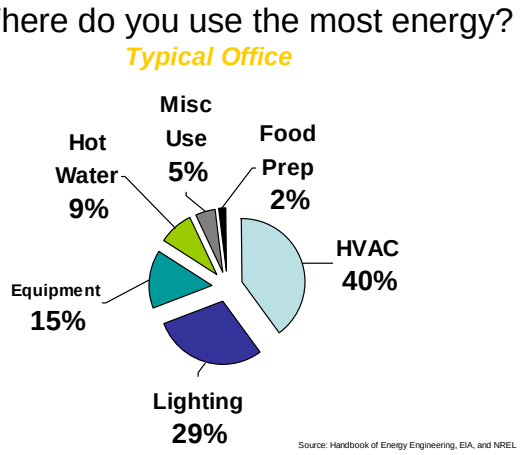
Most energy managers like to start by fine-tuning their existing building system to get the most out of it that they can. For a minimal cost, we can improve TDOT buildings operation and maintenance program and tune up the boilers and HVAC equipment to save energy consumption and cost.

In general, the estimated costs of no-cost/low-cost energy saving improvements is about 25% of the annual savings for implementation and maintenance, so out investment would show an immediate payback in savings (E Source, 2006).

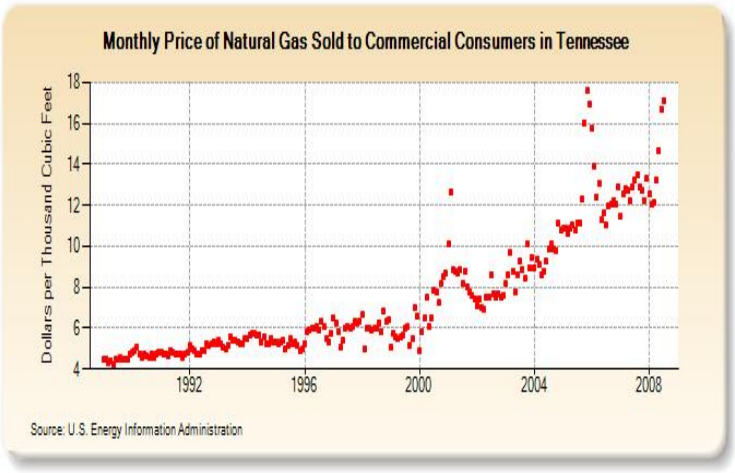
Continued savings from better preventive maintenance and no-cost/low-cost improvements is dependent upon long-term interest in monitoring of the programs. Savings will be lost if maintenance and vigilance is allowed to slip over time.

After our no-cost/low-cost energy management program is in place and running smoothly, we might start planning projects that will require capital investment, but will yield substantial energy savings. By investing in energy conservation measures with simple paybacks less than five years, we can expect to save 15-40% of our base energy use (E Source 2006).

In a typical office environment, the energy consumption is broken down in the following manner:



In addition to rising electric costs discussed earlier in this report, natural gas prices are also climbing.



TDOT Buildings Profile Development for Energy Efficiency Program

- Identify and group building facilities of similar size to which a template or suite of energy efficiency opportunities might apply.
- By using 80/20 rule, identify the top 20 percent of buildings that consume 80 percent of the energy. Then next step would be to identify other buildings that consume most energy.
- Benchmarking of buildings with higher energy use.
- Metering technologies to help in identifying the equipment in the buildings that need to be looked at in terms of high energy consumption
- Development of energy use database.

The database would allow the grouping of facilities by size, function, location, intensity and other practical information. Being able to group or sort these facilities by category expedites evaluations including energy savings opportunities, asset preservation activities, sustainable and others.

Key Buildings Audit to identify energy efficiency opportunities

Perform preliminary or walk-through audits of key facilities in groups that are functionally similar. Perform Energy Survey of ten percent of total TDOT covered buildings with higher EUI on annual basis to include the followings:

- Overall building information
- Information on major energy-using building equipment
- Types of equipment contained in the building
- Energy consumption and billing data
- Building operating schedule hours
- Thermostat set-points
- Lighting levels
- Type of HVAC system

- Outside wall/roof exposure
- Energy intensity (Btu/Square foot)

Efficient Energy Management Implementation
The first step in improving energy efficiency is to understand of where, how, and how much energy is used. Accurate information is the foundation of effective management. And it is important to understand how much energy is consumed at the individual building-level, at the campus-level, and at the agency-level (i.e., TDOT).

Once energy use is benchmarked and energy use patterns are tracked then TDOT will be in a position to implement efficient energy management strategies. The following outline illustrates the variety of opportunities that TDOT has to implement efficient energy management strategies throughout the department.

The most common energy conservation opportunity found in existing commercial buildings falls into the following nine categories:

- **Building Envelope**

Energy is saved when the heat exchange between the building and the outside environment is reduced and/or sun light heat and internal heat gains are controlled. The following project ideas on energy savings TDOT can initiate:

1. Reduce heat conduction through ceilings and roofs
2. Reduce solar heat gain through roofs
3. Reduce heat conduction through walls
4. Reduce heat conduction through floors
5. Control solar heat gain through glazing areas
6. Reduce infiltration

- **Building Operation**

An enormous amount of energy is wasted because building equipment is operated improperly and unnecessarily. When the building is not occupied, the building systems should be turned off or their operation reduced to a minimum. Depending on building operations, the following systems' operating hours can be curtailed during slack hours:

HVAC Systems

Energy may be saved in HVAC systems by reducing ventilation requirements, improving the performance of space conditioning equipment such as boilers, furnaces, chillers, air conditioners, and heat pumps; using energy-efficient cooling systems; and reducing the occurrence of reheating or re-cooling.

