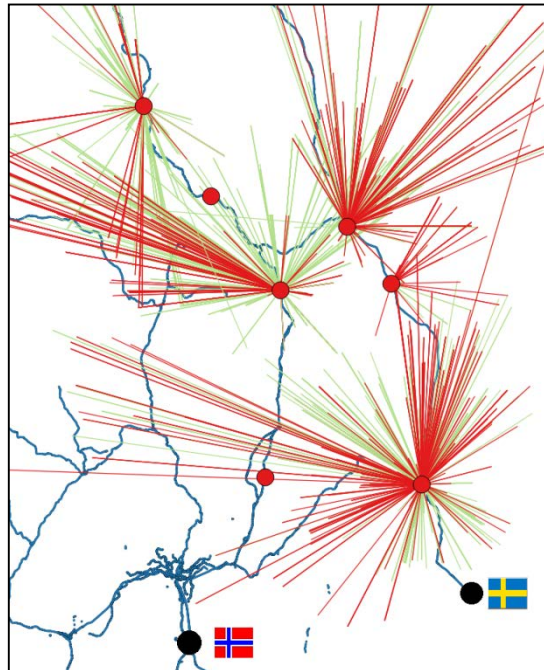


Modeling multimodal transport in Norwegian wood supply





Dag Fjeld
Dag Skjølaas

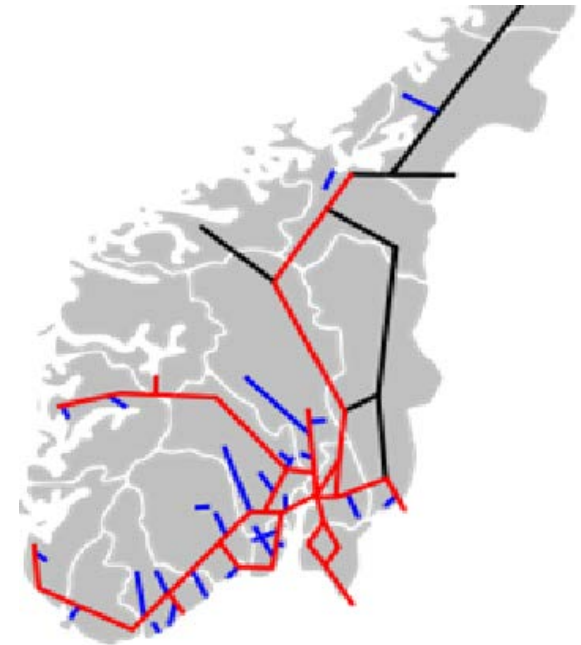
Background


Restructuring of pulp mill capacity

Limited rail electrification

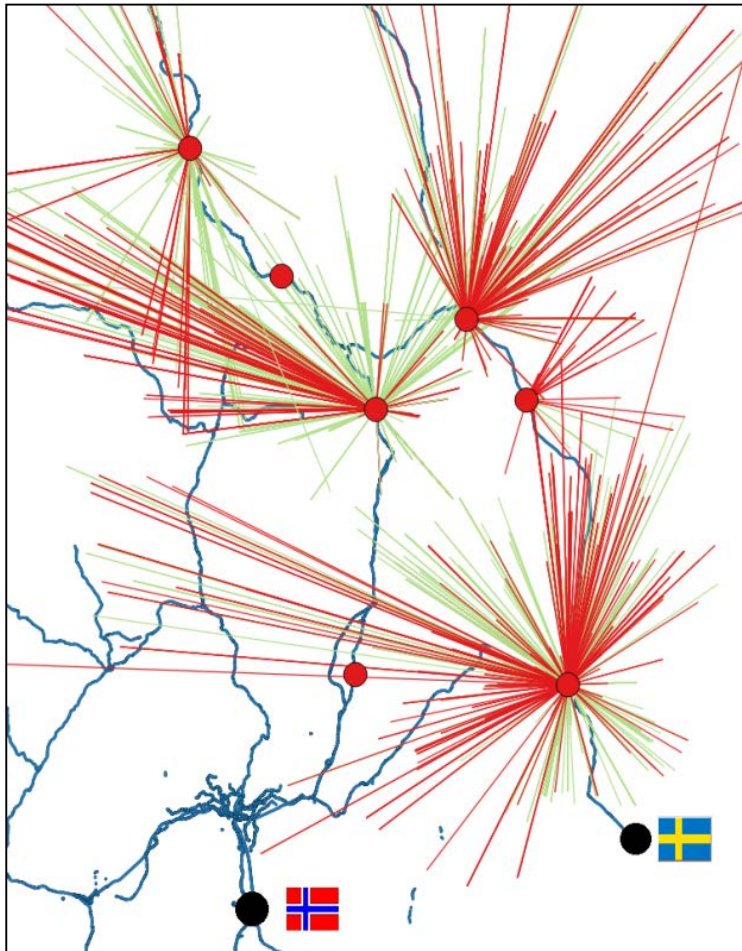


spruce pulpwood 
pine + spruce pulpwood 



 electric
 diesel

Objective & models



Compare cost levels for varying levels of

- terminal capacity
- demand and electrification

between optimal wood flow solutions
using simple transport problem in Excel*

Model 0: $\min \sum \text{truck} + \text{rail costs}$
...+ terminal-specific costs added after optimization

Model 1: $\min \sum \text{truck} + \text{terminal} + \text{rail costs}$

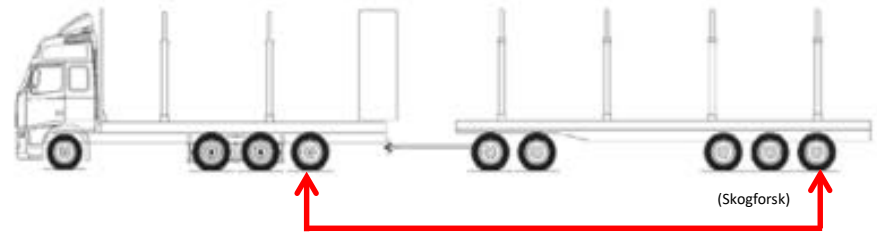
given restrictions:

