LIBEMOD

Rolf Golombek

CREE - CenSES Modelforum

October 24, 2013

Stiftelsen Frischsenteret for samfunnsøkonomisk forskning

Ragnar Frisch Centre for Economic Research

www.frisch.uio.no

LIBEMOD

- Equilibrium model for energy markets in (Western) Europe
- Application of standard economic theory
- Private agents vs. governments
- Model variants
  - Time horizon
  - Market structure
  - Deterministic vs. stochastic
- Applications
  - Energy market liberalizations
  - Environmental and energy policy
  - New technology CCS

Frischsenteret

LIBEMOD - references

- Aune, Golombek, Kittelsen and Rosendahl (2004): Liberalising the Energy Markets of Western Europe.
- Aune, Golombek and Kittelsen (2004): Does Increased Extraction of Natural Gas Reduce Carbon Emissions?
- Aune, Golombek, Kittelsen and Rosendahl (2008): *Liberalizing European Energy Markets - An Economic Analysis*.
- Golombek, Greaker, Kittelsen, Røgeberg and Aune (2011): Carbon capture and storage in the European power market.
- Golombek, Kittelsen and Haddeland (2012): Climate change: Impacts on electricity markets in Western Europe.
- Golombek, Brekke and Kittelsen (2013): Is electricity more important than natural gas? Partial liberalizations of the WE energy markets.
- More to come...

Frischsenteret

LIBEMOD – basic structure

- Energy goods
  - Coal (3), gas, oil, bio (2), electricity
- Agents
  - Producers of energy
  - End users of energy
  - Traders
  - Governments
- Countries – model country vs. ex. country/region
- Markets
  - World
  - European
  - Domestic
- Determination of "all" quantites and prices in Europe and global CO2 emissions.

Frischsenteret

LIBEMOD – basic structure, cont.

- Supply
  - Extraction/production of fossil fuels and bio energy (1 time period)
  - Production of electricity (several technologies, 4 time periods)
- Demand
  - Nested CES 5 levels (households, service, industri, transport)
  - Power plants
- Transport - nodes
  - International (capacity)
  - Domestic (differentiated user cost)

Frischsenteret

LIBEMOD – basic structure, cont.

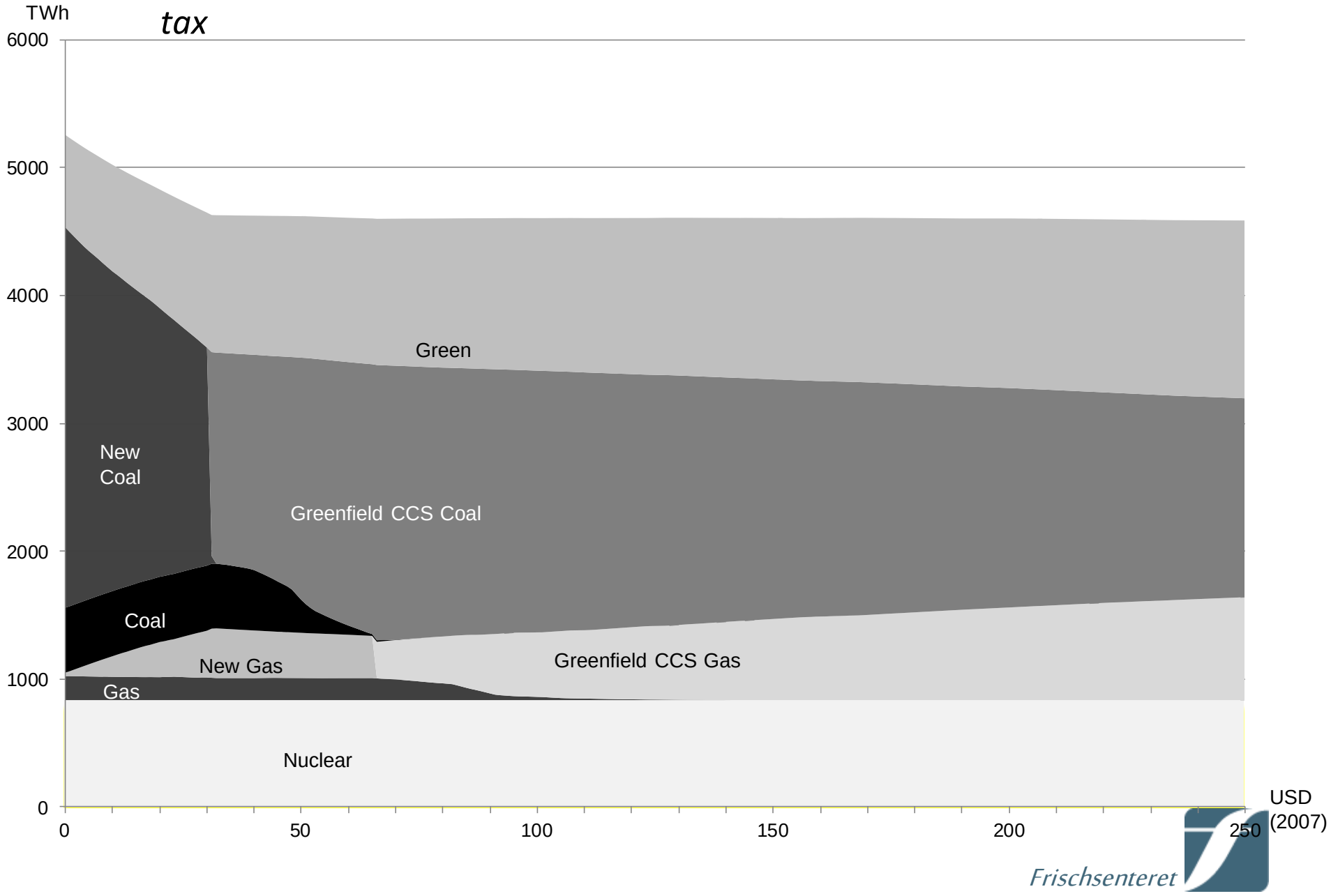
- Short run: All capacities are given
- Long run: Expand capacities if profitable
  - New power plants
  - New international pipes/electricity lines
  - Depreciation

