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College on Evaluation of Energy Technologies and Policies for Implementation of Agenda-21

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Modelling Combined Heat & Power Technology

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Modeling of Combined Heat and Power Plants

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Topics covered

Single fuel back pressure units,

Multiple fuel back pressure units,

Single fuel extraction units,

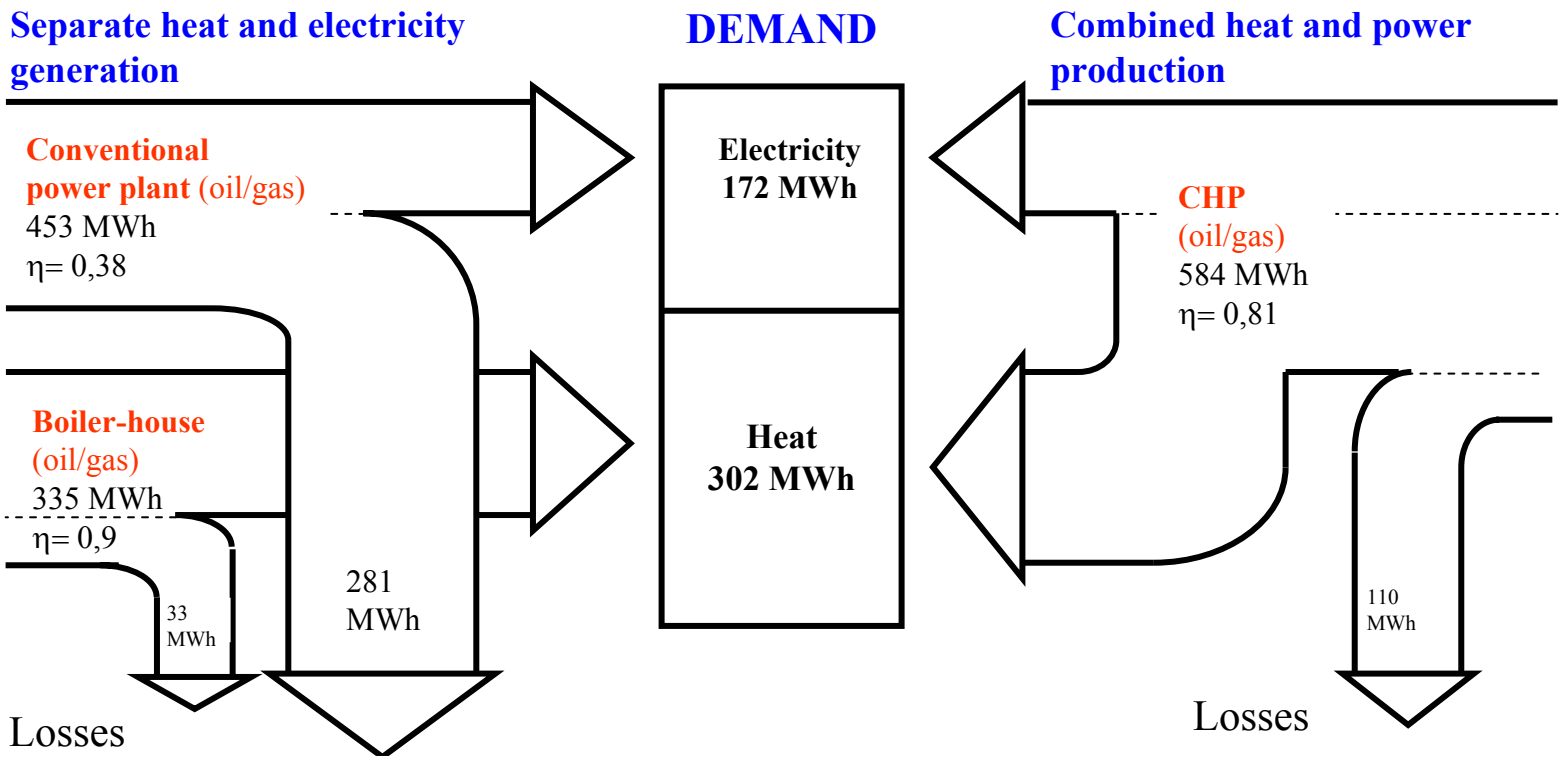
Multiple fuel extraction units,

Ability to cover heat and electricity demand,

CHP with heat accumulator,

Data example for case studies.

Combined and separate heat and electricity production



Total primary energy requirement 788 MWh

Total primary energy requirement 584 MWh

Saving of primary energy requirement 26%

Types of combined heat and power plants

Back pressure CHP – relation between heat and electricity output is fixed,

Extraction CHP – heat and electricity output is not in a fixed relation.

