Price Risk Based Power Portfolio Optimization with Liquidity Constraints

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Power as a product

Electricity cannot be stored:

- Production and consumption have to be equal.

Demand side:

- Short-term demand is inelastic.
- The future demand/consumption is uncertain.

Supply side:

- Given power plant capacity.
- Transportability, infrastructure constraints.
- Solar and wind power production uncertainties,
- power plant outages.

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Power related markets

Wholesale electricity market

The traded product is electricity

- for a given time period,
- with a given power level for each (quater) hour,
- sometimes with some tolerance.

Capacity market

- Cross-border capacities.

Regulation power market

- Balancing energy.
- Control power market.

Transmission System fees

- Transmission system operation fee.
- Charges for ancillary services.
- Distribution charges.

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Standard power products

Spot market (day-ahead/$D-1$)

- hourly and block products.

Intraday market (D)

- hourly products.

Derivatives market

- futures (standard forward products),
- options (typically on futures with different expiries).

Typical profiles of standard products

- base-load: 0-24, all days,
- peak-load: 8-20, Mo-Fr,
- off-peak: complementary of peak-load.

Typical maturities of standard products

- day, week, month, quater, year

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OTC markets

TFS Hungarian Power

Trader in Focus:

Wed 24/04/2013	Hungary Baseload							Hungary Peak (08-20)						
	Code	Qty	Bid	Ask	Qty	Code	Last	Code	Qty	Bid	Ask	Qty	Code	Last
Thu 25/04/2013							32,50							
Fri 26/04/2013		10	28,00	34,00	10									
Sat 27/04/2013														
Sun 28/04/2013														
Mon 29/04/2013		10	33,10	36,00	10		33,90							
Tue 30/04/2013		10	29,50	38,75	10									
WkEnd 27/4-28/		25*	23,50	24,00	10									
WkEnd 4/5-5/														
Wk18 29/04/13		5	28,40	29,25	10		29,75							
Wk19 06/05/13		10	28,10	32,25	10									
Wk20 13/05/13		10	34,25	36,25	5									
Wk 18-13 (WD)														
Wk 19-13 (WD)														
Bal of Month														
May-13		10	33,75	34,20	10		33,80		5	40,75	41,75	5		41,00
Jun-13		10	36,50	37,25	5		37,00		10	44,75	47,50	10		
Jul-13		10	40,50	44,00	5									
Aug-13		10	42,00	49,00	10									
Sep-13		10	43,00	49,00	10									
Oct-13														

Hungarian Power Exchange (HUPX)

MARKET DATA

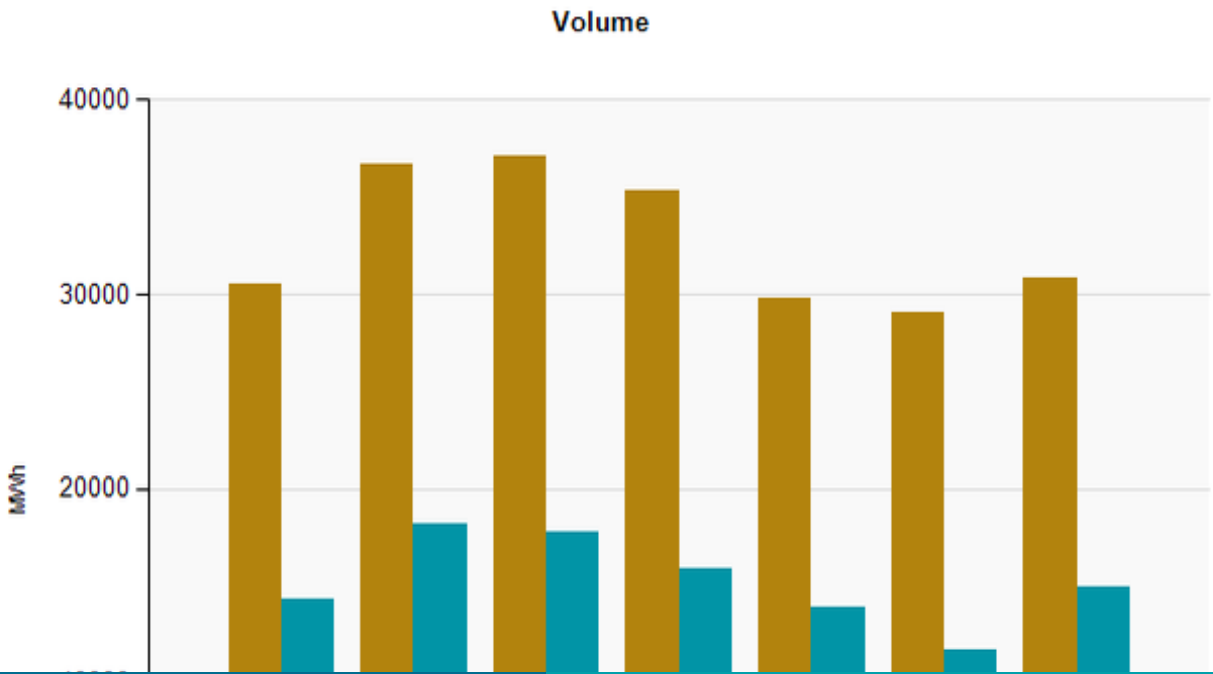
HUPX DAM | HUPX PhF

Please enter the code: E R T OK

ATC values | Weekly data | Data Chart | Aggregated | MC results

Delivery day: 27/10/2014

Report Type



HUPX DAM

Delivery day	28/10/2014
Price Base (€/MWh)	56.26 ▲
Price Peak (€/MWh)	72.60 ▲
Vol. Day (MWh)	28,891.5 ▼
Vol. Month (MWh)	952,563.5
ATC values	Delivery day: 29/10/2014

Read more

HUPX PhF

	base price (€/MWh)	base volume (lot)	peak price (€/MWh)	peak volume (lot)
Wk45-14	47.87 ▼		N/A	
Wk46-14	44.00 ▼		N/A	
Wk47-14	44.67 ▼		N/A	
Wk48-14	45.00 ▼		N/A	
Nov-14	44.63 ▼		55.44 ▼	
Dec-14	43.40 ▼		5 53.26 ▼	
Jan-15	46.25 ▼		55.36 ▼	
Q1-15	45.42 ▼		5 55.61 ▼	
Q2-15	37.70 ▼		45.89 ▲	
Q3-15	43.73 ▼		53.13 ▲	
Q4-15	44.55 ▲		53.86 ▲	
YR-15	42.85 ▼		10 52.12 ▲	
YR-16	42.79 ▼		52.25 ▼	
YR-17	42.80 ▼		52.02 ▼	

European Energy Exchange (EEX)

eeX Products Trading Market Data Access Training

Power Products offered at EEX

	Products	Contracts
Spot market **24/7**	· Day-Ahead Auction (CH) · Day-Ahead Auction (DE/AT, FR) · Intraday (DE, AT, FR, CH)	**Day-ahead market** · Hour and block contracts (DE/AT, FR, CH) **Intraday market** · Hour and block contracts (DE/AT, FR) · 15-minute contracts (DE/AT, CH)
Derivatives Market	· Phelix-Futures (DE/AT)	· Day Futures

Business situations

Long-term procurement plan

- Given the (net) demand curve for the next year.
- Find a long-term purchase plan based on derivatives.

Hedging open positions

- New contracts, new information:
- portfolio rebalancing.

Transfer price

- Customer with given consumption curve.
- Calculation the procurement cost of the consumption.

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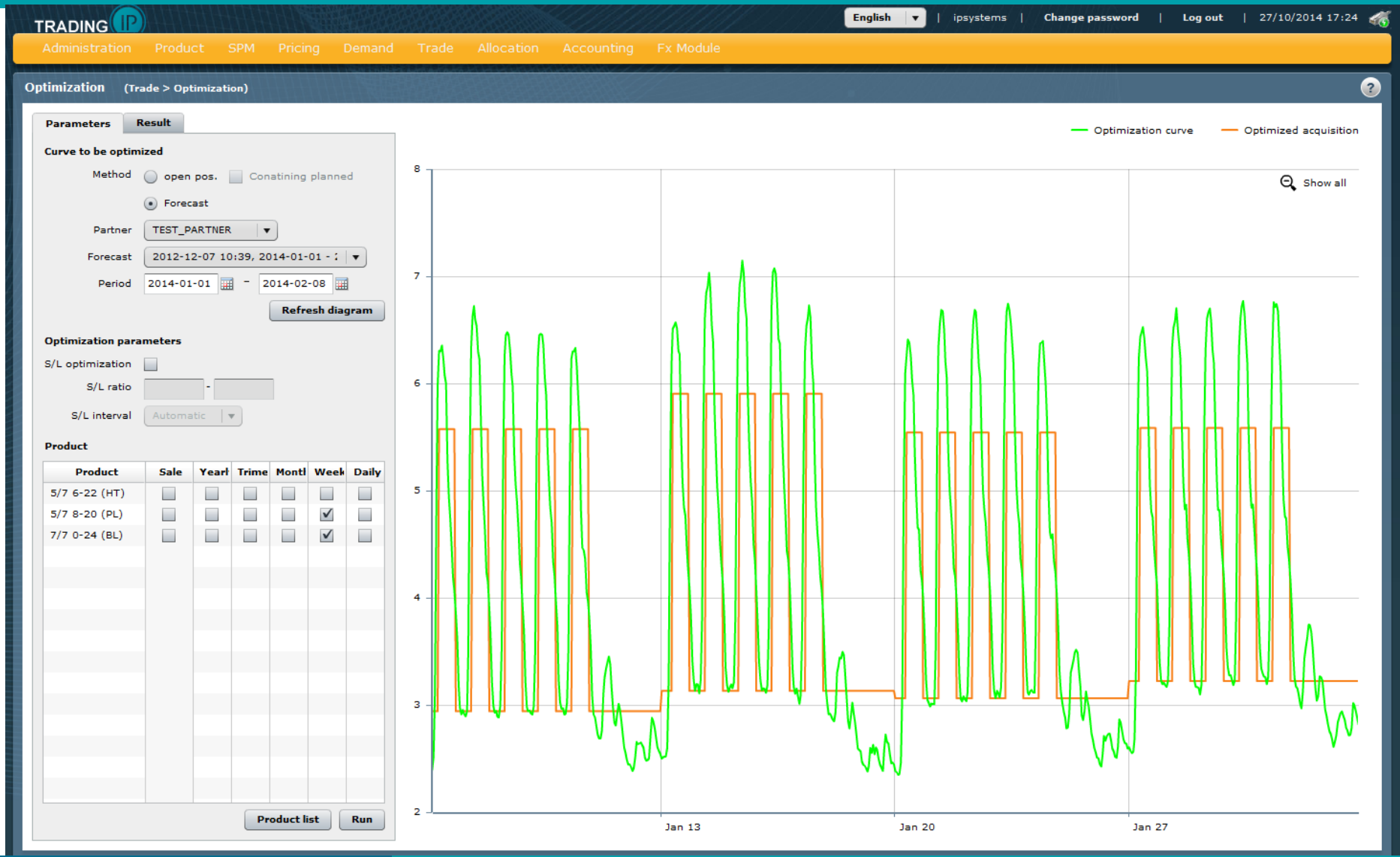
Volume-based hedging



Expected value vs. Risk: St. Petersburg paradox

(de Montmort 1713, Bernoulli 1738)
A casino offers a game of chance in which a fair coin is tossed at each stage.

- The pot starts at 2 dollars,
- and is doubled every time a head appears.

What would be the fair price of the game?
Consider, the expected value of the payout:

$$E(Payout) = \frac{1}{2} \cdot 2 + \frac{1}{2^2} \cdot 2^2 + \frac{1}{2^3} \cdot 2^3 + \dots$$

$$= 1 + 1 + 1 + \dots = \infty$$

Hence, selling all your wealth, then paying all the money to the casino to enter the game seems to be a reasonable choice!(?)

