



TECHNICAL SESSION 5 · DAY 2

Technical and Operating Assumptions Underpinning the Financial Model

Capacity · plant life · land · CUF & availability · gross-to-net losses · resource variability · generation & sales

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Energy Policy · Tariff · Private Investment · Climate Finance & Carbon Markets

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SAARC Training Workshop on Financial Modeling for Renewable Energy Projects

Map for illustration only; not an authoritative depiction of boundaries.



SESSION 5 · LEARNING OBJECTIVES

What you will be able to do after this session

- 1 Define installed capacity, plant life and land treatment consistently with the PPA
- 2 Distinguish CUF, plant load factor and availability — and compute CUF
- 3 Build the gross-to-net loss chain for solar, wind and small hydro
- 4 Set heat rate, fuel price and tipping-fee assumptions for bioenergy and WtE
- 5 Apply P50/P75/P90/P99 correctly for regulators, lenders and investors
- 6 Trace how each technical assumption moves the tariff



ROADMAP

From megawatts to money: every arrow is a model line



Model default: 50 MW solar → gross 92.0 GWh → net 85.29 GWh in year 1 → CUF 19.5%



PHYSICAL ASSUMPTIONS

Capacity, plant life and land — get the basics exactly right



Installed capacity

- DC (modules) $\neq$ AC (inverters) $\neq$ contracted capacity at the meter
- Tariffs are paid on net energy at the delivery point
- Model: $\text{in_Cap_MW} = \text{AC net contracted MW}$



Plant life

- Typical economic life: solar 25–30 yrs, wind 20–25, small hydro 30–50
- Tariff / PPA term usually equals the modelled life
- Debt tenor and equity redemption must fit inside it



Land

- Availability, title and access drive schedule risk
- Treatment: capitalise purchase cost or expense a lease in O&M
- Model switch: in_LandTreat



DEFINITIONS

CUF, plant load factor and availability are not the same thing

Capacity utilisation factor (CUF)

$\text{Net energy} \div (\text{MW} \times 8,760 \text{ h})$

The key yield metric for resource-driven RE

Plant load factor (PLF)

$\text{Actual output} \div \text{output at full load while dispatched}$

A dispatch concept from thermal plants — use with care for RE

Availability

$\text{Hours able to generate} \div \text{hours in period}$

Guaranteed by O&M contracts; excludes resource shortfall

Worked example (model)

$$85.29 \text{ GWh} \div (50 \text{ MW} \times 8.76) \\ = \mathbf{19.5\% \text{ CUF}}$$

