How to Develop a Heavy-Duty Diesel Technology Verification Program

A Comprehensive Resource Manual

SmartWay®
U.S. Environmental Protection Agency

CONTENTS

INTRODUCTION

MODULES

APPENDICES

Message from U.S.Environmental Protection Agency's Chris Grundler

Chris Grundler, Director, Office of Transportation and Air Quality (OTAQ), EPA

The United States' economic health, indeed the world's, is dependent upon the safe, speedy, and secure movement of goods, commodities, materials, and food. Moving this freight not only drives economic growth and development, but it also is a significant global force of its own: employing millions and spurring investment, innovation, and worldwide interdependencies.

Largely powered by diesel engines, the freight sector is growing and heavy-duty trucks are its bedrock. Globally, CO_2 emissions from freight transport are growing at a faster rate than passenger vehicles. As freight activity in the United States increases, projections are that during this same time frame, growth in greenhouse gas emissions from freight will exceed growth in greenhouse emissions from all other transportation activities.[1]

To combat these emissions and health effects, U.S. EPA has established partnership programs that spur innovation, drive cost savings, and encourage efficiency improvements for fleet owners, operators, manufacturers, and others throughout the transportation sector.

One such program is EPA's National Clean Diesel Campaign (NCDC), which supports regulatory programs for newer engines and innovative voluntary programs for the millions of older diesel engines in use in the United States. NCDC promotes strategies to reduce diesel emissions including retrofitting, repairing, replacing, and repowering engines; reducing idling; and switching to clean fuels.

Aiding this effort, EPA's SmartWay Transport Partnership, established in 2004, uses a market-based, public-private collaboration framework to provide tools to improve fuel efficiency and reduce emissions in the freight sector. The SmartWay Technology Program employs established testing protocols to verify the performance of technologies that reduce GHGs and air pollutants from freight transport. Thanks to these efforts, manufacturers are producing innovative fuel-saving and emissions reduction technologies that fleets are using with the added confidence that verification brings.

1. EPA (2016). Why Freight Matters to Supply Chain Sustainability. Retrieved from: https://www.epa.gov/smartway/why-freight-matters-supply-chain-sustainability.

This manual is designed to provide information, best practices, lessons learned, and guidance to enable organizations, agencies, and others to design, build, and implement their own programs. Our sincere hope is that others will use this guidance to develop programs that will benefit host countries and ultimately the global climate.

MODULE I

Why Develop a Heavy-Duty Diesel Technology Verification Program?

Learn about the negative effects diesel emissions have on human health and the environment and the benefits of creating a technology verification program (TVP). Key concepts include public health and environmental impacts of diesel emissions, economic and societal benefits of a TVP, and the importance of having an objective performance evaluation of technologies.

SECTIONS

Suggested time for this module: 2 hours

The transportation and freight industries rely heavily on diesel engines, which emit significant amounts of pollutants that affect public health and the environment. Older diesel engines offer opportunities to reduce emissions, cut fuel consumption, and lower operating costs if retrofitted with the appropriate technologies or retired early and replaced with higher-efficiency, lower-polluting new engines. A technology verification program (TVP) offers owners and operators of diesel fleets performance-based, objective methods for measuring and comparing various technologies and strategies that can reduce diesel emissions, improve fuel economy, and benefit human health and the environment.

The impacts of diesel emissions are discussed below, along with the benefits associated with adopting a TVP.

A Public Health

Many Americans are exposed to diesel engine emissions every day. These emissions include oxides of nitrogen (NO_X), particulate matter (PM, including black carbon), volatile organic compounds (VOCs), air toxics, and other pollutants.[1] Exposure to NO_2, PM, and toxics directly impacts human health. NO_X and VOCs can also react and combine with other pollutants in the atmosphere to form ground-level ozone, as well as additional PM and other toxics, which can affect human health. The U.S. Environmental Protection Agency (EPA) classifies ground-level ozone, NO_2, and PM as criteria pollutants, whose concentrations must be limited to protect human health and the environment with an adequate margin of safety. The health impacts of these pollutants include:

- *Respiratory and cardiovascular disease.* PM emissions from diesel engines contain inhalable particles, including "fine" PM (diameter smaller than 2.5 micrometers), "coarse" PM (diameters between 2.5 and 10 micrometers), and "ultrafine" PM (diameters under 0.1 micrometers).[2] Exposure to fine PM has been linked with a number of health effects, including cardiovascular and respiratory effects as well as premature death. There is less conclusive evidence that exposure to coarse PM and ultrafine particles is also associated with these health effects.[3]

1. NO_X consists of two compounds: nitric oxide (NO) and nitrogen dioxide (NO_2).
2. Fine, coarse, and ultrafine PM are also known as $PM_{2.5}$, $PM_{2.5\text{-}10}$, and ultrafine particles. PM_{10} represents the combination of $PM_{2.5}$ and $PM_{2.5\text{-}10}$.
3. EPA (2009). *Integrated Science Assessment for Particulate Matter (Final Report)*. EPA/600/R-08/139F. Chapter 8 and Chapter 2.

Exposure to NO_2 is associated with the exacerbation of asthma, particularly due to the greater sensitivity of the airways, as well as other respiratory effects.[4] In the presence of sunlight, NO_X reacts with VOCs to create ground-level ozone, exposure to which can increase the risk of asthma development and exacerbation, lung function reductions, respiratory-related hospital admissions and emergency department visits, and premature death.[5]

- *Cancer.* The PM in diesel exhaust, a large fraction of which is fine and ultrafine particles, readily adsorbs gaseous pollutants. Inhaled particles can settle in the lungs and, depending on their size, can pass into the circulatory system. In 2002, EPA determined that exposure to diesel exhaust was likely to be carcinogenic to humans. In 2012, on the basis of more recent studies, the World Health Organization (WHO) classified diesel engine exhaust as carcinogenic to humans, finding sufficient evidence to link it to lung cancer.

Children, older adults, people with pre-existing lung or heart diseases, and people with lower socioeconomic status are considered to be at greater risk for adverse health effects of PM. For NO_2, children, older adults, and people with asthma are considered to have greater health risks associated with exposure. People with asthma, older and younger age groups, people with reduced intakes of certain vitamins (C, E), and outdoor workers are considered to be at greater risks from ozone exposure.

Efforts from numerous programs have helped Los Angeles and other polluted areas reduce air pollution from all sources and greatly increase visibility.[6]

As a result of EPA's most recent standards, today's new diesel engines emit substantially less PM, NO_X, VOCs, and other pollutants. A recent study of highway diesel engines meeting EPA's standards for model years 2007, 2010, and later found significantly reduced levels of PM (≥90 percent), VOCs (≥90 percent), and NO_X (≥50 percent and ≥90 percent for 2007 and 2010

4. EPA (2016). *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (2016 Final Report).* EPA/600/R-15/068.
5. EPA (2013). *Integrated Science Assessment of Ozone and Related Photochemical Oxidants (Final Report).* EPA/600/R-10/076F.
6. Source: "Los Angeles Times Photographic Archive , UCLA Library. Copyright Regents of the University of California, UCLA Library."

standards, respectively), relative to the previous standards (i.e., those for the 2004 model year). Although the differences in toxicity between pre- and post-2007 highway engines have not been extensively examined, a large animal study found no evidence that exposure to exhaust from a 2007-compliant engine increased incidence of tumors in rats. As such, the overall toxicity of exhaust from highway engines meeting EPA's 2007 and 2010 standards is likely to be substantially reduced compared with exhaust from engines not meeting those standards.

What Is Black Carbon, and How Does It Impact the Environment?

Black carbon is the most strongly light-absorbing component of PM that comes from the incomplete combustion of fossil fuels, biofuels, and biomass. Older, less efficient engines and higher-sulfur diesel fuels are significant sources of black carbon. Black carbon is very effective at absorbing light and also reduces the reflectivity of snow and ice, which contributes to increased temperatures and accelerated snowmelt.

B The Environment

NO_X, PM, and greenhouse gases (GHGs) harm many aspects of the natural environment, including but not limited to soils, water, wildlife, vegetation, weather, and climate. Haze and smog from air pollution impact visibility.

- *Damage to soils, water, vegetation, and wildlife.* NO_X can be deposited onto the ground where it negatively impacts land-based ecosystems. For example, soil acidification reduces trees' ability to absorb key nutrients, resulting in injury to forests and slower growth. NO_X can also be deposited into bodies of water, harming aquatic ecosystems. NO_X, as well as sulfur oxides (SO_X), acidify streams, lakes, and rivers, killing wildlife and causing a loss of biodiversity.
- *Weather and climate.* Diesel fuel combustion releases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), which trap heat in Earth's atmosphere. Diesel engines can also emit significant amounts of black carbon (BC), which contributes to warming.
- *Visibility.* Air-polluting diesel engines, and many other sources, create smog and haze, which can significantly impact visibility. Compromised visibility can affect transportation safety, contribute to congestion, and discourage tourism.

Objective testing with established protocols creates a level playing field and ensures the validity of performance claims.

C Objective Performance Evaluation

Creating a TVP helps new and innovative environmental technologies become known and available locally. TVPs evaluate a particular technology's emissions reductions and fuel savings to determine and verify that reductions are credible, scientifically sound, and proven.

Technology verification requires an unbiased standardized evaluation method. Rigorous third-party testing of the technology helps demonstrate whether or not the claimed emissions reductions or fuel savings are accurate/real. The verification process includes specific laboratory and/or field testing, where the precise methods of testing are selected according to the type of technology being tested. Manufacturers commonly provide real-world performance data over time. This "in-use" testing verifies the effectiveness of the technology as it ages. The manufacturer may also provide a warranty for each verified technology.

In addition, a rigorous verification procedure provides a "level playing field" for all vendors of a given technology type, clearly differentiating products that perform well from those that do not meet performance levels. In this way, TVPs serve as an unbiased arbiter of technical information.

Once evaluated, the TVP lists the products on its "verified technologies" list. A fleet owner can refer to the verified technologies list and be confident of the specific level of emissions reductions or fuel savings the technology will achieve over time.

D Economic Benefits

The economic benefit of a TVP extends to manufacturers, carriers, shippers, members of the freight industry, and the broader economy.

- *Support of technical innovation.* TVPs encourage technological advances. A published list of verified technologies clearly shows the estimated effectiveness of emissions reduction or fuel-saving products, allowing fleet owners to compare products before making a purchase. The resulting competition among technology manufacturers spurs innovation, better serving customers in search of the most cost-effective means of reducing emissions and fuel costs.

  Technological improvements have come about through the verification testing of products to determine the effective reduction of the primary pollutant as well as the impact on pollutants

that are not the primary target. In some instances, the primary pollutant may be reduced, but another may increase. Modifications and improvements made by the manufacturer during the verification process address unforeseen issues and utimately improve the technology overall.

"Green freight" programs incentivize freight carriers to improve their carbon footprint and/or reduce their criteria pollutant emissions to compete for shipper business. For example, EPA's SmartWay program promotes the use of aerodynamic truck and trailer treatments such as side fairings, which have become increasingly common on U.S. tractor-trailers and can reduce fuel consumption by 5 percent or more. SmartWay shippers preferentially hire carriers who demonstrate more fuel-efficient, lower-emissions operations. Accordingly, carriers can help ensure the improved performance of their fleets through investment in SmartWay-verified technologies.

- *New local industry.* A TVP can foster local manufacturing activity and related services, such as laboratories specializing in testing emissions reduction and fuel-saving technologies. A TVP can also create demand for new jobs installing and maintaining verified technologies.
- *Sustainable freight equipment sector.* A more sustainable freight and transportation sector strengthens economic growth and provides energy security. Technologies that reduce GHG emissions strengthen the freight sector by reducing operating costs, improving companies' ability to compete globally, and reducing risk from climate change.

  TVPs also support freight customer needs for global carbon accounting and reporting. More and more frequently, the freight industry is asked to define its contribution to its customers' carbon footprints and climate risk. As a result of customer interest, corporate customers, shareholders, lenders, and insurers are increasingly demanding reliable estimates associated with green freight technology performance to complement their own corporate social responsibility plans. TVPs help provide reliable technology performance estimates for freight customer use.
- *Enhanced public relations.* Companies that participate in a TVP by voluntarily adopting emissions-reducing or fuel-saving measures can receive reputational and public relations benefits. For example, participants can highlight the fact that tested and verified technologies are in use on their vehicles and post information on their corporate websites. TVP participants such as carriers, shippers, and logistics providers who adopt cleaner technologies can be recognized as part of a green freight annual awards program and in press releases acknowledging companies with superior environmental performance.

GROUP EXERCISE 1:

Identify Benefits of a Diesel Emissions TVP

List the economic, public health, and environmental benefits of reducing diesel emissions in your country or region.

E Host Agency Benefits

Agencies operating a TVP benefit from having a transparent system that helps verify and quantify emissions reductions associated with various technologies. These emissions data make it easier for the host agency to track associated health, environmental, and air quality benefits from the program, which can provide strong arguments to support the program. Agencies operating a TVP who understand the potential of technologies to reduce emissions can use data to support the planning and development of stronger air quality initiatives. In addition, agencies can help industry by fostering technology development and sharing the results of testing and verification with the community.

