CONSTRUCTION OF SMALL POWER PLANTS AT OIL AND GAS FIELDS

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Block Energy

The process of preparing crude oil for transport

Boilers

Flare

Adding additives deemulgators

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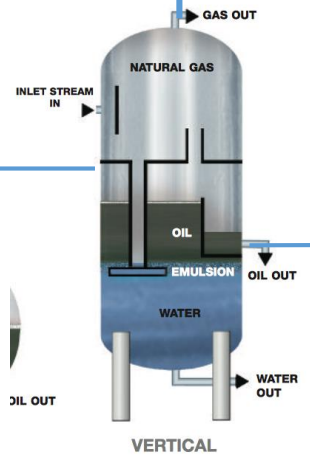
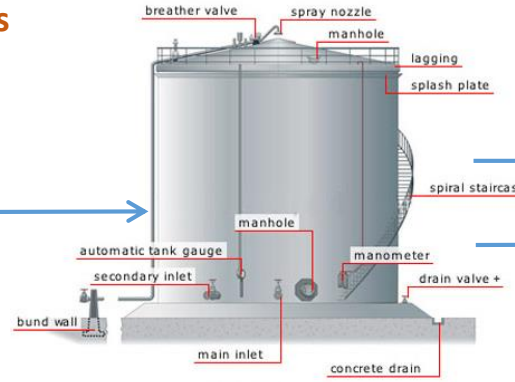