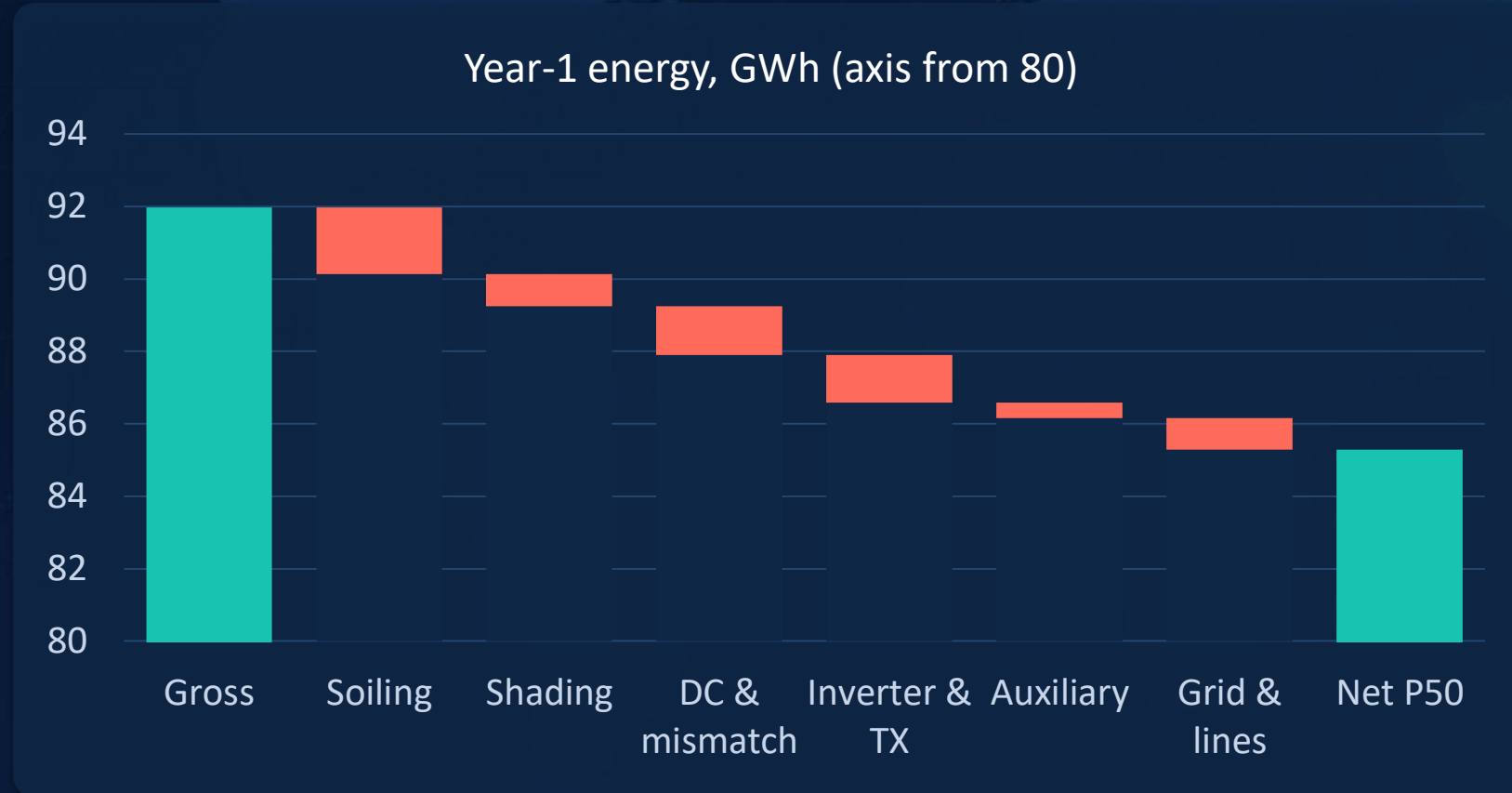
IRENA global average for new utility PV
(2024): 17.4%

Trap: a 99% available plant can still have a low CUF — availability measures the machine, CUF measures the machine AND the resource.



LOSS CHAIN

Gross to net: where the energy goes (50 MW solar)



Loss	%	GWh
Soiling	2.0%	1.84
Shading	1.0%	0.90
DC & mismatch	1.5%	1.34
Inverter & TX	1.5%	1.32
Auxiliary	0.5%	0.43
Grid & lines	1.0%	0.86
Net / total	7.3%	85.29

Source: Workshop model, Solar PV defaults (Tech_Library) — illustrative; use your yield-assessment report.



LOSS DEEP DIVE · WIND

Wind: wake, shear and direction decide the yield



Wake losses Upwind turbines slow the wind for those behind; layout vs prevailing direction matters. Model default 7%.



Wind shear Speed rises with height: $v_2 = v_1 \times (h_2/h_1)^\alpha$. Measure at or near hub height.

