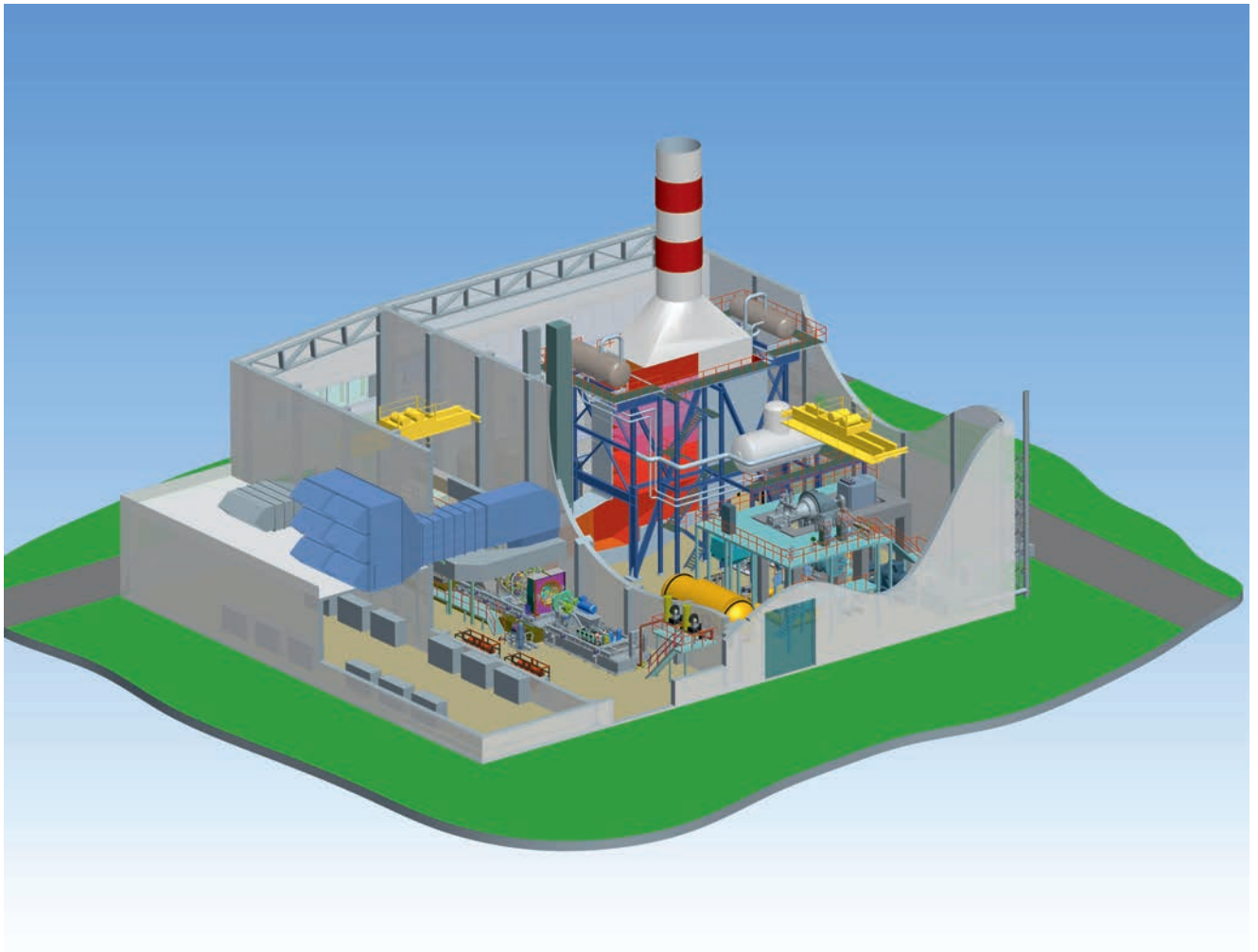




# Combined Cycle Power Plants 42 and 84 MW



Package supplies of power equipment

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## Combined Cycle Power Plants 42 and 84 MW

JSC "REP Holding" is a leading Russian power engineering company, a manufacturer and supplier of new-generation power equipment.

"REP Holding" performs engineering design, manufacture and package supply of power and electrical equipment for gas, oil, metallurgical and chemical industry, power generation and integrated power grid.

Combined Cycle Power Plants are designed to maximize the economical efficiency of electric and heat power generation while maintaining the flexibility and reliability in supplying of electric power, heat and process steam to regular consumers.

### Advantages

- Utilization of exhaust gas heat from the gas turbine in the steam circuit of the CCP significantly increases economical efficiency and flexibility of the electric power generation;
- CCP based on GTE-32 have electric efficiency of 46.7%;
- The CCP unit equipment makes it possible to generate heat power in required amounts;
- High reliability due to modern design techniques and technologies applied in the design of the core element-gas turbine engine;
- Total service life to de-commissioning is no less than 200 ths. hours;
- Average service life between overhauls is no less than 48 ths. hours (while operating in the base mode on standard fuel (natural gas as per GOST 5542 is used as the main and backup fuel)).
- High economical efficiency of the plant at various operating conditions.

