Current state, practice and conditions for the implementation of RES projects in the Kyrgyz Republic

The Clinic Workshop "Renewable Energy in Central Asia: Potential for Small- and Medium-sized Solutions"

18-20 May 2022

Almaty, Kazakhstan

Funded by the European Union

WECOOP
EU – Central Asia Cooperation on
Water – Environment – Climate Change

Stantec ACTED

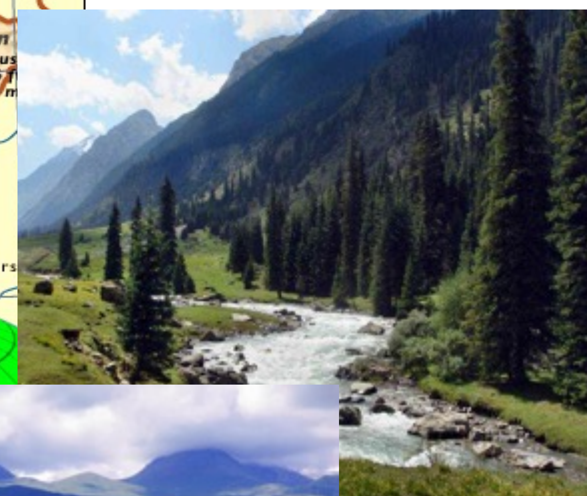
This project is implemented by the consortium led by Stantec, with ELLE (Estonian, La
Environment), ACTED, and Kommunal kredit Public Consulting as the consortiu

Brief information on Kyrgyzstan

Geographical position – 39-43 d.w.
Territory – 200 thousand sq.km,
95% - mountains
Population – 6,5 million
Density of population 20 persons\sq.km

Population – urban 40%
– rural 60%

Borders with: Uzbekistan, Tajikistan, Kazakhstan, China



Potential of renewables

Kyrgyzstan has a great potential of renewables. Utilization of this potential can increase the provision with indigenous energy resources and reduce dependence on imports. Available resources of renewable energy theoretically could cover 50,7% of required energy in Kyrgyzstan. The potential resources of renewable energy actually available at the current level of techniques development total 840,2 mln TOE yearly.

- **Solar energy (thermal) – 490000 MWh**
- **Solar energy (electric) – 22500 MWh**
- **Wind energy - 44560 MWh**
- **Small water flows - 80 bl. kWh**
- **Biomass - 1300000 MWh**

Can cover - 50,7 % of energy consumption in Kyrgyzstan

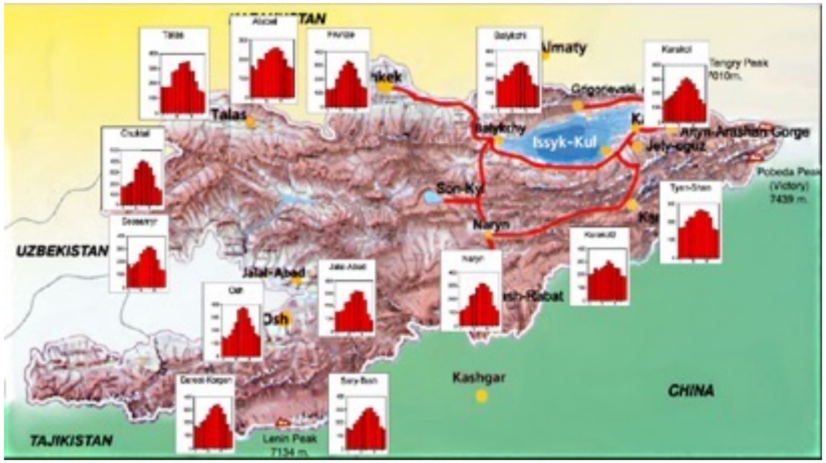
Technical potential - 20%

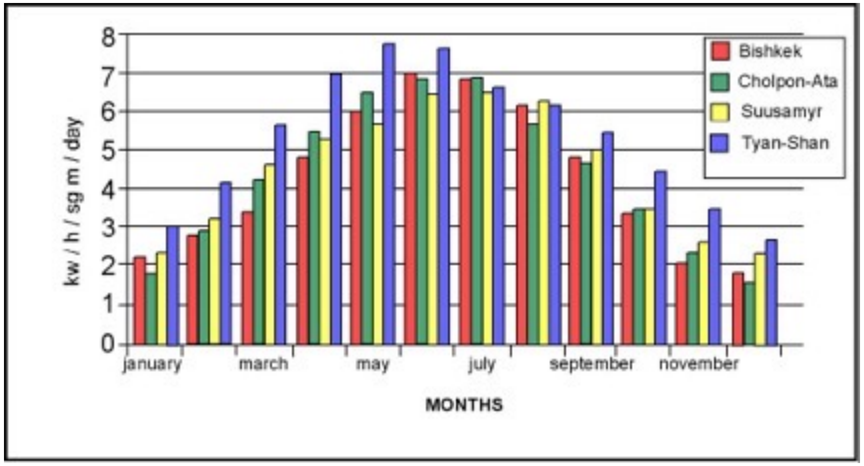
Economical potential - 5,6 %

Practical application – less then 1%

Solar energy

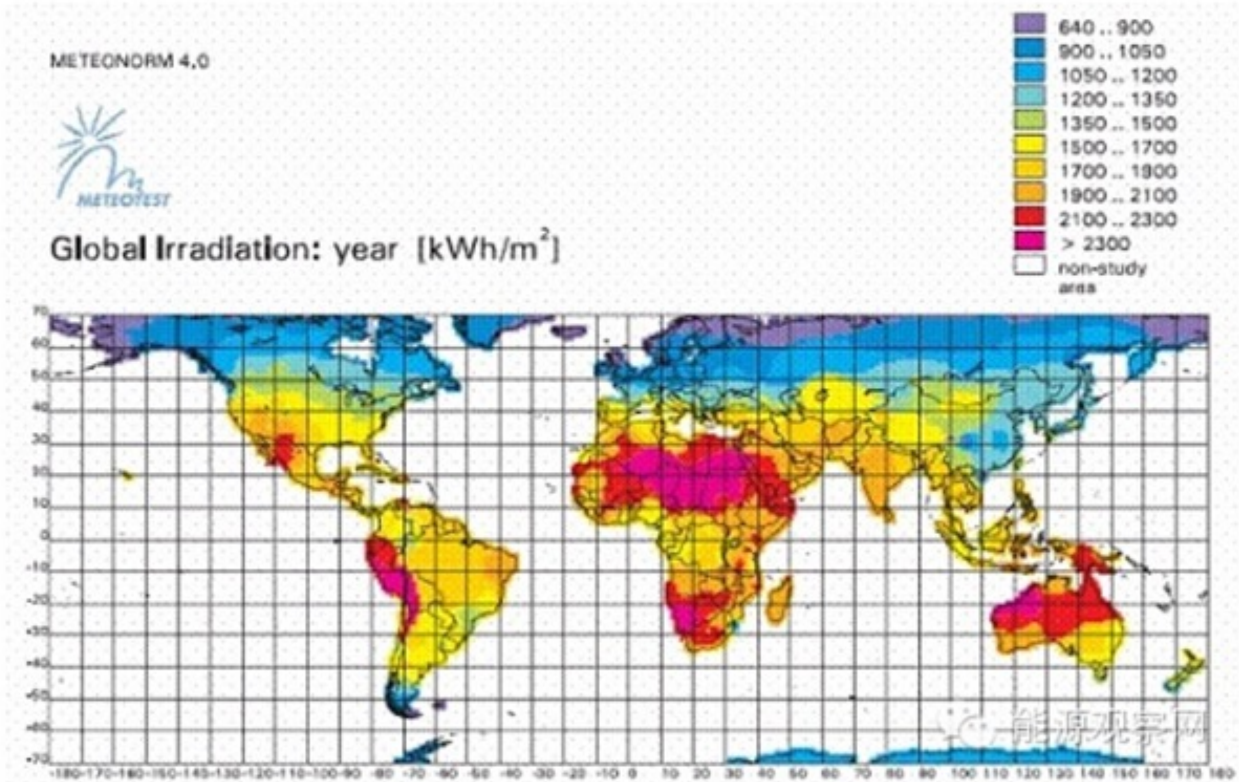
The year average amount of solar energy is about 2500 kW·h/m2. The average annual duration of solar radiance accounts for 2500-2600 hours. 1 m2 of solar thermal collector can provide 500-600 W/h in summer and 300-400 W/h in winter and can generate 1028-1278 kW·h of energy yearly. Yearly the following equipment could be produced: solar collectors - 100-150 th. m2, photovoltaic transducers - up to 3,2 MW.





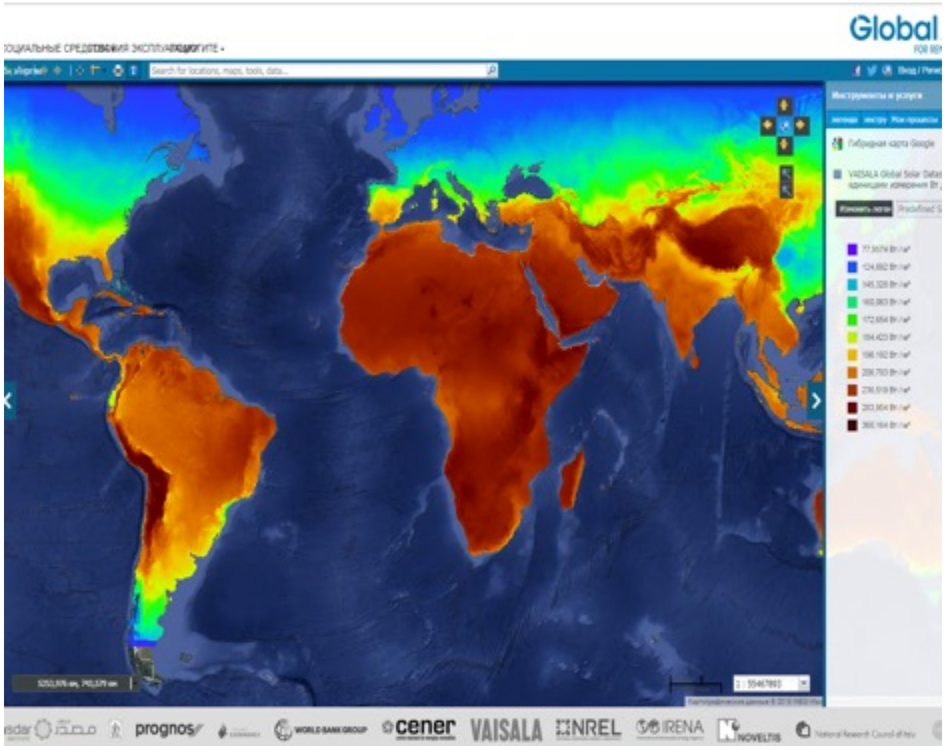
Ideal solar radiation resource

Month	Radiation (kWh/m²)
Jan	62.5
Feb	78.1
Mar	127.6
Apr	154.9
May	195.1
Jun	200.9
Jul	219.3
Aug	187.5
Sep	157.8
Oct	108.9
Nov	69.2
Dec	47.3
Annual	**1609.1**



- NOTE: The data in the left table refers to Meteonorm (Pvsyst).

