Minimal Thermal Generation in Power Systems

Inferring Private Cost Parameters from Observed Firm Behavior

Lion Hirth | hirth@neon-energie.de

Strommarkttreffen TechTalk | 20 Feb 2015

neon neue energieökonomik

Merit-order dispatch vs. must-run constraints

Merit-order dispatch

- power plants bid variable costs
- produce if price > variable costs (positive margin)
- do not produce otherwise

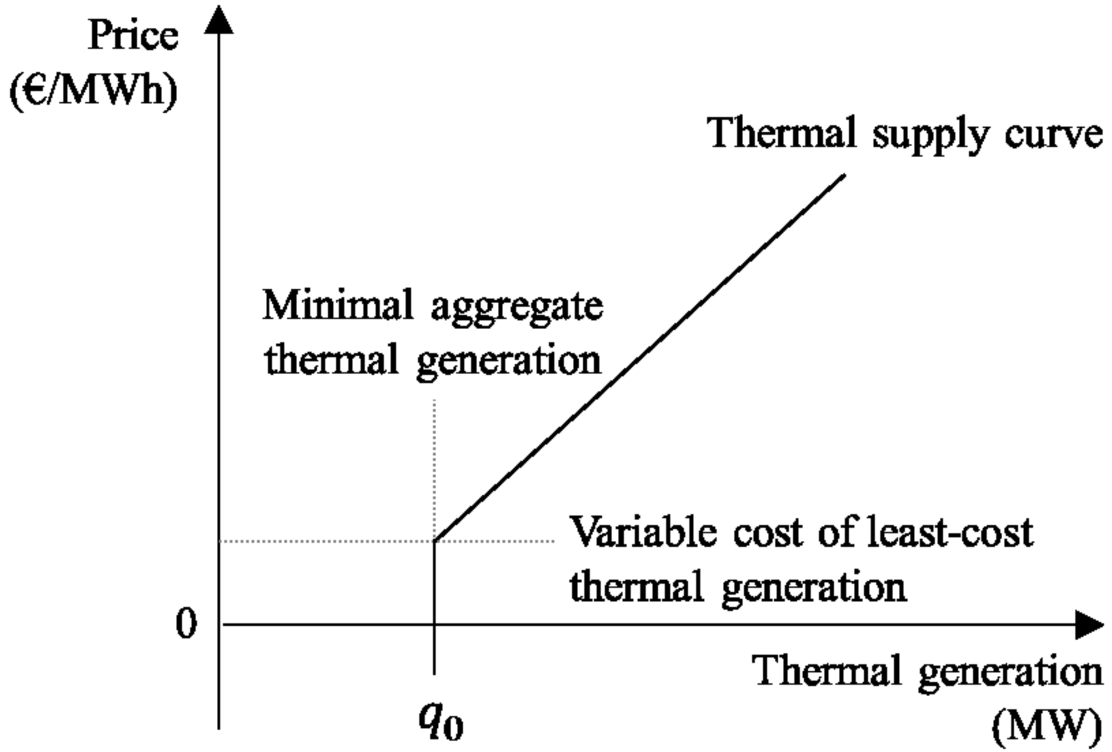
This is inaccurate