JSC "REPH" offers CCP-42 and CCP-84 power units out of the thermal and mechanical equipment supplied

#### **A single-unit CCP-42 includes:**

- the gas circuit equipment: gas turbine unit based on T32 (MS5002E) gas turbine engine produced by REP Holding with a gearbox and turbo-generator;
- steam circuit equipment: waste-heat boiler and steam turbine unit (STU) T-12-6,0/0,12 produced by REP Holding with a turbo-generator.

#### **A double-unit CCP-84 includes:**

- the gas circuit equipment: two gas turbine units based on T32 (MS5002E) gas turbine engine produced by REP Holding with gearboxes and turbo-generators;
- steam circuit equipment: two waste-heat steam boilers and one steam turbine unit (STU) T-22-6,0/0,12 produced by REP Holding with a turbo-generator.

A binary thermo-dynamic cycle is realized in CCP-42 and CCP-84.

The CCP main equipment features maximum commonality and is to be assembled from the modular units.

### STU technical characteristics

Parameter, UOM	Value for CCP-42	Value for CCP--84
Electric power rating, MW	42	83
Nominal electric efficiency when operating in the condensing mode, %	46.7	46.7
Heat power rating, Gcal/h	19	47
Nominal fuel gas flow ( $H_u = 50056$ kJ/kg), kg/h	6400	12800
The required fuel gas pressure at the GTU inlet - ....., kgf/cm <sup>2</sup> (g)	$\geq 32$	
Emergency fuel	Natural gas	
Ambient air temperature, °C	+15	
GTE starter type	Electric	
Lubrication system for the gas turbine engine, gearbox and turbo-generator	Common	
Lubrication system for STU and turbo-generator	common	
Oil applied (for gas turbine engine, gearbox, turbo-generator, steam turbine)	Tn-22C	
GTU oil tank capacity, m <sup>3</sup> : gas turbine engine / gearbox/ turbo-generator	14	
STU oil tank capacity, m <sup>3</sup> : Steam turbine / turbo-generator	6	
Irrecoverable oil losses, kg/h gas turbine engine / gearbox/ turbo-generator / steam turbine	0,4	0,8
GTU time to idle running, min	10	
GTU time to nominal mode (as part of CCP), min	40	
Consumed auxiliary power when 2 GTU operating under load, kW	420	850
Specified service life for GT and ST, h	to 200 000	
Interrepair service life for GT and ST, h	48 000	
Life time, years	25	
Mass of the power unit (waste-heat boiler), t	675	1150

The power unit equipment can be arranged in a separate building for new construction (presented in this proposal), in an easily erected hangar-type building (for some climatic zones), as well as in the reconstructed buildings of GRES (State Regional Power Station) (based on the results of detail engineering).

T32 gas turbine (MS5002E) developed by General Electric and localized for series production by REP Holding in accordance with the licensed documentation is the most critical element of the above-mentioned power units.

The turbine features modern parameters, high reliability and excellent ecological indices.

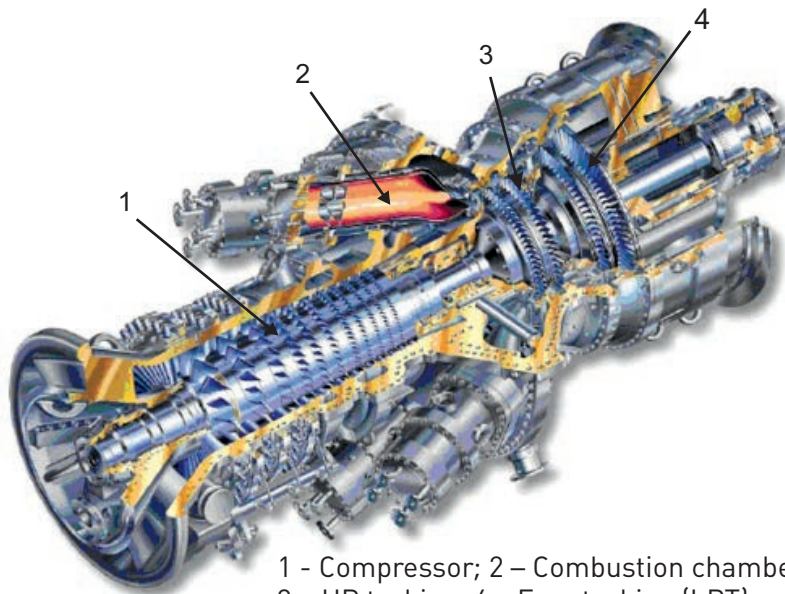
## The main equipment of the CCP

### Gas turbine

GE-designed MS5002E gas turbine engine is serially produced by REP Holding under license.

In its design MS5002E consists of two modules: gas turbine proper on its own base plate and auxiliary base plate with all the systems providing the GTE operability.

Oil of Tn-22C type is allowed for application.