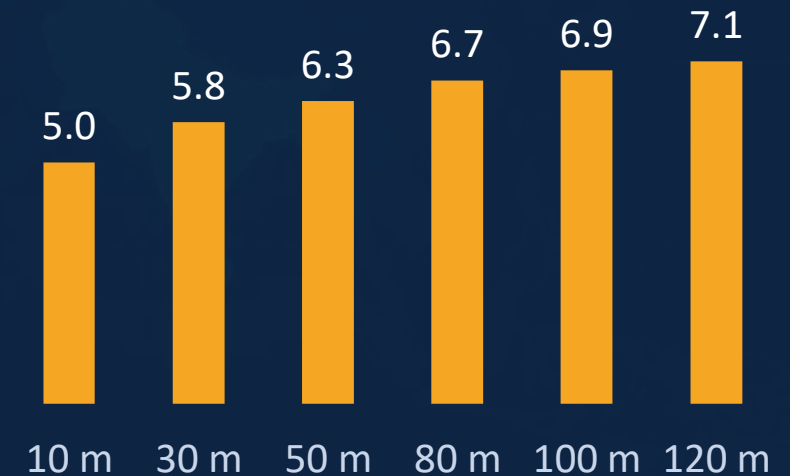


Resource direction A narrow wind rose allows tighter spacing; a broad one raises wake losses.



Air density & turbulence Hot, high sites produce less; turbulence reduces power-curve performance.

Speed vs height ($\alpha = 0.14$)



5.0 m/s at 10 m → 6.9 m/s at 100 m →
~2.6× the power



LOSS DEEP DIVE · SOLAR

Solar: soiling, heat and degradation erode output every year



Soiling Dust and pollution — pre-monsoon build-up in South Asia; cleaning frequency is an O&M trade-off



