Power plant efficiency models and economic dispatch methods

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Objectives and expectations

Efficiency model

Objectives

- description of market behavior
- modeling demand-supply conditions
- determination of operating and marginal costs
- estimation of pollutant emissions

Expectations

- simplicity and minimal data requirements
- acceptable accuracy

Objectives and expectations

Economic dispatch method

Objectives

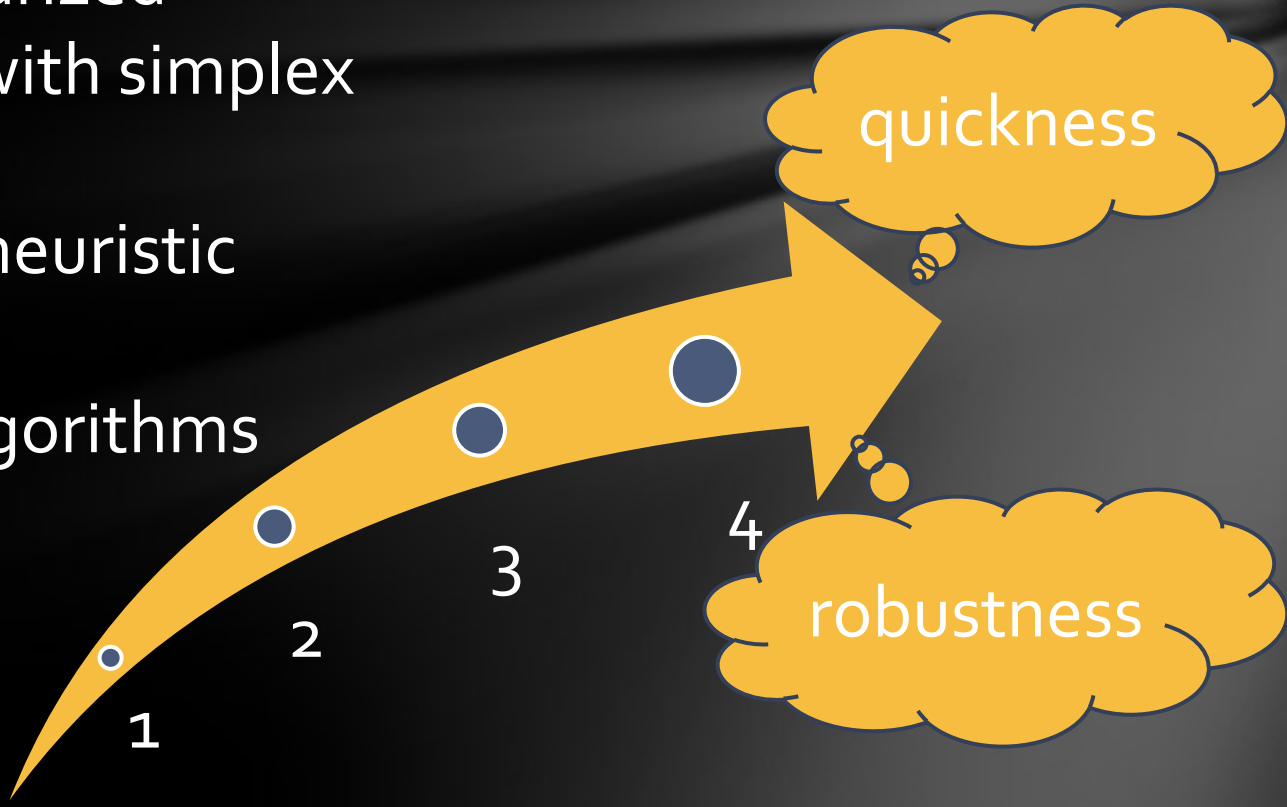
- determination of minimum operating costs
- robustness