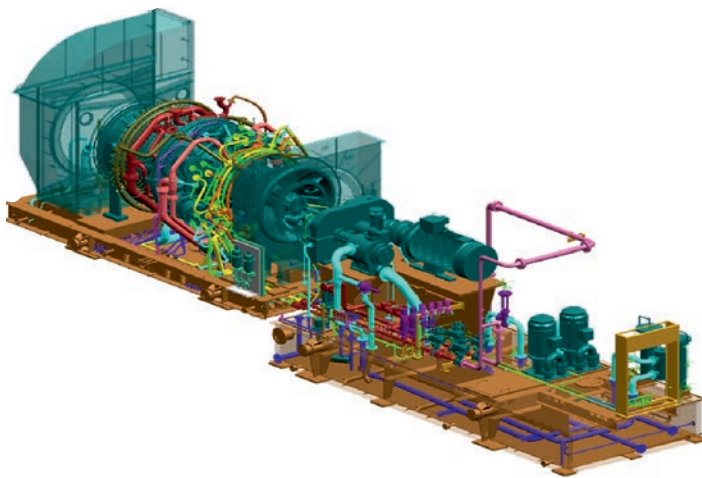


1 - Compressor; 2 – Combustion chamber;  
3 – HP turbine; 4 – Free turbine (LPT)

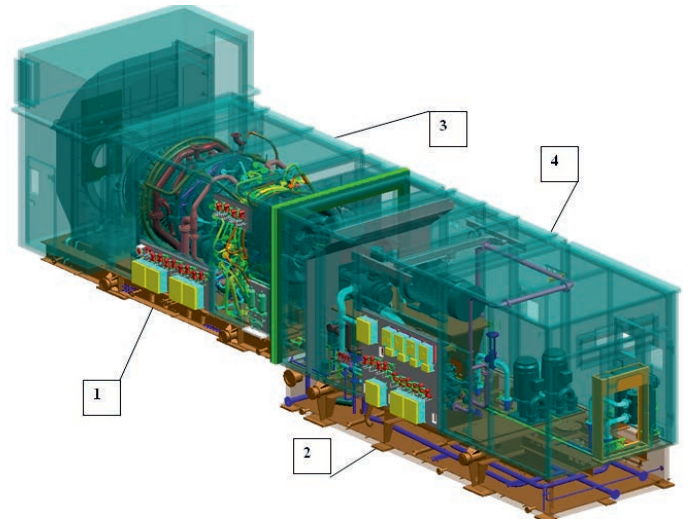
To reduce the noise and to provide heat balance of the GTE the turbo-unit itself and the auxiliary base plate are covered with a noise-and-heat insulation enclosures which are also designed for placement of the lighting system, transducers and switching to other parts of the unit; beside this, units are equipped with all the instrumentation and electrical equipment necessary for its functioning.

The enclosures are equipped with the fire-fighting and explosion-protection systems, gas and flame detectors.

1. MS5002E turbo-unit on its base plate
2. Auxiliary base plate with the GTE support systems:
  - starting system with el. motor and disengaging clutch,
  - oil supply system,
  - fuel supply system.
3. Noise-and-heat insulation enclosure of the GTE
4. Noise-and-heat insulation enclosure of the auxiliary base plate



GTE and auxiliary base plate configuration  
(with the enclosures removed)



MS5002E GTE configuration consisting  
of the turbo-unit and auxiliary base plate  
with noise – and heat insulation enclosures

### MS5002E parameters at the nominal conditions

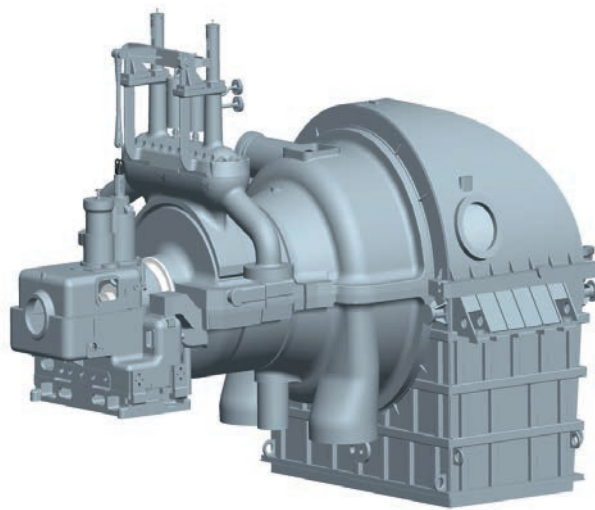
Description	Unit	Value
Shaft power rating (ISO)	MW	32
Efficiency in simple cycle (ISO)	%	36
Exhaust gas flow	Kg/s	102
Exhaust gas temperature	oC	511
Pressure ratio	-	17
Speed	rpm	5714

## Steam turbine

For CCP-42 and CCP-84 are being used steam turbines T-12-6,0/0,12 and T-22-6,0/0,12.

These steam turbines are of active type, one-cylinder, with controlled heating steam extraction. Double-pressure steam is used in the turbines. The flow passage consists of a two-row regulation stage and 13 pressure stages.

The typical ST scope of supply for CCP includes the steam turbine proper on the base plate, automatic governing and protection system, oil supply system which is common with the el. generator, auxiliary equipment, including condenser, ejectors, a device to extract the air-and-steam mixture from the seals etc., compl. set of instrumentation, SPTA, metal structures, maintenance platforms etc.



