（№２　２００３年１０月１６日号目次）

特集：ロシアにおける新エネルギー開発その２

今号では№１に引き続き、ロシアの新エネルギー開発のうち、ヒートポンプ・システムの開発、バイオマスのエネルギー利用、潮汐エネルギー利用の現状と各分野の主な製品・プラントをご紹介いたします。

１．ロシアにおけるヒートポンプ・システムの開発

ロシアの冬は長く厳しいため熱供給に膨大なコストがかかり、発電のほぼ倍のコストがかかっていると言われており、エネルギー資源の 45%が熱供給に費やされている。

従来の熱供給の欠点は、エネルギー変換の点からも経済的にも環境的にも効率が低いことである。また、エネルギー資源の輸送も効率的とは言えない。

したがって、熱供給にも新しいシステムの導入が求められており、そのひとつがヒートポンプで、自然の温度変化（５度～30 度）ないし産業施設の排熱を利用するものである。

世界では現在 1,500 万以上のヒートポンプが稼働しており、2020 年には先進国の熱供給の 75%はヒートポンプが担うと見られている。世界のヒートポンプ先進国は米国、日本、カナダ、スカンジナビア諸国である。

ロシア国内では現在 100 強のヒートポンプで合計出力 70MW しか稼働していないが、ロシアは暖房期間が長く燃料輸送にコストがかかることから、諸外国よりもヒートポンプがさらに効率的であることが判明している。

ロシアで 10kW から大型の 3,000kW のヒートポンプを製造しているのは株式会社「エネルギヤ」（ノヴォシビルスク）と「Teplomash」のグループ、そしてキーロフ工場（サンクトペテルブルグ）のみである。ヒートポンプの稼働地はカムチャッカ、アルタイ、ノヴォシビルスク、ノリリスク、リトアニア、カザフスタンである。リトアニアには、西側との競争入札に打ち勝って、ロシアから 3,000kW のヒートポンプが２基納められた。その理由は、性能は同等でありながらロシア製ヒートポンプの方が価格が安かったからである。

「エネルギヤ」と「Teplomash」のグループは、今後需要に応じて生産量を 10 倍に、単体出力を 30,000kW に拡大することができるという。

いくつかの要素がヒートポンプの迅速な普及を妨げてきたが、最大の理由はロシアの熱供給の料金が安かったからである。しかし、これら料金は電気・ガスも含めて急速に引き上げられており、それとともにヒートポンプの活用が増大することは間違いない。

ロシア連邦政府と統一電力システムももちろんその点は認識しており、連邦プログラムでは 2003 年から 2010 年までに定格出力 543.9Gcal/h のヒートポンプを導入し、標準燃料換算 22.1 万ｔを代替するとしている。主な設置予定地はクラスノヤルスク地方、ノヴォシビルスク州、イルクーツク州、モスクワ市およびモスクワ州である。

２．主なロシア製ヒートポンプ

①HEAT PUMPS produced by the Energiya Company

The Energiya Company is one of Russia's leading designers and manufacturers of heat pumps of various capacity.

At present, the Company produces heat pumps featuring the following characteristics:

Heat pumps of the Energiya Company with screw compressors

Heat pump	NT - 500	NT - 1000	NT - 3000
Heating efficiency, kW At 8 ° C source water temperature:	500	1,000	2,500
At 25 ° C source water temperature	800	1,600	4,000
Power consumption, kW: At 12 ° C source water temperature	149.7	297.3	595.4
At 25 ° C source water temperature	161.4	315	630
Heated area, m^2 (accounted at the rate of 0.7 kW per m^2)	7,143	14,280	35,700
Version	Monoblock	Separate	Separate
Total weight, kg	9,700	13,000	24,000

NT - 500

NT - 1000

Heat pumps of the Energiya Company with piston compressors

Heat pump	NT - 80	NKT - 110	NKT - 300
Heating efficiency, kW At 12 ° C source water temperature	105	155.7	311.4
At 25 ° C source water temperature	184.5	233.6	467.2
Power consumption, kW: At 12 ° C source water temperature	35	51.2	102.4
At 25 ° C source water temperature	43.4	55	110
Version	Monoblock	Monoblock	Monoblock
Dimensions, mm	2,375*900*1,155	3,900*2100*1,495	4,500*2,100*2,100
Weight, kg	1,400	4,500	4,500

NT - 80

NKT - 110

NKT - 300

As a low potential source of heat, use can be made of industrial and treated waste water; process water; subsoil, artesian and thermal water; sea, river and lake water; water- and heat-supply systems; heat released during purification of flue gases and any discharged heat flows.

Efficient and trouble-free functioning of heat pumps is ensured by automation means. Pumps operation is governed by the microprocessor control system.

Besides batch production, the Energiya Company can at the Customer's request produce a heat pump of any shape and capacity, including a low-capacity pumps for individual heating of dwellings.

A service life of heat pumps prior to overhaul is as follows:

- 60,000 h for heat pumps with screw compressors;
- 45,000 h for heat pumps with piston compressors.

