



# GREEN GREASE PROJECT MANUAL

A Guide to Converting a Diesel Truck  
to Run on Waste Vegetable Oil

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## Part 0. Background

Rudolph Diesel invented the diesel engine in the 1890's to convert chemical energy into mechanical energy. It is best known for its use as an internal combustion engine. Although we generally associate diesel engines with fossil fuel in the form of petroleum diesel, diesel engines were originally powered by peanut oil and used predominantly plant-based fuel sources. For this reason it is perfectly acceptable to revert back to the use of these types of renewable fuel sources to run a diesel engine. Whether you are motivated by eliminating fuel costs or reducing harmful emissions, converting a diesel engine to run on waste vegetable oil (WVO) is a great alternative to alternative, more widely-used fuel sources. Additionally, it is relatively easy and will not damage your existing engine.

There are two parts of the diesel system that should be understood prior to converting the vehicle: the fuel system and the coolant system. Fuel is brought from the tank through a filter. After it passes through the filter, the fuel enters the injector pump connected to the engine. The fuel is split into several different lines and enters the engine's cylinders, where it is combusted. Diesel systems do not burn all of the fuel that enters the engine. The unused fuel is returned to the tank. The engine heats up due to the friction in the moving parts. Radiator fluid (coolant) passes through the engine and cools it. The now warm radiator fluid is cooled in two different ways. It passes through the cabin to defrost windows or heat the car, or it runs through the radiator where it is cooled by air flow and fans. In this conversion, the fuel system is changed to run either diesel or WVO and the coolant is used to heat the oil.

## ***Frequently Asked Questions:***

*Is this conversion going to damage my diesel engine?*

No. The conversion is specifically designed so that both the current diesel fuel system and the vegetable oil fuel system are intact. This means that you may choose to run the car on diesel fuel whenever you want, but you can also follow the instructions below to run the car on WVO. As long as you pay careful attention to the “Vehicle Operation” section of this manual and are diligent about maintaining the vegetable oil system, you should have few or no problems with the vehicle.

*What are the differences in quality between vegetable oil and petroleum diesel fuel?*

Vegetable oil has very similar properties to diesel fuel. If you currently get 25 mpg (11 km/L) using petroleum diesel, you will still get the same mileage with WVO. It is important to note that vegetable oil reacts differently to low temperatures than diesel fuel because, when it cools down it begins to solidify. However, the following conversion system uses waste heat produced in the engine to constantly warm the oil. When the oil is hot (around 160 degrees F or 71 degrees C) it has a comparable viscosity to diesel fuel and will behave similarly in the engine (it should not cause problems or damage to the fuel injector, filter, or any other parts of the engine).

*Does using vegetable oil actually reduce vehicle emissions?*

Yes. Typically emissions are reduced by about 50% compared to petroleum diesel engines. Specifically WVO burns with much lower production of carbon monoxide, particulate matter, and hydrocarbons.

*How will the conversion affect government certification testing?*

If you choose to have your vehicle inspected while it is running on vegetable oil it is likely to perform better on emissions tests. However, we are unaware of any problems or issues that the government might have. Check with your local government for more information.

*Is it financially worthwhile to convert my engine?*

In almost every case, yes. Many of the parts required to convert the engine may be recycled and acquired from junkyards or reused parts shops for free or inexpensively. In total the parts for this conversion cost about \$300 to \$400. But if you filter your own WVO, you will be getting the bulk of your transportation fuel for free, which, depending on the current price of diesel, could save you more than the cost of the conversion within the first few months of operation.

## Introduction

Waste picker cooperatives in Sao Paulo collect WVO to reuse it or sell it. Catadores schedule to pick up the WVO at houses, restaurants, or central collection centers. The WVO is then transported to waste picker cooperatives where it is filtered. The filtered WVO can be used as fuel to power converted diesel trucks. Using WVO as a fuel in waste picker cooperatives offsets traditional fuel costs.