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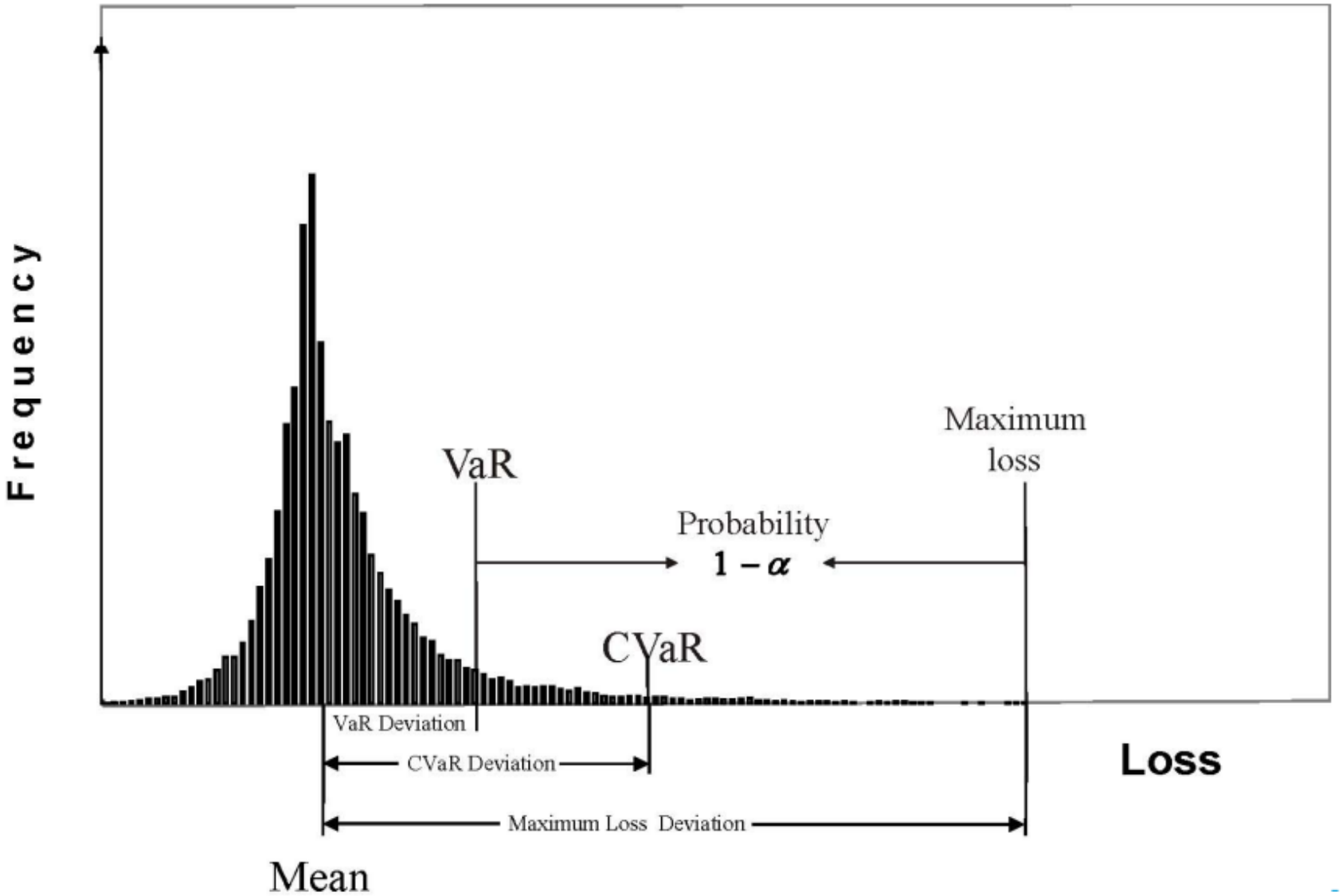
(Conditional) Value-at-Risk



Exact definition of (Conditional) Value-at-Risk

Let the random loss denoted by L and the level of significance denoted by $0 < \alpha < 1$.

Definition (Value-at-Risk)

$$VaR_\alpha(L) = \min\{z | F_L(z) \geq \alpha\}.$$

Definition (Conditional Value-at-Risk)

$$CVaR_\alpha(L) = \int_{-\infty}^{+\infty} z dF_L^\alpha(z),$$

where

$$F_L^\alpha(z) = \begin{cases} 0, & \text{if } z < VaR_\alpha(L) \\ \dfrac{F_L(z) - \alpha}{1 - \alpha}, & \text{if } z \geq VaR_\alpha(L) \end{cases}$$

Calculation of Conditional Vale-at-Risk

Definition (Upper Conditional Value-at-Risk)

$$CVaR_\alpha^+(L) = E\left[L|L > VaR_\alpha(L)\right].$$

Also called Mean Excess Loss and Expeced Shortfall.

Definition (Lower Conditional Value-at-Risk)

$$CVaR_\alpha^-(L) = E\left[L|L \geq VaR_\alpha(L)\right].$$

Also called TailVaR.

Theorem

$$CVaR_\alpha(L) = \begin{cases} \lambda_\alpha(L)VaR_\alpha(L) + (1-\lambda_\alpha(L))CVaR^+(L), & F_L\left(VaR_\alpha(L)\right) < 1 \\ VaR_\alpha(L), & F_L\left(VaR_\alpha(L)\right) = 1, \end{cases}$$

where

$$\lambda_\alpha(L) = \frac{F_L\left(VaR_\alpha(L)\right) - \alpha}{1-\alpha}$$

Properties of CVaR

The major innovation of the definition of CVaR:

- CVaR is continuous with respect to L,
- CVaR is convex in L.

Some remarks:

- VaR, CVaR - ,CVaR + may be non-convex
- $VaR \leq CVaR^{-} \leq CVaR \leq CVaR^{+}$

CVaR is a coherent risk measure.If A and B are two portfolios, then

1. $CVaR(\emptyset) = 0$,
2. if $A \leq B$ then $CVaR(A) \leq CVaR(B)$,
3. $CVaR(x \cdot A) = x \cdot CVaR(A)$,
4. $CVaR(A + x) = CVaR(A) - x$, where x is cash (constant),
5. $CVaR(A + B) \leq CVaR(A) + CVaR(B)$, subadditivity.

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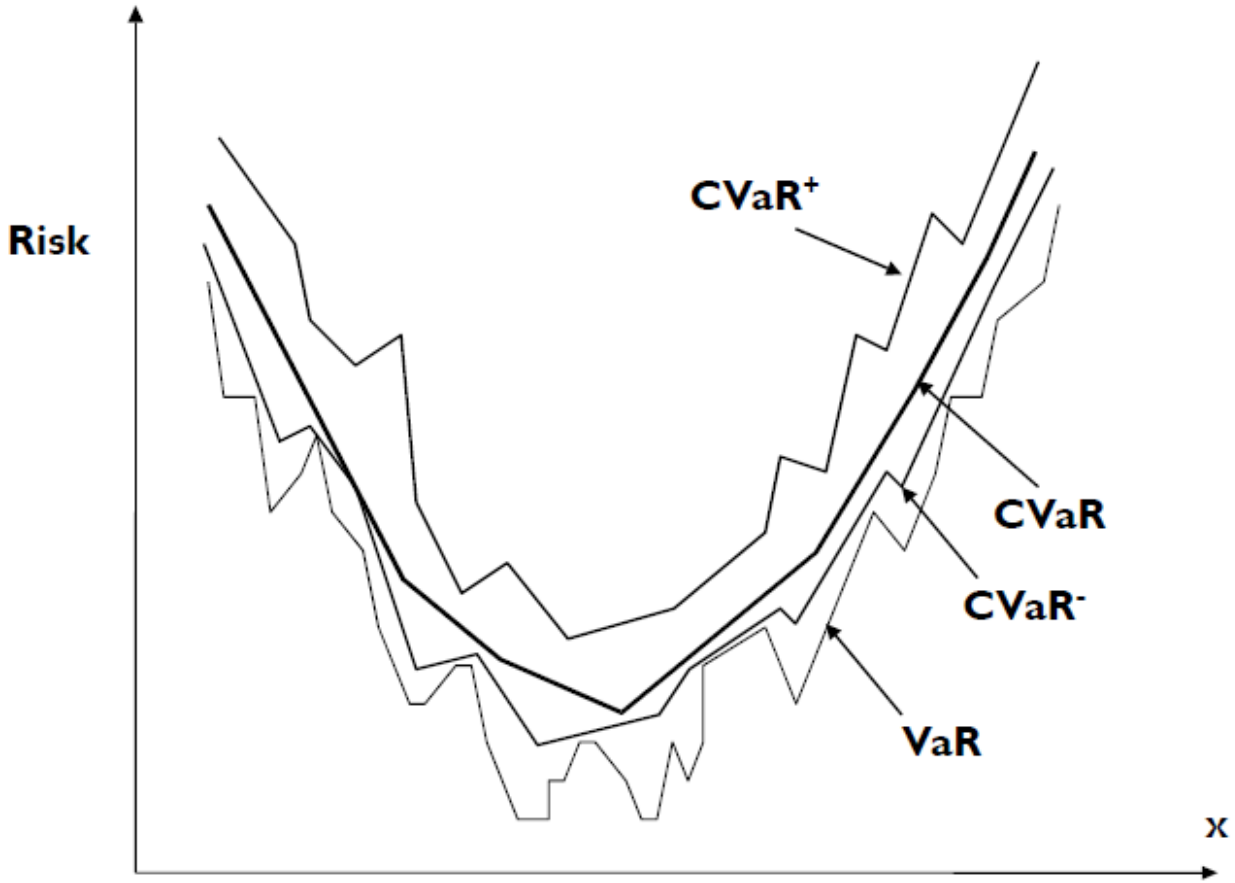
Convexity of CVaR



Rockafellar, R.T. and S. Uryasev (2000). Optimization of conditional value-at-risk. *Journal of Risk* **2**, 21–41.

Planning and holding periods

There is a planning horizon, typically more than one year.
The portfolio consists of

- an aggregate net demand curve,
- and long and short positions of standard forward products.

Each product as well as the demand curve must be within the planning horizon.

There is a holding period, typically 2 weeks.

- The portfolio cannot be re-hedged within the holding period.
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Mark-to-Market (MtM)

Each ingredient of the portfolio can be valued in the following way.

- In case of standard forward products:
  - if the product has price on the market, then that should be used,
  - if there is no contract on the product, then some consistent market-based approximation can be used.