The estimated cost of the a heat pump of 1 Gcal/h heating efficiency makes up from $160 thou. to $180 thou.

A list of objects where heat pumps are installed is rather wide: child institutions, hospitals, plants, farms, water canals, heat power plants, cottages etc.

During the last ten years, the Energiya Company commissioned about 100 heat pumps of various capacity on the post-Soviet territory. The first plants installed in the Kamchatka area have been functioning for over eight years already.

Organizations:

Designers and manufacturers:
Energiya Company
18/1 Kutateladze St., Novosibirsk 630128, Russia
Tel.:(383-2) 34-47-91, 39-13-89
Fax: (383-2) 39-13-97
E-mail: energy@online.nsk.su
Website: http://www.nsk.su/~energy/index.htm

Kirov-Energomash Works
47 Stachek Prosp., St. Petersburg 198097, Russia
Tel.: (812) 183-82-45
Fax: (812) 252-16-92
E-mail: market@kz-energo.spb.ru
Website: http://www.kz-energo.spb.ru

②HEAT PUMPS of the KARAT DESIGN OFFICE

The KARAT Design Office is engaged in the development and mounting of heat pump systems.

The KARAT heat pumps are used for supplying heat to buildings and constructions of various application of 80-1,500 m^2 area located apart from central grids, as well as for household heeds.

The operation of heat pumps depends on the presence of a low-potential heat source, e.g. subsoil heat or heat of a water source (natural basins, wells, industrial and household drains, technical water etc.).

KARAT fabricates, installs and adjusts heat pumps of the following capacities: 5, 10, 18, 25, 30, 50, and 60 kW.

Specifications of heat pumps of the KARAT Design Office

Parameters	TNU-KR-5	TNU-KR-10	TNU-KR-18	TNU-KR-25	TNU-KR-50
Output power, kW	5.5	10	18	25	50
Power consumption, kW	2	3.3	6	8.5	18
Heated area, m^2	80-130	180-300	260-350	360-500	650-1,000
Pipe installation area, m^2	120-180	270-375	390-525	540-750	1,050-1,500
Power mains (voltage, frequency)	220 V 50 Hz	380 V 50 Hz	380 V 50 Hz	380 V 50 Hz	380 V 50 Hz
Weight, kg	100	200	250	400	450
Main unit dimensions, m	0.5×0.4×1	0.6×0.4×1.7	0.6×0.45×1.8	0.8×0.65×2	1.61×0.65×2
Boiler dimensions (diameter x height), m	0.7×1.75	0.81×2.0	0.81×2.46	0.81×2.46	0.81×2.46

At present, the KARAT-designed heat pumps TNU-KR-10 and TNU-KR-18 are mounted in cottages near Moscow and St. Petersburg. They ensure round the year supply of hot water and heating of rooms.

Checks made during the guarantee period showed reliable operation of pumps, preset seasonal and daily modes of operation being maintained automatically.

10 kW heat pump. General view

Using the TNU heat pumps has the following advantages:

- High efficiency of energy conversion as against electric heaters and electric boilers;
- Pure technology with ozone-friendly chladone, no atmospheric emission of harmful substances and carbon dioxide;
- Reliable unmanned operation;
- Minimal operating costs as compared with other fuel-based heating systems;
- Service life prior to overhaul prolonged to 15-20 years;
- Small dimensions and weight of the heating system

Organizations:

Manufacturer:
KARAT Design Office
113, bldg. 2, Krasnoputilovskaya St., St. Petersburg 196240, Russia
Tel:(812) 122-71-11
Fax: 375-16-17
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Website: www.okbkarat.ru

③AUTOMATED HEAT PUMP SYSTEM

The automated heat pump system is intended for converting heat potential of surface soil into thermal energy of a higher potential.

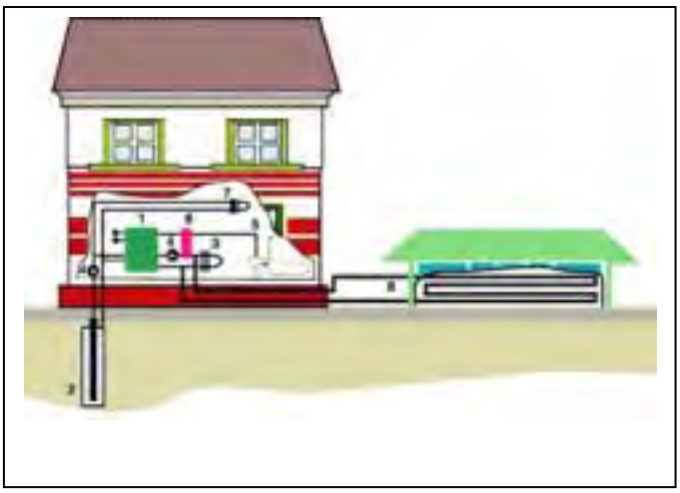
The said system includes the following units: airtight refrigerant compressor, heat exchange apparatuses, automatic control unit, peak-load regulator, hot water tank.

