Energy Procurement Portfolios and Production Planning

Enterprise-wide Optimization
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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

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Model

$$\min \quad \sum_{h\in\mathcal{H}}\sum_{p\in\mathcal{P}}(c_{f,p}P_{h,f,p} + c_s P_{h,s,p} + K_{h,p}) + \qquad (1)$$

$$\sum_{p\in\mathcal{P}}\Big(\sum_{h\in\mathcal{H}_1} c^1_{b,p}P_{h,b,p} + \sum_{h\in\mathcal{H}_2} c^2_b P_{h,b}\Big) + \qquad (2)$$

$$\sum_{p\in\mathcal{P}}\alpha \sum_{h_1\in\mathcal{H}}\sum_{h_2\in\mathcal{H}} P_{h_1,s,p}[V^{s,p}]_{h_1,h_2}P_{h_2,s,p} + \qquad (3)$$

$$\sum_{p\in\mathcal{P}}\sum_{a\in\mathcal{A}} x_{a,p}dc_{a,p} \qquad (4)$$

s.t.

$$\forall h\in\mathcal{H}, a\in\mathcal{A}, p\in\mathcal{P} \qquad P_{h,a,p} \le Mx_{a,p} \qquad (5)$$

$$\forall h\in\mathcal{H}, p\in\mathcal{P} \qquad \sum_{a\in\mathcal{A}} P_{h,a,p} = P^u_{h,p} \qquad (6)$$

$$\forall d\in\mathcal{D}, p\in\mathcal{P}, g\in\mathcal{G} \qquad inv_{d,p,g} = inv_{d-1,p,g} + \textstyle\sum_{t\in\mathcal{T}}\eta(P^u_{h,p}) - dem_{d,p,g} \qquad (7)$$

$$p\in\mathcal{P} \qquad \sum_{a\in\mathcal{A}} x_{a,p} \le 1 \qquad (8)$$

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Model formulation

Model

$$K_{h,p} = \begin{cases} c^2_{q,p} P^q_{h,p} & \text{if } y_{h,p} = 1 \\ c^1_{q,p} P^q_{h,p} & \text{o.w.} \end{cases}$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad \sum_{\substack{\hat{h} \in \mathcal{H} \\ \hat{h} \leq h}} P_{\hat{h},q,p} - qlimit \leq M y_{h,p} \qquad (9)$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad M + K_{h,p} \geq c^2_{q,p} P_{h,q,p} + M y_{h,p} \qquad (10)$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad M y_{h,p} + K_{h,p} \leq c^2_{q,p} P_{h,q,p} + M \qquad (11)$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad M + K_{h,p} \geq c^1_{q,p} P_{h,q,p} + M(1 - y_{h,p}) \qquad (12)$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad M(1 - y_{h,p}) + K_{h,p} \leq c^1_{q,p} P_{h,q,p} + M \qquad (13)$$

$$\forall h \in \mathcal{H}, p \in \mathcal{P} \qquad y_{h,p} \geq y_{h-1,p} \qquad (14)$$

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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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