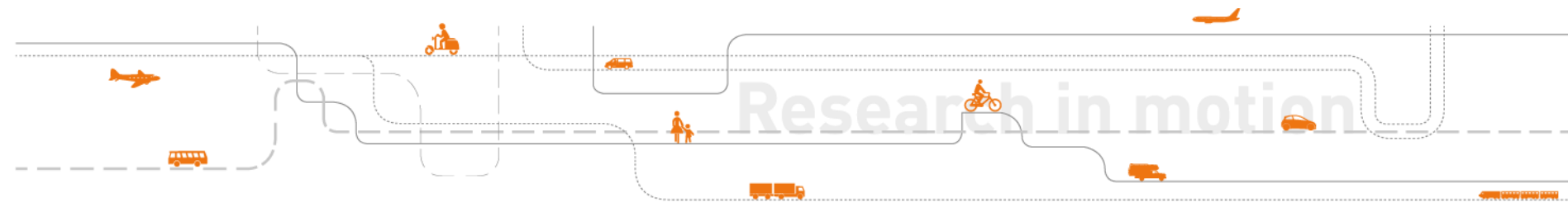


# Marginal noise costs of terminal activity changes

Ronny Klæboe og Kenneth Løvold Rødseth

EXPORT final conference  
Oslo, 12.09.2017

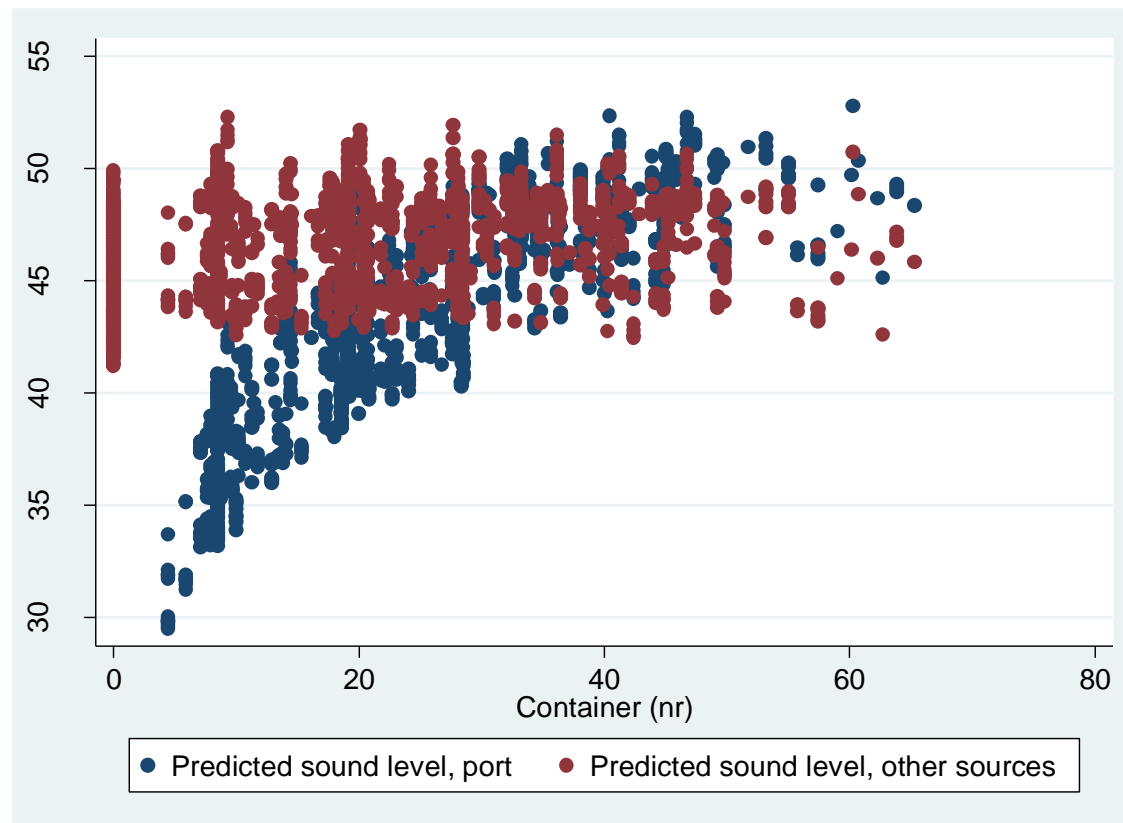


# Procedures

- **Step 1:** Statistical analyses of changes in emitted noise as a consequence of activity levels (#containers)
  - *Uses information from Oslo Harbour noise measurement time series combined with harbour statistics, and historical weather conditions to establish relationships*
- **Step 2:** Uses GIS-simulations and simple analytical calculations to derive changes in noise exposure for affected population as a function of the changes in the emitted noise level

