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Rational technology for processing oil shale from different deposits in the world

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Technology of processing oil shale

by means of pyrolysis

was realized by ENIN staff

and was awarded in 2008

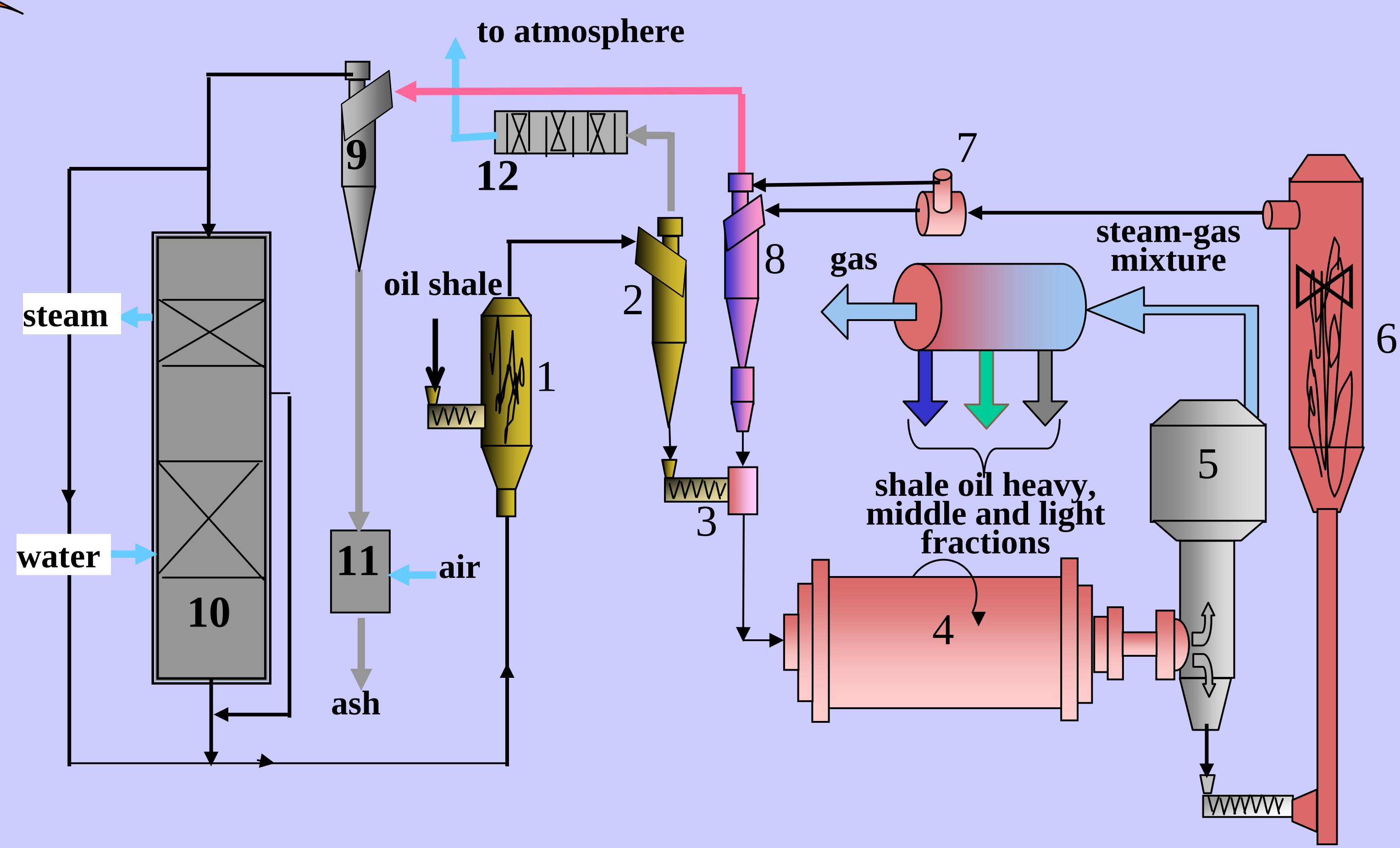
by International Premium

“Global Energy”

It is possible to apply it

in different countries

Schematic diagram of thermal processing of Baltic oil shale
Unit UTT-3000



1 – aero-fountain air spray drier, 2 – dry shale cyclone, 3 – mixer,

4 – drum reactor, 5 – dust separator, 6 – aero-fountain furnace, 7 – flow separator,

