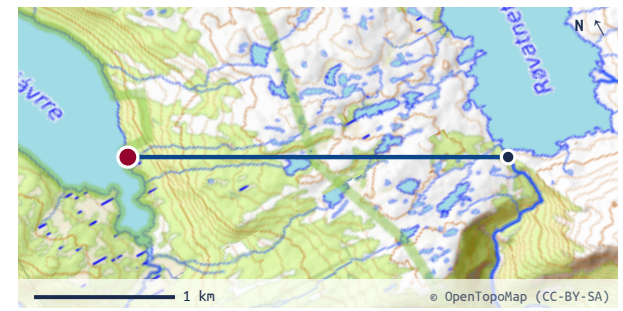
Røvatn

Run-of-river · · price zone **NO4** — full-year optimised dispatch, 1 Jan – 31 Dec 2025.

INSTALLED	MAX FLOW	RESERVOIR
4,3 MW	2,2 m³/s	0 h · 0,0 Mm³

WATERCOURSE & COMPONENTS · NARVIK



THE HEADLINE · 2025

Co-optimising Røvatn across **all balancing markets** lifted modelled revenue **+134 %** over day-ahead-only dispatch — almost entirely from reserve capacity, not extra energy.

+134 % REVENUE UPLIFT

€ 114 213 ADDITIONAL / YEAR

PERFORMANCE — ALL MARKETS (HYBRID)

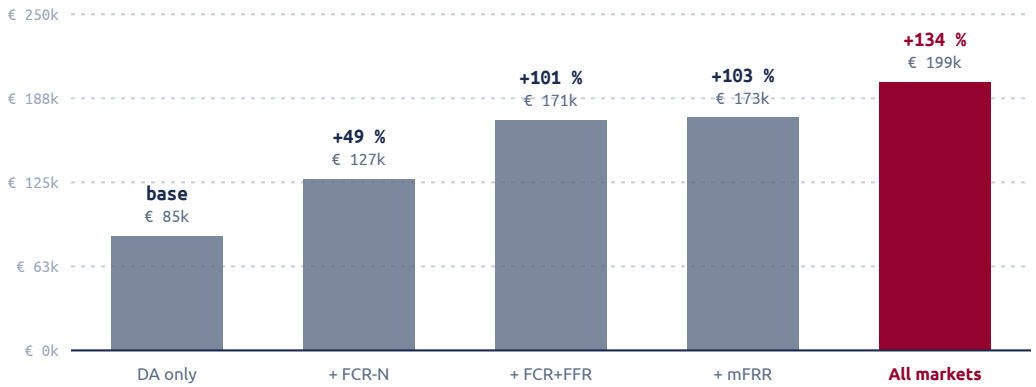
SELECT MARKET STRATEGY ↓

Day-ahead only	DA + FCR-N (standalone)	DA + FCR + FFR (hybrid)	DA + FCR-N + mFRR (standalone)	**All markets (hybrid)**

TOTAL REVENUE	ENERGY	CAPACITY FACTOR	CAPTURE RATE	RESERVOIR CYCLES	SPILL
€ 199 471	8 165	21,7 %	189 %	n/a	7,4
+134,0 % vs. DA only	MWh to grid	of 4,3 MW	24,4 €/MWh realised (all markets ÷ energy)	full equiv. / yr	Mm³ · 32,7 %

REVENUE BY STRATEGY

EUR · Δ vs day-ahead only



REVENUE BY MARKET

All markets (hybrid) · reserved MW · activated MWh/h

MARKET	AVG MW	ACT MWH	PEAK MW	REVENUE	SHARE
Day-ahead energy	–	0,93	4,3	€ 69 812	35%
FCR-N reserve	0,28	0,03	1,6	€ 62 783	31%
FCR-D up	0,04	0,00	1,7	€ 3 814	2%
mFRR up / down	0,63	0,00	4,3	€ 51 435	26%
FFR profile + flex	0,09	0,00	0,9	€ 11 628	6%
Total				**€ 199 471**	

THE MARKET STRATEGIES · what each scenario co-optimises

1 **Day-ahead only**
Spot-price optimised dispatch only — no reserves. The revenue baseline.

2 **DA + FCR-N (standalone)**
Adds FCR-N (symmetric frequency reserve). Autonomous droop setpoint, capped at 10 % of capacity.

3 **DA + FCR + FFR (hybrid)**
FCR-N + FCR-D up + fast frequency response (FFR). Assumes a small ESS hybrid for the sub-second products.

4 **DA + FCR-N + mFRR (standalone)**
FCR-N plus manual restoration reserve (mFRR up/down) — TSO-activated, needs an operations function.

