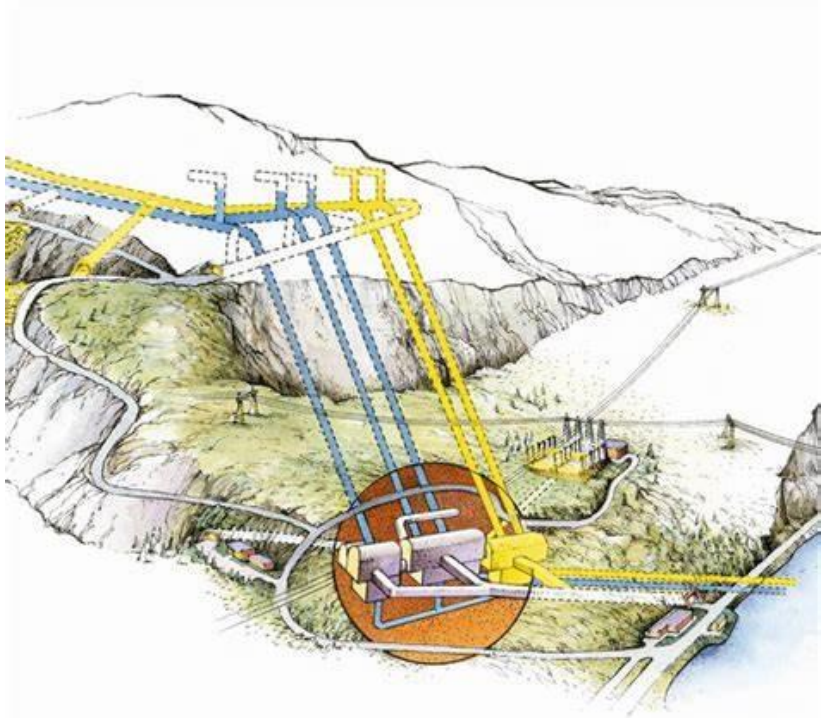
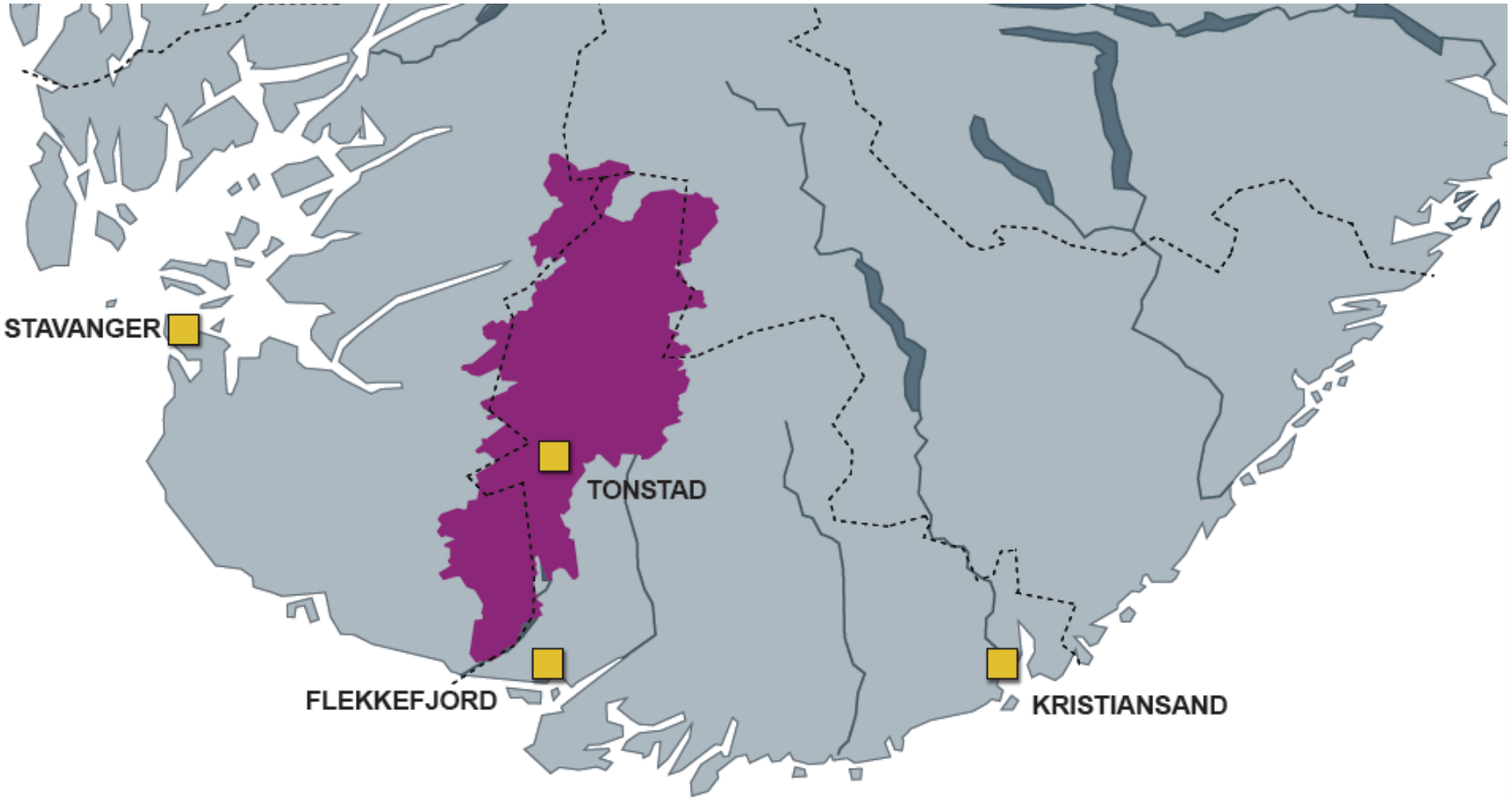