Double – pressure steam turbine T-22-6,0/0,12

### Nominal parameters of T-12-6,0/0,12 and T-22-6,0/0,12 steam turbines

Parameter	UOM	Value for T-12-6,0/0,12	Value for T-22-6,0/0,12
Electrical power	MW	12,0	24,0
Effective electric efficiency	%	80	
Steam rate, total	t/h	45,2	90,0
Speed	Rpm	3000	
Mass of the turbine	T	50	60
Mass of the condenser	T	28	35
Overall dimensions without tuturbo-nerator (LxBxH)	m	5,0 x 3,7 x 3,2	5,7 x 3,7 x 3,2
Elevation of the STU plplatform (TBD)	m	7,2	7,2

### Waste-heat boiler

The waste-heat steam boiler is vertical, drum-type, with double pressure of generated steam and with a deaerator designed for atmospheric pressure.

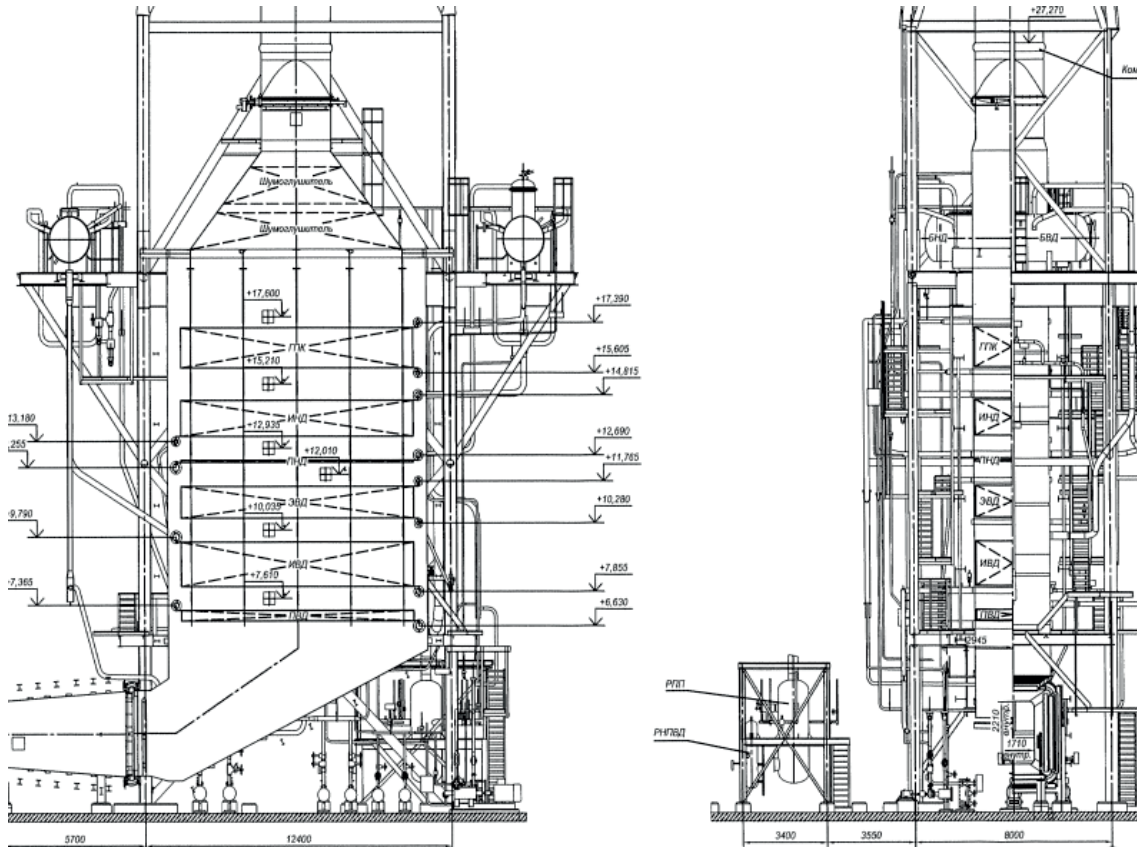
The waste-heat steam boiler comprises 5 heat-exchange sections: reheating, evaporating and superheating heating surfaces. The evaporating circuit of the waste-heat steam boiler includes LP and HP drums. The circulation in the evaporating circuit is of forced type. The waste-heat steam boiler heating surfaces are arranged vertically. The waste-heat steam boiler is made gas-tight due to the metal sheathing. The heating surfaces are composed of tubes with outside fins suspended onto the boiler structure and are supplied in modules.

Expansion joints are provided for at the boiler inlet and outlet, a noise silencer is provided for at the outlet.

The main design characteristics of the updated boiler (with consideration for the required parameters of the process steam extraction) in the nominal conditions are given in the Table below.

#### Technical characteristics of the waste-heat steam boiler

Characteristic	Value at T, °C		
	-14	+2	+15
Ambient air temperature, °C	-14	+2	+15
Nominal gas flow at the boiler inlet, kg/s	111	105	100
Gas temperature at the boiler inlet, °C	493	504	514
Temperature of the boiler off-gas, °C	115	112	110
Feedwater temperature, °C	40	40	40
High pressure circuit:			
– maximum steam-generating capacity, t/h	43,5	43	42
– steam pressure at the boiler outlet, MPa	6,1	6,1	6,1
– steam temperature downstream of the boiler, °C	469	477	486
Low pressure circuit:			
– maximum steam-generating capacity, t/h	11,2	10,4	9,7
– steam pressure at the boiler outlet, MPa	0,65	0,65	0,65
– steam temperature downstream of the boiler, °C	268	270	270
Load control range, %	40-100		
Aerodynamic resistance of the boiler, Pa	≤3250		
Overall dimensions of the boiler (L×B×H), m	16x12x28		
Equivalent sound level at a distance of 1 m, dB (A)	≤80		



Arrangement and overall dimensions of the waste-heat steam boiler

### Synchronous turbo-generators

To convert the mechanical energy at the output shaft of the turbine into the electrical energy, synchronous turbo - generators produced by JSC "Elektrotyazhmash - Privod" (Lysva), LLC "PO "Leningrad electric machine building plant (LEZ)», (Saint-Petersburg, "Ruselprom") are used. It is possible to use synchronous generators of suitable capacity, speed and sense of rotation produced by other companies.