This manual will show you how to convert a traditional diesel engine to run on WVO and how to properly operate the vehicle. The manual is divided into three parts: 1.) the engine conversion process, 2.) the collection of the WVO from nearby sources, and 3.) the filtration of WVO.

## Part 1. Conversion

A traditional diesel fuel system usually involves a tank, one or two filters, an injection pump, and the engine itself. There may also be a secondary pump to help transfer the fuel from the tank to the filters. All diesel engines return unused fuel, so there is also a line from the engine back to the tank.

To make the engine run on vegetable oil, a second fuel system is added. This will be identical to the first, except that it will have heaters in several places to make the oil hot enough to run through the engine without damaging it. The two systems meet at a 3-way valve, or similar structure, which the driver uses to control fuel flow. A second valve system controls the return fuel flow, sending diesel to the diesel tank and WVO back to the veggie oil side of the system.

### ***Section 1. Necessary tools and parts***

The following parts are required to properly convert the engine. (Parts may be purchased locally or may be acquired through scavenging.):

#### 1) WVO TANK:

The tank will hold WVO. Conversions usually require plastic boat tanks, a metal tank, or a 55 gal (208L) steel drum; however, you can be creative about what you choose to use as a WVO tank. The only requirement is that the tank must be sealed and heat-resistant. Additionally it must be large enough to fuel a truck for an entire day. WVO efficiency is similar to diesel.



2) HOSE CLAMPS

20 big ones (5/8" or 15.875mm)

30 little ones (5/16" or 7.938mm)



3) FUEL LINES

Heat resistant rubber hoses:

1/2" (12.7mm) – 40-50 feet or about 20 meters

\* You might want small sections of clear hose for a few locations



4) CONEXOES "T"

1/2" (12.7mm) metal or plastic (4)



5) ZIPTIES

You will need many zipties.



6) DIESEL WATER SEPARATING FILTER + HEAD (with 2-4 fuel in and out connectors)

Usually used for boats.



7) SOFT COPPER TUBING

3/8" (9.53mm) to wrap around filter. Around 10' long  
 1/2" (12.7mm) to place inside tank. 10'-15' long (3-4.5 meters)  
 Heat resistant up to 160 degrees Fahrenheit. (71 degrees Celsius)



8) BRASS COMPRESSION FITTING

1/2 to 1/2" (12.7mm)  
 Connects barb to copper tubing



9) BARBS to connect hoses to valves (compression fittings)

1/2" (12.7mm) to 3/8" (9.53mm)  
 1/2" (12.7mm) to 5/8" (15.875mm) (2)



10) VALVES

Single direction (4)  
 OR  
 Three-way valves (2)



12) SEALANT

High temp red RTV silicone sealant to seal tank



13) PIPE THREAD COMPOUND

eg: Teflon tape

14) SCRAP & WOOD METAL (optional for tank)

\*If you are anywhere near São Paulo, this is a great location to get cheap, used diesel parts:

JR Diesel  
 Thiago Santos  
 Av. Presidente Kennedy, 888/901 - Vila São José

Osasco- SP - Cep: 06298-190  
 (11) 3298-6000  
 www.jrdiesel.com.br

**The following tools will also be necessary:**

- 1) standard electric drill
- 2) wrenches (various sizes) and sockets (optional to tighten clamps)
- 3) hole saw
- 4) screw drivers (Phillips and flathead, various sizes)
- 6) tube cutter (to cut copper tubing)
- 7) utility knife
- 8) RTV silicone
- 9) measuring tape
- 10) Optional: maintenance parts: MITYVAC hand valve pump to suck air from tubing.

\*If you do not have access to some of these tools, you might be able to substitute tools that can perform similar tasks.

