Solar power plant

Concentrated Solar Power – CSP

Station with solar energy concentrator and Stirling engine

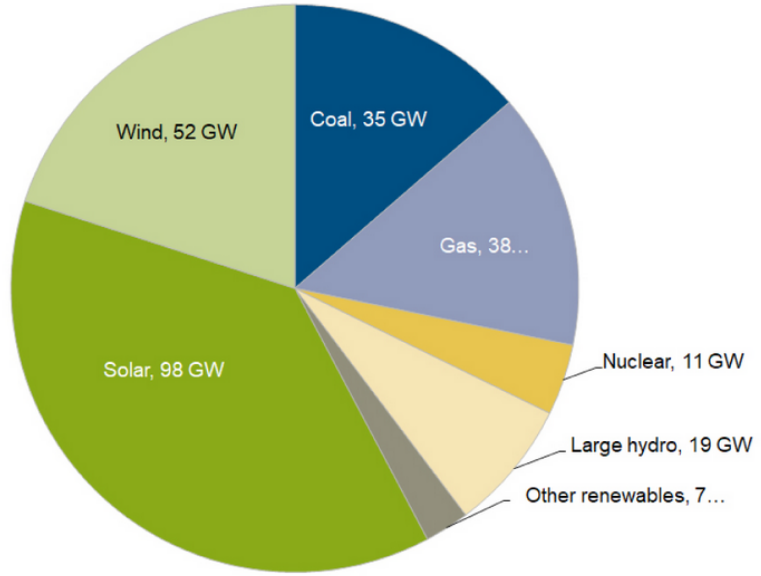
by Akor Direkt GmbH

Solar generation as an effective type of investment activity

Trends in the world:

- The use and consumption of energy in the world is growing every year.
- The global trend in the field of electricity is the development and implementation of renewable energy technologies (RES).
- RES solves global environmental problems such as warming, and local ones such as gas pollution and smog in cities.
- Sunlight (radiation) is one of the most affordable, reliable and cheap inexhaustible forms of energy on Earth.
-

In 2017, investors invested $ 160.8 billion in solar energy, introduced 98 GW.



Source: UN Environment, Bloomberg New Energy Finance

Growth of generating capacity in the world for 2017.

Solar energy set a record for the growth of installed capacity in 2017. and added 38% to the indicators of 2016.

At the same time, it allows RES quickly build energy infrastructure for expansion and development or development of new territories. Standard operational solution-diesel generation gives extremely expensive electricity with time-consuming and costly maintenance, with poor environment.

Leaders of SES development: China, USA and India ... Plans of the world community until 2050. raise the volume of generating capacity tenfold...

Solar generation technologies

At the moment, mainly two industrial technologies for obtaining energy from sunlight are used:

- PV - allows you to receive only electricity when irradiated semiconductor,
- Conversion of thermal energy from concentrated sunlight into electrical and thermal energy (concentrated solar power - CSP).

On the one hand, power plants built on the basis of PV technology tend to be cheaper in terms of the cost of one installed kW of electricity with ease of installation, however, on the other hand, have a low efficiency. (up to 20%), which further deteriorates with each year of operation (due to burnout cells), large losses due to heating panels, significantly limited life (budget models actually serve up to 10 years), repairable, and as part of the panels themselves are harmful substances (heavy metals, etc.), which leads to the need for additional cash costs for the disposal of "electronic waste".

Concentrated solar power - CSP

Benefits of CSP:

CSP station has a high efficiency (25-35%), thanks to the sun tracking system and the absence of inverters

- the efficiency is constant throughout the service life and does not decrease with increasing temperature
- long service life (up to 40 years and more), easy maintenance and low-cost repair, thanks to its design
- cost-effective disposal (additional income from disposal)
- the use of installations does not exclude the use of land in agriculture

✓ **The main advantage of the CSP station is the additional use of heat energy. After receiving electric energy up to 30-40% of thermal energy can be used in technological processes.**

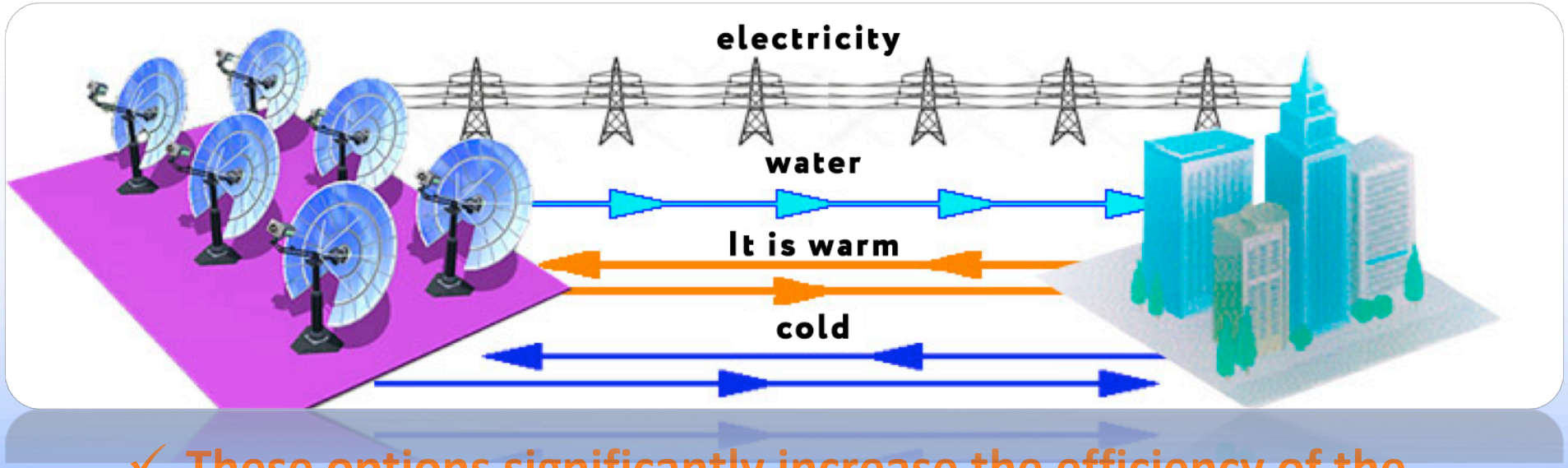
Akor Direkt GmbH

Concentrated solar power - CSP

Additional benefits of CSP:

The CSP station can be optionally equipped with reliable devices for the use of the received heat at the request of the customer in order to:

- heating of premises, use of heat in production processes
- obtaining cold as part of the climate control of the premises, obtaining cold for the process
- desalination and treatment of toxic industrial effluents using treated water in agriculture.



