IN FORESTRY OPERATIONS:

FUEL ECONOMY COUNTS!

2nd Edition

FPInnovations

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The constant increase in fuel prices has highlighted the importance of limiting consumption. This guide looks at various ways of controlling fuel costs and makes specific suggestions for different logging machines such as harvesters, feller-bunchers, forwarders, skidders and delimbers.

The information contained in this guide is taken from the following report, reserved for FPInnovations members:

Makkonen, I, 2004, *Saving fuel in mechanized forestry operations*, Internal report, IR-2004-08-08.

Also available in French.

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WHAT FACTORS INFLUENCE FUEL CONSUMPTION?

Even though the continuing increases in fuel prices are raising operating costs for forestry equipment, the design, maintenance practices, and operating conditions of forestry machines, as well as how they are used, also influence fuel consumption.

As the owner of forestry machines, you can reduce the impact of increased operating costs by purchasing new equipment that is proven to have low fuel consumption. In contrast, if you already own or operate forestry equipment, you need be well informed on how to adequately maintain and correctly operate your equipment so as to reduce fuel consumption.

According to various experts, fuel consumption differs among the different types of equipment. These differences can be explained by three main factors: the design of the machine, the engine technology, and the operator's work methods.

- the design of the machine (60%)
- the engine technology (20%)
- the operator's work methods (20%)

Purchasing the wrong machine for the job can clearly have a considerable impact on fuel consumption.

IMPROVING FORESTRY EQUIPMENT FUEL EFFICIENCY

Choosing accessories wisely and using them appropriately can have a strong impact on fuel consumption.

Engine power

Diesel engines provide a wide range of power outputs but operate at different degrees of efficiency for each power level. In general, these engines are most efficient when operating at the speed (rpm) where they develop their maximum torque and use 75% of this torque. An engine operated in this manner will consume less fuel. Therefore, when the machine requires less power, operators should reduce engine speed so as to maintain a high output torque. Remember that the combination of high engine speed with low output torque increases fuel consumption. Operators of forestry equipment should avoid traveling in the woods at excessive engine speed. The use of moderate engine speed can save fuel and reduce maintenance and repair costs without decreasing productivity.

Engine tiers, pollution controls and fuel efficiency

Emissions "Tiers" were initiated in the 1990's by the U.S. Environmental Protection Agency (EPA), with the goal of reducing particulate matter and oxides of nitrogen (NOx). This goal was realized, but fuel consumption increases were commonly observed. However, sophisticated electronic engine management, machine onboard computers (OBC), and hydraulic controls made these fuel consumption increases acceptable due to higher productivity levels. With the introduction of Tier 3 Interim, fuel consumption improvements have been observed, and Tier 4 engines should result in even better fuel consumption in most operations.

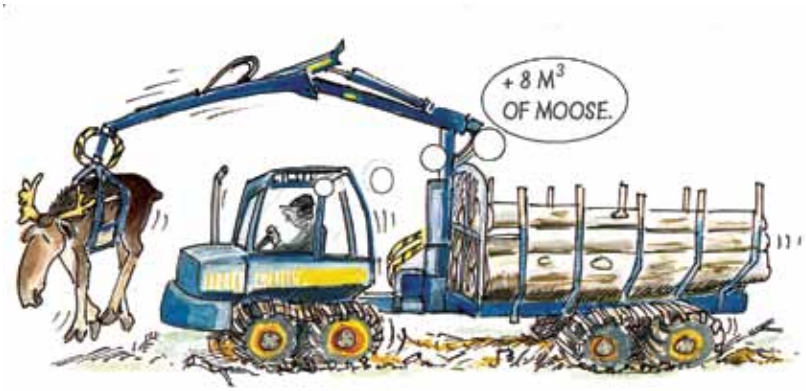
Machine owners should be aware that Tiered engines can have many of their operating parameters "fine-tuned" to a specific set of operating characteristics that can reduce fuel consumption significantly. Speak to your machine supplier; do not accept off-the-shelf engine or OBC settings.

The fan

Thermostatic fans and hydraulically driven variable-speed fans improve fuel consumption only if the machine's cooling system is up to the job. In general, the fan should not be required to work at full speed under all working conditions. A fan that operates continuously at full speed consumes 1 to 2 liters of fuel per hour (L/h).

