CONSTRUCTING FORWARD CURVES IN ENERGY MARKETS

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Tereza Klášterecká
Trading

DEFINITION OF POWER AS A TRADABLE COMMODITY

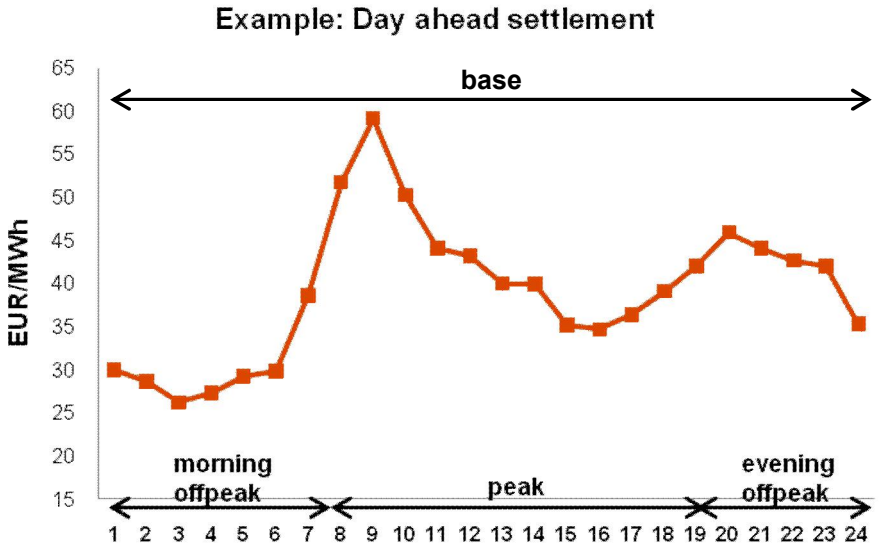
- Power is traded in MWh
- Minimum traded unit is 1MWh in a single hour
- Typically, power is structured in certain standardized forward/futures contracts
  - **Delivery**
  - **Load Profile**
  - **Country**
  - **Settlement:** financial/physical

LOAD PROFILES

- Single hours
- Base – all day
- Peak – working days 8:00 to 20:00
- Off-peak = base – peak
- Morning off-peak – 0:00 to 8:00
- Evening off-peak – 20:00 to 0:00