Shading Near objects, row-to-row and horizon shading

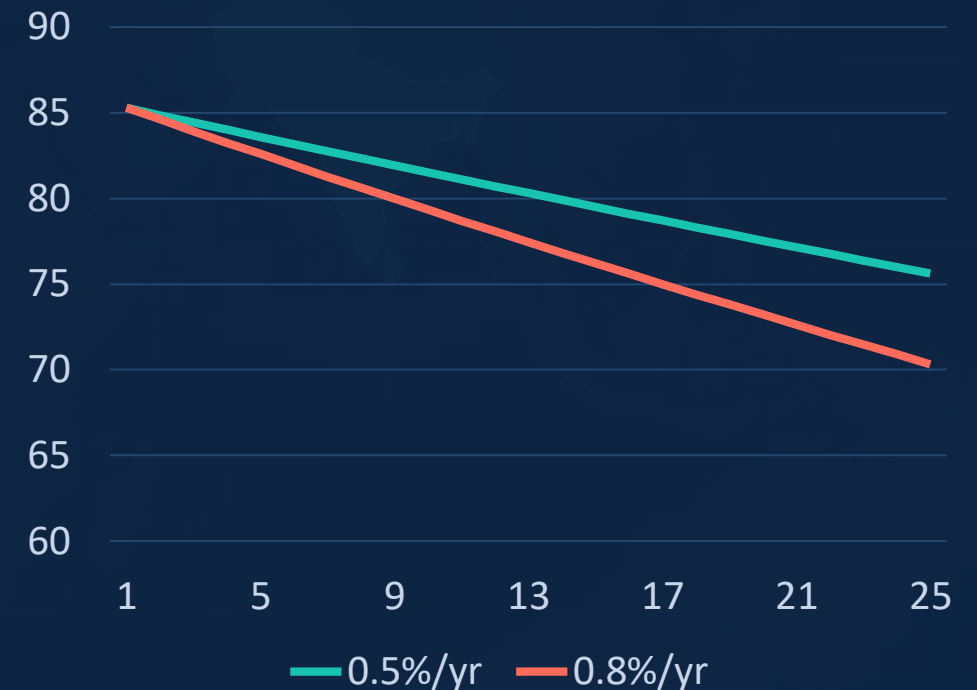


Temperature Hot modules produce less; ventilation and module choice matter



Degradation Module output declines each year — model default 0.5%/yr

Net energy (GWh) by operating year

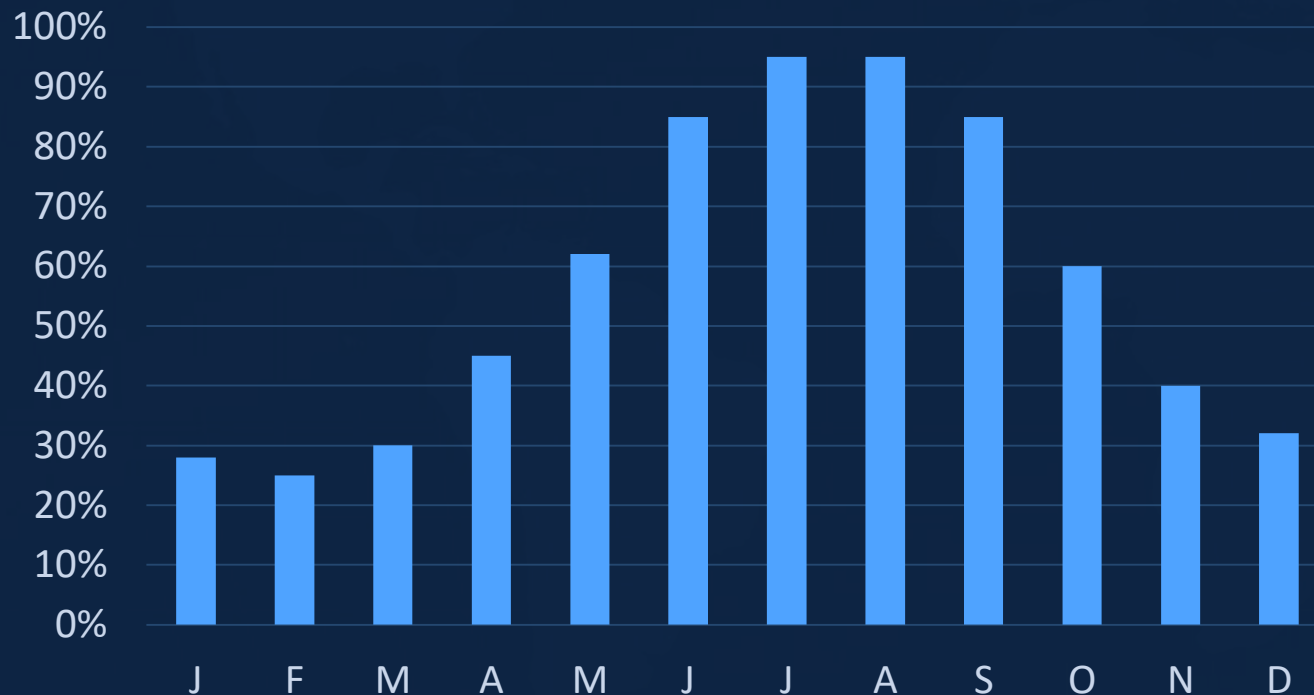




LOSS DEEP DIVE • HYDRO

Small hydro: the river sets the calendar

Illustrative monsoon-fed run-of-river: monthly CUF



Flow-duration curve

sets design flow and annual energy

Environmental flow

water that must bypass the turbines

Head losses

friction in intake and penstock

Sediment & outages

turbine wear during high-silt months

Source: Monthly profile is illustrative only (annual average $\approx$ 57%).



DISPATCHABLE RE · ASSUMPTIONS

Fuel-based RE: heat rate, fuel and gate fee set the EPP

Heat rate (GJ/MWh) = $3.6 \div \text{net efficiency}$

Fuel cost (USD/MWh) = heat rate × fuel price

Waste (t/MWh) = heat rate ÷ calorific value

Tipping credit (USD/MWh) = t/MWh × gate fee

Availability, not resource, sets CUF: Planned & forced outages and fuel shortfalls replace irradiance and wind as the key losses.

Auxiliary load is large: Fans, pumps and flue-gas cleaning consume 8–15% of gross output.