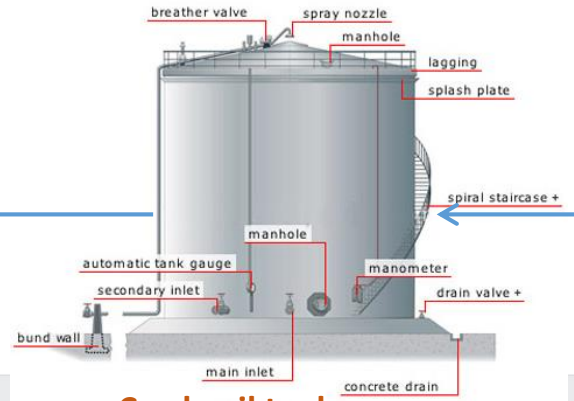
Separated water

Oil well pipelines

Collector

Separator

Tank / dehidrator



Dehidrated oil

Oil transportation to refinery

Oil filling station

Crude oil tank

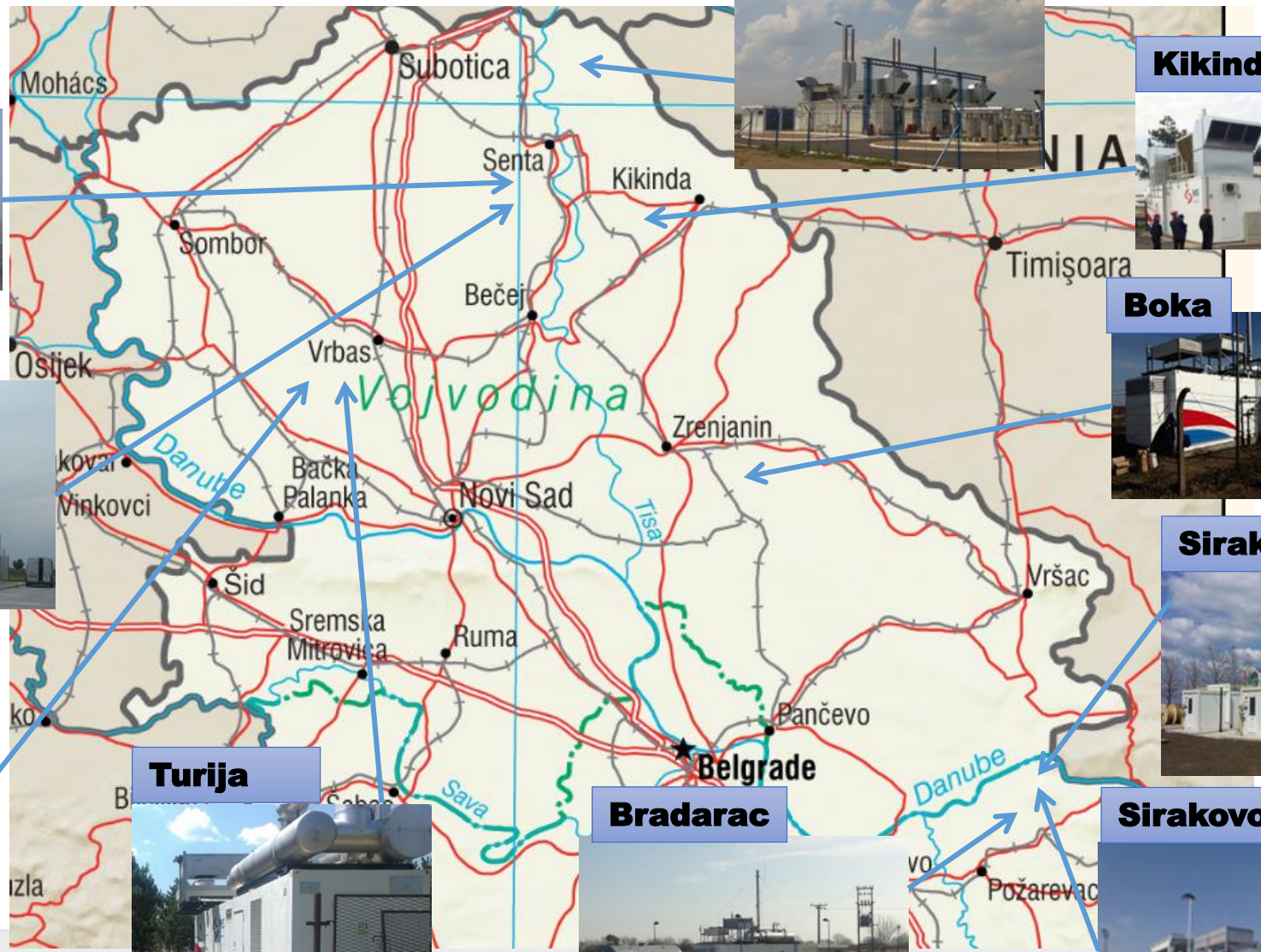
Gas composition

Oil field	CH_4	C_2H_6	C_3H_8	iC_4H_{10}	nC_4H_{10}	iC_5H_{12}	nC_5H_{12}	C_6H_{14+}	N_2	CO_2
Sirakovo	78,43	11,78	4,86	0,86	1,67	0,49	0,64	0,97	0,12	0,18
Velebit (dissolved gas)	81,55	4,41	0,47	0,07	0,04	0,01		0,04	4,01	9,4
Velebit (permeate gas)	59,81	1,05	0,04	0	0	0	0	0	5,71	33,39
Kikinda	85,19	5,41	3,58	1,22	1,71	0,53	0,64	0,25	1,44	0,03
Turija	76,42	4,54	5,33	1,37	2,77	0,95	0,96	1,19	0,42	6,05
Boka	83,86	2,88	1,79	0,37	0,87	0,27	0,42	0,73	6,56	2,25
Bradarac	70,95	14,68	7,84	0,94	1,55	0,37	0,38	0,2	0,24	2,85
Majdan X	36,88	3,55	1,96	0,34	0,67	0,18	0,20	0,32	9,57	46,32
Srbobran	49,60	1,14	0,37	0,08	0,15			0,07	10,01	38,58

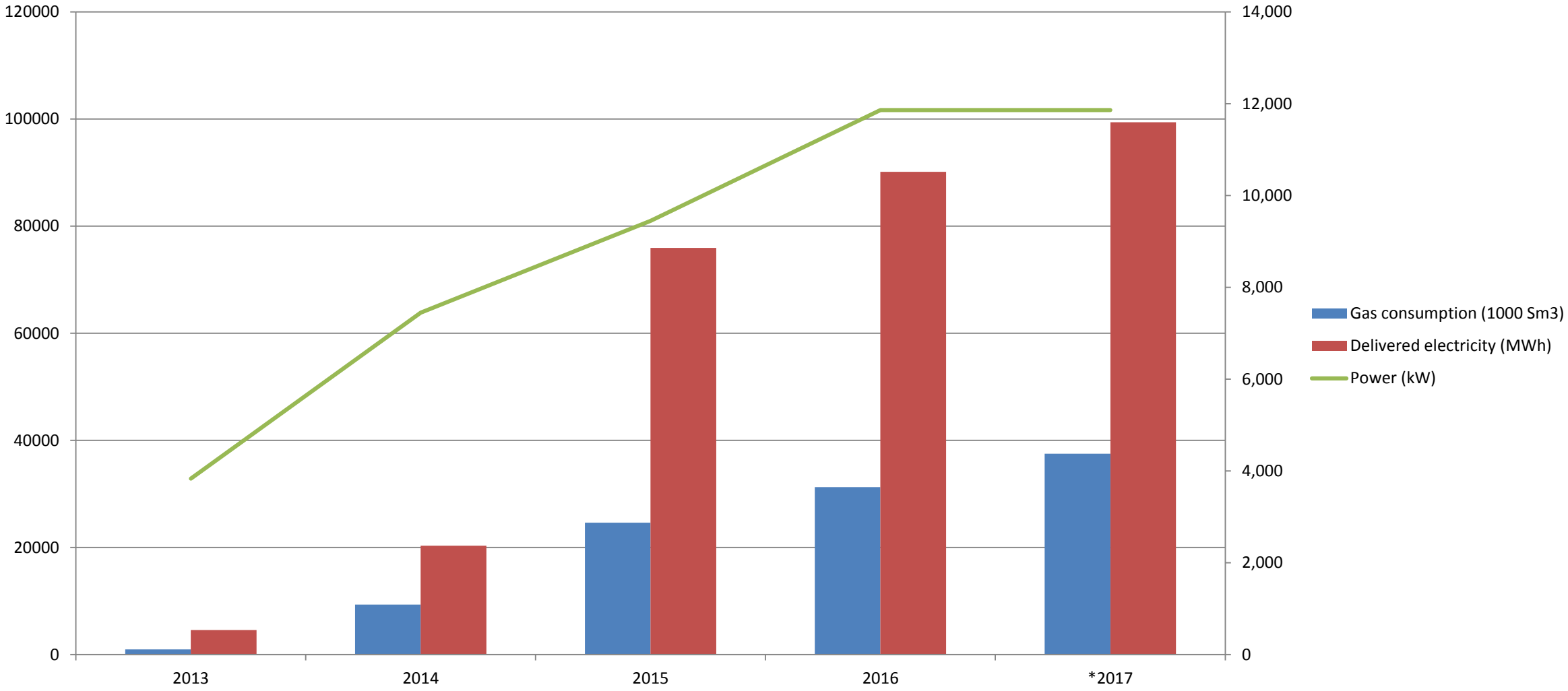
Constructed small power plants

	Electric power	Thermal power	Gas consumption	Electrical efficiency	Engine manufacturer	Put in operation
	kW	kW	Nm^3/h	%		
Sirakovo	850	904	172	39,9	Caterpilar	August 2013
Sirakovo 2/1	1.000		197	43,1	Caterpilar	June2015
Sirakovo 2/2	1.000		197	43,1	Caterpilar	June2015
Velebit 1	995	1040	256	42,6	Caterpilar	December2013
Velebit 2	995	1040	256	42,6	Caterpilar	December2013
Velebit 3	1.000		394	41,2	Caterpilar	January 2015
Velebit 4	1.000		394	41,2	Caterpilar	January 2015
Kikinda	995	1100	241	41,3	Jenbacher	November 2013
Turija	995	1118	196	40,6	Caterpilar	December 2014
Boka	330	370	77	41,4	Caterpilar	September 2014
Bradarac	300	345	57	40,9	Caterpilar	December 2014
Majdan X	2400		1185	39,5	R-Schmitt	August 2016
Srbobran 1	995		450	41,5	Caterpilar	August 2014
Srbobran 2	995		450	41,5	Caterpilar	August 2014
Sum	13.860	5.917	4.522			