Basic elements:

1. Heat pump ATNU-10;
2. Vertical ground heat exchanger;
3. House heating system;
4. Circulation pumps;
5. Hot water supply system;
6. regulator

Additional elements:

7. Air cooling system (summer);
8. Greenhouse heating system (spring, autumn).



Specifications:

Parameters	ATNU -10	ATNU -12	ATNU -15
Heating capacity in the rated mode, kW	10.3	12	14
Heating system water temperature, °C	45 to 55	45 to 55	45 to 55
Power consumption, kW	3.5	4.5	5.0
Mains voltage, V	380/220	380	380
Main unit dimensions, mm	510×940×1,520	966×616×1,590	966×616×1,590

The ATNU system ensures as follows:

- Heating and automatic maintenance of the preset room temperature;
- Year-round supply of heat water;
- Cooling of auxiliary premises (larders, vegetable storerooms);
- Seasonal (spring, autumn) heating of greenhouses.

The said system provides for 60-70% power consumption decrease as compared with conventional heating and conditioning systems.

Organizations:

Manufacturer:
Rybinsk Instrument-Making Plant
89 Serov Passage, Rybinsk 152907, Yaroslavl Region, Russia
Tel:(0855) 55-02-98, 55-29-41, 55-87-00
Fax: (0855) 55-45-24
E-mail: pribor@yaroslavl.ru
Website: http://rzp.narod.ru/

④lithium bromide absorption heat pumps

Absorption heat pumps, or thermotransformers are ecology-friendly small-size installations used for heating or hot-water supply using for the purpose low-potential energy sources.

Researchers from S. Kutateladze Institute of Thermal Physics (Siberian Branch of the Russian Academy of Sciences - RAS) have developed industrial lithium bromide absorption heat pumps (LBAHP) and new generation coolers for heating/cooling water and other medium.

LBAHP are intended for applying low-temperature (20-30 ^{o}C) industrial waste heat or environmental heat into one suitable for heating, hot water supply, or other purposes.

The given LBAHP feature a reduced steel intensity, overall dimensions, and increased service life (to at least 20 years). Using those pumps will save up to 70 % of fuel used for heat generation. The LBAHP pay-back period is not large – from one to three years.

At present, LBAHP of the following standard sizes are available:

- Refrigerating machines for cooling water to 6 °C using various heat sources (steam, hot water, fuel), refrigerating capacity from 250 to 5,000 kW;
- Heat pumps for heating water to 55-80 °C, with the use of low-potential waste heat (20-40 °C) and various heat sources, refrigerating capacity from 500 to 5,000 kW.

LBAHP of 2 MW capacity has been successfully operating for over two years at the Novosibirsk cogeneration plant No. 4.

The “EES of Russia” Company recommended using LBAHP at heat power plants. Supply and engineering support of heat pumps is provided by the Teplosibmach Company.

Organizations:

Designer:
S. Kutateladze Institute of Thermal Physics, RAS Siberian Branch
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Supplier:
Teplosibmach Company
1 Academician Lavrentyev Passage, Novosibirsk 630090, Russia,
Tel: (3832) 342560, 39-10-43
Fax: (3832) 331097
E-mail:, tepsm@mail.ru
Website: http://sibchiller.narod.ru/

⑤その他の主要ヒートポンプ設計・施工会社（or 研究所）

No.	Enterprise name	Enterprise address
1	COMPRESSOR Refrigerator Equipment Plant	5 Vtoraya Ul. Entuziastov, Moscow 111024 Tel: (095)273-44-37 Fax: (095) 755-94-61 E-mail: info@compressor.ru Website: http://www.compressor.ru
2	SALUT Federal State Unitary Enterprise	16 Budenny Prosp., Moscow 105118 Tel.: (095) 369-80-01 E-mail: eio@salut.ru Website: http://www.salut.ru
3	RAS Institute of High Temperatures	13/19 Izhorskaya St., Moscow 127412 Tel.: (095) 485-8244 Fax: (095) 485-9922 E-mail: oivtran@oivtran.iitp.ru Website: http://oivt.nm.ru/
4	TRITON Ltd.	32a Chukotskaya St., Nizhni Novgorod 603146, P.O.B. 257 Tel.: (8312) 621-220 Fax: (8312) 621-033 E-mail: triton@pop.sci-nnov.ru

３．ロシアにおけるバイオマスのエネルギー利用

バイオマス（林業・農業廃棄物、わら、糞尿、家庭から出る固形ゴミの有機成分）のエネルギー利用は、潜在力が高く環境にやさしいという理由から世界の多くの国々で最も急速に発展しているエネルギー分野のひとつである。

ロシアにおける有機廃棄物の年間総量は 3.9 億ｔ以上で、その内訳は乾量で農業 2.5 億ｔ（牛・豚の飼育 1.5 億ｔ、農作物栽培１億ｔ）、林業・木材加工 7,000 万ｔ、都市固形ゴミ 6,000 万ｔ、生活排水 1,000 万ｔである。これらの廃棄物を処理することにより、標準燃料換算 1.5 億ｔ以上（バイオガス１億ｔ(1,200 億 m^3)、エタノール 3,000～4,000 万ｔ）が得られる。