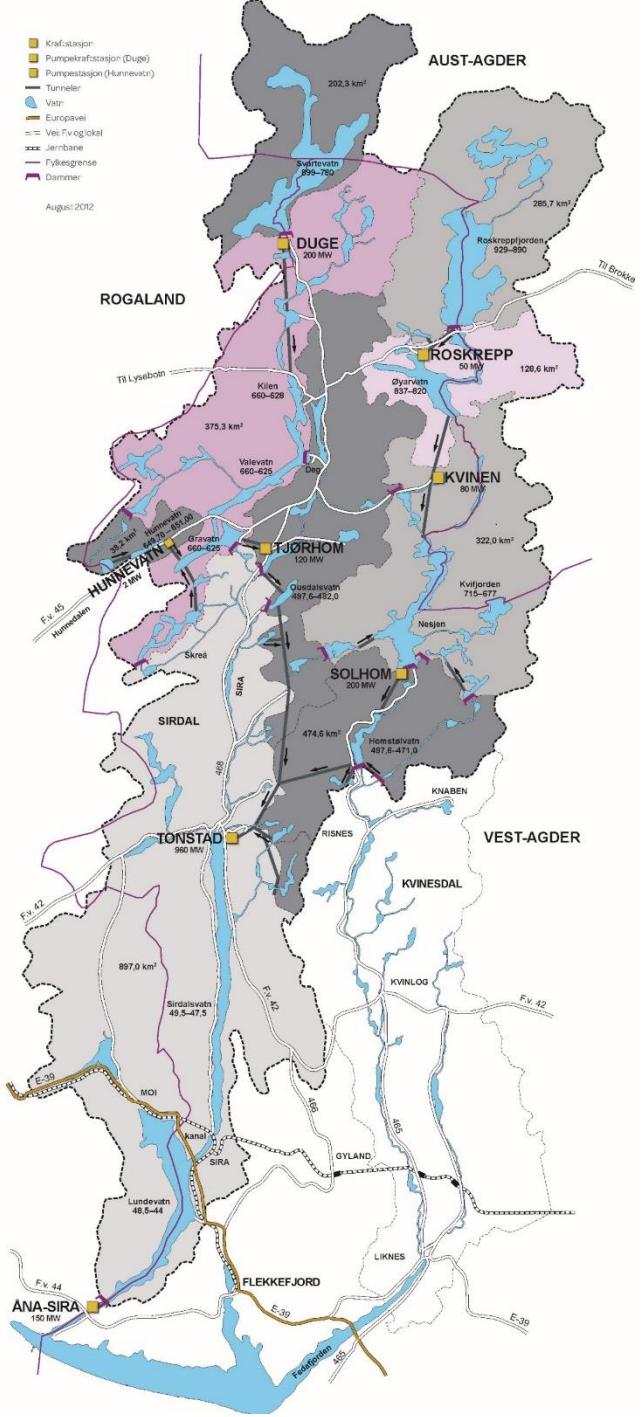
Investments in new pumping capacity in Sira-Kvina hydropower