The power train

The power train must be matched to the engine capacity to operate efficiently. Mechanical transmissions should provide a range of gear speeds so the operator can reduce engine speed to the lowest speed needed. Hydrostatic transmissions are often equipped with an electronic control. The acceleration pedal then signals the desired travel speed to the computer, which adjusts the engine speed and fuel flow in response. This approach minimizes fuel consumption.



LOAD-SENSING HYDRAULIC SYSTEMS WORK BEST IN OPERATIONS WITH VARIABLE LOADS

Differential lock

Automatic differential locks sometimes lock at inappropriate times, and the resulting slippage of one or more wheels increases fuel consumption. A manual differential lock, used when needed, is more efficient. The use of manual differential locks at appropriate times can reduce fuel consumption. However, operators must pay careful attention to wheel behavior to obtain good results. Hydrostatic transmissions, when paired with direct-drive wheels, can be designed to provide very precise control of wheel rotation. As a result, each wheel can turn at the most appropriate speed, thereby minimizing wheel slippage, soil disturbance, and fuel consumption.

Hydraulic systems

The effectiveness of a hydraulic system depends on several factors that are difficult for a buyer to determine. It is possible to lose considerable efficiency through a poor choice of the mechanical and hydraulic components of a forestry machine. Load-sensing hydraulic control systems are generally the best choice for forestry machines, followed by constant-pressure systems. Load-sensing systems regulate the hydraulic pump's pressure and flow to meet the demands of the machine's hydraulic functions. An increase in pressure from 1.5 to 2.5 MPa can provide better flow control even though this leads to a slight loss of power. Load-sensing systems are particularly appropriate for situations in which the load varies.

Operators should use as many hydraulic functions as possible simultaneously, since this increases the load on the engine and thus, the work is performed more rapidly.

It is preferable to install flexible hydraulic oil hoses of appropriate diameter and to be particularly careful to avoid elbow fittings or tight bends in the lines. In constant-pressure and constant-flow systems, the output of the hydraulic pump is not adjustable. The operator sets the engine speed in order to vary the hydraulic flow to meet the needs and to improve the system's efficiency.

Operating conditions have significant influence on fuel consumption. Hauling loads uphill, as well as sinking or slippage of wheels, increase fuel consumption significantly for skidders and forwarders. Similarly, the size of the trees being handled and their resistance to cutting affect the fuel consumption of single grip harvesters, feller-bunchers, and delimbers.

Hydraulic oil cooler

Hydraulic oil coolers should be equipped with a thermostat that lets the oil warm more rapidly and maintain its optimal temperature longer. The initial temperature of the thermostat should be adjustable by the operator so as to maintain the oil at its optimal viscosity. Oil viscosity varies depending on the type of oil used (summer vs. winter). Too-thick oil slightly increases fuel consumption, whereas too-thin oil increases component wear. Increasing the diameter of the hydraulic line does not significantly reduce fuel consumption and does not solve problems related to overheating the oil.

Before purchasing a forestry machine

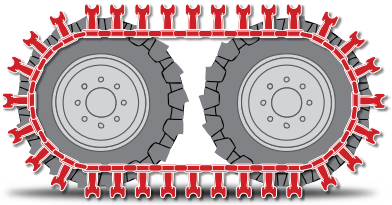
As it is difficult for potential buyers to evaluate all the technical aspects of a forestry machine, they should arrange to see the prospective machine while it is working in a real operation and to ask the owner about fuel consumption. As a general rule, larger and heavier machines consume more fuel than lighter machines.

WHAT IMPROVES FUEL ECONOMY?

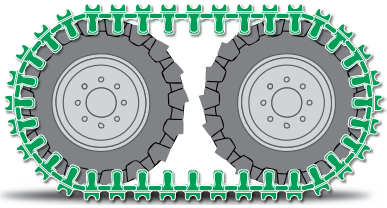
Optimal use of a machine and good preventive maintenance of forestry equipment are effective means of saving fuel. Here are some other simple, practical tips that can help:

- Use the work lights only when required. Their use can increase fuel consumption by up to 0.5 L/h.
- For machines equipped with a boom loader, fuel consumption during boom use can be reduced, up to 5%, by moving the machine close to the load and not maximizing boom reach.
- Choose tires of adequate dimensions so as to minimize sinking and loss of traction. According to studies conducted by FPInnovations, skidders equipped with high-flotation tires have lower fuel consumption than skidders with narrow tires on soils prone to rutting. However, the narrow tires provide greater mobility in deep snow. Thus, it would be best to use different tires in each season.