ロシア国家科学技術プログラム「環境にやさしいエネルギー」によると、バイオマスのエネルギー利用は以下の方針で進むことになっている。

・バイオマス（硬度 60%まで）の燃料への変換：直接燃焼、熱分解、ガス化、液化

エネルゴ・テクノロジー・カンパニー（サンクトペテルブルグ）では、ガス発電機で稼働するコジェネレーション設備を目的として、固形バイオマスのガス化装置を開発中である。過去に行われたガス発電プラント建設の経験をもとに、効率向上のために大気吹き込みによる積層ガス化プロセスを利用したガス発電プラントを設計した。熱容量 100、200、600、3,000、5,000kW の一連のガス発電プラントの設計を終え、100kW と 200kW のプラントの試験生産を準備中である。テスト済みの 600kW と 3,000kW プラントの一括生産も近いうちに開始する予定である。

ガス発電プラントのスペックは、スウェーデン、フィンランド、イスラエルの企業が興味を示すほど、現代の要求にマッチしている。

・バイオテクノロジーを用いたバイオマス（水分 75%以上）のバイオガスへの変換

通常は、バイオテクノロジーを用いた変換には 75%以上の水分を含んだ有機廃棄物を使用するが、ロシアでは排水沈殿物と固形家庭廃棄物から固相メタンを発生させるなど、水分がより少なくてもバイオマスを変換することが可能である。

バイオガスは主として、牛・豚の飼育、作物栽培、食品工業、アルコール製造から出る廃棄物、生活排水、および排水沈殿物の処理過程で発生する。

近年ロシアで形成されてきた多様な農業生産形態と農業経営者の急速な成長は、操作が簡単な小規模バイオガス・システムの発展を促してきた。主なプラントはエコロス・カンパニーが設計した IBGU-1、BIOEN-1 で、後者は牛 25 頭を擁する農場を対象とした独立型バイオガス発電モジュールである。

IBGU-1 および BIOEN-1 とも工場組み立ての市販装置であり、IBGU-1 の据付は２～３日、BIOEN-1 の据付は７～10 日要し、双方とも稼働のために３～５日を要する。

ロシア連邦政府はバイオマスのエネルギー利用の重要性を認識しており、連邦プログラムでは 2003 年から 2010 年までに 152.02MW、2,753.74GCal のバイオマス利用エネルギー生産設備を導入し、標準燃料換算 686,370ｔを代替するとしている。

４．主なバイオマス利用エネルギー生産設備

①IBGU-1 INDIVIDUAL BIOGAS PLANT

IBGU-1 is intended for ecology-friendly processing of all kinds of organic waste from a farm with five-six cattle head or 50-60 pig head or 500-600 poultry head for obtaining gaseous fuel (biogas) and organic fertilizers.

Biological, thermophile, and methane-generating processing of organic wastes yields efficient ecology-friendly liquid organic fertilizers. Those fertilizers contain mineralized nitrogen as ammonium salts (nitrogen form most easy for assimilation), mineralized phosphorus and potassium, other macro- and microelements required for plants, biologically active substances, vitamins, amino acids, soil-structuring humus-like compositions.

One ton of such fertilizers is equal by effect to 80-100 tons of the initial manure raw or other organic substances.

The plant processes daily from 50 to 200 kg of organic wastes of at least 85% humidity (manure, feces, plant remains, solid domestic wastes). Such a system helps fully solve the problem of removal, neutralization, and processing of farm wastes.

The daily volume of biogas released makes up, depending on the amount of raw material charged, from 3 to 12 m^3 (composition: 55-60% of methane, 35-45% of carbon dioxide, no hydrogen sulfide). 1 m^3 of biogas is equal to 0.6 m^3 of natural gas, 0.7 l of black oil, 0.4 l of gasoline, 3.5 kg of firewood, 12 kg of manure briquettes.

The initial raw humidity shall be 85% at least and 93% at most.

As raw materials for uninterrupted operation of the biogas and fertilizer plant use can be made of all organic wastes of the plant and animal origin formed at farms, namely:

- Cattle manure from two (50-60 kg daily) to six head (200 kg daily), manure from small cattle and pigs (from 20 to 60 head), poultry droppings (from 200 to 600 head);
- Plant remains: leafy tops, grass, straw, corn and sunflower stems etc.;
- Solid domestic wastes: paper, cardboard, textile, food remains.

The IBGU-1 set includes as follows:

- Bioreactor - methane tank, 2.2 m^3 volume;
- Wet-type gas holder, 3 m^3 volume;
- Trestle with ladder;
- Trolley with bucket;
- Manual hoisting device;
- Fertilizer storage tank.

The IBGU-1 is factory-assembled commercial equipment rated for operation in any climatic zone. At the extreme subzero temperatures it is recommended to locate a bioreactor indoors for convenience of operation and reduction of heat losses.