- The aggregate net demand curve can be valued by the so-called Hourly Price Forward Curve (HPFC).
  - The HPFC gives forcast for the price of each hourly spot product.
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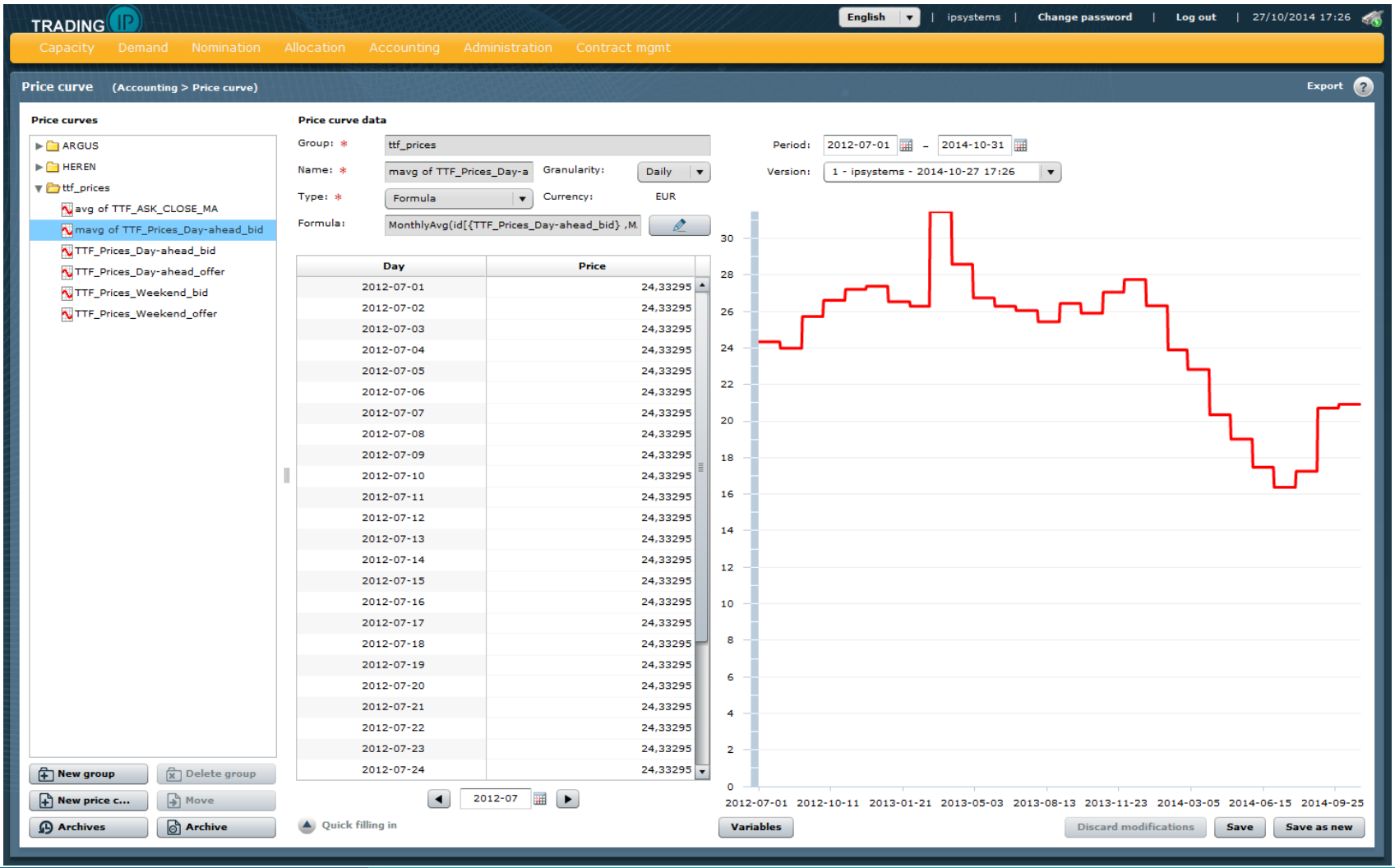
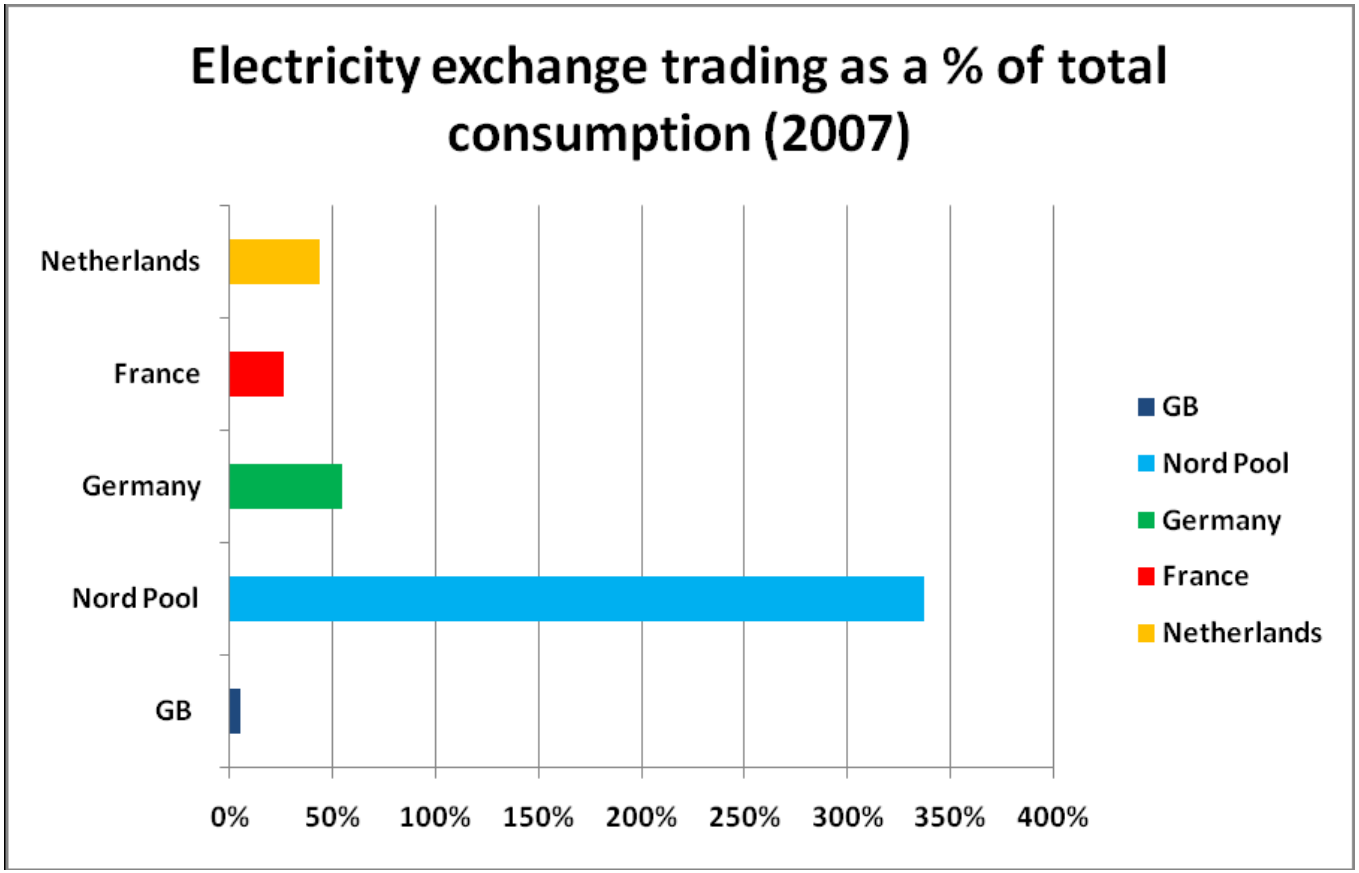
Price curves

Electricity is non-storable: it has different unit price for each hour.



The market: Liqudity

The liquidity of wholesale energy markets is very poor.



The main reasons are: vertical integration, a lack of interconnection, imbalance prices, collateral requirements.

(C)VaR vs. (C)PaR

The valuation of a portfolio is splitted into two parts.

- The liquid part of the portfolio
  - consists of the positions that can be closed on the market immediately.
  - The subportfolio can be valued by forward prices.
- The illiquid part of the portfolio
  - consists of the remainder positions that cannot be closed because of the market illiquidity.
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The "business" terms

- (Conditional) Profit-at-Risk means the "mathematical" (C)VaR value of the illiquid part of the porfolio.
- (Conditional) Value-at-Risk means the (C)VaR value of positions that can be closed.

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The problem: Input

- Initial portfolio: net demand curve and forward products,
- the holding period,
- at the beginning of the holding period:
  - available forward products with their liquidity bounds,
  - prices of the forward products,
  - HPFC.
- For the end of the holding period:
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  - scenarios:
    - for the price of the forward products,
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The problem: Objective

- Let us calculate the changes in value of the hedged portfolio for each scenario.
- The changes in value is a profit-type quantity. Profit=-Loss. Hence, the profit based CVaR can be calculated from the portfolios.
- Our aim is to find the hegding strategy (i.e., forward product trading strategy at the beginning of the holding period), which optimize the CVaR value.

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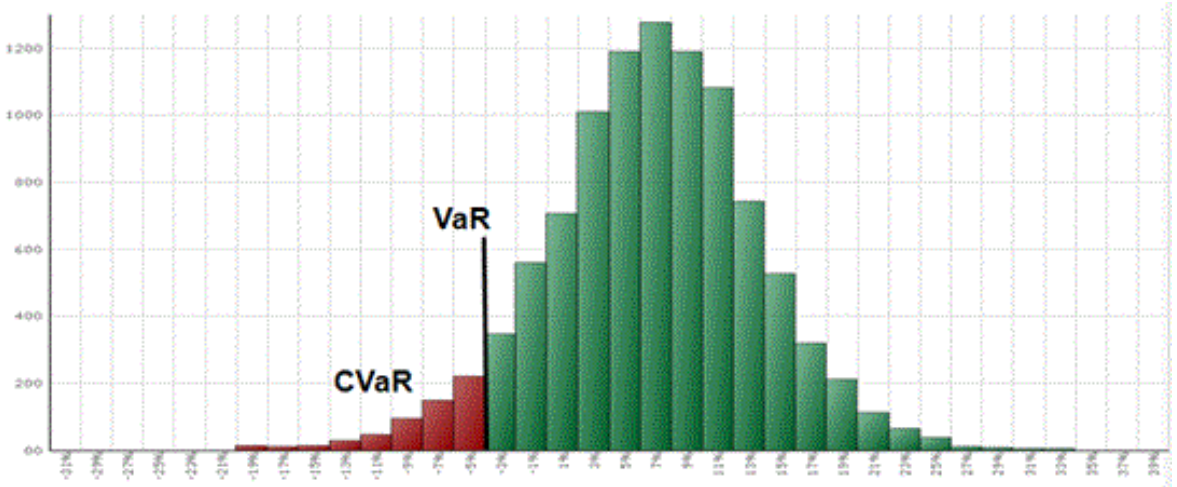

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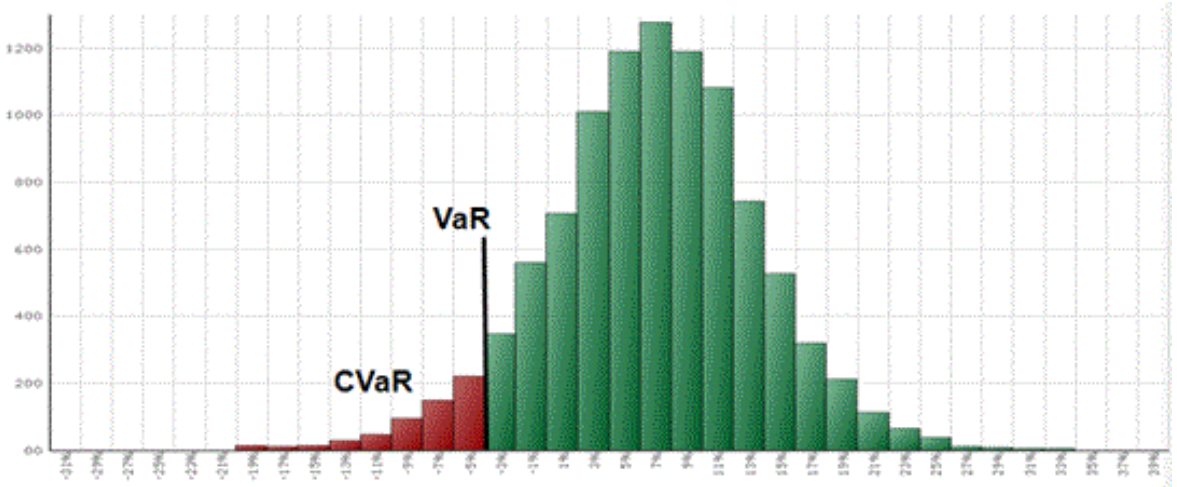

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Alternative definition of CVaR

Pflug, G. C. (2000). Some remarks on the value-at-risk and the conditional value-at-risk. In Probabilistic constrained optimization (pp. 272-281). Springer US.

$$CVaR_\alpha(L) = \min_v \left\{ v + \frac{1}{1-\alpha} E[L-v]^+ \right\}$$

$$VaR_\alpha(L) = \arg\min_v \left\{ v + \frac{1}{1-\alpha} E[L-v]^+ \right\}$$

Optimization of CVaR

- Define the loss function

$$L = f(\boldsymbol{x}, \boldsymbol{Y}),$$

where $\boldsymbol{x}$ is the decision vector and $\boldsymbol{Y}$ is a random vector.

