Final report

IPN Project: Development of a new harvesting system in difficult terrain: Excavator based yarding

1. Background and aims of the project

There are about 28 M m^3 of mature commercial timber (Spruce and Pine) in steep and difficult terrain in Norway, with approximately the same volume approaching maturity in the next development class. While the lack of infrastructure is the most significant barrier to accessing this resource, the socio-economic situation in Norway requires highly mechanized harvesting systems that are also technically feasible. Cable-yarding is a harvesting technique that offers low-impact access to steep terrain, but is traditionally labor intensive and the economic efficiency is low.

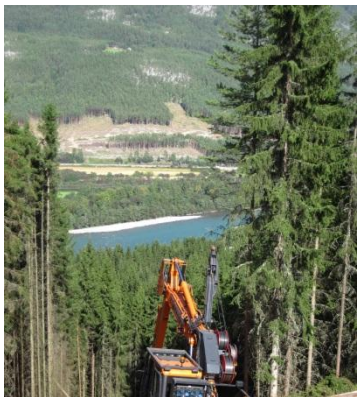


Figure 1 The Zöggeler yarder at work near Kvam in Gudbrandsdalen

This project therefore looked at a new cable yarding concept – a highly mobile and fully integrated unit that does not need to be guyed, and can be operated by a crew of 2. The project started out by making a comparison of various machines on the market, then followed the purchase, implementation, and operation of the selected machine over a period of 18 months. The original goals of the project were:

- To identify the potential volume that would be available to such a machine, given the machine attributes
- To quantify the benefits of using yarders that do not have to be guyed
- To investigate the benefits of a machine that is flexible enough to be used only seasonally

Other important issues that also needed to be addressed included:

- Understanding the functionality and advantages and disadvantages of the range of machine concepts on the market and their working principles – as well as the interpretation of these amongst all stakeholders
- Learning what the current and longer term productivity levels are and under what conditions they could be improved upon
- Knowing more on how beneficial it is that the machine has integrated yarding and processing capacity - i.e. does this increase or retard productivity, and what are the economic consequences

2. Results achieved in relation to the above goals and their consequences

a.) With regard to the potential areas available to this kind of machine (range < 250 m from road edge, slope>40%) the GIS analysis showed over 2400 ha in Mjøsen area (Gudbrandsdalen) alone – at roughly 3-4 days per ha, this equates to minimum 30 machine-years, which more than justifies the basis for this kind of investment.

b.) With regard to the benefits of not guying the machine, these were more difficult to quantify. While time and effort is saved (much improving the crew workload), a lot of the benefit goes to the

trucking company, who instead of having to turn and then reverse some distance to the yarder on narrow and steep roads, now pass the yarder, turn at the next junction then pass the yarder again. This results in quite substantial disturbance for the yarding operation, especially if transport has backlogged and there is a higher truck arrival frequency. Machine operators were not observed using the mobility of the machine during yarding or processing but only in cleaning the landing during corridor changes. This is partly because timber is stacked on all sides of the machine. A yarder without processing capacity would likely benefit more from such mobility as high piles of trees in front of the machines is both unproductive and dangerous

c.) With regard to flexibility and the seasonal utilisation of the machine for e.g. farming, the survey conducted amongst all interested parties at the outset of the project showed that professional contractors had very little interest in this option. The fact that the processor and winch on the selected machine have such a high capital cost (160 NOK/h), and therefore have to be continuously utilised, meant that there was little point in pursuing this for the machine chosen in the project.

d.) With regard to the functionality of alternative machines and especially the interpretation of this among stakeholders, an analysis of questionnaire response data showed the relative prioritization of 10 different functions by 5 stakeholder groups. Minimizing the capital cost in selecting a machine was the factor of least importance for all. Selecting a machine with a tower was the single most important factor for contractors, while processing capability was considered the most important issue for operations managers, academics and instructors, as well as authorities. Interestingly, this group were united and differed from the contractors on both these points, while e.g. on the need for an extra stable base machine, the operations managers were in unison with the contractors.

An important result is that there are clearly different perceptions of things between groups- something to be aware of in discussions e.g. between forest operations managers and contractors, or authorities who might be considering and application for investment support.

e.) With regard to the productivity levels and costs being achieved by the machine, results from field studies have shown that, for the inland region, it will be difficult to produce much more than around 5 m^3 per effective hour on average. Considering the system costs is around 1250 NOK per scheduled hour, specific net costs are about 250 kr /m^3 (i.e. before administration and profit markup). While a normal yarder has a utilisation rate of only 60-65%, this machine is assumed to have one of at least 75-80%, due to the short rigging times and simplicity of operation.