- annual supply per area (45 w/pine, spruce)
- annual demand per market (2 w/pine, spruce)
- terminal transshipment restrictions
- terminal capacity restriction (m^3/yr)

For an annual transport volume of 1,4 million m^3 pulpwood

Truck transport: area-specific max GVW

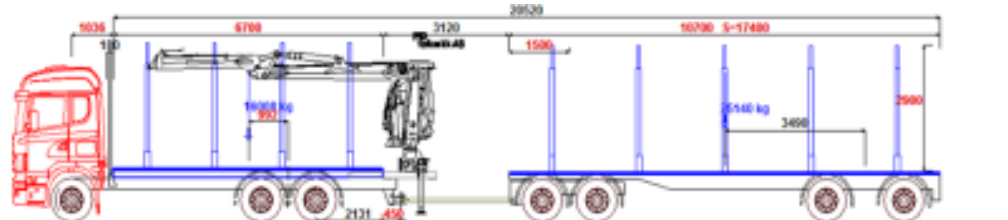
74t \Rightarrow 49t load



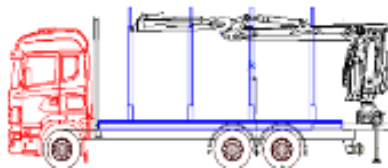
60t \Rightarrow 38t load

56t \Rightarrow 34t load

50t \Rightarrow 28t load



(D. Skjølaas)

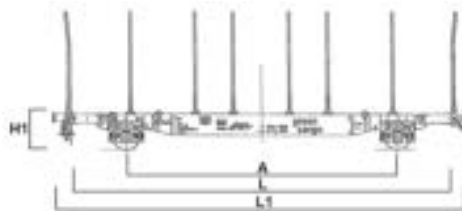


Rail transport : market-specific train configurations

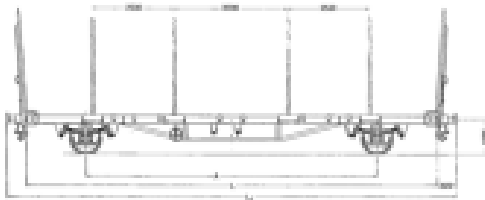
domestic $\approx 800-1100 \text{ m}^3/\text{train}$ export $\approx 1700 \text{ m}^3/\text{train}$



sgnss wagons (3,4 t/meter)



laaps wagons (2,7 t/m)