Locations of small power plants



Gas consumption and electricity generation



Applied technology

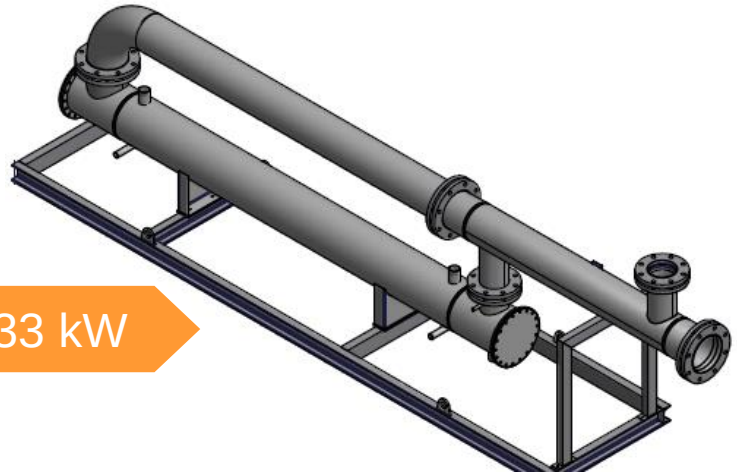
Gas dryer

Container of small power plant

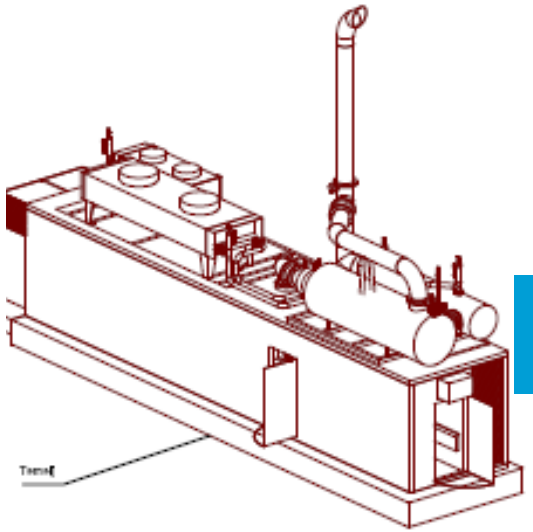
- IC engine coupled with generator
- Equipment for heat delivery
- Auxiliary equipment

Container of electric power unit

- Transformer 0,4 kV / 20 kV
- Switch gear



Gas 2333 kW



1000 kWb

960 kWn

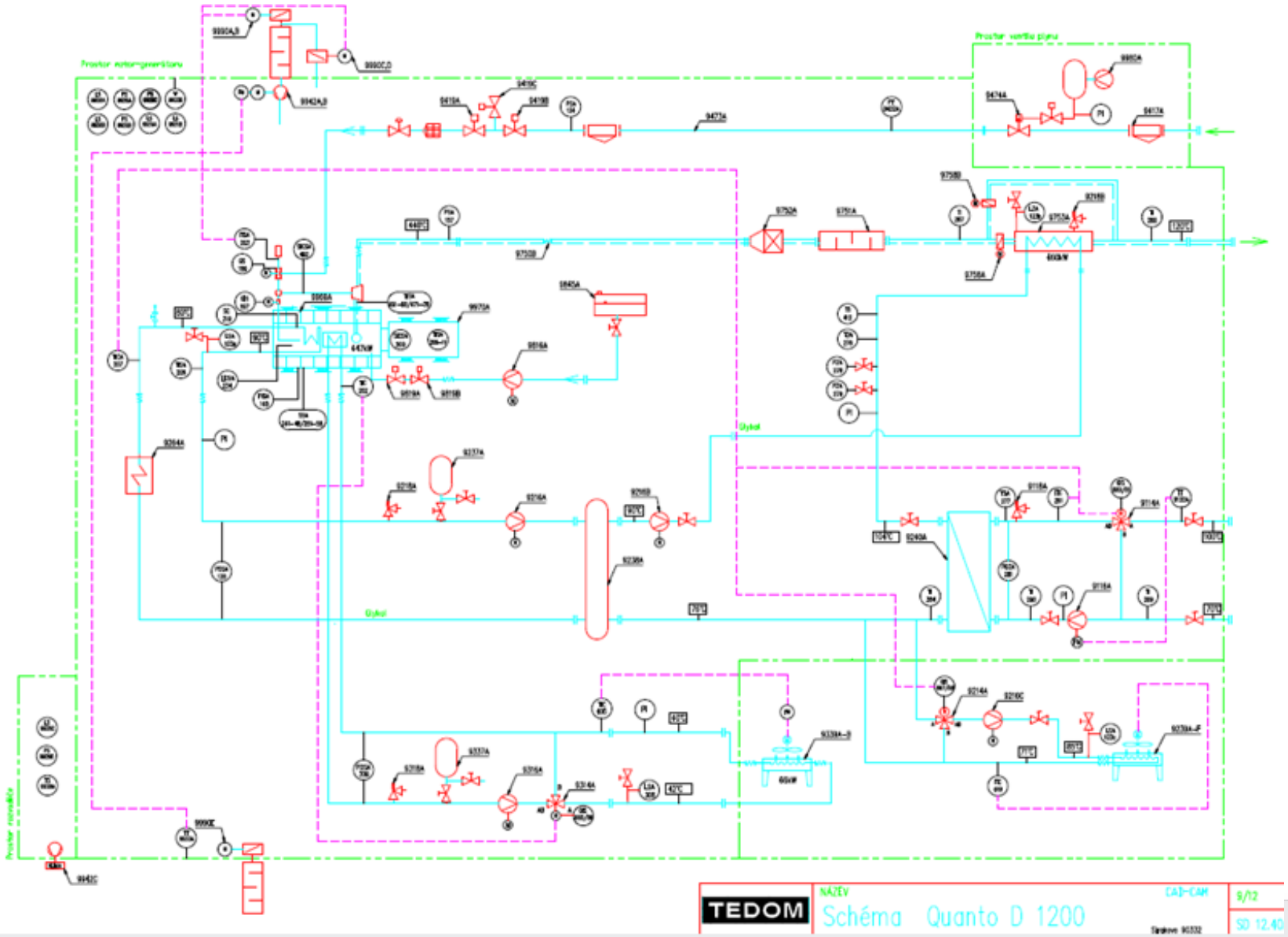
40 kW (4% own consumption)