Frøydis Kvinen & Raymond Tjørhom
Production planners/Sira-Kvina Hydropower
Per Aaslid
Research Scientist/SINTEF Energy Research

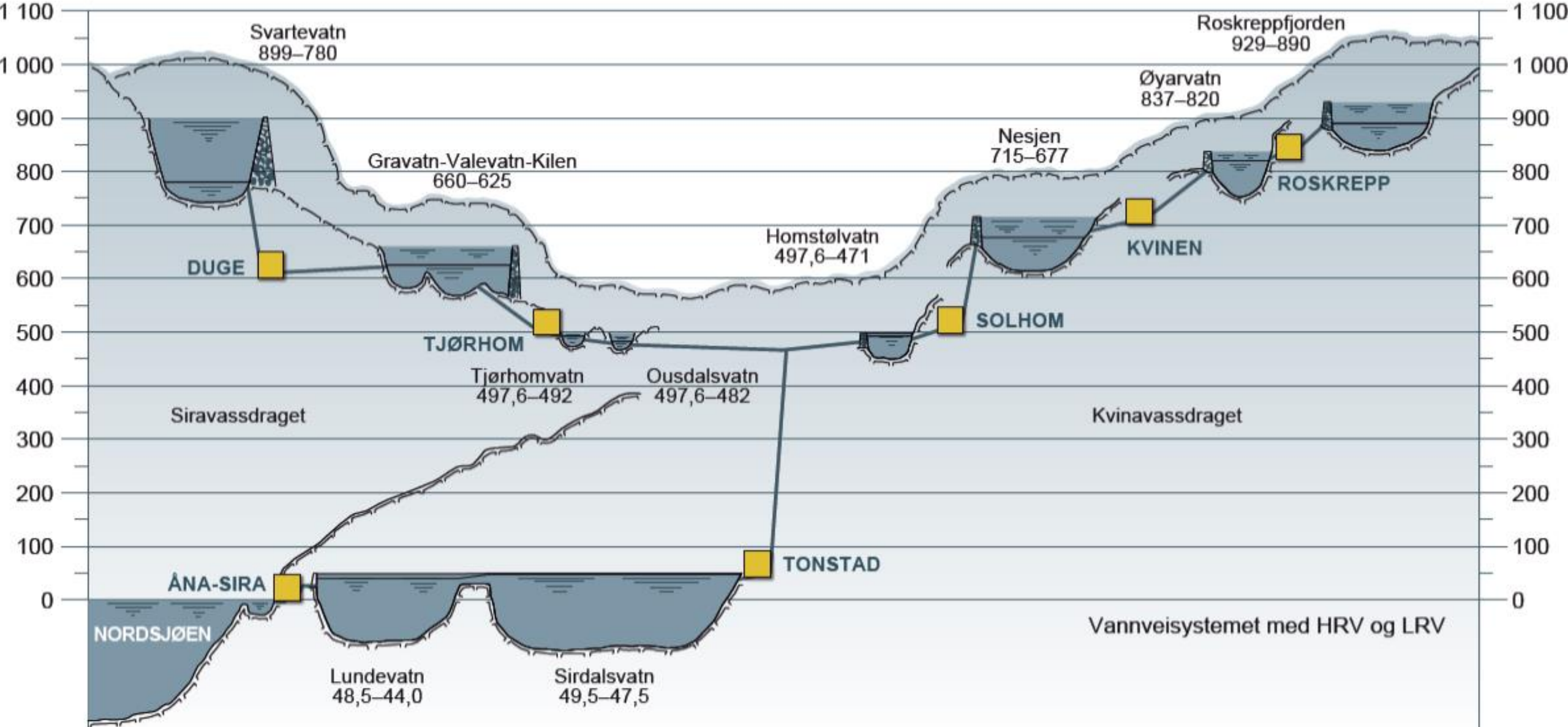
Sira-Kvina Hydropower





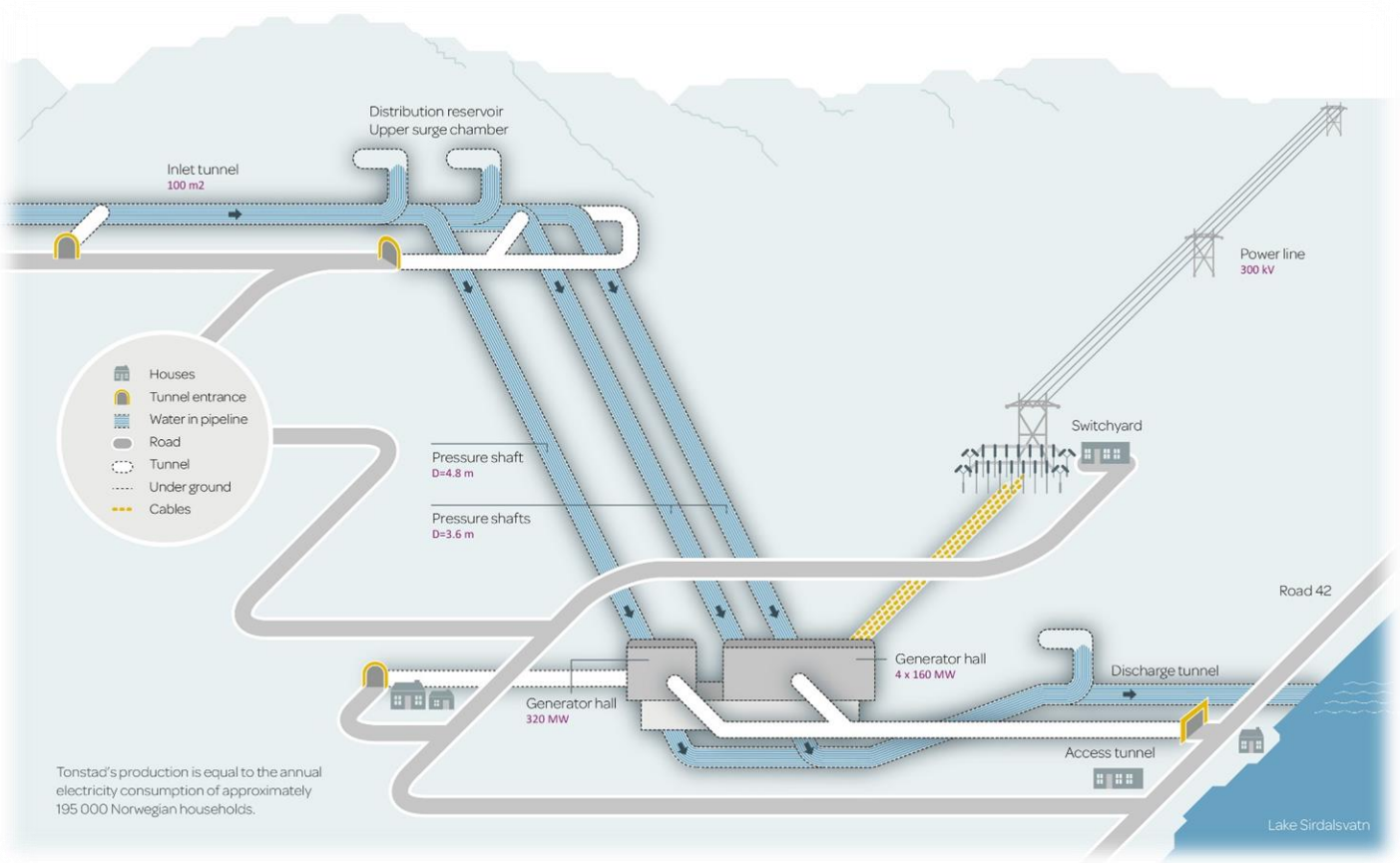
Sira·Kvina
HYDROPOWER

River and reservoir system



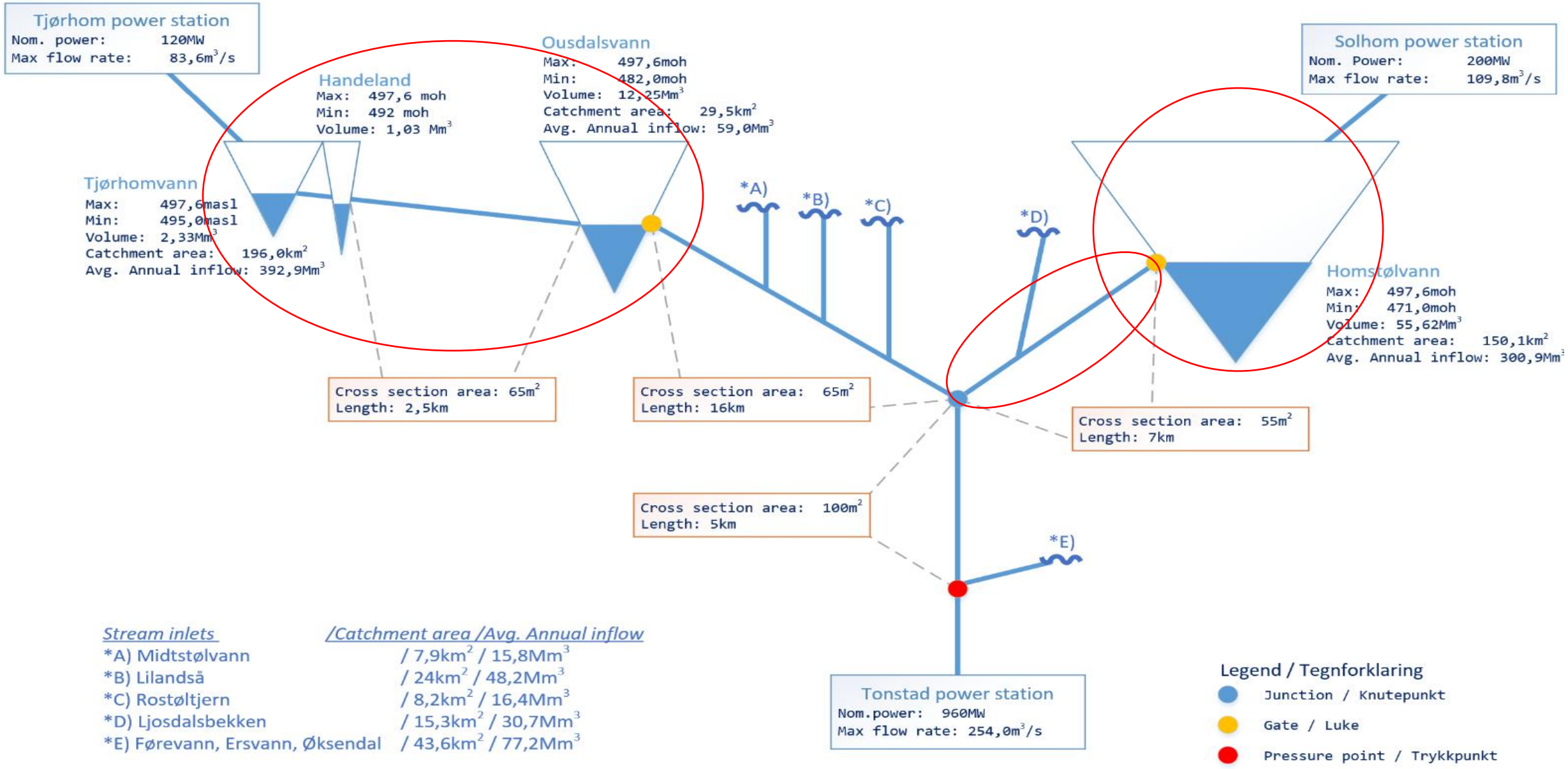
Tonstad power station

- Generation units
  - 1968 - 2 x 160 MW
  - 1971 - 2 x 160 MW
  - 1988 - 1 x 320 MW
- Average annual production:
  - 3888 GWh (1961-1990)
  - 4261 GWh (2005-2014)
- Elevation head:
  - 450 meter



Sira·Kvina HYDROPOWER

Physical challenges



Stream inlets	*/Catchment area /Avg. Annual inflow*
*A) Midtstølvann	/ 7,9km² / 15,8Mm³
*B) Lilandså	/ 24km² / 48,2Mm³
*C) Rostøltjern	/ 8,2km² / 16,4Mm³
*D) Ljosdalsbekken	/ 15,3km² / 30,7Mm³
*E) Førevann, Ersvann, Øksendal	/ 43,6km² / 77,2Mm³