5 **All markets (hybrid)**
Co-optimised across every balancing market (DA, FCR-N/D, mFRR, FFR) as a hybrid.

Day-ahead only	DA + FCR-N (standalone)	DA + FCR + FFR (hybrid)	DA + FCR-N + mFRR (standalone)	**All markets (hybrid)**

01 SCENARIO COMPARISON · uplift vs. day-ahead only

STRATEGY	REVENUE	REVENUE (BAR) · Δ VS DAY-AHEAD		ENERGY (MWH)	CAPTURE RATE	CAP. FACTOR	RESERVE UTIL.
Day-ahead only	€ 85 258		–	11 546	81 %	30,7 %	0 %
DA + FCR-N (standalone)	€ 127 244		+49,2 %	9 087	121 %	24,1 %	7 %
DA + FCR + FFR (hybrid)	€ 171 112		+100,7 %	6 846	162 %	18,2 %	14 %
DA + FCR-N + mFRR (standalone)	€ 173 239		+103,2 %	9 424	164 %	25,0 %	26 %
All markets (hybrid)	€ 199 471		+134,0 %	8 165	189 %	21,7 %	24 %

02 WATER BALANCE & CAPTURE · All markets (hybrid)

TOTAL INFLOW
22,7
Mm³ · Sildre (Rauvatn) × 0.43 — scaled so capped-turbinable energy matches the NVE concession estimate (12 GWh; beta)

TURBINED
15,3
Mm³ through turbine

SPILL (LOST)
7,4
Mm³ · 32,7 % of inflow

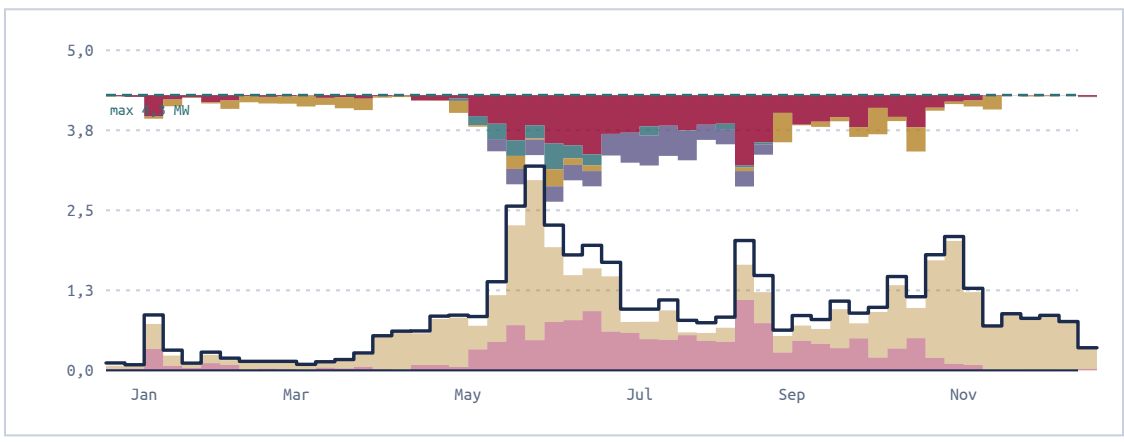
AVG RESERVOIR
n/a
% of usable volume

CAPTURE RATE
189 %
revenue ÷ (inflow energy × 8,7 €/MWh)