Solar Resource Maps



Global data mapIRENA

General map of RES GIS WIER

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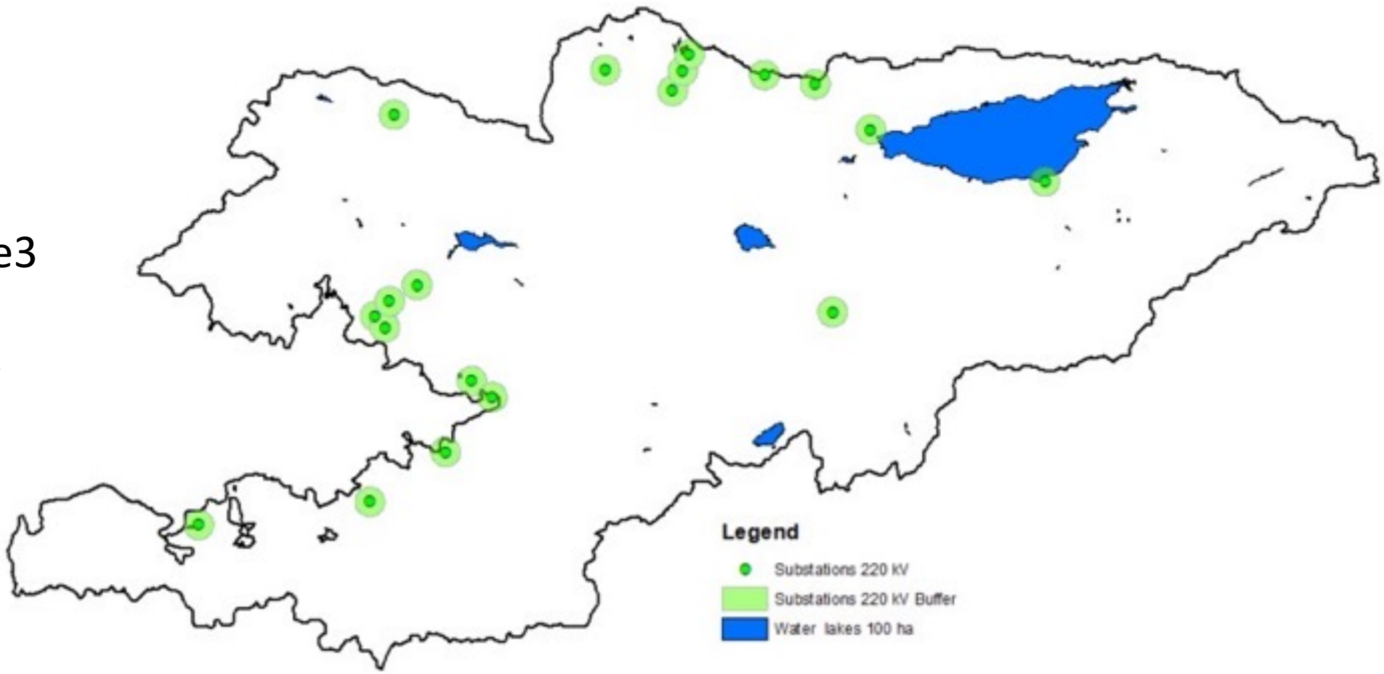
Scenario 2 outcomes (220 kV substations within a 10 km radius):

- Bazar-Korgon reservoir
- Ala-Archinskoe3 reservoir
-Ala-Archinskoe reservoir



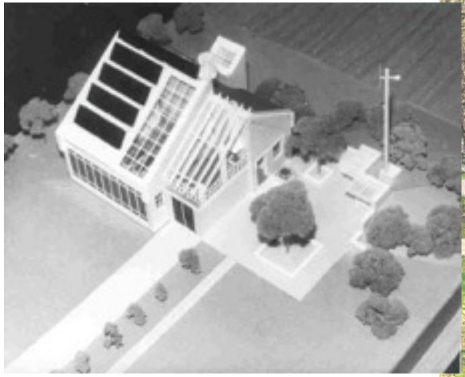
Scenario 2: location of 220 kV substations and lakes

SOLAR PROJECT PIPELINE IN KYRGYZSTAN

- GoKG signed Memorandum with Chinese company for 1,000 MW of SPP projects in Issyk Kul region
- GoKG agreed with Spanish company to implement 250 MW Solar project in Issyk Kul region
- MoE signed Memorandum with Masdar to build 500 MW of Solar projects in Issyk Kul region (EBRD will finance this project)
- WB agreed with MoE and is planning to initiate Scaling Solar program in KG for 500 – 1,000 MW solar, but will start with 100 MW Solar project

Developments

Various types of solar thermal collectors are developed: cellular solar collector, lamellate solar collector, plate-piped solar collector, bimetallic solar collector, solar collector with flat concentrators. Each product has its own characteristics and differs with correspondent design solutions. A series of solar water heating systems are elaborated: solar installation of individual use with combined storage tank, solar water heating installation of seasonal operation regime. Multicomponent air-water solar power installation has been developed jointly by the Kassel University (Germany) and the KSTU (Kyrgyzstan). The prototype was installed on a boiler-house "Rotor" located in Bishkek. The installation is able to convert the energy of two main sources of energy: solar radiation and ambient air enthalpy. Such solution allows the seasonal solar power installation to maintain operability in the nighttime.



Solar-air installation at the Rotor boiler house

Used to direct water in the Rotor boiler house in Bishkek

Solar system of Bishkekteploenergo

- In Bishkek, 364 flat solar collectors with a capacity of 1.4 kW / h each were experimentally installed on the territory of Bishkekteploenergo, each with a total capacity of 0.518 MW or 0.445 Gcal / h.
  At the same time, natural gas saving will amount to 124.8 thousand cubic meters per year for the amount of 2.2 million soms at the current tariff.
  "A total of Gagarin's boiler room is provided with heat energy bath No. 5, kindergarten No. 141, school № 55, PL № 20,94, 91; 34 personal accounts for residential users and 4 dormitories. "

- Customer -Bishkekteploenergo
- The amount of the contract is 470 thousand soms
- Timing
- Object - boiler room Rotor
- Design of flat solar collectors

The content of the work

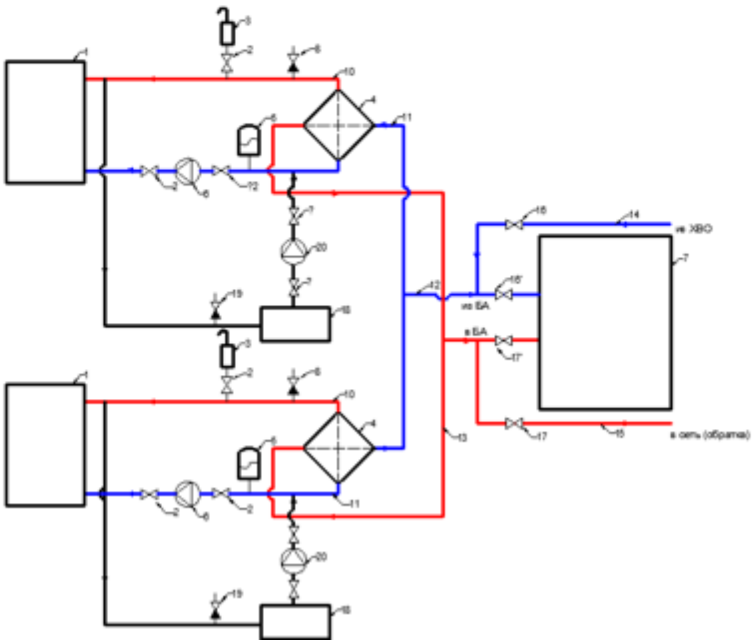
1. Rationale and choice of circuit diagram
2. General schemes for piping the collector field and heating networks
3. Thermal mechanical part
4. Power supply
5. Ecology
6. Draft design

Initial data

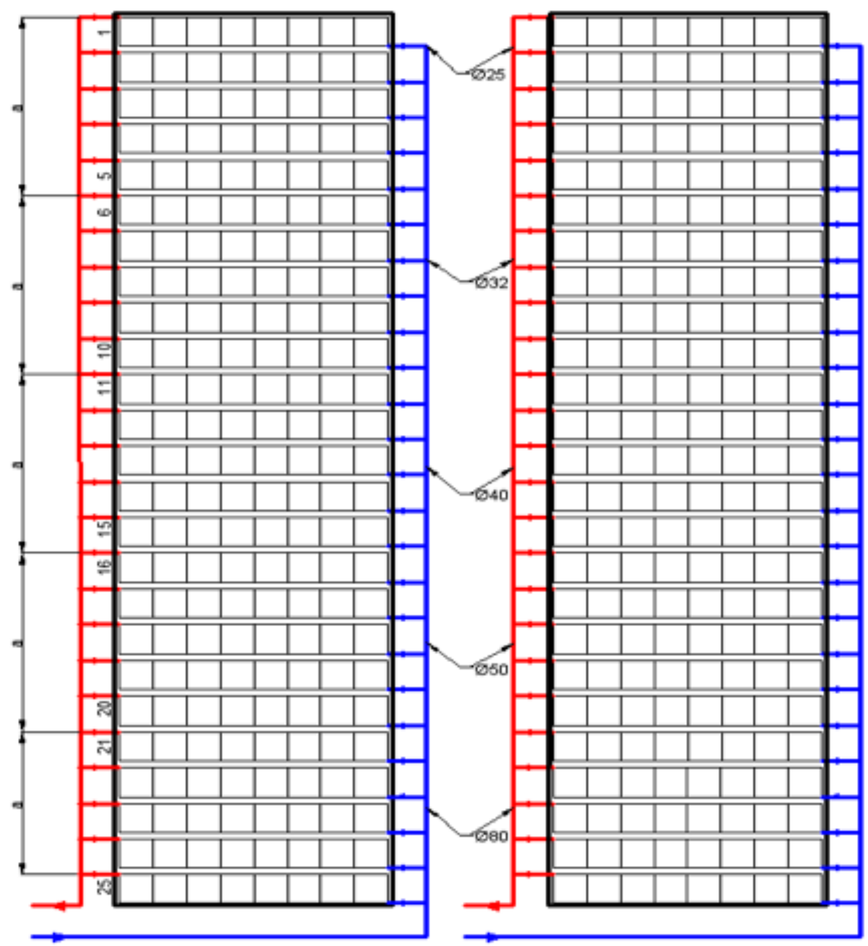
- Solar radiation intensity for Bishkek
- 500 collectors
- Temperature difference in high-speed heat exchanger 125 kW
- Reserve volumes of storage tanks 2*800 m^3

- The total installed capacity of the solar heating system is estimated at 1,750 kW, and the annual energy production, taking into account the average annual sunshine for Bishkek, is 4,637.5 MWh yeargн.
- The system makes it possible to save a significant part of the energy generated by solid fuel and, accordingly, to reduce CO2 emissions.

Schematic diagram of a solar installation



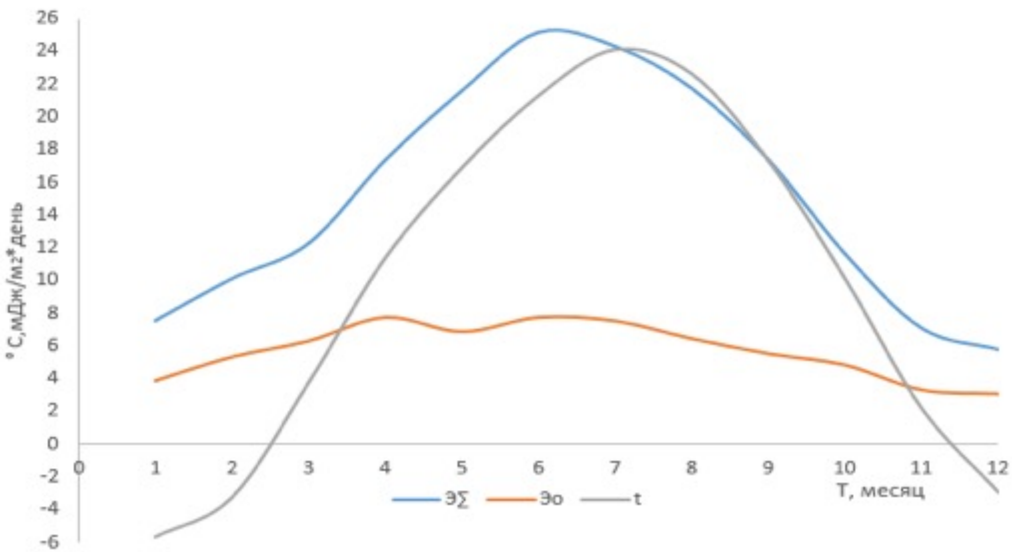
Scheme of piping of the collector field and heat networks



25 rows, two modules per row

25x16=400 pcs. collectors

Calculation and evaluation of the intensity of solar radiation,inter-row distances



$$\alpha = \varphi - |\delta_{cp}| = 42{,}8 - 12{,}5 = 30{,}3^{\circ}$$

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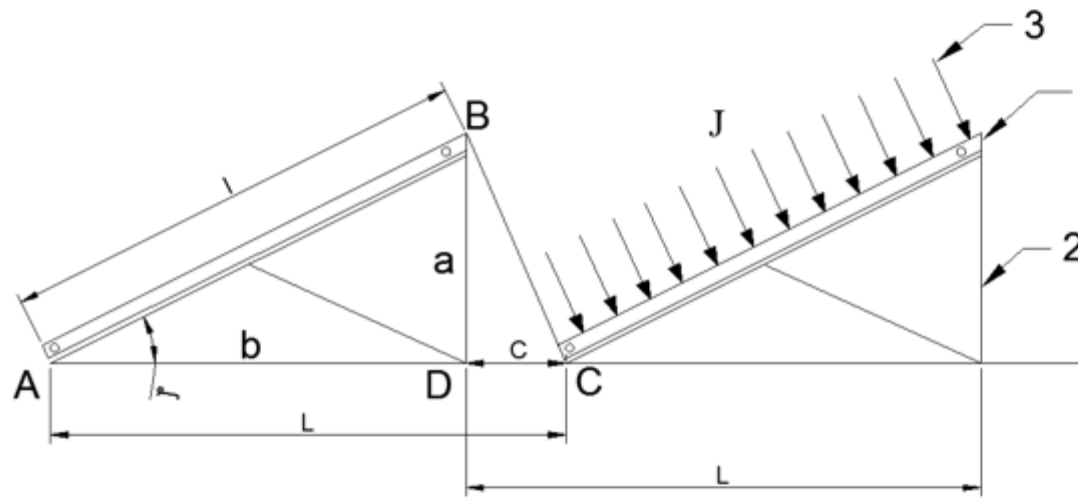

