Integrated course „Energy Economics“
- Energy Trading – Wholesale markets for electricity

Chair of Energy Systems | Department of Energy Systems
Technische Universität Berlin

Outline – Electricity Trading

- Role of energy trading
- Submarkets and trading forms
- Trading products
- Balance group concept
- Credit risk management

What is energy trading

Trading is buying and selling, i.e. exchanging commodities.

Electricity is a homogeneous product – uniform and standardised: a commodity.

Other commodities: agricultural (wheat, coffee), metals (gold, steel) etc.

Other energy commodities: natural gas, crude oil, LNG, coal
Related markets: freight, CO_2 emission allowances

Energy trading has parallels to financial markets (shares, bonds and other financial instruments) – even with its particularities due to the physical nature of electricity (gas/oil/coal etc.) as underlying.

Energy trading and Financial markets

Future prices cannot be predicted based on historical prices.

The best prediction of tomorrow's price P_{t+1} is today's price P_t.

The unique reason for a change in price is arrival of "news" not correlated with information available at time *t*.

Transparency (availability of information to all market participants) is a crucial prerequisite for efficient market functioning.

Trading forms: Exchange vs. OTC

Mediated trading: power pool or power exchange

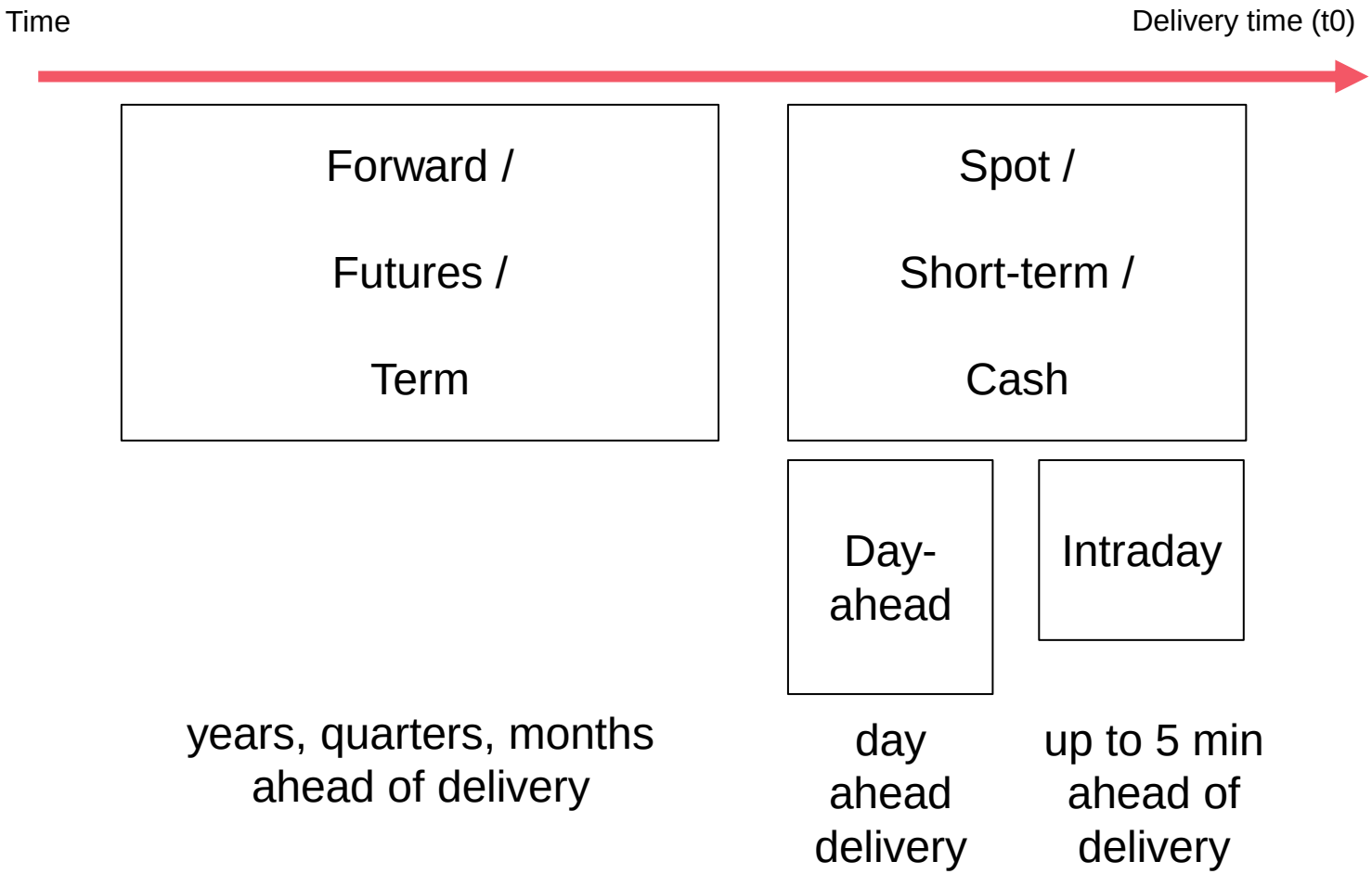
- organised auction resulting in a uniform price
- highly standardised products; no room for negotiation
- transparency
- regulated
- clearing and colateral costs

Bilateral trading: over-the-counter (OTC)

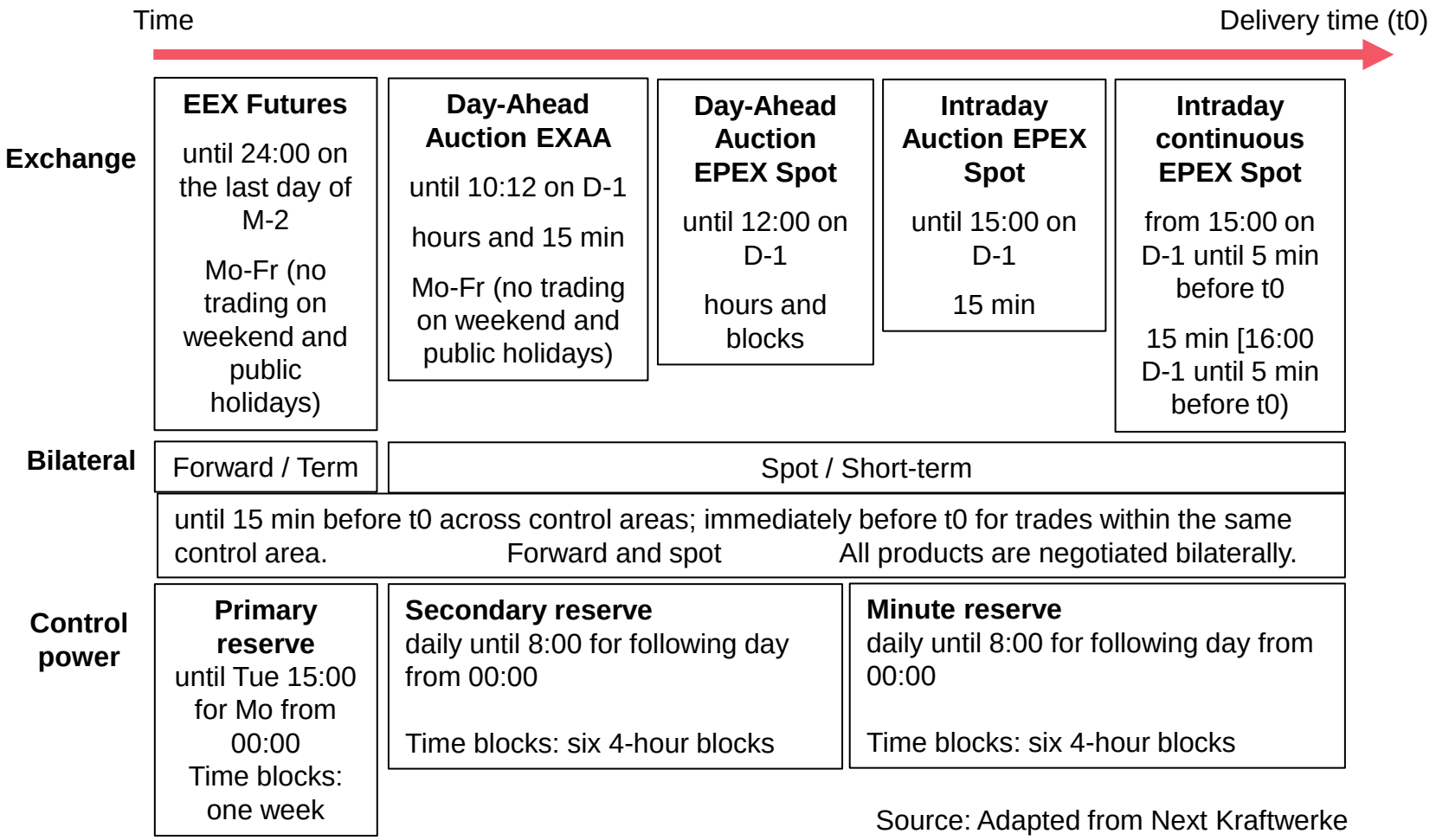
- intermediation cost (opportunity cost or broker fee)
- individual prices agreed between pairs of buyers and sellers
- (≈pay-as-bid principle)
- standard framework agreements: EFET/GTMA; ISDA; DRV etc.
- unregulated

Typically: Combination of exchange and OTC trading.

Energy trading: Submarkets



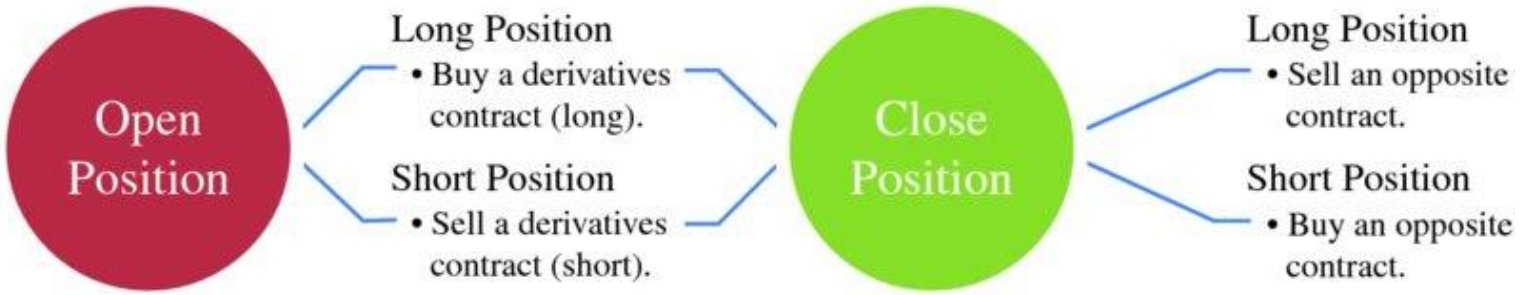
Energy Trading: Submarkets



Source: Adapted from Next Kraftwerke

Forward markets: Continuous trading

Traders take up forward positions based on market expectations but can reverse them later up until delivery by offsetting (back-to-back) purchases or sales.



1. Buy a contract to cancel out an earlier sale (cover a short).
2. Sell a contract to close an earlier purchase (cover a long).

Source: Mack, Energy trading and risk management, 2014

Forward markets: Long and short positions

Long position: trader benefits from a price increase.

E.g. trader buys electricity forward at today's market price. If the market price rises, the trader will be able to sell the contract later at a higher price and realise a profit.

Short position: trader benefits from a price decrease.

E.g. trader sells electricity forward at today's market price. If the market price goes down, the trader will be able to buy the same product later at a lower price and realise a profit.