F Industry Engagement

Creating a TVP presents an opportunity to engage freight transportation industry stakeholders and technology manufacturers in a new way, which can strengthen relationships with government agencies, regulators, and the TVP host. For example, by bringing industry into the early stages of TVP design and development, the host will not only gain access to a broad set of perspectives and valuable feedback, but the resulting industry engagement will likely increase the program's success, since those key stakeholders will feel more involved in the program and its success. Having a list of reliable verified technologies (and unfettered access to it) should be a strong incentive for industry to participate and make the program a success, and a verified technologies list can help minimize investment risks and improve emissions and performance for older vehicles in their fleets.

Notes

MODULE II

Getting Started

Gain insights into the most common types of technology and fuel options addressed in verification programs and potential constraints to technology adoption. Learn about other TVPs to help design your program and reach stakeholders to encourage their support and participation. Key factors influencing the design and scale of your TVP include assessing pollutants of concern, the extent of the air quality problem in your area, and the specific characteristics and operating conditions of your area's vehicle fleet.

SECTIONS

Suggested time for this module: 2 hours

A Assessing Air Pollution and Fleet Characteristics

What are your region's specific characteristics and circumstances?

- What air pollutants and related health effects are most pressing?
- Are the air quality problems primarily local (e.g., specific to facilities or neighborhoods), regional (city-wide), or national?
- Which mobile sources contribute the most to these problems?
- What are the characteristics of these sources, and how do they typically operate in your area?

Environmental agencies often maintain local and/or regional air quality monitoring networks, collecting daily or hourly air quality measurements over many years. These agencies compare their data to national or international air quality standards to determine the extent of local conditions.[1] Use this information to identify the extent and location of local pollutants and their health impacts. For example, diesel engines are typically the largest contributors to PM and NO_X emissions in many areas, while gasoline engines generally produce much higher amounts of hydrocarbon (HC) and carbon monoxide (CO). In addition, marine vessels and locomotives frequently contribute to local "hot spot" exposures in neighborhoods near ports or rail yards.

An emissions inventory illustrates which sources contribute the most to different pollutant emissions. For example, an inventory may find that half of mobile source PM emissions come from heavy-duty diesel trucks more than 10 years old. This information allows you to focus on control technologies suited to reducing PM from these specific sources.

The following table summarizes the key types of inventories for on-road vehicles, along with the situations

How SmartWay's Program Evolved

Before SmartWay, it was difficult for fleets to sort through claims of fuel-saving and emissions reduction devices and equipment and how they might perform in use. EPA's initial work to evaluate retrofit technology performance involved the retrofit of older, in-use "urban buses" with emissions reduction technology. After these urban bus technologies were proven through certification testing and in-use operation, the retrofit program expanded to include device verification to reduce pollutant emissions from school bus, truck, locomotive, marine, and various non-road engines. Later, the program expanded to include verification of fuel-saving technologies, which reduce CO_2 emissions and save money for trucking fleets.

1. WHO offers air quality guidelines online for use in determining impacts of local air quality on public health: www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/.

for which they are most appropriate. Similar inventory methods are available for marine, rail, and other mobile sources.

Key Emissions Inventories

Type of Emissions Inventory	Level of Effort/ Expertise	Typical Applications
Fuel-based: from total fuel consumption	Low	Commonly developed for national-level estimates using aggregated fuel use by type (gasoline, diesel, marine residual, etc.). Reasonably accurate for CO_2, SO_X.
Travel-based, aggregated: daily or annual distance travelled by vehicle and fuel type	Moderate	Usually developed for national or regional estimates. Relies on emissions models (e.g., EPA MOVES or EU COPERT) with assumptions regarding driving patterns, engine load, etc. Provides reasonable estimates for NO_X, HC, and CO.
Travel-based, project-specific: daily or hourly distance travelled, with detailed information on road configurations, speeds, engine loads, etc.	High	Developed for "hot spot" emissions estimates. Uses emissions models with highly detailed, site-specific inputs. Operations data may be obtained directly from local fleet operators/ experts. Preferred method for determining PM exposure.

Consult with your local air quality agency to determine if the emissions inventory information it has is adequately precise for the pollutants of concern and scale of the air quality problem. The information obtained from a reliable emissions inventory may be enough for you to determine what types of vehicles, fuels, and technologies to focus on when developing your verification program. However, you may choose to prioritize your efforts based on actual health risks and/or costs, rather than just the associated emissions levels. Your local environmental agency may have developed these estimates using such tools as EPA's BENMAP (Benefits Mapping and Analysis Program)[2] or related software program.

After you have identified the vehicle types and engines your TVP may target, evaluate their characteristics and operating conditions. The following factors can have a significant impact on the success or failure of the different control technology options:

- Are the target engines predominantly:
  - On-road or off-road?
  - If on-road, are they light- (smaller vehicles or engines) or heavy-duty?
  - Do they use diesel or gasoline?
  - Are they operated by large, centrally controlled and fueled fleets or by small owner-operators?
- What is the distribution of kilometers travelled or hours of use per year across the fleet?
- What is the engine age distribution?

2. More information about EPA's BENMAP can be found at: www.epa.gov/benmap.

- Do the on-road vehicles frequently operate under low-speed, stop/start (urban) conditions, or high-speed steady-state (highway) conditions?
- Do they experience significant periods of extended idling?
- Do the on-road vehicles haul heavy loads on a regular basis, and if so, what are their common body styles and trailer configurations?
- Does vehicle operation require significant power for auxiliary functions (e.g., power takeoff, air conditioning or heating, other in-cab amenities)?
- Can the target vehicles and engines be easily identified and monitored over time?
- What is the condition of the vehicles and engines in the fleet? Are they in good working order? What are the maintenance practices?

The answers to these questions will go a long way toward identifying the most appropriate technologies for your program.

GROUP EXERCISE 2:

Identify Sources of Emissions Inventory Data

Develop a list of reliable, preferably publicly available data sources to help you better understand your area's emissions inventory. How would you collect data should none be currently available?

B Technologies, Regulations, and Other Programs

Based on the assessments described above, consider types of technologies that would be appropriate for the highest-polluting vehicles/equipment in your region. The specific technologies and strategies will vary depending upon the target pollutants:

- Exhaust aftertreatment technologies primarily target PM (including related toxics and BC), with some technologies also targeting NO_X. Secondary benefits may be seen for CO and HC.

Vehicle and engine maintenance to ensure proper vehicle operation is absolutely necessary for emissions reduction and fuel savings. As a first step, educate fleets on the importance of proper maintenance, and make sure certain fleets are properly maintained before considering retrofit.

- Engine upgrades and retrofits target reduced fuel consumption and/or emissions.
- Fuel-saving technologies target CO_2 primarily via reduced engine load and idling, although secondary NO_X and PM reductions may be seen.
- Alternative/low-carbon fuels generally lower CO_2 emissions, with PM reductions also common.

Many of these technologies and strategies may be included in new vehicle designs by original equipment manufacturers (OEMs) or applied to existing vehicles using retrofits.

The following provides a short summary of the emissions reduction, fuel-saving, and clean fuel strategies commonly considered for broad fleet application, with a focus on on-road diesel vehicles.

A detailed assessment of the technology, fuel, and operational strategies for reducing emissions and saving fuel associated with freight movement was developed for the Climate and Clean Air Coalition's Global Green Freight Action Plan—see www.globalgreenfreight.org/resources/global-green-freight-0.

Defining the Terms

Aftertreatment systems

Exhaust aftertreatment systems reduce tailpipe emissions by converting pollutant molecules into less harmful compounds. For example, a NO_X adsorber catalyst stores NO and NO_2 and then converts these molecules into N_2, CO_2, and H_2O under fuel-rich operation. For many advanced aftertreatment systems to function, the operator must have available and consistently use fuel with very low sulfur levels.

Exhaust Aftertreatment

Exhaust aftertreatment devices are designed to reduce criteria pollutant emissions. While these technologies benefit the environment, incentives may be needed to encourage adoption if there are no regulatory requirements.

- *Diesel oxidation catalyst (DOC).* These devices facilitate a reaction between PM, HC, and CO in the exhaust to produce primarily CO_2 and H_2O. DOCs are entirely passive systems that can be retrofitted on vehicles of widely varying age and, accordingly, are the most widely implemented diesel aftertreatment technology retrofit in the world.[3] DOCs operating in North America typically reduce PM emissions by 20 to 50 percent, HC by 40 to 90 percent, and CO by 40 to 60 percent.
- *Diesel particulate filter (DPF).* DPF devices are now standard on OEM trucks in the United States and the EU. For new trucks, most DPFs are wall-flow types, which are made up of

3. Manufacturers of Emission Controls Association (2009). *Retrofitting Emission Controls for Diesel-Powered Vehicles.*

many porous axial tubes with alternating tubes capped at either the entrance or exit. The wall between tubes provides a surface to collect PM. Alternatively, the surface of flow-through type filters is made up of a catalyzed metal mesh grid. Flow-through filters do not have as high a filtration efficiency as wall-flow systems, and they are more appropriate for retrofitting older engines with higher levels of PM emissions. Wall-flow filters must be cleaned of ash that does not burn off during the regeneration cycle (see below), so every few years the DPF must be removed for cleaning.[4]

For those DPFs that can be regenerated to remove PM buildup, there are two main approaches: active and passive. With both of these methods, the PM compounds trapped on the filter react with the compounds in the incoming exhaust to create CO_2 and other gaseous byproducts.

- In active regeneration, a control device measures the pressure difference across the DPF; when the pressure hits a threshold, the regeneration process begins. During regeneration, the control unit either increases the temperature of the incoming exhaust or creates an oxidizing environment with an auxiliary fuel injector placed in the exhaust stream. This causes the truck to incur a small fuel consumption penalty (typically < 2 percent) during regeneration. Another development in DPF technology uses electrical power to heat the DPF for regeneration in place of fuel injection to reduce fuel consumption.

- Passive regeneration systems do not require monitoring the DPF pressure but are regenerated any time the engine operates at high loads and exhaust temperatures. Passive retrofit DPF devices are limited to engines that spend adequate time at high loads. If the engine operates with low exhaust temperatures for an extended period, the DPF could clog. A clogged DPF needs to be removed and cleaned or replaced, resulting in downtime for the truck, and the filter may not be covered under warranty.

DPFs are especially effective in reducing PM emissions, with wall-flow units operating at 90 percent or higher effectiveness in the United States. HC and CO reductions can be similar.

- *Selective catalytic reduction (SCR).* SCR systems are designed to create a chemically reducing environment in the exhaust to eliminate NO_X. SCR systems inject ammonia or urea in liquid form into the exhaust upstream of a catalyst substrate. OEM-type SCR systems use urea as the working fluid instead of ammonia. Urea supports similar reactions to ammonia, but it has a much lower toxicity level. Both reductants react with NO_X in the exhaust stream to produce nitrogen and water.

4. Manufacturers of Emission Controls Association (2009). *Retrofitting Emission Controls for Diesel-Powered Vehicles*.

Vehicles/engines equipped with SCR must carry a tank of urea, which is typically mixed with water and sold as diesel exhaust fluid (DEF). Generally, SCR systems require the DEF tank to be replenished as necessary while in use and at scheduled service intervals.

Properly installed and maintained SCR systems are highly effective at reducing NO_X and HC emissions, operating at upwards of 80-percent effectiveness in the United States. PM reductions are lower but still significant, in the 20 to 30 percent range.

Aftertreatment concepts generally involve the combination of one PM filtering device and one NO_X-reducing device. Common aftertreatment combinations are:

- LNC/LNT + (DPF or DOC)
- DOC + SCR
- SCR + DPF
- DOC + DPF

- *Lean NO_X catalyst (LNC) or lean NO_X trap (LNT).* These systems usually reduce NO_X via fuel injected into the exhaust in the presence of a catalyst, incurring a small fuel economy penalty.
  - In the LNC, the catalyst continuously reduces a portion of exhaust NO_X. This is usually done with a small amount of fuel continuously or periodically injected upstream. However, these devices can also operate without exhaust fuel injection, though their effectiveness is greatly reduced.[5] LNC system effectiveness is variable, resulting in NO_X reductions between 5 and 40 percent in the United States.
  - In the LNT, also known as a NO_X adsorber catalyst, NO_X entering the exhaust is stored temporarily on catalyzed surfaces. LNT systems can have an effectiveness of over 90 percent under certain conditions.
- *Fuel sulfur and aftertreatment systems.* Many of the devices listed above require low fuel sulfur levels to function with higher efficiency. DOC and SCR retrofits can tolerate moderate sulfur levels, but other devices such as DPFs generally require fuel sulfur levels of 15 ppm. As a result, the first step in many retrofit programs is to ensure the desired aftertreatment types can function given available fuel sulfur levels.

Ultra-low-sulfur diesel (ULSD) fuel, no higher than 15 ppm, enables the introduction of new emissions control technologies such as DPFs, catalysts, and other controls. Fuels with higher sulfur content can generally reduce the effectiveness of these technologies. Therefore, it is important to ensure that a ready supply of ULSD exists before retrofitting these technologies to achieve full emissions benefits over their full useful life.

