cigre | PARIS 2022

NOSBiH НОСБиХ

University of Sarajevo
Faculty of Electrical Engineering Sarajevo

Study Committee C5

ELECTRICITY MARKETS & REGULATION

11011 - Session 2022

Risk Evaluation for Ancillary Service

Omer HADZIC[1], Adnan MUJEZINOVIC[2], Zijad BAJRAMOVIC[2] Irfan TURKOVIC[2]

[1]Independent system operator in Bosnia and Herzegovina

[2]University of Sarajevo, Faculty of Electrical Engineering

Motivation

- Electricity market is specific for its quality and quantity nature and as such it carries significant financial risks for all market participants.
- This paper propose application of Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) indicators in order to evaluate and analyze the potential financial risks when providing ancillary service.
- Different mathematical models for VaR and CVaR calculation are discussed and applied in a simulation scenario.
- Portfolio optimization technique based on minimization of Conditional Value-at-Risk function is proposed for transmission system operators.

Introduction

- When it comes to ancillary services procurement, there are many ways for their procurement in the market's surrounding, such as:

1. liability to provide ancillary services;
2. procurement of ancillary services based on concluded contracts (for example through periodical tender announcements);
3. procurement of ancillary services in the market, for example through the initial ancillary services market (initial ancillary services market – market with determined initial price);
4. free ancillary services market, balancing market.

- The above listed methods are being combined in ancillary services markets with the purpose to cover all time frames.
- Researches indicate that the purpose of risk management is to bring unacceptable risks to an acceptable level and keep them on that level.
- In the competitive market environment risk management play important role for the all market participants. On the electricity balancing market financial and technical risk must be managed.

Risk evaluation and management

Financial risk can be evaluated by following indices:

- Value-at-Risk (VaR)
- Conditional Value-at-Risk (CVaR)

Risk indices VaR and CVaR are calculated using following methods:

❖ Historical simulation method,

❖ Variance-covariance method (RiskMetrics model),

❖ Monte-Carlo method.

Value-at-Risk

- VaR can be interpretated as measure trying to present the riskiness of financial entities in the future. This can mathematically be interpreted as follows:

$$\int_{-\infty}^{VaR_{\alpha}} f(x)dx = 1-\alpha$$

- VaR is focused on the risk of portfolio loss and is defined as maximum expected loss with certain confidence level (for example 95%) in relation to a specific time horizon.
- In addition to VaR, indicators such as Marginal VaR and Component VaR are used in risk management.
- Marginal VaR can be represented as an additional value of risk that a new investment position adds to a portfolio and is mathematically defined as:

$$\Delta VaR_i = k \cdot \frac{\sigma_{i,P}}{\sigma_P} = k \cdot \sigma_P \cdot \beta_i = \frac{VaR}{P} \cdot \beta_i$$

- Component VaR is the contribution of specific component on the change of total VaR. Component VaR can be calculated:

$$Cmp\_VaR_i = \Delta VaR_i \cdot w_i \cdot P = \frac{VaR}{P} \cdot \beta_i \cdot w_i \cdot P = VaR \cdot \beta_i \cdot w_i$$

- Sum of Component VaRs of all portfolio asset is equal to the entire portfolio VaR. Therefore, the following can be written:

$$\sum_{i=1}^{N} Cmp\_VaR_i = VaR \cdot \sum_{i=1}^{N} \beta_i \cdot w_i = VaR$$

Study Committee C5

ELECTRICITY MARKETS & REGULATION

11011 - Session 2022

Risk Evaluation for Ancillary Service

Conditional Value-at-Risk

- CVaR is often suggested as an alternative risk indicator to VaR. Unlike VaR, CVaR provide additional information on distribution tail losses that exceed VaR. Mathematical CVaR is defined as:

$$CVaR_{\alpha} = \frac{1}{1-\alpha} \cdot \int_{-\infty}^{VaR_{\alpha}} x \cdot f_x(x)\, dx$$