But: **Long ≠ Buy**, and Short ≠ Sell For example:

1. Buying a commodity at a price a year from now is a short position. *The position benefits the trader only if the current market higher than the market price in one year (i.e. in falling price case)*

2. Purchasing a commodity at the market price and selling it at a fixed price (both short) is an open position, rather than a closed one. *Trader benefits from selling at a fixed price (other than the current market price) if the price falls.*

See: Edwards, Energy trading & investing, 2010, p. 5

Rolling of futures

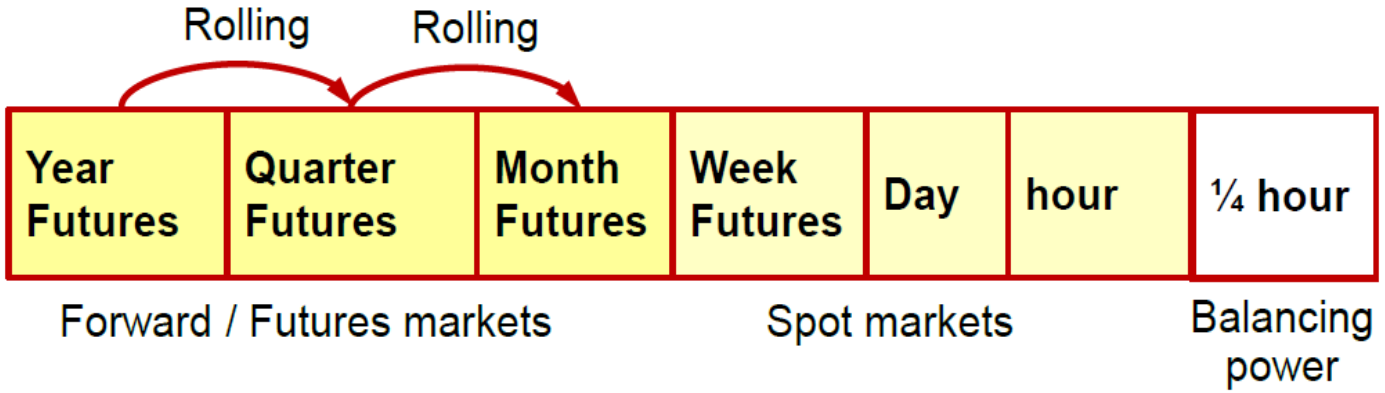
A futures trader has two options:

- closing the contract on or before the maturity date (delivery period) by selling or
- rolling over the contract

Source: Mack, Energy trading and risk management, 2014

Rolling of futures (continued)

At the beginning of the delivery period, the initial product splits into a set of equivalent shorter-term products.
Longer maturities cascade into corresponding shorter marturities.

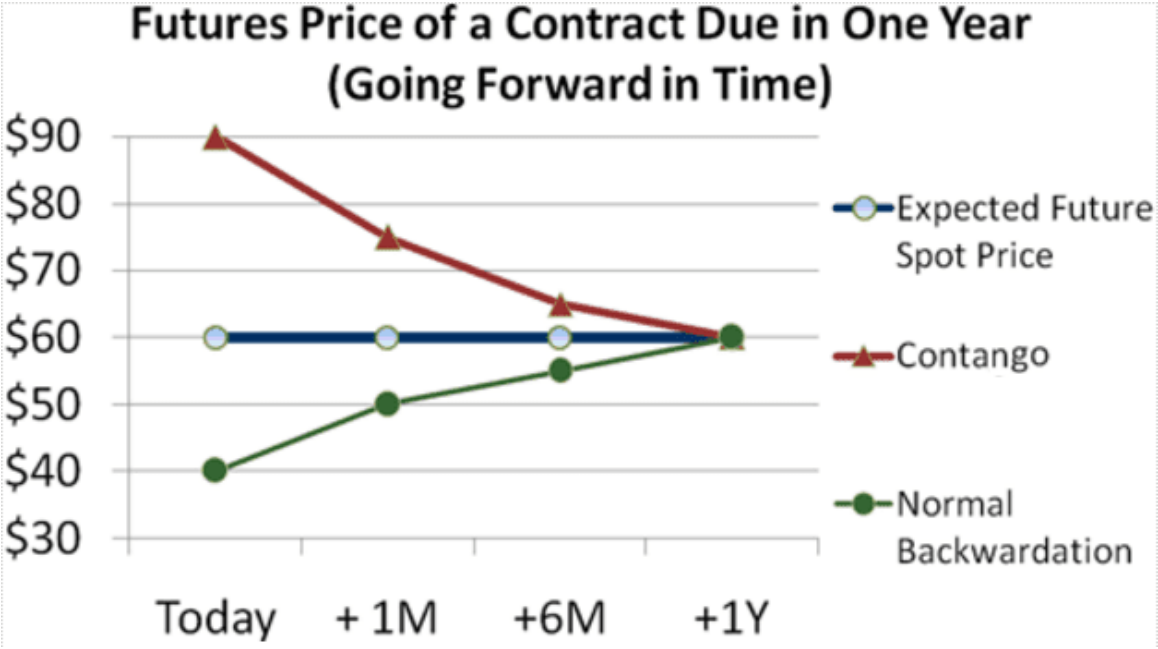


„On the third ECC Business Day before the beginning of the delivery period, each open position in a Year Future is replaced by equivalent positions in the three Month Futures for the delivery months from January through to March and the three Quarter Futures for the second through to the fourth delivery quarter whose delivery periods together correspond to the delivery year."

Source: EEX Contract Specifications

Forward market: Price development patterns

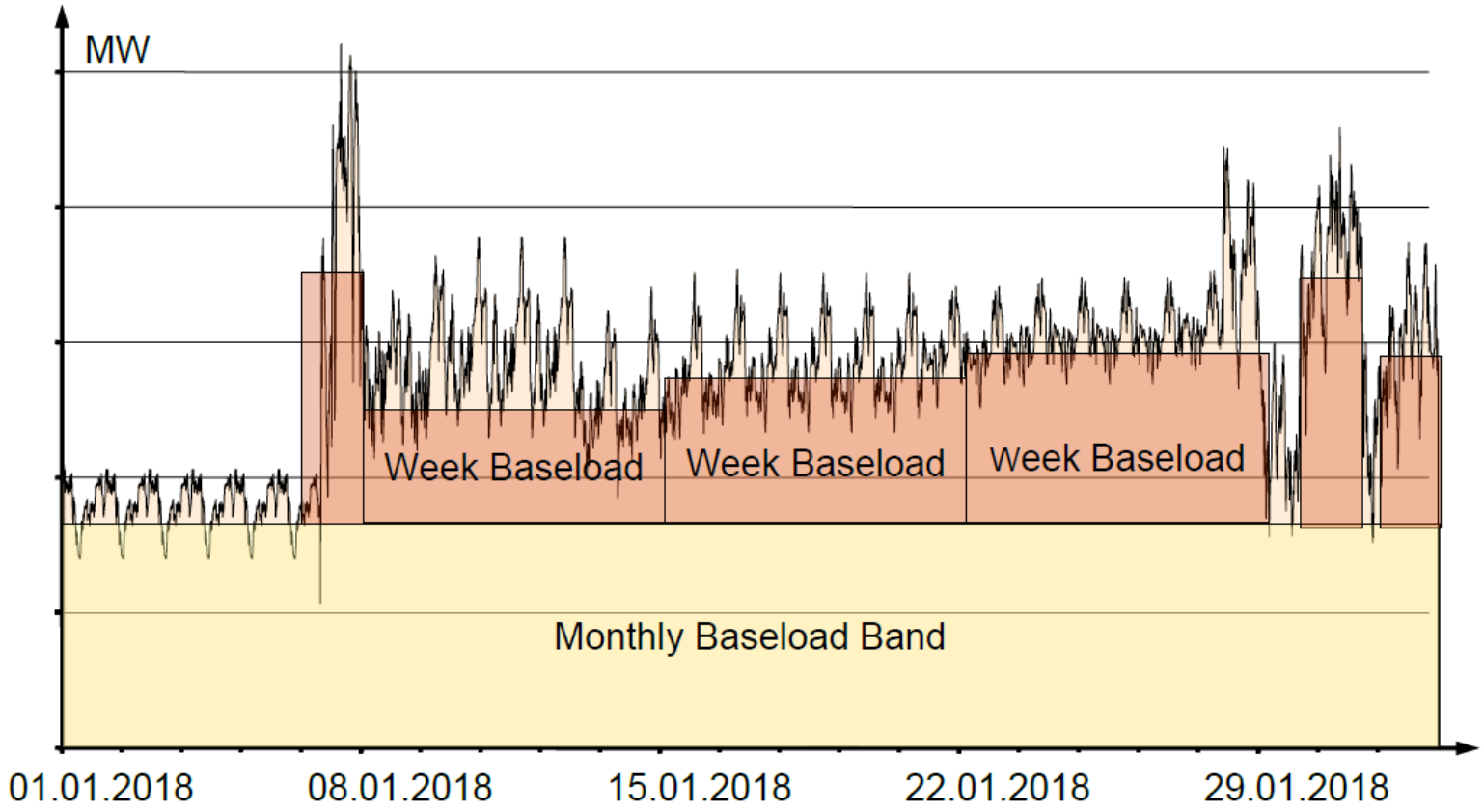
Contango: forward price exceeds the spot price.
Backwardation: spot price exceeds the forward price.
Market participants are driving the forward price up/down in line with their expectations.



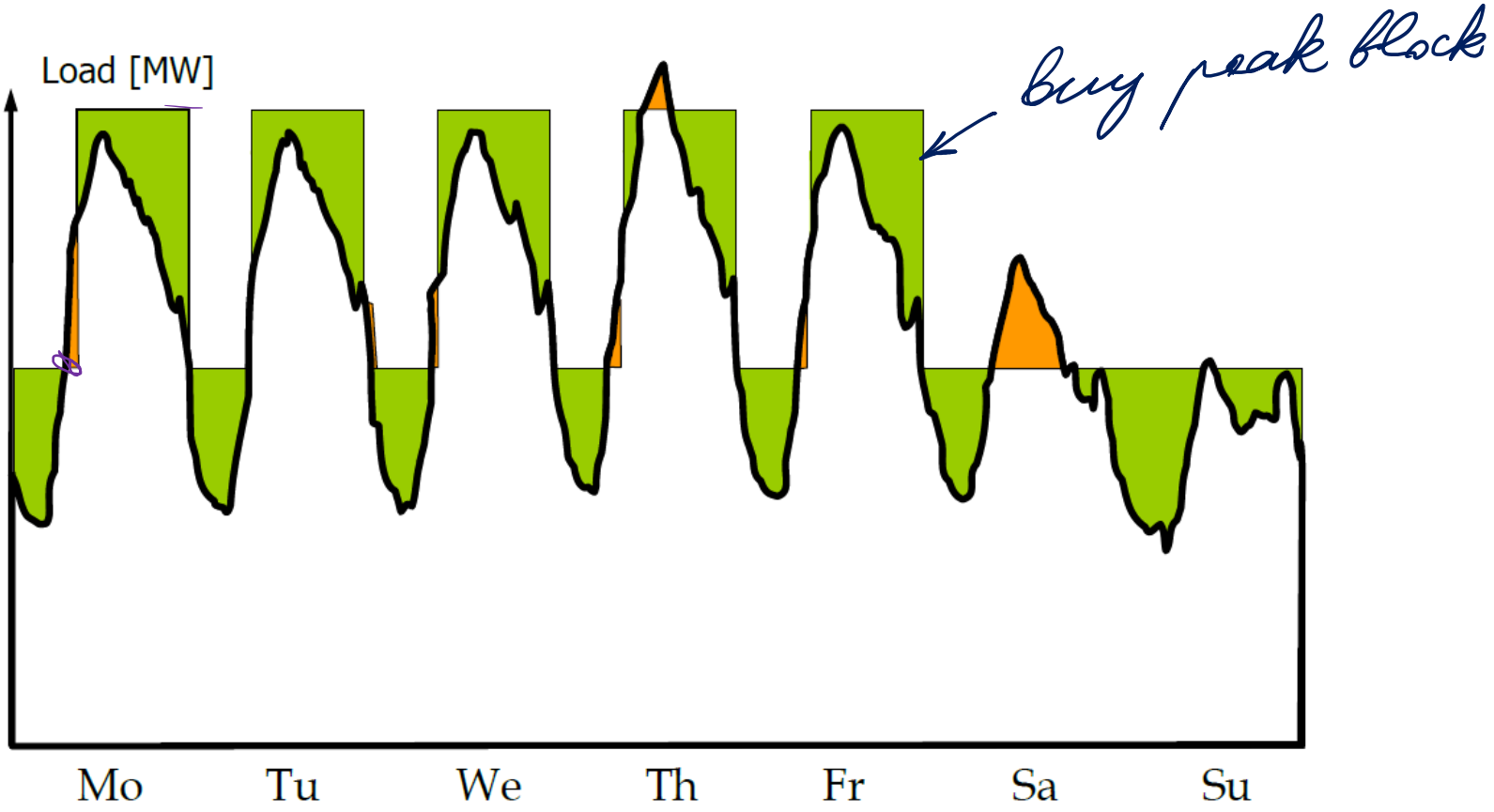
Source: Mack, Energy trading and risk management, 2014