Inps wagons (2,5 t/m)

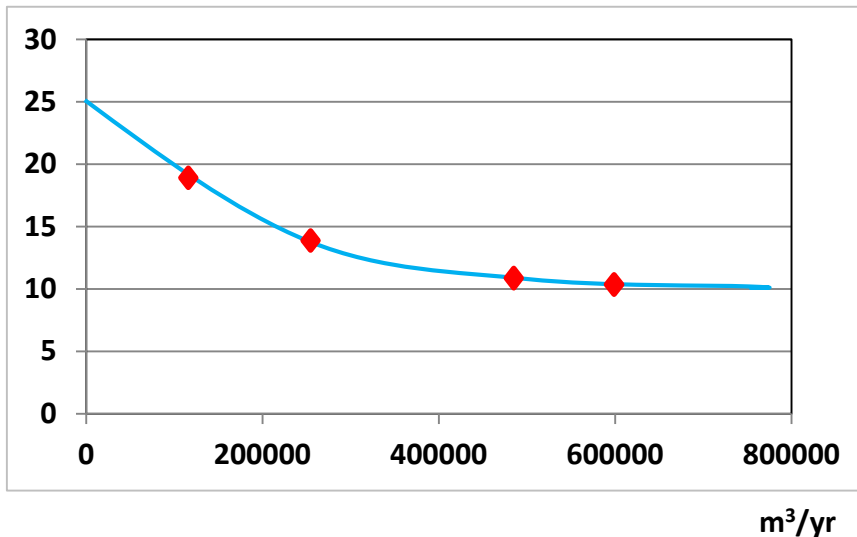
Cost functions

Truck transport: NOK/m³= fixed + variable (km)

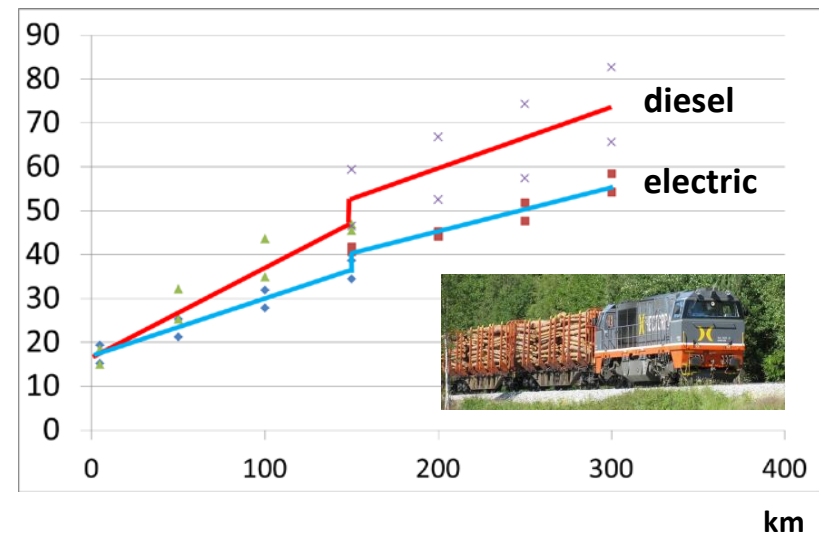
| Max GVW | 50 t | 56 t | 60 t |
|--------------------------------|------|------|------|
| fixed NOK/m ³ | 26 | 24 | 22 |
| variable NOK/m ³ km | 0,72 | 0,67 | 0,62 |