Russia fabricated and realized 55 sets, Kazakhstan, 10 sets.

Service period: 10 years (at least).

IBGU-1 estimated cost: $5,000.

Organizations:

Designer:
EcoRos Company
74, bldg. 4, office 75, Leningradsky Prosp, Moscow 125315, Russia
Tel/fax: (095) 152-67-55, 147-36-69
E-mail: ekoros-zao@mtu-net.ru

②BIOEN-1 AUTONOMOUS BIOENERGY MODULE FOR FARMS

The BIOEN-1 module processes organic wastes from 25-30 cattle head or 250-300 pig head or 2,500-3,000 poultry head and operated in the autonomous mode independent of centralized power supply sources.

The module equipment set includes as follows:

- Two bioreactor - methane tanks, 5 m^3 volume each;
- Wet-type gas holder, 12 m^3 volume;

At the customer's request, the module can be equipped with the following facilities:

- Biogas heat generator, 23 kW power;
- Electric generator, 4 kW power;
- Household biogas stove;
- IR biogas burners, 5 kW power.

Specifications:

- Area heated by BIOEN-1: from 150 to 200 m^2;
- Daily output of organic wastes processed (of 85% humidity): up to one ton;
- Daily output: up to 40 m^3 of biogas (60% of methane), up to 80 kW-hr of electric power, up to 230 kW-hr of thermal power;
- Daily output of organic fertilizers: one ton;
- Internal energy demands for maintaining the thermophilic process: 30%.

The BIOEN-1 module can be assembled into two-, three- and four section batteries for processing wastes from:

- 50, 75, and 100 cattle head;
- 500, 750, and 1,000 pig head;
- 5,000, 7,500, and 10,000 poultry head.

Service life: 10 years (at least).
Pay-back period for realized fertilizers or extra crop: from half a year to one year.

The BIOEN-1 module can operate in any climatic conditions.

BIOEN-1 estimated cost: $35,000.

Organizations:

Designer:
EcoRos Company
74, bldg. 4, office 75, Leningradsky Prosp, Moscow 125315, Russia
Tel/fax: (095) 152-67-55, 147-36-69
E-mail: ekoros-zao@mtu-net.ru

③BEU-2.5 – BEU-20 BIOENERGY PLANTS

Bioenergy plants with the bioreactor working volume ranging from 2.5 to 20 m^3 are intended for processing organic effluents of stock breeding and plant growing into liquid organic fertilizers, as well as into combustible gas and thermal energy.

Plants with up to 10 m^3 working volume of the bioreactor serve for processing wastes from small- and medium-size farms. The BEU-10 – BEU-20 plants are also used as an element of big biotechnological complexes, for developing waste processing technologies and using the products obtained, for personnel training, and for preparing biological ferments for the start of a big plant.

The humidity of raw loaded into the bioreactor depends on a kind of effluent and varies from 85 to 92%. Biomass loading/unloading are automated, mixing takes place in the continuous or discrete mode. The intensity of biomass mixing is regulated in a wide range allowing to monitor the gas release process.

The daily power consumption of the BEU plants does not exceed 2.5 kW-hr, labor consumption, from one to three man-hour.

The delivery set includes as follows:

- Bioreactor;
- Raw-loading pump;
- Automatically controlled gas water boiler;
- Heat insulation;
- Outdoor insulation enclosure (when placing BEU plant outside)
- Heat exchanger;
- Tank for fertilizers
- Documents set.

The plants are delivered with different versions of heat insulation:

- For regions with the hot climate and in case of BEU location in a heated premise;
- For regions with the moderate and cold climate.

The Institute-elaborated documents were used in fabricating and commissioning the BGU-5, BEU-10, and BEU-20 plants.

Basic characteristics of products made

Indicator		Unit of measurement	Quantity
Biogas composition	methane	%	60-70
	carbon dioxide		40-30
	other gases		1
Fertilizer composition	common nitrogen	% of wet mass	0.3-0.4
	ammonia nitrogen		0.15
	phosphorus oxide		0.04
	potassium oxide		0.15-0.3
	active growth stimulators of the auxin class	-	-

Main technical data of the plants

Designation	Daily capacity, m^3		Power, kW		Area occupied, m^2
	biogas	fertilizers	full	load	
BEU-2.5	8	0,5	1.9	1.5	9.5
BEU-5	15	1.0	3.8	2.5	15.0
BEU-7.5	22	1.5	5.6	3.5	20.0
BEU-10-1	30	2.0	7.5	4.6	24.5
BEU-10				5.5	20.0

Main specifications of bioreactors

Designation	Dimensions, mm		Weight, kg
	length	height	
BEU-2,5	1,600	1,600	250
BEU-5	3,000		430
BEU-7,5	4,400		610
BEU-10-1	5,800		810
BEU-10	3,000	2,050	1,070
BEU-15	4,400		1,320
BEU-20	5,800		250

Organizations:

Designer:
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④BGU BIOGAS PLANTS

Biogas plants are intended for ecology-friendly treatment of organic wastes and obtainment of gaseous fuel (biogas).