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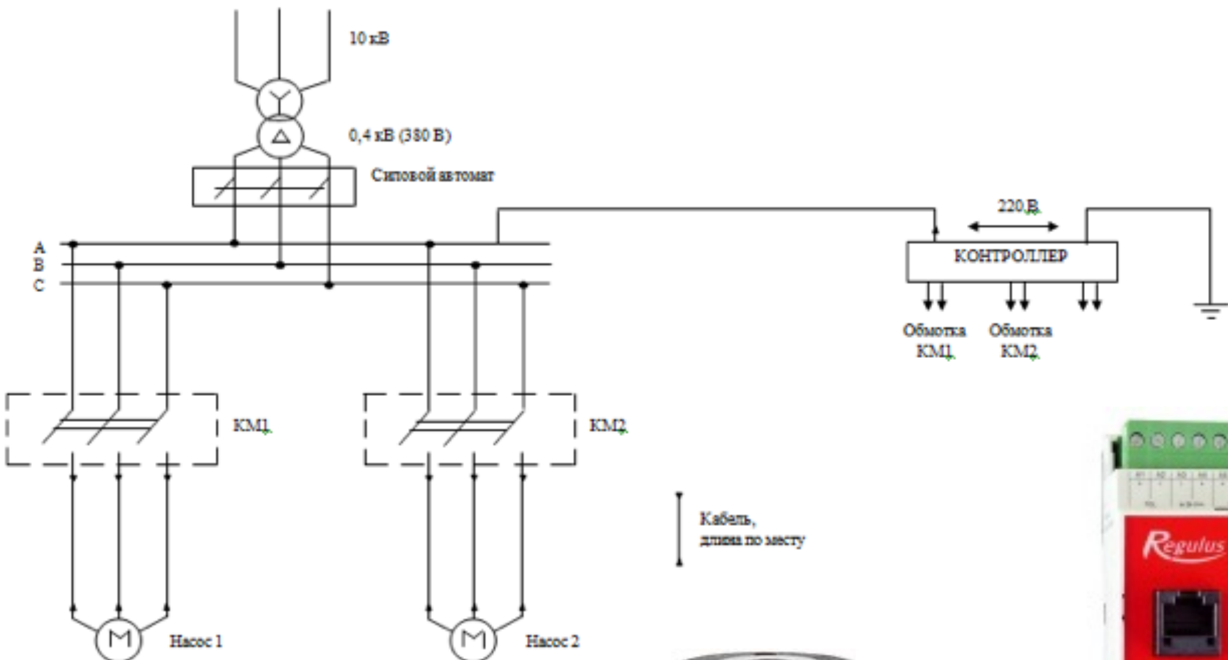
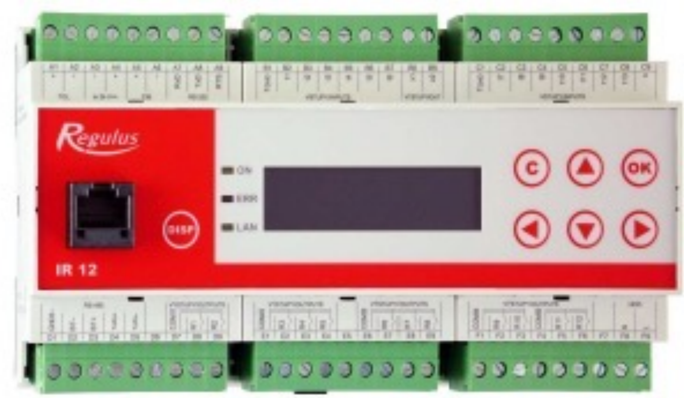
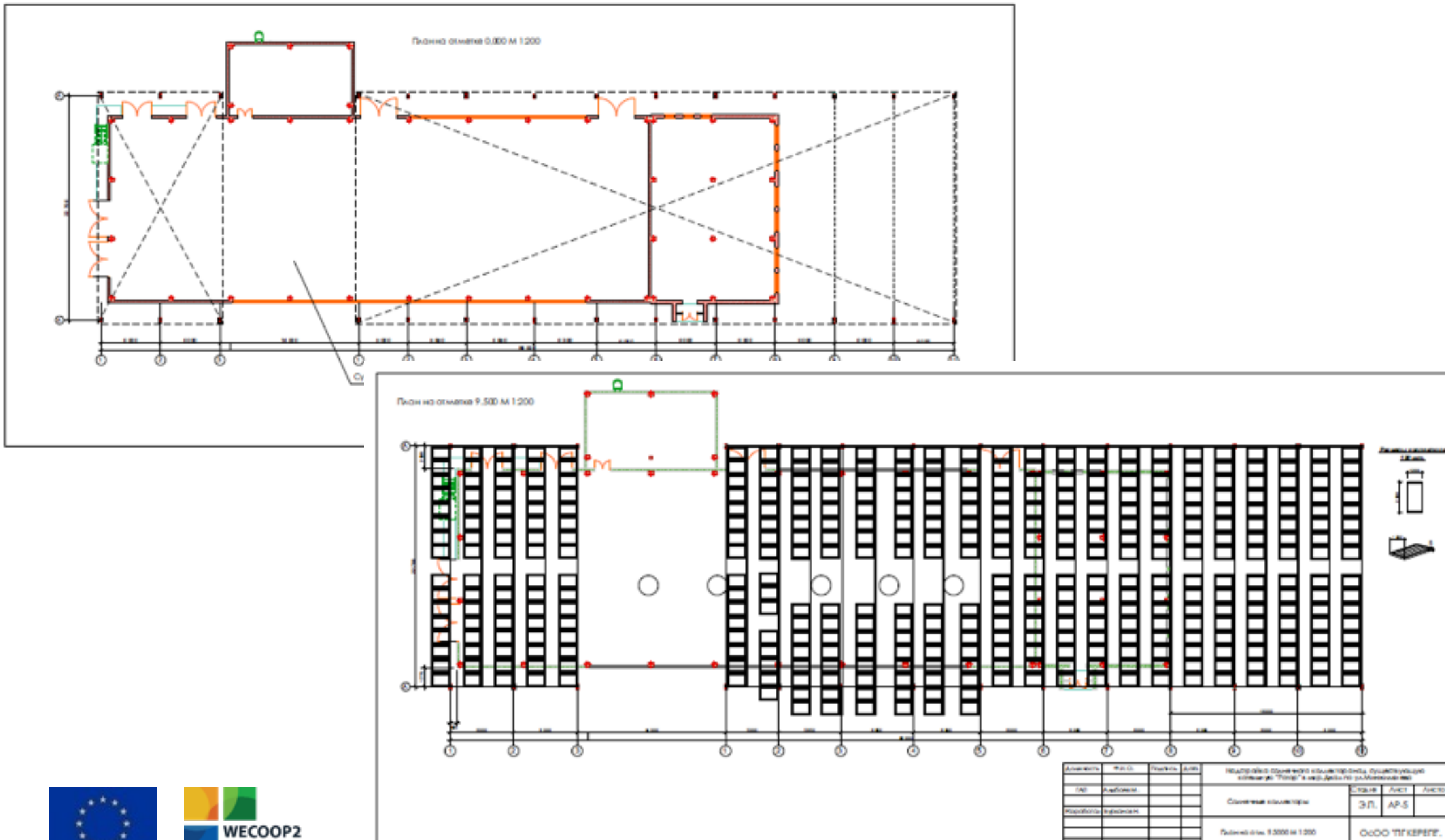
Power supply





Preliminary design



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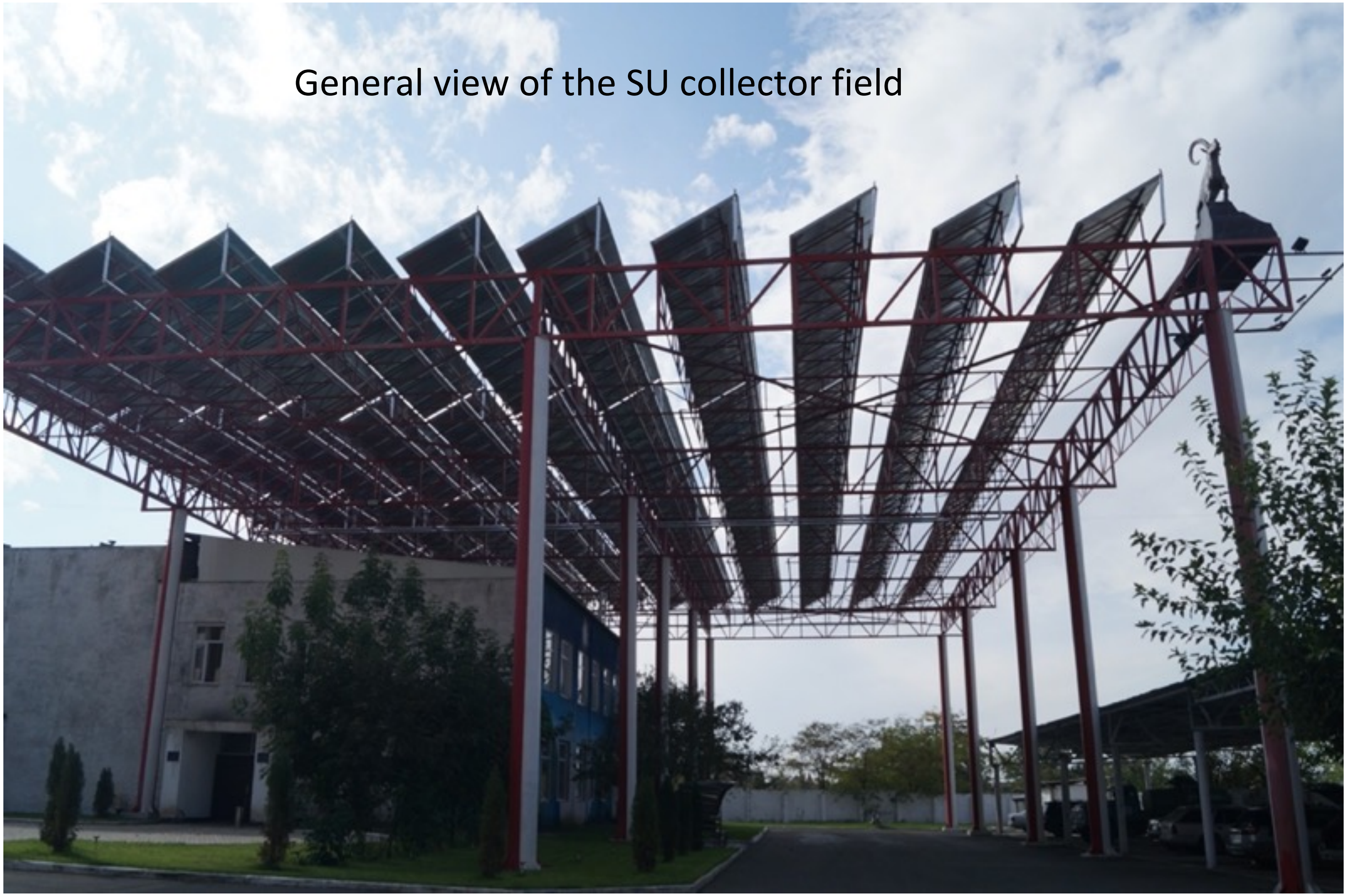

General view of the SU collector field

Elements of the supporting structure of the control room and the boiler room with a monitoring and control system

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Backup tanks accumulators

Jaamat village "1 May" with UNDP support in the Kyrgyz Republic
Settlement: village "1 May" with a population of 950 people; the total number of farmers grazing livestock on the jailoo is more than 800 people.

