Illustrative Hedging Strategies in Energy Markets

Generators, Consumers, and Marketers

Quant Insider

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Purpose. This Notebook gives a *visual, equation-first* guide to hedging electricity exposure with futures, tailored to three market participants: generators (long power), consumers (short power), and marketers (intermediaries).

1 Quick Primer

- Spot price at delivery: S (\$/MWh). Futures price fixed today: F (\$/MWh).
- Generator variable cost: C (\$/MWh). Consumer pass-through price (revenue cap): R (\$/MWh).
- Marketer sells to customer at fixed price P_c and/or buys from generator at fixed price P_g.
- Optimal hedge ratio (minimum-variance): $h^* = \rho \frac{\sigma_S}{\sigma_F}$ via OLS regression of ΔS on ΔF.

2 Parameters (edit and recompile)

Default values used in the figures: $F = \$18,\ C = \$20,\ R = \$20,\ P_c = \$18.10,\ P_g = \$17.90.$

3 Generator: Short Hedge (Sell Futures)

Setup

A generator is naturally long electricity: it sells power at S while incurring cost C.

$$\text{Physical P\&L} = S - C, \qquad \text{Futures P\&L (short)} = F - S, \qquad \Rightarrow \text{Total} = (S-C)+(F-S) = F-C.$$

The hedge *locks in* a flat net price F (hence total P&L is constant $F - C$).

Illustration

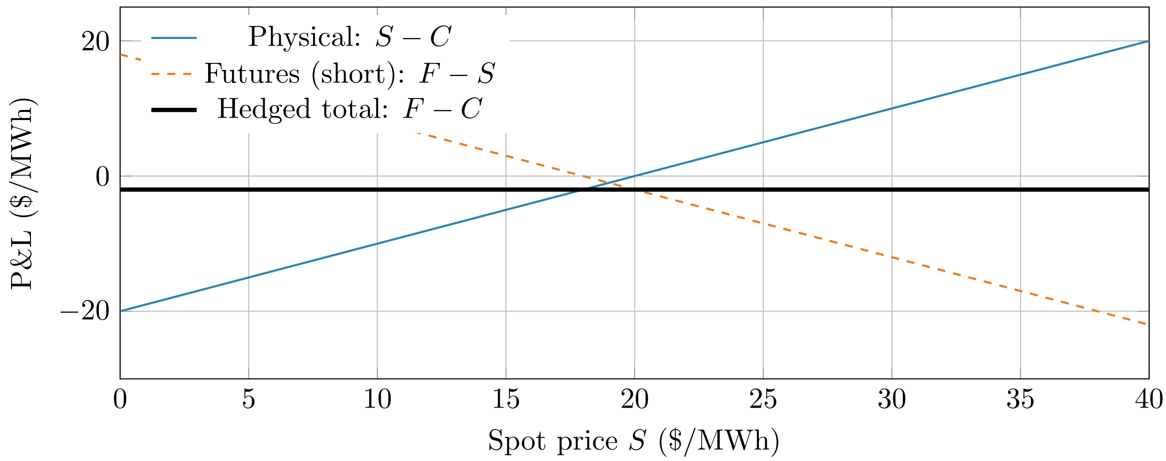

Figure 1: Generator hedged payoff: flat at $F - C$ (here $18 - 20 = -2$).

Key risks: basis (location/time), volume (actual MWh vs hedge), timing (monthly futures vs daily spot).

4 Consumer: Long Hedge (Buy Futures)

Setup

A consumer is effectively short electricity: it must buy at S but may have fixed output/revenue R.

$$\text{Physical P\&L} = R - S, \qquad \text{Futures P\&L (long)} = S - F, \qquad \Rightarrow \text{Total} = (R-S)+(S-F) = R-F.$$

The hedge *locks in* a flat net margin $R - F$ (cost certainty at F).