- $$F_\alpha(\boldsymbol{x}, v) := v + \frac{1}{1-\alpha} E\left([f(\boldsymbol{x}, \boldsymbol{Y}) - v]^+\right)$$
- Then
$$CVaR_\alpha\left(f(\boldsymbol{x}, \boldsymbol{Y})\right) = \min_v F_\alpha(\boldsymbol{x}, v).$$
- Hence,
$$\min_{\boldsymbol{x}} CVaR_\alpha(L) = \min_{(\boldsymbol{x}, v)} F_\alpha(\boldsymbol{x}, v)$$

Optimization based on scenarios

Discrete distribution:

$$P(\boldsymbol{Y} = \boldsymbol{y}^i) = p_i, \;\; i = 1, \ldots, I.$$

Then:

$$F_\alpha(\boldsymbol{x}, v) = v + \frac{1}{1-\alpha} \sum_{i=1}^{I} \left[f(\boldsymbol{x}, \boldsymbol{y}^i) - v \right]^+$$

Hence, the the CVaR minimization can be formulated as

$$\begin{aligned} \min_{(\boldsymbol{x}, v)} \quad & v + \frac{1}{1-\alpha} \sum_{i=1}^{I} p_i z_i \\ \text{subject to} \quad & \\ f(\boldsymbol{x}, \boldsymbol{y}^i) - v \quad & \leq z_i, \;\; i = 1, \ldots, I \\ z_i \quad & \geq 0. \end{aligned}$$

Liquidity constraints

- y_{f0}^{r-}: binary variable that equals 1 iff the short position product f cannot be closed entirely,
- y_{f0}^{c+}: binary variable that equals 1 iff the long position product f can be closed entirely,
- pos_{ft}^{c-}: absolute value of the short position of product f if the position can be closed entirely
- pos_{ft}^{r+}: absolute value of the long position of product f if the position can be closed entirely

Value of the liquid and illiquid subportfolio, respectively:

$$cv_0 = \sum_{f=1}^{FP} \left(-U_{f0} y_{f0}^{r-} - pos_{f0}^{c-} + pos_{f0}^{c+} + L_{f0} y_{f0}^{r+} \right) P_{f0}$$

$$rv_0 = \sum_{f=1}^{FP} \left(-pos_{f0}^{r-} + U_{f0} y_{f0}^{r-} + pos_{f0}^{r+} - L_{f0} y_{f0}^{r+} \right) R_{f0} - R_{LC0}$$

The objective function

$$\max CVaR_\alpha(cv_H + rv_H - cv_0 - rv_0)$$

Linear objective function:

$$\max\left(-v + \sum_{i=1}^{I} -\frac{1}{I(1-\alpha)} z^i\right)$$

subject to

$$-cv_H^i - rv_H^i + cv_0 + rv_0 - v \leq z^i, \qquad i \in \{1, \ldots, I\}$$

The objective function

$$\max CVaR_\alpha(cv_H + rv_H - cv_0 - rv_0)$$

Linear objective function:

$$\max \left(-v + \sum_{i=1}^{I} -\frac{1}{I(1-\alpha)} z^i \right)$$

subject to

$$-cv_H^i - rv_H^i + cv_0 + rv_0 - v \leq z^i, \qquad i \in \{1, \ldots, I\}$$

Multiple optima

Minimizing the number (cost) of transactions. E.g., do not buy Jan, Feb, Mar products instead of Q1.

$$\min \sum_{f=1}^{FP} \left(x_f^- + x_f^+ \right)$$

subject to

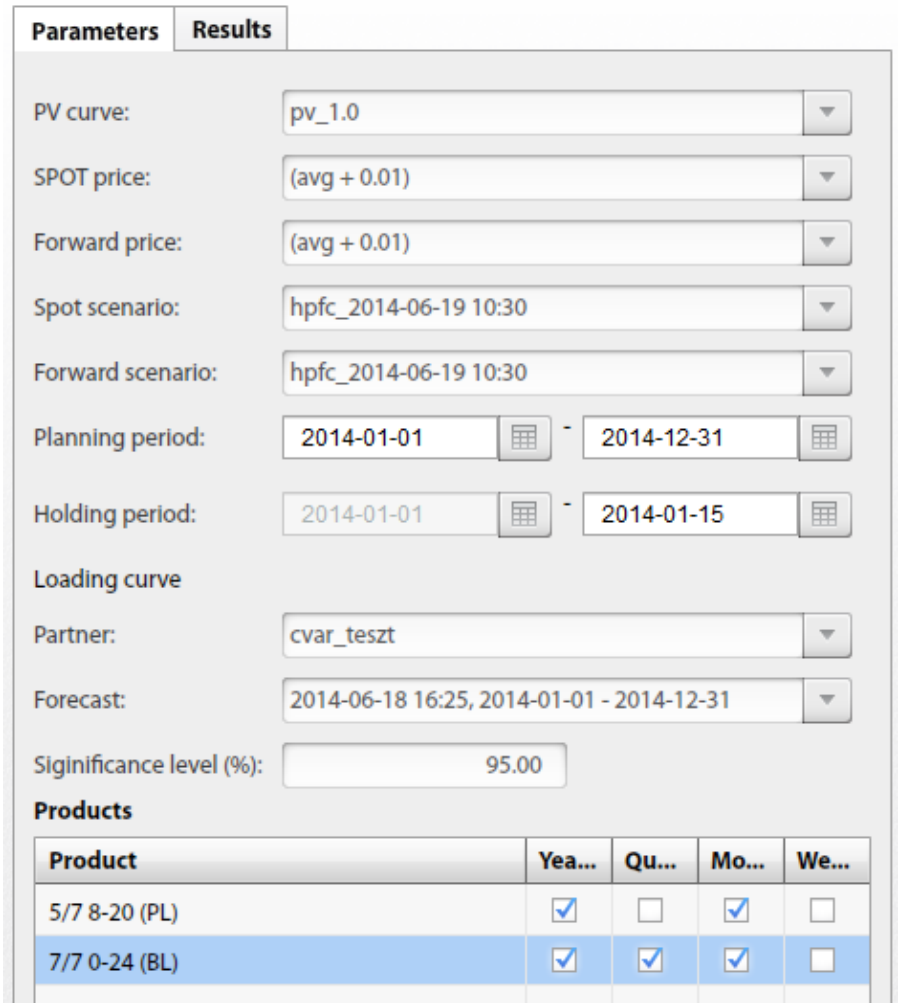
$$\begin{aligned} x_f &\leq x_f^+, & f &\in \{1, \ldots, FP\} \\ -x_f &\leq x_f^-, & f &\in \{1, \ldots, FP\} \end{aligned}$$

$$\left(-v - \frac{1}{I(1-\alpha)} \sum_{i=1}^{I} z^i \right) \geq CVaR_{opt}$$

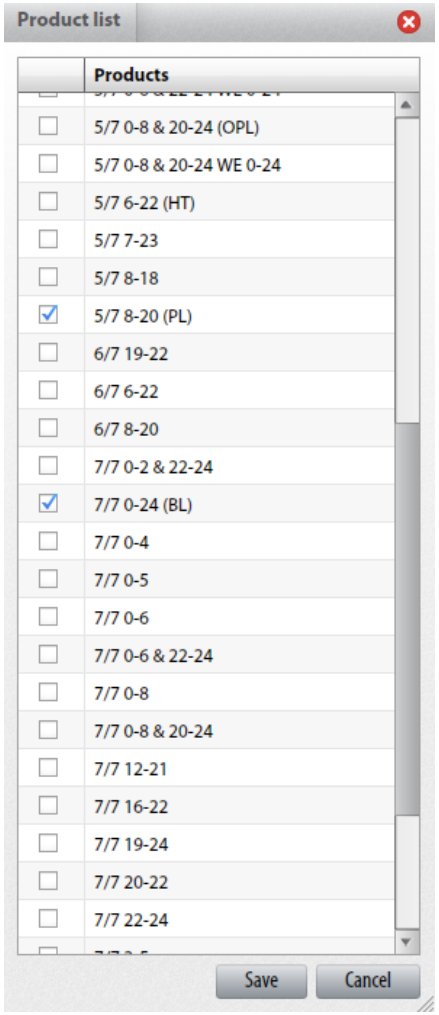
Input data


KIP
https://ekiptest2.ips.hu/KIP_PIAC13/KIP.html
index plural
TRADING IP
English | ipsystems | Change password | Log out | 27/10/2014 14:49
Administration Product SPM Pricing Demand Trade Allocation Accounting Fx Module Risk management
CVaR (Risk management > CVaR)
Parameters Results
PV curve: pv_1.0
SPOT price: (avg + 0.01)
Forward price: (avg + 0.01)
Spot scenario: hpfc_2014-06-19 10:30
Forward scenario: hpfc_2014-06-19 10:30
Planning period: 2014-01-01 - 2014-12-31
Holding period: 2014-01-01 - 2014-01-15
Loading curve
Partner: cvar_teszt
Forecast: 2014-06-18 16:25, 2014-01-01 - 2014-12-31
Siginificance level (%): 95.00
Products
Product Yea... Qu... Mo... We...
5/7 8-20 (PL)
7/7 0-24 (BL)
Products
Limits
Run
Position and hedging
Distribution
500
450
400
350
300
250
200
150
100
2014 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Optimized
Modified
Forecast

Input data


Parameters
Results
PV curve:
pv_1.0
SPOT price:
(avg + 0.01)
Forward price:
(avg + 0.01)
Spot scenario:
hpfc_2014-06-19 10:30
Forward scenario:
hpfc_2014-06-19 10:30
Planning period:
2014-01-01
2014-12-31
Holding period:
2014-01-01
2014-01-15
Loading curve
Partner:
cvar_teszt
Forecast:
2014-06-18 16:25, 2014-01-01 - 2014-12-31
Siginificance level (%):
95.00
Products
Product
Yea...
Qu...
Mo...
We...
5/7 8-20 (PL)
7/7 0-24 (BL)