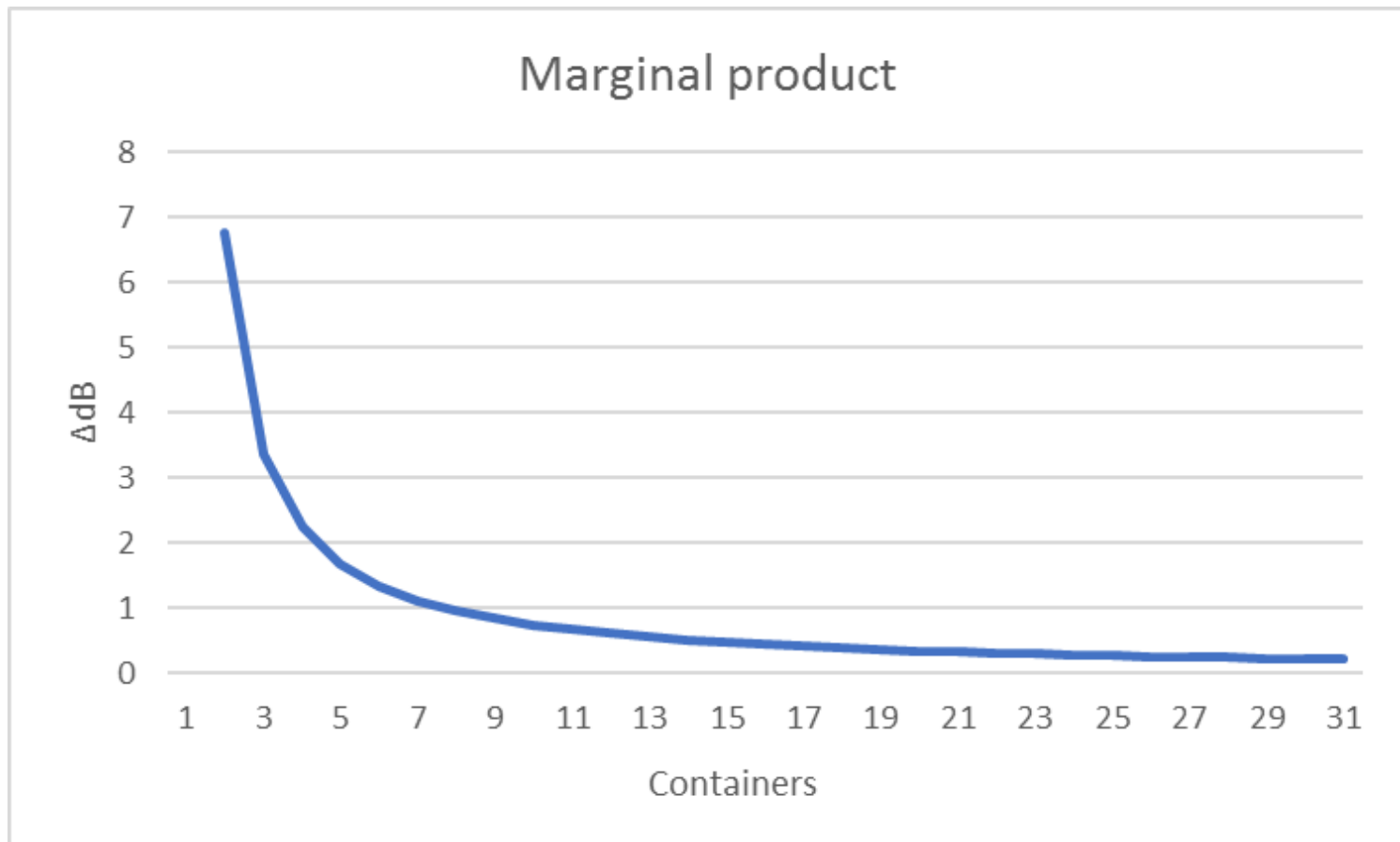
# The contribution of container handling to noise emissions

- Econometric study of Oslo Harbour (2014)
  - *Noise level at measurement site ( $L_{Aeq}$ , 1hr)*