## ***Section 2. Preparing the Tank***

### **Step 1. Determine location for WVO tank.**

The first step in the conversion process is choosing a suitable tank. It needs to hold the WVO fuel and be heat resistant (to about 160 degrees F or 71 degrees C). Metal or high-density plastic tanks work best. Decide where the tank should go in your vehicle. Key considerations are ease of filling the tank and maintaining access to spare tire.

### **Step 2. Put heat-exchange system in tank.**

Once you've acquired the tank and chosen the location, you should rinse out the tank to make sure it does not have too much dirt or debris inside. It is possible to do this with water, but it is even better to use some diesel fuel or WVO so that you do not end up with excess water in your tank. If you use fuel you can collect it once it exits the tank, filter it again, and reuse it. Then you can put the heat exchanger inside. The heat exchanger is a loop of 1/2" (12.7mm) plumbing copper. You will need a hole in the tank large enough to insert the copper loop. The hole should be in the top of the tank so that oil doesn't leak out.



Finding a place for the tank



Hole cut into top of the tank



To install the heat exchanger measure the depth and width of the tank, and create a copper coil that will fit inside. The coil should sit near the bottom of the tank, and the two ends of the copper tube should bend up and extend outside the hole you cut in your tank. Use a thin metal or wooden plate (or the part of the tank you cut off) with two 1/2" (12.7mm) holes for both ends of the copper tube to close the hole you cut in the top of the tank. Do this by coating the bottom of the plate with high-temperature gasket sealant, such as RTV silicone and pressing it firmly into place. Then, to insure that it is securely attached, fasten the plate with screws. The two ends of the copper tube should protrude from the 1/2" (12.7mm) holes in this seal.

*\*Note:* If the tank you are working with does not have existing ports for the fuel send and fuel return lines you will need to drill four holes total in the plate mentioned above.



Above: Bending copper loop to fit into tank

Right: Putting loop through the hole on top of the tank



Next, cut a small section of rubber hose to fit around each end of the copper tube. These will slide into place to seal the space between the copper and the holes in the top of the tank.



After tank has been sealed and closed with sealant and screws.

Two ends of copper protrude from tank, you will be connecting these to the coolant system later on.

### Step 3. Put tank into your vehicle

When the tank is ready, install it in the location you chose on your vehicle.



For this vehicle, a location in the bed of the truck was selected. It is near the truck's engine, so less hosing is required. It is also easily accessible for refueling.

### Step 4. Establish fuel line and path for hoses

A third hole in the tank will be necessary for connecting the WVO fuel line to the tank. Oftentimes an outlet already exists in the tank. If this is the case, then you will be able to simply connect the rubber hose that will act as your fuel line to the outlet. This may involve threading a barb onto the existing outlet and using a hose clamp to connect the rubber hose to the barb. It is easiest to put the hose clamp onto the hose before connecting it to the fitting. If you connect the hose and then try to open the clamp to fit it over the hose, the clamp might not work as well. If you are having difficulty getting the hose to attach to the fitting, a little bit of WVO will grease up the connection and make it easier to slide on.

If this outlet does not exist, drill an additional 1/2" (12.7mm) hole in the plate that your copper heat exchanger protrudes from. Run a section of hose in through this hole so that it lies flat on the bottom of the tank. If the hose does not fit snugly in the hole you can wrap additional rubber between the hose and the edge of the hole. You should then fill any seams or spaces with sealant so that oil does not leak out of the tank.

*\*Note:* If the tank comes with a fuel outlet on the bottom you will need to create housing for the tank that will lift it off of the floor of the vehicle to allow the fuel line to run under the tank and connect to the outlet. Alternately, you could use the hole-saw to cut a hole in the floor of the vehicle and run the fuel line from under the vehicle directly to the outlet.



View looking underneath the tank. On each side, there are blocks to prop up the tank.

The nozzle coming down from the center is the fuel outlet.

If the tank you are using is from a diesel engine it should also have a port for the fuel return line. If so, you can simply connect the return line to this port with a hose clamp. If not, simply insert a hose into a fourth hole in the plate covering the large hole in the tank and secure it.



