Residual Demand Based Competitive Analysis: an example

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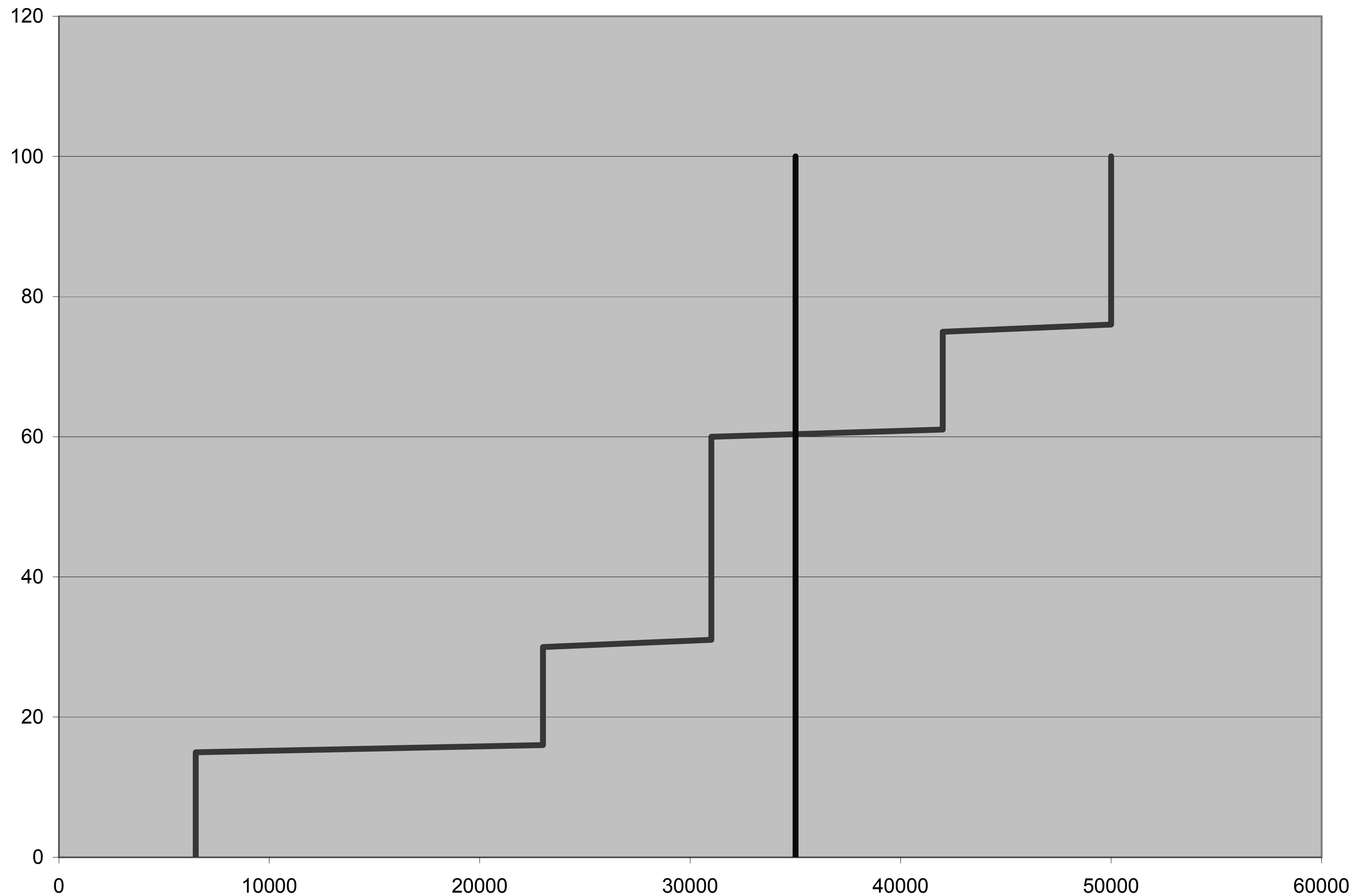
MSC