Correcting for utilisation at 80% gives a specific cost of around 312 kr/m^3. By comparison, the mean harvesting price with a harvester/forwarder in Norway is 120 kr/m^3. Processing rates are highly sensitive to tree size and can be increased significantly by deploying the machine in stands with larger trees. For an increase in mean tree size from 0.32 m3 to 0.56 m^3, processing productivity increased by 60%, roughly 5 m^3/h. Faster processing leaves a larger amount of system time for yarding, increasing overall productivity.

In good conditions in coastal regions, productivity rates of closer to 8 m^3 were achieved. Increasing tree size also increases yarding performance, but not to the same degree. Yarding speed (carriage speed) and load size were generally low. Smaller trees do not provide tailspars that are stable enough to operate with higher tension – and speed – in the line.

f.) With regard to whether the fully integrated machine is better than two separate machines, or whether it should be used with a two or three man crew, a systems analysis tested for corridor lengths of 75 m, 150 m and 250 m provided very clear guidelines. The two machine system (one yarder and one processor) showed a system productivity approximately twice that of the single machine system at shorter distances, decreasing to about 60 % higher at the longest corridor distances.

The 3-man crew shows a productivity level only marginally higher than the 2-man, this increases with tree size but decreases with corridor length, as the longer cycle-times make felling a smaller part of the system hour. The 3-man crew results in a far higher specific cost as the 3rd person is only partially utilised, and contributes only marginally to system productivity, but considerably to costs.

At the shortest distances the two machine system is slightly cheaper than the integrated machine with a 2-man crew, but with increasing yarding distance, the expensive processing machine has longer and longer waiting times, making the system more costly than the integrated machine.

With only marginal cost differences, it will always be beneficial to apply the system with the smallest crew under Norwegain socio-economic conditions, the crews need to be highly mobile at a national level, and this results in numerous challenges, not least recruitment and accommodation. Single machine systems are likely to have a higher technical availability, as there is a strong tendency to use old machines for processing in two machine systems, and regular breakdowns on these cause interference and reduced overall production in such systems.

3. General conclusions

This project looked at the purchase, implementation and continued improvement of a unique new machine concept for harvesting timber from shorter steep slopes. Around 40 stakeholders were consulted on their understanding and expectations of excavator-based cable yarders before the studied machine was purchased. The Zöggeler machine that was settled on generally performed well and had a high technical availability.

The flexibility provided by not having to guy the yarder both saves downtime and allows the machine to operate on narrow mountain roads, while still providing access to passing timber trucks. However, the anticipated benefits of mobility during yarding – e.g. in avoiding obstacles or over-piling of timber, were not utilised.

The machine uses a processing head that is over-dimensioned for timber in inland-Norway, and processing rates here are generally too low, resulting in excessive production costs. To improve economic performance, the machine should be deployed in stands with trees as large as possible, primarily in the coastal regions, as productivity increased around 60% with a mean tree volume increase from 0.32 to 0.56 m^3. The broad diameter distribution in the typically unthinned stands, and the high number of assortments produced was also found to be detrimental to productivity.

The time and productivity functions developed in the project could be used for more differentiated price setting, as they illustrate the considerable cost differences depending on stand characteristics. Improved accuracy in predicting the cost of operations at a stand level is critical in a sector that is characterized by narrow economic margins.

Even the most modern yarders with integrated processing are not fitted with Nordic tree bucking management systems. This makes the collection of productivity data both expensive (researcher needs to be onsite) and inaccurate (tree volumes are roughly estimated), and the introduction of these systems in the future would likely improve the integration of cable yarders into the general timber supply chain.

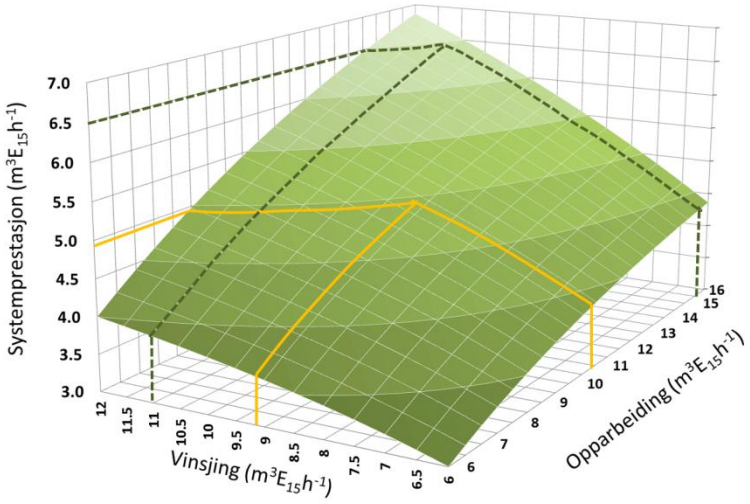
Although the system studied here did offer a safe and highly modern working environment, and performance was in line with international norms, harvesting costs achieved with this machine were still at least double those of a ground based CTL system, indicating a continued dependence need for government subsidies if these – environmentally benign – harvesting methods are to be prioritized in in mountain forests.