Product types



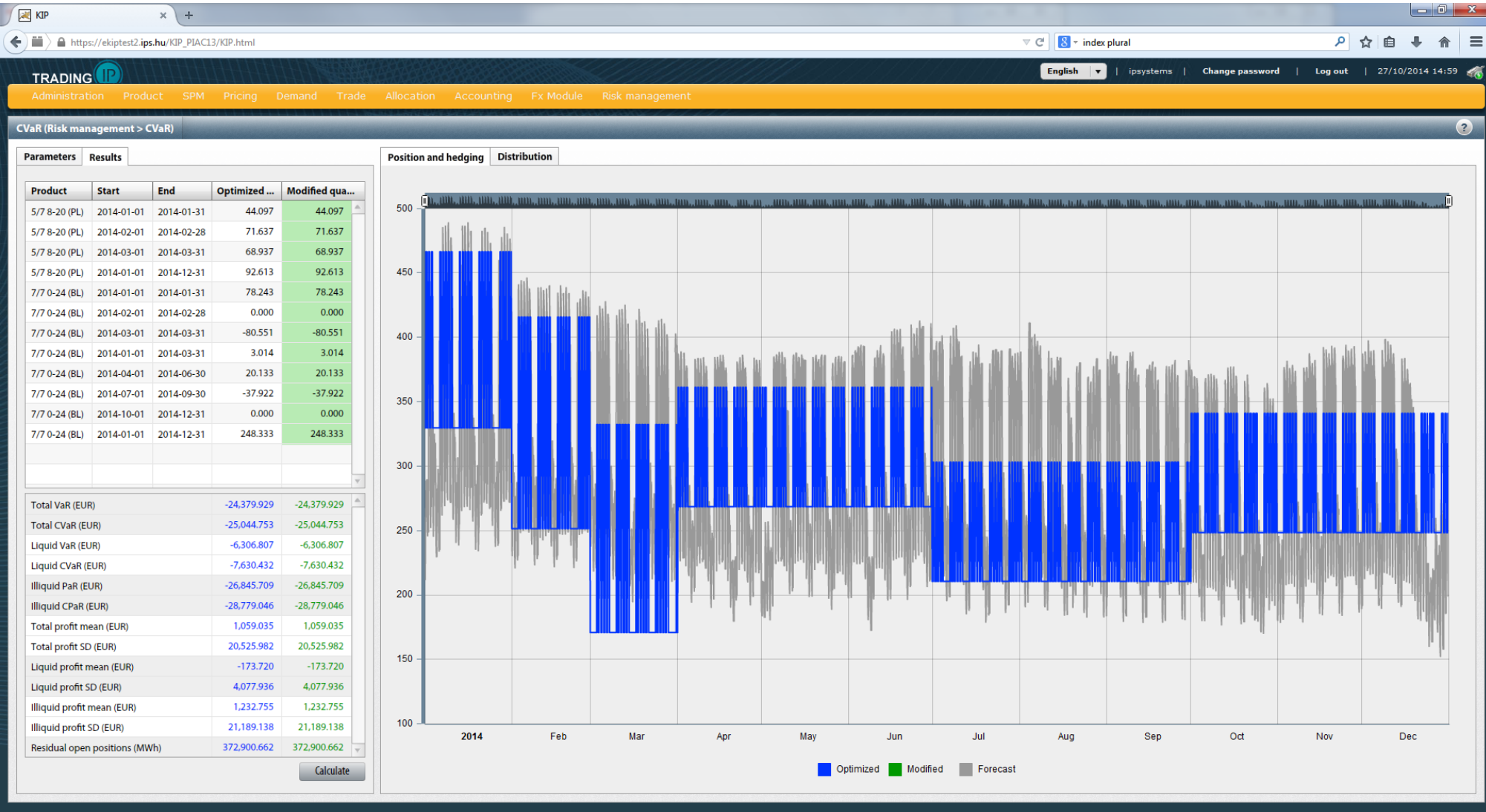
Liquidity limits and initial positions

Limits

Products	Period	Start	End	Position	Trading limit - lower	Trading limit - top	Closing limit T0 - lower	Closing limit T0 - top	Closing limit TH - lower	Closing limit TH - top
5/7 8-20 (PL)	M1	2014-01-01	2014-01-31	0	1,000	1,000	1,000	1,000	0	0
5/7 8-20 (PL)	M2	2014-02-01	2014-02-28	0	1,000	1,000	1,000	1,000	0	0
5/7 8-20 (PL)	M3	2014-03-01	2014-03-31	0	500	100	500	100	550	150
5/7 8-20 (PL)	Y1	2014-01-01	2014-12-31	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	M1	2014-01-01	2014-01-31	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	M2	2014-02-01	2014-02-28	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	M3	2014-03-01	2014-03-31	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	Q1	2014-01-01	2014-03-31	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	Q2	2014-04-01	2014-06-30	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	Q3	2014-07-01	2014-09-30	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	Q4	2014-10-01	2014-12-31	0	1,000	1,000	1,000	1,000	0	0
7/7 0-24 (BL)	Y1	2014-01-01	2014-12-31	0	1,000	1,000	1,000	1,000	0	0

Save Cancel

Results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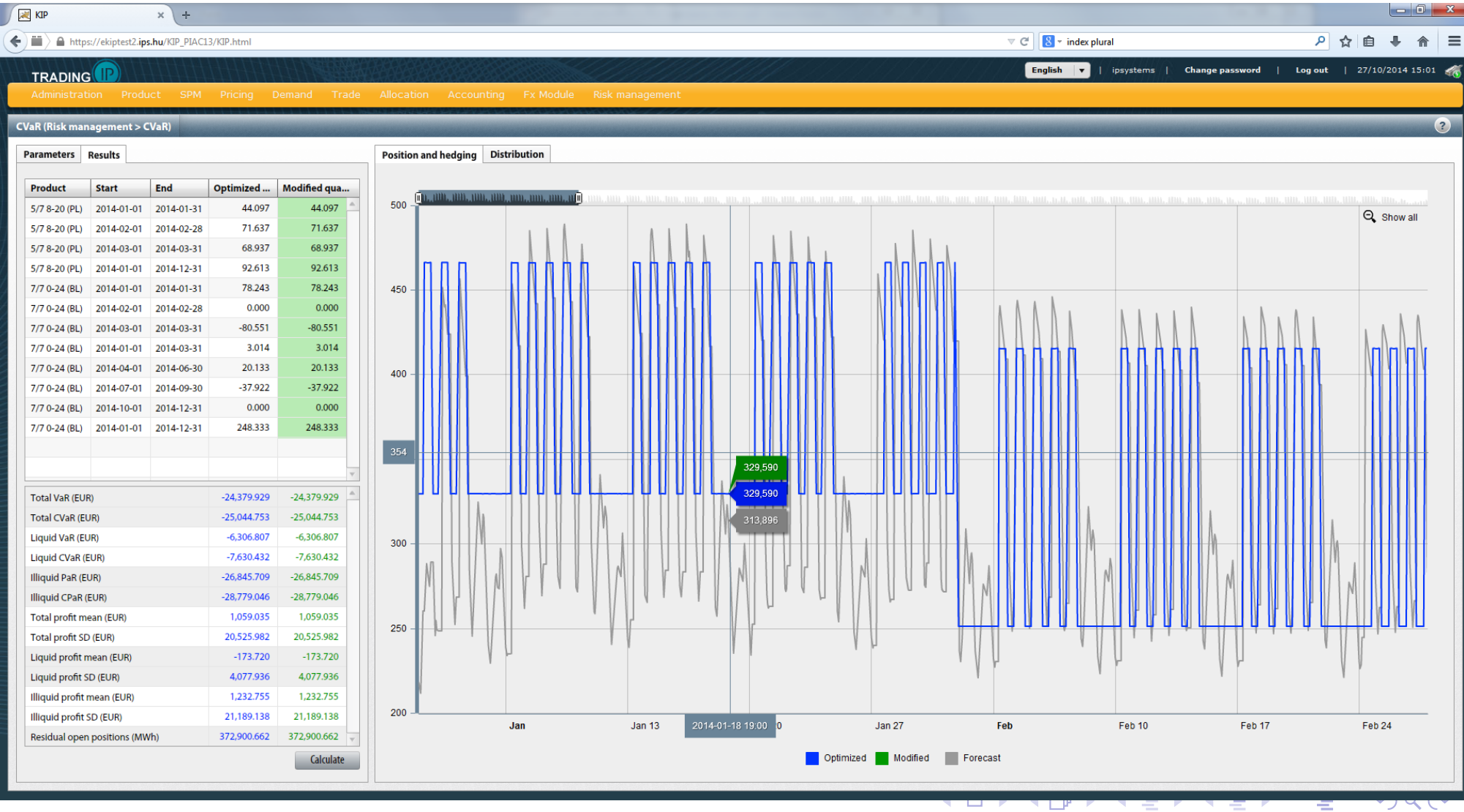
CVaR (Risk management > CVaR)
Parameters Results
Position and hedging Distribution
Product Start End Optimized ... Modified qua...
5/7 8-20 (PL) 2014-01-01 2014-01-31 44.097 44.097
5/7 8-20 (PL) 2014-02-01 2014-02-28 71.637 71.637
5/7 8-20 (PL) 2014-03-01 2014-03-31 68.937 68.937
5/7 8-20 (PL) 2014-01-01 2014-12-31 92.613 92.613
7/7 0-24 (BL) 2014-01-01 2014-01-31 78.243 78.243
7/7 0-24 (BL) 2014-02-01 2014-02-28 0.000 0.000
7/7 0-24 (BL) 2014-03-01 2014-03-31 -80.551 -80.551
7/7 0-24 (BL) 2014-01-01 2014-03-31 3.014 3.014
7/7 0-24 (BL) 2014-04-01 2014-06-30 20.133 20.133
7/7 0-24 (BL) 2014-07-01 2014-09-30 -37.922 -37.922
7/7 0-24 (BL) 2014-10-01 2014-12-31 0.000 0.000
7/7 0-24 (BL) 2014-01-01 2014-12-31 248.333 248.333
Total VaR (EUR) -24,379.929 -24,379.929
Total CVaR (EUR) -25,044.753 -25,044.753
Liquid VaR (EUR) -6,306.807 -6,306.807
Liquid CVaR (EUR) -7,630.432 -7,630.432
Illiquid PaR (EUR) -26,845.709 -26,845.709
Illiquid CPaR (EUR) -28,779.046 -28,779.046
Total profit mean (EUR) 1,059.035 1,059.035
Total profit SD (EUR) 20,525.982 20,525.982
Liquid profit mean (EUR) -173.720 -173.720
Liquid profit SD (EUR) 4,077.936 4,077.936
Illiquid profit mean (EUR) 1,232.755 1,232.755
Illiquid profit SD (EUR) 21,189.138 21,189.138
Residual open positions (MWh) 372,900.662 372,900.662
Calculate
500
450
400
350
300
250
200
150
100
2014 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Optimized Modified Forecast

