

NW-5 Cargo Vessel Economic Analysis

2000 T Inland Cargo Barge

Diesel vs Battery Swap (LFP + Solar) — 28-Year Comparison

Long-term cargo contract · 100% utilisation · 320 km route

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Executive Summary

Battery Swap wins on every financial metric: 61% lower TCO, 31% higher NPV, 2-year payback

TCO (PV, Cr INR)	NPV (Cr INR)	Break-even Year	TCO Gap (PV)
Diesel ₹259 Cr	Diesel ₹338 Cr	Diesel Year 2	Diesel Swap saves
Swap ₹101 Cr	Swap ₹497 Cr	Swap Year 2	Swap ₹159 Cr
₹159 Cr lower	₹159 Cr higher	Swap on 63% more capital	Same at every cargo rate

Key Takeaways

- Battery Swap TCO is 61% lower in PV terms (₹101 Cr vs ₹259 Cr)
- NPV ₹159 Cr higher — ₹497 Cr vs ₹338 Cr over 28 years (full P&L basis at ₹2/t-km)
- Both options recover capital in 2 years; Battery Swap creates ₹159 Cr more absolute value
- TCO saving of ₹159 Cr is independent of cargo rate — it holds at every rate tested

Operating Profile & Voyage Logistics

Route, vessel, and the battery swap mechanic that enables the savings

Parameter	Value
Vessel size (LxBxDxT)	85x12x3.5x2.5 m
Displacement (t)	2,650
Cargo capacity (t)	2,000
Max / Cruise speed (kn)	8 / 7
Voyage distance (km)	320
Trips per one-way voyage	4
Operating days / year	350
Voyages per year	175
Total cargo per year (t)	3,50,000

Swap Mechanic	Value
Fleet size (barges)	6
Battery packs	9
Pack : barge ratio	1.5 : 1
Swap time (min)	30
End-of-voyage charge (hrs)	~21.7
Battery DoD (LFP)	80%
Solar plant (kW)	20

A — B — C — D — E
0 80 160 240 320 km
Swap at B, C, D | Cargo load/discharge at A & E

Battery Pack Rotation Schedule

9 packs keep 6 barges in continuous operation — 1.5:1 ratio is the minimum that works

Fleet Size

6 Barges

Battery Packs

9 Packs

Pack Ratio

1.5 : 1

Swap Stops

3 / Voyage

Pack	Cycles / 94-hr window	Cycles / Year	Yrs to 3,500	Replacement Yr
B1, B2, B3 (most used)	6	535	6.5	Year 7
B4–B9 (reserve)	5	445	7.9	Year 8
Fleet Total	48	4,275	—	—

- Packs charge strictly sequentially — never more than 1 pack charging at any station simultaneously; the 30-min swap is the exact scheduling buffer between consecutive charge cycles
- Each pack needs ~465 kW over 4 hrs (0.21C — within LFP safe range); one ~500 kW charger per station is sufficient for the entire fleet
- Shore infrastructure: ~₹1.5–2.5 Cr per station installed; ₹6–10 Cr for all 4 stations on the route — charger reliability is a critical operational dependency