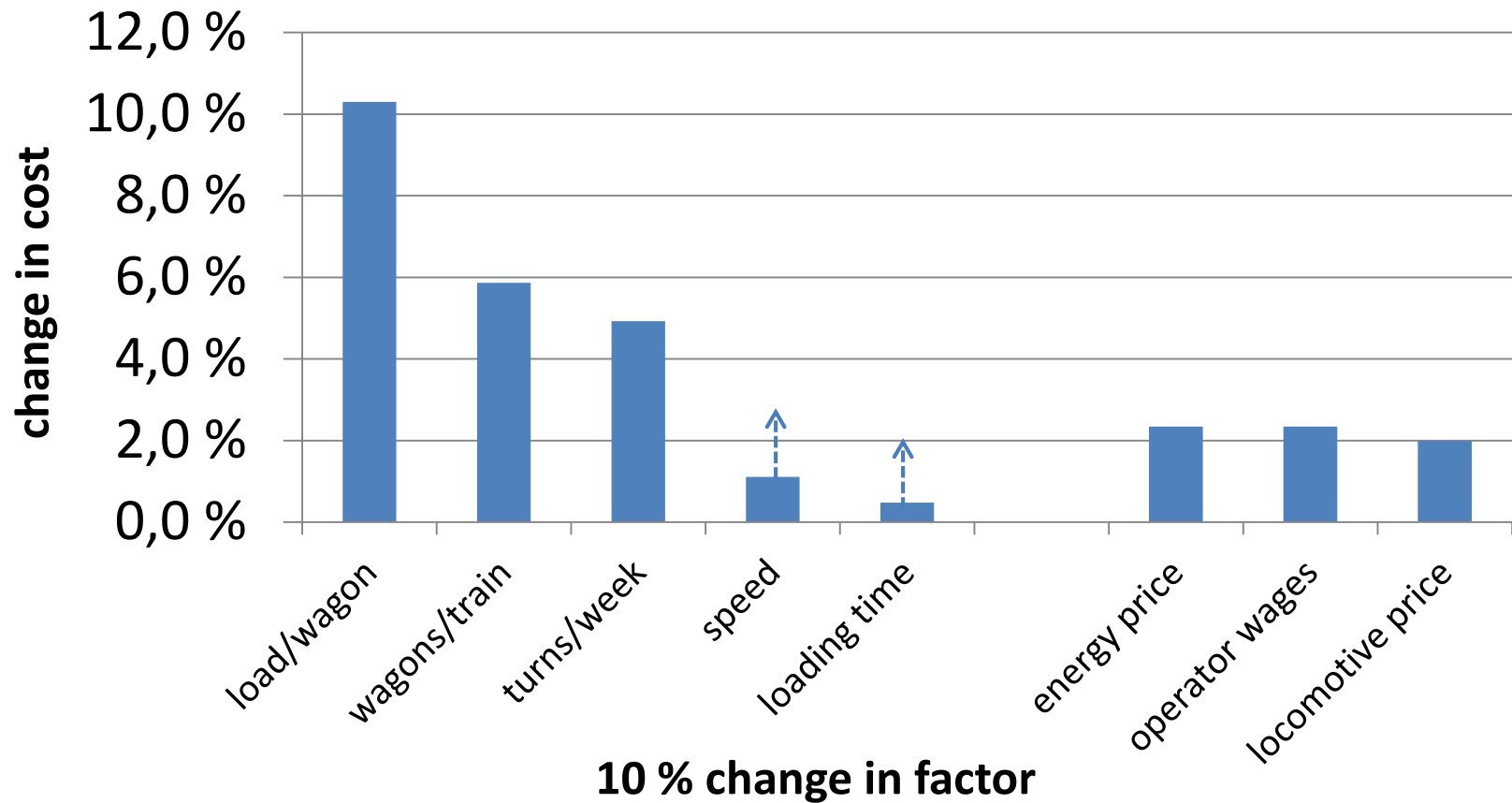
Terminal handling: NOK/m³



Rail transport: NOK/m³

