DAY-AHEAD ECONOMIC LOAD DISPATCH FOR OIL SHALE POWER PLANTS IN DEREGULATED ELECTRICITY MARKET

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Outline

- Introduction
- Research objects
- Optimization techniques
- Model formulation
- Results and discussion
- Conclusions

Importance of the topic

- **electricity market deregulation**:
    - competitive conditions
    - price fluctuations
- **traditional economic load dispatch**:
    - environmental impact
    - technological restrictions
- **complex undertaking**:
    - oil shale production characteristics
    - lack of algorithm and tool

Objectives of the paper

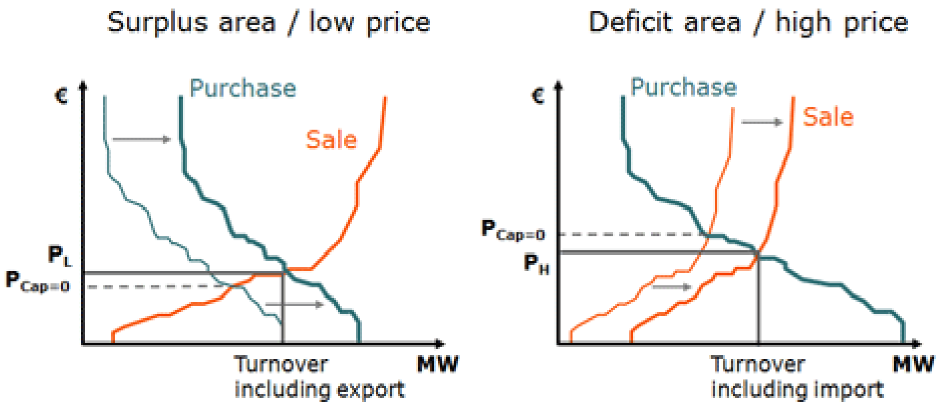
- **elaboration** of day-ahead economic load dispatch algorithm;
- algorithm **implementation** by using different optimization techniques;
- effectiveness **estimation** of used optimization techniques.

Tasks of the paper

- input-output characteristics determination;
- analysis and evaluation of the existing optimization techniques;
- practical testing of proposed algorithm;
- evaluation and summing up the research results.

Input-output characteristics

- input and output characteristics from deregulated market;