03 HOW THE PLANT WAS DISPATCHED · optimised dispatch for the selected strategy

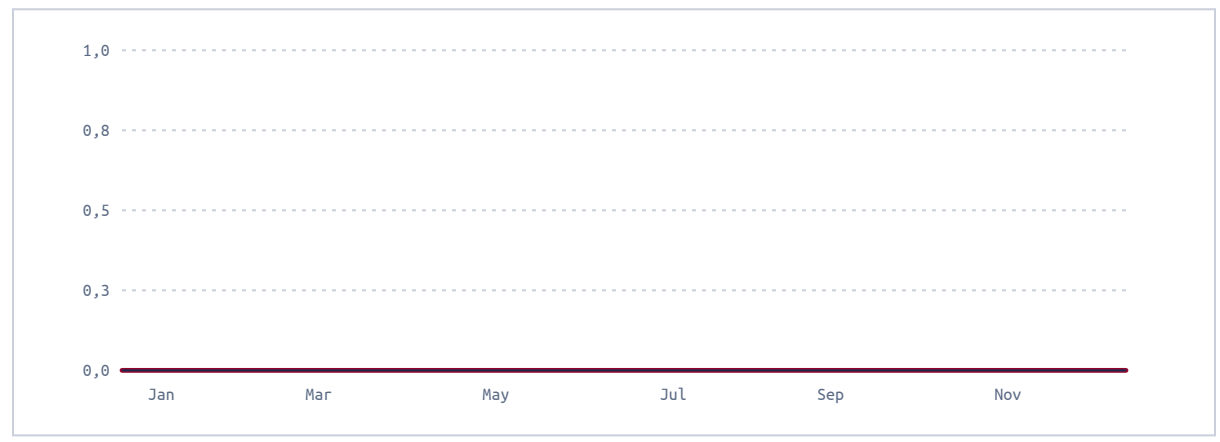
RESERVE CAPACITY HELD

All markets (hybrid) · up from top, down from bottom



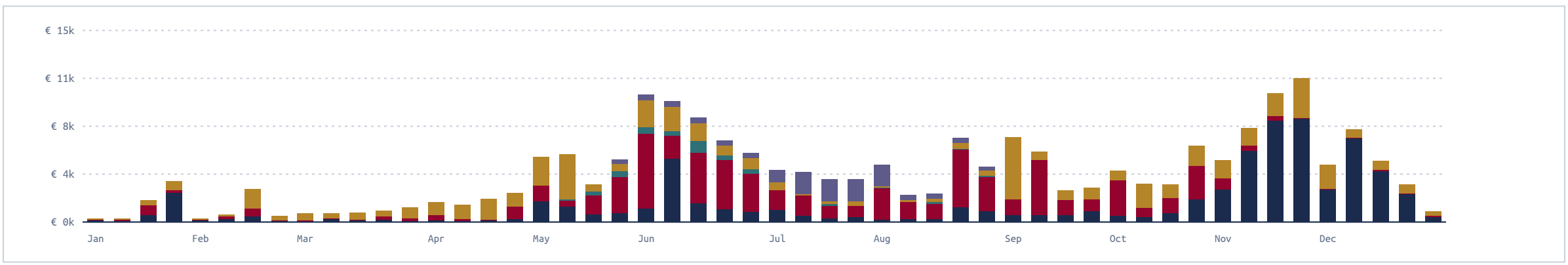
RESERVOIR TRAJECTORY

weekly · Mm³ · all strategies, selected highlighted



WEEKLY REVENUE BY MARKET

All markets (hybrid) · 52 equal periods

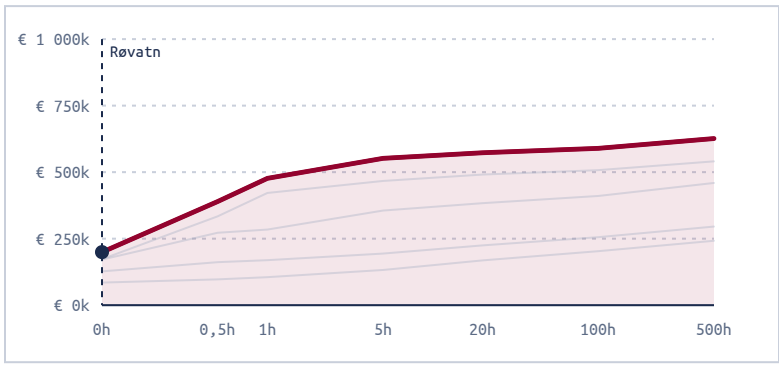


Day-ahead only	DA + FCR-N (standalone)	DA + FCR + FFR (hybrid)	DA + FCR-N + mFRR (standalone)	**All markets (hybrid)**

01 WHERE THE MARGINAL VALUE IS

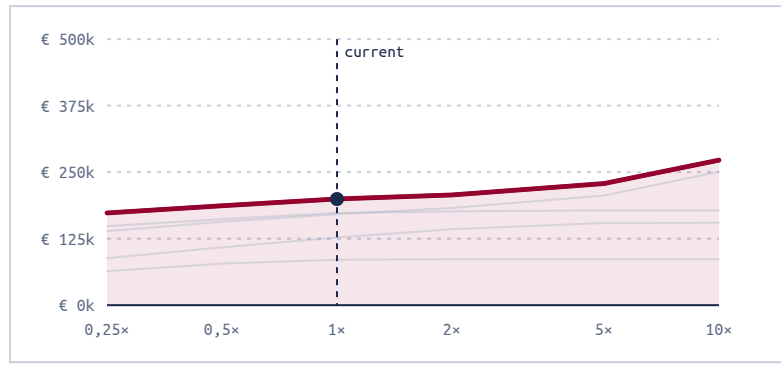
Sensitivity of optimised revenue to the plant's physical envelope, under each market strategy. The **highlighted line is the selected strategy**; the dashed marker is Røvatn's current operating point.