# What is the additional noise ( $\Delta L_{\text{aeq}, 1 \text{ hr}}$ ) generated by an extra container

- $\Delta L_{\text{aeq}, 1 \text{ hr}}$  decreases with activity level

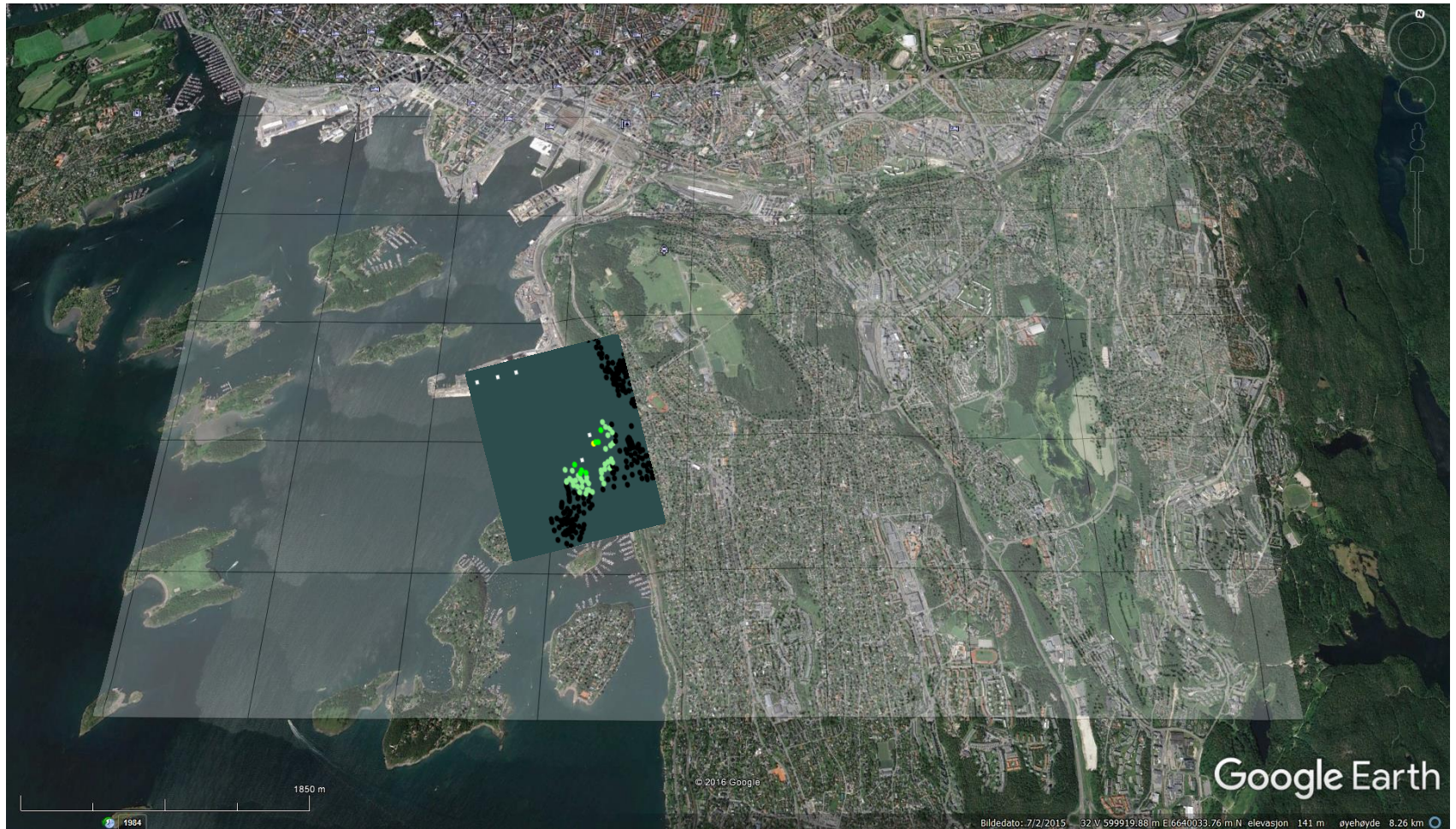


# What is the additional noise ( $L_{den}$ ) generated by an extra container

- $L_{den}$  – Evening and night weighted noise levels
  - 5 dB malus in the evening
  - 10 dB malus at night
- Example: 20 containers on/off loaded  $\frac{\partial L_{den}}{\partial y} \approx 0.02$  dBA