8 – heat carrier cyclone, 8 – heat carrier cyclone, 9 – ash cyclone,

10 – recovery boiler, 11 – ash heat exchanger, 12 - filter

Unit UTT-3000 in city Narva for thermal processing of oil shales

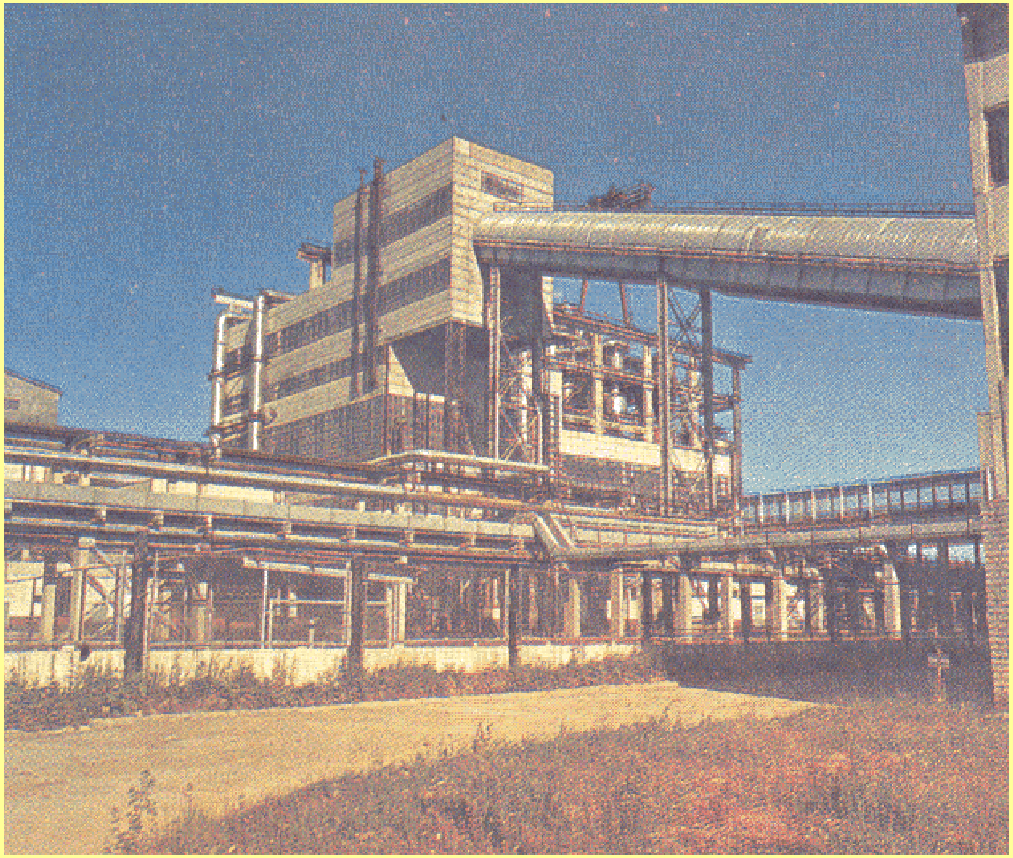
Is in operation since 1989 ➔ more than 17 years

View of

the section

for thermal

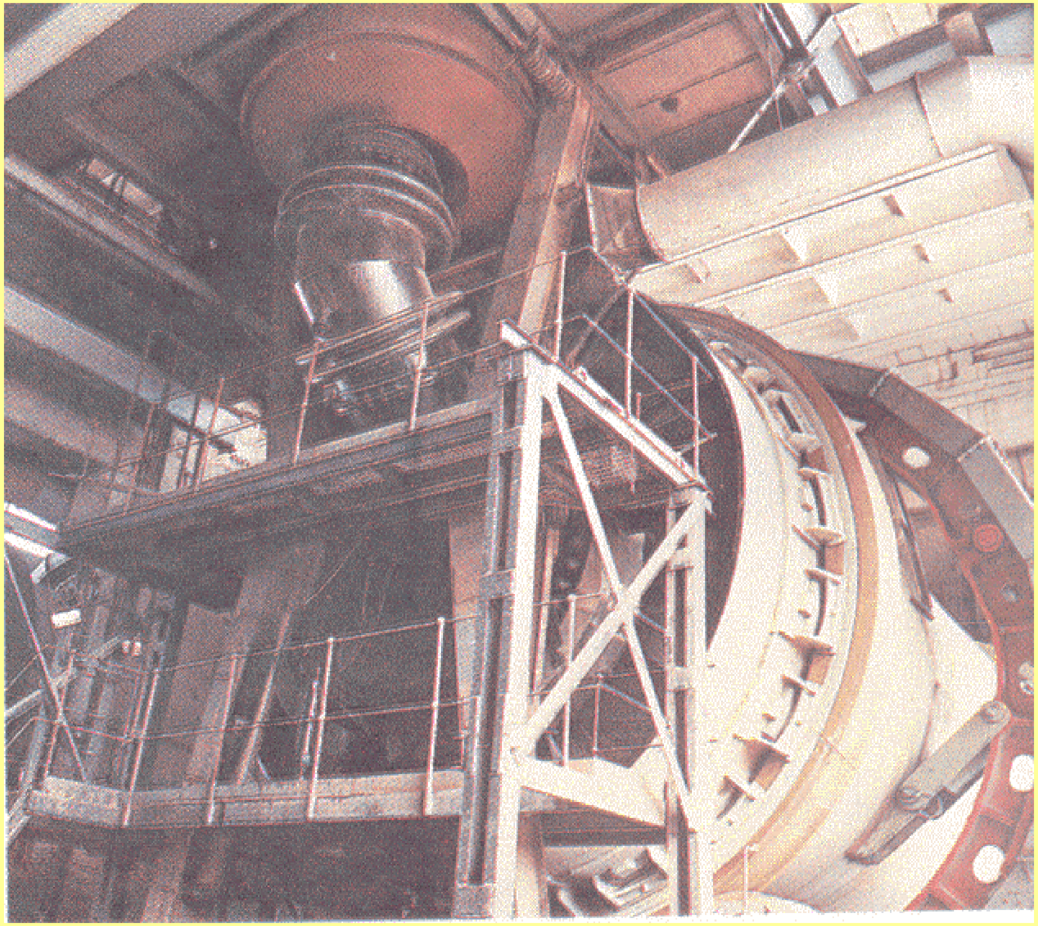
decomposition



Unit UTT-3000 in city Narva for thermal processing of oil shales

Rotating

drum reactor



Unit UTT-3000 has the following advantages:

