02 Measuring Energy

Václav Šebek

Measuring Energy

- Literature:
  - Bhattacharyya, S.C., 2011. *Energy Economics: Concepts, Issues, Markets and Governance*. Springer London, London.
  - Chapters 2 and 13

Energy

- Heat, light, motive force, chemical transformation etc.
- 2 thermodynamic laws
  - Mass and energy cannot vanish but transform
  - No 100% conversion – losses inevitable
- Primary x Secondary energy
  - Primary – directly from nature (oil, coal, wind, sun, nuclear…)
  - Secondary – derived from Primaries (electricity, gasoline…)

Energy

- Other divisions (boundaries change)
  - Renewable x Non-Renewable
  - Commerical x Non-Commercial
  - Modern x Traditional
  - Conventional x Non-Conventional

Energy System

- Supply – Conversion – Consumption
- Extraction → PES → Transport → Final Energy → End use app → Useful energy
- Losses
- Energy corporations all through the system → wide variety of companies

Energy Information

- Broadly required data:
  - Energy use by various economic activities
  - E production, transformation and delivery to various users
  - „Field“ technical and operating statistics
  - Financial and cost information
  - Macro-economic, social, political information

Energy Information

- Transorm into information about energy…
  - Pricing
  - Investment
  - Research & Development
  - System Management
  - Contingency Plan
  - Long-term Planning

Energy Accounting Framework

- Comprehensive account of energy flows including losses and any consumption
- See table
  - Production – transformation – consumption

- Accounting units
  - Commodity (physical, tonnes, barrels…)
  - Overal **Energy** Balance (common unit, eg BTU, GJ, TOE…) – easier comparison

Energy Accounting Framework

Supply-side
Production (+)
Trade (import/export) (+/-)
Bunkers (transport costs, e.g. Tankers) (-)
Stock change (+/-)
Primary energy requirement (PER)

Conversion
Statistical difference (+/-)
Transformation input (-)
Energy sectors‘ own use (-)
Transmission and Distribution losses (-)
Net supply available

Net domestic consumption
Final energy consumption
↘ Agriculture
↘ Industry
↘ Transport
↘ Residential
↘ Commercial
↘ Non-energy uses

- Total energy needed to satisfy country’s demand and transformation requirements
- Primary need (shown in TPES)
- Efficiency indicator
- Sectorial situation may be analyzed

Energy Accounting Units - Example

Tab – A lignite surface mine yearly consumption decomposition

Consumer	TJ	kt	GJ/t	Share			
				TJ	kt	ktce	ktoe
PP Chvaletice	16 631	978	17,00	32%	33%	567	397
Refinery Litvínov	7 072	530	13,35	14%	18%	241	169
HP Otrokovice	4 523	274	16,51	9%	9%	154	108
Paperworks Mondi Štětí	4 358	180	16,70	8%	6%	149	104
HP Strakonice, a.s.	1 754	112	15,66	3%	4%	60	42
HP Třinec	1 698	106	16,00	3%	4%	58	41
HP Poříčí	789	47	16,79	2%	2%	27	19
PP Hodonín	446	27	16,63	1%	1%	15	11
Export	6 640	332	20,00	13%	11%	227	159
Retail	8 360	418	20,00	16%	14%	285	200
Total/mean	**52 271**	**3 004**	**17,40**	**100%**	**100%**	**1 784**	**1 248**

All units above are scientific – commercial units (eg TCE) might be not

Lignite Surface Mine

Useful Ratios

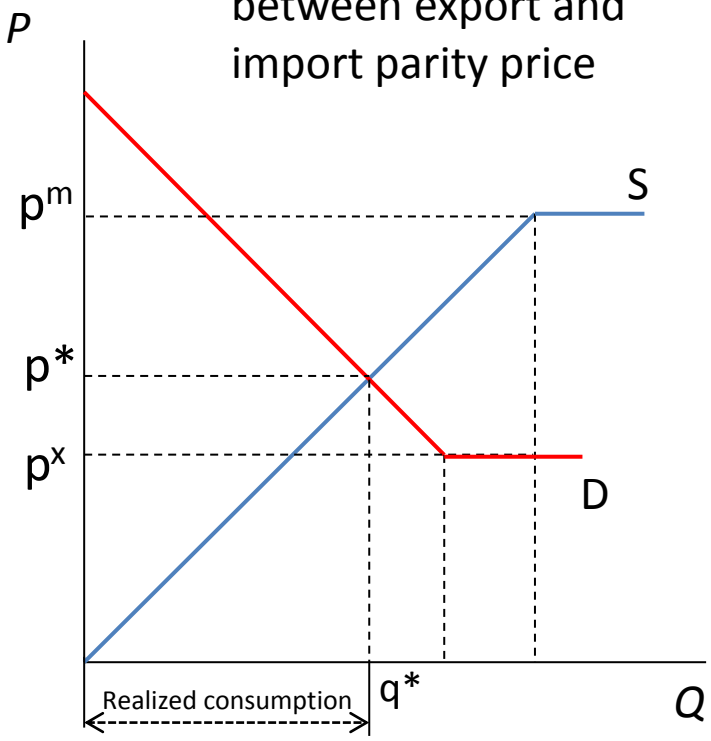
- Energy supply mix
  - Share of various sources on primary supply
- Self-reliance
  - What portion of energy is of domestic origin
- Share of renewables
- Power generation mix
- Efficiency
  - Electricity production
  - Refining
  - Overall
- Per capita consumption (primary and final)
- Energy intensity