Illustration

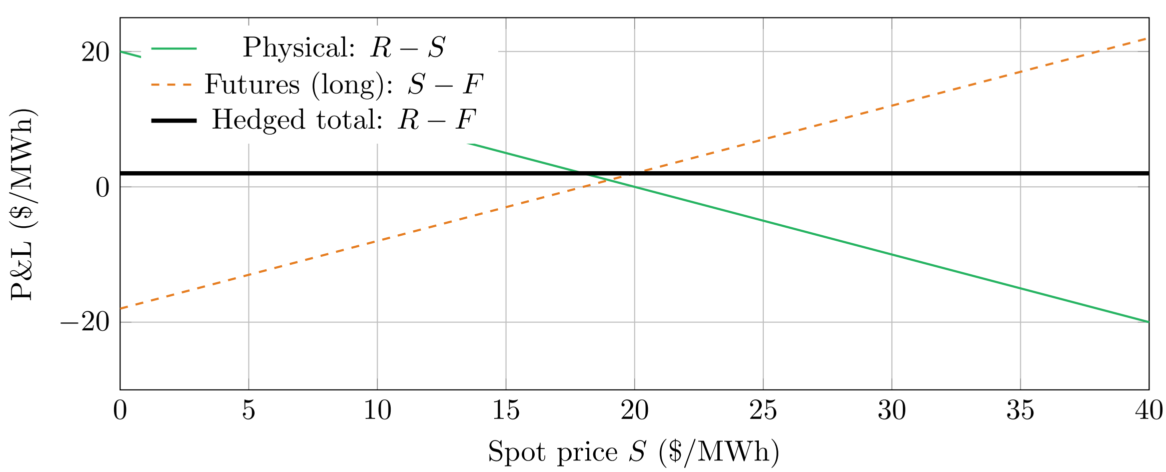

Figure 2: Consumer hedged payoff: flat at $R - F$ (here $20 - 18 = 2$).

Note. If the consumer can partially pass through costs (R not fixed), the optimal hedge ratio $h^* < 1$.

5 Marketer: Spread Hedges

A. Marketer Long Hedge (fixed sell)

Marketer promises to sell at fixed P_c in the future (e.g., retail tariff). To lock the purchase cost, go long futures.

$$\text{Physical P\&L} = P_c - S, \qquad \text{Futures P\&L (long)} = S - F, \qquad \Rightarrow \text{Total} = P_c - F \equiv \text{locked margin.}$$

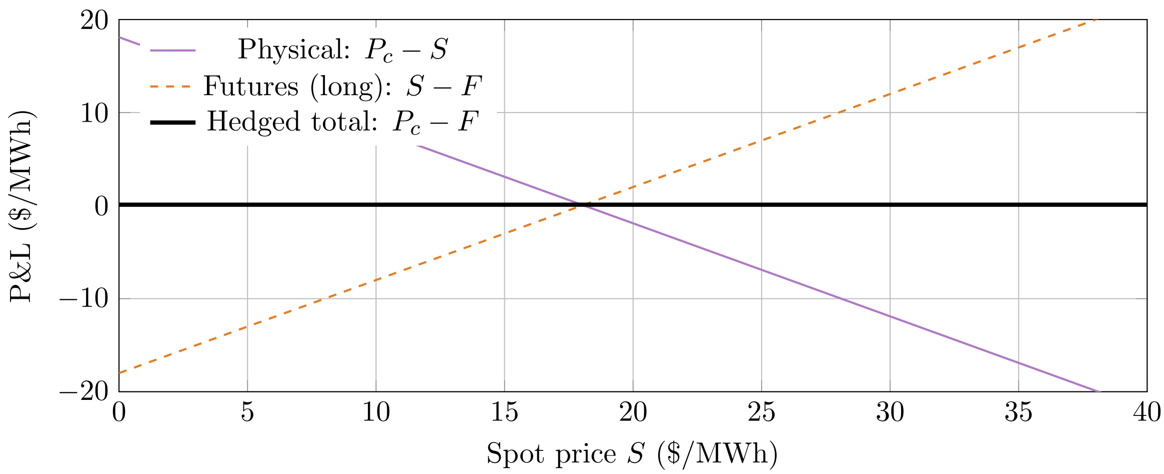

Figure 3: Marketer long hedge locks $P_c - F$ (here \$0.10/MWh).