### Parameters of synchronous generators for CCP

Description	UOM	Value		
Turbo – generator type		ТТК-32-К-2РУ3-Г	ТПС-25-2ЕУ3	ТПС-12-2ЕУ3
Manufacturer		Elektrotyazhmash - Privod	LEZ	LEZ
Power rating	MW	32	25	12
Total power	MWA	40	32	15
Efficiency		0,982	0,980	0,978
Power factor		0,8	0,8	0,8
Voltage	kV	10,5	10,5	10,5
Speed	Rpm	3000	3000	3000
Cooling		air	Water with a built-in cooler	
Overall dimensions	M	6,2 x 2,6 x 2,6	5,9 x 4,3 x 3,4	5,15 x 3,7 x 2,8
Mass of the generator	t	55,4	43	29,5

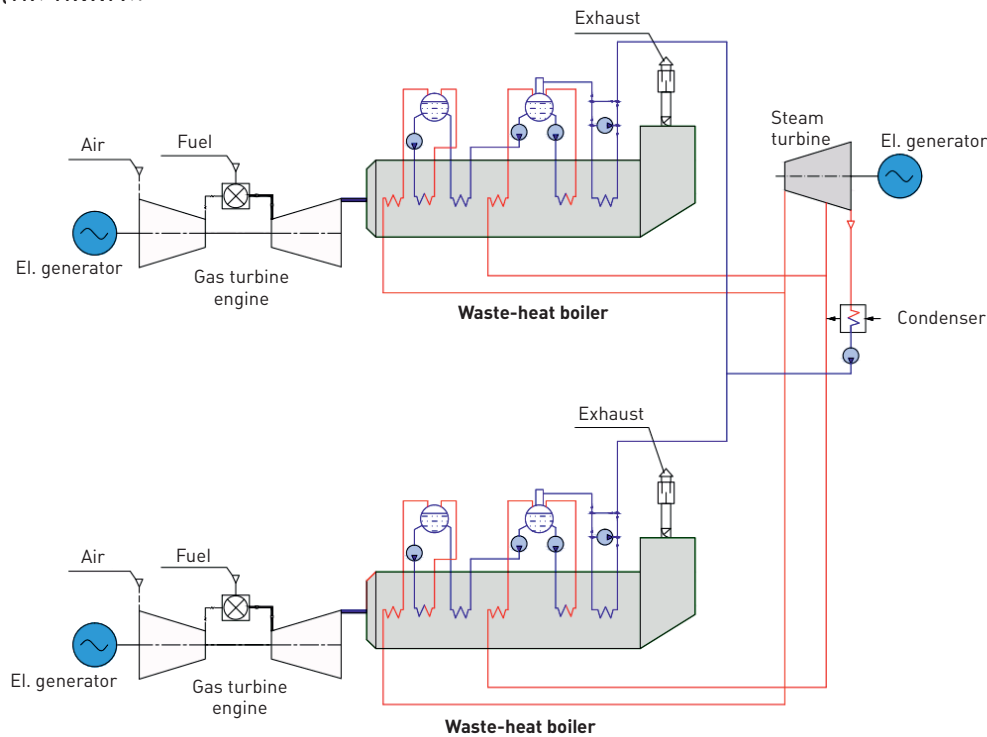


## Standard Combined Cycle Power Plant rated at 84 MW

Combined Cycle Power Plant CCP-84 includes gas circuit equipment: two gas turbine units (GTU), as well as steam circuit equipment: one steam turbine unit (STU).

In the CCP the exhaust gas heat from two gas turbines is used in the production of power-generating and process steam in two waste-heat steam boilers. Steam from the waste-heat steam boilers arrives through the common HP and LP headers to one steam turbine (see diagram at Fig. 1). From the LP header the required amount of steam is also extracted for production needs (the diagram does not show steam extraction).