Sample power purchase portfolio

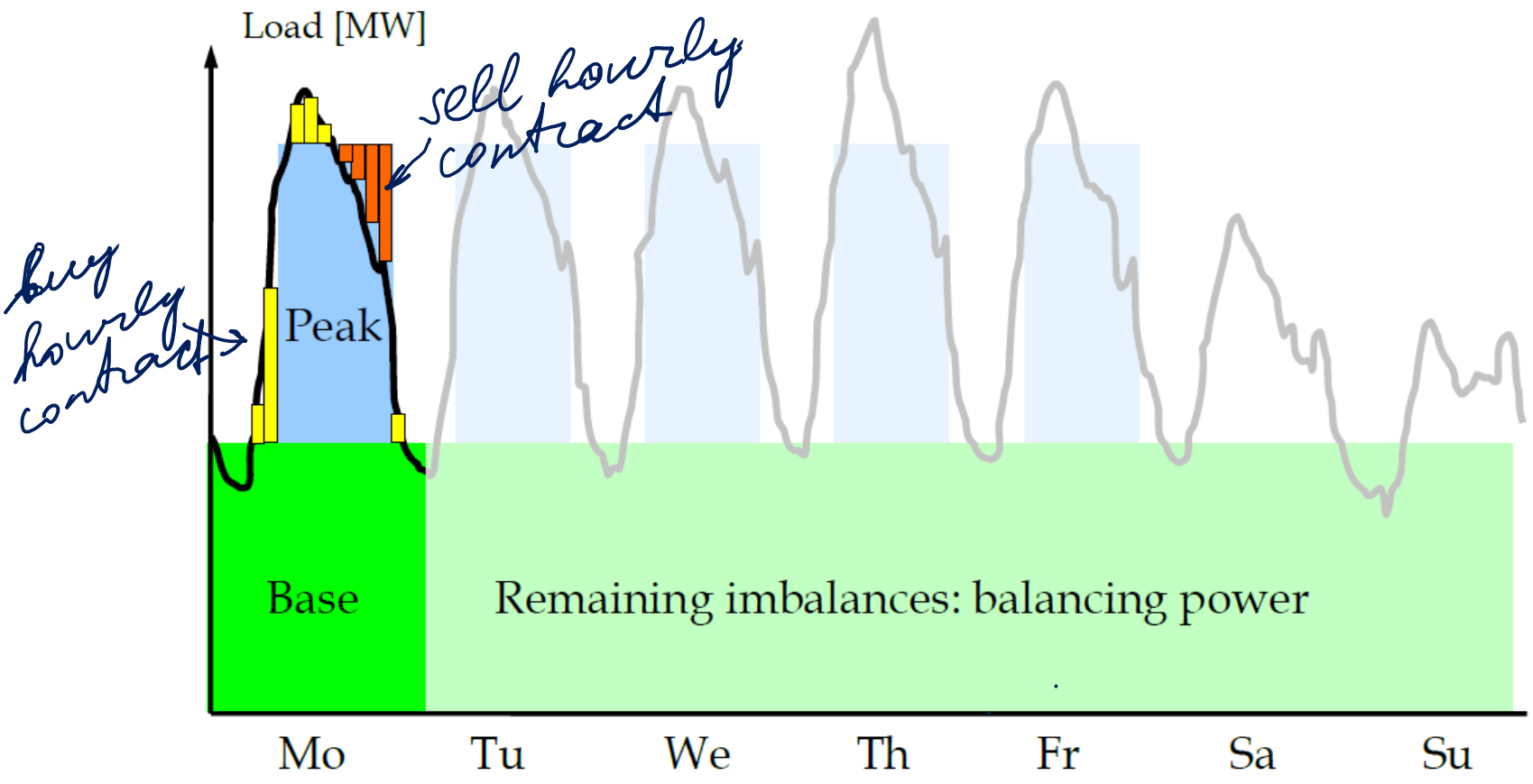
Standardised futures do not match with typical load schedules.



Portfolio management of a power retailer



Day-ahead contracts for singular hours



Market liquidity

Churn rate is the ratio of traded volume to physically delivered volume.

i.e. how many times the electricity generated/consumed has been traded before delivery

Bid-ask spread is the difference between the ask price (sell side) and the bid price (buy side).

Market depth is the volume of buy and sell orders.

Liquidity impacts:

- the intermediation costs and the bid/ask spread
- the time horizon and costs for closing a position

EPEX Spot Day-ahead auction

Double-sided auction: bid and ask order book (order book trading)

Uniform price auction: market clearing price for each product (hour or block)

Hourly contracts and blocks (base, peak etc.)

Occurs daily at 12h for delivery on the following day (0-24h)

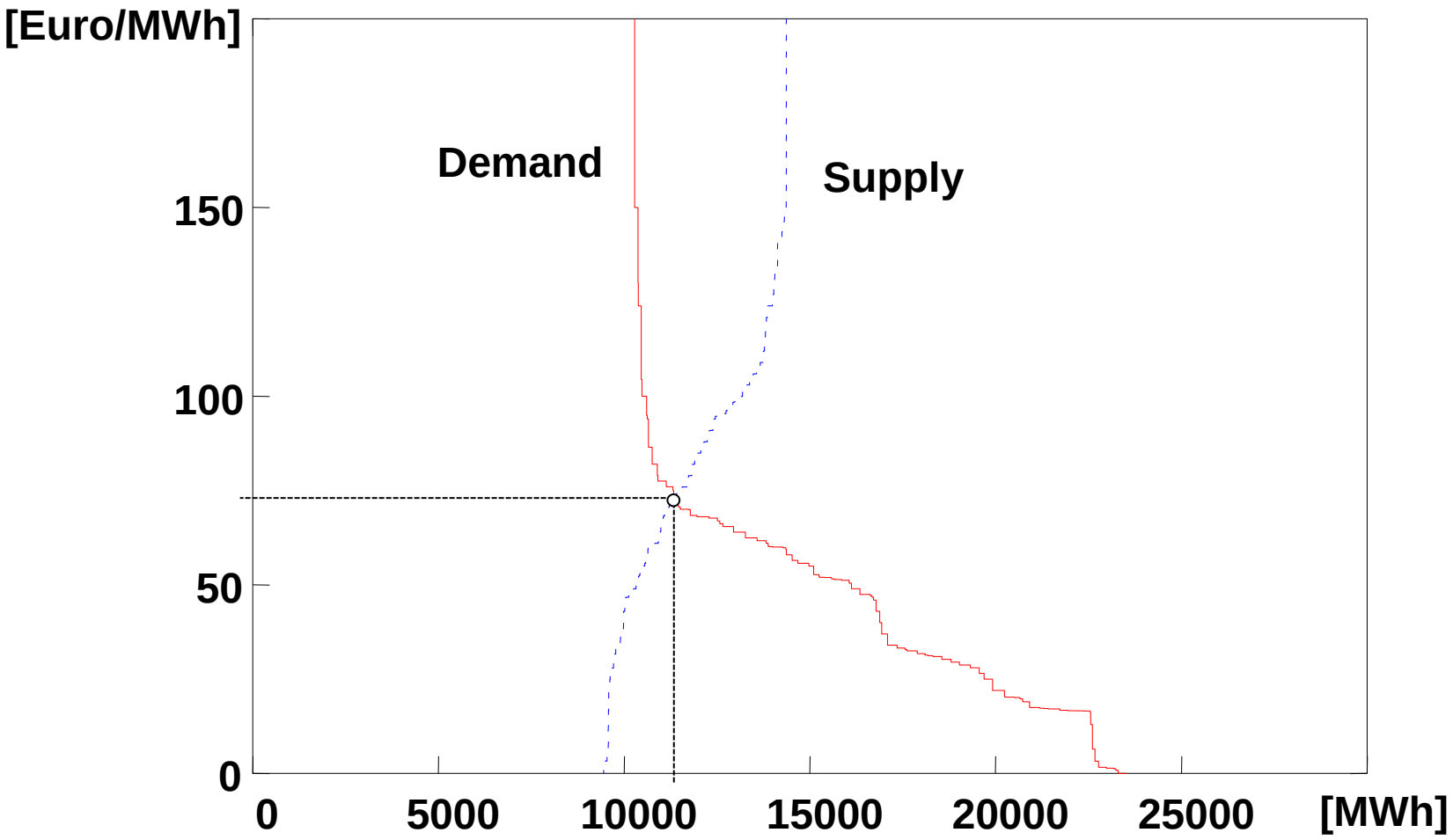
Price publication time: asap from 12:42h

Volume tick (min order amount/amount increment): 0,1 MWh

Min price: -500 €/MWh; Max price: 3.000 €/MWh

Bidding curves at EEX

[delivery period Monday, 6.11.2006, 8-9 h]



EPEX Spot Day-ahead auction: Product description

Day-ahead auction with delivery on the German/Luxembourg TSO zones

https://www.epexspot.com/en/product-info/auction/germany-luxembourg

Size

The minimum volume increment is 0.1 MW for individual hours and 0.1 MW for blocks.

Tick

The minimum price increment is EUR 0.1 per MWh.

Underlying

Electricity traded for delivery the following day in 24 hour intervals.

Special case: A full 25 hour Excel template is needed when the clocks are set to winter time. Hour 3 and 3X can contain different values. When the time is switched to summer time the system automatically deletes the exceeding quantities for hour 3 (i.e. 2.00 am to 3.00 am).

Place of Delivery

Deliveries are made within either of the following TSOs zones:

- Amprion GmbH
- Tennet TSO GmbH
- 50Hertz Transmission GmbH
- TransnetBW GmbH

All these places of delivery form one market zone.

Product description (continued)

Auction hours:
The daily auction takes place at 12.00 pm, 7 days a week, year-round, including statutory holidays.

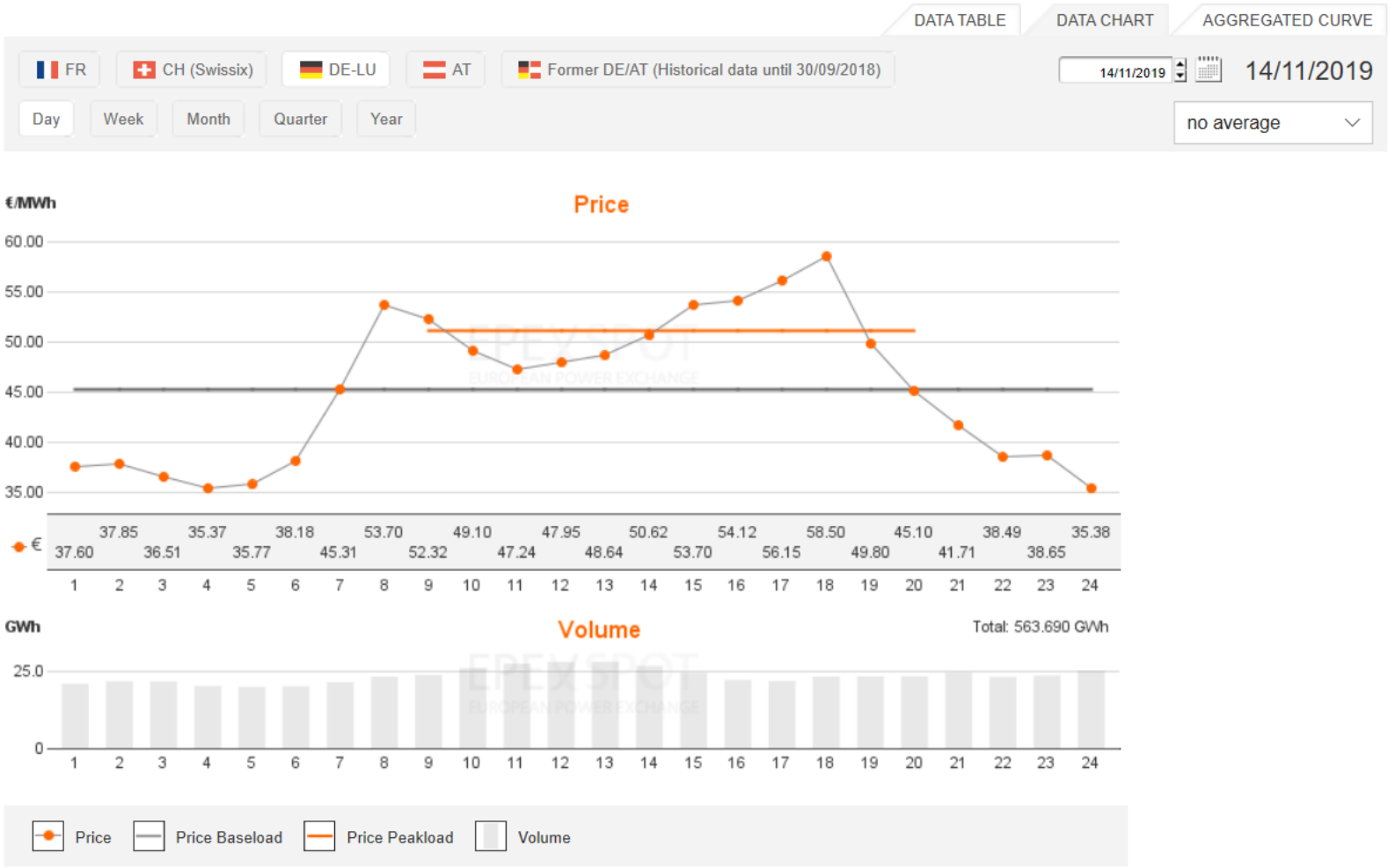
Type of orders:

-Individual hours
Orders contain up to 256 price/quantity combinations for each hour of the following day. Prices must be between -500 €/MWh an 3000 €/MWh. The 256 prices are not necessarily the same for each hour. A volume – whether positive, negative or nil – must be entered at the price limits. A price-inelastic order is sent by putting the same quantity at the price limits.