Expectations

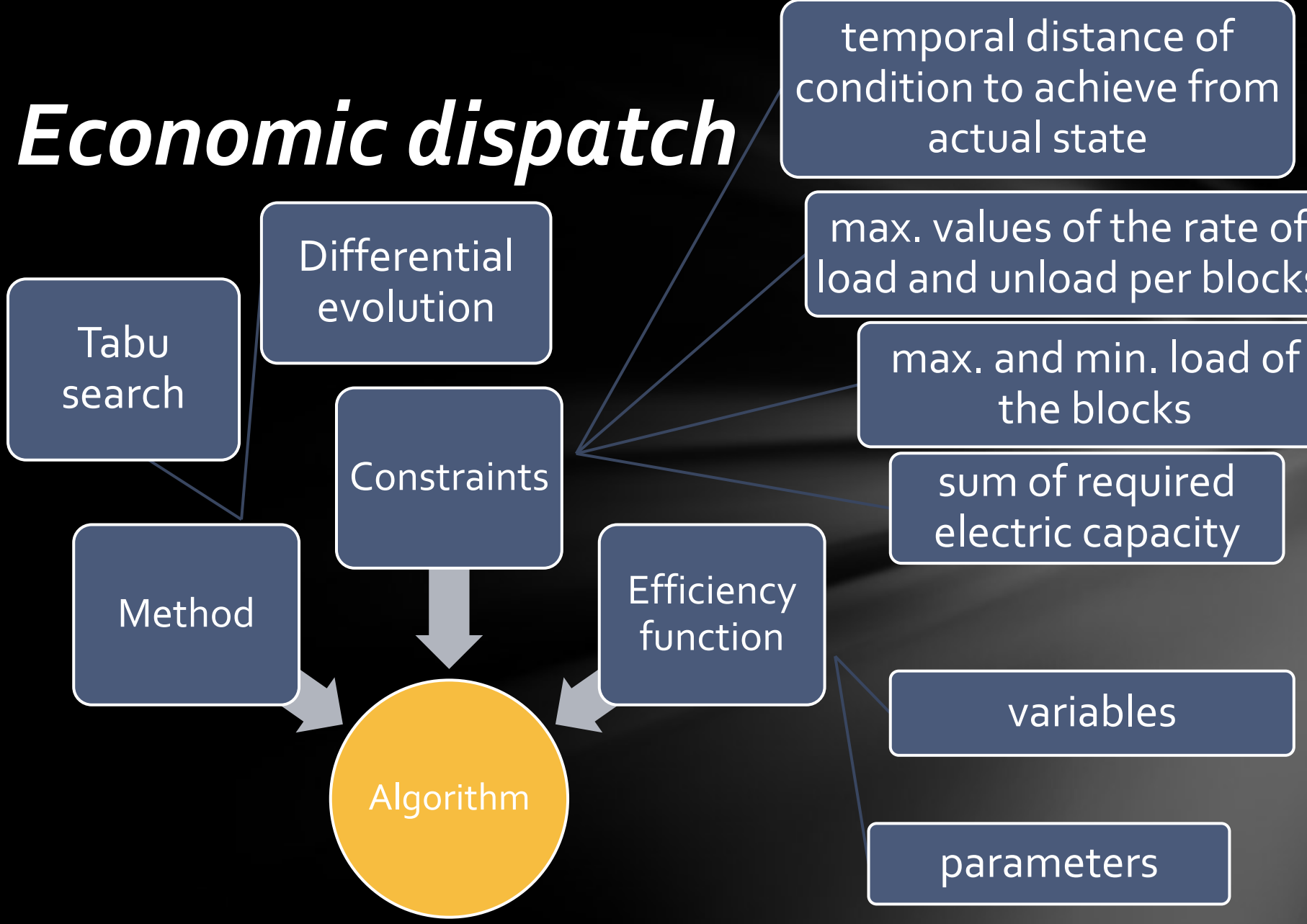
- quickness
- high hit probability
- ability to operate in real time

Economic dispatch methods

1. simultaneous analytic solutions of equations
2. solution of linearized programming with simplex method
3. semi-analytic, heuristic solution
4. evolutionary algorithms