Results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Administration Product SPM Pricing Demand Trade Allocation Accounting Fx Module Risk management
CVaR (Risk management > CVaR)
Parameters Results
Position and hedging Distribution
Product Start End Optimized ... Modified qua...
5/7 8-20 (PL) 2014-01-01 2014-01-31 44.097 44.097
5/7 8-20 (PL) 2014-02-01 2014-02-28 71.637 71.637
5/7 8-20 (PL) 2014-03-01 2014-03-31 68.937 68.937
5/7 8-20 (PL) 2014-01-01 2014-12-31 92.613 92.613
7/7 0-24 (BL) 2014-01-01 2014-01-31 78.243 78.243
7/7 0-24 (BL) 2014-02-01 2014-02-28 0.000 0.000
7/7 0-24 (BL) 2014-03-01 2014-03-31 -80.551 -80.551
7/7 0-24 (BL) 2014-01-01 2014-03-31 3.014 3.014
7/7 0-24 (BL) 2014-04-01 2014-06-30 20.133 20.133
7/7 0-24 (BL) 2014-07-01 2014-09-30 -37.922 -37.922
7/7 0-24 (BL) 2014-10-01 2014-12-31 0.000 0.000
7/7 0-24 (BL) 2014-01-01 2014-12-31 248.333 248.333
Total VaR (EUR) -24,379.929 -24,379.929
Total CVaR (EUR) -25,044.753 -25,044.753
Liquid VaR (EUR) -6,306.807 -6,306.807
Liquid CVaR (EUR) -7,630.432 -7,630.432
Illiquid PaR (EUR) -26,845.709 -26,845.709
Illiquid CPaR (EUR) -28,779.046 -28,779.046
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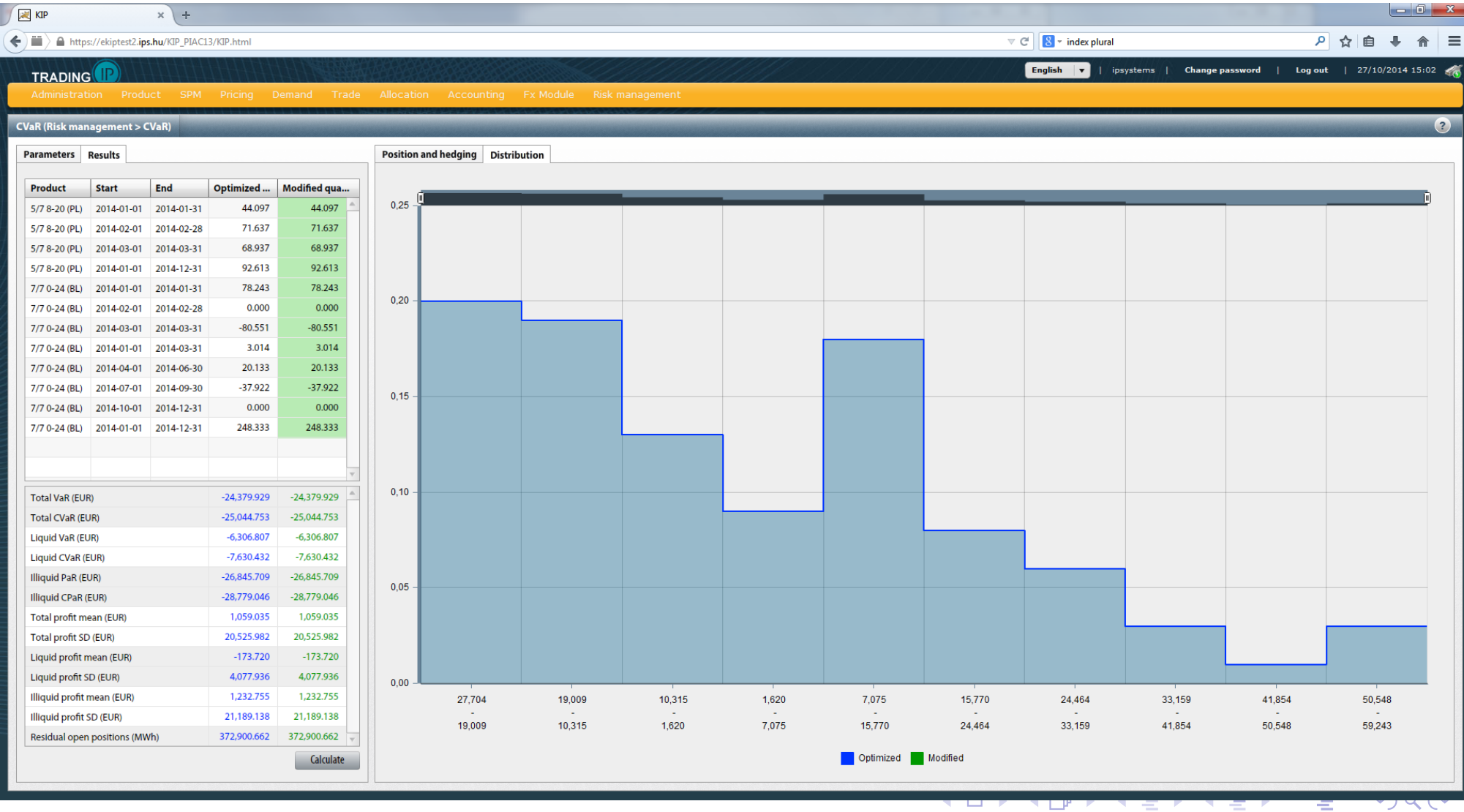
Total profit SD (EUR) 20,525.982 20,525.982
Liquid profit mean (EUR) -173.720 -173.720
Liquid profit SD (EUR) 4,077.936 4,077.936
Illiquid profit mean (EUR) 1,232.755 1,232.755
Illiquid profit SD (EUR) 21,189.138 21,189.138
Residual open positions (MWh) 372,900.662 372,900.662
Calculate
500
450
400
354
300
250
200
329,590
329,590
313,896
Show all
Jan
Jan 13
2014-01-18 19:00
Jan 27
Feb
Feb 10
Feb 17
Feb 24
Optimized
Modified
Forecast

Profit histogram



Modification

Parameters | Results

Product	Start	End	Optimized ...	Modified qua...
5/7 8-20 (PL)	2014-01-01	2014-01-31	44.097	44.097
5/7 8-20 (PL)	2014-02-01	2014-02-28	71.637	71.637
5/7 8-20 (PL)	2014-03-01	2014-03-31	68.937	68.937
5/7 8-20 (PL)	2014-01-01	2014-12-31	92.613	92.613
7/7 0-24 (BL)	2014-01-01	2014-01-31	78.243	78.243
7/7 0-24 (BL)	2014-02-01	2014-02-28	0.000	0.000
7/7 0-24 (BL)	2014-03-01	2014-03-31	-80.551	-80.551
7/7 0-24 (BL)	2014-01-01	2014-03-31	3.014	3.014
7/7 0-24 (BL)	2014-04-01	2014-06-30	20.133	20.133
7/7 0-24 (BL)	2014-07-01	2014-09-30	-37.922	-10.000
7/7 0-24 (BL)	2014-10-01	2014-12-31	0.000	0.000
7/7 0-24 (BL)	2014-01-01	2014-12-31	248.333	248.333

Comparison

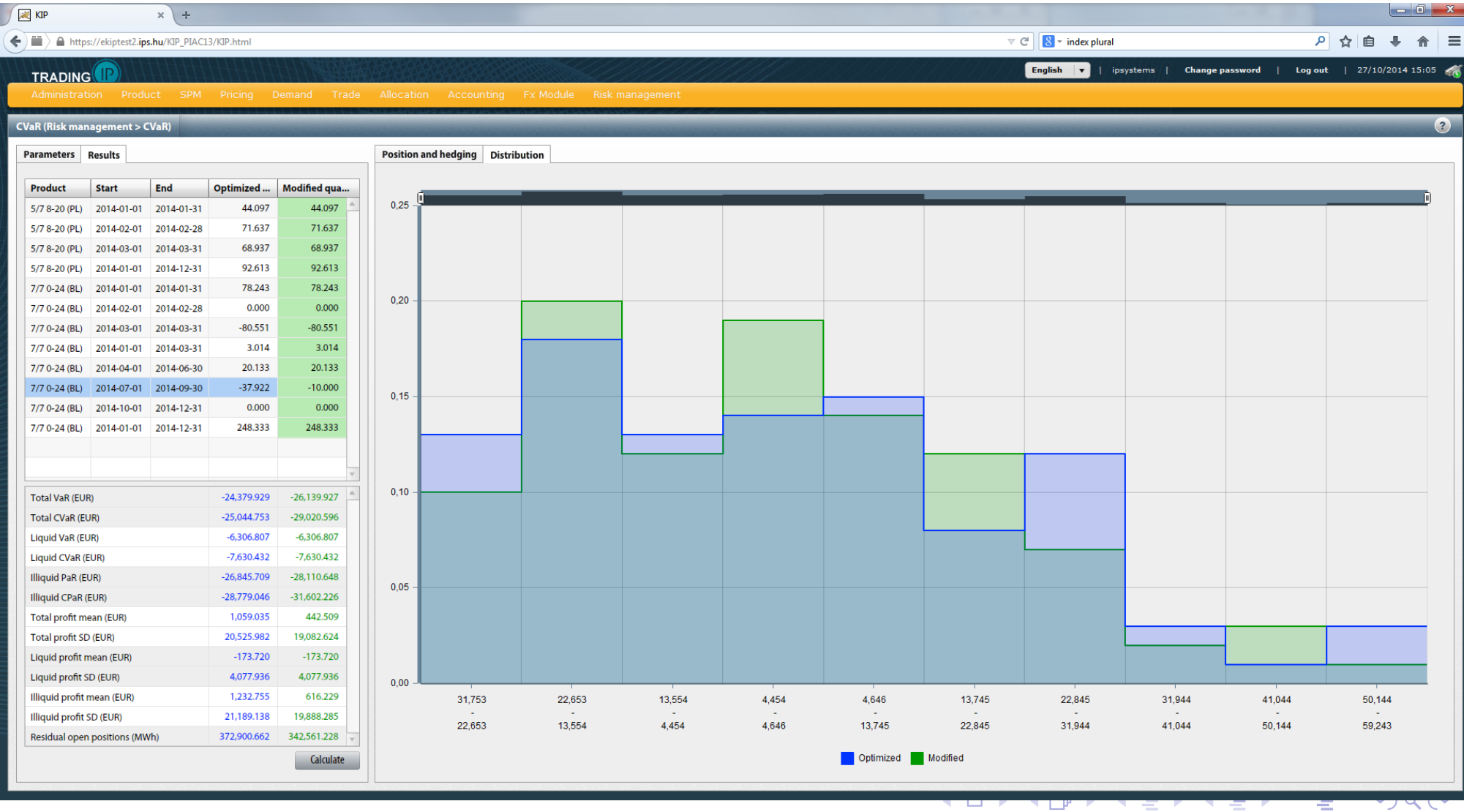

KIP
https://ekiptest2.ips.hu/KIP_PIAC13/KIP.html
index plural
TRADING IP
English | ipsystems | Change password | Log out | 27/10/2014 15:05
Administration Product SPM Pricing Demand Trade Allocation Accounting Fx Module Risk management
CVaR (Risk management > CVaR)
Parameters Results
Position and hedging Distribution
Product Start End Optimized ... Modified qua...
5/7 8-20 (PL) 2014-01-01 2014-01-31 44.097 44.097
5/7 8-20 (PL) 2014-02-01 2014-02-28 71.637 71.637
5/7 8-20 (PL) 2014-03-01 2014-03-31 68.937 68.937
5/7 8-20 (PL) 2014-01-01 2014-12-31 92.613 92.613
7/7 0-24 (BL) 2014-01-01 2014-01-31 78.243 78.243
7/7 0-24 (BL) 2014-02-01 2014-02-28 0.000 0.000
7/7 0-24 (BL) 2014-03-01 2014-03-31 -80.551 -80.551
7/7 0-24 (BL) 2014-01-01 2014-03-31 3.014 3.014
7/7 0-24 (BL) 2014-04-01 2014-06-30 20.133 20.133
7/7 0-24 (BL) 2014-07-01 2014-09-30 -37.922 -10.000
7/7 0-24 (BL) 2014-10-01 2014-12-31 0.000 0.000
7/7 0-24 (BL) 2014-01-01 2014-12-31 248.333 248.333
Total VaR (EUR) -24,379.929 -26,139.927
Total CVaR (EUR) -25,044.753 -29,020.596
Liquid VaR (EUR) -6,306.807 -6,306.807
Liquid CVaR (EUR) -7,630.432 -7,630.432
Illiquid PaR (EUR) -26,845.709 -28,110.648
Illiquid CPaR (EUR) -28,779.046 -31,602.226
Total profit mean (EUR) 1,059.035 442.509
Total profit SD (EUR) 20,525.982 19,082.624
Liquid profit mean (EUR) -173.720 -173.720
Liquid profit SD (EUR) 4,077.936 4,077.936
Illiquid profit mean (EUR) 1,232.755 616.229
Illiquid profit SD (EUR) 21,189.138 19,888.285
Residual open positions (MWh) 372,900.662 342,561.228
Calculate
500
450
400
350
300
250
200
150
100
2014 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Optimized Modified Forecast

