Energy Procurement Portfolios and Production Planning

Enterprise-wide Optimization
13 October 2011

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Overview of the Problem

● Objective
  – Minimize production costs
  – Find a portfolio of contracts
  – Find the optimal power import schedule
  – Working in Hourly time buckets

● Contract types available:
  – Fixed price (FP or f)
  – Quantity-based tiered (QB or q)
  – Time-based tiered (TB or b)
  – Spot market access (SP or s)
Modeling updates since our last meeting in March 2011

- Removed Energy Storage System (ESS) concept
  - Expensive to implement
  - High loss rates make ESS impractical
- Added modeling of multiple production sites making multiple products (instead of one site making one product)
- Enforce a single contract at each location in each time period (instead of permitting multiple contracts)
- Continued to use deterministic demands and to enforce the “no stock-outs” rule
Model formulation

Model

\[ \begin{align*}
\min \quad & \sum_{h \in \mathcal{H}} \sum_{p \in \mathcal{P}} (c_{f,h} P_{h,f,p} + c_2 P_{h,f,p} + K_{h,p}) + \\
& \sum_{p \in \mathcal{P}} (\sum_{h \in \mathcal{H}_1} c_{1,h} P_{h,b,p} + \sum_{h \in \mathcal{H}_2} c_{2,h} P_{h,b}) + \\
& \sum_{h_1 \in \mathcal{H}_1} \sum_{h_2 \in \mathcal{H}_2} P_{h_1,s,p} [V_{s,h_1,h_2} P_{h_2,s,p} + \\
& \sum_{p \in \mathcal{P}} \sum_{a \in \mathcal{A}} x_{a,p} d_{a,p}]
\end{align*} \tag{1} \]

s.t.

\begin{align*}
\forall h \in \mathcal{H}, a \in \mathcal{A}, p \in \mathcal{P} \quad & P_{h,a,p} \leq M x_{a,p} \tag{5} \\
\forall h \in \mathcal{H}, p \in \mathcal{P} \quad & \sum_{a \in \mathcal{A}} P_{h,a,p} = P_{h,p}^{\mu} \tag{6} \\
\forall d \in \mathcal{D}, p \in \mathcal{P}, g \in \mathcal{G} \quad & inv_{d,p,g} = inv_{d-1,p,g} + \sum_{i \in \mathcal{T}} \eta(P_{h,p}^{\mu}) - dem_{d,p,g} \tag{7} \\
\forall p \in \mathcal{P} \quad & \sum_{a \in \mathcal{A}} x_{a,p} \leq 1 \tag{8}
\end{align*}
Model formulation

\[ K_{h,p} = \begin{cases} 
  c_{q,p}^2 p_{h,p}^q & \text{if } y_{h,p} = 1 \\
  c_{q,p}^1 p_{h,p}^d & \text{o.w.} 
\end{cases} \]

\[ \forall h \in \mathcal{H}, p \in \mathcal{P} \quad \sum_{\frac{h}{h} \in \mathcal{H}} P_{h,q,p} - q_{\text{limit}} \leq M y_{h,p} \quad (9) \]

\[ \forall h \in \mathcal{H}, p \in \mathcal{P} \quad M + K_{h,p} \geq c_{q,p}^2 p_{h,q,p} + M y_{h,p} \quad (10) \]

\[ \forall h \in \mathcal{H}, p \in \mathcal{P} \quad M y_{h,p} + K_{h,p} \leq c_{q,p}^2 p_{h,q,p} + M \quad (11) \]

\[ \forall h \in \mathcal{H}, p \in \mathcal{P} \quad M + K_{h,p} \geq c_{q,p}^1 p_{h,q,p} + M(1 - y_{h,p}) \quad (12) \]

\[ \forall h \in \mathcal{H}, p \in \mathcal{P} \quad M(1 - y_{h,p}) + K_{h,p} \leq c_{q,p}^1 p_{h,q,p} + M \quad (13) \]

\[ y_{h,p} \geq y_{h-1,p} \quad (14) \]
Conclusions and Observations

- Additions would be necessary to make the model more believable
  - Need to consider dynamic customer sourcing – which may necessitate distribution modeling
  - Hourly-level production modeling will require more precise plant models for results to be accepted by the business area
  - Demand volatility would need to be taken into account (stochastic modeling)

- Setting of the “risk factor” must reflect your operational reality

- Electricity pricing options at adjacent production sites are often highly correlated – if not identical (that is, 2 plants on the same power contract) – thus limiting the effectiveness of this model
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