Economic dispatch



Hybrid algorithm

Tabu search

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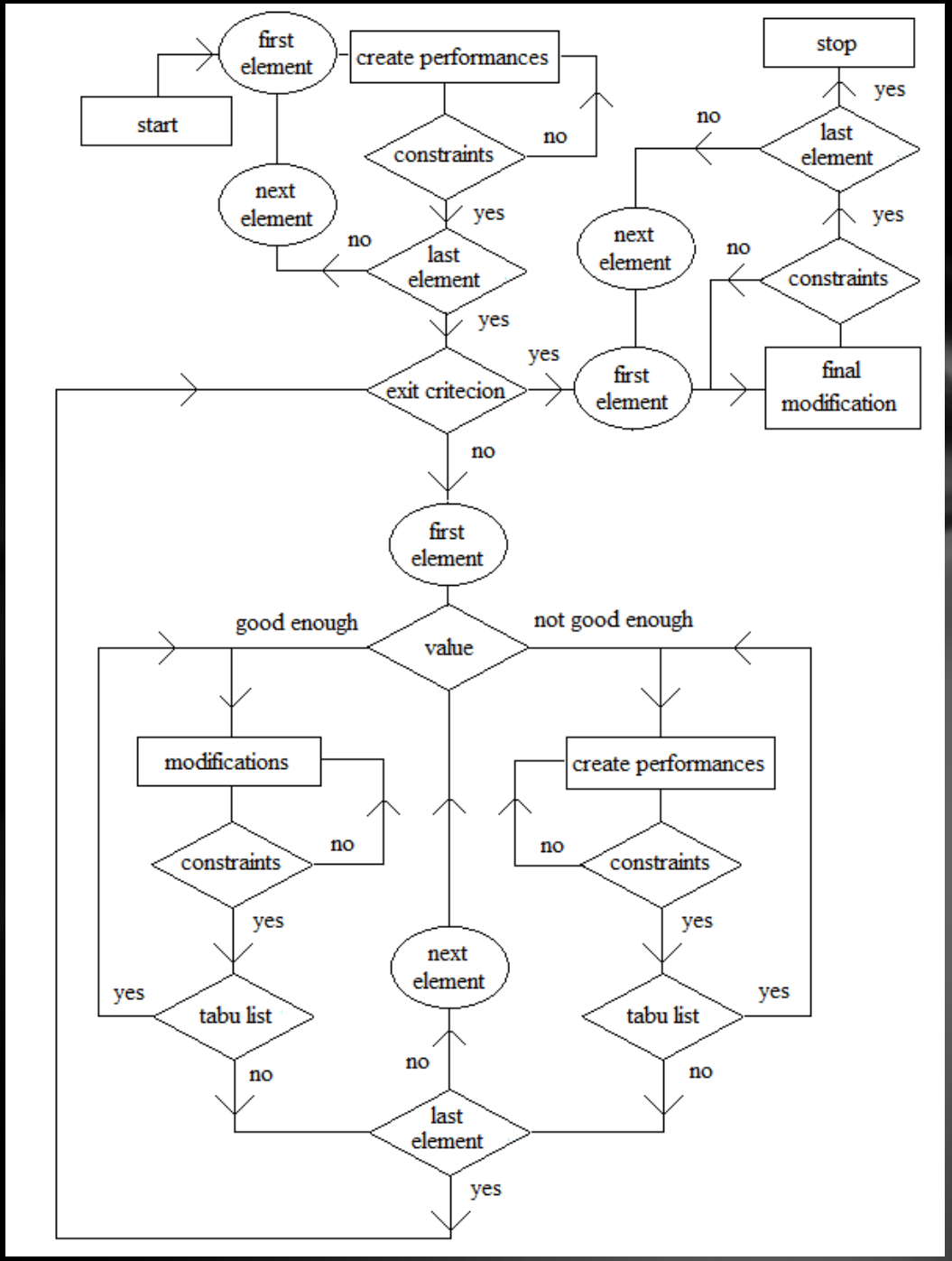
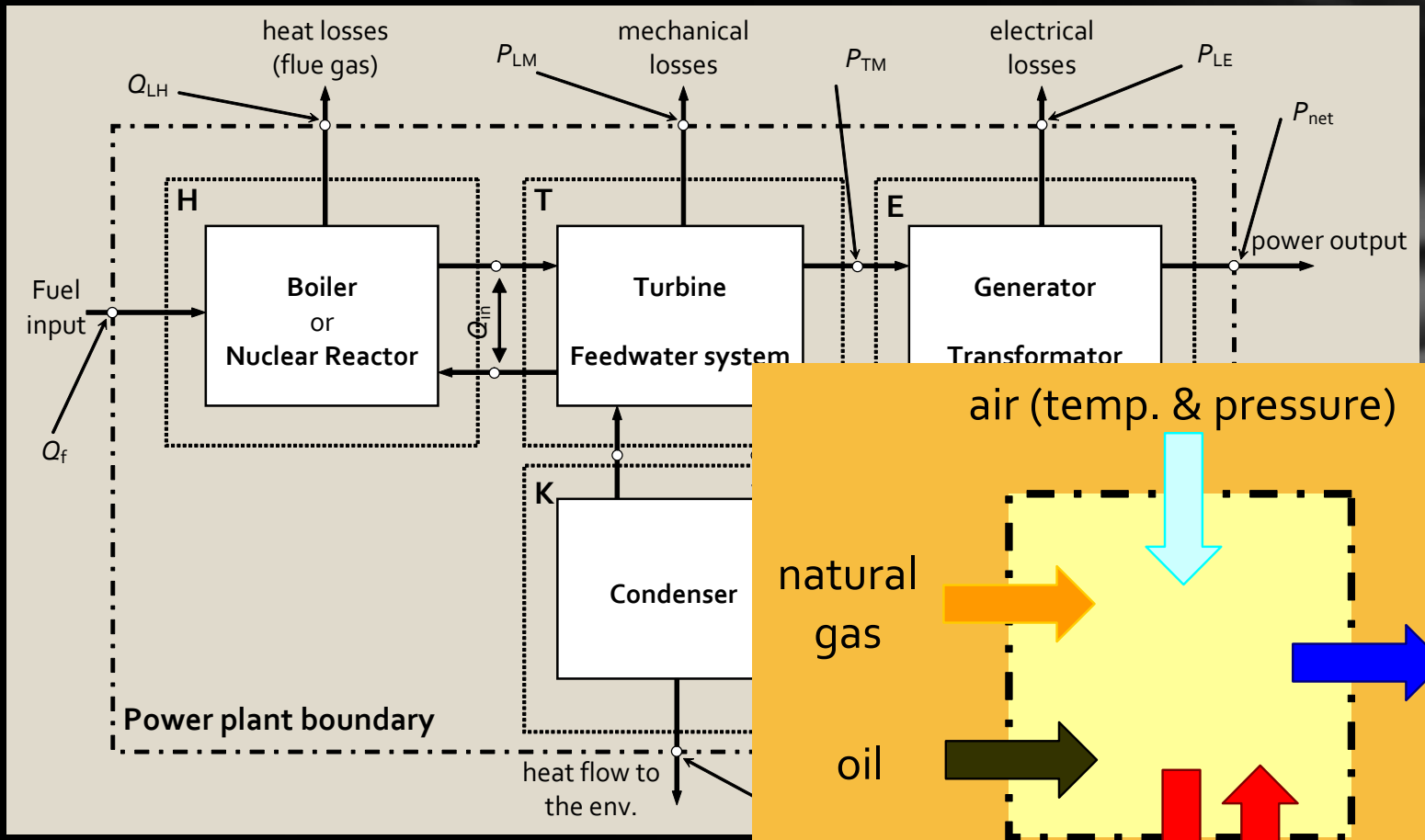
Differential evolution