Some energy data issues

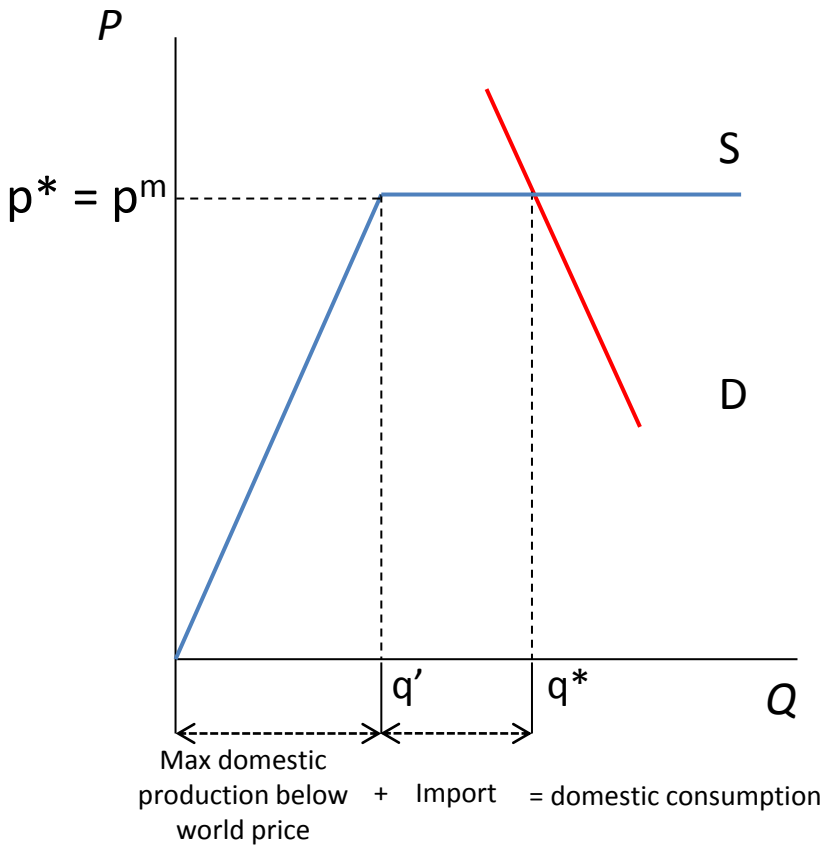
- Availabilty
  - lags, various sources, imprecision, confidentiality
- Quality
  - Different standards and methodologies, deliberate changes, trade and balance discrepancies
- Cross border comparison
  - Traditional fuels, terminologies, sectors definition, accounting
- Common measurment
- Conversion factors

Energy Pricing

a) Self-sufficient country
- Price set domestically between export and import parity price