Two Configurations Compared — Same Vessel, Two Power Trains

Diesel

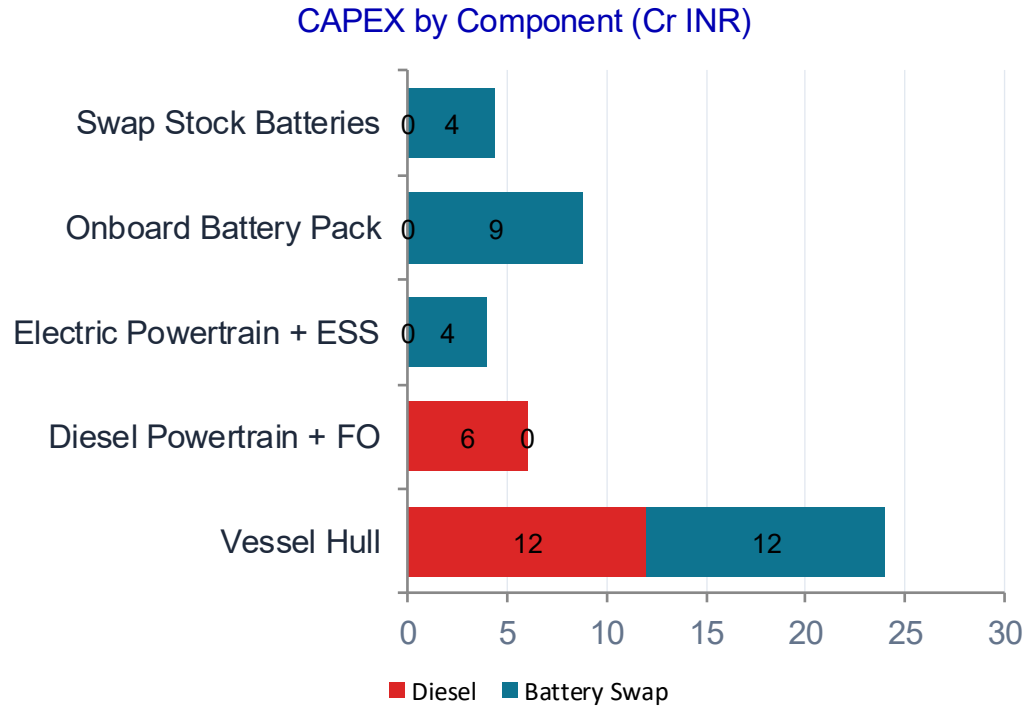
Power at max speed	715 kW
Power at cruise speed	550 kW
Power train	2× diesel engines + GB + FO system
Energy source	Diesel @ ₹100/L
Battery DoD	—
Battery replacement	—
Fuel consumption/yr	7,67,025 litres
Energy cost (Year 1)	₹7.67 Cr
Crew	3 crew × 2 sets

Battery Swap (LFP + Solar)

650 kW
500 kW
2× motors + GB + ESS + battery packs
Grid + 20 kW Solar @ ₹7/kWh
80% LFP chemistry
Every 7 years (₹15K/kWh)
—
₹1.61 Cr
3 crew × 2 sets

CAPEX Breakdown

Battery Swap carries 63% higher upfront CAPEX — ₹11.3 Cr premium, recovered in 2 years