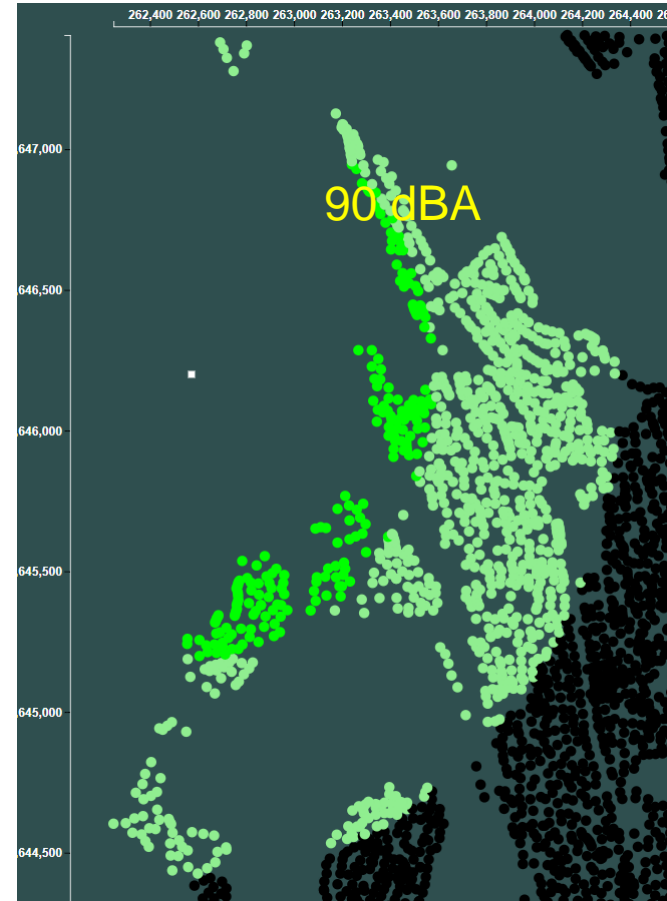
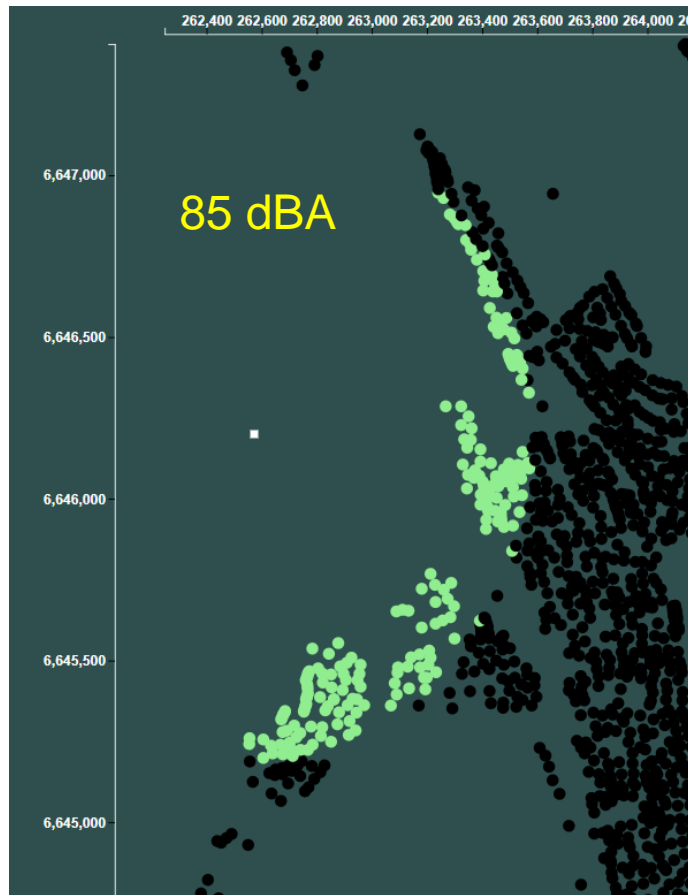
	$\frac{\partial L_{den}}{\partial L_s}$	$\frac{\partial L_s}{\partial y}$	$\frac{\partial L_{den}}{\partial y}$
Day	0.02	0.34	0.01
Evening	0.03	0.34	0.01
Night	0.08	0.34	0.03

