

Analysis and control of fuel consumption rates of harvesting systems: A review of international studies

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Introduction

The fuel consumption of equipment during forest harvesting operations is still not well known and existing measurement technologies are largely untested. Considering forest industry's need, many countries have developed and compared tools to quantify, control and analyse fuel consumption to create suitable analysis methods. Despite environmental and economic concerns on the fuel consumption of various harvesting machines due to emissions and increasing fuel costs, there are not many studies available on this topic. This bulletin aimed to collect the relevant information through reviewing previous studies in different countries.

Fuel consumption rates

Comprehensive trials have been carried out to quantify the fuel consumption rates for different harvesting methods (Sambo, 2002). The cut-to-length (CTL) method, with a harvester and forwarder, used 2.0 L/m³ which is lower than 2.7 L/m³ for the whole tree (WT) method, including a feller-buncher, skidder and processor. The CTL systems studied in Austria and Western Australia also had lower fuel consumption per unit volume harvested (Table 1). This might be a result of using two machines within the CTL method compared with three machines in the WT method. The WT operations in the Austrian study, using cable yarder, consumed less fuel per cubic metre of wood harvested than the Canadian and Western Australian case studies. These differences are most likely due to the Austrian case study having a chain saw for felling and a tower yarder for extraction that had very high productivity (Table 1). WT methods using skidders will be more common in areas with difficult terrain with steeper slopes and smaller tree sizes resulting in reduce machine productivity and typically increased fuel consumption per unit volume harvested.

Transportation is the most fuel consuming element of a wood supply chain. In Sweden, secondary timber transport consumed about 50% of total fuel usage while harvesting and extraction operations consumed 33-40% (Lindholm, 2006). Holzleitner et al. (2011) analysed the time and fuel consumption of round wood transportation in Austria using a monitoring system that combined information from the machine's computers (over CAN-bus) with GPS-data. An average 0.77 L of diesel fuel per km or 2.09 L/m³ of wood was consumed during their study. This average consumption is higher than the results provided by Lindholm (2006) of 0.56 L/km, but this is expected with longer transport distances on less sloped terrain in

Sweden. A survey of timber transport fuel consumption in south-east Victoria indicated a result between the Swedish and Austrian results with a fuel rate of 0.62 L/km for single truck and 0.67 L/km for B-double truck (Griffin and Brown, 2010).

Table 1. Fuel consumption for two harvesting methods

Harvesting method	Total fuel consumption (L/m ³)		
	Canadian case study (Sambo, 2002)	Austrian case study (Holzleitner et al. 2011)	Australian case study in Blue gum plantations (Ghaffariyan and Sessions, 2012)
WT (feller-buncher, skidder, processor)	2.7	2.2 (chain saw, yarding with tower yarder, processor)	2.6
CTL (harvester-forwarder)	2.0	1.6	1.4

Controlling and reducing fuel consumption rates

Different approaches can be applied to control and reduce fuel consumption in forest operations. FPInnovations in Canada have produced a guide that has also been adapted by Tigercat (Makkonen, 2004; www.tigercat.com). A few of the key suggestions from the guide that apply for Australian operations include:

- Use diesel engines at their maximum speed to utilise all potential.
- Do not use thermostatic fans and hydraulically driven variable-speed fans at full speed under all working conditions. A fan that operates continuously at full speed consumes 1 to 2 litres of fuel per hour.
- Use the work lights only when required, their use can increase fuel use by 0.5 L/h.
- Minimize idling. A typical feller-buncher engine can consume up to 2.5 L/h while idling.
- Keep the radiator and oil cooler clean. This helps keep the oil at the right temperature to reduce fan operation for thermostat-controlled fans.
- Choose tires to minimize sinking and loss of traction. Skidders equipped with high-flotation tires have lower fuel consumption than skidders with narrow tires on soils prone to rutting.
- Plan landing and skid trails in the most appropriate locations. Where possible plan landing location at downhill as downhill skidding and forwarding require less fuel.

Other ideas have been also suggested by Finnish scientists to reduce fuel consumption of ground-based logging systems (Karjalainen and Asikainen, 1996). These ideas are equally applicable in Australian forest operations;

- Improve driver education, to educate drivers about driving techniques to reduce fuel consumption and to improve driver safety.
- Switch to another transportation mode, e.g., rail if it is a viable service.
- Use the most appropriate size of equipment for the task.
- Integrate operations (e.g., AFORA has studied integrated fibre plus and industrial wood recovery by forwarder in pine plantations in NSW and south west WA (Walsh et al. 2012, Ghaffariyan et al. 2014)).
- Use alternate fuels e.g., biofuels derived from forest biomass.

Parameters influencing fuel consumption rates

The influencing parameters are mainly machine design (60%), engine technology (20%) and operator's work method (20%) (Makkonen, 2004). In a German case study, harvesters, forwarders and skidders were classified into small, medium and large classes based on their engine power. Fuel consumption was found to be lower for smaller engine powers which can be taken into consideration as one of the criteria to choose proper machine size/type (Weise and Rosenbach, 2011). Increased truck payloads have also been shown to be able to reduce fuel consumption per m³ of wood delivered by over 20% (Griffin and Brown, 2010; Löfroth and Svenson, 2012).

Take-home messages

- Fuel consumption is impacted by machine design thus choosing appropriate machine size for each task is a key decision.
- Skilled and educated operators can play a key role to reduce machine fuel usage.
- Case studies have been recently conducted by AFORA but more comprehensive trials will be required in Australian harvesting operations to effectively exploring how to better manage and reduce fuel consumption within the forestry supply chain.

More information

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