5. Manufacturers of Emission Controls Association (2009). *Retrofitting Emission Controls for Diesel-Powered Vehicles*.

- *Closed crankcase ventilation.* Older engines may have crankcases that are vented directly to the atmosphere. During the combustion cycle, a small amount of combustion byproducts slip past the engine's piston rings (a process called blow-by) and into the crankcase. Closed crankcase ventilation (CCV) systems redirect blow-by gases back into the intake air stream of the engine. They are usually equipped with liquid filters that capture droplets of oil and return them to the engine oil system. CCV system effectiveness is variable, but it is commonly between 5 and 10 percent for PM in the United States.

Engine Repowers, Upgrades, and Retrofits

- *Clean diesel verified technologies for vehicles and engines.* Options to save fuel and reduce emissions from truck, marine, and locomotive engines include replacing, repowering, or upgrading engines, as well as installing retrofit emissions control technologies. Engine repowers (replacing an older diesel engine with a newer lower-emissions engine) that incorporate the latest emissions control technologies provide significant emissions reductions. Engine upgrades or retrofit devices can be installed on new or existing engines and equipment to reduce pollutant emissions and fuel consumption.

  Retrofit devices for truck, marine, and locomotive engines are included in the Clean Diesel Verified Technologies List on EPA's website: www.epa.gov/verified-diesel-tech/verified-technologies-list-clean-diesel.

Fuel-Saving Technologies

- *Aerodynamic retrofits.* Aerodynamic retrofits are one of the most common strategies to achieve fuel efficiency improvements in trucks. The devices are attached to the tractor or trailer and reduce the drag acting on the vehicle. Adopting an integrated package of strategies can reduce fuel consumption by 10 percent or more, depending on operating conditions (e.g., the percent of time operating at high vehicle speed).

Schneider National Achieves Significant Savings by Using a Range of Verified Technologies and Fuel-Saving Strategies

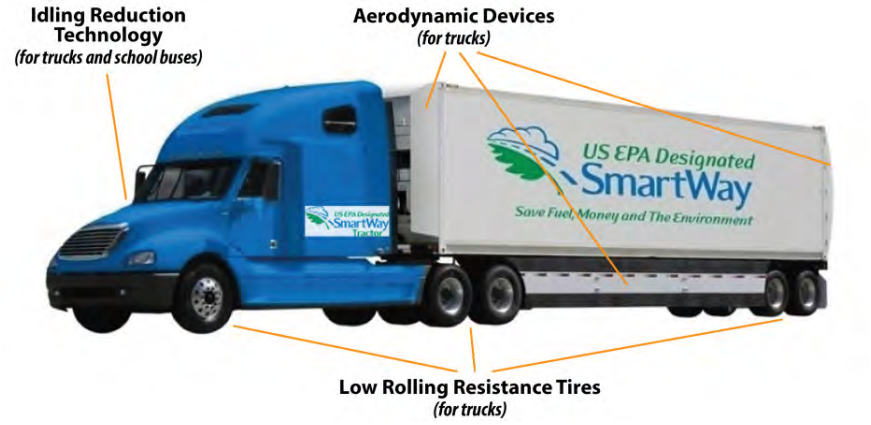
Schneider National has realized significant fuel and cost savings from integrating energy-efficient techniques into its business—from aerodynamics to idling reduction. Among its strategies, the entire fleet has aerodynamic tractors and trailers, saving nearly 28 million gallons of fuel worth approximately U.S. $80 million. In addition, Schneider's drivers use speed management strategies, such as limiting speed to a maximum of 65 mph, which saved approximately 13 million gallons of fuel, resulting in savings of roughly U.S. $39 million. Also, its engines have a two-minute idling limitation, and direct-fired heaters are used in 80 percent of the trucks. Through its idle reduction strategies, Schneider alone has saved approximately 11 million gallons of fuel.

For tractors, open wheels and rotating tires create large amounts of turbulence, as do exposed fuel tanks, side mirrors, and air filters. At the front of the truck, sharp edges at the hood and fenders can increase drag as well. As air passes around the rear of the tractor, drag is created in the truck/trailer gap. The following devices and strategies can reduce the drag in these areas:

- Chassis skirts
- Wheel covers
- Roof fairings and high-roof designs
- Cab side-extending fairings
- Generally smoothing the tractor (making the bumpers, mirrors, fenders, tool boxes, and steps aerodynamically integrated)
- Relocating tractor components (e.g., air cleaners, exhaust stacks) so they are not directly in the wind

The trailer has four key areas that contribute to aerodynamic drag: the trailer gap, the underbody, the wheel trucks (or bogie), and the flat back surface for box trailers. The following trailer treatments can be used to reduce these aerodynamic drag effects:

- Trailer nose cone
- Side skirts or side fairings
- Bogie covers or fairing
- Trailer wheel covers
- Boat tails or trailer end fairing
- Aerodynamic mudflaps



A trailer equipped with side skirts, gap fairings, and a rearboat tail

- *Rolling resistance.* Low rolling resistance tires and retreads can improve fuel efficiency by 3 percent or more depending upon operating conditions. The following options can help reduce rolling resistance:
  - » Low rolling resistance tires
  - » Single-wide tires
  - » Low rolling resistance retreads
  - » Tire and wheel alignment
  - » Proper tire inflation/tire pressure monitoring and automatic tire inflation

Rolling resistance is the resistance created when trying to roll a tire. Rolling resistance losses account for 13 percent of the power requirements for a heavy-duty vehicle operating on a highway. Low rolling resistance tire technology reduces the rolling resistance compared to traditional tires in use and can provide a fuel and emissions benefit for the engine. EPA has demonstrated that certain low rolling resistance tires and retread technologies can reduce both costs and emissions for long-haul Class 8 tractor-trailers by 3 percent or more when placed on all axles.

- *Driveline efficiency improvements.* Fluid lubricants resist the rotation of driveshafts, pumps, and gears due to viscous and shear effects, causing excess energy loss as heat. These effects can be reduced by specifying low-viscosity lubricants designed to meet the lubrication requirements of engines, transmissions, and rear differentials while reducing the energy loss from viscous drag. Estimated efficiency improvements for advanced lubricants and bearings are approximately 1 to 2 percent.[6]

- *Idle reduction.* Heavy-duty vehicles, locomotives, and marine vessels (ships) often idle for extended periods. The most common reason for extended idling is to keep climate control, electrical, and pressurized systems operating. Reducing long-duration truck, locomotive, and marine idling will save fuel and reduce emissions. EPA has published guidance documents about quantifying idle emissions reductions.[7]

  Various technologies are available to reduce extended idling periods:

  - » Auxiliary power units
  - » Direct-fired diesel heaters

6. U.S. Department of Transportation (2010). *Report to Congress: Transportation's Role in Reducing U.S. Greenhouse Gas Emissions*. Retrieved from http://www.reconnectingamerica.org/assets/Uploads/DOTClimateChangeReport-April2010-Volume1and2.pdf. Table 3.3D.

7. EPA (2004). *Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity*. EPA 430/B-04/001. Retrieved from www3.epa.gov/ttn/naaqs/aqmguide/collection/cp2/20040101_otaq_epa-420_b-04-001_truck_idling_rmission_reductions.pdf.

- Automatic engine shutdown and startup
- Battery-powered air conditioning
- Thermal storage systems

Truck Stop Electrification (TSE) and Shore Power

Truck drivers typically idle their vehicles during mandated rest periods to provide power for on-board air conditioning, heat, and electricity needs. TSE sites allow truckers to access off-board heating, ventilation, and air conditioning (HVAC) and electric grid power instead of running their engines, thereby saving 1 gallon of fuel per hour of idling time displaced.

A typical overhead gantry-based TSE system providing HVAC, electrical, and internet services to a long-haul truck.

Shore power/electrification is also used for ships and locomotives to reduce idling when ships are docked and when locomotives are not in operation in railyards. Marine Shore Connection Systems allow maritime vessels to "plug in" to land-based electrical power while at dock instead of using on-board diesel auxiliary engines. Shore power systems must enable a compatible vessel's main and auxiliary engines to remain off while the vessel is at berth.

Behavioral Strategies

Promote policies and programs that reduce fuel consumption and emissions by modifying behavior. For example, a program can train employees to commit to using techniques that eliminate unnecessary idling and place time limits on running the main engine when it is not needed. Regulations that limit idling times can be employed as well. Employing monitoring devices to track idling times is useful to provide feedback to employees on the amount of fuel they have saved and recognize their improvements over time with reward programs. In addition, limiting speed during operation via a speed governor, driver/operator training, and congestion planning are valuable options that should be considered to enhance your technology program.

Fuel Strategies

In addition to making sure low-sulfur fuel is available, diesel vehicle operators have a few fuel-related options for reducing CO_2 and criteria pollutant emissions:

- *Biodiesel blends.* Operators can often fuel existing trucks with biodiesel blends. Blends of conventional diesel with up to 20-percent biodiesel are compatible with most existing engines

and infrastructure. Operators should refer to OEM guidance to verify that the biodiesel use does not void the warranty, as some manufacturers have biodiesel exclusions.

Operating a diesel engine with biodiesel typically results in lower PM emissions. Data regarding its effect on NO_X emissions vary. EPA data show a slight increase in NO_X emissions while other sources report a slight decrease.

- *Cetane-enhancing additives.* Cetane additives can improve combustion efficiency within a diesel engine. These additives can reduce NO_X and PM formation, especially in older engines. Cetane enhancers generally do not have an appreciable benefit when used with higher-cetane base fuels; i.e. those with a cetane number 50 or more.

- *Natural gas conversion.*[8] Natural gas retrofit systems are available for a variety of heavy truck makes and models and can often be installed by local vendors. Natural gas use practically eliminates PM emissions, a great benefit when replacing older diesel engines. NO_X emissions may also be reduced, although carbon emission impacts are likely equivocal relative to diesel.[9]

  However, there is a noted concern regarding emissions from the oil and gas industry. In January 2015, as part of the the U.S. commitment to addressing climate change, EPA outlined a number of steps it plans to take to address methane and smog-forming volatile organic compound (VOC) emissions from the oil and gas industry, in order to ensure continued, safe, and responsible growth in U.S. oil and natural gas production. As a result, EPA proposed and finalized New Source Performance Standards for the oil and gas industry to achieve both methane reductions and additional reductions in VOCs. EPA has also committed to developing standards of performance for existing oil and gas sources.

Review Regulations

Review the relevant transportation-related regulations and operating conditions in your region to see how they might impact the adoption of verified technologies.

- *Diesel fuel sulfur regulations.* Near-zero levels of sulfur (15 ppm or less) are required for many aftertreatment devices (e.g., DPFs) to be effective. If low-sulfur diesel fuel is not consistently available in your area, this will significantly limit the emissions reduction technologies appropriate for your program.

---

8. U.S. Department of Energy (2016). Natural Gas Vehicle Emissions. Retrieved from www.afdc.energy.gov/vehicles/natural_gas_emissions.html.
9. Improperly maintained compressed and liquefied natural gas equipment can leak large amounts of methane, resulting in a much greater GHG impact than equivalent diesel vehicles.

- *Local safety requirements and operating constraints*. Certain regulations and operating factors may exclude or limit what would otherwise be promising technologies. Make sure to consult with your local transportation regulators to identify any potential impediments to specific technologies before selecting your program options.

GROUP EXERCISE 3:

Identify Target Technologies

What technologies are well-suited to the emissions challenges your area faces? Are there additional constraints that might preclude promising technologies from having a significant impact?

Overview of Technology Verification Programs

Several nations and regions around the world have developed programs to help the freight sector operate more efficiently and with fewer emissions. As you develop your TVP, you may decide to borrow elements from these programs rather than developing test methods and analysis procedures from scratch. In the United States, there are two government TVPs:

- *EPA Clean Diesel Technology Program and SmartWay* (www.epa.gov/verified-diesel-tech). EPA has two TVPs. The Clean Diesel Technology Program evaluates criteria pollutant reduction products, while the SmartWay program focuses on technology that improves fuel efficiency and reduces GHG emissions. The programs are related, as the exhaust retrofit technologies promoted under the SmartWay program are managed under the Clean Diesel Technology Program. The Clean Diesel Technology Program also coordinates with the California Air Resources Board's (ARB's) TVP, so that manufacturers of emissions control technologies can verify their product for both programs through one application process.
- *California ARB Diesel Emission Control Strategies Verification* (www.arb.ca.gov/diesel/verdev/verdev.htm). The California ARB's program is designed to support the various in-use California fleet regulations to reduce PM and NO_X emissions in the state of California. ARB publishes a verified technologies list online, which is updated as manufacturers complete their verification process. The California ARB list is used widely throughout the United States and coordinates with EPA's Clean Diesel Technology Program.