1. HVAC Systems Ventilation
2. Improve chiller efficiency

3. Improve AC or Heat Pump Efficiency
4. Reduce energy used for Tempering supply air
5. Use energy-efficient cooling systems

HVAC Distribution Systems Energy Loss

Energy conservation opportunities for distribution systems fall into two areas: reduction of energy required to transport fluids and reduction of energy losses during transport.

1. Reduce System Flow Rates
2. Reduce System Resistance

Water Heating Systems

In, general, heating and distribution of hot water consumes less energy than space conditioning and lighting. Water heating energy is conserved by reducing load requirements, reducing distribution losses, and improving the efficiency of the water heating systems.

1. Reduce Hot Water Loads
2. Reduce Hot Water Heating System Losses
3. Use Energy-Efficient Water Heating Systems

Lighting Systems

In general, lighting accounts for a significant portion of electrical energy consumed in a building. Energy is saved and electric demand is reduced by reducing illumination levels, improving lighting system efficiency, curtailing operating hours, and using day-lighting. Reduction of lighting energy can also increase the energy use of building heating and decrease cooling system consumption, since internal heat gains are reduced.

However, this heat-of-light is often a relatively expensive method of heating a building. If the building cooling is to be replaced, implementation of energy conservation opportunities for lights could allow for a smaller cooling unit.

1. Reduce Illumination Requirements
2. Install Energy-Efficient Lighting Systems
3. Use Day lighting

Power Energy Load Management Systems

The inefficient operation of power systems stems mainly from a low power factor. Low power factor can be improved with power factor correction devices and high-efficiency motors. Additional energy can be saved by installing energy-efficient transformers and replacing existing motors with small and higher efficiency-motors or by installing variable-speed motor drives.

Evaluation of these energy conservation opportunities requires a determination of the building

demand profile. Several weeks of data in 15-minute intervals should be taken with energy measurement meter. These measurements need to be taken both in the cooling and heating season.

1. Reduce Peak Power Demand
2. Install Energy-Efficient Motors

- **Information Technology Systems**

As we see a tremendous increase in use of digital technologies, the energy consumption in buildings has been rising too. The Energy Star has provided guidelines to conserve energy. The biggest savings can be achieved by buying energy-efficient computers and servers.

1. Energy Star compliant equipment inventory
2. Centralized PC power management strategy
3. Data center/server assessment for energy- efficient operation

- **Water Conservation**

This is one of the most neglected parts of building operation in terms of savings. There is a misconception that water is a part of energy. This causes neglect in savings water. There are simple steps that can be used to conserve water in the buildings. These are:

1. Public Information and Education Programs
2. Distribution System Audits, Leak Detection Repair
3. Water Efficient Landscape
4. Toilets and Urinals (including waterless)
5. Faucets and Showerheads
6. Single-Pass Cooling Systems
7. Miscellaneous High Water-Using Processes
8. Water Reuse and Recycling

- **New Energy Savings Technology Applications**

Due to increase in costs of tradition energy fuels and electricity, there is a big trend in using renewable energy sources to offset the energy costs. Nevertheless, these are still costly in terms of financial payback. However, as we progress in new technologies, we will see more energy savings applications in building.

1. Solar power
2. Wind Power
3. Geothermal Heat

TDOT Building Energy Management Implementation Plan

Areas of Assessment	TDOT Actions Needed
Energy Management Accountability	
Energy Policy	Building energy policy to be developed and communicated to all the employees
Energy Manager	Energy Manager position (F-T or P-T) to be established
Regional Energy Manager	Regional facility manager position to be strengthened to emphasize energy management
Site Facility Manager	Closely work with Regional Facility Managers
Energy Management Team	Cross-functional team to be developed in TDOT
Energy management Plan	To be developed in line with TDOT business plan
Energy Cost Accountability	Establish energy management accountability assignment in TDOT
Energy Purchase Policy and Plan	The policy is in place but needs to be strengthened and monitored
Energy Efficiency Awareness Plan	The energy manager with the help from energy management team to develop energy awareness plan
Energy Efficiency Communication	Establish energy efficiency communication plan with the help from TDOT Communication Division
Energy Efficiency Recognition	Establish a recognition plan as TDOT initiates and implements energy management plan
Energy Performance Goals/Objectives	
Goals or Potential Goals	TDOT to develop energy savings goal in line with Governor's energy savings goal
Energy Costs Priorities-Urgency	Energy manager with the help from TDOT management to develop cost reduction priorities
Cost Savings Culture	TDOT to develop education and awareness program for energy cost savings and broadcast often to employees
Energy Management Training	One day course to be developed for energy management program at TDOT
Incentives for Energy savings Idea	Incentives plan need to be developed as we progress on energy management at TDOT
Return on Investment mentality	Yes we have ROI mentality but only at the highest level of TDOT organization. It needs to be expanded to the lower level employees
Measurement of Results	Performance measurement to be devised and monitored