B. Marketer Short Hedge (fixed buy)

Marketer agrees to buy from a generator at fixed P_g. To lock the sale price, go short futures.

$$\text{Physical P\&L} = S - P_g, \qquad \text{Futures P\&L (short)} = F - S, \qquad \Rightarrow \text{Total} = F - P_g.$$

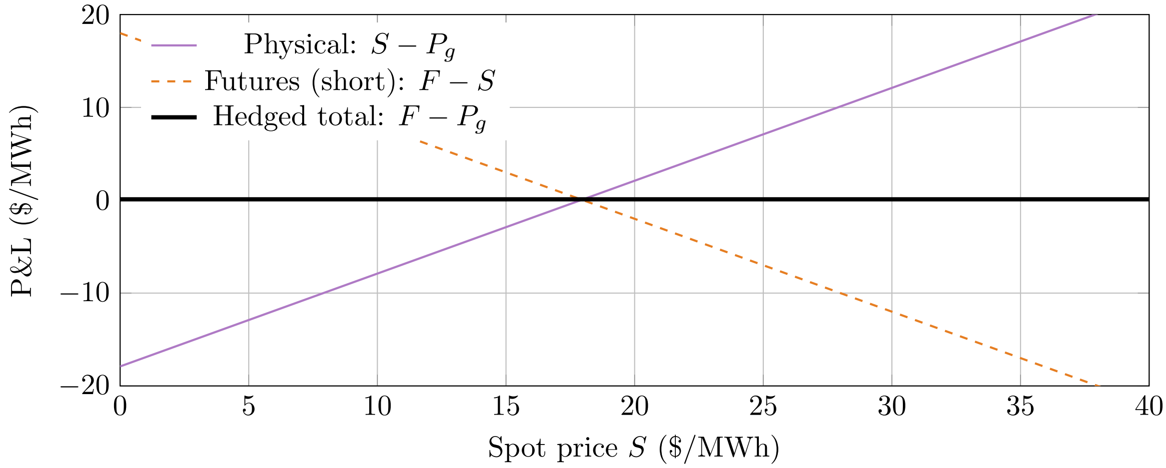

Figure 4: Marketer short hedge locks $F - P_g$ (here $0.10/MWh).

6 Basis, Volume, and Timing Risks

Basis. Basis $= S_{\text{local}} - F_{\text{contract}}$. Location (hub) and tenor mismatches drive residual variance.
Volume. Actual generation/load may deviate from hedged MWh. Consider dynamic rebalancing or swing options.
Timing. Monthly futures vs daily/hourly spot; roll risk for long horizons ("stack and roll").

7 Optimal Hedge Ratio h^*

Let ΔS_t and ΔF_t be changes over the hedging interval. An OLS of ΔS_t on ΔF_t yields

$$\Delta S_t = \alpha + h^* \, \Delta F_t + \varepsilon_t, \qquad h^* = \rho \, \frac{\sigma_S}{\sigma_F}.$$

For cross-hedges (e.g., spark spreads), F may reference a related commodity (gas or an LMP hub). Estimate h^* on synchronized, seasonally matched data.

8 At-a-Glance Playbook

Participant	Futures Action	Natural Position	Objective
Generator	Sell futures (short)	Long electricity	Lock selling price; hedge downside to F
Consumer	Buy futures (long)	Short electricity	Lock purchase cost; cap upside at F
Marketer (sell fixed)	Buy futures (long)	Synthetic short	Lock $P_c - F$ spread
Marketer (buy fixed)	Sell futures (short)	Synthetic long	Lock $F - P_g$ spread

9 Appendix: Extend the Template

Ideas to expand in your Overleaf project:

- Add *hedge ratio h^* sliders* via `pgfkeys` and re-plot partial hedges.
- Model *basis distributions* by adding an independent term B with zero mean and variance σ_B^2.
- Include *spark spread* hedging: $\mathrm{SS} = P_{\text{power}} - HR \cdot P_{\text{gas}}$ with heat rate HR.
- Plot *stack-and-roll* P&L paths across months to visualize roll risk.