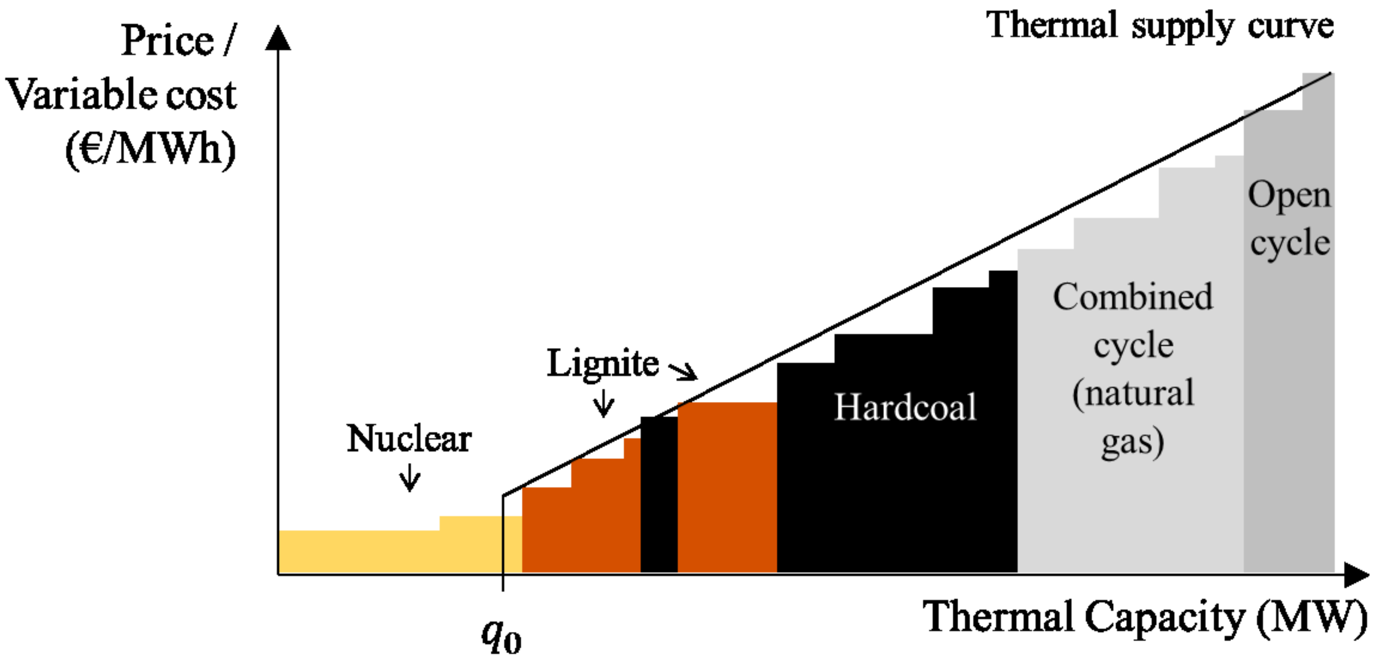
- high price levels: scarcity pricing, exercise of market power
- low price leves: must-run constraints

"Must-run constraints"

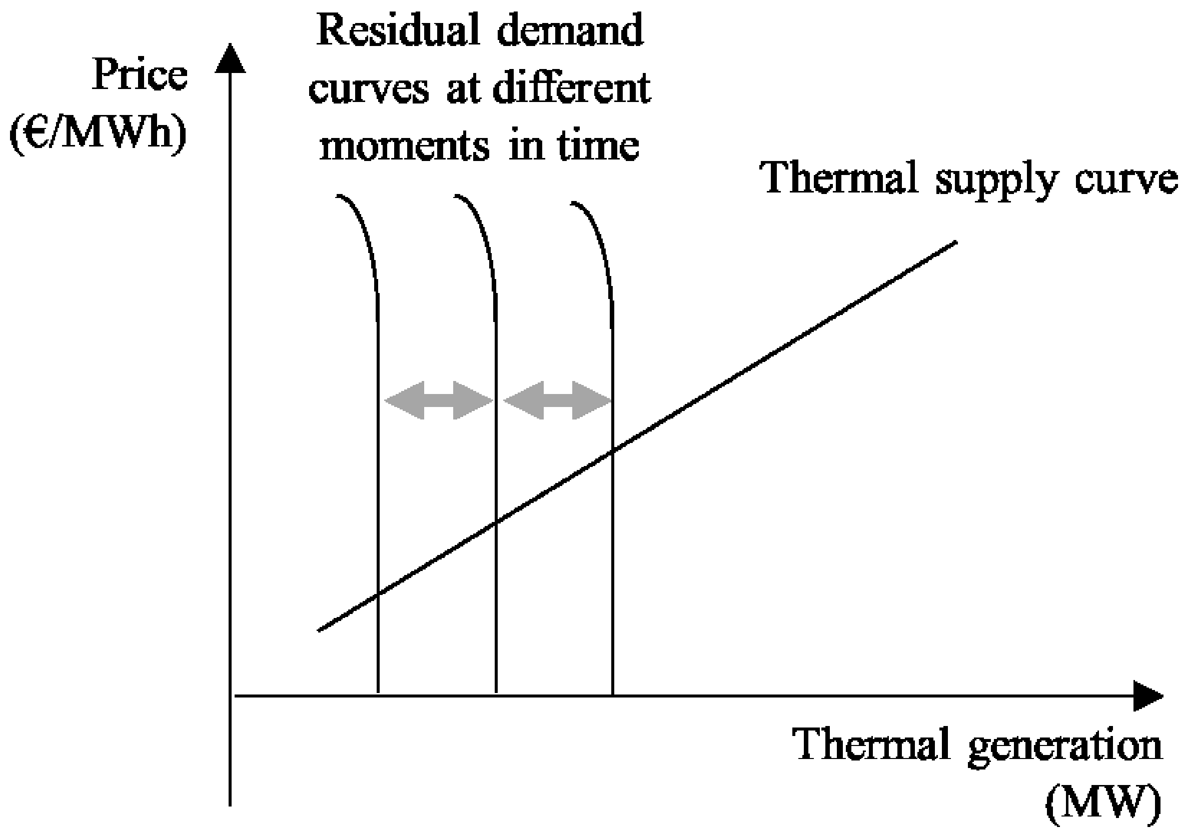
- Def: anything that makes power plants produce at negative
- ("inflexibility")
- co-generation (heat or ancillary services)
- dynamic constraints (unit commitment problem)
- at the level of a single plant, these issues are well understood