940 kWn

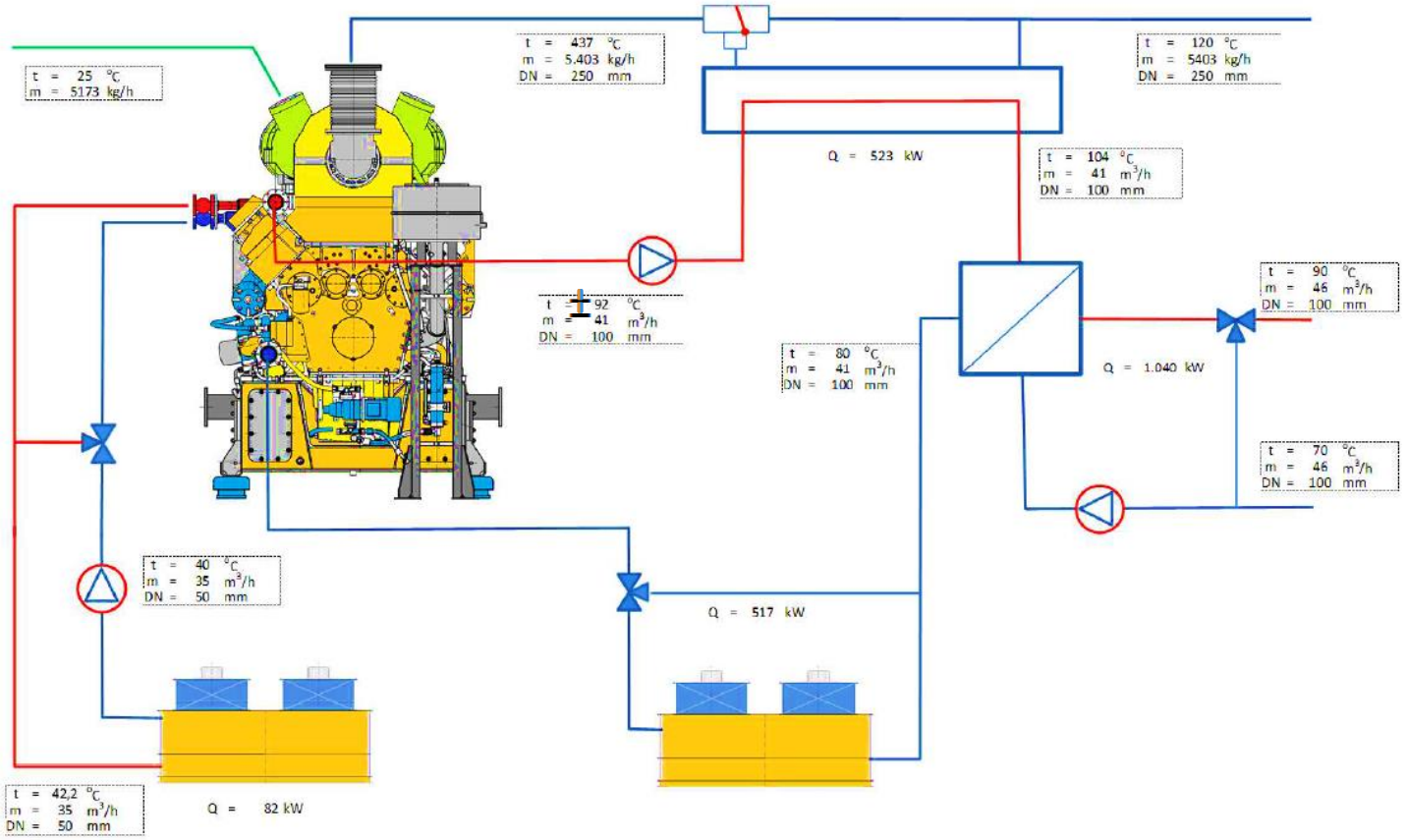
20 kW (2% losess)