Comparison

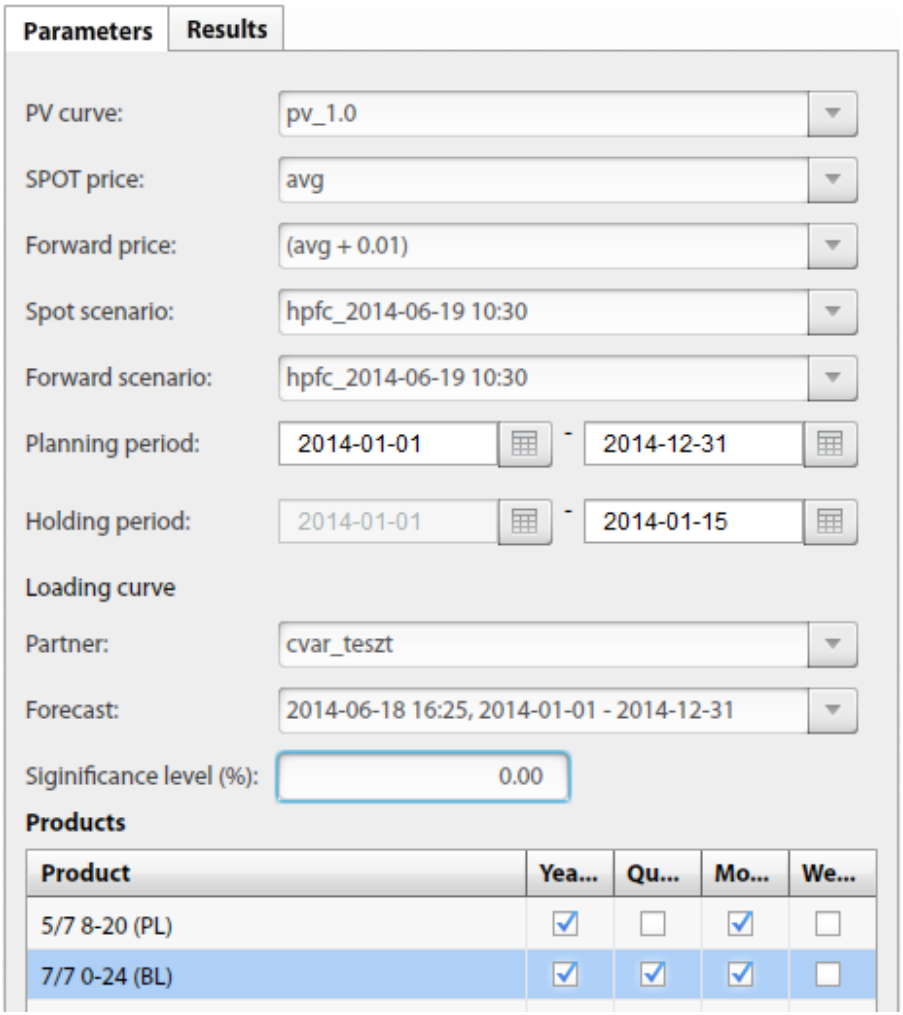
Total VaR (EUR)	-24,379.929	-26,139.927
Total CVaR (EUR)	-25,044.753	-29,020.596
Liquid VaR (EUR)	-6,306.807	-6,306.807
Liquid CVaR (EUR)	-7,630.432	-7,630.432
Illiquid PaR (EUR)	-26,845.709	-28,110.648
Illiquid CPaR (EUR)	-28,779.046	-31,602.226
Total profit mean (EUR)	1,059.035	442.509
Total profit SD (EUR)	20,525.982	19,082.624
Liquid profit mean (EUR)	-173.720	-173.720
Liquid profit SD (EUR)	4,077.936	4,077.936
Illiquid profit mean (EUR)	1,232.755	616.229
Illiquid profit SD (EUR)	21,189.138	19,888.285
Residual open positions (MWh)	372,900.662	342,561.228

Calculate

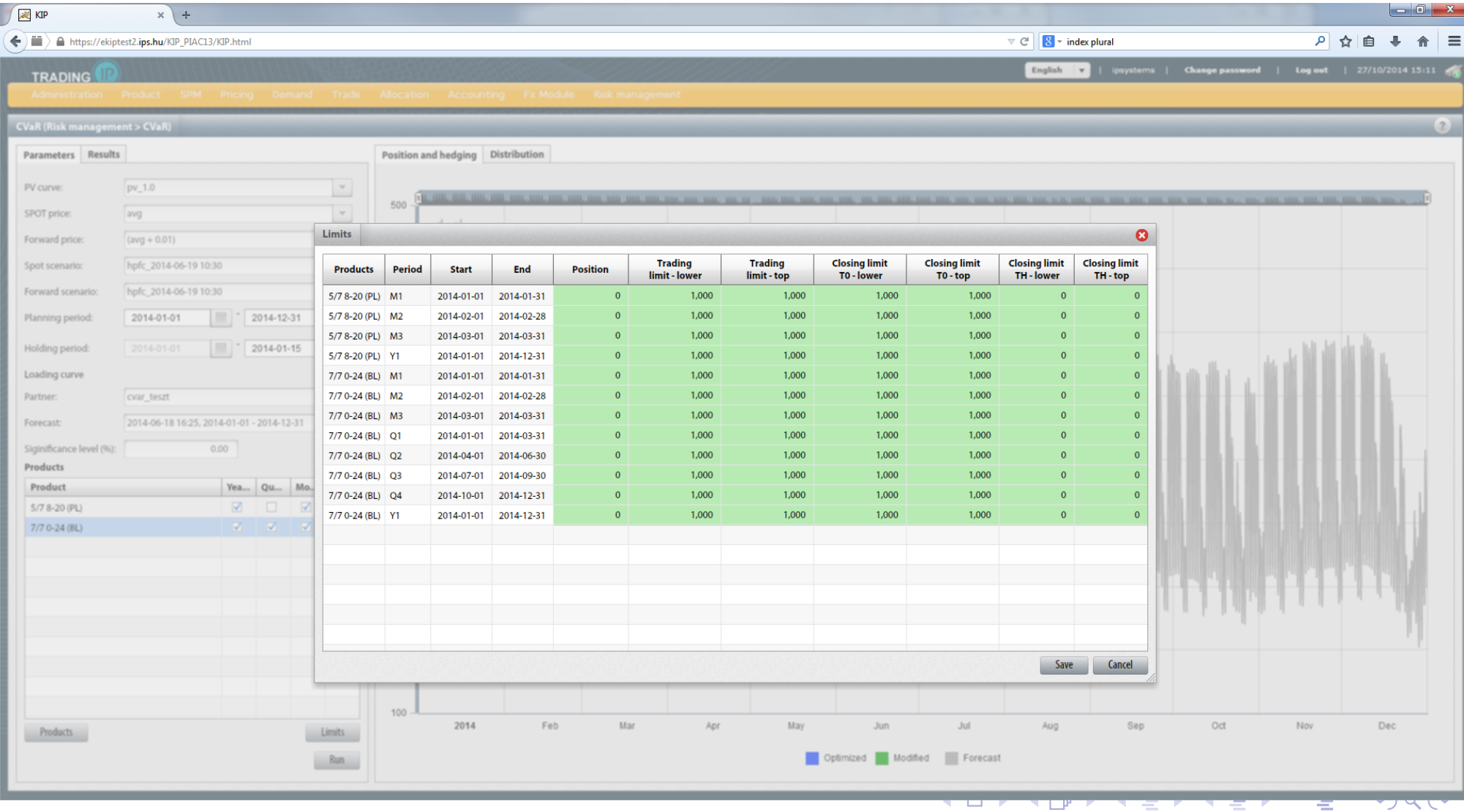
Comparison: histograms



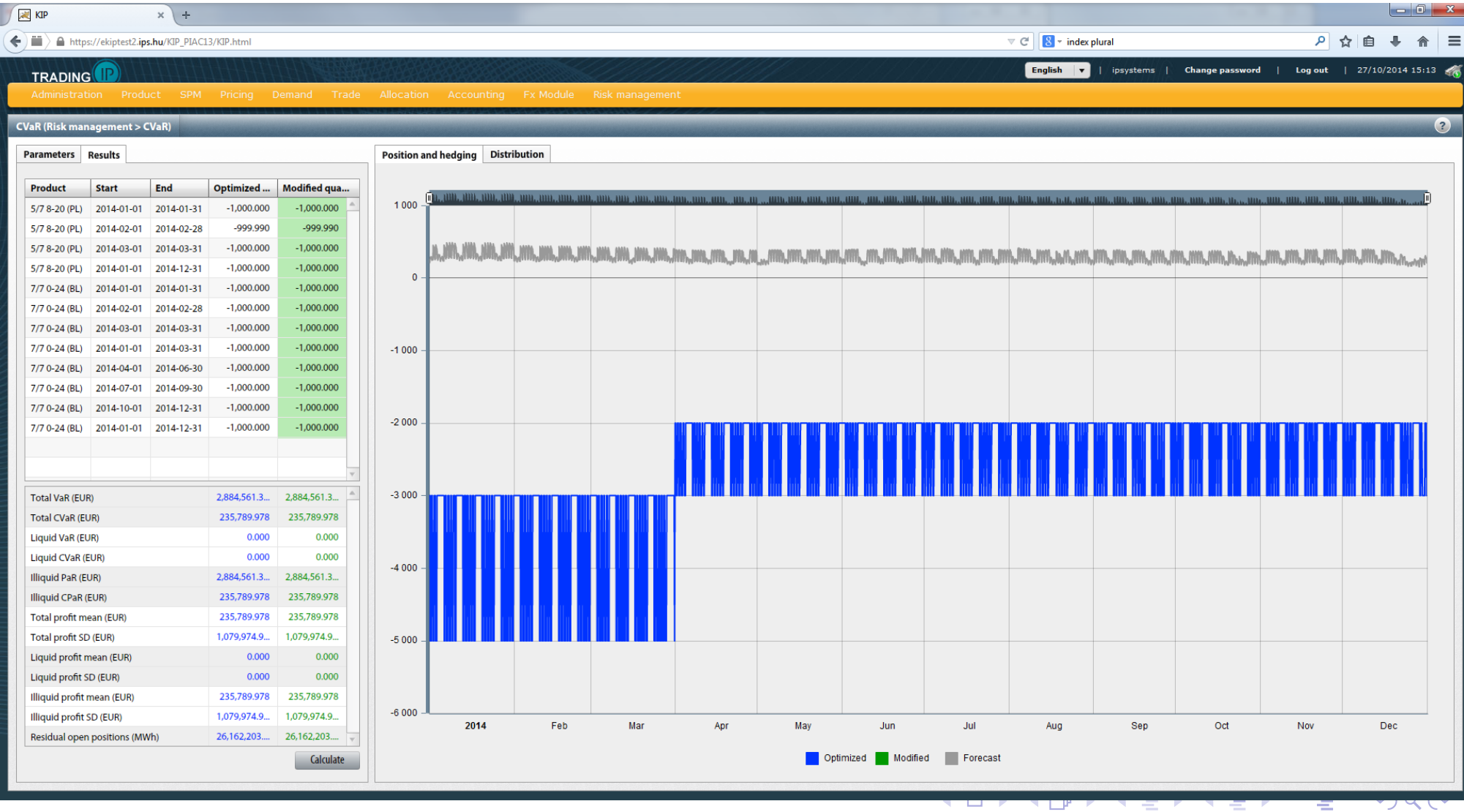
Expected value: zero level of significance