Tools for investment analysis

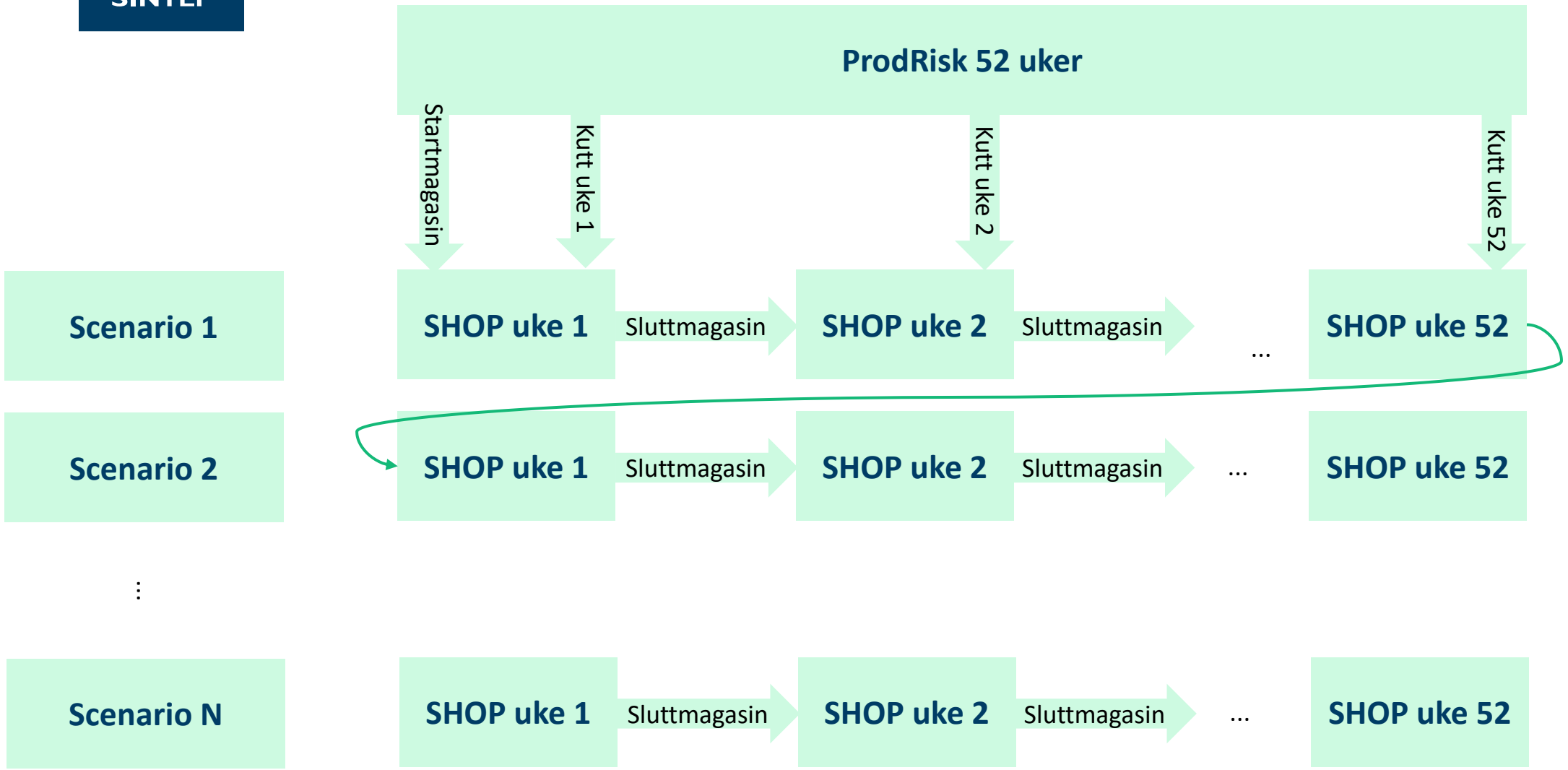
ProdRisk

- Long time horizon
- Stochastic
  - Multi-stage
  - Sophisticated statistical model of inflow and price correlations
- Aggregated plant description
- Limited representation of hydraulic couplings

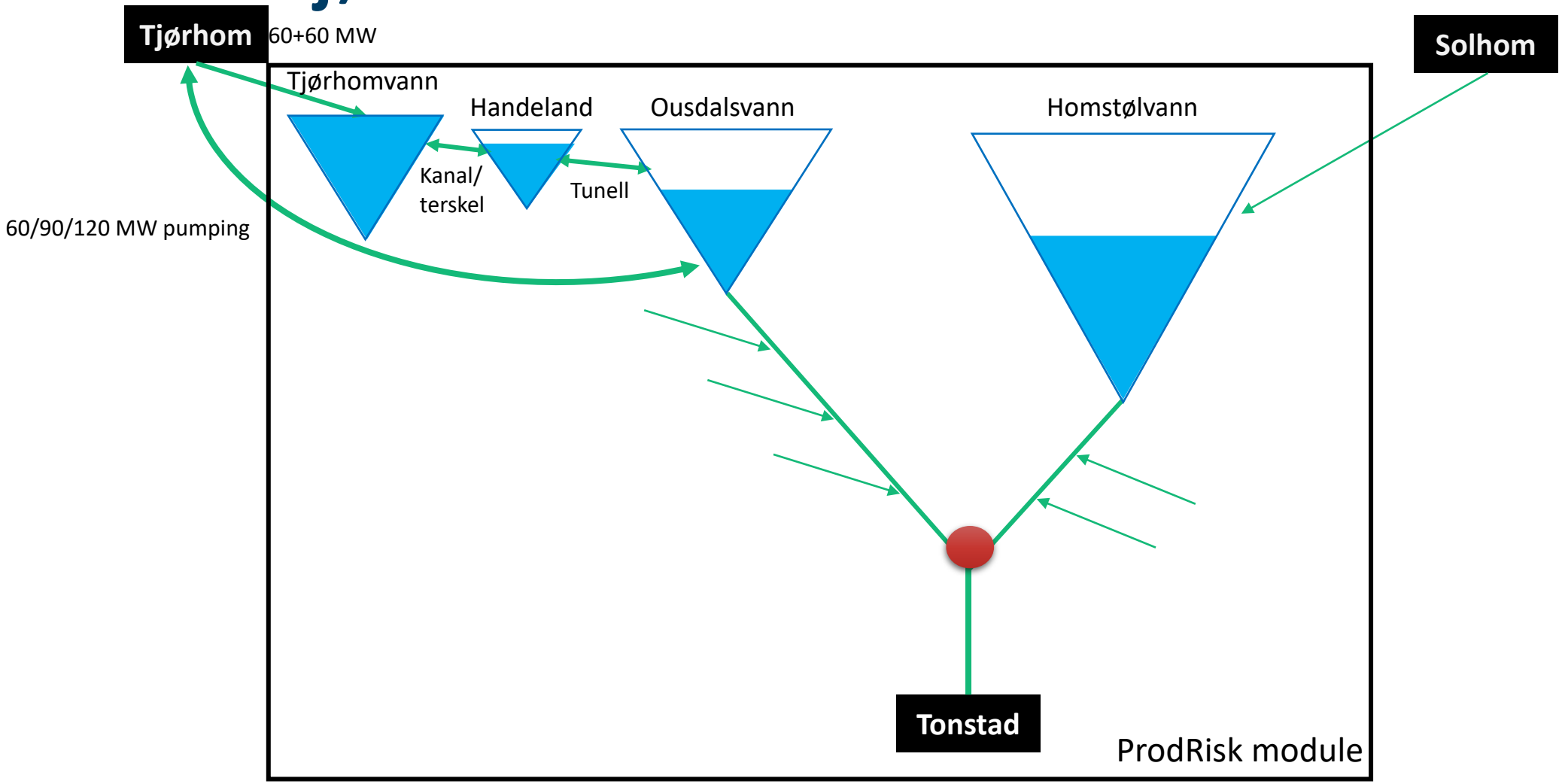
SHOP

- Short time horizon
- Deterministic
- Detailed plant model on unit level
- Detailed representation of tunnels and rivers