Energy Consumption Management	
Tracking of energy use	Initially use a basic tool to keep track of energy use on a monthly basis for all the TDOT buildings. TDOT can use software that other state agencies would use once approved for use. Hopefully this software can be integrated with Edison.
Energy use Benchmarking	TDOT could use Energy Star Portfolio Manager to assess building energy efficiency for all the TDOT buildings
Energy management Assessment	Energy Audit for buildings that do not have EMS should be conducted. The focus should depend on the nature of the building and potential energy savings. TDOT might need to use outside energy professional companies and TDOT can assign some personnel to work with them.
Energy use Metering and Sub-metering	For larger buildings w/out EMS, metering and sub-metering of equipment installed should be performed to determine energy consumption. Details will be developed once we start working on energy management program
Best Practice Applications	Research and evaluate best practices in energy savings in other Tennessee state agencies or transportation agencies of other states to apply at TDOT
Facility Energy Management O&M	
Management Structure to support	Energy management structure should be improved for better accountability
Documentation and drawings	We have documents but not in a way that could be used effectively
Energy Consuming devices Documentation	There is a need for documenting energy consuming equipment listing for each TDOT buildings
Categorizations of Building Types	We have this but needs to be improved for better utilization for various analytical work
Availability of energy Measuring tools	TDOT should allocate some funding to buy basic energy management tools
Requirement of energy use (estimate)	Energy management Team should develop an estimate of energy use for each building
Measurement of actual energy use	Use metering technology or use existing meter to track actual energy use
Understanding of Potential savings	Energy management team should develop a rough estimate of potential energy savings after energy audit
Operation and Maintenance Procedures	Energy management team could develop a simple operation and maintenance guide for each building depending on the size and its existing equipment in the building
Walk through energy audit	Walk through audit need be done once a year
Recognition of Intangible benefits	Energy management team could focus on intangible benefits of a better managed building in terms of energy use and comfort environment
Alternative energy options	As new energy technology is available, the energy team could keep in mind for its application, if possible, in terms of energy savings and comfort
Facility Maintenance and Operation Contracts	The facility maintenance contract might be reviewed often and modified for its better controls

Appendix B: Fun Facts

1) According to the U.S. Department of Energy, the United States consumes on average 390 million gallons of gasoline per day (http://www.eia.doe.gov/basics/quickoil.html). This equates to one hundred forty two billion, three hundred fifty million gallons of gasoline per year (142,350,000,000 gallons/year). This staggering level of consumption does not include diesel or other petroleum products.

2) According to calculations based on U.S. Department of Energy data, the 125,000 BTU energy content of 1 gallon of typical, regular, unleaded gasoline is equivalent to 500 human hours of agricultural type work.

3) According to a year 2000 report (http://www.bts.gov/) by the U.S. Department of Transportation, Bureau of Transportation Statistics, data shows Tennessee ranked number one in the nation for tons of domestic shipments at 135,281 thousand short tons, with a 1997 value of $47.3 million.

4) According to Nashville MTA, a standard public bus sits 56 people and the local, one-way fare is $1.60.

5) According to recent estimates, there are over 1 billion personal computers in use worldwide today; a number that would have been unimaginable just 20 years ago. This massive growth in computer sales translates to an equally substantial growth in the number of unwanted computers. Until recently, donating or discarding your old systems were the only options. However, a more comprehensive electronics recycling industry has developed in response to the market demand in the last few years.

6) According to the Michigan Office of Waste Reduction Services, typical business offices generate about 1.5 pounds of waste paper per employee per day.

7) According to the Wisconsin Department of Natural Resources, in the United States, we use enough office paper each year to build a 10-foot-high wall that's 6,815 miles long, or two and a half times the distance from New York to Los Angeles.

8) According to the City of Knoxville's Task Force on Energy and Sustainability, the City of Knoxville's government spends $9.7 million a year on energy, burns through more than 2.4 million gallons of gasoline and diesel fuel, and produces more than 75,000 tons of carbon dioxide emissions and 2.1 million pounds of waste annually.

9) According to the Tennessee Advisory Commission on Intergovernmental Relations, if 20% of Tennessee state employees telecommuted just 1 day a week for 10 months, it would result in 15 million fewer miles driven and reduce carbon monoxide emissions by 142 tons.

10) According to Suffolk County Stormwater Management, stormwater pollution is the number one cause of water pollution in the United States.

11) In August 2008, Americans drove 15 billion fewer miles, or 5.6 percent less, than they did in August 2007 – the largest ever year-to-year decline recorded in a single month, Secretary Peters said. She added that over the past 10 months, Americans have driven 78 billion fewer miles than they did in the same 10 months the previous year. Texans alone drove 1.3 million fewer miles, the Secretary added. Transit ridership, meanwhile, saw an increase of 6.2 percent this summer compared to last, said Secretary Peters. In Texas, the DART rail system saw an increase of 15 percent this summer, one of the largest in its 12-year history, she noted.

12) According to the U.S. DOE, Tennessee consumed 390 million Btu of total energy per capita in 2005. This ranks Tennessee 16th in per capita energy consumption in the United States.

13) According to the U.S. DOE, Tennessee consumed 74,910,000 barrels of gasoline in 2006, which does not include other petroleum product consumption. This equals two billion three hundred fifty nine million six hundred sixty five thousand (2,359,665,000) gallons of gasoline in 2006 consumed in Tennessee.

14) Per Commissioner Nicely on September 26, 2008, even though gas prices have started to decline as it has become more available in the last few days, the cost of fuel is still on the minds of consumers and TDOT is a major consumer of petroleum products. In July our fuel cost was $1.25 million dollars. Our on and off-road vehicles consumed over 145,000 gallons of gasoline and 170,242 gallons of diesel.

15) According to the Weather Channel website, if all US cars had proper tire pressure it would save 100 M barrels of oil each year.

16) According to the U.S. DOE, Energy Information Administration, low tire pressure wastes over two million gallons of gasoline in the United States every day! Save about a tank of gas a year by keeping your tires properly inflated. And make sure to have your tires correctly aligned to maximize fuel economy.

17) Carrying around an extra 100 pounds in your car reduces your fuel economy by up to two percent. Take with you only what you need and be sure to place luggage inside instead of in the trunk or on the roof to minimize drag and maximize your mileage.