# Ormsund/Sjursøya harbour area imported into HSTOY



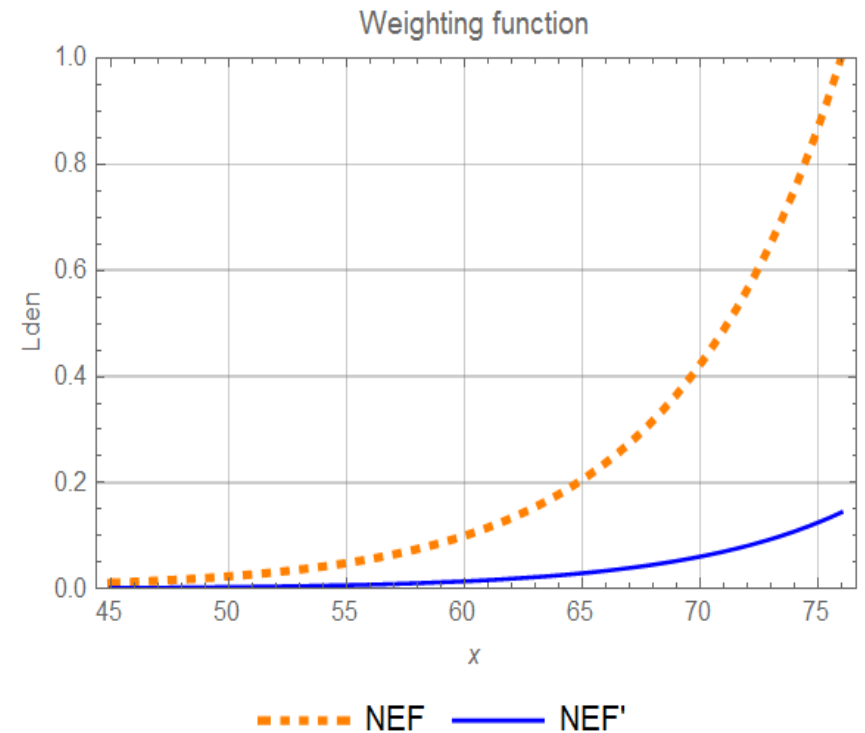
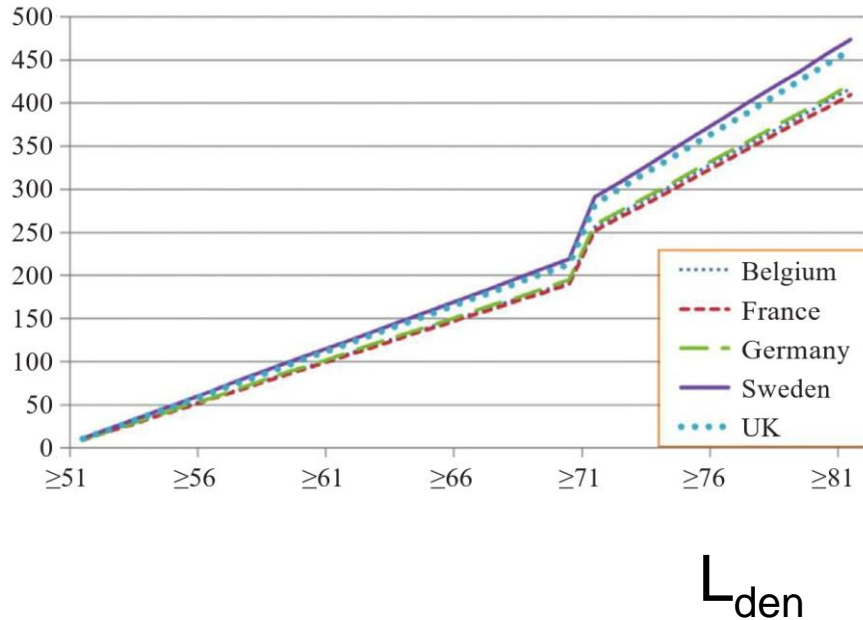