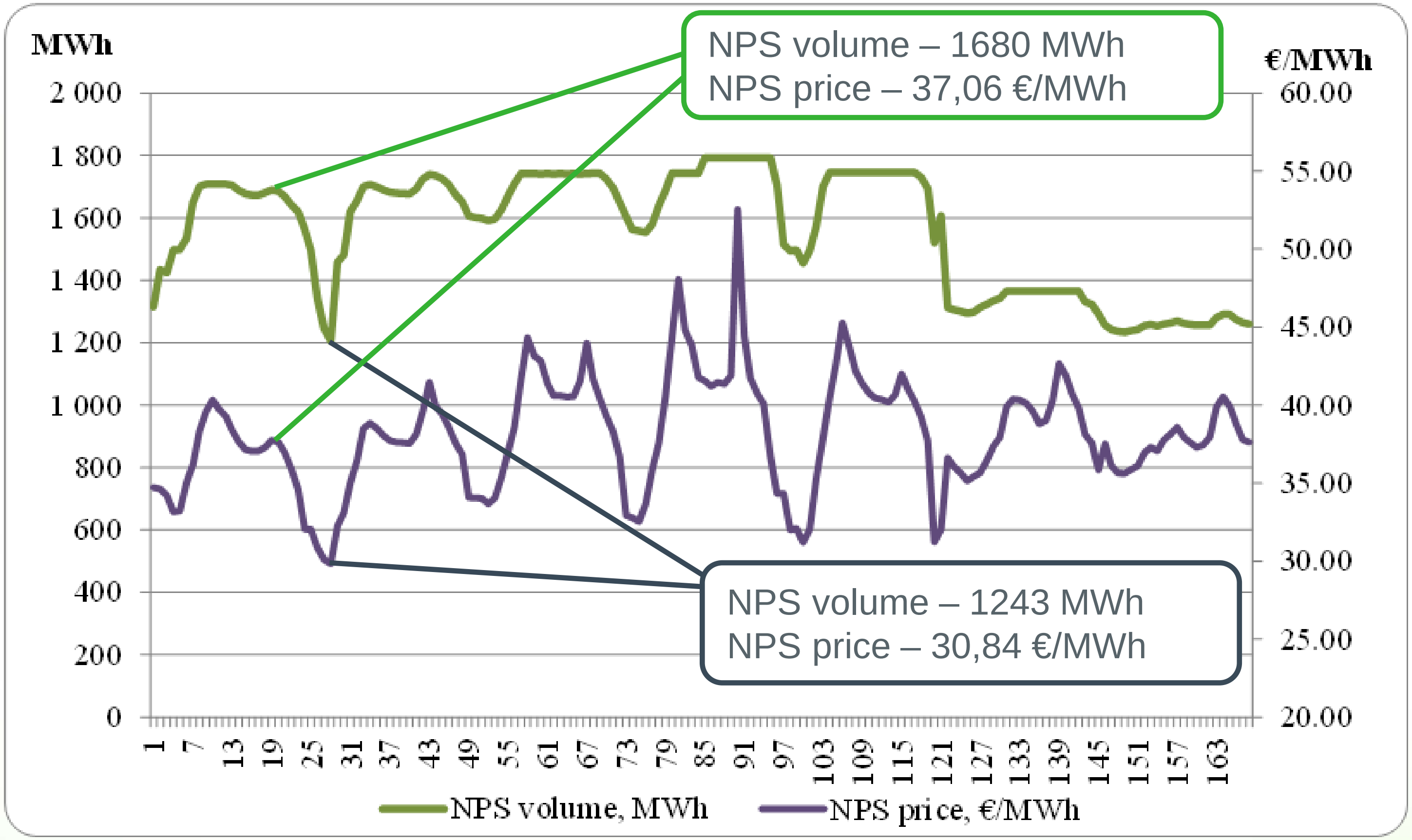
P_L and P_H → Prices for each area when full utilization of trading capacity

$P_{Cap=0}$ → Price in area with isolated price calculation.

Figure 1. Market price and market balance principle
Source: NordPoolSpot

- input and output characteristics from power plant units;
- limitations related to technological and environmental requirements;
- optimality conditions of power units operation.

NordPoolSpot market



NPS volume – 1680 MWh
NPS price – 37,06 €/MWh

NPS volume – 1243 MWh
NPS price – 30,84 €/MWh

Figure 2. Electrical power price and volume fluctuations of a typical winter week
Source: NordPoolSpot

Optimization techniques

- primal simplex - maximization problem;
- dual simplex - minimization problem;

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gives an upper and lower bound on the
optimum value of the solution

- interior-point method – the improvement over simplex algorithms, reaches an optimal solution by traversing the interior.