Diesel CAPEX

₹18 Cr

Hull ₹12 + Powertrain + FO ₹6

Battery Swap CAPEX

₹29.3 Cr

Hull ₹12 + Motor ₹4 + ESS ₹8.86 + Swap ₹4.43

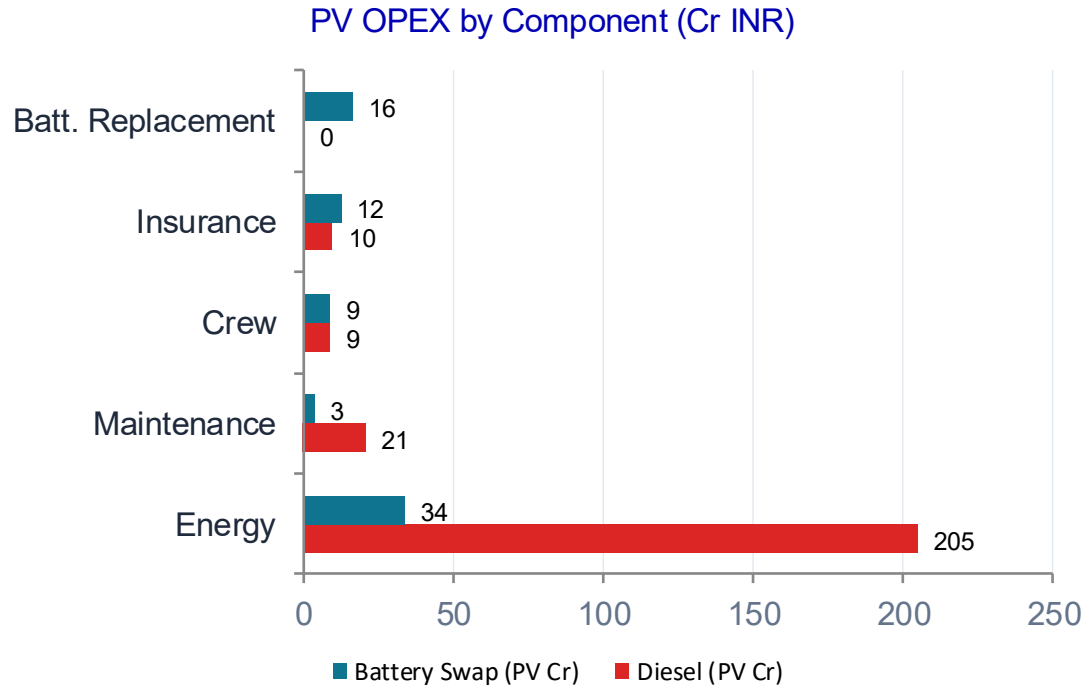
CAPEX Premium

₹11.3 Cr

Recovered through OPEX savings within 2 years

OPEX Breakdown — Present Value, 28 Years

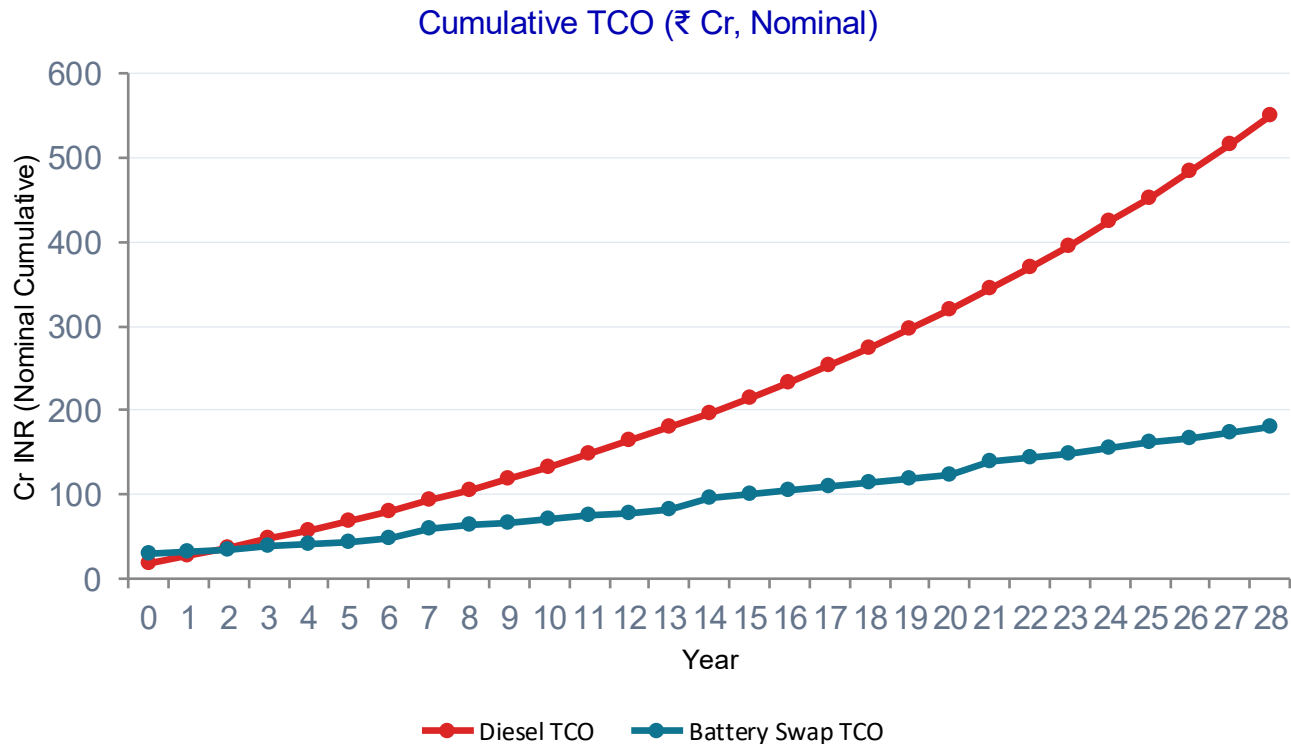
Energy cost alone saves ₹172 Cr in present value — the single dominant driver of the ₹159 Cr TCO advantage



Component	Diesel	Swap	Savings
Energy	₹205.2 Cr	₹33.7 Cr	₹171.6 Cr ✓
Maintenance	₹20.5 Cr	₹3.4 Cr	₹17.1 Cr ✓
Crew	₹8.8 Cr	₹8.8 Cr	—
Insurance	₹9.6 Cr	₹12.2 Cr	-₹2.6 Cr
Battery repl.	—	₹16.2 Cr	-₹16.2 Cr
Net TCO (PV)	₹259 Cr	₹101 Cr	₹159 Cr ✓

