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Innovative Hybrid Chipper for Forest Chip Production

A Theoretical Technology Transfer Case Study

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Robert Prinz
Natural Resources Institute Finland (Luke)

Background

The Kesla C 860 H hybrid chipper was introduced for the first time at the FinnMetko forest machinery exhibition in August 2014 in central Finland, and for the second time at the Hakevuori Forest Energy Day at Askola in southern Finland in March 2015.

Figure 1. Hybrid chipper when chipping logging residues at a roadside site.

The first version of the Kesla C 860 H hybrid chipper is mounted on a three-axle Volvo FM 440 truck chassis with a Kesla 2112T timber loader with a cabin for the operator during chipping. The Kesla C860 hybrid chipper weighs 8200 kg. The Kesla C 860 H hybrid chipper is powered by an inline four-cylinder Volvo Penta TAD572VE diesel engine in a hybrid arrangement with an electric motor.

The Kesla C 860 H is the world's first full hybrid wood chipper. It has been made from the perspective of improving the performance of the machine and the fuel economy. The system offers an optimal solution to save fuel and to lower emissions. The required energy is generated by a diesel engine with the support of a super capacitor energy storage system. The motors driving the chipper and hydraulic pumps are permanent-magnet motors, and the overall system minimizes the loss of energy and provides high energy efficiency. There is no mechanical connection between the diesel engine and chipper.

The technology readiness level (TRL) can be stated as TRL 9: the system is ready for full scale deployment, and the technology in its final form is ready for commercial deployment.

The hybrid chipper technology was studied during the Infres project and the main productivity and fuel consumption figures on the machine level have been published (Prinz et al. 2018). The cost levels of the entire fuel supply chain have not been calculated so far. The chipper and especially the hybrid system have been under continuous development and follow up-studies are needed for the precise determination of the productivity, fuel consumption and operating costs.

Drivers and barriers in the RE technology case

The manufacturer of the technology has listed a number of advantages provided by the innovative technology offering innovative and effective technology for forest residual biomass supply: according to the manufacturer, the required diesel engine power could be about 50% lower than required for present systems; the system is designed to deliver an estimated 20 to 40% lower fuel consumption compared to a traditional wood chipper. This could lead to better efficiency as there is no mechanical connection between diesel and chipper. Additionally, the vehicles used could be smaller because the carrying capacity and the required cargo space is less than usual. A key point is that it is easy to optimize the diesel engine to run it at a fuel-efficient level and the diesel-engine can operate optimally most of the time. Another benefit is the possibility to get energy from the power grid, in which case no local pollution is produced.

Monitoring the performance

Time studies were carried out to test the new hybrid technology chipper, Kesla C 860 H, with pulpwood and logging residues. Productivity, fuel consumption, the quality of the chips and the noise during chipping operation were measured and analysed. The study results were compared to findings from previous studies examining conventional chippers. The machine costs of the entire fuel supply chain have not been calculated so far.

Figure 2. Hybrid chipper when chipping logging residues and blowing them onto a truck-trailer transportation vehicle.

Pre-conditions for the technology transfer and adaptation in different partner regions

The main requirements and pre-conditions for transferring the technology and applying it in other partner regions could be, among others, the following factors:

- Resource availability
- Skilful and experienced operators.
- Experience and expertise in the maintenance of the technology
- Funding

A main driver for the technology transfer could be the fuel efficiency, whereas the main barriers could relate to financial risks for capital investment and technological risk due to uncertainties relating to long-term performance, reliability and costs.

Material & Methods

Improvement of the pre-conditions for the technology transfer and adaptation in different partner regions

The balance of capacities between chippers and the transportation of chips determine the outcome of the system, and the productivity and costs of the chipper are important factors. Expected parameters to be improved towards transferring the technology and applying it in other partner regions could be listed as follows:

- Improved knowledge of costs and supply system requirements
- Support for improved market access of the technology Reduction of risks relating to long-term performance and costs through simulation of one-year's performance

Since chip trucks need to wait for the chipper to chip directly onto the loading space of the trucks and since the chipper needs to wait for a truck to be present before being able to do chipping operations, both activities, chipping and transportation are dependent on each other. Therefore, the simulation of supply systems was considered a suitable method to obtain realistic information on the supply system applied to the hybrid chipper and costs. Thus, the method used was discrete-event simulation using the software WITNESS where a modified version of the simulation model presented by Väätäinen et al. (2017) was used. Several assumptions and input adjustments were made for the scenario runs assuming a one-year supply of forest chips based on logging residues to a combined-heat-and-power (CHP) plant in Eastern Finland, which was used as end-use facility in this case.