It is a part of the Suusamyr aiyl okrug

Lack of power supply in remote pasture pastures

Pump capacity	3 kW	5 kW	10 kW
Amount of solar panels	12×260 w	20×260w	40×260w
Mounting area	15 м²	30 м²	60 м²
Feed from the well (head 40м) *	80 м³ day	130 м³ day	260 м³ day
Feed from the pond (head 8м) *	150 м³ в day	250 м³ day	500 м³ day

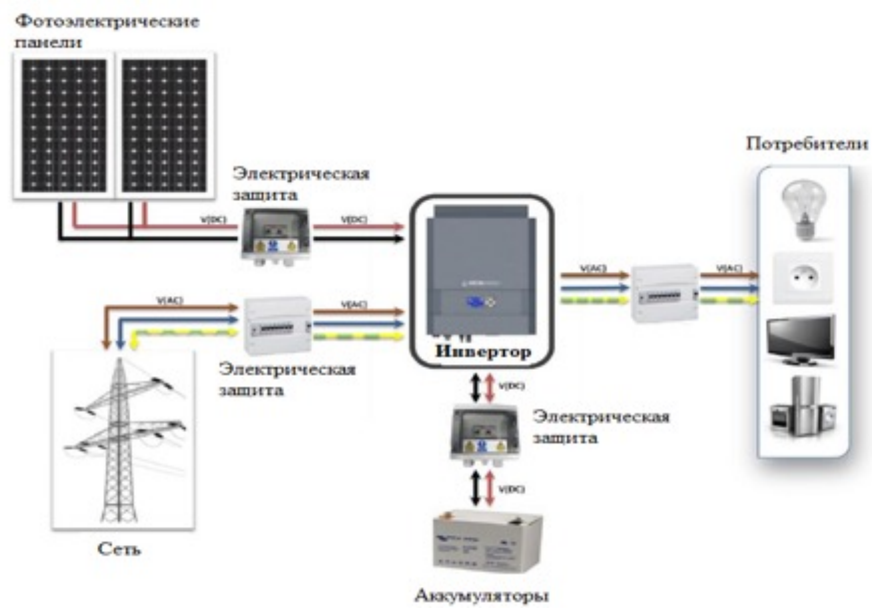
Current studies

- Pilot study – Smart grid testing VostokElectro

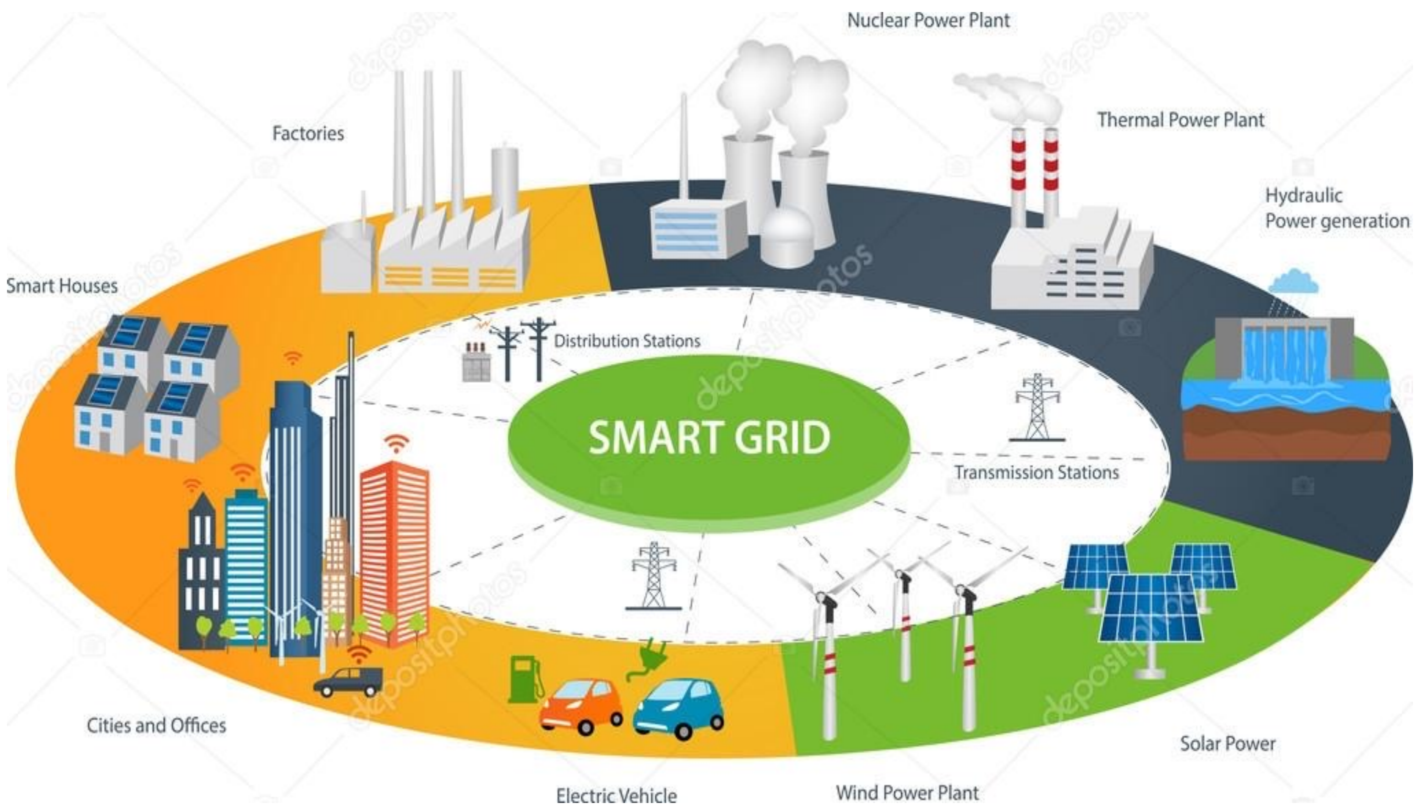
- Automation of power supply and power distribution systems in 10/0.4 kV networks (Smart Grid)
- Decrease in commercial and technical losses
- Improving the reliability, uninterrupted power supply to consumers and reducing the time and cost of switching production by automating processes
- Automation of monitoring parameters of the quality of electrical energy at distribution transformers
- Influence of the quality of electrical energy and voltage parameters on the level of electricity losses in medium and low voltage distribution networks are investigated
- Proposals were developed for the implementation of automation, voltage control and regulation devices at 10 / 0.4 kV transformers

Current studies

- Pilot study – Micro-grid
- creation of conditions for the transfer of electrical energy generated by Renewable Energy Sources (RES) to the electrical network at the level of Households
- Installation at one of the social institutions of Karakol, namely, the Municipal Kindergarten No. 3 located in the research project implementation area, the Solar Power Station (Solar PV Station) with inverter equipment for transmission of electricity generated by the Station to the electrical network (Grid Invertor) for 10-15 kw.



The use of renewable energy technologies in power distribution networks of 10, 0.4 kV - the construction of the concept of Smart Grid.

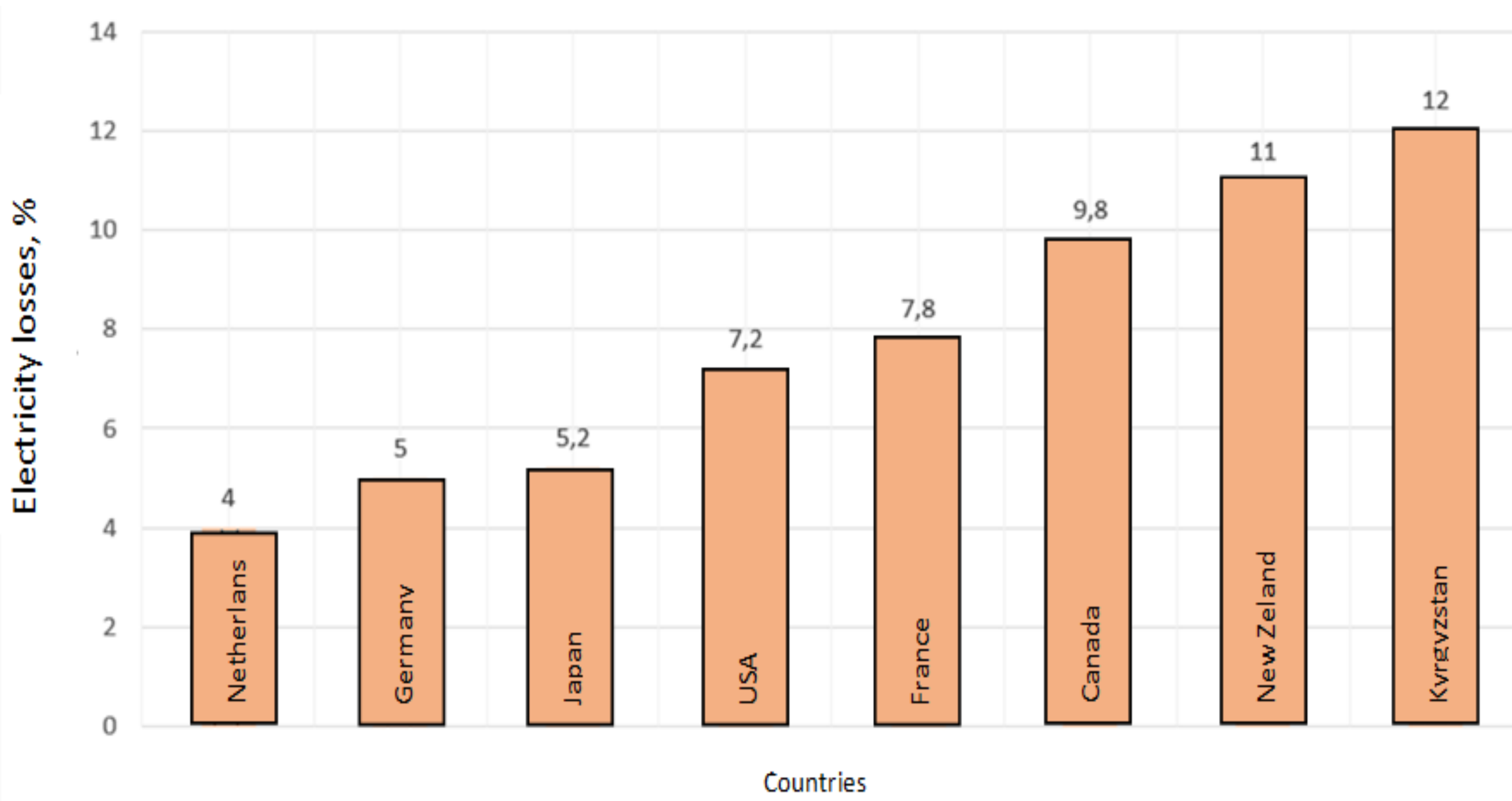


Total installed smart meters:

Total registered consumers - 1,248,200 subscribers.

Installed smart meters - 230,000 subscribers (20%)

Power losses



Electric energy quality parameters.

- Steady voltage deviation
- Sine Wave Voltage Distortion Factor
- Coefficient asymmetries voltages in reverse order
- Coefficient asymmetrie szero sequence voltage
- Frequency deviation
- Coefficient of the nth harmonic component (up to the 40th harmonic)
- Voltage swing
- Voltage dip duration
- Dose flicker
- voltage pulse
- Temporary overvoltage

Summary of major events and alarms at the pilot site.

Event	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019	April 2019	May 2019	June 2019	July 2019	August 2019
Total registered eventsand alarms.	1455	3895	1357	1473	913	580	805	2357	1898	378	510	574
Increased voltage on the phases.	266	1421	51	33	63	24	650	1774	697	246	27	313
Undervoltage on the phases.	fourteen	97	157*	783*	415*	481*	103*	130*	224	113	144	108
Lowvoltage quality	487	812	884	64	83	92	135	114	211	84	173	83
Limitationby power short-term power failures.	94	214	848	214	363	214	117	305	407	46	37	110
Other events	47	59	83	42	51	36	87	52	41	65	eighteen	26

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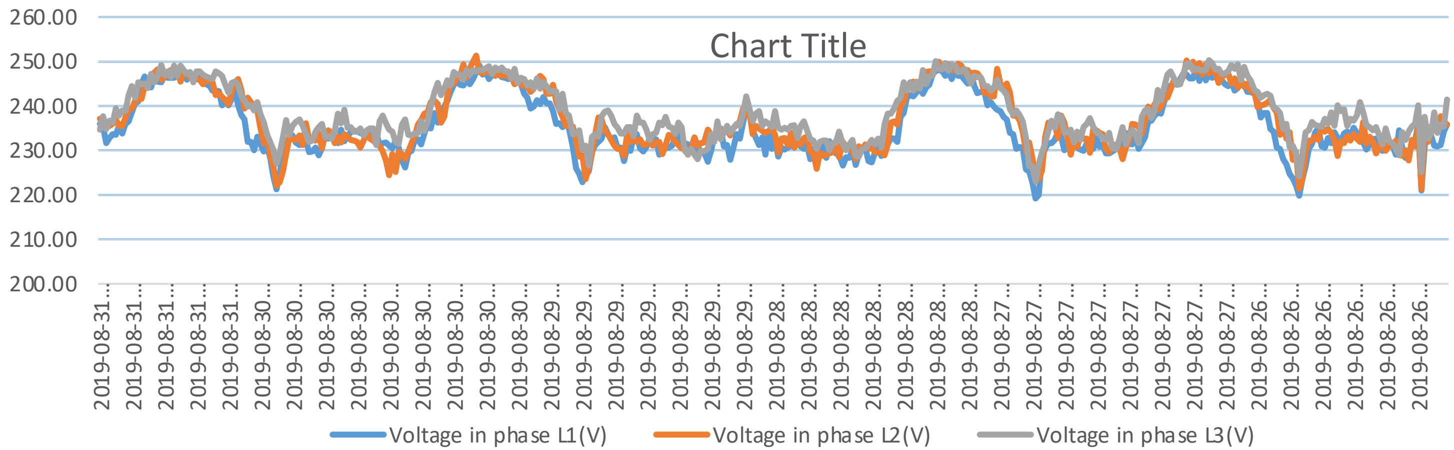
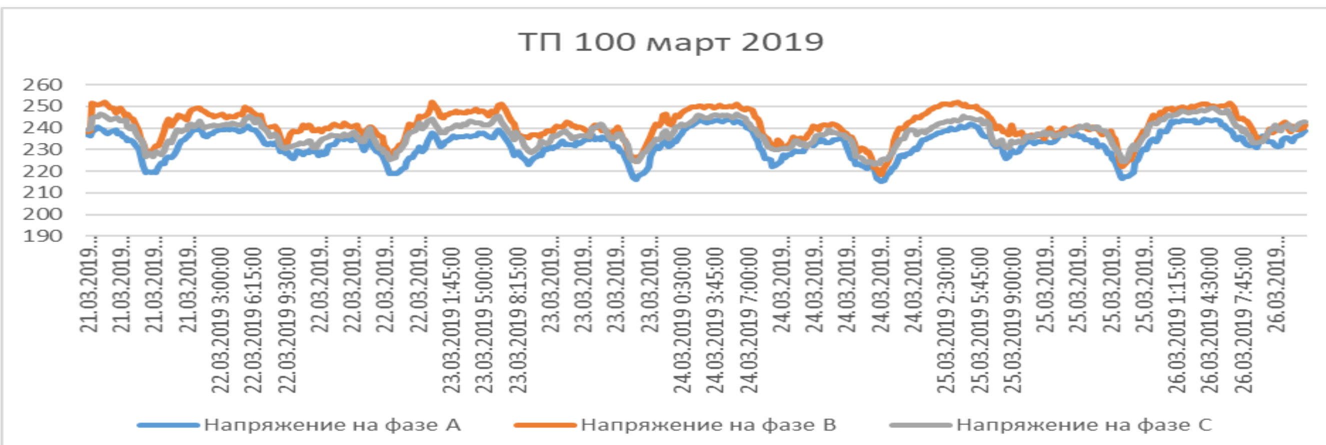
F- "Avtobaza" bus voltage TP 100