# Simple simulations using HSTOY - here exposure from single noise event



Light green (lime) [45-50] dBA Green=[50-55] dBA

# Heatco – cost linear (with health penalty) for high values. Some use exponential cost (e.g. Denmark)

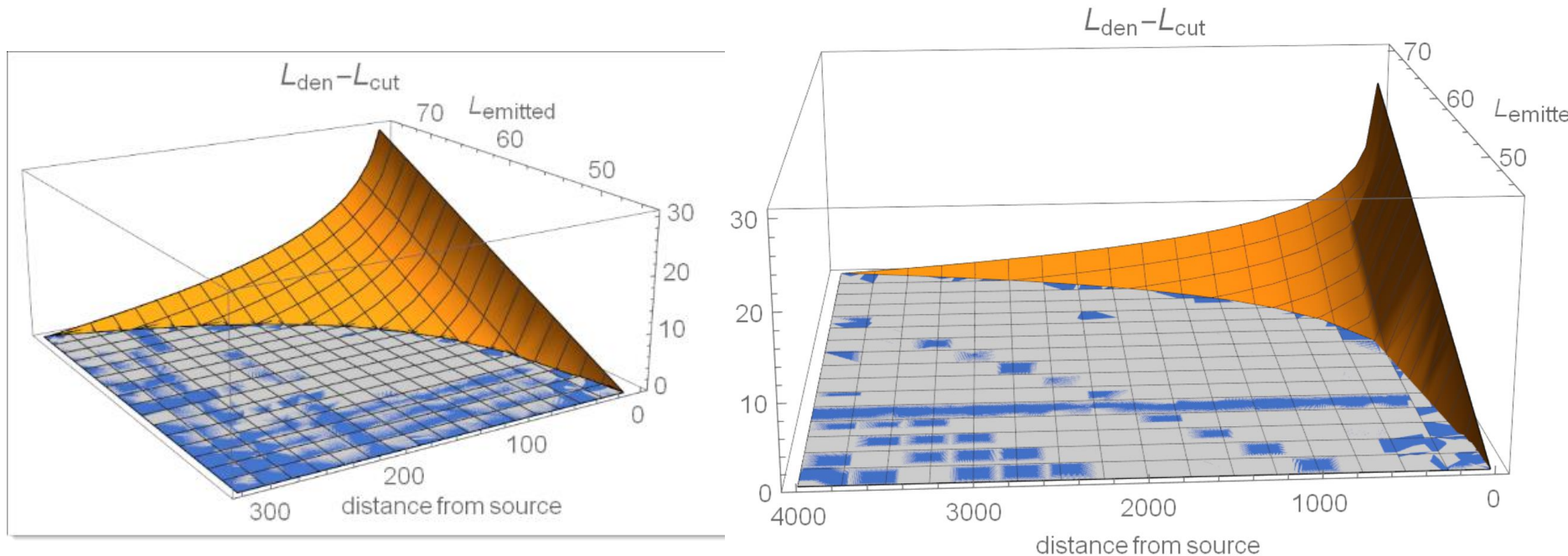


Simple calculations

Use 380 NOK / dBA person year



# When emitted noise level increases, the area affected also increases



Noise exposure as a function of emitted noise and distance. Left : **point source**, right : **line source**.

# Disregard of the influence area leads to too low marginal noise costs

Marginal increase in influenced area:

$$\text{Point source : } \partial A / \partial L_{den} = \left( \sqrt[20]{10} \right)^2 = \sqrt[10]{10} \approx 1.25$$

$$\text{Line source : } \partial A / \partial L_{den} = \left( \sqrt[10]{10} \right)^2 = \sqrt[5]{10} \approx 1.58$$

Area already exposed \* population density \* unit noise cost \*  $\delta L_{den}$  +

Additional area exposed \* population density \* unit noise cost \*  $\frac{\delta L_{den}}{2}$

This means that the marginal noise cost could be  $0.5 * 25\% = 12.5\%$  higher in the case of point source, and  $0.5 * 58\% = 29\%$  higher for a line source than when disregarding the increase in influence area.

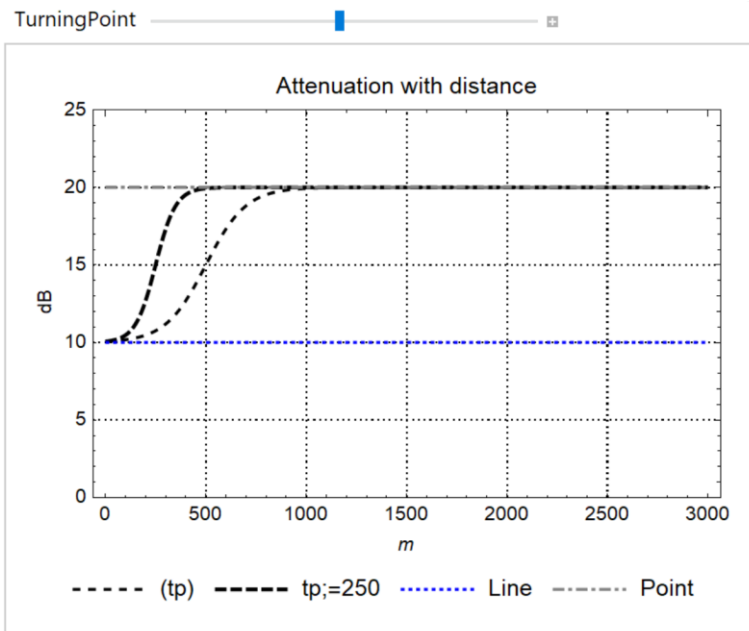
The importance of an extended influence area depends on topography, shielding and other context factors.