- **Add tire chains or tracks to wheeled forestry machines only when required.** They provide better mobility but also increase the rolling resistance and the weight of the machine. As a result, they increase fuel consumption.
- **If you use wheel tracks, choose tracks whose connecting links lie close to the tire periphery.** The further these links are from the tire periphery, the greater the distance the treads must travel and thus, the greater the fuel consumption (see figure).

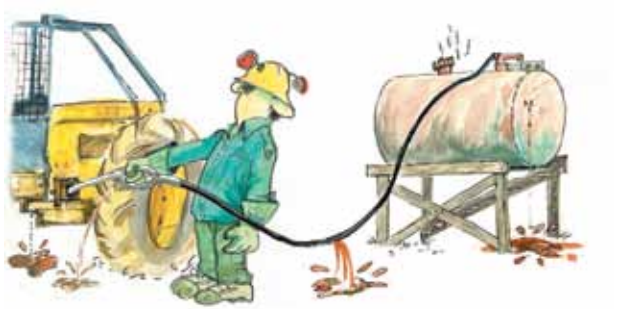


These links lie relatively far from the tire periphery.



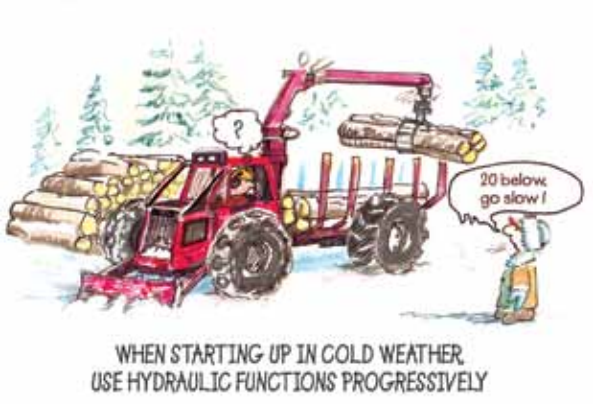
These links are closer. Thus the tracks help reduce fuel consumption.

- **Keep all tracks and chains properly tensioned. Slack chains or tracks increase fuel consumption due to excessive slippage.**
- **Keep the fuel-supply system components in good shape, since leaks and spills increase fuel costs.**



- **Minimize engine idling.** A typical feller-buncher engine can consume up to 2.5 L/h while idling.

- **Follow the cold weather start-up procedures specified for your machine so as to shorten the warm-up period.** Depending on the temperature, let the engine idle for 5 to 10 minutes. Next, use the hydraulic functions slowly, keeping the engine speed at around 1100 rpm. If you hear noise from the pumps, reduce the speed.

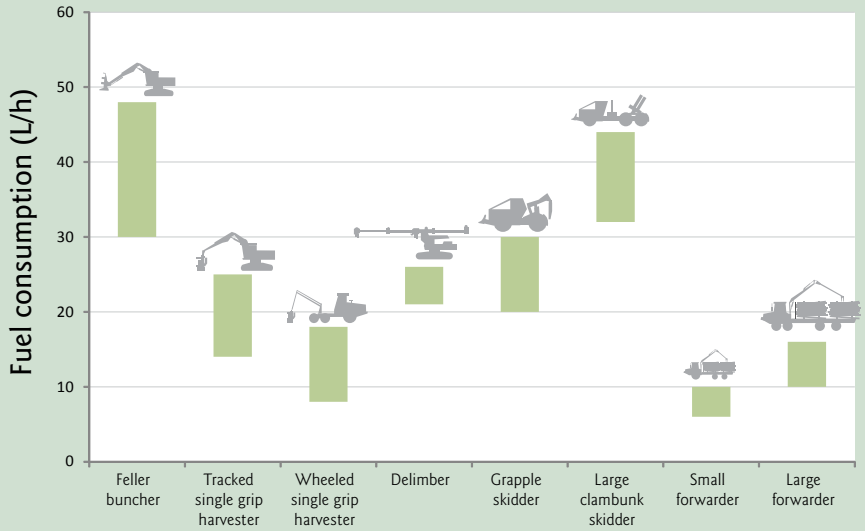


- **Keep the radiator and oil cooler clean.** This helps keep the oil at the right temperature, thereby reducing fan operation for thermostat-controlled fans.