Optimization techniques

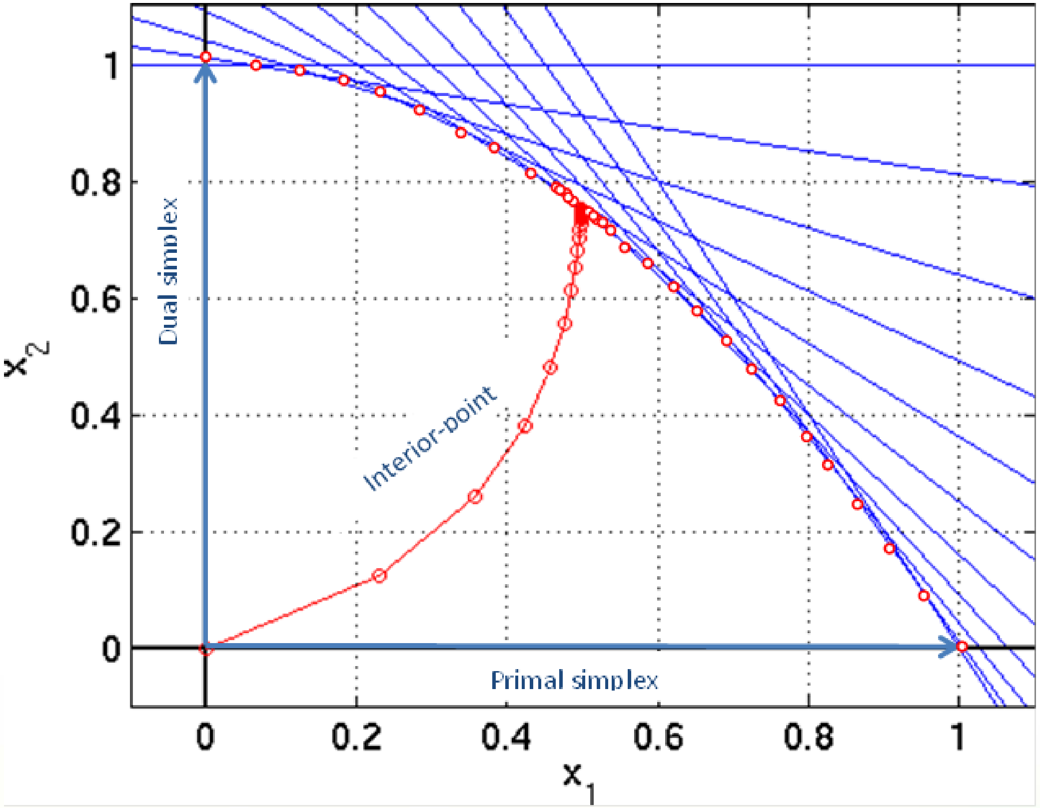


Figure 3. The primal, dual and interior-point method solution
Source: (Dantzig, Thapa, 2003)

Model formulation

Objective Function:

Minimize $$C_{tot}^{VC}(t) = \sum_{u=1}^{m} C_u^B(t) + \sum_{u=1}^{m} C_u^w(t) + \sum_{u=1}^{m} C_u^{SU}(t)$$

$C_{tot}^{VC}(t)$ - total variable costs,

$C_u^B(t)$ - primary energy costs,

$C_u^w(t)$ - environmental impact costs,

$C_u^{SU}(t)$ - start-up costs,

u - power units, $u = 1,\dots,m$

t - time interval.

Model constraints

- NordPoolSpot electricity production volume: $P_e^{NPS}(t) - \sum_{u=1}^{m} P_u(t) = 0$
- Electrical power limits to the power units: $P_u^{min} \leq P_u(t) \leq P_u^{max}$
- Thermal load for cogeneration unit: $Q^D(t) - \sum_{u=1}^{m} Q_u(t) = 0$
- Heat power limits to the power units: $Q_u^{min} \leq Q_u(t) \leq Q_u^{max}$
- Ramp rate requirements: $P_{u,\tau+1} - P_{u,\tau} \leq R_u$
- Emission limit values: $W_{u,e}(t) \leq W_{u,e}^{max}$
- Retort gas usage limitation: $B_{u,RG}(t) \leq B_{u,RG}^{max}$
- Restriction for number of start-ups: $m_u(t) \leq m_u^{max}$
- Minimum down-time: $T_{u,t}^{down-time} \geq T_{stay-off}^{min}$
- Minimum up-time: $T_{u,t} \geq T_{must-run}^{min}$