Technical parameters of CHP's

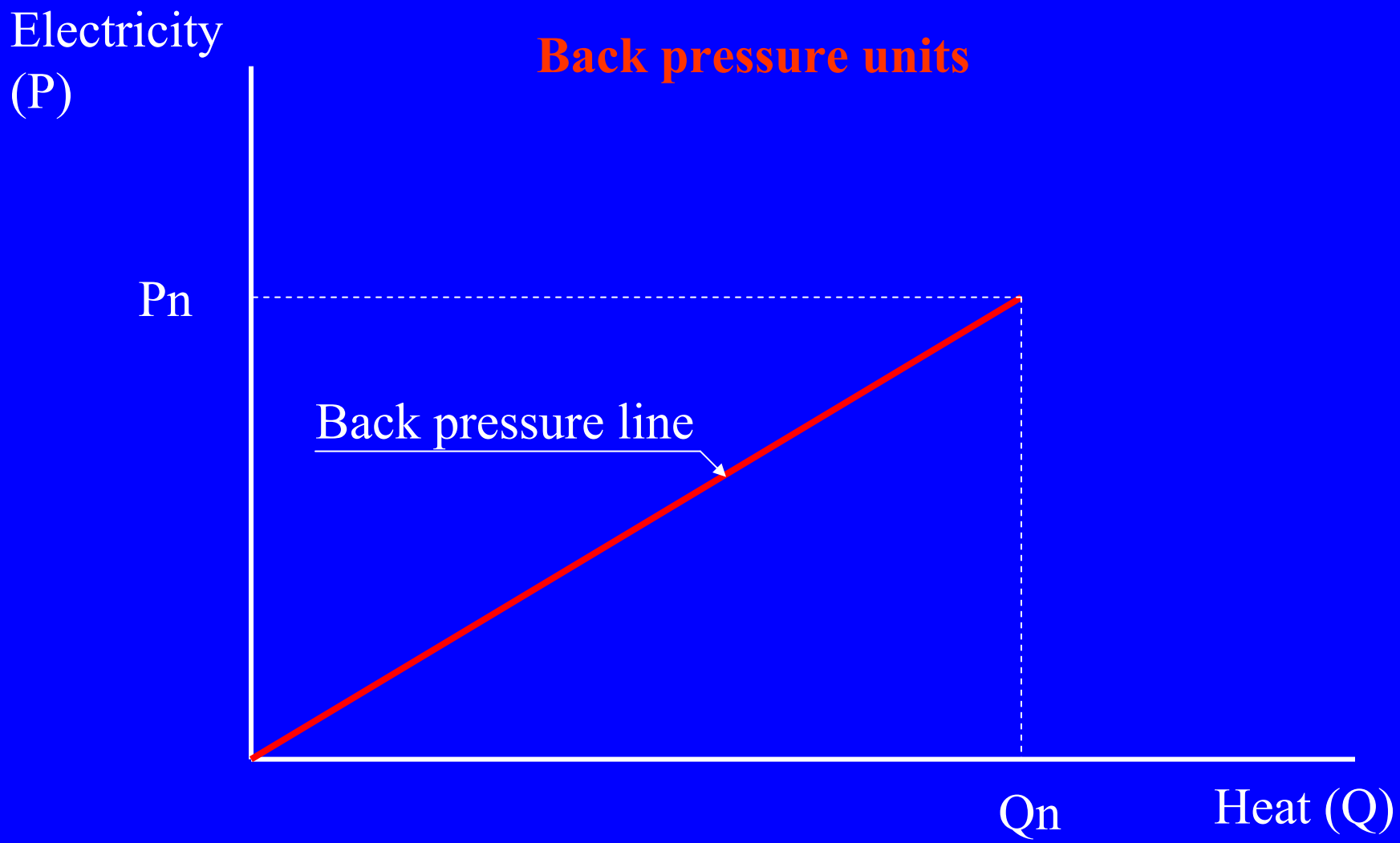
Back pressure units

Nominal electrical capacity (Pn),

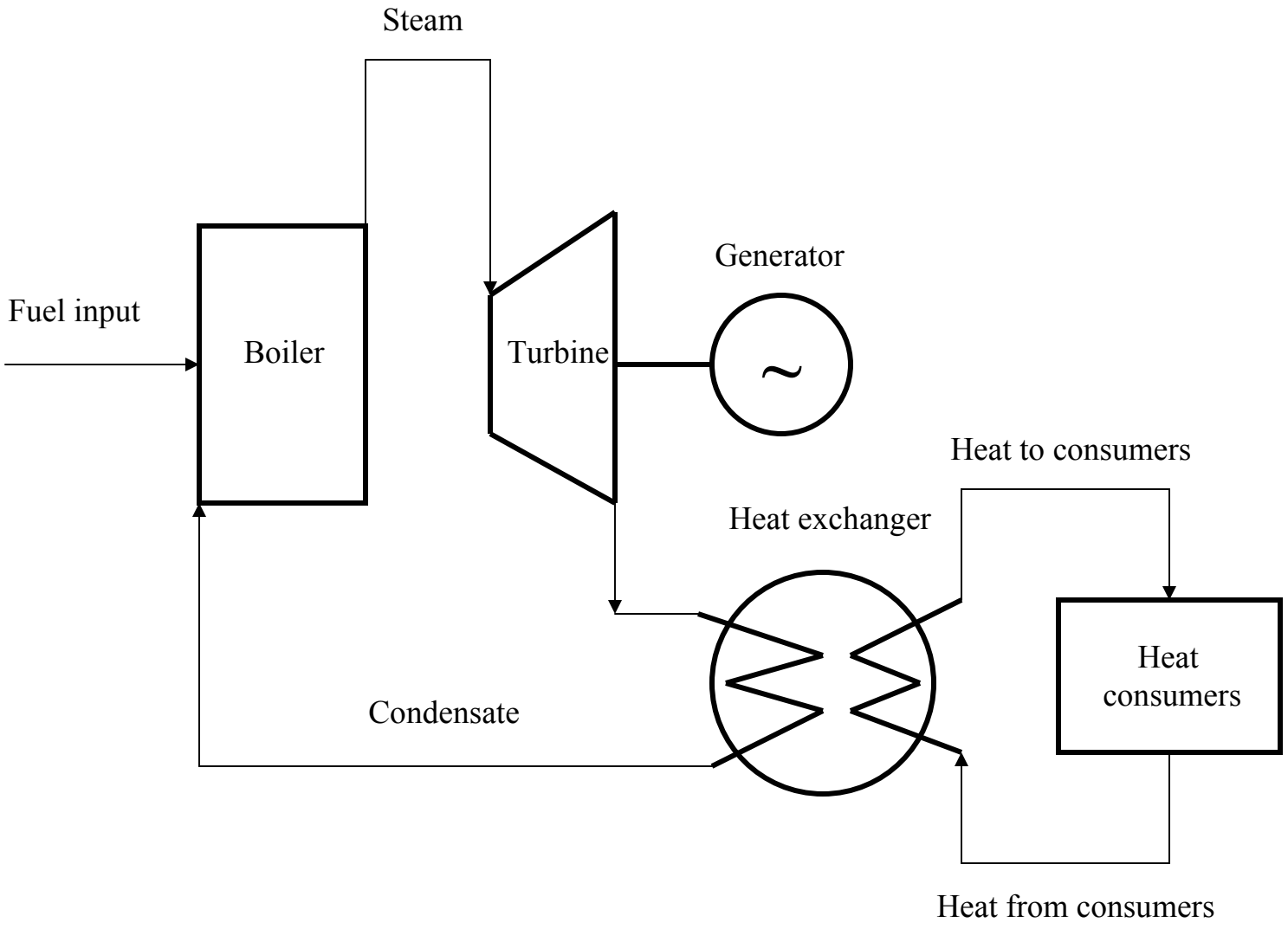
Nominal thermal capacity (Qn),

Total fuel efficiency η_{Σ}

Relation between heat and electricity output

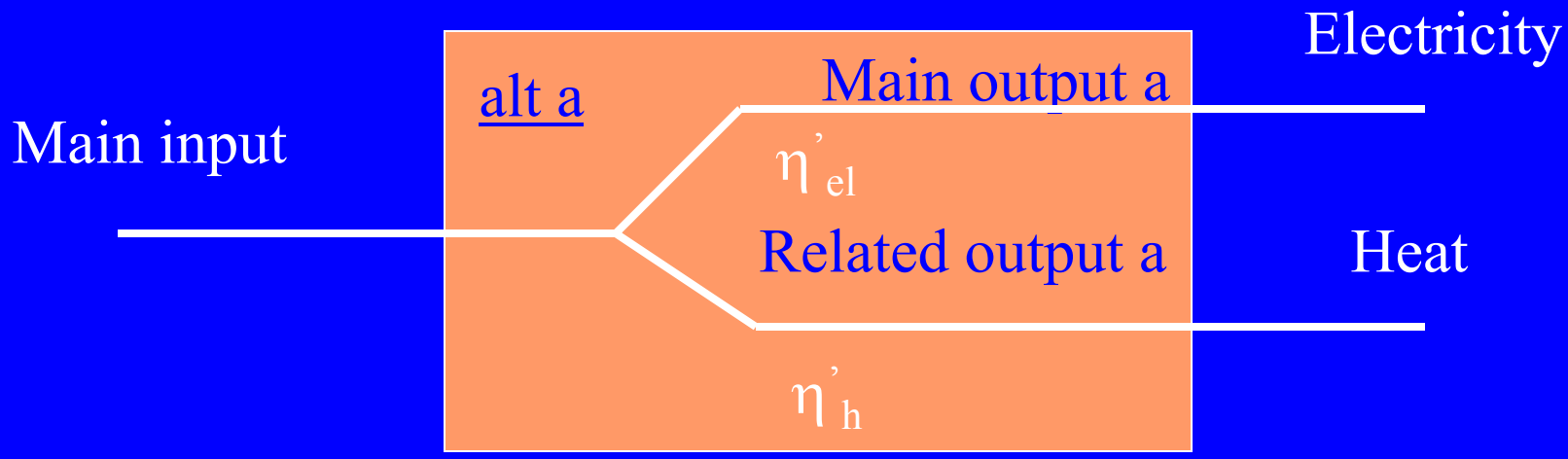


Back pressure units



Representation of CHP in MESSAGE

Back pressure unit



$$\eta'_{el} = \frac{Pn}{(Pn + Qn)/\eta_{\Sigma}} \; ; \qquad \eta'_{h} = \frac{Qn}{(Pn + Qn)/\eta_{\Sigma}} \; ; \qquad \mathbf{P' = Pn} \; ;$$

Representation of CHP in MESSAGE

Back pressure unit

$Pn = 23.3$ MW; $Qn = 102.3$ MW; $\eta_{\Sigma} = 0.825$;

$$P' = Pn = 23.3 \text{ MW};$$

$$\eta'_{el} = \frac{Pn}{(Pn + Qn)/\eta_{\Sigma}} = \frac{23.3}{(23.3+102.3)/0.825} = 0.153;$$

$$\eta'_{h} = \frac{Qn}{(Pn + Qn)/\eta_{\Sigma}} = \frac{102.3}{(23.3+102.3)/0.825} = 0.672;$$

Cost data of CHP's

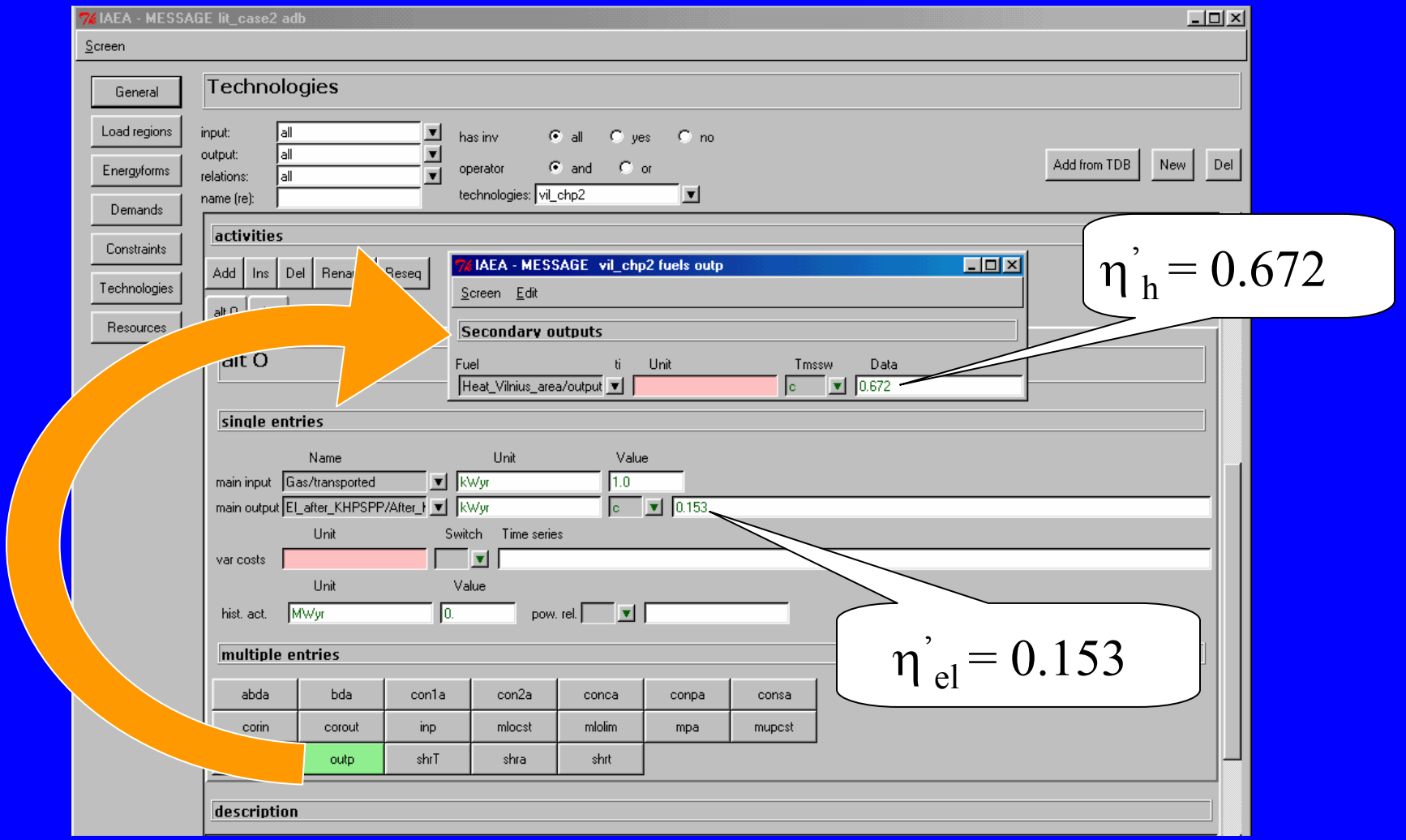
Back pressure units

Investment costs and fixed O&M costs are related to electrical capacity,

Variable O&M costs are related to electricity output.