- The heat of combustion **gas obtained after pyrolysis in units UTT is in** 2.5-3.0 times more **than in the plants of other countries. So, the calorific value of pyrolysis gas after the processing of oil shale of Leningradskoye deposits is 42,2 MJ/kg.**

- The gas **obtained in the UTT units represents** a marketable product **- a fuel for gas turbines, while in other technologies the considerable part of gas is used in the cycle itself for combustion in the reactor.**

- **The utilization of ash instead of gas for pyrolysis** increases the efficiency **of inits up to 84-89%, while the efficiency doesn't exceed 65% for the majority of plants of other types.**

- The total efficiency of cleaning **of gas-vapor mixture in cyclones** achieves 99.5%. **Owing to it, the content of dust doesn't exceed 1.0-1.5% even in the heavy fractions of oil shale.**

- **The** UTT-3000 units process the waste automobile tires **in a mixture with oil shale. The processing of grounds saturated by oil products (for example, because of accidents during transportation) is also technically possible and was confirmed in practice.**

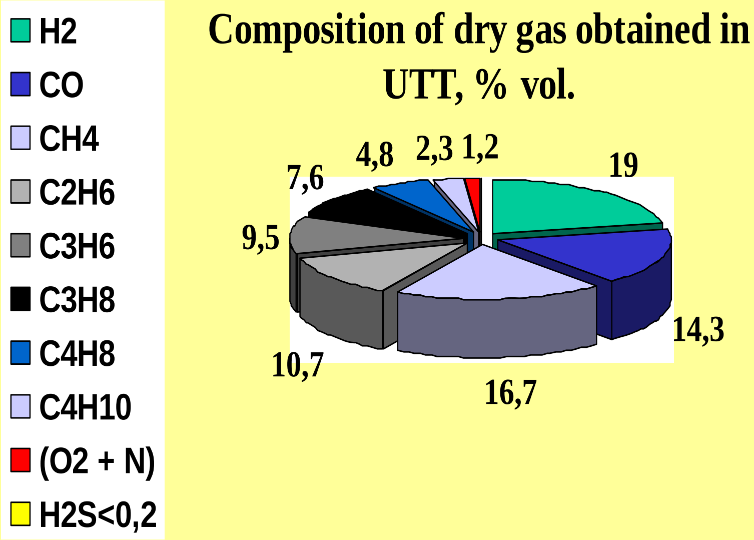
Main characteristics of oil shale fractions obtained in the units UT.

Oil shales of Leningradskoye deposit

Fractions of shale oil	Density, kg/m^3 (for 20°C)	Elementary composition in maximum, %				Heat value, MJ/kg	% evaporation in the end of boiling
		sulfur	water	ash	Mechanical admixtures		
Total shale oil	950-1000	0.8	0.3	0.1	0.15	38	64
Heavy oil	1050-1100	0.6	1.0	0.8	1.0	36.5	60
Middle oil	1010	0.8	0.3	0.1	0,15	37.4	70
Diesel oil (fuel for gas turbine)	925	0.8	0.1	0.015	0,02	38.4	85
Petroleum fraction	810-825	1.0	0.1	abs	abs	41.2	90

Characteristics of gas obtained in UTT from the oil shales Leningradskoye deposit

Content of hydrogen sulfide	3.2 g/nm^3
Content of sulfur	2.86 g/nm^3 ; 0.249% (mass)
Content of hydrocarbon	25.0 g/nm^3
Density	1.148 kg/m^3
Low calorific value	42.2 MJ/kg; 48.44 MJ/m^3
Output of gas per ton of oil shale	41.0 kg/t; 35.71 nm^3/t



Tests of oil shale from 35 deposits of different countries were made in ENIN laboratories