A binary thermo-dynamic cycle is realized in the double-unit CCP-84. The CCP circuit diagram is shown in the figure:



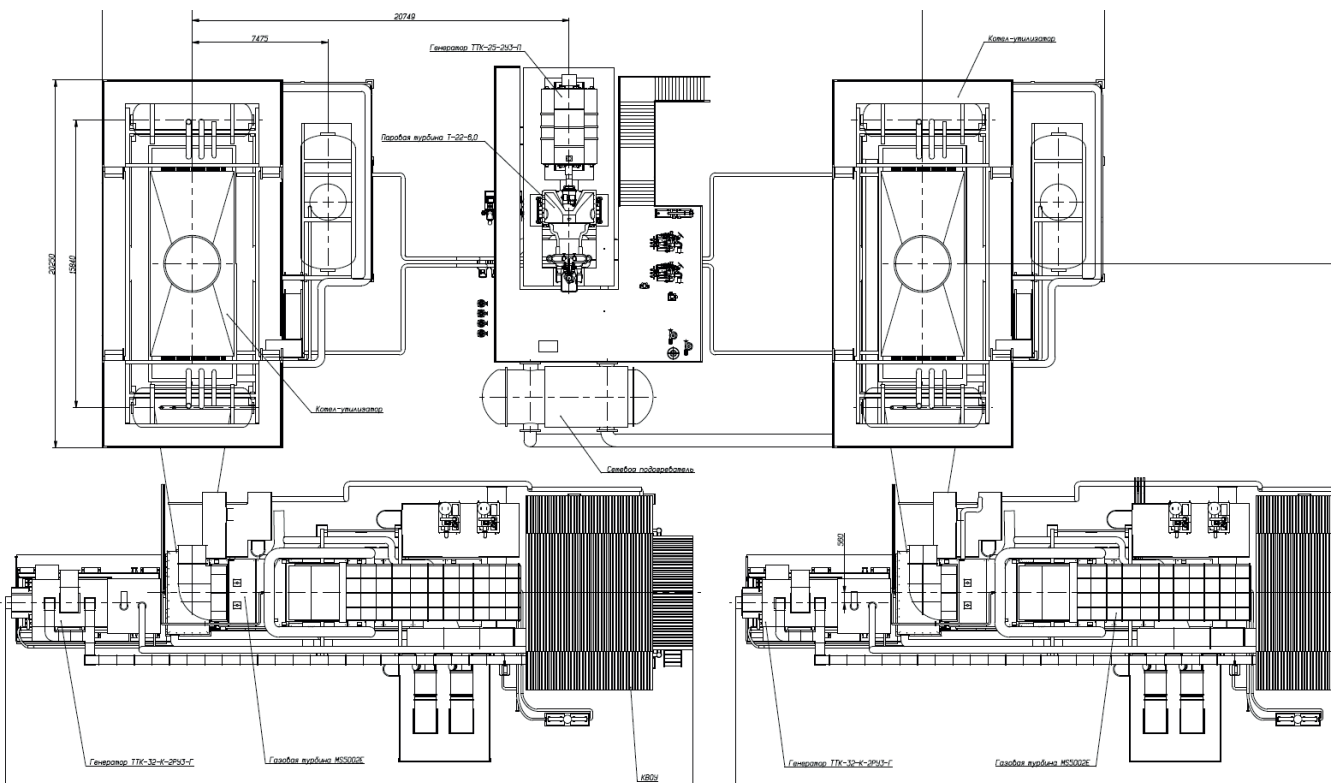
CCP-84 circuit diagram

### CCP- 84 MW configuration

- MS5002E gas turbine (GT) (under GE license) - 2
- Turbo-generator (EG) for GT - 2
- Gearbox to transmit power from the GT to the turbo-generator - 2
- Filter house - 2
- Double-pressure waste-heat steam boiler - 2
- Double-pressure steam turbine (ST) -1
- Water condenser - 1
- Turbo-generator (EG) for ST - 1
- Common systems: air ducts, steam lines, gas ducts, metal structures - 1
- Electric equipment - 1
- APCS (Automatic Process Control System) - 1