Carbon Capture and Storage (CCS)

- End-of-pipe solution to remove most of the carbon
- Huge investments are required
- Operation of CCS is very energy demanding
- Greenfield vs. retrofitting
- Install/build gas/coal power plants with CCS only if profitable
  - Requires price on carbon emissions or investment subsidies
- What is the market potential for CCS in WE in 2030?

Frischsenteret

Powerproduction in Europe 2030 by technology as function of Carbon tax



Frischsenteret

Energy market liberalization

- Energy industry in WE: has typically been lots of "imperfections"
- Liberalization efforts – nationally
- EU liberalization efforts
  - Attempts to establish internal energy markets from late 80'ies
  - Several directives have been passed
  - Partial and incremental changes so far
    - Still much market power in the gas industry and end-user price regulations
- Future liberalization efforts may meet resistance
  - Industry interests, energy security concerns, etc.
- What types of liberalization yield large increases in welfare?

Assessing the extent of market imperfections

- Basic idea: observe that price exceeds marginal cost – reflects degree of "market imperfections"
- Let data and LIBEMOD determine degree of market imperfections
- Distinction between
  - Electricity vs. natural gas
  - Domestic markets vs. EU trade
  - Production vs. retail
- Deviation parameter
  - Electricity production ("tax" - conjectural variation)
  - Retail (electricity and natural gas)

Frischsenteret

Partial liberalizations in WE

Results for 2000

- Average electricity deviaton parameter corresponds to roughly 25 percent of the average producer price of electricity

- Average retail parameters relative to average end-user prices (%)

	Household	Industry	Gas power
Electricity	34	8	
Natural gas	15	12	16

- Much strong redistribution effects from liberalizing domestic electricity markets than from domestic natural gas markets
- Much stronger redistribution effects from EU gas trade than from EU electricity trade

Frischsenteret

LIBEMOD - Supply of electricity

- Technologies
  - Steam coal, brown coal, natural gas, oil, nuclear, reservoir hydro, run-of-river, pump hydro, wind, solar
  - Distribution of efficiency parameters
  - New technolgoies – efficiency (thermal) and location (RE)
- Cost components
  - fuel
  - other operating
  - maintained capacity
  - start-up
  - investment

Frischsenteret

Supply of electricity, cont.

- General technology restrictions
  - Production cannot exceed maintained capacity
  - Maintained capacity used to electricity production or to sold as reserve power capacity
  - Required downtime for maintenance
  - Start up capacity relative to instantaneous production
- Specific technology restrictions – reservoir hydro
  - Capacity of reservoir
  - Use of water cannot exceed availability of water
- Specific technology restrictions – other renewables
  - Access to land
- Max profits s.t. restrictions

Wind power

- Best wind sites used first
- Production in period t: $\bar{\psi}_t \, f(K^{PM}) K^{PM}$
- The f-function is decreasing
- Costs of investment: $c^{inv} K^{inv}$

Frischsenteret

Solar power

- Actual capacity in a year: $K = k\,\Omega = \frac{1}{7}\Omega$

- Max capacity in a year: $\hat{K} = k\,\hat{\Omega}$
- Efficient annual solar hours: z
- Annual production of solar: $zK \equiv \bar{\Theta}\bar{\Omega}\Omega$
- Production in period t: $\bar{\psi}_t\, zK$.
- Sites differ – best sites always used first: $z = z(\frac{K}{\hat{K}})$
- The z-function is decreasing

Frischsenteret