OPTIMAL BIOMASS TRUCK LOAD SIZE AND WORK MODELS FOR LOADING OF LOOSE BIOMASSES

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In Finnish transport conditions the total weight of typical bioenergy truck is 64 tons and the volume of load space is about 160 m$^3$. The weight of empty truck is about 31 tons. A typical payload size of loose biomaterials like logging residues, stumps and small sized whole trees is under 25 tons. Hence, 33 ton maximum payload is not often reached because of the low material density. Truck driver can compress the load with grapple by pushing the material harder or position material pieces carefully to the load space during the loading. However, this takes time and on a short driving distances it might be feasible to drive uncompressed loads instead of consuming much time for loading. This study was divided into two parts and the objectives of the studies were to: calculate optimal payload size on different transport distances and describe productive work models for biomass truck loading with loose biomass materials.

Figure 1. Typical bioenergy truck for loose material transport in Finland.

The most cost-effective way of truck transport is to enable driving with full payloads. The load can be full either on the basis of weight, volume or energy content depending on the properties of the material to be transported. Typically, loose biomass payloads are much under the allowed load weights due to loose material characteristics. The payload weight is also dependent on the material moisture content and the material type. Work methods to load loose biomasses into the load space influence also the total payload size. In other words, how much time or what kind of compression techniques are used during the crane loading cycles. These work methods and techniques to compress the load are crucial to reach high payloads.
On the other hand, loading of truck is also affected by contract type that transport company has signed with the customer. In first case, the entrepreneur can be paid according to the amount of energy, MWh’s, delivered. The entrepreneur maximizes the energy content of the load and transporting of material decreasing the energy content will be minimized. In this kind of contracting, the entrepreneur often also optimizes parts of the transport chains, for example when transporting material from roadside storages to terminals where comminution operations for the material to achieve higher energy content are performed. In this case, the load size is optimized in relation to driving distance and loading time.

In the second contract type, the truck entrepreneur is paid on a weight basis. The entrepreneur tries to make the most burdensome loads, where the responsibility of the quality management of the material is mainly on the customer. Customer orders when to transport certain bioenergy piles.

In this study, a model for optimal payload size was formed based on the given work phase time consumptions. Metsäteho’s roundwood transport cost calculation sheet was converted to bioenergy transport by changing crucial truck, distance, time consumption and load parameters. To reach the other aim of the study, the features of three different kinds of work models were described: a work model for loading of small sized stump material, a work model for loading of normal sized stump material, a work model for loading of middle size stump load with short loading time and a work model for loading of logging residues. Work models are described in detail in publication Ovaskainen & Lundberg (2016).

Figure 2 describes euros per ton cost as a function of load weight. On a different average transport distances the minimum cost varies depending on the payload. Thus the optimal payloads can be found from the minimum cost points of different transport distances.

![Figure 2](image)

**Figure 2.** Optimal payloads, in other words minimum costs for different transport distances are presented on a dotted red line.

In figure 3, blue line indicates the optimal load size when loading time is consumed according to loading time curve (red line). For example, if the transport distance is 30 km, the payload should be 30 tons at least. If it takes shorter time to load the payload, the transport distance could be shorter and vice versa.
The results indicate, that already over 50 km transport distances the load space should be full loaded with 64 ton trucks. The driving distance versus driving time optimization is very much dependent on the loading time. The loading time curve was based on the data of the work method study loads and did not differ much of the previous time consumptions of loading of biomasses. If the optimal load size is reached in a shorter time on a specific distance, the extra time could be used for reaching even higher payload or transporting a little longer distance. To reach 64 ton payload is very time consuming task if the material is dry, under 35 % precipitation. For this reason, work methods and techniques to compress the load are needed in addition to normal work procedures.

**Keywords:** bioenergy, truck transport, payload, work model, compression, optimization

**Literature**