Efficiency model

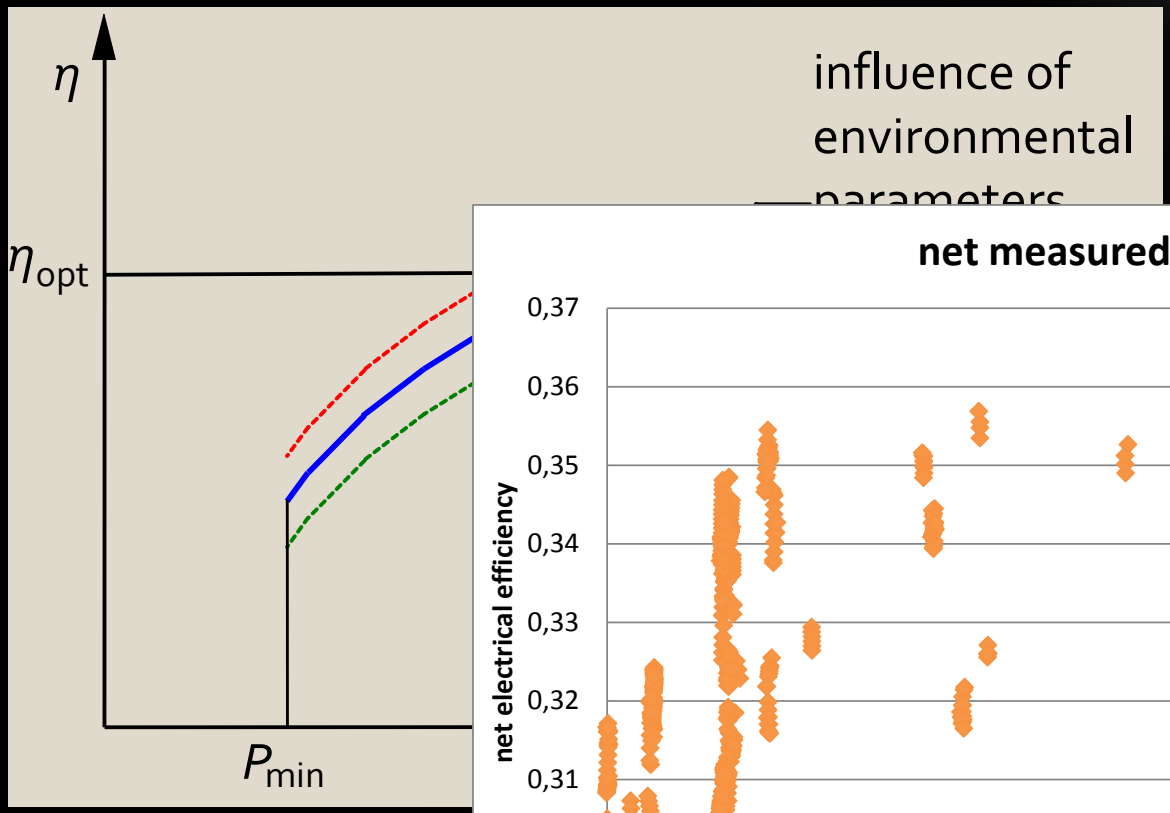
Detailed model

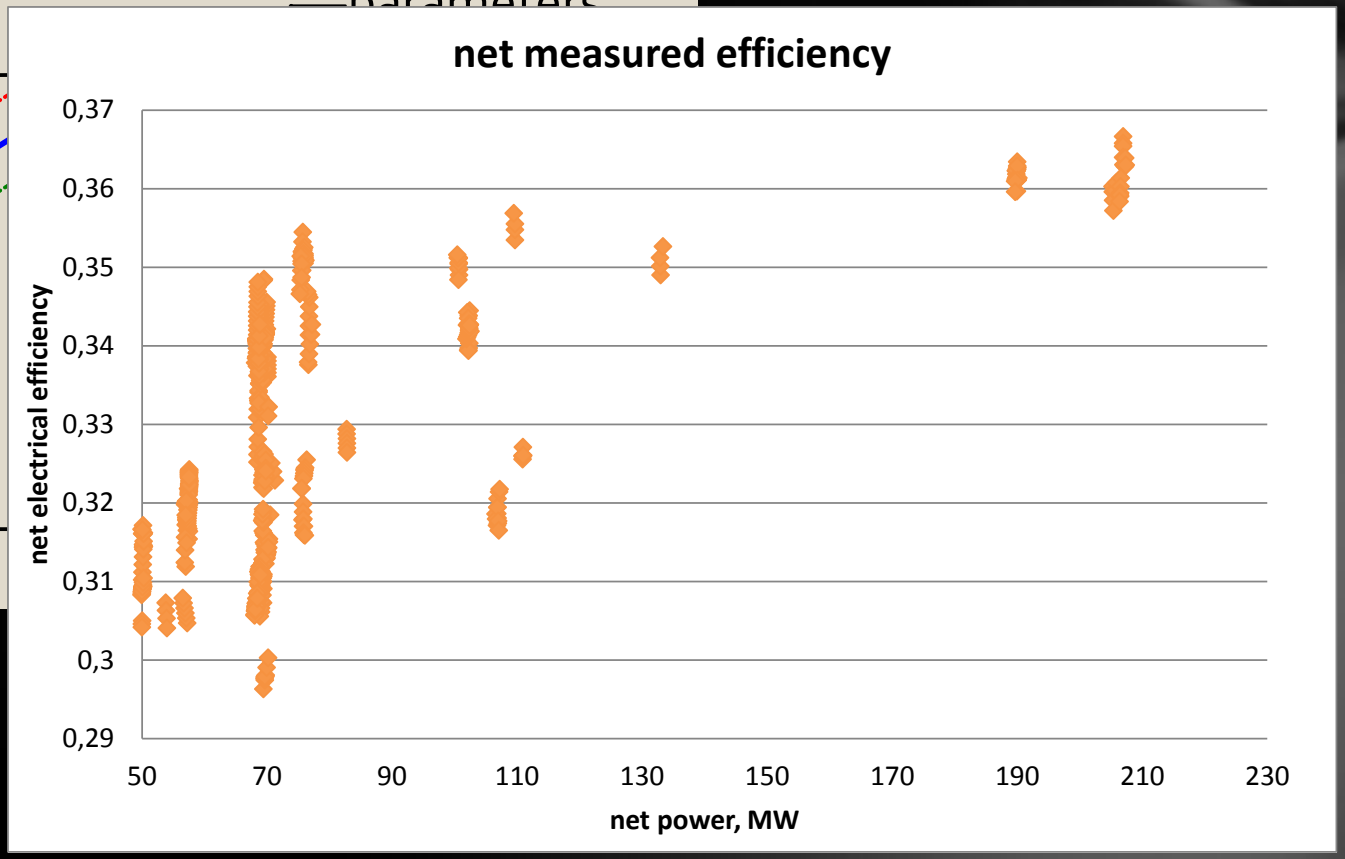


Black box model

Power plant efficiency

Theoretical





Measured

Efficiency function

Base function