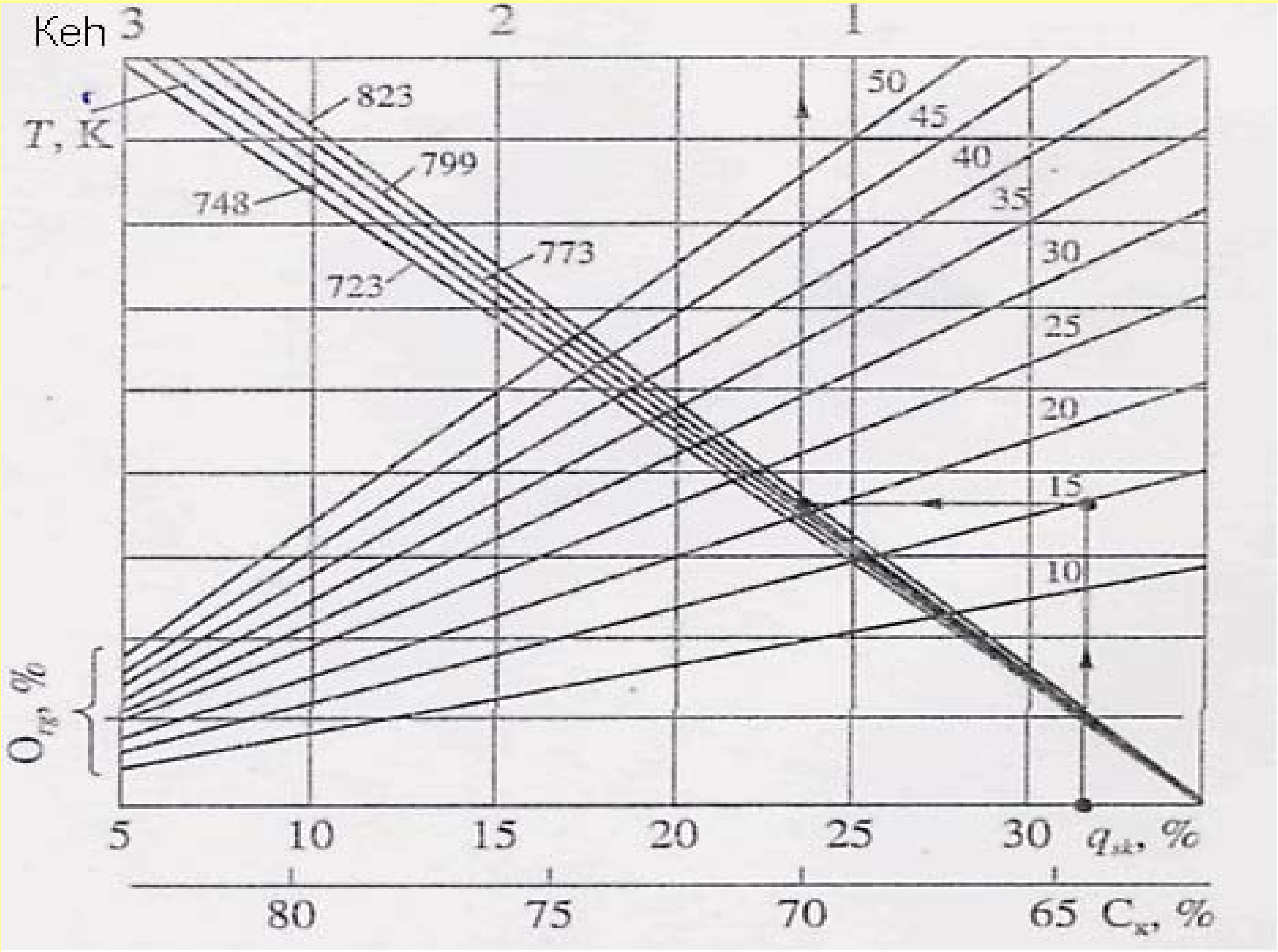
- ***Results of tests allowed to form nomograms***
- ***They permit to determine quantitatively the possibility of our technology application for oil shale of different quality existing in the world***

It was concluded that it is possible to use this technology for the different deposits of oil shale with the net calorific value more than 3.77 MJ/kg

Table 1. Kerogen composition for oil shale of different deposits

Deposit	Composition of kerogen of oil shail			
	C	H	O	S
1. Pribaltyiskoye (Estonia)	77.3	9.8	11.2	1.7
2. Leningradskoye (Russia)	77.7	9.8	11.3	1.2
3. Kashpirskoye (Russia)	61.1	7.3	23.8	7.8
4. Kenderlikskoye (Uzbekistan)	73.8	8.4	17.8	
5. Boltyshskoye (Ukraine)	68.0	9.3	18.3	1.9
6. Timakhdi (Morocco)	70.5	9.3	12.4	7.8
7. Green-River (USA)	80.9	11.4	6.9	0.8
9. Nerke (Sweden)	69.5	7.7	16.8	6.0
10. Lotiani (Scotland)	63.0	10.1	26.2	0.7
11. Render (Australia)	63.1	7.9	28.3	0.7
12. Irati (Brazil)	68.1	10.3	17.9	3.7
30. Rotem (Israel)	65.0	7.0	15.4	10.7

Fig. 1. Nomogram for coefficient Keh as a function of physical and chemical properties: Org - concentration of organic material in dry mass of shale, %; Ck - carbon concentration in kerogen, %.
T – pyrolysis temperature, K, qsk – semicoke output (after pyrolysis) per conventional organic mass.



