Techno-Economic analysis of common work of Wind and CCGT plant by offering continuous level of power to electricity market

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INTRODUCTION

Due to the variability and uncertainty, wind plants cannot participate in the electricity market, especially those for the power exchanges. For this purpose, in this paper is presented a techno-economic analysis of work of wind plants together with CCGT plant as support for offering continues power to electricity market. The main motivation for this analysis is to investigate both technical and economical possibilities to participate on power exchanges by offering continuous guarantied power from wind plants by backing-up them with a CCGT power plant.

METHODOLOGY

Objective of this work is to examine, on the basis of the model, technical and economic indicators of the CCGT power plant in function of balancing or stabilising variable electricity production from wind. For this purposes, a model in the programming tool PLEXOS is made. Description of the model and the software can be found further in this paper.

FLEXIBILITY OF THE CCGT

This type of drive CCGT depends on the nature of the wind in the area, frequent switching of CCGT plant and the associated high costs are expected. Two cases are examined:

Case 1
$$CCGT + WPP \rightarrow Market \rightarrow P_{market} = P_{wind}$$
Frequent start-ups and shutdowns
$$P_{out\_CCGT} \notin \langle 0, P_{max}\rangle \rightarrow P_{out\_CCGT} \in \langle P_{min}, P_{max}\rangle$$

Case 2
$$CCGT + WPP \rightarrow Market \rightarrow P_{market} > P_{wind}$$

$$\text{Costs (Case 1)} > \text{Costs (Case 2)}$$

TIME RESOLUTION

Because of the complexity of the model and the many technical constraints, duration of the optimisation is set according to a set time resolution of the simulation so that the total number of analyzed time intervals is constant.

TIME RESOLUTION (min)	1	5	10	60
TOTAL OPTIMISATION DURATION (h)	1	5	10	60

OPTIMISATION TOOL

After entering the required system parameters, defining scenarios and determining the planning period, PLEXOS runs a specialized program for solving mathematical optimization problems, solver (MOSEK, Gurobi, Xpress-MP, and CPLEX)

PLEXOS

| CCGT	WIND	DUMMY POWER PLANT	ELECTRICITY MARKET	POWER CONSUMPTION
Detailed model according to the given input data	ARIMA MODELING	Marginal cost$_{dummy}$ >> Marginal cost$_{CCGT}$ Marginal cost$_{dummy}$ << VoLL	EPEX 2014	Fixed

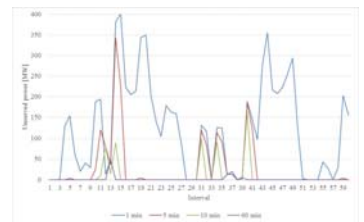**Wind power plant power output in market environment**

Electricity price (EPEX, January, 2014.)

RESULTS

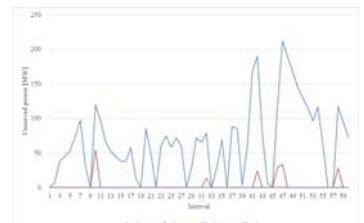The presented results were obtained on 3.6 GHz based processor with 32 GB RAM using CPLEX solver under PLEXOS® 7.
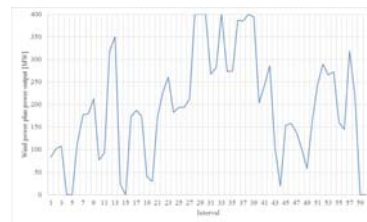
Wind power plant power output in Case 1

CCGT unserved power in Case 1

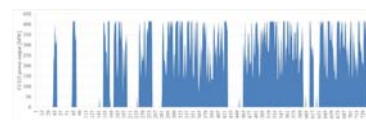**Wind power plant power output in Case 2**

CCGT unserved power in Case 2

CCGT power output in market environment (Gas price 2 €/GJ)

CCGT power output in market environment (Gas price 6 €/GJ)

CCGT power output in market environment (Gas price 4 €/GJ)

CONCLUSION

$$P_{CCGT} > P_{min\,CCGT}$$

$$P_{market} \geq P_{max\,Wind} + P_{min\,CCGT}$$

The paper shows that with the same variability of the Wind in the optimization with higher time resolution real technical limitations of CCGT power plants come better to the fore, especially in term of the speed of raising and lowering output power. In terms of economic feasibility, balancing of Wind power output by CCGT power plants in the optimisation model in hour resolution is compared to the competitiveness of the CCGT plant in relation to the electricity market as an alternative to balancing. It is shown that the greatest impact on competitiveness or production costs of the CCGT power plant has a price of fuel – gas.

Fuel price	Share of wind farm	Share of CCGT	Share of market
2 €/GJ	27,4 %	70,1 %	2,5 %
4 €/GJ	27,4 %	51,3 %	21,3 %
6 €/GJ	27,4 %	20,2 %	52,4 %
8 €/GJ	27,4 %	0 %	72,6 %