DELIVERY

- Hour, Day-Ahead, Workdays, Weekend
- Week, Month, Quarter, Season, Year

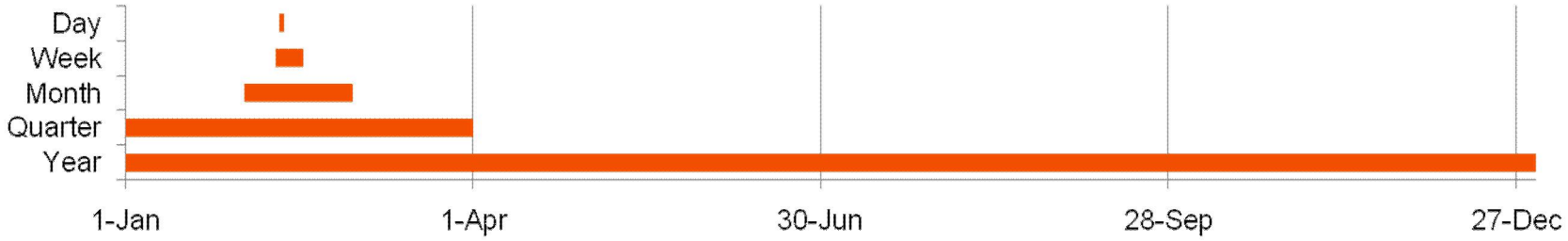


FORWARD CURVES AGGREGATE TRADED PRODUCTS

EXAMPLE

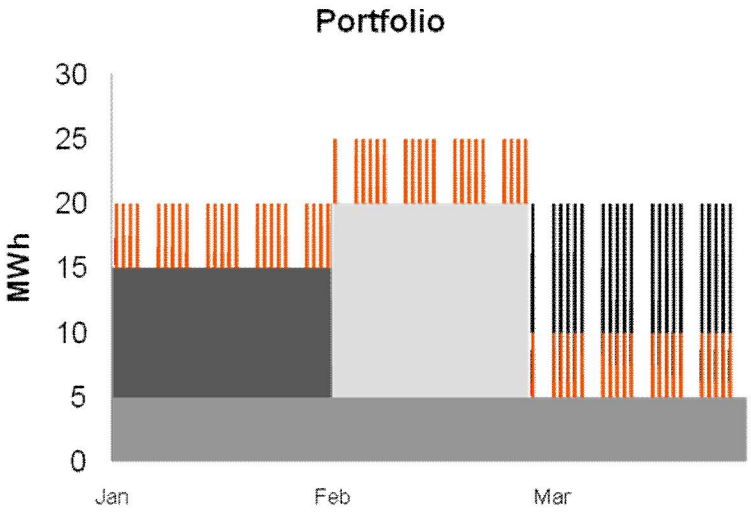
•As delivery approaches, power in “hour 2” of 10th Feb 2014 can be traded as part of different standardized products

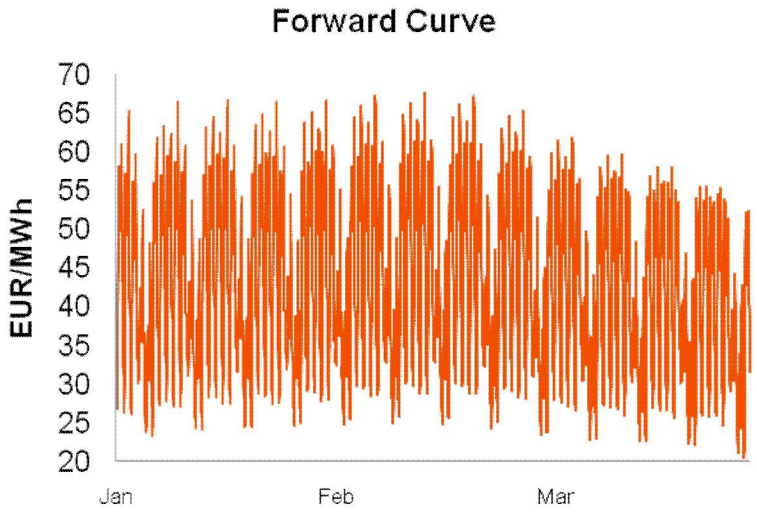
- Calendar Year 2014
- Q1 2014
- Feb 2014
- Week 7 2014
- Day 10-Feb-2014
- Individual hour



- USAGE: valuation of portfolios of products & non-standard diagrams & modeling of the assets (power plants, gas storages, ...)
- USERS: traders, risk management, analysts, etc.