1040 kW Hot water 90/70° C

P&ID of the cogeneration plant

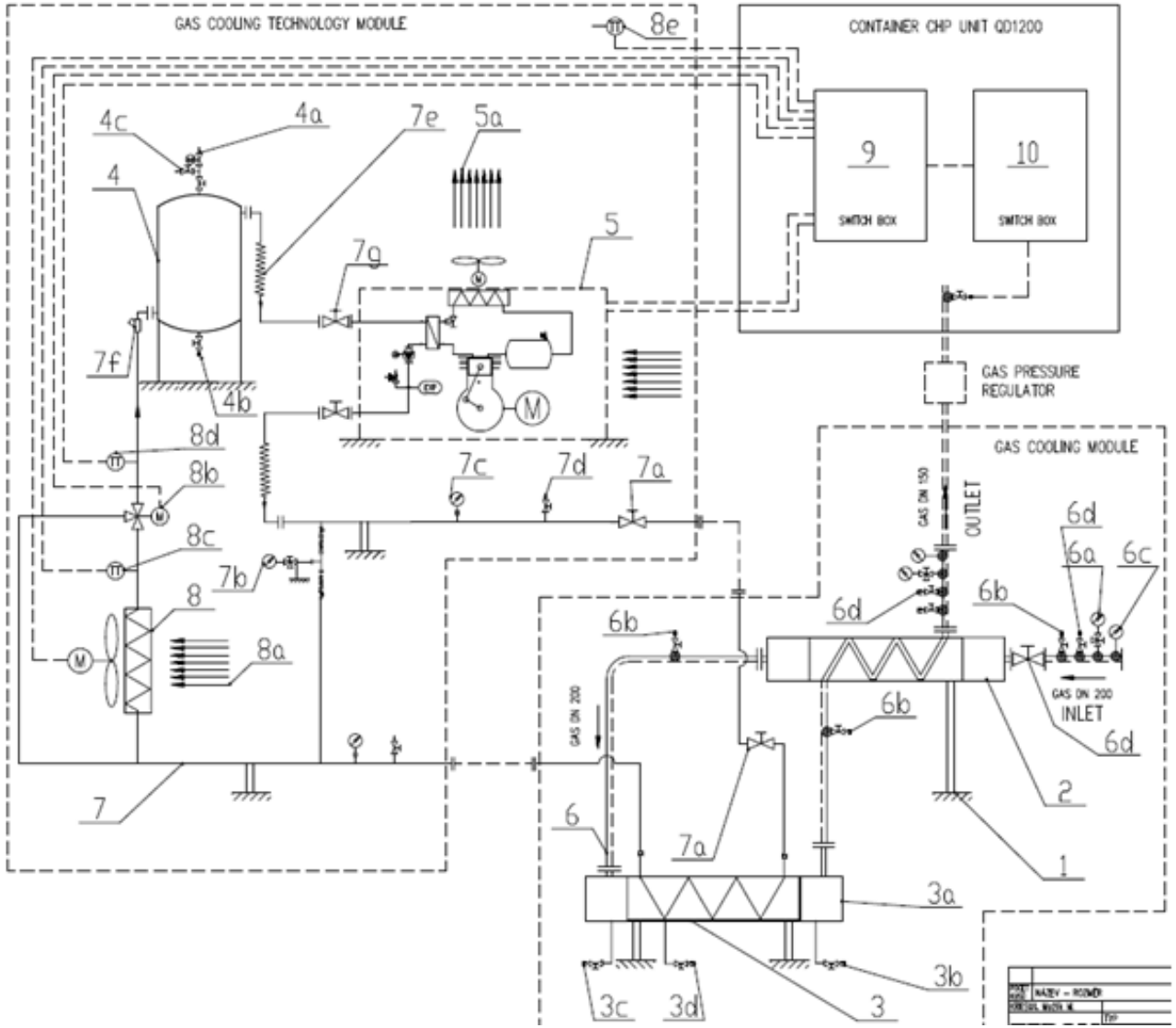


Energy balance of small power plant



Parameter	Unit			
Rating	%	100	75	50
Electric power ISO 5828-1	kW 8%	995	746	498
Thermal power engine circuit	kW 8%	517	401	291
Thermal power technological circuit / low temp	kW 8%	82	55	33
Thermal power exhaust gases at 120 °C	kW 8%	523	430	322
Radiation losses	kW 8%	41/27	38/23	33/20
Thermal power	kW 8%	1040	831	613
Temperature of exhaust gases	°C	437	461	486
Mass flow of exhaust gases	kg/h	5.403	4.114	2.860
Mass flow of air for combustion	kg/h	5.173	3.937	2.735
Fuel power	kW 5%	2.333	1.806	1.275
Electrical / thermal efficiency	%	42,6/44,6	41,3/46,0	39,0/48,1
Overall efficiency	%	87,2	87,3	87,1