18) Idling for more than 10 seconds uses more gas and emits more global warming pollution than restarting your car! Also, the best way to warm up a car in winter months is to drive it. When the temperature is below freezing, give it 30 seconds—that's all you need.

19) Keeping your engine properly tuned can save you up to 165 gallons of gas per year. Checking spark plugs, oxygen sensors, air filters, hoses and belts are a few examples of maintenance that can result in potential savings of over $400.

20) Thicker than required oil will reduce your gas mileage, because it takes more energy to push through thick oil than it does through thinner oil. Check your owner's manual for the recommended viscosity, and ask for it specifically when you get your oil changed.

21) The following are examples of the economic benefits of integrating multimodal strategies into a sustainable transportation plan and promoting transit oriented density (TOD):
    a) Attracts new business – In the last decade, rail stations in London, Brussels, Philadelphia and Washington D.C. have all been renovated into lively complexes with offices, restaurants, and shops.
    b) Generates sales - Toronto area consumers spent over $56 million on bike accessories and repairs in 1991.
    c) Encourages local circulation of money - In Los Angeles, 80¢ of every $1.00 spent on public transport gets re-circulated in the region, translating into $3.80 in goods and services. Conversely, 85¢ of every $1.00 spent on gas leaves the region.
    d) Stimulates retail trade - Twenty-six studies of “pedestrianization” and traffic calming in Britain and Germany showed a positive effect, with shops inside the “pedestrianized” areas being more successful than those outside.
    e) Offers cost effective services - "Cops on Bikes" programs offer cost-effective police services for many areas, with lower costs and greater flexibility than policing in automobiles.
    f) Encourages high value land use - In Atlanta, $70 billion in apartments, offices and other developments have been built near the rapid transit rail lines.(3) Around Washington D.C. 40% of new building space in the 1980s, worth $3 billion, was built within walking distance of a Metro stop.
    g) Increases productivity - A study on U.S. government spending and its impact on worker productivity estimated that a 10-year $100 billion increase in public transport spending would boost worker output by $521 billion, compared with $237 billion for the same spending on highways.
    h) Reduces transportation costs - A business plan for a videoconferencing network at the BC Ministry of Transportation projects an investment of $977,000 will recover $2,241,500 in travel costs over two years.
    i) Enables economic development - In Montgomery County, MD a study found that if growth continued in the usual pattern, economic development would be stifled by traffic congestion. In contrast, if growth were focused in pedestrian- and bike-friendly clusters along an expanded transit system, and commuter subsidies were revised to discourage car-use, jobs and households could double without exacerbating traffic congestion.
    j) Reduces infrastructure costs - New urban expressways cost up to $100 million per mile while rail and bike facilities cost on average $15 million and $0.1 million.
    k) Creates Jobs - Sustainable transportation offers job creation possibilities in services, high technology, construction, design, manufacturing, maintenance, education, and research. For a more detailed list see our accompanying fact sheet Job Types in Sustainable Transportation (SUSTRAN 1998).

22) According to a year 2000 report by the U.S. Department of Transportation, Bureau of Transportation Statistics, data show Tennessee ranked number one in the nation for tons of domestic shipments at 135,281 thousand short tons, with a 1997 value of $47.3 million.

23) According FHWA, since 1993, truck traffic on urban highways has increased by more than twice as much as passenger traffic.

24) According FHWA, The capacity of the freight rail system has shrunk significantly. Since 1975, ton-miles moved increased by nearly 100 percent, but miles of track have decreased by over 40 percent, even as volume continues to grow.

25) According FHWA, globalization is stressing the already over-burdened port system. From 1990 to 2000, tonnage at U.S. ports increased by approximately 14 percent, while capacity expanded only marginally.

26) According to EPA, long-duration truck and locomotive engine idling is responsible for 11 million tons of CO_2 annually, nationwide. Medium and heavy-duty truck idling is responsible for 35.2 teragrams (35,200 million metric tons) of CO_2 -equivalent emissions. Extended idling therefore makes up 0.03 percent of all U.S. truck emissions.

27) According to the American Public Transit Association (APTA), even with gas prices declining below the September 2008 national average price of gasoline ($3.678 per gallon) a person can achieve an average annual savings of $9,596 per year by taking public transportation instead of driving based on September's gas prices and the average unreserved parking rate according to the APTA's "Transit Savings Report". The report is a monthly analysis that shows the average annual savings represents more than one third more than the average amount a household pays for food in a year ($6,111), according to the Food Institute.

28) An empirical study in Toronto found that an increase in residential units in the downtown area reduced commute trips to the center by 240 trips per work day per 100 units build (Nowland and Stewart 1991).

29) The infill residential developments from 1975 to 1988 reduced one-way peak-hour demand by about 3,000 auto trips and by about 7,800 transit trips, thereby saving considerable public monies that would have been needed for expanding the transportation network. This and other study data are interpreted as evidence that the job and housing balance may help under very congested conditions if densities are sufficient to permit walking and bicycling and are clustered near good-quality transit services (Johnston and Ceerla 1995).

30) Greenwire, 10 October 2008 - The global carbon market is on pace to grow more than 80 percent this year to $116 billion, according to the clean-technology research and analytics firm New Energy Finance.

31) ChinaCSR, 6 October 2008 - China's first national emission trading marketplace, the Tianjin Emissions Exchange, unveiled to the public 50 days after the Beijing Environment Exchange and the Shanghai Environment and Energy Exchange were set up. Analysts say global carbon market will pass $100B by 2008 year's end.