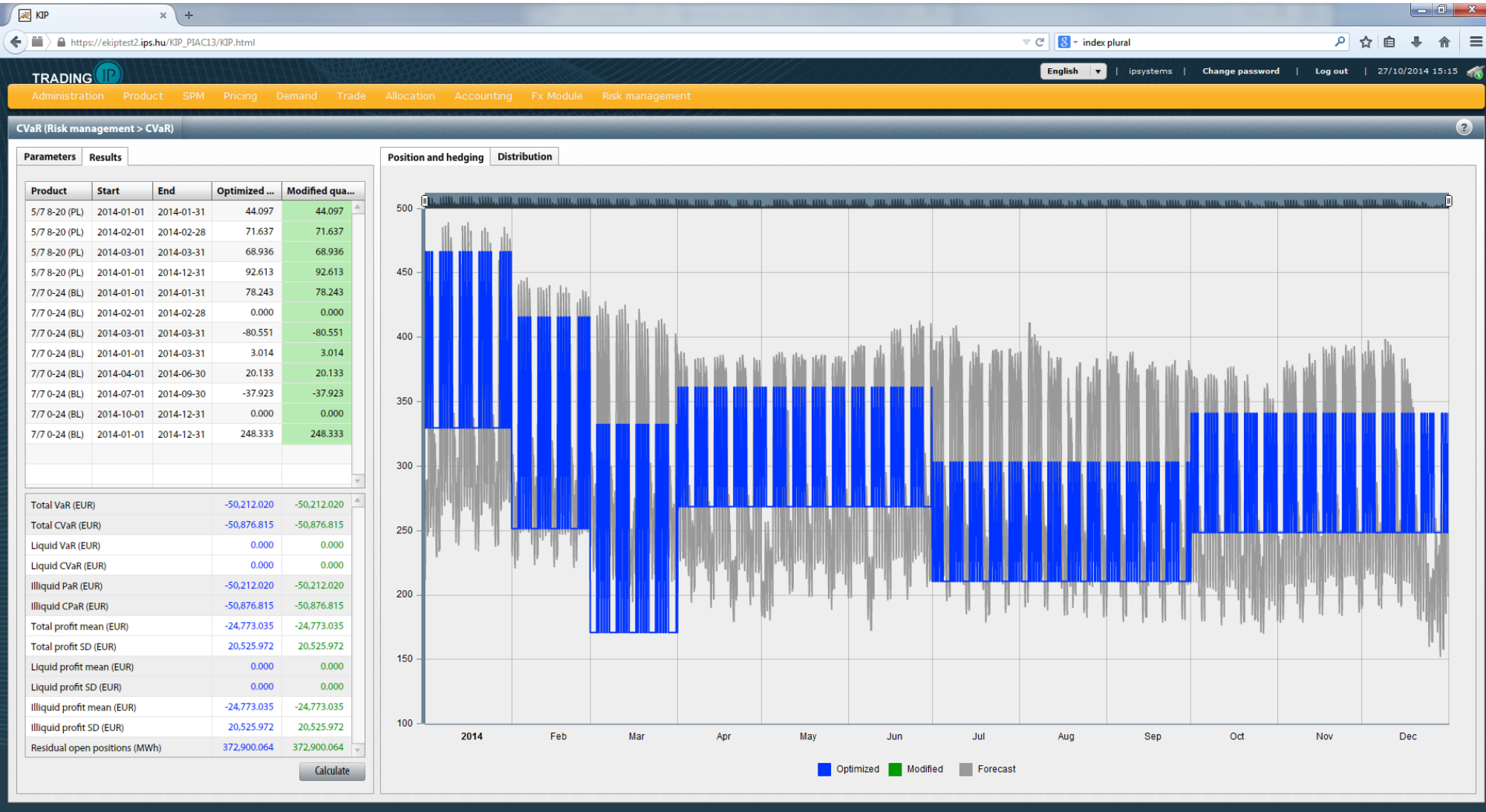
Liquidity limits



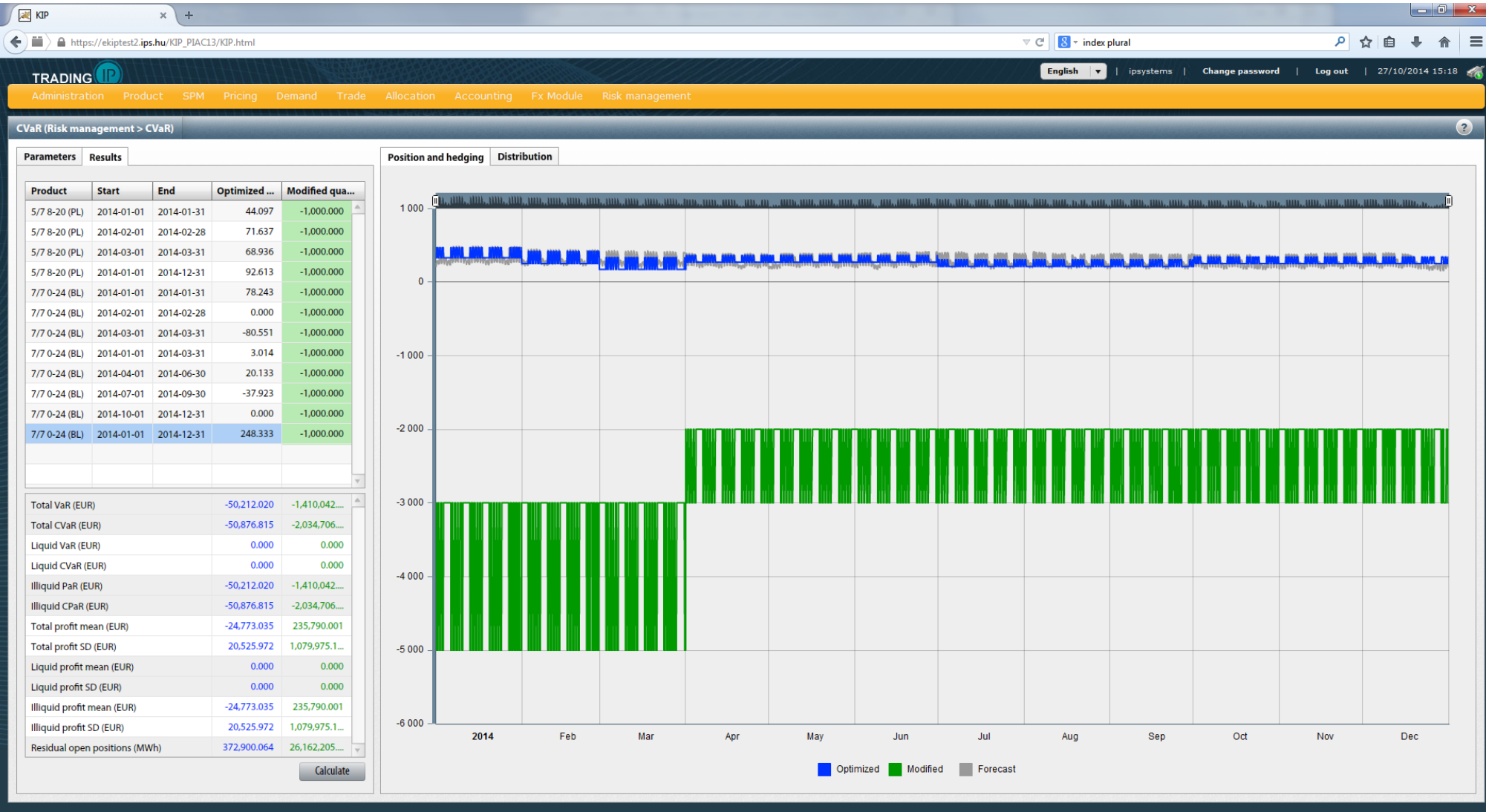
Result of expected value



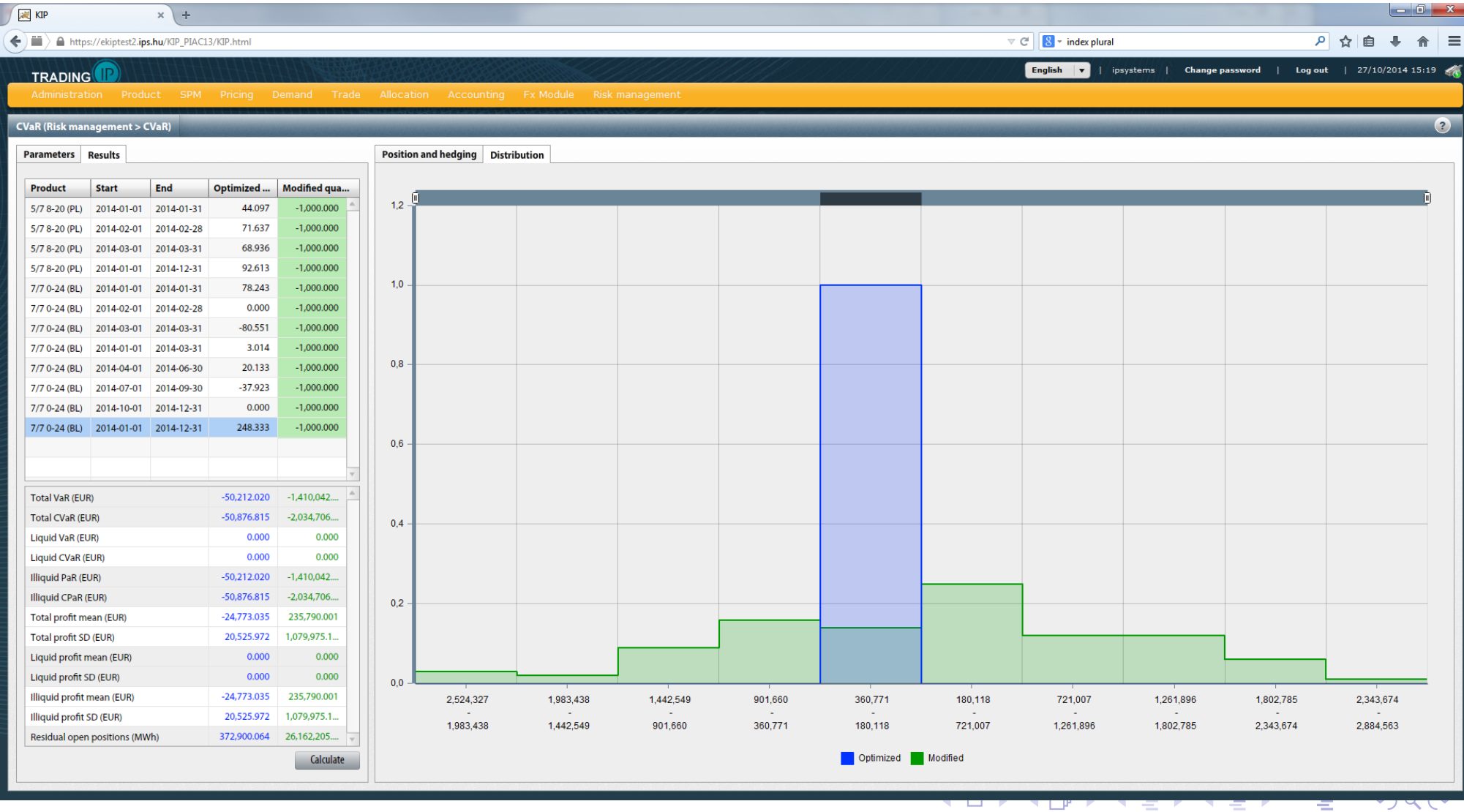
Result of CVaR at level of significance 95%



Comparison: residual open positions



Comparison: histograms



Benefits of CVaR

1. CVaR is a coherent risk measure.
   (Subadditivity)
2. CVaR accounts for losses exceeding VaR.
   (In the energy markets, the distribution of loss is usually non-normal and heavily tailed.)
3. CVaR is continuous in L.
4. CVaR is convex in L.
5. CVaR optimization can be reduced to convex programming and in some cases to linear programming.

Benefits of the application

1. In spite of the deterministic model, the risk of price moving is
   - managed and
   - measured exactly.
2. The tool supports both of the
   - traders/portfolio managers: instant risk information and support,
   - and risk managers/controllers: instant risk indices.
3. Usually, the risk manager measures the risk of open positions (tipically by VaR or CVaR).
   - The liqudity reserve is calculated based on the risk indicator.
   - Based on the risk minimiser tool the traders are minimising the CVaR.
   - The CVaR is a coherent risk measure, hence the risk of the overall portfolio will be lower and the necessary liqudity reserve will decrease.