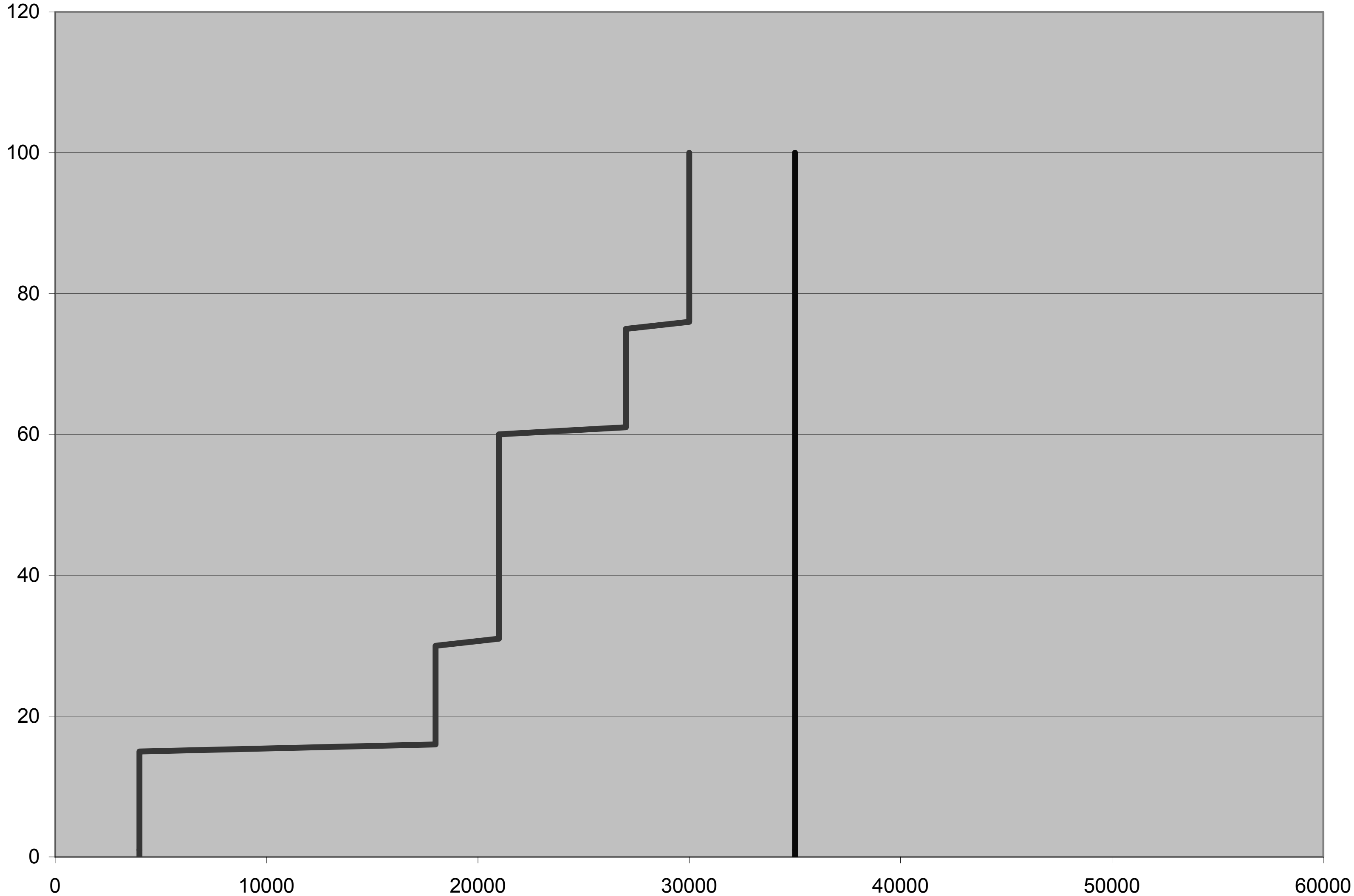
Market Structure

	Capacity with costs at or below					Native Demand
	$15/MWh	$30/MWh	$45/MWh	$60/MWh	$75/MWh	
Firm A	500	1000	2000	3000	4000	
Firm B	500	1000	2000	3000	4000	
Firm C	500	1000	2000	3000	4000	
Firm D	500	1000	2000	3000	4000	
Firm E	500	1000	2000	3000	4000	
Small Instate	4000	8000	9000	9000	10000	
Import	10000	20000	22000	28000	30000	10000
Total	0	33000	41000	52000	60000	35000