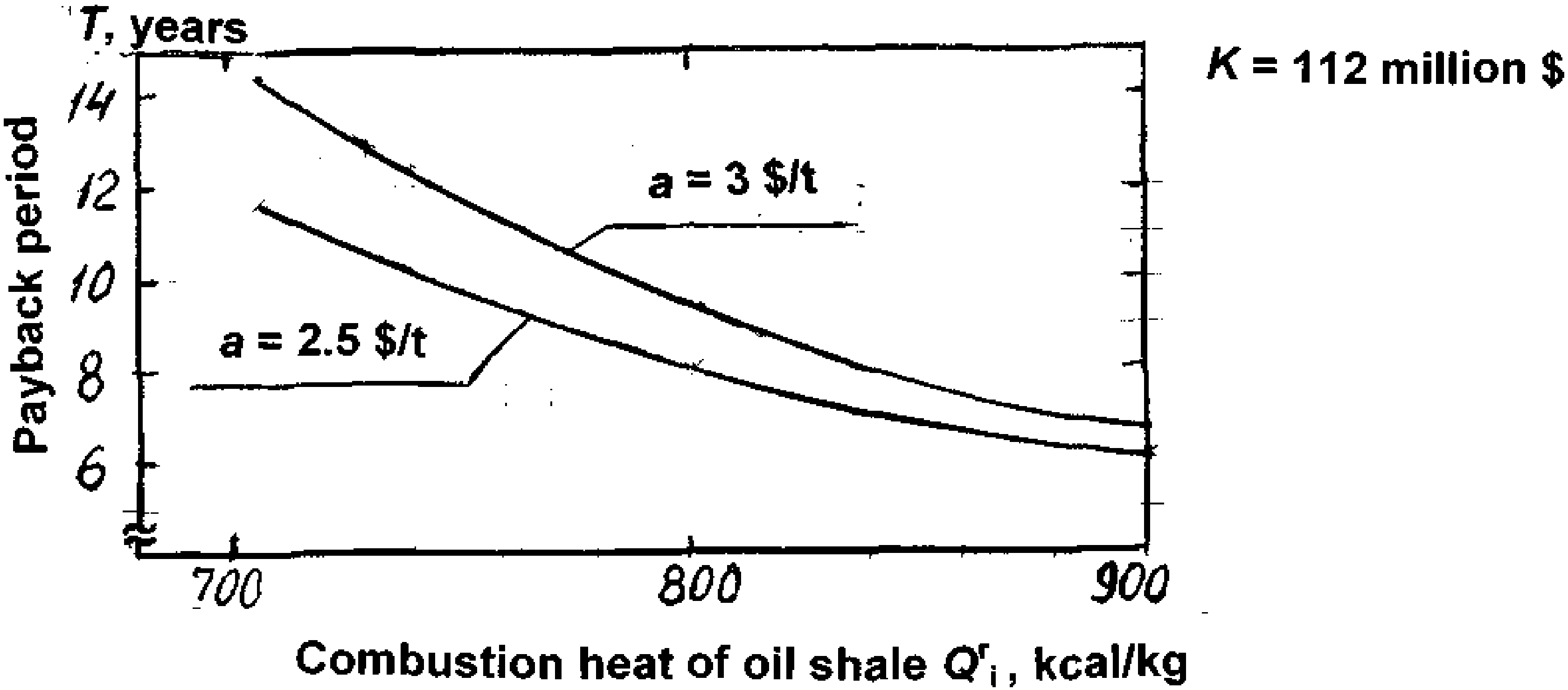
Yield of products as a result of processing one ton of oil shale's working medium

Deposit, heat of combustion of the shale's working mass, and carbonate content in it	Total yield of tar, kg/t	Tar's heat of combustion, MJ/kg	Yield of semicoke gas, nm3/t	Semicoke gas's heat of combustion, MJ/nm^3
Baltic shale *Qri* = 8.37 MJ/kg *(CO2)r* = 16.7%	130.66	38.0	35,71	48.4
Jordanian shale (El-Lajun), *Qri* = 6.82 MJ/kg *(CO2)r* = 19%	105	35.4	53	28.8
Israeli shale (Rotem) *Qri* = 3.77 MJ/kg *(CO2)r* = 20.5%	58	36.8	28	20.2

Indicators of Leningrad deposit	1	2	3	4
Capital investments	150	150	160	160
Yearly sales of products: - shale oil, thousand t	325	325	325	325
- semi-coke gas. thousand tce	147	147	147	147
- electric energy, million kWh	170	170	170	170
- from processing general rubber goods:				
- shale oil, thousand t		50		
- semi-coke gas/ thousand tce		30		
Cost of saled products: - shale oil, $/t	300	300	350	350
- semi-coke gas, $/tce	215	215	215	215
- electricity, $/kWh	0.06	0.06	0.06	0.06
Cost of oil shale, $/t	10	10	10	10
Product proceeds, million $/year	139.31	161.83	155.56	155.56
incl.: shale oil	97.5	112.5	113.75	113.75
semi-coke gas	31.61	39.13	31.61	31.61
electricity	10.2	10.2	10.2	10.2
Expenses of production, million $/year	49.5	49.5	44.8	49.8
including: - fuel cost	25	25	20	25
- depreciation	4.5	4.5	4.8	4.8
- direct labor cost, materials, reagents	20	20	20	20
Profit on sales, million $/year	89.81	112.33	110.768	105.76
Net earning after taxes, million $/year	65.83	82.95	1.59	77.79
Measures of effectiveness (discount rate – 10%):				
Net present value, million $	459,96	604.3	586.71	554.51
Internal norm of profit,%	39.48	47.6	44.63	42.91
Income rate	4.36	5.41	5.01	4.79
Payback period, years: from beginning of construction	4.6	4.18	4.31	4.4
from putting into operation of 3 plants	1.6	1.18	1.31	1.4
Discount payback period, years: from beginning of construction	5.11	4.54	4.72	4.84
from putting into operation of 3 plants	2.11	1.54	1.72	1.84

Indicators of deposit El-Ladjune	1	2	3	4
Capital investments	120	120	120	120
Yearly sales of products: - shale oil, thous. t	274	274	274	274
- semicoke gas. thous. tce	71	71	71	71
- electric energy, million rWh	500	500	500	500
Cost of saled products: - shale oil, $/t	240	300	240	300
- semicoke gas, $/tce	200	200	200	200
- electricity, $/kWh	0.05	0.05	0.05	0.05
Volume of processed ooil shale, million t/year	2.535	2.535	2.535	2.535
Cost of oil shale, $/t	5	5	5	5
Product proceeds. Mln $/year	104.96	121.4	104.96	121.4
incl.: shale oil	65.76	82.2	65.76	82.2
semicoke gas	14.2	14.2	14.2	14.2
electricity	25.0	25.0	25.0	25.0
Expenses of production, million $/year	29.16	29.16	34.23	34.23
incl: - cost of processed shale	12.68	12.68	17.75	17.75
- depreciation	3.98	3.98	3.98	3.98
- direct labour cost	2.5	2.5	2.5	2.5
-other expenses	10	10	10	10
Profit on sales, million $/year	75.8	92.24	70.73	87.17
Net earning after taxes, million $/year	70.49	85.78	65.78	81/07
Measures of effectiveness (discount rate – 10%):				
Net present value, million $	508,76	637.29	469.1	597.54
Internal norm of profit,%	46.03	53.59	43.59	51.27
Income rate	5.4	6.51	5.06	6.17
Ratio of profit/expenses	2.33	2.63	2.11	2.38
Payback period, years: from beginning of construction	3	2.5	3	2.6
from putting into operation of 3 plants	1	0.5	1	0.6
Discount payback period, years: from beginning of construction	4	3	4	3
from putting into operation of 3 plants	2	1	2	1