The scenario calculations assumed a 60-tonne truck-trailer for transportation and a hybrid chipper using the current productivity and fuel consumption performance parameters presented by Prinz et al. (2018). Cost factors included an assumed 20% higher investment cost for the hybrid chipper compared to a conventional chipper. A second hypothetical scenario assumed further development of the hybrid chipping technology performance and assumed the same productivity as is currently achieved by a conventional chipper at a lower rate of fuel consumption (same level as the current hybrid chipper).

A detailed description of the method, simulation and calculation details applied to the hybrid technology chipper will be provided in a separate document in the form of a scientific article.

Preliminary results

The preliminary results indicate that the average total costs of forest supplied chips would be 16.8 euro per solid cubic meter of wood chips for the current development stage of the hybrid technology when transporting the chips over an assumed average transportation distance of approximately 60 km using a common 60 tonne truck-trailer to a typical CHP plant in Eastern Finland (see Figure 3).

Chipping using input parameters of the current hybrid chipper results in costs of 7.8 euro per solid cubic meter contributing to the share of chipping at the total supply costs. Transportation costs resulted in 8.9 euro per solid cubic meter at an average transportation distance of approximately 60km from the roadside to the plant.

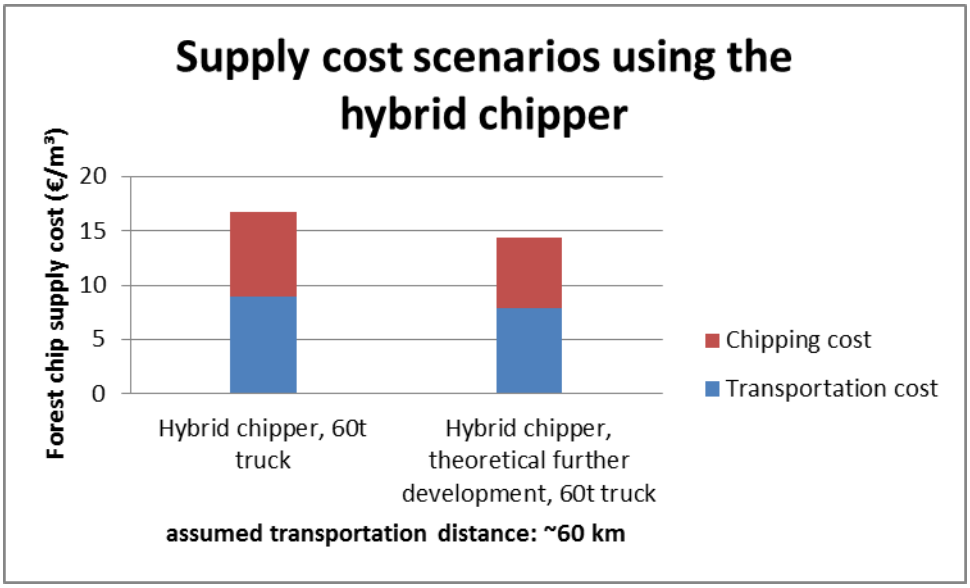

Figure 3. Average total forest chip supply costs for two chipping scenario cases applying the hybrid chipper for a one-year supply of logging residue chips to an example CHP plant.

Theoretical scenario assuming further development

The second hypothetical scenario assumed further development of the hybrid chipping technology performance and assumed the same productivity as is currently achieved by a conventional chipper (Prinz et al. 2018) with lower fuel consumption as the current hybrid chipper resulted in an average total forest chip supply cost of 14.3 euro per solid cubic meter of wood chips. Chipping costs contributed 6.4 euro per solid cubic meter to the total supply costs, whereas the transportation costs were 7.9 euro per solid cubic meter.