→ *what is the minimal level of thermal generation in a large real-world power system?*


Price
(€/MWh)
Thermal supply curve
Minimal aggregate
thermal generation
Variable cost of least-cost
thermal generation
0
Thermal generation
(MW)
q_0


Price /
Variable cost
(€/MWh)
Thermal supply curve
Open
cycle
Combined
cycle
(natural
gas)
Hardcoal
Lignite
Nuclear
q_0
Thermal Capacity (MW)

The classical identification problem – solved?



Data

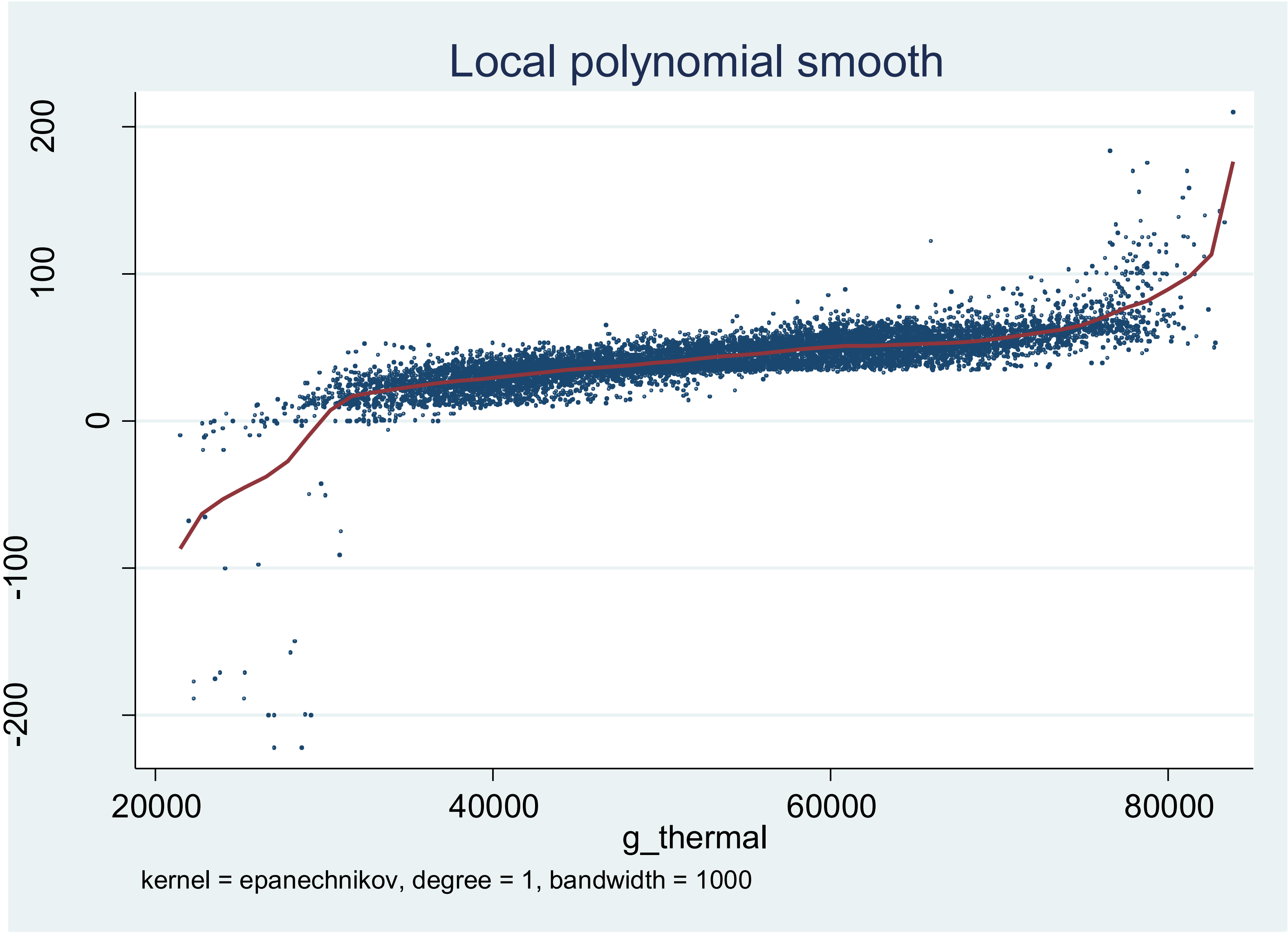
Table 1: Number of hours with low or negative day-ahead prices in Germany.