Dependence of payback period of capital investments from shale oil sales on the calorific value (Q^r_i) of oil shale and its cost with the price of substituted oil m= 120 $/t for Rotem, Israel (4 UTT-3000)



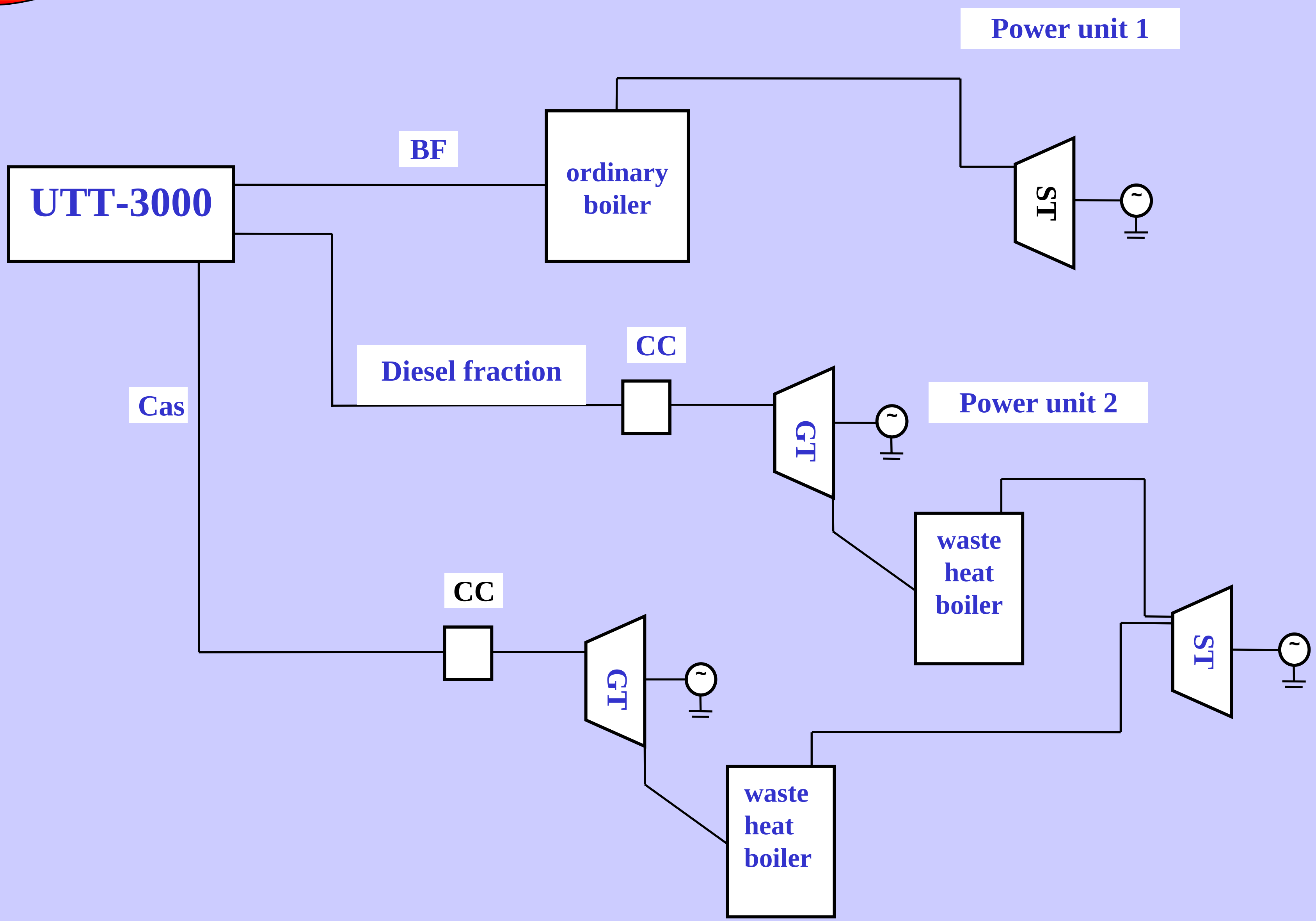
ENIN is currently continuing to perfect the UTT-3000 units

- Raising reliability and economic efficiency
- increasing the yield of diesel fraction

New schemes increase the use of shale'e heat and the yield of diesel fractions

- Technology allows to solve the problem of natural oil resources' depletion
- Makes oil shale the competitive fuel to high quality coals due to using the products of shale processing for power generation by combined-cycle units

Diagram of electric power plant working with the products of shale processing and using the combined cycle