FUEL CONSUMPTION BY DIFFERENT TYPES OF FORESTRY MACHINES

The range in fuel consumption depends on the type of forestry machine used. As mentioned previously, the engine design is responsible for 60% of the fuel consumption. Dividing daily fuel use by hour meter reading will yield liters consumed per hour. However, lower values may not necessarily indicate a more efficient machine, as long idle durations or low productivity can create the illusion of good fuel economy. In other words, a low fuel consumption per hour does not pay if there is very little production. A better measure is liters of fuel consumed per cubic meter (or tonne) of wood produced. This measure of fuel intensity is the best method for measuring your cost of production in terms of fuel use and will

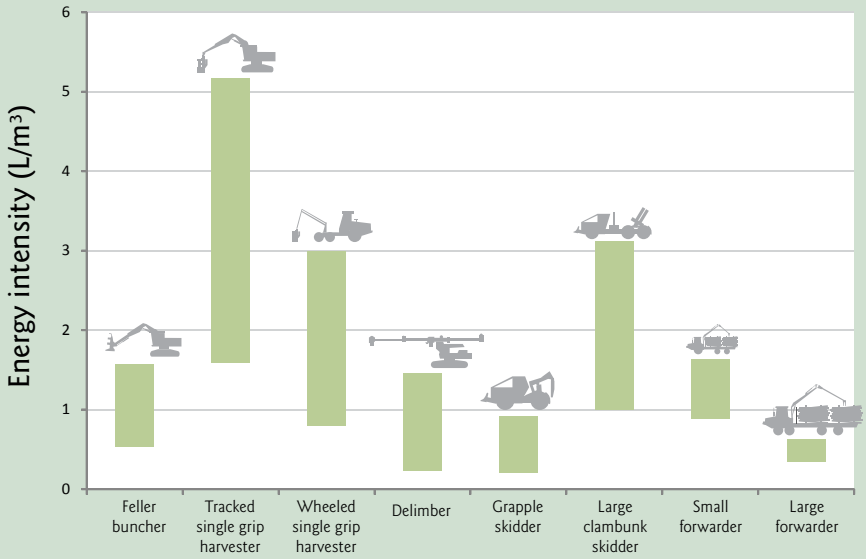
Variation in fuel consumption (L/h)
by various forestry machines during typical operations



help you gauge improvements in operator methods or work practices. Measuring productivity on a daily basis can be challenging, but newer machines with on-board computers can track productivity on a relative basis and are a repeatable means of doing so.

The figure below shows the fuel consumption and energy intensity for common forestry machines.

Variation of the energy intensity (L/m³)
by various forestry machines during typical operations*



* Energy intensity will vary with travel distance.

MEASURING FUEL IS THE FIRST STEP IN MANAGING FUEL

Much of the fuel consumed during forest operations is dispensed from remote tanks. Virtually all operations depend on an in-woods network of portable tanks ranging from 450-5000 liters. Most of these tanks are equipped with an external pump that is powered by the electrical system on the machine receiving fuel. As they are sometimes moved and refilled on a daily basis in all types of weather conditions, it is not uncommon for these tanks and the associated pumps and meters to be found in various states of serviceability. The following are commonly observed deficiencies related to in-woods fuel dispensing devices.