4. Norsk sammendrag

Dette prosjektet fulgte anskaffelsen og innkjøringen av et innovativt nytt maskinkonsept – en bardunfri taubane med løpende liner og opparbeidingsaggregat. Maskinkonseptet er nytt i det den ikke trenger bardunering, og at den er utstyrt med både opparbeidings- og vinsjings kapasitet. Banen kan dermed drives av bare to mann. Tidsforbruk og arbeidsbelastning ved bardunering, immobilitet på smale velteplasser, og mangel på erfarent mannskap er tre av de største utfordringer for taubanedrifter i Norge i dag. I prosjektet er det derfor sett på hvordan, og i hvilke omfang denne maskinen løser utfordringene, samt på prestasjons- og kostnadstall under ulike forhold.

Den studerte kranen er en Zöggeler gravemaskin-montert bane med løpende line og opparbeidingskapasitet, som nå har vært i bruk i ca.18 måneder. En GIS analyse viste at det for denne type maskin – en som må stå på skogsbilveien og har en rekkevidde på maks 250 m – finnes hogstmoden skog nokk til ca. 30 årsverk i Mjøsen Skog's område alene.

Produksjonsmessig kan det ventes en gjennomsnittlig prestasjon på ca. 5 m^3 pr effektive arbeidstime i innlandsstrøkene, økende opp til ca. 7 m^3 i timen i kyststrøk hvor større trær forekommer. Prestasjonen henger delvis sammen med at opparbeidingsaggregatet er bygd til skogforholdene i alpene, og er dermed overdimensjonert i forhold til trærne i innlands-Norge, men håndterer store trær uten problemer. Ettersom en systemtime inneholder både vinsjing og opparbeidings elementer, og at de to funksjoner ikke kan utføres samtidig som de ellers kan på f.eks. Mounty kraner, påvirkes systemprestasjon av begge delfunksjonene. En økning i prestasjonen i opparbeiding med f.eks. 1 m^3/t medfører en økning i systemprestasjon på bare ca. 0,5 m^3/t (se figur 1 nedenfor).



Figur 1. Følsomhetsanalyse av systemprestasjon i forhold til økninger i vinsjing og/eller opparbeiding. Den gule linjen viser prestasjonen under feltforsøket mens den mørkegrønne viser hva det er mulig å oppnå hvor trær har en størrelse på ca. 0.5 m3

Den Zöggeler maskinen som ble studert i dette prosjekt har en anskaffelsespris på ca. 2.8 millioner kr. og vil, med et 2-manns lag, koste ca. 1.250 kr pr. effektiv time. For taubaner generelt overstiger utnyttelsesgradene sjeldent 65%, men pga. den kortere riggetid blir estimatet for denne maskinen noe høyere – ca. 80%. Kostnadspris for tømmerhogst er beregnet til ca. 250 kr/m^3, eller 312 kr/m3 når utnyttelsesgraden medregnes. Prisen er fortsatt over det dobbelte av hva vanlige drifter med hogstmaskin og lassbærer bør koste.

For å sammenlikne to- og tre-manns lag, samt effekten av eventuelt å fordele vinsjing og opparbeiding ut over to basmaskiner, ble det utført en simulering av ulike arbeidsmomenter. Det viste seg at det er så godt som alltid billigere å kjøre med 2-manns lag, ettersom den tredjemannen sjeldent blir utnyttet i en grad tilsvarende timekostnaden (dog kan det oppstå situasjoner med felling av store trær til nedovervinsjing på korte strekker hvor det ville være nyttig med en ekstra mann på laget).

Når riggingskostnader regnes med vil dagens maskinløsning alltid være billigere enn et system med 2 basmaskiner, dog vil prisene ligge tett i forhold til hverandre på korte vinsjestrekninger (opp til ca. 100 m). På de lengre strekker vil det oppstår så mye kostbar ventetid på opparbeiding at det ikke vil kunne lønne seg å ha den på separate basmaskin.

Konklusjonen er, at mens det er rikelig med oppdrag til slik en maskin i Norge, og mens maskinen på mange måte fungerer veldig godt og viser en høy teknisk utnyttelsesgrad, er prestasjonen fortsatt for lav til at konseptet kan sies å være revolusjonerende innen hogst i bratt terreng. Fordelene med Zöggeleren ligger i det at den skaper et sofistikert og trygt arbeidsmiljø med redusert arbeidsbelastning, og at den kan betjenes av bare to mann – noe som har stor betydning for rekruttering, og ikke minst opprettholdelse av dyktig mannskap.