Index fuel separately: Fuel belongs in the Energy Purchase Price, indexed to a fuel-price index.

Model default	Biomass	WtE	Biogas
Net efficiency	25%	20%	38%
Heat rate, GJ/MWh	14.4	18.0	9.5
Fuel price, USD/GJ	3.0	0 (waste)	2.0
Fuel cost, ¢/kWh	4.32	—	1.89
Waste, t/MWh	—	3.0	—
Tipping credit, ¢/kWh	—	-4.50	—
EPP in model, ¢/kWh	4.92	-2.50	3.09

Source: Workshop model Tech_Library defaults (illustrative) — use fuel-supply contracts and plant data.



EMERGING TECHNOLOGIES · ASSUMPTIONS

Geothermal, solar thermal & hydrogen: key assumptions



Geothermal

Reservoir decline

Output falls without make-up wells — model: 0.8%/yr

Parasitic load

Brine pumps, non-condensable gas removal — ~7%

Exploration success

Capex contingency until wells are proven



Solar thermal

Direct irradiation

Uses DNI, not GHI — needs clear skies

Storage hours

Molten-salt storage raises CUF (model: 50%)

Parasitics

Pumps and heat tracing — ~8% of output



Green hydrogen

Electricity use

≈ 55 kWh per kg H₂ (model default)

Utilisation

Solar-only supply runs ~1,700 h/yr; hybrid supply cuts LCOH

Stack life

50,000 operating hours (IEA assumption)

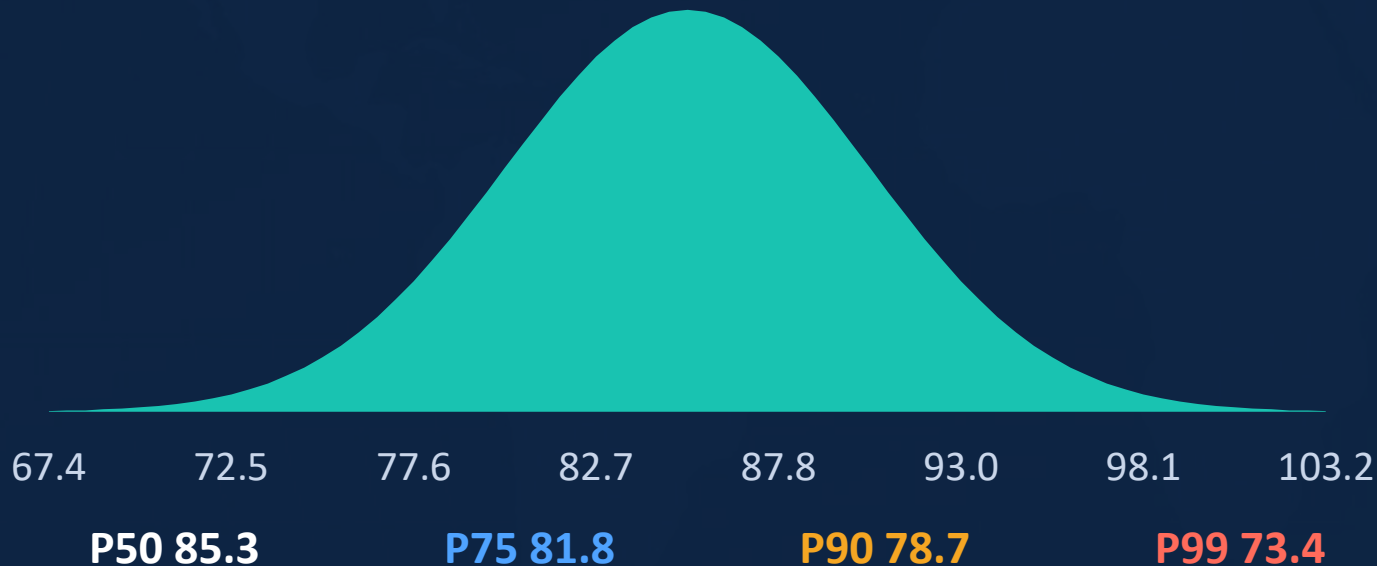
Source: Workshop model defaults; IEA Global Hydrogen Review 2025 assumptions annex (stack life).



