Metsäteho

Optimal biomass truck load size and work models for loading of loose biomasses

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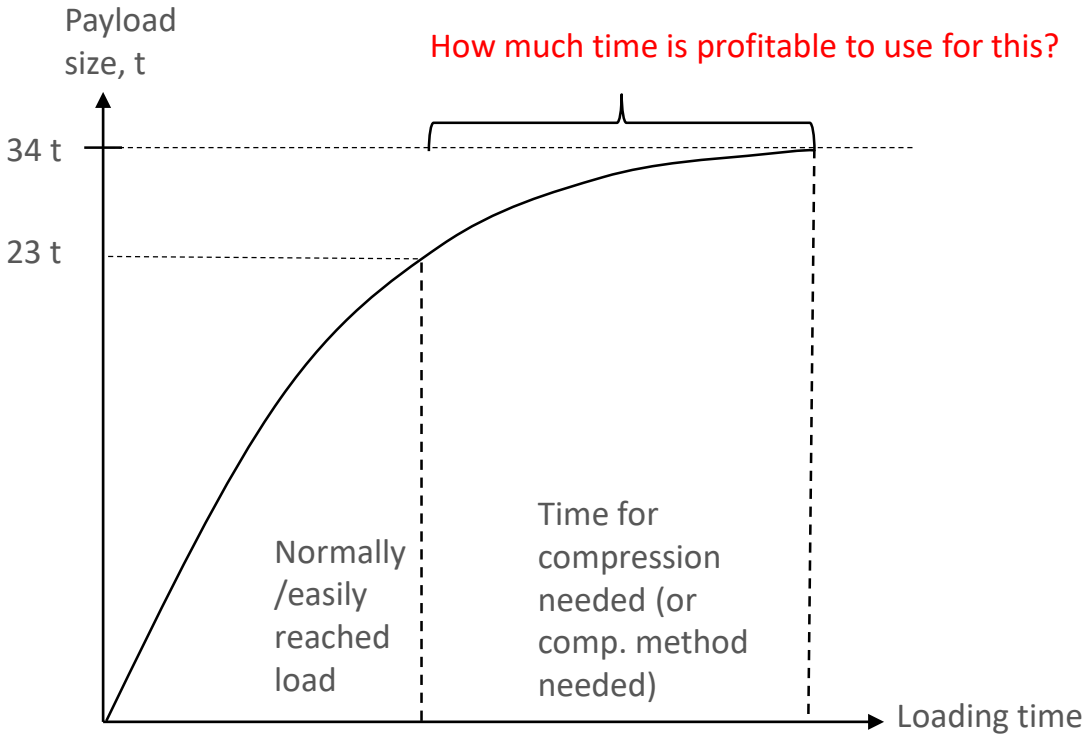
Content

- Background and theory
- Optimizing driving distance and loading time
- Biomass truck loading work model study
- Conclusions

Background

- The most cost effective way of transport is to enable driving with full payloads.
- Typically loose biomass loads (stumps and logging residues) are much under the allowed weights.
- In Finnish conditions allowed total weight of a typical bioenergy truck is 64 tons and the volume of load space is about 160 m^3.
- Weight of empty truck is about 31 tons. Typical payload size with stumps or logging residues is under **25** tons and the maximum load **34** tons is not reached often.

Loading of loose biomass



- On the other hand, is it necessary to get full payload on a short transport distance and, instead, use the saved time for driving?

Truck drivers' "principle" for loading

"You should not use too much time for making high payload because during that time you'll drive one more load …"