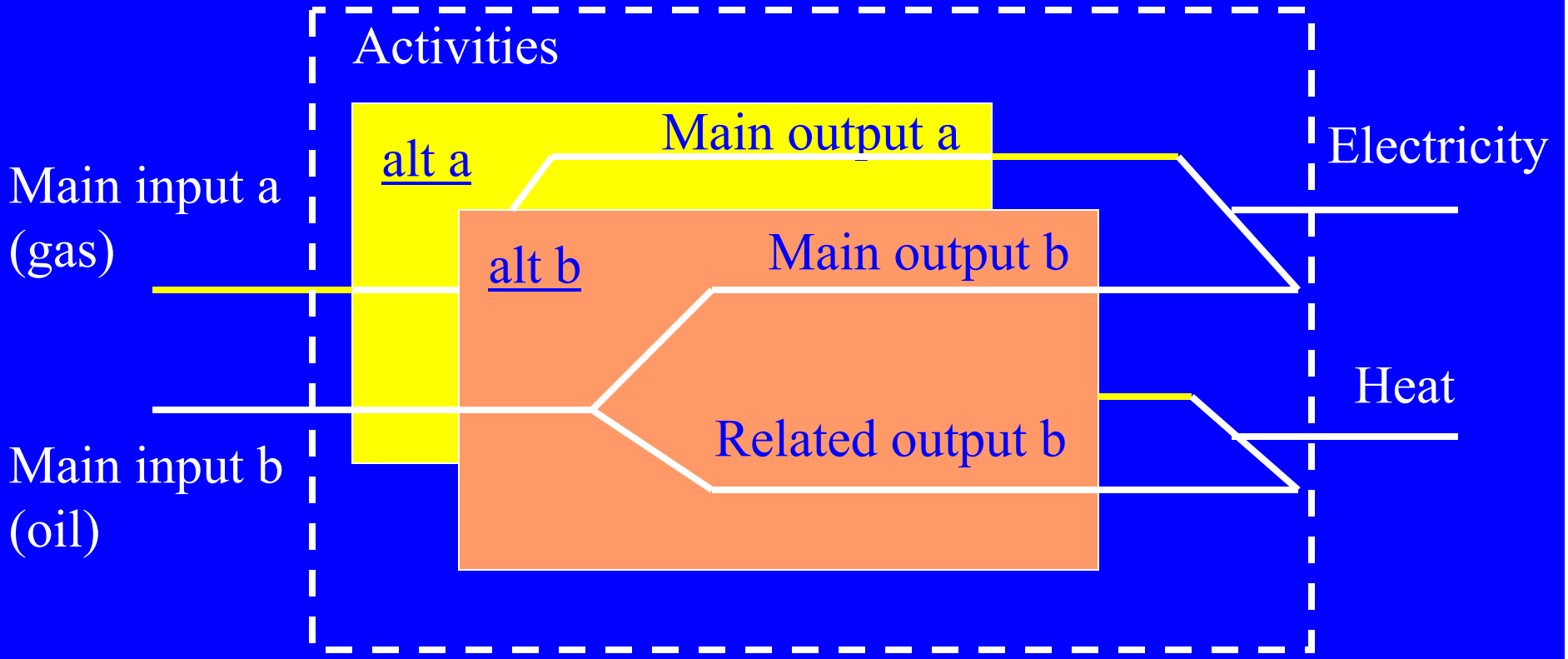
Representation of CHP in MESSAGE

Back pressure units



Representation of CHP in MESSAGE

Multi fuel back pressure unit



Technical parameters of CHP's

Extraction units

Nominal electrical capacity in CHP mode (Pn),

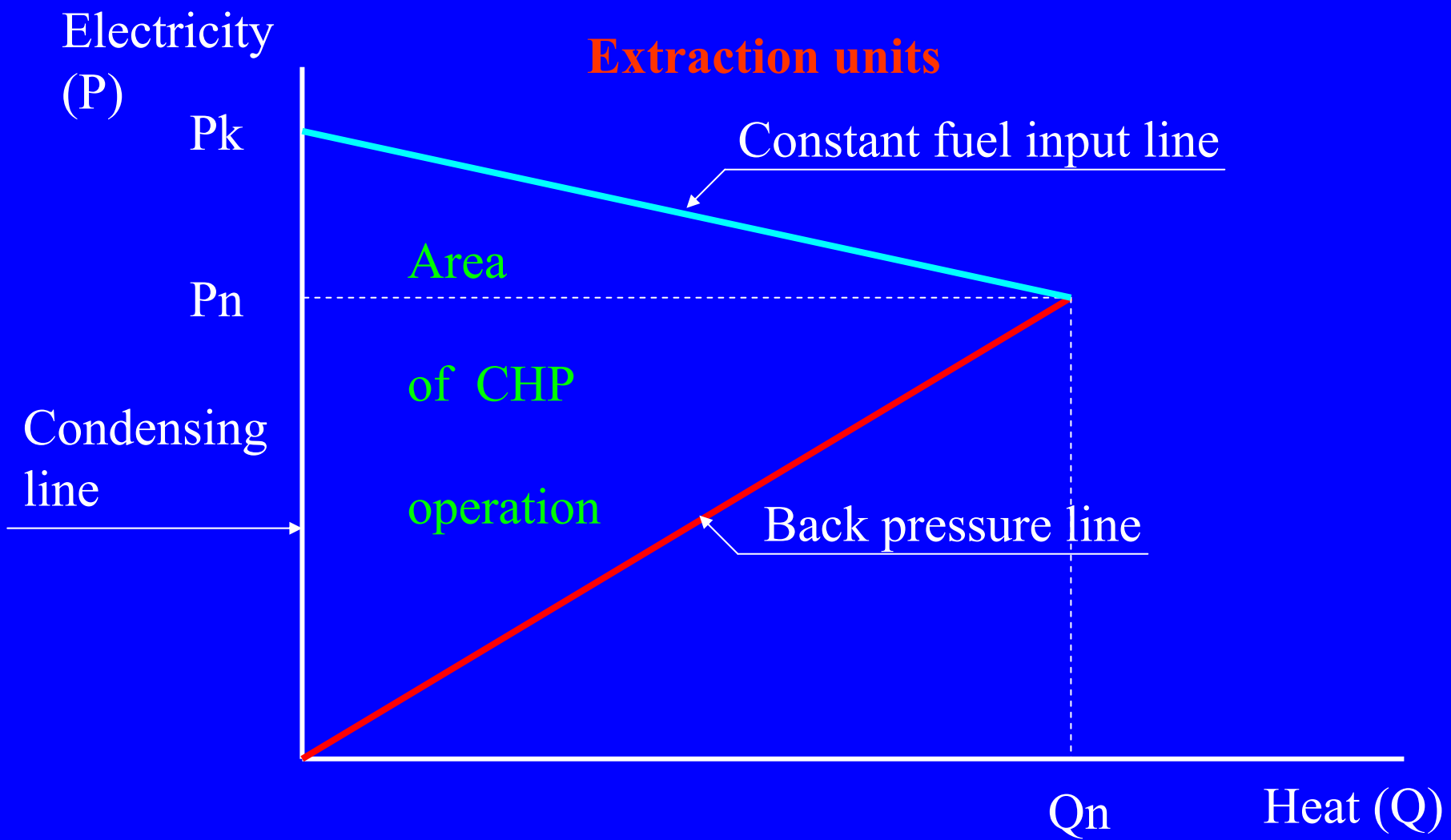
Nominal electrical capacity in condensing mode (Pk),

Nominal thermal capacity (Qn),

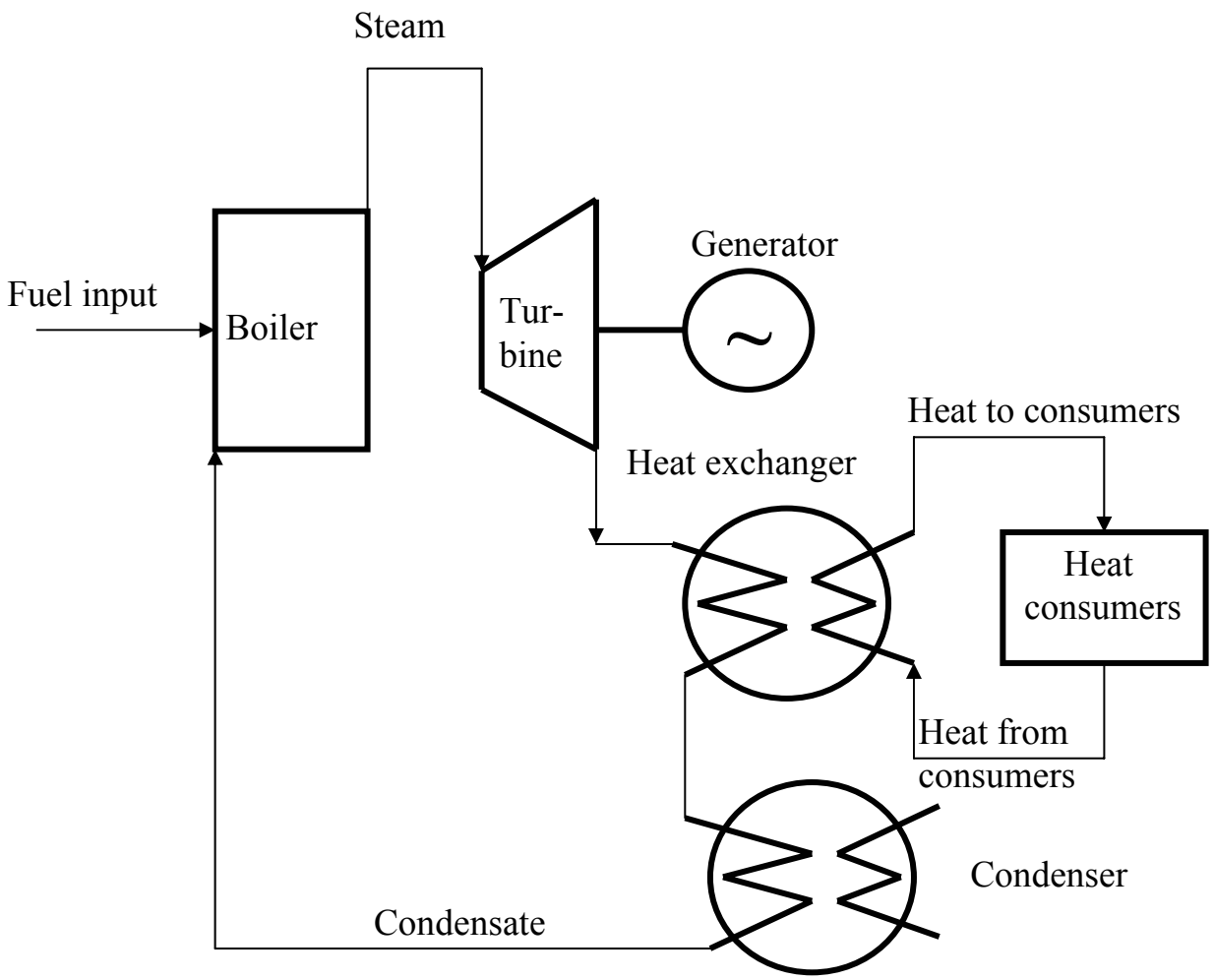
Fuel efficiency in condensing mode (ηk),

Fuel efficiency in CHP mode (Total efficiency) (η_T).