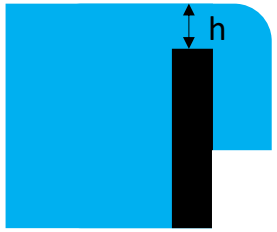
Simulator ProdRisk + SHOP



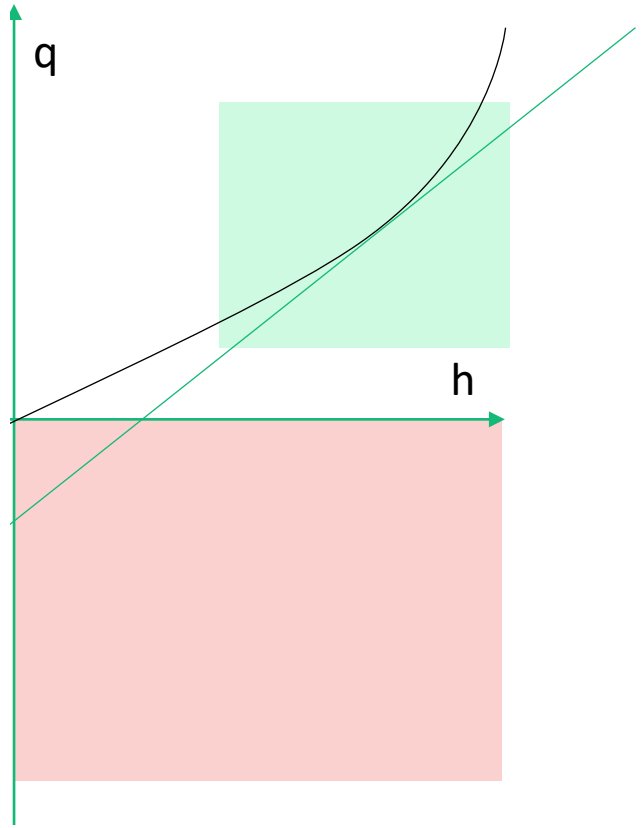
Tjørhom – Handeland - Ousdalsvann



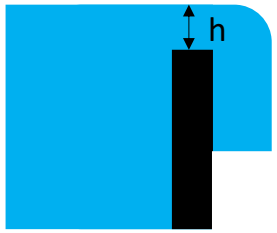
Weir flow



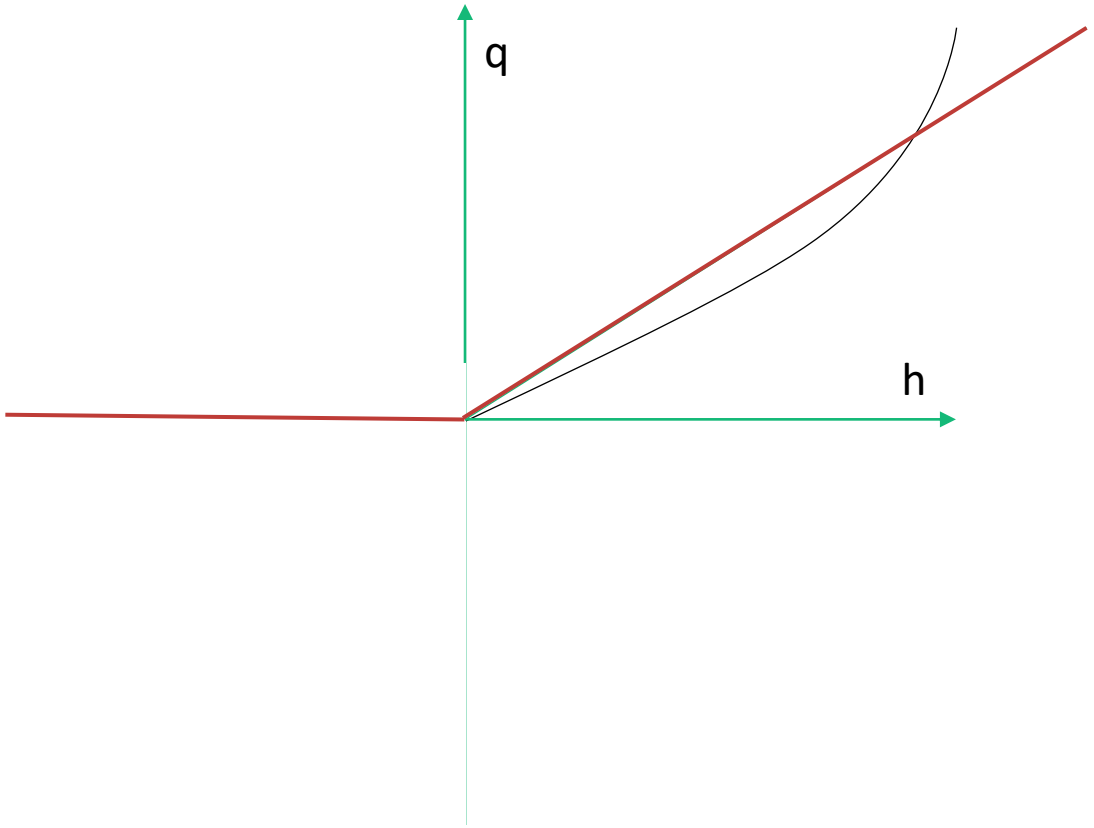
$$q = C_w \, L \, h^{1.5}$$



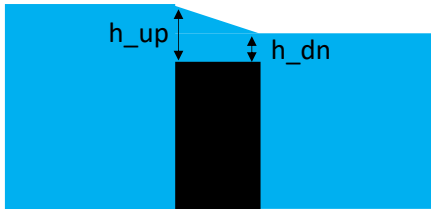
Weir flow



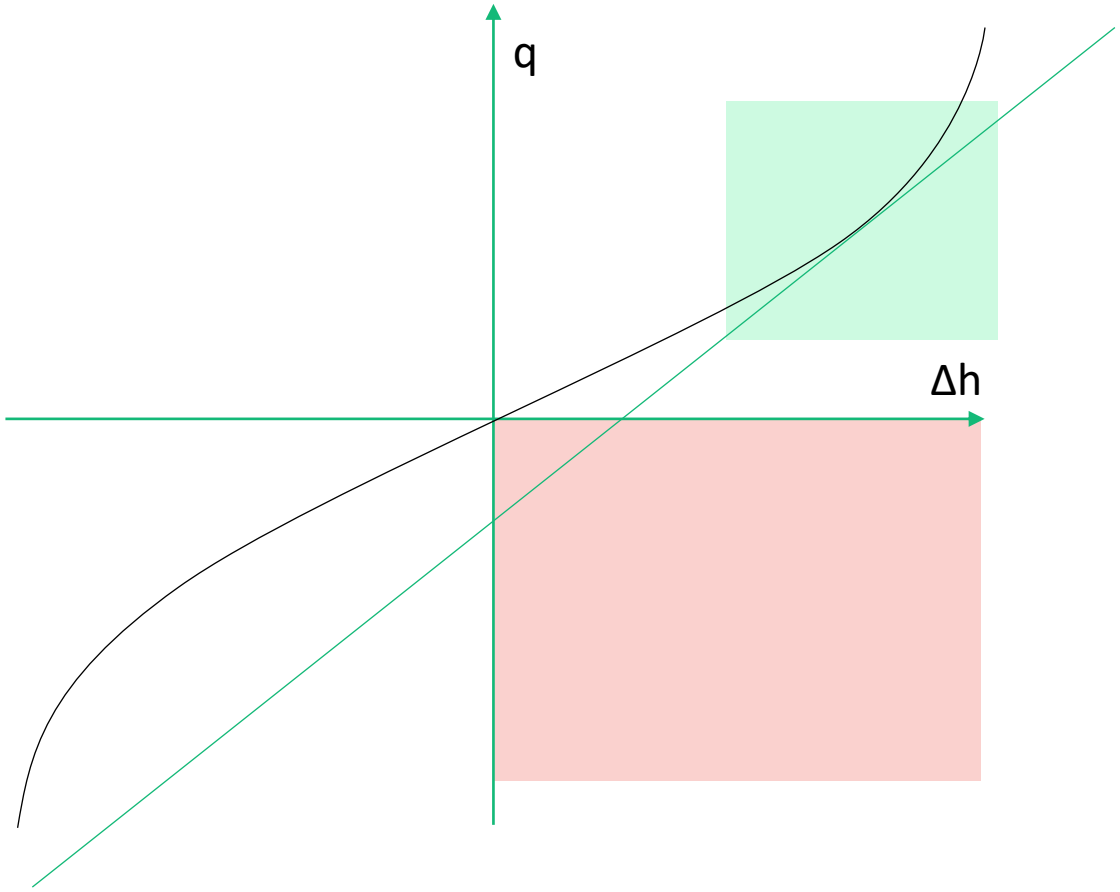
$$q = C_w \, L \, h^{1.5}$$