Tip: Search-and-replace the numerical parameters (F, C, R, P_c, P_g) at the top of each plot to reflect your book.

10 Extended Modules

10.1 Partial Hedge with h^* (Sliders via Parameters)

Set a global hedge ratio parameter and re-plot. Change `\def\h{...}` to any value in $[0, 1]$ before compiling.

Generator with Partial Hedge. Total P&L: $(S-C)+0.75\,(F-S) = (1-0.75)\,S+(0.75F-C)$. $0.75 = 0$ (unhedged), $0.75 = 1$ (full hedge), $0 < 0.75 < 1$ (partial hedge).

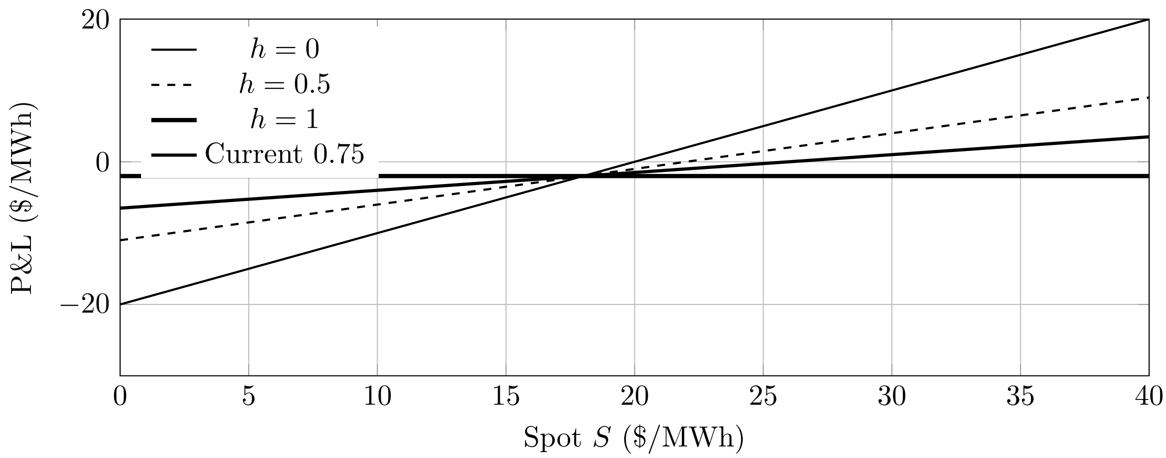

Figure 5: Generator partial hedge: slope $(1 - 0.75)$ interpolates between unhedged and flat.

Consumer with Partial Hedge. Total P&L: $(R-S)+0.75\,(S-F) = (0.75-1)\,S+(R-0.75F)$.

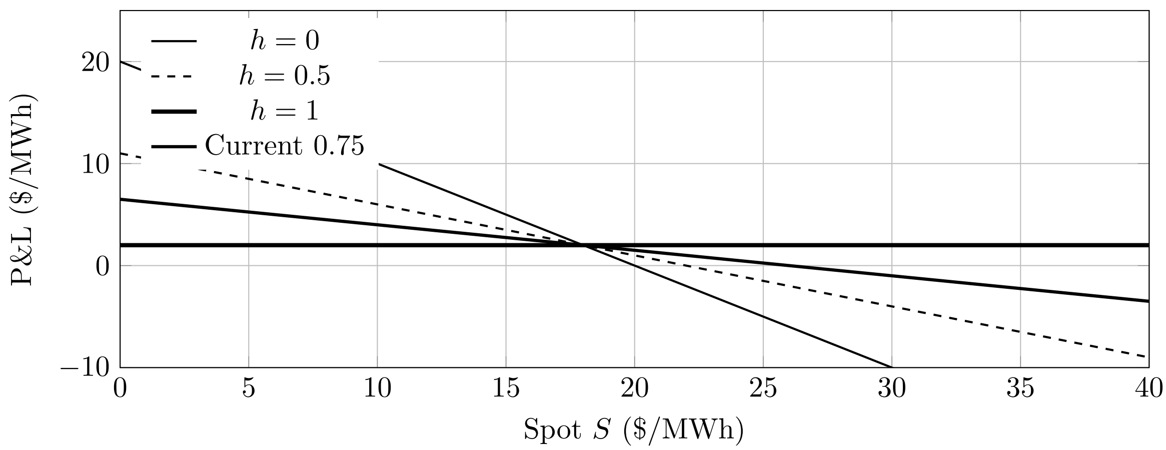

Figure 6: Consumer partial hedge: slope $(0.75 - 1)$ approaches flat at $0.75 = 1$.