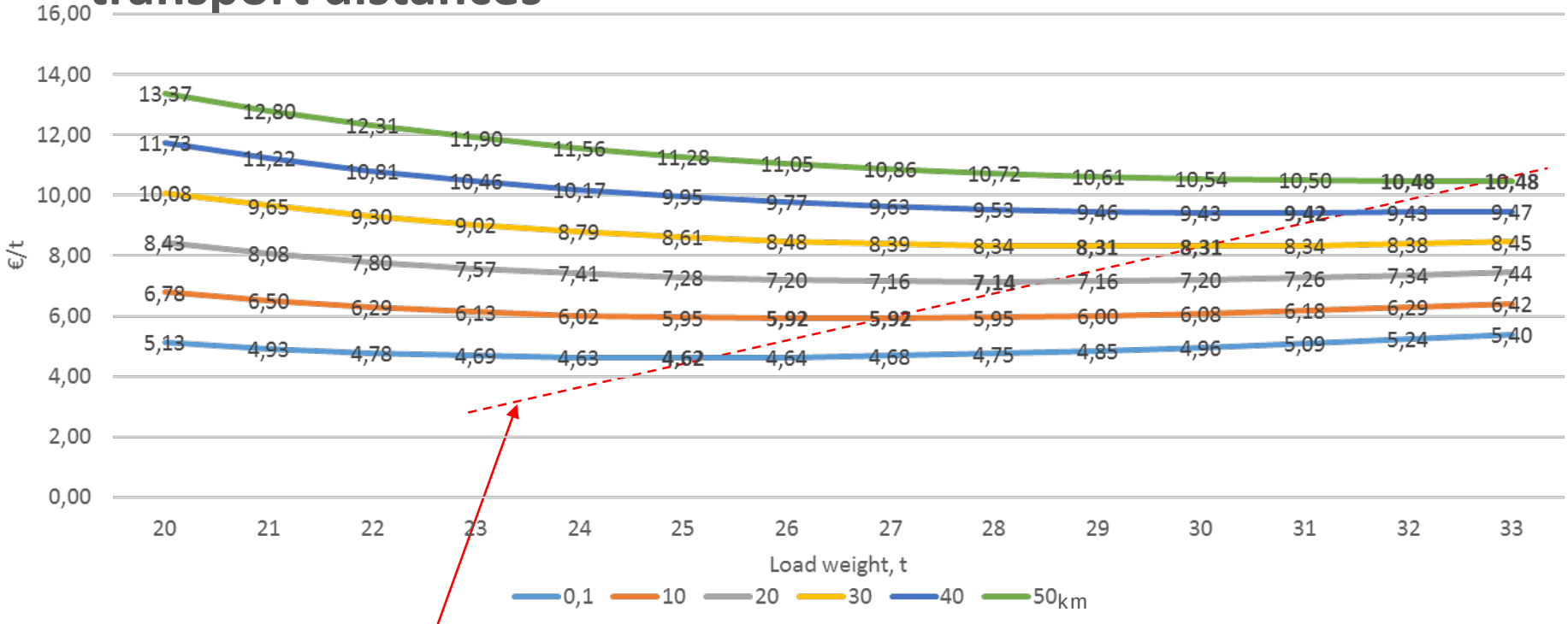
What is suitable time for loading on different transport distances i.e. what is suitable load size on different distances?

On the other hand, work methods/techniques to load loose biomasses influence also the total load volume. What kind of compression movements can be done and where?