✓ **These options significantly increase the efficiency of the station and the profitability of investment in the project!**

Solar generation as an effective type of investment activity

Proposal

- invest in renewable energy facilities, based on high-yield (high - efficiency) modern solar stations such as Concentrated Solar Power-CSP with a long service life with minimal maintenance and without alienation of land from agricultural turnover.

Akor Direkt GmbH

CSP economy

Comparative table of advantages of CSP and PV:

Indicators	PV	CSP
Electric power generation	+	+
Heat generation	-	+
Cold generation	-	+ Optional with the cost of 1kW h cold=0,02 us dollars.
Desalter	-	+ Optional the cost of desalination of 1 ton of water for the period of operation (40 years) 0.01 USD.
Service life before renovation (years)	15	40
Disposal costs	Additional payment for recycling, harmful substances, pollution, financial costs in the future.	Renewal and re-use, refund for materials
The deterioration of the efficiency	Yes, 10% or more in 10 years	No, the efficiency is constant.
Maintainability	-	+
Area 1 MW of ELECTRICAL energy, with technological passages (sq. m.)	10.000 sq. m.	5.000 sq. m. Actually occupied under columns 160 sq. m.
Area 1 MW of ELECTRIC and THERMAL energy, with technological passages (sq. m.)	10.000 sq. m.	2.500 sq. m. Actually occupied by columns 80 sq. m.
The price of developing an overall (electric + thermal) of annual energy 1kvtch. up to 5 MW. installed capacity of the solar power plant.	0,6	0,5
The price of electric power generation average annual 1kvtch. up to 5 MW. installed capacity of the solar power plant.	0,6	1,0
The price of developing an overall (electric + thermal) of annual energy 1kvtch. over 5 MW. installed capacity of the solar power plant.	0,5	0,5
The price of developing an overall (electric + thermal) of annual energy 1kvtch. over 5 MW. the installed capacity of the solar power plant is designed for the service life.	0,0333	0,0125

CSP economy

Comparison of 20 MW plant installed capacity CSP and PV:

1. The amount of electricity generated in 25 years:

- CSP: **933.450.000 kWh electric**
  + 933.450.000 kWh thermal
- PV: **652.880.000 kWh**
- Actual electricity generation is **43%** more than PV .

2. Possible service life:

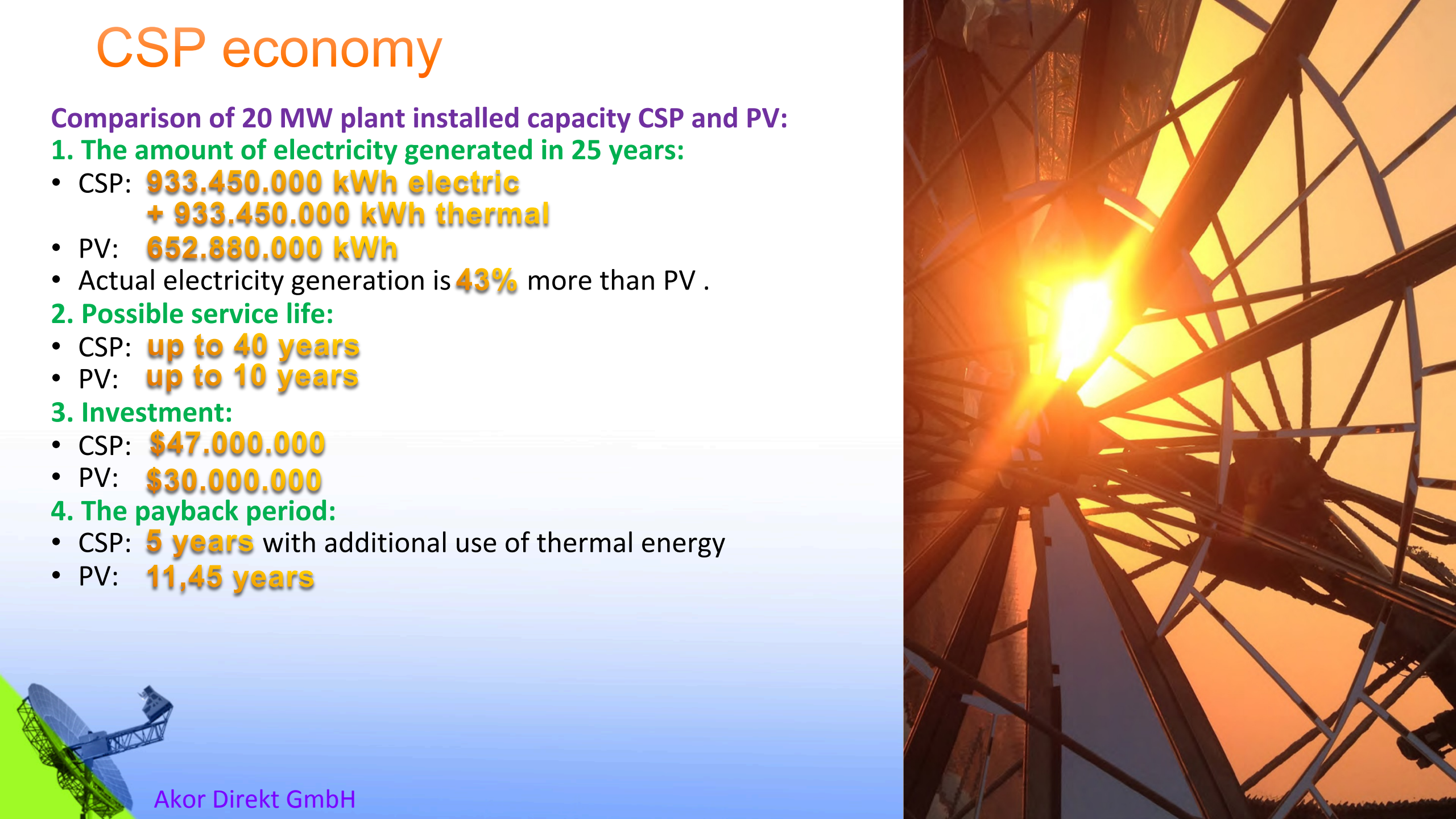
- CSP: **up to 40 years**
- PV: **up to 10 years**