Plant models:

- BGU-0.1 – laboratory plant. Seven plants manufactured
- BGU-2.0 – plant for small farms (processing of manure from three cattle head). Three plants manufactured.
- BGU-25 – plant for farms (processing of manure from 25 pig head). Seven plants manufactured.
- BGU-50 – plant for farms (processing of manure from 45-50 pig head). Two plants manufactured.
- BGU-150 – modernized plant for farms (processing of manure from 400 cattle head).
- BGU-500 – plant for farms (processing of manure from 24,000 pig head. Four plants manufactured.

BGU-150

BGU-500

BGU specifications

Model	Quantity and volume of reactors, m^3	Raw processed	Daily output by initial raw, t	Total daily release of biogas, m^3	Estimated cost, $
BGU-2,0	1x2,0	Cattle manure	0,1	1.5	1,800
BGU-25	1x25	Pig manure	1.5	20	8,400
BGU-50	1x50	Pig manure	3.0	40	13,500
BGU-150	2x150	Cattle manure	25	300	67,500
BGU-500	4x125 1x500	Cattle manure Pig manure	40 100	400 450	152,000

Organizations:

Designer:
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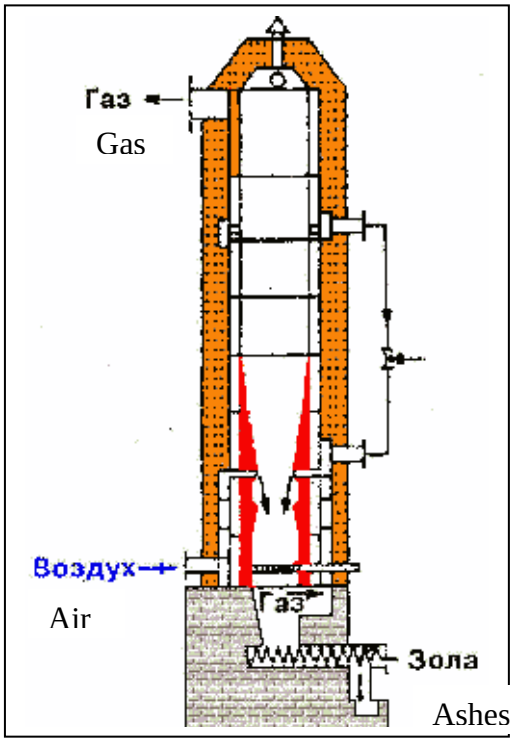
⑤THERMOCHEMICAL GAS GENERATORS

Biomass processed in a gas generator yields gaseous fuel practically free from active admixtures of pyrolysis resins and acids, which can be combusted without additional purification in fire chambers of steam and water boilers, in various heating and drying facilities, in stationary power-generating internal combustion engines, by public services supplying heat and hot water to apartments.

The initial raw for gas generators can be any organic waste: wood chips, bark, agricultural and domestic wastes.
The gas obtained features a high calorific effect (8.5 m^3 of generator gas are equivalent to 1 kg of black oil). As against direct combustion of solid fuel. The use of generator gas is a more pure process from the environmental point of view.



Specifications:

Rated power, MWt	Rated dry gas release, m^3/h	Raw (wood waste)		Shaft height, m	Shaft inner dimensions, mm	Rated air consumption, m^3/h
		Consumption, kg/h	Humidity, % (max)			
0.1	70	40	35	1.8	200x400	45
0.6	500	380	50	5.0	∅ 950	350
1.0	850	750	55	6.0	∅ 1,130	600
3.0	2,500	2,200	60	8.0	800x2,500	1,900

Technical documents have been elaborated for gas generators of 100, 200, 600 kWt and 3 MWt rated power. Gas generators of 600 kW and 3 MW have been tested on various kinds of plant biomass (peat, wood chips, forest residue, domestic and agricultural waste, e.g. sunflower husk).

Burners for combusting generator gas have been elaborated and certified.

A gas generator, 3 MW power, operates at the Pologi Oil Extraction Plant (Ukraine). Gas generators of 100 and 600 kW power can be seen at the demonstration gas generation plant in St. Petersburg.

UTG-600 gas generator

The UTG-600 gas generator is intended for thermochemical processing of plant raw, peat, brown coal agricultural and domestic waste into combustible gas. Gas obtained can be used as fuel in any power plant (furnaces of boilers, dries etc.), internal combustion engines, also as a power source in manufacturing processes.

The gas generator can operate on various kinds of organic raw, as follows: forest and sawmill residue (wood chips, bark, touchwood, sawdust), agricultural wastes, peat, shale, lignin, domestic wastes. The raw materials shall conform to the requirements given below as regards humidity, content of ash and fraction composition). The highest calorific effect of generator gas is achieved at the raw humidity of 28-30% (mass).
Some kinds of agricultural wastes (e, g. straw) and coals form ash with the softening temperature of 1100 °C and lower.
In gasifying such a raw material certain problems may arise regarding ash descent, that is why raw materials shall be checked for conformity to the above characteristic.