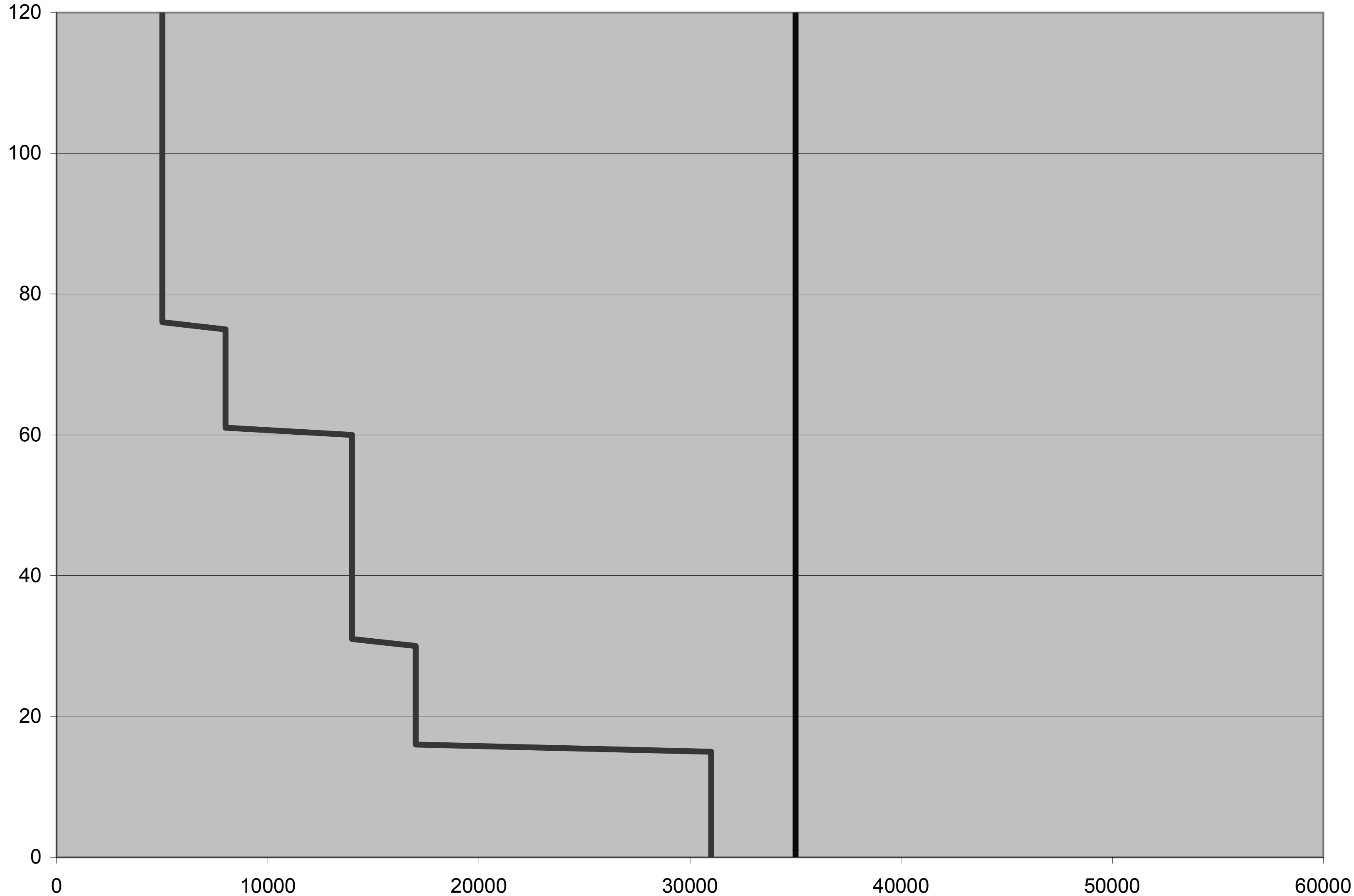
Total Supply



Competitive "Fringe" Supply



Inverse Residual Demand



Cournot Firms Maximize Profits

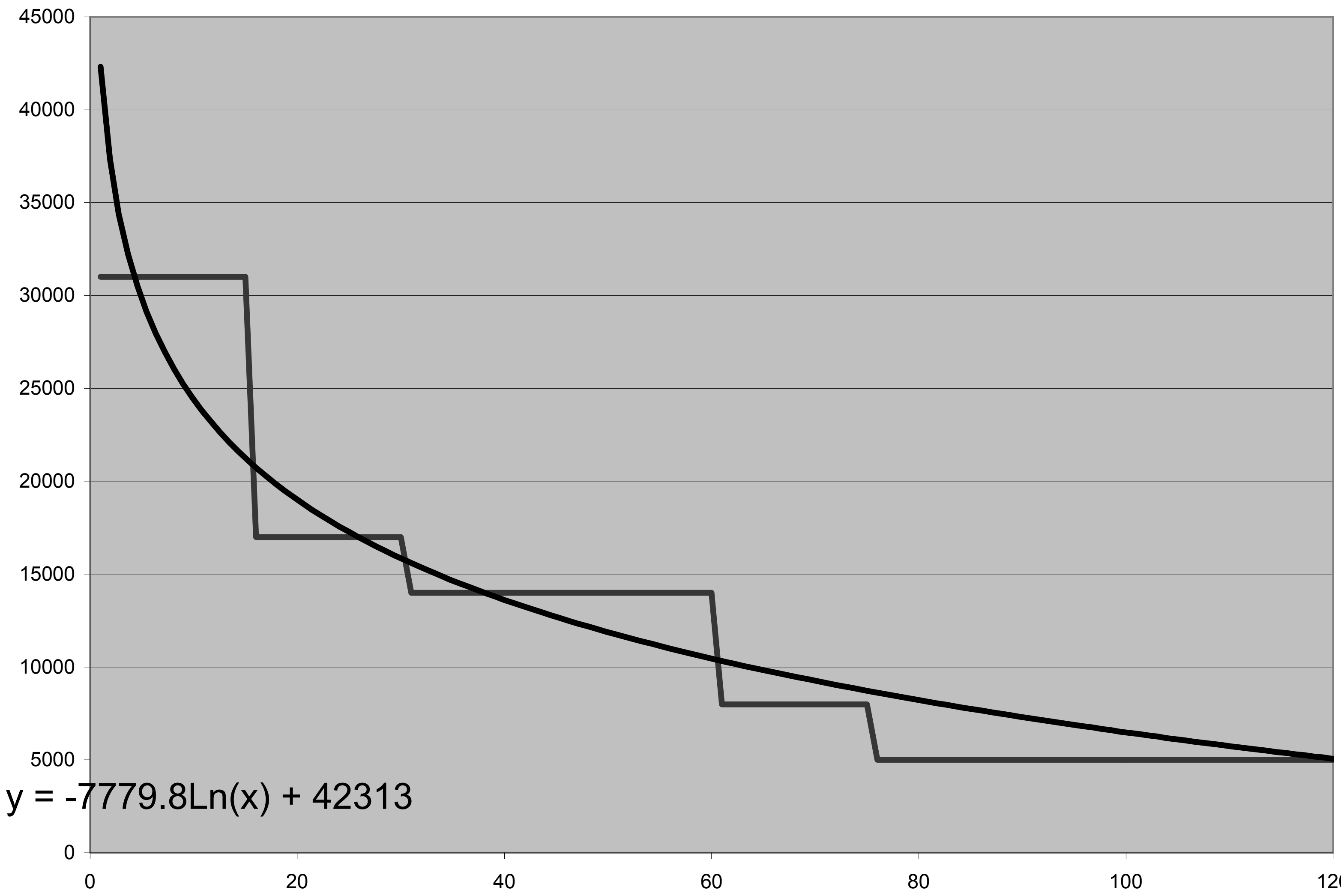
- Solve first order conditions for profit maximization – taking into account contracts and retail obligations

$$\frac{\partial \pi_{i,t}}{\partial q_{i,t}} = p_t^w(q_{i,t}, q_{-i,t}) + [q_{i,t} - q_{i,t}^r] \cdot \frac{\partial p_t^w}{\partial q_{i,t}} - C_{i,t}'(q_{i,t}) \geq 0.$$

Solution Options

- Iterative grid search
  - each firm iteratively searches for best Q given Q's of other firms. Repeat until convergence
    - deals well with discontinuities like steps in the residual demand function
    - may not converge – possibly multiple equilibria
- Analytic solution
  - Simultaneously solve FOC for each Cournot firm
    - should yield unique solution
    - can accommodate optimal hydro scheduling
    - requires a fit of smooth function to fringe supply curve

Residual Demand



- market demand $Q_t = a_t - b\ln(p_t)$,
- $a = 42313, b = 7779.8$
- or inverse $p_t = \exp((a_t - Q_t)/b)$.