10.2 Basis Risk Visualization

Let local spot be $S_\ell = S_{\text{ref}} + B$, where $B \sim \mathcal{N}(0, \sigma_B^2)$ captures location/quality/tenor basis. With futures settling to S_{ref}, the residual P&L exposure to basis remains. We visualize a $\pm 1.96\,\sigma_B$ band.

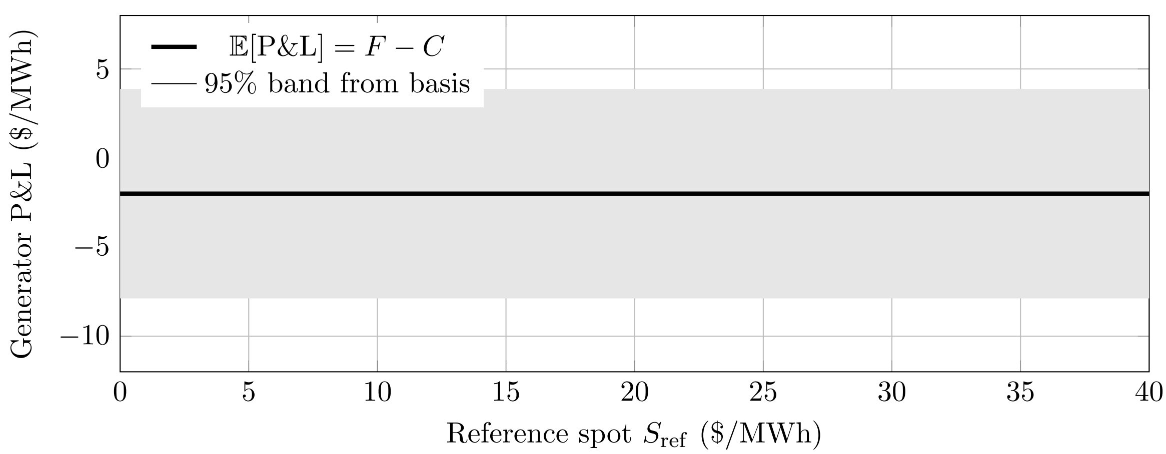

Figure 7: Basis leaves a residual band even under perfect futures convergence. Increase σ_B to see wider risk.

10.3 Spark Spread Hedging (Power vs Gas)

Define spark spread $\text{SS} = P_{\text{power}} - HR \cdot P_{\text{gas}}$ with heat rate HR (MMBtu per MWh). A generator can hedge gas using gas futures with $h_g \approx HR$ and hedge power using power futures to lock P_{power}.

Locked Gross Margin. With power and gas futures, locked margin per MWh is $55 - HR \cdot 6.0$.