$$\eta\ P = \eta_{\text{opt}} \left\{ 1 - Xv \left(\frac{P_{\max}}{P} \right) \left[\left(\frac{1}{v^2} \right) \left(\frac{P}{P_{\max}} \right)^2 - 1 \right]^2 \right\}$$

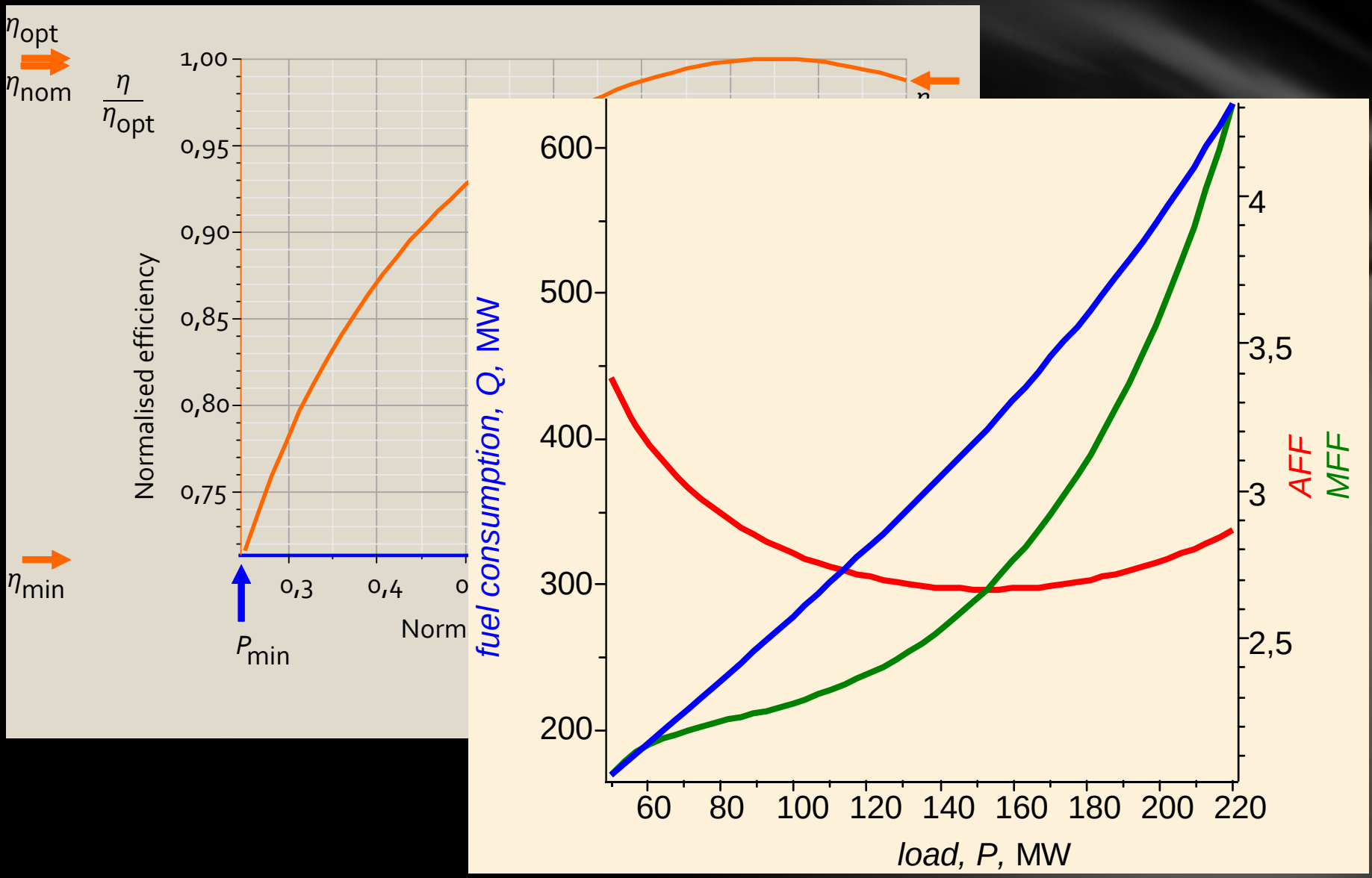
Average fuel factor (specific fuel consumption)