32) On September 30, under the Regional Greenhouse Gas Initiative (RGGI), 59 bidders from the energy, financial and environmental sectors of six states purchased 12.5 million greenhouse gas emission allowances for $3.07 each in a first of its kind allowance auction. The $38.5 million raised will be directed towards the development of renewable and energy efficient technologies. "The first RGGI auction has successfully used market forces to set a price on carbon, and this will send a clear market signal to support the investment in clean energy technologies," said Pete Grannis, commissioner of the New York state Department of Environmental Conservation and RGGI chairman. RGGI is viewed as a possible model for a national program to reduce US emissions of carbon dioxide.

33) On September 30, University of Calgary climate change scientist David Keith announced significant progress in near-commercial technology that captures CO_2 directly from the air. "The thermodynamics suggests that air capture might only be a bit harder than capturing CO_2 from power plants. We are trying to turn that theory into engineering reality," said Keith. Air capture is different from carbon capture and storage (CCS) because with CCS the collection device must be installed next to the emission source and the CO_2 is funneled underground. Instead, the air capture device can capture CO_2 from ambient air in any location. The technology is still in its beginning stages. "It now looks like we could capture CO_2 from the air with an energy demand comparable to that needed for CO_2 capture from conventional power plants, although costs will certainly be higher and there are many pitfalls along the path to commercialization," said Keith.

34) A recent American Planning Association (APA) national survey found that 78 percent of voters believe it is important for Congress to help communities solve problems associated with urban growth and land use.

35) In 1998, TDOT began purchasing flex fuel vehicles that number approximately 1,011 in our current fleet.

36) According to a County and Cities 2006 census survey, 76% of Americans drive to and from work by themselves despite rising gas costs and economy concerns.

37) The state of Tennessee currently has 53.2 miles of interstate high occupancy vehicle lanes located in middle Tennessee. The first high occupancy vehicle lane in the state of Tennessee was built in the Nashville metro area on Interstate 65 in Davidson and Williamson Counties.

38) According to FHWA's 2006 Highway Statistics, nine Southeastern states made up about 25.55 percent of national VMT.

39) The federal government pays eighty percent of the cost for the wildflower program and the state pays the remaining twenty percent. TDOT can plant over 800 acres of wildflowers for a total cost of $28,000 in state funding and this naturalized landscaping is both aesthetically pleasing and reduces mowing costs and related air pollution.

Appendix C: Go Green Suggestions

The TELA Class of 2008 reached out to all TDOT employees for their ideas and suggestions as to how the Department could reach its goal of sustainable transportation. Below are some of the enthusiastic responses we received from our fellow TDOT employees.

1) As an alternative to mowing the right-of-way and medians, TDOT could establish a pilot program to see if growing Switch Grass to be processed as an alternative fuel might be feasible.

2) Because vegetation naturally removes CO_2 from the air, TDOT should consider researching what types of vegetation could be grown in the right-of-way to for carbon sequestering. Federal Highway Administration's (FHWA) Office of Natural and Human Environment is conducting a Carbon Sequestration Pilot Project (CSPP). The goals of the project are to quantify the amount of carbon that can be sequestered using native vegetation management on DOT lands and to estimate the revenue that could be generated through the sale of "carbon credits" on an emissions trading market.

3) The Canadian government is funding hydrogen fuel injection units for school buses to increase fuel mileage and reduce mobile source emissions. These units use a small amount of water, electrolyze it into two atoms of hydrogen and one atom of oxygen then inject it into the vehicle's intake system to reduce the amount of fuel burned. The fuel burns cleaner, with fewer emissions. TDOT should consider installing this technology in our fleet to conserve fuel and reduce emissions.

4) As commuter rail lines are developed, it might be possible to install bicycle lanes adjacent to the railroad tracks to facilitate bicycle commuting.

5) Supporting alternative transportation simultaneously advance economic development and environmental quality; therefore, the multimodal program should continue to be a high priority area for TDOT.

6) We need more detailed, proactive information delivered to commuters in a timely and tailor-made fashion. For example we should strive to provide pre-trip and en-route traveler information that includes real-time information on routes, road conditions and alternative modes of transportation.

7) With a bicycling plan already in place it should be the state's position to construct the most cost efficient system to meet the needs of both the motoring public and bicycling community. The bicycling community is small but growing.

8) The Federal Highway Administration (FHWA) announced the new Office of Innovative Program Delivery, which will provide states with stronger and more effective federal support to deliver transportation projects. The office will work with state departments of transportation to help them explore opportunities with innovative financing and congestion pricing and tap into the $400 billion in private funds available world wide for investment in transportation infrastructure. Existing FHWA activities such as public private partnerships, innovative financing, experimental projects and tolling authorities will be merged into the new office, which will improve access and communication for the states. The Office of Innovative Program Delivery will provide national leadership and advice for states pursuing innovative and non-traditional transportation projects. Contact: Nancy Singer at 202-366-0660.

9) Construction debris could be ground into mulch just like brush. It could then be spread around existing trees near the job site. Also, lumber could be donated to "Habitat for Humanity" or other groups. They would probably even come pick it up.

10) When traveling to inspect bridges, we should use a fuel-efficient vehicle (not an SUV) and we should plan our route to inspect multiple bridges on a single trip.

11) Implement a no idling policy for all on-road and off-road TDOT vehicles. Unless it is very cold, vehicles even diesels don't need to idle. Diesels are 20% more efficient than gas vehicles so TDOT should purchase diesels or other fuel-efficient vehicles whenever practical.

12) All the TDOT maintenance facilities that do oil changes could collect used motor oil and burn it to heat their garages. Used motor oil can be burned cleanly. Many mechanics are doing this.