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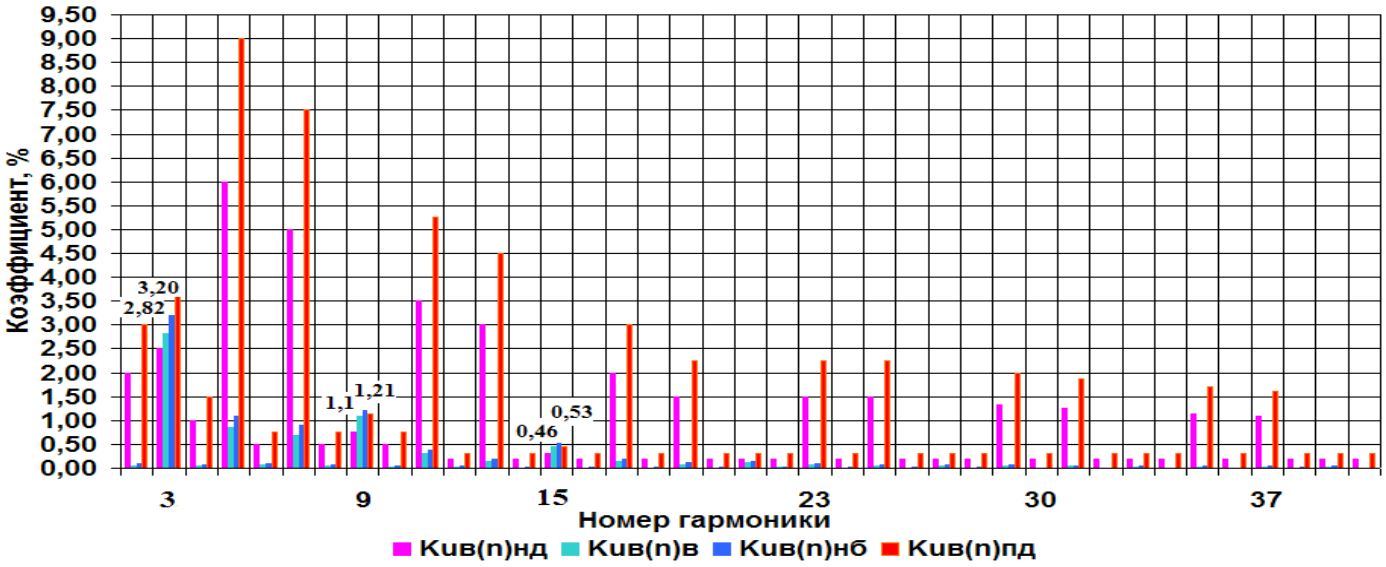
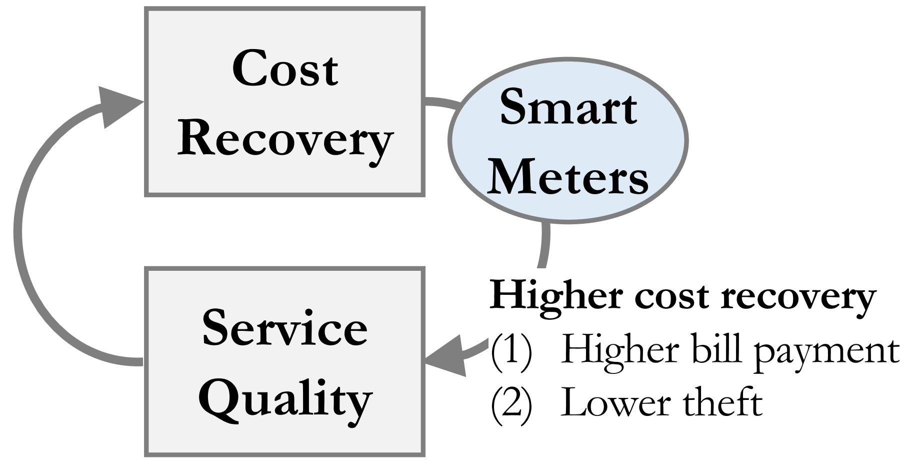
Coefficients of non-sinusoidal voltage and the influence of harmonics.



Can smart meters improve cost recovery?

Potential mechanisms:

- Meters better capture electricity consumption at low voltages
- Measuring electricity consumption in real time → faster, better identification of losses
- Disconnect/reconnect households remotely → improve payment enforcement



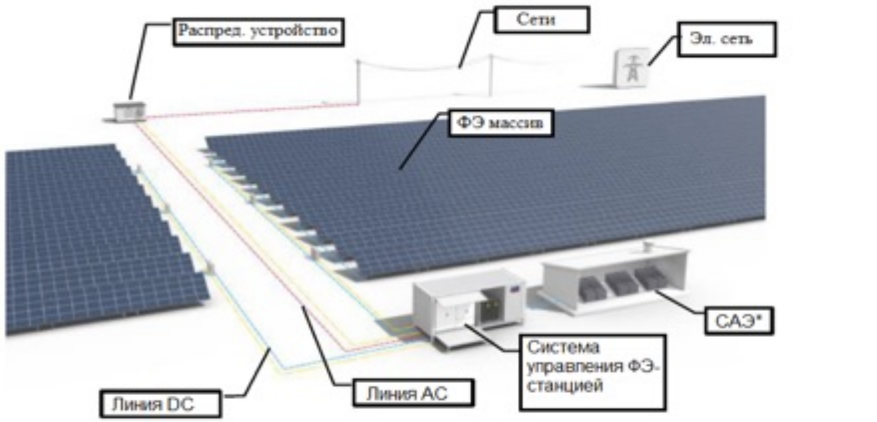
- **Development of a project proposal for the joint operation of the solar power plant with the power grid**

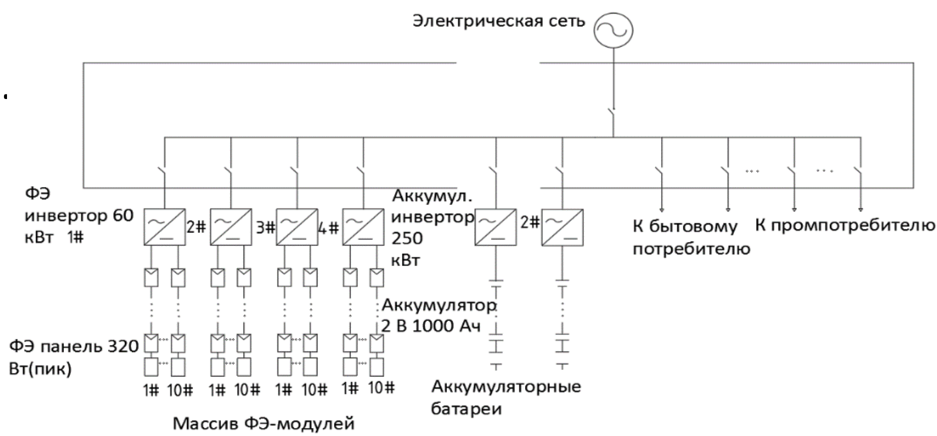
- **Synthesis of a hybrid circuit system of a photovoltaic power plant and micro-grid installations**

- **Feasibility study of project implementation and recommendations for the implementation of systems**

Synthesis of a hybrid circuit system of a photovoltaic power plant and micro-grid installations

- **network system microgrid**
- As a new technical solution for areas with frequent power outages in distribution networks, which is typical for Kyrgyz power system was developed and designed installation micro grid using photovoltaic converters and power storage system.
- During the design of the installation, an electrical circuit was worked out, consisting of a system of batteries with a total capacity of 1800 kWh, battery inverters with a capacity of 250 kW * 2, an array of photovoltaic panels with a total capacity of 256 kW (peak), inverters of 60 kW * 4.





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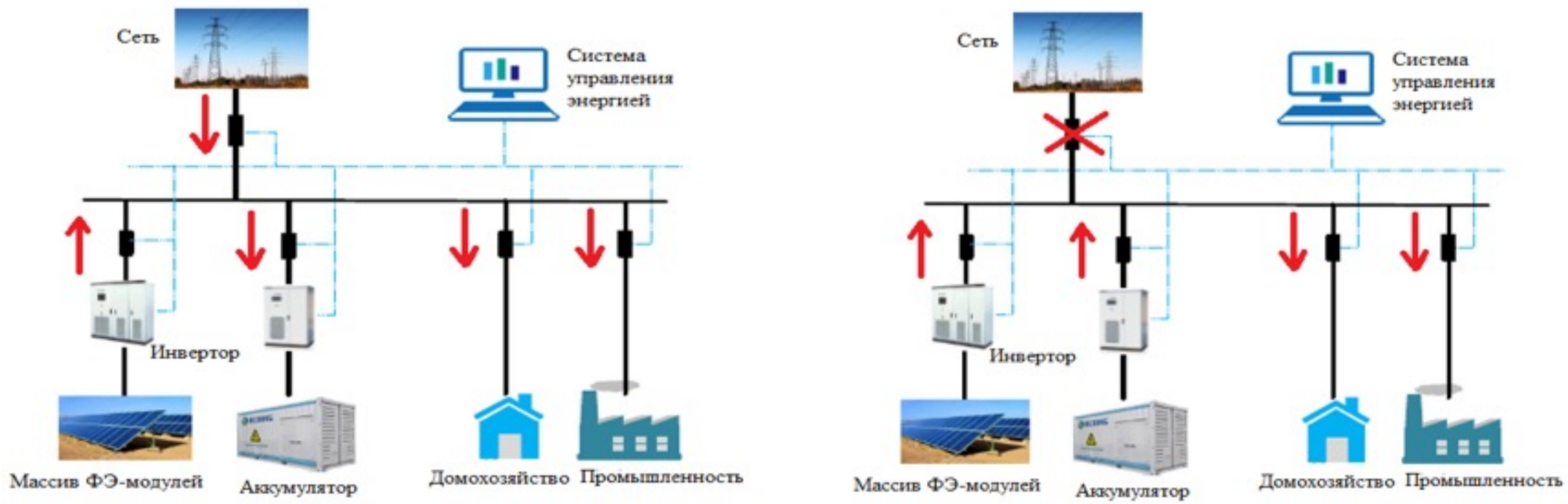
Synthesis of a hybrid circuit system of a photovoltaic power plant and micro-grid installations



- The purpose of the creation and application of the installation micro grid is an:
- - improved quality and reliability power supply consumers;
- - energy saving and reduction in the cost of electricity;
- - promotion and development of the use of RES.

Feasibility study of the implementation of projects and recommendations for the implementation of systems - on the example of a network FES

FES power	20 MWp
Estimated capital costs	24,220,000.00 USD
Estimated operating costs	400,000 USD/year
Feed-in Tariff (Tariff under the Electricity Sales Agreement (ESA))	0.194 USD/kWh for the first 6 years; 0.0324 USD/kWh from 7th to 15th year.
Estimated periodSRE	15 years
Electricity production for the 1st year	31,360,000 kWh
taxes	Import duty 0% VAT 12% Sales tax 3% Income tax 10%

- VNR = 5%;
- Payback period = 6 years.