$$AFF = \frac{1}{\eta\ P} = \frac{1}{\eta\ load}$$

Marginal fuel factor

$$MFF = \frac{\mathrm{d}\ P \cdot AFF}{\mathrm{d}P} = P \frac{\mathrm{d}AFF}{\mathrm{d}P} + AFF$$

Efficiency function - Theory



Efficiency function - Corrections

Influencing factors (condensing unit with steam sendout)

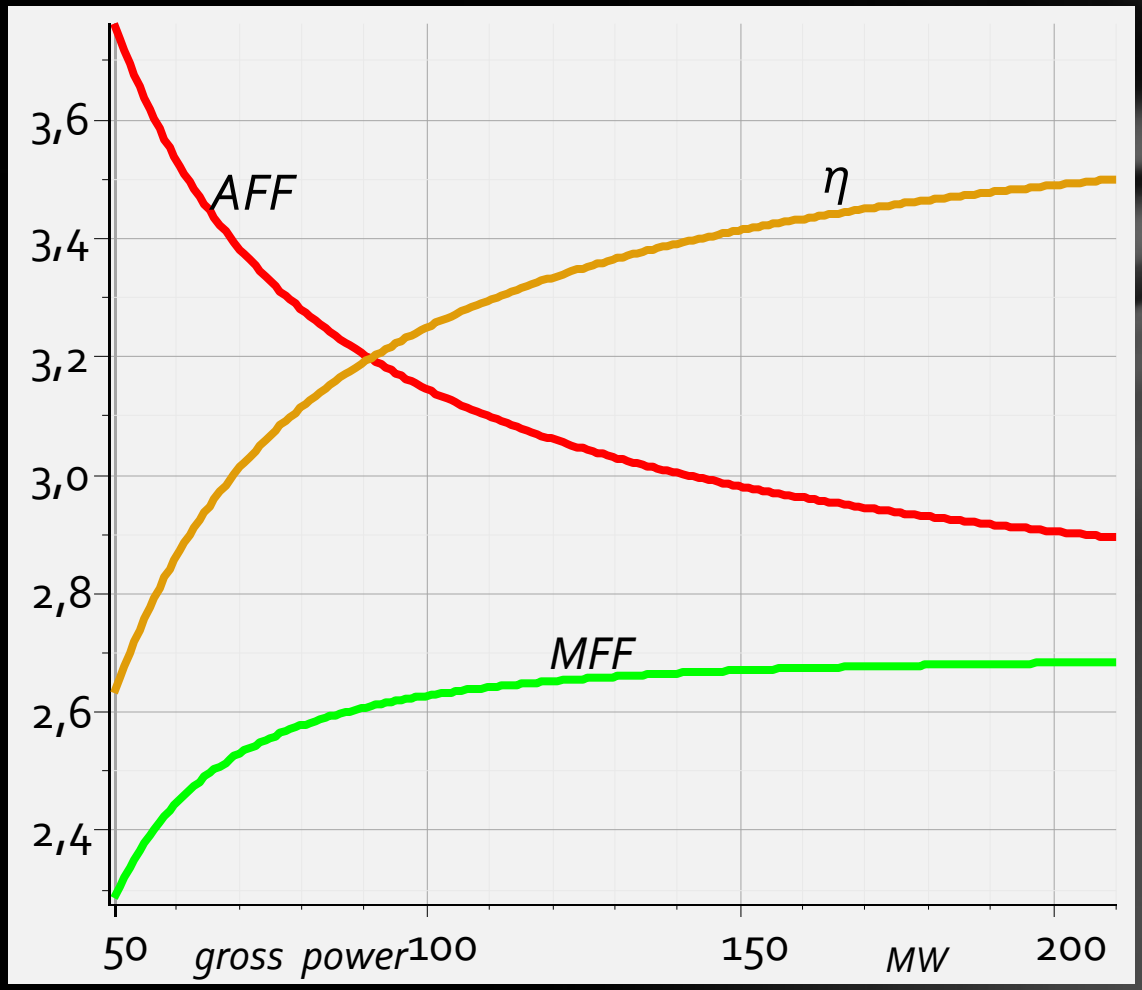
- steam in- and outlet (mass flow only)
- air pressure and temperature
- fuel type