-Blocks
Block orders are used to link several hours on an all-or-none basis, which means that either the bid is matched on all of the hour or it is entirely rejected. Block orders have a lower priority compared with single hourly orders. The quantity may be different for every hour of the block. A block order is executed for its full quantity only. A block order is executed or not by comparing its price with the volume-weighted average of the hourly market clearing prices related to the hours contained in the block.

Standard block orders
- Block Baseload covering hours 1 to 24
- Block Peakload covering hours 9 to 20
- Block Night covering hours 1 to 6
- Block Morning covering hours 7 to 10
- Block High Noon covering hours 11 to 14
- Block Afternoon covering hours 15 to 18
- Block Evening covering hours 19 to 24
- Block Rush Hour covering hours 17 to 20
- Block Off-Peak 1 covering hours 1 to 8
- Block Off-Peak 2 covering hours 21 to 24

EPEX Spot Day-ahead auction

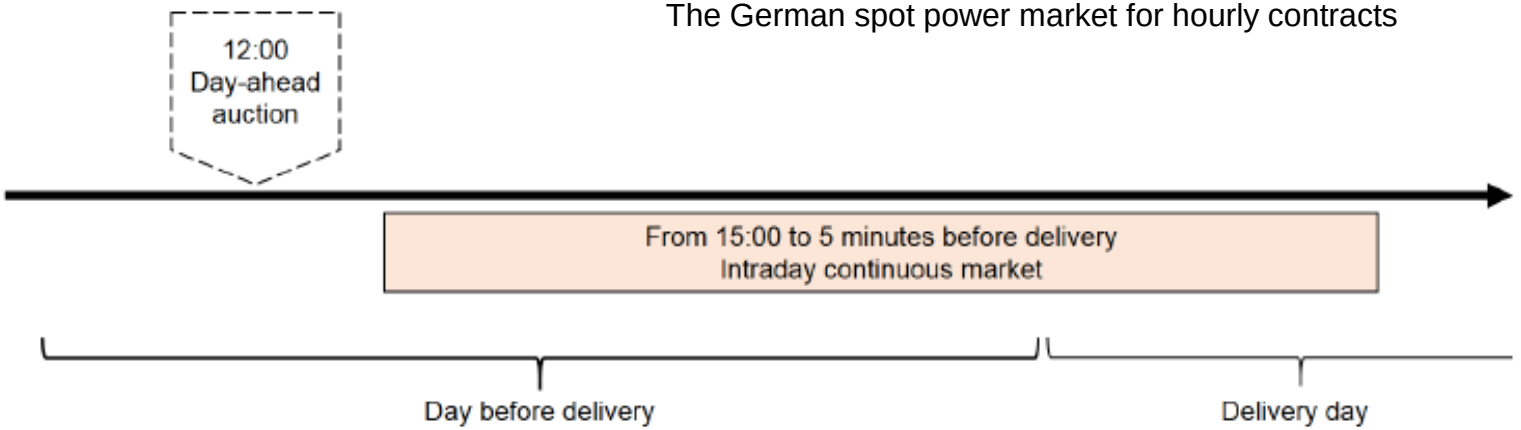


Intraday market

Intraday market reflects a growing need for flexibility close to delivery due to a growing share of volatile renewables.

Intraday market serves for adjusting trading positions based on corrected forecasts closer to real-time.

The German spot power market for hourly contracts



Source: Balardy, 2018

- uniform price auction for hourly products; daily at 3 pm (d-1)
- uniform price auction for 15-min products; daily at 4 pm (d-1)
- continuous intraday market for hourly products

What is a trading product

Trading product is combination of transaction features:

- Underlying asset — *electricity*
- Delivery point — *TSO control area*
- Delivery period — *start date / end date*
- Delivery amount — *contract capacity [MW]*, *contract quantity [MWh]*

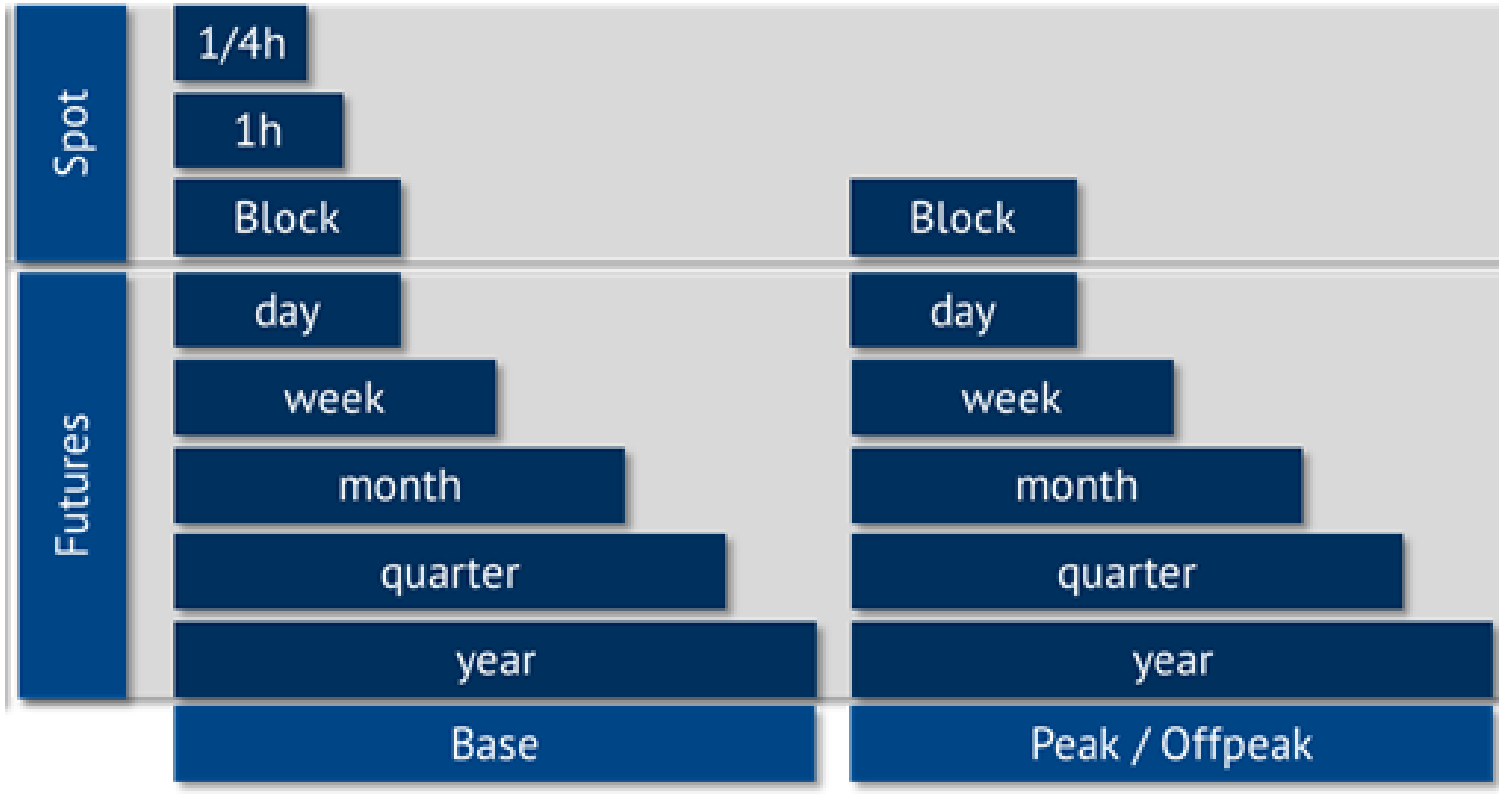
Price

A certain amount of product is traded at a certain price.

A bid (offer to buy) or ask (offer to sell) is characterised by: product, price, trading day and time.

→ different market price of the same product at different times

Electricity product types based on delivery period



Source: Energy Brainpool

Product types

- Physical vs. Financial
  - Physical product implies physical delivery of the underlying (i.e. electricity).
  - Financial product implies exchange of cash without physical delivery (no set-up with TSO required) → Swap

- Fixed-price vs. floating price (index-based)
  - Fixed price is stated as an amount of money per unit of underlying
  - Floating price is determined by reference to a price index publication at a time point after deal conclusion.

- Fixed-amount vs. options

Product types: Swaps

Swaps is a general category of financial products

- fixed-for-floating swap: Party A is fixed price payer; Party B is floating price payer (=reference price based on a price index published in the future → market price); only the difference is exchanged each month

e.g. large consumer (as Party A – fixed price payer) hedging price risk from their long-term supply contract with an index-based price

- floating-for-floating swap: both Party A and Party B pay their respective floating price

- swaption: option to enter into a swap
- floor, cap, collar etc.

Trade life cycle - OTC

Deal conclusion → (Confirmation) → Nomination → Settlement

Possible by any means of communication: written contract via phone (on recorded line) – with or without broker via email via electronic broker platform (screen) **Deal capture in the company's trading system**	In case of non-written deal conclusion for forward transactions Objective: align the parties' understanding of the terms of the transaction > identify and resolve any discrepancy before delivery	Delivery obligations are performed by nominating to TSO: Trader (balance responsible party) submits (net) delivery amount with each counterparty for each day before 14:30h on D-1	Invoice and payment for each delivery month in the following month Standardised payment terms: Invoice in the beginning of the following month; payment date on the 20th (5th working day for financial contracts)

Trade life cycle - EEX

EPEX SPOT transmits trade information to the central counterparty European Commodity Clearing (ECC) for settlement and delivery.

ECC nominates deliveries to the relevant TSO on behalf of the exchange member until applicable nomination deadline (14:30 pm).

Souce: EPEX SPOT

Balancing group: Linking the virtual and physical worlds

Balancing group (BG) is a virtual energy volume account associated with one or more grid users within a control area.

- each grid connection point is allocated to one balancing group
- balance responsible party (BRP) is responsible for balancing its BG's saldo (feed-in and consumption) for each 15 min – incl. through trading on spot markets
- deviations are penalised by imbalance fees

Analogy to a bank account:

TSO	***≈Bank***
Balance responsible party	*≈Account holder*
EIC	*≈Account number*
Balancing circle	*≈Bank account*
Energy deliveries	*≈Payments*

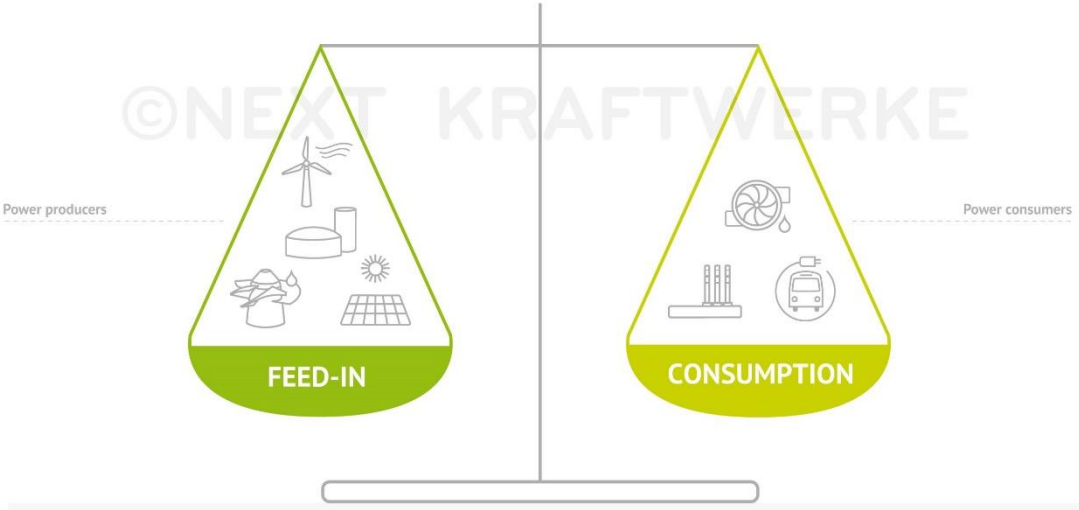
Balancing group (continued)

Trading on transmission grid level, i.e. performing delivery by scheduling to TSO, assumes no physical restrictions within a market area.