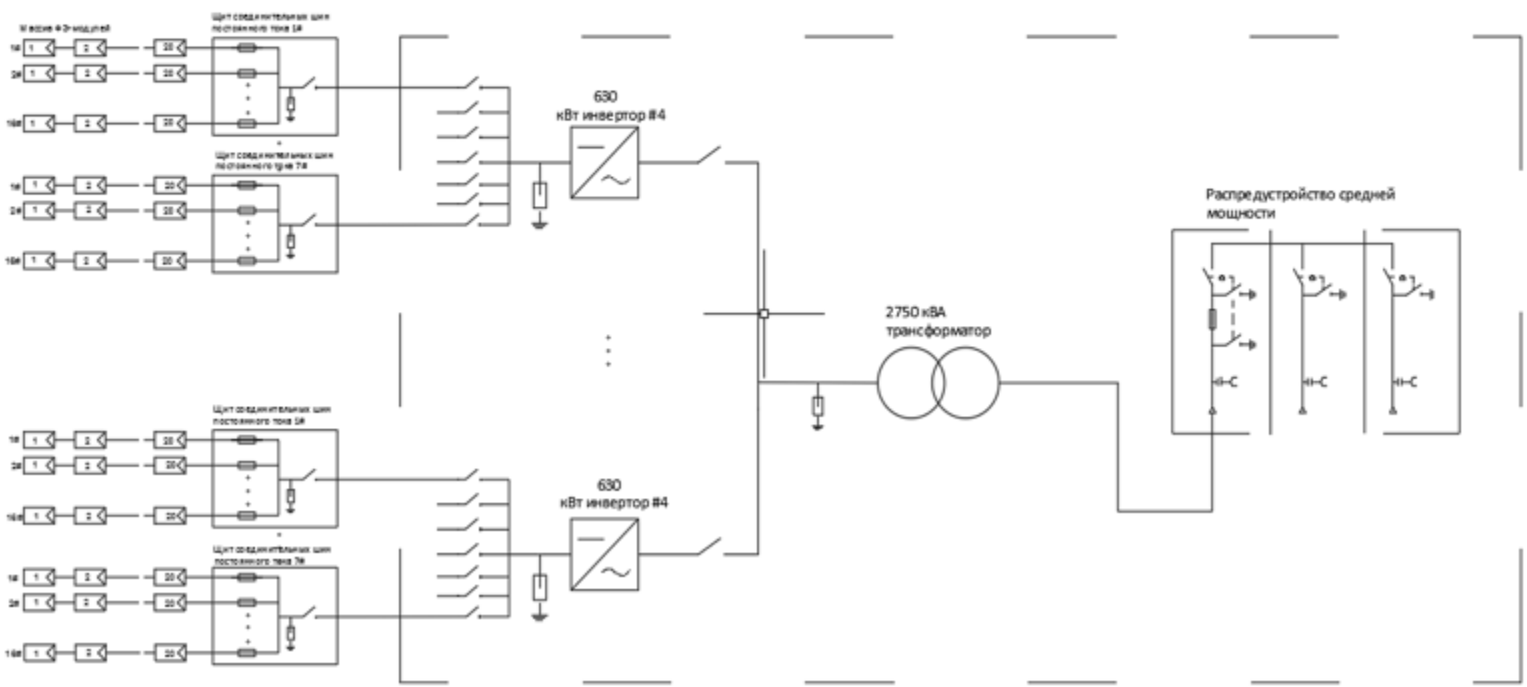
Synthesis of a hybrid circuit system of a photovoltaic power plant and micro-grid installations

- **On-grid photovoltaic station**

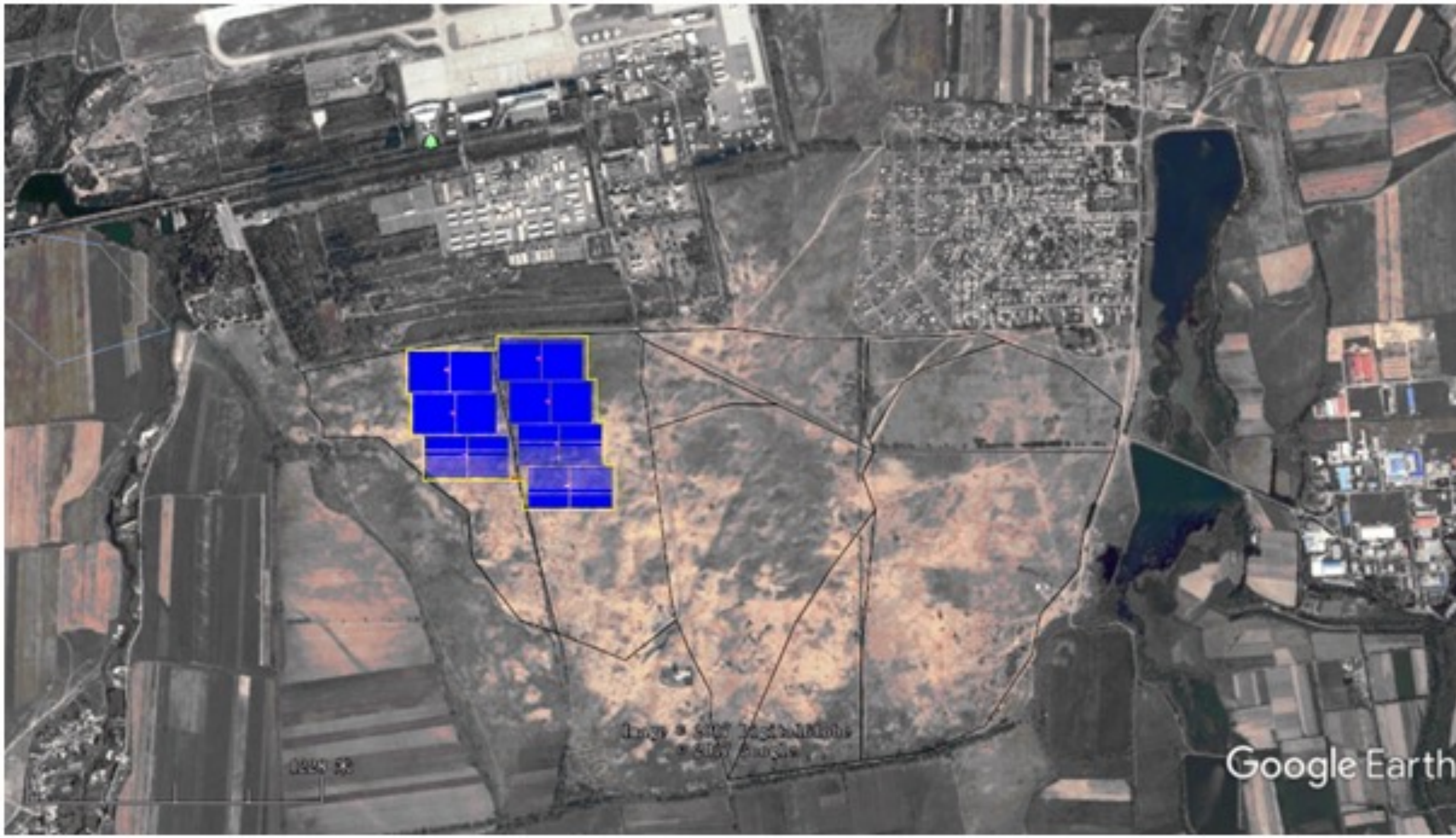
Name	Specification
FES power	20MW(peak)
PV modules	320V(peak)/ 62720PCS.
Max. AC output	17.5MW
PV inverter station	2.5MW/ 7PCS.
AC output voltage	35kV(according to local conditions)
Sub block	2.87MW(peak)/ 7blocks
PV mounting system	Ground installation type

Synthesis of a hybrid circuit system of a photovoltaic power plant and micro-grid installations

- Structurally, the following scheme of a photovoltaic plant is proposed:
- - The station consists of 7sub-blocks2.87 MW(peak) each;
- -Sub-blocksconnected to neighbors, and further connected to a grid connection point (power plant / transmission line);
- - Each block consists of 8960 pieces. modules 320 W (peak) and one inverter unit with a capacity of 2.5 MW combined with a step-up transformer.



20MWp PV Plant Layout (Only for reference)



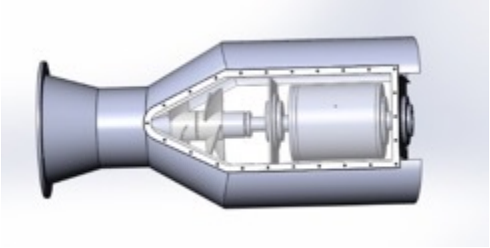
Small hydroelectric power station

Operating small hydroelectric power station KR

	Name					
1	**Malaya hydroelectric power station**	Chuiskaya region, BChK*	**0.4**	**ten**	derivational	1929
2	**Lebedinovskaya hydroelectric power station**	Chuiskaya region, BChK	**7.6**	**28.6**	derivational	1948
3	**Alamedinskaya HPP-1**	Chuiskaya region, BChK	**2.2**	**11.8**	derivational	1945
4	**Alamedinskaya GES-2**	Chuiskaya region, BChK	**2.5**	**12**	derivational	1948
5	**Alamedinskaya GES-3**	Chuiskaya region, BChK	**2.1**	**12**	derivational	1951
6	**Alamedinskaya GES-4**	Chuiskaya region, BChK	**2.1**	**12**	derivational	1952
7	**Alamedinskaya GES-5**	Chuiskaya region, BChK	**6.4**	**fifteen**	derivational	1957
8	**Alamedinskaya GES-6**	Chuiskaya region, BChK	**6.4**	**fifteen**	derivational	1958
9	**Bystrovskaya hydroelectric power station**	Chuiskaya region, Chu river	**8.7**	**26.3**	derivational	1954
	Total "JSC "Chakan HPS"		**38.4**			
10	**Issyk-Ata hydroelectric power station**	Chuiskaya region, Issyk-Ata river	**1.6**	**70**	derivational	2008
1	**Kalininskaya hydroelectric power station**	Chuiskaya region, river Karabalta	**1.4**	**60**	derivational	1998
12	**Maryam hydroelectric power station**	Chuiskaya region, Ak-Suu river.	**0.5**	**34**	derivational	2015
13	**Tegermentinskayahydroelectric power station**	Chuiskaya region, river Tegermenty.	**3**	**200**	derivational	2016
14	**Kok-Sai hydroelectric power station**	Issyk-Kul region, R. Kok-Sai	**3.4**	**486**	derivational	2019
15	**Konur-Olonskaya hydroelectric power station**	Issyk-Kul region, river Konur-Olon	**3.6**	**480**	derivational	2019
16	**Naimanskaya hydroelectric power station**	Osh region, R. Hiring	**0.6**	**24**	derivational	2005
17	**Kyrgyz-Ata hydroelectric power station**	Osh region, R. Kyrgyz-Ata	**0.25**	**thirty**	derivational	2016
19	**Jidalik hydroelectric power station**	Osh region, r.Shakhimardan	**one**	**12**	derivational	1948
	Total private SHPP		**15.35**			
	Total		**53.75**			
	*BChK - Large Chui channel					

Realized patents and equipment:

Birotor mHPP



Patents:

2).Birotoria microhydro–Pat. No. 11506 dated 10/31/12

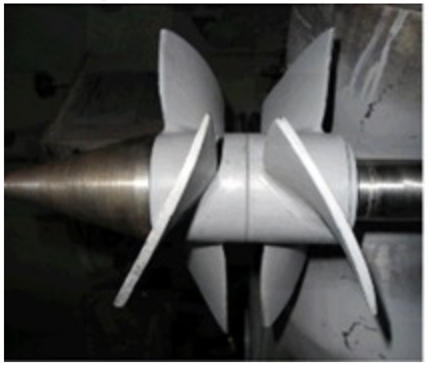
4).micro hydro power plantPat. No. 1748 dated May 28, 2015

Short description

The received patents are connected with new scientific directions of the theory of calculation and design of a fundamentally new classMicro HPP– Birotor SHPPs. Based on the development of theoretical foundations, the transformation of the energy of mountain streams into birotorMicro HPP, experimental and industrial samples of installations have been manufactured and created, providing increased reliability, economic attractiveness, high efficiency and foothill zones where the height difference of the river bed is not large.

The results of the study were transferred for industrial production to the republicKazakhstan.