	Coefficient	Std. Error	t-ratio	p-value	
const	1,13984	0,0714827	15,9456	<0,00001	***
P_gross	**0,00138361**	**7,20074e-05**	**19,2148**	**<0,00001**	***
P_gross^2	**-4,31467e-06**	**2,69952e-07**	**-15,9831**	**<0,00001**	***
st_out	**-0,00294359**	**0,000129861**	**-22,6672**	**<0,00001**	***
st_in	**0,000502311**	**0,000235524**	**2,1327**	**0,03326**	**
st_out^2	**7,23838e-05**	**5,58452e-06**	**12,9615**	**<0,00001**	***
st_in^2	-2,06377e-05	1,76376e-05	-1,1701	0,24232	
t_air	**0,000291736**	**3,67589e-05**	**7,9365**	**<0,00001**	***
fuel_ratio	**0,0238803**	**0,00169621**	**14,0786**	**<0,00001**	***
p_air	**-0,000872738**	**6,94403e-05**	**-12,5682**	**<0,00001**	***

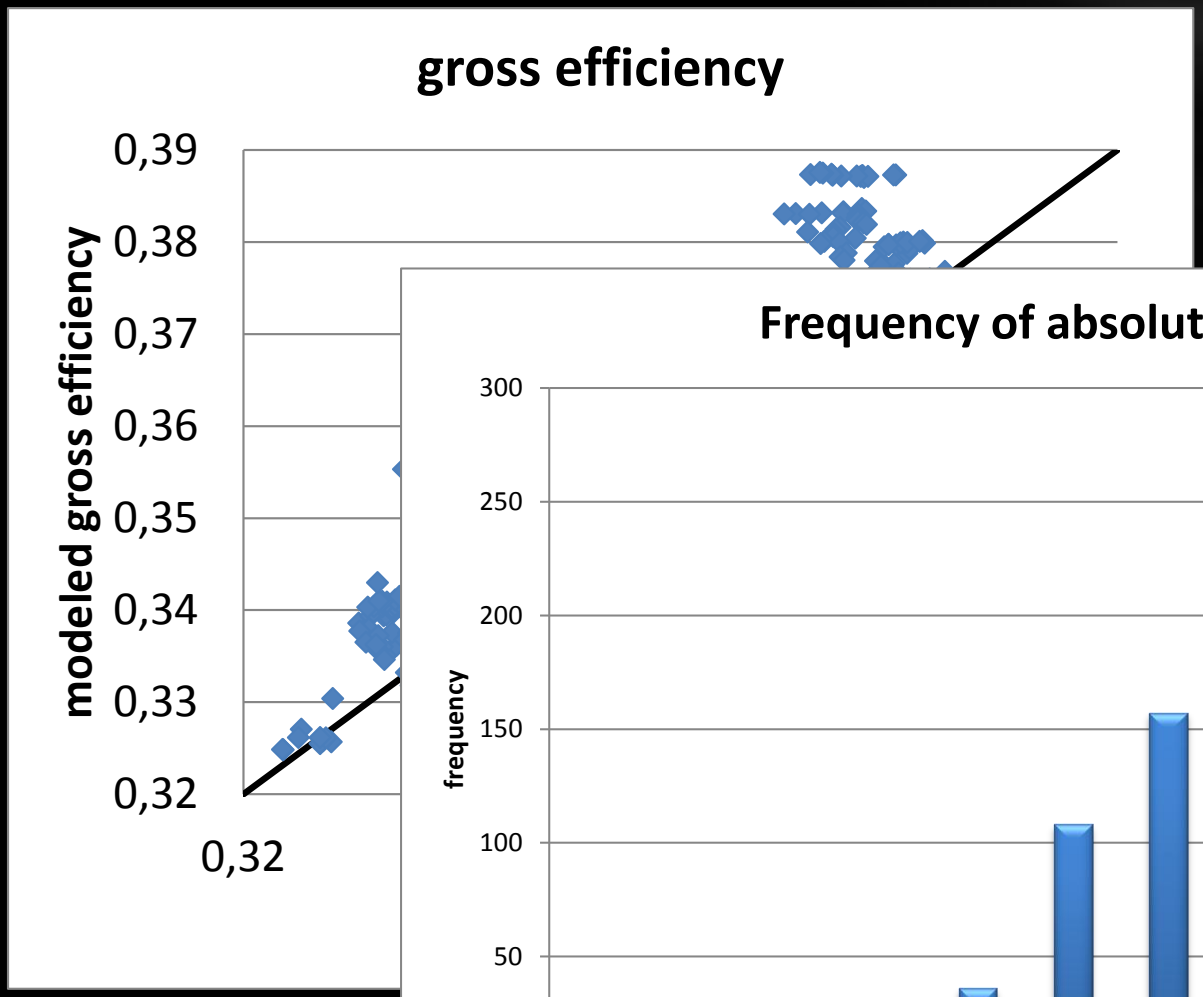
Mean dependent var	0,350585	S.D. dependent var	0,015191
Sum squared resid	0,026942	S.E. of regression	0,005855
R-squared	0,853143	**Adjusted R-squared**	**0,851462**
F(9, 786)	710,9734	P-value(F)	0,000000
Log-likelihood	2967,407	**Akaike criterion**	**-5914,813**
Schwarz criterion	-5868,017	Hannan-Quinn	-5896,832