Worldwide, there are a number of other organizations, such as the European Verification of Emission Reduction Technologies (VERT), that offer verification support. While the purpose of all TVPs is similar, specific program elements and overall scope may vary. The TVPs described above are compared in the following table, which presents the geographic scope, program type, pollutant focus, main elements, and list of industry participants for each:

TVP Elements

Program (Administrating Agency)	Geographic Scope	Program Type	Environmental Focus	Main Program Elements[a]	Type of Members/ Participants[b]
Clean Diesel (EPA)	U.S.	Public-private partnership	PM and NO_x	P, T	T, R, L, S, M, N
SmartWay (EPA)	U.S.	Public-private partnership	Fuel/Energy	P, T, B	T, R, L, S, M
Diesel Emission Control Strategies Verification (California ARB)	California & U.S.	Public-private partnership	PM and NO_x	P, T	T, R, L, S, N
VERT Association	Europe	Nonprofit-led	PM, particularly ultrafine	P, T, B	T, R, L, S, M, N

[a] P = published list of technologies, T = third-party testing, B = branding

[b] T = trucking, R = rail, L = logistics, S = shippers, M = marine, N = non-road equipment

As shown in the table above, TVPs have some or all of the following main program elements:

- *Published list of technologies.* Arguably the most important product of a TVP, the verified technologies list typically includes the name of the technology, the percent of emissions reduced or fuel saved, and the name of the product's manufacturer. A technology's presence on the list indicates that it has undergone rigorous testing using standardized protocols to assess the emissions reduction or fuel savings.
- *Third-party testing.* Third-party testing refers to tests performed by an independent laboratory or testing group. An alternative to third-party testing is in-house testing performed by the TVP agency.
- *Branding.* Branding helps fleets publicize their use of technologies that meet certain performance levels. The use of branding (e.g., logos) also raises the visibility of the TVP.

C Stakeholder Participation

As you begin to plan your TVP, include and engage various people and organizations who are part of the industry and who have a stake in having technologies verified. By seeking their involvement in these early stages, you will realize two important benefits:

- Your program will be stronger, since a wide variety of stakeholders will contribute a broad set of perspectives and provide valuable feedback on your initial plans.
- By getting involved on the ground floor, your stakeholders will be more inclined to participate in and advocate for the program. They will be well-positioned to serve as advisory board members and allies as the program gets up and running.

Consider coordinating with the following groups:

- Freight industry
  - » Green freight organizations
  - » Large truck, rail, marine, and air freight carriers
  - » Local, regional, and national trade associations, such as trucking industry associations
  - » Large shipping and logistics companies, preferably international, with a substantial presence in your country (e.g., retailers, manufacturers, consumer goods, and commodity providers)
  - » Companies that participate in other TVPs internationally
- Manufacturers
  - » Original equipment/vehicle manufacturers
  - » Vendors of after-market parts and retrofit equipment (e.g., replacement parts, add-on parts, catalytic converters)
  - » Vendors of alternative fuels or fuel additives
- Testing facilities, including laboratories with equipment and expertise to carry out standard testing protocols
- Public and nonprofit environmental, air quality, public health, and transportation organizations

- Government transportation, environmental, and public health agencies, including local and state agencies with jurisdiction over local air quality regulations
- Advocates for the environment, public health, and improved air quality

- Professors and researchers at leading colleges, universities, and research centers who have an interest in diesel emissions reduction strategies and related policies

GROUP EXERCISE 4:

Brainstorm Stakeholders

Consider the benefits and risks of a TVP from the different perspectives of multiple stakeholders, such as freight companies, technology manufacturers, testing facilities, environmental organizations, and others.

MODULE III

Design Your Program

Explore how to establish goals for your program, including the types of technologies to select. Learn how to estimate a budget for the program and obtain funding. Explore different elements of a successful program, and finish by determining your program's staffing requirements. Key concepts include: prioritizing the most appropriate/cost-effective technologies; strategically using information from existing TVPs; and designing program elements to encourage high-quality applications from vendors, widespread technology adoption among fleets, and reliable/durable performance benefits from verified technologies.

SECTIONS

Suggested time for this module: 4 hours

A Performance Goals and Technologies

Begin by establishing environmental/energy goals for your program. The goals should be quantitative so you can measure your program's progress over time. Differentiate between short-term (one year), medium-term (approximately three years), and long-term (more than five years) goals. Consider your region's air quality levels as well as regional fuel cost and GHG reduction targets when establishing these goals.

Environmental/energy goals may include:

- Annual mass emissions reductions—e.g., X million metric tons of CO_2 or tons of PM reduced per year.
- Fuel savings reductions—millions of gallons of fuel saved and/or a fuel cost savings target.
- Efficiency performance improvement per vehicle/fleet—e.g., X percent improvement for vehicles/fleets adopting verified technologies relative to regional or national fleet average performance levels. Comparison relative to a baseline truck or fleet will demonstrate improvements in terms more meaningful to fleet operators than average annual improvements at the regional/national level.

Next, identify promising technologies. As discussed in Module II, there are a wide variety of technologies for reducing diesel engine emissions and fuel consumption. Given funding and staffing constraints, your TVP will most likely need to focus on a relatively small number of technologies, at least during the first years of operation. Consider your program's environmental/energy and participation goals to decide what types of control strategies your TVP will cover. Prioritize the technology options based on the following:

- *The types of vehicles/engines primarily responsible for high fuel use and emissions of concern.* This information can be obtained from emissions inventories and fleet characterization studies for your specific region (see Section A of Module II for details).
- *List of potential technologies.* Prepare a list of technologies that may be applied effectively to targeted vehicles/engines. Start by reviewing the verified technology and vendor lists from the EPA, California ARB, and VERT programs, along with effectiveness estimates. Follow up by investigating vendor and academic publications regarding real-world performance and operation.

- *The availability and cost associated with the potential control strategies.* Before proceeding, contact technology vendors to determine if specific product offerings are still produced, as well as sold and maintained in your region. Then obtain current price quotes for capital, installation, and maintenance for both low- and high-volume purchases.
- *Cost-effectiveness of potential strategies.* Compile estimated dollars per ton of emissions reductions, or net fuel cost savings per kilometer travelled, to compare the relative cost-effectiveness of the different technologies under consideration. These values may need to be adjusted for your region based on local fuel prices, average distance travelled, baseline fleet emissions, and baseline fuel economy. See Appendix A: Cost and Effectiveness Ranges for Selected Technologies.

Once you have identified your initial technology targets, estimate the level of fleet participation needed to meet your environmental/energy goals, based on standardized assumptions and calculations regarding the emissions reduction and fuel savings potential of the various technology options. Technology effectiveness is expressed in terms of percentage reductions (e.g., 3-percent fuel savings for verified trailer fairings), so you will also need to estimate baseline fleet emissions and fuel consumption levels (before technology application) in order to calculate potential emissions reduction and fuel savings levels. Consult with your region's emissions inventory experts to estimate baseline emissions and fuel consumption rates.

Example participation goals include:

- Carrier participation targets (e.g., 100 fleets agreeing to review their fleet and make improvements in the first year, 250 fleets in the second year)
- Technology penetration targets (e.g., a specified target retrofit with verified technologies or reduction kits within the first four years)

Finally, establish the TVP activity levels required to support the fleet participation targets, including which technologies to focus on first, ensuring adequate testing lab support and approval of the required number of applications per year. Obtaining multiple high-quality applications for each technology type is particularly important, since this encourages competition and continual product improvement among technology vendors.

Examples of TVP activity goals are to:

- Establish application and testing protocols for Technology Type "A" in year 1, for Technology Type "B" by year 3... (e.g., begin by verifying DPFs and DOCs, expand the program to include idle reduction technologies).

- Recognize X testing labs by year 1, etc.
- Aim for a minimum number of companies to submit applications by year 1.
- Aim for a minimum number of companies to receive approval by year 2.

All of these steps involve several assumptions, such as the number of applications received per year, the number of fleets adopting verified technologies, actual fleet activity levels (e.g., kilometers per year travelled), and the associated emissions/fuel consumption reduction. TVP administrators have limited control over these factors, so you will likely need to revisit and revise your overall program goals at regular intervals.

NOTE: While you may set multiple goals covering a variety of criteria, your public outreach and recruiting efforts should focus on a single, easy-to-understand measure (e.g., number of trucks retrofitted with verified devices per year), regularly evaluating and reporting on progress toward this goal.

GROUP EXERCISE 5:

Program Goal Setting

List some example environmental, participation, and verification goals for your TVP for the first year and then the first five years. Indicate steps you would need to take to reach those goals and how you would measure your success in meeting them.

B Establish a Budget

Having a sense of how much funding you will need to launch and sustain your program is important for planning and raising the necessary capital. To figure out your funding needs, take the following steps:

1. ***Seek input from other programs.*** Other TVPs have experience setting startup and operational budgets. Reach out to those administrators, and collect information on their experience:
   - How much funding did their program require in its first year?
   - How much funding did their program require in its second and subsequent years?
   - What were the major cost components of their budget, such as technical support staff (including number of staff, outreach/communication, and other administrative costs)?

- Was that level of funding adequate to launch their program as envisioned? Has it been enough to sustain and grow their program?
- What sources did they rely on to secure funding?
- How did the funding levels change over the first five years for the major cost components?
- What sources would they recommend for you to pursue?

2. ***Create a detailed line-item budget from the bottom up.*** Your program may have limited funding in its first year or two, so it is very important to plan your allocation of these limited funds carefully for maximum benefit. Consider creating distinct budgetary "bins," such as those shown below, to manage and track your program spending, as well as anticipate future funding needs.

   - *Startup costs.* These are largely one-time items, such as costs for initial staff recruitment, field audit equipment, developing the application evaluation process and verification test methods, and establishing test lab certifications. Although many of these activities will continue at a lower level in the future, their costs are most significant during the first year or two of program operation.
   - *Technology verification.* This includes costs associated with evaluating the performance of vendor technologies equipment in reducing fuel consumption and air pollutants based on information and data submitted by manufacturers. Expect to test a large number of technologies in the initial years and fewer later on. If these costs are borne directly by the technology vendors themselves, exclude them from your TVP budget.
   - *General operating costs.* Technical staff will be involved in a wide variety of day-to-day support activities, including reviewing applications, responding to vendor questions, engineering research, coordinating audit activities, and evaluating program performance, among many other activities. In addition, the program will always require some general administrative support (word processing, answering phones, coordinating meetings, etc.).
   - *Recruitment and outreach.* This includes ongoing outreach to technology manufacturers and laboratory testing facilities, as well as educating and engaging trucking companies and others about the benefits of your program. Your program's outreach costs will include creating a program website and initial marketing materials. Expenses in this category should be higher in the program's early years, since these materials will only need to be maintained and updated after the initial investment. Also plan for travel to events and IT support for the program's database development and maintenance.

C Secure Funding

Securing funding for a new program is often difficult. It may come from a mix of sources that depend on many outside factors, including interest from national and regional government agencies in transportation and freight-related issues, available capital, the role and influence of nongovernmental organizations, and program capacity. To secure funding for your program:

1. ***Do your research.*** Investigate all reasonable sources of funding, both locally and internationally. Possible sources include public sector agencies in your country that oversee transportation, environmental, public health, climate change, economic development, labor, and public infrastructure spending, as well as private family and corporate foundations and trade associations. Also research international and bilateral organizations such as the World Bank and the Inter-American Development Bank, which may be able to provide grant funding or contracts.
   - The World Bank: www.worldbank.org
   - The Inter-American Development Bank: www.iadb.org
2. ***Frame your program benefits in clear monetary—and other—terms.*** If your program is successful, how much money will be saved? How many jobs will be created? What are the projected emissions reductions and fuel savings? What other economic, health, and environmental benefits will accrue to participating companies, the public, and the nation? Funders and investors are going to want to know what their return on investment will be.
3. ***Involve all of your stakeholders from the outset.*** Funding for your program can come from many sources. Be open to thinking creatively about matching funds, dedicated funding (money earmarked for a single purpose), seed funding, charitable contributions, one-time grants, loans, etc., and how these sources combined can provide adequate funds to launch your program.
4. ***Build creative cost structures.*** Consider establishing application fees, testing discounts for early participants, membership fees, and fees for discrete benefits such as logo usage to generate funds for the program. (If you consider charging fees, be sure to consider costs as well as benefits, since high fees could discourage vendor participation.) Many programs also use in-kind contributions to sustain efforts. For example, a TVP could have partner governmental organizations host its website or dedicate staff as an in-kind contribution.

Consider also the benefits of establishing a grant program with funds dedicated to helping fleets and others acquire verified technologies by covering the cost difference between verified and conventional technologies or purchasing them outright. Grant programs, even ones that can afford to make only modest awards, can have a significant impact and stimulate activity throughout the supply chain. Grants can expedite technology installation and use in highly visible fleets, which help stimulate the demand for these technologies among other end users. This in turn incentivizes more manufacturers to participate in the program and can contribute momentum to your program as a whole. Additionally, the resulting increase in sales early on can help reduce costs and help bring more affordable products to market.

How Nonprofits Secure Funding

Nonprofit organizations secure funding through multiple sources. Individuals or companies who decide to become members pay an annual fee in exchange for recognition and other benefits from the organization. In addition to membership dues, nonprofits earn income through fees for service, including through government contracts and from manufacturers of DPFs. One nonprofit, VERT, provides filter testing and verification services for DPF manufacturers, as well as testing services and verification for filter media, regeneration fuel additives, and filters' on-board monitoring units. VERT receives funding from government agencies to conduct pilot studies and knowledge transfers focused on diesel bus and truck retrofit programs.