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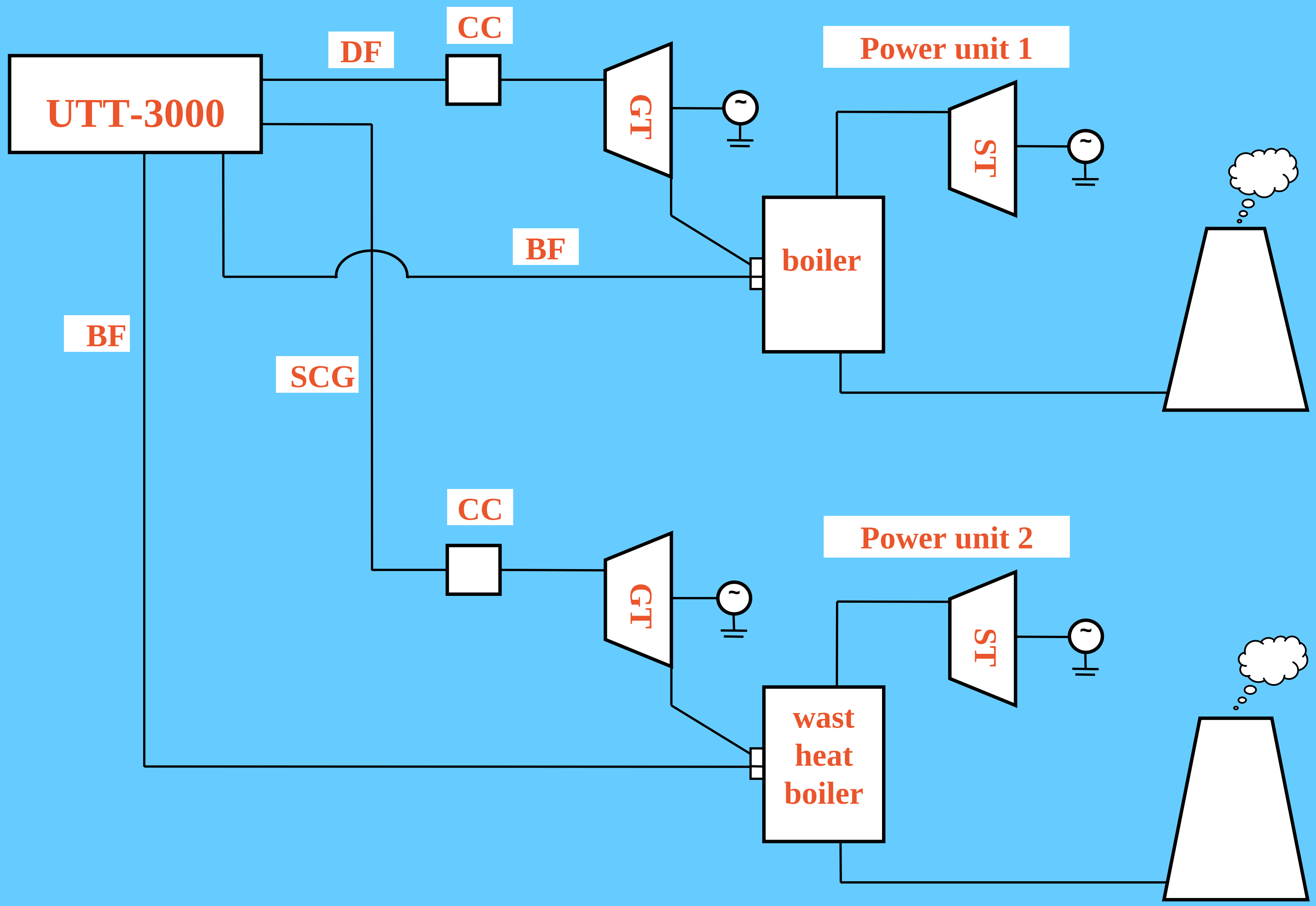
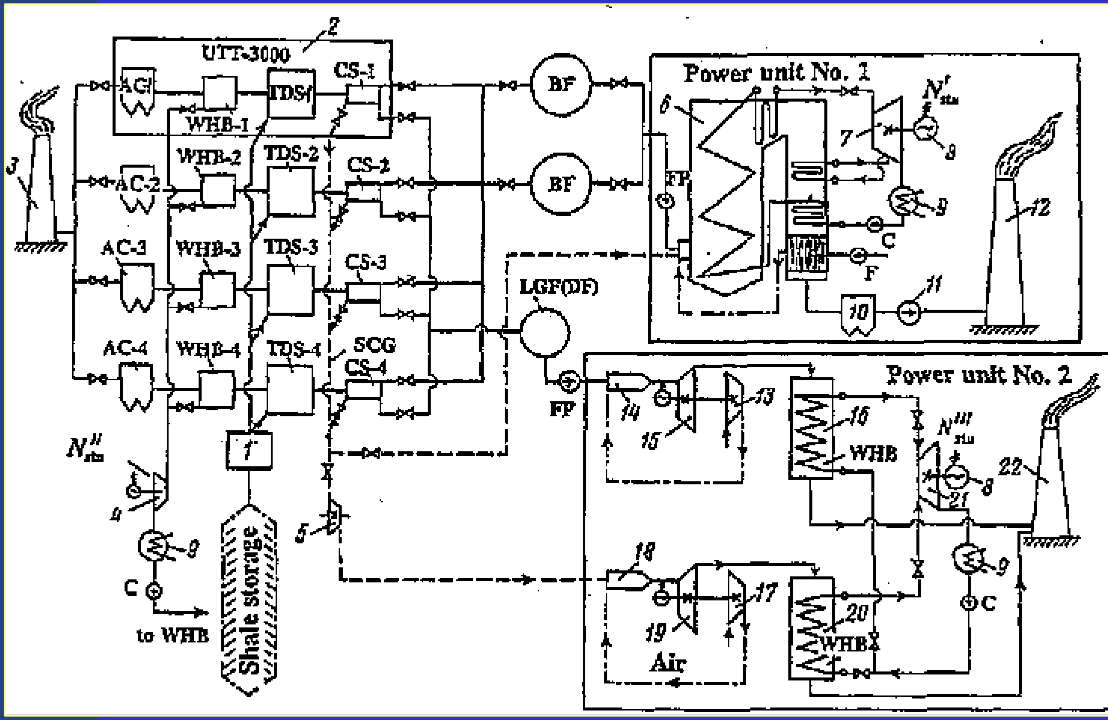