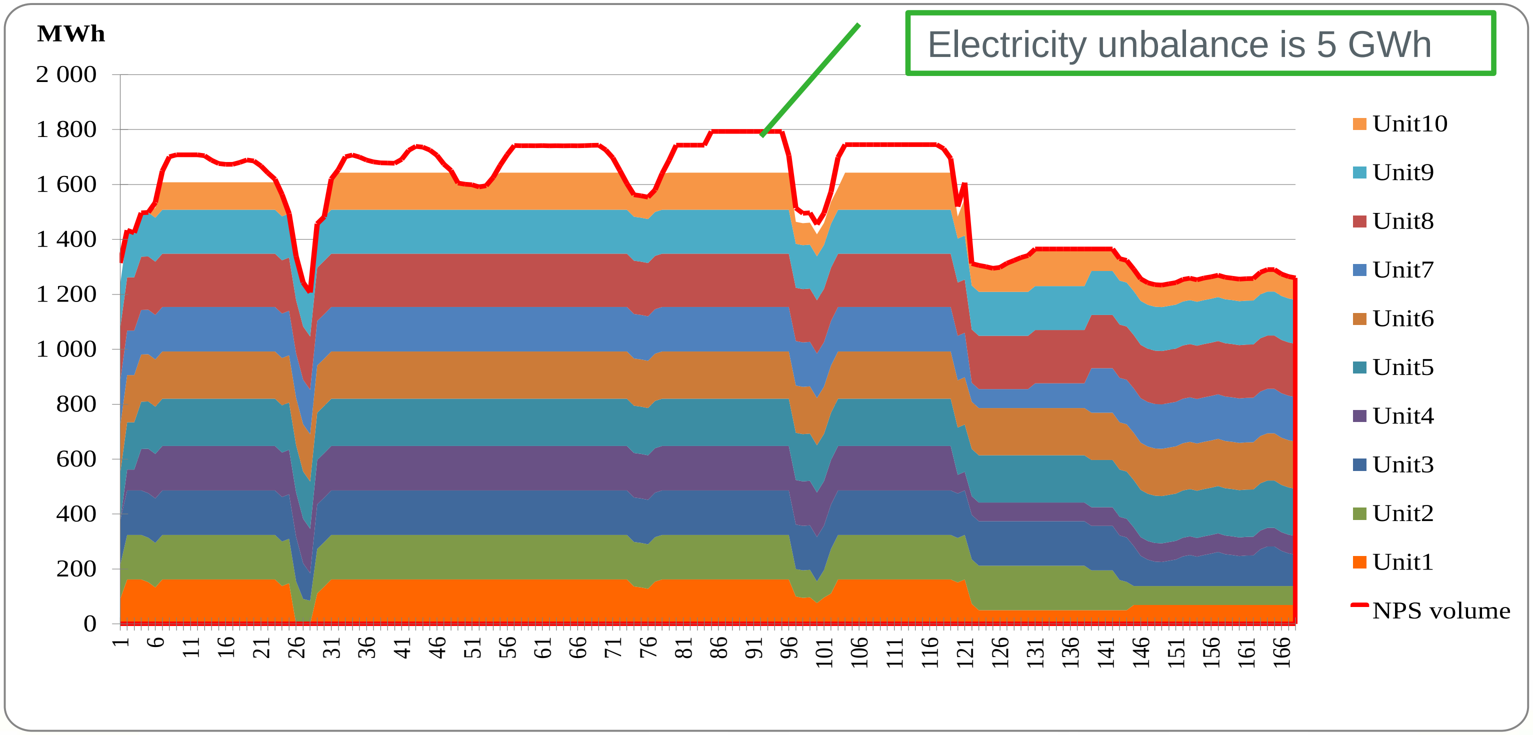
Results and discussion (1/5)

Algorithm	Manufacturing variable costs, m €	Manufacturing fixed costs, m €	Generation costs, m €	CPU*, sec
Winter week				
Interior-point	9,93	1,67	11,60	**509**
Dual simplex	9,96	1,67	11,63	515
Primal simplex	9,99	1,67	11,66	576
Summer week				
Interior-point	6,88	1,67	8,07	**528**
Dual simplex	6,88	1,67	8,07	529
Primal simplex	6,88	1,67	8,07	544

Table 1. Generation costs and CPU time for winter and summer week
Source: Compiled by the author

** CPU - central processing unit*

Results and discussion (2/5)



Electricity unbalance is 5 GWh

Figure 4. The optimal electrical power output of the power units in the winter week
Source: Compiled according to the author’s calculations

- Total generation costs – 11,6 m €
- CPU time – 509 sec

Results and discussion (3/5)