- CVaR satisfies four axioms of coherence, which, consequently, qualifies CVaR as a coherent measure of risk. In fact, it shows that any coherent risk measure can be presented as a combination of convex CVaRs with different levels of confidence.
- In addition to the CVaR, two additional parameters are usually used as an risk measures CVaRα(+) and CVaRα (-).
- CVaRα(+) known as expected shortfall which represents the expectation that random value *x* strictly exceed VaR value. This can be defined by following equation:

$$CVaR_{\alpha(+)} = E\left[x \mid x > VaR_{\alpha}\right]$$

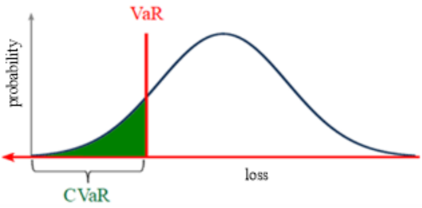
- CVaRα(-) is tail VaR which represents the expectation that random value *x* weakly exceed VaR value. This can be defined by following equation:

$$CVaR_{\alpha(-)} = E\left[x \mid x \geq VaR_{\alpha}\right]$$

- Relation between different risk indicators is as follow:

$$VaR_{\alpha} \leq CVaR_{\alpha(-)} \leq CVaR_{\alpha} \leq CVaR_{\alpha(+)}$$

- Graphical interpretation of VaR and CVaR risk indicators



Portfolio optimization

- Optimizing a multi-asset portfolio is possible by minimizing CVaR:

$$\min_{\{x \in X\}} CVaR$$

- Optimization was done by linearization of objective function and by application of following constrains:

$$\min_{\{x \in X, \varsigma \in R, z \in R^J\}} \varsigma + \upsilon \cdot \sum_{j=1}^{J} z^j$$

$$z^j \geq f\left(x, y^j\right) - \varsigma$$

$$z^j \geq 0$$

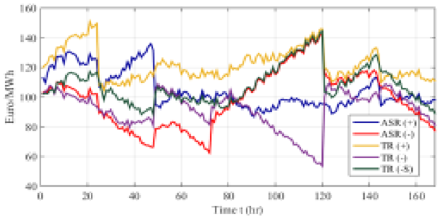
$$\upsilon = \left((1-\alpha) \cdot J\right)^{-1} = const$$

- where *ζ* is value of CVaR at point x_1, *v* is number of linear equal segments, the slope of the *j*-th lineralized section and *J* is total number of lineralized segments.

Case study

- The system operator portfolio of 1,090,000.0 €, with the parameters of each ancillary services are as follows:
- secondary control energy 'up', ASR+ = 300.000,0 €;
- secondary control energy 'down', ASR– = 215.000,0 €;
- tertiary control energy 'up', TR+ = 470.000,0 €;
- tertiary control energy 'down', TR– = 70.000,0 €;
- energy to secure the system's safety, TR-s = 35.000,0 €.

- The considered hourly change in prices when purchasing ancillary services for a period seven days.



http://www.cigre.org

Study Committee C5

ELECTRICITY MARKETS & REGULATION

11011 - Session 2022

Risk Evaluation for Ancillary Service

- VaR and CVaR risk indicators calculation results

Method	VaR (€)	CVaR (€)
Historical simulation method	8,771.82	17,151.50
Variance-covariance method	12,823.84	25,137.62
Monte Carlo method	12,823.85	25,074.44

- Individual value of VaR values, Marginal VaR and Component VaR values are given in the following table

Ancillary service	VaR(€)	ΔVaR (%)	Cmp_VaR (%)
ASR (+)	19,591.95	2.22	8.42
ASR (-)	15,915.37	72.37	-5.39
TR (+)	29,534.33	11.12	-1.31
TR (-)	8,912.61	12.87	-0.12
TR (-s)	2,176.33	1.42	0.16

Portfolio optimization effects

- In the following table, the effects of application of portfolio optimization are presented.

Service	Inital values of the individual services (€)	Optimal values of the individual service (€)
ASR(+)	300,000.00	356,483.2
ASR(–)	215,000.00	80,368.6
TR(+)	470,000.00	427,811.8
TR(–)	70,000.00	204,018.0
TR(-s)	35,000.00	20565.4
Total	**1,090,000**	**1,089,247.00**

Conclusion

- This paper propose application of Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) indicators in order to evaluate and analyse the potential financial risks when providing ancillary service with purpose to balance the electric power system.
- Different calculation methods for these two risk measures are presented within this paper. It was shown that both risk indicators (VaR and CVaR) can be applied for measuring risk when providing ancillary service.
- When dealing with ancillary service risk management ie portfolio optimization, only risk indicator CVaR is suitable to be used. The reason for this is superior mathematical properties of CVaR in relation to VaR.
- Portfolio optimization in case of multiple financial instruments (as in case of ancillary service portfolio) was introduced within this paper based on CVaR function minimisation. It was shown that proposed approach is suitable for the ancillary service portfolio optimization.