The generator shall be installed outdoors while the control panel, indoors. After being ignited with the aid of firewood (2 m^3), which takes from two to three hours, the generator shall be shifted to the basic fuel. The generator shall operate constantly, 48-h breaks without repeated ignition are admissible.

Specifications:

Rated power, kWt	600
Permissible range of power change, % of the rated	30-140
Initial raw relative humidity, %	up to 50
Maximal size of initial raw particles, mm	200
Permissible number of particles sized less than 2 mm in the initial raw, % (mass)	less than 25
Consumption of air fed to the gas generator, nm^3/h	100-600
Rated air consumption, nm^3/h	300-400
Fuel consumption in terms of dry mass, kg/h	100-600
Gas generator working pressure, kPa	102-150
Gasification chamber temperature, °C	500 1,100
Lowest combustion heat for generator gas, MJ/ nm^3	4-6
Generator gas humidity, % (mass)	up to 25
Dry gas consumption, nm^3/h (rated mode)	600
Maximal ash content in the initial raw, %	5
Thermal efficiency factor, %	85
Gas generator dimensions, mm	5,240x3,100x3,040
Design weight of metal structures, t	8.5
Consumed power, kW: o in the operation mode o during startup	 up to 15 up to 30

Organizations:

Designer:
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５．ロシアにおける潮汐エネルギー利用

今世紀に大規模な利用が予想される潮汐エネルギーは、今日の電力消費の 15%をカバーすることが可能である。潮汐発電プラント（以下 TPP とする）は有害放出物を大気中にばら撒かず、土地を水没させる必要もなく、火力、水力、原子力発電と違って人間には何の害ももたらさない。しかも生産する電力のコストは最も安い。

ロシアにおける潮汐エネルギー利用は 60 年以上の実績がある。最初の潮汐発電プラントであるキスログブスカヤ TPP は 1968 年に操業を開始した。

現在ロシアではオホーツク海においてタグルスカヤ TPP（8.0 GW）およびペンジンスカヤ TPP（87 GW）の２つのプロジェクトが推進中であるが、これは南東アジア地域へのエネルギー供給において電力が不足しているためである。白海に建設予定のメゼンスカヤ TPP（11.4 GW）で生産する電力は東西統合送電システムを経由して西欧に移送することも可能である。

最初にキスログブスカヤ TPP の建設に用い、その後サンクトペテルブルグの止水ダム建設に用いた浮揚技術は、ダムをベースとした古典的な建設技術と比較して投下資本額を三分の一まで削減することができる。

世界で最初の潮汐発電所であるランス（フランス）TTP およびキスログブスカヤ TPP の 35 年にわたる TPP 運転の経験から潮汐発電プラントの以下の特質が明らかとなった。

- エネルギーシステムの中で、定格の負荷においてもピーク時の負荷においても安定操業ができ、月間電力生産量が保証されている。
- 火力発電と異なり、大気を汚染しない。
- 水力発電と異なり、国土を水没させる必要がない。
- 原子力発電と異なり、危険性がない。
- ノーダム浮揚技術と効率のよい新式直交水力ユニットを使用するため、TPP に対する建設投資額は水力発電プラント建設に要する投資を上回ることはない。
- 電力原価は最も安い（35 年間にわたるランス潮汐発電所の稼働で証明された）。

ロシアでは TPP プロジェクトの有効性は、バレンツ海の特別海洋科学基地（キスログブスカヤ TPP）において行われた海洋資材、建設、設備、防錆技術調査により実証された。

ロシアにおいて新しく効率的かつ容易に製造できる直交水力ユニットが開発されたことにより、TPP 建設コストの大幅な削減が可能となった。

ロシアにおける潮汐エネルギー利用の主要研究機関は、ハイドロプロジェクト研究所、パワーストラクチャー研究所（RIPS）である。

上記研究所では、極北を含む陸上および大陸棚の発電と水力構造物に関する総合的研究開発を推進し、潮汐発電の優位性を最大限に利用している。

６．ロシアの潮汐発電プラント

①KISLOGUBSKAYA TPP (acting)

The experimental Kislogubskaya TPP located on the Barents Sea coast, near the settlement of Ura-guba (90 km from Murmansk) serves as research base of RIPS. Since 1968, the plant is part of the KolaEnergo Company ascribed to the Tulomsky hydropower plant system.

The plant making use of the tidal energy has one enclosed reversible unit, 400 kW installed capacity, of the French make. The power plant is used by the RIPS and HydroProject institutes for researches.

The TPP territory is also used for researches carried out by the Polar Institute of Oceanology and Fishery and by one of hydrometeorological stations of the Murmansk Region.

The floating powerhouse of the Kislogubskaya TPP prior to hauling

At present, the Kislogubskaya TPP is being reconstructed.