Relation between heat and electricity output

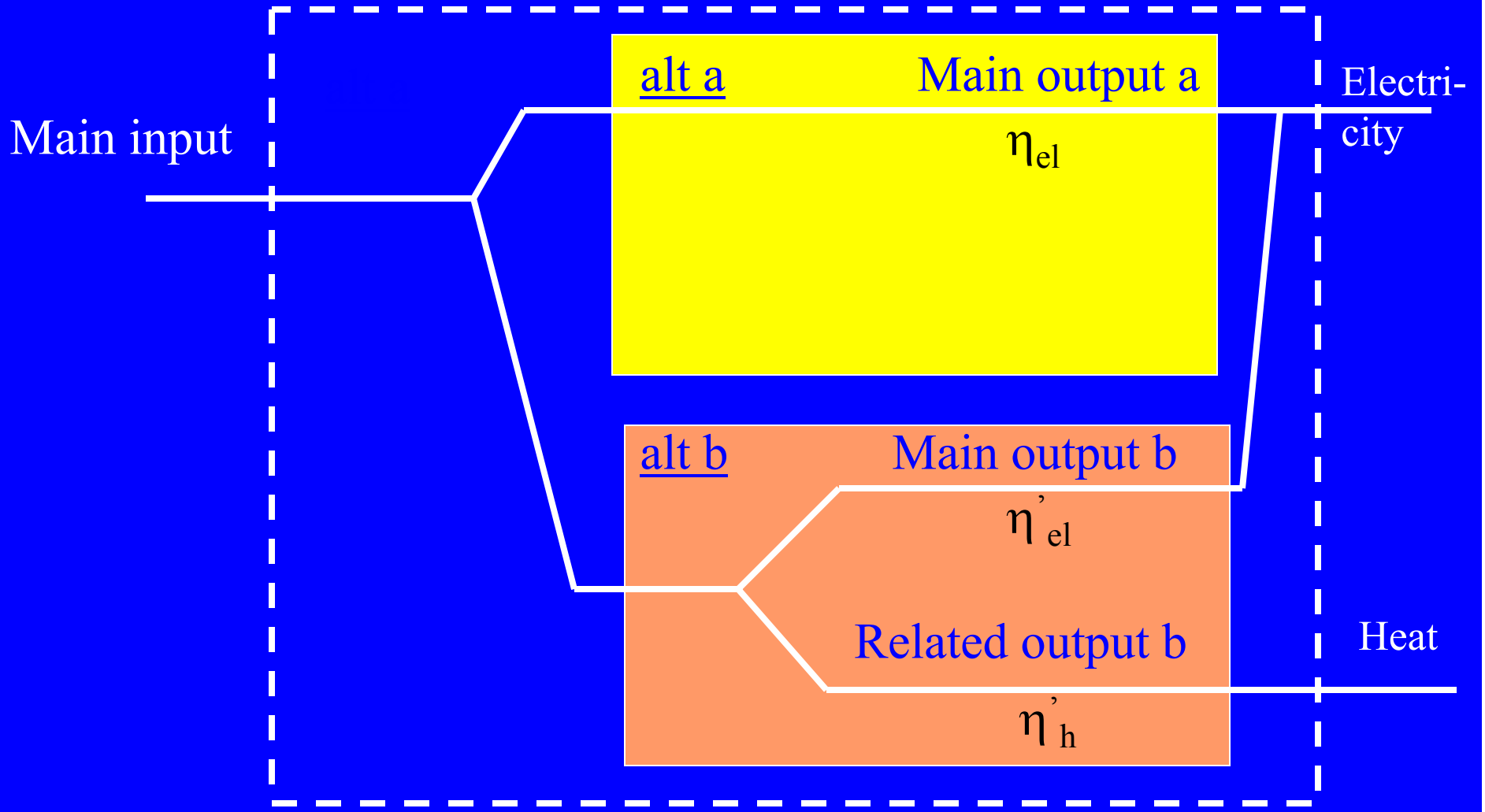


Extraction unit



Representation of CHP in MESSAGE

Extraction unit (single fuel)



Representation of CHP in MESSAGE

Extraction unit (single fuel)

$Pn = 171.8$ MW; $Pk = 208$ MW; $Qn = 302.3$ MW;

$\eta_k = 0.357$; $\eta_T = 0.81$;

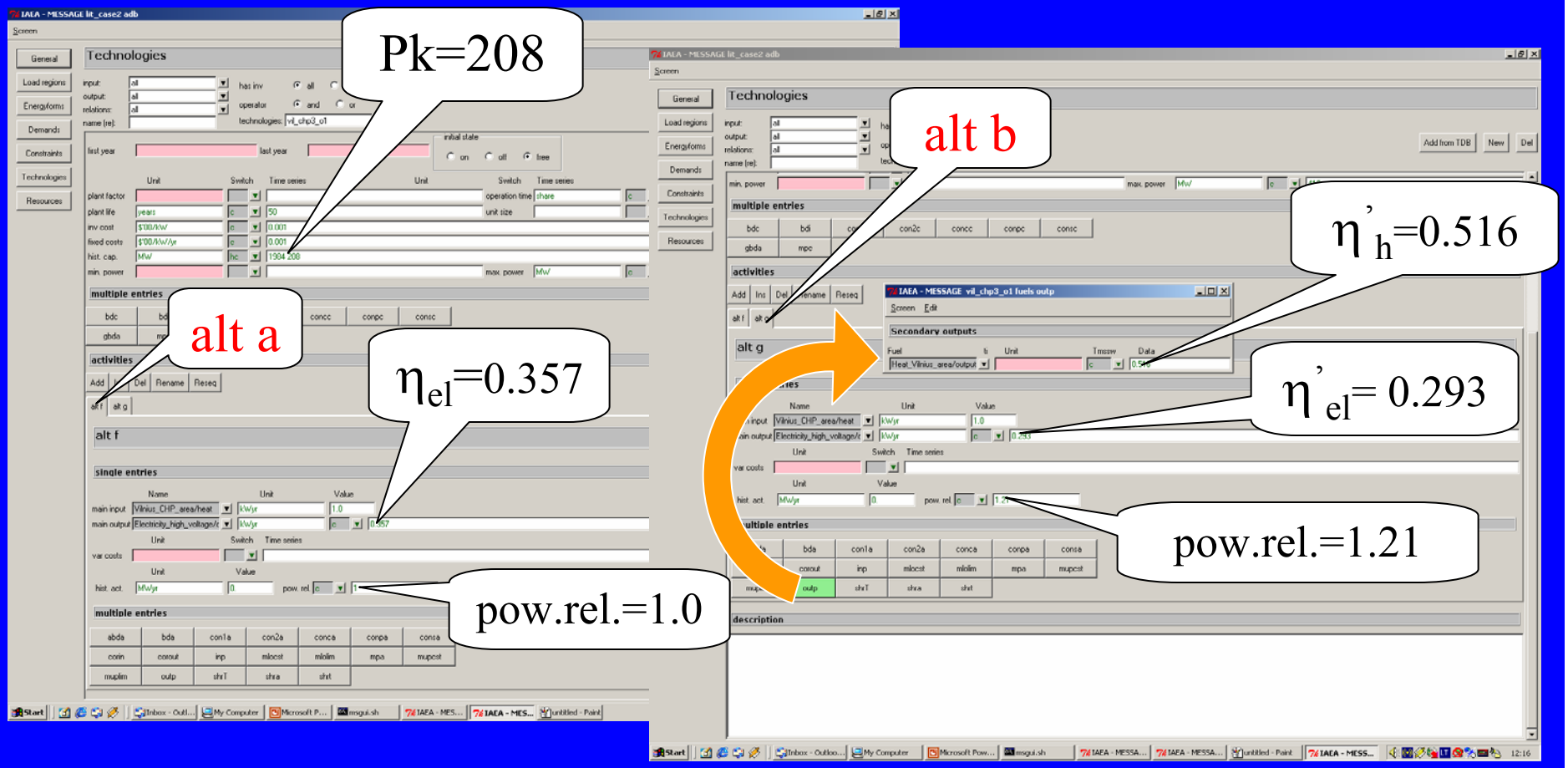
$$\eta_{el} = \eta_k = 0.357;\ \text{(Power relation) pow.rel.} = \frac{Pk}{Pn} = \frac{208}{171.8} = 1.21;$$

$$\eta'_{el} = \frac{Pn}{(Pn + Qn)/\eta_T} = \frac{171.8}{(171.8+302.3)/0.81} = 0.293;$$

$$\eta'_{h} = \frac{Qn}{(Pn + Qn)/\eta_T} = \frac{302.3}{(171.8+302.3)/0.81} = 0.516;$$

Representation of CHP in MESSAGE

Extraction unit (single fuel)