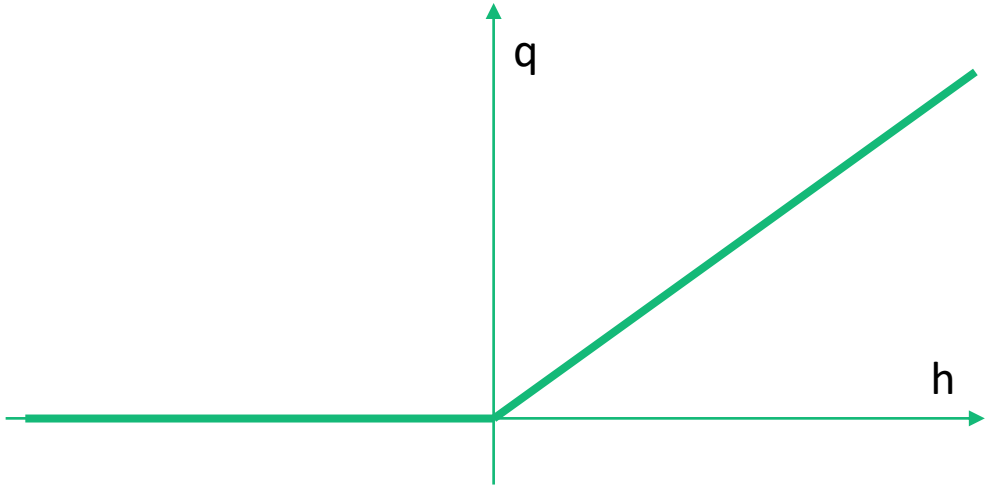


Submerged weir



$$q = C_w \, L \, h_{up}^{1.5} \left(1 - \left(\frac{h_{dn}}{h_{up}}\right)^{1.5}\right)^{0.385}$$




q
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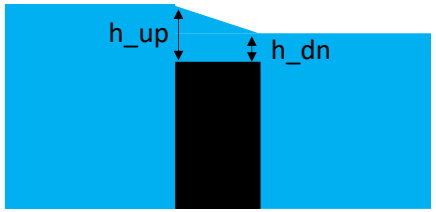
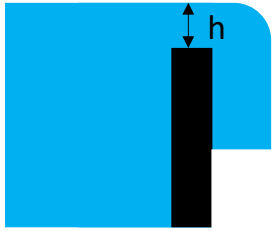

h_up
h_dn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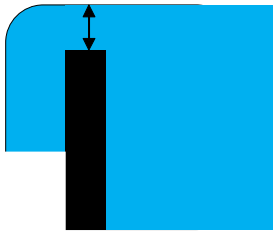