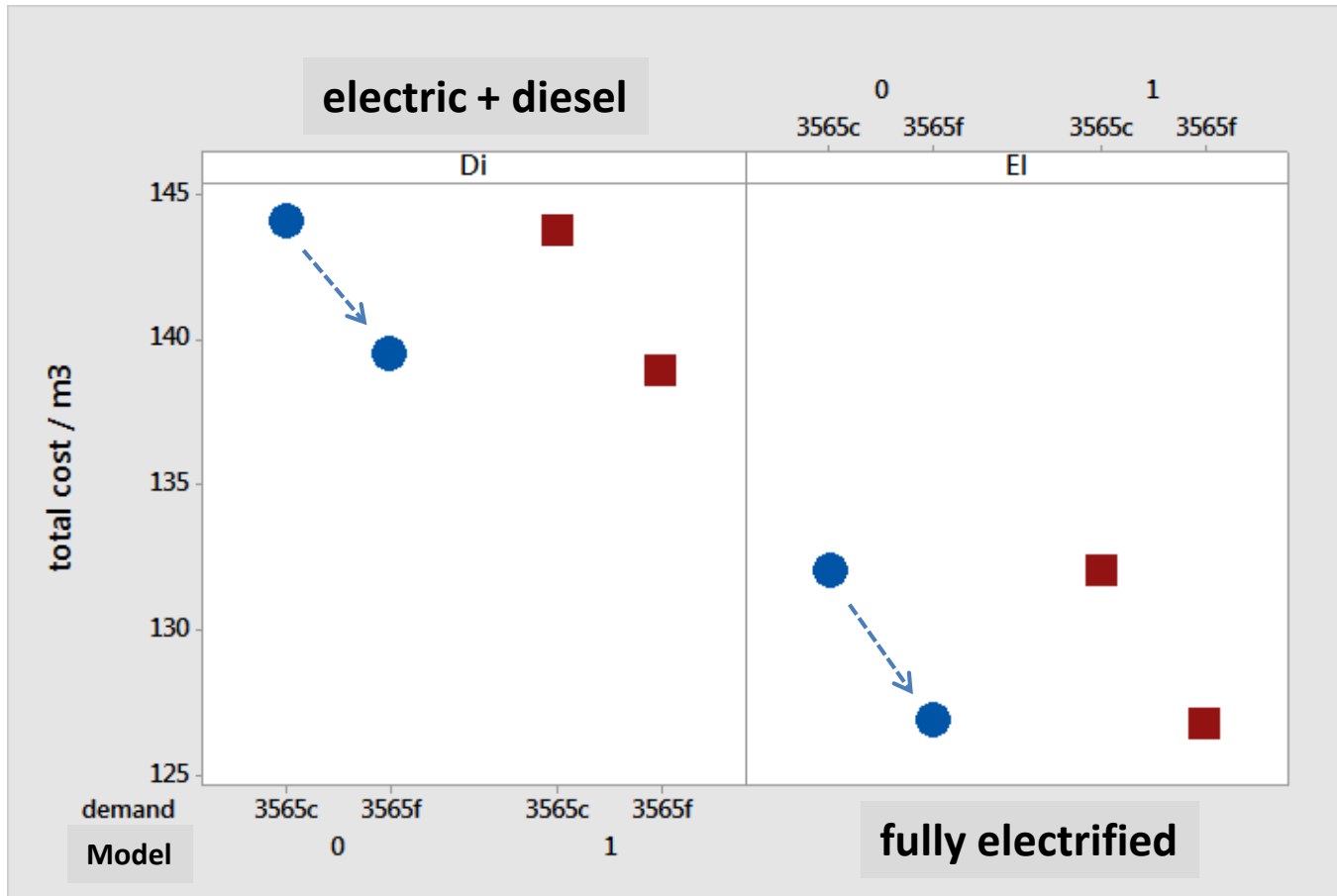


Ranking of factors influencing rail transport costs (NOK/m³)