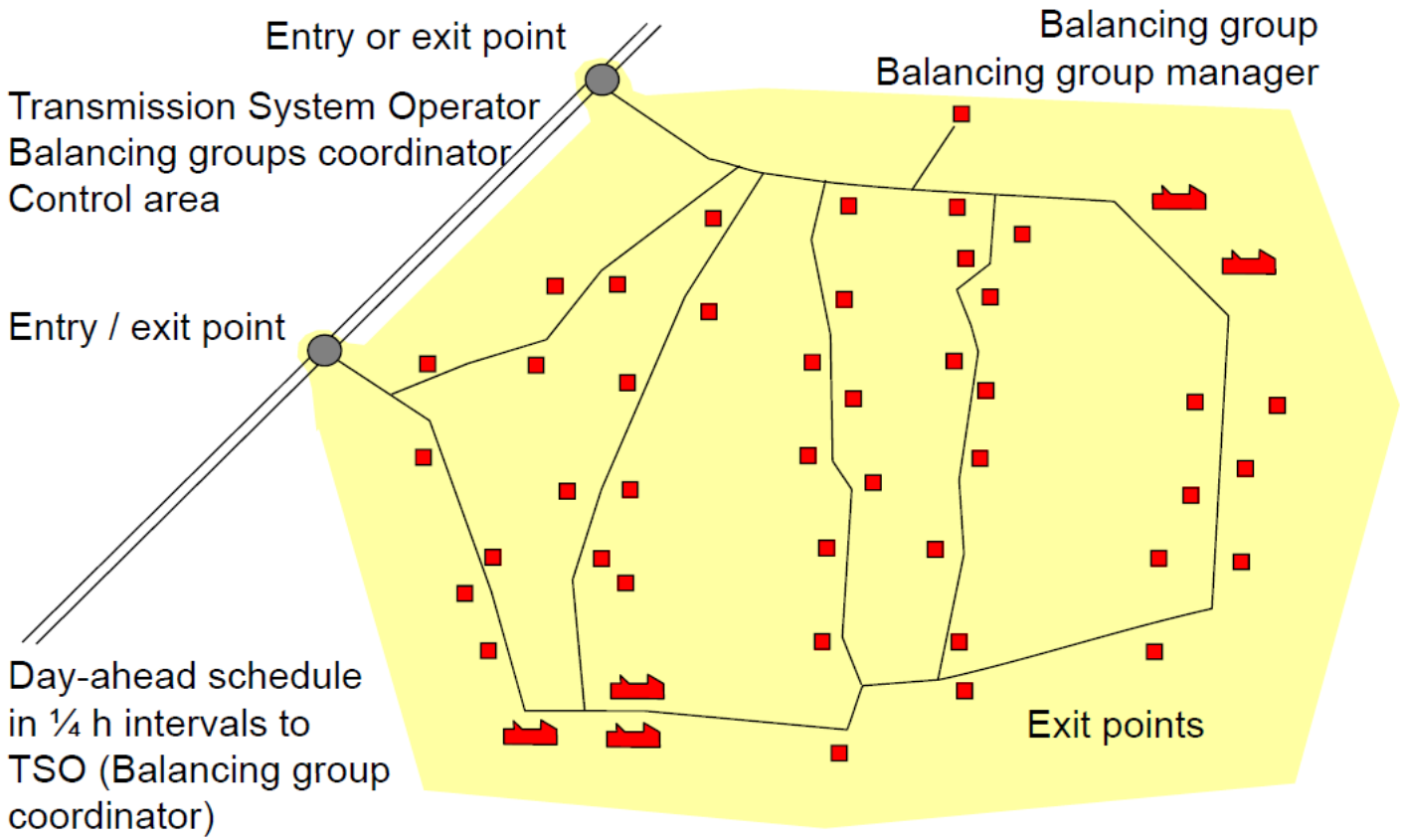
Depending on the nature and composition of a balancing group, the BGR transmits to the TSO forecasted load or generation and/or buy and sell amounts.

Imbalance fee is uniform for the control area (in Germany: for all four control areas), symmetric and based on actual activation of control power.

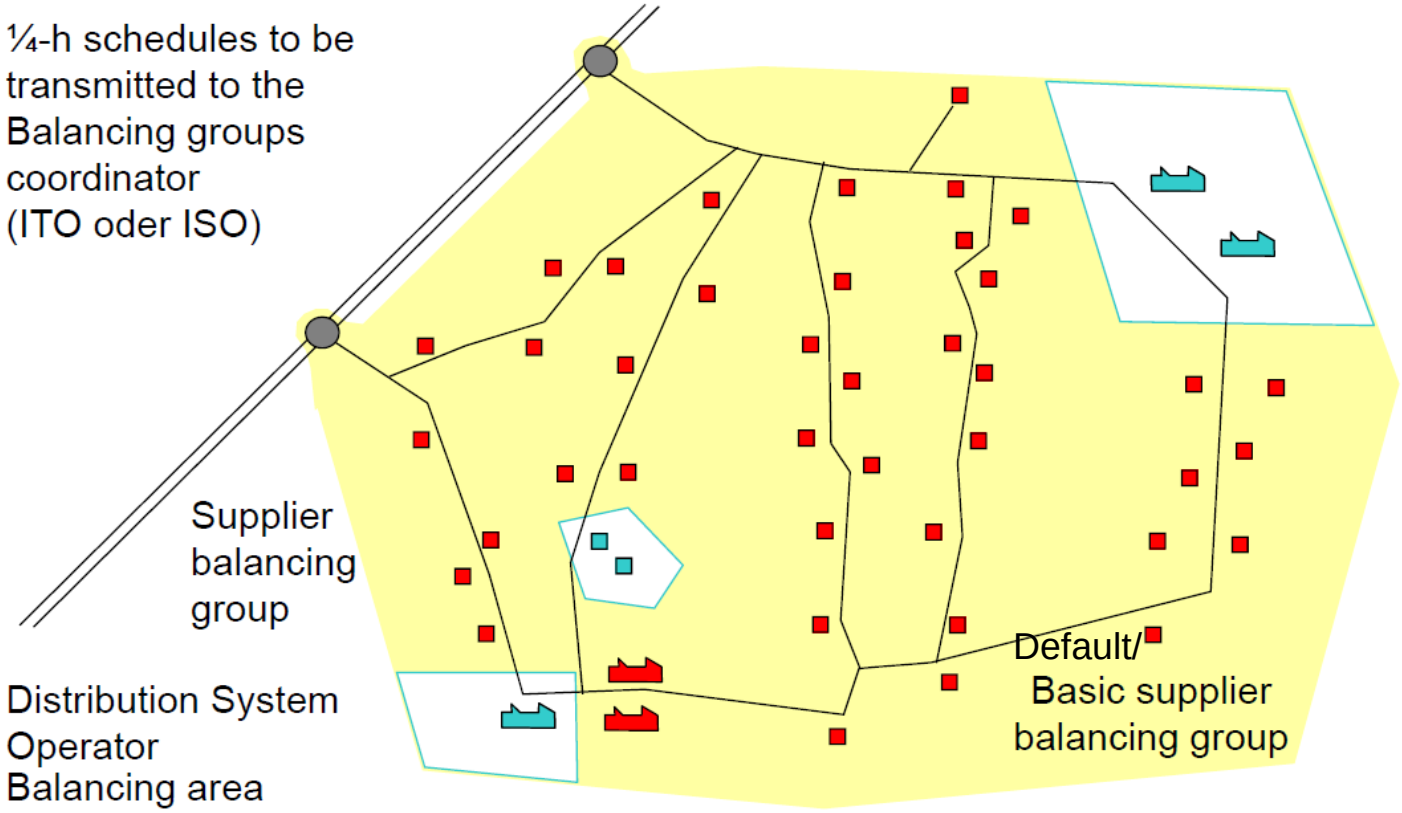
Schedule is power per time unit exchanged between BCs, fed into or consumed from the grid.



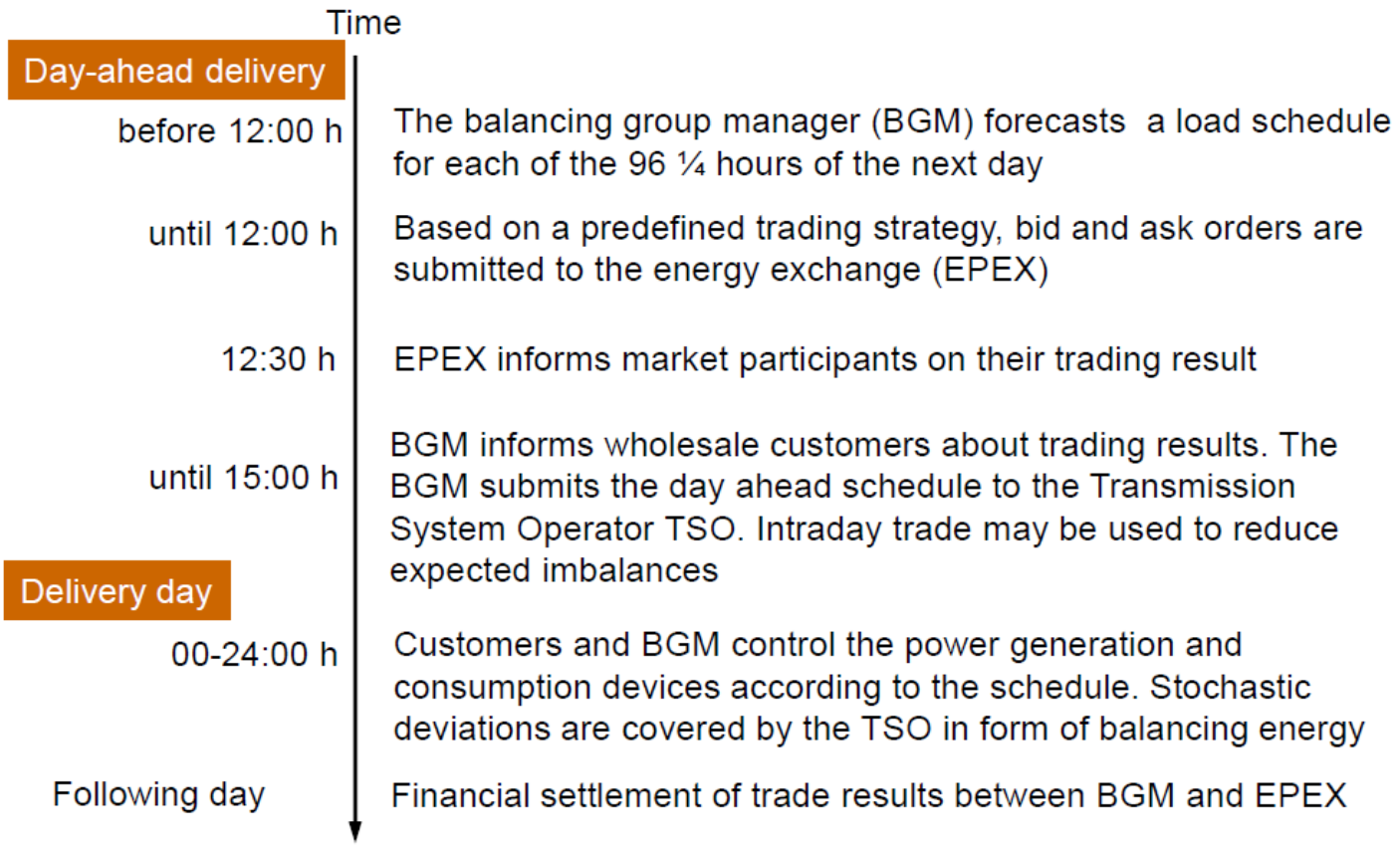
Market roles and processes at TSO level



Market roles and processes at DSO level



Tasks of the Balancing group management



Reasons for imbalances

- Unplanned outage of generation units
- Unplanned outage or activation of large loads
- Forecast gap in volatile RES generation
- Inaccurate forecast of demand

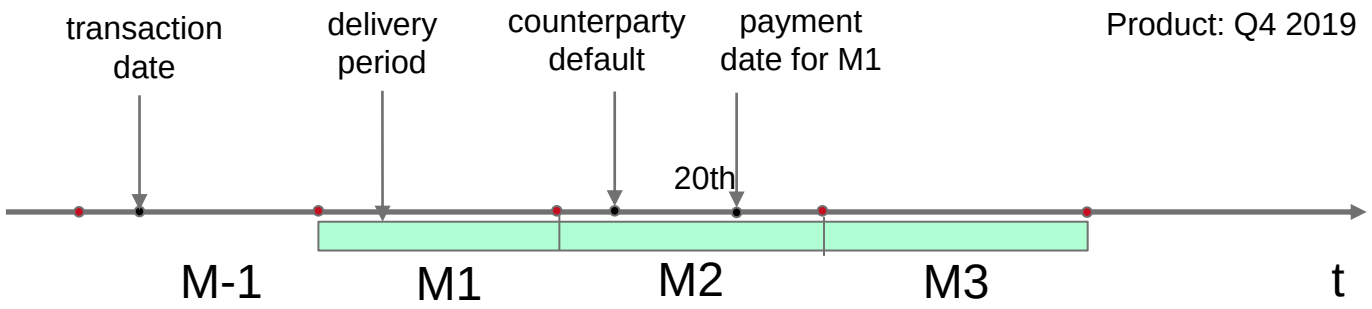
Credit risk management: Terminology

„Exposure is a measure of loss if an adverse materialisation of uncertainties occurs for a particular decision.“ *

Mark-to-market accounting is regular (daily) valuation of all open trading positions based on the current market price of the product.