PROBABILITY OF EXCEEDANCE

Resource variability: P50, P75, P90, P99

Year-1 energy, 50 MW solar ($\sigma = 6\%$)



$$P_{xx} = P50 \times (1 - z \cdot \sigma)$$

$$z: P75 = 0.674 \cdot P90 = 1.282 \cdot P99 = 2.326$$

P90 = energy exceeded in 9 years out of 10

σ combines resource, model and measurement uncertainty



UNCERTAINTY BY TECHNOLOGY

Who uses which P-value — and what it costs

50 MW plant	σ (1-yr)	P50 GWh	P90 GWh	P90 / P50	P99 / P50
Solar PV	6%	85.3	78.7	0.923	0.860
Wind	12%	122.7	103.9	0.846	0.721
Small hydro	10%	189.9	165.6	0.872	0.767



Regulator

P50 — the tariff should reflect expected output



Lender

P90 / P99 — size debt so bad years still pay



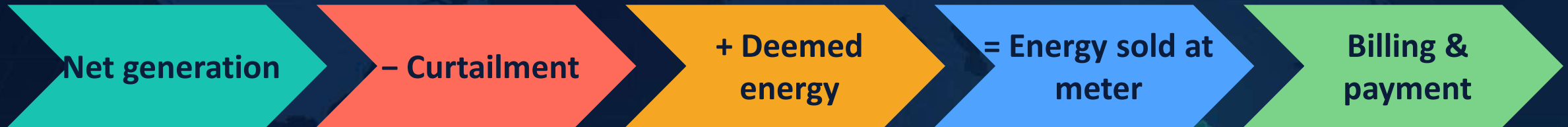
Equity

P50 returns, P90 downside



GENERATION & SALES

From generation to sales: what the off-taker actually pays for



Take-or-pay

Off-taker pays for energy the plant could have delivered but was not dispatched (deemed / non-project missed volume). Protects the project; burdens the buyer.

Take-and-pay

Off-taker pays only for energy actually delivered. Curtailment risk stays with the project — lenders will price it.