2006	59
2007	110
2008	97
2009	188
2010	68
2011	35
2012	93
2013	126
2014	132

Thermal generation cannot be observed direclty

$$g_t^{thermal} \approx \hat{l}_t \ \cdot \varphi^l + x_t \ - g_t^{wind} \cdot \varphi^{wind} - g_t^{solar} - 11\,GW - \hat{n}_t^{ps}$$

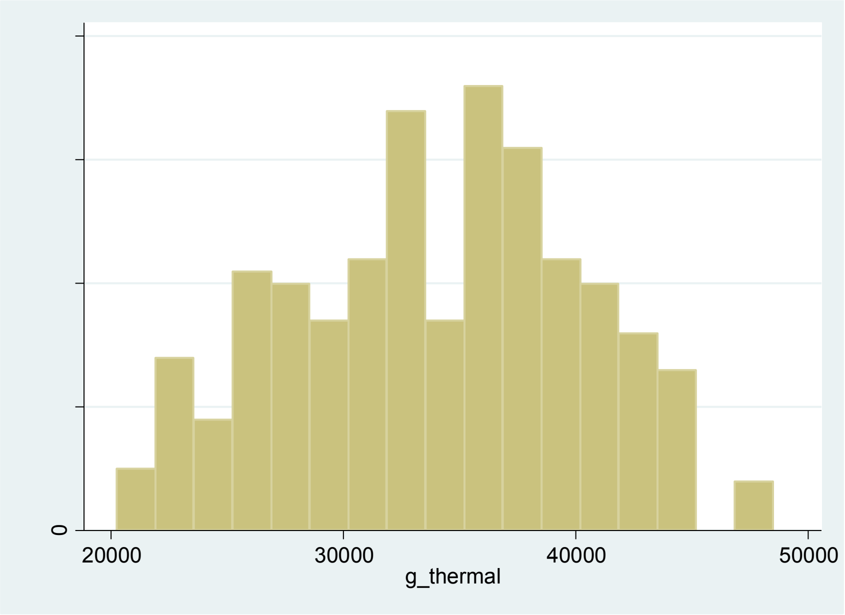
- scaling of load (→ Maximilian)
- scaling of wind generation (→ yearly scaling factor)
- biomass, hydro generation (→ assumed to be base load)
- pumped hydro dispatch (→ at low/negative prices, 2/3 assumed to be pumping)


Local polynomial smooth
200
100
0
-100
-200
20000
40000
60000
80000
g_thermal
kernel = epanechnikov, degree = 1, bandwidth = 1000

Min gen (q_0) level: 34 GW – but significant variation

Table 3: Descriptive statistics of low price events

	Mean
Obs	301 (1.2% of sample)
Price	-16 €/MWh
Load	55 GW
Wind generation	17 GW
Solar generation	3 GW
Net exports	6 GW
Pumped hydro generation	- 4 GW
Thermal generation	34 GW



Point estimate for minimal thermal generation: 34 GW.

$$g_t^{thermal} = \beta_0 + \beta_1 \cdot Winter + \beta_2 \cdot Peak + \beta_3 \cdot Year + \varepsilon_t$$

Table 4: Regression results.

Model	(1)	(2)
Estimator	OLS	OLS
Obs	301	301
Dependent variable	q_0	q_0
Winter	2.8***	2.4***
Peak period	7.1***	5.2***
Winter * Peak period	- 2.5	1.8
2013	5.7***	5.6***
2014	11.9***	11.9***
Duration	-	-0.45***
Constant	26.1***	29.1***
Adjusted R^2	0.48	0.54

Asterisks denote significance at *10%, **5%, and ***1% level.

Findings

- during times of negative margins, on average 34 GW of thermal capacity kept producing
- apparently significant inflexibility! ("must-run constraints")
- large variation in this level – sometimes generation was reduced to 20 GW, sometimes operators kept 49 GW online despite making losses
- higher in winter (CHP?), higher in peak times
- longer duration of periods of negative margins led to lower levels of thermal generation
- we expected learning – but thermal minimal generation levels *increased* 2012 – 2014

Minimal Thermal Generation in Power Systems

Inferring Private Cost Parameters from Observed Firm Behavior

hirth@neon-energie.de

USAEE Working Paper No. 15-203