Objectives of the study

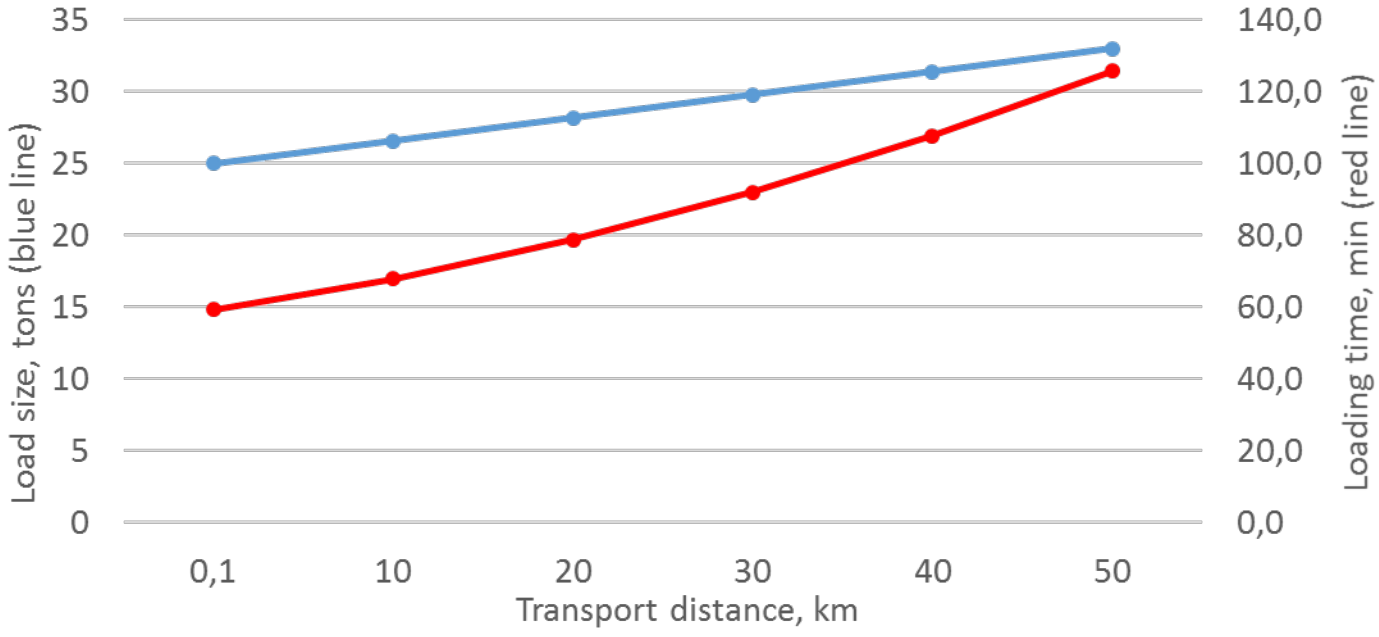
- calculate optimal payload size on different transport distances for logging residues
- describe productive work models for truck loading with loose biomass materials

Results – costs of transport of loose logging residues on different transport distances



- The optimal payloads can be found from the minimum points of different transport distances (bolded values).

Optimal load size and transport distance in connection to loading time



- 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 a payload, the transport distance could be shorter and vice versa.

Discussion

- For 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.

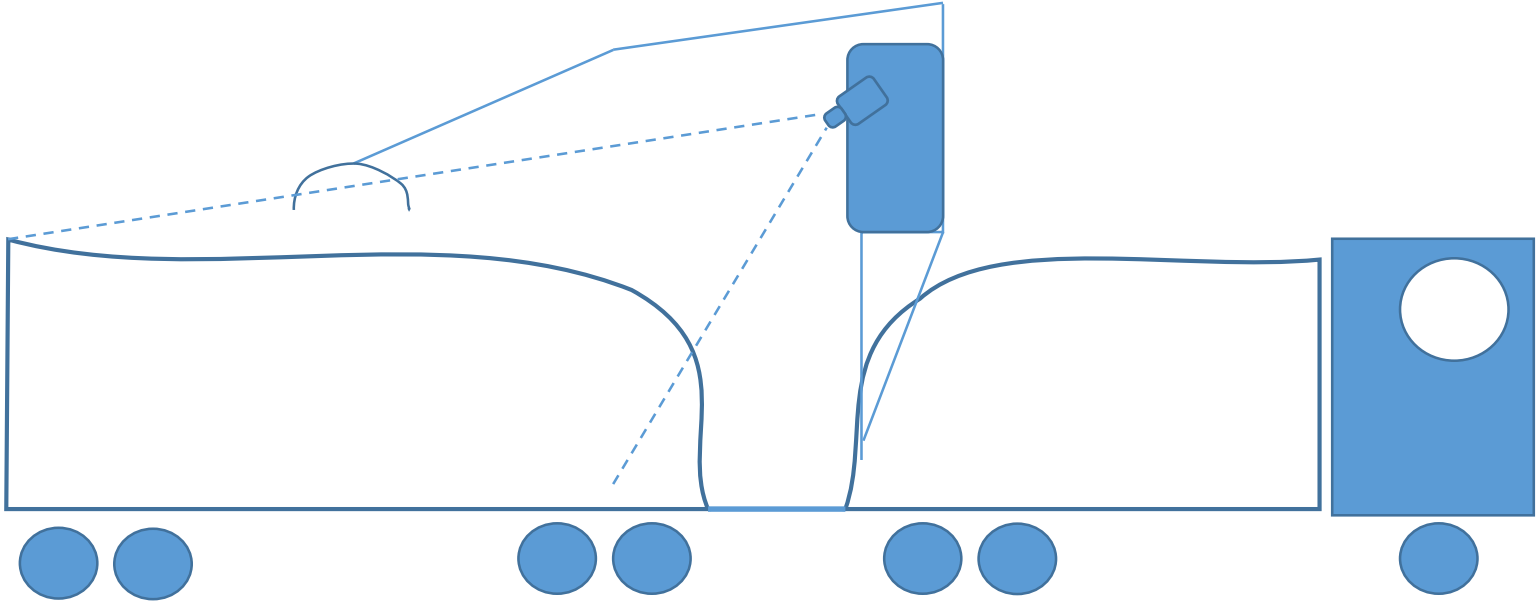
- If the optimal load size is reached in a shorter time on a specific distance, the extra time could be used for reaching even higher payload or transporting a little longer distance.