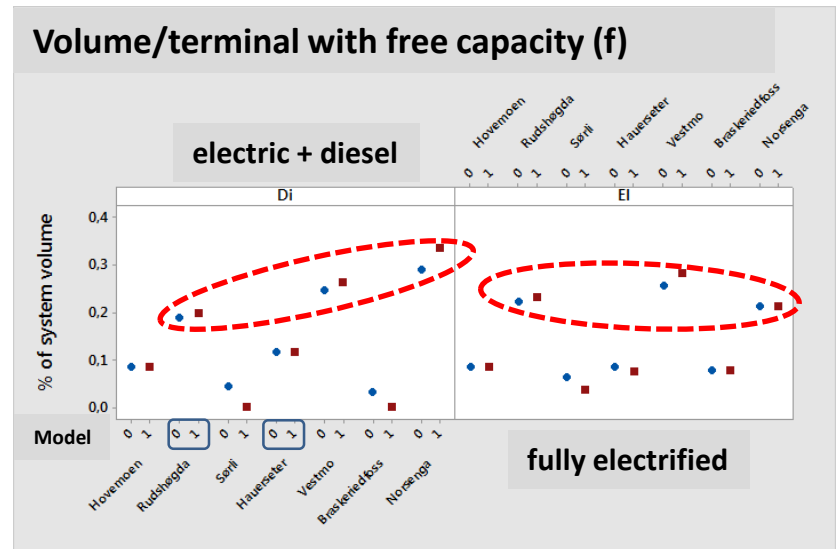
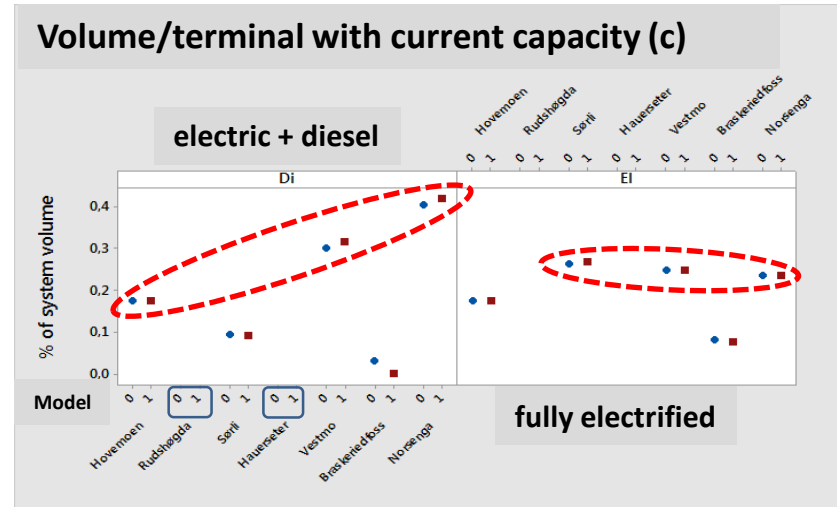
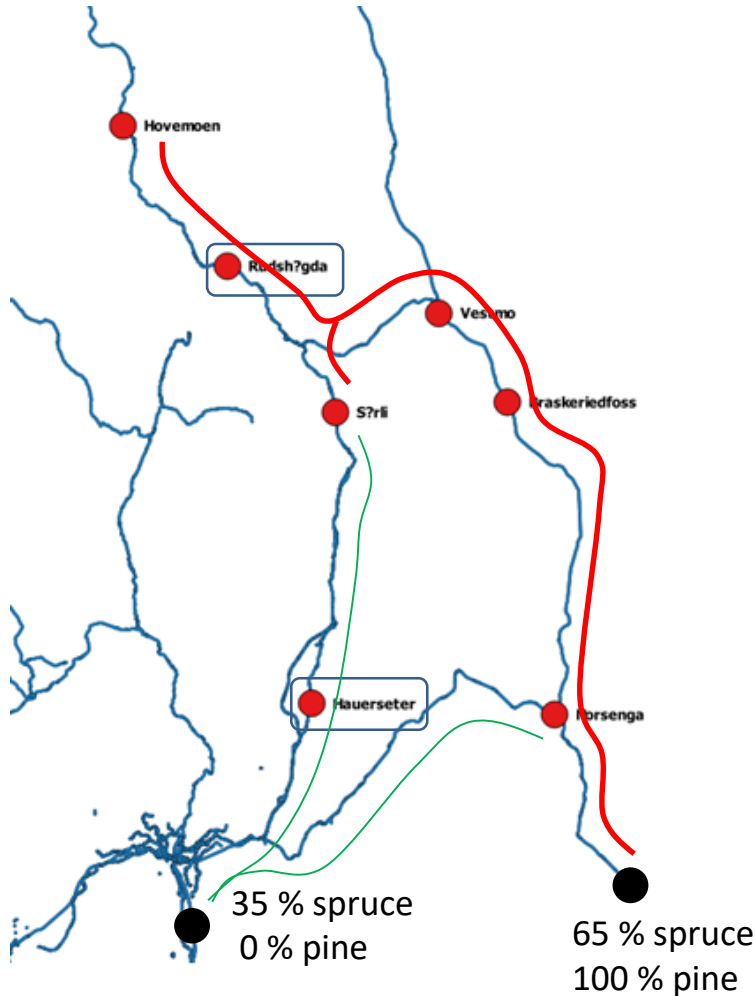