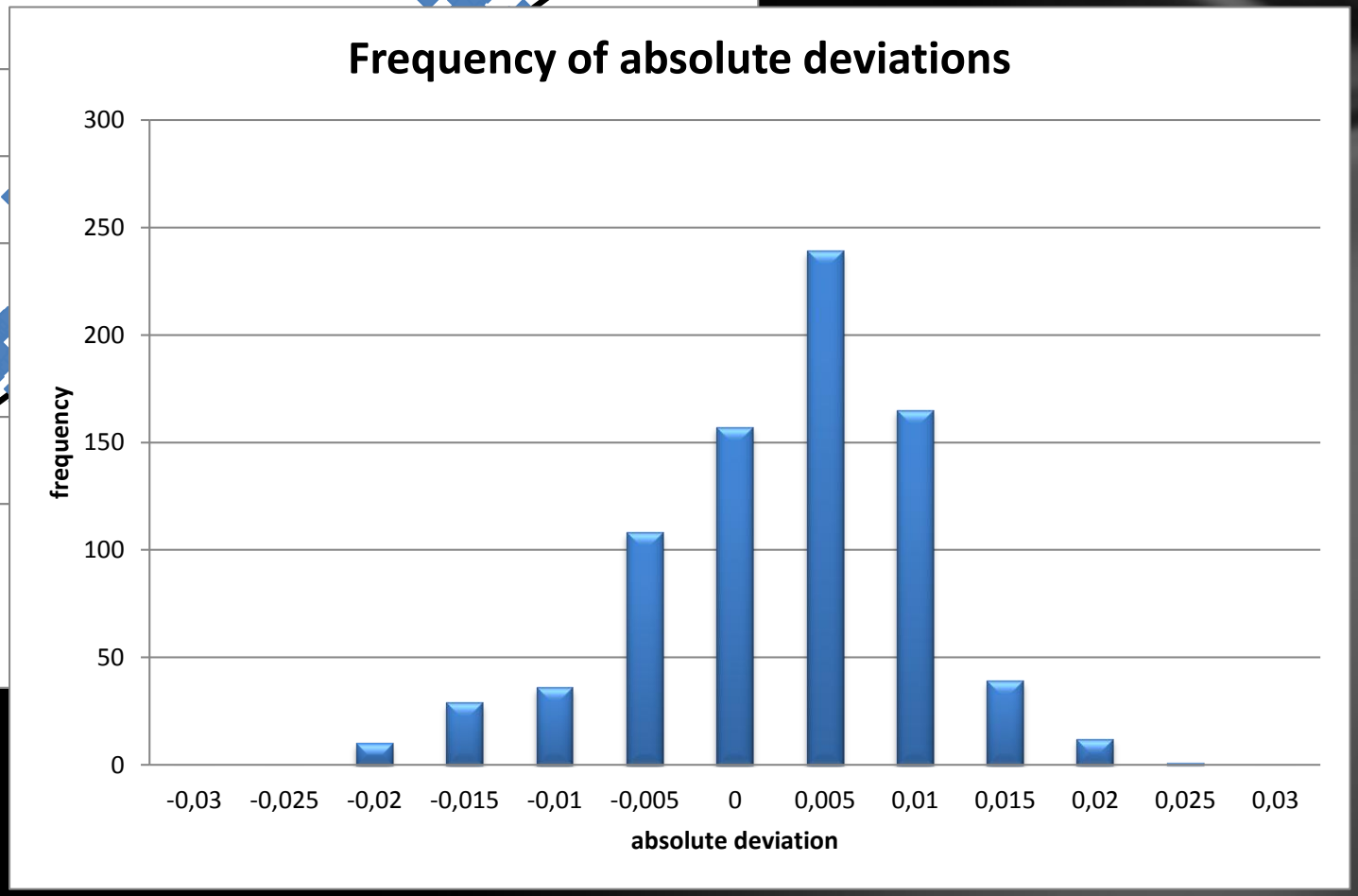
Efficiency function - Corrections

$$\eta = \eta_{opt}\left\{1 - Xv\left(\frac{P_{max}}{P}\right)\left[\left(\frac{1}{v^2}\right)\left(\frac{P}{P_{max}}\right)^2 - 1\right]^2\right\} \cdot C_1\ \dot{m}_{steam}\ \cdot C_2\ T_{air}\ \cdot C_3\ fuel\ \cdot C_4\ p_{air}$$



Efficiency function – Model validation





Thank you for your attention!