The tank used in this conversion was designed for a diesel vehicle. It already had a fuel return line on the top, so a hose was connected to this and is long enough to reach the engine.

Finally, you will need a hole in the top of the tank large enough to pour the oil into the tank for refueling. Most tanks already have a hole and cap but if not you can cut a new one with a hole saw and create a cover to prevent the oil from spilling out of it while driving.

### ***Section 3. Installing grease filter***

#### **Step 1. Wrap copper coil around filter**

To keep the WVO warm as it passes through its dedicated filter, wrap the filter in 3/8" (9.53mm) copper tubing. To make sure the filter has maximum contact with the coil, you can shift the coils slightly using your hands. This will keep the filter from slipping out.



Above: Wrapping the copper hose around the filter  
 Right: Shifting the coil to maximize contact between coil and filter



## Step 2. Attach filter to the vehicle

Find a clear spot for the filter either near the tank or near the engine's fuel injector. Use bolts to attach the filter to a sturdy piece of metal.



In this conversion, the WVO filter was placed next to the diesel filter. In this picture, the diesel filter is on the right, and the WVO filter is on the left with the coil wrapped around it.

The filters are located near the tanks, underneath the bed of the truck.

## Section 4. Installing hoses

This section details the process of installing hoses in the system. These hoses will deliver coolant into the system to heat up the fuel as well as take the WVO from the tank and deliver it to the engine.

### Step 1. Run hoses throughout system

Now you will connect the WVO system to the coolant system and the fuel line. To do this, you will need to connect the copper loop in the tank and the copper coil to the coolant system in the vehicle. You will use three hoses that will together travel from the grease tank, passed the filter, and then to the engine. When choosing a path for the hoses, make sure that they clear the ground and avoid moving parts on the vehicle. If the hoses have to pass through the vehicle at any point, through the floor of the vehicle to the tank for instance, use a drill and a 5/8" (15.875mm) hole-saw to create an opening for the hoses. Make sure that the hole is large enough for three hoses to pass through.

Once you have determined a path, cut three pieces of hose: 1.) the FUEL LINE will starts at the grease fuel tank, connect to the filter, and continue on to the engine; 2.) COOLANT LINE A will go from the grease tank, pass by the filter without connecting, and to the engine; 3.) COOLANT LINE B starts at the grease tank, connects to the copper coil around the filter, and goes on to the engine.

Cut your three hoses so that they can travel from the tank, to the filter, and end at the engine. Leave yourself around a meter of extra length of hose for errors. Attach one length of rubber hose to each end of the copper tubing that protrudes from the WVO tank using hose clamps.

These are now one end of the COOLANT LINES A and B. They will carry the radiator fluid from the front of the vehicle to the copper coil inside your tank, which will heat the WVO in the tank. Attach the third hose (FUEL LINE) to the fuel outlet on your grease tank with a hose clamp, as discussed above.



This image is of the top of the tank. There are now two hoses, COOLANT LINES A & B, attached to the two ends of the copper coil that were protruding from the tank before.

### Step 2. Connect hoses to the filter

Run COOLANT LINE B from your grease tank to the copper tubing coiled around your filter, cut the hose, insert one end of the copper coil inside the hose and secure the line with a hose clamp. Take the other half of coolant line b, which you just cut, and similarly connect it to the other end of the copper coil. The line will then continue to the engine for later connection.

Run COOLANT LINE A, which is already connected to one of the copper tubes protruding from your grease tank, along a similar path as coolant line b; however, rather than attaching to the filter or copper coil, coolant line a goes directly to the engine.

Run the FUEL LINE which is already connected to the grease tank to the filter, cut the hose, attach it to the input port coming on the filter, attach the rest of the hose to the output port on the filter and then follows the path of the other two hoses to the engine. You might want to use a small section of clear hose right at the output port on the filter so that you can easily see whether or not the fuel is circulating through the filter.