3. Investment:

- CSP: **$47.000.000**
- PV: **$30.000.000**

4. The payback period:

- CSP: **5 years** with additional use of thermal energy
- PV: **11,45 years**



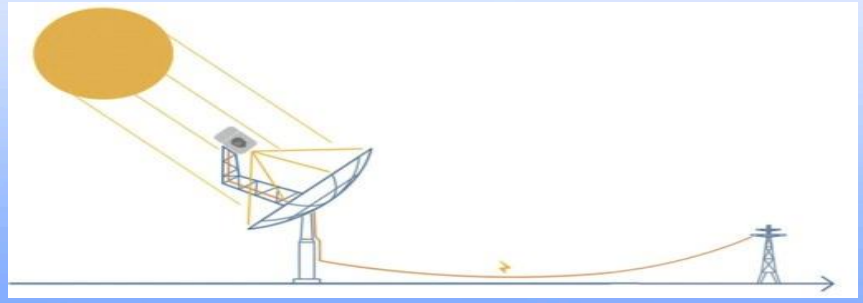
The principle of CSP

How it works:

The basis of the CSP installation is a solar ray concentrator (parabolic mirror) and a tandem Stirling engine and asynchronous generator.

How to achieve high and constant efficiency, low-cost maintenance and maintainability with such a long service life:

- The servo system controls the movement of the concentrator after the sun by means of a servo drive, so that the maximum possible amount of solar energy is captured for further conversion
- The original modification of the Stirling engine, unpretentious in operation, developed using a specially created mathematical model for optimization of processes, is used
- Reliable asynchronous electric machine in generator mode works directly on the load or electrical distribution network without inverter, which leads to the absence of losses and the absence of additional "harmful" current harmonics overheating the electrical equipment in the adjacent network
- All elements are easily replaceable and have a long service life. Maintenance costs are no more than 0.05% of the installation cost per year.



The principle of CSP

How it works:

- The use of CSP plants does not exclude the use of land in agriculture.

Under certain restrictions, the column on which the concentrator is mounted with the installation can be increased in length, so as not to restrict the movement of agricultural machinery and people. Thus, the actual area occupied by CSP installation is reduced to the area of the Foundation.

A typical single installation of 25 kW mirror area of about 92 sq.m. will require 4 sq. m. under the Foundation.

In the business model of the company significantly reduces the cost of land alienation or lease for a solar station.

Additional options-heat, cold and fresh water, can be a great integrated solution for farmers.

The above significantly increases the value of the offer and the efficiency of investments, reduces the payback time by tens of percent.

The principle of CSP table

Indicator of the system as a whole	Value
Efficiency	up to 30% of electricity and up to 40% of heat
Mirror	92 sq. m./4 sq. m.
Rated power	25-30 kW
Frequency	50 Hz
Voltage	3-phase, 400V variable
The weight of the system	up to 6 tone
Sun tracking system	Two-axis 0-360 degree in the horizontal plane and 0-90° degrees in the vertical
Concentrator indicator	**Value**
Type	Parabolic dish
The area of the hub	94,8-105,4 sq. m.
Efficiency	94-100%
Reflection power	93-95%
Focal length	7.3-8.5 m

The principle of CSP table

The tandem indicator of Stirling engine and electric generator	Value
Remote control	Modbus or Internet connection to SCADA
Type Of Stirling	Alpha type or 4-cylinder
Working gas	Helium
Operating temperature / pressure	720°C / 20Mpa
Volume of gas	380 cubic centimeters
Generator	Asynchronous machine
Rotation speed	about 1500 rpm
Weight	920 kg
Environmental conditions	**Value**
Operating conditions	16 meter per second
Working conditions	44 meter per second
Temperature	-20 to +50 ° C working, -40° to +70° C acceptable
DNI	250W/㎡–1050 W/㎡
Earthquake	≤6 magnitudes
Height over sea level/Humidity	≤3000 м/ ≤90%(25°C)
Working conditions	**Value**
Term of work	up to 40 years

Concentrated solar power - CSP

The use of CSP plants:

- for lighting and heating of houses, districts, cities
- for the supply of electricity and heat or cold industrial enterprises
- for lighting, heating and supply of clean drinking water and greenhouses.