If you elect to establish a grant program, you must factor the need for the additional capital into your fundraising goals and activities. While raising additional capital for a grant program may seem difficult, the payoff of such a program can be enormous. For example, EPA's SmartWay program benefited from a grant program in its early and subsequent years. Its first grant cycle was modest, providing $100,000 in funding to a small number of applicants. EPA's grant program has grown in the intervening years, and the program recently announced $26 million in funding for projects that achieve significant diesel emissions reductions in fleets operating in areas with poor air quality.

D Design Program Elements

The primary product resulting from a TVP is a published list of diesel emissions reduction and fuel-saving technologies that have been verified to reduce emissions and/or fuel consumption by a specified amount and for a particular warranty period. The elements below provide examples of how vendors may qualify their products for the list and how TVP staff can maintain and promote the list.

1. ***Identify "pre-qualified" technologies.*** Many technologies may provide essentially the same performance levels regardless of where they are adopted. For example, certain idle reduction devices such as direct-fired heaters have a simple, robust design with low variability in their emissions rates. In such a case, it may be more cost-effective to rely on the emissions reduction estimates developed for other TVPs than to "reinvent the wheel" by requiring full performance testing again.

   On the other hand, certain technologies may have highly variable performance depending upon local conditions. For example, many exhaust particulate control technologies are highly dependent on both engine load profiles and diesel fuel sulfur levels. If a particular technology was verified by another program under operating conditions significantly different from those in your region, these technologies should undergo verification testing tailored for your program.

   Therefore, the first step in designing your TVP is to decide which, if any, technologies verified through other programs can be considered valid and effective for your TVP. This may require a detailed engineering assessment by your program's technical staff as well as consultation with local fleet operators and other experts regarding regional operating considerations.

GROUP EXERCISE 6:

Pre-Qualified Technologies

List technologies that have been verified under other programs that may pre-qualify for your TVP.

2. ***Define technology classifications.*** The technologies on your program's verified list can have a wide range of effectiveness in terms of percent fuel saved or emissions reduced, leading to uncertainty among potential adopters. Establishing minimum performance levels and then classifying verified technologies into groups according to their level of effectiveness simplifies the presentation and assessment of the achievable benefits for both participants and the host agency.

   By defining cutoffs for program qualification (e.g., DOCs achieve at least a 30-percent reduction in PM emissions), you provide a clear target for technology vendors and instill confidence in the fleets investing in these technologies. By providing a performance-based classification system to group the technologies into fewer categories, you also make it easier for fleet

managers to understand the benefits they can expect. This in turn will likely boost participation in your program. In addition, it will be easier to communicate the performance of verified technologies to the public and policy makers.

EPA's SmartWay program and ARB's Diesel Emission Control Strategies Verification Program both use tiered classifications to group technologies according to fuel savings or reduced emissions. ARB requires a minimum of a 25-percent reduction in either PM or NO_x emissions to be verified and classifies technologies into Level 1, Level 2, or Level 3, where the PM reductions are at least 25, 50, and 85 percent, respectively. SmartWay rates the effectiveness of aerodynamic technologies using four percent-based categories (see "How SmartWay Does It"). Not all TVPs utilize this program element, however. EPA's Clean Diesel Technology Program publishes the emissions reductions for each technology rounded to the nearest percent. The VERT program does not approve PM reduction devices over a range of effectiveness; it only verifies those that achieve a reduction of 95 percent in particle number concentration.

You can also use predefined performance levels to build in leverage points that reinforce the value of your program. For example, if your program has three performance designations (e.g., bronze, silver, and gold), you may allow fleets adopting technologies that meet silver or gold levels to display program logos, a distinct value for public relations. Similarly, fleets that install gold-level technologies may be eligible for preferential access at ports or inclusion in emissions reduction trading programs. Such measures may incentivize program participation, although they will frequently require coordination across multiple agencies and businesses.

How SmartWay Does It

SmartWay verifies aerodynamic devices and combinations of devices for the following fuel savings categories:

- 1% (1%–3.9% fuel savings)
- 4% (4%–4.9% fuel savings)
- 5% (5%–8.9% fuel savings)
- 9% (9% and higher fuel savings)

SmartWay verifies new tires and retread technology for low rolling resistance based on target values designed to achieve at least a 3-percent fuel reduction when used on all axle positions.

SmartWay idle controls are verified based on the ability of the device or system to reduce unnecessary idling by shutting down the main truck, locomotive, or marine engine while providing heating, cooling, or electrical power by alternative means.

SmartWay also issues technical bulletins that provide useful information on technologies' lubricants, tire inflation systems, and others that are not verified but which have a proven ability to reduce emissions and fuel consumption.

3. ***Create an application process.*** The application process includes the steps a technology manufacturer must follow in order for its product to become officially verified by your program. A formal application document should provide sufficient information for your staff to evaluate the manufacturer's claims of fuel savings or emissions reductions.

   In the United States, verification programs administered by EPA and ARB have a two-step application process. EPA and ARB programs delve into different levels of detail in the preliminary application. EPA's process starts with a request for basic information about type of technology and contact information for follow-up. EPA then requires a secondary application, which is technology-specific and requests detailed information on the testing procedures, facilities, and results. In contrast, ARB's TVP application contains a high level of detail upfront in the preliminary application.

   The primary components of any TVP application should include:

   - *Identification of applicant and technology.* The application should clearly identify the applicant, including: company name, company representative name (point of contact), address and phone number of the company representative, and the name of the technology or product.
   - *Technology type.* Technology type refers to the broad product category, such as trailer fairings or DPF. You may want to include a table of technology types that your program currently verifies. Alternatively, your application could list technologies not verified by the program.
   - *Detailed component list and function.* The technical description should provide details on each component in the device, including the dimensions and weight. You may also request a schematic of the system design (and depiction of the operations, if appropriate). The schematic should be accompanied by a list identifying all components and text covering the principles of operation. The principles of operation should address the technical reasons the device leads to lower fuel consumption or a reduction in emissions.
   - *Device compatibility.* Applicants must address the issue of the device's compatibility with the engine, including design features that may vary across engines and the device's effect on overall engine performance.[1] For each device seeking verification, the applicant should identify the intended applications, addressing the following:

1. Based on the age and condition of the engine, it may be advisable to replace the engine with an updated model or rebuild the engine to a cleaner, more efficient version.

- The specific truck/equipment manufacturer(s), model years, emissions standards, and/or engine families the device is intended for. Certain devices, such as aerodynamic trailer treatments, may also require a description of configuration/body type constraints.
- The potential for the device to cause drivability, engine performance, or fuel efficiency impacts, for example due to increased backpressure and potential clogging in DPFs.
- The regeneration strategies of DPFs and how regeneration events affect truck/equipment operation.
- Operating conditions where the device will not achieve the performance levels established in verification, such as low exhaust temperature conditions for SCR units.
- Operating conditions that may lead to decreased durability or safety concerns.
- Details regarding noise level compliance, if applicable.
- Vehicle and engine condition requirements (all maintenance must be up to date and engines and equipment should be in good operating condition prior to installation or retrofit).

- *Verification type.* Following the technical description, the application should indicate which type of verification the applicant seeks. The type of verification available will depend on how you have structured your program. For example, if you have classified PM reduction potential into groups—similar to ARB's Levels 1, 2, and 3 for PM reduction thresholds of 25, 50, and 85 percent—then your applicant may seek designation in a particular category on your verified technologies list. The applicant should also clearly specify the actual emissions reduction or fuel savings achieved through testing.

- *Test protocol.* Each applicant will present an initial test plan for the TVP technical staff to review who may then work with the applicant to modify test procedures for improved accuracy and precision if needed. See "Verification Testing" on III-13 for details regarding how performance measurements will be made.

- *Installation and maintenance requirements.* Finally, the application should include information on installation requirements, such as the required placement of the device. If the technology is only compatible with a particular engine family and/or specific model years, the applicant should clearly convey this information. The applicant should also identify maintenance practices, including lubricating requirements, along with any potential failure modes, possible misfueling issues, and procedures for resetting monitors after maintenance. Maintenance requirements should be specific; for example, they should include objective criteria for establishing whether a PM filter

is "cleaned" and the consequences for failing to meet criteria. Regarding failure modes, the applicant should describe any unfavorable operating conditions that would cause reduced effectiveness or durability of the technology and any safety concerns. The applicant should also specify the noise level compliance and instructions on how to handle spent components or materials removed from the technology.

- *Alternative fuel and additives.* Diesel engines that operate on alternative fuels (e.g., biodiesel) or fuels containing additives (e.g., cetane enhancers) can reduce emissions compared to the baseline diesel sold in your country or region. Alternative fuels or additives may merit a separate application because the testing requirements and types of environmental concerns that could arise (e.g., spills, flammability concerns, human exposure) differ significantly from other device-based technologies.

ARB's TVP requires a separate addendum to the main application for the verification of alternative fuels or additives. An applicant seeking verification under ARB's TVP must specify the chemical composition of the fuel or additive; the concentration of fuel additives; and specific properties, including sulfur content, total aromatic content, total polycyclic content, nitrogen content, density, and specific measures of volatility. ARB's fuel-specific application also lists a variety of testing requirements regarding the order of repeated emissions tests using a standard "reference" fuel, as well as the proposed alternative/additive.

An essential element of your TVP's application process is establishing how and when communication takes place between your program staff and technology manufacturers as a technology undergoes the verification process. By setting up a process with responsibilities and scheduled delivery dates, the overall verification process (which can be lengthy and complex) is broken down into manageable pieces, making it easier to understand and share required information. Establish a clear communication plan and share it in advance with potential applicants in order to facilitate the data submittal and approval process. Over the long term, consider holding webinars to ensure ongoing communication and data-sharing regarding the application and testing process, which will help with recruitment and retention efforts.

For inspiration in developing applications, visit other TVP websites, and note how they structured their forms.

GROUP EXERCISE 7:

Become Familiar with Vendor Applications

Are you ready to approve vendor applications? What should you look for, and how can you help vendors correct their mistakes? Even the most straightforward vendor applications are not always completed accurately, and vendors will need help and guidance to correct them. A sample application can be found in Appendix B: Group Exercise Materials.

4. ***Conduct verification testing.*** Before a technology can be accepted onto a verified list, it will need to undergo emissions/performance testing to ensure that it meets the minimum qualifications for the program and establish its estimated emissions reductions and/or fuel savings performance. The TVP should establish guidelines and minimum testing requirements.

   Testing should be performed by an independent, qualified research facility/laboratory, and test labs should be formally accredited, such as by meeting ISO standards.[2] Finally, the measurement technology should meet all the criteria specified in the testing protocol(s) applicable to the technology.

   Your TVP should define the verification testing process that applicants need to satisfy. The applicant should propose a specific plan for a given device, with input and ultimate approval from the TVP. This process should include tests to establish emissions and/or fuel consumption reductions, demonstrate effectiveness in the field, and assess durability. Specific requirements for engine preconditioning and test fuels should be included as well.

   Guidelines for establishing the verification testing protocol are detailed below:

   - *Measuring emissions reduction or fuel savings.* Emissions and/or fuel consumption testing is required for an engine with and without the device installed (usually a prototype device) to provide a basis for calculating the device's effectiveness. The applicant must select the appropriate test engine(s) and/or vehicle(s) for which the device was designed. The age (in hours of use) or mileage accumulation level of the device at the time of testing should be specified, as well as any requirements for the method of aging (discussed under "Durability Testing on page III-15"). The applicant should demonstrate that the selected

2. ISO/IEC 17025—https://www.iso.org/publication/PUB100424.html.

characteristics represent the range of applications intended for the device. To make test protocol development easier, the TVP may define groups of engines that are considered similar, so that one engine can represent an entire group.

The procedure used to demonstrate the effectiveness of the device may require laboratory testing, on-road testing, or a combination of the two. Laboratory testing must include specific engine or chassis duty-cycles and procedures that represent typical operating conditions the device will experience in the real world.

For many devices, typical emissions certification cycles will be adequate. If on-board emissions measurement will be used, the test procedure should reflect local conditions (e.g., pavement quality, road grade, perhaps ambient conditions) and be replicable for the tests with and without the device. Devices that improve fuel economy through reduced road load, such as aerodynamic improvements or low resistance tires, may be better assessed with specific test protocols focused on the specific improvement, such as wind tunnel tests or road load coastdowns.

Example test procedures that may be appropriate for different emissions and fuel reduction technologies are shown in the table below:

Example Test Procedures Applicable to Emissions and Fuel Savings Devices

Operating Regime	Applicable Technologies	Example Test Procedures*
Highway driving	DPF (PM) SCR (NO_X, HC) DOC (CO, HC, PM) Aerodynamic (fuel, CO_2) Low rolling resistance tires (fuel, CO_2)	Heavy-duty FTP (engine) Heavy-duty supplemental emissions test (engine) HWFET (chassis) NTE (on-road) SAE J1321 track test Coastdown test Wind tunnel CFD ISO 28580 SAE J 1269
City driving	DPF (PM) SCR (NO_X) DOC (CO, HC)	Heavy-duty FTP (engine) Heavy-duty UDDS (chassis) Central business district (chassis)
Idle	Idle off, APU, FOH, shore power	Idle test-approved protocol

*Test procedure details can be found at: www.dieselnet.com.