EXAMPLE: PORTFOLIO VALUATION





Product	Delivery	Size
Q1	base	5
Jan	base	10
Feb	base	15
Q1	peak	5
Mar	peak	10

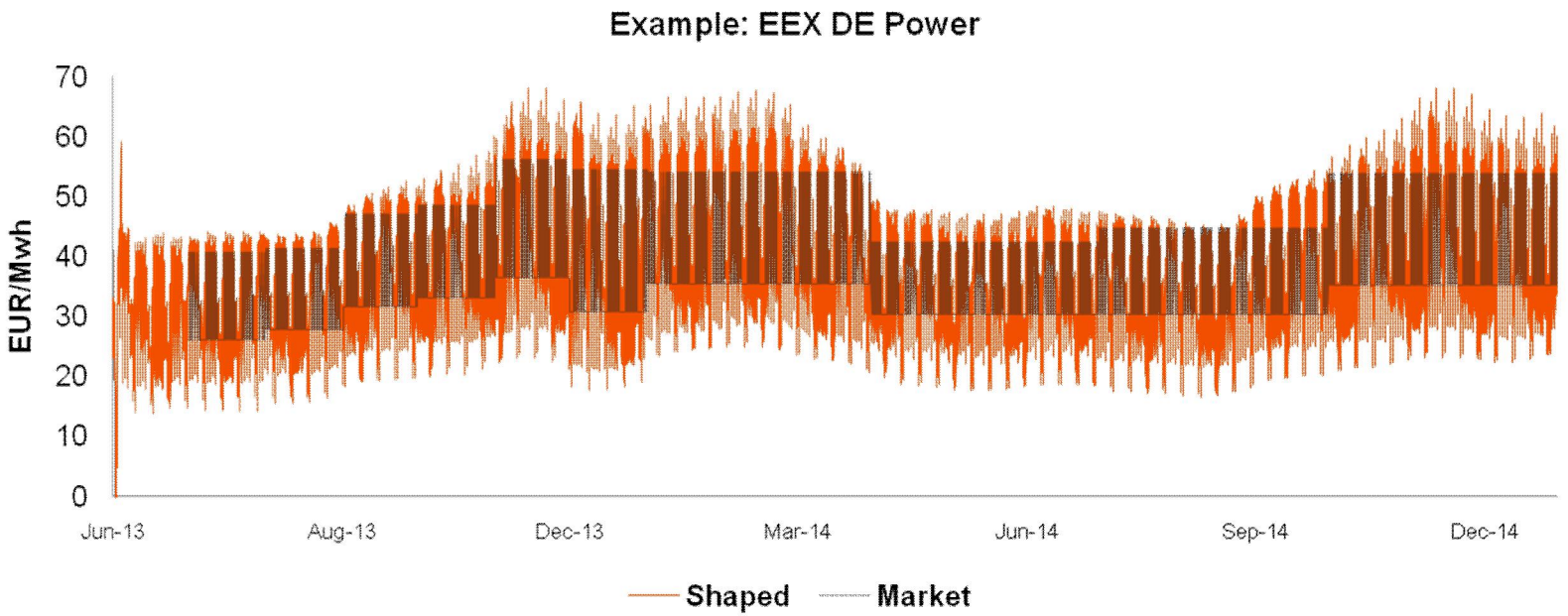
The total value of a portfolio can be calculated from the forward curve as

$$MWh * FW\ Curve$$

Value of example portfolio 1,533,885 EUR

REQUIREMENTS ON THE NATURE OF THE CURVES

- Aggregation of price data from all market traded products into a single curve/instrument
- Non-arbitrage across the curve
- Shaping the “flat” parts of the curve - indexing
- Smoothening the curve – eliminating “ugly” transitions



THE RECIPE: BUILDING THE FORWARD CURVE

Building block	Challenge
1) Aggregation of market prices into a single forward curve	• If arbitrage exists, which products should be used to build the curve
2) Calculation of indexes	• How to calculate indexes – mean, median, trimmed mean..., interpolation • Which indexes to calculate • How much historical data to use
3) Indexing the market curve	• Conflicting indexes • Market price constraints
4) Smoothing the indexed curve	• Subjective – how smooth should the curve be • Market price constraints
5) Automation	• Implementation in existing infrastructure

EXAMPLE: USING QUADRATIC OPTIMIZATION TO SMOOTH FORWARD CURVES

- Quadratic optimization is used to smooth the indexed curve
- The parameters in the objective function are weights of different intervals of smoothing
  - λ_1 - step 1, next day
  - λ_2 - step 7, next week
  - λ_3 - step 30, next month
- The constraints are the market prices of the market products

$$min \quad \sum_{i=1}^{T}(x_i - C_i)^2 + \lambda_1 \sum_{i=2}^{T-1}(x_{i-1} - 2x_i + x_{i+1})^2 + \lambda_2 \sum_{i=8}^{T-7}(x_{i-7} - 2x_i + x_{i+7})^2 + \lambda_3 \sum_{i=31}^{T-30}(x_{i-30} - 2x_i + x_{i+30})^2$$

$$subject\ to \quad Ax = b$$

MATLAB IN ANALYTICAL INFRASTRUCTURE