13) I would like to propose a study be initiated and completed to show the number of state employees that have a take home vehicle - who are not in the emergency services - i.e. life and death - responders. If these employees are not called out more than two (2) times a month, it would save the state thousands of dollars in fuel and maintenance costs by implementing a policy that the state vehicle remain at the office and only be driven during working hours, for official business purposes.

14) I think we should accept and apply multi-modal planning approach at all levels in order to incorporate multi-modal options in roadway design. In other words, we cannot have multi-modal design approach if we do not have multi-modal planning approach.

15) We would be able to significantly reduce the idling of our HELP trucks if we provided a radio system that does not require a vehicle repeater. The present system requires that our trucks be running when we our out of our vehicles so that we may use the Vehicle Repeater.

16) Explore a grant program for truckers [in-state] to enable them to purchase auxiliary power equipment to retrofit their trucks. This, of course, probably goes beyond TDOT's scope - but perhaps TDOT could partner with TDEC/Revenue/EPA/FHWA.

17) To save money, keep the work in-house. Consultants cost three times as much, and the work is usually not as good as it would be if done in house. Plus, there is less re-work needed.

18) Transition our fleet to hybrid vehicles. We tend to think in terms of hybrid cars, but the technology can be applied to trucks as well.

19) Do more to promote high-occupancy commuting. Park and ride areas have been constructed in various places across the state and my experience has been that they are not being maintained properly.

20) I suggest we reclaim the shower/dressing room on "A" level in the James K. Polk building for the male bicycle commuters in our building (the women have a room already). What could be more energy efficient and environmentally friendly not to mention healthy, than bicycling to work. It also helps to relieve parking problems downtown.

21) Set a schedule to check the tune on aging fleet vehicles. I notice many times vehicles issues are not addressed until something actually breaks.

22) Give strong consideration to a four (4) day workweek. With proper planning and implementation, we can serve and meet the needs of the public in all areas of state government. The savings in our general operating costs can be reduced. And, I feel with proper public notification and explanation, the public will give us the support. It is just as likely many state employees can reduce costs related to the daily work routine.

23) Provide more vans for state employees to car pool. According to recent research, van pooling is the most fuel-efficient method for commuting. Vans use much less fuel per person transported than buses or trains. Plus van pooling can be much more flexible for time and location than buses or trains. I am not sure how the state vans for car pooling work now, but I have heard they are phasing them out. Most of the cost of the vans can be offset by fees paid by the riders over the life of the vans.

24) If major improvements or new roads are needed on state routes in urban areas, TDOT should consider including sidewalks wherever it is practical to encourage walking and biking.

Appendix D: Helpful Websites

American Association for Budget and Program Analysis
http://www.aabpa.org/main/mpubs.htm

American Association of State Highway and Transportation Officials
http://www.transportation.org/

American Council for an Energy-Efficient Economy Reports
http://www.aceee.org/energy/reports.htm

American Enterprise Institute for Public Policy Research
http://www.aei.org/research/filter.all/default.asp

American Planning Association
http://www.planning.org/

American Psychological Association (APA) Publication Manual
http://apastyle.apa.org/

American Psychological Association (APA) Style Citation Format Wizard
http://www.stylewizard.com/apa5/apawiz.html

American Public Transportation Association
http://www.publictransportation.org/default.asp

American Public Transportation Association - State
http://www.apta.com/links/state_local/tn.cfm

Association for the Study of Peak Oil & Gas (ASPO)
http://www.peakoil.net/

Association of Environmental and Resource Economists
http://www.aere.org/index.html

Association of Metropolitan Planning Organizations
http://www.ampo.org/publications/index.php

Beijing, China – Air Quality
http://www.sciencedaily.com/releases/2007/04/070413102036.htm

Blue Book – Legal Citations
http://www.law.cornell.edu/citation/

BP Statistics on World Energy
http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622

Brookings Institute
http://www.brookings.edu/

Calculators and Modeling Tools from U.S. EPA
http://www.epa.gov/OMS/stateresources/tools.htm

Carbon Dioxide Information Analysis Center
http://cdiac.ornl.gov/

Carbon Management Council
http://www.carboncouncil.org/

Center for Urban Transportation Research – University of South Florida
http://www.cutr.usf.edu/index2.htm

Clean Air Partnership
http://www.cleanairpartnership.info/

Clean Fuels Development Coalition
http://www.cleanfuelsdc.org/

CO_2 Balance – calculate carbon footprint
http://www.co2balance.com/

Congress for the New Urbanism
http://www.cnu.org/resources/publications

Cool People Care
http://www.coolpeoplecare.org/

Die Off – an individual's perspective
http://www.dieoff.org/

Discover Magazine
http://discovermagazine.com/

Drive Clean – TX DOT
http://www.drivecleanacrosstexas.org/main.stm

Earth Policy Institute
http://www.earth-policy.org/

Earth911
http://earth911.org/

Ecological Economics – Wikipedia
http://en.wikipedia.org/wiki/Ecological_economics

Ed's Eco-Friendly Life
http://www.livingwithed.net/

Empirical Cost-Benefit and Environmental Value Estimates
http://envirovaluation.org/

Energy End-Use Forecasting
http://enduse.lbl.gov/about.html

Energy Information Administration (EIA) - Official Energy Statistics from the U.S. Department of Energy (DOE)
http://www.eia.doe.gov/

Energy Policy Act of 2005
http://www.er.doe.gov/bes/EPAct_2005_08AUG05.pdf

Energy Revolution
http://www.energyblueprint.info/usa.0.html

EnviroLinks Environmental Resources and Subject Matter Experts
http://www.envirolink.org/