Alligator clips

- Lighter gauge wire

Plug and socket connector

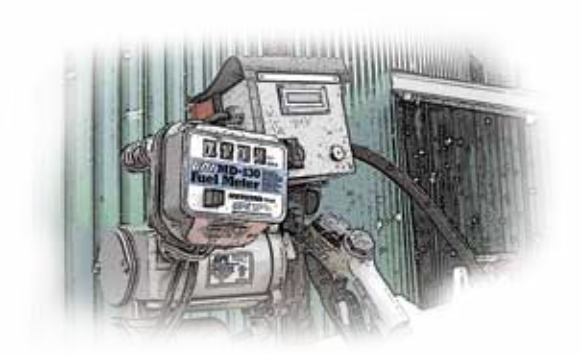
- 10 or 12 gauge wire

Fuel pump wiring

A 50-80 liter per minute fuel pump can draw in excess of 20 amps when first started and 10-15 amps (model dependant) once running. If the pump is to deliver fuel at its full-rated capacity, it requires good wiring and solid connection to the power source. While varying with pump models, a heavy duty fuel pump used in the woods will require a three-strand, 10- or 12-gauge wire suitably jacketed for exterior sub zero usage. Use of lighter gauge wire can result in reduced flow rates, over-heating and possibly fire, or damage to the electrical motor. Additionally, alligator clips, while a convenient method of connecting to a temporary power supply, should be avoided as this type of connection is inadequate for the current drawn by the pump. Installing a good quality "plug and socket" connector will ensure minimal voltage drop between the power source and the pump, providing for optimum fuel flow and reduced fueling time.

Fuel filters

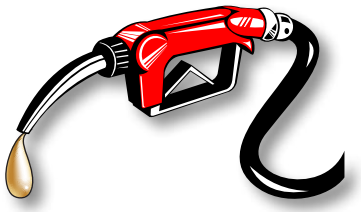
In the woods, fuel tanks are rarely fitted with a fuel filter, but their use is essential to maintaining your equipment. Installing fuel tank filters is easy and less costly than machine downtime. It is recommended that filters that remove water ("water separator") in addition to particles be used to ensure clean and dry fuel.



Fuel meters

The first step in reducing fuel consumption is measuring how much you currently consume. Simple, inexpensive mechanical flow meters will provide the required information and are available from any fuel supply company. Properly maintained and calibrated, most are capable of an accuracy between 1 and 2%. Nutating disc meters are recommended for their high tolerance to dirt and foreign objects, rugged construction, and compact design. Follow the manufacturer's instructions for calibration and take note that they are not as accurate as meters intended for commercial fuel sales.

Using fuel meters and recording the information will let everyone on the crew know that fuel tracking and use is important! Furthermore, it provides the operator with a benchmark that allows comparison between operating conditions and is the first step towards embarking on a fuel conservation effort. Many operations claim "noticeable" reductions in fuel consumption following the implementation of a simple fuel monitoring program.



TIP
Remember, the first step in managing fuel consumption is to measure your fuel consumption.

To increase accuracy of your fuel meter, here are a few simple tips:

❶ **Where possible, avoid pumping small volumes, and** when possible, refill less often but with larger volumes.

❷ **Avoid interruptions during the fueling event.** Each time the nozzle trigger is stopped, the system starts to drain itself back into the tank.

❸ **Fully depress nozzle trigger.** Half flow volumes can increase "false flow" readings.

❹ **Stop pump if you have emptied the dispensing tank of fuel.** The airflow from the pump will be recorded by the meter. The meter does not recognize the difference between fluid and air. It is simply a flow, so it is measured.

BIODIESEL IN FOREST OPERATIONS: A QUICK OVERVIEW

The new federal regulations that came into effect on July 1, 2011 now require an average of 2% renewable fuel in all diesel fuel. The use of biodiesel, on a lifecycle basis, helps reduce greenhouse gas (GHG) emissions and dependency on foreign petroleum. However, what will be the impact on our harvest operations?

Under these regulations, it is the fuel producers who are responsible for ensuring the average content of 2% (B2), so users need not worry. However, some precautions still need to be taken to ensure harvest operations are compatible with biodiesel. Storage of the B2 blend does not require any changes to usual operations other than having the proper filters at the storage tank outlet. In addition, all engines designed after 1994 can use B2 to B5 concentrations without being modified.

Benefits

- Lean solvent that cleans tanks, pipes and the injection system;
- Oiliness greater than that of petro-diesel (reduces engine wear);
- Thermal stability of blend;
- A higher cetane number than that of petro-diesel increases ignitability and improves combustion;
- Can slightly lower fuel consumption with higher concentrations (B5-B20);
- Fuel tax refund of approximately $0.17/L of B100.

