Financial Risk Management

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Outline

Definition of Risk

GenCo Financial Risk Management: Three Illustrative Scenarios

• A GenCo signs a bilateral contract with an LSE at its bus
• A GenCo purchases FTR contracts and signs bilateral contracts with LSEs at different buses
• A GenCo jointly participates in a day-ahead energy market, an FTR market, and bilateral contracts with LSEs at different buses

Financial risk management as a four-stage process
Definition of Risk

- K/S rough definition of risk (Chapter 2.4): Deviation from an expected outcome.

- More precise definition of financial risk from the perspective of a profit-seeking GenCo:

  **Financial Risk** = The possibility that a *financial* outcome for the GenCo *adversely* deviates from what the GenCo anticipated.
Financial Risk Management for a Profit-Seeking GenCo

Objective:
- Maintain the “best” possible portfolio of contracts at all times

Contracts Available For Inclusion in GenCo’s Portfolio: Examples
- Forward bilateral contracts: forward electric energy contracts
- Day-ahead energy market trades: forward electric energy contracts
- Financial transmission rights (FTRs): forward financial contracts

Data Gathering:
- Transmission grid information
- Historical electricity, fuel price, load and outage data

Sources of Uncertainty:
- Uncertainty about demand conditions and rivals’ supply offers
- Uncertainty about fuel costs
Settlement of an FTR Obligation

**Example:** Settlement $\pi(FTR_{AB})$ of an FTR contract for $FTR_{AB}$ MWs from a “source bus” A to a “sink bus” B:

$$\pi(FTR_{AB}) = (LMP_B - LMP_A) \times FTR_{AB} \ \$/\text{h}$$

**Figure:** FTR Obligation and Liability Calculation
**Scenario One:** GenCo G3 can acquire a forward bilateral contract with LSE 2

**Financial Bilateral Contract:**

If GenCo 3 contracts with LSE 2 for q MWs at strike price p for hour h, these responsibilities and liabilities are incurred:

- At hour h, if $LMP_h^3 \geq p$ then GenCo 3 pays LSE 2 the amount $[LMP_h^3 - p]q$.
- However, if $LMP_h^3 < p$ then LSE 2 pays GenCo 3 the amount $[p - LMP_h^3]q$.
- $LMP_h^3$ is the locational marginal price at bus 3 in hour h.
Scenario Two: GenCo G3 can acquire forward bilateral contracts with LSEs and purchase FTR contracts from ISO.

Financial Transmission Rights:

If GenCo G3 purchases $q$ MWs of FTRs with source at bus 1 and sink at bus 4 at price $r$: The corresponding FTR will be transferred to GenCo G3 for purchase amount $r \cdot q$. The payout (or payment due) for FTR in hour $h$ is $[\text{LMP}_4^h - \text{LMP}_1^h] \cdot q$.

Risk Issues:
Uncertainty results in possible price risk at all buses for G3.

Bus 1: G1
Bus 2: LSE 1
Bus 3: G3
Bus 4: LSE 2
Bus 5: G5

Listing 1:
- Source: LSE 1
- Sink: G3
- MW: ...
- Price: ...

Listing N:
- Source: LSE 1
- Sink: G3
- MW: ...
- Price: ...
Need for FTRs to “make whole” forward bilateral contracts between GenCos and LSEs at different buses