Elements of an experimental sample of a birotor microhydroelectric power station



Impellers of bi-rotor micro HPP

Building of a bi-rotor micro hydroelectric power station

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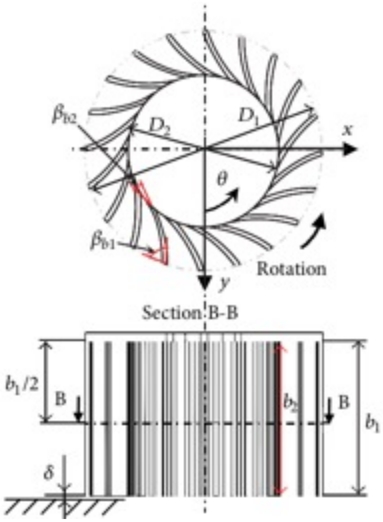
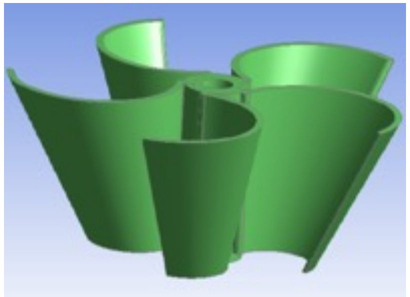
Analysis of the types of hydroturbines used for vortex microhydro power plants

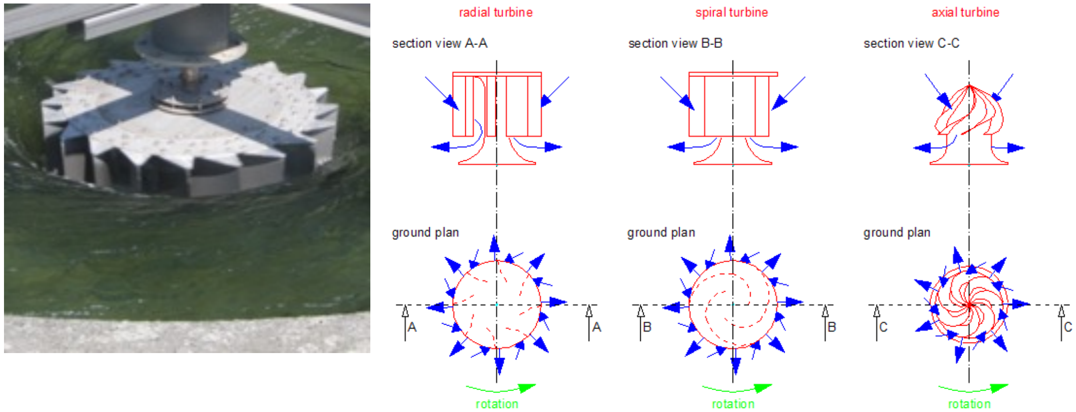


Centrifugal impeller

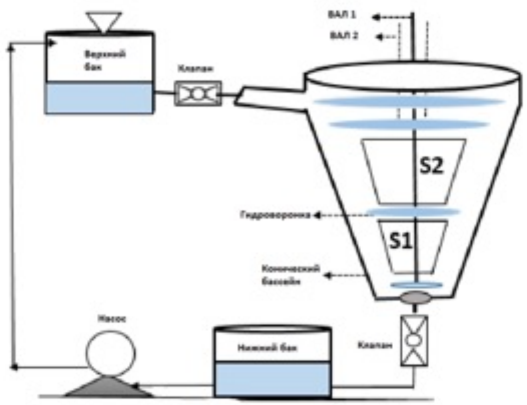
Vertical Angle Hydro Turbines



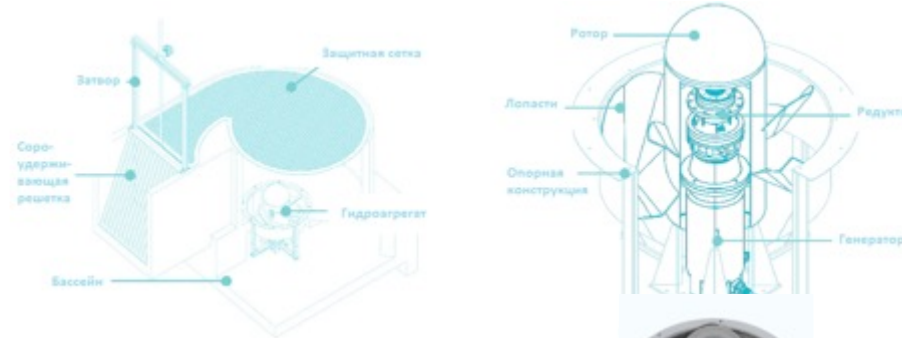
With reverse cone configuration



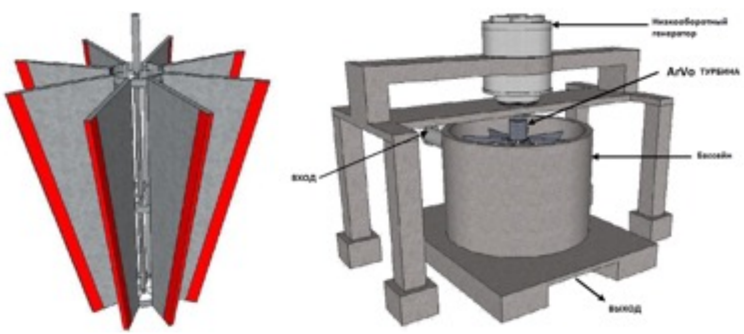
Hydro turbinesZotlöterer



Two-stage whirlpool turbine

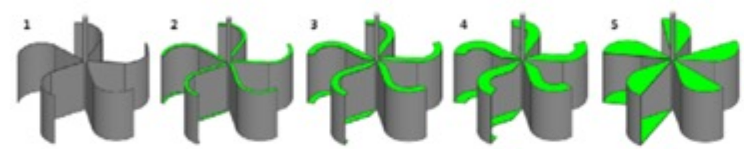


whirlpool hydraulic unit
Turbulent



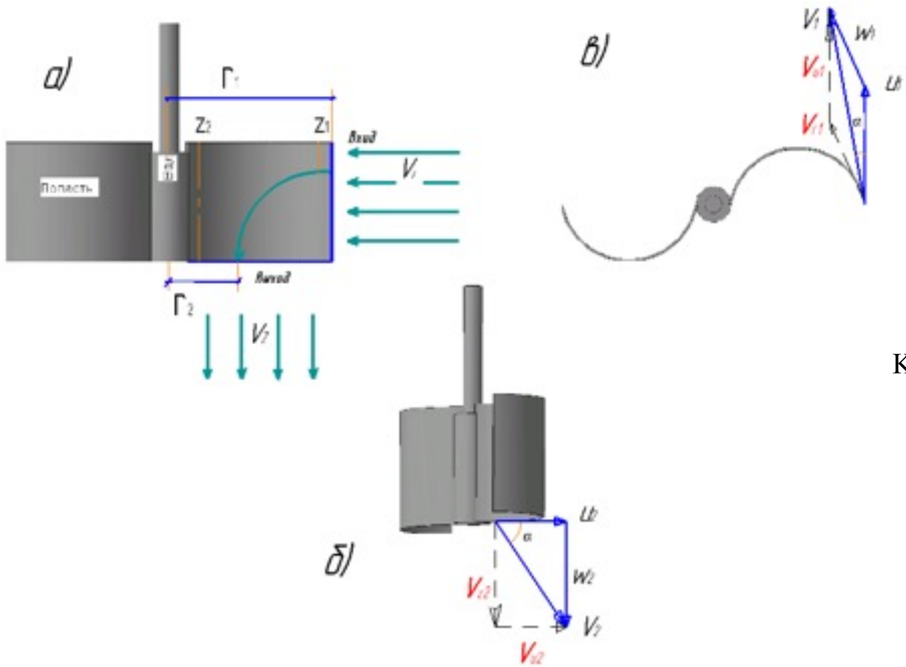
ARVO whirlpool turbine

	Model 1	Model 2	Model 3	Model 4	Model 5
Момент [Нм]	1.53	5.28	8.71	7.26	4.55
Пропрции перегородок (%)	0	25	50	75	100



Hydroturbines with baffles

Kinematics of the flow in the impeller of a gravitational whirlpool micro HPP



Velocity triangles built on the blades of a whirlpool turbine

Peripheral speed u_1 is determined by the formula:

$$u_1 = \frac{2\pi r_1 n}{60}$$

Absolute speed at the impeller inlet:

$$v_1 = V_{u1} + V_{r1}$$

$$V_{u1} = V_0 cos\alpha; V_{r1} = \frac{Q}{2\pi r_1 b}$$

Relative speed:

$$\vec{w}_1 = \vec{v}_1 - \vec{u}_1;$$

Knowing the moment and setting the angular velocity of the impeller, we can determine: $N_{\text{рк}} = M\omega$

$$M = \frac{\rho Q}{2\pi}(\bar{\Gamma}_1 - \bar{\Gamma}_2)$$

$$\Gamma_1 = 2\pi r_1 V_{1u}$$

$$\Gamma_2 = 2\pi r_2 V_{2u}$$

$$M = \rho Q(r_1 V_{1u} - r_2 V_{2u})$$

$$N_{\text{рк}} = \rho Q(r_1 V_{1u} - r_2 V_{2u})\omega$$

$$u_1 = r_1\omega$$

$$u_2 = r_2\omega$$

$$Q_m = \rho Q$$

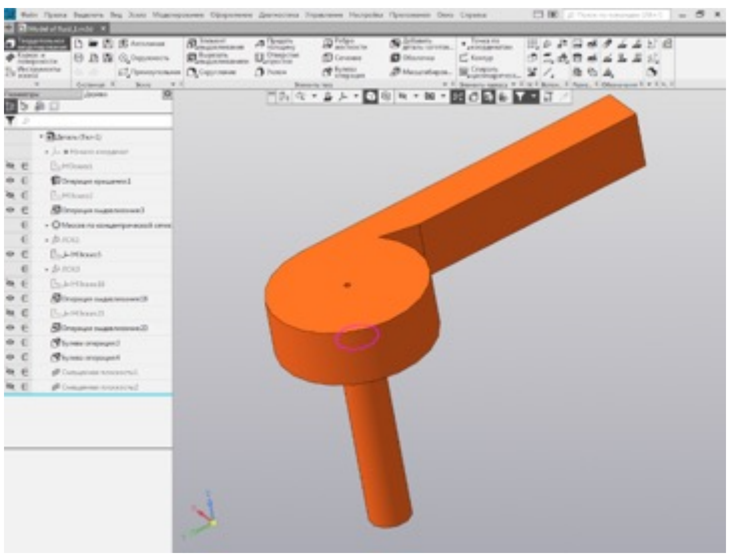
$$\boxed{\boldsymbol{N_{\text{рк}} = Q_m(u_1 V_{1u} - u_2 V_{2u})}}$$

Simulation of fluid flow in a whirlpool micro hydroelectric power station usingKompasFlow

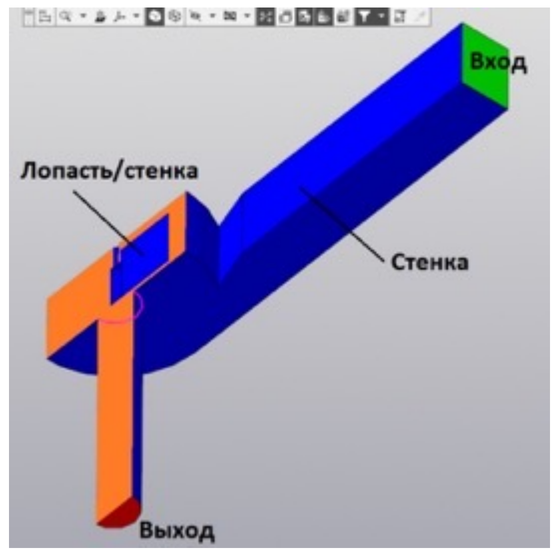
Computational fluid dynamic scomputational fluid dynamics,**CFD**) is a subsection of continuum mechanics, including a set of physical, mathematical and numerical methods designed to calculate the characteristics of flow processes.

In this study, the application was used KompasFlow (TESIS company), which is an express analysis tool integrated into KOMPAS-3Daero-hydrodynamics of the designed object.