Line diagram of a TPP with a combined-cycle unit that operates on the products of thermal processing of shale from the Leningrad deposit with discharge of gases into waste-heat boilers after the gas turbines

1 - Crusher
2 - UTT-3000
3 - Smokestack waste-heat boilers
4 - turbogenerator for waste-heat boilers
5 - Semicoke-gas compressor
6 - Steam power-generating boiler
7&21 - Steam turbines
8 - Generator
9 - Condenser
10 - Gas-cleaning unit
11 - Exhaust fan
12&22 - power units' smokestacks
13 &17 - air compressors
14 &18 - GT combustion chambers
15&19 - Gas turbines (GT)
16&20 - GT units' waste-heat boilers
F - fan
C - condensate pump
P - UTT-3000's spark plug
TDS -thermal-decomposition section
WHB - UTT-3000's waste-heat boiler
AC - UTT-3000's ash collector



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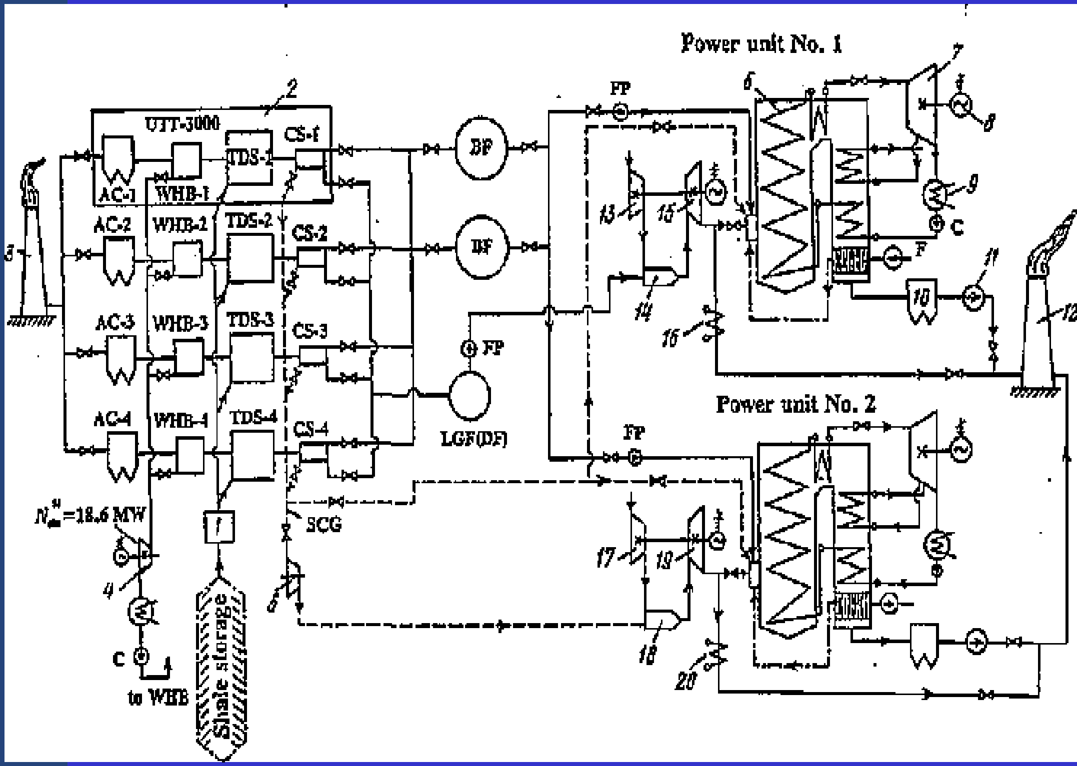

Thermal Efficiency of different types of TPP in %

		Pulvirized shale in chamber furnace	UTT-3000 + Rankine cycle	UTT-3000 + Combined cycle
Oil shale with low-calorific value	European climate	27	33	38
	Hot climate	25	30-31	35-36
Oil shale with high-calorific value	European climate	30	35	40-41
	Hot climate	27-28	33	38

Thank you very much

for your attention

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Geological resources of oil shale and shale oil in Russia, million t

Basin	Oil shale resources	Shale oil resources
Baltic (Russian part)	10246.7	1386.2
Timaro-Pechorsky	4888.0	351.4
Vychegorsky	58103.8	4590.0
Central	59.6	5.4
Volzhsky	25822.4	2805.5
South Ural	47.55	2.8
Oleneksky	380000.0	19000.0
Sinsko-Botomsky	220000.0	5500.0
Irkutsk's region and Transbaikalia	111.7	60.5
TOTAL	700288.85	33701.8