- 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.

Productive work models for biomass truck loading with loose biomass materials

Data collection methods

- Loading of trucks was filmed from the loader cabin point of view.
- Payload sizes were collected from bridge scales.
- Totally 12 different biomass truck drivers participated the study.

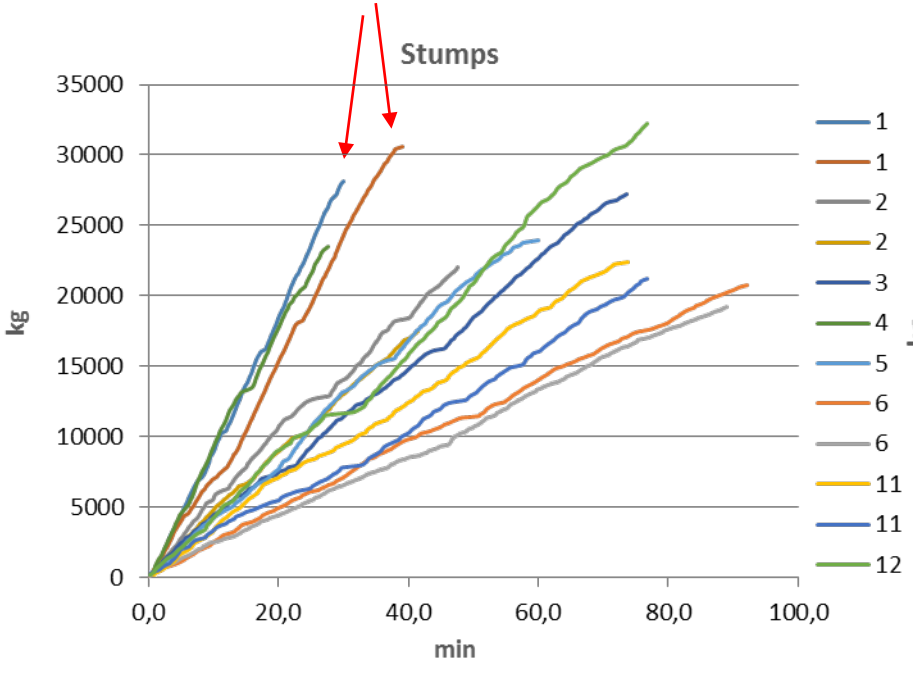


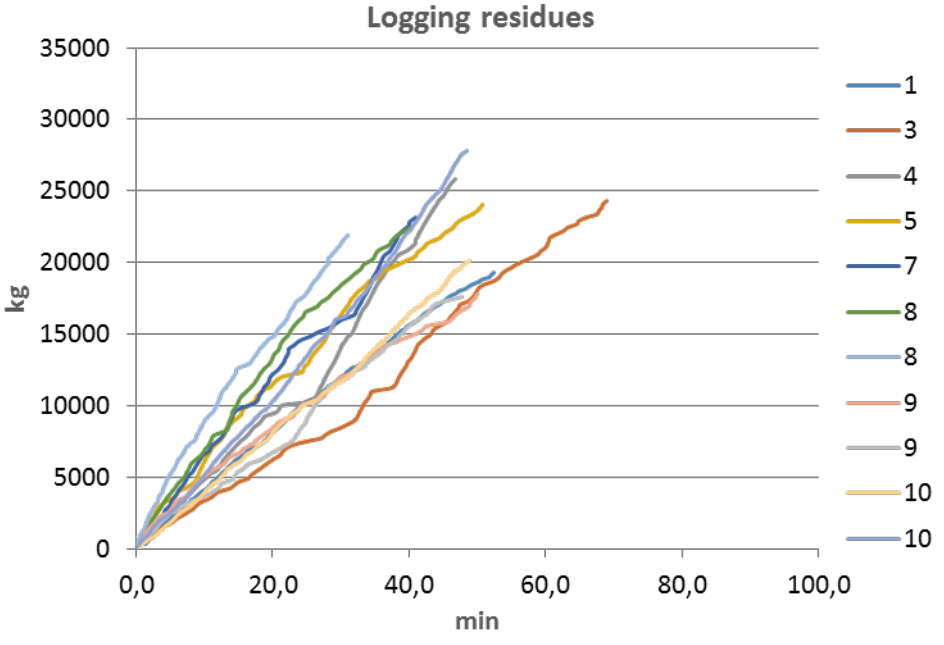
Study loads

	Loads	Mean, kg	Min, kg	Max, kg	St. Dev., kg
Stumps	12	24068	17500	32200	4374
Logging residues	11	22197	17580	27820	3125

- 23 loads of stumps, logging residues and small size trees were observed.
- Material in stump loads was mainly spruce and logging residue loads were typically spruce including little birch in some loads.
- All the piles were stored at least for a one year so the variation in moisture contents were stabilized on some level.

Cumulative load volume figures for stumps and logging residue loads





- The variation in loading times was considerably higher in stump loads compared to logging residues. The homogeniety of logging residue material explains the low variation.
- With red arrows marked curves represent stump material loads with small piece size. That material densified well without extra compaction movements.

Work models for loading of loose biomasses

- Four different kinds of work models were recognized of the data

- Work model for loading of
  1. small sized stump material load
  2. typical sized stump material load
  3. middle sized stump load with short loading time
  4. logging residues

Common features for stump and logging residue loading

Independent of the loaded material some common features exist for effective loading work:

- Short loading distance from pile to load space, if possible.
- The use of extension of the trailer.