Cost data of CHP's

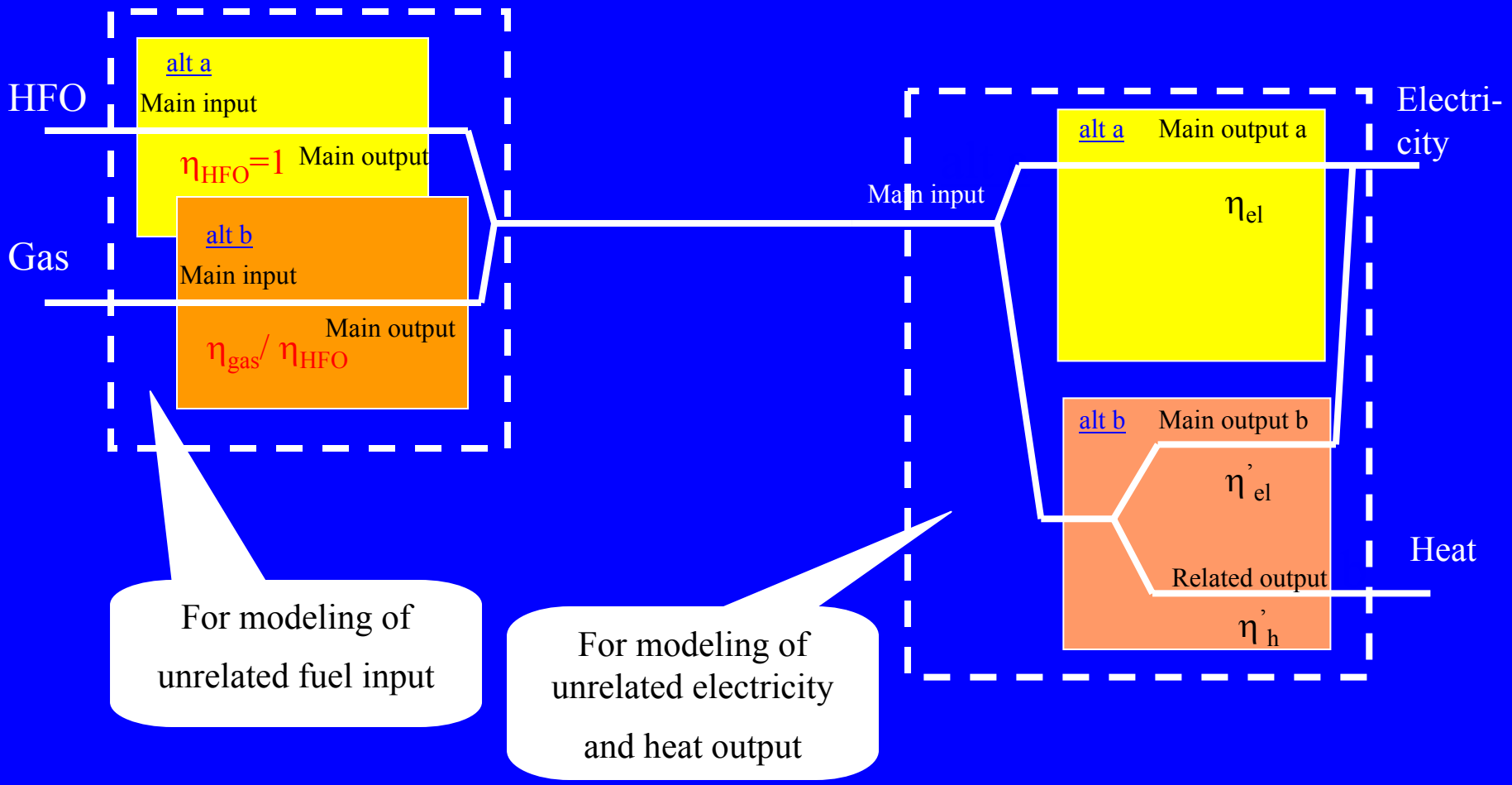
Extraction units

Investment costs and fixed O&M costs are related to power capacity in condensing mode,

Variable O&M costs are related to electricity output In condensing regime.

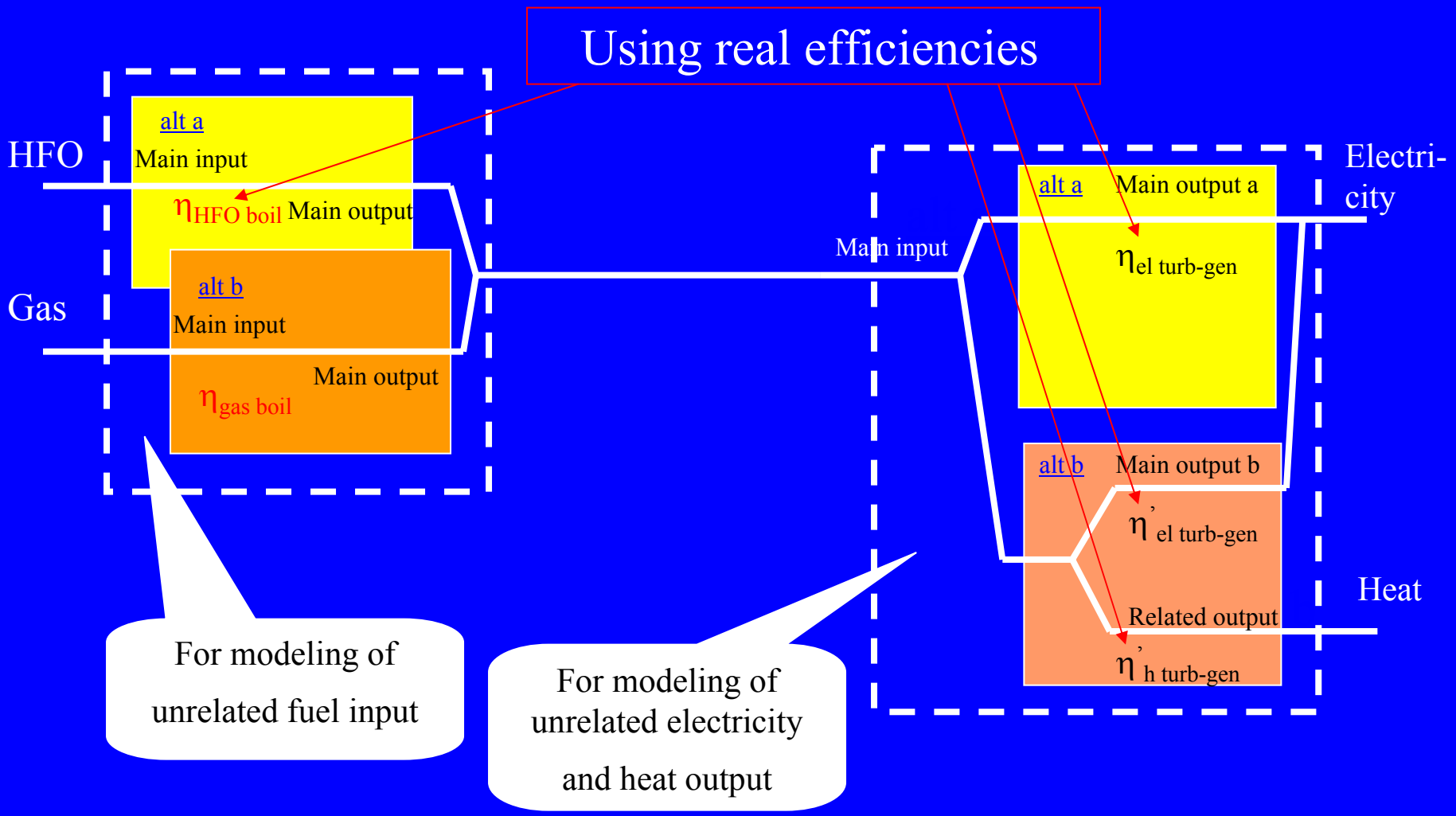
Representation of CHP in MESSAGE

Extraction unit (multiple fuel)