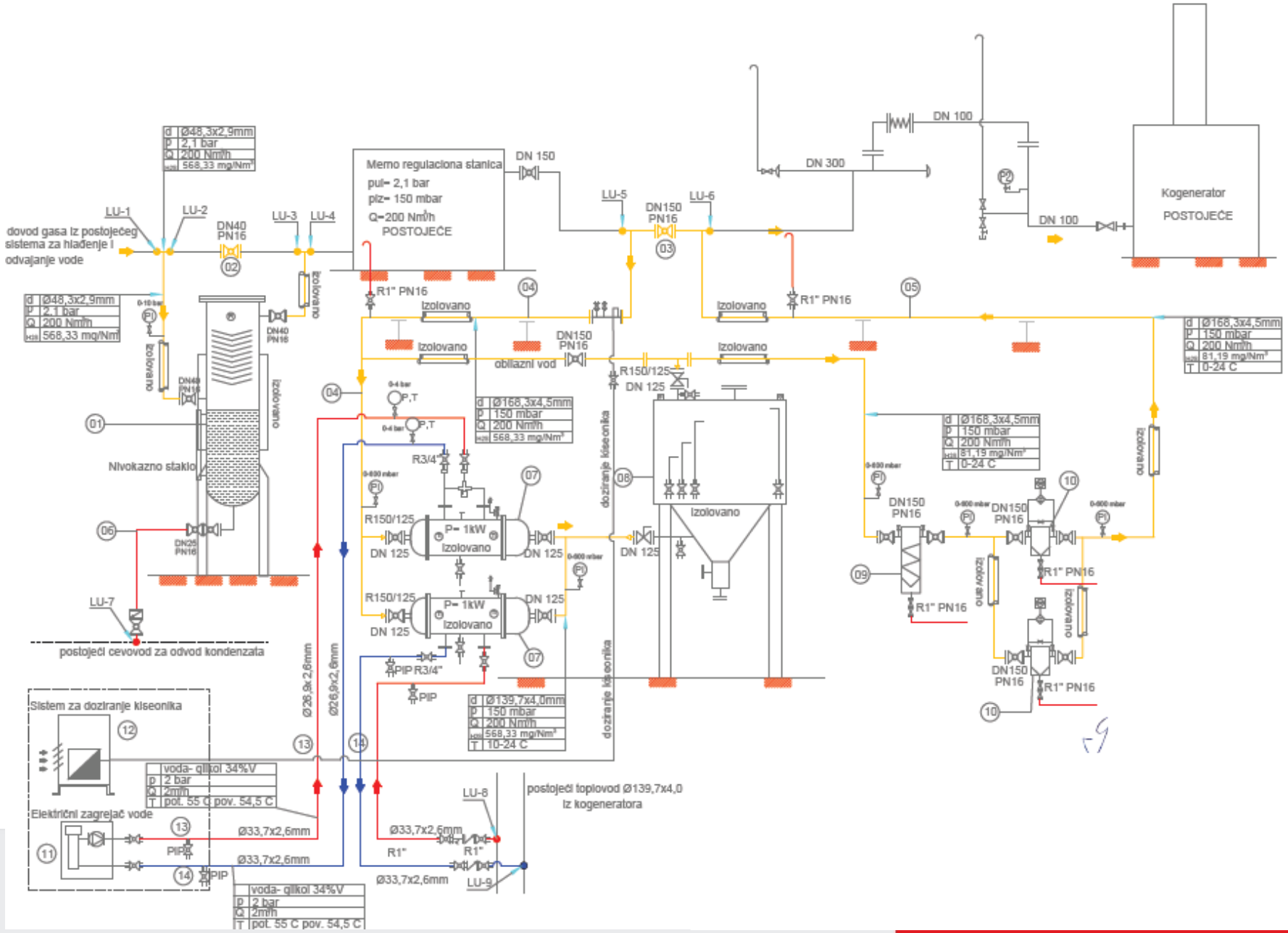
P&ID scheme of gas dryer



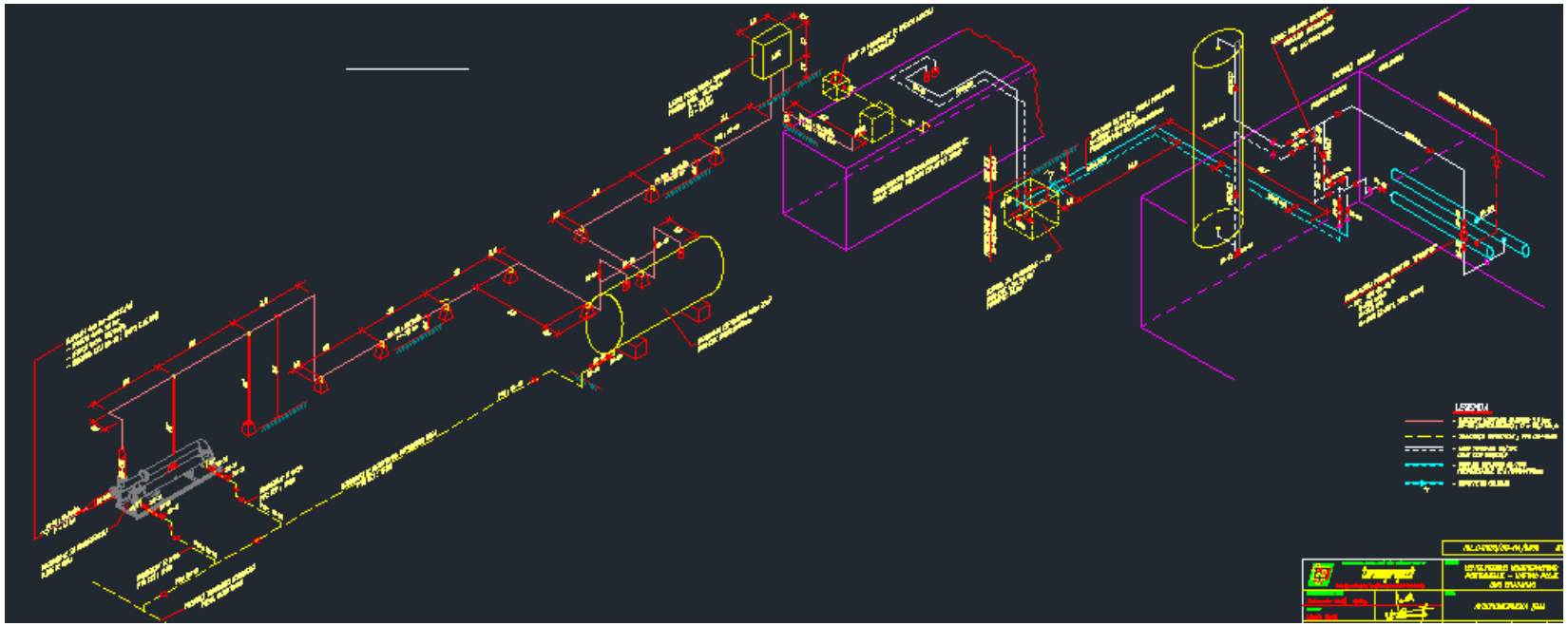
Challenges during construction and exploitation of small power plants