②MEZENSKAYA TPP (projected)

General

The Mezenskaya TPP (projected) shall be located on the White Sea coast, in the Mezensky Bay accumulating the basic resources of tidal energy in Russia's European part, the tide height reaching 10.3 m.

A section jutting out to sea most of all was chosen as the basic one for locating the TPP powerhouse and the spillway dam in natural depths. The area of a basin cut off by the future dam is 2640 km^2. The would-be capacity of the TPP was estimated at 11.4 GW. Power generated will be sold on home and foreign markets of the North-West region, in Russian and EC power systems.

Facilities

The powerhouse is designed as 150 floating units of the thin-walled cell structure. The spillway dam is made from 172 floating units with four bottom conduits in each. The left- and right-bank dams of the 53.2 km total length at the depth of up to 10 m, are made with sides fastened with floating reinforced concrete slabs. The dam also accommodates a ship lock and fishways. The validation of reliability and strength of the floating units operating under the combined load was based on the calculation of their mode of deformation, taking into consideration the 30-year operation of the Kislogubskaya TPP powerhouse and experience gained while constructing the St. Petersburg check dam.

“Polar” concrete

While erecting the TPP structures use will be made of the non-fouling ice-resistance frost-proof concrete. Ice and seawater exert on TPP structures quite a number of various impacts (mechanical, physical, chemical, and biological) leading to concrete destruction. Concrete for the Mezenskaya TPP was elaborated upon a thorough analysis of various concrete grades on marine benches of the Kislogubskaya TPP in the Barents Sea.

The frost-proof concrete applied during the Kislogubskaya TPP construction has not shown any destruction during the 30-year operation period, and the concrete strength has reached 60-87 MPa against the design value of 40 MPa.

Floating technology of construction

The Mezenskaya TPP shall be built by using the dam-free floating technology. A period of construction is specified as eleven years, the primary units are to be commissioned in seven years.

The floating technology first applied while constructing the Kislogubskaya TPP allowed one third cut of expenditure as against the classical dam-based method. Big floating units were based on those of the St. Petersburg check dam built in 1985 for protecting the city against floods.

Ice protection

Many-year investigations of the Mezen Bay and laboratory simulation of the TPP ice regime allowed to develop an anti-ice system including as follows: separate location of turbine passages and drain trunks, application of ice-resistance concrete, vertical head walls of at least 4 m thickness with ice-proof coating, removal of the penstock inlet from the head wall etc.

Development of a novel orthogonal unit

The RIPS-elaborated cross-flow (orthogonal) turbine as an alternative to axial-flow Kaplan turbines (traditional for TPP) was proposed as the base turbine for the Mezenskaya TPP. Owing to the two-way operation and a 1.4 time higher idle capacity (vs. axial-flow machines), the annual power output at a TPP with orthogonal turbines is equal to that with the axial-flow SEW turbines though the efficiency factor of orthogonal turbines is lower. It should be noted that with the equal number of spillway openings the value of TPP installed capacity and throughput are almost the same. With the equal diameter of the turbine water wheel the total weight (and, hence, the cost) of orthogonal units is 2.2 times reduced as against the SEW units. The amount of concrete in the TPP powerhouse with orthogonal hydraulic units is less by 12%. But the main advantage of orthogonal turbines is a simple geometry of blades allowing their lot production in any engineering shop. Applying the orthogonal units not only decreases the mass and cost of power equipment but also helps solve the basic problem of TPP construction: the necessity of using a great number of expensive hydraulic units.

③TUGURSKAYA TPP (projected)

General

The TPP location: Russia, Tugursky Bay, south part of the Sea of Okhotsk, not far from Nikolaevsk-on-Amur, 600 km from Khabarovsk, 940 km from Japan.

The bay natural conditions favoring the construction of a high-capacity tidal power plant are as follows:

- Average height of tide at the bay entry: 4. 74 m;
- The bay is protected by the Shantarskie Isles against strong winds and heavy ice of the Sea of Okhotsk;
- The area of the basin (if locating the TPP at the bay entry) is 1800 km^2, the bay width at the entry is 37 km, which allows accommodating there about 1,000 of hydraulic units of 7-9 MW capacity.

The Russian model of using the tidal energy tested for over 30 years at the Kislogubskaya TPP enables efficient integration of intermittent but stable flows of tidal energy with those from other types of power plants.

Purpose of the project

- reduction of the production, transport and combustion of fuel for thermal power plants by seven million tons of equivalent fuel;
- annual reduction of atmospheric emissions in the Far East region by 17 million tons;
- provision of the region consumers, including those from the Republic of Korea, Japan, and China with cheap and reversible tidal energy.

Main indicators:

Installed capacity: 7980 MW;
Annual power output:- 20 billion kW-hr

The planned period of the TPP construction is eleven years, the first units being commissioned in seven years. The construction shall be carried on with the use of the advanced floating method (without dams) which shall enable transferring over 82% of the construction and erection job volume to the Nakhodka or Japan docks. The amount of investment shall be determined while concluding a respective contract.

Organizations:

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