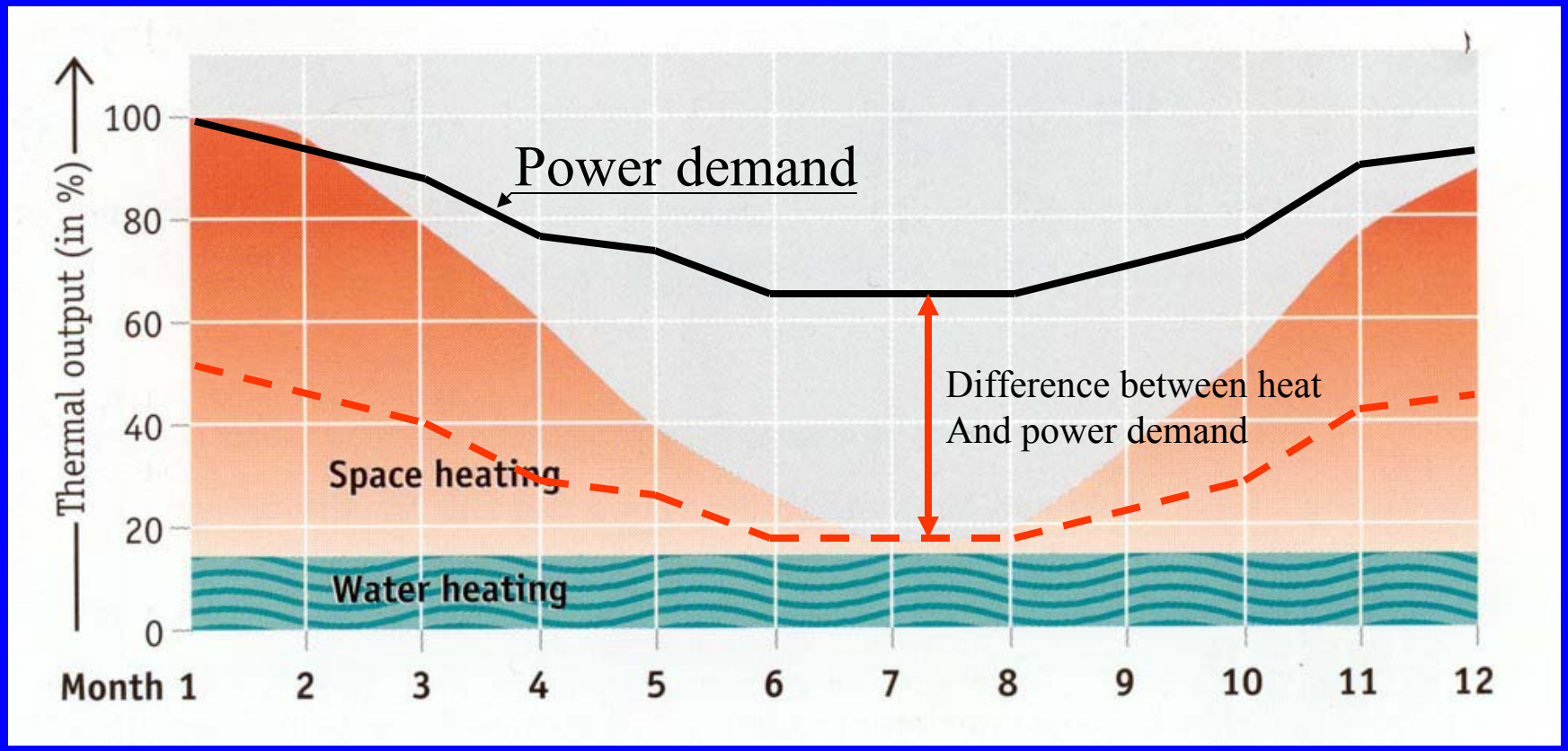


Representation of CHP in MESSAGE

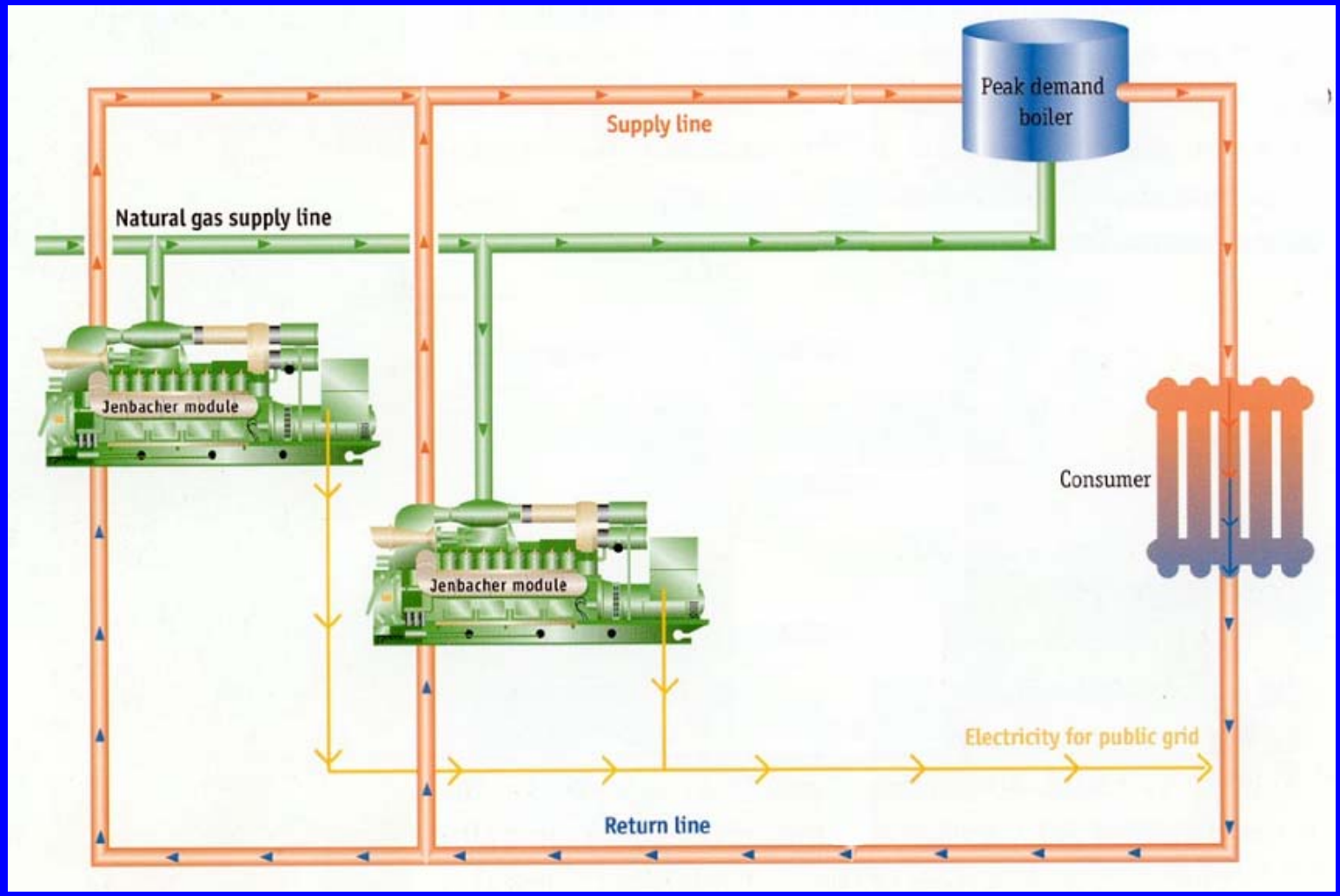
Extraction unit (multiple fuel)



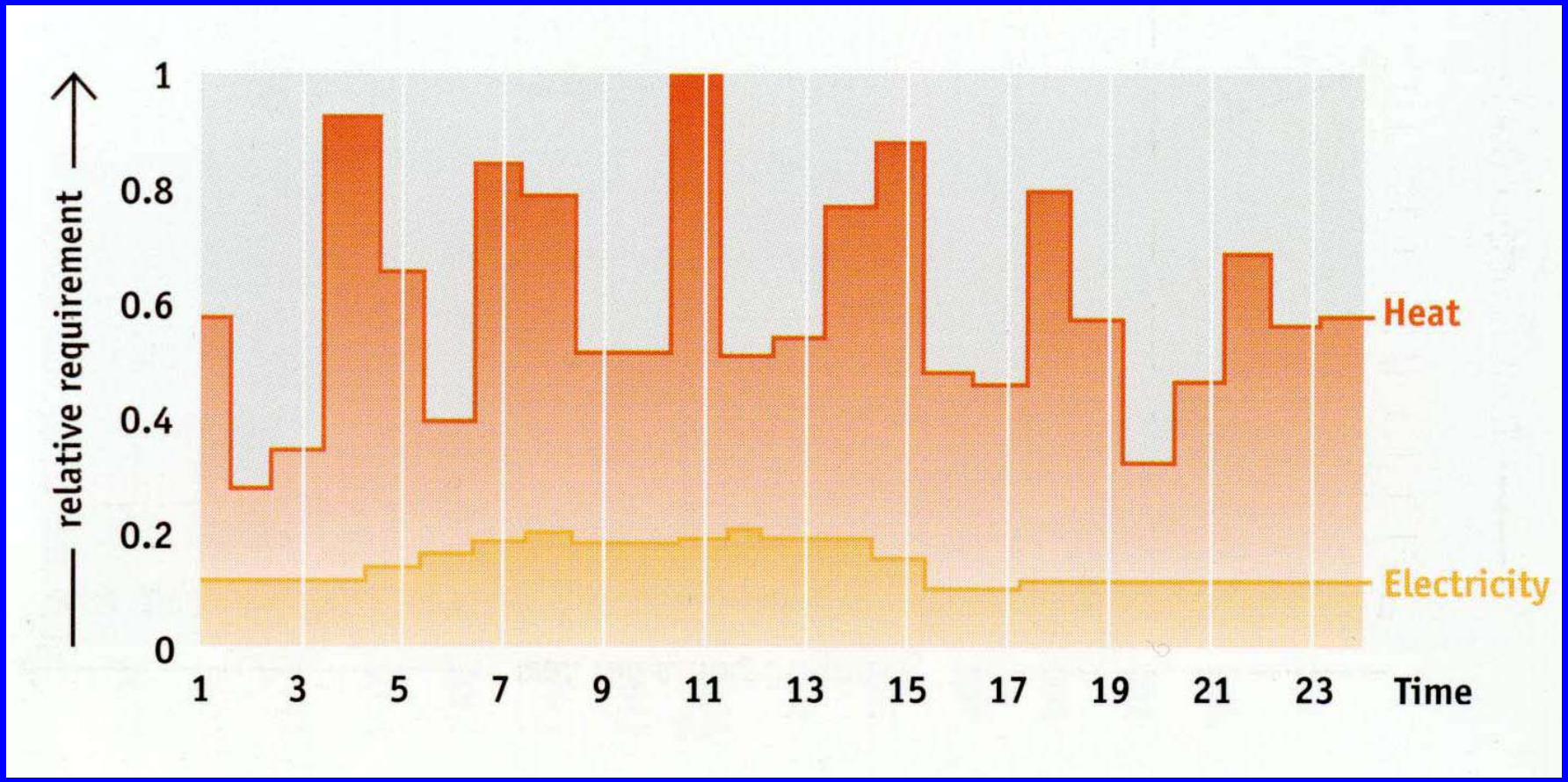
Ability of CHP to cower heat and power demand