Metering & billing

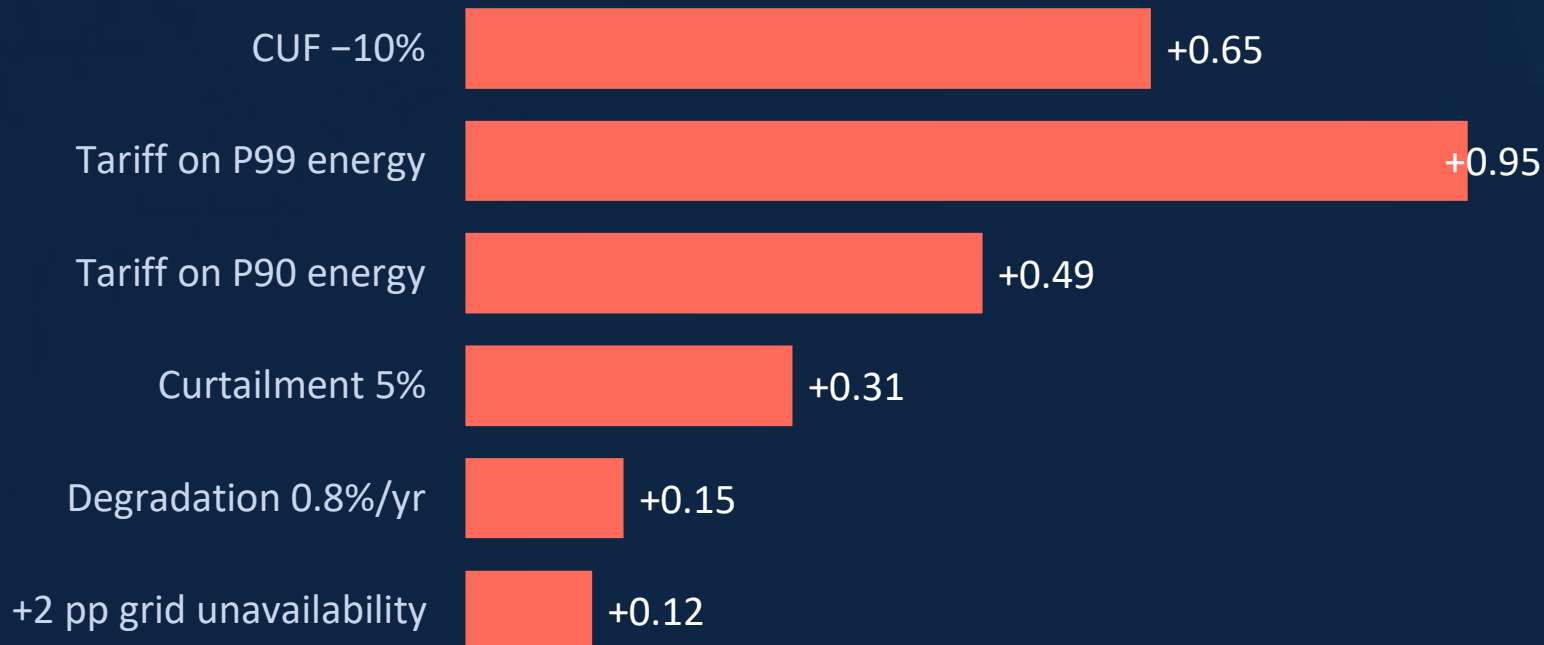
Delivery-point metering, monthly invoices, payment days (model: receivables 60 days) drive working capital.



MODEL RESULTS

What each technical assumption does to the tariff

Increase in levelised tariff vs base 5.88 ¢/kWh



+11%

Tariff increase from a 10% over-estimate of CUF

Verify the yield report before the financing terms — errors here are the most expensive.

Source: Workshop tariff model, Solar PV defaults.



GOOD PRACTICE

Assumptions register: every number needs a source and an owner

Parameter	Typical evidence	Validated by	Model input
Resource (GHI, wind, flow)	≥1 yr on-site data + long-term satellite / reanalysis	Independent engineer	in_CF_Gross
Loss chain	Energy-yield report (simulation)	Independent engineer	in_Loss1–6
Degradation	Module / turbine warranty, test data	Technical adviser	in_Deg
Availability	O&M contract guarantee	Lenders	in_Loss6
Curtailement	Grid study, dispatch history	System operator	in_Curt
Uncertainty σ	Yield report uncertainty table	Independent engineer	in_Sigma
Plant life	Technical due diligence	Regulator	in_Life



INTERACTIVE

Spot the error — three flawed assumptions

1 *“Fixed-tilt solar in the plains: CUF 28%.”*

Implausibly high — global average for new PV is 17.4% (2024); demand the yield report.

2 *“Set the tariff on P99 energy to be safe.”*

Consumers overpay most years: tariff rises 5.88 → 6.84 ¢.

3 *“No degradation over 25 years.”*

Overstates year-25 energy by ~11% at 0.5%/yr.



SESSION 5

Key takeaways



Model energy step by step: capacity → gross → losses → degradation → curtailment → sales.



Keep CUF, PLF and availability distinct — each belongs in a different contract and a different model line.



Tariffs on P50, debt on P90/P99: know which number each stakeholder needs.



A 10% error in yield outweighs most financing debates — source and validate every assumption.

NEXT ► After lunch: Working Exercise I — build your own model's inputs, capital cost and generation blocks.