* Perreira et al, IEEE Computer Applications in Power, vol. 13, 2000, p. 22

Credit risk management: Credit risk exposure – OTC



- **Settlement exposure**: delivered but unpaid amount * contract price (≈50 days; credit exposure updated after payment)
- **Mark-to-market exposure**: contract amount from default date until end of delivery period * mark-to-market

Credit exposure for a portfolio depends on the **netting rules**:

Does the jurisdiction of the counterparty allow cherry-picking, i.e. performing under in-the-money transactions and dropping the ones that are out-of-the-money?

Creditworthiness: Long-term corporate credit ratings

	Moody's	S&P	Fitch	Meaning
Investment Grade	Aaa	AAA	AAA	Prime
	Aa1	AA+	AA+	High Grade
	Aa2	AA	AA	
	Aa3	AA-	AA-	
	A1	A+	A+	Upper Medium Grade
	A2	A	A	
	A3	A-	A-	
	Baa1	BBB+	BBB+	Lower Medium Grade
	Baa2	BBB	BBB	
	Baa3	BBB-	BBB-	
Junk	Ba1	BB+	BB+	Non Investment Grade Speculative
	Ba2	BB	BB	
	Ba3	BB-	BB-	
	B1	B+	B+	Highly Speculative
	B2	B	B	
	B3	B-	B-	
	Caa1	CCC+	CCC+	Substantial Risks
	Caa2	CCC	CCC	Extremely Speculative
	Caa3	CCC-	CCC-	In Default w/ Little Prospect for Recovery
	Ca	CC	CC+	
		C	CC	In Default
			CC-	
	D	D	DDD	

Creditworthiness: Financial ratios

EBIT to Interest – interest coverage ratio

Funds from operations to Total debt

Total debt to Total capitalisation – leverage ratio

Credit risk management involves continuous monitoring of each counterparty‘s creditworthiness and utilisation of the credit line by outstanding (live) trading transactions.

Breach of pre-agreed threshold indicators for creditworthiness triggers a credit call – request to provide additional colateral.

Colateral types

Stand-alone credit line – no initial colateral

Parent company guarantee

Stand-by letter of credit

Bank guarantee

Cash collateral

Colateral amount:

Expected loss given default = Expected value of collateral

Creditworthiness impacts transaction costs.

Clearing

Source: Energy Brainpool

Clearing (continued)

Clearing is performed by European Clearing Counterparty (ECC).

Credit risk exposure is determined similarly to OTC trading.

Margining is the process of continuously recalculating the credit exposure under open positions based on the current market price and adjusting the amount of collateral required to cover it.

- Initial margin: cash collateral or other first-class guarantee to ensure that the exchange member fulfills their obligations under open transactions.
- Variation margin: daily margining based on mark-to-market calculation – resulting into a margin call as necessary.

Risk of clearing banks is limited to overnight risk.

Clearing at EEX (via ECC)

Exposure Type	Margin Type	Description
Current Exposure	**Variation Margin**	Mark-to-market value (change) of all open positions in futures using the latest market prices received from the markets
	Premium Margin	ECC's options are Premium Style (i.e. no daily Variation Margin is calculated). Therefore Premium Margin has to be deposited for net short positions. For net long positions, credits from Premium Margin are used to offset other margin requirements
	Current Exposure Spot Market[3] (CESM)	The net value (payment amount) of all concluded transactions on the spot markets during the day that have not been settled
Potential Future Exposure	**SPAN® Initial Margin**	SPAN® Initial Margin covers the risk in open positions in futures and options
	Supplementary Initial Margin (MCAP)	Covers the difference between the allowed 80% margin reduction and the current margin reduction if the latter is higher
	Delivery Margin	Delivery Margin covers the risk in positions in physically settled futures during the delivery period (e.g. natural gas futures)
	Initial Margin Spot Market (IMSM)	The IMSM is called for expected spot in the future and serves as a buffer to reduce intraday margin calls.

Source: ECC

Margining process

To cover the counterparty risk, each trader is obliged to sustain a margin account at the energy exchange (or the clearing house). In addition, the trader has to open a maintenance account and to transfer an initial margin that depends, among others, on the expected volume of his open positions

If a trader holds an open position and the futures price exceeds the contracted price, the clearing house transfers the price difference times contract size from the maintenance account to the margin account of the seller and from the margin account to the maintenance account of the buyer.

Margining process (continued)

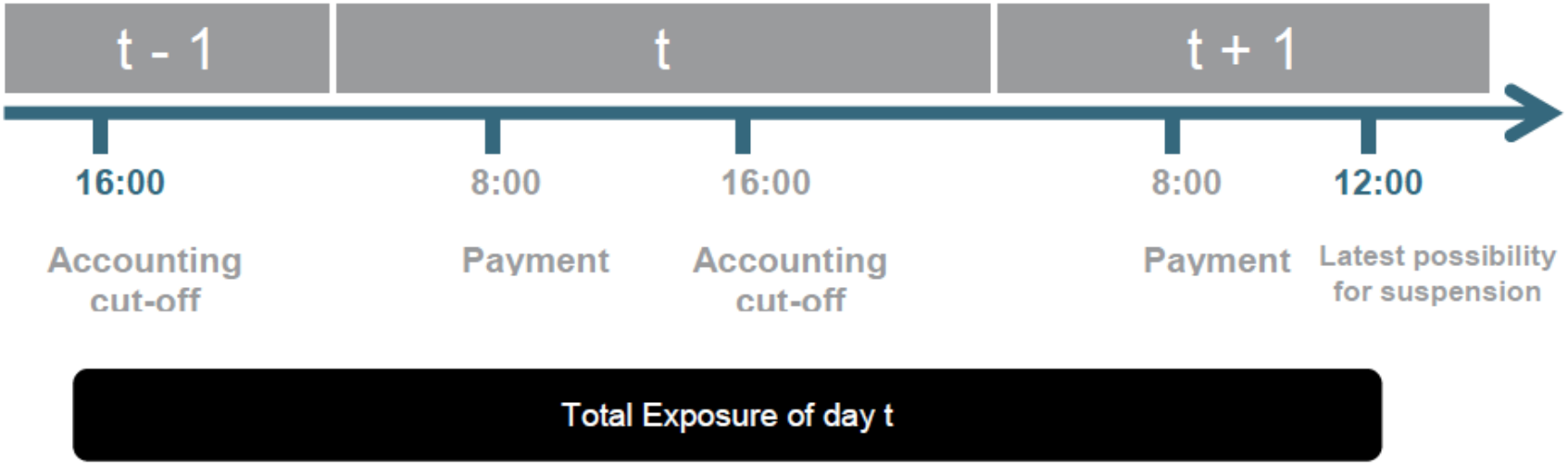
Debits and credits are adjusted at the end of each trading day according to the market price at closure.

If the maintenance account drops below a maintenance margin, the trader has to remargin the maintenance accounts within short time. Otherwise all open positions of the trader are closed by the clearing house at market conditions.

Calculation of Spot Margin

Spot Initial Margin (IMSM) is called for expected transactions.

The daily exposure at day t comprises all spot transactions that have been concluded between the accounting cut-off of the previous ECC business day and the latest point in time where a trading participant in default would be suspended from trading.



Source: ECC

Market transparency: REMIT

EU Regulation No 1227/2011 on wholesale energy market integrity and transparency (REMIT) Art. 4:

Market participants are obliged to publicly disclore in an effective and timely manner inside information regarding business or facilities that they control or operate for production, storage, consumption or transmission (of electricity and gas). *Information relevant to the capacity and use of facilities, incl. planned or unplanned availability.*

Prohibited activities:

- Insider trading → *non-discriminatory disclosure of inside information (see above); prohibition to trade or recommend trading on its basis unless published*
- Market manipulation: *giving misleading signals as to supply, demand or price; actions to secure an artificial price level (incl. in collusion with other market participants/persons)*

EEX Market transparency platform

VERBUND AG	2019/06/11 07:00	2019/06/14 20:00	Power plant Häusling – has technical problems and will be in maintenance activities with 180MW storage pump.	← *unplanned maintenance of an Austrian storage pump power plant*
Statkraft Markets GmbH	2019/06/08 00:00	2019/06/09 00:00	Publication of operational mistake - Wrong EEX bid Event: Failure in spot-market bid Impact: Sold too much power on the German EPEX day-ahead market	← *to avoid accusation of attempted market manipulation*
Statkraft Markets GmbH	2019/06/08 00:00	2019/06/08 23:59	Publication of operational mistake - Wrong EEX bid Event: Failure in spot-market bid Impact: Sold too much power on the German EPEX day-ahead market	
Uniper	2019/06/07 15:30	2019/06/30 23:59	Trials planned on Provence 4 Biomass on june 2019. Impact on the load over that period.	
Statkraft Markets GmbH	2019/06/06 06:45	2019/06/06 12:00	Outage cancelled at gas-fired power plant Knapsack 2: 0 MW out of 426 MW non-available since 06.06.2019 at 06:45 until 06.06.2019 at 12:00	
Statkraft Markets GmbH	2019/05/29 03:45	2019/05/30 00:00	Outage at gas-fired power plant Knapsack 2: 426 MW out of 426 MW non-available since 29.05.2019 at 03:45 until 30.05.2019 at 00:00; reason: failure	← *short outage of a gas power plant*
RWE Generation	2019/05/27 06:00	2019/05/29 00:00	GuD Dormagen: recommissioning tests after gas turbine overhaul will start on the 27th of May at 06:00 CET: dispatch will contain ramp up and down phases which are not exactly predictable (max output 190 MW).	
PZEM Energy BV	2019/06/01 07:00	2019/06/18 17:00	Further to a TenneT request, the Sloe 10 production level will be 0 MW.	← *redispatch for a Dutch CCGT*

Source: www.eex-transparency.com

Trading motives and trader types

Trader categories:

- asset-backed – trade to optimise assets / hedge price risk
- merchant / proprietary – speculate / gamble

Generators have a natural net long position: their value increases with rising prices.

Final consumers have a natural net short position: they benefit from falling prices.

Marketers who buy and resell power can be long or short.

Generators are exposed to volatile fuel prices / fixed selling prices.

Retailers are exposed to volatile purchase prices / fixed selling prices.

Trading strategies: Managing price risk

Risk is a source of uncertainty.

There is a fundamental tradeoff between risk and return.

Risk management is identifying and analysing risks and deciding if to accept or mitigate uncertainty.

The goal is to achieve an optimal risk-return profile of a portfolio.

Hedging

Hedging is reducing risk (i.e. uncertainty) by taking a position that offsets the risk of the existing position (equal and opposite exposure to the same underlying asset).

Hedging limits a potential loss and reduces a potential profit.

Final consumers (industrial and commercial), typically, lack trading capability and sufficient market insight and resort to hedging for better cost planning.

Traders hedge positions that they are not able or willing to close (e.g. long-term supply contract at a fixed price).

Generators like wind and solar projects may hedge the price risk via long-term fixed-price power purchase agreements (PPA) to facilitate financing.