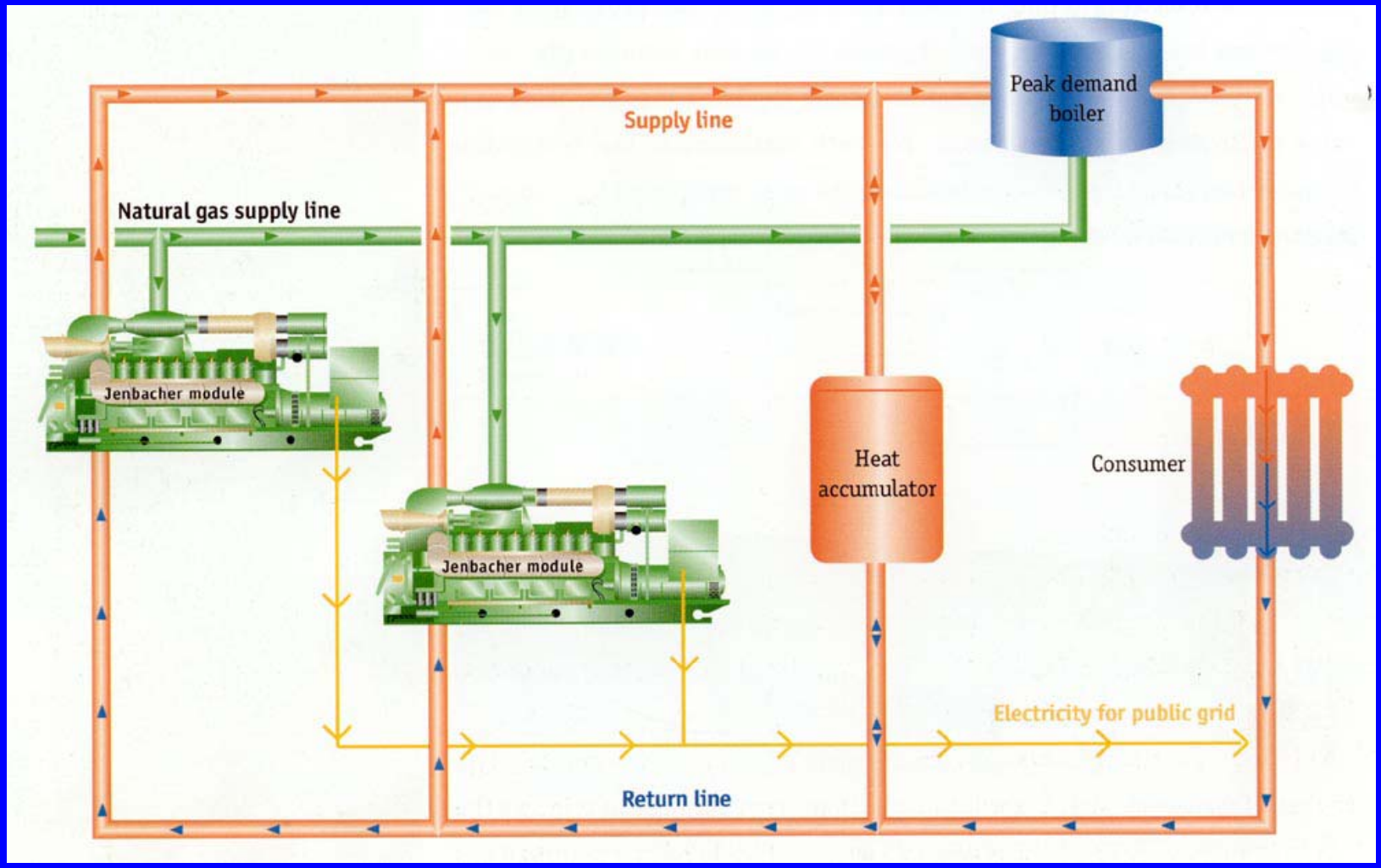
Joining of CHP's with heat only boilers



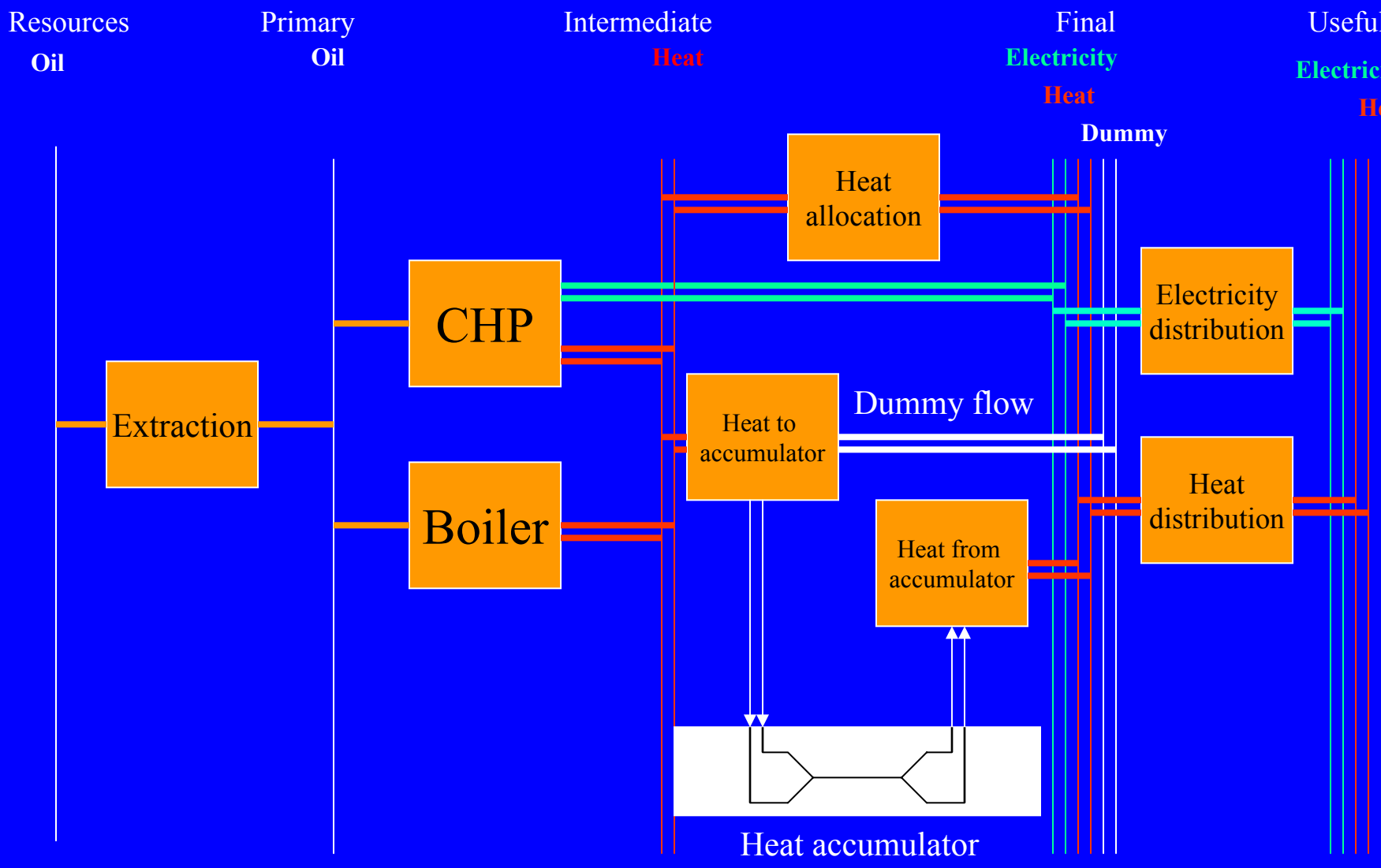
Heat load fluctuations



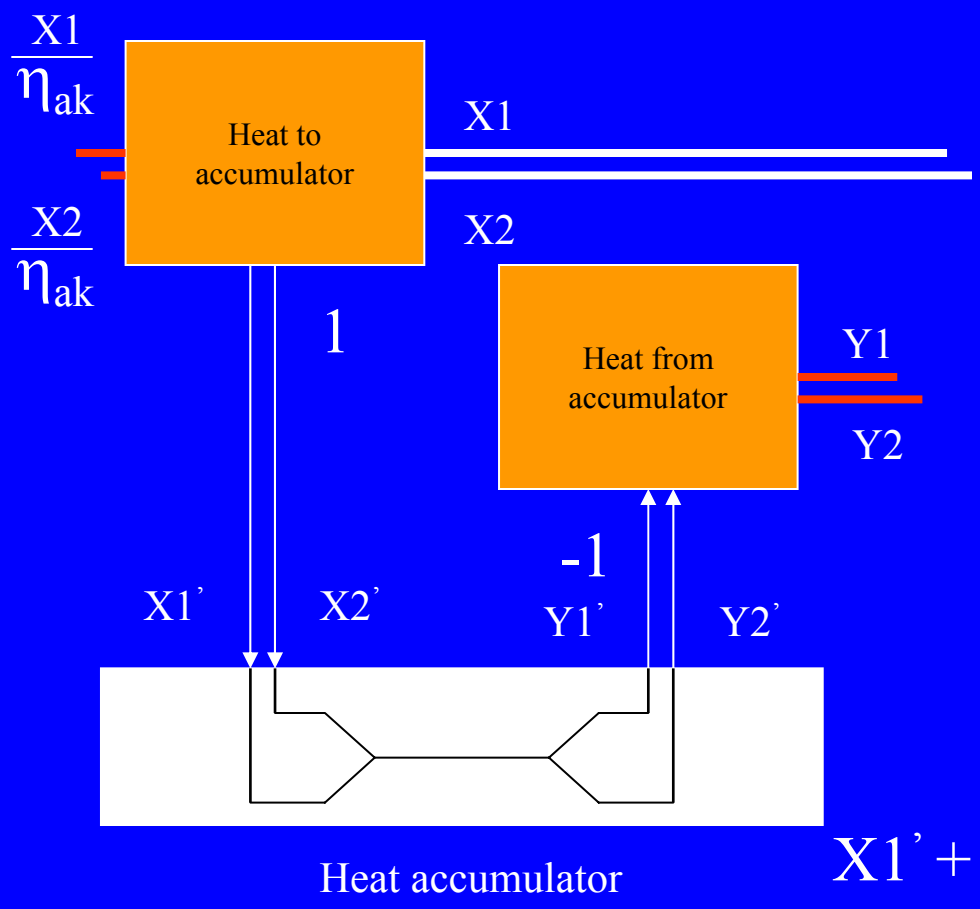
CHP with heat accumulator



Modeling of CHP with heat storage



Principle equations for heat accumulator



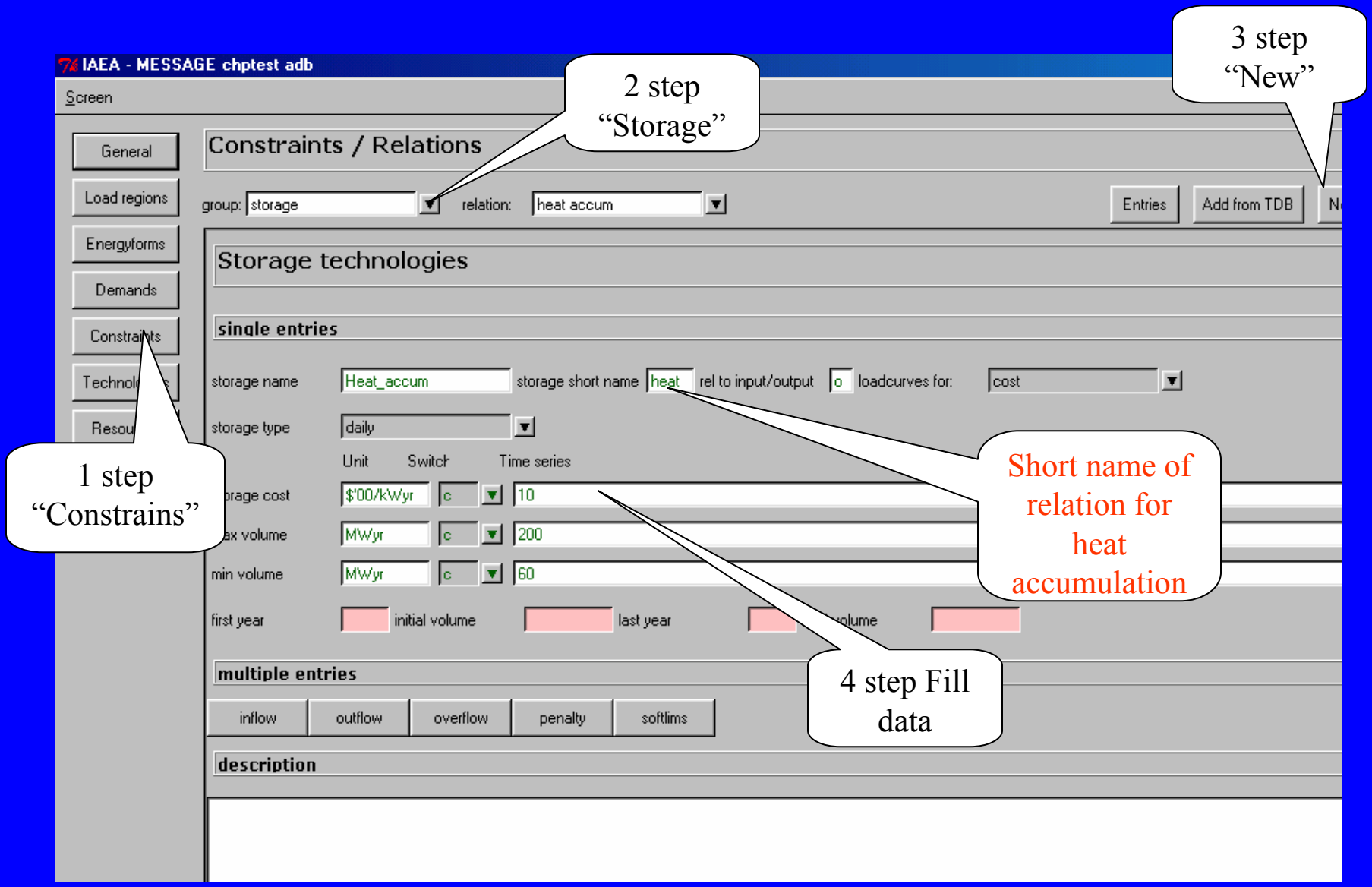
$X1' = X1; \quad X2' = X2;$

$Y1 = Y1'; \quad Y2 = Y2';$

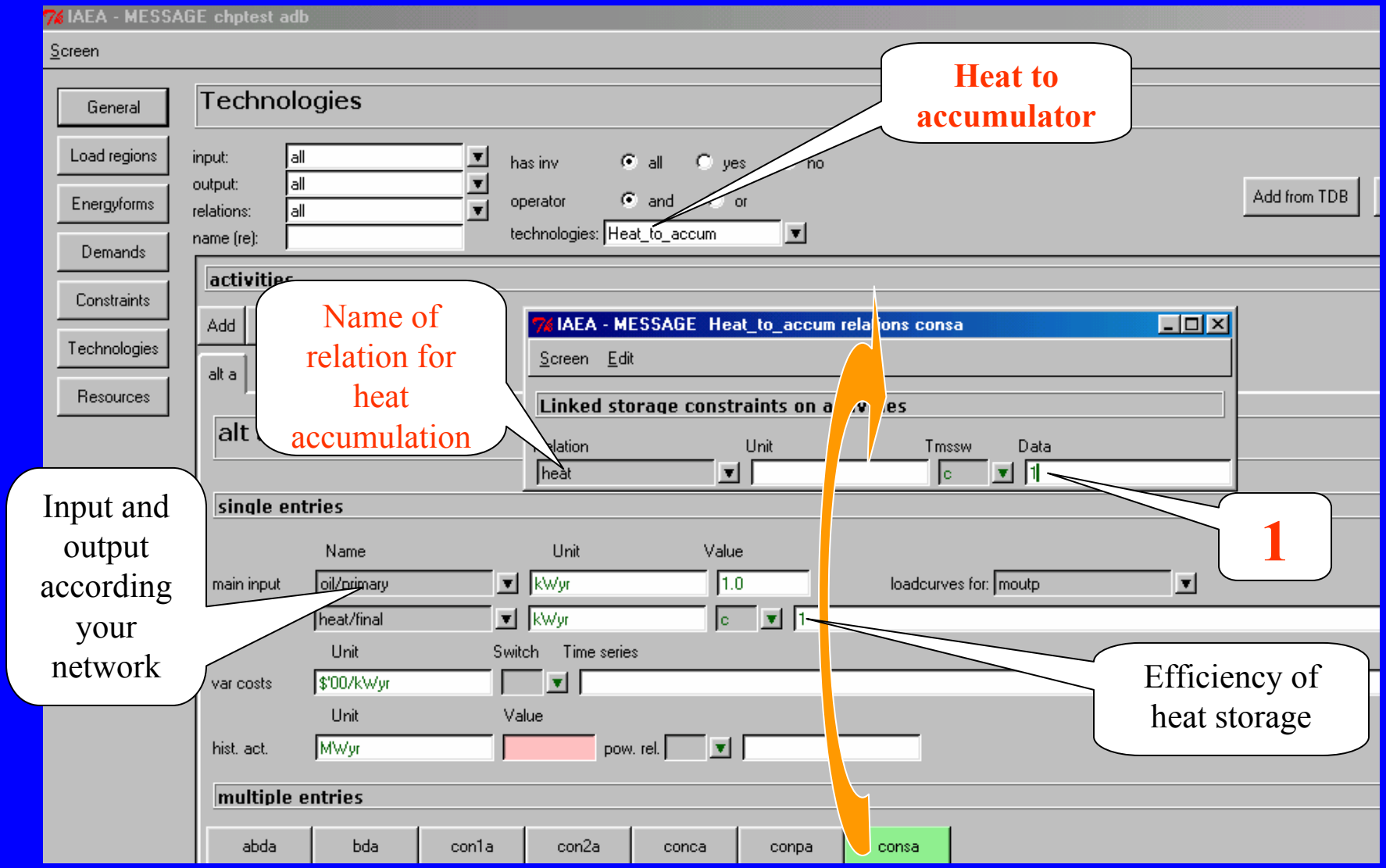
$X1' - Y1' <= \text{active volume};$

$X1' + X2' - Y1' - Y2' <= \text{active volume};$

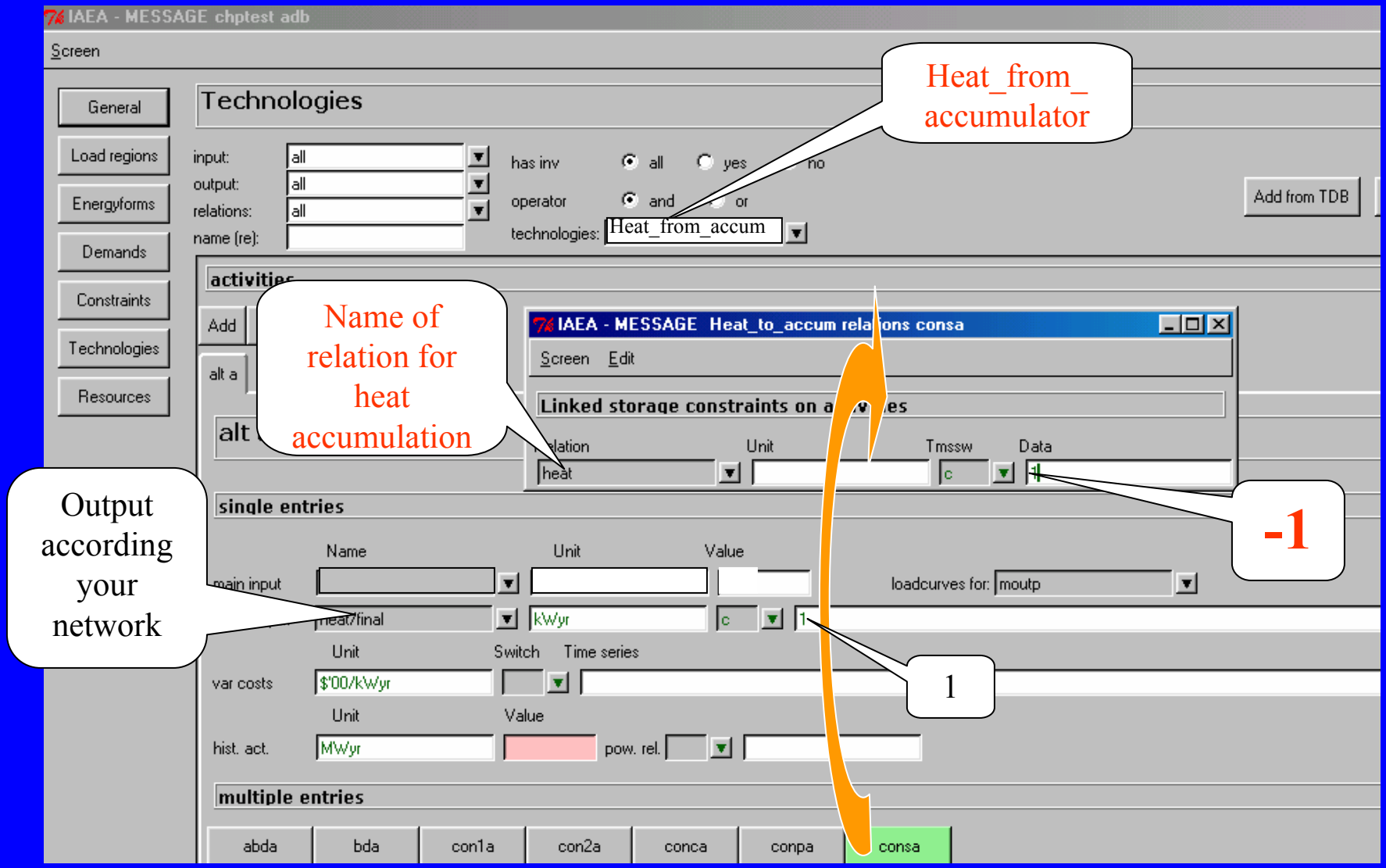
Data sheet for heat accumulator



Technology “Heat to accumulator”



Technology “Heat from accumulator”



Parameters of small back presure CHP based on natural gas

		Cento 42 AP	Cento 65 AP	Cento 75 AP	Cento 100 SP	Cento 140 SP	Plus twin 44 AP	Plus twin 88 AP	Premi 22 AP	Premi vari 22 AP