Cumulative TCO Trajectory — 28 Years

Battery Swap TCO crosses below Diesel in Year 3 — and the gap widens every year thereafter



Diesel TCO at Yr 28

₹551 Cr

nominal cumulative

Swap TCO at Yr 28

₹180 Cr

nominal cumulative

Year 28 Savings

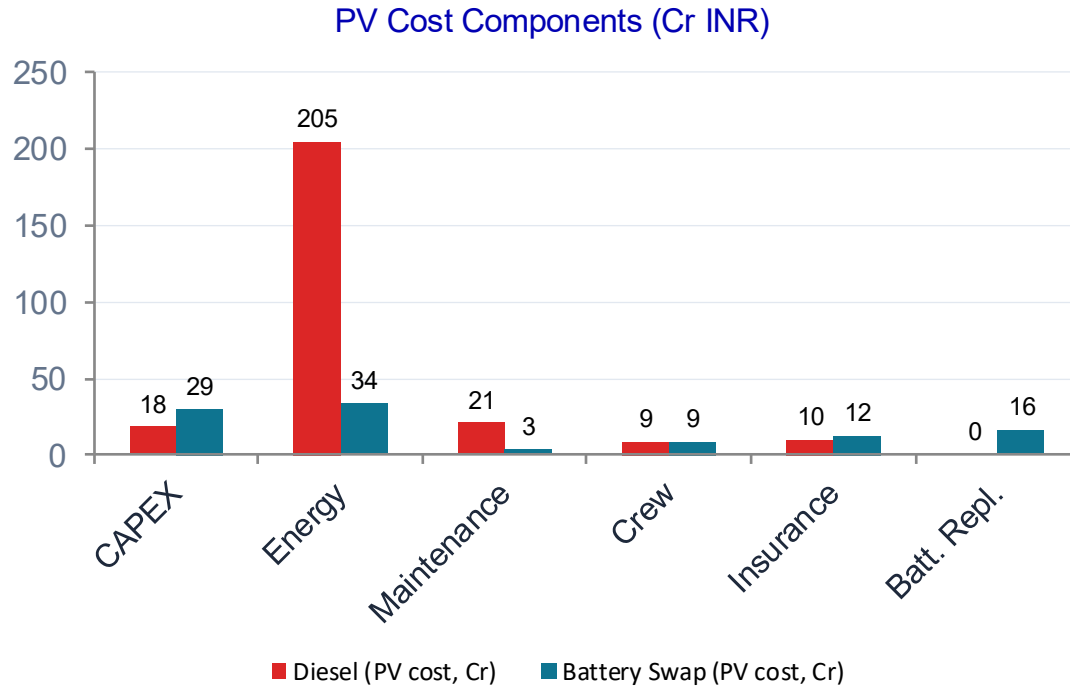
₹371 Cr

67% lower

Step-jumps at Yrs 7, 14, 21 = battery replacement events

NPV & Returns Analysis

Battery Swap NPV is ₹159 Cr higher — on identical revenue and same 2-year payback



NPV — Diesel

₹338 Cr

NPV — Battery Swap

₹497 Cr

TCO — Diesel (PV)

₹259 Cr

TCO — Battery Swap (PV)

₹101 Cr

Simple Payback (both)

2 Years

NPV Advantage (Swap)

₹159 Cr

Sensitivity Analysis

Battery Swap NPV positive across ALL scenarios; Diesel NPV exposed to fuel-price risk

Diesel NPV (Cr INR) — diesel price × discount rate

₹/L ↓ / Rate →	5%	7%	9%	11%	13%
₹80/L	376	285	222	176	143
₹100/L (base)	335	254	197	156	126
₹120/L	294	222	172	136	110
₹140/L	253	191	147	116	93

Battery Swap NPV (Cr INR) — discount rate only (unaffected by diesel price)

Discount Rate	5%	7%	9%	11%	13%
Battery Swap NPV	497	374	288	227	183 ✓

Cargo Rate Sensitivity — NPV gap = ₹158 Cr at every cargo rate

Rate (₹/t-km)	Diesel NPV	Swap NPV
₹1.06 (IWT)	58	216 ✓
₹1.41 (Rail)	163	321 ✓
₹1.75 (IWT+margin)	264	422 ✓
₹2.00 (Base)	339	497 ✓
₹2.25 (Stretch)	414	572 ✓
₹2.58 (Road)	512	670 ✓
₹3.00 (Premium)	638	796 ✓

