

# Futures pricing in electricity markets

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# Agenda

## 1. Energy Markets

- ▶ History
- ▶ Spot Markets
- ▶ Economics of Spot Prices
- ▶ Futures Market

## 2. Energy Derivatives

- ▶ The Market
- ▶ Spread Options
- ▶ Caps and Floors
- ▶ Swing Options

## Pre-Liberalisation

Liberalisation of the German electricity market started in April 1998

Before liberalisation: system based on calculatory costs, prices according to 'cost-plus' rule

- Integrated value-chain: production, grid, distribution
- Electricity production to secure supply within a regional monopole
- Long-term supply contracts
- No liquid market on the whole sale market
- Regulated consumer prices, regulated investments

## Post-Liberalisation

System is market based: higher volatility of prices, flexibility

- Unbundling of value-chain
- Power plants are used optimally (no obligation to secure supply)
- New players and products
- Trading in Long- and Short-positions on a liquid whole sale market
- Investments based on market expectations

## Markets

Power can be traded at

- Nordpool
- European Energy Exchange

All exchanges have established spot and futures markets.

## EEX Spot Market

### Trading in

- Power
- Natural gas
- CO<sub>2</sub> emission rights
- Power day-ahead auctions (DE, AU, FR, CH)
  - ▶ 24 hours of respective next day traded in one-hour intervals or block orders:
  - ▶ Baseload 1-24h; Peakload 9-20h; Night 1-6h; Rush hour 17-20h; Business 9-16h
- Continuous power intraday trading (DE, FR), until 75 minutes before delivery (delivery on same or following day in single hours or blocks)

- Participants submit their price offers|bit curves
- EEX system prices are equilibrium prices that clear the market
- EEX day prices are the average of 24-single hours
- Similar structures can be found on other power exchanges (Nord Pool, APX, etc.)

## EEX Spot Market Price Processes

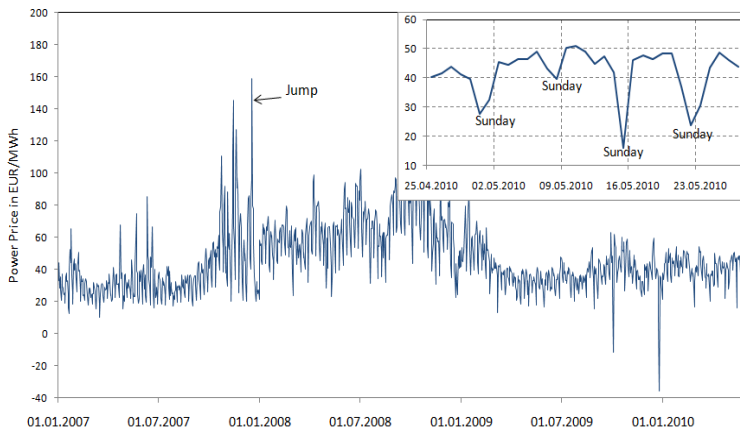


Figure 1: EEX Phelix daily spot prices 2007-2010



## Why differs electricity from commodities?

- Non-storable
- Homogeneous
- Produced through various methods
- Production should be when there is demand
- High fluctuation in demand
- No short-term elasticity in demand

## Basic economic concepts

- A producer produces only if marginal costs are met
- There is only one price of a homogeneous product
- Only producers with marginal costs below the market price will produce
- Production which only meets marginal costs (MC) does not cover the fixed costs

## Economics of Electricity Production

- MC for power plants  $\approx$  prices of fuel and CO<sub>2</sub> certificates
- Order of power plant use
  - ▶ wind
  - ▶ solar
  - ▶ water
  - ▶ nuclear
  - ▶ coal
  - ▶ gas
  - ▶ oil
- To meet demand power plants are added in order of increasing MC (merit order)
- The marginal power plant fixes the market price  
**for all plants in use**