# Attenuation for an area source

Attenuation factors: 20 for point and 10 for line source:

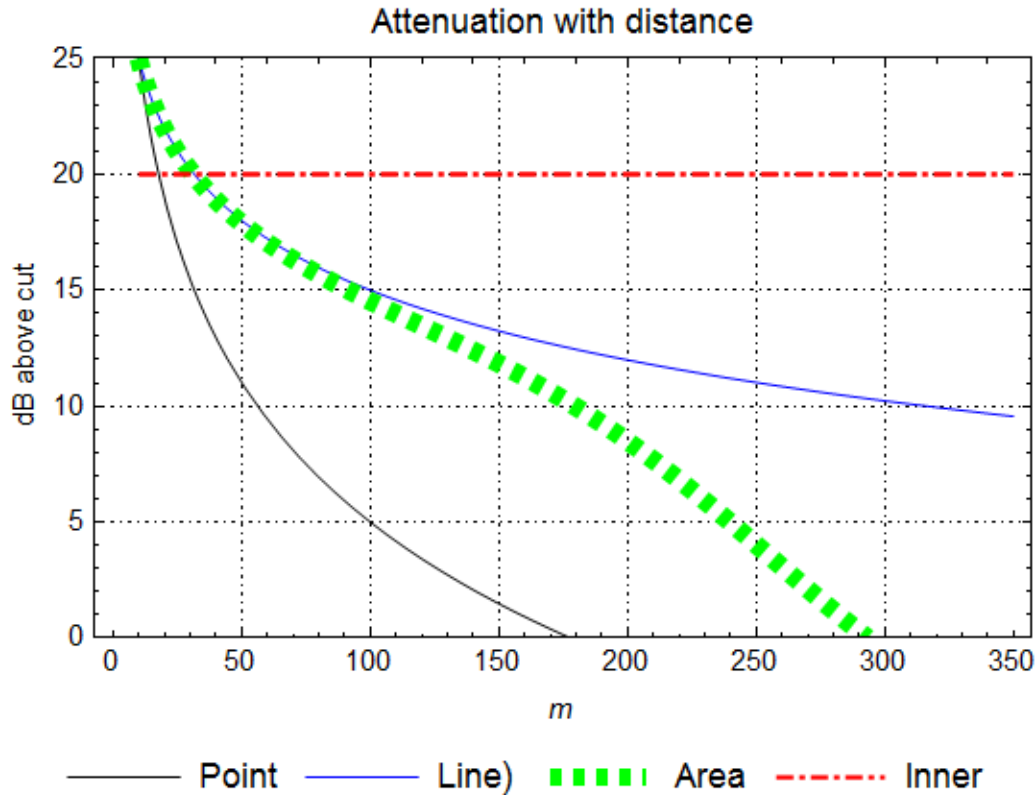
$$L_{den} = L_{emitted} - 20 \log_{10}(d / d_{ref}) \quad d_{ref} = 10m$$

$$L_{den} = L_{emitted} - 10 \log_{10}(d / d_{ref}) \quad d_{ref} = 10m$$



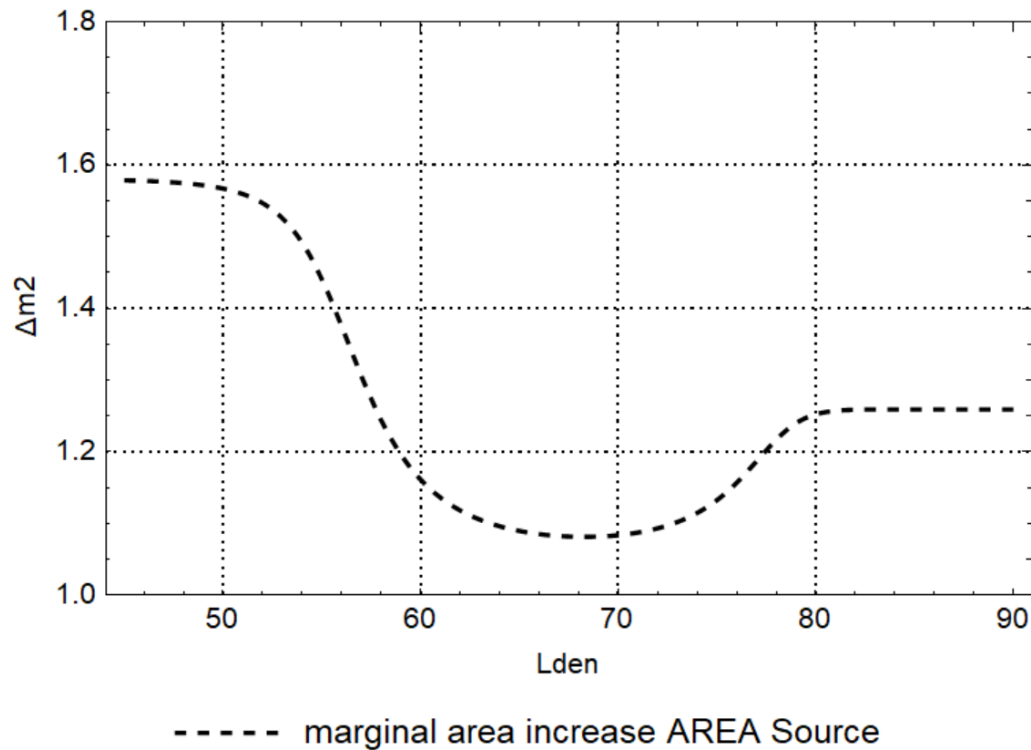
$$\text{Att}(d, tp) = 10 \log_{10} \left( \frac{1}{1 + e^{-\frac{5(d-tp)}{tp}}} \right) + 10$$