The tests listed above may be adopted in their entirety. Alternatively, they may provide a basic template or starting point that can be modified to reflect your unique local operating conditions.

To determine if an existing test cycle from the table is adequate or if a new cycle is needed, you will need an assessment of the operating conditions that a vehicle equipped with the control device will experience in the field.

- *Durability testing.* For technologies whose performance may diminish over time, the applicant should demonstrate the durability of the device, namely the ability of the device to perform at verified levels for the duration of its useful life. Useful life must be defined and justified by the applicant. Durability testing should be performed on devices that have been aged either through field use or laboratory methods, as specified by the TVP.

- *Field demonstration.* As determined to be appropriate, the applicant should demonstrate the performance of the system under real-world operating conditions. This requirement could be waived if the durability testing was accomplished through field-based demonstrations. Otherwise, this component of the test program should require reporting on key engine parameters (e.g., exhaust temperature, engine speed, backpressure measurements), emissions measurements, photographic evidence of the installed device, third-party statement of field use and performance, and any electronic error codes generated while using the device.

5. ***Conduct in-use testing.*** For added confidence in devices approved for the verification list, manufacturers can conduct a separate test program to demonstrate that the devices are working as intended in actual use. In-use testing can be similar to verification testing in that it tests engines with and without devices to determine emissions reductions or fuel savings. The TVP should specify overall elements of the in-use testing, such as:

   - The number of devices sold that will trigger in-use compliance testing based on projected overall sales in your country, as well as the maximum time allowed to pass after meeting this threshold.

   - The vehicle selection, device age, and test procedures to be used for the program (laboratory or field measurement, test cycles, preconditioning, etc.). Consistency with the verification test procedure is preferred.

   - The threshold that defines a passing device, usually as a percentage of emissions reductions and fuel savings established in the verification testing, if some loss in effectiveness is considered acceptable under real-world conditions (e.g., 75 percent of the verification reductions).

- Consideration of testing "without device" engines, which will need to be tested before devices are installed. The sample of these engines will need to be large enough to account for engines that leave the fleet (due to accidents, etc.) before the time that "with device" in-use testing is required.
- Influence of maintenance or other factors that would affect device performance in the in-use test.
- The number of devices that must pass to provide sufficient evidence of in-use compliance, whether additional tests are required in the event of a device failure, and what level of failure is required to have a device removed from the verification list.

How ARB Does It

The California ARB sets forth clear expectations on important milestones throughout its verification process. As summarized below, ARB also grants 15-day extensions on a case-by-case basis, if there is good cause and the manufacturer requests the extension in advance of the timetable set forth below.

Technology manufacturer submits preliminary application.

Agency reviews the preliminary application and notifies applicant in writing *within 30 days* of receiving the application of whether it is complete or requires additional materials or clarification. If the latter, manufacturer must provide the materials *within 60 days* of the date on the notification letter.

The agency conducts a technical review of the preliminary application to determine whether it is adequate to support the development of a test plan approval letter. If satisfactory, the agency issues a test plan approval letter to the applicant *within 45 days*.

The technology manufacturer submits a final application (with test results).

The agency reviews final application for completeness and again notifies applicant *within 30 days*. Agency then performs technical review of test results and compliance. *Within 60 days* of determining whether the final application is complete and in good technical standing, the agency will verify the diesel emissions control strategy.

At any point throughout the process, the agency may request additional supporting materials. The manufacturer must reply *within 60 days* of notification.

6. ***Manage vendor data and maintain the verified technology list.*** Technology vendors will often provide confidential business information (CBI) as part of their application, including detailed engineering and performance data. Your TVP must develop rigorous procedures for handling and storing CBI in order to assure your applicants that their data will be kept private and secure.

   Establish clear legal guidelines and policies regarding privacy and data security during the program development phase. When possible, work with applicants on an individual basis to balance concerns for confidentiality with the need for transparency to more clearly demonstrate technology effectiveness claims.

   Once the application for a specific technology has been approved, place it on your program's official verified technology list. Post the list on your program website. Establish and publicize fixed schedules for product eligibility, review, and the procedures for removing products from the list. For example, TVP staff may be required to attempt to contact with vendor representatives three times before removal, and vendors may have up to three months to appeal (e.g., by submitting independent in-use verification data). Defining the terms for both inclusion and removal from the list beforehand will reduce uncertainty and encourage technology vendor participation in the program.

Notes

MODULE IV

Launch Your Program

Learn about design and development steps to launch and sustain a successful technology verification program. Key concepts include administrative infrastructure, branding, program website development, outreach activities, and managing program data.

SECTIONS

Suggested time for this module: 2 hours

A Program Infrastructure

Adequate and appropriate staffing for the program is important. While staffing needs will certainly change with program growth, in this early stage consider recruiting staff with the following skill sets to help establish and cover critical program functions:

- Program management and administration
- Budget/financial management and analysis
- Ability to provide technical support for in-use verification/auditing
- IT/website and tool development
- Stakeholder engagement, outreach, marketing, and branding

Depending on the skills of your team, your program may need at least two or three full-time equivalents. Your first hires should have broad program management experience; experience with technologies, technology verification, and testing protocols and facilities; and connections to manufacturers and end users. Seek out managers with voluntary program design and implementation experience and technical leads with an understanding of control technologies, emissions/performance testing, and automotive engineering.

Plan to orient staff to give them the background they need to support the program. Consider developing a manual that outlines the responsibilities for each job title. Also provide training on how to use all program tools, such as using the program database to track and maintain technology lists, manufacturer contact information, testing performance, etc.

Once your program is ready to launch, add staff to help review and approve applications, as well as staff with technical expertise in and a deeper knowledge of emissions reduction and fuel-efficient technologies and strategies; trends in the heavy-duty industry and the manufacturing sector; relevant air quality policies, programs, and stakeholders; and current testing programs, protocols, and facilities.

You will also need database and Web programmers and administrators. Before hiring, ask candidates how they would set up systems to track contact information, track the progress of technologies being tested and approved, and provide news and helpful information for administrators and users. Importantly, database and web developers—as well as all other staff—need to

understand the mechanics and importance of identifying and protecting CBI through the use of firewalls, password protections, encryptions, and other means.

You will also need staff who have some marketing, brand management, and communication expertise. While outside experts and consultants can provide specialized marketing and branding services, plan to use in-house staff to manage all outgoing and internal communications.

Later on, once your program has reached the expansion phase, you will need to hire new staff to support the development of new initiatives and technologies. To develop new initiatives, staff will need the following qualities:

- Entrepreneurial mindset
- Ability to write and interpret technical reports and convey technical knowledge
- Ability to identify trends and understand technology adoption life cycle

GROUP EXERCISE 8:

Stakeholder Role Play

Participate in a group role play to highlight the areas of expertise TVP staff should have to operate the program and be responsive to stakeholders. Refer to "Stakeholder Scripts" in Appendix B: Group Exercise Materials.

B Branding

Branding defines a positive and memorable image of your program to your equipment manufacturers, stakeholders, and the public, leading to increased and sustained industry engagement. Take time before the program is launched to think about your brand and develop branding and outreach building blocks to use as the program develops. Choose program branding that is specific enough to accurately represent the program but maintains relevance as the program develops over time.

To get started, follow the steps below:

1. ***Develop a program brand, including a logo and logo use criteria.*** Establishing and presenting a consistent brand is important for marketing and outreach. It unifies your program under one easily recognizable symbol, provides a shorthand for referencing your program, and helps you distinguish your program from others.

   Create a brand identity that represents your program and conveys its attributes, values, purpose, and strengths:

   - Articulate your program's core values and services and how they are different from those of other similar programs, such as its consistent, rigorous verification procedure that can help "level the playing field" for all vendors of a given technology by clearly differentiating quality products from those that do not meet their claimed performance levels.
   - Identify the target audience and frame your mission, values, and services to address their needs.
   - Assess your program and collect feedback on an ongoing basis to continually strengthen and maintain your brand's effectiveness.

   Describe your brand in a one- or two-page document ("brand platform"). Share this document with your whole team so that everyone sees and understands your brand in the same way, which will help everyone present your program, its value, and services in a clear and consistent way.

GROUP EXERCISE 9:

Create a Brand Platform

Defining a program brand is not as easy as it seems. To start, brainstorm answers to the following questions:

- What is your program's mission?
- How is your program different from others?
- What are the benefits and features of your program?
- Who is the target audience of your program? Who are the stakeholders?
- What qualities do you want to be associated with your TVP?

Use your responses to draft a one-page brand platform for your program.

2. ***Create a logo.*** Your program logo helps define your brand and will be used on all materials, electronic and print. Use it consistently to quickly build a recognizable brand. The logo should reflect your brand identity, incorporating the colors, look, and feel you want associated with your brand.

   To begin, choose a color palette for your logo that will establish colors for use in all outreach materials. Use caution when selecting a palette. Different cultures have different associations with colors.

   Also choose fonts and styles. Adopt a standard set of widely available yet distinctive fonts to use in printed and electronic materials, including presentations and brochures. Consider hiring a qualified graphic design artist who can not only design the artwork but can also provide templates, logos in the right formats and dimensions, and an internal style guide for your staff to follow.

3. ***Develop basic outreach materials.*** Once you have finalized your program's brand and logo, develop some basic outreach materials. Each should be program-branded and must include the program logo and contact information.

   At first, you might only develop one basic program brochure. It should briefly describe your program and its mission, as well as provide a "call to action" for each audience type. The call to action for manufacturers might ask them to submit their technologies for testing, whereas the call to action for trucking companies might be to use verified technologies. Eventually, separate brochures targeting technology manufacturers, trucking companies, and the general public will probably be required.

Tip

Consider obtaining a trademark registration for your program and partner logo domestically and internationally. This will provide you with the ability to prevent its use by unauthorized parties and better control the way that your brand is used worldwide. The Madrid Protocol provides a centrally administered system of obtaining "bundled" trademark registrations in different jurisdictions.

How SmartWay Does It

SmartWay logo use guidelines include the following "dos and don'ts":

- SmartWay logos must be used in their entirety. The graphics may not be altered.
- The SmartWay logo files approved for use can only be obtained by contacting EPA.
- Logos must be applied on a white background.
- Logos must be legible at all times.

The full logo guidelines can be found at: https://www.epa.gov/smartway/how-apply-smartway-logo-your-smartway-tractors-and-trailers.

C Program Website Development

A program website is an important resource that serves as a repository for all program information and potentially a communications hub that administrators can use to monitor and disseminate communications to manufacturers. At a minimum, the website should include information on verified technologies, program news, official program materials (such as the program brochure), technical reports, links to external resources, and general background information. The website should reflect the program's brand (logo, colors, tone).

Verified Technology for SmartWay and Clean Diesel

The SmartWay and Clean Diesel Technology Program webpages (www.epa.gov/verified-diesel-tech) are a key resource for all program stakeholders and the general public. They serve as a central and universally accessible repository of program information for SmartWay's Technology Program. EPA staff update these webpages on a regular basis with announcements and all types of new content.

The SmartWay and Clean Diesel website (and the Technology Program's webpages) resides within EPA's website, so it fits within EPA's overall web design, navigation, and structure. When planning your program's website, start by determining who will host it, and work within any design and operational boundaries they present. Potential hosts include government agencies, advocacy organizations, and trade associations. (If your TVP is independently operated, its website may also be independent.) If you elect to have your program website hosted by another organization, you will lose some control over how it functions but potentially gain additional credibility and cross-promotional benefits that come from being associated with your host.

The SmartWay and Clean Diesel Technology Program webpages organize content under two sub-headings in eight tabs:

Clean Diesel

- Learn about
- Verification process
- Verified list
- Formerly verified list
- Contact list for verified technologies (as per website)

SmartWay

- Technology for trucks and school buses
- Technology for locomotives
- Technology for marine

As you consider your program's website structure and design, peruse the SmartWay and Clean Diesel Technology Program's webpages and the websites of other TVPs to get ideas of what type of information can be housed on your website and how to organize it. However, keep in mind that all websites are works in progress! They can and should be analyzed and refreshed regularly to be as responsive to visitors' needs as possible.

In addition to verified technologies (perhaps organized into categories, such as aerodynamics, tires, retrofits, etc.), include information on relevant regulatory activity, announcements and advisories, portals to the database, FAQs, a page about the program, program contact personnel, and other useful information.

D Outreach Activities

In large part, the success of your program will be built on incentivizing manufacturers to submit technologies for verification, as well as making end users aware of and interested in using those verified technologies through effective outreach and public recognition opportunities. To facilitate these behaviors, plan and conduct targeted outreach and communications on a regular basis.

Before you begin, clearly define and identify your target audiences, how they receive and consume information, and by what means. Once you know which manufacturers and end users will benefit from your program, as well as the associations and organizations they belong to, the websites they visit, the news outlets and trade publications they read and respect, the conferences they attend, etc., use the following professional outreach strategies to deliver your message about your program:

1. ***Leverage current relationships.*** Approach professional colleagues, industry experts, industry organizations and companies participating in related programs about the launch of your program, and ask them to help spread the word. If you want to target multinational companies, check with SmartWay staff from EPA or Natural Resources Canada to see if they are already SmartWay Partners in the United States or Canada.