- In stump lifting in the forest, the size of stump piece is dependent on the lifting method and operator.
- Instead, logging residues are not comminuted or split during the cutting or short distance transportation operations and, therefore, the piece size is rather homogenous.
- For these reasons, material size influence also the work method, especially on stumps.

Discussion

- Material size proved to be important factor in stump loading work models -> for this reason, two of the models were based on material size.

- To speed up stump loading with small size material, a larger grapple would be one option.

- In logging residue loading, compressing movements are even more important compared to stump material: **press, squeeze and turn.**

- The drivers aimed to make ”compressed bundles” of the tares by making different kinds of movements with the grapple in the pile and in the load space. Therefore, the most effective way to improve loose logging residue loading would be a grapple that would densify and bundle a single tare during the lifting moment to the load space.

BEST thanks

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Tekes

Literature

Korpilahti, A. 2015. Bigger vehicles to improve forest energy transport. Metsäteho's slide series 3/2015. 33 p.

Ovaskainen, H. 2012. Työmallit koneellisessa puunkorjuussa. Metsätehon raportti 221. 46 p.

Ovaskainen, H. & Lundberg, H. 2016. Optimal biomass truck load size and work models for loading of loose biomasses. Metsäteho's slide series 3b/2016. 48 p. [http://www.metsateho.fi/wp-content/uploads/Tuloskalvosarja_2016_03b_Optimal_biomass_truck_load_size_and_work_models_for_loading_of_loose_biomasses.pdf]

Poikela, A. 2015. Compression potential – "doupling energywood load size". Metsäteho's slide series 2/2015. 15 p.

BEST research program final report: http://bestfinalreport.fi/