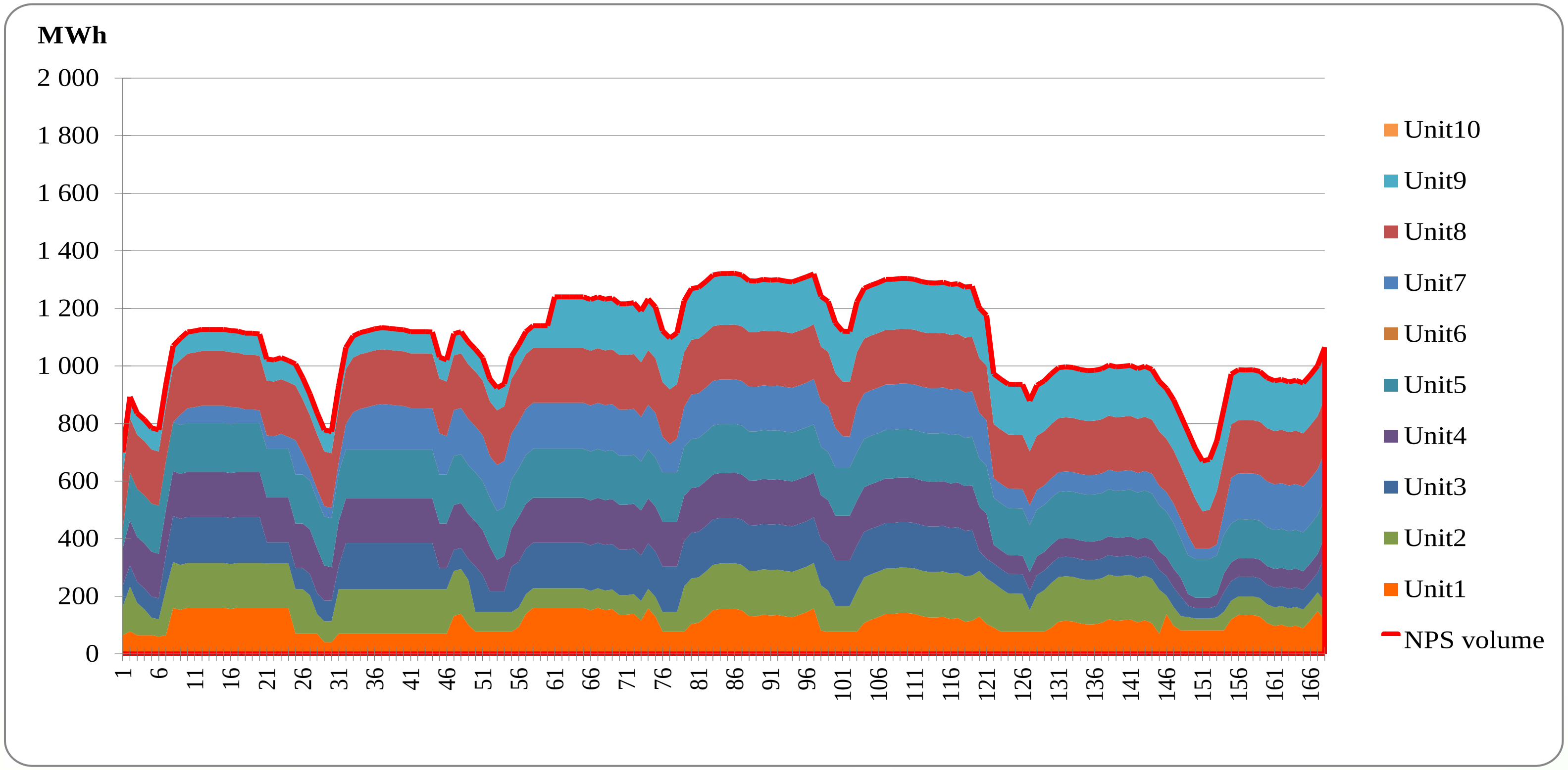