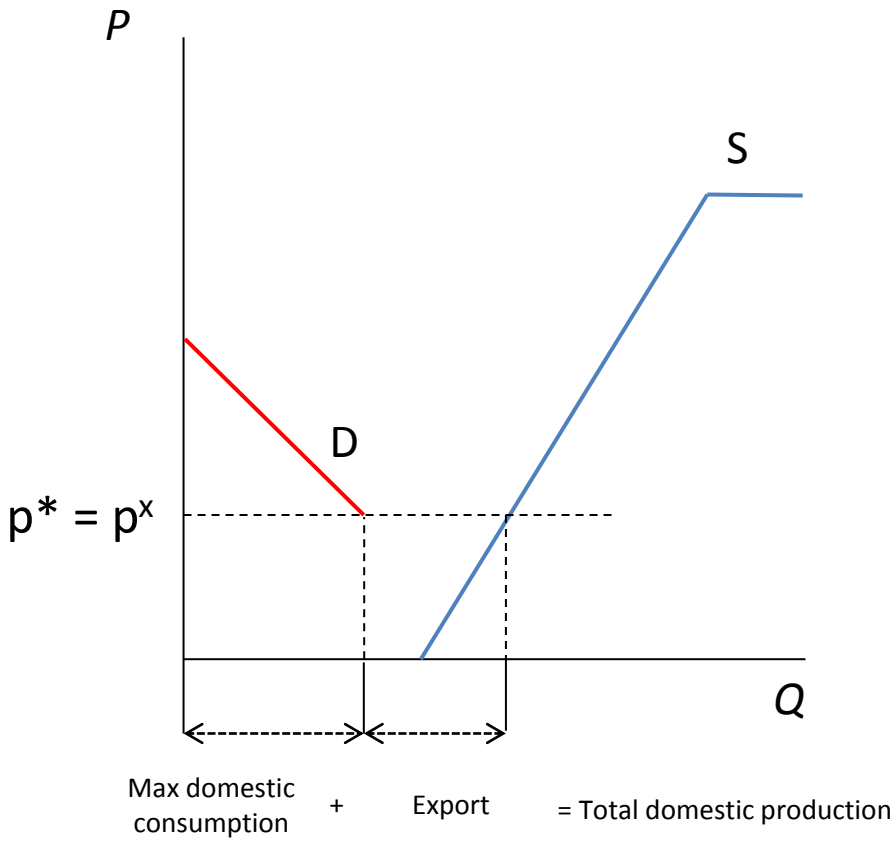


b) Importing country
- Import (world) price

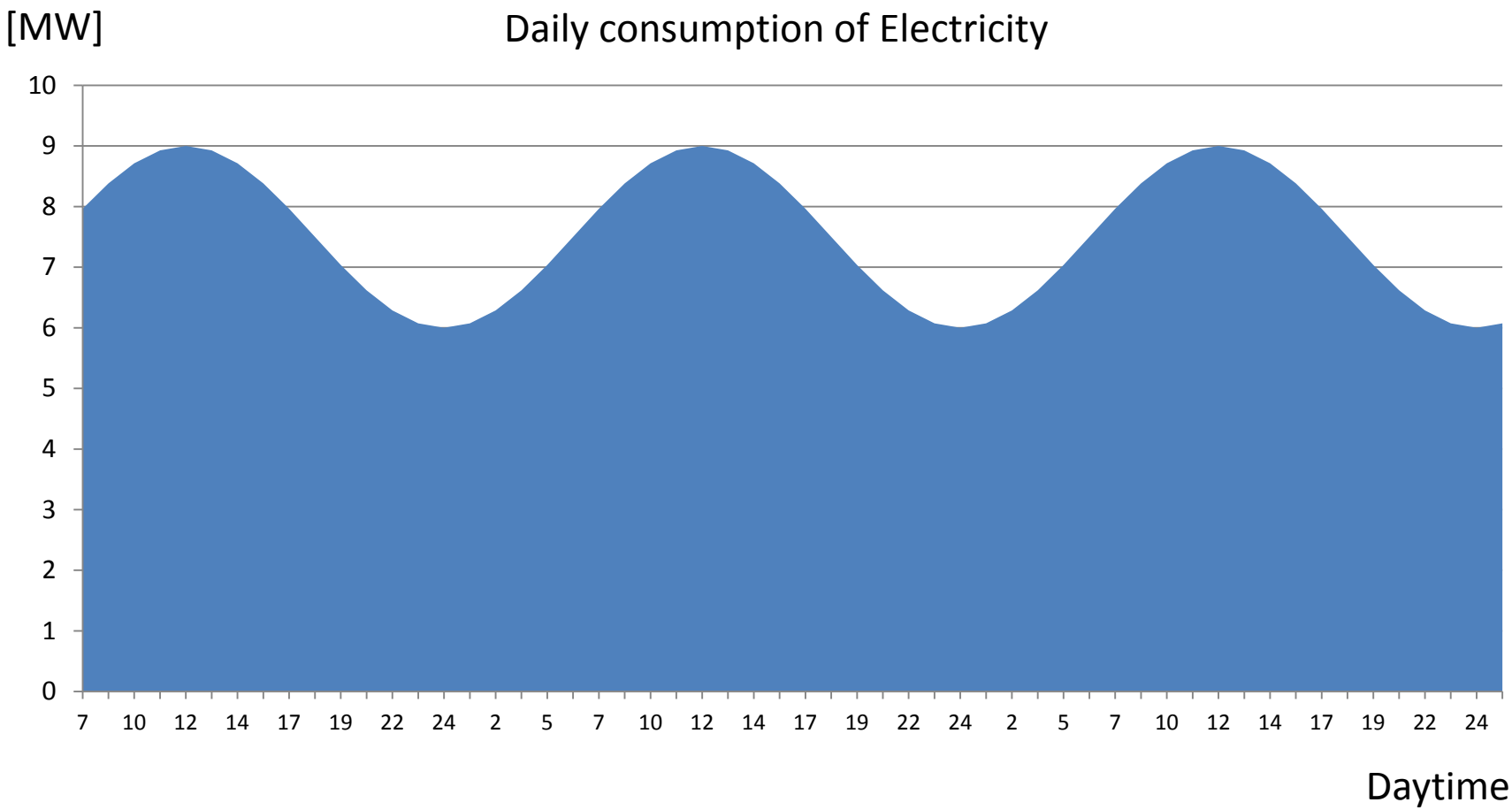


Energy Pricing

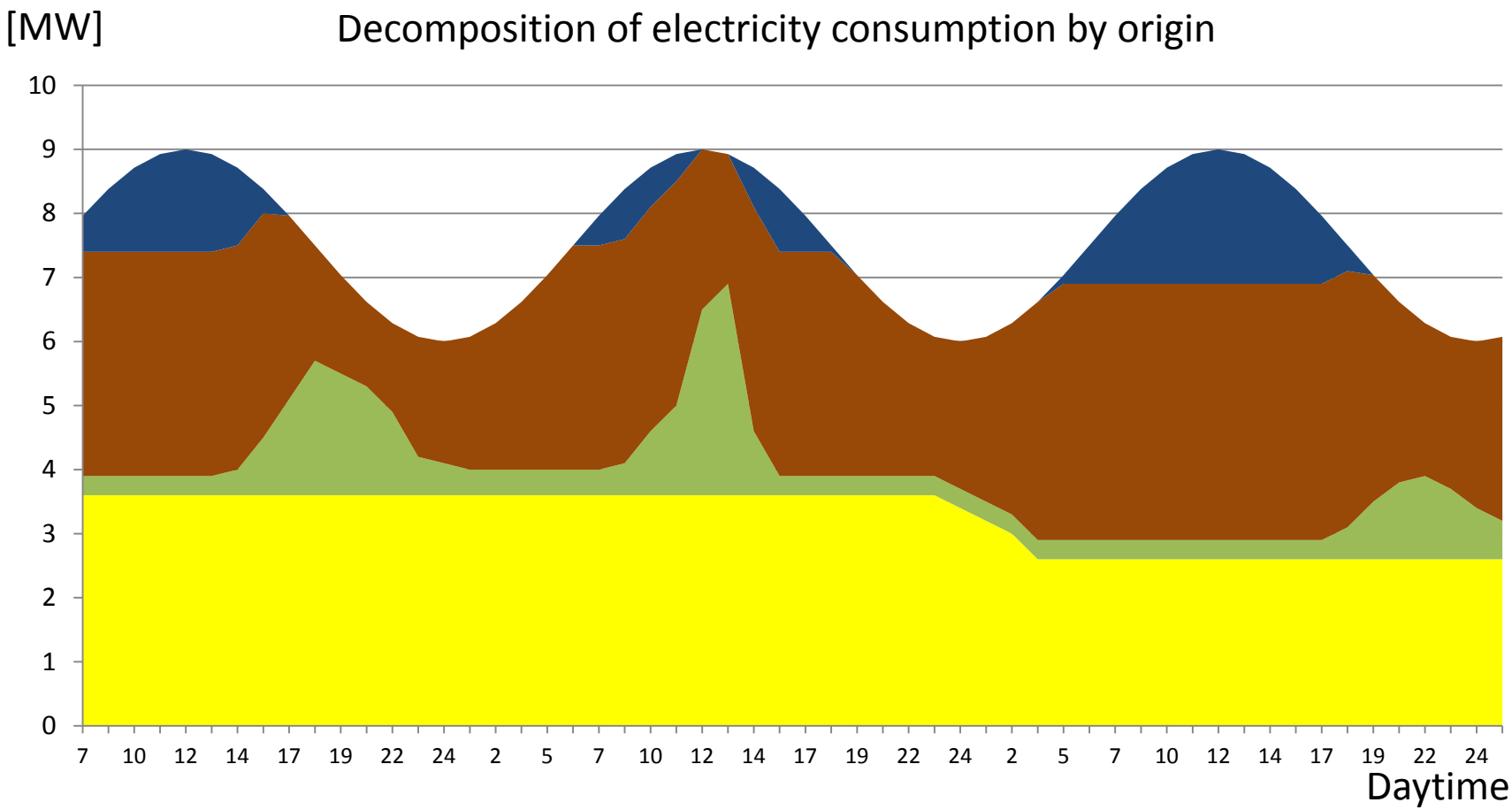
c) Net exporter
- Domestic demand satisfied below world price
- Equilibrium price should be that of world price
- In reality domestic prices of oil exporters significantly lower due subsidies