Swap viable at all tested rates; NPV gap holds at ₹158 Cr across every cargo rate
 At IWT benchmark (₹1.06): Diesel NPV ₹58 Cr vs Swap ₹216 Cr — ₹158 Cr advantage holds

Decarbonisation & Public Value

2,025 t CO₂/year avoided — and the advantage grows as India's grid decarbonises

Annual CO₂ avoided

2,025 t

vs diesel baseline

Lifetime diesel saved

21.5 M ltrs

over 28 years

Import substitution value

₹215 Cr

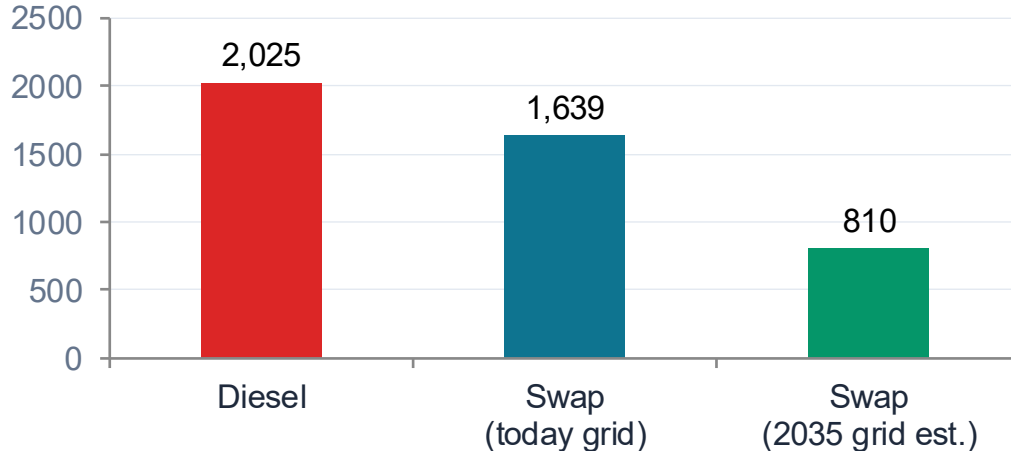
flat ₹100/L × 21.5M ltrs

CO₂ saved over 20 years

40,499 t

cumulative

Annual CO₂ Emissions (tonnes/vessel)



Policy Externalities

- ₹215 Cr/vessel in diesel import substitution over 28 years (flat ₹100/L × 21.5M litres; ~₹448 Cr with 5%/yr escalation)
- Redirects spend from imports to domestic battery, motor & solar manufacturing (PLI aligned)
- Eliminates PM2.5, NOx, SOx — air quality co-benefits along populated waterways
- At 2035 grid mix (0.35 kg/kWh), lifetime emissions drop ~60% vs diesel baseline
- Social cost of carbon ₹4,200/t → ₹4.5–14 Cr unmonetised public value per vessel

Policy Recommendations

Five targeted interventions to accelerate deployment — ranked by leverage

01 Build Swap & Charge Infrastructure

Fund swap stations at NW-1 (Ganga), NW-2 (Brahmaputra) & NW-3 (West Coast Canal). ~₹1.5–2.5 Cr per station installed; ₹6–10 Cr per 4-station route. One ~500 kW charger per station is sufficient.

02 Viability-Gap Funding for CAPEX Premium

Cover 30–40% of the ₹11.3 Cr premium for first 20–50 deployments to build operational evidence base.

03 Standardise Battery Pack Form Factors

BIS + IWA mandate on pack voltage, comms, mechanical interface — enables inter-operator swap interoperability.

04 Co-locate Solar at Charging Stations

200–500 kW solar at each major swap terminal — offsets grid demand, lowers carbon intensity.

05 Include IWT in PLI-Eligible Sectors

Designate inland battery-electric shipping under PLI for Advanced Chemistry Cells & associated manufacturing.

Battery Swap is the Financially Superior Choice

on a 28-Year Horizon — and a Stronger National Policy Bet

TCO (PV)	₹259 Cr → ₹101 Cr	61% lower	NPV (PV)	₹338 Cr → ₹497 Cr	₹159 Cr higher
TCO saving	₹159 Cr	Same at every cargo rate	Payback	2 years (both)	Same recovery
CO ₂ avoided	2,025 t/year	Grows as grid cleans	Import sub.	₹215 Cr avoided	Flat ₹100/L × 21.5M ltrs