✓ **These options are incredibly increase the efficiency of the station and the profitability of investment in the project!**

The introduction of the CSP

Zhang Jiakou Project
Hebei Province, China

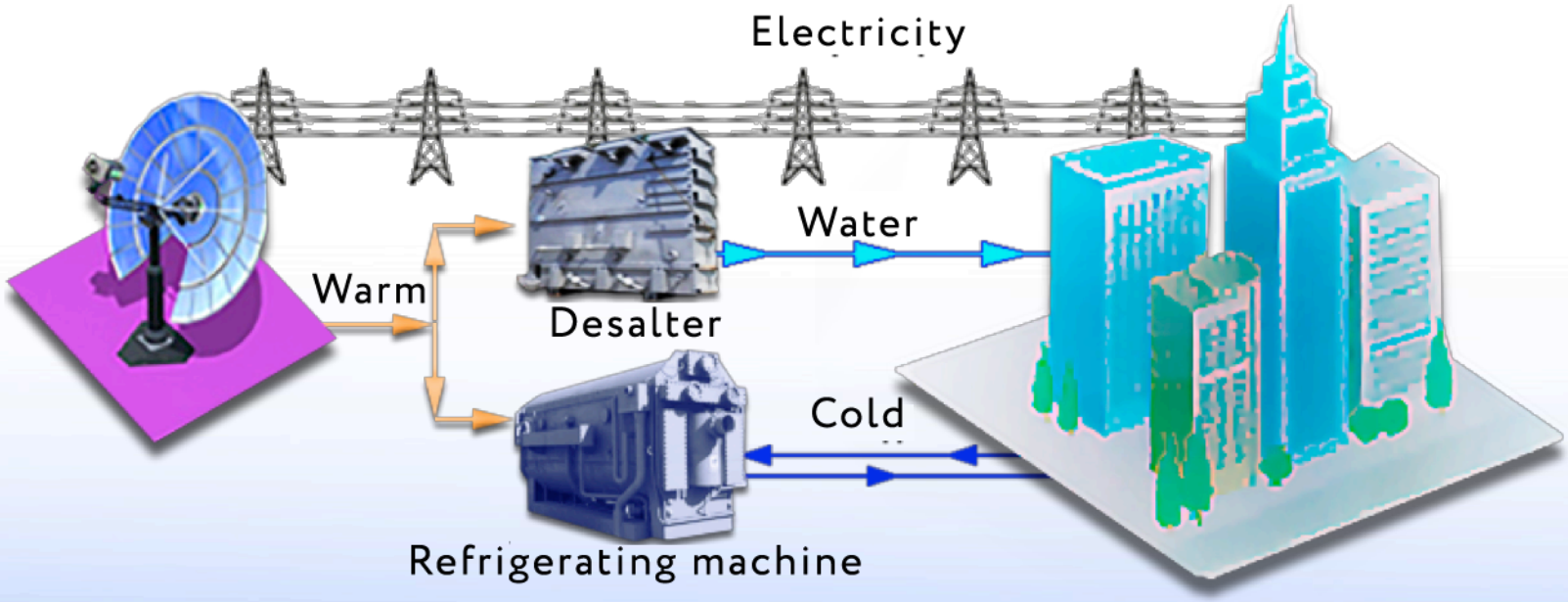
Ordos Project
Inner Mongolia, China

Zhang Jiagang Project
Jiangsu Province, China

- At the moment, there are examples of installed and operating CSP power plants in China and Mongolia.
- Projects are being developed for countries: France, USA, Cyprus, Angola, Nigeria, Russia.

Concentrated solar power - CSP

Additional options using the generated thermal energy of CSP installations



Desalter

Akor Direkt GmbH

Desalter:

Characterized by unique consumer properties:

- long service life (at least 25 years)
- ecological cleanness
- low acoustic pollution (noise)
- low power consumption
- no need for continuous removal of products separated from clean water (automatic washing)
- ability to control the intensity of scale formation
- blocks are scaled from 20 to 7000 liters per hour
- easy maintenance

✓ **The desalination plant is based on innovative developments created in cooperation with scientists of Novosibirsk Akademgorodok.**

Desalter

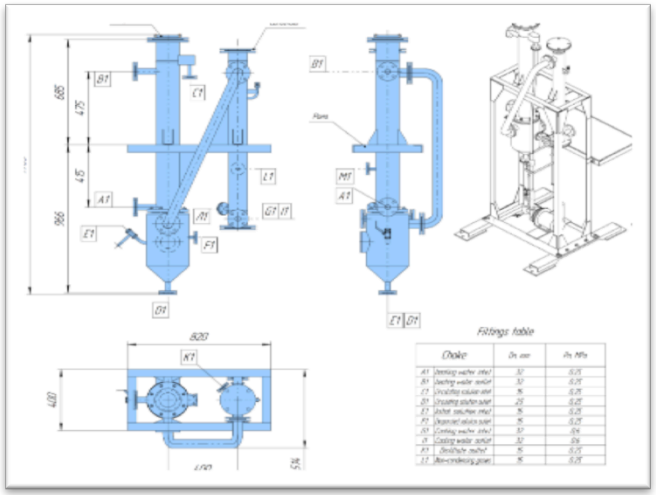
Application:

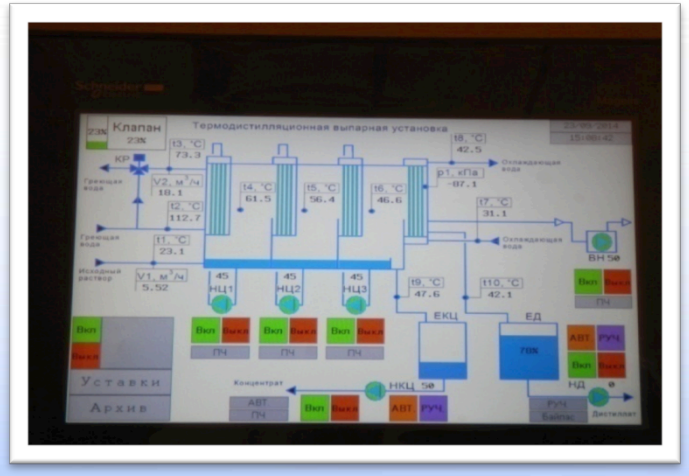
- obtaining drinking water in any volumes
- preparation of water for irrigation in agricultural production
- cleaning of heavily polluted industrial effluents for reuse in the process