This is the filter after hoses have been connected. Clear sections of hose are used in some places to check if fluid runs through them when the truck is running.

COOLANT LINE B is connected to both ends of the copper coil.

The FUEL LINE comes from the tank's fuel outlet and connects to the filter's input port. The line then leaves the filter with a bit of clear hose, and continues to the engine

If any of the connections are not tight enough, scrap tubing can be used to tighten the connection. (You can do so by putting a 3/8" (9.53mm) tube into one that has 1/2" inner diameter.) Simply cut a strip of tubing and slice in lengthwise, so you have a flat piece of rubber. Wrap it around the smaller tube and then fit the larger tube over this. This process can be done with most connections, including valves, splices, or "T"s, that can not be tightly connected.

### Step 3. Connect coolant lines A and B to your vehicle's coolant system

The other hose from the tank will be connected into the vehicle's coolant system. Using a utility knife carefully cut the "hot" hose. To identify which hose provides the heat, start the engine and place your hands on the coolant hoses entering and exiting the cabin and feel for which one heats up first. This hose is the one that will provide the heat to the WVO system.

Insert a small section of copper tubing into one side of the "hot" hose. Then, insert the other side of the copper tubing into the second hose from the tank. Secure this connection with two clamps. You will then run a section of 1/2" (12.7mm) rubber hose from the cut you have just made in the "hot" hose to the other end of the copper coil around the filter. Attach this section to the copper coil with a hose clamp. Finally attach the other end of the new section of hose to the available side of the "hot" hose by inserting a small section of copper into both hoses as before and securing with two hose clamps.



This picture is of the coolant line coming off the engine that was cut. The right side has been connected to one of the installed coolant lines, and the left side is still open. It will be connected to the other coolant line

The final flow of coolant through the system will be as follows: The hot radiator fluid is diverted from the "hot" hose, flows through the heat exchanger wrapped around the veggie oil filter, is carried by our system to the heat exchanger in the WVO fuel tank, and is then carried back to the "hot" hose, creating a closed loop heating system. (see diagram)

Now you will secure the hoses to the vehicle with zipties. It is a good idea to secure the hoses together so they won't move and chafe against each other or your vehicle. Use cut up sections

of rubber hose or other salvaged items to create bumpers that will protect your rubber hoses in locations that are prone to chafing. In order to reduce heat loss through the hoses, it may also be necessary to wrap the three hoses in an insulating material, like newspaper.

Once the coolant system is completed, add more water/coolant into the system. The additional hosing is currently empty and will need to be filled. At this point, you should start the vehicle on diesel and test to see if the coolant line gets warm. You can feel the heat by running your hand along the hose, but it will be first noticeable at the copper tube coiled around the filter. You should also check the system for leaks.



Image of the hoses leaving the truck bed, ziptied together for protection

### **Section 5. Installing valves and completing WVO system**

Now that the WVO tank and filter are in place, you can install the valves that control the flow of fuel and allow the engine to be run on either diesel or WVO. We will install two (or four) valves. Two valves will be used to determine whether diesel fuel or WVO is going into the engine. A simple test will determine if more valves are needed to return fuel – the unused fuel that the engine gets rid of and sends back.

#### **Step 1. Valves controlling input of fuel**

To prepare the valves, you have the barbs that fasten into the valves and the Teflon tape. Wrap the tape around the fastening end of the barb 3-6 times, in a clockwise direction (when looking at the fastening end). This creates an airtight seal between the valve and the barb, which will keep air from getting into the system or fuel from leaking out.



Be sure to wrap the Teflon tape around enough times to enough a secure and airtight connection.