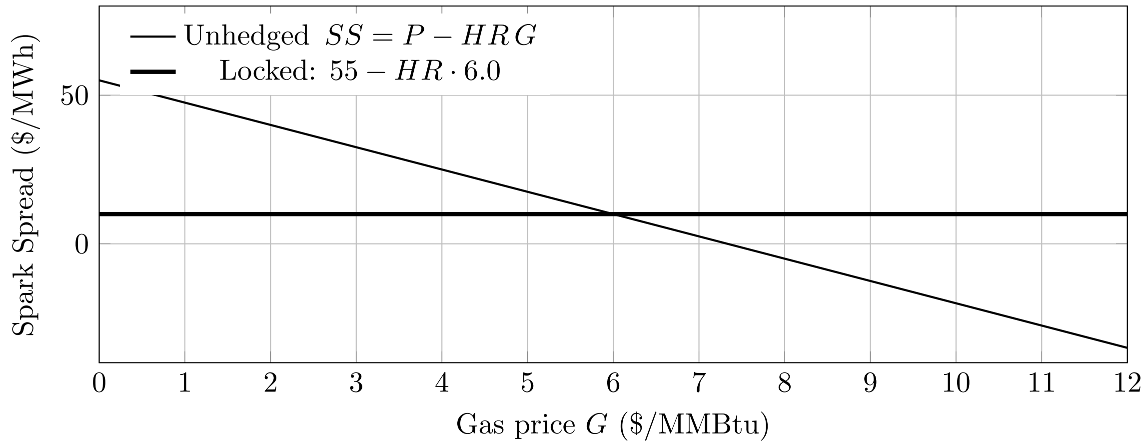

Figure 8: Spark spread vs gas price; futures lock a flat gross margin at $55 - HR\,6.0$.

Note. For tolling deals, include variable O&M and start/stop costs; for locational gas-power, add basis terms for each leg.

10.4 Stack-and-Roll: Visualizing Roll Yield

We hedge a 12-month physical exposure using front-month futures, rolling monthly. Roll P&L each month t (cash-at-roll for a short hedge) is $\text{Roll}_t^{\text{cash}} = F_{t-1,\,t+1} - F_{t-1,\,t}$. Backwardation ($F_{t-1,\,t+1} < F_{t-1,\,t}$) yields negative cash-at-roll; contango yields positive. Over the life of the hedge, convergence benefits the short in backwardation and hurts in contango.

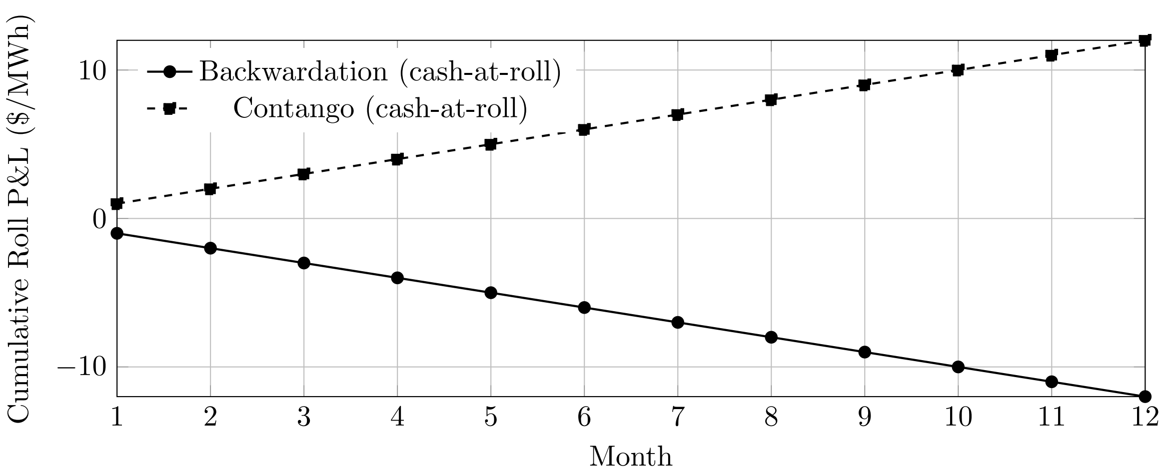

Figure 9: Cumulative roll yield under stylized backwardation/contango. Replace with your forward curve data as needed.

10.5 How to Plug in Real Data

- Export hub power futures and gas futures from your ETRM. Fit h^* via OLS on synchronized returns.
- Compute basis standard deviation σ_B by hub vs contract (e.g., DA LMP vs monthly futures).

- Replace the toy roll coordinates with your monthly $F_{t-1,t}$ and $F_{t,t}$ series to get realized roll P&L.

Parameter Recap (edit at top of each block): F, C, R, P_c, P_g, h, σ_B, HR, 55, 6.0.