Desalter

Three-stage plant with a capacity of 7.5 t/h for desalinated water

The installation with capacity of 20 kg/h of desalinated water





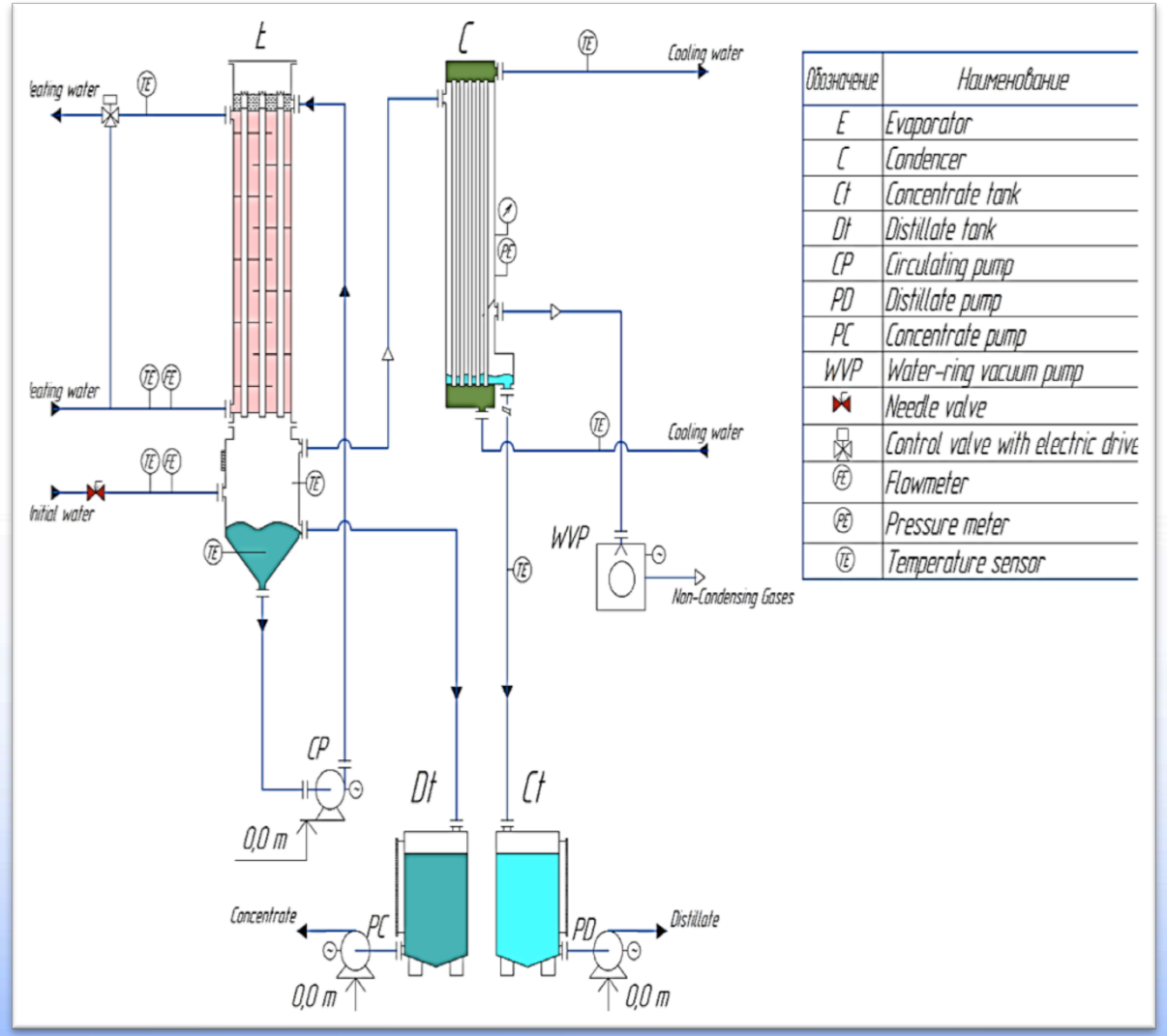
An example of a SCADA system in operation

Desalter

Principle of operation:

The single-stage installation is made on the basis of a vertical pipe evaporator with a falling liquid film.

The initial solution (can be river or sea water after coarse filtration) with a salt concentration of up to 30 g/l and a temperature of about 20-30 °C, is fed to the evaporator with a falling film of liquid E, where it is evaporated. Evaporated solvent flows into the container of concentrate CT.
The process of evaporation of water from the solution in the installation is carried out under vacuum (vacuum).



Обозначение	Наименование
E	Evaporator
C	Condencer
Ct	Concentrate tank
Dt	Distillate tank
CP	Circulating pump
PD	Distillate pump
PC	Concentrate pump
WVP	Water-ring vacuum pump
	Needle valve
	Control valve with electric drive
FE	Flowmeter
PE	Pressure meter
TE	Temperature sensor