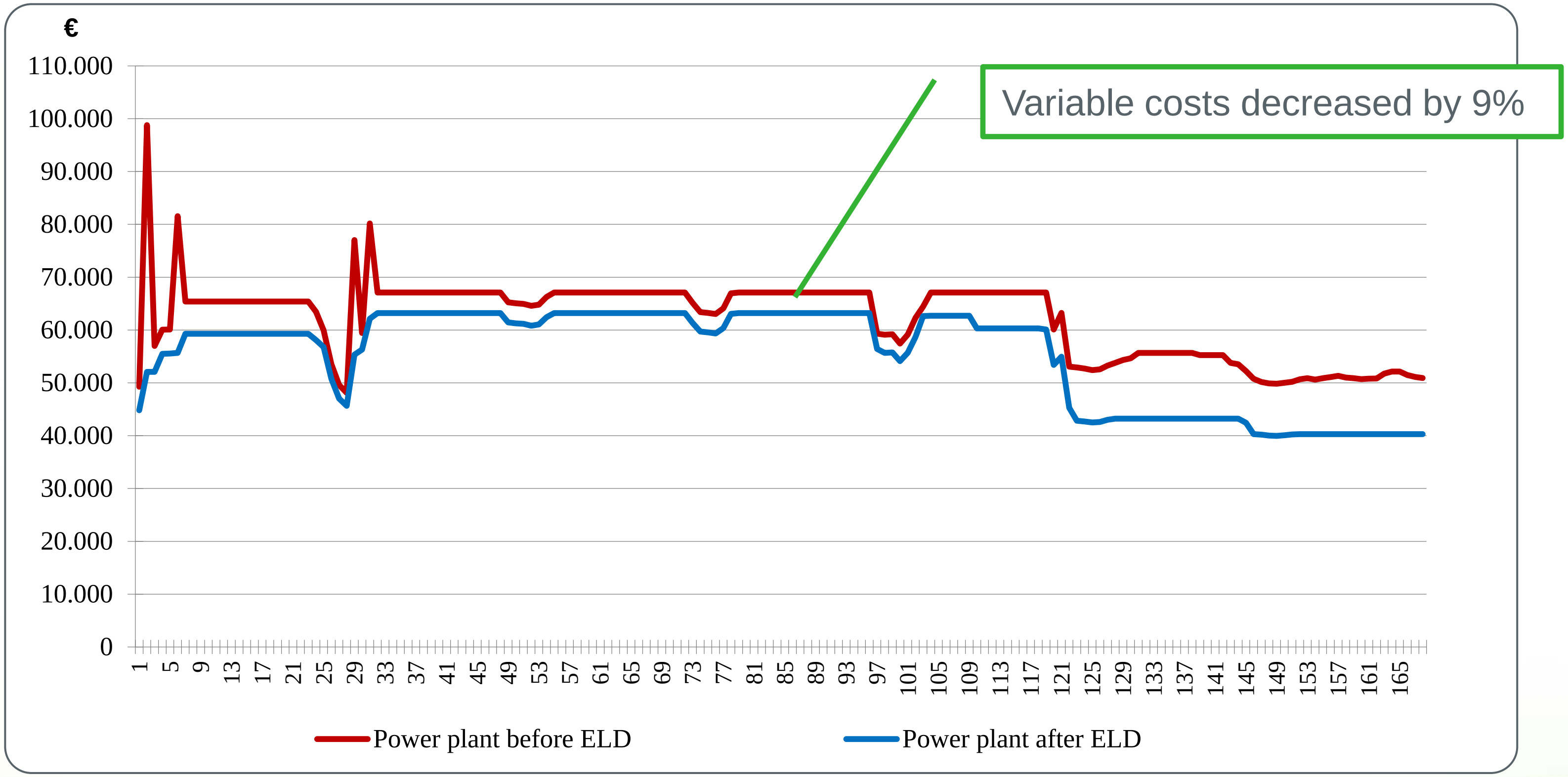