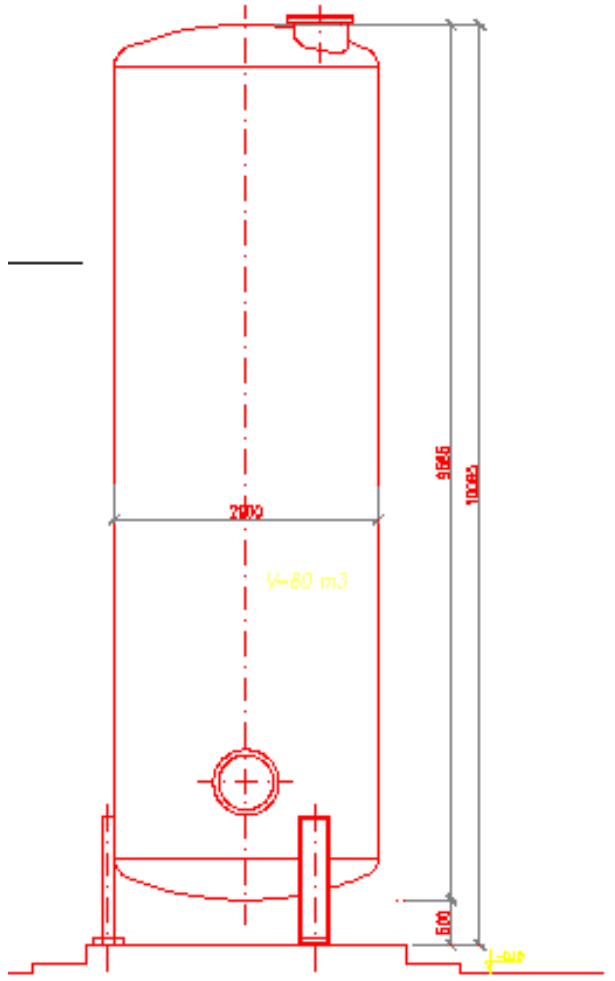
- High content of inert gases (CO_2, and N_2), such as gas from the Srbobran gas field and gas from the oil field Majdan.
- Increased content of heavy hydrocarbons in gas.
- Reduction of emissions of harmful gases into the atmosphere (CO, NO_X).
- Increased H_2S content, as a consequence H_2S extraction facilities is installed.
- Interruption of gas supply - example small power plant (SMP) Bradarac and installation of gas buffer.
- Fluctuations in heat demand - example ME Bradarac and construction of heat accumulator.
- In order to secure continuous operation of electricity consumers at the oil field Velebit in an event of a power supply interruption caused by ED grid failure isolated operation of SMP Velebit 1 and 2 is established. Isolated operation of SMP is secured by installation of load banks. In such a way losses in oil production due to power supply failure are avoided or reduced to minimum.
- Connection points on the ED grid - installation of long cable connections (SMP Sirakovo 2 - 5 km, SMP Srbobran - 4 km).

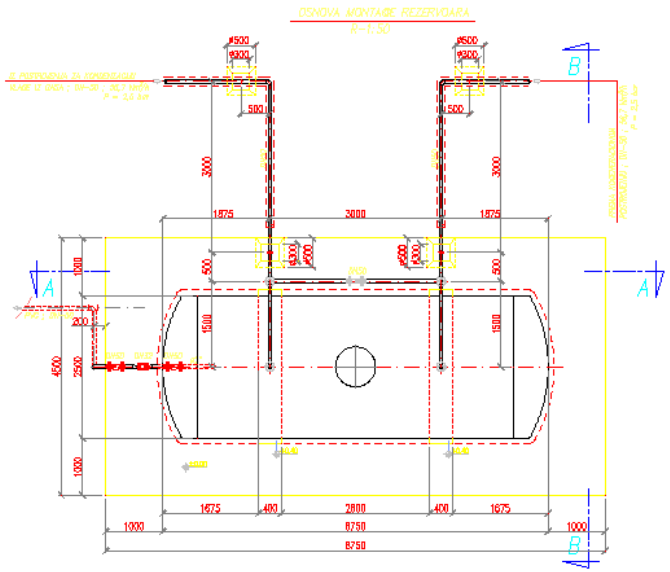
Increased H_2S content and H_2S extraction facilities