2. ***Use industry resources.*** Consult industry trade publications and other sources to identify manufacturers and others who will benefit from your program. Discuss your program with prominent industry organizations for ideas and support.

3. ***Attend conferences, expos, and events.*** Attend relevant events, such as trade shows and shipper and carrier conferences, to increase the visibility of your program. Before you go:
   - Be sure to understand who is attending and what they are looking to get out of the event, and frame your program to match those expectations.
   - Have visually appealing program materials on hand to display and distribute.
   - Schedule time to network with other attendees and exhibitors.

Consider also developing and hosting a series of public workshops and/or webinars to educate fleet owners, local agencies, and other end users about the verified list of technologies and its value.

> **Tip**
>
> Your target audience members are running businesses. Be respectful of their time when making direct calls and avoid any communications that may be construed as telemarketing or "spam."

4. ***Conduct face-to-face meetings.*** When budgets allow, face-to-face meetings can be an effective outreach technique.

5. ***Use cold calls and direct mailings.*** If you have or can secure contact information of industry group members, you can call them directly (make a cold call) and/or send direct mailings. To get the best results, make sure the membership organization endorses your program, try to have the mailing co-signed or co-branded by the membership organization's highest executive, send a mailing before making a call, and be sure to include information on the benefits of the program tailored to the recipient. Place follow-up calls shortly after your mailing is scheduled to arrive, and reference the letter early on in the phone conversation.

6. ***Incorporate public recognition.*** Conducting outreach is easier when there are news to share and stories to tell. By integrating public recognition components into your program, you can create stories to push to the media while also positively reinforcing participants' experience with your program. For example, collect a list of the names of companies using verified technologies and the technologies' manufacturers and put the list on your website, post it on social media, and release it to the media, acknowledging the positive steps companies and manufacturers are taking to help the environment. Also consider conferring awards at an annual conference to the most active participants and manufacturers. You can also publicly thank these stakeholders in paid advertisements and unpaid announcements that appear in trade publications or the general media.

As you conduct outreach, create a list of stakeholders and their contact information so you can communicate with them electronically about the program. This contact information should be housed in the program's database (see next section).

GROUP EXERCISE 10:

Communications Plan Basics

Communications plans often begin by defining basic elements such as:

- *Target audience(s)*—who do you want to reach?
- *Primary messages or call to action*—what do you want them to do? Tailor these to each audience.
- *Dissemination mechanisms*—how are you going to reach the target audience?
- *Frequency of dissemination*—how often are you going to reach the target audience?

Brainstorm these different elements for your program and complete this matrix to establish the basic foundation of a communications plan.

Target Audience	Primary Messages or Call to Action	Dissemination Mechanisms	Frequency
Fleet managers	Use the list to inform your equipment and retrofit purchasing decisions	• Publications read by fleet managers • Websites visited by fleet managers • Freight conferences • Direct contact	• Ad every quarter • Banner for six months • Annual • Two contact attempts

E Managing Program Data

Building and using a database is highly recommended to manage all program data in a central and secure location. The database will be central to the efficient operation of the program and serve multiple functions. If built with the right types of functionality, it could:

- Provide a publicly available portal that allows visitors to gain access to information on industry participants/manufacturers and verified technologies, including test results and technology performance.
- Store and protect internal program information, such as contact information for manufacturers, organizations, and other stakeholders, as well as other CBI.
- Generate electronic communications between the program and manufacturers, trucking companies, and the public.
- Collect all applications, submittals, and approvals.
- Track data quality and calculate program benefits.

It is therefore essential to launch the database successfully before the first technology verification application is submitted.

After designing and beta-testing your relational database, confirm that it is ready for data entry, as well as uploading, approving, and processing technologies. Next, make sure that program and database administrators are fully trained on database use and their responsibilities. To minimize potential data loss, ensure that regular data backups occur in case of system outages or other problems. Also perform regular data validation checks to confirm that there are no "orphaned" or bad records. Finally, maintain adequate security procedures to protect data and avoid unauthorized data modification.

MODULE V

Evaluate, Refine, and Expand

TVPs are dynamic, so it is important to assess the current condition of your program periodically and introduce changes as appropriate. Learn how to transition your program beyond its initial structure to ensure that it continues to meet the needs of your stakeholders (e.g., the freight industry, technology manufacturers, testing facilities, government agencies, advocacy organizations, researchers). Key concepts include periodically evaluating program performance, collecting feedback from stakeholders, and making interim changes to your program.

SECTIONS

Suggested time for this module: 1.5 hours

A Evaluate Program Performance

Conduct an annual assessment of your TVP's performance, comparing accomplishments to date with your overall program goals (see Module III, Section A). For example, consider undertaking the following types of evaluations every year:

- Determine the number of applications received, processed, approved, denied, and in process.
- Estimate the number of companies and vehicles installing verified technologies.
- Calculate the yearly and cumulative emissions reductions and/or fuel savings associated with these installations.
- Assess program staff performance, including time and expenses associated with application processing, communications and outreach, and test protocol development.
- Periodically audit verified technology to confirm performance.

The results of your annual performance review will help identify problem areas that need to be addressed as well as areas of strength that should be continued and possibly expanded.

GROUP EXERCISE 11:

Examine an Example Benefits Calculation

To become familiar with the process of calculating the annual emissions benefits delivered by a TVP, conduct an annual emissions benefits calculation. Refer to Appendix B: Group Exercise Materials, "Example Benefits Calculation Worksheet."

B Collect Feedback

Participants in your TVP will have valuable insights based on firsthand experience into whether your program is delivering on its promises and serving a major need. It's important to recognize the value of their feedback and let it serve as the basis for both minor adjustments and major changes to your program.

When to collect feedback. Collecting feedback to assess your program's performance and areas for improvement is not a one-time event. It should be an ongoing effort. Some potential opportunities to collect feedback can take place during:

- Initial program development meetings with stakeholders
- Development and rollout of new tools (such as payback calculators) or when making significant updates to existing tools
- Review of the program three years after its initial launch and on a regular basis thereafter (such as every two or three years)
- Review by independent, third-party stakeholders (e.g., trade associations, academics)

What to ask. The specific questions you ask when collecting feedback will depend upon the development stage of your program, the type of feedback that you are seeking, and your program's individual characteristics. Some feedback may be quantitative in nature (e.g., focusing on the market penetration of a particular technology), while other feedback may be more qualitative (e.g., determining overall levels of satisfaction with the program, identifying specific complaints or uncertainties). Below are some examples of questions to pose to various program stakeholders. Note that certain safeguards may be needed when collecting this information since some questions ask for confidential information.

Example questions for technology vendors:

- How many of your verified units have been sold and installed in your region, by year?[1]
- Do you anticipate the market increasing or decreasing for currently verified technologies?
- Do you believe the technology verification test conditions are reasonably representative of real-world vehicle/engine operation for your target market?
- Did the test laboratory (or laboratories) that you used provide services at a reasonable price?
- Were there any performance issues associated with your test lab?
- Did you receive adequate information regarding this program's data requirements and the TV process overall?
- Are we publicizing the verified technologies list adequately?
- What suggestions do you have that can help us improve our TVP?

1. Separate questions may be needed if installers are different from the manufacturers.

Example questions for purchasers of verified technologies:

- Has the verified technology performed as expected?
- If not, please describe any unexpected operation problems and/or costs.
- Have you submitted any warranty claims, and if so, were there any problems with the claim process?
- Have you publicized your technology purchases to your clients or the public?
- Has the adoption of verified technologies in your fleet had a measurable impact on your sales efforts?
- Are you interested in any technologies that are not currently included on the verified list? If so, which ones and why?

Example questions for test labs:

- Has your business changed noticeably as a result of the TVP?
- Has the TVP provided adequate information regarding facility and test requirements and reporting procedures? Are these requirements reasonable?

GROUP EXERCISE 12:

Brainstorm Feedback Questions

What questions should you ask to collect the feedback you want? It is not always as straightforward as you might expect. Generate a list of feedback questions that you can use to collect insights on your program and how to improve it.

How to collect feedback. You can collect feedback using a variety of tools and techniques. Some common ones include:

- *Surveys.* Surveys are useful in collecting information from a large number of people. Your collected information may be either quantitative or qualitative, using either multiple choice or open-ended free response.
- *Interviews.* One-on-one interviews provide the opportunity to obtain deeper information by posing questions and then asking follow-up questions, depending on responses. Conducting interviews takes more time than administering surveys, and usually the sample size is much smaller.

- *Focus groups.* Focus groups are an intermediate method between surveys and interviews led by a trained and experienced facilitator. They provide more in-depth information than surveys, but not nearly as much as one-on-one interviews. Focus groups are composed of participants with common experiences or backgrounds and are often used to test or "dry run" program messages, marketing campaigns, and published materials prior to full "live" implementation.
- *Stakeholder meetings.* Meetings and workshops provide a forum for two-way communication with stakeholders. You are able to convey new information regarding your program and also interact with stakeholders to obtain feedback regarding this new information.

Make Interim Changes

The results from your annual performance assessment, combined with the feedback you collect from stakeholders, will help you determine the types of changes that should be made to your program. In many cases, this information will suggest minor modifications to processes or administrative procedures. In other cases, the findings may indicate the need for a significant overhaul or correction. Some potential situations that may require significant adjustments include:

- *Communication and administrative strategies need to be updated.* Technology vendors, test labs, and/or product purchasers may express dissatisfaction with the TVP's administrative and other processes. For example, processing applications may take significantly more time than manufacturers and vendors anticipate, causing frustration and dissatisfaction. Delays may result from an inadequate or unclear description of data submittal requirements or test procedures, support staff being over-committed or needing additional training, or many other reasons. Modify the application guidelines and/or review processes, instructions, outreach materials, and program budgets as needed in order to maintain stakeholder support and participation in the program.
- *Estimated emissions reductions are short of targets.* Emissions reduction targets may not be met for a number of reasons, including lower-than-expected technology adoption rates or unanticipated performance problems with the technologies. Investigate the following developments and issues to continually improve the emissions reduction performance of your TVP:
  - » *Real-world operating situations undermine technology effectiveness.* The real-world conditions under which diesel engines operate might be significantly different than the conditions upon which the technology effectiveness was based. Some examples might

include lower quality of fuels "at the pump," limited effectiveness of the technology because of certain speeds or other engine loads, and effectiveness estimates based upon limited ambient temperatures. Review current test procedures and revise them based on new information on representative operating conditions.

  - » *Market is moving away from particular technologies.* For instance, after a verified technology is initially adopted, virtually all stakeholders may begin to favor a different technology. Alternatively, the effectiveness of a verified technology might be reduced when it is used with an emerging technology. Continually assess promising technologies under development, and consider how their broad acceptance could affect your program.
  - » *Certain technologies are economically favorable/unfavorable.* Individual stakeholders will make their technology investment decisions based upon their own circumstances, with economic considerations likely being the most important. Over time, certain technologies will emerge as more economically favorable and will be widely adopted compared to others that are more costly. This is especially difficult because the comparative economic favorability may not be readily known at the time of your program implementation. Periodically review the financial viability of verified technologies as well as promising technologies under development to help focus future program resources.
  - » *Certain verified technologies are no longer manufactured or maintained.* Particular technologies within your program may no longer be manufactured, or owners may not be able to obtain third-party maintenance services. This may be due to the manufacturer going out of business, or the manufacturer may have decided to stop producing and selling that particular technology. Be prepared to remove such products from the verified technologies list.

- *Modify and/or expand the list of certified testing laboratories.* Technology vendors may prefer obtaining the services of different labs, depending upon their past experience with approved labs. In addition, if the TVP expands to include new technologies, current labs may not be equipped to perform proper testing of the new systems. Periodically review the list of approved/certified test labs and consider expanding the list to new labs as needed.