Cost comparisons with current demand

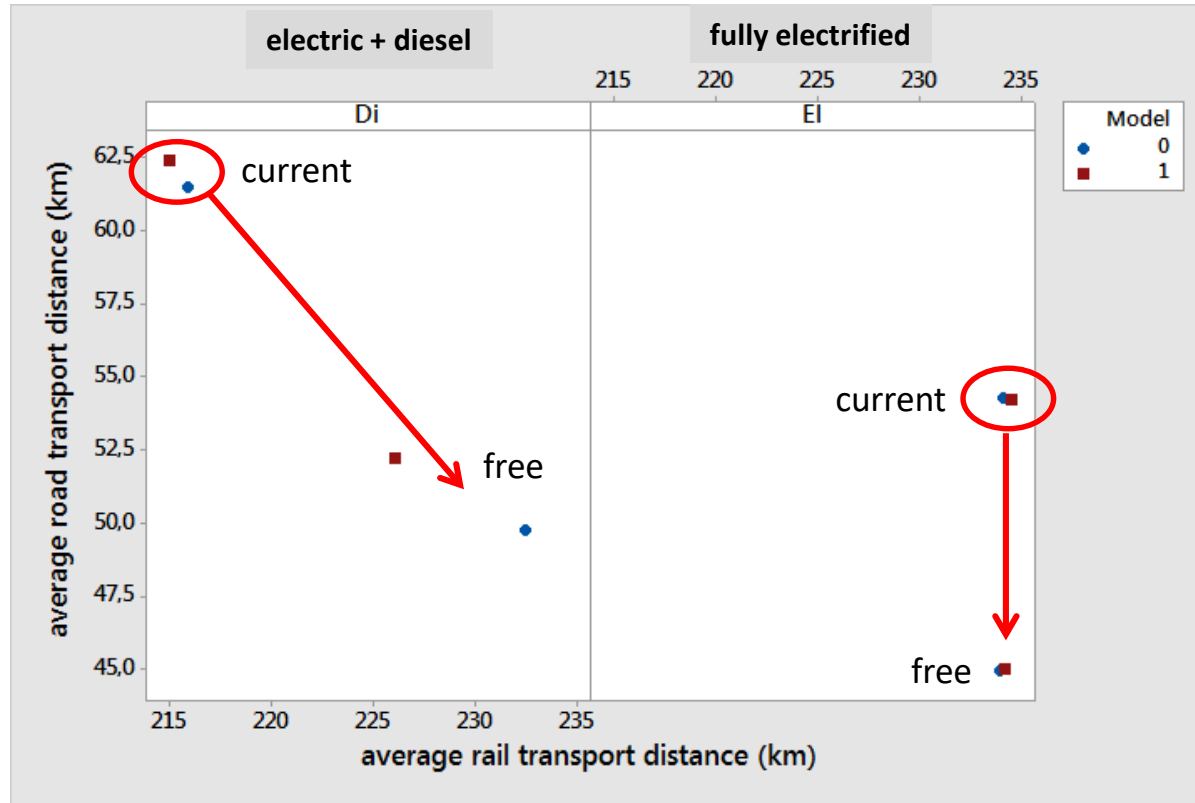
for current (35/65c) vs free (35/65f) terminal capacities