The first set of valves control whether diesel or WVO is going into the injector pump. A “T” connector and two valves will be needed. Now that the valves are prepared, put them in the approximate area you want them. Make sure that any hoses connected to the valves are long enough to reach the desired location. There is a stock hose that goes from the outlet of the diesel filter to the injector pump. Remove the end connected to the pump by cutting or disconnecting the line and connect it to one of the valves. Diesel fuel may spill out a little, so be prepared. Using 1/2” (12.7mm) hose, connect the other side of the diesel valve to one of the ports on the “T” connector. If possible, you should use a small section of clear hose so you can see the fuel traveling through the valve. The single port in the “T” connector is connected to the injector pump where the original diesel line was connected. Secure connections with hose clamps.



This valve system will be put in place to control the fuel flow. Sections of clear hoses are used to show fuel flowing, and can be helpful during troubleshooting if something goes wrong.

Now, take the fuel line coming from the WVO filter’s outlet and connect it to the WVO valve. The other end of the valve is then connected to the last port on the “T” connector. You might want a section of clear hose after this valve as well so that you can see the fuel as it travels to the engine. You should now have two valves entering into the “T” connector, which then leads into the engine. This system controls which type of fuel is being used.

When finished, secure the valves to the location you selected. This may require the installation of brackets or planks that will provide a surface on which to attach the valves. Then draw the fuel through the hose and make sure there is no air in either the diesel or WVO lines. This can be done using a small hand valve pump, or similar tool. If air is in the line, the engine will stall and need to be bled (see troubleshooting section). After the lines have been primed, you might want to start the truck on diesel to ensure that everything is connected securely, and that there is no air in the diesel line.

If available, a three-way valve could be used in place of the two valves and “T” connection to direct the fuel. It will have one port dedicated to connecting the fuel systems to the engine. The other two will bring diesel or WVO from their respective filters. The valve will control which fuel is being used.



## Step 2. Returning fuel

The first step is to find the fuel output hose that brings unused fuel out of the engine. The simplest way to locate the fuel line that returns fuel to the diesel tank is to follow it into the engine compartment and look to see where it connects.

Since your system can run off of WVO or diesel fuel, you will need to be able to send the unused fuel to the appropriate tank. A set of valves similar to the setup bringing the fuel to the engine will be installed to direct the fuel. First, disconnect or cut the fuel line coming out of the engine, and connect it to the single port of a “T” connector. Next, as with the input section, two valves will be connected, one to each of the remaining open ports on the “T” connector. Use 1/2” (12.7mm) hose to connect one valve to the other side of the cut output hose to return unused diesel fuel to its tank. Next, take a section of 1/2” (12.7mm) hose and connect the other valve to the return fuel port on the WVO tank.



This is an example of how the T connection is used. The bit of clear hose is coming off the engine's fuel return, runs into the T, where it goes either to the left or right, depending on which valves (not pictured) are open.

As with the input valves, the output valves will need to be secured to the vehicle. It is a good idea to keep all valves close to each other for ease of access, and to label them according to fuel type (WVO or diesel) and direction (input or return).



This image is an example of how you could mount your valves so that they are all in one place and easily accessible. In this situation, the blue valves control which fuel come into the system, and the red control which tank the fuel is returned to.

If you do not have access to enough hose, other options are available for returning fuel that reduces hose requirements. In these situations WVO can be returned back into the system via a “T” connector in the WVO fuel line.

If available, a three-way valve could be used in place of the two valves and “T” connection to direct the fuel. It will have one port dedicated to connecting the fuel systems to the output of the engine. The other two ports will return diesel or WVO to their respective filters or tanks. The valve will control where the unused fuel goes after it leaves the engine.

When finished, follow the “Vehicle Operation” section in this manual to switch from diesel to WVO. Your car should always be started on diesel, and if you won’t be driving for an hour or more, you should run it on diesel again before you shut it down. The first time you run your car you should look for leaks and tighten any loose connections.