Recommendations

- The solvent effect can cause impurities in the system when first used; changing the filters avoids any problems;
- Ensure the quality of the biodiesel (ASTM standard) to avoid problems due to product separating in cold weather;
- Ensure biodiesel is mixed with the right grade of diesel, considering the region and climate.

For further information on biodiesel, see guides produced by FPInnovations at www.fpinnovations.ca or contact us by phone at 514-630-4100 (Eastern office) or 604-224-3221 (Western office).

TIPS FOR REDUCING FUEL CONSUMPTION WITH DIFFERENT FORESTRY MACHINES

The following table presents various fuel-saving solutions for the different types of forestry machine you may be using:

- Tracked feller-buncher

- Wheeled single-grip harvester

- Tracked single-grip harvester

- On firm ground with few obstacles, try to work using the middle range of the boom's reach (4 to 6 m) in front of the harvester; this reduces the energy required to move the boom.
- On soft or stony ground, or when travel becomes more difficult, try to harvest the maximum number of trees while staying at the same position.
- Telescoping booms permit faster movement of the felling head towards the tree that will be cut, require less power, and reduce fuel consumption.

- Wheeled single-grip harvester

- Tracked single-grip harvester

- Exert as little pressure as possible on the delimbing knives and feed rollers while still maintaining high delimbing quality.
- Use the energy of the falling tree to help you move forward or to delimb the stem; this move requires considerable skill. However, the energy provided is free.
- Keep the saw chain and delimbing knives sharp; cutting and processing of logs requires more power, and thus more fuel, when the cutting surfaces grow dull.

- Tracked single-grip harvester

- Tracked feller-buncher

- Avoid sharp changes in direction during travel; gradual turns produce less skidding and consume less fuel than sharp turns.
- For machines equipped with a cab-leveling system, use the hydraulic cylinders provided for this purpose to keep the cab level; pivoting a tilted cab requires more power, thus consumes more fuel.
- Avoid unnecessary cab rotation or boom movements.

- Tracked feller-buncher

- Immediately replace damaged or worn saw teeth; this will require less power, thereby increasing productivity and improving the cut quality.
- Stop the saw motor during prolonged travel on the cutover.

- Grapple skidder

- Cable skidder

- Forwarder

- Clambunk skidder

- Minimize turns while traveling with a load; it's preferable to turn gradually, since this consumes less fuel than sharp turns.
- Install landings and extraction trails at the most appropriate locations; this approach both decreases fuel consumption and increases productivity.
- Try to travel on soils with a good bearing capacity; traveling in soils with poor bearing capacity requires more power, thus consumes more fuel.
- Use tire chains or tracks only when required to provide better mobility or flotation; these accessories require more power, thus more fuel.
- Where possible plan work so that landings are located downhill. Moving loaded equipment uphill requires more fuel.

- Grapple skidder

- Cable skidder

- Clambunk skidder

- Transfer as much of the load as possible onto the skidder; by raising the load higher and closer to the cab, you reduce the friction of the tops on the ground and thus decrease fuel consumption.
- Balance the pressure between the front and the rear tires ; the rear tires deflect more, increasing the amount of friction against the ground, when the rear of these machines is under a load.

- Forwarder

- For loaders with a telescopic extension, pull the logs as close as possible to the machine using the telescoping feature before lifting the logs onto the forwarder; lifting the logs at full extension requires more power and thus more fuel.
- Avoid raising the logs high above the load bunk's pickets; position the forwarder as close as possible to the log piles and try to pass the logs between the pickets rather than above them, since fuel consumption increases the higher you raise the logs.

- Clambunk skidder

- During loading, position the skidder as close as possible to the piled logs; fuel consumption increases when stems must be raised at full boom extension.
- During loading, place the butts of the stems as close as possible to the cab; this will increase the proportion of the load's weight on the rear of the skidder and reduce friction between the stems or crowns and the ground.

- Cable skidder

- Use a remote control during winching to reduce fuel consumption; the engine speed is lower with a winch that is remotely controlled than it is when the winch is operated by the operator from the cab.

- Delimber

- Keep the bearings of sliding or telescoping booms well lubricated and in good condition so as to reduce friction.
- Exert the minimum possible pressure on the delimbing knives while maintaining delimbing quality.
- Keep the delimbing knives and the topping saw sharp; these operations require more power with dull knives, and thus more fuel.

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