Electrical capacity	kW	42	65	75	100	150	44	88	22	22
Thermal capacity	kW	64,5	97	125	161	226	91	182	45,5	45,5
Input (fuel) capacity	kW	124	189	244	305	430	155	310	77,5	77,5
Efficiency (electrical)	%	33,8	34,4	30,7	32,8	34,8	28,4	28,4	28,4	28,4
Efficiency (thermal)	%	52,0	51,3	51,2	52,8	52,8	58,8	58,8	58,8	58,8
Efficiency (totall)	%	85,8	85,7	81,9	85,6	87,4	87,2	87,2	87,2	87,2
Gas consumption at 100% capacity	$м^3$/h	13,2	20,0	25,8	32,3	45,5	16,4	32,8	8,2	8,2
Gas consumption at 75% capacity	$м^3$/h	10,8	16,3	20,6	26,8	39,8	13,2	26,4	6,6	6,6
Gas consumption at 50% capacity	$м^3$/h	8,3	12,5	16,4	20,3	31,5	10,4	20,8	5,2	5,2
Temperature of water input/output	°C	70/90	70/90	70/90	70/90	70/90	70/90	70/90	70/90	70/90
Investment cost	K$	43.800	52.300	44.200	68.000	82.800	25.000	50.000	12.500	11.500