# Attenuation functions

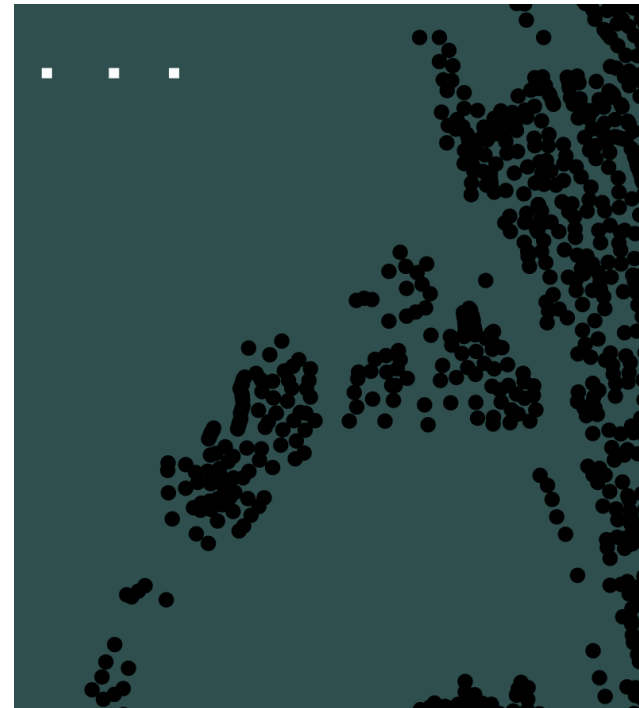
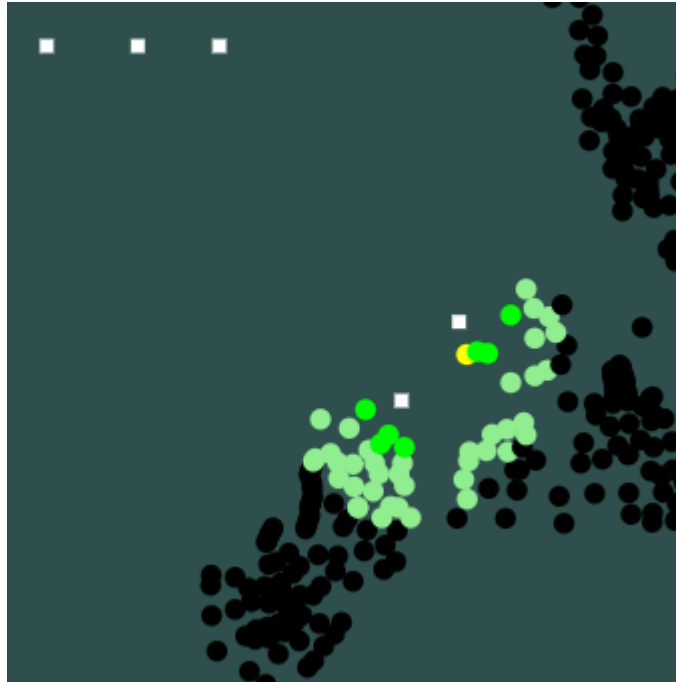


Attenuation with distance. Emitted noise 70dBA, cut off 45dBA.

# Marginal area affected per dBA increase



# Affected dwellings with and without Ormsund terminal using HSTOY





# Conclusions

- Marginal noise costs can be derived using noise planning software HSTOY to calculate base line exposure and change in exposure for each person affected.
- Marginal noise cost can be set to about 380 NOK / person year and dBA
- With a change in  $L_{den}$  of 0.02 dBA per extra container the cost is about 7.60 per person affected & year
- In the case of Sjursøya nobody lives within the influence area and the marginal cost is zero.
- HSTOY can be used to derive initial coarse estimates of the marginal cost from changed activity levels at one or more terminal areas