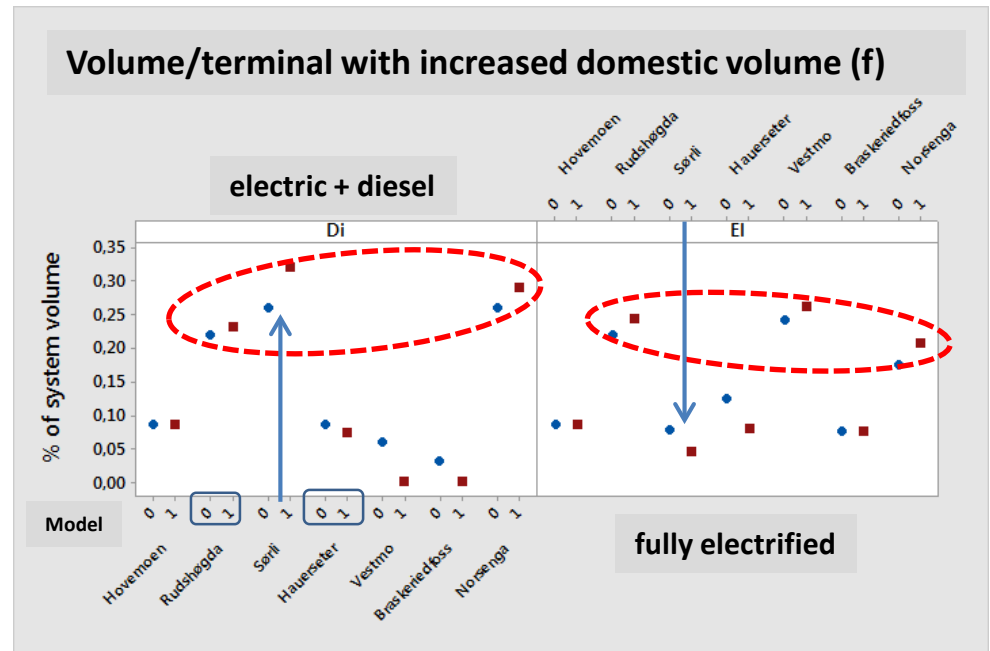
Solutions : Top three terminals with current demand



Solutions: Changes in average road and rail distance

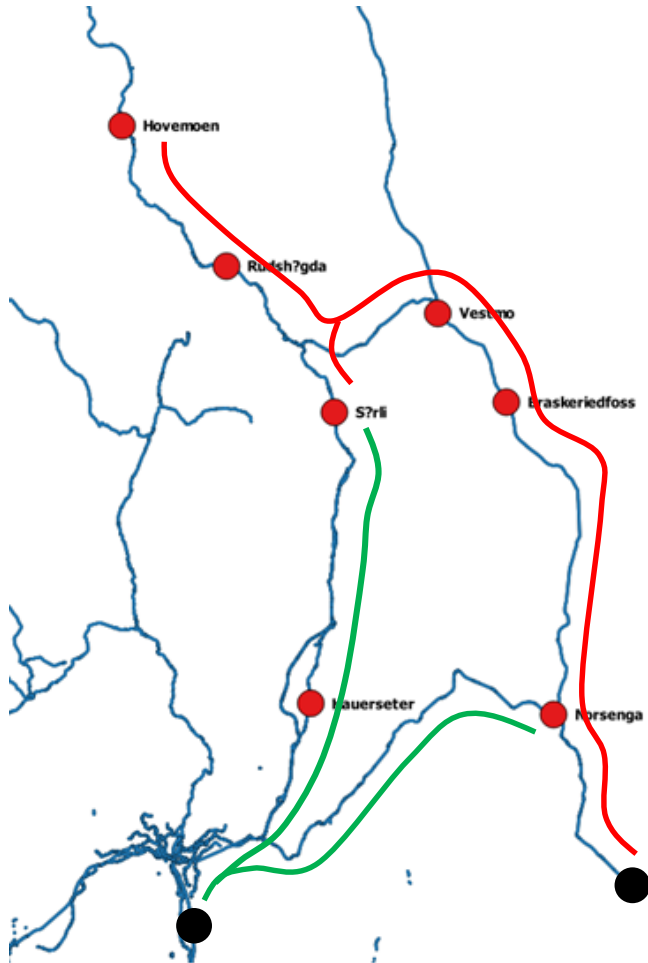


Solutions: Top three terminals with increased domestic demand



Market-specific cost development*

with current capacity/demand/electrification



| | | Costs (NOK/m ³) | | |
|----------|----------------------------------|-----------------------------|-----------------|----------|
| | Volume (1000 m ³) | w/ current flows | w/optimal flows | |
| | | | «own volumes» | «all-in» |
| Domestic | 325' | 132 | 132 | ↑ 139 |
| Export | 275' | 149 | 143 | ↓ 103 |
| Sum | | | 122 | |

*spruce pulpwood (sort 102)

In conclusion

*«It is always wise to look ahead,
but difficult to look
further than you can see»*

Winston Churchill