## **Part 2. Collection**

Collecting sufficient quantities of WVO tends to be the bottleneck that prevents this practice from being profitable. If the quantities that can be collected from each location are too low, if the collection points are too far apart, or if the WVO itself is low quality, cooperatives may end up losing money on this endeavor. It sometimes costs \$200 dollars or more per month in fuel expenses just to travel to collect the veggie oil. However, if you work to develop strong relationships with local neighborhood residents, restaurants, and businesses, it should be possible to collect enough WVO to both power your diesel vehicles and still earn additional money from selling lower quality oil to biodiesel companies.

### ***Section 1. Door-to-door collection***

Many cooperatives currently acquire WVO through door-to-door collection. This is the easiest method of collecting, and allows you a good deal of flexibility. Depending on how large of an area you are collecting from and how much oil is produced in that particular neighborhood, you can collect once a day or once a week. If you choose to collect once a week, it is a good idea to time your collection so that it falls earlier in the week than the municipality’s oil collection. This way you lose less of the oil to other sources.

By collecting door-to-door you are also able to interact more directly with the source of the WVO, which means you can talk to the residents about the quality of the oil and any problems you encounter with it. You can also inform them about what you are doing with it. This is a great way to build community ties and help spread information about alternate fuel sources.

If you wish to spread awareness of veggie oil collection, or to expand your collection to new areas, one useful method to consider is to work with a church. After the sermon you can ask parishioners to stay behind to discuss collaborating with you in the collection of WVO. If you have the means to do so, you might also consider distributing flyers with more information about WVO collection that people can take home with them. Some cooperatives have seen success with this method.

## ***Section 2. Advanced collection systems***

If you are well-organized and able to network with businesses and organizations it is possible that you could work with a partner group that is looking to improve their recycling program. If they have funding and are willing to experiment innovative solutions to WVO collection, the opportunities are nearly endless.

One example is Cooperglicerio which is based underneath an overpass in Sao Paulo. This cooperative works with the hospital Bandeirantes to operate 25 WVO collection facilities throughout the city. The Cooperglicerio/Bandeirantes partnership has created advertisements and incentives to persuade the employees of local businesses to donate their WVO to collection sites rather than pouring it down the drain. The catadores are then responsible for picking up the WVO at each of designated sites.

## ***Section 3. Store in appropriate location***

Regardless of how the collection happens and of how much WVO is collected, it is important to properly store the veggie oil. This will help prevent damage to the engine and will also ensure a greater percentage of higher quality oil, which means more fuel and more cost savings for you.

Ideally the WVO should be stored in large, dark or black containers (like barrels) in the sun. Keeping the containers in the sun warms the oil and helps it settle and separate more completely, leaving you with cleaner veggie oil. It is also very important that the containers are sealed. This keeps excess water out of the oil, and the less water there is in the oil, the more efficiently it will burn, making it less likely to cause any damage to your engine. Finally, be sure to clearly label the containers if they have different quality fuel in them. For instance, it would be disadvantageous to mix up a container that had dirty oil meant to be composted with a container of clean oil that had been set aside to power your vehicle.

## **Part 3. Filtration**

Filtering the WVO prior to putting it into the vehicle is an important step to ensure that the oil will not leave particles in the truck's engine. The process involves use of sunlight, gravity, and time.

### ***Section 1. Necessary tools and parts***

Smaller containers in which the oil is collected and stored.

A large barrel (preferably black or dark colored)

Tightly knit cloth (pillow case, pants, etc.) with a tight seam, bag-shaped

Funnel (can be made from half of a soda bottle)

### ***Section 2. Filtering WVO***

Once the oil is collected, it must be stored in a well-lit area. Let the oil sit for at least a week. The heat from the sunlight helps water, particles, and any other impurities settle out of the oil. After the oil has settled there will be particulate matter in the bottom of the bottle, and the oil at the top should be fairly transparent. The top, cleaner half of the oil will be filtered through the cloth filter, and the bottom, dirtier half will be kept to work with later. Position the cloth filter in the large barrel. Pour the top, clean half of the oil into the filter, which will empty into the larger barrel. Consolidate the dirty oil into a few bottles using the funnel to transfer it. Let this sit in the sun again, for a week or two depending on the cleanliness of the oil. The process will then be repeated, taking the cleaner oil off the top and leaving the dirty oil behind. Some dirty oil will always be left behind, and this may be sold to the biodiesel companies. The particulate matter can be composted.