## Merit order (no trade)

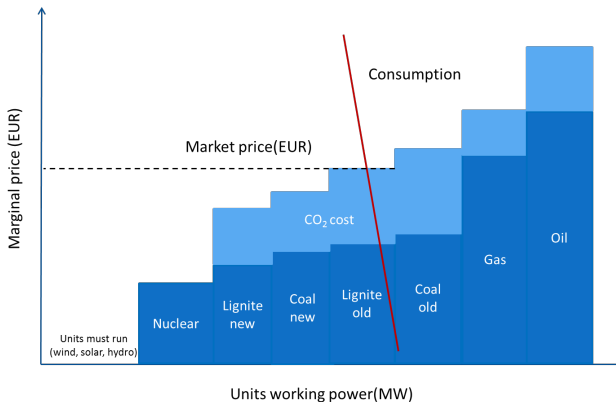


Figure 2: Merit order. Source: Mentor EBS

## EEX Futures Market

### Traded products

- ▣ Futures contracts for power, natural gas, emissions, coal, wind power
- ▣ Phelix Futures and Phelix Baseload or Peakload montly power index for the current month, the next nine months, eleven quarters and six years with cash settlement
- ▣ Baseload and Peakload FR/DE Power Futures for the current month, next six months, seven quarters and six years with physical settlement, obliging for continuous delivery of 1MW during a month, quarter, a year
- ▣ Actively exchange traded: 7 months, 5 quarters, 2-3 years
- ▣ OTC transactions

## The Beamer-Package

- Beamer is the latest package to create slides with  $\text{\LaTeX}$
- Slides need to be compiled to PDF, not DVI/Postscript
- Remember: PDFLaTeX accepts PNG, JPEG and PDF not EPS/PS
- If you *need* Postscript, RTFM

## The LvB Beamer Style

- The LvB Beamer Style is defined via *beamerdefs.sty*, *colordef.sty* and *lvblisting.sty*, which must always be provided in the source folder.
- All operators are to be defined by `\operatorname{}`. Note the difference:

*Var*    defined by `\operatorname{}`  
*Var*    not defined by `\operatorname{}`

- Remember to start and end the `displaymath` environment by `\[` and `\]` and not `$$`.

## Predefined comands

- For your convenience you may set up new commands via `\newcommand{}{}{}`.
- This has been done in the two following cases:
  - ▶ Use `\quantnet` to include the quantnet icon (right-aligned):



The name of the quantnet is to be written in black.

- ▶ Use `\BBI{}` to link to the BBI:

*Carl Friedrich Gauss* on BBI: 

- Some commands are already defined, e.g. `\ln` and `\log`



## Equations

- Equations covering several lines may be written in the *align* environment instead of the older *eqnarray* environment. Only this way it can be ensured, that the colour of the equation and of the according equation numbering match.
- `align*` omits the equation numbering, as does `\notag`.

```
1 \begin{align}  
2 4x + 8 &= (3-2)^2 \\  
3 4x &= -7 \notag \\  
4 x &= -\frac{7}{4}  
5 \end{align}
```

$$4x + 8 = (3 - 2)^2 \quad (1)$$

$$4x = -7$$
$$x = -\frac{7}{4} \quad (2)$$

## Tables

Title	Title
2.13	1.45
3.14	6.85

Table 1: Include a short, but meaningful caption.

- Follow the Cambridge University Press Style.
- Not more than 2 decimal digits in a column.
- Tables and their captions are to be written in black.

## Tables

```
1 \begin{table}
2 \begin{center}
3 \begin{tabular}{cc}
4 \hline\hline
5 Title & Title\\
6 \hline
7 2.13 & 1.45 \\
8 3.14 & 6.85 \\
9 \hline\hline
10 \end{tabular}
11 \caption{Include a short, but meaningful caption.}
12 \end{center}
13 \end{table}
```

## Figures

```
1 \begin{figure}[htb]
2   \begin{center}
3     \includegraphics[
4       scale=0.2]{
5         Figures/vola}
6     \caption{Include a
7       short, but
8       meaningful
9       caption.}
10   \end{center}
11 \end{figure}
```

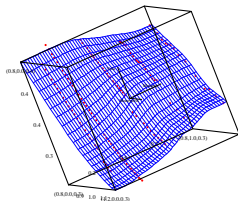


Figure 3: Include a short, but meaningful caption.