Environmental and Energy Study Institute
http://www.eesi.org/

Environmental Council of the States (ECOS)
http://www.ecos.org/

Environmental Defense Fund – Subject Matter Experts
http://www2.environmentaldefense.org/page.cfm?tagid=1006

Environmental Defense Fund – Transportation Figures
http://www2.environmentaldefense.org/article.cfm?contentID=8161

Environmental Glossary, Abbreviations and Acronyms from U.S. EPA
http://www.epa.gov/OCEPAterms/aterms.html

Environment-Green
http://www.environment-green.com/

EPA SmartWay Calculator
http://www.epa.gov/smartway/calculator/loancalc.htm

European Renewable Energy Council
http://www.erec.org/

FHWA - Bike and Pedestrian Program
http://www.fhwa.dot.gov/environment/bikeped/index.htm

FHWA - Carbon Sequestering Project
http://www.environment.fhwa.dot.gov/strmlng/newsletters/sep08nl.asp

FHWA – Environmental Toolkit
http://environment.fhwa.dot.gov/index.asp

FHWA – Freight Planning
http://www.fhwa.dot.gov/freightplanning/talking.htm

FHWA - International Programs – Reports
http://international.fhwa.dot.gov/

FHWA – Planning and Environmental Resources
http://www.fhwa.dot.gov/hep/index.htm

FHWA – Travel Demand Management Strategies
http://ops.fhwa.dot.gov/tdm/ref_material.htm

Global Warming Early Signs
http://www.climatehotmap.org/

GlobaLex
http://www.nyulawglobal.org/Globalex/Climate_Change_Kyoto_Protocol.htm

GOVERNING.com – article on sustainability
http://www.governing.com/articles/0804sustain.htm

Governor's Energy Task Force
http://www.tennesseeanytime.org/energy/

Green Building Initiative (GBI)
http://www.thegbi.org/home.asp

Green Car Congress – information on fuel cost vs. VMT
http://www.greencarcongress.com/2008/06/us-vehicle-mile.html

Green Economics Institute
http://www.greeneconomics.org.uk/

Green Peace – Global Warming
http://us.greenpeace.org/site/PageServer?pagename=PHS_Get_the_Facts

Green Values – Stormwater Toolbox (calculator)
http://greenvalues.cnt.org/calculator

Green Vehicle Guide
http://www.epa.gov/greenvehicles/Index.do

Guide to Grammar and Writing
http://grammar.ccc.commnet.edu/grammar/

Inconvenient Truth – Climate Crisis
http://www.climatecrisis.net/

Integrated environmental and transportation infrastructure planning
http://www.environment.fhwa.dot.gov/integ/eo13274_toc.asp
http://www.fhwa.dot.gov/hep/climatechange/index.htm

Intergovernmental Panel on Climate Change
http://www.ipcc.ch/

International Society for Ecological Economics
http://www.ecoeco.org/

InterScience
http://www3.interscience.wiley.com/cgi-bin/home

IRIS (Integrated Risk Information System)
http://cfpub.epa.gov/ncea/iris/index.cfm

ISO 14000 – Environmental Management Standards
http://www.iso.org/iso/iso_14000_essentials

ITS Benefits
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/Singlebenefit?OpenForm&Benefit=Energy+&+Environment

Life the oil crash – energy conversion facts
http://www.lifeaftertheoilcrash.net/Research.html#anchor_70

Managing Travel Demand: Applying European Perspectives to U.S. Practice
http://international.fhwa.dot.gov/traveldemand/index.cfm

Managing Travel Demand: Applying European Perspectives to U.S. Practice - 2006
http://international.fhwa.dot.gov/links/pub_details.cfm?id=541

Michigan DOT – Commute Cost Calculator
http://mdotwas1.mdot.state.mi.us/public/rideshare/drivingcost.cfm

MIT – Fact Sheet on U.S. Transportation Energy
http://web.mit.edu/mit_energy/resources/factsheets/TransportationUS.pdf

Methodologies to assess impacts of infill on air quality from U.S. EPA
http://www.epa.gov/otaq/stateresources/transconf/policy/compari.pdf

NAFA Fleet Management Association
http://www.nafa.org/

NASA Goddard Institute
http://www.giss.nasa.gov/

National Academy of Sciences
http://www.nationalacademies.org/

National Center for Atmospheric Research
http://www.ncar.ucar.edu/

National Center for Bicycling and Walking
http://www.bikewalk.org/

National Commission on Energy Policy
http://www.energycommission.org/

National Institutes of Health
http://www.nih.gov/

National Science Foundation
http://www.nsf.gov/

National Transportation Organization Coalition (NTOC)
http://www.ntoctalks.com/

NTOC past presentations – including Managing TDM to Mitigate Congestion
http://www.ntoctalks.com/web_casts_archive.php

Natural Resources Defense Council (NRDC)
http://www.nrdc.org/policy/legislation.asp?gclid=CKCQgIqj2JMCFQIyxwodQEeSTA

News Releases from U.S. EPA
http://www.epa.gov/newsroom/index.htm

Oil Price Information Service
http://www.opisnet.com/

PBS
http://www.pbs.org/

Peak VMT article
http://www.postcarbon.org/peak-vmt

Peter Cox, University of Exeter
http://esi-topics.com/gwarm2006/interviews/PeterCox.html

Pickens Plan
http://www.pickensplan.com/

Post Carbon Institute
http://www.postcarbon.org/

Pros and Cons of Controversial Issues
http://www.procon.org/

Research Navigator
http://www.researchnavigator.com/index.asp

Rock Mountain Institute
http://www.rmi.org/

Science Direct
http://www.sciencedirect.com/

Sierra Club Transportation Solutions
http://www.sierraclub.org/solutions/transportation.asp