Options terminology

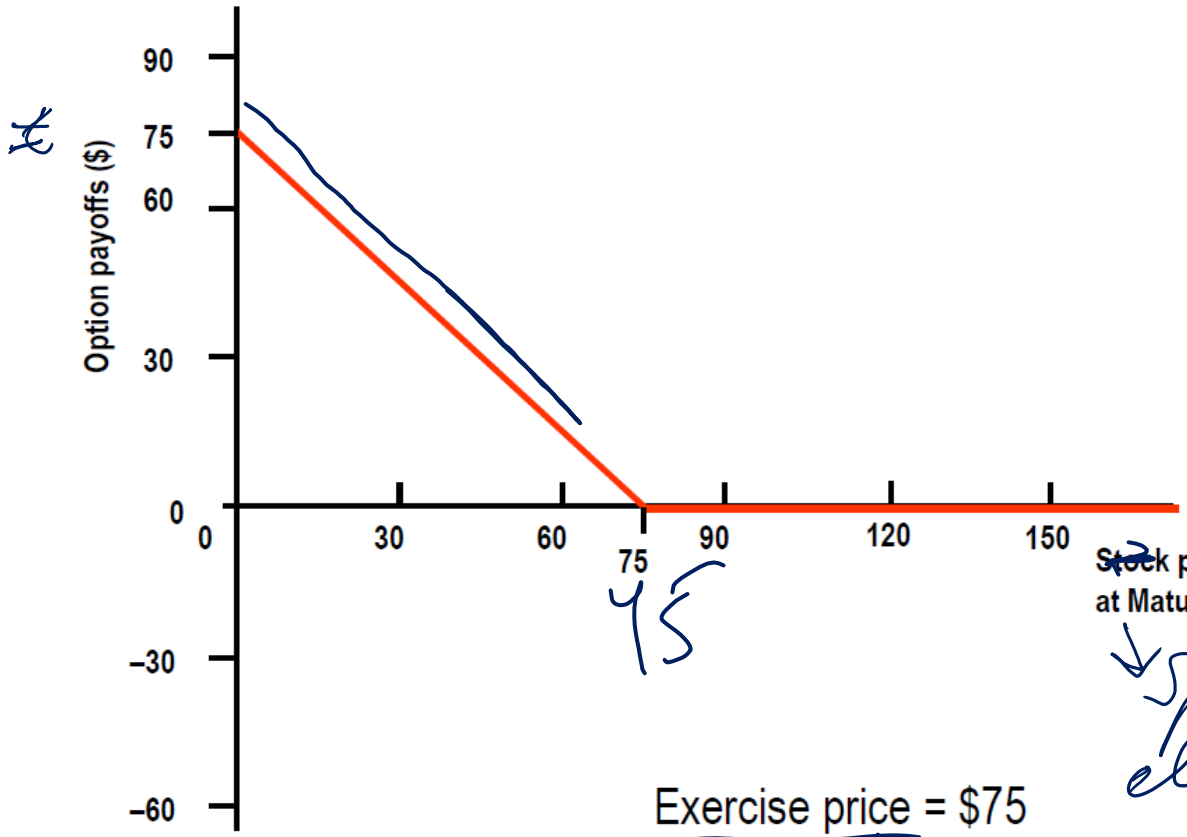
An option gives the holder the right, but not the obligation, to buy or sell a specified quantity of an underlying on (or before) a specified future date, at a predetermined price.

- Excercising the option is buying or selling the underlying.
- - Call option is a right to buy.

  - Put option is a right to sell.
- Expiry (expiration/maturity date) is the date on (or until) which the option can be excercised.
- - European options can be excercised only at expiry.

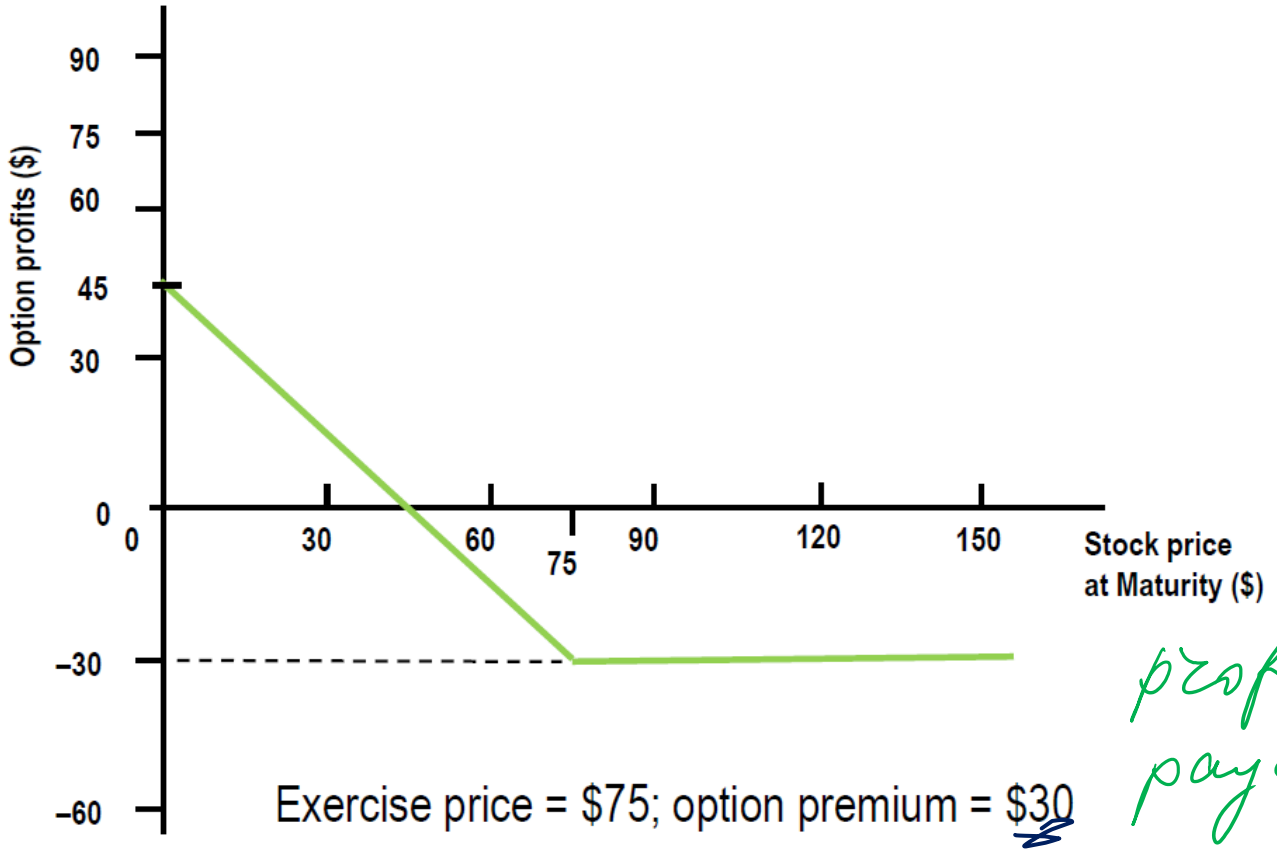
  - American options can be excercised at any time up to expiry.
- Strike (excercise) price is the pre-agreed buy or sell price.
- Option premium is a fixed amount paid by the holder (option buyer) to the writer (option seller) upon concluding an option.