Desalter

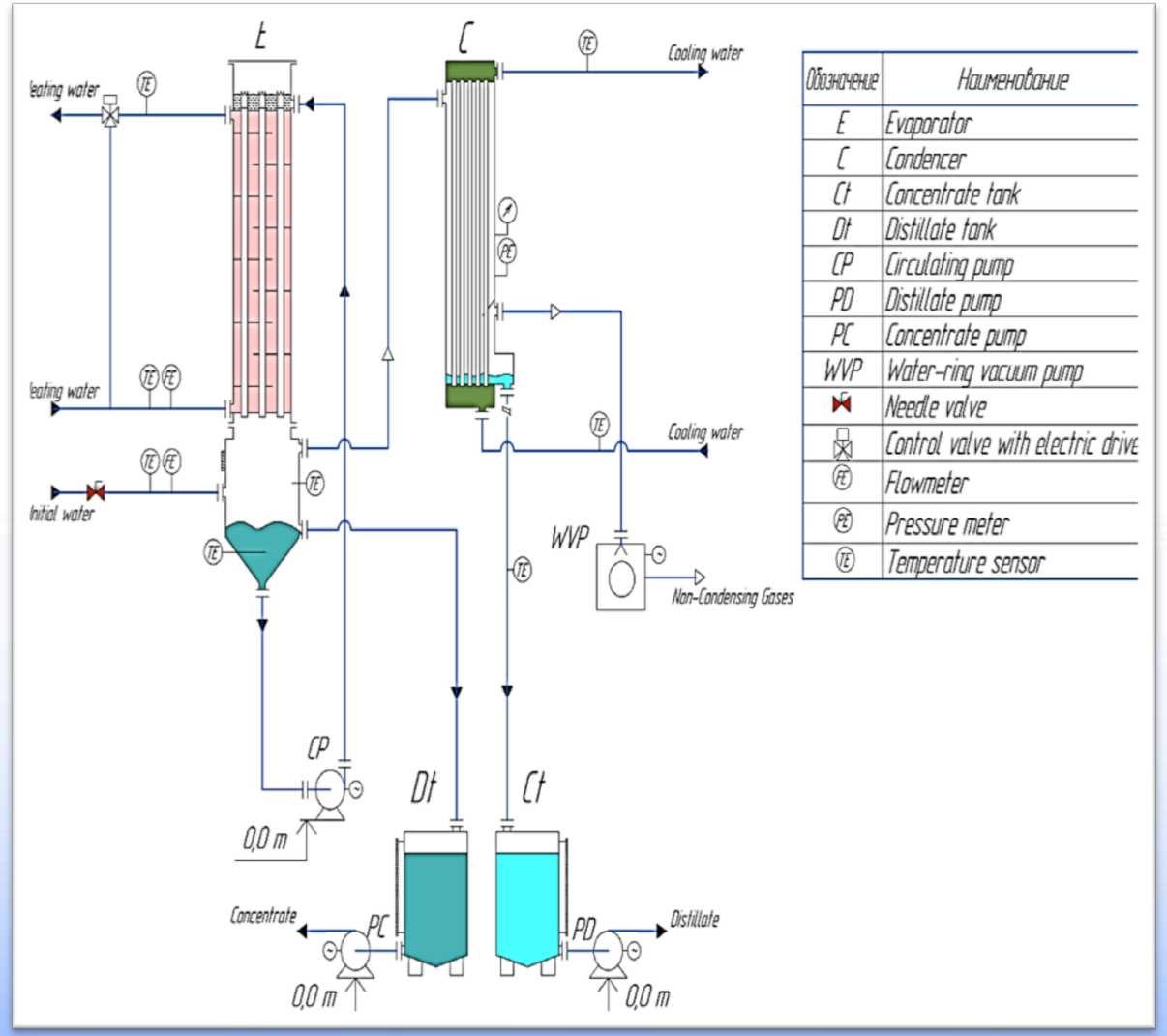
Principle of operation:

Heating water from an external source is supplied to the intertubular space of the heating chamber of the evaporator E, providing evaporation of moisture from the solution.

From the evaporator E, the secondary steam is discharged into the water-cooled condenser from the condenser and the distillate dt is drained from the Condenser, from where the DP pump is pumped for further use.

The steam-air mixture from condenser C is continuously pumped out by the wvp water-ring vacuum pump.

The required amount of distillate (desalinated water) is maintained by regulating the flow of heating water.



Обозначение	Наименование
E	Evaporator
C	Condencer
Ct	Concentrate tank
Dt	Distillate tank
CP	Circulating pump
PD	Distillate pump
PC	Concentrate pump
WVP	Water-ring vacuum pump
	Needle valve
	Control valve with electric drive
FE	Flowmeter
PE	Pressure meter
TE	Temperature sensor

Technical characteristics of the units

The name of the parameter and dimension	Thermodistillation plant (Watermaker)			
	TDU 20	TDU 300	TDU 600	TDU 1000
Productivity of the initial solution, kg / h	up to 140	up to 2100	up to 4200	up to 7000
Total salt concentration in the initial solution, %	up to 3,0			
The temperature of the feed solution at the entrance to the installation, °C	20-30			
Distillate (fresh water) capacity, kg / h	20	300	600	1000
Distillate temperature, °C	up to 60			
Amount of evaporated solution, kg / h	up to 120	up to 1800	up to 3600	up to 6000
Heating water inlet temperature, °C	up to 95			
Heating water consumption, m3 / h	up to 2	up to 30	up to 60	up to 100
Cooling (circulating) water consumption, m3 / h	up to 2	up to 30	up to 60	up to 100
Cooling water temperature at the plant inlet, °C	up to 45			
Cooling water temperature at the outlet of the unit, °C	up to 50			
Installed electric power, kW	1,5	2,6	3,1	4,0
Electric power consumption, kW	up to 1,1	up to1,7	up to 2,0	up to 2,8

Refrigerating machine

Akor Direkt GmbH


Akor Direkt GmbH

Refrigerating machine

In addition to the CSP, Refrigeration machines (XM) can be supplied running on the heat generated to generate artificial cold.