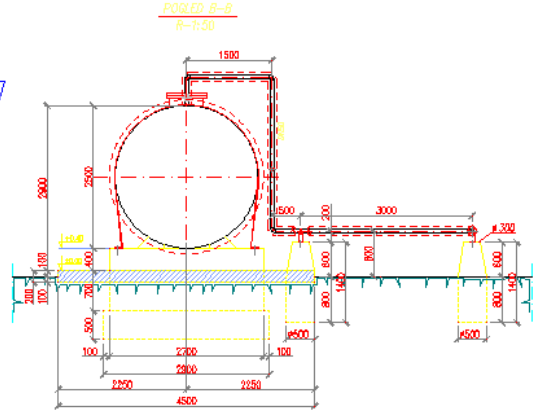


Interruption of gas supply - installation of gas buffer as tech. solution

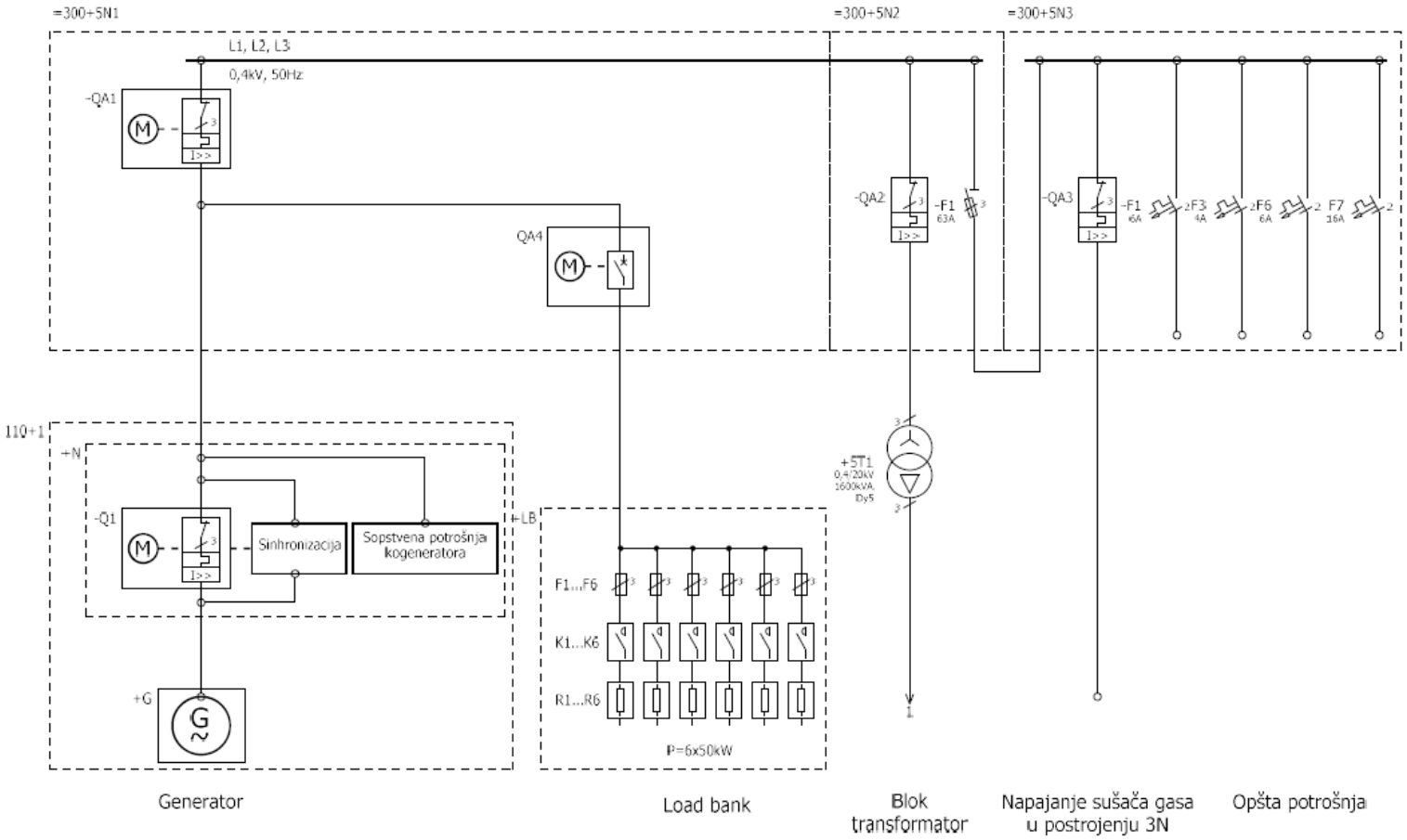








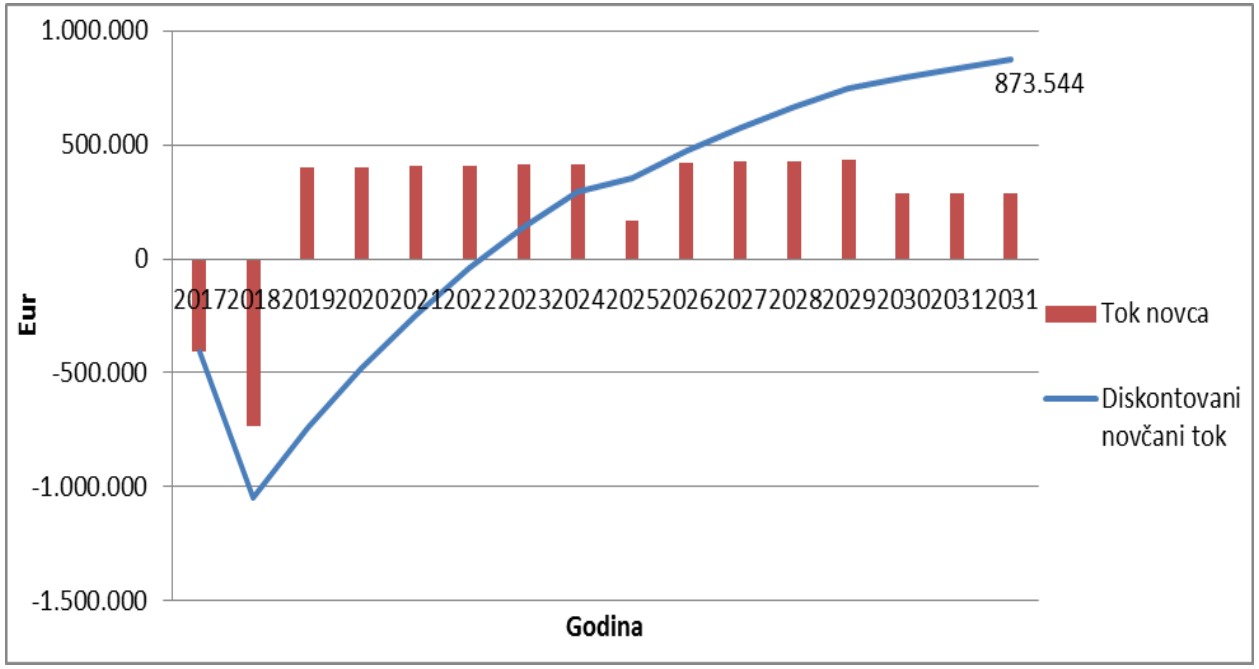
Isolated operation and installation of load banks on Plant Velebit 1 & 2



Economic evaluation of projects

Electric power	1000	kWe
Net/gross power	0,94	
Electrical efficiency	42,6	%
Thermal power	1.040	kWth
Thermal efficiency	44,6	%
LHV	40	MJ/Sm^3
Gas consumption	210	Sm^3/h
Annual working hours	8.000	h/year
Investment cost	1.350.000	Euro
Price of electricity	71,83 – 78,54	Euro/MWh
Price of heat	0,00	Euro/kWh
Price of fuel	0,00	Euro/Sm^3
Maintenance cost	9,00	Euro/h
General overhaul cost	250.000	Euro
Taxes	20	%
Discount rate	14	%

Investment cost	1.350.000	€
Project time period	15	years
NPV	873.544	€
PI	1,67	-
DPP	5,22	years
IRR	30%	%



THANK YOU FOR YOUR ATTENTION