- $q_i^{Th,j}$ is thermal production of type j from firm i
- unit type j has marginal cost $c(q_i^{Th,j}) = K_i^j$
- and capacity $q_{i,\max}^{Th,j}$

Equilibrium Conditions

$$\begin{aligned}
\text{For } q_{it}^{Th,j}, \forall i \quad &\neq \quad f, j, t : \\
0 \quad &\geq \quad \left(1 - \frac{(q_{it} - q_{it}^r)}{b_t}\right) e^{\left(\frac{a_t - \sum_l q_{lt}}{b_t}\right)} - K_i^j - \psi_{it}^j \perp q_{it}^{Th} \geq 0 \ ;
\end{aligned} \tag{A1}$$

For $\psi_{it}^j, \forall i, j, t : \qquad 0 \leq \ \psi_{it}^j \ \perp \ q_{it}^{Th,j} \leq q_{it,\max}^{Th,j}$;

Solutions for example

- Perfect competition
  - price = \$30.00, qi = 3170
- Cournot with no contracts
  - price = \$44.64, qi = 2552
- Cournot with contract qc = 2000 for each Cournot firm
  - price = \$34.25, qi = 2999

Other Issues

- Threshold mark-up levels
  - should be higher than for benchmark studies
  - can examine uncertainty from the “fit” of the import curve – develop confidence intervals
  - Price cap level may effect average mark-up
- Treatment of energy limited
  - can optimize or “peak shave”
- Treatment of derivative contracts