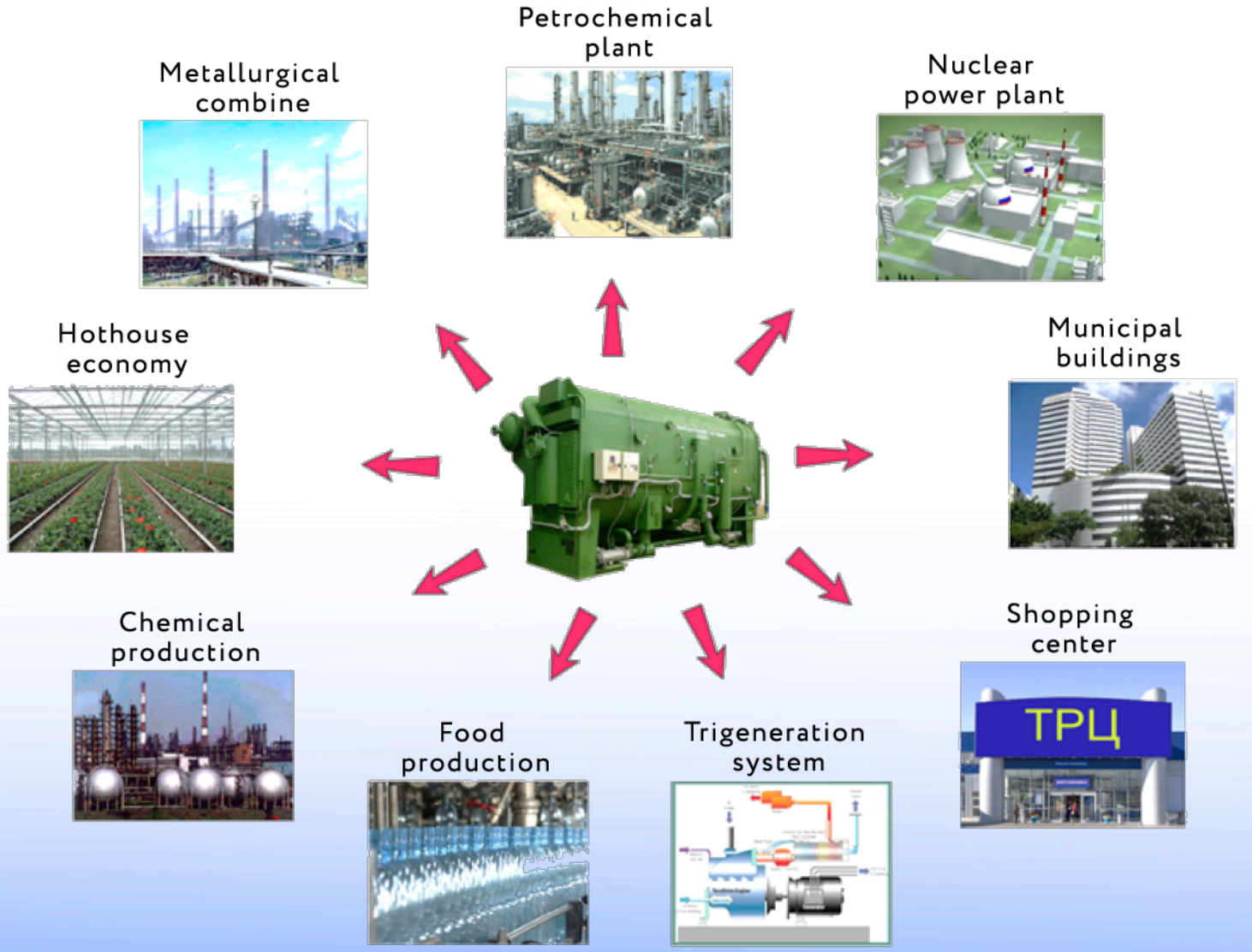
Refrigerating machines are built on the principle of:

lithium bromide absorption thermo transformers.

HMM, these have high consumer properties:

- fire and explosion safety
- long service life (at least 25 years)
- ecological cleanness
- low acoustic pollution (noise)
- low power consumption

Scope and principle of operation

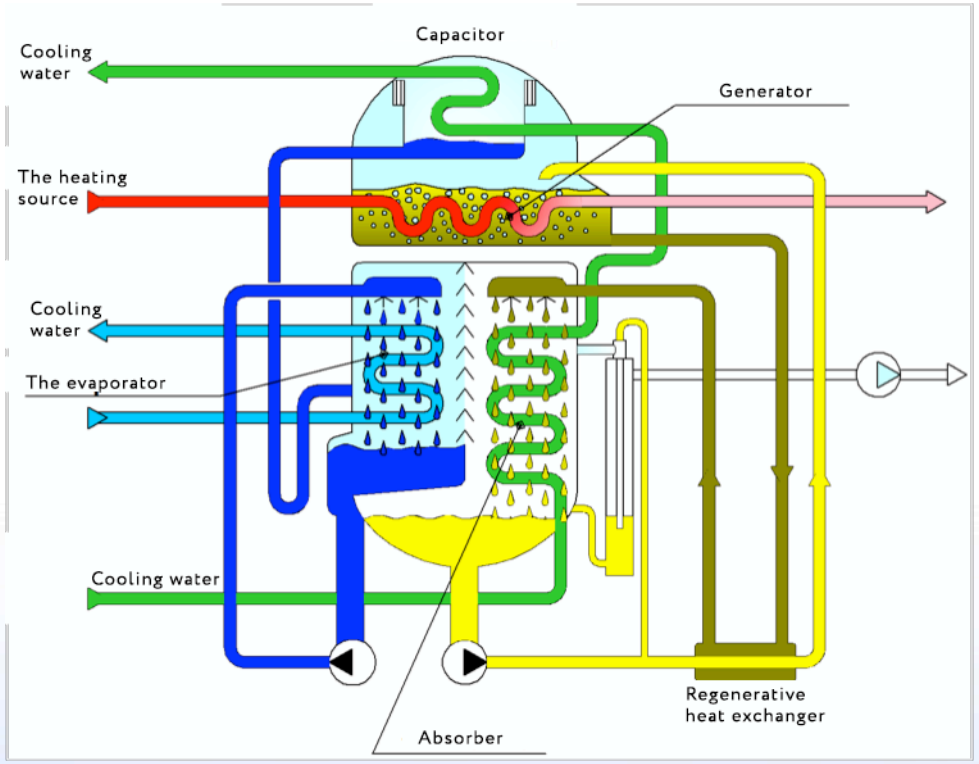


Refrigerating machine

Just at the moment developed and produced thirty modifications of XM:

- with water and steam heating with single-stage (ABCM-B, ABCM-P) and two-stage (ABHM2-P) regeneration of the solution with cooling capacity from 600 to 4000 kW
- with low-temperature water heating with single-stage solution regeneration (ABCM-HN) power from 600 to 4000 kW

Since 2001, dozens of ABCM have been manufactured and put into operation.