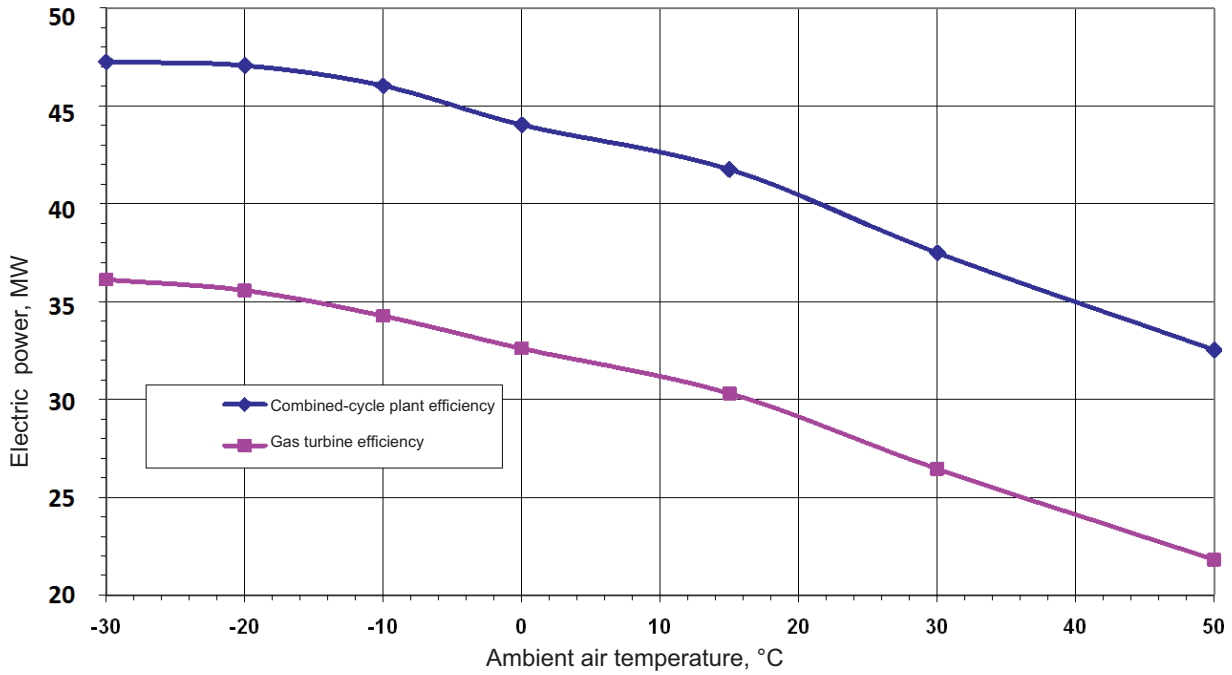


- |  |                                     |
|--|-------------------------------------|
| 1 – GT-32 gas turbine engine (MS5002E) | 7 - waste-heat steam boiler         |
| 2 – GTU turbo-generator                | 8 – Air heating system              |
| 3 – STU turbo-generator                | 9 – APCS                            |
| 4 – Gearbox                            | 10 – Network heater                 |
| 5 – Filter house                       | 11 – Network pump                   |
| 6 – Steam turbine                      | 12 – Electric equipment compartment |