Six Case Studies on Integrated Transportation
http://www.environment.fhwa.dot.gov/integ/eo13274_toc.asp

Smart Growth
http://www.smartgrowth.org/Default.asp?res=1024

Smart Growth Toolkit
http://www.smartgrowthtoolkit.net/

Sprawl City
http://www.sprawlcity.org/

Sprawl Watch
http://www.sprawlwatch.org/

State and Local Transportation Resources from U.S. EPA
http://www.epa.gov/OMS/stateresources/policy/pag_transp.htm

Sustainable Prosperity
http://sustainableprosperity.ca/

Sustainable Transport Action Network (SUSTRAN)
http://www.gdrc.org/uem/sustran/sustran.html

Tellus Institute
http://www.tellus.org/

Tennessee Advisory Commission on Intergovernmental Relations (TACIR)
http://state.tn.us/tacir/publications.htm

Tennessee Department of Economic & Community Development – Energy Division
http://www.tennessee.gov/ecd/energy.htm

Tennessee Department of Transportation - TDOT SmartCommute
http://www.tdot.state.tn.us/smartcommute/default.htm

Tennessee Traffic History
http://ww3.tdot.state.tn.us/traffichistory/

Tennessee Transit Guru
http://www.transitguru.com/TENNESSEE.html

Texas Transportation Institute – Urban Mobility Report
http://mobility.tamu.edu/ums/

The Joint Global Change Research Institute
http://www.globalchange.umd.edu/

The Weather Channel – Scientific Reports
http://climate.weather.com/science/

TNMUG Freight Planning
http://web.utk.edu/~tnmug08/docu.htm

TN Watershed Groups
http://frank.mtsu.edu/~waterwks/WatershedGroups3.htm

Transportation Research Board (TRB) – Climate Change & Transportation
http://trb.org/news/blurb_detail.asp?id=8828

TRB – Transportation Research Record Online
http://trb.metapress.com/home/main.mpx

TVA – Energy Right Program
http://www.energyright.com/

U.S. Census Bureau
http://www.census.gov/

U.S. Department of Commerce
http://www.commerce.gov/

U.S. Department of Energy (DOE)
http://www.doe.gov/about/nationalenergypolicy.htm

U.S. DOE – EIA State Energy Use Data
http://tonto.eia.doe.gov/state/

U.S. DOE – National Renewable Energy Laboratory
http://www.nrel.gov/

U.S. DOT Bureau of Transportation Statistics
http://www.bts.gov/
http://www.bts.gov/publications/transportation_statistics_annual_report/2007/pdf/entire.pdf

U.S. DOT Federal Highway Administration – environmental toolkit
http://www.environment.fhwa.dot.gov/

U.S. DOT Federal Highway Administration – implementation strategy
http://www.fhwa.dot.gov/hep/step/strategy.htm

U.S. DOT Federal Transit Administration – reports and publications
http://www.fta.dot.gov/publications.html

U.S. Environmental Protection Agency
http://www.epa.gov/

U.S. EPA – Climate Change Science
http://www.epa.gov/climatechange/

U.S. EPA's National Center for Environmental Economics
http://yosemite.epa.gov/ee/epa/eed.nsf/pages/homepage

U.S. Forest Service Climate Change Resource Center
http://www.fs.fed.us/ccrc/

U.S. General Services – GSA
http://www.gsa.gov/Portal/gsa/ep/channelView.do?pageTypeId=8199&channelPage=%2Fep%2Fchannel%2FgsaOverview.jsp&channelId=-13345

U.S. Government – Environment, Energy, Recycling & Conservation Page
http://www.usa.gov/Citizen/Topics/Environment_Agriculture.shtml

U.S. Government Federal Statistics Program
http://www.fedstats.gov/

U.S. Government Home Page
http://www.usa.gov/

U.S. Government's Air Now Program
http://www.airnow.gov/

U.S. National Science Foundation
http://www.nsf.gov/

Union of Concerned Scientists
http://www.ucsusa.org/

United Nations
http://www.un.org/english/

United States Botanic Garden
http://www.usbg.gov/education/events/index.cfm

United States Energy Association
http://www.usea.org/

United States Society for Ecological Economics
http://www.ussee.org/

Urban Environmental Management – Sustainable Transportation
http://www.gdrc.org/uem/sustran/sustran.html

Urban Institute
http://www.urban.org/

VMT Growth Factors Percentage by Tennessee County
http://www.epa.gov/ttn/naaqs/ozone/areas/vmt/vmttngf.htm

Waste-Wise
http://www.epa.gov/wastewise/

World Business Council for Sustainable Development
http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?MenuID=1

World Energy Council
http://www.worldenergy.org/default.asp

World Trade Organization
http://www.wto.org/

WSDOT – HOT Lane Pricing
http://www.wsdot.wa.gov/Projects/SR167/HOTLanes/

Zero Air Pollution (ZAP) cars – Kentucky Manufacturing Plant
http://www.nationalledger.com/artman/publish/article_272622028.shtml

Appendix E: TELA 2008 Class Members

Larry Binion
Jason Blankenship
Steve Chipman
Tremecca Doss
Curt Duncan
Pat Ferrell
Amy Griffin
Danielle Hagewood
Andrea Hall
Robert Jowers
David Kee
Charles King
Tyler King
Rick Knoll
Mark McAdoo
John Phillip
Kristin Qualls
Michael Rebick
Tammy Sellers
Brij Singh
Shawna Smith
David Sparks
Phil Trammel

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