✓ **The desalination plant is based on innovative developments created in cooperation with scientists of Novosibirsk Akademgorodok.**

Innovative development

Development of XM for production of cold in the negative temperature range

Typically, water is used as a refrigerant, and it is impossible to obtain lower temperatures. However, in many industrial applications there is a need for lower cooling temperatures, including negative:

- obtaining the so-called "ice-cold" water to cool milk
- cooling of the storage space with the food
- plastic production technology: cooling of recycled water for extruders, cooling of molds and dies; etc.

✓ **The establishment of waste heat recovery low-temperature UH based on LiCl with negative temperatures the boiling point of the refrigerant will reduce the consumption of electricity to generate refrigeration.**

Development of XM on an alternative working body

Around the world, the main absorbent of XM is an aqueous solution of lithium bromide (LiBr). An aqueous solution based on LiCl salt is considered as an alternative absorbent in XM.

LiCl has a number of advantages over LiBr:

- the cost is less than almost 2 times
- significantly less corrosion activity

Technical characteristics of refrigeration units

Refrigerating machine ABHM-VN	600Вн	1000Вн	1500Вн	2000Вн	3000Вн	4000Вн
Cooling capacity, kW	550	960	1440	1800	2500	3330
Heating water consumption, m3 / h	70	122	183	228	317	422
Cooling water consumption, m3 / h	95	165	248	310	430	573
Cooling water consumption, m3 / h	165	288	432	540	750	998
Installed electric power, kW	3,5	4,5	5,1	6,1	8,6	12,7
Hydraulic circuit resistance - water cooled - cooling water - heating water	 4,5 10,9 2,1	 5,3 11,6 5,3	 4,9 11,3 5,2	 7,2 9,3 8,0	 4,9 6,3 11,0	 9,3 13,3 3,4
Overall dimensions, m L – length B – width H – height	 5,10 1,60 3,10	 5,34 1,84 3,26	 5,42 2,30 3,45	 6,70 2,22 3,50	 7,30 2,65 3,95	 9,30 2,65 3,95
Weight, tons - dry - in working condition	 8,7 12,7	 11,6 14,2	 16,3 24,7	 18,5 29,4	 24,5 37,0	 31,1 47,7

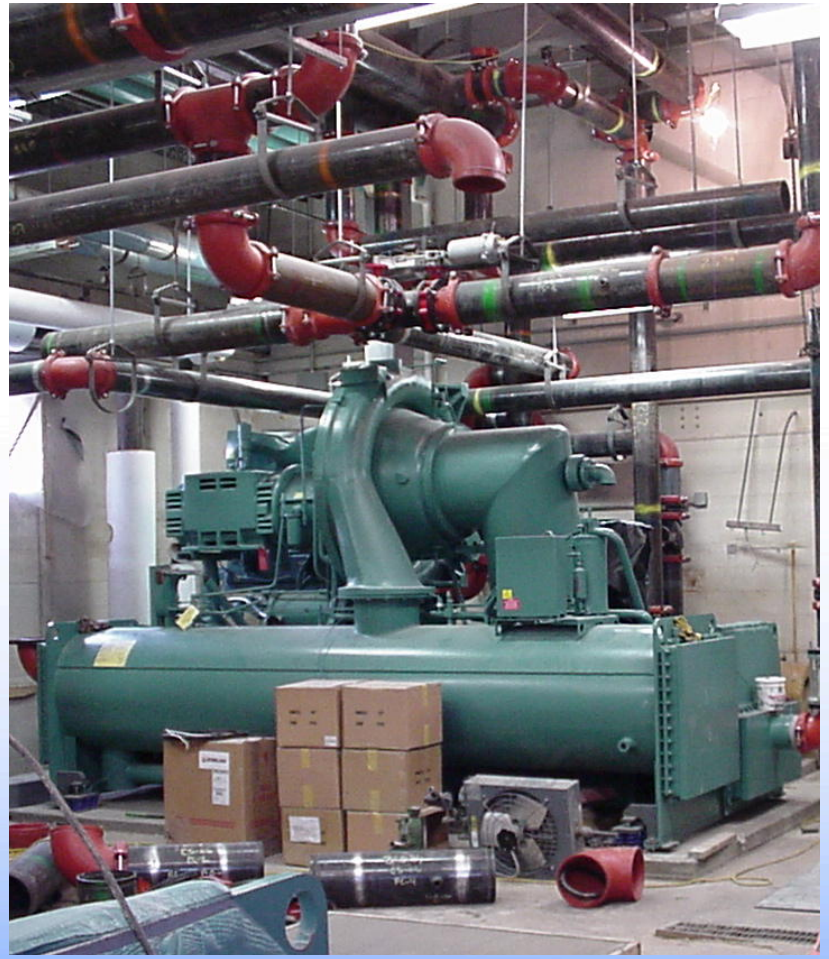
Data are shown for the following parameters of heat-carriers:
- cooling water temperature-12/7°C
- cooling water temperature-27/35°C
- heating water temperature-90/80°C

Allowable pressure:
- cooling water-1 MPa
- cooling water-0.6 MPa
- heating water-0.6 MPa

Application

Some implemented examples of optional refrigeration units more power

Compression refrigerating machines (CHM)



Absorption lithium bromide refrigerating machine(ABHM)

Two refrigerating machines ABHM-1500ts with total capacity of 3000 kW

OOO "Karachinsky source", n. Karachi, NSO, 2010

Purpose: cooling of mineral water.

Refrigerating machine ABHM-3000П capacity of 3000 kW

FKP "Anoit", Kuibyshev, NSO, 2008

Purpose: water cooling of the technological cycle.

Refrigerating machine ABHM-1000vn with capacity of 960 kW
OOO "Basket-6", Lipetsk, 2012
Purpose: for air-conditioning of sausage.

Refrigerating machine ABHM-2000П power of 2100 kW
CoAO "nitrogen", Kemerovo, 2012
Purpose: for cooling water and other media in technological cooling systems of caprolactam production .