Thus, the hypothetical scenario, when assuming the further development of the hybrid chipping technology performance, could reduce the forest chip supply costs by 2.4 euro per solid cubic meter compared to the “current status”, if the same productivity currently achieved by a conventional chipper at lower fuel consumption compared to the current hybrid chipper could be achieved under the theoretical given conditions. However, the varying annual production of wood chips delivered to the plant will need to be taken into account and studied further.

Further detailed results will be provided in form of a scientific article.

Conclusions

This report is about an innovative hybrid chipper for forest chip production and is a purely theoretical technology transfer case based on a simulation study using input data from the literature.

Several parameters for improving knowledge and thus contributing towards the transfer of the technology and applying it in other partner regions were the focus of this study. The emphasis was on the fuel supply costs and supply system requirements for this technology in order to support the market access of this new technology and to reduce the risks relating to long-term performance and costs for such technology through the used method. The method used was a discrete-event simulation with the simulation of one year's performance.

Improvements through knowledge and technology transfer activities resulting in new pre-conditions for the technology transfer and adaptation in different partner regions

The hybrid chipper technology is an innovative development in chipping technology. Under the right operational environment there may be opportunities for transferring this technology. If the pre-conditions allow and especially if the development of the hybrid chipper technology continues, there may be good transfer opportunities for this technology suitable for the given conditions and requirements.

As was expected from the current level of technological readiness, a new technology readiness level was not achieved; however, improved knowledge may result in new pre-conditions for technological transfer.

Dissemination channels used to share the results towards transferring this technology and its business delivery include the sharing of results through an upcoming scientific publication and this knowledge transfer report, which is shared on GREBE dissemination channels. The target group are all stakeholders in the field of forest energy and potential customers of this innovative technology.

An additional detailed description of method, simulation and calculation details, as well as further results will be provided in a separate document in the form of a scientific article.

References:

Alakangas E., Routa J., Asikainen A., Nordfjell T. (Eds.) 2015. Innovative, effective and sustainable technology and logistics for forest residual biomass. Summary of the INFRES project results. 40pp.

Kokko K. 2015. KESLA C860H. full hybrid wood chipper. Power Point presentation. Infres project. 10pp.

Laitila J., Antikainen J., Asikainen A., Immonen J., Mononen E., Kaksonen P., Kokko K., Suutarinen J. 2015. Demoreport 17 - Joint Demonstration of the Large Nine Axle Chip Truck-Trailer Unit and the Hybrid Chipper – D4.5. Infres project report. 28pp. Available at: http://www.forestenergy.org/observer:get_page/observer/action/details/itemid/693&viewportheight=985&viewportwidth=1920

Laitila J., Routa J., Prinz R., Kokko K., Kaksonen P., Suutarinen J., Eliasson L. 2015. Prototype of Hybrid Technology Chipper – D4.6. Infres project report. 19pp.

Prinz R., Laitila J., Eliasson L., Routa J., Järviö N., Asikainen A. 2018. Hybrid solutions as a measure to increase energy efficiency – study of a prototype of a hybrid technology chipper, International Journal of Forest Engineering, https://doi.org/10.1080/14942119.2018.1505350

Väätäinen K., Prinz R., Malinen J., Laitila J., Sikanen L. 2017. Alternative operation models for using a feed-in terminal as a part of the forest chip supply system for a CHP plant. Global Change Biology Bioenergy 9(11):1657-1673. doi: 10.1111/gcbb.12463

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Contact

Western Development Commission,
Dillon House, Ballaghaderreen,
Co. Roscommon, F45 WY26, Ireland.

Tel: +353 (0)94 986 1441
Email: paulineleonard@wdc.ie

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GREBE will be operated by eight partner organisations across six regions:

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About GREBE

GREBE is a €1.77m, 3-year (2015-2018) transnational project to support the renewable energy sector. It is co-funded by the EU's Northern Periphery & Arctic (NPA) Programme. It will focus on the challenges of peripheral and arctic regions as places for doing business, and help develop renewable energy business opportunities provided by extreme conditions.