Peak and Off-Peak Pricing

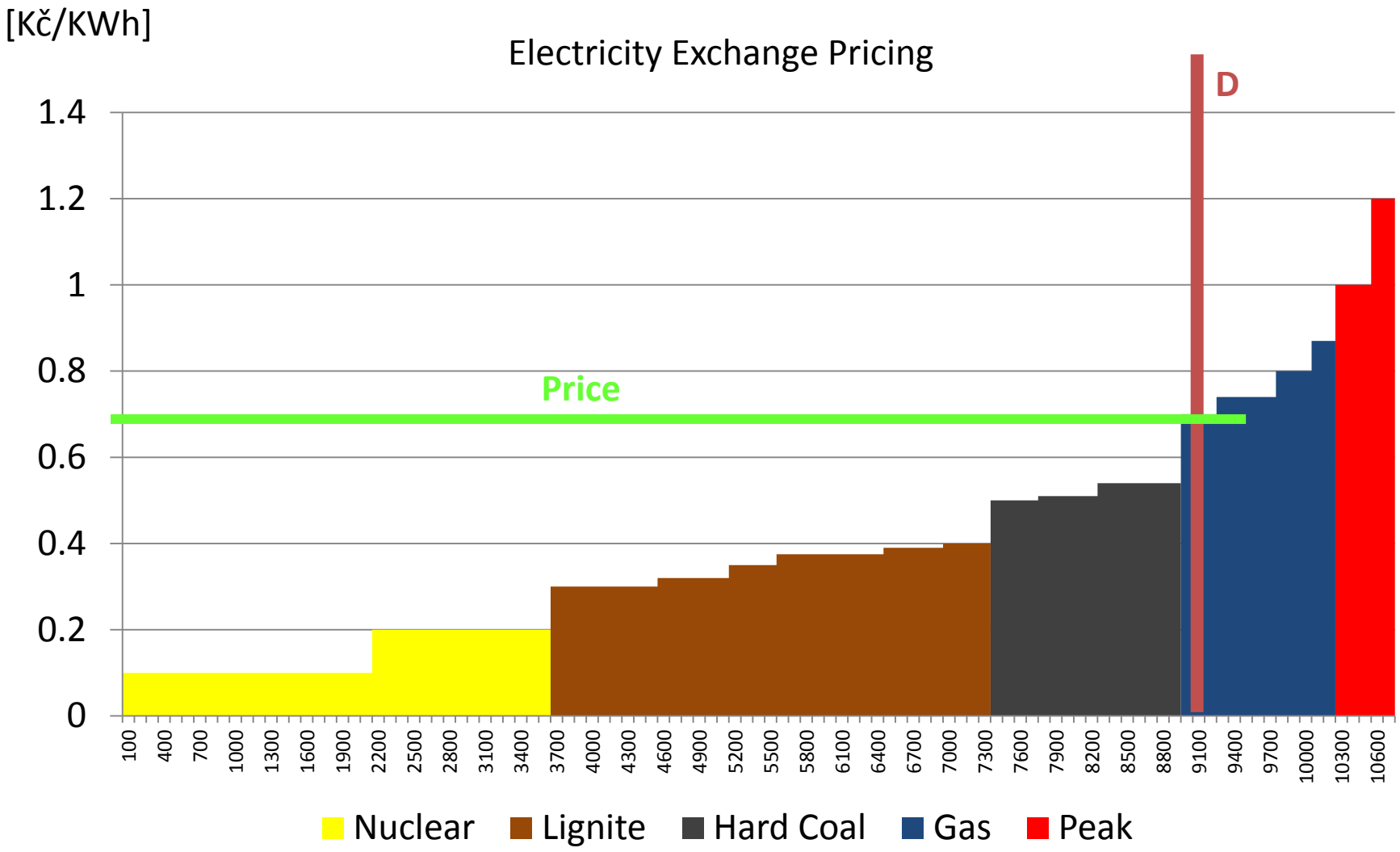


Peak and Off-Peak Pricing

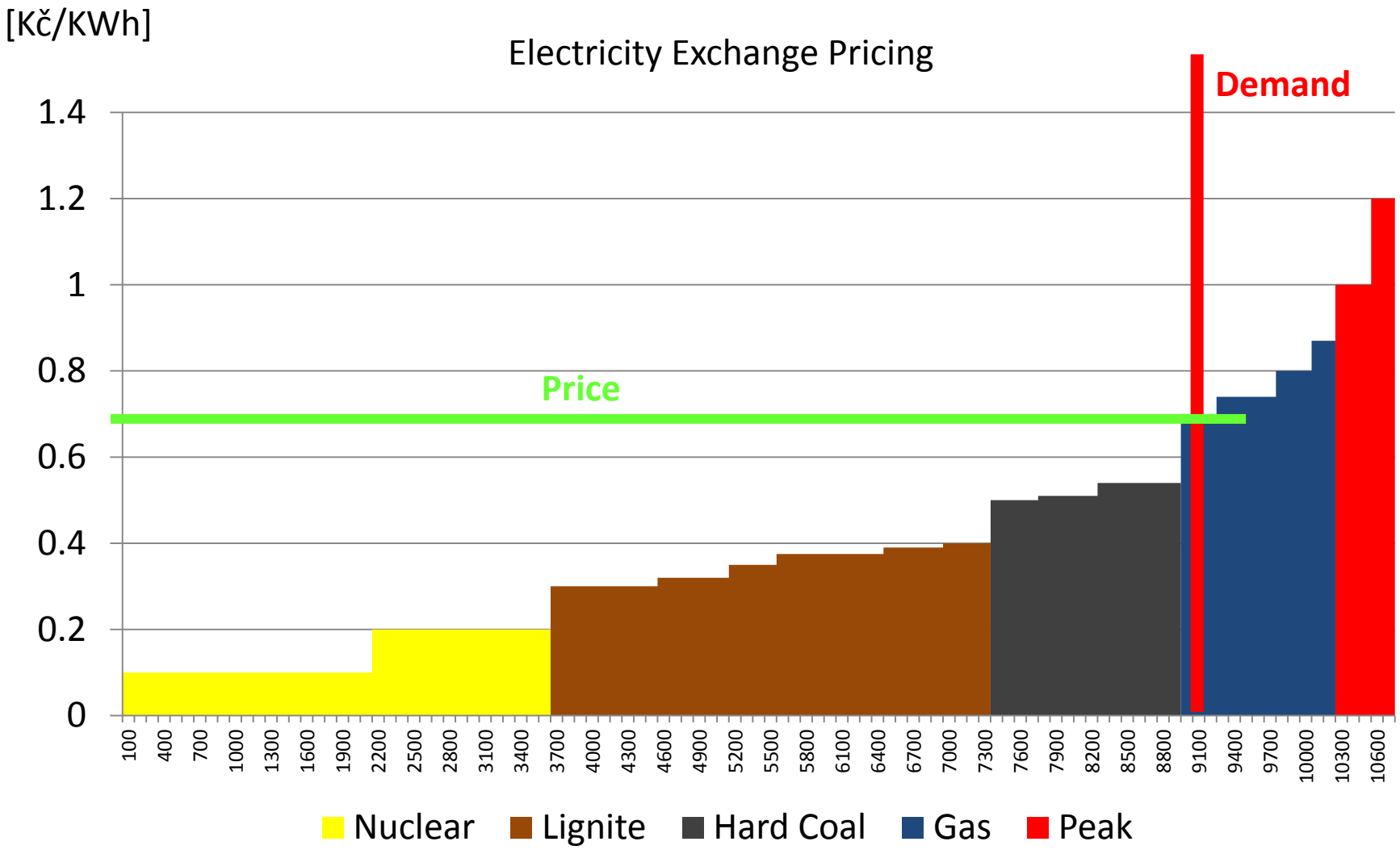


Nuclear (yellow) – Renewables (green) – Coal (brown) – Peak gas (blue)