Put Option Payoff



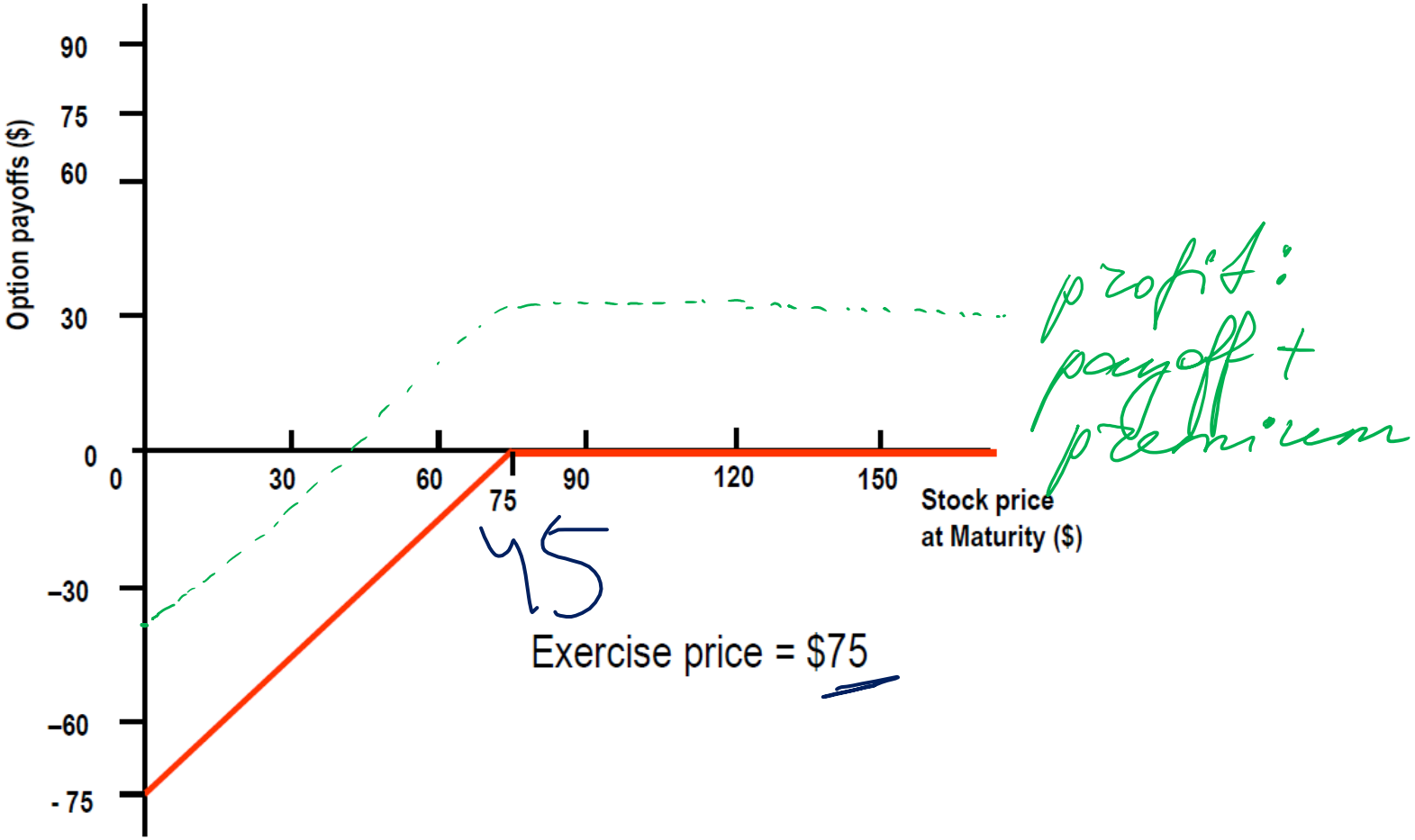
Exercise price = $75

Put Option Profits

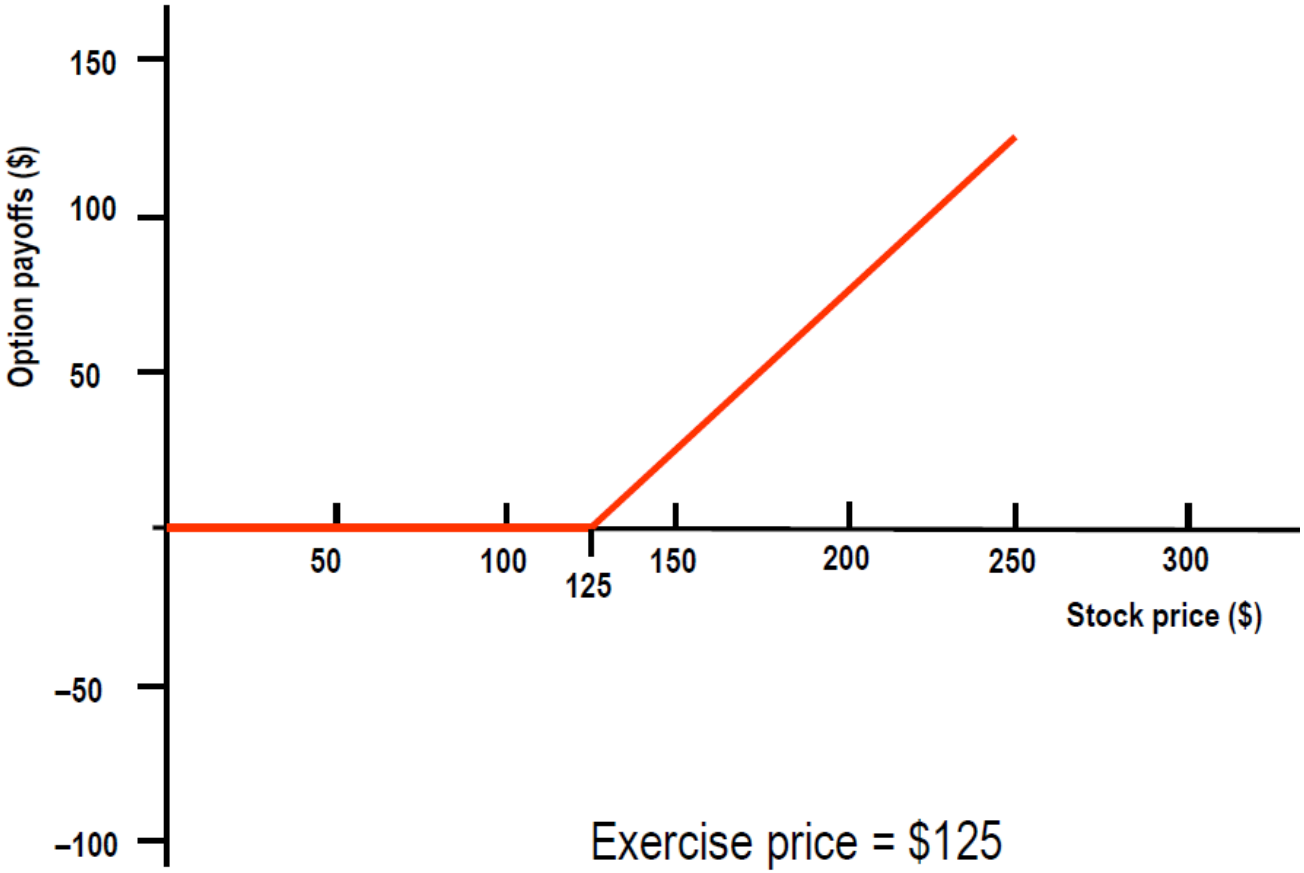


profit = payoff − premium

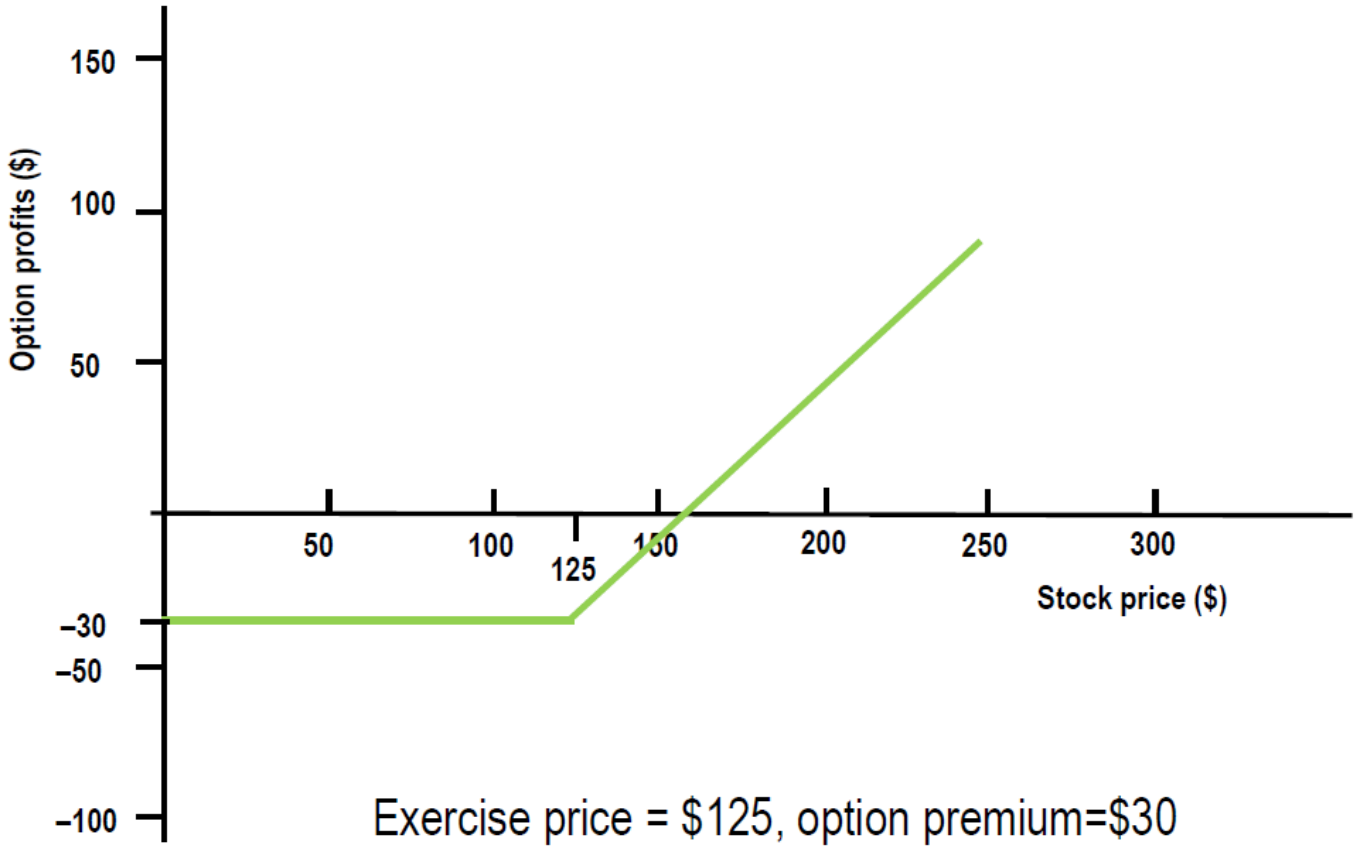
Put Option Writer's Payoffs



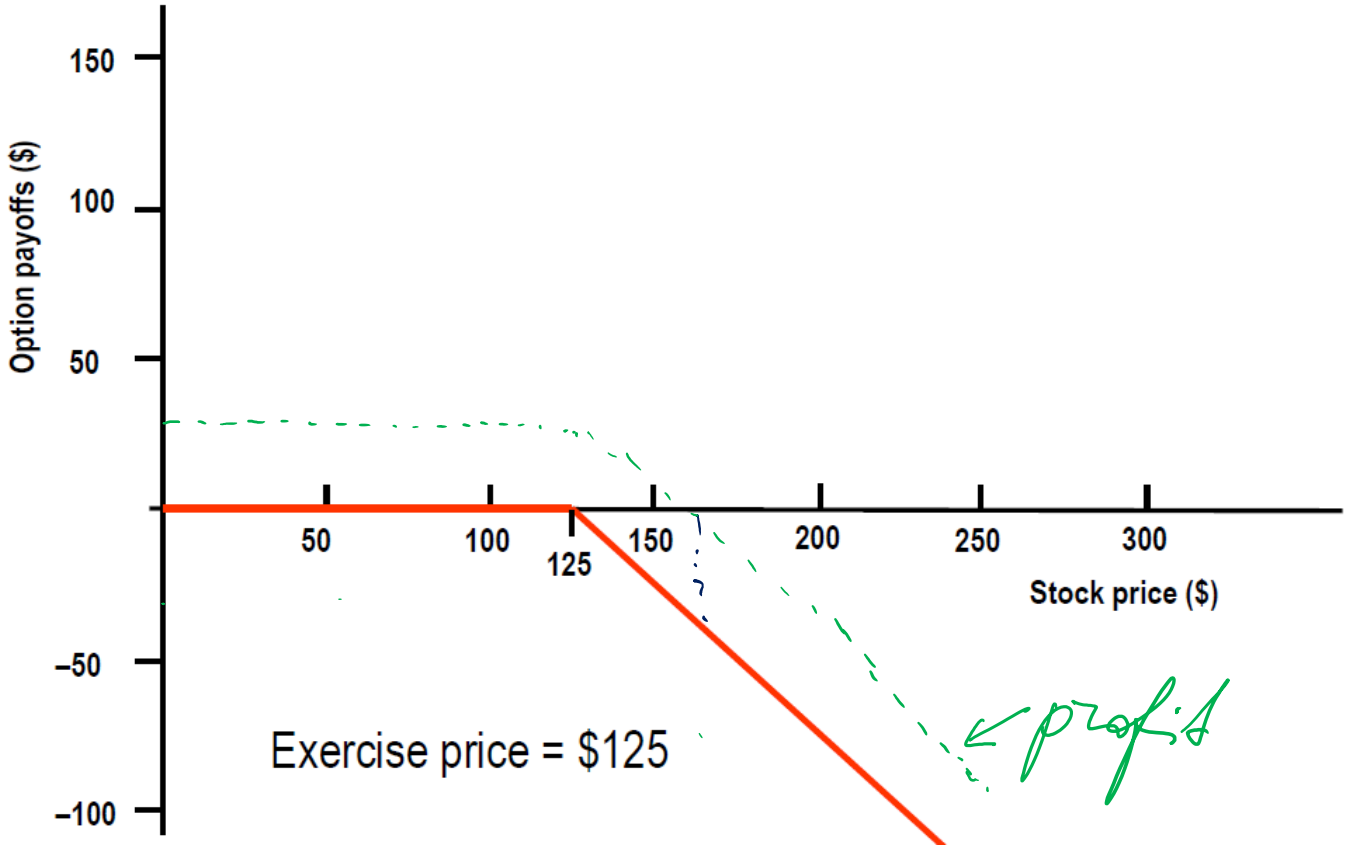
Call Option Payoffs



Call Option Profits



Call Option Writer's Payoffs



Options terminology (continued)

In-the-money: positive payoff in case of option excercise.

At-the-money: zero payoff in case of option excercise.

Out-of-the-money: negative payoff in case of option excercise.

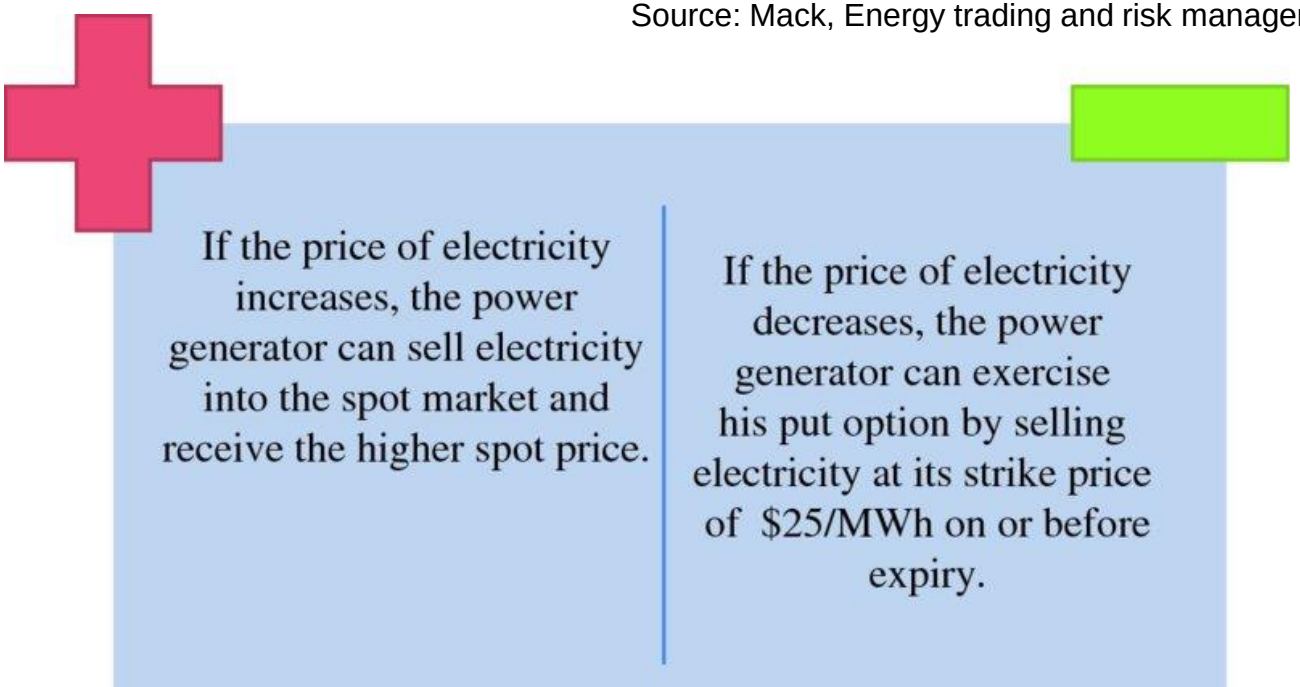
Call option is in-the-money if strike price < spot price.

Put option is in-the-money if strike price > spot price.

Generator hedging with put options

A power generator uses put options to guarantee a minimum selling price for its generated electricity. Suppose the electricity futures contract price is $25/MWh. The power generator wishes to receive at least $25/MWh for the physical sale of power. To accomplish this, the power generator purchases a put option for a premium of $1/MWh.

Source: Mack, Energy trading and risk management, 2014



Consumer hedging with call options

A power consumer can hedge against price increases by purchasing a call option. Suppose the electricity futures contract price is $25/MWh. The end user wishes to pay no more than $25/MWh. To accomplish this, the end user purchases a call option for a premium of $0.75/MWh.

Source: Mack, Energy trading and risk management, 2014