The caption is, as in tables, to be written in black and please provide any legend in the caption and not in the graph itself.

## Examples

To create an example, use the color `isegreen` and the following structure:

```
1 \color{isegreen}  
2 \textbf{Example:} Example  
   title  
3  
4 \smallskip  
5 Here you can state your  
   example, which may also  
   include calculations.  
6 \color{black}
```

**Example:** Example title

Here you can state your example,  
which may also include  
calculations.

## Subtitles

Subtitles are to be highlighted via bold text and followed by a small skip afterwards (no colon):

```
1 \textbf{Subtitle}  
2  
3 \smallskip  
4 Here you can state the  
   content according to  
   the subtitle.
```

### **Subtitle**

Here you can state the content according to the subtitle.

This may also be applied to state proofs, theorems etc.

## Brackets

- Use the bracket sequence  $\{(a + b = c)\}$
- Conventional bracket rules represent an exemption of this rule.  
For example:

$$Y \sim N(\mu(X), \sigma(X))$$

- Let  $\text{\LaTeX}$  take care about the correct size by preceding the bracket by `\left` and `\right`.

## Rules to write nice slides

- Use `\section{}` and `\subsection{}` to structure your presentation. The section will appear in the upper right corner of your slides.
- You can set up hyperlinks via `\label{LINKNAME}` (reference point) and `\ref{LINKNAME}` (reference).
- Remember
  - ▶ 6-8 lines per slide
  - ▶ 8 words per line



- The numbering of any enumeration should match the colour of the corresponding text (preset colour: black). Modifications may be made through the *itemize* environment:

`\item[\color{isegreen}1.]`

Itemize items are predefined (blue) and excluded from this rule.

- Use `\top` to write the symbol of transpose, it produces

$$x^{\top}y$$

- Use `\ldots` to write the symbol for three dots, it produces

$$x \in \{1, \dots, n\}$$

- The commands `\widehat{}` and `\widetilde{}` for a hat or a tilde are to be preferred over the the smaller `\hat` respectively `\tilde` commands:

$$\begin{array}{c} \widehat{Y} \text{ vs. } \hat{Y} \\ \widetilde{Y} \text{ vs. } \tilde{Y} \end{array}$$

- The norm is to be written via `\|`. It produces  $\|K\|$
- The  $\mathcal{O}$  and  $\mathcal{O}$  for convergence may be written via `\mathcal{O}` and `\mbox{\scriptsize $\mathcal{O}$}`.
- The operator for exponential terms with Euler's  $e$  as the base is defined by `\exp`:

$$\exp(1) \approx 2.718282$$

- Use `\stackrel{\mathcal{L}}{\rightarrow}` to write the symbol for convergence in distribution and denote the normal distribution by `\operatorname{N}`, this produces

$$X \stackrel{\mathcal{L}}{\rightarrow} N(0, \sigma^2)$$

- Use `\operatorname{P}` to write the symbol for probability, it produces

$$P(X = x) = \frac{\exp(-\lambda)\lambda^x}{x!}$$

- Use `\stackrel{\operatorname{as.}}{\sim}` to write the symbol for asymptotic distribution, it produces

$$X \stackrel{\operatorname{as.}}{\sim} \chi^2$$

- Use command `\stackrel{\operatorname{def}}{=}` to write the symbol for definition, it produces

$$X \stackrel{\text{def}}{=} \frac{a}{b}$$

- Use commands `\Re` or `\Im` to write the symbols for the real or imaginary part, it produces

$$X = \Re\{Y\}, Y = \Im\{Z\}$$

- To write the symbols for the minimizing argument, use `\operatorname{arg}\,``\underset{x}{\operatorname{min}}`, it produces

$$a = \arg \min_x \{f(x)\}$$

- Use `\operatorname{\mathbf{I}}` for the indicator function:

$$\mathbf{I}\{x < 1\}$$

- Use `\ln` or `\log` to write the symbols for natural logarithm or decimal logarithm, it produces

$$1 = \ln(\exp(1)), \quad 1 = \log(10)$$

- Use `\operatorname{E}` to write the symbol for expectation, it produces

$$E[X] = \mu$$

## Using listings for source

Slides containing a listing also need [containsverbatim] as option.  
For 'highlighting' of XploRe keywords see listing.tex.

```
1 library("metrics")
2 randomize(10178)
3 z=(uniform(n).>0.5)~(normal(n).<0.5)
```

## Piecewise Uncovering I

The following example uses  $\langle 1 - 2 \rangle$  commands to piecewise hide and uncover text.  $\langle 1 - 2 \rangle$  makes the first item appear only on slides 1 and 2,  $\langle 2 - \rangle$  has the second item visible from slide 2 onwards.

- Itemize environments

- (i) First Roman point.

# Piecewise Uncovering I

The following example uses  $\langle 1 - 2 \rangle$  commands to piecewise hide and uncover text.  $\langle 1 - 2 \rangle$  makes the first item appear only on slides 1 and 2,  $\langle 2 - \rangle$  has the second item visible from slide 2 onwards.

- Itemize environments
- can be uncovered or hidden

- (i) First Roman point.
- (ii) Second Roman point, uncovered on second slide.



## Piecewise Uncovering I

The following example uses  $\langle 1 - 2 \rangle$  commands to piecewise hide and uncover text.  $\langle 1 - 2 \rangle$  makes the first item appear only on slides 1 and 2,  $\langle 2 - \rangle$  has the second item visible from slide 2 onwards.

- can be uncovered or hidden

- piecewise.

- (i) First Roman point.

- (ii) Second Roman point, uncovered on second slide.

- (iii) Last Roman point.

## Piecewise Uncovering II

There is an easier way using  $\backslash \text{item} < + - >$

- Itemize environments

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## Piecewise Uncovering II

There is an easier way using \item < +- >

- Itemize environments
- can be uncovered or hidden
- piecewise.

## Hiding text...

Text on the first slide.

Shown on all slides.

## Hiding text...

Text on the first slide.

Shown on second and third slide.

- Still shown on 2nd and 3rd slide.

Shown on all slides.

## Hiding text...

Text on the first slide.

Shown on second and third slide.

- Still shown on 2nd and 3rd slide.

- Shown on slides 3 and 5.

Shown on all slides.

## Hiding text...

Text on the first slide.

- ☐ Shown from slide 4 on.

Shown on all slides.



## Hiding text...

Text on the first slide.

- ☐ Shown from slide 4 on.
- ☐ Shown on slides 3 and 5.

Shown on all slides.

## Further Information

Further Information can be found in the  $\text{\LaTeX}$  version of this document, where some more details are explained and important specifications are highlighted.

Suggestions to improve the style or the explanations are welcome!

## For Further Reading



Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl  
*The Not So Short Introduction to L<sup>A</sup>T<sub>E</sub>X2e*  
available on [www.ctan.org](http://www.ctan.org), 2008



Scott Pakin  
*The Comprehensive L<sup>A</sup>T<sub>E</sub>X Symbol List*  
available on [www.ctan.org](http://www.ctan.org), 2008



Frank Mittelbach and Michel Goossens  
*The L<sup>A</sup>T<sub>E</sub>X Companion – 2nd ed.*  
Addison-Wesley, 2004

## For Further Reading



Mark Trettin and Jürgen Fenn

*An essential guide to L<sup>A</sup>T<sub>E</sub>X2e usage*  
available on [www.ctan.org](http://www.ctan.org), 2007



Wikipedia Wiki Books

*LaTeX-Wörterbuch: InDeX*  
available on [www.wikipedia.de](http://www.wikipedia.de)



Till Tantau

*User Guide to the Beamer Class, Version 3.07*  
available on [www.sourceforge.net](http://www.sourceforge.net), 2007