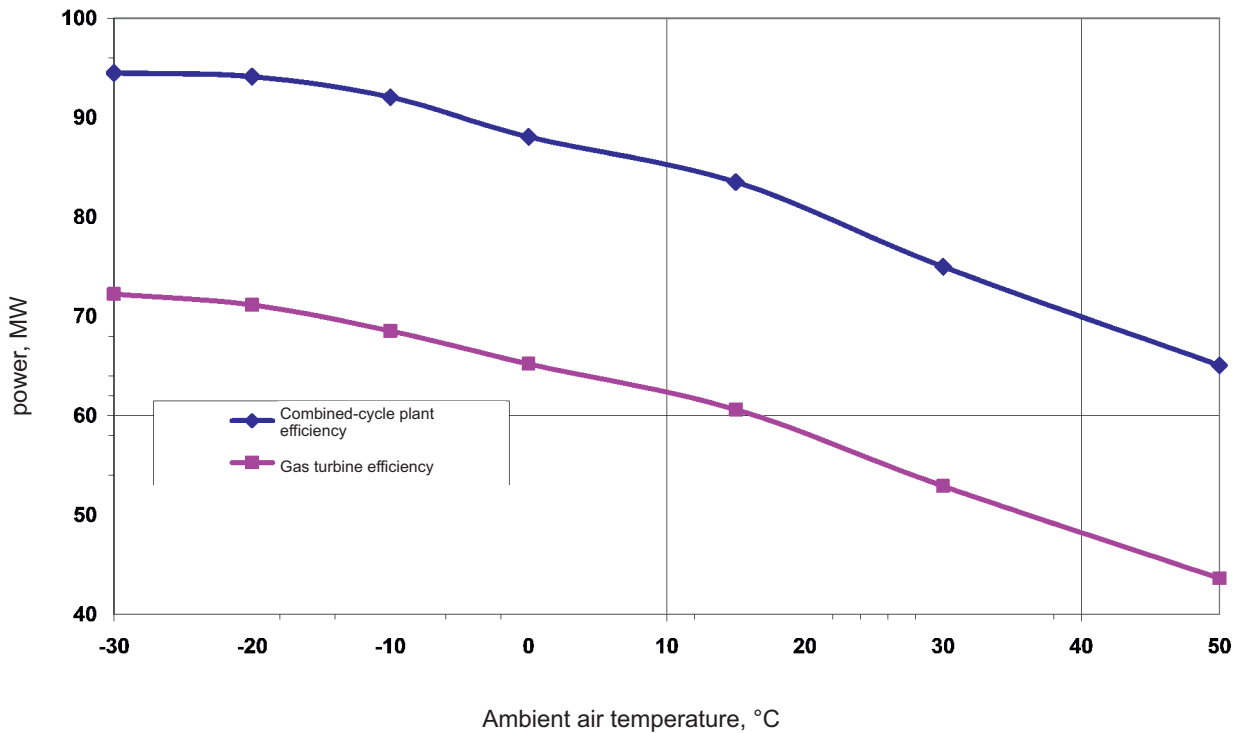


CCP-84 equipment layout

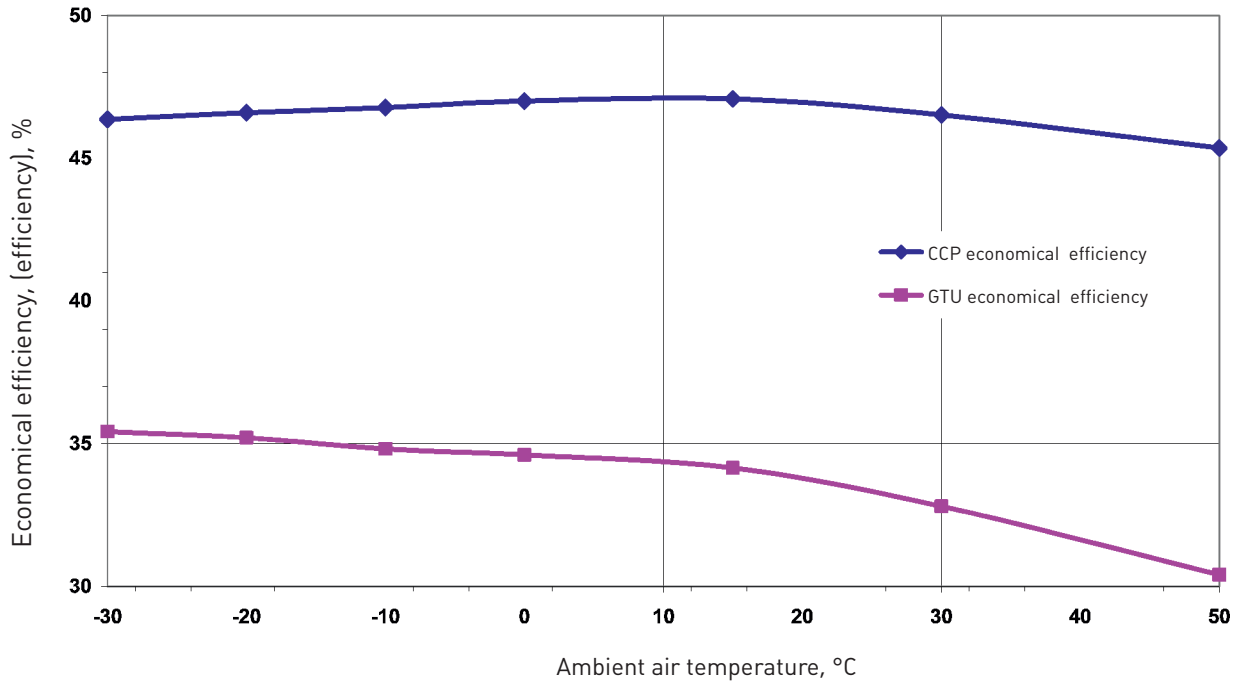
## Climatic characteristics of the CCP (site conditions):



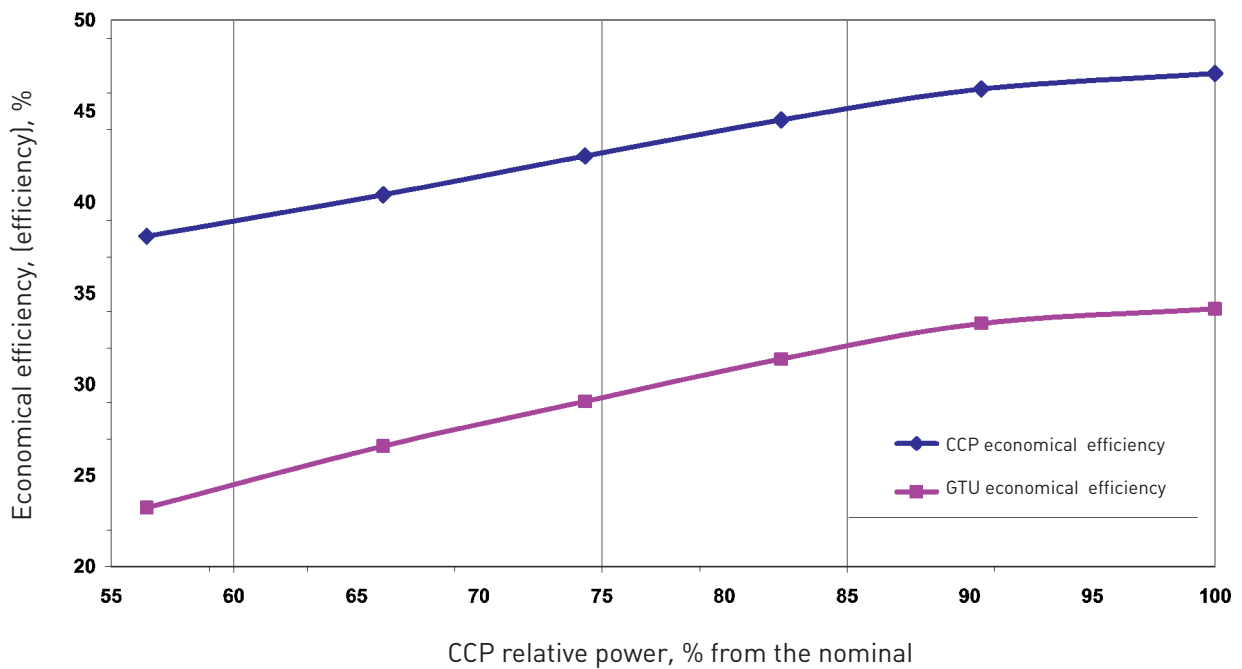
Climatic characteristics of CCP-42 and GTU electric power  
Nominal load conditions



Climatic characteristics of CCP-84 and GTU electric power  
Nominal load conditions



Climatic characteristics of electric efficiency (gross) for CCP-42, CCP-84 and GTU  
Nominal load conditions



Performance characteristic of electric efficiency (gross)  
for CCP-42, CCP-84 and GTU for normal atmospheric conditions (+15°C)  
at equal electric load on both gas turbines.

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