- Suppose on Day D that GenCo G3 at Bus 3 signs a forward bilateral contract with LSE 3 at Bus 4 for sale of q MWs at strike price \( p = 40 \$/MWh \) at hour H of D+1.
- This bilateral contract has a “contract for difference” clause requiring each party to “make whole” the other to assure the effective price is \( p = 40 \$/MWh \).
- But at hour H of D+1, \( \text{LMP}_3 = 30\$/MWh < p < \text{LMP}_4 = 50\$/MWh \).
- \( G3 \) gets \( q \cdot 30\$/MWh \) (too little) & LSE 3 pays \( q \cdot 50\$/MWh \) (too much) relative to \( p \), no way for either to “make whole” the other.
- Suppose in addition on Day D that \( G3 \) also acquired an FTR for q MWs from Bus 3 to Bus 4 for hour H on Day D+1.
- \( G3 \)'s net earnings from energy sales plus FTR holding at hour H of D+1 are \( q\text{LMP}_3 + q[\text{LMP}_4 - \text{LMP}_3] = q \text{LMP}_4 = q \cdot 0.50 \$/MWh \).
- \( G3 \) can now “make whole” LSE 3 with a payment of \( q \cdot 10 \$/MWh \).
Scenario Three: GenCo G3 simultaneously trades in the day-ahead energy market as well as securing forward bilateral and FTR Contracts

Risk Issues:
Uncertainty for G3 results in possible price risk at all buses plus risk of adverse dispatch in the day-ahead energy market.
Integrated Operation of Energy and FTR Markets

D = 0

**FTR – Auction:**
- Submit bids/offers to buy/sell FTRs
- Allocate FTRs optimally to all bidders
- GenCos acquire FTRs to hedge against expected price risk in future

0 < D < 365

**Day – Ahead Energy Market Auction:**
- Submit offers to supply power
- Decide optimal supply quantities and LMPs
- GenCos submit offers to supply energy on day \(D+1\)

**End of Day D**
- Energy market and FTR settlement based on day \(D+1\) LMP values
Financial Risk Management as a Four-Stage Process

◆ **Stage One: Identification and Modeling of Risk Factors**
  - Identify underlying risk factors (*Example*: Uncertain fuel price $P_f$)
  - Build a sensible model for these risk factors (e.g., a prob dist fct)
    *Example*: \( \text{Prob}(P_{f1}) = 2/3, \text{Prob}(P_{f2}) = 1/3 \)

◆ **Stage Two: Derivation of a Portfolio Loss Function**
  - *Example*: \( \text{Loss}(P_{f1}) = 100/h, \text{Loss}(P_{f2}) = 50/h \)

◆ **Stage Three: Derivation of Comprehensive Risk Measures**
  - *Examples*: Variance, Value-at-Risk (VaR), Conditional Value-at-Risk (CVaR)

◆ **Stage Four: Portfolio Optimization**
  - *Examples*: Select portfolio to
    - Min [Expected Loss] (Example: Expected Loss = \( \sum \text{Prob}(p_{fj})\text{Loss}(P_{fj}) \))
    - Max [Expected Return Rate - Risk] with *risk = variance of return rate*
    - Max [Expected Return Rate - Risk] with *risk = VaR or CVaR for loss pdf*
Value at risk (VaR): How bad can things get?
- We are \( \alpha \)% certain that our loss will be less than or equal to \( \text{VaR}_\alpha(L_q) \) dollars over the next \( N \) days from holding the portfolio \( q \) with loss function \( L_q \).
- \( \alpha \)%: Confidence level
- Negative loss = Gain

Conditional value at risk (CVaR): If things get bad, how much can we expect to lose?
- CVaR: The conditional expected loss during an \( N \)-day period given that the loss is greater than or equal to VaR
Var/CVar and Recent Financial Crisis

- In theory, the pdf of a portfolio’s loss function provides complete info about its risk.
- However, too cumbersome for practical use.
- Portfolio managers have instead relied on simpler measures of risk, such as variance of the return rate $R$, where

$$ R \approx \frac{Value_{D+1} - Value_D}{Value_D}. $$

- Beginning in 1990s, portfolio managers have increasingly used Var and CVar in place of variance in recognition that risk is in fact a “one-sided tail event” - i.e., protect against big loss, not big gain!
- But use of simplistic scalar risk measures (variance, VaR, CVar,...) has been singled out as key explanation for recent financial crisis.
- The charge is that portfolio managers failed to properly assess the riskiness of the financial assets they were selling to clients.
References

- ** Kirschen/Strbac, *Power System Economics*, Sections 2.4 (pp. 33-39) and 6.3.5 (pp. 191-200)