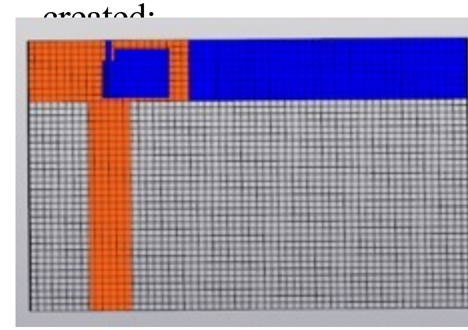
We form a geometric model calculation area GVVMHES:



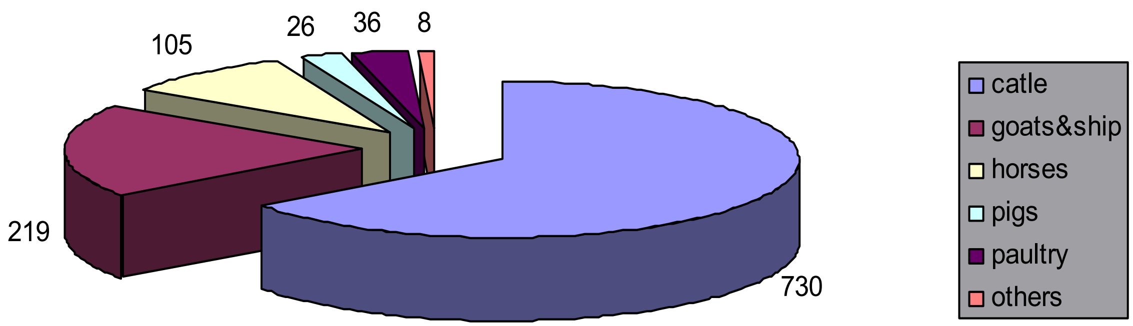
Boundary conditions are set:

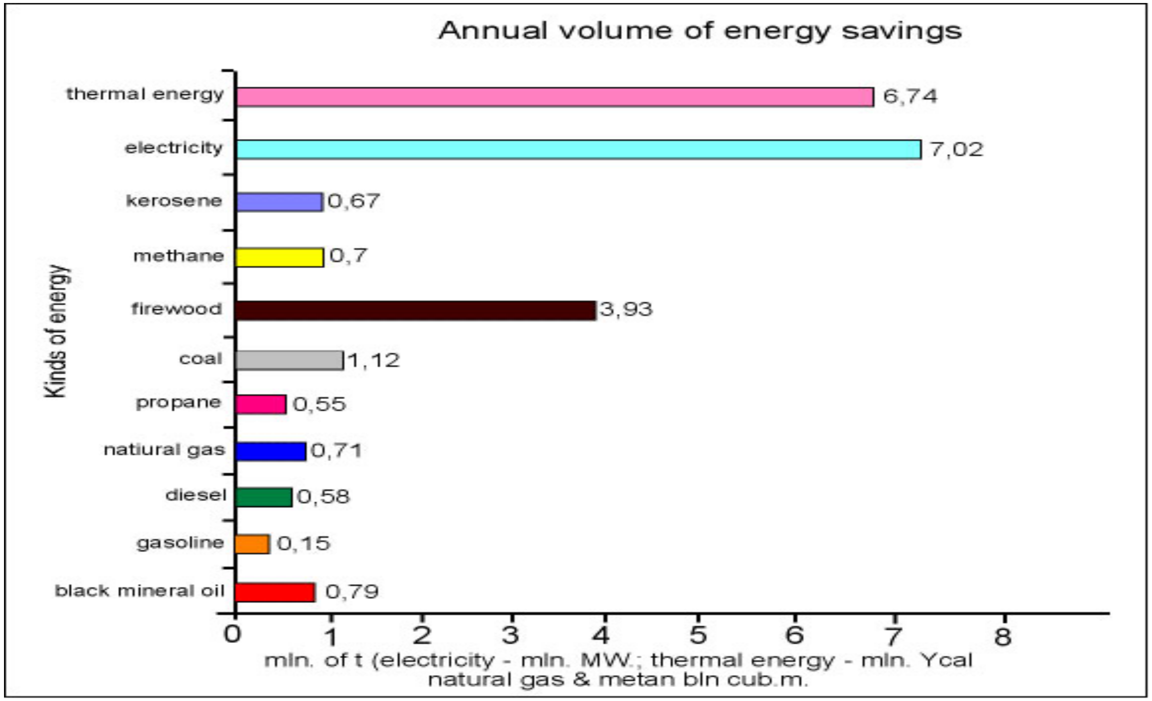


A computational grid uniform along all axes is created:



Biomass resources in Kyrgyzstan (million cubic meters per year)





Stantec umweltbundesamt WECOOP2 EU-Central Asia enhanced regional cooperation on Environment, Climate Change and Water

Realized patents and equipment:

BSU Industrialproduction(JSC "Jaz"")

Operating BGU for Kindergarten

Operating BGU rural bath

Short description

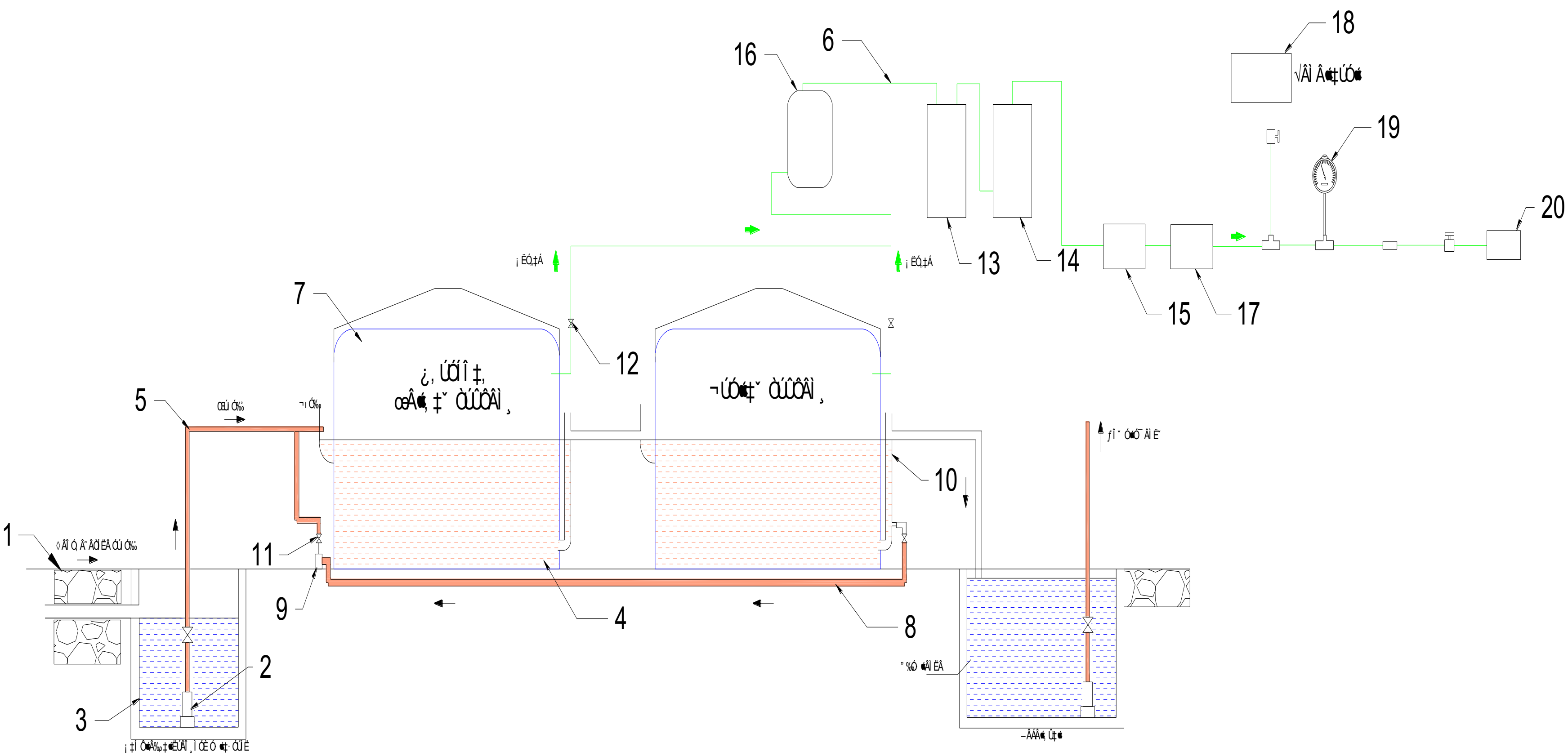
Research is aimed at the development and creation of various types of biogas plants for the production of combustible biogas and environmentally friendly highly efficient organic fertilizers by processing industrial and agricultural waste.

A number of BGU designs for power supply have been developed and createdlow-energyautonomous consumers, large dairy farms and social facilities (rural baths, kindergartens, schools, etc.)

According to the results of developments, more than 80 biogas plants have been introduced in all regions of the republic in the whole country. Installed capacities of methane techs from 5-10 m3 /day. up to 500-600m3/day.

The manufacture of standard equipment for BSU was mastered by JSC "Jaz» . The design and construction of BSU is carried out by a number of other private companies.

BGU TECHNOLOGICAL SCHEME



WECOOP2
EU-Central Asia enhanced regional cooperation on Environment, Climate Change and Water

Stantec umweltbundesamt

GENERAL VIEW OF BGU

Technical and economic indicators

BSU

- Average annual production of biogas - 20 thousand m^3
- The average annual electricity generation is 120 thousand. kWh
- Obtaining highly effective organic environmentally friendly fertilizers - 360 tons.
- Increasing crop yields by 15-20%

Structural elements of BSU

gas holder

biogas generator

WECOOP2
Stantec umweltbundesamt

Metatank

Circulation pump

Biogas combustion stove

Structural elements of BSU

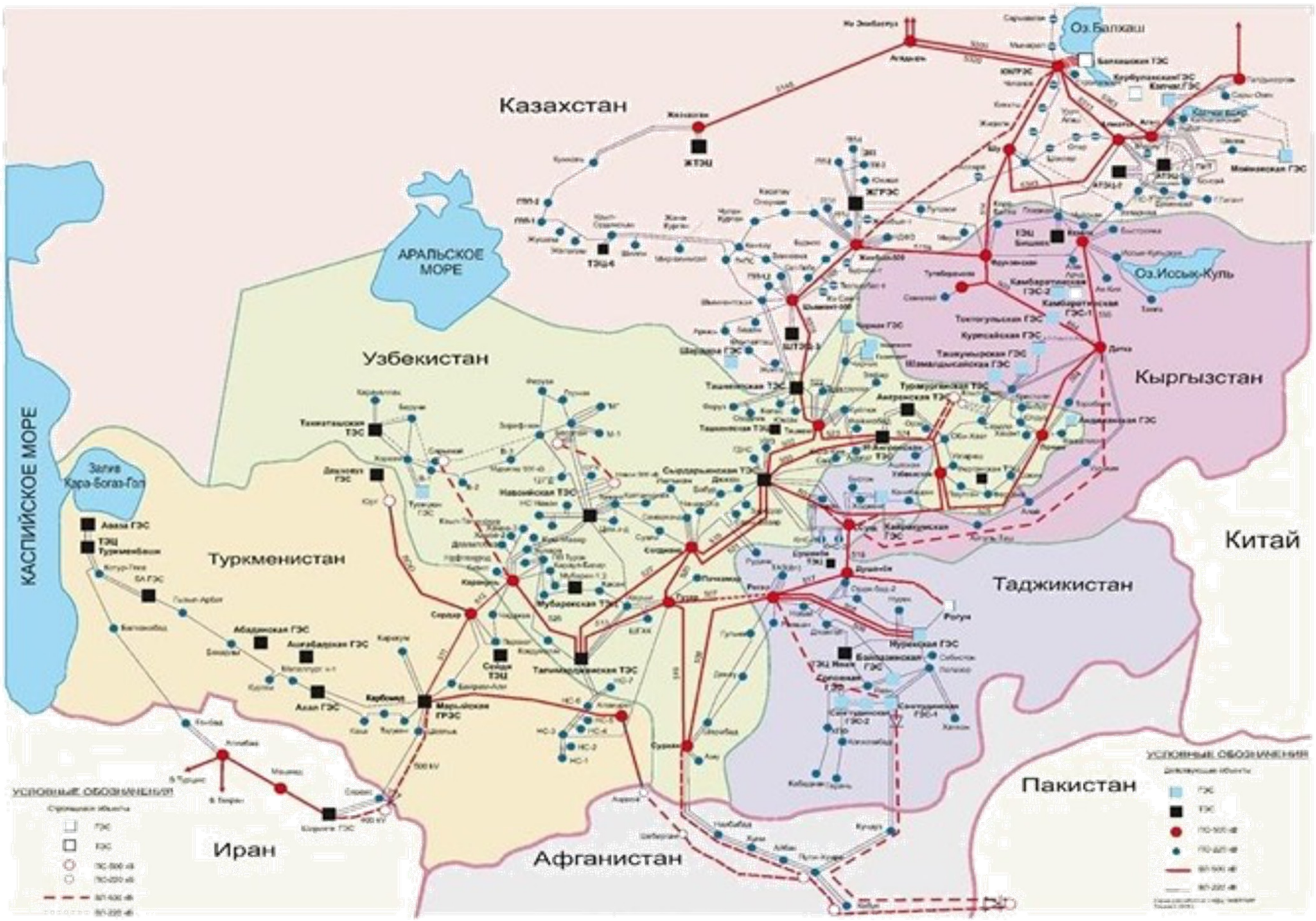
Gas meter

Control block

pressure sensors and moisture trap

Compressor

ICES of CA



Казахстан
Узбекистан
Туркменистан
Кыргызстан
Таджикистан
Китай
Пакистан
Афганистан
Иран
КАСПИЙСКОЕ МОРЕ
АРАЛЬСКОЕ МОРЕ
Оз.Балхаш
Оз.Иссык-Куль
Залив Кара-Богаз-Гол

Thank you!

Funded by the European Union

WECOOP

EU – Central Asia Cooperation on Water – Environment – Climate Change

Stantec ACTED

This project is implemented by the consortium led by Stantec, with ELLE (Estonian, La
Environment), ACTED, and Kommunal kredit Public Consulting as the consorti