## Part 4. Vehicle Operation

Now that the vehicle has been converted, it is important to always operate the vehicle properly to ensure that the system does not encounter any damage. The truck should be started on diesel and run for five to ten minutes depending on whether or not the day is particularly cold. This gives the WVO time to heat up until it has a low enough viscosity to be run in the diesel engine. In the system containing two valves, one for diesel and one for WVO, the system can be switched to WVO while the truck is still running. First, open the WVO valve; then, close the diesel valve. Maintaining this order means that fuel is always running to the engine. If both valves are closed at the same time, the engine will not receive fuel, and will stall. If the system includes return valves, these must be done in a similar order, opening the WVO valve first, and then closing the diesel. When finished driving the vehicle, the system should once again be run on diesel for five minutes. This ensures that no WVO is left in the engine for long periods of time. During colder weather this could potentially cause the oil to congeal (gel-up) in the engine and damage the system.

All parts in the conversion should be permanent, unless they are damaged by some unseen problem. However, just as with the diesel filter, the WVO filter will need to be changed. Keep an eye out for any problems with the filter, and check to ensure it is separating the water (by emptying the water holding compartment regularly).

## Part 5. Troubleshooting

- Always check for inexpensive, easy-to-fix problems first to avoid unnecessary costs
- The most common problems are air in the fuel lines and blockages in the WVO fuel outlet and filter.
- Begin at the engine and work your way toward the tank tracing the hoses and making sure that all of the connections and hose clamps are tight and not leaking.
- Any time there are valves, ensure that the connection between the barbs and the valves are airtight. If they are loose, try to tighten them using wrenches, and wrap additional Teflon tape around the connection.

If you have been able to install clear sections of hose in any locations, you should pause after you make each adjustment to start the engine and observe whether or not you still have air in the lines.

If you have made sure that all of the connections are tight and you are still having problems, the next step is to check the fuel outlet line in the WVO tank. You can begin by disconnecting the fuel line from the outlet port on the WVO tank to make sure that fuel is able to pass through the port. If it cannot, it is possible that there is dirt or debris in the tank or in the WVO, blocking the output port. To check, insert something into the port to clear the blockage and then check whether or not the fuel easily flows. If this is the problem, you will have to empty the tank, clean it out thoroughly, and then refill the tank with filtered oil. Always make sure that the WVO that you are putting into the tank is clean and well-filtered.

If problems persist, there might be a blockage in the WVO filter that you installed. The likelihood of this happening increases if you are using a recycled filter. To check whether or not there is a blockage in your filter, you need to disconnect the filter from the lines and remove it completely. You can blow into the inlet of the filter on the filter housing, and check to see if the air exits the outlet of the filter. If this does not happen then there may be a blockage in the filter itself or in the housing. Because it is more accessible, start by replacing the filter. If this does not solve the problem, you will need to replace the filter housing.

If, after all of these adjustments, you are still having problems starting the engine there may be residual air in the lines. If this is the case, you will have to “crack the injectors” by bleeding the air out of the lines at each injector. To do this, loosen the nuts on the tops of each injector and run the starter. You should start to see fuel spitting from the tops of the injectors, mixed with air bubbles. Continue to run the starter, giving it frequent breaks to cool down, until there is more fuel than air coming from the injectors. At that point, tighten the nuts, cycle the glow plugs, and try starting the engine. If it still won't start, repeat the process. The procedure of bleeding the air out of the injectors can significantly wear down the battery's charge. Therefore, if you have to repeat the process many times, make sure you have a spare battery close at hand or someone nearby to give you a jumpstart.