APPENDICES

Appendix A: Cost and Effectiveness Ranges for Selected Technologies

Costs and Benefits of On-Road Retrofit Technologies for On-Highway Freight Trucks

Device	Benefit (% Reduction in Fuel Consumed)	Capital Cost ($ U.S.)	Operating Cost ($ U.S.)	Co-Benefit or Side Effect
Tractor roof and side fairings	1–2%[a] 2–10%[b] 3–5%[c]	250[a,d] 300–1,800[b]	—	
Vortex generators on truck and trailer	Up to 2–3%[b,e]	220[b]	—	Can increase the stability (or perceived stability) of the truck and trailer.
Tractor side skirt	3–4%[b,c]	1,500–2,000[b]	—	
Trailer side skirt	5.6–7%[b,e]	700–1,000[f]	50–400/year if damaged[g]	Susceptible to damage on severe terrain or over steep railroad crossings.
Trailer nose cone	2–3.8%[b,h]	800–1,260[b]	—	
Trailer boat tail/rear fairing	2–4%[a] 2.8–4.8%[b,h] 4–6%[c]	1,000–1,600[f]	—	Can cause a loading delay depending on how quickly it can be moved out of the way of the trailer doors.
Low rolling resistance tires	5%[a] 1–2%[c] 3% or more[i]	455[a,d] 240[c] 300–500[j]	—	Can also reduce NO_x emission rate by 3%.[i]
Single-wide tires	9–12%[a] 2.6%[k] 5%[k] Up to 10%[b] 4–6% (trailer)[c] 5–10%[j]	450[a,d] 900 (trailer)[c] 1,700[j]	—	Weight reduction can benefit cargo capacity. Can also reduce limp-home ability of truck in case of a blowout.
Low-friction driveline lubes	1.5–3%[k]	—	Up to 0.004 per mile[b]	
Automatic tire inflation system	Variable	700–1,000[f]	—	

Costs and Benefits of the Extended-Idle Reduction Strategies

Device	Benefit (% Reduction in Fuel Consumed)	Costs ($ U.S.)	Co-Benefit or Side Effect
APU	8.1%[k] 4–8%[l] 5–6%[m]	5,000–12,000[l]	Increased weight, noise, and maintenance, but flexible and can be used anywhere. Does require yearly maintenance.
Diesel heat	4.3%[k] 1–3%[l]	1,000–3,000[l]	Can only provide heat.
Engine start/ stop control	5.6%[k] 2–3%[l]	0 (OEM)[l] 1,325–3,750 (retrofit)[l]	Engine starting and stopping can interrupt driver rest.
Battery AC	Variable[n]	1,600–6,900[l]	Batteries add weight to vehicle, and cooling systems may not be able to keep cab cool on hotter days.
Thermal storage	7–8%[o]	2,700[p]	Very efficient when used for heat, as it uses heat that would otherwise be wasted. Does require some extra fuel consumption for cooling, however.
Dual TSE*	7–8%[o]	Capital cost for operator: 125–2,500 (approximately 0.50 per hour[l] to 1.00 per hour[q]) 1,700[p] For truckstop: 4,500–8,500 per space[q]	There are a limited number of available parking spaces at equipped truck stops. Weight and investment of systems are not beneficial if the truck must spend some rest periods at non-TSE locations. Operators become subject to pricing variation of TSE company.
Single TSE**	7–8%[o]	Minimal capital costs: 1.85–2.18 per hour[l] up to 2.45–2.89 per hour[q] For truckstop: 10,000–20,000 per space[q]	There are a limited number of available parking spaces at equipped truck stops. Weight and investment of systems are not beneficial if the truck must spend some rest periods at non-TSE locations. Operators become subject to pricing variation of TSE company. Systems can also provide ancillary benefits such as TV or internet connectivity.

Costs and Emissions Reduction Levels of Various Retrofit Aftertreatment Devices

After treatment Type	Percent Reduction in Pollutant Emissions				Cost ($ U.S.)	Fuel Economy Penalty[r]
	NO_x	PM	HC	CO		
DOC	—	20–40%[s] 25–50%[t]	40–70%[s] 50–90%[t]	40–60%[s]	600–4,000 + 2 hours[s] 500–2,000[t]	—
DPF (wall-flow)	—	85–95%[s] >85%[t]	85–95%[s] 50–95%[t]	50–90%[s]	8,000–50,000 + 7 hours[s] 7,000–30,000[t]	1%
DPF (partial/ flow-through)	—	Up to 60%[s] 30–60%[t]	40–75%[s] 50–95%[t]	10–60%[s]	4,000–6,000 + 7 hours[s] 5,000–7,000[t]	< 1%
CCV[u]	—	Variable 5–10%[t]	—	—	450–700[s]	—
SCR[u]	Up to 75%[s] 80%[t]	20–30%[t]	80%[t]	—	10,000–20,000[s] 16,000–20,000[t]	< 1%
LNC[u]	5–40%[s] 5–30%[t]	—	—	—	6,500–10,000[s] 15,000–20,000[t]	3%
Biodiesel use[v]	-2%[w]	10.1%[w]	21.1%[w]	11%[w]		1–2%[x]

* A system that allows trucks to use electrical power from an external source. At properly equipped locations, drivers can shut off the main truck engine and plug into an electrical outlet that provides power for heaters, air conditioners, marker lights, and other accessories. With an initial investment of onboard equipment, trucks need to be equipped with the appropriate internal wiring, inverter system, block heaters, and HVAC system to take advantage of TSE. After this equipment is installed, drivers simply plug the vehicle into an electrical outlet.

** A system consisting of stand-alone units that drivers can connect to their trucks. These units have all the necessary off-board equipment and utilities and require no retrofit on the truck. A typical system consists of one unit per parking space and offers drivers heating, ventilation, air conditioning, electricity, internet, and cable. In cold climates, drivers can install block heaters, and these can be powered by the system as well. A unit is placed in the passenger's window. This unit provides for multimedia usage with a screen and keyboard connections. It also provides vents necessary to heat and cool the cabin while the driver sleeps.

a. International Council on Clean Transportation (2011). *European Union Greenhouse Gas Reduction Potential for Heavy-Duty Vehicles*. TIAX reference no. D5625.
b. National Research Council (2010). *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*.
c. International Council on Clean Transportation (2013). *Trailer Technologies for Increased Heavy-Duty Vehicle Efficiency*.
d. Converted euros to U.S. dollars using 1.3 dollars per euro (as of the December 2011 publication date).
e. Values taken from manufacturer-supplied data, not independent test data.
f. Sharpe, B., and M. Roeth (2014). *Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector*. Retrieved from www.theicct.org/sites/default/files/publications/ICCT_trailer-tech-costs_20140218.pdf.
g. Lowe, M., G. Ayee, and G. Gereffi (2009). Chapter 9: Hybrid Drivetrains for Medium- and Heavy-duty Trucks. In *Manufacturing Climate Solutions: Carbon-Reducing Technologies and U.S. Jobs*. Retrieved from www.cggc.duke.edu/environment/climatesolutions/greeneconomy_Ch9_HybridDrivetrainsforTrucks.pdf.
h. ERG converted values from percent fuel economy improvement to percent fuel consumption reduction.
i. EPA (2016). Low Rolling Resistance Tires. Retrieved from https://www.epa.gov/sites/production/files/2016-06/documents/420f16024.pdf.
j. International Energy Agency (2012). *Technology Roadmap—Fuel Economy of Road Vehicles*.
k. Federal Railroad Administration (2009). *Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors*.
l. National Research Council (2010). *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*.
m. International Council on Clean Transportation (2013). *Trailer Technologies for Increased Heavy-Duty Vehicle Efficiency*.
n. Values available in the literature do not take fuel burned for increased alternator charging load into consideration and therefore are not appropriate from an engineering perspective.
o. These estimates are based on the estimated total fuel burn during idling for an average long-haul truck. The devices can reduce fuel consumption up to this total amount. See Northeast States Center for a Clean Air Future, International Council on Clean Transportation, Southwest Research Institute, and TIAX (2009). *Reducing Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO_2 Emissions*.
p. Argonne National Laboratory (2000). *Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks Center*. Publication no. ANL/ESD-43.
q. Millard-Ball, A. (2009). *Truck Stop Electrification and Carbon Offsets*.
r. Jackson, M., R. Schubert, and E. Kassoy (2005). *Comparative Costs of 2010 Heavy-Duty Diesel and Natural Gas Technologies*. TIAX reference no. D0286.
s. U.N. Centre for Regional Development (2011). *Best Practices in Green Freight for an Environmentally Sustainable Road Freight Sector in Asia*. Retrieved from http://www.uncrd.or.jp/content/documents/6EST-5A-BGP.pdf.
t. Manufacturers of Emission Controls Association (2009). *Retrofitting Emission Controls for Diesel-Powered Vehicles*.
u. Can combine with DOC or DPF to reduce emissions from all four pollutants.
v. Trucks with aftertreatment systems will have lower benefits and penalties from biodiesel use.
w. EPA (2002). *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*. EPA-420-P-02-001.
x. Biodiesel use typically results in a well-to-wheels GHG emission reduction in spite of the increased fuel consumption rate.

Appendix B: Group Exercise Materials

Sample Vendor Application (see page III–13, Exercise 7)

Vendors interested in receiving verification for their technology from this agency must complete this form and email it to XXXX@ProgramX.gov with "Request for Verification" in the subject line. Our program administrator will confirm receipt by email and will contact you if additional information is needed.

Contact information:

Company name: WhatTire Corp.

Contact person: WhatTire Corp.

Work phone: +44 555 123 4567

Cell phone: _____

Email: john.smith@whattire.com

Mailing address: 5725 Whattire Dr

Manufacturing facility address: Shanghai, 201814

Product description:

(please provide specifics that include: product name, product ID/serial/part numbers, component manufacturer, and a short description of the product)

Product: Low Rolling Resistance Tires that minimize the energy wasted as a tire rolls, thereby decreasing required rolling effort and improving vehicle fuel efficiency. By using low resistance tires on all axles, a combination long-haul truck can reduce fuel consumption by 3% annually, resulting in hundreds of gallons of fuel saved per year while cutting carbon dioxide and other pollutant emissions.

Please describe the environmental benefit that your technology provides:

Additional information: (please answer with yes/no)

???	Are you seeking placement of your technology on Program X's Verified Technologies List?
Yes	Is this the first time you have submitted this product/technology for Program X verification?
	Does your product have regulatory requirements that supersede verification?
No	Are you currently pursuing verification with any other programs for this technology?
Don't Know	Is your product commercially available?
No	Is your product still in the research and development stage?
Maybe	Does your product have performance data that you can share?
No	Will your product carry any safety or health concerns?
	Can you provide training requirements for safe and effective operation of your technology?
1 year	Does your company offer a full warranty for this technology?

In signing below, you certify that all submitted information is accurate:

John		7/28/2017
Print Name	Signature	Date

Stakeholder Scripts (see page IV–3, Exercise 8)

Sample Questions for Technology Vendors

1. Who may apply to a technology verification program?
2. Why should I seek verification for my new technology?
3. What technologies are good candidates for verification?
4. When is a technology ready for verification?
5. What is the verification process?
6. How do I submit a technology for verification with your program?

Sample Questions for Fleet Managers

1. What are green products and services?
2. How do I learn more about available verified technologies?
3. Why should I use these technologies?
4. Does this program endorse specific products or companies?
5. What are the most important things I should consider when purchasing green products and services?

Example Benefits Calculation Worksheet (See page V–2, Exercise 11)

To estimate the annual emissions reductions associated with your program, you will need to collect some information from each participating fleet, such as:

- The type of verified technologies that have been installed
- The type, age, and number of vehicles that installed the verified technologies
- The annual miles travelled for each vehicle type/age/technology combination

Below is an example emissions reduction calculation for one truck fleet:

A. Collect fleet and associated verified technology data:

- Verified technology installed: *Purifilter Diesel Particulate Filter (DPF)*
- Number of trucks that installed the technology: *10*
- Truck fuel type and class: *diesel 8b (tractor-trailer)*
- Model year of trucks: *1995*
- Kilometers/yr driven per truck: *150,000*

B. For the appropriate truck class and model year in question, confirm that the technology is on your program's list of verified technologies.

To see how to confirm that a technology is on a program's list, visit EPA's Clean Diesel Technology Program website, which is provided as an example reference: www.epa.gov/verified-diesel-tech/verified-technologies-list-clean-diesel.

Step 1 – Scroll down the page to the table and select "all" for "show all entries" in the table.

Step 2 – Sort by "Technology" by clicking on that header.

Step 3 – Find the listing for "Purifilter - Diesel Particulate Filter (DPF) Environmental Technology Verification Logo."

Step 4 – Review the information provided in the "Applicability" column to confirm technology is certified for use on truck class and model year (heavy-duty trucks 1994-2003 model years—confirmed) in this example.

Step 5 – Record the verified emission reductions for pollutants of interest (90% PM).

C. Next, estimate the emissions rate for the trucks prior to technology installation.

[Different regions will have different ways of estimating on-road truck emissions rates. The following reference table is applicable to trucks operating in Canada using ultra-low-sulfur diesel fuel.]

The appropriate emissions rate is highlighted in yellow below:

Year and Class	Diesel NO_x g/km	Diesel PM g/km
1994–2b	6.796	0.301
1994–3	7.337	0.335
1994–4	7.565	0.350
1994–5	8.055	0.365
1994–6	9.406	0.390
1994–7	11.269	0.428
1994–8a	15.425	0.513
1994–8b	16.509	0.535
1995–2b	6.313	0.297
1995–3	7.653	0.353
1995–4	8.004	0.360
1995–5	8.854	0.381
1995–6	9.667	0.395
1995–7	10.904	0.421
1995–8a	15.318	0.511
1995–8b	16.471	0.534
1996–2b	6.368	0.306
1996–3	7.696	0.352
1996–4	8.723	0.374
1996–5	9.592	0.396
1996–6	10.362	0.409
1996–7	11.926	0.440
1996–8a	15.551	0.515
1996–8b	16.606	0.537

D. Calculate annual emissions prior to installation as follows:

PM = (0.534 g/km x 150,000 km/yr per truck x 10 trucks) / 1,000,000 g/tonne = 0.8MT per year

E. Then calculate *annual* emissions reduction as follows:

0.90 x 0.8 MT = 0.72MT PM per year

F. Repeat this process for other pollutants of interest and all participating fleets to estimate total program benefits. Compare these estimates to your program goals to determine if you should make adjustments for the coming years.

United States Environmental Protection Agency
Office of Transportation and Air Quality
1200 Pennsylvania Ave., NW
Washington, DC 20460

EPA-420-B-21-028
May 2021
www.epa.gov