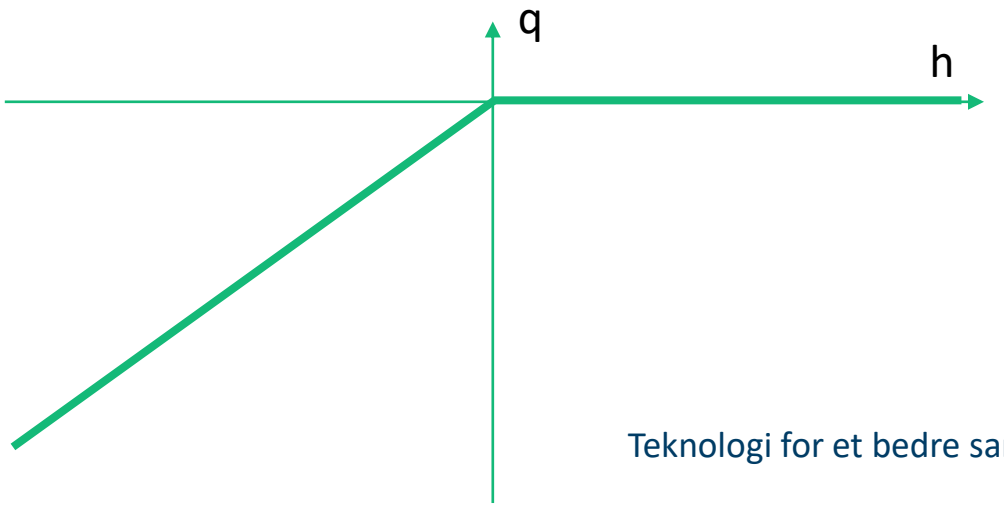
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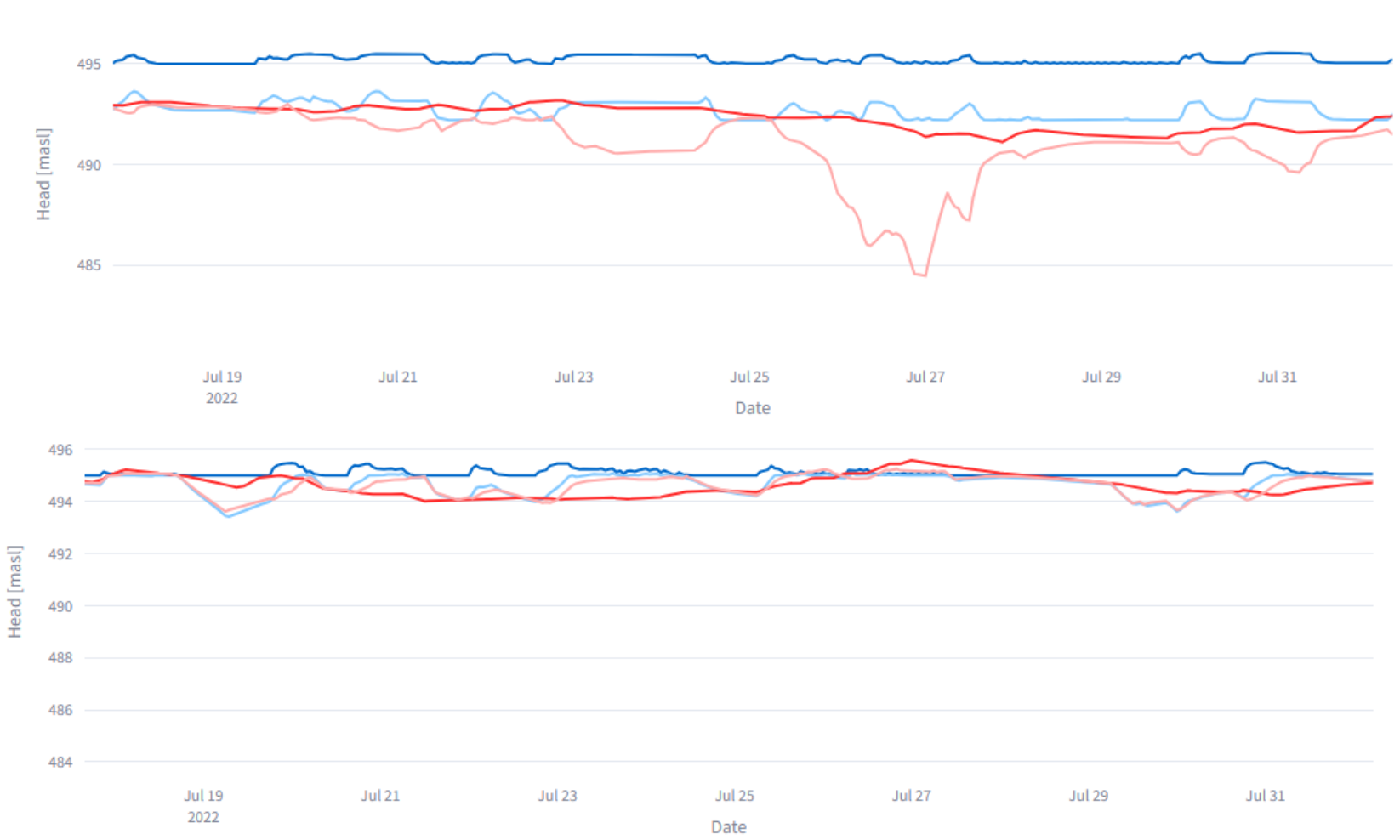
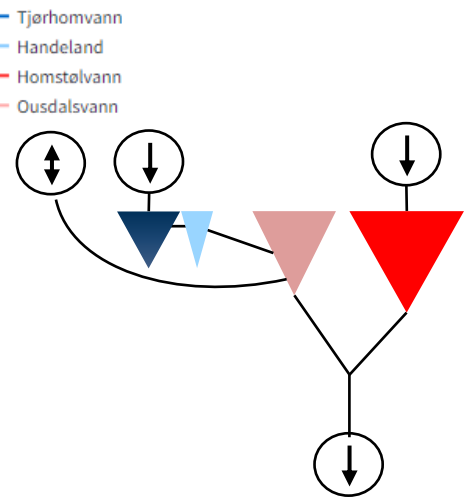
Reservoir levels before and after pump





Summary

- The Sira-Kvina watercourse has several operational limits due to small reservoirs and physical flow limitation.
- These limitations are important drivers for new investments in the watercourse.
- The combination of SHOP and ProdRisk enables us capture physical limitations in the watercourse more accurately in investment analysis.

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