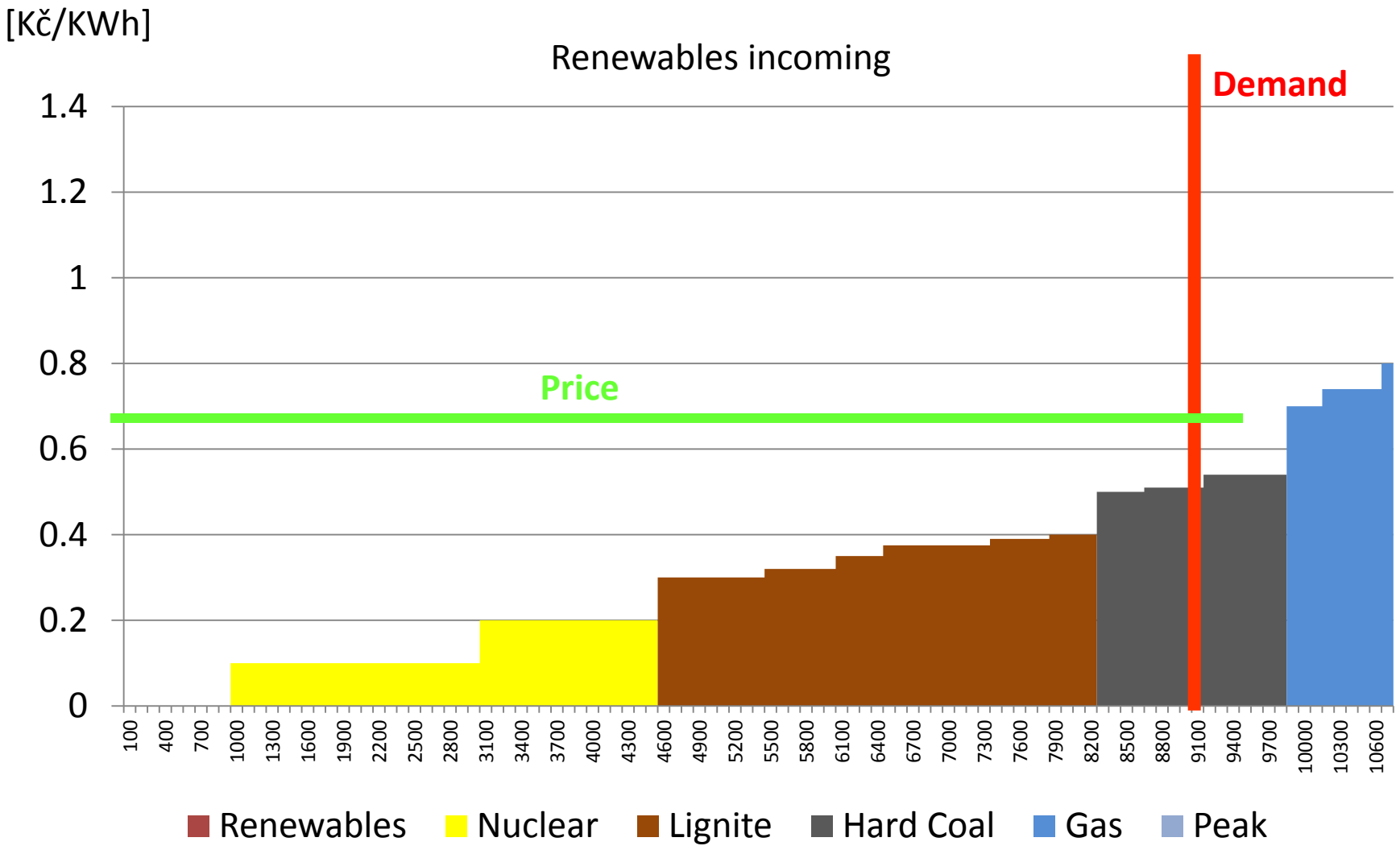
Peak and Off-Peak Pricing



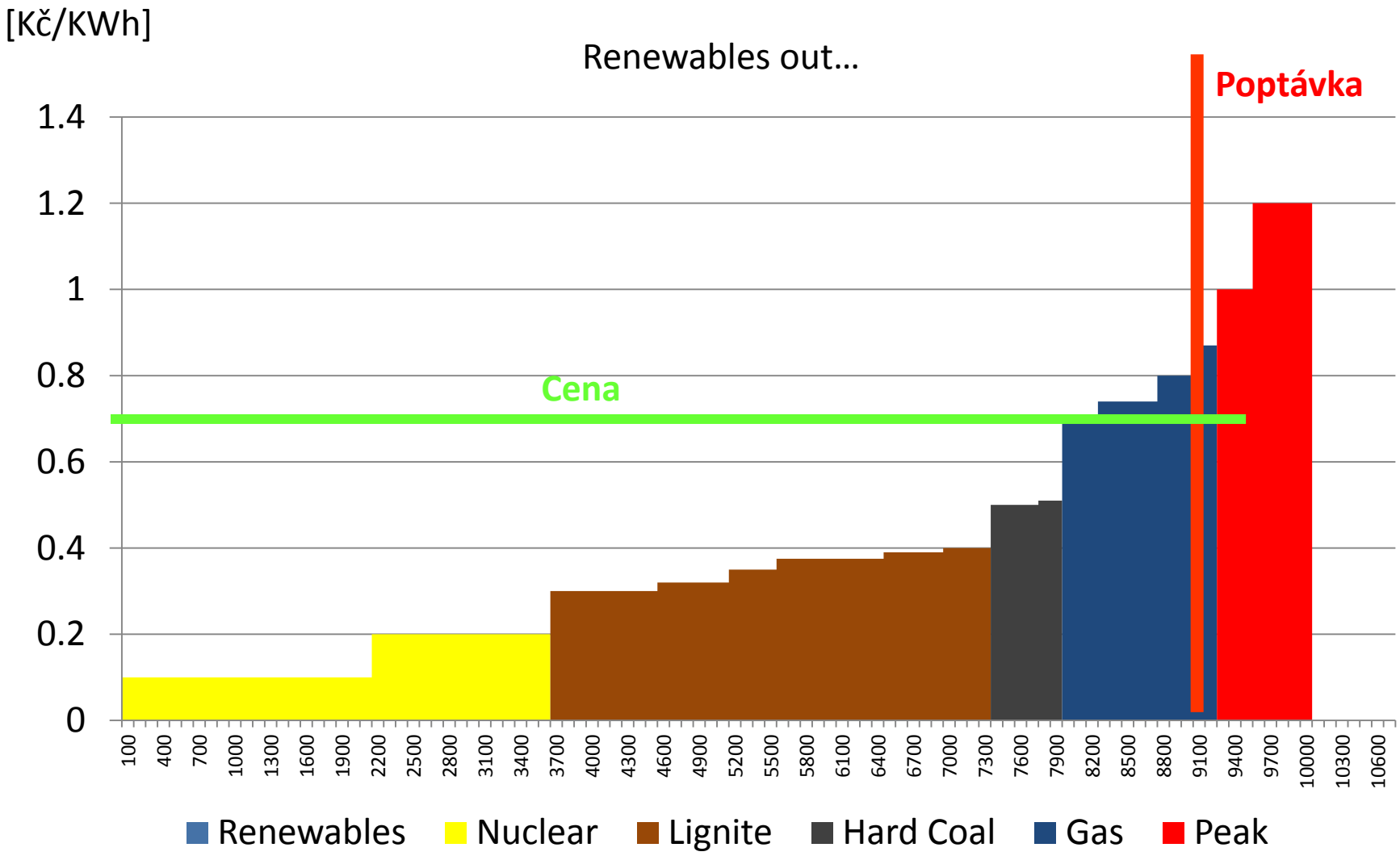
Renewables and Electricity Pricing



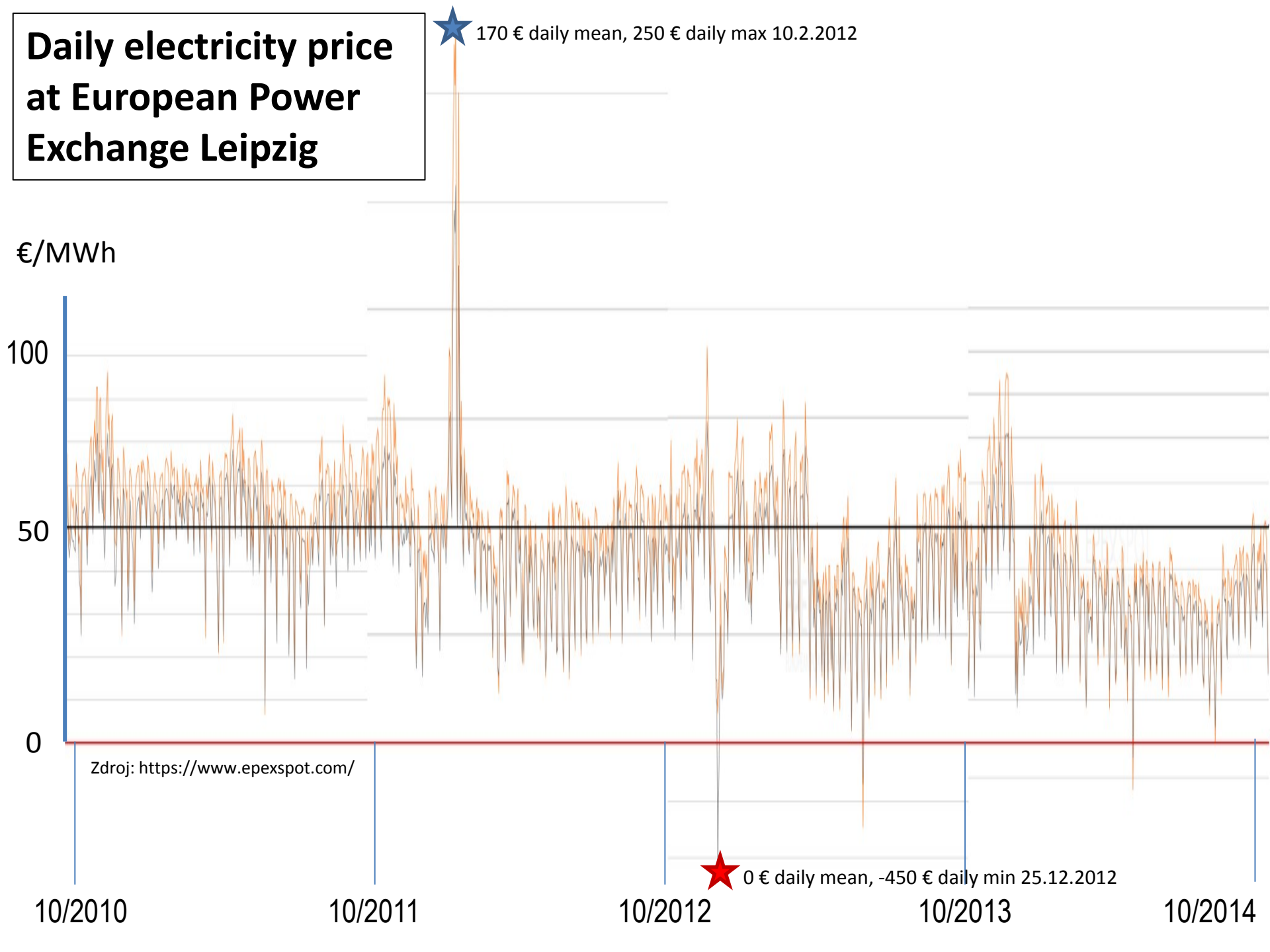
Renewables and Electricity Pricing



Renewables and Electricity Pricing



Daily electricity price at European Power Exchange Leipzig



Allowances v Taxes

- Government aims to decrease CO2 emissions
- Two ways of achieving that:
  - Tax – payment for each ton of CO2 emitted
  - Tradable allowances – permission to emit particular volume of CO2
- Different parameters
  - Tax – maximum price for decarbonisation is set
  - Allowances – maximum volume is set

Example 1