Figure 5. The optimal electrical power output of the power units in the summer week
Source: Compiled according to the author’s calculations

- Total generation costs – 8,1 m €
- CPU time – 528 sec

Results and discussion (4/5)



Variable costs decreased by 9%

Figure 6. Variable costs of the power plants in the winter week
Source: Compiled according to the author's calculations

Results and discussion (5/5)

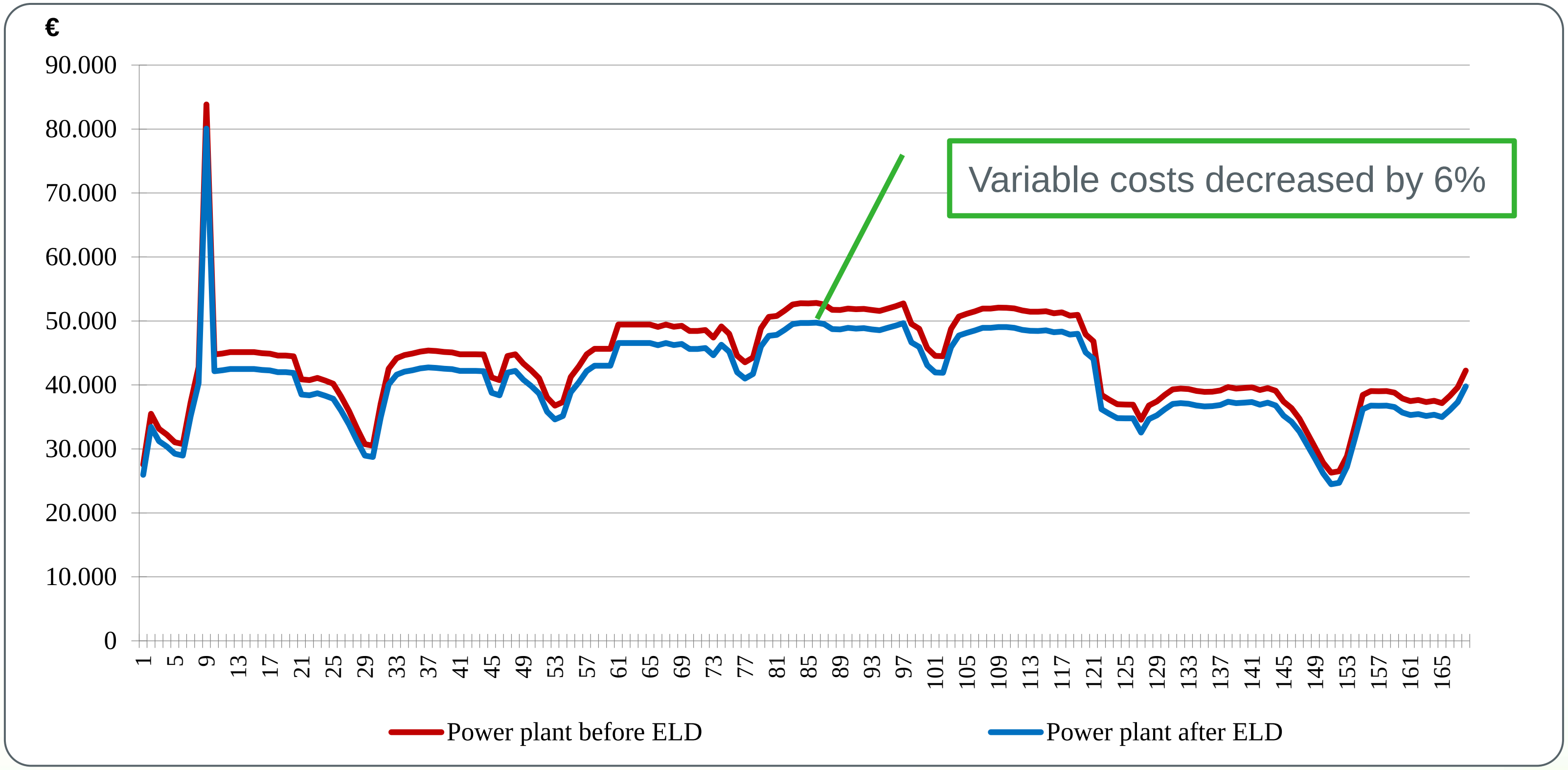


Figure 7. Variable costs of the power plants in the summer week
Source: Compiled according to the author's calculations

Conclusions

- 42 tests have been carried out with different properties;
- interior-point algorithm provides the best performance with less CPU time for solving;
- the results using primal, dual and interior-point methods have a marginal difference;
- implementation of algorithm could decrease the variable costs of power plant up to 9%;
- proposed algorithm served as a basis for more accurate economic dispatch model.

THANK YOU!

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