STORAGE DISCHARGE DURATION



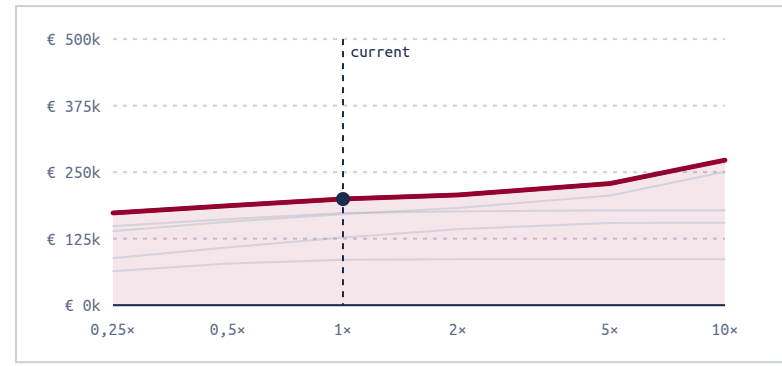
Annual revenue vs. usable storage hours (log). Marker = as-built.

TURBINE CAPACITY



Annual revenue vs. turbine flow capacity (× as-built, log). Marker = as-built.

PLANT SCALE



Revenue vs. scaling turbine + reservoir together (× as-built, fixed inflow). Saturates when the plant outgrows its water.

All markets (selected) · Other strategies · Røvatn as-built

MARGINAL VALUES & BINDING CONSTRAINTS

as-built · All markets (hybrid)

Marginal water value	17,1 €/MWh	Extra revenue from one more MWh of stored water
Turbine capacity (+1 MW)	1 800 €/yr	Extra annual revenue from a turbine uprate at current scale
Storage (+1 MWh)	110 420 €/yr	Extra annual revenue from more usable storage (≈0 when over-provisioned)
Reserve-cap headroom (+1 MW)	2,8 €/MW·h	Extra €/MW·h from relaxing the binding reserve reservation cap
Day-ahead spot (reference)	8,7 €/MWh	Avg. zone NO4 day-ahead price
Reservoir upper bound	binds 100 %	Share of hours at the cap — spill risk in the melt

READING MARGINAL (SHADOW) PRICES

A marginal (shadow) price is the extra revenue the optimiser would earn from **one more unit** of a scarce resource — an MWh of stored water, +1 MW of turbine, +1 MWh of storage, or +1 MW of reserve-cap headroom — holding everything else fixed.

A value near **zero** means that limit isn't binding: loosening it wouldn't help, so don't invest there. A **large** value flags the binding bottleneck — where a relaxed limit or an upgrade would pay back, and roughly how much it is worth per year. They answer: *what is holding this plant back, and what is it worth to change it?* (Values are for the selected strategy at the as-built size.)

RECOMMENDATIONS

1 2025: +134 % — the reserve hedge in action

Day-ahead alone earned €85 000 at NO4's 8,6 €/MWh; full participation €200 000/yr. FCR-N standalone added €42 000 (+49 %) autonomously — commissioning with prequalification in hand converts a marginal spot year into a solid one. Perfect-foresight upper bounds; reconcile the 12,0 vs 10,1 GWh production basis with NVE.

2 mFRR and hybrid effectively tied again (€173 000 vs €171 000)

mFRR alone was €64 000/yr. Two years of evidence say the fork is a pure cost-structure decision for Ballangen Energi; the revenue will not separate the options. FCR-N standalone remains the unconditional first step.

3 Capture price hit 100 % of spot — the water story is now about reserves

At 2025 prices the plant's dispatch timing is no longer the issue (capture 8,6 vs spot 8,6 €/MWh); what caps revenue is reserve headroom. The sweep prices 0,5 h of buffering at €389 000/yr versus €200 000 as-built — same magnitude as 2024 — and spill at full reserves is 33 % of inflow. If the intake design still has any flexibility, this is where it pays.

Generated with AI assistance · subject to expert review before use.

SIMULATION SETUP & ASSUMPTIONS

MODEL

Method	MILP co-opt.
Solver	CBC
Segments	5
Boundary	cycling res.

HORIZON

Period	2025 full-year
Resolution	60 min MTU
Hours	8 760
Storage bounds	concession

HYDROLOGY

Inflow source	Sildre (Rauvatn) × 0.43 — scaled so capped-turbinable energy matches the NVE concession estimate (12 GWh; beta)
Station	Rauvatn
Total inflow	22,7 Mm³
Usable res.	0,0 Mm³ · 0 h

CAPS

FCR-N	10% / 40% hyb.
FCR-D	40%
FFR	10%
mFRR	100%

MARKETS & PRICES

Strategies	DA · FCR-N/D mFRR · FFR
Price zone	NO4
Avg spot	8,7 €/MWh