- Two types of PP in a Country – A and B
- Both emit 40t CO_2 per year = total 80t/y
- Different emission reduction costs per 10t
  - A = $2,000; B = $4,000
- Government' objective is 60t CO_2 per year
  - Regulation
  - Tax
  - Allowances

Example 1

1. Regulation
   - Each PP must decrease emissions by 10t/y
   - Costs = 2,000 + 4,000 = **$6,000**
2. Allowances
   - 60t allowances issued, both A and B get 30t
   - B buys 10t allowances from A and emits 40t
   - A emit 20t … total emissions 60t
   - Costs = 2 * 2,000 = **$4,000**
   - Price of allowance between $2k and $4k
3. Taxation
   - T < $2k … no emission reduction & C+T = $0 + $0…16k
   - $2k < T < $4k … 40t of A reduced & C+T = $8k + $8k…16k
   - $4k < T … all emissions reduced & C+T = $16k + $0

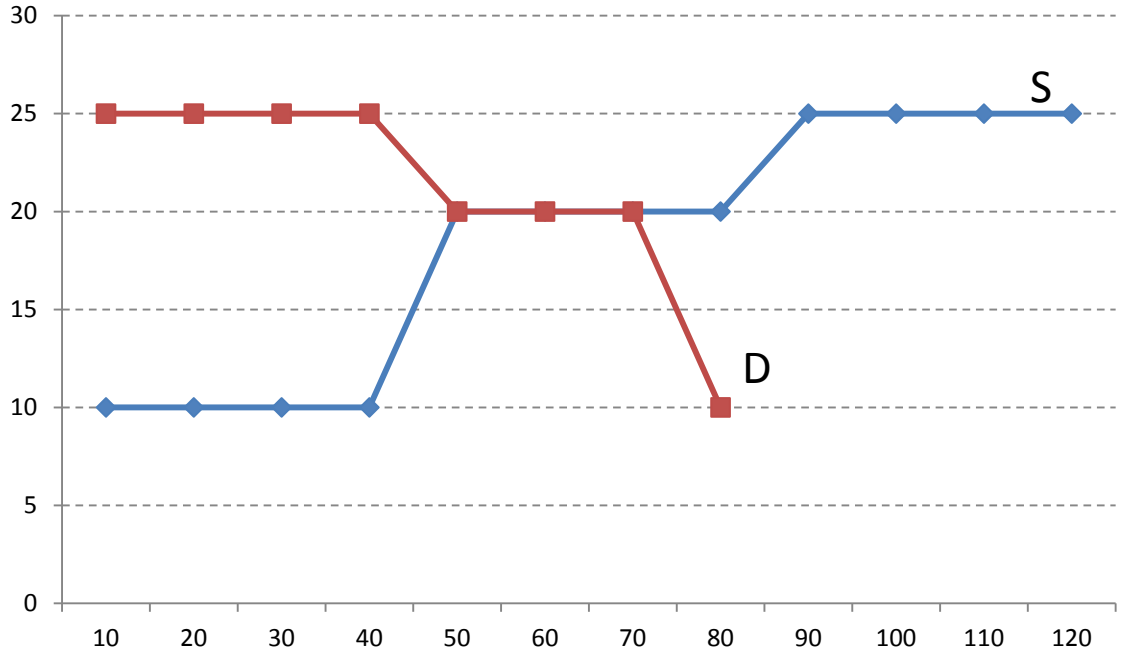
Example 2

Company	Emissions [t]	Costs reducing 1 t
A	70	20
B	80	25
C	50	10
Total	200	

- Government objective: 120 t
- Method: Allowances
- Who will sell at what price?
- What will be final cost of reducing emissions?

Example 2

Company	Emissions [t]	Costs reducing 1 t
A	70	$20
B	80	$25
C	50	$10
Total	200 (120 allowances issued)	



- C sells 40t allowances to B **at price of $20**
- Total costs = $1,100
  - A reduces 30t at $20
  - B doesn't reduce
  - C reduces 50 at $10
- Costs w/o trade
  - $1,700